United States Department of Agriculture

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Animal and Plant Health Inspection Service

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Weed Risk Assessment for *Ageratum conyzoides* L. (Asteraceae) – Billygoat plant

Left: *Ageratum conyzoides*. Top right: *Ageratum conyzoides* seedlings (Parker, 1992). Bottom right: Dense infestation (photo by Bryan Harry, at www.botany.Hawaii.edu).

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1. 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 or 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 a plant species for the entire United States or for any area within it. We 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 were to change. Finally, we use Geographic Information System (GIS) overlays to identify 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 *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 any type of system (production, anthropogenic, or natural) for the assessment, which results in a very broad evaluation. This is appropriate for the types of actions considered by our agency, such as Federal regulation. Furthermore, risk assessment and risk management are distinctly different phases of pest risk analysis (IPPC, 2016). 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.

2. Plant Information and Background

SPECIES: *Ageratum conyzoides* L. (NGRP, 2018).

FAMILY: Asteraceae

SYNONYMS: *Ageratum latifolium* Car., *Ageratum cordifolium* Roxb., *Ageratum odoratum* Vilm. (Dave's Garden, 2018; Ming, 1999), *Ageratum album* Stend (Ming, 1999), *Cacalia mentrasto* Vell. (Ming, 1999).

COMMON NAMES: Billygoat plant, billygoat weed, goat weed, bluebonnet, bluetop (NGRP, 2018), tropical whiteweed (NRCS, 2018).

BOTANICAL DESCRIPTION: *Ageratum conyzoides* is an erect, branching, slightly aromatic, annual herb which grows to approximately 1 m in height with shallow roots (Okunade, 2002; Kohli et al., 2006). The stems and leaves are covered in short, white hairs (Kaur et al., 2012). Leaves are opposite, simple, ovate, and about 7.5 cm long, with toothed margins and glandular trichomes (Okunade, 2002; Lusweti et al., 2011; Ming, 1999). It forms a shallow tap root (Kaur et al., 2012). The flowers are white to purple and up to 6 mm across; the inflorescence contain 30 to 50 flowers arranged in a corymb (Okunade, 2002; Ming, 1999). The fruit is a ribbed, black achene about 1.25 to 2 mm long, with an aristate pappus (stiff, bristle-like tip) (Kohli et al., 2006; Johnson, 1971; Ming, 1999; Boj˘nanský and Fargašová, 2007). Seeds are small, about 3.4 mm long by 0.33 mm wide (Kaur et al., 2012).

INITIATION: PPQ received a market access request for commercially-produced grain of wheat, *Triticum* spp. for consumption from Bulgaria, Hungary, and Lithuania. A commodity risk assessment determined that *A. conyzoides* could be associated with this commodity as a grain contaminant. For this weed risk assessment, PERAL evaluated the risk potential of this species to the United States in order to help policy makers determine whether it should be regulated as a Federal Noxious Weed.

WRA AREA[1]: United States and Territories

FOREIGN DISTRIBUTION: *Ageratum conyzoides* is native to Mexico south through Central America (e.g., Costa Rica, El Salvador, and Nicaragua), the Caribbean (e.g., Bahamas, Cuba, and Haiti), and most of South America (e.g., Argentina, Benin, Brazil, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela) (NGRP, 2018; Johnson, 1971; Coffey et al., 2011). It is a common, pantropical weed that is now naturalized well beyond its native range (Batish et al., 2006; Johnson, 1971) into Southeast Asia (e.g., China, India, and Japan), central Africa (e.g., Burkina Faso, Cameroon, Ethiopia, Nigeria, and Tanzania), Oceania (e.g., Australia, Indonesia, and Papua New Guinea), and some parts of Europe (e.g. Austria, Bulgaria, France, the Netherlands, and Sweden) (NGRP, 2018; GBIF, 2018). It is considered invasive in India (Batish et al., 2006; Kohli et al., 2006), Bangladesh (Akter and Zuberi, 2009), Indonesia (Kaur et al., 2012), and parts of Africa (e.g. Kenya, Tanzania, and Uganda) (Lusweti et

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted (definition modified from that for "PRA area") (IPPC, 2017).

al., 2011). It has been cultivated in Europe as an ornamental. Cultivation was first recorded in England in 1714 and the plant has since been cultivated in Bosnia-Herzegovina, Bulgaria, France, and Sweden (Johnson, 1971; Greuter, 2006). *Ageratum conyzoides* has also been cultivated in Fiji and Australia and is now reported to have escaped and become invasive in several habitats (Kaur et al., 2012).

U.S. DISTRIBUTION AND STATUS: *Ageratum conyzoides* is native to Puerto Rico and the U.S. Virgin Islands (NRCS, 2018). It has become naturalized in North America and has been reported in approximately a dozen counties across 12 states (Alabama, California, Connecticut, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, Missouri, and North Carolina) (Kartesz, 2018; NRCS, 2018; Swearingen and Bargeron, 2018; Imada, 2012) (Fig. 1). The first record of *A. conyzoides* in the United States is from Mobile, AL in 1886, when it escaped from a garden and naturalized in cultivated ground (Keener et al., 2018). In Hawaii, *A. conyzoides* is controlled with 2,4-dichlorophenoxyacetic acid (2,4-D) (Motooka et al., 2003). We found no evidence that it is regulated as a federal or state noxious weed (e.g., 7 CFR § 360, 2018; AMS, 2018; NPB, 2018), and it is not listed as reportable or actionable at ports of entry (PestID, 2018). This species is listed as invasive in natural areas, including Haleakala National Park in Hawaii (Swearingen and Bargeron, 2018). Although *A. conyzoides* is not commonly cultivated or sold in the United States (Dave's Garden, 2018; Univ. of Minn., 2018; Bailey Nurseries, 2018; DeBaggio's Herb Farm and Nursery, 2018), it is available from one distributor in Alabama (Sand Mountain Herbs, 2018) and several foreign vendors on eBay (eBay, 2018), which could increase the potential for domestic movement.

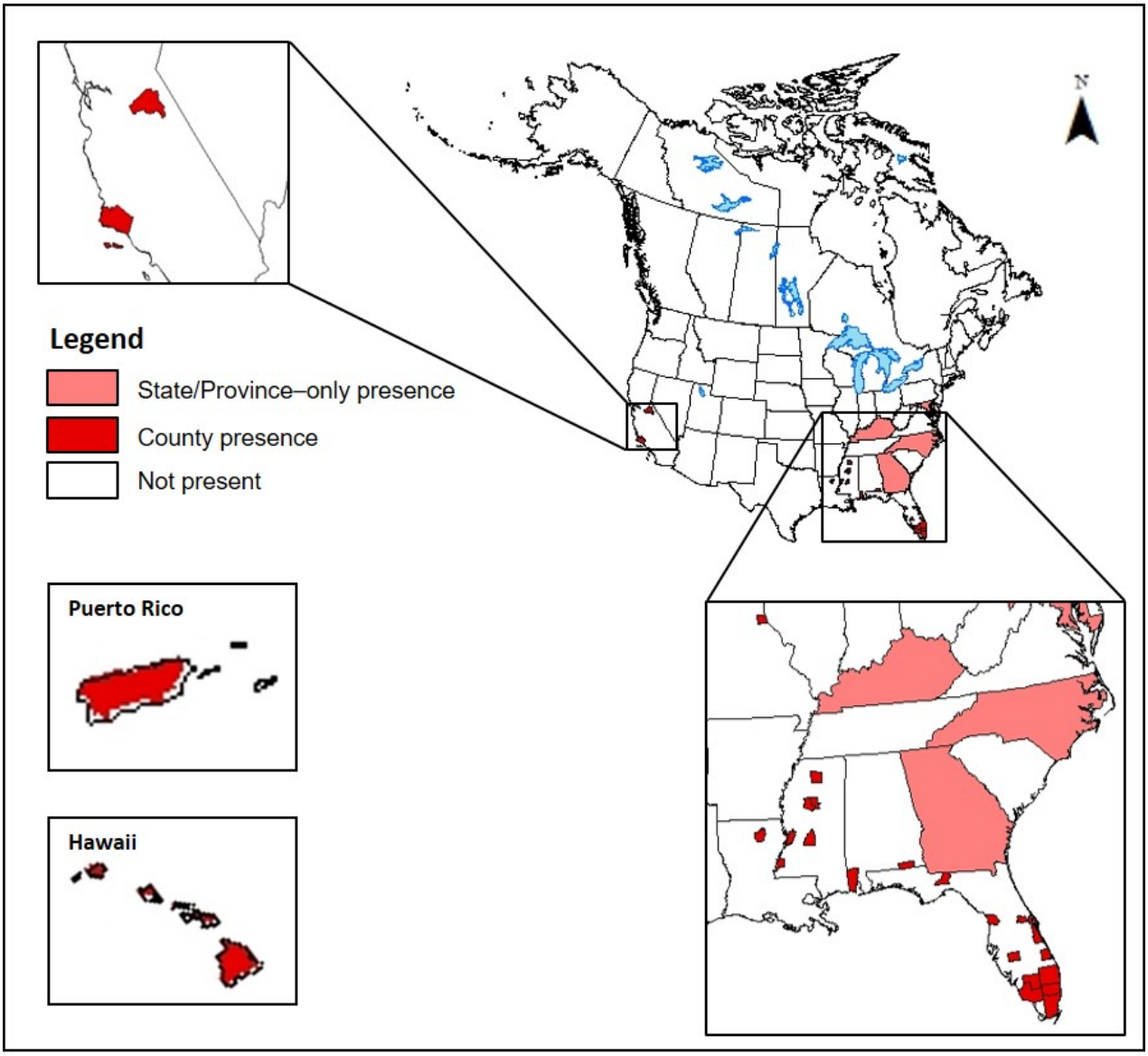

Figure 1. Reported distribution of *A. conyzoides* in the United States and Canada. The records shown here were obtained primarily from other species distribution databases (EDDMapS, 2018; NRCS, 2018) and were not independently verified by PERAL. Scales differ for Hawaii, Puerto Rico, California, and the continental United States and Canada. Some of the northern reports (Connecticut and Missouri) likely represent cultivated plants and transient escapes. [See herbarium records at the SERNEC Data Portal, 2018)].

3. Analysis

ESTABLISHMENT/SPREAD POTENTIAL

Ageratum conyzoides has demonstrated the ability to establish and spread, as it has become naturalized well beyond its native range (Batish et al., 2006; Johnson, 1971). The species has a

pantropical distribution and is now found in Asia, Africa, North America, Central America, the Caribbean, South America, Europe, and Oceania (GBIF, 2018). It is considered highly invasive in many parts of the world, especially in areas that are experiencing drought conditions (Molyneux et al., 2011). *Ageratum conyzoides* is considered invasive in India: it was introduced from tropical America, and its range expanded rapidly, especially in agricultural fields, along roadsides, and in gardens (Negi and Hajra, 2007; Kohli et al., 2004; Kohli et al., 2006; Batish et al., 2006). It has a high fecundity rate, with plants producing between 5,000 and 95,000 seeds, which are shed for five to eight months (Ekeleme et al., 2005; Kohli et al., 2006). *Ageratum conyzoides* also spreads quickly through stolons (Kohli et al., 2006) and can form dense monospecific stands with up to 1000 plants per m² (Ekeleme et al., 2005). The fruit is an achene with an aristate pappus and is easily dispersed by wind, water, animals (Kohli et al., 2006; Kaur et al., 2012; Holm et al., 1977; Johnson, 1971) and by people through trade and agricultural activities (Johnson, 1971; Clifford, 1959; Singh, 2002). We had low uncertainty for this risk element.

Risk score = 21 Uncertainty index = 0.09

IMPACT POTENTIAL

Ageratum conyzoides is primarily a weed of disturbed areas and agricultural lands. It is considered a serious or principal weed in over 20 countries by Holm et al. (1979). In India, it reduces yields in major staple crops, such as wheat, corn and rice (Kohli et al., 2006; Batish et al., 2006; Kaur et al., 2012). Manandhar et al. (2007) report reductions in rice (25-47 percent) and straw (13-38 percent) yields due to *A. conyzoides* (Manandhar et al., 2007). In grasslands, *A. conyzoides* can create large monocultures and has been found covering 58 percent of the area (Kaur et al., 2012). It outcompetes native grasses, causing a shortage of fodder (Kohli et al., 2006). In forest edges, *A. conyzoides* has been reported as a serious competitor of medicinally and aromatically important herbal species (Kohli et al., 2006; Dogra et al., 2009; Kaur et al., 2012). Dogra (2009) reports a 20 percent decline in populations of valuable indigenous medicinal plants (*Achyranthes aspera, Trifolium repens, Centella asiatica, Ziziphus jujuba, Adhatoda vasica*) in the Shivalik hills of Himachal Pradesh, India after the invasion of *Ageratum conyzoides* (Dogra et al., 2009). In natural areas, *A. conyzoides* forms dense monospecific stands that threaten the abundance and diversity of native plants (Kohli et al., 2004; Kaur et al., 2012). *Ageratum conyzoides* has been reported to reduce species diversity by 50 percent and native flora density by 64 percent in the Northwestern Indian Himalayas (Kohli et al., 2004). This species is listed as invasive in natural areas, including Haleakala National Park in Hawaii (Swearingen and Bargeron, 2018). *Ageratum conyzoides* produces allelopathic chemicals that inhibit the growth of other species (Kohli et al., 2006; Okunade, 2002; Batish et al., 2006; Kato-Noguchi, 2001). At low densities, this species can easily be mechanically removed, as it is a shallow rooter; however, the soil may remain contaminated by allelochemicals (Kohli et al., 2006; Chauhan and Johnson, 2009). A wide range of herbicides have been used to control *A. conyzoides* in major crops (Batish et al., 2006; Singh, 2002; CABI, 2018); however, some resistance to ASL inhibitors (B/2) herbicides has been reported (Heap, 2018). Although *A. conyzoides* is widely used in traditional medicine systems throughout much of Africa, Asia, and South America (Okunade, 2002; Johnson, 1971), the pungent oils released are reported to cause giddiness, nausea, and sometimes allergic reactions in humans (Kohli et al., 2006). *Ageratum*

conyzoides contains pyrrolizidine alkaloids, which are toxic to humans and livestock (Wiedenfeld, 2011; Molyneux et al., 2011). Veno-occlusive disease, characterized by chronic liver disease, fever, and jaundice, is a fatal disease that was identified in a small village in Ethiopia in 2001 (Bane et al., 2012). While the cause of this outbreak has not been verified, it is reported to likely be associated with a toxin from *A. conyzoides* growing near the primary water source of the village (Kleiman et al., 2008; Wiedenfeld, 2011). Due to the abundance of information, we had low uncertainty for this risk element.

Risk score = 3.6 Uncertainty index = 0.07

GEOGRAPHIC POTENTIAL

The map for *A. conyzoides* represents the joint distribution of Plant Hardiness Zones 7-13, areas with 0-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, steppe, Mediterranean, humid subtropical, and marine west coast. We had some uncertainty concerning if this species could survive in Mediterranean habitats; however, we answered yes with high uncertainty, as it occurs in a few such locations throughout its distribution, particularly when these habitats are located near a tropical zone. Based on the three climatic variables above, we estimate that about 33 percent of the United States is suitable for the establishment of *A. conyzoides* (Fig. 2). This predicted distribution is based on the known distribution of the species elsewhere in the world and was generated using both point-referenced localities and general areas of occurrence.

In determining the area of the United States shown to be climatically suitable (Fig. 2) for species establishment, we considered only three climatic variables. Other variables, such as soil and habitat type, novel climatic conditions, or different plant genotypes, may alter the areas in which this species is likely to establish. *Ageratum conyzoides* occurs in tropical and subtropical regions and is frequently found in croplands, pastures, grasslands, forests, wetlands, coastal dunes, wastelands, gardens, and roadsides (Batish et al., 2006; Negi and Hajra, 2007; Kohli et al., 2006). This species generally prefers sandy soils but can grow in a variety of habitats, most commonly in proximity to human habitation (Kohli et al., 2006; Okunade, 2002).

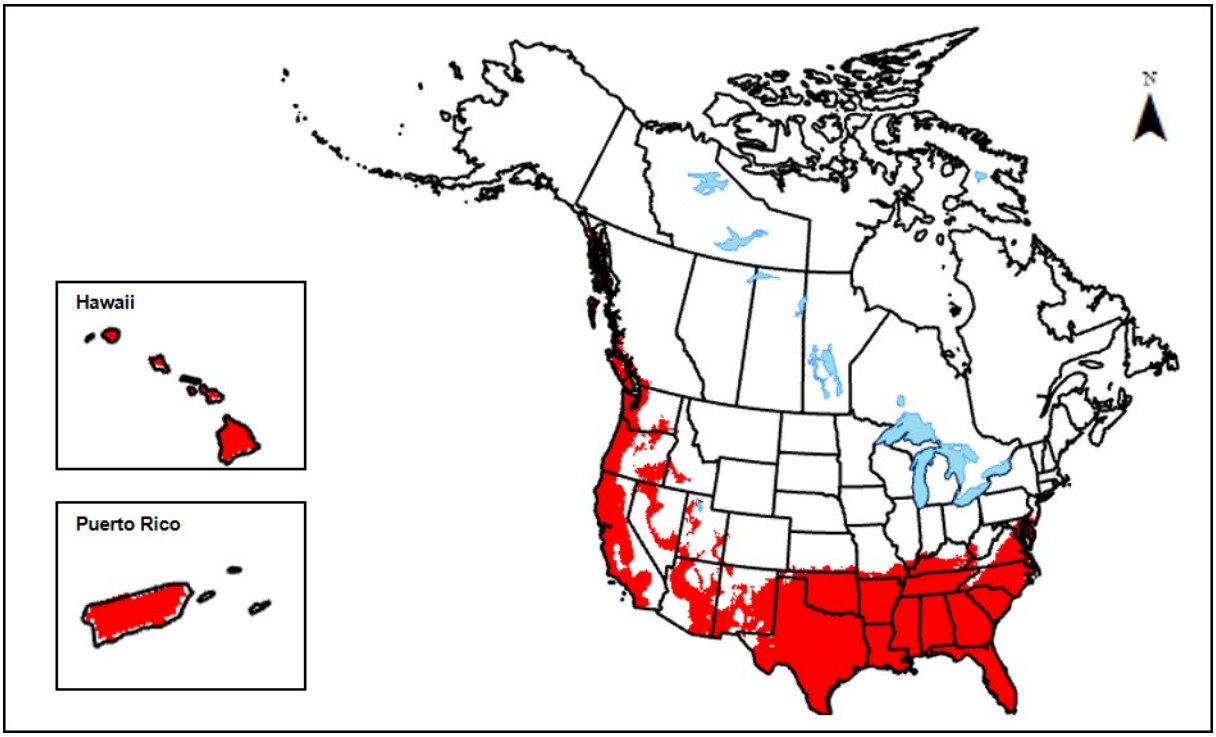

Figure 2. Potential geographic distribution of *Ageratum conyzoides* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

ENTRY POTENTIAL

Ageratum conyzoides is already present in the United States, where it is native to Puerto Rico and the U.S. Virgin Islands (NGRP, 2018) and has become naturalized in some states (NRCS, 2018). It has been reported in about a dozen counties across 12 states (Alabama, California, Connecticut, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, Missouri, and North Carolina) (EDDMapS, 2018; Kartesz, 2018; NRCS, 2018; Swearingen and Bargeron, 2018). Based on our analysis, we determined that this species has a relatively high likelihood of entering other areas of the United States. On a scale of 0 to 1, where 1 represents the maximum likelihood of entry, *A. conyzoides* scored 0.70. Our evaluation resulted in a high score because of the evidence that it is readily dispersed by people through trade and agricultural activities (Johnson, 1971; Clifford, 1959; Singh, 2002). While *A. conyzoides* is not commonly cultivated in the United States, we did find one herb seed supplier in Alabama selling it (Sand Mountain Herbs, 2018); seeds are also available from some foreign vendors on eBay (eBay, 2018).

Risk score = 0.70 Uncertainty index = 0.21

4. Predictive Risk Model Results

Model Probabilities: P(Major Invader) = 95.2%
P(Minor Invader) = 4.7%
P(Non-Invader) = 0.2%
Risk Result = High Risk
Secondary Screening = Not Applicable

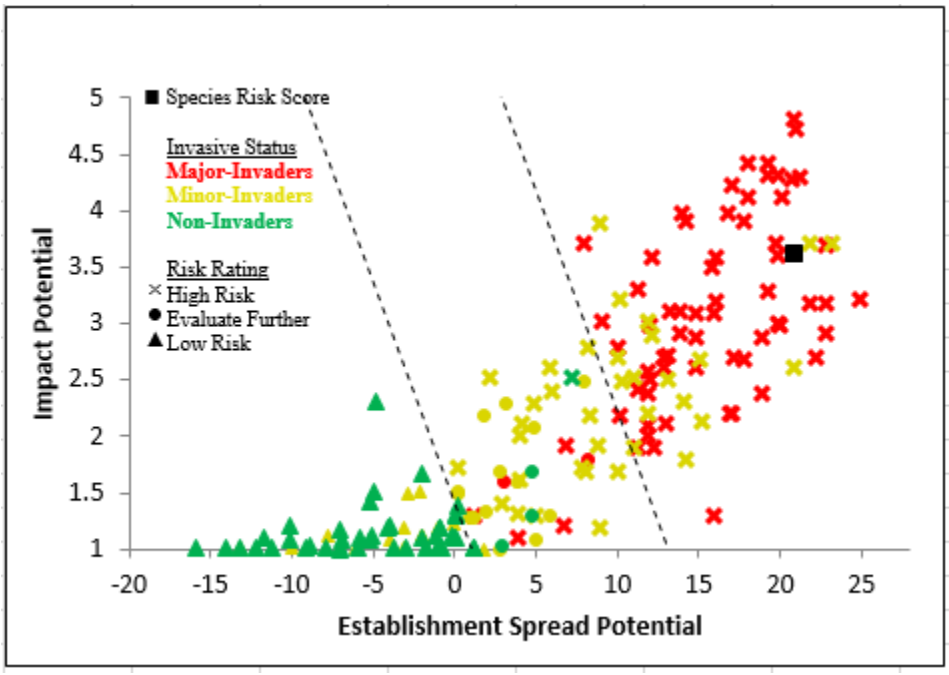

Figure 3. *Ageratum conyzoides* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

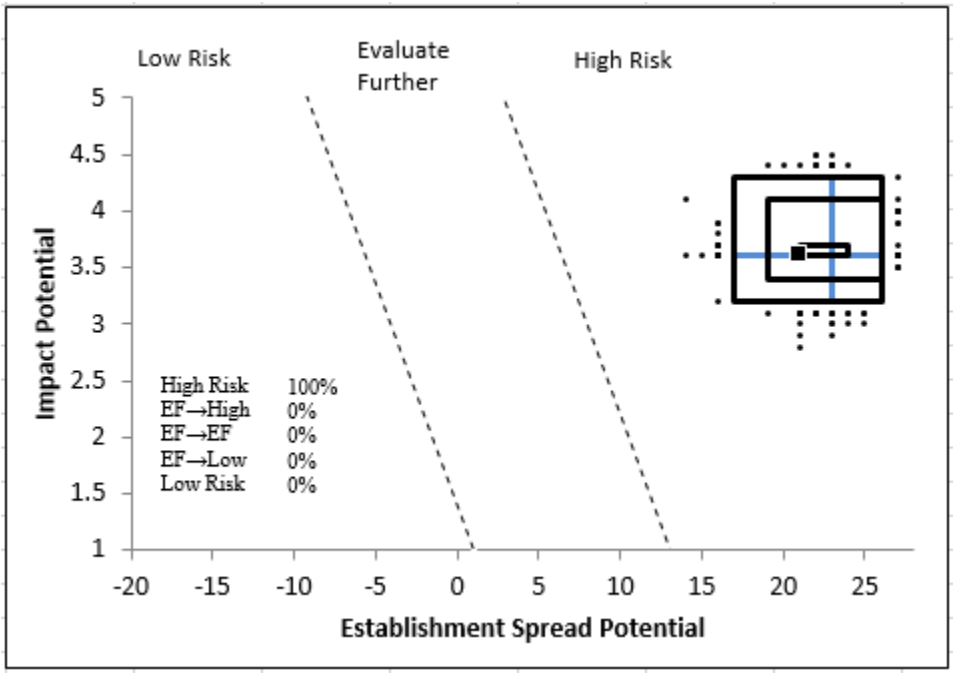

Figure 4. Model simulation results (N=5,000) for uncertainty around the risk score for *A. conyzoides.* The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

5. Discussion

The result of the weed risk assessment for *A. conyzoides* is High Risk (Fig. 3), and this is well-supported by the results of our uncertainty simulation (Fig. 4). *Ageratum conyzoides* is an annual herb that has demonstrated a strong ability to establish and spread. It is readily spread by wind, water, and animals and as a hitchhiker on cars, equipment, and commodities. It has become widely naturalized beyond its native range and readily spreads due to prolific reproduction and multiple dispersal mechanisms. Seeds are small, about 3.4 mm long by 0.33 mm wide, and have a pappus that helps them attach to surfaces. This species is widely considered a weed of agricultural, anthropogenic, and natural areas, where it rapidly colonizes and forms dense thickets. It has been reported as a significant weed of chickpea, rice, maize, sugarcane, wheat, and other crops. *Ageratum conyzoides* is allelopathic. It is controlled mechanically and chemically, but the species is reported to have developed some herbicide resistance.

6. Acknowledgements

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SUGGESTED CITATION

PPQ. 2019. Weed risk assessment for *Ageratum conyzoides* L. (Asteraceae) – Billygoat plant. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC. 26 pp.

DOCUMENT HISTORY

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7. Literature Cited

7 CFR § 360. 2018. Code of Federal Regulations, Title 7, Part 360, (7 CFR §360 - Noxious Weed Regulations). Office of the Federal Register, National Archives and Records Administration, Washington, DC.

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.

Akter, A., and M. Zuberi. 2009. Invasive alien species in Northern Bangladesh: identification, inventory and impacts. International Journal of Biodiversity and Conservation 1(5):129-134.

AMS. 2018. State Noxious-Weed Seed Requirements Recognized in the Administration of the Federal Seed Act. United States Department of Agriculture, Agricultural Marketing Service (AMS), Gastonia, NC. 122 pp.

APHIS. 2018. 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).

Bailey Nurseries. 2018. Bailey Nurseries. Last accessed May 29, 2018, http://www.baileynurseries.com/imagelibrary/gallery.

Baker, H. G. 1972. Human influences on plant evolution. Economic Botany 26(1):32-43.

Bane, A., T. Seboxa, G. Mesfin, A. Ali, Y. Tsegaye, M. Tensae, S. Selassie, and T. Haile. 2012. An outbreak of veno-occlusive liver disease in northern Ethiopia, clinical findings. Ethiopian Medical Journal 50(2):9-16.

Barua, I., J. Deka, and M. Devi. 2013. Invasive weeds and vegetation dynamics in Assam. Weed Science Society Conference October 22-25, 2013, Bandung, Indonesia.

Batish, D. R., R. K. Kohli, H. P. Singh, and D. B. Saxena. 1997. Studies on herbicidal activity of parthenin, a constituent of *Parthenium hysterophorus*, towards billgoat weed (*Ageratum conyzoides*). Current Science 73(4):369-371.

Batish, D. R., H. P. Singh, S. Kaur, and R. K. Kohli. 2006. Phytotoxicity of *Ageratum conyzoides* residues towards growth and nodulation of *Cicer arietinum*. Agriculture, ecosystems & environment 113(1-4):399-401.

Boj˘nanský, V., and A. Fargašová. 2007. Atlas of seeds and fruits of Central and East-European flora: the Carpathian Mountains region. Springer Science & Business Media, Dordrecht, Netherlands 1046 pp.

Burrows, G. E., and R. J. Tyrl. 2012. Toxic Plants of North America. John Wiley & Sons.

CABI. 2018. Crop Protection Compendium. Commonwealth Agricultural Bureau International (CABI). http://www.cabi.org. (Archived at PERAL).

Cao, M., Y. Tang, C. Sheng, and J. Zhang. 2000. Viable seeds buried in the tropical forest soils of Xishuangbanna, SW China. Seed Science Research 10(3):255-264.

Chauhan, B. S., and D. E. Johnson. 2009. Influence of tillage systems on weed seedling emergence pattern in rainfed rice. Soil and Tillage Research 106(1):15-21.

Clifford, H. 1959. Seed dispersal by motor vehicles. Journal of Ecology 47(2):311-315.

Coffey, E. E., C. A. Froyd, and K. J. Willis. 2011. When is an invasive not an invasive? Macrofossil evidence of doubtful native plant species in the Galápagos Islands. Ecology 92(4):805-812.

Cullen, J., S. G. Knees, and H. S. Cubey. 2011. The European Garden Flora, Flowering Plants: A Manual for the Identification of Plants Cultivated in Europe, Both Out-of-Doors and Under Glass. Cambridge University Press, Cambridge.

Dave's Garden. 2018. Plant files database. Dave's Garden. https://davesgarden.com/guides/pf/go/54661/. (Archived at PERAL).

DeBaggio's Herb Farm and Nursery. 2018. DeBaggio's Herb Farm and Nursery, Growers of Quality Herb, Vegetable, and Ornamental Plants Since 1975. Last accessed May 29, 2018, http://www.debaggioherbs.com/index.html.

Dogra, K., R. Kohli, S. K Sood, and P. Dobhal. 2009. Impact of *Ageratum conyzoides* L. on the diversity and composition of vegetation in the Shivalik hills of Himachal Pradesh (Northwestern Himalaya), India. International Journal of Biodiversity and Conservation 1(4):135-145.

eBay. 2018. Listings Database. http://www.ebay.com/. (Archived at PERAL).

EDDMapS. 2018. Early Detection & Distribution Mapping System (EDDMapS). The University of Georgia - Center for Invasive Species and Ecosystem Health. http://www.eddmaps.org/. (Archived at PERAL).

Ekeleme, F., F. Forcella, D. W. Archer, I. O. Akobundu, and D. Chikoye. 2005. Seedling emergence model for tropic *Ageratum* (*Ageratum conyzoides*). Weed Science 53(1):55-61.

GBIF. 2018. Global Biodiversity Information Facility (GBIF). http://data.gbif.org/welcome.htm. (Archived at PERAL).

Go Botany. 2018. *Ageratum conyzoides* L. tropical whiteweed. New England Wild Flower Society. https://gobotany.newenglandwild.org/. (Archived at PERAL).

Gopinathan, K., R. Varatharajan, and T. Ananthakrishnan. 1981. Incidence of *Microcephalothrips abdominalis* (Crawford) (Thysanoptera: Insecta) in relation to the pollination biology of the weed *Ageratum conyzoides* Linn. (Compositae).

Greuter, W. 2006. Occurrence details for *Ageratum conyzoides*. Euro+Med Plantbase. http://ww2.bgbm.org/EuroPlusMed/query.asp. (Archived at PERAL).

Guerrero, A. M., and A. Tye. 2009. Darwin's Finches as Seed Predators and Dispersers. The Wilson Journal of Ornithology 121(4):752-764.

Hao, J. H., S. Qiang, T. Chrobock, M. van Kleunen, and Q. Q. Liu. 2011. A test of Baker's law: breeding systems of invasive species of Asteraceae in China. Biological Invasions 13(3):571-580.

Heap, I. 2018. 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, Florida, U.S.A. 391 pp.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds: Distribution and Biology. Krieger Publishing Company, Malabar, Florida. 610 pp.

Imada, C. T. 2012. Hawaiian native and naturalized vascular plants checklist. Bishop Museum, Honolulu, Hawaii.

IPPC. 2016. 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. 16 pp.

IPPC. 2017. 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. 34 pp.

Johnson, M. F. 1971. A Monograph of the Genus *Ageratum* L. (Compositae-Eupatorieae). Annals of the Missouri Botanical Garden 58(1):6-88.

Joseph, I. I., G. Arsène, T. Awa, and K. N. Joseph. 2017. Seed viability and emergence depths of *Ageratum conyzoides* L. (Asteraceae). American Journal of Agricultural Research 2(7):1-6.

Kartesz, J. 2018. The Biota of North America Program (BONAP). Taxonomic Data Center. . http://bonap.net/tdc. (Archived at PERAL).

Kato-Noguchi, H. 2001. Assessment of the allelopathic potential of *Ageratum conyzoides*. Biologia Plantarum 44(2):309-311.

Kaul, M., and Neelangini. 1989. Male sterility in diploid *Ageratum conyzoides* L. Cytologia 54(3):445-448.

Kaur, S., D. R. Batish, and R. Kohli. 2012. *Ageratum conyzoides*: an alien invasive weed in India. Pages 57-76 *in* J. R. Bhatt, J. S. Singh, S. P. Singh, R. S. Tripathi, and R. K. Kohli, (eds.). Invasive Alien Plants: An Ecological Appraisal for the Indian Subcontinent. CABI Publishing.

Keener, B. R., A. R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. Alabama Plants Atlas. University of West Alabama http://www.floraofalabama.org/Default.aspx. (Archived at PERAL).

Kleiman, R., E. D. Rentz, E. Teshale, N. Thompson, and H. Schurz-Rogers. 2008. Update on research and activities at the centers for disease control and prevention, and the agency for toxic substances and disease registry. Journal of Medical Toxicology 4(3):197-200.

Kohli, R. K., D. R. Batish, H. P. Singh, and K. S. Dogra. 2006. Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Lantana camara* L.) in India. Biological Invasions 8(7):1501-1510.

Kohli, R. K., K. S. Dogra, D. R. Batish, and H. P. Singh. 2004. Impact of invasive plants on the structure and composition of natural vegetation of northwestern Indian Himalayas. Weed Technology 18(sp1):1296-1300.

Kong, C., F. Hu, T. Xu, and Y. Lu. 1999. Allelopathic potential and chemical constituents of volatile oil from *Ageratum conyzoides*. Journal of Chemical Ecology 25(10):2347-2356.

Kong, C., F. Hu, and X. Xu. 2002. Allelopathic potential and chemical constituents of volatiles from *Ageratum conyzoides* under stress. Journal of Chemical Ecology 28(6):1173-1182.

Kong, C., F. Hu, X. Xu, W. Liang, and C. Zhang. 2004. Allelopathic Plants. *Ageratum conyzoides* L. Allelopathy Journal 14(1):1-12.

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.

Lusweti, A., E. Wabuyele, P. Ssegawa, and J. R. Mauremootoo. 2011. Invasive plants of East Africa (Kenya, Uganda and Tanzania), Lucid v. 3.5 key and fact sheets. National Museums of Kenya, Makerere University, BioNET-EAFRINET, CABI & The University of Queensland http://keys.lucidcentral.org/keys/v3/eafrinet/index.htm. (Archived at PERAL).

Mabberley, D. J. 2008. Mabberley's Plant-Book: a portable dictionary of plants, their classifications and uses (3rd Edition). Cambridge University Press, New York. 1021 pp.

Manandhar, S., B. B. Shrestha, and H. D. Lekhak. 2007. Weeds of paddy field at Kirtipur, Kathmandu. Scientific World 5(5):100-106.

Marks, M., and A. Nwachuku. 1986. Seed-bank characteristics in a group of tropical weeds. Weed Research 26(3):151-158.

Martin, P., and J. 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(1):91-100.

Ming, L. C. 1999. *Ageratum conyzoides*: A tropical source of medicinal and agricultural products. Pages 469-473 *in* J. Janick, (ed.). Perspectives on New Crops and New Uses. ASHS Press, Alexandria, VA.

Molyneux, R., D. Gardner, S. Colegate, and J. Edgar. 2011. Pyrrolizidine alkaloid toxicity in livestock: a paradigm for human poisoning? Food Additives & Contaminants: Part A 28(3):293-307.

Motooka, P., L. Castro, D. Nelson, G. Nagai, and L. Ching. 2003. Weeds of Hawaii's Pastures and Natural Areas; An Identification and Management Guide. College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa.

Negi, P., and P. Hajra. 2007. Alien flora of Doon Valley, Northwest Himalaya. Current Science 92(7):968-978.

Ngongolo, K., S. Mtoka, A. Mahulu, and K. Mafuwe. 2014. Floral visitors of the *Ageratum conyzoides* in Amani Nature Reserve, Tanzania. International Journal of Development and Sustainability 3(5):1060-1065.

NGRP. 2018. Germplasm Resources Information Network (GRIN). United States National Germplasm System. https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?103793. (Archived at PERAL).

Nickrent, D. 2018. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL, U.S.A. Last accessed July 23, 2018, http://www.parasiticplants.siu.edu/ListParasites.html.

NPB. 2018. Laws and Regulations The National Plant Board (NPB). Last accessed May 21, 2018, http://nationalplantboard.org/laws-and-regulations/.

NRCS. 2018. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. http://plants.usda.gov. (Archived at PERAL).

Okunade, A. L. 2002. *Ageratum conyzoides* L. (Asteraceae). Fitoterapia 73(1):1-16.

Parker, C. 1992. Weeds of Bhutan. Sayce Publishing, St Leonards, Exeter, United Kingdom.

PestID. 2018. Pest Identification Database (PestID). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. https://aqas.aphis.usda.gov/aqas/. (Archived at PERAL).

PIER. 2018. Pacific Island Ecosystems at Risk (PIER). United States Forest Service. http://www.hear.org/pier/ (Archived at PERAL).

Popay, A., T. James, W. Williams, and A. Rahman. 2003. Risk assessments of weed seeds on imported fresh produce. New Zealand Plant Protection 56:1-4.

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.

Queensland Government. 2018. *Ageratum conyzoides* L. Environmental Weeds of Australia for Biosecurity Queensland, Queensland, Australia. Last accessed July 20, 2018, www.biosecurity.qld.gov.au

Randall, R. P. 2007. The introduced flora of Australia and its weed status. CRC for Australian Weed Management, Adelaide, Australia 528 pp.

Randall, R. P. 2017. A Global Compendium of Weeds, 3rd edition. Department of Agriculture and Food, Western Australia, Perth, Australia. 3654 pp.

Sand Mountain Herbs. 2018. Sand Mountain Herbs. Fyffe, Alabama. Last accessed May 21, 2018, http://www.sandmountainherbs.com/index.html.

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

SERNEC Data Portal. 2018. Collections Database. SouthEast Regional Network of Expertise and Collections (SERNEC). http://sernecportal.org/portal/index.php#. (Archived at PERAL).

Sharma, V. 1987. Comments on the identity of *Ageratum conyzoides* L., and *A. houstonianum* Mill.—two naturalized weeds in India. Feddes Repertorium 98(11-12):557-560.

Singh, H., D. Batish, S. Kaur, and R. Kohli. 2003. Phytotoxic interference of *Ageratum conyzoides* with wheat (*Triticum aestivum*). Journal of Agronomy and Crop Science 189(5):341-346.

Singh, S. 2002. Interception of weeds in imported agricultural commodities. Annals of Agricultural Research 22(1):83-87.

Swearingen, J., and C. Bargeron. 2018. Invasive Plant Atlas of the United States. http://www.invasiveplantatlas.org/. (Archived at PERAL).

Univ. of Minn. 2018. Plant Information Online Database. Universtiy of Minnesota. http://plantinfo.umn.edu/search/plants. (Archived at PERAL).

Walker, R. 2018. Parasitic Plants Database. Rick Walker http://www.omnisterra.com/bot/pp_home.cgi. (Archived at PERAL).

Wiedenfeld, H. 2011. Plants containing pyrrolizidine alkaloids: toxicity and problems. Food Additives & Contaminants: Part A 28(3):282-292.

Xuan, T. D., T. Shinkichi, N. H. Hong, T. D. Khanh, and C. I. Min. 2004. Assessment of phytotoxic action of *Ageratum conyzoides* L. (billy goat weed) on weeds. Crop protection 23(10):915-922.

Yadav, P. K., and D. L. Mandal. 2008. Survey on Occurrence and Distribution of Weeds in Tea Lands of Nepal. Agricultural Research For Poverty Alleviation and Livelihood Enhancement, Kathmandu, Nepal.

Appendix A. Weed risk assessment for *Ageratum conyzoides* L. (Asteraceae)

We present 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 in which 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 - negl	5	*Ageratum conyzoides* is native to South and Central America, including Argentina, Chile, Ecuador (Galápagos Islands), El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela (NGRP, 2018; Ming, 1999; Coffey et al., 2011). *Ageratum conyzoides* is considered highly invasive in many parts of the world, especially areas that are experiencing drought conditions (Molyneux et al., 2011). It is considered invasive in India: it was introduced there from tropical America and expanded its range rapidly, especially in agricultural fields, along roadsides, and in gardens (Negi and Hajra, 2007; Kohli et al., 2004; Batish et al., 2006; Kohli et al., 2006). It is a common, pantropical weed that is now naturalized well beyond its native range (Batish et al., 2006; Johnson, 1971) into Southeast Asia (e.g., China, India, and Japan), central Africa (e.g., Burkina Faso, Cameroon, Ethiopia, Nigeria, and Tanzania), Oceania (e.g., Australia, Indonesia, and Papua New Guinea), and some parts of Europe (e.g. Austria, Bulgaria, France, the Netherlands, and Sweden) (NGRP, 2018; GBIF, 2018). It was likely introduced to the United States as an ornamental that later escaped (Kohli et al., 2006; Go Botany, 2018), and it is now listed as invasive in natural areas, including in Haleakala National Park in Hawaii (Swearingen and Bargeron, 2018). The alternate answers for the uncertainty simulation were both "e."
ES-2 (Is the species highly domesticated)	n - low	0	Although this species may be cultivated to a minor extent (Sand Mountain Herbs, 2018), we found no evidence indicating that it is highly domesticated or has been bred for reduced weed potential.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-3 (Significant weedy congeners)	y - negl	1	The genus *Ageratum* includes about 40 American species (Mabberley, 2008; Kong et al., 2004). Based on the Global Compendium of Weeds, only *A. houstonianum* emerges as a significant weed (Randall, 2017). *Ageratum houstonianum* (blue billygoat weed) is reported as a weed of tea, cinchona, and coffee plantations (Yadav and Mandal, 2008) and is categorized as a serious or principal weed in Australia and Thailand (Holm et al., 1979). It is also considered invasive in India, where it is a weed of several crops and of indigenous vegetation and forest ecosystems (Barua et al., 2013).
ES-4 (Shade tolerant at some stage of its life cycle)	n - high	0	*Ageratum conyzoides* tolerates shade (Kaur et al., 2012) but does not germinate as frequently or flourish as well in the shade of forest canopies (Cao et al., 2000). It is a weed of medicinally important herbs in the understory of forests in India (Kohli et al., 2006), but because it is primarily a weed of sunny, disturbed sites and croplands (PIER, 2018), and because it is not clear whether the forests where it is reported have closed or somewhat open canopies, we answered no with high uncertainty.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	*Ageratum conyzoides* is neither a vine nor an herb with a basal rosette. It is an erect annual herb, 30-80 cm tall (Okunade, 2002; Ming, 1999).
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	*Ageratum conyzoides* quickly spreads through stolons (Kohli et al., 2006) and is able to form populations with up to 1000 plants per m² (Ekeleme et al., 2005). "It is an aggressive colonizer that can maintain dense populations" (Kaur et al., 2012).
ES-7 (Aquatic)	n - negl	0	*Ageratum conyzoides* can be found growing along river and canal banks, as well as in swamps and marshy lands (Kaul and Neelangini, 1989). It is not, however, an obligate aquatic plant. It is primarily a plant of disturbed sites and agriculture.
ES-8 (Grass)	n - negl	0	*Ageratum conyzoides* is not a grass; it is an erect, herbaceous annual, in the family Asteraceae (Holm et al., 1979).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	*Ageratum conyzoides* is in the family Asteraceae, which is not one of the families known to contain nitrogen-fixing species (Martin and Dowd, 1990; Santi et al., 2013). Furthermore, it is not a woody plant.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	*Ageratum conyzoides* can produce 5,000-95,000 seeds per plant, and it sheds seeds for five to eight months (Kohli et al., 2006; Ekeleme et al., 2005). Seeds remain viable for one year (Kohli et al., 2006; Ming, 1999).
ES-11 (Self-compatible or apomictic)	y - mod	1	In a study of plant breeding systems, pollinators were excluded from *A. conyzoides* flowers in one experiment, and the anthers and stigmas of several capitula were removed in another. The species was reported to set seed in both experiments (Hao et al., 2011). *Ageratum conyzoides* has been reported in the literature as being

Question ID	Answer - Uncertainty	Score	Notes (and references)
			self-compatible (Hao et al., 2011; Baker, 1972) as being and self-incompatible (Ming, 1999; Kong et al., 2004), and as showing a low degree of apomixis (Hao et al., 2011). Although we found reports of self-incompatibility, we answered yes because the plant breeding study conclusively showed the plants can set seed without pollination.
ES-12 (Requires specialist pollinators)	n - negl	0	*Ageratum conyzoides* is pollinated by a polyphagous thrips, *Microcephalothrips abdominalis* (Gopinathan et al., 1981). A total of 182 visitors were reported visiting *A. conyzoides*, and 92.5 percent of the floral visitors were reported to probe the flowers (Ngongolo et al., 2014). Another study concluded that *A. conyzoides* is self-compatible and also shows a low degree of apomixis (Hao 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 - mod	1	*Ageratum conyzoides* is an annual herb (Okunade, 2002; Kohli et al., 2006) with a life span of one year (Baker, 1972). It also spreads quickly through stolons (Kohli et al., 2006). Although we found no specific evidence indicating the possibility of multiple generations per year from vegetative reproduction, we chose both alternate answers as 'a,' as this may be occurring.
ES-14 (Prolific seed producer)	y - low	1	*Ageratum conyzoides* can produce 5,000-95,000 seeds per plant and is able to form populations with up to 1000 plants per m² (Kohli et al., 2006; Ekeleme et al., 2005). Approximately 50 percent of seeds will germinate shortly after they are shed (Holm et al., 1977), and generally less than 50 percent of the seeds of this plant remain viable after one year of soil burial (Joseph et al., 2017).
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	Seeds are dispersed on the tires of machinery and vehicles (Clifford, 1959). *Ageratum conyzoides* seeds easily attach to fibers, clothing, and fur, resulting in passive transportation (Johnson, 1971).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - low	2	*Ageratum conyzoides* is a contaminant of seeds and grain moving in trade (Lusweti et al., 2011; CABI, 2018; Molyneux et al., 2011).
ES-17 (Number of natural dispersal vectors)	3	2	Fruit and seed descriptions for questions ES-17a through ES-17e: *Ageratum conyzoides* has a typical achene fruit with pappus and is easily spread by wind and water and on animals. Seeds are small and extremely lightweight (Kaur et al., 2012).
ES-17a (Wind dispersal)	y - negl		Wind is an important means of seed dispersal (Johnson, 1971). The fruit is an achene with an aristate pappus (stiff, bristle-like tip) which is easily disseminated by wind (Kohli et al., 2006; Ming, 1999; Kaur et al., 2012).
ES-17b (Water dispersal)	y - negl		*Ageratum conyzoides* produces a large number of seeds which are easily disseminated by water (Kohli et al., 2006; Johnson, 1971; Holm et al., 1977). Seeds are small and extremely lightweight, and the achene has a

Question ID	Answer - Uncertainty	Score	Notes (and references)
			pappus, all of which would aid in dispersal via water (Kaur et al., 2012; Kohli et al., 2006).
ES-17c (Bird dispersal)	? - max		The small ground finch (*Geospiza fuliginosa*) in Santa Cruz was reported to crush and eat *A. conyzoides* seeds. This finch species has been reported to pass viable seeds of several species, but *A. conyzoides* was not recorded in the study (Guerrero and Tye, 2009). Seeds are very small and contain a pappus that easily attaches to fur, hair, and fibers (Kohli et al., 2006; Johnson, 1971) and could likely attach to feathers; however, we have no direct reports of this.
ES-17d (Animal external dispersal)	y - negl		*Ageratum conyzoides* seeds easily attach to fur and are passively transported externally on animals (Kohli et al., 2006; Johnson, 1971).
ES-17e (Animal internal dispersal)	n - low		We found no evidence of viable seeds dispersed internally by animals. Livestock is reported to not feed on this species, as it is toxic and causes ulceration (Kaur et al., 2012).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - mod	1	Seeds are viable for only one year (Kohli et al., 2006; Ming, 1999), but as this species is common in cultivation and urban areas, seeds are able to build up and maintain large populations of the plant (Marks and Nwachuku, 1986). Generally, less than 50 percent of the seed of this plant remains viable after one year of soil burial. Viable seed proportions for this species vary according to depths of burial. In a seed burial experiment, seeds buried at depths of 2.5 cm and 10 cm resulted in 28 percent and 26.5 percent viable seeds, respectively. Seeds buried at a depth of 5 cm resulted in the highest rate of viable seeds at 43 percent. The highest growth of seedlings (75%) were observed at the soil surface (Joseph et al., 2017).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	n - high	-1	We found no evidence that this species is tolerant or resistant to mutilation. *Ageratum conyzoides* is a shallow-rooted plant that is easily removed when found in small quantities (Kohli et al., 2006), suggesting tillage would likely manage this species in some agricultural settings (Chauhan and Johnson, 2009).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	y - negl	1	This species is reported to have developed resistance to B/2 herbicides in 2013 in Brazil, allowing it to infest cotton and soybean. "B/2 herbicides are known as ALS inhibitors (Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)" (Heap, 2018).
ES-21 (Number of cold hardiness zones suitable for its survival)	5	0	(Notes not required)
ES-22 (Number of climate types suitable for its survival)	6	2	(Notes not required)
ES-23 (Number of precipitation bands suitable for its survival)	11	1	(Notes not required)

Question ID	Answer - Uncertainty	Score	Notes (and references)
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	y - negl	0.1	Multiple studies have reported that *A. conyzoides* produces allelopathic chemicals (Kohli et al., 2006; Okunade, 2002; Batish et al., 2006; Kato-Noguchi, 2001). In a laboratory study, *A. conyzoides* inhibited the growth of several plant species, suggesting that it may produce allelochemicals (Kato-Noguchi, 2001; Xuan et al., 2004). Multiple phenolic compounds and putative allelochemicals have been found in the leaves, stems, and roots of *Ageratum conyzoides* (Xuan et al., 2004). In several field studies, *A. conyzoides* weed residues in the soil significantly reduced plant growth, suggesting phytotoxic phenolics in the residues (Batish et al., 2006; Kong et al., 1999; Kong et al., 2002).
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that *A. conyzoides* is parasitic. It does not belong to a family known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2018; Walker, 2018).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - mod	0	We found no evidence that *A. conyzoides* changes ecosystem processes and parameters.
Imp-N2 (Changes habitat structure)	y - negl	0.2	*Ageratum conyzoides* outcompetes native grasses (Kohli et al., 2006). It is a serious invader of the medicinally and aromatically important herbal understory of forests in India and greatly threatens the abundance and diversity of these herbal species by forming large monotypic mounds (Kaur et al., 2012; Kohli et al., 2006).
Imp-N3 (Changes species diversity)	y - negl	0.2	When introduced in rangelands, it outcompetes native grasses (Kohli et al., 2006). *Ageratum conyzoides* affects native species by releasing phenolic acids and volatile oils from its leaves and flowers (Kohli et al., 2006; Okunade, 2002; Batish et al., 2006). Kohli et al. (2004) observed a 50 to 64 percent loss in diversity and density of native flora in the Northwestern Indian Himalayas.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - high	0.1	*Ageratum conyzoides* is primarily a weed of disturbed sites and agricultural areas, where it would likely not affect Federally threatened or endangered species; however, it has been reported to outcompete herbal species in forest communities (Kohli et al., 2006). Dogra (2009) reports a 20 percent decline in populations of valuable indigenous medicinal plants (*Achyranthes aspera, Trifolium repens, Centella asiatica, Ziziphus jujuba, Adhatoda vasica*) in the Shivalik hills of Himachal Pradesh, India after the invasion of *Ageratum conyzoides* (Dogra et al., 2009). It forms dense stands, excluding other species, and has been reported to change species diversity (see evidence under Imp-N2 and Imp-N3). We answered 'yes' with high uncertainty because it is most likely to be found as a weed along roadsides, in other disturbed areas, and in agriculture but has impacts in natural areas.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - high	0	*Ageratum conyzoides* is primarily a weed of disturbed sites and agricultural areas.
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]	c - low	0.6	*Ageratum conyzoides* is considered an environmental weed in eastern Queensland (Queensland Government, 2018). It is listed as invasive in natural areas, including Haleakala National Park in Hawaii (Swearingen and Bargeron, 2018). In South Africa, *A. conyzoides* was introduced as an ornamental plant and has since escaped and become invasive in many places, including reserves and protected areas like Kruger National Park (Kaur et al., 2012). It is a difficult weed to control (Ming, 1999). The soil can be contaminated with allelochemicals after removal of the plant (Kohli et al., 2006). As a shallow rooter it is easy to remove by hand at low densities, but this is not realistic when large areas are covered. A wide range of herbicides (atrazine, alachlor, paraquat, glyphosate, and simazine) are available for its control (Kohli et al., 2006; Batish et al., 1997). The 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 - negl	0	We found no evidence of *A. conyzoides* impacting personal property, human safety, or public infrastructure.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	The pungent oil released from *A. conyzoides* can cause giddiness, nausea, and sometimes allergic reactions in humans (Kohli et al., 2006); however, we found no evidence that this property deters people from using an area infested with these plants.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - low	0	We found no evidence that *A. conyzoides* negatively affects ornamental plants and vegetation. *Ageratum conyzoides* has been used a garden ornamental (Negi and Hajra, 2007; Kaur et al., 2012; Kohli et al., 2006 Go Botany, 2018).
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a)	b - mod	0.1	*Ageratum conyzoides* was introduced from tropical America to India and spread rapidly along roadsides

Question ID	Answer - Uncertainty	Score	Notes (and references)
Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]			and forest edges and in gardens (Negi and Hajra, 2007). It has been collected on the campus of Panjab University, Chandigarh, India (Singh et al., 2003). The literature reports this species as being easily removed by hand at low densities, and a number of herbicides are available for its control (Kohli et al., 2006; Batish et al., 1997, Singh, 2002), Alternate answers for the uncertainty simulation were both "c" because while there is evidence of control efforts, that are not specific to anthropogenic systems.
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - negl	0.4	*Ageratum conyzoides* invades agricultural fields and interferes with crops. It causes yield reductions in major staple crops in India, such as wheat, corn, and rice (Kohli et al., 2006; Batish et al., 2006). Manandhar et al. (2007) report reductions in rice (25-47 percent) and straw (13-38 percent) yields due to *A.conyzoides* (Manandhar et al., 2007).
Imp-P2 (Lowers commodity value)	n - low	0	We found no evidence that *A. conyzoides* reduces commodity value.
Imp-P3 (Is it likely to impact trade?)	y - negl	0.2	*Ageratum conyzoides* is a contaminant of seeds and grain moving in trade (Lusweti et al., 2011; CABI, 2018; Molyneux et al., 2011), is listed as a noxious weed in Australia (Randall, 2007), and is regulated by New Zealand (APHIS, 2018).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - low	0	We found no evidence that *A.conyzoides* affects the quality or availability of irrigation or strongly competes with plants for water.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - negl	0.1	*Ageratum conyzoides* contains 1,2-dehydropyrrolizidine ester alkaloids (dehydroPAs), which cause livestock poisoning, primarily by damaging the liver (Molyneux et al., 2011; Burrows and Tyrl, 2012).
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	*Ageratum conyzoides* is a weed in agricultural fields and interferes with crops. It causes yield reductions in major staple crops in India, such as wheat, corn, and rice (Kohli et al., 2006; Batish et al., 2006; Kaur et al., 2012). It is reported as an aggressive weed that is difficult to control (Ming, 1999; Singh et al., 2003). A wide range of herbicides have been used to control *A. conyzoides* in major crops. Bentazone, butachlor, 2,4-D, MCPA (2-methyl-4-chlorophenoxyacetic acid), and oxidiazon provide effective control in rice; nicosulphuron and acetochlor are used in maize; and cyanazine, metolachlor, metribuzin and cinmethylin are used in soybean (CABI, 2018). Alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2018).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that this species occurs in this Zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that this species occurs in this Zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that this species occurs in this Zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that this species occurs in this Zone.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence that this species occurs in this Zone.
Geo-Z6 (Zone 6)	n - negl	N/A	Three points, all under greenhouse cultivation in Delaware.
Geo-Z7 (Zone 7)	y - high	N/A	5 points in Bolivia, 4 points in Sweden (preserved specimens, not clear if these are real observations), 2 points in Connecticut (old records from wastelands, probably not established), 2 points in France, and 1 point each in Argentina and China.
Geo-Z8 (Zone 8)	y - low	N/A	Some points in Taiwan; 10 points in Bolivia; a few points in China, Colombia (mountainous region), and Mexico; 3 points in South Africa; and 2 points in Japan.
Geo-Z9 (Zone 9)	y - negl	N/A	Brazil; some points each in Argentina, Australia, Paraguay and South Africa; and a few points in Mexico.
Geo-Z10 (Zone 10)	y - negl	N/A	Australia, Brazil, and some points in Argentina and Paraguay.
Geo-Z11 (Zone 11)	y - negl	N/A	Australia, Benin, and Brazil.
Geo-Z12 (Zone 12)	y - negl	N/A	Brazil, Nicaragua, and Tanzania.
Geo-Z13 (Zone 13)	y - negl	N/A	Brazil, Costa Rica, and El Salvador.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Colombia, Costa Rica, Guyana, and Papua New Guinea.
Geo-C2 (Tropical savanna)	y - negl	N/A	Australia and Brazil. Two points in Mexico.
Geo-C3 (Steppe)	y - negl	N/A	Some points in Ethiopia; a few points in Tanzania; 3 points each in Burkina Faso and Nigeria; 2 points each in Australia, Cameroon, and Mexico.
Geo-C4 (Desert)	n - mod	N/A	Few points in Tanzania, and 1 point each in South Africa and Sudan. Because these records may be in protected microhabitats not representative of the broader region, we answered no.
Geo-C5 (Mediterranean)	y - high	N/A	Some points in Ethiopia; a few points in Colombia and Ecuador; and 1 point each in Australia, Kenya, and South Africa. Based on the number of points, we answered yes; however, we have high uncertainty as to whether this species could grow throughout this climate class. It may only occur in Mediterranean zones located close to tropical zones.
Geo-C6 (Humid subtropical)	y - negl	N/A	Argentina, Australia, Brazil, China, and Paraguay.
Geo-C7 (Marine west coast)	y - negl	N/A	Some points in Bolivia, Brazil, China, Colombia, Ecuador, Mexico, and Peru. Two points in India and 1 point in Nepal.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C8 (Humid cont. warm sum.)	n - negl	N/A	Two points in Missouri (found in greenhouse cultivation) and 2 points in Connecticut.
Geo-C9 (Humid cont. cool sum.)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - high	N/A	Some points in Brazil and 1 point each in Africa, Botswana, Senegal, and Sudan. In this range, the species is probably limited to wetter microhabitats.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Brazil and throughout central Africa, which includes this precipitation band.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Australia, Brazil, and throughout central Africa.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Australia, Brazil, and throughout central Africa.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Australia, Brazil, and throughout central Africa.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Australia, Brazil, Central America, and throughout central Africa.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Brazil, Central America, throughout central Africa, and some in Australia.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Brazil, Central America, throughout central Africa, and some in Australia.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Brazil, Central America, and throughout central Africa.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Brazil, Central America, and throughout central Africa.
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Central America, Costa Rica, Colombia, Papua New Guinea, and throughout central Africa.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	*Ageratum conyzoides* is native to Puerto Rico and the U.S. Virgin Islands (NRCS, 2018). It has become naturalized in North America and is currently distributed in about a dozen counties in 12 states (Alabama, California, Connecticut, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, Missouri, and North Carolina) (Kartesz, 2018; NRCS, 2018; Swearingen and Bargeron, 2018). In order to assess the entry potential of this species, we set this answer to no.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - negl	0	We found no evidence that that species is proposed for import into the United States.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-3 [Human value & cultivation/trade status: (a) Neither cultivated or positively valued; (b) Not cultivated, but positively valued or potentially beneficial; (c) Cultivated, but no evidence of trade or resale; (d) Commercially cultivated or other evidence of trade or resale]	d - mod	0.5	*Ageratum conyzoides* is occasionally cultivated in Europe (Cullen et al., 2011; Johnson, 1971; Greuter, 2006). It has been cultivated in Fiji and Australia and is now reported to have escaped and become invasive in several habitats (Kaur et al., 2012). This species is not commonly cultivated in the United States. It is available from one herb distributor in Alabama (Sand Mountain Herbs, 2018); seeds are also available from some foreign vendors on eBay (eBay, 2018). *Ageratum conyzoides* is sometimes confused with *Ageratum houstonianum*, which is widely sold as an ornamental (Sharma, 1987; Queensland Government, 2018). We had moderate uncertainty because of the confusion with a species that is regularly sold as an ornamental in the United States.
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - negl		*Ageratum conyzoides* is native to South and Central America, including El Salvador, Guatemala, Honduras, Nicaragua, Panama, Venezuela, Peru, Argentina, Chile, Paraguay, Uruguay, Ecuador, and Mexico (NGRP, 2018; Ming, 1999; Coffey et al., 2011; Johnson, 1971). The species has a pantropical distribution and is now found in Asia, Africa, North America, Central America, the Caribbean, South America, Europe, and Oceania (GBIF, 2018).
Ent-4b (Contaminant of plant propagative material (except seeds))	? - max		We found no evidence of *Ageratum conyzoides* as a contaminant of propagative plant material.
Ent-4c (Contaminant of seeds for planting)	y - mod	0.08	*Ageratum conyzoides* is thought to have been introduced as a contaminant in garden plant seeds in Africa (Lusweti et al., 2011).
Ent-4d (Contaminant of ballast water)	n - mod	0	We found no evidence that *A. conyzoides* propagules spread in ballast water.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - low	0	We found no evidence of *A. conyzoides* as a contaminant of aquarium plants or other aquarium products. This species is not likely to be found with aquatic plants or materials.
Ent-4f (Contaminant of landscape products)	n - high	0	We found no evidence of *A. conyzoides* as a contaminant of imported landscape products. CABI (2018) reports that seeds can easily be transported in soil and have been found as contaminants of garden waste, but we found no additional evidence in the literature.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	y - mod	0.04	Seeds are dispersed on the tires of machinery and vehicles (Clifford, 1959).
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - negl	0.02	The seeds of *A. conyzoides* are found as contaminants in millet and other cereals (Wiedenfeld, 2011). *Ageratum conyzoides* seed has been found on fresh fruit imported to New Zealand (Popay et al., 2003).
Ent-4i (Contaminant of some other pathway)	a - mod	0	We found no evidence that *Ageratum conyzoides* is a contaminant of other pathways.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-5 (Likely to enter through natural dispersal)	y - high	0.06	*Ageratum conyzoides* is found in Mexico (Johnson, 1971) and in the Northern Caribbean (GBIF, 2018). The fruit is an achene with an aristate pappus (stiff, bristle-like tip) and is easily dispersed by wind (Ming, 1999; Kohli et al., 2006; Johnson, 1971). Seeds are minute, about 3.4 mm long by 0.33 mm wide, and extremely light weight. Kaur et al. (2012) report that seeds are transported hundreds or thousands of miles, but we found no direct evidence to support this statement.