Weed Risk Assessment for *Phyllostachys aureosulcata* McClure (Poaceae) – Yellow groove bamboo

United States Department of Agriculture

Animal and Plant Health Inspection Service

August 20, 2012

Version 1

Phyllostachys aureosulcata (source: lewisbamboo.com).

Agency Contact:

Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science and Technology

Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

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.

***Phyllostachys aureosulcata* McClure – Yellow groove bamboo**
Species Family: Poaceae
Information Initiation: In an email dated February 21, 2012, Marilyn Jordan from The Nature Conservancy in Long Island, New York asked the PERAL Weed Team to analyze *Phyllostachys aureosulcata*, a common and problematic running bamboo present in Long Island. As we began assessing *P. aureosulcata*, we learned that it is often confused with its congener, *P. aurea*, which is also problematic. We decided to assess both species simultaneously to help us differentiate the risk potential of both species. In this document, we assess *P. aureosulcata*.
Foreign distribution: *Phyllostachys aureosulcata* is native to China, mainly in the Anhui, Zhejiang, and Jiangsu provinces (Ohmberger, 1999).
U.S. distribution and status: This bamboo has been cultivated for many years in the United States and has only recently been reported as naturalizing. It has naturalized in Illinois (Basinger, 2001), Pennsylvania (DavesGarden, 2012; Kartesz, 2011), West Virginia, Texas, Georgia, Alabama, Mississippi (Kartesz, 2011), and Kentucky (NRCS, 2012).
WRA area[1]: Entire United States, including territories.

1. *Phyllostachys aureosulcata* analysis

Establishment/Spread Potential *Phyllostachys aureosulcata* is widely cultivated and has naturalized in nine U.S. states. Where naturalized it appears, with few exceptions, to have spread from cultivated sites (e.g., Basinger, 2001). The exceptions include stands of *P. aureosulcata* in riverine areas along the Susquehanna River in Pennsylvania and next to a bridge abutment in

[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).

Connecticut, both of which are thought to have originated from rhizomes washed downstream from an upstream source (DavesGarden, 2012; Ward, 2012a). Other than via rhizomes in water, as above, *P. aureosulcata* lacks long-distance dispersal mechanisms. This running bamboo species primarily spreads via underground rhizomes that emerge each spring (Young and Haun, 1961). The American Bamboo Society states that all running bamboos can become pestiferous and recommends either planting these species in containers or installing rhizome barriers around the planting area (ABS, 2008). Other characteristics contributing to this species' E/S risk score include unintentional dispersal by humans (e.g., rhizomes in yard waste), tolerance of above-ground mutilation, and a minimum generation time of one year. The uncertainty associated with this element was low.
Risk score = 5 Uncertainty index = 0.19

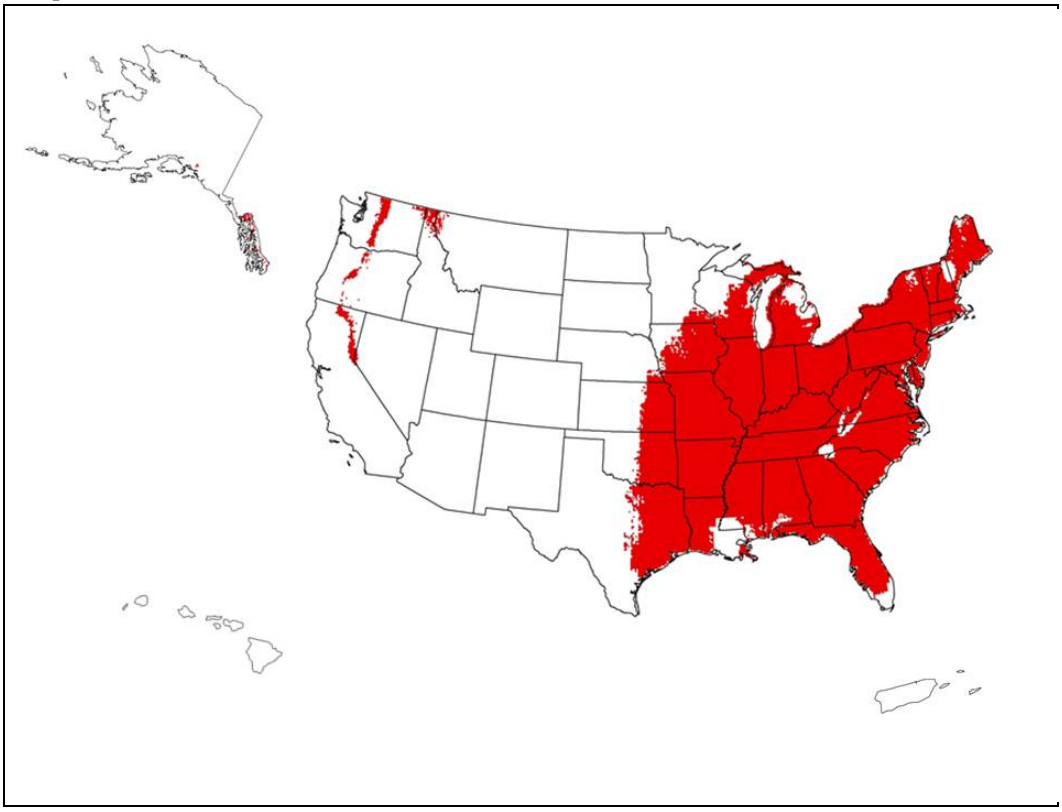
Impact Potential *Phyllostachys aureosulcata* primarily affects anthropogenic areas (cities, suburbs, home gardens and their surrounding areas). This species damages sidewalks and driveways, destroys swimming pools, invades septic systems, establishes in lawns, and shades out other vegetation (Rickel, 2012). Multiple townships have established ordinances restricting the planting and growth of running bamboos, and many of those specifically target *Phyllostachys* spp. (e.g.,Brookhaven NY, 2012; West Bradford PA, 2011). This species forms monocultures (Ward, 2011) which changes community structure in natural areas. We found no evidence that it is an agricultural weed. A moderate level of uncertainty was associated with this element.
Risk score = 2.6 Uncertainty index = 0.22

Geographic Potential Based on three climatic variables, we estimate that about 32 percent of the United States is suitable for the establishment of *P. aureosulcata* (Fig. 1). That is based on the species' known distribution (native or naturalized) elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *P. aureosulcata* represents the joint distribution of Plant Hardiness Zones 4-10, areas with 30-60 inches of annual precipitation, and the following Köppen-Geiger climate classes: humid subtropical, humid continental warm summers, and humid continental cool summers.

Limited information is available on its full native distribution in China and that hindered our ability to estimate geographic potential. Other environmental variables, such as soil and habitat type, may limit the areas in which this species is likely to establish, but based on the wide cultivation of *P. aureosulcata* it may establish in areas beyond the predicted range. For example, this bamboo is grown in and sold from nurseries in the Pacific Northwest (e.g., Greer Gardens, 2012) and can likely establish in that climate. Additionally, the predictive map (Fig. 1) does not include southeastern Louisiana, because we found no reports of *P. aureosulcata* being native or naturalized in areas with an average annual rainfall greater than 60 inches. Despite that, this bamboo can likely establish and spread in southeastern Louisiana.

Entry Potential Because *Phyllostachys aureosulcata* is established in the United States (see U.S. distribution and status, above), we did not assess this risk element.

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



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 0.199
P(Minor Invader) = 0.692
P(Non-Invader) = 0.108

Risk Result = Evaluate Further

Secondary Screening = High Risk

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

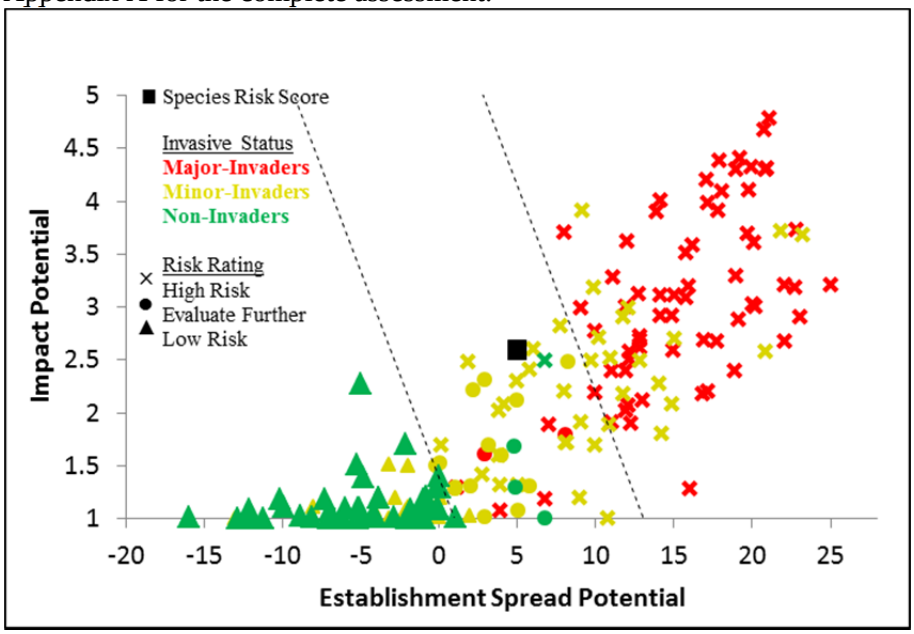
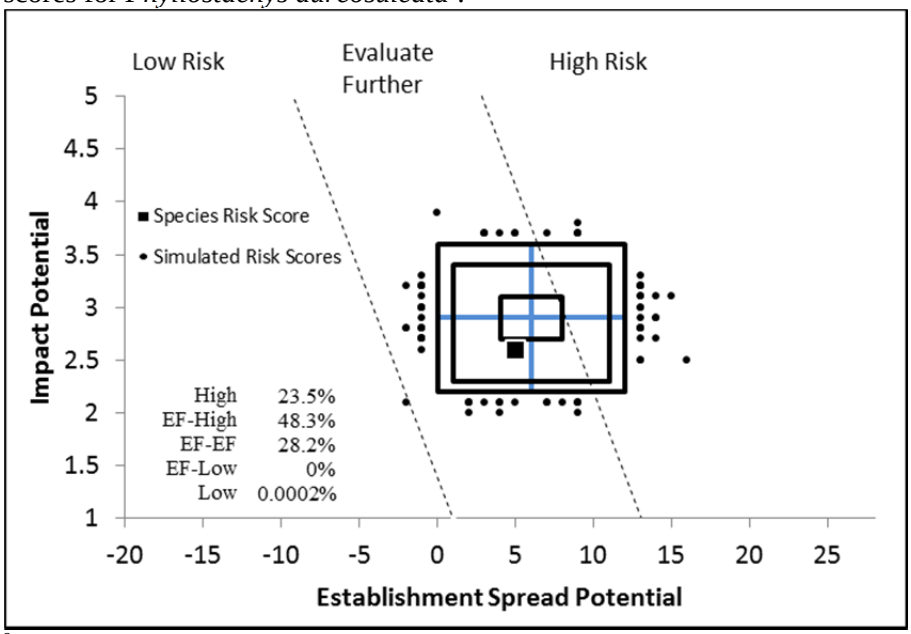


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Phyllostachys aureosulcata*[a].



[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 risk scores for *P. aureosulcata* indicate it is a minor-invader, but the secondary screening tool gave a result of High Risk (Fig. 2). That happened primarily because the species has demonstrated an ability to spread beyond areas where it is intended to grow. In our uncertainty analysis, 72 percent of the iterations resulted in an outcome of High Risk (Fig. 3).

Phyllostachys aureosulcata did not obtain higher risk scores because of relatively low seed production, limited dispersal mechanisms, and impacts that are primarily limited to anthropogenic areas. Because it can spread vegetatively in all directions, if given enough time and space, it will eventually form a forest (Young and Haun, 1961). That behavior may impact natural as well as anthropogenic areas. Literature on bamboo cultivation in the United States makes it clear that such species should not be planted near buildings and must be contained (Young and Haun, 1961). In addition to local restrictions on planting mentioned above, some nursery groups (e.g., the Connecticut Green Industry) are mounting a special trade and public education campaign on bamboo to mitigate future problems (Musgrave, 2010).

Some confusion exists over the identity of running bamboos, particularly *P. aurea* and *P. aureosulcata*, in northern states and possibly elsewhere. Because these species behave similarly in suitable environments, we expect their invasive and impact potential will be similar. Managing these species similarly may be prudent.

4. Literature Cited

7 U.S.C. § 1581-1610. 1939. The Federal Seed Act, Title 7 United States Code § 1581-1610.

7 U.S.C. § 7701-7786. 2000. Plant Protection Act, Title 7 United States Code § 7701-7786.

ABS. 2008. Runners and clumbers. Factsheet. American Bambo Society (ABS): promoting the beauty and utility of bamboo. Last accessed 7/12/2012, http://www.bamboo.org/GeneralInfoPages/RunnersAndClumpers.html.

bambooweb.info. n.d. *Phyllostachys aureosulcata*. A single cane of *Phyllostachys aureosulcata* is flowering in a grove. http://www.bambooweb.info/ShowBambooPictures.php?Type=B&Button=Search&BooID=257&Desc=&Loc=&Match=257&Cat=*&Genus=*&r=20&s=20&np=4. (Archived at PERAL).

Basinger, M. A. 2001. Additions to the vascular flora of Illinois. Transactions of the Illinois State Academy of Science 94(4):199-205.

Brookhaven NY. 2012. Public notice for a hearing on the proposed Introductory Local Law #10 of 2012, Amending Chapter 49 of the Code of the Town of Brookhaven entitled 'property maintenance' by adding Section 49-4 entitled 'bamboo restriction' and Section 49-5 entitled 'penalties for offenses.' Meeting date 7/12/2012. Last accessed 4/25/2012, http://agendapublic.brookhaven.org/.

Chou, C.-H., and C.-M. Yang. 1982. Allelopathic research of subtropical vegetation in Taiwan. II. Comparative exclusion of understory by *Phyllostachys edulis* and *Cryptomeria japonica*. Journal of Chemical Ecology 8(12):1489-1507.

CTIPC. 2011. Running bamboo status update. Connecticut Invasive Plant Council (CTIPC).

Czarnota, M. A., and J. Derr. 2007. Controlling bamboo (*Phyllostachys* spp.) with

herbicides. Weed Technology 21:80-83.
DavesGarden. 2012. Plant files database. http://davesgarden.com/guides/pf/go/1764/. (Archived at PERAL).
EDDMaps. 2012. EDDMaps (Early Detection and Distribution Mapping System), Center for Invasive Species and Ecosystem Health, University of Georgia. Online database available at: http://www.eddmaps.org. (Archived at PERAL).
Flora of China. 2006. *Phyllostachys aureosulcata* McClure. Vol. 22, pp. 163-180. (Archived at PERAL).
GBIF. 2012. Global Biodiversity Information Facility (GBIF), Online Database. http://data.gbif.org/welcome.htm. (Archived at PERAL).
GISD. 2008. Global Invasive Species Database (GISD). Invasive Species Specialist Group (ISSG), The World Conservation Union (IUCN). http://www.issg.org/database/welcome/. (Archived at PERAL).
Gonzalez, L., and B. Christoffersen. 2006. The quiet invasion: a guide to invasive plants of the Galveston Bay Area. Houston Advanced Research Center, The Woodlands, TX. Available at: http://www.galvbayinvasives.org. (Archived at PERAL).
Greer Gardens. 2012. Ornamental grasses. Bamboo. *Phyllostachys aureosulcata*. http://www.greergardens.com/ornamental_grasses1.htm. (Archived at PERAL).
Gu, X., and X. Wu. 1994. A study of associative nitrogen fixation of bamboo rhizosphere. Forest Research 7(6):618-623.
Gu, X., and X. Wu. 1998. Study on several nitrogen fixation strains from *Phyllostachys pubescens* roots [Abstract]. Forest Research 11(4):377-381.
Gucker, C. L. 2009. *Phyllostachys aurea*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/.
Halvorson, J. J., K. A. Cassida, K. E. Turner, and D. P. Belesky. 2010. Nutritive value of bamboo as browse for livestock. Renewable Agriculture and Food Systems 26(2):161-170.
Haverford PA. 2011. Town of Haverford, PA, Ordinance No. 2640-2011.
Heap, I. 2012. The International Survey of Herbicide Resistant Weeds. www.weedscience.com. (Archived at PERAL).
HSU. n.d. Bamboo. *Phyllostachys* spp. Lindl. and Prax. Fact sheet. Henderson State University (HSU), Arkansas.
IPPC. 2012. International standards for phytosanitary measures (ISPM#5): Glossary of phytosanitary terms. IPPC & Food and Agriculture Organization of the United Nations, Rome. 38 pp.
Isagi, Y., and A. Torii. 1977. Range expansion and its mechanisms in a naturalized bamboo species, *Phyllostachys pubescens*, in Japan. Journal of Sustainable Forestry 6(1-2):127-141.
Janzen, D. H. 1974. Why bamboos wait so long to flower. Annual Review of Ecology and Systematics 7:347-391.
Kartesz, J. T. 2011. The Biota of North America Program (BONAP). North American Plant Atlas (http://www.bonap.org/MapSwitchboard.html). Chapel Hill, N.C. [maps generated from Kartesz, J.T. 2010. Floristic Synthesis of North America, Version 1.0. Biota of North America Program (BONAP). (in press)]. http://www.bonap.org/. (Archived at PERAL).
Keeley, J. E., and W. J. Bond. 1999. Mast flowering and semelparity in bamboos: the bamboo fire cycle hypothesis. The American Naturalist 154(3):383-391.
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.
Langeland, K. A., and R. K. Stocker. 2001. Control of non-native plants in natural areas of Florida (SP 242). University of Florida, Institute of Food and Agricultural Sciences, Gainseville, FL, U.S.A. 34 pp.
LBJWC. 2007. *Phyllostachys aurea* Carr. ex. A. & C. Rivire. Online invasive plant database, Lady Bird Johnson Wildflower Center (LBJWC). Texasinvasives.org. Texas Invasive Plant and Pest Council (Producer). http://texasinvasives.org.
Lemke, C. 2008. Cal's Plant of the Week: *Phyllostachys aureosulcata* - yellow groove bamboo. University of Oklahoma Department of Botany and Microbiology. Available at http://www.plantoftheweek.org.
McClure, F. A. 1957. Bamboos of the genus *Phyllostachys* under cultivation in the United States. Agriculture Handbook No. 114, USDA Agricultural Research Service, Washington, D.C.
Musgrave, M. E. 2010. Letter from M.E. Musgrave, Chair, Connecticut Invasive Plants Council, to R. Blumenthal, Connecticut Attorney General, on September 25, 2010. Last accessed 4/20/2012, http://www.hort.uconn.edu/cipwg/IPCArchives.html Meeting dated 9/14/2010.
Nickrent, D. L. 2012. The Parasitic Plant Connection. Southern Illinois University Carbondale. http://www.parasiticplants.siu.edu/. (Archived at PERAL).
NRCS. 2012. The Plants Database. USDA-Natural Resources Conservation Service (NRCS). http://plants.usda.gov. (Archived at PERAL).
Ohmberger, D. 1999. The Bamboos of the World: Annotated Nomenclature and Literature of the Species and the Higher and Lower Taxa. Elsevier B.V.
Ontario Bamboo. n.d. Winter bamboo. Ontario Bamboo. Available at: http://www.ontariobamboo.com/winter-bamboo.html.
Rackham, O. 2008. Ancient woodlands: modern threats. New Phytologist 180:571-586.
Reaves, B. 2011. Invader of the month: Bamboo. Have you been bamboo-zled? Invasive species of concern in Maryland. Available at: http://www.mdinvasivesp.org.
Rickel, C. 2012. *Phyllostachys aureosulcata* (yellow groove) - All invading - No containment or knowledge of. Information provided by C. Rickel to the Connecticut General Assembly in connection with a pending House Bill 5122 to regulate the growth and sale of golden bamboo (www.cga.ct.gov/).
Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Elchbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. Terrestrial Ecoregions of North America: A Conservation Assessment. Island Press, Washington, D.C. 485 pp.
Smith, C. 2008. Invasive plants of North Carolina. North Carolina Department of Transportation, NC, U.S.A. 189 pp.
Stapleton, C. M. A., G. N. Chonghaile, and T. R. Hodkinson. 2004. *Sarocalamus*, a new Sino-Himalayan bamboo genus (Poaceae: Bambusoideae). Novon 14(3):345-349.
Swearingen, J. 2011. Invasive Plant Atlas of the United States. University of Georgia - Center for Invasive Species and Ecosystem Health, and the National Park Service. http://www.invasiveplantatlas.org. (Archived at PERAL).
Thompson, V. 2004. Associative nitrogen fixation, C4 photosynthesis, and the evolution of spittlebugs (Hemiptera: Cercopidae) as major pests of neotropical sugarcane and forage grasses. Bulletin of Entomological Research 94:189-200.
Ward, J. S. 2011. Letter from Jeffrey Ward, CT Agricultural Experiment Station, to L.A. Magnarelli, Director, CT Agricultural Experiment Station, dated 7/21/2011.

Ward, J. S. 2012a. Email from Jeffrey Ward, CT Agricultural Experiment Station, to Leslie Newton, CPHST PERAL, dated 5/29/2012.

Ward, J. S. 2012b. Running bamboo (*Phyllostachys* spp.) in Connecticut. Presentation given at the Connecticut Agriculture Experiment Station (CAES) Plant Science Day, 8/1/2012, by Jeffrey Ward, Station Forester, Department of Forestry and Horticulture, CAES. .

Weakley, A. S. 2010. Flora of the Carolinas, Virginia, Georgia, northern Florida, and Surrounding Areas (2010 draft). University of North Carolina Herbarium, Chapel Hill, NC, U.S.A. 994 pp.

West Bradford PA. 2011. Ordinance 11-01. An ordinance to prohibit the growth of bamboo so to cause a dangerous condition to the use of public highways or to impair the use or maintenance of a public road in West Bradford Township. Last accessed 4/25/2012, http://www.westbradford.org/htmls/ordinances.htm.

Young, R. A., and J. R. Haun. 1961. Bamboo in the United States: description, culture, and utilization. Agricultural Handbook No. 193. USDA Crops Research Division, Agricultural Research Service, Washington, D.C.

Appendix A. Weed risk assessment for *Phyllostachys aureosulcata* McClure (Poaceae). The following information was obtained from the species' risk assessment, which was conducted using Microsoft Excel. The information shown in this appendix 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 (Status/invasiveness outside its native range)	f - high	5	Naturalized in the United States (NRCS, 2012). Naturalized in Illinois; it is vegetatively spreading from an old home site into dry-mesic upland forest (Basinger, 2001). Cultivated as an ornamental in SC, VA, WV; persistent, or spreading from plantings (Weakley, 2010). Escaped from cultivation in Connecticut and spreading into yards, roadsides, natural areas (Rickel, 2012. Although most of the plants in natural areas in Connecticut appear to be the result of spread from ornamental plantings, one clump next to a bridge abutment may have originated from dispersal downstream (Ward, 2012a). *Phyllostachys aureosulcata* plants form large clumps and can be very invasive if not kept in check; author states, "I have personally seen landscapes where this plant has taken over the whole yard" (Lemke, 2008). Running bamboos, including *P. aureosulcata*, send out rhizomes in all directions from each culm; rhizomes may extend 15 to 25 feet within a growing season (Young and Haun, 1961). Alternate answers for the Monte Carlo simulation are both "e".
ES-2 (Domesticated to reduce weed potential)	n - low	0	There are at least 5 cultivars within the species *Phyllostachys aureosulcata*; they are distinguished primarily by culm and leaf color (Ohmberger, 1999). Although *P. aureosulcata* is a popular ornamental, there is no evidence that it has been bred in any way to reduce weed potential.
ES-3 (Weedy congeners)	y - negl	1	Running bamboos in general and *Phyllostachys* species in particular have proven themselves to be problematic in both natural and anthropogenic settings. A number of towns in northern states have enacted legislation to control the sale and planting of running bamboos, including the genus *Phyllostachys* by name (Brookhaven NY, 2012; West Bradford PA, 2011). *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 now dominates 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 (monoculture), 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).
ES-4 (Shade tolerance)	n - low	0	Full sun (Halvorson et al., 2010). Full sun to light shade (Lemke, 2008).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-5 (Climbing or smothering growth form)	n - negl	0	This plant is neither a vine nor does it have a basal rosette of leaves. *Phyllostachys aureosulcata* is a running bamboo. It spreads primarily through underground rhizomes which produce culms each spring; culms of this giant bamboo can grow up to 33 feet high and 1.5 inches in diameter (Young and Haun, 1961).
ES-6 (Dense thickets)	y - negl	2	Where well-established in full sunlight, this bamboo forms dense, nearly impenetrable thickets with NO native vegetation (Ward, 2012a). *Phyllostachys aureosulcata* plants form large clumps and can be very invasive if not kept in check Lemke, 2008). All running bamboos, including the genus *Phyllostachys*, spread primarily by rhizomes; new culms usually appear above ground in mid-spring at varying space intervals (rhizomes may extend 15 to 25 feet underground); a more or less open thicket is produced and, with the giant species (which includes *P. aureosulcata*), eventually a forest (Young and Haun, 1961).
ES-7 (Aquatic)	n - negl	0	Terrestrial plant (Young and Haun, 1961).
ES-8 (Grass)	y - negl	1	Bamboos constitute the subfamily Bambusoideae of the grass family Poaceae (Young and Haun, 1961).
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), answering 'unknown' with maximum uncertainty.
ES-10 (Viable seeds)	y - mod	1	Delayed seed production has evolved in bamboos to escape seed predation (Janzen, 1974). We could not locate information detailing the specific intermast period for *P. aureosulcata*, but other *Phyllostachys* species may experience intermast periods of 13 to over 100 years (Janzen, 1974). That *P. aureosulcata* does flower is evident by a photograph obtained from the American Bamboo Society taken by a Michigan bamboo nursery (bambooweb.info, n.d.). Additionally, the online database Plants for a Future provides information on the best method for germinating the seeds of *P. aureosulcata* (PFAF n.d.).
ES-11 (Self-compatible)	? - max	0	Evidence suggests that (bamboo) flowers are cross-pollinated, suggesting that isolated clones may produce few or no seeds (Janzen, 1974).
ES-12 (Special pollinators)	n - low	0	Bamboos are wind-pollinated (Gucker, 2009). Evidence suggests that flowers are cross-pollinated, suggesting that isolated clones may produce few or no seeds (Gucker, 2009; Janzen, 1974).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-13 (Min generation time)	b - low	1	Spreads vegetatively (via rhizomes), forming large colonies over time (HSU, n.d.). New shoots appear early in midspring(Young and Haun, 19611). For all species within the genus *Phyllostachy*s (including *P. aureosulcata*), the terminal bud of a rhizome usually dies before active growth begins the following spring and this results in the development and growth of several lateral buds behind the terminal bud; by repeated branching the rhizomes grow in all directions if conditions are favorable (Young and Haun, 1961). "The bamboo culm emerges from the ground with the diameter that it will always have, and it attains its full height in a few short weeks. It never increases in diameter or height after the few weeks of growing, though it may remain alive for many years. The new culms produced each successive year emerge from the ground with a greater diameter and reach a greater height before they stop growing, because the plant has extended its underground system of rhizomes and roots during the intervening period" (one year) (McClure, 1957). Alternate answers for the Monte Carlo simulation are both "c".
ES-14 (Prolific reproduction)	n - low	-1	Seed production occurs rarely in bamboos (Janzen, 1974); this bamboo spreads vegetatively via rhizome growth.
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	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 contaminates 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). Description of flowers and seeds: Flowering branchlets spicate, ca. 8.5 cm, scaly bracts ca. 4, gradually larger; spathes 4 or 5, glabrous or sparsely puberulous; auricles and oral setae absent, blade subulate, small. Pseudospikelets 5-7 per spathe, usually absent from lowest one. Spikelets with 1 or 2 florets. Glumes 1 or 2, keeled; rachilla puberulous; lemma 1.5-1.9 cm, distally pubescent; palea slightly shorter than lemma, distally pubescent; lodicules ca. 3.5 mm. (Flora of China, 2006).
ES-17a (Wind dispersal)	n - low		See comment in ES17.
ES-17b (Water dispersal)	? - max		The presence of naturalized stands of *P. aureosulcata* beside rivers and streams suggests that culms and rhizomes can be moved by water and washed downstream from upstream sources (EDDMaps, 2012; Ward, 2012a).
ES-17c (Bird dispersal)	n - low		See comment in ES17.
ES-17d (Animal external dispersal)	n - low		See comment in ES17.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17e (Animal internal dispersal)	n - low		See comment in ES17.
ES-18 (Seed bank)	n - low	-1	No evidence.
ES-19 (Tolerance to loss of biomass)	y - negl	1	That *P. aureosulcata* tolerates mutilation is evident by the difficulty people have in controlling the spread of this bamboo. For example: "Even though all canes cut, rhizome web still invades; shoots up daily - cannot kill it; digging rhizomes - all lawn destroyed" (Rickel, 2012). "Fully invading State land and running up along Merritt Parkway. DOT not able to kill it (workers mow it and it comes back up fast)" (Rickel, 2012).
ES-20 (Herbicide resistance)	n - low	0	*Phyllostachys aurea*, *P. aureosulcata*, and *P. bambusoides* can be controlled but requires 1+ years with herbicide; effective herbicides include glyphosate (Roundup(®) and diclobenil (Casoron®, Barrier®) (Ward, 2012b). Although it takes effort and often multiple applications, running bamboos within the genus *Phyllostachys* can be controlled with glyphosate herbicides (Czarnota and Derr, 2007; Smith, 2008). There are no *Phyllostachys* species listed by the International Survey of Herbicide Resistant Weeds (Heap, 2012).
ES-21 (# Cold hardiness zones)	7	0	
ES-22 (# Climate types)	3	0	
ES-23 (# Precipitation bands)	3	-1	
Impact Potential			
General Impacts			
Imp-G1 (Allelopathic)	? - max		Unknown. 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).
Imp-G2 (Parasitic)	n - negl	0	No species within the family Poaceae is known to be parasitic (Nickrent, 2012).
Impacts to Natural Systems			
Imp-N1 (Ecosystem processes)	? - max		Unknown. If this bamboo were to become established along a stream, it could alter food webs; its congener, *P. aurea*, is said to have this effect (Gonzalez and Christoffersen, 2006; LBJWC, 2007).
Imp-N2 (Community structure)	y - mod	0.2	*Phyllostachys aureosulcata* forms monocultures: "I have never seen a species so thoroughly dominate a site and form a monoculture that completely excludes other species" (Ward, 2011). All running bamboos within the genus *Phyllostachys* spread via underground rhizomes, at first forming thickets and, with giant species (including *P. aureosulcata*), eventually a forest (Young and Haun, 1961).
Imp-N3 (Community composition)	y - low	0.2	"Where well-established in full sunlight, bamboo forms dense nearly impenetrable thickets with NO native vegetation. In small gaps with some trees (similar to a shelterwood), the bamboo is less dense and lesser vegetation is still present (Ward, 2012a). Bamboos can form very dense single-species thickets that displace native plant species and create dense shade that makes it difficult for seedlings of native seedlings to survive (Swearingen, 2011). Running bamboos will take over

Question ID	Answer - Uncertainty	Score	Notes (and references)
			any sunny or semi-shaded area forming impenetrable thickets and effectively crowding out all native vegetation (Reaves, 2011).
Imp-N4 (T&E species)	? - max		Unknown. Because running bamboos (including *P. aureosulcata*) spread by rhizomes, form forests, and can outcompete other species fairly easily, it is expected that this bamboo could affect threatened plant species under the right conditions.
Imp-N5 (Globally outstanding ecoregions)	? - max		This is difficult to predict. Most of the reports about impact in natural areas come from Connecticut and New York, neither of which include globally outstanding ecoregions as defined by Ricketts et al. (Ricketts et al., 1999). If this bamboo becomes established in natural areas and is neglected for an extended period of time, it could certainly affect native plant communities.
Imp-N6 (Natural systems weed)	c - mod	0.6	Vegetatively spreading from an old home site into dry-mesic upland forest in Illinois (Basinger, 2001). Information provided to the Connecticut General Assembly documents multiple examples of escapes from cultivation in which *P. aureosulcata* is spreading into natural areas (Rickel, 2012). The Connecticut Department of Energy and Environmental Protection has drafted a proposal to list *P. aureosulcata* (and *P. aurea*) as "potentially invasive" in CT because it either has naturalized or has the potential to naturalize and has the potential to impact natural areas (CTIPC, 2011). Alternate answers for the Monte Carlo simulation are both "b".
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Affects property, civilization, ...)	y - negl	0.1	A citizen in Connecticut, to support pending legislation to regulate running bamboo has documented the following problems with *P. aureosulcata*, each on a different property: rhizomes have traveled under the sidewalk and reached central air conditioning units; rhizomes have cracked and lifted new asphalt driveway; rhizomes have destroyed swimming pool; rhizomes are invading septic and leaching fields; rhizomes are growing into power lines (Rickel, 2012). "The running bamboos are not suitable for growing near buildings or where space is otherwise limited" (Young and Haun, 1961).
Imp-A2 (Recreational use)	n - mod	0	No evidence.
Imp-A3 (Affects ornamental plants)	y - negl	0.1	Continual nuisance, invading all landscape and killing peonies, hydrangea, lilac, crabapple, roses all invaded; all lawn destroyed; invading 30 year old forsythia hedge (Rickel, 2012).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-A4 (Anthropogenic weed)	c - negl	0.4	There are a number of towns in New York, Pennsylvania, and other northern states that have either adopted or are considering ordinances regulating the sale and growth of running bamboos (*Phyllostachys* spp. included) (e.g., Brookhaven NY, 2012; Haverford PA, 2011; West Bradford PA, 2011). In residential areas in Connecticut, *P. aureosulcata* is spreading into neighboring properties, sending rhizomes and shoots into yards, gardens, hedges, etc.; homeowners are trying to control it by cutting and digging up rhizomes but removal is proving difficult. Information provided to the Connecticut General Assembly documents multiple examples of *P. aureosulcata* causing problems and various controls being applied in an attempt to stop the invasions into neighboring properties (Rickel, 2012). The Connecticut Invasive Plants Council looked at *P. aureosulcata* in 2010 and determined that it did not meet the definition of an invasive plant because it does not occur except in immediate proximity to ornamental plantings; the CT Green Industry was in the process of mounting a special trade and public education campaign on bamboo to avoid future problems (Musgrave, 2010). If grown in landscape, they need some sort of barrier to keep them in bounds; author states "I have personally seen landscapes where this plant (*P. aureosulcata*) has taken over the whole yard" (Lemke, 2008). The running bamboos are not suitable for growing near buildings or where space is otherwise limited; plots are kept within bounds by breaking off new shoots in the spring that start outside the set limits (all running bamboos) (Young and Haun, 1961).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 - low	0	This bamboo is relatively well known; there is no evidence that it invades agricultural settings or that it is an agricultural weed.
Imp-P2 (Commodity value)	n - low	0	This bamboo is relatively well known; there is no evidence that it invades agricultural settings or that it is an agricultural weed.
Imp-P3 (Affects trade)	n - low	0	This bamboo is relatively well known; there is no evidence that it invades agricultural settings or that it is an agricultural weed.
Imp-P4 (Irrigation)	n - low	0	This bamboo is relatively well known; there is no evidence that it invades agricultural settings or that it is an agricultural weed.
Imp-P5 (Animal toxicity)	n - negl	0	*Phyllostachys* foliage (including *P. aureosulcata*) can meet the maintenance or growth needs of goats and other ruminants (Halvorson et al., 2010).
Imp-P6 (Production system weed)	n - low	0	This bamboo is relatively well known; there is no evidence that it is an agricultural weed. Alternate answers for the Monte Carlo simulation are both "b".
Geographic Potential			
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	Too cold (see comment in Geo-Z4 and Z5).
Geo-Z2 (Zone 2)	n - negl	N/A	Too cold (see comment in Geo-Z4 and Z5).
Geo-Z3 (Zone 3)	n - negl	N/A	Too cold (see comment in Geo-Z4 and Z5).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z4 (Zone 4)	y - low	N/A	In areas with winter temperatures as low as -34C, the above-ground portions of *P. aureosulcata* will die but this bamboo will grow back in the summer (Ontario Bamboo, n.d.).
Geo-Z5 (Zone 5)	y - low	N/A	Hardy to Zone 5 (zones 5 to 10) DavesGarden, 2012). Can tolerate -15C or -20C (Ohmberger, 1999).
Geo-Z6 (Zone 6)	y - negl	N/A	Zone 6 (DavesGarden, 2012); U.S. (CT, WV p.s. EDDMaps, 2012).
Geo-Z7 (Zone 7)	y - negl	N/A	Zone 7 (DavesGarden, 2012); Native: China (Anhui, Jiangsu) (Ohmberger, 1999); CT, NY, MD, DC, WV (p.s. EDDMaps, 2012); PA (occ. Kartesz, 2011).
Geo-Z8 (Zone 8)	y - negl	N/A	Zone 8 (DavesGarden, 2012); Native: China (Anhui, Zhejiang, Jiangsu) (Ohmberger 1999); MS (occ. Kartesz, 2011); AL (p.s. GBIF 2012; occ. Kartesz, 2011).
Geo-Z9 (Zone 9)	y - negl	N/A	Zone 9 (DavesGarden, 2012); U.S. (TX) (occ. Kartesz, 2011).
Geo-Z10 (Zone 10)	y - mod	N/A	Zone 10 (DavesGarden, 2012; Greer Gardens, 2012).
Geo-Z11 (Zone 11)	n - low	N/A	No evidence.
Geo-Z12 (Zone 12)	n - low	N/A	No evidence.
Geo-Z13 (Zone 13)	n - low	N/A	No evidence.
Koppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - mod	N/A	No evidence.
Geo-C2 (Tropical savanna)	n - low	N/A	No evidence.
Geo-C3 (Steppe)	n - low	N/A	No evidence.
Geo-C4 (Desert)	n - negl	N/A	No evidence.
Geo-C5 (Mediterranean)	n - negl	N/A	No evidence.
Geo-C6 (Humid subtropical)	y - negl	N/A	Native: China (Anhui, Zhejiang, Jiangsu) (Ohmberger, 1999); U.S. (MD, DC, TN, AL) (p.s. EDDMaps, 2012; GBIF, 2012); WV, MS, AL (occ. Kartesz, 2011).
Geo-C7 (Marine west coast)	n - mod	N/A	No evidence.
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	U.S. (PA) (occ. Kartesz, 2011); CT (p.s. EDDMaps, 2012).
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	U.S. (CT, NY) (p.s. EDDMaps, 2012); (WV) (occ. Kartesz, 2011).
Geo-C10 (Subarctic)	n - low	N/A	No evidence.
Geo-C11 (Tundra)	n - negl	N/A	Too cold (see comment in Geo-Z4 and Z5).
Geo-C12 (Icecap)	n - negl	N/A	Too cold (see comment in Geo-Z4 and Z5).
10-inch precipitation bands			
Geo-R1 (0-10")	n - negl	N/A	No evidence.
Geo-R2 (10-20")	n - negl	N/A	No evidence.
Geo-R3 (20-30")	n - low	N/A	No evidence.
Geo-R4 (30-40")	y - negl	N/A	Native: China (Anhui, Zhejiang, Jiangsu) (Ohmberger, 1999); U.S. (WV) (p.s. EDDMaps, 2012); (TX) (occ. Kartesz, 2011).
Geo-R5 (40-50")	y - negl	N/A	Native: China (Anhui, Zhejiang, Jiangsu) (Ohmberger, 1999); U.S. (WV, MD, DC, VA, CT, NY) (p.s. EDDMaps, 2012); (KY (p.s. GBIF, 2012); (TX) (occ. Kartesz, 2011).
Geo-R6 (50-60")	y - negl	N/A	Native: China (Anhui, Zhejiang, Jiangsu) (Ohmberger, 1999); U.S. (TN, AL) (p.s. GBIF, 2012); MS, AL (occ. Kartesz, 2011).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R7 (60-70")	n - mod	N/A	No evidence.
Geo-R8 (70-80")	n - low	N/A	No evidence.
Geo-R9 (80-90")	n - low	N/A	No evidence.
Geo-R10 (90-100")	n - low	N/A	No evidence.
Geo-R11 (100"+)	n - low	N/A	No evidence.
Entry Potential			
Ent-1 (Already here)	y - negl	1	Naturalized in southern Illinois; most of the 13 southernmost counties in IL have *P. aureosulcata* (Basinger, 2001). Growing (and naturalized) in New York (Long Island) (Jordan, 2012), Connecticut (Ward, 2012). Naturalized in Arkansas (HSU n.d.).
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	