United States Department of Agriculture

United States Department of Agriculture

Animal and Plant Health Inspection Service

September 29, 2017

Version 2

Weed Risk Assessment for *Gymnocoronis spilanthoides* (D. Don ex Hook. & Arn.) DC. (Asteraceae) – Senegal tea plant

Top left: Upright stems of *Gymnocoronis spilanthoides* (source: HaWalter Stahel, Environmental Bay of Plenty, Bugwood.org). Bottom left: Horizontal stems of *G. spilanthoides* (source: Robert Vidéki, Doronicum Kft., Bugwood.org). Right: *Gymnocoronis spilanthoides* infestation along a stream in Te Kowhai, Waikato, New Zealand (source: P. Mabin, http://www.weedbusters.co.nz/).

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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/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, 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: *Gymnocoronis spilanthoides* (D. Don ex Hook. & Arn.) DC. (NGRP, 2017).

FAMILY: Asteraceae

SYNONYMS: *Alomia spilanthoides* D. Don ex Hook. & Arn. (NGRP, 2017), *Gymnocoronis attenuata* DC. (NGRP, 2017). Additional synonyms are available from The Plant List (2017).

COMMON NAMES: Senegal teaplant (NGRP, 2017), Senegal tea plant (CRC, 2003), temple plant (NGRP, 2017), water snowball (CABI, 2012).

BOTANICAL DESCRIPTION: *Gymnocoronis spilanthoides* is an emergent aquatic, perennial rhizomatous herb with erect or ascending stems from 1 to 1.5 meters tall (Ardenghi et al., 2016). Stem fragments can root along the nodes (Timmins and Mackenzie, 1995). Leaves are opposite and 7.5 to 18 cm long (Ardenghi et al., 2016). Flowers are white to yellowish, and like most asters, borne on flowering heads called capitula (Ardenghi et al., 2016). Fruit are ribbed, ellipsoid achenes (i.e., seeds) that are 0.8 – 2 mm long, 0.5 mm wide, and without a crown or pappus (Ardenghi et al., 2016; Panetta, 2010; Parsons and Cuthbertson, 2001). For a more detailed description, see Ardenghi et al. (2016).

INITIATION: The Plant Epidemiology and Risk Analysis Laboratory (PERAL) originally evaluated this species in 2012 in response to a request by PPQ's National Weeds Program Manager, Al Tasker. Then in 2016, there was a notification that this species had become naturalized in a new country, Italy, for the first time (Ardenghi et al., 2016). PPQ's Weeds Cross-Functional Working Group requested that PERAL revise the original weed risk to incorporate any new information that may have been recently published on this species.

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

FOREIGN DISTRIBUTION: *Gymnocoronis spilanthoides* is native to South America, in Argentina, Bolivia, Brazil, Paraguay, Peru, and Uruguay (GBIF, 2017; NGRP, 2017). Relative to other *Gymnocoronis* species reported to be present in Mexico and Central America, *G. spilanthoides* is reported to be restricted to South America (cited in Tippery et al., 2014). Some sources indicate it is native from Mexico to Argentina (e.g., Parsons and Cuthbertson, 2001), but we found no original work or herbarium specimen (e.g., GBIF, 2017; MBG, 2017) supporting its presence in Mexico or Central America. *Gymnocoronis spilanthoides* has been introduced to and become naturalized in China (Tian-Gang and Yan, 2007), Hungary (Torok et al., 2003), India (Kohli et al., 2012; Sarma and Borah, 2012), Italy (Ardenghi et al., 2016), Japan (Kadono, 2004), Taiwan (Jung et al., 2009), and in Australia and New Zealand (NGRP, 2017). It has also been reported to be present in Senegal (Parsons and Cuthbertson, 2001). It was most recently detected in Zerbolò, Italy in 2015 in an irrigation canal, and

[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).

further surveys found it distributed throughout the local irrigation network (Ardenghi et al., 2016). *Gymnocoronis spilanthoides* is imported into European countries by the aquarium trade (Brunel, 2009) and probably became established in Italy via this pathway (Ardenghi et al., 2016). This species has been traded worldwide as an aquarium and pond plant since the 1960's (Ardenghi et al., 2016). In Hungary, the northernmost point in its global range, *G. spilanthoides* is restricted to a lake supplied by a hot water spring (Ardenghi et al., 2016). In 2012, the European Plant Protection Organization placed it on an observation list of invasive alien plants (EPPO, 2017; Hussner, 2012). Recently, *G. spilanthoides* was prioritized for pest risk analysis in Europe to determine whether it should be regulated under a European Union regulation for the prevention and management of the introduction and spread of invasive alien species (Tanner et al., 2017). This species is considered invasive wherever it has been introduced (Ardenghi et al., 2016; Kaneko, 2012; Torok et al., 2003), and is regulated in Australia (The University of Queensland, 2017), New Zealand (Timmins and Mackenzie, 1995), Japan (Kaneko, 2012), and the Republic of Korea (APHIS, 2017b).

U.S. DISTRIBUTION AND STATUS: *Gymnocoronis spilanthoides* is cultivated in the United States by aquarium and pond hobbyists (APC, 2017; Aquarium Plants, 2017; Florida Aquatic Nurseries, 2017), and is commercially available for retail (e.g., Amazon, 2017; Aquarium Plants, 2017). We found one eBay vendor who offers to ship plants of this species from Spain to the United States (eBay, 2017). We found no evidence that *G. spilanthoides* has escaped or become naturalized in the United States (e.g., EDDMapS, 2017; Kartesz, 2017; NRCS, 2017). In 2016, it was evaluated by the California Department of Food and Agriculture (CDFA) and found to present a High pest risk potential to the state and given a pest rating of “A” (Randhawa, 2016), which effectively prohibits its import and use in state commerce (Kelch, 2017). CDFA will formally list this species as a state noxious weed in the near future (Kelch, 2017). The Oregon Department of Agriculture lists this species as a target for early detection and rapid response (ODA, 2007). We found no other evidence that this species is regulated as a noxious weed in the United States (e.g., NPB, 2016; USDA-AMS, 2016).

3. Analysis

ESTABLISHMENT/SPREAD POTENTIAL

As described above, *G. spilanthoides* has naturalized and spread in other regions of the world. Native to the Neotropics, this herbaceous perennial is an aquatic plant that establishes in wetlands and the edges of bodies of water (CRC, 2003; Parsons and Cuthbertson, 2001). Its stems are hollow, inflated, and buoyant, and typically form dense floating mats that extend into deep water (CRC, 2003; Parsons and Cuthbertson, 2001). Stem fragments readily root and give rise to new plants. Plant propagules (stem fragments and seeds) are dispersed by water and on mud that attaches to animals’ hooves (CABI, 2012; Parsons and Cuthbertson, 2001). *Gymnocoronis spilanthoides* is also dispersed unintentionally by people when they dispose aquarium plants in the environment or move contaminated equipment (e.g., boats) (CRC, 2003). Also contributing to this species’ risk score is its tolerance to mutilation and persistence in soil seed banks (Panetta, 2010; Parsons and Cuthbertson, 2001). There was an average amount of uncertainty associated with this risk element.

Risk score = 16 Uncertainty index = 0.17

IMPACT POTENTIAL

Gymnocoronis spilanthoides is considered a weed and is managed in natural and anthropogenic systems (CRC, 2003). It is regulated in Australia (The University of Queensland, 2017), New Zealand (Timmins and Mackenzie, 1995), Japan (Kaneko, 2012), and the Republic of Korea (APHIS, 2017b), and targeted for eradication in cities in Western Australia (Hussey and Lloyd, 2002). Dense mats of *G. spilanthoides* alter community structure and exclude native species (CRC, 2003; Timmins and Mackenzie, 1995; WMC, 2012). Large infestations can block waterways, with subsequent impacts on flooding, irrigation, and recreational access (CRC, 2003; MPI, 2012; WMC, 2012). Torok et al. (2003) categorized this species as an ecosystem transformer[2], and others report that rotting vegetation ruins water quality (ISSG, 2012; WMC, 2012). Although the available evidence for this species transforming ecosystem processes is not well supported, in general, aquatic plants that form dense mats on the water surface and then decompose in the water column are likely to change ecosystem functioning by creating anaerobic conditions, increasing peat formation, and lowering water pH (Howard and Harley, 1997; Villamagna and Murphy, 2010). We had very high uncertainty for this risk element.

Risk score = 3.4 Uncertainty index = 0.27

GEOGRAPHIC POTENTIAL

Based on three climatic variables, we estimate that about 29 percent of the United States is suitable for the establishment of *G. spilanthoides* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and general areas of occurrence. The map for *G. spilanthoides* represents the joint distribution of Plant Hardiness Zones 7-13, areas with 20-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, humid subtropical, marine west coast, Mediterranean, and humid continental cool and warm summers.

The area of the United States shown to be climatically suitable (Fig. 1) for species establishment considered only three climatic variables. Other variables, for example, water depth, hydrology, novel climatic conditions, or plant genotypes, may alter the areas in which this species is likely to establish. *Gymnocoronis spilanthoides* grows in areas of wet marshy soils and in areas with still or very slowly moving waters (CABI, 2012; Parsons and Cuthbertson, 2001), such as ponds, creeks, canals, wetlands, and drains (Ardenghi et al., 2016; Timmins and Mackenzie, 1995). It grows both on creek

[2] Transformers are "invasive plants which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent of that ecosystem" (Richardson et al., 2000).

beds and along the banks, extending floating stems onto the water surface (CRC, 2003). It is resistant to frost and able to survive periods of submersion (Timmins and Mackenzie, 1995).

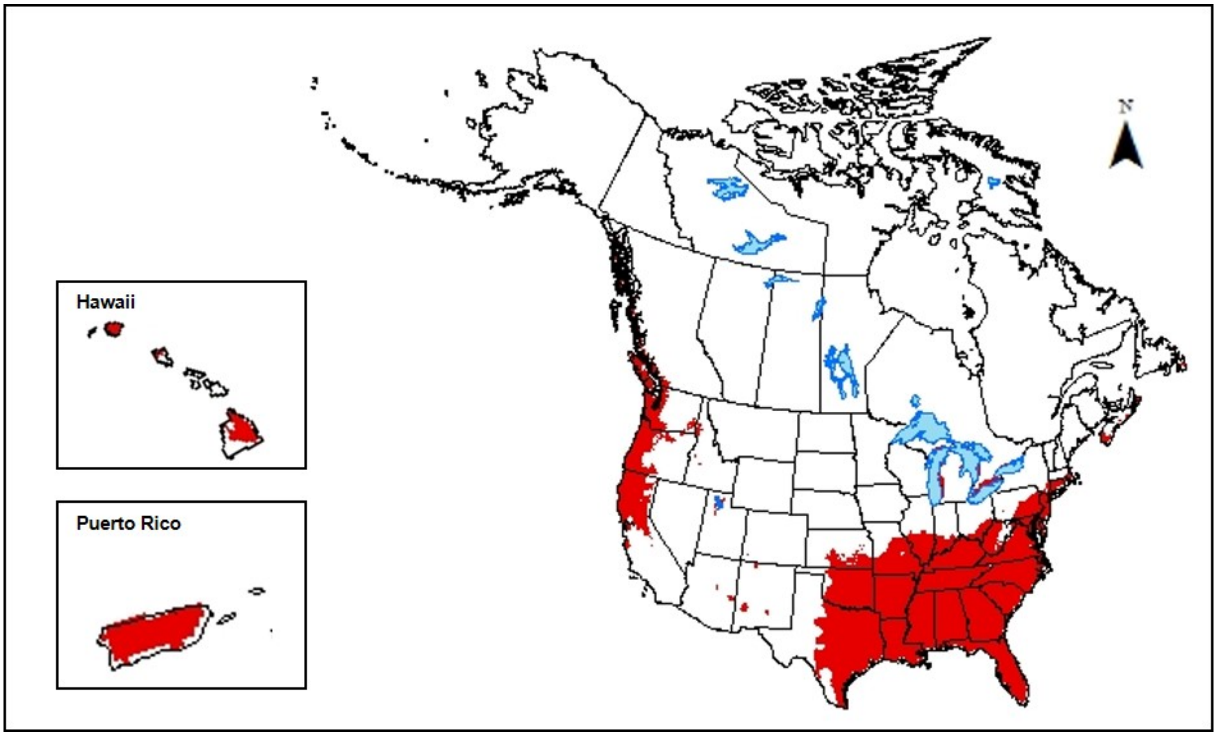

Figure 1. Potential geographic distribution of *Gymnocoronis spilanthoides* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

ENTRY POTENTIAL

Although *G. spilanthoides* is already present in the United States as a cultivated ornamental (APC, 2017; Aquarium Plants, 2017; Florida Aquatic Nurseries, 2017), we evaluated this risk element to determine how additional material may enter the United States. On a scale of 0 to 1, where 1 represents the maximum risk score, *G. spilanthoides* obtained a value of 0.52 on our assessment scale. Contributing 0.50 points to this score, the main and most likely pathway for entry is as plants intentionally introduced for cultivation. *Gymnocoronis spilanthoides* has been traded worldwide as an aquarium and pond plant since the 1960's (Ardenghi et al., 2016). It was introduced into Japan either as an ornamental plant or for use in water purification with no regard for its ability to purify water (Kaneko, 2012). We found one eBay vendor from Spain offering to ship plants to the United States (eBay, 2017).

Risk score = 0.52 Uncertainty index = 0.17

4. Predictive Risk Model Results

Model Probabilities: P(Major Invader) = 84.3%
P(Minor Invader) = 15.1%
P(Non-Invader) = 0.6%

Risk Result = High Risk

Secondary Screening = Not Applicable

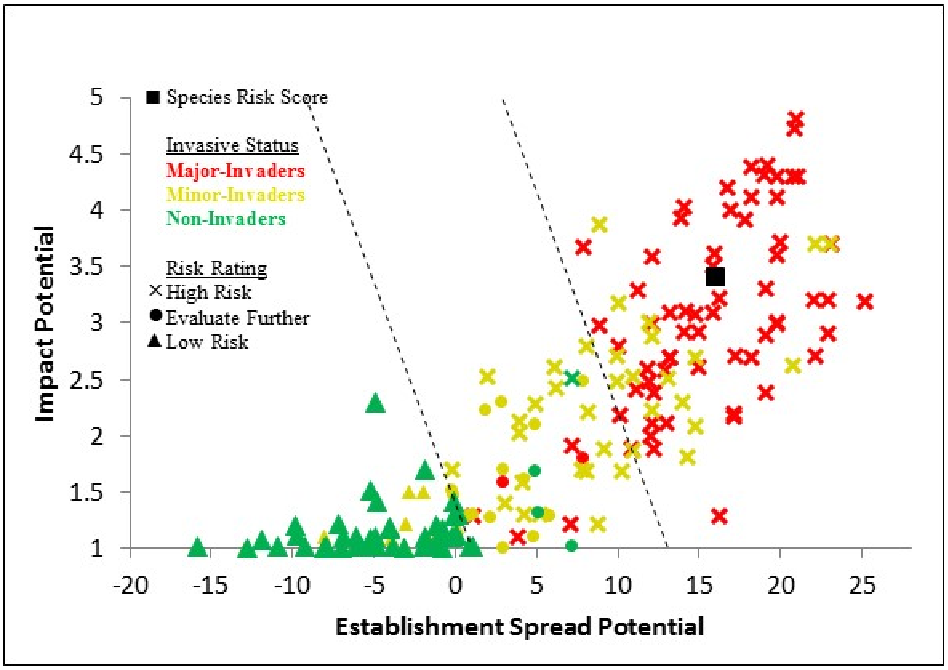

Figure 2. *Gymnocoronis spilanthoides* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

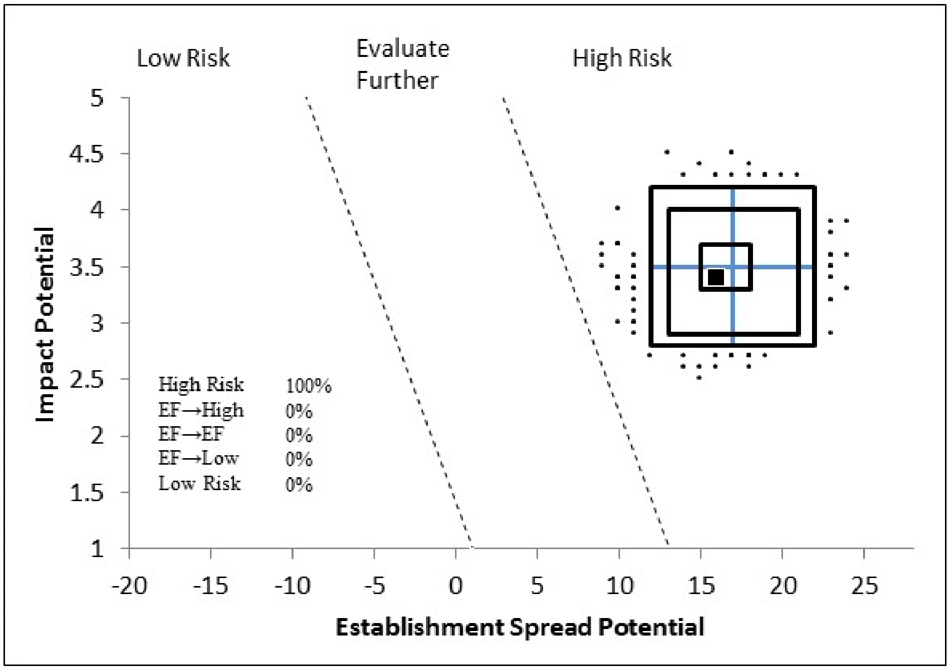

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *G. spilanthoides*. The blue “+” symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

5. Discussion

The result of the weed risk assessment for *G. spilanthoides* is High Risk (Fig. 2). Despite the uncertainty associated with this assessment, our result was robust (Fig. 3). Thus, even if some of the answers in the assessment were to change based on new evidence, the result of the assessment is likely to still be High Risk. *Gymnocoronis spilanthoides* has been evaluated with other weed risk assessment models, and in all cases it has ranked relatively high (Champion and Clayton, 2001; Parker et al., 2007; Pheloung, 1995; Randhawa, 2016; Weber and Panetta, 2006). Notably, we found very few ecological studies on *G. spilanthoides*, particularly on its impacts. Many of the resources we found referenced the weed management guide published by the Cooperative Research Centre of Australia (CRC, 2003). Additional studies or primary reports of its impacts would be valuable.

Risk managers should be aware that *G. spilanthoides* is in the aquarium trade (Champion et al., 2010; Kadono, 2004; Parsons and Cuthbertson, 2001) and is cultivated in the United States (APC, 2017; Aquarium Plants, 2017; Florida Aquatic Nurseries, 2017). Although some infestations in Australia resulted from careless disposal of aquarium plants, some infestations started as deliberate releases in public land for harvest by aquarists (CRC, 2003). Controlling *G. spilanthoides* in Australia has been challenging because herbicides are sometimes ineffective when plants are growing in standing water. Furthermore, any kind of mechanical control that fragments plants may result in new plants establishing downstream (ISSG, 2012). Adult plants grow at a rate of 15 cm a week under fertile conditions, and can continue to grow underwater (Timmins and Mackenzie, 1995).

6. Acknowledgements

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SUGGESTED CITATION

PPQ. 2017. Weed risk assessment for *Gymnocoronis spilanthoides* (D. Don ex Hook. & Arn.) DC. (Asteraceae) – Senegal tea plant. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC. 24 pp.

DOCUMENT HISTORY

September 29, 2017: Version 2.
August 1, 2011: Version 1.

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Appendix A. Weed risk assessment for *Gymnocoronis spilanthoides* (D. Don ex Hook. & Arn.) DC. (Asteraceae)

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 - negl	5	*Gymnocoronis spilanthoides* is native to South America (GBIF, 2017; NGRP, 2017). It was introduced to Australia in the mid-1970s and documented as naturalized by 1980 (Parsons and Cuthbertson, 2001). It is fully naturalized in New Zealand (Howell and Sawyer, 2006) and India (Kohli et al., 2012; Sarma and Borah, 2012), and has recently become naturalized in China (Tian-Gang and Yan, 2007), Taiwan (Jung et al., 2009), and Italy (Ardenghi et al., 2016). In Japan, plants readily escape cultivation and establish in the surrounding environment, and the species is now rapidly expanding its distribution there (Kadono, 2004). "The wild form of this species was first found in Aichi Prefecture in 1996. Its distribution area has been rapidly expanding in the Kanto, Tokai, Kinki, and Kyushu areas" (Kaneko, 2012). It has been collected from numerous locations along the Tone River in Japan (GBIF, 2017), suggesting it is spreading along that water course. It is considered invasive (Category 5A) in Australia (Randall, 2007) and in Hungary (Torok et al., 2003). In northern Italy in a period of a few years, this species spread about two kilometers (Ardenghi et al., 2016). Alternate answers for the uncertainty simulation are both "e."
ES-2 (Is the species highly domesticated)	n - low	0	This species is cultivated as an aquarium and pond plant (APC, 2017; Aquarium Plants, 2017; Champion et al., 2010; Kadono, 2004; Parsons and Cuthbertson, 2001). We found no evidence that it has been highly domesticated.
ES-3 (Significant weedy congeners)	n - low	0	There are 2–3 species in this genus (Mabberley, 2008). A literature search did not indicate that any other species are weedy (e.g., Randall, 2017).
ES-4 (Shade tolerant at some stage of its life cycle)	y - high	1	We answered yes because one source indicates it can tolerate shade (Timmins and Mackenzie, 1995). However, we used high uncertainty because this was

Question ID	Answer - Uncertainty	Score	Notes (and references)
			an anecdotal piece of information that was not supported with any documentation.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	*Gymnocoronis spilanthoides* is not a vine or a plant that forms basal rosettes; it is a perennial herb that forms rounded bushes (Parsons and Cuthbertson, 2001). Its stems are erect, or prostrate and scrambling (Parsons and Cuthbertson, 2001).
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	This species forms dense mats and infestations (Ardenghi et al., 2016; Weber, 2003; WMC, 2012); also see the picture on the cover page of the WRA.
ES-7 (Aquatic)	y - negl	1	*Gymnocoronis spilanthoides* is a freshwater or marsh emergent perennial (MPI, 2012; Parsons and Cuthbertson, 2001). Plant stems are erect at first, but later become prostrate and scrambling (Parsons and Cuthbertson, 2001). Stems are hollow, inflated, and buoyant, and typically form floating mats that extend into deeper water from the edges of water bodies (CRC, 2003; Parsons and Cuthbertson, 2001). Seedlings can grow underwater and later emerge (Parsons and Cuthbertson, 2001).
ES-8 (Grass)	n - negl	0	This species is not a grass; it is a plant in the Asteraceae family (NGRP, 2017).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that this species fixes nitrogen. It is not in a plant family typically associated with nitrogen fixation (Martin and Dowd, 1990; Santi et al., 2013), nor is it a woody species.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	It reproduces by seed (Kaneko, 2012; Parsons and Cuthbertson, 2001; Timmins and Mackenzie, 1995; WMC, 2012).
ES-11 (Self-compatible or apomictic)	? - max	0	Unknown.
ES-12 (Requires specialist pollinators)	n - low	0	The flowers attract many insects including butterflies as pollinators (Kadono, 2004). It has been introduced as a butterfly-attracting plant (Panetta, 2010). Pollen grains have been detected in honey (Malacalza et al., 2005) and bee nests (Dalmazzo and Vossler, 2015). Enough circumstantial evidence indicates it does not require specialist pollinators. Furthermore, it is able to produce seeds (Parsons and Cuthbertson, 2001; WMC, 2012) where it has been introduced, suggesting it does not need a specialist pollinator.
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 - high	1	*Gymnocoronis spilanthoides* is a perennial herb (Parsons and Cuthbertson, 2001) that reproduces from seed and vegetative fragments. We found no information about how quickly germinating seeds can reach reproductive maturity; however, it seems unlikely that plants require four years or more. In winter, plants die back to the ground and regrow at the beginning of the next growing season (Parsons and Cuthbertson, 2001). Based on how quickly it is reported to grow in aquaria (Krombholz, 1997), it is possible it may experience multiple generations per

Question ID	Answer - Uncertainty	Score	Notes (and references)
			year under natural conditions if plant stems are frequently mutilated. We answered "b" with high uncertainty. Alternate answers for the uncertainty simulation were "c" and "a."
ES-14 (Prolific seed producer)	n - negl	-1	The following data came from a study of the reproductive potential of plants in two urban populations in Australia (Vivian-Smith et al., 2005). Researchers observed about 0-100 and 0-10 inflorescences (capitula) per square meter, and measured 11.8 and 4.3 seeds produced per capitulum, respectively. They obtained germination rates of up to 83 percent (Vivian-Smith et al., 2005). Thus, assuming maximum flowering, seed set, and germination, plants can produce 980 (100 × 11.8 × 0.83) seeds per square meter. This is much lower than the 5,000 viable seeds per square meter threshold for prolific reproduction that is required by this question. Other reports, whether citing Vivian-Smith et al. (2005) or based on their own observations, indicate seed production is not very high (CRC, 2003; WMC, 2012). Consequently, we answered no with negligible uncertainty. Ardenghi et al. (2016) report seed viability rates of 25 to 67 percent, depending on growth chamber conditions.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	*Gymnocoronis spilanthoides* is spread by boats, trailers, fishing equipment, lawnmowers, and probably most importantly, the disposal of aquarium plants (CRC, 2003; Timmins and Mackenzie, 1995; WMC, 2012). It became established at a rubbish dump in New Zealand (Heenan et al., 1999).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	? - max	0	Unknown. In the abstract of one report, the authors state that it enters China by cargo (Gao and Chen, 2011), but it is not clear from this if the authors meant it can be a contaminant of cargo or whether the plant is a commodity itself. Otherwise, we found no evidence that it is likely to follow a pathway as a contaminant (e.g., APHIS, 2017a).
ES-17 (Number of natural dispersal vectors)	2	0	Propagule traits for questions ES-17a through ES-17e: Fruit are ribbed, ellipsoid achenes (i.e., seeds) that are 0.8 – 2 mm long, 0.5 mm wide, and without a crown or pappus (Ardenghi et al., 2016; Panetta, 2010; Parsons and Cuthbertson, 2001).
ES-17a (Wind dispersal)	n - negl		Seeds are too heavy for wind dispersal (Parsons and Cuthbertson, 2001) and drop near the parent plant (CRC, 2003). They do not have a pappus.
ES-17b (Water dispersal)	y - negl		Seeds and stem fragments are water-dispersed, and stems are buoyant (Ardenghi et al., 2016; CABI, 2012; Parsons and Cuthbertson, 2001; Timmins and Mackenzie, 1995).
ES-17c (Bird dispersal)	n - mod		We found no evidence of bird dispersal or that bird dispersal would be a significant mechanism for spread.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17d (Animal external dispersal)	y - low		Seeds are dispersed in mud sticking to animal hooves (Parsons and Cuthbertson, 2001). Stem fragments can be spread on the hooves of animals (WMC, 2012).
ES-17e (Animal internal dispersal)	n - mod		We found no evidence of internal animal dispersal or any indication that this would be a significant dispersal mechanism.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - negl	1	A three-year seed burial experiment showed that seeds retain their viability over long periods if light is excluded; the author believes that seeds could easily remain viable in the soil for many years (Panetta, 2010).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - negl	1	Stem and leaf fragments with midribs readily form adventitious roots, leading to formation of new plants and colonies (Boppré and Colegate, 2015; Kaneko, 2012; Parsons and Cuthbertson, 2001; Timmins and Mackenzie, 1995). A weed management guide for Australia asks citizens not to try to manage it themselves, as the plant can spread very easily from dislodged stem fragments (CRC, 2003). Stem fragments may be dispersed by water movement, planting, and drainage machinery (Timmins and Mackenzie, 1995). It readily resprouts after mowing (Ardenghi et al., 2016).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	? - max		Unknown. *Gymnocoronis spilanthoides* is very hard to kill, and herbicides are effective only on the upper parts of the plant, as submerged parts are not killed and can regrow (CRC, 2003). "Following repeated efforts, glyphosate has proven to be ineffective in south Queensland, and it shows some resistance to the most commonly approved aquatic herbicides" (CABI, 2012). This species is not listed by Heap (2017) as resistant. It is not clear from the available evidence whether this species is resistant or tolerant to herbicides, or whether the herbicides were simply not suitable for use in aquatic habitats. Without additional information, we answered unknown.
ES-21 (Number of cold hardiness zones suitable for its survival)	7	0	
ES-22 (Number of climate types suitable for its survival)	7	2	
ES-23 (Number of precipitation bands suitable for its survival)	9	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	? - max		Unknown. One source reports it is highly allelopathic (cited in Kaneko, 2012); however, we were unable to confirm whether this is based on laboratory studies or field reports.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that this species is parasitic. The Asteraceae family is not known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	y - high	0.4	This species is classified as a transformer species in Hungary (Torok et al., 2003), but a detailed description or explanation is lacking. It is reported that rotting vegetation ruins water quality (WMC, 2012). "If large-scale die offs of this species occur, water quality may decline" (ISSG, 2012). Although the available evidence for *G. spilanthoides* is weak and speculative, in general, aquatic plants that form dense mats on the water surface and then decompose in the water column are likely to change ecosystem functioning by creating anaerobic conditions, increasing peat formation, and lowering water pH (Howard and Harley, 1997; Villamagna and Murphy, 2010). Consequently, we answered yes with high uncertainty.
Imp-N2 (Changes habitat structure)	y - mod	0.2	This species forms mats over shallow and deep water (CRC, 2003; Gunasekera et al., 2002; WMC, 2012). Formation of vegetative mats in an aquatic ecosystem that is normally more open affects the distribution and density of plant layers in this community. We answered yes but used moderate uncertainty because this was not directly stated in the literature.
Imp-N3 (Changes species diversity)	y - negl	0.2	"Senegal tea grows very quickly, and is known to rapidly cover water bodies with a floating mat, excluding other plants and the animals that rely on them" (MPI, 2012; Timmins and Mackenzie, 1995). It degrades natural wetlands by displacing native plants (CABI, 2012; WMC, 2012). It is considered a threat to Australian rangeland biodiversity (Martin et al., 2006). Based on this evidence and pictures of dense infestations in New Zealand (e.g., WMC, 2012), we used negligible uncertainty.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - low	0.1	Because it excludes other plants and animals (CRC, 2003; ISSG, 2012), it is likely to affect threatened and rare species.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	y - mod	0.1	Some authors believe this plant poses a significant threat to the health of wetland ecosystems (ISSG, 2012). Given the impacts to community diversity and structure described above, and the likely impacts to ecosystem impacts, it seems that this species could affect entire ecoregions. There are numerous wetland and aquatic habitats (e.g., the Florida Everglades) in globally outstanding ecoregions in the United States (Ricketts et al., 1999) where this species could establish.

Question ID	Answer - Uncertainty	Score	Notes (and references)
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 - negl	0.6	*Gymnocoronis spilanthoides* is an environmental and rangeland weed in Australia (Martin et al., 2006; Randall, 2007; The University of Queensland, 2017). It is controlled and routinely monitored in natural systems in Australia (CRC, 2003; Gunasekera et al., 2002; The University of Queensland, 2017). In Japan, several groups have been controlling this species since it was first detected in Lake Biwa, and local managers hope to eradicate it from the lake (Kaneko, 2012). Control methodologies are described in various references (CABI, 2012; CRC, 2003; Parsons and Cuthbertson, 2001). 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)	y - negl	0.1	"The effects of flooding are made much worse because infestations block drainage channels" (MPI, 2012). This species has caused flooding because it blocks drainage channels and streams (CABI, 2012; WMC, 2012). Infestations block drainage channels (ISSG, 2012). Drainage channels are important for controlling stormwater.
Imp-A2 (Changes or limits recreational use of an area)	y - negl	0.1	The long branches produce a tangled web of vegetative material that stretches across the water surface and quickly impedes waterflow, navigation, and recreation (Gunasekera et al., 2002; Parsons and Cuthbertson, 2001; Timmins and Mackenzie, 1995). "Recreational activities, irrigation and navigation may also be affected" (MPI, 2012). *Gymnocoronis spilanthoides* decreases the environmental value of wetlands, their natural beauty, and recreational value (CRC, 2003).
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - mod	0	We found no evidence of this impact.
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]	c - negl	0.4	*Gymnocoronis spilanthoides* is considered a weed of anthropogenic areas because it clogs drainage ways and causes flooding (CRC, 2003). Some aquarium hobbyists think that this species is somewhat weedy even in aquaria (Krombholz, 1997). One source states that for drainage systems plants should first be sprayed with herbicides, then a week later management crews should remove all plant material and silt up to a meter deep (CRC, 2003). After this species was found in cultivation in Perth, Australia, all known were destroyed since it is a state noxious weed (Hussey and Lloyd, 2002). This species is controlled by Manukau City Council in New Zealand (Timmins and Mackenzie, 1995). In some urban creeks in Australia, officials are trying to eradicate it (Vivian-Smith et al., 2005). Alternate answers for the uncertainty simulation were both "b."

Question ID	Answer - Uncertainty	Score	Notes (and references)
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - mod	0	In Italy, a 12 square meter patch of this species was detected growing on the edge of and into a patch of rice, but there was no evidence of economic impacts (Ardenghi et al., 2016). We found no other evidence of impacts on agricultural yields. Another WRA rated this impact as low likelihood but did not provide any supporting documentation (DPI, 2012).
Imp-P2 (Lowers commodity value)	n - mod	0	We found no evidence of this impact.
Imp-P3 (Is it likely to impact trade?)	n - high	0	*Gymnocoronis spilanthoides* is regulated in Australia (The University of Queensland, 2017), New Zealand (Timmins and Mackenzie, 1995), Japan (Kaneko, 2012), and the Republic of Korea (APHIS, 2017b). It is illegal to import and cultivate in Australia and New Zealand (CABI, 2012). However, because there is no clear evidence that it is likely to follow a trade pathway (see ES-16 above), we answered this question as no with high uncertainty.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	? - max	0	In irrigation canals up to one meter deep in northern Italy, *G. spilanthoides* "occupies extended stretches up to 519 m long, forming isolated but dense monospecific mats with a 90−100 % cover, usually occupying the whole canal width (1−4 m)" (Ardenghi et al., 2016). Because this species can occur in irrigation canals, and because it impedes waterflow and navigation (Boppré and Colegate, 2015; Gunasekera et al., 2002; Parsons and Cuthbertson, 2001), it may affect irrigation (ISSG, 2012; MPI, 2012); however, because we found no direct evidence of this, we answered unknown.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	? - max		Unknown. We found no direct evidence that *G. spilanthoides* is toxic to animals. It is eaten by animal stock and has been known to provide grazing during winter in wet areas (ISSG, 2012). However, recently, Boppré and Colegate (2015) discovered that it produces pyrrolizidine alkaloids, which are toxic substances that some plants use to deter herbivores, and are also potentially toxic to humans. Given that *G. spilanthoides* forms extensive and dense populations over water surfaces, the authors expressed concern that some of these toxic compounds may leach into water supplies and potentially affect livestock and people, and they recommended that any deliberate use of this plant should be considered with caution (Boppré and Colegate, 2015).
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but	b - high	0.2	We did not find any evidence that this species is generally considered an agricultural weed. However, in Italy, it was detected growing on the edge of and into a patch of rice (Ardenghi et al., 2016). It was

Question ID	Answer - Uncertainty	Score	Notes (and references)
no evidence of control; (c) Taxon a weed and evidence of control efforts]			also reported at a farm dam in Australia, where initial control was not successful (Parsons and Cuthbertson, 2001). A New Zealand website provides some suggestions for control, including a statement that sites infested with this species should not be grazed so that animal stock do not release seeds and stem fragments (WMC, 2012). This suggests that there is at least interest in limiting its further spread in these systems. We answered "b" because there is some evidence that it is weedy in production systems, and used "a" and "c" as alternate answers for the uncertainty simulation.
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2017; queried on 09/15/2017).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z6 (Zone 6)	n - low	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z7 (Zone 7)	y - mod	N/A	One point in Japan. Present in Keszthely, Hungary (CISEH, 2012). Present in Hévíz, Hungary, where it is restricted to a thermal lake (Ardenghi et al., 2016). These two sites in Hungary are close together, so it is not clear if they represent the same population.
Geo-Z8 (Zone 8)	y - low	N/A	A few points in Australia and Japan. Three points in New Zealand. Present in Gaoting Town, China (Gao and Chen, 2011) and Osaka prefecture, Japan (Nobuyuki, 2005).
Geo-Z9 (Zone 9)	y - negl	N/A	Australia and Argentina. A few points in Brazil and Japan. It is growing in a region of Italy where the mean minimum temperature in January is slightly below -1 ˚C (Ardenghi et al., 2016).
Geo-Z10 (Zone 10)	y - negl	N/A	Many points in Argentina, Brazil, and Paraguay. Some points in Australia. This species is frost tolerant (CABI, 2012) if under water (Timmins and Mackenzie, 1995).
Geo-Z11 (Zone 11)	y - negl	N/A	Several points in Bolivia, Brazil, and Peru.
Geo-Z12 (Zone 12)	y - mod	N/A	Two points in Brazil, one point in Bolivia, and one in Taiwan.
Geo-Z13 (Zone 13)	y - mod	N/A	Three points in Taiwan.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - mod	N/A	A few points in Bolivia and one in Brazil.
Geo-C2 (Tropical savanna)	y - negl	N/A	Bolivia, Brazil, Paraguay, and Peru.
Geo-C3 (Steppe)	n - high	N/A	We found no evidence that this species occurs in this climate type, but we suspect that it is climatically suitable if there are appropriate aquatic environments available.
Geo-C4 (Desert)	n - low	N/A	We found no evidence that this species occurs in this climate type.
Geo-C5 (Mediterranean)	y - mod	N/A	A few infestations near Perth, Australia (CRC, 2003), and sold in an aquarium shop in Perth (GBIF, 2017). We found one point near this climate type in northern Italy (Ardenghi et al., 2016).
Geo-C6 (Humid subtropical)	y - negl	N/A	Argentina and Paraguay. Some points in Brazil and Taiwan. One point in Uruguay. Present in Kyushu, Japan (Kadono, 2004).
Geo-C7 (Marine west coast)	y - mod	N/A	A few points in New Zealand. One point in Australia.
Geo-C8 (Humid cont. warm sum.)	y - high	N/A	Because this tropical species occurs in Hungary under humid continental cool summers (CISEH, 2012; Torok et al., 2003), it seems very likely it will also be able to occur in this climate type as well, based on the Köppen-Geiger climate classes (Peel et al., 2007).
Geo-C9 (Humid cont. cool sum.)	y - high	N/A	Present in Hungary (Ardenghi et al., 2016; CISEH, 2012; Torok et al., 2003).
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence that this species occurs in this climate type.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that this species occurs in this climate type.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that this species occurs in this climate type.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - negl	N/A	We found no evidence that it occurs in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	n - high	N/A	We found no evidence that it occurs in this precipitation band.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Bolivia, Brazil, and Paraguay. Present in Keszthely, Hungary (CISEH, 2012).
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Argentina and Paraguay. A few points in Australia.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Argentina and Paraguay. A few points in Australia. One point in New Zealand.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	A few points each in Argentina and Brazil.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	A couple of points each in Bolivia and Brazil. Two points in New Zealand. One point in Taiwan.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Several points in Japan. One point in Brazil.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Several points in Japan. One point near this band in Taiwan.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	One point in Brazil. Present in Kyushu, Japan (Kadono, 2004).
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Four points each in Peru and Taiwan.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	*Gymnocoronis spilanthoides* is cultivated in the United States by aquarium and pond hobbyists (APC, 2017; Aquarium Plants, 2017; Florida Aquatic Nurseries, 2017), and is commercially available for retail sale (e.g., Aquarium Plants, 2017). However, to evaluate the potential for additional material to be introduced to the United States, we set this answer to no.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - high	0	We found no evidence that additional material has been proposed for entry, but note that an eBay vendor from Spain is offering to ship plants to the United States (eBay, 2017).
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 - negl	0.5	*Gymnocoronis spilanthoides* has been traded worldwide as an aquarium and pond plant since the 1960's (Ardenghi et al., 2016). In Australia, it was intentionally planted outside in the natural environment for cultivation by the aquarium trade (Parsons and Cuthbertson, 2001). It was introduced into Japan either as an ornamental plant or for use in water purification and with no regard for its ability to purify water (Kaneko, 2012). There are cultivars featuring reddish stems or foliage, and variegated leaves (Ardenghi et al., 2016).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	n - mod		Some sources indicate it is native from Mexico to Argentina (e.g., Parsons and Cuthbertson, 2001), but we found no original work or herbarium specimen (e.g., GBIF, 2017; MBG, 2017) indicating that it is present in Mexico or Central America. Relative to other *Gymnocoronis* species reported to be present in Mexico and Central America, *G. spilanthoides* is restricted to South America (cited in Tippery et al., 2014).
Ent-4b (Contaminant of plant propagative material (except seeds))	n - high	0	We found no evidence of it being this type of contaminant (e.g., APHIS, 2017a).
Ent-4c (Contaminant of seeds for planting)	n - high	0	We found no evidence of it being this type of contaminant (e.g., APHIS, 2017a).
Ent-4d (Contaminant of ballast water)	? - max		Unknown. As an aquatic plant, seeds and vegetative propagules may be present in ballast water.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	? - max		We found no evidence of this pathway, but because aquatic plant shipments are often contaminated with other aquatic plants (e.g., Maki and Galatowitsch, 2004), we answered this question as unknown.
Ent-4f (Contaminant of landscape products)	n - high	0	We found no evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	y - negl	0.02	*Gymnocoronis spilanthoides* is spread by boats, trailers, fishing equipment, lawnmowers, and probably most importantly, the disposal of aquarium plants (CRC, 2003; Timmins and Mackenzie, 1995; WMC, 2012).
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	n - low	0	We found no evidence (e.g., APHIS, 2017a). Because this pathway seems unlikely, we used low uncertainty.
Ent-4i (Contaminant of some other pathway)	a - high	0	We found no evidence.
Ent-5 (Likely to enter through natural dispersal)	n - low	0	Assuming this species is not present in Mexico (see evidence under Ent-4a), we consider this pathway to be unlikely.