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Version 1

Weed Risk Assessment for *Pogostemon stellatus* (Lour.) Kuntze (Lamiaceae) – Water star

Top left: Habit of *Pogostemon stellatus*. Top right: A growth form with wider leaves. Bottom: A small clump in an aquarium. All photos obtained with permission (Nelson, 2017) from Tropica's (2017) website.

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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, 2015). Although we may use evidence about existing or proposed control programs in the assessment, the ease or difficulty of control has no bearing on the risk potential for a species. That information could be considered during the risk management (decision-making) process, which is not addressed in this document.

2. Plant Information and Background

SPECIES: *Pogostemon stellatus* (Lour.) Kuntze (The Plant List, 2017)

FAMILY: Lamiaceae

SYNONYMS: *Anuragia stellata* (Lour.) Raizada, *A. tomentosa* (Dalzell) Raizada, *Dysophylla benthamiana* Hance, *D. stellata* (Lour.) Benth. Ex Wall., *Eusteralis stellata* (Lour.) Panigrahi, *Pogostemon japonicum* (Miq.) Kuntze (The Plant List, 2017). For additional synonyms see The Plant List (2017). This species is erroneously known as *Eusteralis stellata* in the trade (APC, 2017; Flowgrow, 2017). *Pogostemon stellatus* is placed in the subgenus *Dysophyllus* section *Verticillatus* (Ingrouille and Bhatti, 1998), which up until recently was recognized as a separate genus (El-Gazzar and Watson, 1967; Panigrahi, 1984).

COMMON NAMES: Water star (Flowgrow, 2017).

BOTANICAL DESCRIPTION: *Pogostemon stellatus* is an herbaceous, annual aquatic herb with overwintering (perennating) buds beneath the surface of the water, but at some point may be growing above the surface of the water, depending on water levels (El-Gazzar and Watson, 1967). It produces whorls of 4-8 linear to lanceolate leaves (APC, 2017). Depending on nutrient and light levels in the water column, leaves may be either green, purple, or orange (APC, 2017). Stems are hollow, up to 1 cm in diameter at the base and grow 14-40 cm long (Flowgrow, 2017; Li and Hedge, 2017). It produces spikes of purple-red flowers and obovoid nutlets (Li and Hedge, 2017). Species in the genus *Pogostemon* produce nutlets (Ingrouille and Bhatti, 1998), but we found no information on their size. For a full botanical description of *P. stellatus*, see Li and Hedge (2017). *Pogostemon stellatus* has an extensive but fragmented distribution, with several different forms in the wild and under cultivation (APC, 2017; Leonida, 2009). The wide-leaf form of *P. stellatus* can sometimes be confused with *Limnophila aromatica* (Leonida, 2009).

INITIATION: PPQ received a market access request for *P. stellatus* for propagation from the Ministry of Food, Agriculture and Fisheries, the Danish Plant Directorate (MFAF, 2009). Because this species is not native to the United States (NGRP, 2015), the PPQ Weeds Cross-Functional Working Group initiated this assessment to determine if it poses a significant pest risk to the United States.

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

FOREIGN DISTRIBUTION: *Pogostemon stellatus* has a widespread distribution (Ingrouille and Bhatti, 1998), and is native to northern Australia, Bangladesh, Bhutan, Cambodia, southeastern China, India, Indonesia, Japan, Laos, Malaysia, Thailand, and Vietnam (Franco F. and Narasimham, 2009; Kumar and Narain, 2010; Li and Hedge, 2017). It is also present and presumably native to Taiwan (Kuo-Huang

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

et al., 1994) and Je-ju Island, South Korea (Yi and Kim, 2016). In Japan, it is considered threatened (Yamada et al., 2011). It has been introduced to Germany (Flowgrow, 2017), the United Kingdom (Aquarium Gardens, 2017), and most likely other countries through the aquarium trade. Wang et al. (2016) categorize *P. stellatus* as invasive in China, but because it is native to China and we found no evidence that it has spread beyond its native range in the country, it is not clear why the authors categorized it as such. *Pogostemon stellatus* is cultivated in the international aquarium trade (e.g., Aquarium Gardens, 2017; eBay, 2017; Flowgrow, 2017), and over the last few years has become more popular with aquarists (APC, 2017; Leonida, 2009).

U.S. DISTRIBUTION AND STATUS: *Pogostemon stellatus* is cultivated in the United States (e.g., AAG, 2017; Florida Aquatic Nurseries, 2017). It can be obtained from online U.S. aquatic businesses (e.g., eBay, 2017; Florida Aquatic Nurseries, 2017), or directly from Thailand-based companies that have plants listed on the internet (Amazon, 2017). We found no evidence that it has escaped from cultivation (e.g., EDDMapS, 2017; GBIF, 2017; Kartesz, 2017; NRCS, 2017). We also found no evidence that any species in this genus is regulated in the United States (e.g., NPB, 2016; USDA-AMS, 2016).

3. Analysis

ESTABLISHMENT/SPREAD POTENTIAL

Pogostemon stellatus is an annual/perennial aquatic plant (Mishra and Narain, 2014) that reproduces by seed (Chowdhury and Das, 2014). Aquarists propagate plants vegetatively by planting cuttings (Leonida, 2009), but we found no evidence whether vegetative reproduction through stem fragmentation is important or even occurs under natural conditions. It forms pure patches in suitable habitats in India (Watve, 2011). It is mostly likely spread naturally via water currents (Yamada et al., 2011), although it may also be spread by animals if the seeds get trapped in their fur (Razi, 1950) or by people since it is a weed of rice fields (Li and Hedge, 2017; Moody, 1989). This species has not become established outside of its native range. Overall, we found very little information on the biology and ecology of this species and could not answer eight of the questions in this risk element, resulting in a very high level of uncertainty.

Risk score = 8 Uncertainty index = 0.39

IMPACT POTENTIAL

Pogostemon stellatus occurs in rice fields in its native range (Li and Hedge, 2017) and is reported to be a weed of rice (Moody, 1989). However, we found no evidence of specific impacts or any meaningful description of its status in rice. Wang et al. (2016) categorize *P. stellatus* as invasive in China, but it is not clear why it is considered invasive. We found no evidence that this species is problematic in natural or anthropogenic systems in its native range. We had very high uncertainty for this risk element because there is very little information available on this species.

Risk score = 1.2 Uncertainty index = 0.42

GEOGRAPHIC POTENTIAL

Based on three climatic variables, we estimate that about 16 percent of the United States is suitable for the establishment of *P. stellatus* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *P. stellatus* represents the joint distribution of Plant Hardiness Zones 8-13, areas with 20-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, humid subtropical, and marine west coast.

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, soil and habitat type, novel climatic conditions, or plant genotypes, may alter the areas in which this species is likely to establish. *Pogostemon stellatus* grows in ditches, pool edges, stream edges, drying rice fields, and seasonally and permanently inundated wetlands (Watve, 2011). It also occurs on riparian bare land or on the floor of riparian forests (Yamada et al., 2011), as well as in damp drained land in Bangladesh (Tahir et al., 1995).

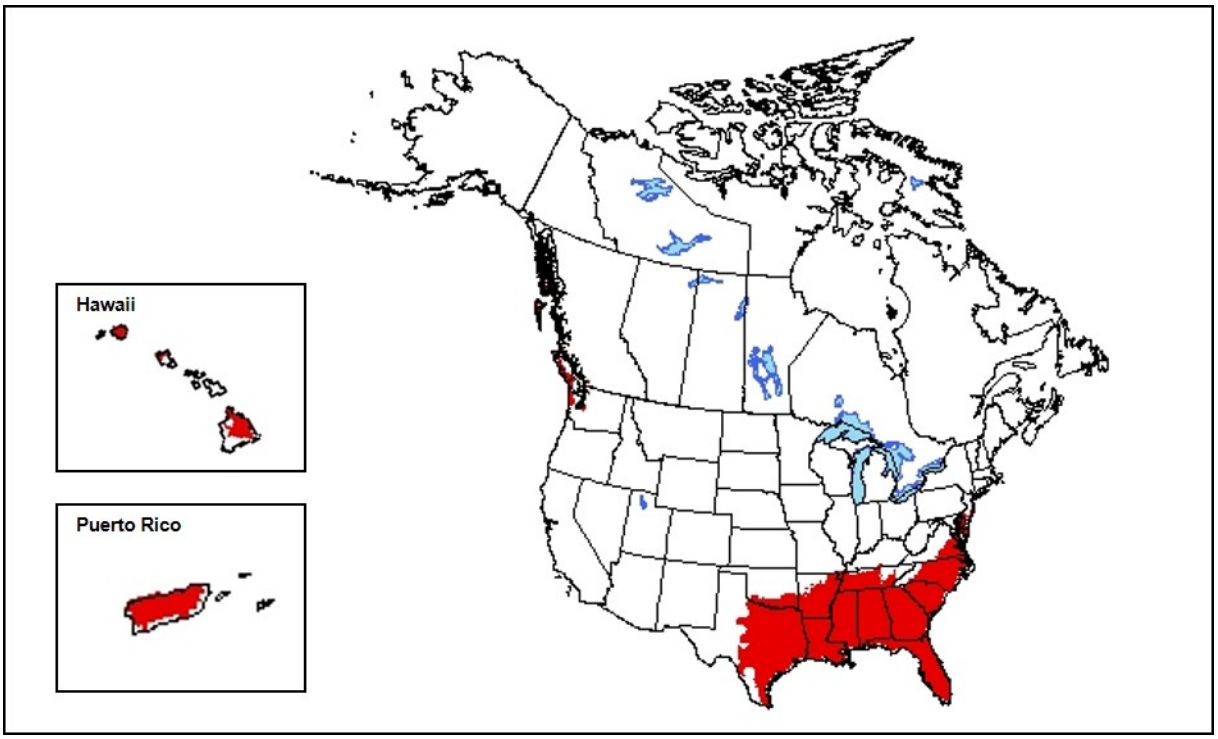

Figure 1. Potential geographic distribution of *P. stellatus* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

ENTRY POTENTIAL

Pogostemon stellatus is already present in the United States, where it is cultivated by aquarium enthusiasts and sold by some retailers (e.g., eBay, 2017; Florida Aquatic Nurseries, 2017). APHIS-PPQ is currently considering a market access request for *P. stellatus* plants rooted in rock wool from

Denmark (MFAF, 2009). If approved, additional plant material would be guaranteed entry into the United States, resulting in the risk score of 1.0 indicated below. We found no evidence that this species is likely to enter the United States as a contaminant or through natural dispersal from nearby regions.

Risk score = 1.0 Uncertainty index = 0.0

4. Predictive Risk Model Results

Model Probabilities: P(Major Invader) = 17.8%
P(Minor Invader) = 69.9%
P(Non-Invader) = 12.2%
Risk Result = Evaluate Further
Secondary Screening = Evaluate Further

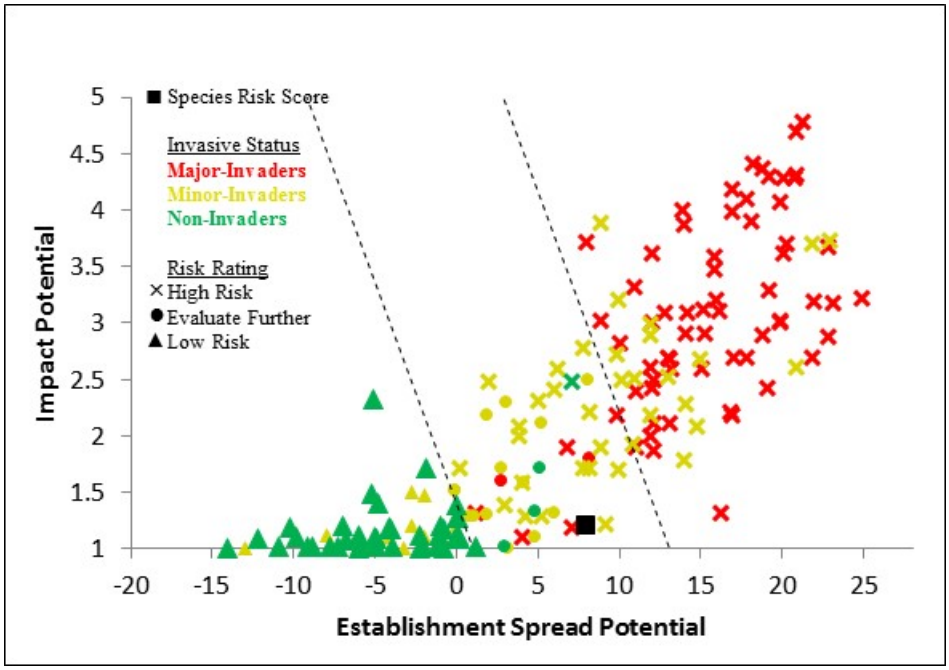

Figure 2. *Pogostemon stellatus* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

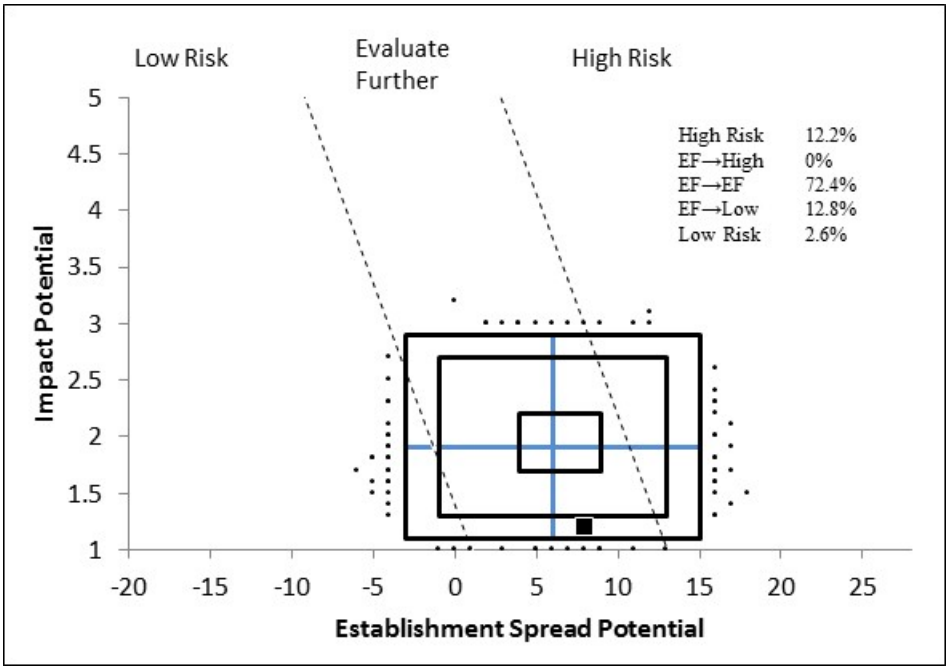

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *P. stellatus*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

5. Discussion

The result of the weed risk assessment for *Pogostemon stellatus* is Evaluate Further after secondary screening (Fig. 2). Due to the very limited amount of biological information available for this species, uncertainty was very high, which resulted in a wide range of simulated risk scores in our uncertainty simulation (Fig. 3). Contributing to the high level of uncertainty is the fact that this species may have only recently been moved outside of its native range for use in freshwater aquaria. Thus, it has had only a limited opportunity to express any potential invasive or weedy behavior. *Pogostemon stellatus* may have some potential to become invasive based on its widespread distribution in southeastern Asia and in the Malesia region of southeastern Asia, and the fact that it is considered weedy (Moody, 1989) and invasive (Wang et al., 2016) in its native range. Conversely, there are reports that it is difficult to grow in aquaria (APC, 2017), suggesting that it may not become invasive. Because of the very high level of uncertainty and number of questions that could not be answered, additional information would help to further resolve this species' risk potential.

6. Acknowledgements

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SUGGESTED CITATION

PPQ. 2017. Weed risk assessment for *Pogostemon stellatus* (Lour.) Kuntze (Lamiaceae) – Water star. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC. 19 pp.

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Appendix A. Weed risk assessment for *Pogostemon stellatus* (Lour.) Kuntze (Lamiaceae)

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]	b - mod	-2	*Pogostemon stellatus* has a widespread native distribution encompassing eastern and southern Asia, through Australia (Ingrouille and Bhatti, 1998; Wang et al., 2016). It has been introduced to Germany (Flowgrow, 2017), the United Kingdom (Aquarium Gardens, 2017), and the United States for cultivation (Florida Aquatic Nurseries, 2017). It is quite likely it is cultivated in other countries as well. We found no evidence this species has escaped or become naturalized where it has been introduced. Wang et al. (2016) categorize *P. stellatus* as invasive in China (Wang et al., 2016). However, because this species is native to China (Li and Hedge, 2017) and because we found no evidence that it has spread beyond its original native range to other areas in the country, we did not answer "f." Based on the scope of this question, an answer of "f" requires evidence that a species is spreading or has spread in areas where it is not native. Since we found no evidence that this species has been in the aquarium trade for more than 75 years, we answered "b" with moderate uncertainty. Alternate answers for the uncertainty simulation were "a" and "d."
ES-2 (Is the species highly domesticated)	n - low	0	*Pogostemon stellatus* is cultivated in the international aquarium trade (e.g., Aquarium Gardens, 2017; eBay, 2017; Flowgrow, 2017), and over the last few years has become more popular with aquarists (APC, 2017; Leonida, 2009). However, we found no evidence indicating that this species is highly domesticated, has been bred for reduced weed potential, or is part of any breeding programs.
ES-3 (Significant weedy congeners)	n - low	0	The genus *Pogostemon* includes about 85 species native to Asia and Africa (Mabberley, 2008), with a center of diversity in India (Ingrouille and Bhatti, 1998). *Pogostemon auricularius*, *P. brachystachys*, and *P. cablin* have been reported as weedy or invasive somewhere in the world (Randall, 2017). *Pogostemon auricularius* and *P. brachystachys* are weeds of rice in southeast Asia (Moody, 1989), and *P. cablin* has escaped from cultivation forming naturalized populations (Yao et al., 2016). However, we found no

Question ID	Answer - Uncertainty	Score	Notes (and references)
			evidence suggesting any of these species are significant weeds.
ES-4 (Shade tolerant at some stage of its life cycle)	y - high	1	Overall, we did not find any direct evidence that *P. stellatus* is shade tolerant. Information from aquarium sites generally state that this species and two closely related aquatic *Pogostemon* species (*P. erectus* and *P. helferi*) prefer strong light for good growth and coloration (Anonymous, 2017; APC, 2017). One hobbyist noted that *P. helferi* plants do not tolerate shade very well (TPT, 2017). The lower leaves of *P. stellatus* begin to shed if the plants do not get enough light (Leonida, 2009). While this evidence suggests that these species do not tolerate low light conditions in aquaria, it does not indicate whether they can survive under low light conditions under natural settings. In its native range, *P. helferi* grows from above the water surface to two meters deep, depending on whether it is the rainy season or not (Christensen et al., 2008). Because these species at times grow as completely submersed aquatics (El-Gazzar and Watson, 1967), it is possible they are tolerant of shady conditions, at least for a short while. Based on our WRA guidelines for this question, we answered yes because these species grow as submersed aquatics.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	*Pogostemon stellatus* is not a vine, nor does it form a basal rosette of leaves. It forms erect stems of whorled leaves (Flowgrow, 2017; Li and Hedge, 2017).
ES-6 (Forms dense thickets, patches, or populations)	y - high	2	Once source states that *Pogostemon stellatus* forms pure patches in suitable habitats (Watve, 2011), suggesting it forms dense patches. We answered yes based on this limited evidence, but used high uncertainty because it is not clear if these patches are indeed dense or if they represent single individuals that have produced many side shoots.
ES-7 (Aquatic)	y - negl	1	This species is an aquatic herb with arenchyma (spongy) tissue in the stems (El-Gazzar and Watson, 1967), which helps it stay buoyant.
ES-8 (Grass)	n - negl	0	This species is not a grass; it is an aquatic herb in the Lamiaceae family (Yao et al., 2016).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that *P. stellatus* fixes nitrogen. Because it is neither woody nor a member of a plant family known to contain nitrogen-fixing species (Martin and Dowd, 1990; Santi et al., 2013), we answered no with negligible uncertainty.
ES-10 (Does it produce viable seeds or spores)	y - low	1	*Pogostemon stellatus* reproduces by seeds (Chowdhury and Das, 2014). "One possible contribution to the persistence of this species [*P. stellatus*] is the supply of viable seeds from upstream" (Yamada et al., 2011).
ES-11 (Self-compatible or apomictic)	? - max	0	Unknown.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-12 (Requires specialist pollinators)	? - max		Unknown.
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	*Pogostemon stellatus* is an annual/perennial (Mishra and Narain, 2014). Plant species in the *Dysophyllus* group of the genus *Pogostemon* are herbaceous annuals and perennials (Ohwi, 1984; Yao et al., 2016). None of the dozens of aquarium blogs and forum discussions that we examined included any comments about this species dying off periodically, suggesting that, at least under culture, it can survive for long periods of time. We found no other information about the generation time or life cycle of *P. stellatus* under natural conditions. Based on the weight of the limited evidence, we answered "b" with high uncertainty. Alternate answers for the uncertainty simulation were both "c."
ES-14 (Prolific seed producer)	? - max	0	Unknown. We found no information on plant population density, breeding effort, or seed production rates.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - high	1	We found no direct evidence of this dispersal pathway. Because *P. stellatus* is present in rice fields, is associated with human activity (Li and Hedge, 2017; Moody, 1989), and presumably produces small seeds (based on the size of the plants), it may be unintentionally dispersed by agricultural activities in these areas. Also, as an aquatic plant, it may also be spread by recreational boating, as many other aquatic macrophytes (e.g., Johnson et al., 2001; Johnstone et al., 1985; Rothlisberger et al., 2010).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	? - max	0	We found no evidence that this species disperses in trade as a contaminant. Because it is a weed of rice (Li and Hedge, 2017; Moody, 1989), it has the potential to be a contaminant of that commodity. However, without knowing more about its phenology in relation to when rice is harvested, we answered unknown.
ES-17 (Number of natural dispersal vectors)	2	0	Fruit and propagule traits for questions ES-17a through ES-17e: The genus *Pogostemon* produces nutlets (Ingrouille and Bhatti, 1998), that are generally self-dispersed (autochory; Bhatt et al., 2012). *Pogostemon stellatus* produces nuts (Mishra and Narain, 2014). We found no information on the size of the nutlets.
ES-17a (Wind dispersal)	n - low		We found no evidence of this type of dispersal mechanism. Because nutlets in general do not possess any specialized mechanisms for wind dispersal (e.g., wings, long hairs), we answered no with low uncertainty.
ES-17b (Water dispersal)	y - mod		We found no direct evidence indicating that seeds are buoyant or are generally dispersed by water, except for one author who speculated that dispersal of viable seeds of *P. stellatus* from upstream is helping to keep populations persistent downstream (Yamada et al., 2011). Because *P. stellatus* is an aquatic plant that lives in and along streams (Li and Hedge, 2017;

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Watve, 2011), it is very likely it is being dispersed by water.
ES-17c (Bird dispersal)	? - max		Unknown.
ES-17d (Animal external dispersal)	y - high		A publication of the dispersal mechanisms of plants in southern India listed both *Pogostemon* and *Dysophylla* as being dispersed epizootically (on animals) (Razi, 1950). It is feasible that small seeds could easily be caught in the fur of passing animals, however, without additional evidence we used high uncertainty.
ES-17e (Animal internal dispersal)	n - high		We found no evidence indicating that seeds are consumed by dispersers. Because plants are not producing any obvious rewards to dispersal agents (e.g., fleshy fruit), we answered no with high uncertainty.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	Unknown.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	Under cultivation, the tops of *P. stellatus* may be trimmed and replanted (Leonida, 2009), suggesting that vegetative fragmentation may result in the establishment of new plants. However, it is unknown whether this occurs under natural settings or not.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - mod	0	We found no evidence (e.g., Heap, 2017).
ES-21 (Number of cold hardiness zones suitable for its survival)	6	0	
ES-22 (Number of climate types suitable for its survival)	4	2	
ES-23 (Number of precipitation bands suitable for its survival)	9	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - mod	0	We found no evidence of allelopathy for this species. Because it seems unlikely that allelopathy is likely to evolve or would have a significant effect in aquatic systems, particularly streams and rivers, we answered no with moderate uncertainty. In a laboratory experiment, essential oils from *P. heyneanus* had a significant inhibitory effect on the germination of seeds of two weed species (Souza Filho et al., 2009), but this is not directly relevant since these data are based on laboratory and not field conditions.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that any *Pogostemon* species is parasitic. Furthermore, these species are not members of a plant family that include parasitic species (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - high	0	We found no evidence of this impact. Although this species has not escaped where has been introduced, because there is so little known about it and because it has only recently been introduced to cultivation and moved outside of its native range, we used high uncertainty for most of the questions in this risk element.
Imp-N2 (Changes habitat structure)	n - high	0	We found no evidence.
Imp-N3 (Changes species diversity)	? - max		One source states that *Pogostemon stellatus* forms pure patches in suitable habitats (Watve, 2011), suggesting it may be competitively superior to other species and displace them. However, without additional information, we answered unknown.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	n - high	0	We found no evidence.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - high	0	We found no evidence.
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	a - mod	0	We found no evidence that this species is a weed of natural systems. Alternate answers for the uncertainty simulation are both "b."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - high	0	We found no evidence of this impact.
Imp-A2 (Changes or limits recreational use of an area)	n - high	0	We found no evidence.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - high	0	We found no evidence.
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	a - mod	0	We found no evidence that this species is a weed of anthropogenic systems. Alternate answers for the uncertainty simulation are both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - high	0	We found no evidence of this impact. However, because so little is known of this species, and because it occurs in and is a weed of rice (Li and Hedge, 2017; Moody, 1989), we used high uncertainty for most questions in this risk element.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P2 (Lowers commodity value)	n - high	0	We found no evidence.
Imp-P3 (Is it likely to impact trade?)	n - high	0	We found no evidence that this species or any species of *Pogostemon* is regulated (e.g., APHIS, 2017). Furthermore, we found no evidence that it is moving in trade as a contaminant. Consequently, we answered no with high uncertainty.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - high	0	We found no evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - mod	0	We found no evidence that *P. stellatus* or any *Pogostemon* species is toxic to animals (e.g., Bruneton, 1999; Burrows and Tyrl, 2013).
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	b - high	0.2	*Pogostemon stellatus* occurs in rice paddies (Li and Hedge, 2017) and is a weed of rice in Bangladesh, Burma, Cambodia, Indonesia, India, Laos, Malaysia, the Philippines, Thailand, and Vietnam, (Moody, 1989). It is also reported to be invasive in China (Wang et al., 2016), suggesting it may be a weedy native species. We found no evidence it is specifically targeted for control, or other evidence that it is weedy or problematic. Consequently, we answered "b" with high uncertainty. Alternate answers for the uncertainty simulation were "a" and "c."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2017).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence.
Geo-Z6 (Zone 6)	n - low	N/A	We found no evidence.
Geo-Z7 (Zone 7)	n - high	N/A	This species is present in the Kanto Plain of Japan (Yamada et al., 2011; Yao et al., 2016), which includes this zone. However, because this zone represents a minor portion of this region and because there was no other evidence that the species occurs in this hardiness zone, we answered no with high uncertainty.
Geo-Z8 (Zone 8)	y - low	N/A	A few points in China. Present in the Anhui and Zhejiang provinces of China (Li and Hedge, 2017), which include this zone. Present in the Kanto Plain of Japan (Yamada et al., 2011; Yao et al., 2016), which includes this zone.
Geo-Z9 (Zone 9)	y - low	N/A	Some points in China. Kanto Plain in Japan (Yamada et al., 2011; Yao et al., 2016), which is mostly Zones 8 and 9.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z10 (Zone 10)	y - negl	N/A	Some points in Papua New Guinea. A few points in China. One point in India. Present in India, Uttar Pradesh (Kumar and Narain, 2010), which is mostly represented by this zone.
Geo-Z11 (Zone 11)	y - negl	N/A	Northern Australia and Papua New Guinea. A few points in Laos. One point in Thailand.
Geo-Z12 (Zone 12)	y - negl	N/A	Northern Australia and Papua New Guinea. One point in Thailand.
Geo-Z13 (Zone 13)	y - negl	N/A	Northern Australia and Papua New Guinea.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Papua New Guinea. A few points in Indonesia. Two points in Laos. General distribution throughout Malesia (Yao et al., 2016).
Geo-C2 (Tropical savanna)	y - negl	N/A	Northern Australia. Four points in Thailand. India (Orissa State; Franco F. and Narasimham, 2009).
Geo-C3 (Steppe)	n - high	N/A	Two points in northern Australia near the edge with tropical savanna. Because there were no other points in this climate class in Australia, which is botanically well sampled, we answered no, assuming that this climate class is generally not well suited for this species.
Geo-C4 (Desert)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C5 (Mediterranean)	n - mod	N/A	We found no evidence that this species occurs in this climate class, but believe it may be able to if there are suitable water bodies.
Geo-C6 (Humid subtropical)	y - negl	N/A	China, Taiwan, and India (Uttar Pradesh, Bihar State; Watve, 2011). Kanto Plain in Japan (Yamada et al., 2011).
Geo-C7 (Marine west coast)	y - high	N/A	This species is reported to occur throughout most of India, southeast Asia, and the Malesia region (Watve, 2011; Yao et al., 2016). Tamil Nadu, India, and Fujian, China include this climate class.
Geo-C8 (Humid cont. warm sum.)	n - low	N/A	We found no evidence that this species occurs in this climate class.
Geo-C9 (Humid cont. cool sum.)	n - negl	N/A	We found no evidence.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - negl	N/A	We found no evidence that this species occurs in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	n - mod	N/A	We found no evidence.
Geo-R3 (20-30 inches; 51-76 cm)	y - mod	N/A	Australia.
Geo-R4 (30-40 inches; 76-102 cm)	y - low	N/A	Australia. Regional occurrence in India (Uttar Pradesh Watve, 2011).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Australia. Regional occurrence in India (Uttar Pradesh Watve, 2011).
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Australia. Regional occurrence in India (Orissa; Franco F. and Narasimham, 2009).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Australia. Regional occurrence in India (Orissa; Franco F. and Narasimham, 2009).
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Australia. Regional occurrence in India (Orissa; Franco F. and Narasimham, 2009).
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	This species occurs in Bangladesh and southeastern China (Li and Hedge, 2017; Watve, 2011; Yao et al., 2016), which include this precipitation band.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	A few points in Papua New Guinea.
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Some points in Papua New Guinea. India (Kerala; Watve, 2011).
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	*Pogostemon stellatus* is cultivated in the United States (e.g., AAG, 2017; Florida Aquatic Nurseries, 2017). It can be obtained from online U.S. aquatic businesses (e.g., eBay, 2017; Florida Aquatic Nurseries, 2017), or directly from Thailand-based companies that have plants listed on the internet (Amazon, 2017). However, to evaluate other pathways by which it may enter the United States, we answered this question as no.
Ent-2 (Plant proposed for entry, or entry is imminent)	y - negl	1	PPQ received a market access request for *P. stellatus* for propagation from the Ministry of Food, Agriculture and Fisheries, the Danish Plant Directorate (MFAF, 2009). Thus, if approved, its entry is imminent.
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	N/A	*Pogostemon stellatus* is cultivated in the international aquarium trade (e.g., Aquarium Gardens, 2017; eBay, 2017; Flowgrow, 2017) and can be obtained from Thailand-based companies selling it on Amazon (2017). It is also used to treat fever in India (Franco F. and Narasimham, 2009). A natural compound from *Dysophylla stellata* (*P. stellatus*) was evaluated for its anti-inflammatory properties (Gautam et al., 2011; Gautam et al., 2010).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - negl	N/A	This species is native to China (Li and Hedge, 2017) and is considered invasive there (Wang et al., 2016).
Ent-4b (Contaminant of plant propagative material (except seeds))	n - high	N/A	We found no evidence.
Ent-4c (Contaminant of seeds for planting)	n - high	N/A	We found no evidence.
Ent-4d (Contaminant of ballast water)	n - high	N/A	We found no evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4e (Contaminant of aquarium plants or other aquarium products)	? - max	N/A	Unknown.
Ent-4f (Contaminant of landscape products)	n - high	N/A	We found no evidence.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	n - high	N/A	We found no evidence.
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	n - high	N/A	We found no evidence.
Ent-4i (Contaminant of some other pathway)	a - high	N/A	We found no evidence.
Ent-5 (Likely to enter through natural dispersal)	n - low	N/A	Because we found no evidence it is present or even naturalized in neighboring regions, it seems unlikely that it will enter the United States via this pathway.