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Animal and Plant
Health Inspection
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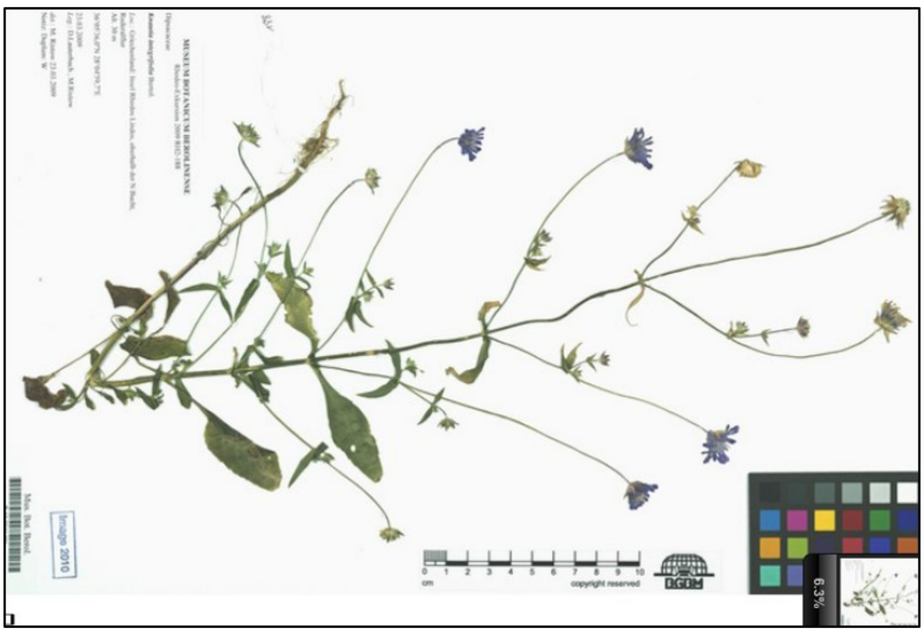
Version 1

Weed Risk Assessment for *Knautia integrifolia* (Honck. ex L.) Bertol. (Caprifoliaceae) – Whole-leaved scabious



Herbarium image of *Knautia integrifolia* (source: Botanischer Garten und Botanisches Museum Berlin-Dahlem; Röpert, 2000+ [continuously updated]).

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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.

	***Knautia integrifolia* (Honck. ex L.) Bertol. – Whole-leaved scabious**
Species Information	Family: Caprifoliaceae (NGRP, 2016), but sometimes placed in the Dipsacaceae (NRCS, 2016), depending on the taxonomic system used.

Synonyms: *Asterocephalus integrifolius* (Honck. ex L.) Raf., *Knautia hybrida* (All.) Coult., *Scabiosa hybrida* All., *S. integrifolia* Honck. ex L., *Succisa integrifolia* (Honck. ex L.) Raf., *Trichera hybrida* (All.) Roem. & Schult., *T. integrifolia* (Honck. ex L.) Roem. & Schult., *Tricheranthes integrifolia* (Honck. ex L.) Soják (The Plant List, 2016), *Knautia bidens* (Sm.) Lindl. (Danin, 2016).

Common names: Whole-leaved scabious (Modzelevich, 2016).

Botanical description: *Knautia integrifolia* is an herbaceous annual with a basal rosette of leaves (Verloove and Vandenberghe, 1998). Flowering stems grow from 20 to 80 cm high. Inflorescences are purple and contain about 20 to 40 flowers (Verloove and Vandenberghe, 1998).

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 *K. integrifolia* 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: *Knautia integrifolia* is native to the Mediterranean region (Mayer and Svoma, 1998; Turland and Chilton, 1994), and its distribution extends to the eastern Balkans and northwestern Anatolia (Rešetnik et al., 2014). It has been reported in Albania (Chaytor and Turrill, 1934), France (GBIF, 2016), Greece (Greuter, 1979), Israel (Danin, 2016), Montenegro (Cakovic et al., 2012), Serbia (Nestorovic and Konstantinovic, 2011), Spain (GBIF, 2016), and Turkey (Dogan et al., 2004). It is not reported from the Carpathian Mountain region of eastern Europe (Bojňanský and Fargašová, 2007). In 1987, *Knautia integrifolia* was detected in Chile, where it is now considered naturalized (Castro et al., 2005). In 1997, it was detected as a casual or ephemeral species near a paste factory in Belgium where grain is processed (Verloove, 2006; Verloove, 2016; Verloove and Vandenberghe, 1998). We found no other instances in which this species has been moved outside of its native range. We also found no evidence indicating that it is cultivated.

U.S. distribution and status: We found no evidence that this species is present in the United States as either a naturalized (e.g., Kartesz, 2016; NGRP, 2016; NRCS, 2016) or cultivated species (e.g., Dave's Garden, 2016; Page and Olds, 2001; Univ. of Minn., 2016).

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

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted (definition modified from that for "PRA area") (IPPC, 2012).

1. *Knautia integrifolia* analysis

Establishment/Spread Potential *Knautia integrifolia* is an annual species (Filibeck et al., 2012) that reproduces by seeds, and is dispersed by ants (Mayer and Svoma, 1998) and trade of contaminated grain and seed (Verloove, 2006). Because the fruit (i.e., the achenes) possess long hairs (Lonchamp, 2000), they may be dispersed unintentionally if they get caught on clothing or animal fur. We found no other evidence of biological traits suggesting that *K. integrifolia* has a high capacity for establishment and spread. Nevertheless, it obtained a moderate score for this risk element because it has been detected twice outside of its native range [e.g., Belgium (Verloove and Vandenberghe, 1998) and Chile (Castro et al., 2005)]. *Knautia integrifolia* is reported to be naturalized in Chile. Several questions in the assessment were answered as "unknown" due to limited information about the biology of this species, resulting in very high uncertainty associated with this risk element.
Risk score = 11 Uncertainty index = 0.37

Impact Potential *Knautia integrifolia* is generally viewed as a weed of agricultural systems in its native range. For example, it is a weed of traditional agriculture in Crete (Turland et al., 2004), of olive groves in Greece (Turland and Chilton, 1994), and of wheat in Italy (Abbate et al., 2013) and in Chile (Matthei, 1995). Eight years after it was detected for the first time in Chile, *K. integrifolia* was classified in a national inventory of weeds of the country as a principal weed, which is a weed that causes numerous impacts in at least one crop, but never causes total crop loss as serious weeds do (Matthei, 1995). We found no additional information about its specific impacts in that country. Overall, we had very high uncertainty associated with this risk element.
Risk score = 1.6 Uncertainty index = 0.40

Geographic Potential Based on three climatic variables, we estimate that about 54 percent of the United States is suitable for the establishment of *K. integrifolia* (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 *K. integrifolia* represents the joint distribution of Plant Hardiness Zones 6-11, areas with 10-80 inches of annual precipitation, and the following Köppen-Geiger climate classes: Mediterranean, humid subtropical, steppe, marine west coast, humid continental warm summers, humid continental cool summers, subarctic, and tundra.

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. *Knautia integrifolia* occurs in grasslands (Foggi et al., 2014; Matthei, 1995), riparian systems (Angiolini et al., 2011), forest plantations (Maccherini and De Dominicis, 2003), sand dunes (Sofia et al., 2006), railway embankments (Filibeck et al., 2012), roadways edges (Dogan et al., 2004), and agricultural habitats such as orchards (Turland and Chilton, 1994) and cereal fields (Abbate et al., 2013) such as wheat (Matthei, 1995).

Entry Potential Because *K. integrifolia* is not present in the United States, we evaluated its entry potential. Although we found no evidence that this species is cultivated anywhere in the world, it is harvested from the wild and used in traditional vegetable dishes in Italy (Guarrera and Savo, 2016); consequently it may be intentionally imported by particular ethnic groups. Furthermore, *K. arvensis* and *K. macedonica* are cultivated as ornamentals in the United States (Page and Olds, 2001; Univ. of Minn., 2016), and thus it is possible that *K. integrifolia* may be imported for planting either unintentionally due to confusion with these taxa or intentionally by horticulturalists interested in other members of the genus. The other most likely pathway for entry is as a contaminant in grain (Verloove, 2006) or seeds for planting (e.g., *K. arvensis*; Salisbury, 1961).
Risk score = 0.11 Uncertainty index = 0.36

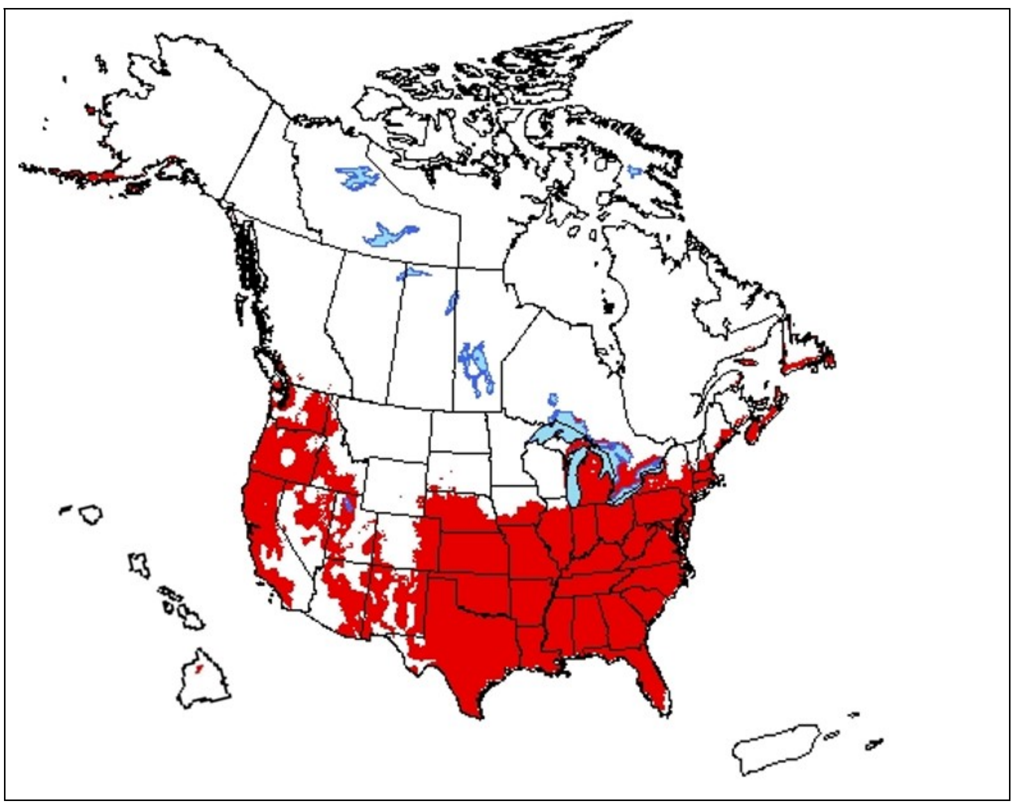

Figure 1. Potential geographic distribution of *Knautia integrifolia* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 35.9%
P(Minor Invader) = 59.0%
P(Non-Invader) = 5.1%

Risk Result = Evaluate Further

Secondary Screening = High Risk

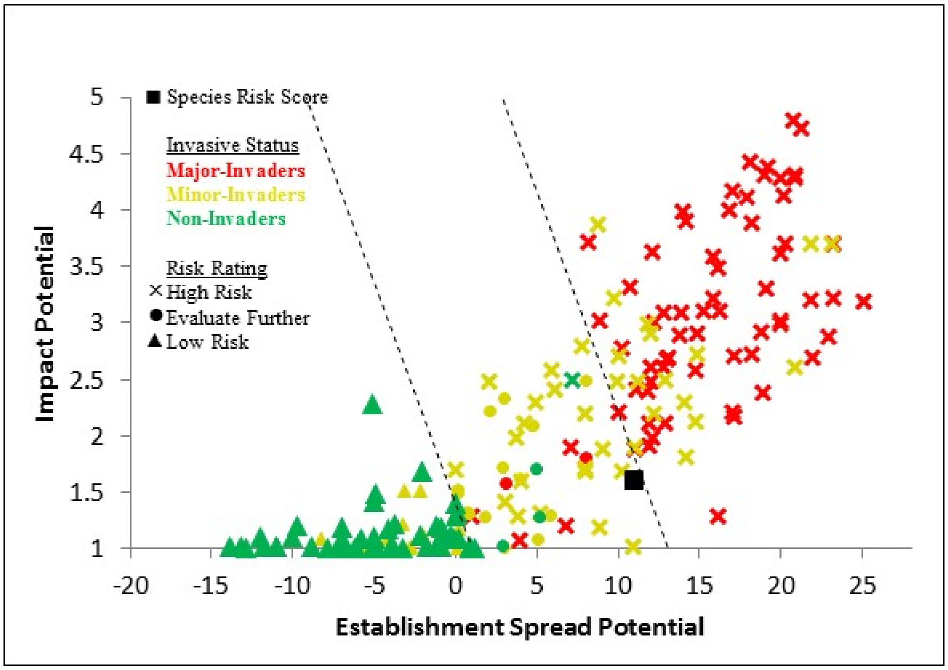

Figure 2. *Knautia integrifolia* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

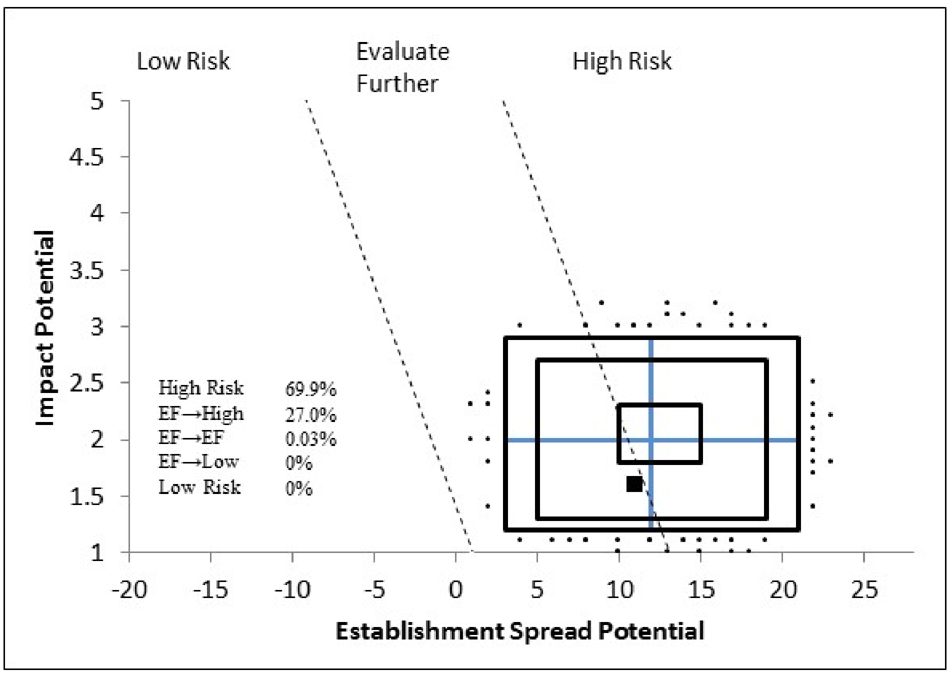

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *K. integrifolia*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Knautia integrifolia* is High Risk after secondary screening (Fig. 2). There was a lot of uncertainty in our analysis because there was very little substantive information available about the biology and status of this species. We could not answer 6 of the 23 questions for the establishment/spread risk element, which resulted in a large distribution of simulated risk scores in our uncertainty analysis (Fig. 3). The results of our uncertainty analysis support our primary result of High Risk. Furthermore, if this species had obtained one more point under establishment/spread potential, it would have obtained a result of High Risk without secondary screening.

Knautia integrifolia is categorized as a principal weed in Chile, where it is having impacts in at least one crop (Matthei, 1995); however, it is unknown to us what those impacts are or how this species was introduced to Chile. Although *K. integrifolia* is reported as a weed in several different crops (see evidence under Imp-A6 in Appendix A), we found no evidence of specific impacts. *Knautia integrifolia* was previously considered a weed in Serbia, but long-term agrochemical use has reduced the weed flora there (Nestorovic and Konstantinovic, 2011). This species has been introduced to only two localities, and almost all of the information reviewed in this assessment relates to its biology and status in its native range, where it is likely subject to control by coevolved predators and pathogens.

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.

Abbate, G., E. Cicinelli, D. Iamonico, and M. Iberite. 2013. Floristic analysis of the weed communities in wheat and corn crops: A case study in western-Central Italy. Annali Di Botanica (Roma) 3:97-105.

Angiolini, C., A. Nucci, F. Frignani, and M. Landi. 2011. Using multivariate analyses to assess effects of fluvial type on plant species distribution in a Mediterranean river. Wetlands 31(1):167-177.

Anonymous. 2014. *Knautia integrifolia*. Blogspot.com. Last accessed June 24, 2016, http://mikres-diadromes.blogspot.com/2016/01/knautia-integrifolia.html.

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

Ansong, M., and C. Pickering. 2014. Weed seeds on clothing: A global review. Journal of Environmental Management 144:203-211.

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/faces/index.jsp. (Archived at PERAL).

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.

Burrows, G. E., and R. J. Tyrl. 2013. Toxic Plants of North America, 2nd ed. Wiley-Blackwell, Ames, IA. 1383 pp.

Cakovic, D., D. Stesevic, V. Ikovic, M. Knezevic, and N. Latinovic. 2012. Contribution to the knowledge of weed flora in Bjelopavlici plain. Agriculture & Forestry 58(4):25-41.

Castro, S. A., J. A. Figueroa, M. Muñoz-Schick, and F. M. Jaksic. 2005. Minimum residence time, biogeographical origin, and life cycle as determinants of the geographical extent of naturalized plants in continental Chile. Diversity and Distributions 11:183–191.

Čertner, M., F. Kolář, P. Schönswetter, and B. Frajman. 2015. Does hybridization with a widespread congener threaten the long-term persistence of the Eastern Alpine rare local endemic *Knautia carinthiaca*? [Abstract]. Ecology and Evolution 5(19):4263-4276.

Chaytor, D. A., and W. B. Turrill. 1934. On the flora of the nearer East. XV. A contribution to the flora of central Albania. Bulletin of Miscellaneous Information (Royal Botanic Gardens, Kew) 1934(10):437-443.

Danin, A. 2016. Flora of Israel [Online Database]. The Hebrew University of Jerusalem. http://flora.org.il/en/plants/. (Archived at PERAL).

Dave's Garden. 2016. Plant files database. Dave's Garden. http://davesgarden.com/guides/pf/go/1764/. (Archived at PERAL).

Dogan, Y., S. Baslar, A. Celik, H. H. Mert, and M. Ozturk. 2004. A study of the roadside plants of West Anatolia, Turkey. Natura Croatica 13(1):63-80.

Ehrendorfer, F., H. G. Baker, and G. L. Stebbins. 1965. Dispersal mechanisms, genetic systems, and colonizing abilities in some flowering plant families. Pages 331-351 *in* H. G. Baker and G. L. Stebbins (eds.). The Genetics of Colonizing Species. Academic Press, New York.

Filibeck, G., P. Cornelini, and P. Petrella. 2012. Floristic analysis of a high-speed railway embankment in a Mediterranean landscape. Acta Botanica Croatica 71(2):229-248.

Foggi, B., L. Lastrucci, M. Gennai, and D. Viciani. 2014. The festuco-brometea grasslands on sandstone and marl-clay-sandstone substrata in Tuscany (Northern-Central Italy). Hacquetia 13(1):115-151.

GBIF. 2016. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). http://www.gbif.org/. (Archived at PERAL).

Greuter, W. 1979. The flora and phytogeography of Kastellorizo (Dhodhekanisos, Greece). 1. An annotated catalogue of the vascular plant taxa. Willdenowia 8:531-611.

Guarrera, P. M., and V. Savo. 2016. Wild food plants used in traditional vegetable mixtures in Italy. Journal of Ethnopharmacology 185:202-234.

Heap, I. 2016. The international survey of herbicide resistant weeds. Weed Science Society of America. http://weedscience.org/. (Archived at PERAL).

Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Leiden, The Netherlands. 438 pp.

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.

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.

Kartesz, J. 2016. The Biota of North America Program (BONAP). North American Plant Atlas. http://bonap.net/tdc. (Archived at PERAL).

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.

Lonchamp, J. P. 2000. *Knautia integrifolia* (L.) Bertoloni L'Institut National de la Recherche Agronomique. Last accessed June 24, 2016, https://www2.dijon.inra.fr/hyppa/hyppa-a/knain_ah.htm#Seed.

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.

Maccherini, S., and V. De Dominicis. 2003. Germinable soil seed-bank of former grassland converted to coniferous plantation. Ecological Research 18(6):739-751.

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.

Matthei, O. J. 1995. Manual de las Malezas que Crecen en Chile. Alfabeta Impresores, Santiago, Chile. 545 pp.

Mayer, V., and E. Svoma. 1998. Development and function of the elaiosome in *Knautia* (Dipsacaceae). Botanica Acta 111(5):402-410.

Messina, A. (Photographer). No Date. *Knautia integrifolia* (L.) Bertol. [Digital Image]. Retrieved from http://luirig.altervista.org/flora/taxa/index1.php?scientific-name=knautia+integrifolia.

Modzelevich, M. 2016. Flowers in Israel. FlowersinIsrael.com. Last accessed June 24, 2016, http://www.flowersinisrael.com/.

MPAAF. 2010. § 319.5 Requirements for submitting requests to change the regulations in 7 CFR part 319. Ministero delle Politiche Agricole, Alimentari e Forestali (MPAAF), Rome. 29 pp.

Nelson, L. S., R. D. Shih, and M. J. Balick. 2007. Handbook of Poisonous and Injurious Plants. Springer, NY. 340 pp.

Nestorovic, M. L. J., and B. Konstantinovic. 2011. Overview of the weed flora in the Serbia. Contemporary Agriculture 60(1-2):215-230.

NGRP. 2016. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program (NGRP). https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx?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.

NRCS. 2016. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. http://plants.usda.gov/cgi_bin/. (Archived at PERAL).

Page, S., and M. Olds (eds.). 2001. The Plant Book: The World of Plants in a Single Volume. Mynah, Hong Kong. 1020 pp.

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.

Randall, R. P. 2012. A Global Compendium of Weeds, 2nd edition. Department of Agriculture and Food, Western Australia, Perth, Australia. 1107 pp.

Rešetnik, I., B. Frajman, S. Bogdanovic´, F. Ehrendorfer, and P. Schönswetter. 2014. Disentangling relationships among the diploid members of the intricate genus *Knautia* (Caprifoliaceae, Dipsacoideae). Molecular Phylogenetics and Evolution 74:97-110.

Röpert, D., (ed). 2000+ [continuously updated]. Digital specimen images at the Herbarium Berolinense: *Knautia integrifolia* (Barcode: B 10 0341491 / ImageId: 315554). Botanischer Garten und Botanisches Museum Berlin-Dahlem. Last accessed June 24, 2016, http://ww2.bgbm.org/herbarium/.

Salisbury, E. 1961. Weeds and Aliens. Collins, London. 384 pp.

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

Sofia, S., V. Georgios, D. Georgios, T. Argyro, and G. Theodoros. 2006. Notes on flora and vegetation of the sand dunes of western Greece. Willdenowia 36(1):235-246.

The Plant List. 2016. The Plant List, Version 1 [Online Database]. Kew Botanic Gardens and the Missouri Botanical Garden. http://www.theplantlist.org/. (Archived at PERAL).

Turland, N. J., and L. Chilton. 1994. Studies on the Cretan flora. 3. Additions to the flora of Karpathos. Bulletin of the Natural History Museum 24(1):91-99.

Turland, N. J., D. Phitos, G. Kamari, and P. Bareka. 2004. Weeds of the traditional agriculture of Crete. Willdenowia 34:381-406.

Univ. of Minn. 2016. Plant Information Online Database. University of Minnesota. https://plantinfo.umn.edu/default.asp. (Archived at PERAL).

Uysal, Ü., E. Karabacak, Ö. Seçmen, and S. Oldacay. 2003. The flora of agricultural areas and their environs in Çanakkale (Lapseki-Ezine). Turkish Journal of Botany 27(2):103-116.

Verloove, F. 2006. Catalogue of neophytes in Belgium (1800-2005). National Botanic Garden of Belgium, Meise, Belgium. 89 pp.

Verloove, F. 2016. Manual of the alien plants of Belgium. Botanic Garden of Meise, Belgium. Last accessed June 24, 2016, http://alienplantsbelgium.be.

Verloove, F., and C. Vandenberghe. 1998. Nieuwe en interessante voederadventieven voor de Belgische flora, hoofdzakelijk in 1997. Dumortiera 72:18-36.

Westmoreland, G. 1983. Weeds of Alberta. Alberta Environmental Centre, Canada. 209 pp.

Appendix A. Weed risk assessment for *Knautia integrifolia* (Honck. ex L.) Bertol. (Caprifoliaceae). 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 - high	5	*Knautia integrifolia* is native to the Mediterranean region (Mayer and Svoma, 1998; Turland and Chilton, 1994), and its distribution extends to the eastern Balkans and northwestern Anatolia (Rešetnik et al., 2014). It has been reported for Albania (Chaytor and Turrill, 1934), France (GBIF, 2016), Greece (Greuter, 1979), Israel (Danin, 2016), Montenegro (Cakovic et al., 2012), Serbia (Nestorovic and Konstantinovic, 2011), Spain (GBIF, 2016), and Turkey (Dogan et al., 2004). It is not reported from the Carpathian Mountain region of eastern Europe (Bojňanský and Fargašová, 2007). In 1997, it was detected as a casual or ephemeral species near a paste factory in Belgium where grain is processed (Verloove, 2006; Verloove, 2016; Verloove and Vandenberghe, 1998). In 1987, *Knautia integrifolia* was detected outside of its native range in Chile (Matthei, 1995). The most comprehensive account of this species status in Chile states that it is present in wheat, in natural grasslands, and along trails, roads, and railways, and that it is causing impacts in wheat (Matthei, 1995). Based on this distribution, we believe that the species has been spreading aggressively in the country. Consequently, we answered this question as "f" with high uncertainty. Alternate answers for the uncertainty simulation were both "e."
ES-2 (Is the species highly domesticated)	n - negl	0	This species is a wild-collected herb used in traditional vegetable dishes in Italy (Guarrera and Savo, 2016). Because we found no evidence that it is cultivated, it is very unlikely that it has been highly domesticated.
ES-3 (Weedy congeners)	y - low	1	There are about 60 species in the genus *Knautia* (Mabberley, 2008). In the Global Compendium of Weeds Database, nine species are reported as weeds, with *K. arvensis* and *K. integrifolia* as the most frequently reported (Randall, 2012). *Knautia arvensis* is a common weed in a few countries (Holm et al., 1979). It is an effective competitor in native and mountain pastures and is difficult to remove once established (Westmoreland, 1983). It is regulated in three Canadian provinces (Kartesz, 2016). In its native range, because of hybridization and introgression, it poses a potential threat to the very rare *Knautia carinthiaca* species (Čertner et al., 2015).
ES-4 (Shade tolerant at some stage of its life cycle)	n - mod	0	This species grows in full sun in clearings of thermophilous forests (Mayer and Svoma, 1998) and sand dunes (Sofia et al., 2006). *Knautia* seeds depend on light for germination (Mayer and Svoma, 1998), indicating that the species is shade-intolerant. However, another study documented that it was present in the vegetation layer of a

Question ID	Answer - Uncertainty	Score	Notes (and references)
			dense coniferous forests in Italy (Maccherini and De Dominicis, 2003), suggesting it may be somewhat shade adapted. Based on the weight of the evidence, we answered no with moderate uncertainty.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	This species is a terrestrial herb with a basal rosette of leaves (Verloove and Vandenberghe, 1998); it is not a vine.
ES-6 (Forms dense thickets, patches, or populations)	n - high	0	We found no direct evidence; however, a photograph suggests it may be able to form somewhat dense patches (Messina, No Date). This photograph shows a small patch that is less than one square meter in size, with numerous flower heads and a canopy coverage of about 80 percent.
ES-7 (Aquatic)	n - negl	0	This species is a terrestrial herb (Verloove and Vandenberghe, 1998) and not an aquatic plant.
ES-8 (Grass)	n - negl	0	This species is not a grass. It is a dicot herb placed in the Caprifoliaceae (NGRP, 2016; The Plant List, 2016).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no direct evidence that it fixes nitrogen. It is neither a woody plant nor placed in a plant family known to contain nitrogen-fixing species (e.g., Martin and Dowd, 1990; Santi et al., 2013).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	The species is classified as a therophyte, which indicates it is an annual that produces viable seeds (Filibeck et al., 2012).
ES-11 (Self-compatible or apomictic)	? - max	0	Flowers are hermaphroditic (Danin, 2016). *Knautia integrifolia* belongs to a group of species that are predominantly outbreeding (Ehrendorfer et al., 1965); however, it is not clear if the species is self-compatible.
ES-12 (Requires specialist pollinators)	n - high	0	A Greek blog shows pictures of *K. integrifolia* flowers with numerous floral visitors (Anonymous, 2014). Although floral visitation does not guarantee pollination, these images suggest that a variety of insects may be able to pollinate the species. *Knautia integrifolia* has become established outside of its natural range in Chile (Castro et al., 2005), where coevolved, specialized pollinators may not occur.
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 - low	1	The plant is an annual (Danin, 2016; Ehrendorfer et al., 1965; Filibeck et al., 2012), which indicates that it has a minimum generation time of one year or less. We found no evidence indicating that it produces multiple generations per year, but because we cannot rule that out, we chose "a" for both of our alternate answers in the uncertainty simulation.
ES-14 (Prolific seed producer)	? - max	0	Unknown. There are 20 to 40 flowers per inflorescence (Verloove and Vandenberghe, 1998). A small patch of this species, which is less than one square meter, has about 60 inflorescences (Messina, No Date). Based on this information, there could be about 1200 to 2400 flowers per the area shown in Messina's image (No Date). However, without estimates of seed production and viability rates, it is impossible to estimate whether this species is a prolific reproducer. As an herbaceous species, it would need to produce more than 5000 seeds per square meter.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - high	1	We found no direct evidence for unintentional dispersal by people. However, achenes of this species have long hairs (Lonchamp, 2000) that may help seeds attach to clothing, Velcro®, or other similar material. Because this species occurs along roadways and railways (Dogan et al., 2004; Filibeck et al., 2012) where people may pass through, it seems likely that seeds may be dispersed unintentionally by people. Hundreds of other weed species have been documented to be dispersed on clothing (Ansong and Pickering, 2014).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - mod	2	Introduced as a grain contaminant into Belgium (Verloove, 2006). *Knautia arvensis,* which has a growth form and size similar to *K. integrifolia* (Bojňanský and Fargašová, 2007), is a contaminant of clover and grass seed (Salisbury, 1961).
ES-17 (Number of natural dispersal vectors)	1	-2	Propagule traits for questions ES-17a through ES-17e: The genus produces elaiosomes at the base of seeds that attract ants as dispersers. Seeds that have had their elaiosomes removed germinate the quickest (Mayer and Svoma, 1998). Achenes have long hairs on them (Mayer and Svoma, 1998).
ES-17a (Wind dispersal)	n - negl		We found no evidence of wind dispersal. Because achenes of *Knautia* have no obvious adaptions for wind dispersal such as plumes or wings (Mayer and Svoma, 1998), we answered no. Furthermore, because the genus is specifically adapted for ant dispersal we used negligible uncertainty.
ES-17b (Water dispersal)	n - mod		We found no evidence of water dispersal.
ES-17c (Bird dispersal)	? - max		We found no specific evidence of bird dispersal. However, because of the long hairs present on *Knautia* spp. achenes (Mayer and Svoma, 1998), it seems possible that seeds may get caught in bird feathers.
ES-17d (Animal external dispersal)	y - negl		The genus *Knautia,* including *K. integrifolia*, is dispersed by ants and is specifically adapted for ant dispersal in several ways (Mayer and Svoma, 1998). Because of the long hairs on the achenes (Mayer and Svoma, 1998), it is possible that they may get caught in animal fur as well.
ES-17e (Animal internal dispersal)	? - max		Unknown. We found no evidence of internal dispersal by animals for *K. integrifolia*, but note that its congener *K. arvensis* can germinate from horse dung (Ansong and Pickering, 2013).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	Unknown. Where it occurs in one forest population site in Italy, it was not found in the soil seed bank in May (Maccherini and De Dominicis, 2003). However, as an annual species of open and disturbed environments, one would expect that it possess some form of long-term dormancy.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	Unknown.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence that this species has developed herbicide resistance. Furthermore, there are no *Knautia* species listed in Heap's (2016) database.
ES-21 (Number of cold hardiness zones suitable for its survival)	6	0	

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-22 (Number of climate types suitable for its survival)	8	2	
ES-23 (Number of precipitation bands suitable for its survival)	7	0	
IMPACT POTENTIAL			Because so little is known about this species, and because it has not been widely introduced to foreign lands, except Chile and Belgium, where any invasive and impact potential can be expressed, we generally used high uncertainty for all of the questions in this risk element.
General Impacts			
Imp-G1 (Allelopathic)	n - high	0	We found no evidence that this taxon is allelopathic.
Imp-G2 (Parasitic)	n - negl	0	We found no direct evidence that this taxon is parasitic. Furthermore, it is not a member of a plant family known to contain parasitic plant species (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - high	0	We found no evidence that this species changes ecosystem properties.
Imp-N2 (Changes habitat structure)	n - high	0	We found no evidence that it changes habitat structure.
Imp-N3 (Changes species diversity)	n - high	0	We found no evidence that it changes species diversity.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	n - high	0	We found no evidence to suggest that this impact is likely.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - high	0	We found no evidence to suggest that this impact is likely.
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 - mod	0	We found no evidence that this species is considered a weed of natural systems; however, we note that *K. arvensis* is considered a weed of mountain pastures in Canada (Westmoreland, 1983). Alternate answers for the uncertainty 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 of this impact, and because it seems unlikely that a terrestrial herb would have this impact, we used low uncertainty.
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	We found no evidence of this impact, and because it seems unlikely that a terrestrial herb would have this impact, we used low uncertainty.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - high	0	We found no evidence that it affects desirable or ornamental plants.
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 - mod	0	*Knautia integrifolia* occurs along roadways in its native range in Turkey (Dogan et al., 2004) and along railway embankments in Italy (Filibeck et al., 2012). However, we found no evidence that it is considered a weed in these systems. Alternate answers for the uncertainty simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P1 (Reduces crop/product yield)	y - high	0	We found no direct or specific evidence of the impact this agricultural weed is having. Matthei (1995) classifies this species as a principal weed in Chile, which means that it is a weed species that causes numerous impacts in at least one crop, but never causes total crop loss as do serious weeds. Although we generally require specific or direct evidence of impacts to answer a yes for this question, because Matthei (1995) provided a comprehensive review of weeds of Chile, and there was no other evidence reporting impacts for this species, we thought at least one question in this risk subelement should be answered as yes to record its status in Chile. We chose this question since this is usually the primary impact that concerns farmers and the most basic impact of agricultural weeds.
Imp-P2 (Lowers commodity value)	n - high	0	We found no evidence of this impact.
Imp-P3 (Is it likely to impact trade?)	? - max		Although we found no evidence that this species is specifically regulated, its congener *K. arvensis* is regulated in the United States (APHIS, 2016). *Knautia arvensis* was introduced to Belgium in grain (Verloove, 2006). Potential difficulty in distinguishing the seeds of these species may therefore impact trade if *K. integrifolia* were detected as a contaminant.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - high	0	We found no evidence of this impact.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	We found no evidence that this species or any of its congeners are toxic to animals (e.g., Burrows and Tyrl, 2013; Nelson et al., 2007).
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]	b - high	0.2	*Knautia integrifolia* is a weed of traditional agriculture in Crete (Turland et al., 2004), of olive groves in Greece (Turland and Chilton, 1994), and of wheat in Italy (Abbate et al., 2013) and Chile (Matthei, 1995). It is reported as a weed in Montenegro, but the type of system was not specified (Cakovic et al., 2012). In Turkey, it is present in dirt roads between fields (Uysal et al., 2003). This species was detected in Chile for the first time in 1987 and is already classified as a principal weed of the country (Matthei, 1995). According to Matthei (1995) principal weeds are those that have several types of impacts on at least one crop, but never cause total crop failure. It is likely that this species is being controlled in Chile, but without specific evidence, we answered "b" instead of "c." *Knautia integrifolia* used to be considered a weed in Serbia, but long-term agrochemical use has reduced the weed flora in that country (Nestorovic and Konstantinovic, 2011). Alternate answers for the uncertainty simulation were "c" and "a."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2016).
Plant hardiness zones			

Question ID	Answer - Uncertainty	Score	Notes (and references)
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 - high	N/A	One point in Italy in a mountainous region. We answered no for three reasons. First, this is just one point and may represent a misidentification. Second, because of dramatic changes in climate over small spatial scales in mountainous regions, this occurrence may in fact be in a warmer hardiness zone. Finally, because this species is an annual, it is possible that this single report is based on an ephemeral population that did not survive winter.
Geo-Z5 (Zone 5)	n - high	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z6 (Zone 6)	y - high	N/A	Two points in France (in a mountainous region). Regional occurrence in Slovenia and Macedonia (GBIF, 2016), and in the Balkans (Rešetnik et al., 2014).
Geo-Z7 (Zone 7)	y - negl	N/A	France and Greece.
Geo-Z8 (Zone 8)	y - negl	N/A	France and Greece. Some points in Syria. Regional distribution in Italy (Angiolini et al., 2011) and Turkey (Dogan et al., 2004).
Geo-Z9 (Zone 9)	y - negl	N/A	France and Greece. A few points in Spain and one point in Chile.
Geo-Z10 (Zone 10)	y - negl	N/A	France, Greece, and Israel. A few points in Spain.
Geo-Z11 (Zone 11)	y - low	N/A	Some points in Greece and Israel. Two points in Spain.
Geo-Z12 (Zone 12)	n - high	N/A	We found no evidence that it occurs in this hardiness zone.
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 - negl	N/A	We found no evidence that it occurs in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that it occurs in this climate class.
Geo-C3 (Steppe)	y - high	N/A	A few points in Greece.
Geo-C4 (Desert)	n - low	N/A	We found no evidence that it occurs in this climate class.
Geo-C5 (Mediterranean)	y - negl	N/A	France, Greece, and Israel (GBIF, 2016). It is widespread in Mediterranean regions (Mayer and Svoma, 1998).
Geo-C6 (Humid subtropical)	y - low	N/A	Two points in Greece, and one on edge of this climate class. Regional distribution in Croatia (GBIF, 2016) and the Balkans (Rešetnik et al., 2014).
Geo-C7 (Marine west coast)	y - negl	N/A	France and Spain.
Geo-C8 (Humid cont. warm sum.)	y - high	N/A	Regional distribution in the Balkans (Rešetnik et al., 2014).
Geo-C9 (Humid cont. cool sum.)	y - mod	N/A	A few points in France. Two points in Bulgaria.
Geo-C10 (Subarctic)	y - mod	N/A	A few points in France. Two points in Greece.
Geo-C11 (Tundra)	y - mod	N/A	A few points in France. Regional distribution in the Balkans (Rešetnik et al., 2014).
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)	n - high	N/A	We found no evidence that it occurs in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Some points in France, Greece, Israel, and Syria.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	France and Spain.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	France and Greece.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	France and Greece. Occurs in an area of Tuscany receiving 100-140 cm of annual precipitation (Maccherini and De Dominicis, 2003).
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Some points in France and Greece. Occurs in an area of Tuscany receiving 100-140 cm of annual precipitation (Maccherini and De Dominicis, 2003).
Geo-R7 (60-70 inches; 152-178 cm)	y - mod	N/A	Two points in France. Regional distribution in Slovenia, Croatia (GBIF, 2016), and the Balkans (Rešetnik et al., 2014).
Geo-R8 (70-80 inches; 178-203 cm)	y - high	N/A	Regional distribution in Slovenia, Croatia (GBIF, 2016), and the Balkans (Rešetnik et al., 2014).
Geo-R9 (80-90 inches; 203-229 cm)	n - high	N/A	May be able to occur here based on regional distribution in Slovenia (GBIF, 2016), but the area corresponding to this precipitation band in Slovenia is small.
Geo-R10 (90-100 inches; 229-254 cm)	n - high	N/A	May be able to occur here based on regional distribution in Slovenia (GBIF, 2016), but the area corresponding to this precipitation band in Slovenia is small.
Geo-R11 (100+ inches; 254+ cm)	n - mod	N/A	We found no evidence that it occurs in this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - low	0	We found no evidence that this species is present in the United States as either a naturalized (e.g., Kartesz, 2016; NGRP, 2016; NRCS, 2016) or cultivated species (e.g., Dave's Garden, 2016; Page and Olds, 2001; Univ. of Minn., 2016).
Ent-2 (Plant proposed for entry, or entry is imminent)	n - mod	0	We found no evidence that this species has been proposed for import or that its entry is imminent.
Ent-3 (Human value & cultivation/trade status)	b - high	0.05	We found no evidence that *Knautia integrifolia* is cultivated anywhere in the world. However, it is a wild-collected herb used in traditional vegetable dishes in Italy (Guarrera and Savo, 2016), and thus may be imported by particular ethnic groups. Furthermore, *K. arvensis* and *K. macedonica* are cultivated as ornamentals in the United States (Page and Olds, 2001; Univ. of Minn., 2016), and thus it is possible that *K. integrifolia* may be imported for planting either unintentionally due to confusion with these taxa or intentionally by horticulturalists interested in other members of the genus.
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	n - low		We found no evidence this species is present in any of these countries (e.g., GBIF, 2016). It is native to the Mediterranean region (Mayer and Svoma, 1998; Turland and Chilton, 1994) and known to have been introduced to only Belgium (Verloove and Vandenberghe, 1998) and Chile (Castro et al., 2005).
Ent-4b (Contaminant of plant propagative material (except seeds))	n - high	0	We found no evidence.
Ent-4c (Contaminant of seeds for planting)	y - high	0.04	We found no direct evidence, but suspect that this is a likely pathway since it is a contaminant of grain (Verloove, 2006). Because *Knautia arvensis* has moved as a contaminant of clover and grass seed (Salisbury, 1961), we answered yes.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4d (Contaminant of ballast water)	n - high	0	We found no evidence.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - low	0	We found no evidence, and we believe that this pathway is unlikely because this species is not an aquatic plant (Verloove and Vandenberghe, 1998).
Ent-4f (Contaminant of landscape products)	n - high	0	We found no evidence.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	? - max		We found no evidence, but we believe that this pathway may be likely because this species occurs along roadway edges (Dogan et al., 2004) and railway embankments (Filibeck et al., 2012), and possibly other disturbed environments, where commodities may sit while waiting transport.
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - low	0.01	It was introduced as a grain contaminant into Belgium (Verloove, 2006).
Ent-4i (Contaminant of some other pathway)	b - high	0.01	We found no direct evidence indicating another potential pathway exists, but we suspect that it is likely to stick to clothing or similar surfaces because of seed hairs (see evidence under ES-15).
Ent-5 (Likely to enter through natural dispersal)	n - negl	0	Because this species is not established in any neighboring geographic regions (e.g., GBIF, 2016), this pathway is currently not very likely.