United States Department of Agriculture

Weed Risk Assessment for *Phalaris paradoxa* L. (Poaceae) – Awned canary-grass

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Version 1

Photos of *Phalaris paradoxa* from Rignanese (2007).

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Introduction

Plant Protection and Quarantine (PPQ) regulates noxious weeds under the authority of the Plant Protection Act (7 U.S.C. § 7701-7786, 2000) and the Federal Seed Act (7 U.S.C. § 1581-1610, 1939). A noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). We use the PPQ weed risk assessment (WRA) process (PPQ, 2015) 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.

The PPQ WRA process includes three analytical components that together describe the risk profile of a plant species (risk potential, uncertainty, and geographic potential; PPQ, 2015). At the core of the process is the predictive risk model that evaluates the baseline invasive/weed potential of a plant species using information related to its ability to establish, spread, and cause harm in natural, anthropogenic, and production systems (Koop et al., 2012). Because the predictive model is geographically and climatically neutral, it can be used to evaluate the risk of any plant species for the entire United States or for any area within it. We then use a stochastic simulation to evaluate how much the uncertainty associated with the risk analysis affects the outcomes from the predictive model. The simulation essentially evaluates what other risk scores might result if any answers in the predictive model might change. Finally, we use Geographic Information System (GIS) overlays to evaluate those areas of the United States that may be suitable for the establishment of the species. For a detailed description of the PPQ WRA process, please refer to the *PPQ Weed Risk Assessment Guidelines* (PPQ, 2015), which is available upon request.

We emphasize that our WRA process is designed to estimate the baseline—or unmitigated—risk associated with a plant species. We use evidence from anywhere in the world and in any type of system (production, anthropogenic, or natural) for the assessment, which makes our process a very broad evaluation. This is appropriate for the types of actions considered by our agency (e.g., Federal regulation). Furthermore, risk assessment and risk management are distinctly different phases of pest risk analysis (e.g., IPPC, 2015). Although we may use evidence about existing or proposed control programs in the assessment, the ease or difficulty of control has no bearing on the risk potential for a species. That information could be considered during the risk management (decision-making) process, which is not addressed in this document.

***Phalaris paradoxa* L. – Awned canary grass**

Species Information

Family: Poaceae

Synonyms: *Phalaris paradoxa* var. *praemorsa* (Lam.) Coss. & Durieu (NGRP, 2016; NRCS, 2016), *P. praemorsa* Lam. (NGRP, 2016; The Plant List, 2013), *P. appendiculata* Schult., *P. obvallata* Trin., *P. pseudoparadoxa* Fig. & De Not., *P. rubens* Ehrenb. ex Trin., *P. sibthorpii* Griseb. (The Plant List, 2013).

Common names: Awned canary grass, bristle-spike canary grass, hooded canary grass, paradoxa grass, paradoxical canary grass, variable canary grass (NGRP, 2016).

Botanical description: *Phalaris paradoxa* is an annual grass that can grow up to 90 cm tall (Hussey et al., 2007) and is the most polymorphic species in the genus (Baldini, 1993). *Phalaris paradoxa* has one fertile spikelet surrounded by either five or six sterile spikelets (Anderson, 1960). The sterile spikelets are broken down into three different categories: clavate, reduced, and normal (Anderson, 1960). The seed size is 2.4-2.6 × 1.2-1.4 mm (Bojňanský and Fargašová, 2007). For a full botanical description see Anderson (1960) and Baldini (1993). *Phalaris paradoxa* and *P. appendiculata* have often been considered to be the same species, but in-depth research by Voshell (2014) has shown them to be separate species. On further inspection, both species have unique reproductive morphology, different molecular markers, and a difference in their distributional ranges (Voshell, 2014).

Initiation: PPQ received a market access request for wheat seed for planting from the government of Italy (MPAAF, 2010). A commodity import risk analysis determined that *P. paradoxa* could be associated with this commodity as a contaminant. In this assessment, we evaluated the risk potential of this species to the United States to help policy makers determine whether it should be regulated as a Federal Noxious Weed.

Foreign distribution and status: *Phalaris paradoxa* is native to northern Africa (Madeira Islands, Canary Islands, Algeria, Egypt, Libya, Morocco, Tunisia), temperate Asia (Saudi Arabia, Yemen, Armenia, Azerbaijan, Cyprus, Iran, Iraq, Israel, Lebanon, Syria, Turkey), and southwestern Europe (Albania, Croatia, Greece, Italy, Slovenia, France, Portugal, Spain) (NGRP, 2016). It is naturalized in New Zealand (Howell and Sawyer, 2006), the Azores, Australia, middle and northern Europe (Austria, the Czech Republic, Germany, Netherlands, Switzerland, Norway, Sweden), Mexico, and South America (Argentina, Uruguay) (NGRP, 2016). It is considered invasive and/or a weed of agriculture in China (Wang et al., 2009), Italy (Baldini, 1993), Chile (Finot and Pedreros, 2012), Nepal (Singh, 2001), and Britain (Thurley and Chancellor, 1985).

U.S. distribution and status: *Phalaris paradoxa* is naturalized in Arizona and California (Kartesz, 2015; NGRP, 2016) and appears to have been present since at least the late 1880s based on herbarium samples (Consortium of California Herbaria, 2016). It is also present in Pennsylvania, New Jersey, Maryland, North Carolina, Louisiana, Nevada, Oregon, and Washington, but its exact status in these states is unknown as it has only been reported from one to two counties in each state (Kartesz, 2015; NRCS, 2016). It is an occasional escape in Hawaii (NRCS, 2016). We found no evidence that *P. paradoxa* is being cultivated in the United States (BackyardGardener.com, 2016; Bailey Nurseries, 2015; Dave's Garden, 2016; Plant Information Online, 2007). We also found no evidence that it is being controlled or regulated (National Association of Invasive Plant Councils, 2015; National Plant Board, 2014).

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

1. *Phalaris paradoxa* analysis

Establishment/Spread Potential

Phalaris paradoxa is an annual grass that reproduces through seed production (Taylor et al., 2004). Seedlings require light to germinate (Taylor et al., 2004) and the majority of seedlings survive until the following season, but some are capable of remaining viable in the soil for a few more years (Taylor et al., 2005; Walker et al., 2006). It can be a prolific seed producer (Collavo et al., 2011; Thurley and Chancellor, 1985), and seeds can benefit from cultivation (Taylor et al., 2005). *Phalaris paradoxa* is self-pollinated (Collavo et al., 2011). It can be unintentionally dispersed by humans (i.e., on contaminated farm equipment, in bird seed, and in grain) (Reynolds, 2002; Ryves et al., 1996) or naturally dispersed by wind (Gal and Alexandre, 2000), birds (Baker-Gabb, 1988), horses (Ansong and Pickering, 2013), and cattle (Woldu and Saleem, 2000). Recent research has shown that *P. paradoxa* has developed resistance to ACCase-inhibiting herbicides (Hochberg et al., 2009; Lucchesi and Sattin, 2002) and other commonly used herbicides (Heap, 2016; Tamayo-Eesquer and Martinez-Carrillo, 2002; Valverde, 2007). For this risk element, we had a very low level of uncertainty because *P. paradoxa* is well studied.

Risk score = 18 Uncertainty index = 0.05

Impact Potential

Phalaris paradoxa is primarily a weed of agricultural systems. It grows taller than some cereal crops (Thurley and Chancellor, 1985) and at densities of 1000 plants per square meter, it reduces wheat yield (Bhan and Froud-Williams, 2006). The related species *P. aquatica*, *P. brachystachys*, and *P. tuberosa* have all been found to be toxic to sheep (Bossard et al., 2000; Bourke et al., 1990; de Luco et al., 1990; Gallagher et al., 1966), and *P. paradoxa* has been implicated in the poisoning and killing three grazing horses in Australia (Bourke et al., 2003). *Phalaris paradoxa* is considered a troublesome agricultural weed in Europe (Weber and Gut, 2005), Israel (Horowitz, 1980),

[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).

and Ethiopia (Negewo et al., 2011). *Phalaris paradoxa* may impact trade, as it is currently considered a weed of quarantine importance in Honduras (Puerto, n.d.) and is prohibited from entry into wheat growing areas in India (Singh, 2001). Despite having limited information on *P. paradoxa* in natural and anthropogenic systems, we had enough information about its impacts in agricultural settings to have low uncertainty for this risk element.
Risk score = 2.8 Uncertainty index = 0.09

Geographic Potential Based on three climatic variables, we estimate that about 77 percent of the United States is suitable for the establishment of *Phalaris paradoxa* (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 *Phalaris paradoxa* represents the joint distribution of Plant Hardiness Zones 5-12, areas with 0-100 inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe, desert, Mediterranean, humid subtropical, marine west coast, humid continental cool summers, and subarctic. It was not clear if *Phalaris paradoxa* occurs in humid continental warm summers. For this prediction, we assumed that this climate was suitable since *P. paradoxa* is prevalent in surrounding climate classes.

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. *Phalaris paradoxa* is generally found in agricultural settings, in pastures, and along roadsides and irrigation canals. To date, *Phalaris paradoxa* has been found in places with variable rainfall (Taylor et al., 2005; Thurley and Chancellor, 1985) and soil types (Finot and Pedreros, 2012; Michael et al., 2010; Thurley and Chancellor, 1985). See the Geographic Potential section of Appendix A for a better understanding of *P. paradoxa* preferences.

Entry Potential We did not assess the entry potential of *Phalaris paradoxa* because it is already present in the United States (Kartesz, 2015; NGRP, 2016; NRCS, 2016).

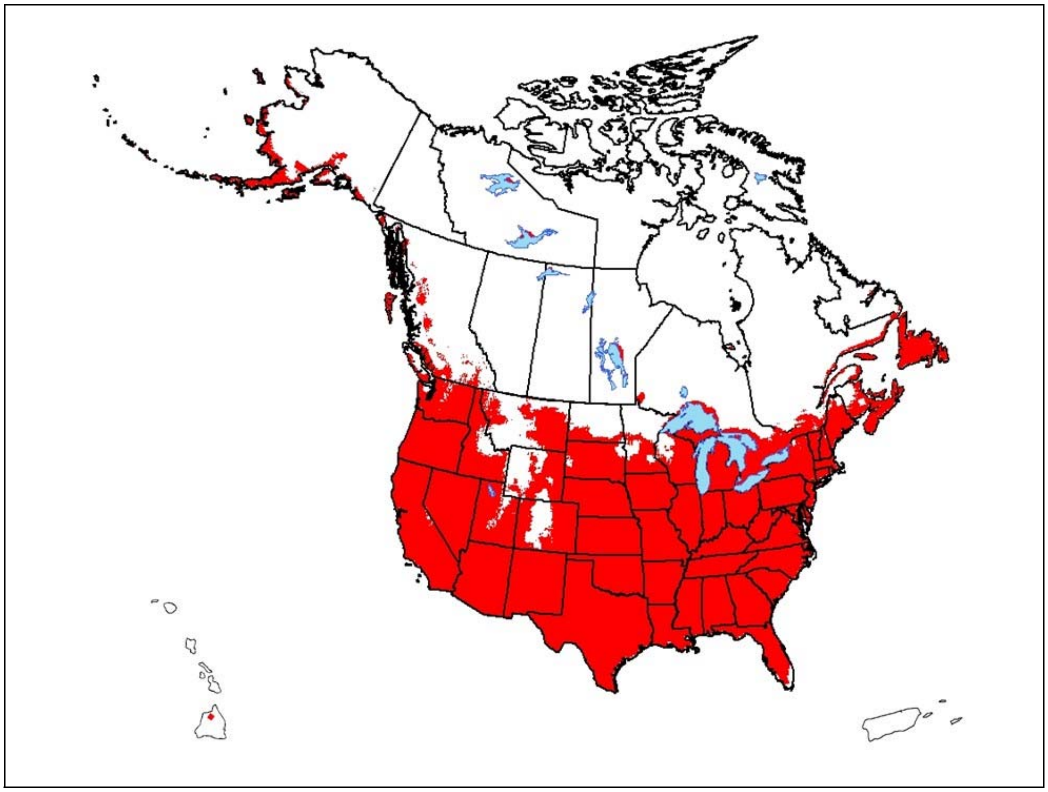

Figure 1. Predicted distribution of *Phalaris paradoxa* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 85.7%
P(Minor Invader) = 13.8%
P(Non-Invader) = 0.5%
Risk Result = High Risk
Secondary Screening = Not Applicable

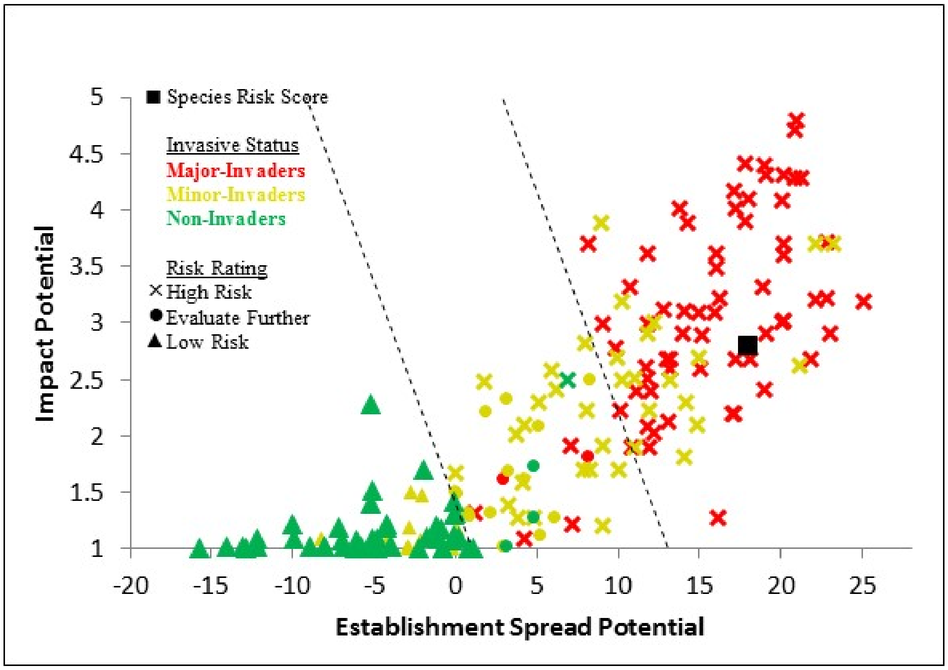

Figure 2. *Phalaris paradoxa* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

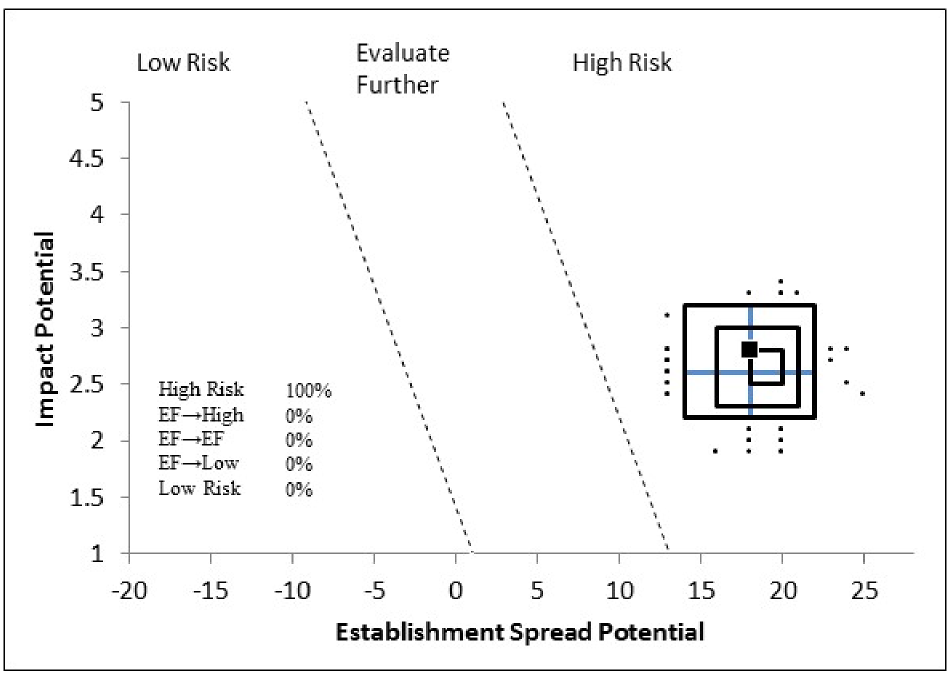

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Phalaris paradoxa*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Phalaris paradoxa* is High Risk (Fig. 2). We are confident in our determination of high risk based on the evidence found and our low level of uncertainty throughout the assessment (Fig. 3). Our result is similar to the results obtained by Singh and Priyadarshi (2014) when they evaluated the weed risk of *P. paradoxa* for India. Their goal was to design a risk assessment to determine potentially invasive weeds that could be imported into India from other countries.

Phalaris paradoxa, P. minor, *P. canariensis*, and *P. arundinacea* are contaminants of wheat flour (Sangster et al., 1983) and have been suspected of causing esophageal cancer in northeast Iran because they have hairs that are believed to break down into siliceous fibers of the size associated with carcinogenicity (Sangster et al., 1983). Despite the study by Sangster et al. (1983), further information about the possible role of *P. paradoxa* as a human carcinogen is lacking. Also, recent research on *P. paradoxa* in Ethiopia, found it to be a reservoir host for Barley yellow dwarf virus (BYDV) and its associated aphid vectors (Bekele, 2011). BYDV is widespread and can be economically devastating for barley crops (Negewo et al., 2011). BYDV can also affect wheat and oat, and is present in the United States (Isleib, 2015). Therefore, *P. paradoxa* has the potential to be a reservoir host for BYDV in agricultural areas of the United States.

Within the last 15 years, the number of reports confirming *P. paradoxa* resistance to herbicides has increased (Heap, 2016, Hochberg et al., 2009; Tamayo-Eesquer and Martinez-Carrillo, 2002; Valverde, 2007). Particular importance should be paid to the recent resistance that has developed in Italian wheat (Lucchesi and Sattin, 2002), since this WRA is a result of an access request for Italian wheat. While *P. paradoxa* is already present in the United States, its distribution is restricted (NRCS, 2016). However, its recent resistance to herbicides and ability to survive in various conditions may encourage its spread within the United States.

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.

Al-Sherif, E., A. K. Hegazy, N. H. Gomaa, and M. O. Hassam. 2013. Allelopathic effect of black mustard tissues and root exudates on some crops and weeds. Planta Daninha 31(1):11-19.

Anderson, D. E. 1960. Taxonomy and distribution of the genus *Phalaris*, Iowa State University, Ames, Iowa.

Ansong, M., and C. Pickering. 2013. A global review of weeds that can germinate from horse dung. Ecological Management & Restoration 14(3):216-223.

Apfelbaum, S. I., and C. E. Sams. 1987. Ecology and control of reed canary grass (*Phalaris arundinacea* L). Natural Areas Journal 7(2):69-74.
APHIS. 2016. Phytosanitary Certificate Issuance & Tracking System (PCIT). United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://pcit.aphis.usda.gov/pcit/. (Archived at PERAL).
BackyardGardener.com. 2016. Backyardgardener, LLC. http://www.backyardgardener.com/. (Archived at PERAL).
Bailey Nurseries. 2015. Bailey Nurseries, Inc. http://www.baileynurseries.com/. (Archived at PERAL).
Baker-Gabb, D. J. 1988. The Diet and Foraging Behavior of the Plains-wanderer *Pedionomus torquatus*. EMU Austral Ornithology 88(2):115-118.
Baldini, R. M. 1993. The genus *Phalaris* L. (Gramineae) in Italy. Webbia 47(1):1-53.
Baldini, R. M. 1995. Revision of the genus *Phalaris* L. (Gramineae). Webbia 49(2):265-329.
Bekele, B. 2011. Achievements of research on Barley and Cereal Yellow Dwarf viruses infecting barley in Ethiopia. Barley Research and Development in Ethiopia. Proceedings of the 2nd National Barley Research and Development Review Workshop. , Holetta, Ethiopia. November 28-30, 2006.
Bhan, A., and R. J. Froud-Williams. 2006. *Phalaris* spp. competition with wheat using an additive design series. Fifteenth Australian Weeds Conference, Adelaide, South Australia.
Bojňanský, V., and A. Fargašová. 2007. Atlas of Seeds and Fruits of Central and East-European Flora: The Carpathian Mountains Region. Springer, Dordrecht, The Netherlands. 1046 pp.
Bossard, C. C., J. M. Randall, and M. C. Hoshovsky (eds.). 2000. Invasive Plants of California's Wildlands. University of California Press, Berkeley, CA, U.S.A. 360 pp.
Bourke, C. A., M. J. Carrigan, and R. J. Dixon. 1990. The pathogenesis of the nervous syndrome of *Phalaris aquatica* toxicity in sheep. Australian Veterinary Journal 67(10):356-358.
Bourke, C. A., S. M. Colegate, S. Slattery, and R. N. Oram. 2003. Suspected *Phalaris paradoxa* (paradoxa grass) poisoning in horses. Australian Veterinary Journal 81(10):635-637.
Collavo, A., S. Panozzo, G. Lucchesi, L. Scarabel, and M. Sattin. 2011. Characterisation and management of *Phalaris paradoxa* resistant to ACCase-inhibitors. Crop Protection 30(3):293-299.
Consortium of California Herbaria. 2016. Data provided by the participants of the Consortium of California Herbaria: *Phalaris paradoxa*. http://ucjeps.berkeley.edu/consortium/. (Archived at PERAL).
Croce, A. 2015. Vascular flora of eight water reservoir areas in southern Italy. The Journal of Biodiversity Data 11(2):1-23.
Dave's Garden. 2016. PlantFiles. http://davesgarden.com. (Archived at PERAL).

de Luco, F., J. F. G. Marin, J. J. Badiola, and A. Ortilles. 1990. *Phalaris* toxicosis in sheep in Spain [Abstract]. Schweizer Archiv für Tierheilkunde 132(8):425-426.

Dunn, S. T. 1905. Alien Flora of Britain. West, Newman, and Co., London, U.K. 208 pp.

Finot, V. L., and J. A. Pedreros. 2012. *Phalaris paradoxa* L. (Poaceae: Phalaridinae), a new introduced weed species in Central Chile. Gayana Botanica 69(1):193-196.

Gal, Z., and Y. Alexandre. 2000. Ancient Infested Wheat and Horsebean from Horbat Rosh Zayit (8), Ramat Gan, Israel. 206-220 pp.

Gallagher, C. H., J. H. Koch, and H. Hoffman. 1966. Disease of sheep due to ingestion of *Phalaris tuberosa*. Australian Veterinary Journal 42(8):279-284.

GBIF. 2015. The Global Biodiversity Information Facility (GBIF): *Phalaris paradoxa* L. Global Biodiversity Information Facility (GBIF). http://www.gbif.org. (Archived at PERAL).

Heap, I. 2016. Herbicide Resistant Hood Canarygrass Globally (*Phalaris paradoxa*). The International Survey of Herbicide Resistant Weeds. http://www.weedscience.com/Summary/Species.aspx?WeedID=128. (Archived at PERAL).

Hochberg, O., M. Sibony, and B. Rubin. 2009. The response of ACCase-resistant *Phalaris paradoxa* populations involves two different target site mutations. Weed Research 49(1):37-46.

Horowitz, M. 1980. Weed Research in Israel. Weed Science 28(4):457-460.

Howell, C. J., and J. W. D. Sawyer. 2006. New Zealand naturalised vascular plant checklist. New Zealand Plant Conservation Network,, Wellington, New Zealand. 60 pp.

Hussey, B. M. J., G. J. Keighery, J. Dodd, S. G. Lloyd, and R. D. Cousens. 2007. Western Weeds: A Guide to the Weeds of Western Australia (2nd ed.). The Weeds Society of WA, Inc., Victoria Park, WA, Australia. 294 pp.

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. 38 pp.

IPPC. 2015. International Standards for Phytosanitary Measures No. 2: Framework for Pest Risk Analysis. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy. 18 pp.

Isleib, J. 2015. Management suggestions for barley yellow dwarf virus control. Last accessed 2016, July 29, http://msue.anr.msu.edu/news/management_suggestions_for_barley_yellow_dwarf_virus_control.

Jones, R. E., D. T. Vere, Y. Alemseged, and R. W. Medd. 2005. Estimating the economic cost of weeds in Australian annual winter crops. Agricultural Economics 32(3):253-265.

Kartesz, J. T. 2015. The Biota of North America Program (BONAP). North American Plant Atlas. http://bonap.net/tdc. (Archived at PERAL).
Koop, A. L., L. Fowler, L. P. Newton, and B. P. Caton. 2012. Development and validation of a weed screening tool for the United States. Biological Invasions 14(2):273-294.
Lucchesi, G., and M. Sattin. 2002. Characterization of ACCase herbicide resistant *Phalaris paradoxa* in Italy. Proceedings of the XII EWRS Symposyum, Papendal, The Netherlands.
Martin, T. G., S. Campbell, and S. Grounds. 2006. Weeds of Australian rangelands. The Rangeland Journal 28(1):3-26.
Michael, D. R., D. B. Lindenmayer, and R. B. Cunningham. 2010. Managing rock outcrops to improve biodiversity conservation in Australian agricultural landscapes. Ecological Management & Restoration 11(1):43-50.
National Association of Invasive Plant Councils. 2015. University of Georgia, Center for Invasive Species and Ecosystem Health. http://na-ipc.org/. (Archived at PERAL).
National Plant Board. 2014. http://nationalplantboard.org/. (Archived at PERAL).
Negewo, T., A. Feyissa, M. Liben, and B. Zemichael. 2011. Achievements of research on weeds and their management in barley in Ethiopia. Barley Research and Development in Ethiopia. Proceedings of the 2nd National Barley Research and Development Review Workshop., Holetta, Ethiopia. November 28-30, 2006.
NGRP. 2016. Germplasm Resource Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program. https://npgsweb.ars-grin.gov. (Archived at PERAL).
Nickrent, D. 2016. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL, U.S.A. Last accessed 2016, June 16, http://www.parasiticplants.siu.edu/ListParasites.html.
Nickrent, D. L., and L. J. Musselman. 2004. Introduction to parasitic flowering plants. The Plant Health Instructor 13:300-315.
NRCS. 2016. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service, National Plant Data Center. http://plants.usda.gov/core/profile?symbol=PHPA5. (Archived at PERAL).
Pasiecznik, N. 2007. Pathways for plant introduction. Pages 14 *in* Pathways for Plant Introduction. Crop Protection Compendium, Wallingford, UK.
Plant Information Online. 2007. Plant and Seed Sources. University of Minnesota. http://plantinfo.umn.edu. (Archived at PERAL).
Portugal, J., T. Vasconcelos, and P. Forte. 2009. Economic Injury Level and Tolerance Threshold of *Phalaris paradoxa* in Wheat Crop. XII Congresso da Sociedad Española de Malherbologia (SEMh), XIX Congresso da Asociacion Latinoamericana de Malezas (ALAM), II Congresso Iberico de Ciencias de las Malezas (IBCM), Herbologia e Biodiversidade numa Agricultura Sustentável, Lisboa, Portugal.
PPQ. 2015. Guidelines for the USDA-APHIS-PPQ Weed Risk Assessment Process. United States Department of Agriculture (USDA), Animal and

Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ). 125 pp.

Puerto, L. R. n.d. Plagas reportadas y de importancia cuarentenaria en Honduras. Programa Nacional de Vigilancia Fitosanitaria-Sanidad Vegetal. 1-86 pp.

Qasem, J. R., and C. L. Foy. 2001. Weed allelopathy, its ecological impacts and future prospects: a review. Journal of Crop Production 4:43-120.

Reynolds, S. C. P. 2002. A Catalogue of Alien Plants in Ireland. National Botanic Gardens, Glasnevin, Ireland. 315 pp.

Richardson, F. J., R. G. Richardson, and R. C. H. Shepherd. 2006. Weeds of the South-east: An Identification Guide for Australia. R. G. and F.J. Richardson,, Meredith, Victoria, Australia. 438 pp.

Rignanese, L. 2007. File: *Phalaris paradoxa* 001.jpeg. http://calphotos.berkeley.edu/cgi/img_query?where-lifeform=any&rel-taxon=contains&where-taxon=Phalaris+paradoxa&rel-namesoup=matchphrase&where-namesoup=&rel-location=matchphrase&where-location=&rel-county=eq&where-county=any&rel-state=eq&where-state=any&rel-country=eq&where-country=any&where-collectn=any&rel-photographer=contains&where-photographer=&rel-kwid=equals&where-kwid=&max_rows=24. (Archived at PERAL).

Rozefelds, A. C. F., L. Cave, D. I. Morris, and A. M. Buchanan. 1999. The Weed Invasion in Tasmania since 1970. Australian Journal of Botany 47:23-48.

Ryves, T. B., E. J. Clement, and M. C. Foster. 1996. Alien Grasses of the British Isles. Botanical Society of the British Isles, London. 181 pp.

Sangster, A. G., M. J. Hodson, and D. W. Parry. 1983. Silicon deposition and anatomical studies in the inflorescence bracts of four *Phalaris* species with their possible relevance to carcinogenesis. New Phytologist 93(1):105-122.

Santi, C., D. Bogusz, and C. Franche. 2013. Biological nitrogen fixation in non-legume plants. Annals of Botany 111(5):743-767.

Sattin, M., M. A. Gasparetto, and C. Campagna. 2001. Situation and management of *Avena sterilis* ssp *ludoviciana* and *Phalaris paradoxa* resistant to ACCase inhibitors in Italy. The BCPC Conference: Weeds, Brighton, U.K. November 12-15, 2001.

Singh, A. G., and A. Sharma. 2014. Documentation of Invasive Alien Plant Species of Rupandehi District, Western Nepal. International Journal of Applied Sciences and Biotechnology 2(2):168-175.

Singh, H. P., D. R. Batish, and R. K. Kohli. 2003. Allelopathic Interactions and Allelochemicals: New Possibilities for Sustainable Weed Management. Critical Reviews in Plant Sciences 22(3-4):239-311.

Singh, S. 2001. Interception of Weeds in Imported Wheat Grain Consignments. Annals of Agricultural Research 22(1):83-87.

Stace, C. 2010. New Flora of the British Isles (2nd ed.), Cambridge, United Kingdom. 1130 pp.

Tamayo-Eesquer, L. M., and J. L. Martinez-Carrillo. 2002. Resistance of Little Seed Canary-grass *Phalaris minor* Retz. and Hood Canary-grass *Phalaris* *paradoxa* L. to commercial herbicides in the Yaqui Valley of Sonora, México. Resistant Pest Management Newsletter 12(1):37-39.

Taylor, I. N., N. C. B. Peters, S. W. Adkins, and S. R. Walker. 2004. Germination response of *Phalaris paradoxa* L. seed to different light qualities. Weed Research 44(4):254-264.

Taylor, I. N., S. R. Walker, and S. W. Adkins. 2005. Burial depth and cultivation influence emergence and persistence of *Phalaris paradoxa* seed in an Australian sub-tropical environment. Weed Research 45(1):33-40.

Taylor, I. N., S. R. Walker, S. W. Adkins, K. Bullen, and N. C. B. Peters. 1999. Dynamics of paradoxa grass (*Phalaris paradoxa* L.) soil seedbank. Twelfth Australian Weeds Conference, Tasmania, Australia. 1999.

Tessema, T., and D. G. Tanner. 1997. Grass weed competition and calculated economic threshold densities in bread wheat in Ethiopia. African Crop Science Journal 5(4):371-384.

Tessema, T., D. G. Tanner, and M. Hassena. 1996. Grass weed competition with bread wheat in Ethiopia: II. Prediction of grain yield loss and implications for economic weed control. African Crop Science Journal 4(4):411-421.

The Plant List. 2013. Version 1.1 [Online Database]. Kew Botanic Gardens and the Missouri Botanical Garden. http://www.theplantlist.org/tpl1.1/record/kew-433532. (Archived at PERAL).

Thurley, B., and R. J. Chancellor. 1985. Observations on the occurrence of *Phalaris paradoxa* in England and Wales. Annals of Applied Biology 107(1):79-86.

USDA-FS. 1953. Grasses Introduced into the United States (Agriculture Handbook No. 58). United States Department of Agriculture (USDA), Forest Service (FS), Washington, D.C. 79 pp.

Valverde, B. E. 2007. Status and Management of Grass-Weed Herbicide Resistance in Latin America. Weed Technology 21(2):310-323.

Voshell, S. M. 2014. Evolutionary history of the canary grasses (*Phalaris*, Poaceae). Doctor of Philosophy, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Walker, S., B. Wilson, H. Wu, M. Widderick, and I. Taylor. 2006. Weed seed persistence with changing farming practices in southern Queensland. 15th Australian Weeds Conference, Adelaide, South Australia.

Walker, S. R., G. R. Robinson, and R. W. Medd. 2001. Management of *Avena ludoviciana* and *Phalaris paradoxa* with barley and less herbicide in subtropical Australia. Australian Journal of Experimental Agriculture 41:1179-1185.

Wang, Z.-B., Y.-F. Chen, and Y.-H. Chen. 2009. Functional grouping and establishment of distribution patterns of invasive plants in China using self-organizing maps and indicator species analysis. Archives of Biological Sciences 61(1):71-78.

Weaver, V., and R. Adams. 1996. Horses as vectors in the dispersal of weeds into native vegetation. Proceedings of the 11th Australian Weeds Conference, Victoria, Australia.

Weber, E., and D. Gut. 2005. A survey of weeds that are increasingly spreading in Europe. Agronomy for Sustainable Development 25(1):109-121.

Weber, E., S.-G. Sun, and B. Li. 2008. Invasive alien plants in China: diversity and ecological insights. Biological Invasions 10:1411-1429.

Woldu, Z., and M. A. M. Saleem. 2000. Grazing induced biodiversity in the highland ecozone of East Africa. Agriculture, Ecosystems and Environment 79(1):43-52.

Xu, H., S. Qiang, P. Genovesi, H. Ding, J. Wu, L. Meng, Z. Han, J. Miao, B. Hu, J. Guo, H. Sun, C. Huang, J. Lei, Z. Le, X. Zhang, S. He, Y. Wu, Z. Zheng, L. Chen, V. Jarosik, and P. Pysek. 2012. An inventory of invasive species in China. NeoBiota 15:1-26.

Appendix A. Weed risk assessment for *Phalaris paradoxa* (Poaceae). Below is all of the evidence and associated references used to evaluate the risk potential of this taxon. We also include the answer, uncertainty rating, and score for each question. The Excel file, where this assessment was conducted, is available upon request.

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 - low	5	*Phalaris paradoxa* is native to Africa (Madeira Islands, Canary Islands, Algeria, Egypt, Libya, Morocco, Tunisia), temperate Asia (Saudi Arabia, Yemen, Armenia, Azerbaijan, Cyprus, Iran, Iraq, Israel, Lebanon, Syria, Turkey), and southwestern Europe (Albania, Croatia, Greece, Italy, Slovenia, France, Portugal, Spain) (NGRP, 2016). It is considered to be fully naturalized in New Zealand (Howell and Sawyer, 2006). It is naturalized in the Azores, Australia, middle and northern Europe (Austria, Czech Republic, Germany, Netherlands, Switzerland, Norway, Sweden), North America [Mexico, United States (Arizona, California)], and South America (Argentina, Uruguay) (NGRP, 2016). It is adventive in the United Kingdom and Belgium (NGRP, 2016). It is considered to be an invasive alien in China (Wang et al., 2009; Weber et al., 2008). It is a casual alien in Ireland, but recent records of its presence are lacking (Reynolds, 2002). It was introduced and has become naturalized in arable fields of central and southern Europe and south Wales (Stace, 2010). Thurley and Chancellor (1985) visited 68 farms in Britian and found that within the past ten years, 40 percent of the farms had seen P. paradoxa spread into four or more fields. In a survey about troublesome weeds in Europe, European weed scientists ranked *P. paradoxa* as having a medium level of potential (rankings of low to high) to continue spreading across Europe (Weber and Gut, 2005). We answered "f" because this species has established and spread in numerous countries beyond its native range. The alternate answers for the uncertainty simulation were both "e."
ES-2 (Is the species highly domesticated)	n - negl	0	We found no evidence that it has been domesticated or bred for traits conferring reduced weed potential. Because we found no evidence that it is currently being cultivated at all, we used negligible uncertainty.
ES-3 (Weedy congeners)	y - negl	1	The genus *Phalaris* consists of approximately 22 species (Baldini, 1995). Randall (2012) lists approximately 16 species of *Phalaris* as weeds ranging from being either invasive to an environmental or agricultural weed. *Phalaris aquatica*, *P. brachystachys*, and *P. tuberosa* have all been found to be toxic to sheep, with results ranging from heart disease to death (Bossard et al., 2000; Bourke et al., 1990; de Luco et al., 1990; Gallagher et al., 1966). *Phalaris arundinacea* is a threat to wetland ecosystems (Apfelbaum and Sams, 1987).
ES-4 (Shade tolerant at some stage of its life cycle)	n - low	0	Experiments by Taylor et al. (2004) showed that various biotypes of *P. paradoxa* collected from Australia and England displayed an increase in germination when exposed to red light while far-red light exposure inhibited

Question ID	Answer - Uncertainty	Score	Notes (and references)
			germination. *Phalaris paradoxa* seedling emergence decreased with an increasing burial depth in experimental plots (Taylor et al., 2005; Taylor et al., 1999). The deeper seeds are buried in soil, the more exposure they have to far-red light than red light. Since *P. paradoxa* showed a reduction in seed germination at greater burial depths and an increase in germination with high exposures of red light, we concluded that *P. paradoxa* needs light to successfully germinate. Because we had data from an experimental study, we answered no with low uncertainty.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	*Phalaris paradoxa* is not a vine or plant that forms basal rosettes; it is a grass that can grow up to 1.75 meters tall (Thurley and Chancellor, 1985).
ES-6 (Forms dense thickets, patches, or populations)	y - low	0	Experimental studies by Portugal et al. (2009) found *P. paradoxa* to occur at densities of 112 plants/m^2. *Phalaris paradoxa* is capabale of forming dense populations with varying degrees of seed production (Thurley and Chancellor, 1985).
ES-7 (Aquatic)	n - negl	0	*Phalaris paradoxa* is not an aquatic plant; it is a terrestrial grass (NGRP, 2016).
ES-8 (Grass)	y - negl	1	It is a grass and a member of the Poaceae family (NGRP, 2016).
ES-9 (Nitrogen-fixing woody plant)	n - low	0	We found no evidence that *Phalaris paradoxa* is a nitrogen-fixing plant. (Martin et al., 2006; Santi et al., 2013).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	*Phalaris paradoxa* produces viable seeds (Taylor et al., 2004; Taylor et al., 2005; Taylor et al., 1999).
ES-11 (Self-compatible or apomictic)	n - low	-1	*Phalaris paradoxa* is not self-compatible (Voshell 2014). When placed in pollination bags, *P. paradoxa* failed to produce fully developed caryopses (Voshell, 2014).
ES-12 (Requires specialist pollinators)	n - negl	0	We found no evidence that *Phalaris paradoxa* requires specialist pollinators. It is mainly self-pollinated (Collavo et al., 2011).
ES-13 [What is the taxon's minimum generation time? (a) less than a year with multiple generations per year; (b) 1 year, usually annuals; (c) 2 or 3 years; (d) more than 3 years; or (?) unknown]	b - negl	1	*Phalaris paradoxa* is an annual (Anderson, 1960; Richardson et al., 2006). In southern Italy, *Phalaris paradoxa* survives the winter season as seeds (Croce, 2015) and flowers in May and June (Baldini, 1993). In Australia, seedling emergence occurs in May through September (Taylor et al., 1999), and samples collected in Chile during the month of August showed plants in both full bloom and the vegetative state (Finot and Pedreros, 2012). The alternate answers for the uncertainty simulation were both "c."
ES-14 (Prolific seed producer)	y - negl	1	Thurley and Chancellor (1985) found that in dense populations of *P. paradoxa*, the seed production rate was 120,000 m^2 and about 16,000 m^2 in less dense populations. In chemically untreated fields in Australia, *P. paradoxa* produced 5,105 seeds/m^2 in wheat fields and 50 seeds/m^2 in barley fields (Walker et al., 2001). *Phalaris paradoxa* produces an average of 85 seeds per inflorescence (Collavo et al., 2011). Because the majority of this evidence meets our threshold, we answered yes with negligible uncertainty.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	Farms in Britain infested with *Phalaris paradoxa* were a result of farmers sharing machinery, a grain dryer, and tracks between fields (Thurley and Chancellor, 1985). In a few

Question ID	Answer - Uncertainty	Score	Notes (and references)
			localities in the U.S. it was found in ballast (USDA-FS, 1953). *Phalaris paradoxa* has often been confused for *Alopecurus protenis*, *A. myosuroides*, and *Phleum pratense* (Thurley and Chancellor, 1985). These species have been the reason for past weed surveys in Britain and until Thurley and Chancellor's (1985) survey, no *Phalaris* species were ever found.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - negl	2	In Ireland, it was introduced as a contaminant of grain (Reynolds, 2002). In the British Isles, it was introduced in grain and bird seed, and on wool (Ryves et al., 1996). In England, it was introduced in grain (Dunn, 1905). It was accidentally introduced into areas of India as a contaminant of cereal grains and animal fodder (Pasiecznik, 2007).
ES-17 (Number of natural dispersal vectors)	2	0	Fruit and seed description for ES-17a through ES-17e: five or six sterile spikelets that fall from the inflorence and surround 1 fertile spikelet, glumes of fertile spikelet are 5.5-8.2 mm long and 1 mm wide, fertile florets of fertile spikelet are 2.5-3.5 mm long and 0.8-1.5 mm wide, long panicles, small caryopses, great variability in panicle and glume length/width (Anderson, 1960).
ES-17a (Wind dispersal)	y - mod		*Phalaris* species with sterile side spikelets are adapted for wind dispersal (Gal and Alexandre, 2000). *Phalaris paradoxa* var. *praemosahas* produces a narrow panicle that is wedge-shaped and stiffer, which makes it too heavy to be dispersed by wind, while *Phalaris paradoxa* var. *paradoxa* is adapted for wind dispersal (Gal and Alexandre, 2000).
ES-17b (Water dispersal)	n - low		We found no evidence that *P. paradoxa* is water-dispersed.
ES-17c (Bird dispersal)	? - max		Seeds can be eaten by birds (USDA-FS, 1953). In Australia, the plains-wanderer (*Pedionomus torquatus*) was found to consume and excrete seeds of *P. paradoxa* (Baker-Gabb, 1988). However, it is unclear if *P. paradoxa* seeds germinated.
ES-17d (Animal external dispersal)	n - low		We found no evidence, and the species is well studied.
ES-17e (Animal internal dispersal)	y - negl		*Phalaris paradoxa* can germinate from horse dung (Ansong and Pickering, 2013; Weaver and Adams, 1996) and cattle manure (Woldu and Saleem, 2000).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - mod	1	Seed burial experiments showed that after two years, *P. paradoxa* experienced a 97-99 percent decrease in seed survival (Taylor et al., 2005). The rate of seed decay within the first 12 months of field seed burial experiments was rapid, with only 10 percent of the original seeds remaining (Taylor et al., 1999). Walker et al. (2006) determined through a series of varying burial experiments, that after two years only 1-4 percent of *P. paradoxa* seeds survived, and after three years no seeds survived.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	n - low	-1	*Phalaris paradoxa* is generally found in established grasslands or open areas such as cleared ditches (Thurley and Chancellor, 1985). On rare occasions in subtropical Australia, grazing has been used to control *P. paradoxa* (Walker et al., 2005). Cultivation of winter crops in Australia can stimulate germination in *P. paradoxa* if the seeds are on the soil surface or buried to a depth no greater than 10 cm

Question ID	Answer - Uncertainty	Score	Notes (and references)
			(0.10 m) (Taylor et al., 2005; Taylor et al., 1999). Seeds from *P. paradoxa* have demonstrated an increase in germination when exposed to cultivation (Taylor et al., 2005; Taylor et al., 1999) and smoke infused water (Adkins and Peters, 2001), but we found little information about grown plants tolerating or benefiting from mutilation. Since the plant is well studied we answered no with low uncertainty.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	y - negl	1	Populations in Israel are developing resistance to ACCase-inhibiting herbicides such as FOPs (aryloxyphenoxypropionates), pinoxaden, and cycloxydim (Hochberg et al., 2009). *Phalaris paradoxa* populations in Italy have developed resistance to ACCase herbicides (Lucchesi and Sattin, 2002). *Phalaris paradoxa* has also demonstrated herbicide resistance to ALS inhibitors and Photosystem II inhibitors (Heap, 2016). Populations in Mexico have developed resistance to fenoxaprop, diclofop, cyhalofop, and tralkoxydim (Valverde, 2007), despite showing varying degrees of susceptibility in 2002 (Tamayo-Eesquer and Martinez-Carrillo, 2002).
ES-21 (Number of cold hardiness zones suitable for its survival)	8	0	
ES-22 (Number of climate types suitable for its survival)	7	2	
ES-23 (Number of precipitation bands suitable for its survival)	10	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	We found no evidence that *Phalaris paradoxa* is allelopathic. However, there is evidence that *P. paradoxa* has been affected by allelochemicals produced by other plants (Al-Sherif et al., 2013; Singh et al., 2003). *Phalaris minor* exhibits allelopathic inhibitory activity on wheat crops (Qasem and Foy, 2001).
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that *Phalaris paradoxa* or its congeners are parasitic; the family Poaceae is not known to contain parasitic plants (Nickrent, 2016; Nickrent and Musselman, 2004).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - low	0	*Phalaris paradoxa* is mainly found as a weed of agriculture (Hussey et al., 2007; Rozefelds et al., 1999; Thurley and Chancellor, 1985). Because we found no evidence that it naturalizes or is weedy in natural systems, we used low uncertainty for most of the questions in this sub-element. We found no direct evidence that *P. paradoxa* changes ecosystem processes and parameters.
Imp-N2 (Changes habitat structure)	n - low	0	We found no direct evidence that it changes habitat structure.
Imp-N3 (Changes species diversity)	y - high	0	In southeastern Australia, *P. paradoxa* is one of many invasive exotic plants that have been shown to decrease reptile diversity in agricultural rock outcroppings (Michael et al., 2010). While *P. paradoxa* has been linked to reptile diversity in agricultural rock outcroppings, there is no

Question ID	Answer - Uncertainty	Score	Notes (and references)
			evidence that *P. paradoxa* changes species diversity in natural communities. Since this species is well studied, we answered no with moderate uncertainty.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - high	0	In Australia the nationally threatened *Aprasia parapulchella* thrives in agricultural rock outcrops and as stated in Imp-N3, *P. paradoxa* is one of many invasive exoctic plants that have been shown to decrease reptile diversity in agricultural rock outcroppings (Michael et al., 2010).
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - low	0	It is unlikely that it will affect U.S. globally outstanding ecoregions.
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	a - low	0	In California *Phalaris paradoxa* has been found in natural systems such as the Golden Gate Park, The Nature Conservancy Vina Plains Perserve, and the Los Banos Wildlife Refuge (Consortium of California Herbaria, 2016). Despite its presence in natural systems, we found no evidence that it is weedy in natural systems, let alone being controlled in them. Currently, the only evidence of control is in relation to agricultural systems. The alternate answers for the Monte Carlo simulation were both "b."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - low	0	We found no evidence that *Phalaris paradoxa* negatively impacts personal property, human safety, or public infrastructure. Currently, the majority of information about *P. paradoxa* focuses on its presence in agricultural systems. For this reason we used low uncertainty for this question, and questions Imp-A2 and Imp A-3.
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	We found no evidence that *Phalaris paradoxa* changes or limits recreational use of an area.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - low	0	We found no evidence that *Phalaris paradoxa* affects desirable and ornamental vegetation.
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	a - low	0	Unintentional introduction in China resulted in *Phalaris paradoxa* inhabiting fields, gardens, roadsides, and grassy slopes (Xu et al., 2012). *Phalaris paradoxa* is found in surrounding habitats of human-created reservoirs in southern Italy (Croce, 2015). Despite the presence of *P. paradoxa* along roadsides, there is no direct evidence that it is considered a weed in anthropogenic systems. Therefore, we answered "a" with low uncertainty. The alternate answers for the uncertainty simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - negl	0.4	Experimental studies showed that *Phalaris paradoxa* reduced wheat yield by 17.4 percent in plantings of 100 *P. paradoxa* plants m^2 (Bhan and Froud-Williams, 2006). To prevent a reduction in crop yield, Walker et al. (2002) found that planting 80 wheat plants m^2, significantly reduced seed production of *P. paradoxa*. Portugal et al. (2009) found through experimental studies that a significant reduction in wheat production when *P. paradoxa* occurred at densities of 112 plants/m^2. During surveys in England and Wales,

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Thurley & Chancellor (1985) found *P. paradoxa* to outgrow all crops except beans and oilseed rape. Despite this observation, no data are available to determine the amount of crop reduction by *P. paradoxa*.
Imp-P2 (Lowers commodity value)	y - high		Surveys determining economic loss (based on management costs, weed contamination, tillage) in Australian annual winter crops, found *Phalaris paradoxa* to be in the lower 10 percent of the 15 most important economic weeds affecting crop yield (Jones et al., 2005). Experimental studies in Portugal found that the economic injury level in wheat fields to be a result of 56 to 112 *Phalaris paradoxa* plants/m^2 (Portugal et al., 2009). While multiple studies have attempted to determine the cost of controlling *P. paradoxa* (i.e., cost of herbicides, wheat production, wheat grain price) (Portugal et al., 2009; Tessema and Tanner, 1997; Tessema et al., 1996), we found no direct evidence of *P. paradoxa* lowering commodity value. Therefore, we answered unknown with maximum uncertainty.
Imp-P3 (Is it likely to impact trade?)	y - low	0.2	*Phalaris paradoxa* can contaminate grain (Dunn, 1905; Reynolds, 2002), bird seed (Ryves et al., 1996), and animal fodder (Pasiecznik, 2007). *Phalaris paradoxa* is considered a weed of quarantine importance in Honduras (Puerto, n.d.). *Phalaris paradoxa* is prohibited from entry in India, specifically wheat growing areas (Singh, 2001). It is listed as a harmful organism weed in Brazil, Guatemala, Taiwain, Colombia, Honduras, Ecuador, and Peru (APHIS, 2016).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - low	0	We found no direct evidence that *Phalaris paradoxa* affects irrigation or strongly competes with plants for water.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - high	0.1	In Australia *P. paradoxa* was suspected of poisoning and killing three horses that were grazing in a wheat paddock (Bourke et al., 2003). *Phalaris aquatica*, *P. brachystachys*, and *P. tuberosa* have all been found to be toxic to sheep with results ranging from heart disease to death (Bossard et al., 2000; Bourke et al., 1990; de Luco et al., 1990; Gallagher et al., 1966). We answered yes with high uncertainty because only one study has suspected *P. paradoxa* of poisoning horses.
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	c - negl	0.6	This species is present in Australian rangelands, but impacts are unknown (Martin et al., 2006). It is considered a troublesome weed in northern and southern Europe's crop systems of fodder, cereals, vegetables and ornamentals, and vineyards (Weber and Gut, 2005). *Phalaris paradoxa* is still considered a serious weed in Israel, after being discovered over 50 years ago (Horowitz, 1980). In Ethiopia, it is considered a major weed in barley crops (Negewo et al., 2011). In Australia, barley crops have been found to be highly competitive against *P. paradoxa* and a combination of barley crops and herbicides has shown the greatest reduction in *P. paradoxa* seeds (Walker et al., 2001). One population in Italy demonstrated a low resistance to diclofop, clodinafop and tralkoyddim herbcidies (Collavo et al., 2011). In Italy it is considered to be a very invasive weed in cultivated fields

Question ID	Answer - Uncertainty	Score	Notes (and references)
			(Baldini, 1993). *Phalaris paradoxa* is a recently introduced weed of agricultural in Chile (Finot and Pedreros, 2012). It has recently been recorded as an invasive weed in Nepal (Singh and Sharma, 2014). In the last ten years *P. paradoxa* has become a problem weed in arable lands despite being a casual species for over 100 years in Britain (Thurley and Chancellor, 1985). In wheat fields in Italy, it was found that *P. paradoxa* is developing resistance to ACCase inhibitor herbicides (Sattin et al., 2001).The alternate answers for the uncertainty simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (Kartesz, 2015).
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)	y - low	N/A	Germany (2 points.).
Geo-Z6 (Zone 6)	y - low	N/A	Norway (4 points.).
Geo-Z7 (Zone 7)	y - negl	N/A	The United States, Spain, France, Italy, Austria, Germany, Sweden, and Greece.
Geo-Z8 (Zone 8)	y - negl	N/A	Japan, the United States, Spain, France, Germany, Belgium, Netherlands, Norway, Turkey, Luxembourg, and Greece.
Geo-Z9 (Zone 9)	y - negl	N/A	New Zealand, Australia, Japan, South Africa, Argentina, Mexico, the United States, Tunisia, Morocco, Spain, Portugal, France, Italy, Belgium, Sweden, Great Britain, Turkey, Syria (GBIF, 2015), China (Yunnan Province) (Wang et al., 2009), Nepal (Rupandehi District) (Singh and Sharma, 2014), and Chile (Santa Cruz) (Finot and Pedreros, 2012).
Geo-Z10 (Zone 10)	y - negl	N/A	Australia, South Africa, Argentina, Mexico, the United States, Canary Islands, Tunisia, Morocco, Spain, Portugal, France, Italy, Great Britain, Greece, Egypt, Syria, Lebanon (GBIF, 2015), China (Yunnan Province) (Wang et al., 2009), Nepal (Rupandehi District) (Singh and Sharma, 2014), and Chile (Santa Cruz) (Finot and Pedreros, 2012).
Geo-Z11 (Zone 11)	y - negl	N/A	Australia, South Africa, Mexico, the United States, Madeira, Canary Islands, Morocco, Spain, Portugal, Greece (GBIF, 2015), China (Yunnan Province) (Wang et al., 2009), and Nepal (Rupandehi District) (Singh and Sharma, 2014).
Geo-Z12 (Zone 12)	y - negl	N/A	Australia, Mexico, Madeira, and Canary Islands.
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - low	N/A	Australia (1 point). We answered no with low uncertainty, because while *P. paradoxa* has been found to grow in areas of varying soil types and rain levels only one record has been recorded in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that it occurs in this climate class.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C3 (Steppe)	y - negl	N/A	Mexico, the United States, Australia, South Africa, Jordan, Israel, Greece, Morocco, Spain (GBIF, 2015), and China (Yunnan Province) (Wang et al., 2009).
Geo-C4 (Desert)	y - negl	N/A	Mexico, the United States, Australia, Canary Islands, Israel, Egypt, Tunisia, and Spain.
Geo-C5 (Mediterranean)	y - negl	N/A	The United States, Australia, South Africa, Jordan, Israel, Syria, Lebanon, Turkey, Greece, Italy, Spain, Morocco, France, Portugal, Madeira (GBIF, 2015), and Chile (Santa Cruz) (Finot and Pedreros, 2012).
Geo-C6 (Humid subtropical)	y - negl	N/A	Argentina, Mexico, Australia, Japan, South Africa, Italy, France (GBIF, 2015), Nepal (Rupandehi District) (Singh and Sharma, 2014), and China (Yunnan Province) (Wang et al., 2009).
Geo-C7 (Marine west coast)	y - negl	N/A	The United States, New Zealand, South Africa, Germany, Netherlands, Belgium, Luxembourg, France, Spain, Great Britain (GBIF, 2015), and China (Yunnan Province) (Wang et al., 2009).
Geo-C8 (Humid cont. warm sum.)	y - high	N/A	We answered unknown because despite finding no direct evidence that *Phalaris paradoxa* is currently found in this climate class, *P. paradoxa* is very common in surrounding climate classes.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Italy, Germany, Sweden, Norway, and France.
Geo-C10 (Subarctic)	y - negl	N/A	Austria, Germany, Norway, France, and Spain.
Geo-C11 (Tundra)	n - low	N/A	Germany (1 point).
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that it occurs in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - negl	N/A	Australia, South Africa, Jordan, Egypt, Israel, Greece, Canary Islands, Tunisia, Morocco, Spain, the United States, and Mexico.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Australia, South Africa, Israel, Syria, Greece, Madeira, Morocco, Spain, Portugal, France, Mexico, and the United States.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	New Zealand, Australia, South Africa, Syria, Lebanon, Israel, Turkey, Greece, Italy, Morocco, Spain, Portugal, France, Sweden, Great Britain, and the United States.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Australia, Turkey, Greece, Morocco, Spain, France, Germany, Netherlands, Belgium, Sweden, Norway, Great Britain, Argentina, Mexico, the United States (GBIF, 2015), Chile (Santa Cruz) (Finot and Pedreros, 2012), and China (Yunnan Province) (Wang et al., 2009).
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Australia, Greece, Morocco, Spain, France, Austria, Germany, Norway, Great Britain, the United States (GBIF, 2015), and China (Yunnan Province) (Wang et al., 2009).
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Australia, Turkey, Greece, Spain, France, Germany, Norway, Great Britain, Mexico, the United States (GBIF, 2015), Nepal (Rupandehi District) (Singh and Sharma, 2014), and China (Yunnan Province) (Wang et al., 2009).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Spain, Germany, Great Britain (GBIF, 2015), Nepal (Rupandehi District) (Singh and Sharma, 2014), and China (Yunnan Province) (Wang et al., 2009).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Japan, Germany, Great Britain (GBIF, 2015), Nepal (Rupandehi District) (Singh and Sharma, 2014), and China (Yunnan Province) (Wang et al., 2009).
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Japan, Italy (GBIF, 2015), and Nepal (Rupandehi District) (Singh and Sharma, 2014).
Geo-R10 (90-100 inches; 229-254 cm)	y - low	N/A	Great Britain and the United States.
Geo-R11 (100+ inches; 254+ cm)	n - negl	N/A	We found no evidence that it occurs in this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	*Because P. paradoxa* is already naturalized in the United States (Kartesz, 2015; NGRP, 2016), we did not evaluate this risk element.
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds for planting)	-	N/A	
Ent-4d (Contaminant of ballast water)	-	N/A	
Ent-4e (Contaminant of aquarium plants or other aquarium products)	-	N/A	
Ent-4f (Contaminant of landscape products)	-	N/A	
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	-	N/A	
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	-	N/A	
Ent-4i (Contaminant of some other pathway)	-	N/A	
Ent-5 (Likely to enter through natural dispersal)	-	N/A	