Weed Risk Assessment for *Phyllostachys aurea* Carr. ex A. & C. Rivière (Poaceae) – Golden bamboo

Maryland Department of Agriculture

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Version 1

Top left and bottom right, a stand of golden bamboo (source: Chuck Bargeron, University of Georgia, Bugwood.org). Top right, leaves of golden bamboo. (James H. Miller, USDA Forest Service, Bugwood.org). Bottom left: a stalk of golden bamboo in Dorchester County, MD (Wayne Longbottom, Maryland Biodiversity Project).

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Introduction The Maryland Department of Agriculture regulates terrestrial ornamental invasive plants under the authority of Md. AGRICULTURE Code Ann. § 9.5-101 et seq. Invasive Plant Prevention and Control. An invasive plant is defined as "a terrestrial plant species that a) did not evolve in the State, and b) if introduced within the State, will cause or is likely to cause, as determined by the Secretary: economic harm; ecological harm; environmental harm; or harm to human health."

Maryland's Invasive Plant Advisory Committee (IPAC) was established by legislative mandate in October 2011. The IPAC's primary responsibility is to advise the Secretary of Agriculture on regulating the sale of invasive plants, and on preventing them from entering Maryland or from spreading further in the state. IPAC evaluates the risk potential of plants already present in Maryland, newly detected in the Maryland or the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

The IPAC evaluates the potential invasiveness of plants using the weed risk assessment (WRA) process developed by the Plant Protection and Quarantine (PPQ) Program of the US Department of Agriculture's Animal and Plant Health Inspection Service (Koop et al. 2012). PPQ's risk model uses information about a species' biological traits and behavior to evaluate its risk potential (Koop et al. 2012).

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 specific region in the United States. In the PPQ process, the geographic potential of the species is evaluated separately so that risk managers can make decisions appropriate for their regions. With respect to Maryland's evaluation process, we use PPQ's Geographic Information System overlays of climate to evaluate the potential for a plant to establish and grow in Maryland. The PPQ weed risk assessment also uses a stochastic simulation to evaluate how the uncertainty associated with the assessments affects the model's predictions. Detailed information on the PPQ WRA process is available in the document, *Guidelines for the USDA-APHIS-PPQ Weed Risk Assessment Process* (APHIS PPQ 2015), which is available upon request.

The IPAC uses a second tool, the Maryland Filter, to assign plant species that score as highly invasive either Tier 1 or Tier 2 status. Maryland regulations define Tier 1 plants as "invasive plant species that cause or are likely to cause severe harm within the State" and Tier 2 plants as "invasive plant species that cause or are likely to cause substantial negative impact within the State." The Maryland Filter considers the actual and potential distribution of a species in Maryland, its threat to

threatened and endangered ecosystems and species in the state, the difficulty of control of the species, and whether added propagule pressure would be likely to increase its persistence and spread significantly. The IPAC then recommends regulations to reduce the risk of the Tiered invasive plants in Maryland.

***Phyllostachys aurea* Carr. ex A. & C. Rivière – golden bamboo**

Species Information

Family: Poaceae

Synonyms: *Phyllostachys breviligula* W.T.Lin & Z.M.Wu (The Plant List 2016).

Common names: golden bamboo, fish-pole bamboo (Gucker 2009).

Botanical description: Golden bamboo is an evergreen, rhizomatous grass with woody stems growing 7-39 feet tall, with a distinct sulcus or groove running along the internodes. Stems and branches are green when young, turning golden yellow as they age. Branches have slender leaves often arranged in a fan shape. Stands spread from long, slender rhizomes (Barkworth et al. 2007, Gucker 2009).

Initiation: This plant is listed on the MD Department of Natural Resources (DNR) Do Not Plant List, a policy document available from MD DNR, which lists approximately 90 plant species that may not be planted on DNR land or used for DNR projects.

Foreign distribution: Native to China and Japan (Weakley 2010). Established in Taiwan, Australia, New Zealand, Mexico, Ecuador, Honduras, Costa Rica, Brazil, Argentina, Bolivia, Spain, the United Kingdom (GBIF 2012), France (van Valkenburg 2014) and Madagascar (Kull et al. 2012).

U.S. distribution and status: *Phyllostachys aurea* is likely the first species of bamboo successfully introduced into the United States, arriving in 1882 in Montgomery, Alabama (Young and Haun 1961). It is established in the mid-Atlantic region (Sarver et al. 2008; Weakley 2015), throughout the southeastern United States from Maryland south to Florida, west to Louisiana and Arkansas, and in the northwest in Oregon (Smith 2008) and California (Hrusa et al. 2002). It is listed as naturalized in California (Hrusa et al. 2002), invasive or potentially invasive in Hawaii (Staples et al. 2002), and is documented as escaped in Pennsylvania, Maryland, Delaware, Virginia, West Virginia, North Carolina, South Carolina and Georgia (EDDMapS 2016). Connecticut imposes severe restrictions of the planting of this species, among other *Phyllostachys* species (Conn. Gen. Stat. §22a-381e 2014). It is considered naturalized or invasive in 273 counties in the United States (Swearingen 2011).

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).

Summary Statement

Phyllostachys aurea, received a rating of High Risk under the PPQ WRA model due to its ability to spread extensively and rapidly by rhizomes, form dense thickets, damage structures and roadways, and also due to its status as a target of active weed removal in multiple jurisdictions. The species received a Tier 2 ranking in the Maryland Filter analysis because although it is widely distributed in the state and is difficult to control because of vegetative reproduction, continued planting is unlikely to increase propagule pressure within the state. The species is documented to occur in an S2 State ranked community type close by an S2 plant species State Listed as Threatened, *Smilax pseudochina*. Continued monitoring of new and existing naturalized populations of golden bamboo is warranted.

1. *Phyllostachys aurea* analysis

Establishment/Spread Potential

Phyllostachys aurea is widely distributed and has naturalized or become invasive in several areas (e.g., Mulvaney 1991; Sarver et al. 2008). It flowers every 7 to 12 years (Miller 2003), but seed production is rarely observed (Gucker 2009). This running bamboo spreads primarily via underground rhizomes that send up new shoots each spring (Gucker 2009), quickly forming dense thickets (Smith 2008; Swearingen 2011). Rhizomes can be transported, such as in yard waste (Langeland and Stocker 2001). Infestations may rapidly expand after disturbance (Miller 2003), including fires because rhizomes are protected underground (Gucker 2009). This element had a low level of uncertainty.

Risk score = 10 Uncertainty index = 0.05

Impact Potential

Phyllostachys aurea impacts both natural and human-dominated areas. It invades secondary forests, forest clearings, and forest edges in a number of areas (Gucker 2009), and displaces native species (Kaufman and Kaufman 2007; Swearingen, 2011). Leaf litter of *P. aurea* along streams changes ecosystem processes by altering stream food webs beginning with litter-feeding stream invertebrates (Gonzalez and Christoffersen 2006, LBJWC 2007). It is targeted for eradication in New Zealand (Veitch and Clout 2002), declared noxious in Australia (Groves et al. 2005), and is controlled in a number of natural areas (Langeland and Stocker 2001). In urban settings, this bamboo has been known to buckle sidewalks, driveways (Invasive.org 2012), house siding (Institute of Invasive Bamboo Research 2016) and invade beachfronts (Batianoff and Franks 1997). Numerous U.S. municipalities have enacted ordinances restricting bamboo planting (Institute of Invasive Bamboo Research 2016), including at least three in Maryland. Because of aggressive spread through underground rhizomes, golden bamboo rarely remains contained within planting boundaries (Smith 2008). Where neglected in gardens, it is difficult to control (Forest Floor 2011), and an established stand can take several years of hard work to completely eradicate (Smith 2008). We found little information on its behavior in agricultural settings. One report lists it as an agricultural weed in Australia, but with no details (Randall

2007). This risk element had an average level of uncertainty.
Risk score = 3.2 Uncertainty index = 0.15

Geographic Potential Based on three climatic variables, we estimated that about 33 percent of the United States is suitable for the establishment of *Phyllostachys aurea* (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 *Phyllostachys aurea* represents the joint distribution of Plant Hardiness Zones 6-12, areas with 10-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: Tropical savannah, Steppe, Mediterranean, Humid subtropical, Marine West coast, and Humid continental warm summer.

The area of the United States shown to be climatically suitable (Fig. 1) is likely overestimated since our analysis considered only 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. Widely planted as an ornamental screen, *Phyllostachys aurea* invades woods edges, forested floodplains, forest clearings, powerline rights of way, neighboring yards, often appearing in moister, sandy soils in open or shaded conditions (EDDMapS 2016, Kyde 2016).

Entry Potential We did not assess the entry potential of *Phyllostachys aurea* because it is already present in the United States (NRCS, 2012).

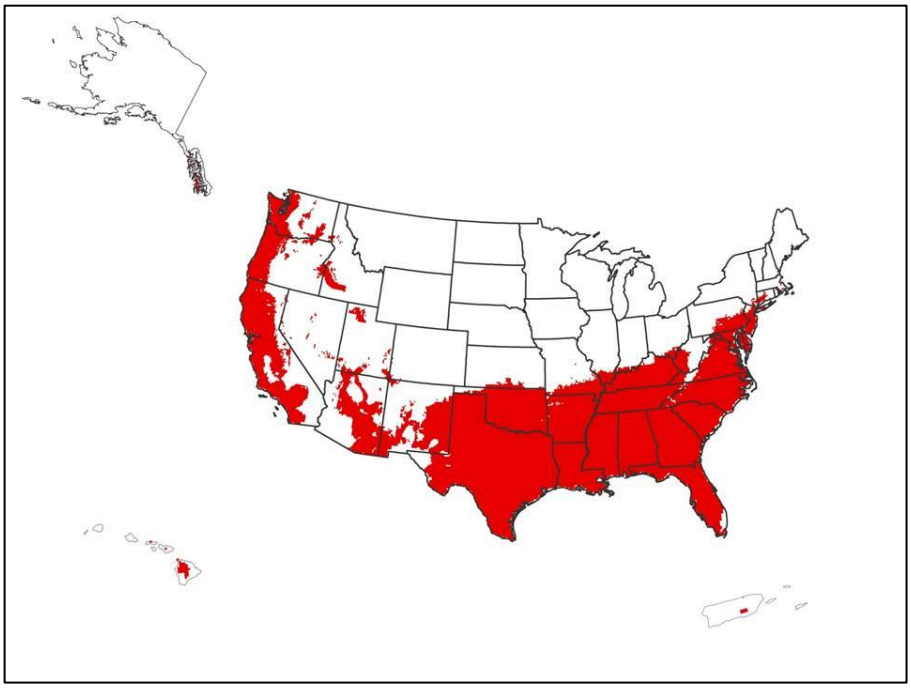

Figure 1. Predicted distribution of *Phyllostachys aurea* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 0.537
P(Minor Invader) = 0.438
P(Non-Invader) = 0.025
Risk Result = High Risk
Secondary Screening = Not Applicable

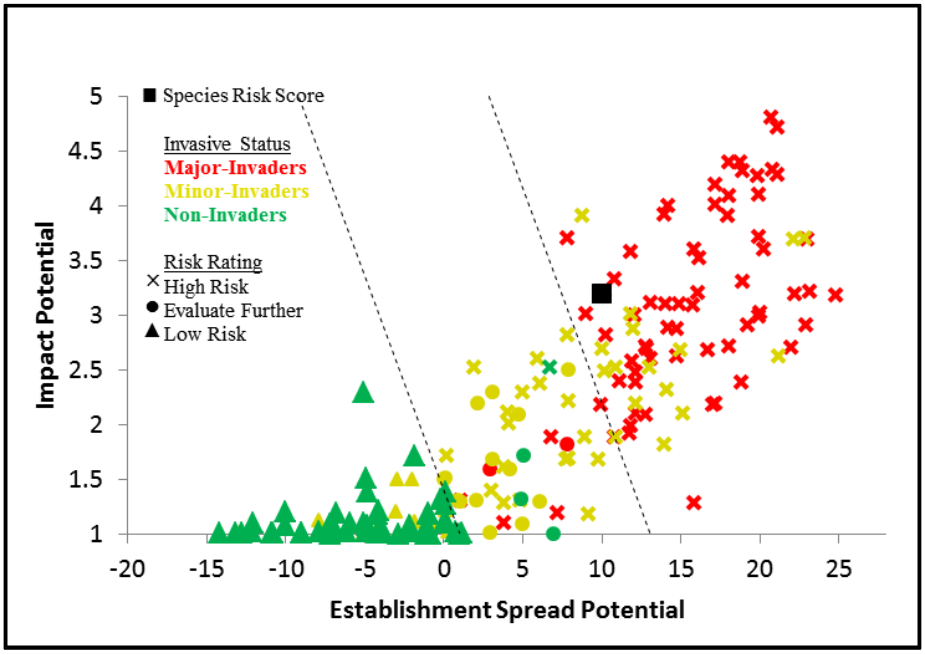

Figure 2. *Phyllostachys aurea* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

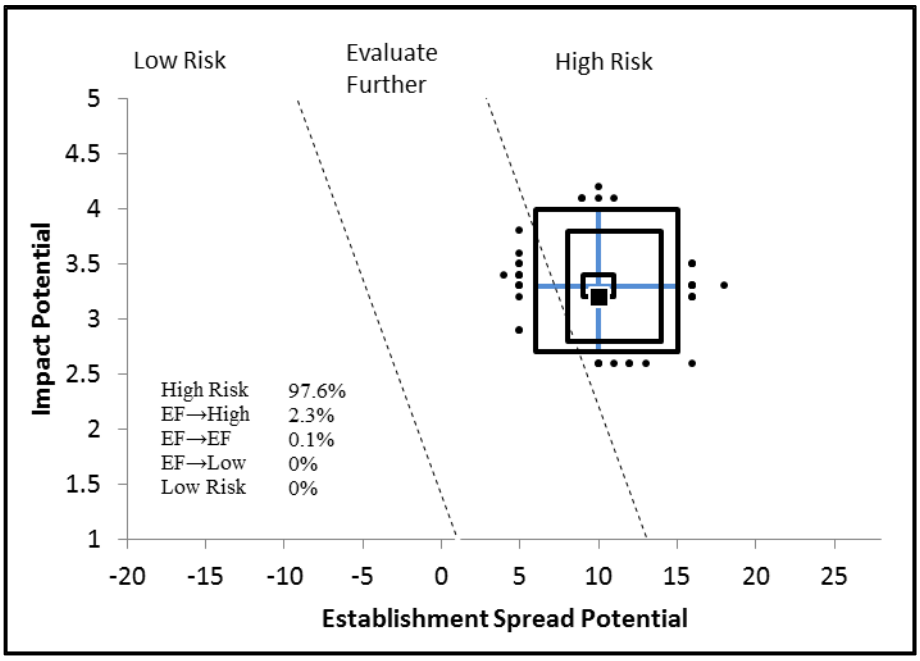

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Phyllostachys aurea*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Phyllostachys aurea* is High Risk (Fig. 2). The PPQ WRA model calculated a 53% chance that this species will be a major invader. This species shares traits in common with other invaders used to develop and validate the PPQ WRA model. Almost all (99.9 percent) of the simulated risk scores in our Monte Carlo uncertainty analysis, including those that underwent secondary screening, resulted in an outcome of High Risk (Fig. 3).

Phyllostachys aurea produces new culms (stems) each spring, after which new branch rhizomes develop. In a well-established colony of running bamboo, these rhizomes may sometimes extend 15 to 25 feet from the originating plant before the end of the season (Young and Haun 1961). Under favorable conditions rhizomes can branch and extend in all directions (Young and Haun 1961). This growth habit makes running bamboos, including *P. aurea*, difficult to control in gardens and urban plantings. Without containment, *P. aurea* will spread to form a dense monospecific stand. All of the hardy running bamboos, the largest of which are in the genus *Phyllostachys*, begin by forming a more or less open thicket; given enough time and space, these species will eventually form a "forest" (Young and Haun 1961). The dense shade and thick leaf layer in the interior of a stand prohibits the growth of other species (Sarver et al. 2008). In natural areas, this behavior changes native community structure and composition (Kaufman and Kaufman 2007, SCEPPC 2008, Swearingen 2011), ultimately threatening areas set aside for conservation.

Phyllostachys aurea ranks as a Maryland Tier 2 plant (Appendix B). It is distributed throughout the state, occurring in three or more physiographic provinces (EDDMapS 2016, Kyde 2016). Because of its rhizomatous growth, it is difficult to control or eliminate (Langeland and Stocker 2001). A few documented patches exist in natural areas. It is found to be growing in areas where it was not deliberately planted, but most of the geo-referenced patches are along roadsides (Kyde 2016, Longbottom 2016). Land managers are actively controlling it (Frey pers. comm., Jones 2015). At least one of the known introductions threatens a State listed S2 Threatened species in a State listed S2 community type. Many of the problems reported from this species occur on maintained property boundaries between gardening neighbors. Because the species has been present in Maryland for more than 50 years and occurs at more than 20 sites in the state, however, it is unlikely that additional plantings will add to propagule pressure. This combination of factors leads to a listing of this species as Tier 2.

Some confusion over the identity of running bamboos has existed, particularly between *P. aurea* and *P. aureosulcata* in northern states. For

example, a bamboo species naturalized in Illinois was originally reported as being *P. aurea* (Basinger 1999) and later corrected to *P. aureosulcata* (Basinger 2001). *Phyllostachys aurea* is somewhat less cold-tolerant than *P. aureosulcata* and is likely to be limited in its northern expansion by winter cold temperatures. Otherwise, they present a similar risk and managing these species similarly may be prudent.

Connecticut enacted a statewide statute in 2013 restricting the planting of running bamboo species, and updated it in 2014 (CT Gen. Stat. Anno. §22a-381e 2014). A number of towns in New York (particularly on Long Island) and Pennsylvania have established or are considering ordinances to regulate the planting and growth of running bamboos in general (Brookhaven NY 2012, Haverford PA 2011, Jordan 2012, West Bradford PA 2011). At least three municipalities in Maryland have considered or added language to their local ordinances concerning running bamboos (Cambridge, MD 2013, College Park MD 2011, Cumberland, MD 2012).

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Appendix A. Weed risk assessment for *Phyllostachys aurea* Carr. ex A. & C. Rivière (Poaceae). 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 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - negl	5	*Phyllostachys aurea* is native to China and Japan (Weakley 2015). It is listed as invasive in Australia (Randall 2007), specifically in the southeastern bushlands (Mulvaney 1991). It is listed as naturalized or invasive in 273 counties in the United States (Swearingen 2011). Specifically, it is listed as invasive in Hawaii (Staples et al. 2002, in the mid-Atlantic region of the United States (Sarver et al. 2008), in Pennsylvania, Maryland, Virginia, West Virginia, and Georgia, including two national parks (EDDMapS 2016). It has naturalized in the Australian Capital Territory (Groves et al. 2005), is fully naturalized in New Zealand (Howell and Sawyer 2006), Corsica and Spain (DAISIE 2009), and Madagascar (Kull et al. 2012). It is naturalizing in the southeast U.S., forming dense stands (Weakley 2015), and is listed and described as a moderate threat in North Carolina, "the most commonly cultivated species that is naturalizing is *P. aurea*" (Smith 2008). Alternate answers for the Monte Carlo simulation are both "e."
ES-2 (Domesticated to reduce weed potential)	n - low	0	This species is widely promoted and sold as an ornamental (Smith 2008) but there is no evidence that it has been domesticated in a way that reduces its weed potential.
ES-3 (Weedy congeners)	y - negl	1	*Phyllostachys pubescens* was introduced from China into Japan in 1746. It is a clonal grass, growing 25 m high, capable of overtopping and killing a big tree; it has come to dominate the hundreds of kilometers of abandoned terrace cultivation that fringe the bases of the mountains and its upward spread is a continuing threat to the ancient woodlands above the terraces (Rackham 2008). *Phyllostachys pubescens* has invaded forests in Japan, forming uniform monolayers of foliage and dominating competing vegetation; between 1975 and 1993, this bamboo had replaced the trees in a once-mixed forest (Isagi and Torii 1977). *Phyllostachys flexuosa* is reported to form dense stands which prevent native vegetation from growing (GISD 2008). *Phyllostachys nigra* and *P. heterocycla* are listed in Australia as Category 5 weeds (Randall 2007) and *P. mitis* is a principal weed in New Zealand (Holm et al. 1979). *Phyllostachys aureosulcata* has naturalized in the United States (Kartesz 2016) and is banned from sale in New York state (NYSDEC 2014).
ES-4 (Shade Tolerance)	n - low	0	Thrives in full sun but is also able to grow and spread in sparsely wooded forests (Smith 2008). Full sun (DavesGarden 2012). Thrives in full sun but can tolerate moderate shade (Forest Floor 2011).
ES-5 (Climbing or smothering growth form)	n - negl	0	*Phyllostachys aurea* is a woody, perennial, reed-like plant that can reach heights up to 30 feet (Meredith 2009, Smith 2008).
ES-6 (Dense Thickets)	y - negl	2	*Phyllostachys aurea* infestations rapidly spread through rhizomes, often forming dense, monotypic thickets (Smith 2008). This bamboo can form dense monocultures that displace native species (Swearingen 2011). They (*P. aurea* and others) will take over any sunny or semi-shaded area forming impenetrable thickets and effectively crowding out all native vegetation (Reaves 2011).

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Running bamboos spread primarily by rhizomes; new culms usually appear above ground in mid-spring at varying space levels; the giant species eventually form a forest (Young and Haun 1961). The plant allows for a dense screen close to the ground as "[t]he density of nodes on the lower portion of the culms also means a greater density of branches" (Meredith 2009).
ES-7 (Aquatic)	n - negl	0	This species is a terrestrial plant (DAISIE 2009), which spreads most rapidly in moist soils (Smith 2008).
ES-8 (Grass)	y - negl	1	*Phyllostachys aurea* is a member of the grass family, Poaceae (Hortus Third 1976, Smith 2008).
ES-9 (N2-fixer)	? - max		Studies from China have shown associative N-fixation in two congeners, *Phyllostachys pubescens* and *P. meyeri* (Gu and Wu, 1994, 1998). Nitrogen-fixing plants fall into three categories, rhizobial, actinorhizal, and associative (Thompson 2004); associative N-fixation is well-demonstrated in rice and several grasses (e.g., sugarcane, forage grasses) within the family Poaceae (Thompson 2004). Because the N-fixing *Phyllostachys* spp. are reported from only one geographic location, and because these are the only reported cases of N-fixation in bamboo (Thompson 2004), we answered "unknown" with maximum uncertainty.
ES-10 (Viable seeds)	y - negl	1	Although this bamboo is capable of reproducing by seed, the rarity of flowering in the United States makes sexual reproduction unlikely (Gucker 2009). Delayed seed production has evolved in bamboos to escape seed predation (Janzen 1974). *Phyllostachys aurea* is reported to flower every 7-12 years (Miller 2003) or every 28-29 years (in Europe and England) (Janzen 1974). It rarely produces flowers and fruit (Smith 2008). It is not known to flower in the southeastern United States (Weakley 2015). A Brazilian study concluded that pollen viability may be an explanation for absence of seed production, or that the bamboo plants may be obligate outcrossers (Filgueiras and Magno 2007). Invasive spread of bamboo by seed is unlikely but cannot be ruled out completely (Lowenstein and Enloe n.d.) *Phyllostachys aurea* rarely flowers - it may not flower for several decades - but when it does it produces flower spikelets containing 8 to 12 flowers; its main form of reproduction is through rhizomes that spread from the parent plant and produce abundant new above ground shoots (DOD 2009).
ES-11 (Self-compatible)	n - mod	-1	Evidence suggests that flowers are cross-pollinated, suggesting that isolated clones may produce little or no seed (Gucker 2009, Janzen 1974). *Phyllostachys* may be an obligate outcrossed species (Filgueiras and Magno 2007). Studies of the congener *P. nidularia* suggest that honey bee visits to flowering bamboo may assist wind-pollination (Huang et al. 2002).
ES-12 (Special Pollinators)	n - negl	0	Bamboos are wind-pollinated (Gucker 2009).
ES-13 (Min generation time)	b - low	1	Most reproduction is vegetative through the expansion of rhizomes (Gucker 2009) and new shoots emerge each spring (Gucker 2009). Although bamboos can produce seeds, they appear to do so very rarely, particularly in introduced areas (Smith 2008; Weakley 2015). *Phyllostachys aurea* is said to flower every 7 to 12 years (Miller 2003). Alternate answers for the Monte Carlo simulation are both "c."
ES-14 (Prolific seed/spore	n - low	-1	Seeds very rarely (every 7-12 years) (Miller 2003). See discussion

Question ID	Answer - Uncertainty	Score	Notes (and references)
production)			under ES-10.
ES-15 (Unintentional dispersal)	y - low	1	Can become established by dumping of yard waste containing rhizome fragments (Langeland and Stocker 2001).
ES-16 (Trade contaminant)	n - low	-1	*Phyllostachys aurea* rarely flowers (Miller 2003) and there is no evidence that seeds have been dispersed as trade contaminants or hitchhikers. Additionally, plant rhizomes of these large woody species are not likely to disperse as contaminants or hitchhikers.
ES-17 (#Natural dispersal vectors)	0 -	-4	Information relevant for ES17a through ES17e: The general opinion about mast-flowering bamboos, which includes the genus *Phyllostachys*), is that they experience infrequent, cyclical flowering with short-lived seed that is not adapted for dispersal by any agent (Stapleton et al. 2004). Most mast-flowering bamboos have passive dispersal, concentrating seedling recruitment near the dead skeleton of the parent plant (Keeley and Bond 1999).
ES-17a (Wind dispersal)	n - low		Most mast-flowering bamboos have passive dispersal, concentrating seedling recruitment near the dead skeleton of the parent plant (Keeley and Bond 1999).
ES-17b (Water dispersal)	y - high		There is the potential for dispersal of bamboo by rhizome fragments along riparian corridors (Ward 2011). Rhizome dispersal of congener *P. aureosulcata* along Muddy River was photodocumented in Connecticut (Institute of Invasive Bamboo Research 2016).
ES-17c (Bird dispersal)	n - low		Most mast-flowering bamboos have passive dispersal, concentrating seedling recruitment near the dead skeleton of the parent plant (Keeley and Bond 1999).
ES-17d (Animal external dispersal)	n - low		Most mast-flowering bamboos have passive dispersal, concentrating seedling recruitment near the dead skeleton of the parent plant (Keeley and Bond 1999).
ES-17e (Animal internal dispersal)	n - low		There is a possibility that giant pandas, whose main food source is bamboo, may disperse seed (Bies 2002). Although the seeds of many herbaceous plants, including grasses, can pass through the guts of large herbivores consuming the seeds along with foliage (Janzen 1984), the general opinion about bamboos is that they experience infrequent, cyclical flowering with short-lived seed that is not adapted for dispersal by any agent (Stapleton et al. 2004). Most mast-flowering bamboos have passive dispersal, concentrating seedling recruitment near the dead skeleton of the parent plant (Keeley and Bond 1999).
ES-18 (Seed bank)	n - low	-1	Seed production in *P. aurea* is rare (see ES-10); it is believed that viability is lost over time and that golden bamboo seeds lack any long-term dormancy (Gucker 2009, Janzen 1974). Seed viability in the congener *P. pubescens* is completely lost after one year (Guangcho 2002).
ES-19 (Tolerance to loss of biomass)	y - negl	1	The species colonizes by rhizomes with infestations rapidly expanding after disturbance (Miller 2003). In Georgia, *P. aurea* stands have been burned after having the stems cut and left on site; in the burned area, golden bamboo sprouted and recolonized the site (Gucker 2009).
ES-20 (Herbicide resistance)	n - low	0	Large infestations of *P. aurea* can be killed by thoroughly wetting the foliage with a 2% solution of glyphosate and a 0.5% nonionic surfactant; large plants can be killed by cutting them down near the ground and spraying the freshly cut stump with a 25% solution of glyphosate (Smith 2008). Foliar application of 3% Roundup Pro or

Question ID	Answer - Uncertainty	Score	Notes (and references)
			application of 5% Roundup Pro to cut culms did not produce consistent control results (Langeland and Stocker 2001). In a greenhouse study, application of various herbicides reduced populations, but none provided 100% control (Czarnota and Derr 2007).
ES-21 (# Cold hardiness zones)	7	0	
ES-22 (# Climate types)	6	2	
ES-23 (# Precipitation bands)	10	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	? - max		Field observations and subsequent laboratory research of a congener, *P. edulis*, in Taiwan suggest that allelopathy may play an important role in interspecific competition (Chou and Yang 1982). Dense shade and possible allelopathic effects allow little if anything to grow beneath bamboo (Lowenstein and Enloe n.d.).
Imp-G2 (Parasitic)	n - negl	0	*Phyllostachys aurea* is a tall, woody bamboo species within the family *Poaceae*. No species within the family *Poaceae* are known to be parasitic (Nickrent 2012).
Impacts to Natural Systems			
Imp-N1 (Ecosystem processes)	y - mod	0.4	Effects of this species are largely undocumented; however, a number of websites state that for streams, *P. aurea* leaf litter alters stream food webs starting with litter-feeding stream invertebrates (Gonzalez and Christoffersen 2006; LBJWC 2007).
Imp-N2 (Community structure)	y - mod	0.2	*Phyllostachys aurea* is known to have the potential to significantly alter the structure of the native vegetation (Veitch and Clout 2002). Running bamboos, including *P. aurea*, spread by rhizomes and eventually form a forest (Young and Haun 1961).
Imp-N3 (Community composition)	y - negl	0.2	Suppresses the growth of native plants (Kaufman and Kaufman 2007). *Phyllostachys aurea* can form dense, monocultural thickets that displace native species (Swearingen 2011). The dense shade and thick leaf layer in the interior of a stand prohibits the growth of other species (Sarver et al. 2008). The plant is known to have the potential to significantly alter the composition of the native vegetation (Veitch and Clout 2002).
Imp-N4 (T&E species)	y - low	0.1	Several bamboo stands in Maryland occur in close proximity to Federally listed Threatened or Endangered species. In addition, bamboo is spreading by a population of long-stalk greenbrier, *Smilax pseudochina* (State Listed as Threatened). Because *Phyllostachys aurea* occurs in the same habitat type as the Federally listed species, and poses a threat to a State Listed species, Maryland's Natural Heritage Program considers the bamboo a threat to them, and we are answering "yes" with low uncertainty.
Imp-N5 (Globally outstanding ecoregions)	y - low	0.1	*Phyllostachys aurea* has invaded secondary forests, forest clearings and forest edges in Texas, is spreading vegetatively from roadsides into hammock/pine-oak forests in Georgia, and occurs in the Piedmont and the Coastal Plain in South Carolina (Gucker 2009). It has naturalized in Hawaii and has formed a monoculture excluding other plant species (Staples et al. 2002). Because much of Hawaii and the southeastern United States are considered globally outstanding ecoregions, we answered "yes" with low uncertainty.
Imp-N6 (Natural systems weed)	c - negl	0.6	The species was targeted for eradication on Raoul Island in New

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Zealand (Veitch and Clout 2002). It was declared noxious in New South Wales and western Australia, classified as an environmental weed, naturalized and known to be a minor problem warranting control at four or more locations within a state or territory, and prohibited from sale in New South Wales (Groves et al. 2005). The plant is not a common problem but once established can spread extensively; populations should be controlled immediately (Langeland and Stocker 2001). Alternate answers for the Monte Carlo simulation are both "b."
Impact to Anthropogenic areas (cities, suburbs, roadways)			
Imp-A1 (Affects property, civilization, ...)	y - negl	0.1	"Planted but soon regretted. Wide-creeping rootstocks form impenetrable solid stands. 'Roots of steel' can buckle sidewalks and driveways" (J.R. Allison Invasive.org, 2012). Photodocumented property damage from Connecticut supported promulgation of state law restricting running bamboo plantings (Institute of Invasive Bamboo Research 2016).
Imp-A2 (Recreational use)	? - max		Although there is no evidence to support a "yes" for this question, it may be possible to reduce the recreational use of an area. For example, this naturalized exotic rarely (but occasionally) invades sandy beachfronts in Queensland, Australia (Batianoff and Franks 1997) and it has invaded two national parks in the eastern United States, one in Virginia and one in West Virginia (EDDMapS 2016).
Imp-A3 (Affects ornamental plants)	y - negl	0.1	A popular garden website has a few negative comments, all from gardeners having to combat this bamboo in their yards - said to "take a lot of your time to keep it in check" (DavesGarden 2012). This bamboo spreads rapidly via rhizome production and will form tall monocultures that shade out all other vegetation. Rapidly running on loose soil, this bamboo has a reputation as an invasive and difficult to control plant in suburban gardens where neglected (Forest Floor 2011). *Phyllostachys* species generate the greatest volume of neighbor to neighbor complaint calls to Maryland DNR invasive plant staff (Author's experience).
Imp-A4 (Anthropogenic weed)	c - negl	0.4	Recorded as having escaped from cultivation in Australia (Randall 2007). "This plant should be avoided at all costs since it rarely remains contained within desirable boundaries; an established stand can take several years of hard work to completely eradicate" (Smith 2008). Alternate answers for the Monte Carlo simulation are both "b."
Impact to Production systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Crop yield)	n - mod	0	No evidence.
Imp-P2 (Commodity Value)	n - mod	0	No evidence.
Imp-P3 (Affects trade)	n - mod	0	No evidence.
Imp-P4 (Irrigation)	n - mod	0	No evidence.
Imp-P5 (Animal toxicity)	n - low	0	*Phyllostachys aurea*, along with other bamboo species, serves as the primary food source for pandas in its native range (Bies 2002). Its congener, *P. aureosulcata*, along with many other *Phyllostachys* species, have been tested and found to be of suitable nutritive value as browse for livestock (Halvorson et al. 2010).
Imp-P6 (Production system weed)	a - mod	0	Recorded as a weed of agriculture in Australia (Randall 2007), however, there is very little information suggesting that this is a weed of agriculture and no specific details could be found in the

Question ID	Answer - Uncertainty	Score	Notes (and references)
			literature. Alternate answers for the Monte Carlo simulation are both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points (pts) obtained from the Global Biodiversity Information Facility, accessed in 2012. Non geo-referenced locations from GBIF and other sources are noted as occurrences (occ.) Original search conducted by USDA APHIS.
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	Tolerates temperatures as low as 0ºF (-18ºC) (Gucker 2009)
Geo-Z2 (Zone 2)	n - negl	N/A	Tolerates temperatures as low as 0ºF (-18ºC) (Gucker 2009)
Geo-Z3 (Zone 3)	n - negl	N/A	Tolerates temperatures as low as 0ºF (-18ºC) (Gucker 2009)
Geo-Z4 (Zone 4)	n - negl	N/A	Tolerates temperatures as low as 0ºF (-18ºC) (Gucker 2009)
Geo-Z5 (Zone 5)	n - low	N/A	Tolerates temperatures as low as 0ºF (-18ºC) (Gucker 2009)
Geo-Z6 (Zone 6)	y - low	N/A	Zones 6-11 (Dave's Garden 2012); tolerates temperatures as low as 0ºF (-18ºC) (Gucker 2009)
Geo-Z7 (Zone 7)	y - negl	N/A	USA (southeast into VA), Japan (GBIF 2012 pts). Tolerates winter temperatures to 0ºF (-18ºC) (Kaufman and Kaufman 2007, Young and Haun 1961).
Geo-Z8 (Zone 8)	y - negl	N/A	USA (southern states), Bolivia, Spain (GBIF 2012 pts).
Geo-Z9 (Zone 9)	y - negl	N/A	Canada (British Columbia), USA (southern states), Mexico, Spain, New Zealand (GBIF 2012 pts).
Geo-Z10 (Zone 10)	y - negl	N/A	USA (CA, FL), Mexico, Argentina, Australia, New Zealand, Taiwan (GBIF 2012 pts).
Geo-Z11 (Zone 11)	y - negl	N/A	Honduras, Brazil (GBIF 2012 pts).
Geo-Z12 (Zone 12)	y - low	N/A	Costa Rica, Ecuador (GBIF 2012 pts).
Geo-Z13 (Zone 13)	n - low	N/A	No evidence.
Koppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - low	N/A	No evidence.
Geo-C2 (Tropical savanna)	y - negl	N/A	Honduras, Costa Rica (GBIF 2012 pts).
Geo-C3 (Steppe)	y - mod	N/A	Spain (GBIF 2012 pts).
Geo-C4 (Desert)	n - low	N/A	No evidence. (Note: There is a point in GBIF, however, upon further investigation, this is an herbarium specimen.)
Geo-C5 (Mediterranean)	y - negl	N/A	California, Spain (GBIF 2012 pts).
Geo-C6 (Humid subtropical)	y - negl	N/A	USA (southern states, eastern seaboard), Brazil, Argentina, Australia, Japan, Taiwan (GBIF 2012 pts).
Geo-C7 (Marine west coast)	y - negl	N/A	Canada (British Columbia), Mexico, Ecuador, Bolivia, UK, Spain, New Zealand (GBIF 2012 pts).
Geo-C8 (Humid cont. warm sum.)	y - low	N/A	USA (DE [EDDMapS 2012 occ.], CT [CTIPC 2011 occ], PA [West Bradford PA 2011]).
Geo-C9 (Humid cont. cool sum.)	n - low	N/A	No evidence.
Geo-C10 (Subarctic)	n - negl	N/A	Too cold based on low temperature tolerance (Gucker 2009).
Geo-C11 (Tundra)	n - negl	N/A	Too cold based on low temperature tolerance (Gucker 2009).
Geo-C12 (Icecap)	n - negl	N/A	Too cold based on low temperature tolerance (Gucker 2009).
10-inch precipitation bands			
Geo-R1 (0-10")	n - low	N/A	No evidence.
Geo-R2 (10-20")	y - negl	N/A	USA (CA), Spain (GBIF 2012 pts.).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R3 (20-30")	y - negl	N/A	USA (CA, southern states), UK, Spain (GBIF 2012 pts).
Geo-R4 (30-40")	y - negl	N/A	USA (southern states), Mexico, Argentina, Spain, Australia (GBIF 2012 pts).
Geo-R5 (40-50")	y - negl	N/A	USA (southern states, east coast), Australia, New Zealand (GBIF 2012 pts).
Geo-R6 (50-60")	y - negl	N/A	USA (southern states), New Zealand (GBIF 2012 pts).
Geo-R7 (60-70")	y - negl	N/A	Canada (British Columbia), USA (LA), Honduras, Brazil, New Zealand, Japan (GBIF 2012 pts).
Geo-R8 (70-80")	y - negl	N/A	New Zealand, Japan (GBIF 2012 pts).
Geo-R9 (80-90")	y - negl	N/A	Ecuador, Taiwan (GBIF 2012 pts).
Geo-R10 (90-100")	y - low	N/A	Present in areas with 80-90 and 100+ inches.
Geo-R11 (100"+)	y - low	N/A	Costa Rica (GBIF 2012 pts).
ENTRY POTENTIAL			
Ent-1 (Already here)	y - negl	1	Probably the first species of bamboo successfully introduced into the United States (1882 in Montgomery, AL) (Young and Haun 1961). Found throughout the SE United States from MD south to FL, west to LA and AR, and northwest to OR (Smith 2008). Found in the mid-Atlantic region of the U.S. (Sarver 2008). Listed as growing (naturalized) in California (Hrusa et al. 2002). Listed as invasive or potentially invasive in HI (Staples et al. 2002). Reported as invasive in, DE, GA, MD, PA, VA, WV (EDDMapS 2016). Listed as naturalized or invasive in 273 counties in the United States (Swearingen 2011). In AL, DE, FL, GA, KY, MD, MS, NC, SC, TN, VA (Weakley 2015).
Ent-2 (Proposed for entry)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	
Ent-4 (Entry as a Contaminant)			
Ent-4a (In MX, CA, Central Amer., Carib., or China)	-	N/A	
Ent-4b (Propagative material)	-	N/A	
Ent-4c (Seeds)	-	N/A	
Ent-4d (Ballast water)	-	N/A	
Ent-4e (Aquaria)	-	N/A	
Ent-4f (Landscape products)	-	N/A	
Ent-4g (Container, packing, trade goods)	-	N/A	
Ent-4h (Commodities for consumption)	-	N/A	
Ent-4i (Other pathway)	-	N/A	
Ent-5 (Natural dispersal)	-	N/A	

Appendix B. Maryland Filter assessment for *Phyllostachys aurea* Carr. ex A. & C. Rivière (Poaceae).

Maryland Filter questions	Answer	Instructions/ Result	Notes
1. Is the plant currently naturalized in Maryland? Yes OR no	yes	Go to question 2	Occurs in Allegany, Anne Arundel, Caroline, Dorchester, Montgomery, Prince George's, Queen Anne's, Somerset, Talbot and Wicomico counties (EDDMapS 2016; Maryland Biodiversity Project 2016, Thompson, Pers. comm., author's observation).
2. What is the species' potential distribution in Maryland? wide OR narrow	wide	Go to question 4	Plants could grow in any of Maryland's physiographic provinces (WRA geographic analysis)
3. Does or could the species harm threatened or endangered Maryland species or community types or CITES listed species occurring in MD? yes OR no			See Question ImpN4 for more information.
4. How feasible is control of the species? easy OR difficult	difficult	Go to Question 5	Plants reproduce vegetatively from rhizomes (Meredith 2009)
5. Is added propagule pressure from sales significantly increasing potential of the species to persist and spread? yes OR no	no	**Tier 2**	*Phyllostachys aurea* has been cultivated in the United States since at least 1907 (NC http://www.biodiversitylibrary.org/page/46847635#page/113/mode/1up) and can reasonably be assumed to have been in Maryland for more than 50 years. It occurs in at least 15 geo-referenced locations within the state (EDDMapS 2016, Longbottom 2016); the authors know of additional sites.