United States Department of Agriculture

Weed Risk Assessment for *Bulbostylis hispidula* (Vahl) R. W. Haines - Beard of the lion

United States Department of Agriculture

Animal and Plant Health Inspection Service

November 26, 2014

Version 1

Herbarium specimen of *Bulbostylis hispidula* from Mozambique showing plant habit (Hyde et al., 2014).

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.

Bulbostylis hispidula **(Vahl) R. W. Haines – Beard of the lion**

Species Information

Family: Cyperaceae

Synonyms: *Bulbostylis exilis* (Kunth) Lye (The Plant List, 2014); *Fimbristylis exilis* (Kunth) Roem. & Schult. (The Plant List, 2014); *F. hispidula* (Vahl) Kunth (NGRP, 2014); *Isolepis exilis* Kunth (Lye, 1996; The Plant List, 2014); *Scirpus hispidulus* Vahl (basionym; NGRP, 2014). Some authors have misapplied the name of *B. hirta* (Thunb.) Svenson to New World occurrences of *B. hispidula* (Lye, 2006; Strong, 2014). To avoid confounding our assessment with information from a different species, we relied on evidence from the African literature for *B. hispidula* and *F. hispidula* to evaluate this species' risk potential. This approach did not exclude much useful information on *B. hispidula* from the Americas, as little is known about New World populations.

Common names: Beard of the lion (Gantoli et al., 2013), and ratgrass (Brink, 2011).

Botanical description: *Bulbostylis hispidula* is a tufted or tussock-forming annual sedge that is 10-40 cm tall, but can reach as high as 80 cm (Brink, 2011; Häfliger, 1982; Kabuye et al., No Date; Lye, 1996). It is very common in tropical Africa (Brink, 2011) and often occurs in open, sandy habitats (Simpson and Inglis, 2001; van Rooyen et al., 2008). *Bulbostylis* spp. are typically sand plants (Kral, 1971; Strong, 2014).

Initiation: APHIS received a market access request from South Africa for corn seeds for planting (South Africa Department of Agriculture Forestry and Fisheries, 2012). During the development of that commodity risk assessment, *B. hispidula* was identified as a weed of potential concern to the United States. The PPQ Weeds Cross-Functional Working Group decided to evaluate this species with a weed risk assessment.

Foreign distribution: This species is native to sub-Saharan Africa, including Madagascar and the Seychelles (Acevedo-Rodríguez and Strong, 2012; NGRP, 2014). Beyond Africa, it occurs in Belize, Cuba, French Guiana, Guatemala, Guyana, Indonesia, Mexico, Nicaragua, Philippines, Suriname, and Venezuela, (Funk et al., 2007; Goodwin et al., 2013; Häfliger, 1982; MBG, 2014; NGRP, 2014). Because of the taxonomic confusion mentioned above, it is not clear to what extent this species occurs in the Americas. Furthermore, USDA's GRIN database indicates *B. hispidula* (Vahl) R. W. Haines is native to Central and South America, but another source (Acevedo-Rodríguez and Strong, 2012) indicates it is exotic in that region. An expert on Cyperaceae clarified that it is an exotic species in the Americas (Strong, 2014).

U.S. distribution and status: We found no evidence that this species is currently present in the United States. A specimen of *B. hirta* (Thunb.) Svenson was collected in 1959 from a manganese ore pile in Canton, Maryland (Reed, 1964). Although we did not find an online image of the specimen to verify its identity, Mark Strong, a Smithsonian expert on the Cyperaceae, stated that based on the description of the specimen in Reed (1964) and other factors, he believes this specimen is likely to be *B. hispidula* (Strong, 2014). Regardless of the identity of this specimen, the plant or plants do not appear to have become established in the United States as neither species is reported in a recent regional flora that includes Maryland (Weakley, 2012).

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

1. *Bulbostylis hispidula* analysis

Establishment/Spread Potential *Bulbostylis hispidula* is an annual plant (Bryson and Carter, 2008) that produces viable seeds (Hérault and Hiernaux, 2004), and which may be dispersed in trade (Reed, 1964). Its wide geographic distribution in sub-Saharan Africa (GBIF, 2014) indicates it has a high adaptive potential to different climates. It has already been introduced to and become established in several other countries (Acevedo-Rodríguez and Strong, 2012). Despite that, its ability to establish and spread is limited by not producing prolific numbers of seeds, not having long-distance dispersal mechanisms (see Appendix A), and being intolerant to mutilation (CIRAD, 2014; Gantoli et al., 2013). We did not find any detailed studies on the life history and ecology of *B. hispidula*, and we could not answer four questions in this risk element. Overall, we had very high uncertainty in this risk element due to the limited amount of information we found about this species.

Risk score = 3 Uncertainty index = 0.33

Impact Potential *Bulbostylis hispidula* is primarily an agricultural weed that can be quite common in some cropping systems, with coverage values of 5-25 percent (Gantoli et al., 2013; Keller et al., 2012). It is reported as a weed of wed rice (Brink, 2011; Goetghebeur and Coudijzer, 1985), corn (Chikoyea et al., 2004; FAO, 2014), lupin (Saayman-duToit, 2003), sugarcane (Fadayomi and Abayomi, 1988), groundnuts (Ashrif, 1967), and grasslands (Häfliger, 1982). In combination with other weeds it is reported to reduce corn yield by up to 58 percent (Keller et al., 2012). This species is managed in crops in Africa and several commercial herbicides in South Africa have been registered for its control (Bromilow, 2010; Wells et al., 1986). Given the

[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).

abundance of *B. hispidula* in some fields, manual labor required for weeding probably lowers crop value. *Bulbostylis hispidula* is reported to be unpalatable (Wells et al., 1986) and is grazed when nothing else is available (Simpson and Inglis, 2001). We found no evidence that this species harms natural systems. We had an average amount of uncertainty in this risk element.
Risk score = 2.3 Uncertainty index = 0.18

Geographic Potential Based on three climatic variables, we estimate that about 27 percent of the United States is suitable for the establishment of *Bulbostylis hispidula* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes georeferenced points and areas of occurrence. The map for *B. hispidula* represents the joint distribution of Plant Hardiness Zones 8-13, areas with 0-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, steppe, desert, Mediterranean, humid subtropical, and marine west coast.

Our determination was based entirely on georeferenced records from Africa (GBIF, 2014) and one regional occurrence in Italy (Wallentinus, 2002). The climatic variation across the region of Africa where *B. hispidula* is native was sufficient to represent the range of climatic variation where it has been reported to occur in the Americas. Thus, our analysis did not have to rely on any of the reported occurrences in Mexico, Central America, and South America, which are less certain due to taxonomic confusion.

The area estimated as suitable in the United States is likely conservative since it only uses three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish. This species (MBG, 2014; Simpson and Inglis, 2001; van Rooyen et al., 2008), as well as the genus (Kral, 1971; Strong, 2014), prefers sandy habitats.

> "*Bulbostylis hispidula* occurs from sea-level up to 2050 m altitude in a large variety of habitats, including dry grassland, seasonally wet grassland and woodland, shrubland, forest openings, dry sandy locations, dunes, shallow soil on rocks, marshes and shores of lakes. It often occurs in fallows and other disturbed habitats, and is a weed of wet rice and upland crops" (Brink, 2011).

Entry Potential We found no evidence that *B. hispidula* is currently present in the United States (see information under U.S. distribution and status, above). Because this species is not cultivated, it is unlikely to be intentionally introduced. It has already demonstrated an ability to spread beyond its native range, however, since it is established in Mexico, Central America, South America, and Italy (Acevedo-Rodríguez and Strong, 2012). We found evidence it may spread as a contaminant of ore (Reed, 1964).
Risk score = 0.13 Uncertainty index = 0.14

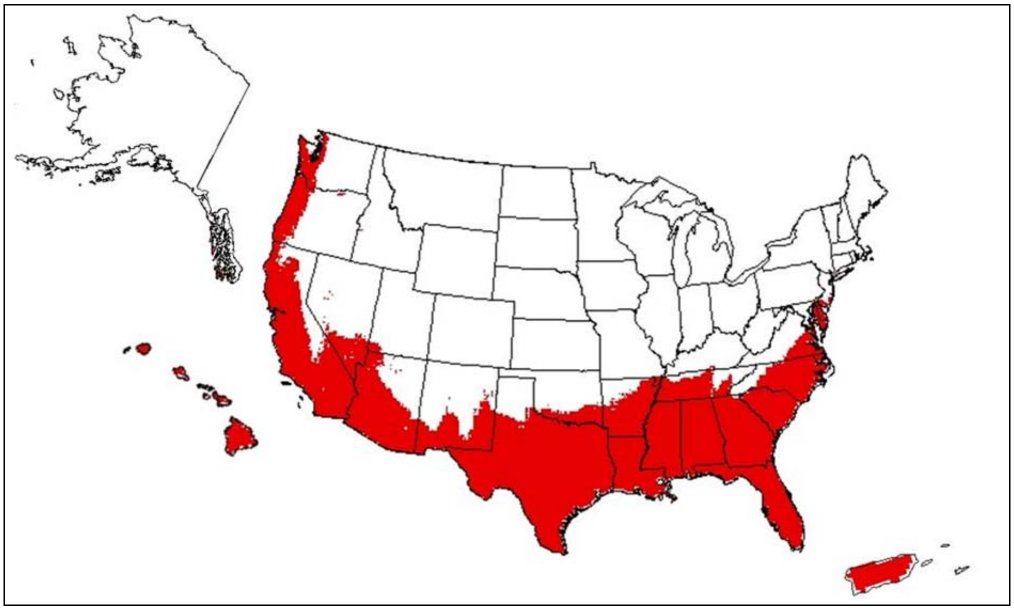

Figure 1. Predicted distribution of *Bulbostylis hispidula* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 11.5%
P(Minor Invader) = 69.6%
P(Non-Invader) = 18.9%
Risk Result = Evaluate Further
Secondary Screening = Evaluate Further

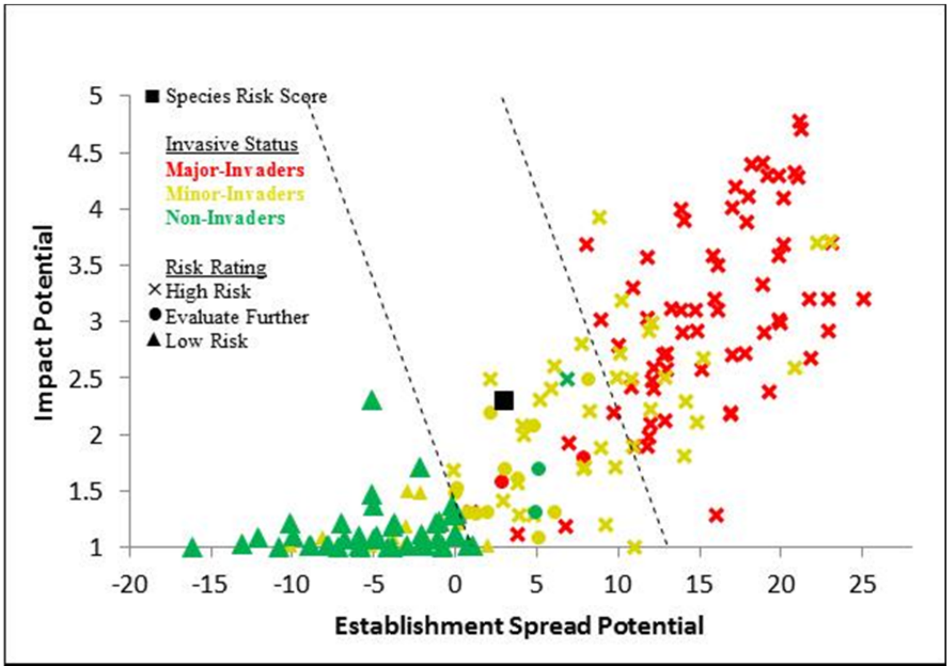

Figure 2. *Bulbostylis hispidula* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

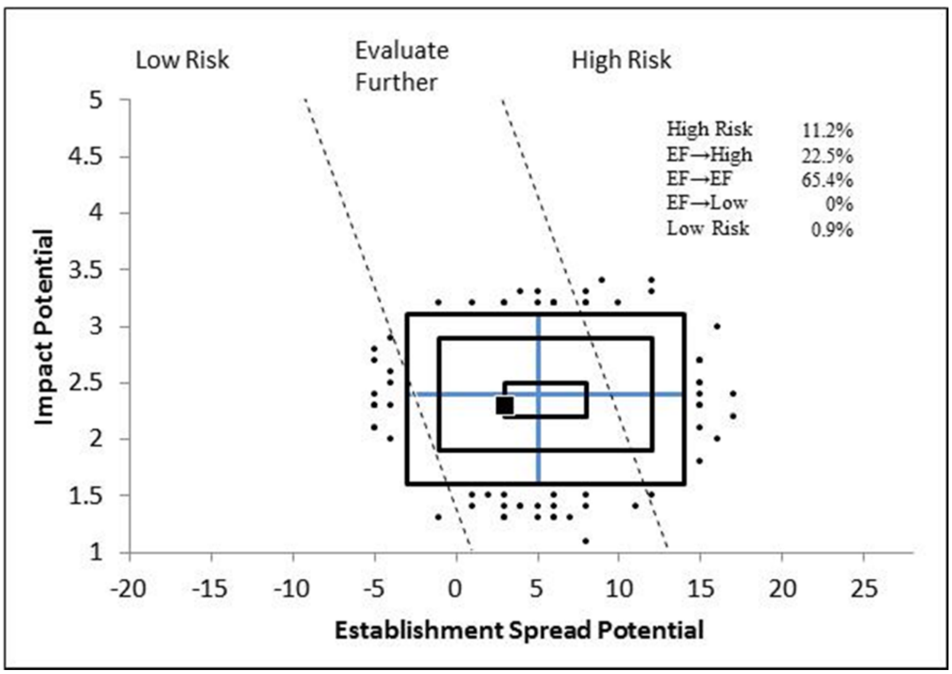

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Bulbostylis hispidula*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Bulbostylis hispidula* is Evaluate Further (Fig. 2), which is supported by our uncertainty analysis (Fig. 3). A conclusion of Evaluate Further means that the species presents a moderate risk potential and that decision makers may have to consider other factors when making regulatory and management decisions. Overall, *B. hispidula*'s risk profile is consistent with species that are considered minor invaders in the United States. *Bulbostylis hispidula* is a highly variable and wide ranging plant in Africa, growing in a wide range of habitats including deserts, steppe, savannas, and subtropical forests (GBIF, 2014; Hall, 1973; Lye, 1996). In its native range, it is particularly abundant in dry regions (Hérault and Hiernaux, 2004) and is an indicator species of declining soil fertility (CIRAD, 2014). Should *B. hispidula* be introduced to the United States and become established, we expect it would establish and spread in open, sandy habitats in agricultural, natural, and anthropogenic systems throughout the southeastern, southern, and western portions of the United States (Fig. 1).

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.

Acevedo-Rodríguez, P., and M. T. Strong. 2012. Catalogue of Seed Plants of the West Indies. Smithsonian Institution, Washington D.C. 1192 pp.

Ahmed, H. E., and E. E. Ali. 2012. Effect of burning intensity on soil seed bank in clay and sandy soils in North Kordofan State, Sudan. Journal of Science and Technology 13(December):2-10.

Anonymous. 1981. Annual report 1979 [Abstract]. The Ministry of Agriculture and Natural Resources, Gambia Crop Protection Services, Gambia. 51 pp.

APHIS. 2014. Phytosanitary Certificate Issuance & Tracking System (PCIT). United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://pcit.aphis.usda.gov/pcit/faces/index.jsp. (Archived at PERAL).

Ashrif, M. I. 1967. Effects of fertilizer, weeding and pre-emergence MCPB on groundnuts in the Gambia. PANS(c) 13(3):207-214.

Bridge, J., P. J. Terry, J. P. Tunstall, and J. M. Waller. 1978. A survey of crop pests, diseases and weeds of the Gambia. Overseas Development Administration, on behalf of the Gambian Government., London. 46 pp.

Brink, M. 2011. *Bulbostylis hispidula* (Vahl) R.W.Haines. Internet record from PROTA (Plant Resources of Tropical Africa). Wageningen University. Last accessed June 24, 2014, http://www.prota4u.org/search.asp.

Bromilow, C. 2010. Problem Plants and Alien Weeds of South Africa, 3rd ed. BRIZA, Pretoria, South Africa. 423 pp.

Bryson, C. T., and R. Carter. 2008. The significance of Cyperaceae as weeds. Pages 15-101 *in* R. F. C. Naczi and B. A. Ford, (eds.). Sedges: Uses, Diversity, and Systematics of the Cyperaceae. Missouri Botanical Garden, St. Louis, MO, U.S.A.

Chikoyea, D., S. Schulza, and F. Ekelemeb. 2004. Evaluation of integrated weed management practices for maize in the northern Guinea savanna of Nigeria. Crop Protection 23:895-900.

CIRAD. 2014. Adventrop V.1.5: Les adventices d'Afrique soudano-sahélienne, Online Database. Centre de coopération Internationale en Recherche Agronomique pour le Développement (CIRAD). http://idao.cirad.fr/applications. (Archived at PERAL).

Fadayomi, O., and Y. A. Abayomi. 1988. Effects of varying periods of weed interference on sugarcane (*Saccharum officinarum*) growth and yield. Nigerian Journal of Weed Science 1(2):65-70.

Faegri, K., and L. Van der Pijl. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford. 244 pp.

FAO. 2014. Database of weed species in crops and countries. Food and Agriculture Organization (FAO) of the United Nations. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/biodiversity/weeds/db-countries/en/. (Archived at PERAL).

Funk, V., T. Hollowell, P. Berry, C. Kelloff, and S. N. Alexander. 2007. Checklist of the plants of the Guiana Shield (Venezuela: Amazonas, Bolivar, Delta Amacuro; Guyana, Surinam, French Guiana). Contributions from the United States National Herbarium 55:1-584.

Gantoli, G., V. R. Ayala, and R. Gerhards. 2013. Determination of the critical period for weed control in corn. Weed Technology 27(1):63-71.

GBIF. 2014. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). http://data.gbif.org/welcome.htm. (Archived at PERAL).

Gérard, B., P. Hiernaux, B. Muehlig-Versen, and A. Buerkert. 2001. Destructive and non-destructive measurements of residual crop residue and phosphorus effects on growth and composition of herbaceous fallow species in the Sahel. Plant and Soil 228(2):265-273.

Goetghebeur, P., and J. Coudijzer. 1985. Studies in Cyperaceae 5: The Genus *Bulbostylis* in Central Africa. Bulletin du Jardin botanique national de Belgique / Bulletin van de National Plantentuin van België 55(1/2):207-259.

Goodwin, Z. A., G. N. Lopez, N. Stuart, S. G. M. Bridgewater, E. M. Haston, I. D. Cameron, D. Michelakis, J. A. Ratter, P. A. Furley, E. Kay, and C. Whitefoord. 2013. A checklist of the vascular plants of the lowland savannas of Belize, Central America. Phytotaxa 101(1):1-119.

Häfliger, E. (ed.). 1982. Monocot Weeds 3. CIBA-GEIGY Ltd., Basle,

Switzerland. 132+ pp.
Hall, J. B. 1973. The Cyperaceae within Nigeria: Distribution and habitat. Botanical Journal of the Linnean Society 66(4):323-346.
Heap, I. 2014. The international survey of herbicide resistant weeds. Weed Science Society of America. http://www.weedscience.org/summary/home.aspx. (Archived at PERAL).
Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Leiden, The Netherlands. 438 pp.
Hérault, B., and P. Hiernaux. 2004. Soil seed bank and vegetation dynamics in Sahelian fallows; the impact of past cropping and current grazing treatments. Journal of Tropical Ecology 20(6):683-691.
Holm, L. G., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1979. A Geographical Atlas of World Weeds. Krieger Publishing Company, Malabar, FL. 391 pp.
Hyde, M. A., B. T. Wursten, and P. Ballings. 2014. Flora of Zimbabwe, Online Database. Zimbabwe Flora Team. http://www.zimbabweflora.co.zw/index.php. (Archived at PERAL).
IPPC. 2012. International Standards for Phytosanitary Measures No. 5: Glossary of Phytosanitary Terms. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy.
Kabuye, C. H. S., G. M. Mungai, and J. G. Mutangah. No Date. Flora of Kora National Reserve. East African Herbarium, National Museums of Kenya, Nairobi, Kenya. 104 pp.
Keller, M., G. Gantoli, A. Kipp, C. Gutjahr, and R. Gerhards. 2012. The effect and dynamics of weed competition on maize in Germany and Benin. Julius-Kühn-Archiv 1(434):289-299.
Klee, M., B. Zach, and K. Neumann. 2000. Four thousand years of plant exploitation in the Chad Basin of northeast Nigeria I: The archaeobotany of Kursakata. Vegetation History and Archaeobotany 9(4):223-237.
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.
Kral, R. 1971. A treatment of *Abildgaardia*, *Bulbostylis* and *Fimbristylis* (Cyperaceae) for North America. SIDA 4:57-227.
Lye, K. A. 1996. A new subspecies of *Bulbostylis hispidula* (Cyperaceae) from Somalia. Willdenowia 25(2):595-600.
Lye, K. A. 2006. The typification and identity of *Cyperus hirtus* Thunb. (1803). Taxon 55(4):1025-1026.
Mabberley, D. J. 2008. Mabberley's Plant-Book: A Portable Dictionary of Plants, Their Classification and Uses (3rd edition). Cambridge University Press, New York. 1021 pp.
Martin, P. G., and J. M. Dowd. 1990. A protein sequence study of the dicotyledons and its relevance to the evolution of the legumes and

nitrogen fixation. Australian Systematic Botany 3:91-100.
MBG. 2014. Tropicos Database. Missouri Botanical Garden (MBG). http://www.tropicos.org/Home.aspx. (Archived at PERAL).
NGRP. 2014. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program (NGRP). http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl?language=en. (Archived at PERAL).
Nickrent, D. 2009. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL. Last accessed June 12, 2009, http://www.parasiticplants.siu.edu/ListParasites.html.
Phillips, M. C. 1992. A survey of the arable weeds of Botswana. Tropical Pest Management 38(1):13-21.
Randall, R. P. 2012. A Global Compendium of Weeds, 2nd edition. Department of Agriculture and Food, Western Australia, Perth, Australia. 1107 pp.
Reed, C. R. 1964. A Flora of the chrome and manganese ore piles at Canton, in the Port of Baltimore, Maryland and at Newport News, Virginia, with descriptions. Phytologia 10:321-406.
Rutherford, M. C., and L. W. Powrie. 2010. Severely degraded dunes of the southern Kalahari: Local extinction, persistence and natural re-establishment of plants. African Journal of Ecology 48(4):930-938.
Saayman-duToit, A. E. J. 2003. Efficacy and phytotoxicity of simazine and terbuthylazine on lupins. South African Journal of Plant and Soil 20(4):188-192.
Santi, C., D. Bogusz, and C. Franche. 2013. Biological nitrogen fixation in non-legume plants. Annals of Botany 111(5):743-767.
Simpson, D. A., and C. A. Inglis. 2001. Cyperaceae of economic, ethnobotanical and horticultural importance: A Checklist. Kew Bulletin 56(2):257-360.
South Africa Department of Agriculture Forestry and Fisheries. 2012. Request for market access for maize (*Zea mays*) seeds for planting from South Africa into the USA. South Africa Department of Agriculture Forestry and Fisheries, Directorate of Plant Health, Pretoria, South Africa.
Strong, M. T. 2014. Seeking clarification on the identify and distribution of *Bulbostylis hispidula* (Vahl) R. W. Haines. Personal communication to A. Koop on June 27, 2014, from Mark T. Strong, botanist with the Smithsonian Institution.
Terry, P. J. 1981. Weeds and Their Control in The Gambia. Tropical Pest Management 27(1):44-52.
The Plant List. 2014. Version 1 [Online Database]. Kew Botanic Gardens and the Missouri Botanical Garden. http://www.theplantlist.org/. (Archived at PERAL).
van Rooyen, M. W., N. van Rooyen, J. du P. Bothma, and H. M. van den Berg. 2008. Landscapes in the Kalahari Gemsbok National Park,

South Africa. Koedoe 50(1):99-112.
Vernon, R. 1983. Field Guide to Important Arable Weeds of Zambia. Department of Agriculture, Mount Makulu Central Research Station, Chilanga, Zambia. 151 pp.
Wallentinus, I. 2002. Introduced marine algae and vascular plants in European aquatic environments. *in* E. Leppakoski, S. Gollasch, and S. Olenin, (eds.). Invasive Aquatic Species of Europe: Distribution, Impacts, and Management. Kluwer Acadmeic Publishers.
Weakley, A. S. 2012. Flora of the Southern and Mid-Atlantic States: Working Draft of 30 November 2012. University of North Carolina Herbarium, North Carolina Botanical Garden, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, U.S.A. 1225 pp.
Wells, M. J., V. M. Balsinhas, H. Joffe, V. M. Engelbrecht, G. Harding, and C. H. Stirton. 1986. A Catalogue of Problem Plants in Southern Africa Incorporating The National Weed List of South Africa. Memoirs of the Botanical Survey of South Africa 53.
Wezel, A., and E. Schlecht. 2004. Inter-annual variation of species composition of fallow vegetation in semi-arid Niger. Journal of Arid Environments 56(2):265-282.

Appendix A. Weed risk assessment for *Bulbostylis hispidula* (Vahl) R. W. Haines (Cyperaceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	e - high	2	This species is native to sub-Saharan Africa, including Madagascar and the Seychelles (Acevedo-Rodríguez and Strong, 2012; NGRP, 2014). Established in Italy (Wallentinus, 2002). It has been reported to occur in Belize, Cuba, French Guiana, Guatemala, Guyana, Indonesia, Mexico, Nicaragua, the Philippines, Suriname, and Venezuela (Funk et al., 2007; Goodwin et al., 2013; Häfliger, 1982; MBG, 2014; NGRP, 2014). USDA's GRIN database indicates *B. hispidula* (Vahl) R. W. Haines is native to Central and South America, but another source (Acevedo-Rodríguez and Strong, 2012) states it is exotic in that region. An expert on Cyperaceae clarified with us that it is an exotic species in the New World (Strong, 2014). We found no information clarifying whether this species is casual or naturalized in Mexico, Central America, and South America. Given the number of records and breadth of distribution in that region and in its native range, we assumed it is naturalized and used high uncertainty. The alternate answers for the Monte Carlo simulation were "d" and "f."
ES-2 (Is the species highly domesticated)	n - negl	0	Plants are collected from the wild in Africa and used in matting, traditional medicines, and straining alcoholic beverages (Brink, 2011; Simpson and Inglis, 2001). We found no evidence this species is cultivated; thus it is highly unlikely to have been bred for traits associated with reduced weed potential.
ES-3 (Weedy congeners)	n - high	0	The genus *Bulbostylis* has about 100-150 species primarily in tropical Africa and America (Lye, 1996; Mabberley, 2008). About a dozen species have been reported to be weedy (Randall, 2012). *Bulbostylis barbata* and *B. puberula* are considered principle weeds in Nigeria and Ceylon, respectively (Holm et al., 1979). However, a more detailed review of Cyperaceae as weeds states that none of the *Bulbostylis* species are considered major weeds (Bryson and Carter, 2008). We answered no, but with high uncertainty because the evidence is somewhat conflicting.
ES-4 (Shade tolerant at some stage of its life cycle)	n - low	0	We found no evidence this species is shade tolerant. This species, like the rest of the genus, tends to occur in open and sunny habitats (Brink, 2011; Bryson and Carter, 2008; Lye, 1996; Strong, 2014). Thus we believe it is unlikely to be shade tolerant.
ES-5 (Climbing or smothering growth form)	n - negl	0	This species is not a vine. It is a short, tufted annual sedge (Brink, 2011).
ES-6 (Forms dense thickets)	n - mod	0	We found no evidence.
ES-7 (Aquatic)	n - negl	0	Not an aquatic. It occurs in terrestrial habitats that range from dry to wet (MBG, 2014; Simpson and Inglis, 2001). It occurs in rocky outcrops in Nigeria (Hall, 1973).
ES-8 (Grass)	n - negl	0	This species is not a grass; it is a sedge (Cyperaceae; NGRP,

Question ID	Answer - Uncertainty	Score	Notes (and references)
			2014).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no direct or specific evidence of nitrogen fixation for this species. This species is not in a plant family known to contain nitrogen-fixing species (Martin and Dowd, 1990; Santi et al., 2013). Furthermore, it is herbaceous (CIRAD, 2014) and not woody.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	*Bulbostylis hispidula* produces viable seeds (Hérault and Hiernaux, 2004). Reproduces via seeds (CIRAD, 2014; Wells et al., 1986).
ES-11 (Self-compatible or apomictic)	? - max	0	Unknown.
ES-12 (Requires special pollinators)	n - low	0	We found no information about this species' pollination biology. However, because the majority of sedges are wind-pollinated (Faegri and Van der Pijl, 1979), we answered no with low uncertainty.
ES-13 (Minimum generation time)	b - negl	1	Annual (Bryson and Carter, 2008). Often an annual and rarely a perennial (CIRAD, 2014; Häfliger, 1982). There are several subspecies in Africa, some are annual, others are perennial (Lye, 1996). It begins flowering 2-4 weeks after germination (CIRAD, 2014), but we found no evidence it has multiple generations per year. Given that it is a tussock-forming species, we do not consider tillering as contributing to the production of new clumps. Alternate answers for the Monte Carlo simulation were both "c."
ES-14 (Prolific reproduction)	n - mod	-1	One study reported extracting an average of 1041 seeds per m^{-2} from the top 2 cm of soil (Hérault and Hiernaux, 2004), but it is unknown whether this represents seed production for one year or multiple years. In that study, only about 10 percent of the seeds germinated (Hérault and Hiernaux, 2004); it is not clear if the other seeds were dormant or not viable. Another author states that *B. hispidula* produces a large number of seeds (Gérard et al., 2001), but the author did not provide numerical estimates of seed production. Because the threshold for a yes answer for an herbaceous species is 5000 viable seeds per square meter, we answered no.
ES-15 (Propagules likely to be dispersed unintentionally by people)	? - max	0	We found no direct evidence that this species is dispersed in this fashion. However, remains of *B. hispidula* from a human settlement in Africa over a 1000-year period indicate that this species has been associated with human civilization for a long time, either as a weed of settlements or agriculture (Klee et al., 2000). We believe that this association with people increases its opportunity for human-mediated dispersal, but without more direct evidence we answered unknown.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - high	2	Assuming the plants that were found on the manganese ore piles in Canton, Maryland were *B. hispidula* (Strong, 2014), this species entered the United States in imported ore (Reed, 1964). It is likely it could also enter in similar trade goods such as sand.
ES-17 (Number of natural dispersal vectors)	0	-4	Fruit and seed characteristics for ES-17a through ES-17e: Fruit is a trigonous nutlet (obtriangular in outline) about 1 to 1.3 mm long and wide (Häfliger, 1982; Lye, 1996).
ES-17a (Wind dispersal)	? - max		We found no evidence that this species is dispersed by wind. However, the preference for open sandy habitats (Simpson

Question ID	Answer - Uncertainty	Score	Notes (and references)
			and Inglis, 2001; van Rooyen et al., 2008), coupled with the small size and shape of the nutlets, suggests that the seeds could be spread over short distances by wind.
ES-17b (Water dispersal)	n - high		We found no evidence. Because this species occurs in marshes and on lake shores (Brink, 2011), we raised uncertainty to high.
ES-17c (Bird dispersal)	n - mod		We found no evidence that this species is dispersed by birds or is likely to attract birds.
ES-17d (Animal external dispersal)	n - low		We found no evidence that this species is dispersed on animals, nor any evidence of morphological features (Häfliger, 1982; Lye, 1996). that would promote such dispersal.
ES-17e (Animal internal dispersal)	? - max		We found no direct evidence of internal animal dispersal. Seeds may be consumed by grazing animals (Simpson and Inglis, 2001; Wells et al., 1986), but it is unknown if they would remain viable after gut passage.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	Unknown.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	n - mod	-1	*Bulbostylis hispidula* does not tolerate repeated weeding (CIRAD, 2014). It is considered easy to control by one author (Gantoli et al., 2013). Note that fire stimulates recruitment from soil seed banks (Ahmed and Ali, 2012), but seed response to fire is not considered in this question.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence that this species is resistant to herbicides. Neither the species nor the genus *Bulbostylis* are listed in the Weed Science Society of America's database of herbicide resistant weeds (Heap, 2014). One source reports 100 percent control with at least some herbicide formulations (Saayman-duToit, 2003). However, it should be noted that the close relative, *Fimbristylis miliacea* is listed as resistant to a few different herbicides (Heap, 2014).
ES-21 (Number of cold hardiness zones suitable for its survival)	6	0	See evidence under geographic potential.
ES-22 (Number of climate types suitable for its survival)	7	2	See evidence under geographic potential.
ES-23 (Number of precipitation bands suitable for its survival)	11	1	See evidence under geographic potential.
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - mod	0	We found no evidence.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that this species is parasitic. Furthermore, this species is not a member of a plant family known to contain parasitic species (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	n - mod	0	We found no evidence. Although there is little detailed information about this species, we used moderate uncertainty in this subelement because we did not find any evidence the species is a weed of natural systems. The available literature indicates it is a weed of production and anthropogenic

Question ID	Answer - Uncertainty	Score	Notes (and references)
			systems (see evidence below).
Imp-N2 (Change community structure)	n - mod	0	We found no evidence.
Imp-N3 (Change community composition)	n - mod	0	We found no evidence.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	n - mod	0	We found no evidence.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	n - mod	0	We found no evidence.
Imp-N6 (Weed status in natural systems)	a - mod	0	We found no evidence that this species is a weed of natural systems. Alternate answers for the Monte Carlo simulation were both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - mod	0	We found no evidence.
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	We found no evidence of this impact. We used low uncertainty because it seems unlikely that a short sedge would restrict recreational access or activities.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - mod	0	We found no evidence.
Imp-A4 (Weed status in anthropogenic systems)	b - mod	0.1	*Bulbostylis hispidula* is considered a roadside (Goetghebeur and Coudijzer, 1985) and ruderal weed (Wells et al., 1986). However, we found no evidence that it is specifically managed for its impact in these areas. Alternate answers for the Monte Carlo simulation were both "a."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - high	0.4	In one site in Benin, *B. hispidula* was one of four principal weeds of corn, with plot coverage values of 5-25 percent (Gantoli et al., 2013; Keller et al., 2012). In conjunction with the other three weed species, and depending on how long weeds were allowed to interfere with crop growth, these species reduced corn yield by up to 58 percent (Keller et al., 2012). *Bulbostylis hispidula* occurs in the fallow period following pearl millet cultivation in Africa (Gérard et al., 2001). It is a frequent species in agricultural fields in Botswana, primarily occurring in large patches or as many scattered individuals, "but its small size makes it a minor competitor" (Phillips, 1992). From the evidence available, it is not clear to what extent *B. hispidula* reduces crop yield alone. However, given the estimates of frequency and density, it is likely interfering with crop growth to some extent.
Imp-P2 (Lowers commodity value)	y - low	0.2	One study that examined weed abundance in maize under different management styles found that *B. hispidula* had a high relative importance index (as measured by weed density and frequency); it obtained the highest importance value under velvet bean and farmer control treatments (Chikoyea et al., 2004). In this study, farmer control included various

Question ID	Answer - Uncertainty	Score	Notes (and references)
			forms of manual weeding and usually represented about 50-70 percent of total farm labor (Chikoyea et al., 2004). Given the abundance of *B. hispidula* in control fields, it is very likely farmers are spending a significant amount of their time controlling this species. *Bulbostylis hispidula* is categorized as replacing preferred grass vegetation (Wells et al., 1986), presumably in pastoral systems, suggesting it may be lowering the value of the land (see additional evidence under Imp-P5).
Imp-P3 (Is it likely to impact trade)	n - mod	0	We found no evidence that this species is regulated by any country (e.g., APHIS, 2014).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	We found no evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	We found no evidence this species is toxic. *Bulbostylis hispidula* is reported to be unpalatable (Wells et al., 1986) and is grazed when nothing else is available (Simpson and Inglis, 2001).
Imp-P6 (Weed status in production systems)	c - low	0.6	*Bulbostylis hispidula* is a weed of cultivation and rice fields (Goetghebeur and Coudijzer, 1985), corn (Chikoyea et al., 2004; FAO, 2014), lupin (Saayman-duToit, 2003), sugarcane (Fadayomi and Abayomi, 1988), and groundnuts (Ashrif, 1967). Weed of grasslands, perennial crops, and aquatic habitats (Häfliger, 1982). Weed of upland crops (Bridge et al., 1978). Weed of arable crops in Zambia (Vernon, 1983). Out of a group of about 20 species, *B. hispidula* was categorized as one of the most important weeds of upland crops in Gambia (Anonymous, 1981), but another work did not consider it a major weed in the country (Terry, 1981). This species in conjunction with other weed species is managed in maize fields in Nigeria (Chikoyea et al., 2004). Despite being very abundant in corn in one Benin study, it is not considered troublesome by farmers because it is easy to control (Gantoli et al., 2013). *Bulbostylis hispidula* is labeled under several registered herbicides in South Africa (Bromilow, 2010; Wells et al., 1986). Alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2014).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z6 (Zone 6)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z7 (Zone 7)	n - mod	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z8 (Zone 8)	y - low	N/A	Lesotho, Namibia, and South Africa.
Geo-Z9 (Zone 9)	y - negl	N/A	Botswana, Namibia, and South Africa. Occurs at a site in South Africa with a mean minimum temperature of -4.0 °C in

Question ID	Answer - Uncertainty	Score	Notes (and references)
			July (Rutherford and Powrie, 2010).
Geo-Z10 (Zone 10)	y - negl	N/A	Botswana, Namibia, and South Africa.
Geo-Z11 (Zone 11)	y - negl	N/A	Benin, Mali, Niger, and Tanzania.
Geo-Z12 (Zone 12)	y - negl	N/A	Cote d'Ivoire, Ghana, and Senegal.
Geo-Z13 (Zone 13)	y - negl	N/A	Congo, the Democratic Republic of Congo, Gabon, Liberia, and Somalia.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - low	N/A	Some points in Cameroon, Equatorial Guinea, Guinea, and Liberia.
Geo-C2 (Tropical savanna)	y - negl	N/A	Benin, Cote d'Ivoire, and Ghana.
Geo-C3 (Steppe)	y - negl	N/A	Mali, Namibia, and Nigeria.
Geo-C4 (Desert)	y - negl	N/A	Botswana, Mali, and Namibia.
Geo-C5 (Mediterranean)	y - high	N/A	Two points in Ethiopia. Established in Italy (Wallentinus, 2002), half of which is Mediterranean.
Geo-C6 (Humid subtropical)	y - negl	N/A	South Africa and a few points in the Democratic Republic of Congo and Tanzania.
Geo-C7 (Marine west coast)	y - negl	N/A	South Africa and one point in each of Angola, Lesotho, and Zimbabwe.
Geo-C8 (Humid cont. warm sum.)	n - low	N/A	We found no evidence that it occurs in this climate type.
Geo-C9 (Humid cont. cool sum.)	n - negl	N/A	We found no evidence that it occurs in this climate type.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence that it occurs in this climate type.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that it occurs in this climate type.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that it occurs in this climate type.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - negl	N/A	Burkina Faso, Mali, and South Africa. Occurs at a site in South Africa receiving on average 180 mm of precipitation per year (Rutherford and Powrie, 2010).
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Botswana, Mali, and Namibia. Occurring in sites in Niger that receives an average of 300-600 mm of precipitation per year (Wezel and Schlecht, 2004).
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Ghana, Somalia, and South Africa. Occurring in sites in Niger that receive an average of 300-600 mm of precipitation per year (Wezel and Schlecht, 2004).
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Benin, Burkina Faso, Cote d'Ivoire, Ghana, and South Africa.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Benin, Cote d'Ivoire, and South Africa.
Geo-R6 (50-60 inches; 127-152 cm)	y - low	N/A	Cote d'Ivoire.
Geo-R7 (60-70 inches; 152-178 cm)	y - low	N/A	Cote d'Ivoire. One point in Guinea and two points in Cameroon.
Geo-R8 (70-80 inches; 178-203 cm)	y - low	N/A	One point in Liberia, a few in Cote d'Ivoire, and one in the Democratic Republic of Congo.
Geo-R9 (80-90 inches; 203-229 cm)	y - low	N/A	A few points in Gabon and one in Nigeria.
Geo-R10 (90-100 inches; 229-254 cm)	y - low	N/A	One point in Congo and one in Tanzania (on edge with the 100+ precipitation band).
Geo-R11 (100+ inches; 254+ cm)	y - low	N/A	Cameroon, Equatorial Guinea, and Liberia.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - low	0	We found no evidence that this species is currently present in the United States. A specimen of *B. hirta* (Thunb.) Svenson was collected in 1959 from a manganese ore pile in Canton, Maryland (Reed, 1964). Although we did not find an online image of the specimen to verify its identity, Mark Strong, a Smithsonian expert on the Cyperaceae, stated that based on the description of the specimen in Reed (1964) and other factors, he believes that this specimen is likely to be *B. hispidula* (Strong, 2014). Regardless of the identity of this specimen, the plants collected from Maryland do not appear to have become established in the United States as neither species is reported in a regional flora (Weakley, 2012).
Ent-2 (Plant proposed for entry, or entry is imminent)	n - low	0	We found no evidence of interest in importing this species.
Ent-3 (Human value & cultivation/trade status)	b - low	0.05	Plants are collected from the wild in Africa and used in matting, traditional medicines, and straining alcoholic beverages (Brink, 2011; Simpson and Inglis, 2001).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - negl		This species is present in Mexico and Central America (Acevedo-Rodríguez and Strong, 2012; NGRP, 2014).
Ent-4b (Contaminant of plant propagative material (except seeds))	n - mod	0	We found no evidence.
Ent-4c (Contaminant of seeds for planting)	? - max		Because this species is associated with agriculture (see references in Imp-P1 through Imp-P6), it is possible its seeds may contaminate agricultural or vegetable seed.
Ent-4d (Contaminant of ballast water)	n - high	0	We found no specific evidence it is a contaminant of ballast water. However, because *B. hispidula* occurs in sandy areas, coastal regions and dunes (Brink, 2011; GBIF, 2014), its seeds may be accidentally taken on with ballast.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - high	0	We found no evidence and in general it seems unlikely.
Ent-4f (Contaminant of landscape products)	? - max		We found no specific evidence that it may contaminate this pathway. However, because this species prefers sandy habitats (MBG, 2014; Simpson and Inglis, 2001; van Rooyen et al., 2008), it may be present in sand that is used in landscaping projects.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	n - mod	0	We found no evidence.
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	n - mod	0	We found no evidence and in general this seems unlikely.
Ent-4i (Contaminant of some other pathway)	e - high	0.08	Assuming the plants that were found on the manganese ore piles in Canton, Maryland were *B. hispidula* (Strong, 2014), then this species entered the United States as a contaminant of this pathway (Reed, 1964). Ore is sometimes stored

Question ID	Answer - Uncertainty	Score	Notes (and references)
			outside on bare ground, so some plant species may either disperse into the ore piles or grow in them. We do not know how *B. hispidula* was introduced to Mexico and other countries in Central and South America. It may have entered as a contaminant of some other traded good, or as a hitchhiker on a means of conveyance (e.g., in mud attached to containers or equipment). Because none of the other pathways considered above seem as likely, we chose "e" with high uncertainty.
Ent-5 (Likely to enter through natural dispersal)	n - mod	0	Because *B. hispidula* is not reported near the U.S. border in Mexico (GBIF, 2014) and because we found no evidence of adaptations for long-distance dispersal, it seems unlikely to disperse naturally into the United States in the near future.