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Weed Risk Assessment for *Lilaeopsis brasiliensis* (Glaziou) Affolter (Apiaceae) – Brazilian micro sword

Top: Lawn-like habit of *Lilaeopsis brasiliensis* under high light in an aquarium. Bottom left: A clump with offshoots being produced along rhizomes. Bottom right: A clump growing in rock wool. 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: *Lilaeopsis brasiliensis* (Glaziou) Affolter (Affolter, 1985)

FAMILY: Apiaceae

SYNONYMS: *Crantzia brasiliensis* Glaziou (Affolter, 1985), *Lilaeopsis carolinensis* var. *minor* A.W. Hill, *L. minor* Prez-Mor. (Affolter, 1985; The Plant List, 2017).

COMMON NAMES: Micro sword (PAC, 2017), Brazilian micro sword (APC, 2016).

BOTANICAL DESCRIPTION: *Lilaeopsis brasiliensis* is a small, perennial creeping herb (Affolter, 1985), which is the typical life form for the genus (Charlton, 1992). It produces a continuous rhizome that is 0.2 to 1.0 mm in diameter from which one to a few leaves develop at each node (Affolter, 1985). Leaves are septate, linear to spatulate or oblanceolate, 1 to 7 cm long, and are hollow and elliptical in cross section for most of their length. Inflorescences are short simple-flowered umbels (2-8 flowered), usually 2 to 25 mm long, and flowers are whitish or maroon-tinted (Affolter, 1985). Fruit is a globose to obovoid schizocarp (dry dehiscent fruit that splits), 1.0–1.0 mm long and 1.1–1.9 mm wide, and with five ribs containing spongy cells. Vertical rhizome branches are weakly developed in this species (Affolter, 1985), and after a little growth, they transform into a horizontal rhizome (Charlton, 1992). For a more detailed description and drawings of the species, see Affolter (1985).

Species in the genus *Lilaeopsis* are difficult to distinguish morphologically for a few reasons, including the reduced nature of the leaves, morphological variability in leaves between submerged and emerged forms, simple umbels, and overlapping variation in fruit traits among some species (Affolter, 1985; Bone et al., 2011; Petersen et al., 2002). In some cases, geographic origin must be used to identify taxa (Bone et al., 2011).

INITIATION: PPQ received a market access request for *L. brasiliensis* 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 (Affolter, 1985), 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: *Lilaeopsis brasiliensis* is native to northern Argentina, southeastern Brazil, Paraguay, and Uruguay (Affolter, 1985; Bone et al., 2011; Forzza et al., 2010). It has been introduced to Australia (Randall, 2007), Canada (Azan, 2011), and China (Wang et al., 2016), and is commercially cultivated in Denmark (Windeløv, 2004). In February 2017, a botanist discovered that *L. brasiliensis* had become naturalized in New Zealand (GBIF, 2017). It has also probably become naturalized in a

[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).

region in Brazil outside of its native range in the country (GBIF, 2017). It is considered invasive in China (Wang et al., 2016). *Lilaeopsis brasiliensis* "is produced by all the major nurseries of the world and can be obtained through most any local fish store that stocks live plants" (APC, 2016; Winterton and Scher, 2007), including in Canada, where there were 415 sales across 20 stores in 2010 (Azan, 2011).

The species *Lilaeopsis mauritiana* was recently discovered on the island of Mauritius (Petersen and Affolter, 1999) and is very closely related to *L. brasiliensis* based on ITS and chloroplast DNA (Bone et al., 2011). Although the fruit types of these two species are distinct, molecular data suggest that the morphologically unique plants of Mauritius may be aberrant members of *L. brasiliensis* (Bone et al., 2011). While the current consensus among sources is that the plants from Mauritius represent a distinct species, if this perspective changed, then the Mauritian population would represent either an unusually disjunct native population of *L. brasiliensis*, or a naturalized occurrence of the species.

U.S. DISTRIBUTION AND STATUS: We found no evidence that *L. brasiliensis* is naturalized in the United States (e.g., EDDMapS, 2017; Kartesz, 2017; NRCS, 2017; Weakley, 2015). Its earliest known date of introduction to the United States is 1985 (Gordon and Gantz, 2011). This species is commonly cultivated in the global trade and is one of the few plants commonly available for the aquarium foreground (APC, 2016). In the United States, it is sold by several online retailers [e.g., in Arizona (PAC, 2017), California (AFA, 2017), and Florida (Aquarium Plants, 2017)] and by sellers on Amazon (Amazon, 2017) and eBay (eBay, 2017). We found no evidence that this species is regulated in the United States (e.g., NPB, 2016; USDA-AMS, 2016).

3. Analysis

ESTABLISHMENT/SPREAD POTENTIAL

Lilaeopsis brasiliensis has already demonstrated some ability to establish, as it has become naturalized in New Zealand and Taiwan, and probably beyond its native range in Brazil (GBIF, 2017). Contributing to a potentially invasive behavior, this species is tolerant of shade (APC, 2016; GBIF, 2017), can form grassy swards (GBIF, 2017), reproduces through both vegetative and sexual reproduction (Azan, 2011; Winterton and Scher, 2007), and is probably self-compatible based on evidence from a conger and other Apiaceae (Affolter, 1985). *Lilaeopsis brasiliensis* is dispersed by water (Hill, 1927) and birds (Affolter, 1985), and, like many other ornamental aquatics, it may be dispersed unintentionally by people (collection record in GBIF, 2017). Because there was so little information available on the biology of this species and because we based many of the answers to the questions on congeneric information, we had very high uncertainty for this risk element. In addition, we could not answer five of the questions.

Risk score = 13 Uncertainty index = 0.39

IMPACT POTENTIAL

Wang et al. (2016) classify *L. brasiliensis* as an invasive species in China, which they define as an exotic species that causes ecological and economic impacts in natural communities and anthropogenic habitats. However, we found no evidence of any specific impacts caused by this species. The points obtained in this risk element were due to its classification as a “weed” by Wang et al. (2016). Due to limited information available for this species, we had very high uncertainty for this risk element. We could not answer eight of the questions with any confidence.

Risk score = 1.2 Uncertainty index = 0.50

GEOGRAPHIC POTENTIAL

Based on three climatic variables, we estimate that about 8 percent of the United States is suitable for the establishment of *L. brasiliensis* (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 *L. brasiliensis* represents the joint distribution of Plant Hardiness Zones 9-13, 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. *Lilaeopsis brasiliensis* occurs on river banks, ditches, sluggish streams, seepage areas, marshes, ponds, and boggy areas from sea level to 1200 meters in elevation (Affolter, 1985). This species may be somewhat salt-tolerant (Affolter, 1985).

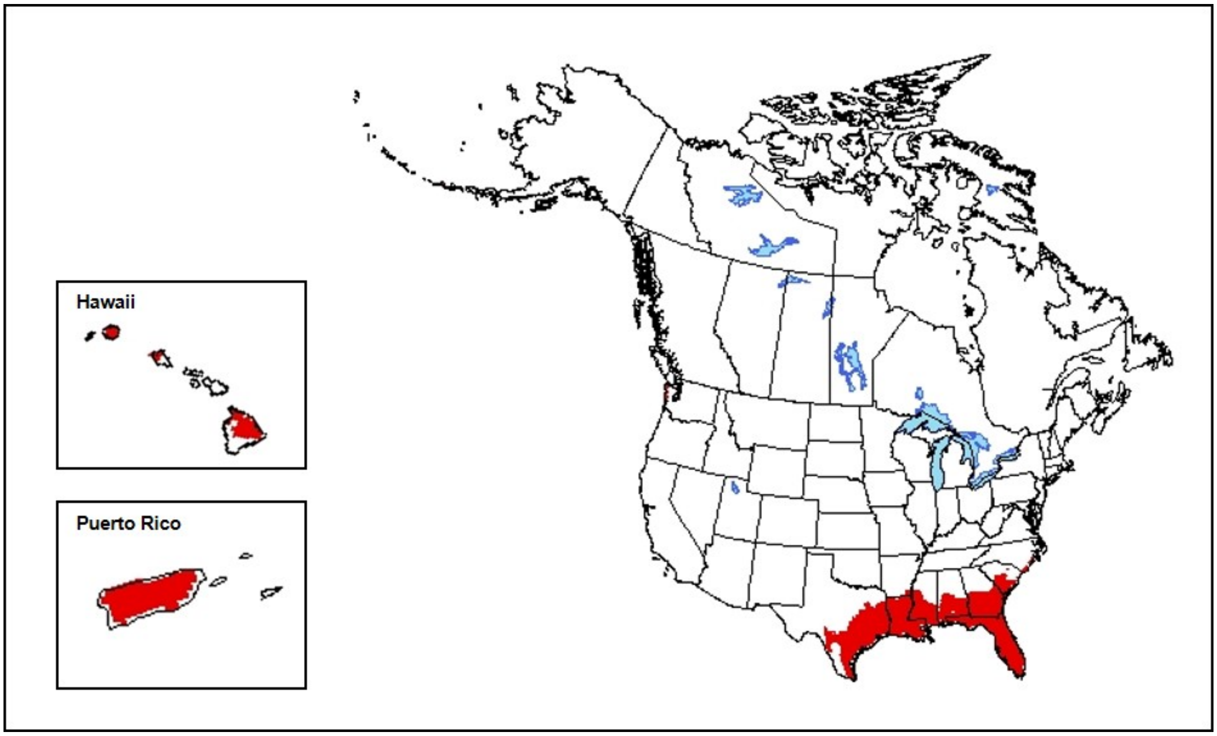

Figure 1. Potential geographic distribution of *Lilaeopsis brasiliensis* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

ENTRY POTENTIAL

Lilaeopsis brasiliensis is present in the United States where it is cultivated and sold as an aquarium ornamental (e.g., AFA, 2017; PAC, 2017). APHIS-PPQ is currently considering a market access request for *L. brasiliensis* 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 maximum 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 Uncertainty index = 0.00

4. Predictive Risk Model Results

Model Probabilities: P(Major Invader) = 41.3%
P(Minor Invader) = 54.5%
P(Non-Invader) = 4.1%
Risk Result = High Risk
Secondary Screening = Not applicable

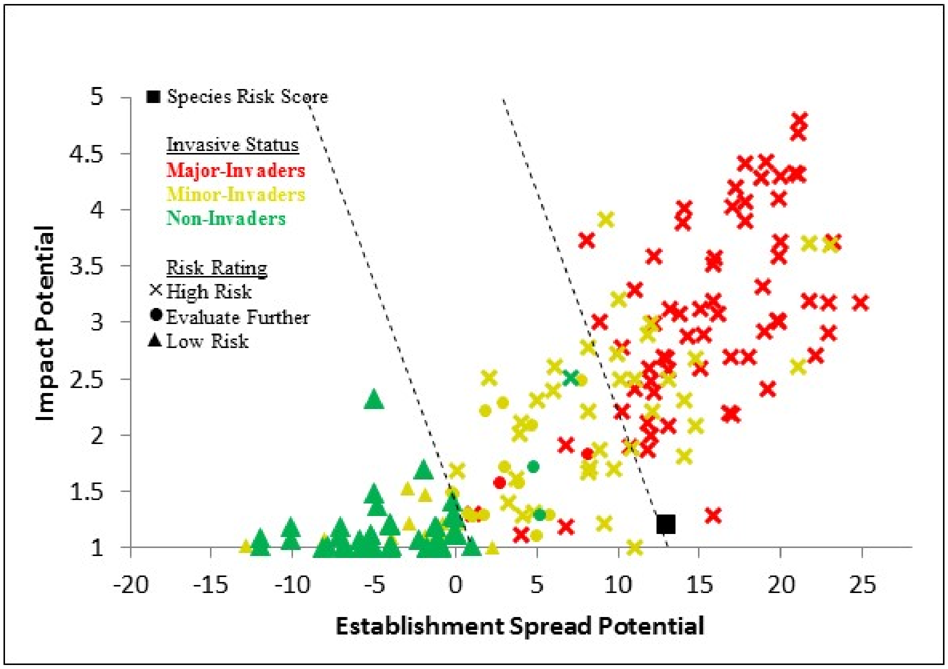

Figure 2. *Lilaeopsis brasiliensis* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

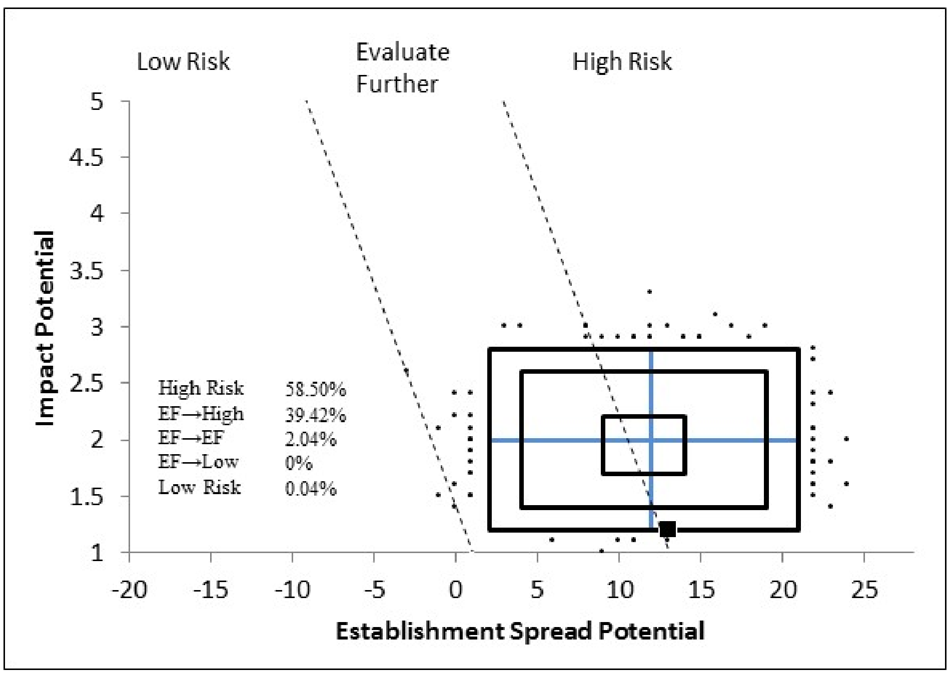

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Lilaeopsis brasiliensis*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

5. Discussion

The result of the weed risk assessment for *L. brasiliensis* is High Risk (Fig. 2). Overall, we had a high level of uncertainty associated with this assessment because of the lack of detailed biological information about the species, and because we had to base some of our answers on congeneric information or traits associated with the genus. Regardless, the majority of the simulated risk scores also resulted in an outcome of high risk (Fig. 3). The risk score for *L. brasiliensis* is located just inside the High Risk region on the edge of the decision threshold. Had the species scored negatively on a single question in either risk element, the primary outcome of the assessment would have been Evaluate Further. However, secondary screening would have bumped that result back up to High Risk. An independent U.S. assessment of this species using the Australian weed risk assessment model resulted in a risk score of five (Evaluate Further), which is two points less than the minimum result of High Risk in that assessment system (Gordon and Gantz, 2011).

Lilaeopsis brasiliensis has probably been in the U.S. aquarium trade for about 30 years (Gordon and Gantz, 2011). Our analysis suggests that it has a suite of traits that increases its likelihood to establish outside of cultivation, as it has elsewhere. However, it is unclear if it would have any significant impacts on our natural and agricultural resources. Field observations of another *Lilaeopsis* species in New Zealand suggest that as a whole, these species may not be very competitive (probably due to their short stature), but their ability to survive fluctuations in water level may help them to persist where more competitive species cannot (Stevenson, 1947).

6. Acknowledgements

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SUGGESTED CITATION

PPQ. 2017. Weed risk assessment for *Lilaeopsis brasiliensis* (Glaziou) Affolter (Apiaceae) – Brazilian micro sword. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC. 22 pp.

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Appendix A. Weed risk assessment for *Lilaeopsis brasiliensis* (Glaziou) Affolter (Apiaceae)

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]	e - high	2	*Lilaeopsis brasiliensis* is native to Argentina, Brazil, Paraguay, and Uruguay (Affolter, 1985; Bone et al., 2011; Forzza et al., 2010). It has been introduced to Australia (Randall, 2007), Canada (Azan, 2011), China (Wang et al., 2016), Denmark (Windeløv, 2004), the United States (PAC, 2017), and likely other countries. It has become naturalized in Taiwan and New Zealand, and possibly in the Brazilian state of Pernambuco, which is outside the species' native range in Brazil (GBIF, 2017). *Lilaeopsis brasiliensis* is also considered invasive in China (Wang et al., 2016), indicating that at the very least it has become naturalized there; however, we found no other evidence confirming its status in the country (e.g., She et al., 2005) or that it is spreading there. It is possible that Wang et al. (2016) were referring to the Taiwanese occurrence. We answered "e" with high uncertainty, and used "f" for both alternate answers for our uncertainty simulation.
ES-2 (Is the species highly domesticated)	n - low	0	*Lilaeopsis brasiliensis* is cultivated (PAC, 2017; Tropica, 2017); however, we found no evidence that this species has been bred for reduced weed potential.
ES-3 (Significant weedy congeners)	n - low	0	*Lilaeopsis* is a genus of about 13-15 warm-temperate to tropical herb species, most of which are native to the Americas (Bone et al., 2011; Mabberley, 2008; Weakley, 2015). Five species are listed under the Global Compendium of Weeds with one reference each about weediness, and one species (*L. carolinensis*) is listed with 11 references (Randall, 2017), suggesting that the genus overall does not pose a significant or major weed threat. *Lilaeopsis carolinensis* is native to the southeastern United States (Weakley, 2015) and has become naturalized on the Iberian peninsula (Bone et al., 2011). We found no information indicating it is a significant weed in Europe.
ES-4 (Shade tolerant at some stage of its life cycle)	y - mod	1	The New Zealand population of *L. brasiliensis* was discovered growing in a shaded site (GBIF, 2017).

Question ID	Answer - Uncertainty	Score	Notes (and references)
			In aquaria, *L. brasiliensis* prefers high to very high light and should be planted away from the shade of other plants for best performance (Windeløv, 2004), but it is also reported to grow under dim lighting (APC, 2016). Based on our guidance for this question, we answered yes because this species can grow under submerged conditions (Affolter, 1985; APC, 2016) and appears to be able to tolerate shade.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	The genus *Lilaeopsis* consists of small, perennial creeping herbs (Affolter, 1985; Britton, 1907); they are neither vines nor herbs with a basal rosette of leaves. Although *L. brasiliensis* is vine-like because of its creeping rhizome, technically it is not a vine or scrambling plant since it does not climb or scramble over other vegetation.
ES-6 (Forms dense thickets, patches, or populations)	y - low	2	The naturalized population of *L. brasiliensis* in New Zealand was described as "swarding" (GBIF, 2017), which implies a relatively dense population of plants. *Lilaeopsis brasiliensis* can form a turf (Charlton, 1992). In aquaria, it will only form lawn-like carpets under very high light (Windeløv, 2004). *Lilaeopsis* "[p]lants growing in sunny, relatively well-drained sites, such as exposed sand or mud flats, often form a low, dense turf" (Affolter, 1985). Plants in the field often grow in dense patches due to clonal vegetative growth along their creeping rhizomes (Affolter, 1985). High light conditions favor denser growth on *L. mauritiana* in aquaria (Windeløv, 2004). The California native *L. masonii* is a rhizomatous, clonal plant where single occurrences may represent a single ramet (< 1 cm^2) to a patch that is about 18 m^2 (Grewell et al., 2013). The U.S. native *L. chinensis* can form dense mats in intertidal mudflats (Moore et al., 2009). Based on this information, we answered yes.
ES-7 (Aquatic)	y - low	1	*Lilaeopsis brasiliensis* grows as both a submerged and emergent plant (Affolter, 1985; APC, 2016). The genus *Lilaeopsis* consists of herbs that live in marshes and whose leaves have been reduced to linear, hollow petioles (Britton, 1907), which help with buoyancy (Raynal, 1977). They occupy damp, marshy, or truly aquatic habitats (Bone et al., 2011). Because *L. brasiliensis* grows submerged and has adaptions for aquatic environments, we answered yes, even though it is not an obligate aquatic plant.
ES-8 (Grass)	n - negl	0	This species is not a grass; it is an herb in the Apiaceae family (Affolter, 1985).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that this species fixes nitrogen. Furthermore, it is not a member of a plant

Question ID	Answer - Uncertainty	Score	Notes (and references)
			family known to contain nitrogen-fixing species (e.g., Martin and Dowd, 1990; Santi et al., 2013), nor is it woody.
ES-10 (Does it produce viable seeds or spores)	y - high	1	We found no evidence describing seed viability rates in the genus or in *L. brasiliensis*. Two sources indirectly indicate that *L. brasiliensis* reproduces by seeds (Azan, 2011; Winterton and Scher, 2007). In his monograph on the genus, Affolter (1985) commented that plants produce viable seed: "In extreme cases, fruits might be able to remain afloat in ocean currents for several weeks or months, without total loss of seed viability." *Lilaeopsis schaffneriana* subsp. *recurva* produces viable seed (Titus and Titus, 2008a). Based on this evidence, we answered yes with high uncertainty.
ES-11 (Self-compatible or apomictic)	y - high	1	We found no information for this species on self-compatibility. Affolter (1985) concluded that the plants of *L. carolinensis* were likely self-compatible or apomictic because isolated clones were able to set fruit. He also cited additional information that most plants in the Apiaceae are self-compatible (cited in Affolter, 1985).
ES-12 (Requires specialist pollinators)	n - high	0	We found no specific information for this species. In his monograph on the genus, Affolter (1985) argued that *Lilaeopsis* species are likely able to self-pollinate based on the frequent fruiting of plants under cultivation and the fact that flowers are relatively small, so gravity alone could transfer pollen to the stigmas. He conducted a pollinator exclusion experiment where he showed that plants of *L. carolinensis* that were covered with nylon stocking still set fruit. He also had a plant produce a single umbel under water that then produced a fruit (Affolter, 1985). Based on this congeneric information we do not think that *L. brasiliensis* requires specialized pollinators.
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]	a - high	2	*Lilaeopsis brasiliensis* reproduces vegetatively, and probably sexually (Azan, 2011; Winterton and Scher, 2007); however, we found no specific information about generation time. The genus *Lilaeopsis* consists of small, creeping, rhizomatous perennial herbs (Bone et al., 2011). Although other *Lilaeopsis* species can expand significantly in size between years, seasons, or both (Affolter, 1985; Titus and Titus, 2008b), it is not clear to us what constitutes an individual plant/generation since plants do not produce distinct ramets, as do other rhizomatous plants (e.g., bananas, irises, running bamboos). *Lilaeopsis* plants essentially consist of leaves emerging from an underground stem. In a way, they are like vines that root along each node.

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Grewell et al. (2013) consider each node along the rhizome as a ramet. If we adopted this perspective, then there would be multiple generations per year given Affolter's observations about expansion. Without additional information, we answered this question as "a" with high uncertainty. Alternate answers for the uncertainty simulation were both "b."
ES-14 (Prolific seed producer)	? - max	0	Unknown. The inflorescences in *Lilaeopsis* plants are simple and have 2 to 15 flowers (Affolter, 1985). New Zealand plants were three-flowered (GBIF, 2017). Increased shading or submergence in water reduces the number of flowers per umbel (Affolter, 1985). We found no other information on reproductive effort.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - high	1	Unknown. We found no definitive evidence of unintentional dispersal by people. Dr. Gardner, who discovered the *L. brasiliensis* population in New Zealand, speculated that it may have established accidentally (or deliberately) through the aquarium trade (collection record in GBIF, 2017). Dr. Gardner also noted other "unusual" exotic aquatic plant occurrences in that same area where *L. brasiliensis* was discovered (GBIF, 2017). In general, recreational boating is an important pathway for the unintentional movement of aquatic macrophytes (e.g., Johnson et al., 2001; Johnstone et al., 1985; Rothlisberger et al., 2010). *Lilaeopsis brasiliensis* occurs on river banks, sluggish streams, and ponds (Affolter, 1985), places frequented by people. Although it is propagated vegetatively under cultivation (APC, 2016), it may be able to reestablish from fragments under natural conditions (see ES-19). In New Zealand, small patches of a different *Lilaeopsis* species can become detached, float to the surface, and reroot elsewhere in a given body of water (Stevenson, 1947). Based on this information, we think that it is likely that *L. brasiliensis* can be dispersed unintentionally.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - mod	-1	We found no evidence. *Lilaeopsis brasiliensis* is not reported to grow in agricultural areas where contamination is more likely.
ES-17 (Number of natural dispersal vectors)	2	0	Propagule description for ES-17a through ES-17e: Fruit of *Lilaeopsis* are schizocarps (Bone et al., 2011). *Lilaeopsis brasiliensis* produces widely globose to widely obovoid fruit, 1.0-1.9 mm long, 1.1-1.9 mm wide, and with all five ribs with spongy cells. There is a tendency for the peduncles and pedicels of most species of *Lilaeopsis*, including *L. brasiliensis*, to recurve as the fruit mature, causing the fruit to either be brought back under water or

Question ID	Answer - Uncertainty	Score	Notes (and references)
			be pressed against the soil surface (Affolter, 1985). While collecting plants of *L. brasiliensis*, Affolter (1985) noticed many fruit had been buried in the sediment.
ES-17a (Wind dispersal)	n - negl		"The fruits of *Lilaeopsis* are too heavy to be blown great distances by wind" (Affolter, 1985).
ES-17b (Water dispersal)	y - negl		*Lilaeopsis brasiliensis* is not only an aquatic plant, but it also produces spongy cells in the ribs of the fruit that increase fruit buoyancy and aid in water dispersal (Hill, 1927). Fruit and vegetative clumps of other members of the genus are dispersed by water (Affolter, 1985; Grewell et al., 2013; Stevenson, 1947; Titus and Titus, 2008b). The fruit of *L. carolinensis* retain their buoyancy for at least 8 months (Affolter, 1985).
ES-17c (Bird dispersal)	y - high		We found no direct evidence that *L. brasiliensis* is dispersed by birds. In explaining the disjunct native distribution of *L. carolinensis* in the northern and southern hemispheres, Affolter (1985) speculated that migrating birds may have carried the seeds. Indeed, a "minimum of seven dispersal events is required to explain the present-day distribution of [the genus] *Lilaeopsis*" across the New World and Australasia (Bone et al., 2011). Although these intercontinental dispersal events have occurred over geologic time scales (Spalik et al., 2010), they support the idea of the likelihood and importance of bird dispersal for the genus. "The fruits of *Lilaeopsis* lack spines or other adhesive structures and they are not sticky. They are small enough, however, to become attached to the feet, bills, or feathers of birds when encased in mud or organic debris. Thus affixed, they could occasionally be transported between suitable habitats" (Affolter, 1985). Affolter (1985) noted one report of a fruit of an unknown *Lilaeopsis* plant being obtained from the stomach of a New Zealand duck, although it is unknown whether the seeds of ingested fruit would remain viable after gut passage.
ES-17d (Animal external dispersal)	? - max		As part of her thesis where she categorized the biological traits of aquatic plants commonly sold in the greater Toronto region, Azan (2011 reported that *L. brasiliensis* is dispersed by animals without providing more detailed information.
ES-17e (Animal internal dispersal)	? - max		Unknown.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	We found no information about long-term seed dormancy in *L. brasiliensis*. *Lilaeopsis schaffneriana* subsp. *recurva* appears to produce a persistent seed bank (Titus and Titus, 2008b). Fifteen-month-old fruit of *L. carolinensis* were viable after being used in an eight-month

Question ID	Answer - Uncertainty	Score	Notes (and references)
			experiment involving floating in fresh and saltwater, and an additional seven months of dry storage (Affolter, 1985).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	In aquaria, cuttings can be used to propagate *L. brasiliensis* (APC, 2016); however, we found no direct evidence that this species is tolerant of mutilation in the wild. In *L. schaffneriana* subsp. *recurva*, "weakly rooted clumps of the plant tear off as a result of scouring during flood events and float downstream to take root elsewhere. Some of these clumps survive, depending on specific conditions where the clump is deposited" (Titus and Titus, 2008b). Small patches of *Lilaeopsis* in New Zealand can become detached, float to the surface, and reroot elsewhere in a given body of water (Stevenson, 1947). Without specific evidence about this species' behavior in the wild, we answered unknown.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - mod	0	We found no evidence that this species is resistant to herbicides (e.g., Heap, 2017). Because it is not reported to occur in agricultural areas and subject to routine applications of herbicides, it seems unlikely that it has developed resistance.
ES-21 (Number of cold hardiness zones suitable for its survival)	5	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 - high	0	We found no evidence that this species or any species in the genus is allelopathic.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that this species is parasitic. It is also not a member of a plant family known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009; Walker, 2014).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	? - max		We found no evidence of this impact for this species. Wang et al. (2016) classify *L. brasiliensis* as invasive in China, which they define as an exotic species that causes ecological and economic in natural communities and anthropogenic habitats (Wang et al., 2016). Because the scope of their study and their definition of invasive focuses on impact, and because *L. brasiliensis*' biology is poorly known we answered most of the questions in this risk sub-element as unknown.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N2 (Changes habitat structure)	? - max		Unknown.
Imp-N3 (Changes species diversity)	? - max		Unknown.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	? - max		Unknown.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	? - max		Unknown.
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]	b - high	0.2	The only evidence we found that this species is considered a weed in natural systems is from Wang et al. (2016), who classify it as a harmful species. Alternate answers for the uncertainty simulation were both "a."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	? - max		Unknown. In New Zealand, an unidentified *Lilaeopsis* species can form dense mats if the plants are uprooted through natural processes from the soft mud of lakes and reservoirs (Stevenson, 1947). Affolter (1985) states, "While walking around the shore of Lake Marymeri, we failed to find any rooted *Lilaeopsis*. However, fresh plants ... were piled up along the shore of the lake in thick clumps. In places, armloads of *Lilaeopsis* could be gathered from a few meters of shoreline." Floating mats of aquatic vegetation could clog pipes, drainages, culverts, etc.
Imp-A2 (Changes or limits recreational use of an area)	? - max		Unknown. If this species becomes uprooted and forms large floating mats (see evidence under Imp-A1), then it might limit recreational use of an area.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	? - max		Unknown. One aquarium keeper said about *L. brasiliensis*: "As this plant is very invasive, runners that grow into neighboring plant groupings will need to be regularly pruned off. These clippings can be used for propagation in other tanks if desired" (APC, 2016). While this information is relevant to this question and would help to support a yes response, because we did not find similar comments from others, we answered unknown.
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 - high	0	One aquarist commented that "it grows like a weed," but not that they considered it a weed (UKAPS, 2017). Another said it was very invasive and needed regular pruning to keep it from spreading into neighboring plants (APC, 2016), but this does not indicate that the plant is undesirable. Because all ornamental plants grow and require pruning to conform to our artificial landscapes and because this evidence above represents only two comments, we do not consider this as sufficient

Question ID	Answer - Uncertainty	Score	Notes (and references)
			evidence that this species is viewed as a weed. Wang et al. (2016) classify *L. brasiliensis* as invasive, which, based on their definition of invasive, includes species that cause economic harm in anthropogenic systems. However, instead of answering "b" as we did under Imp-N6, we answered "a" so as to not overuse this weak evidence. The alternate answers for the uncertainty simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - mod	0	We found no evidence of this impact for *L. brasiliensis*. Because this species is not reported to occur in agricultural areas, we answered most of the questions in this risk sub-element as no with moderate uncertainty.
Imp-P2 (Lowers commodity value)	n - mod	0	We found no evidence.
Imp-P3 (Is it likely to impact trade?)	n - low	0	We found no evidence that any member of this genus is regulated by a U.S. state government (e.g., NPB, 2016; USDA-AMS, 2016) or a foreign government (e.g., APHIS, 2017). Consequently, it is unlikely to impact trade if it could move as a contaminant.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - high	0	We found no evidence. As an aquatic plant, it could potentially impact irrigation.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - mod	0	We found no evidence that this species or genus is toxic to animals (e.g., 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]	a - low	0	We found no evidence that this species is considered a weed of production systems. Alternate answers for the uncertainty simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 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.
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 - negl	N/A	We found no evidence.
Geo-Z7 (Zone 7)	n - negl	N/A	We found no evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z8 (Zone 8)	n - high	N/A	There is a point in Zone 10 in Taiwan that is near this zone.
Geo-Z9 (Zone 9)	y - negl	N/A	Argentina, Brazil, and Uruguay (Affolter, 1985; GBIF, 2017).
Geo-Z10 (Zone 10)	y - negl	N/A	Argentina and Brazil (Affolter, 1985; GBIF, 2017). One point in Taiwan (GBIF, 2017).
Geo-Z11 (Zone 11)	y - low	N/A	A few points in Brazil and Uruguay (Affolter, 1985). One point in New Zealand (GBIF, 2017).
Geo-Z12 (Zone 12)	y - high	N/A	One point in Brazil in Zone 13, near the edge of this zone. Because this species is present in Zone 11 and can survive in Zone 13, it must be able to survive in this zone as well.
Geo-Z13 (Zone 13)	y - high	N/A	One point in Brazil.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - high	N/A	One point in Brazil in the state of Pernambuco. It is not clear if this record represents a naturalized population or casual plants, but for the purpose of this evaluation, we assumed it is naturalized here.
Geo-C2 (Tropical savanna)	y - high	N/A	One point in Paraguay.
Geo-C3 (Steppe)	n - mod	N/A	We found no evidence.
Geo-C4 (Desert)	n - negl	N/A	We found no evidence.
Geo-C5 (Mediterranean)	n - high	N/A	We found no evidence that this species occurs in this climate type, but think that it may be able to if it is warm enough and if it occurs in an appropriate habitat.
Geo-C6 (Humid subtropical)	y - negl	N/A	Most points in South America (Argentina, Brazil, Paraguay, and Uruguay) occur in this climate type. One point in Taiwan.
Geo-C7 (Marine west coast)	y - high	N/A	One point in New Zealand. Some points in South America are generally near this climate type.
Geo-C8 (Humid cont. warm sum.)	n - low	N/A	We found no evidence.
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 it occurs in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	n - high	N/A	We found no evidence.
Geo-R3 (20-30 inches; 51-76 cm)	y - mod	N/A	One point in Argentina (Affolter, 1985) and Paraguay (GBIF, 2017).
Geo-R4 (30-40 inches; 76-102 cm)	y - low	N/A	Two points in Argentina.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Argentina, Paraguay, and Uruguay. One point in New Zealand.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Argentina.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Three points in Brazil.
Geo-R8 (70-80 inches; 178-203 cm)	y - low	N/A	Two points in Brazil.
Geo-R9 (80-90 inches; 203-229 cm)	y - mod	N/A	One point in Brazil.
Geo-R10 (90-100 inches; 229-254 cm)	y - high	N/A	Although we did not see any occurrences in this precipitation band, because it occurs in the lower and higher bands, we answered yes.
Geo-R11 (100+ inches; 254+ cm)	y - high	N/A	One point in Taiwan.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	*Lilaeopsis brasiliensis* is present in the United States, where it is cultivated and sold as an aquarium ornamental (e.g., AFA, 2017; PAC, 2017). 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 *L. brasiliensis* 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	*Lilaeopsis brasiliensis* “is produced by all the major nurseries of the world and can be obtained through most any local fish store that stocks live plants” (APC, 2016; Winterton and Scher, 2007), including in Canada, where there were 415 sales per year across 20 stores in 2010 (Azan, 2011). It has been studied to determine whether it can be used to help clean up water polluted by heavy metals (i.e., phytoremediation) (Ostroumov et al., 2012).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - negl	N/A	It has been introduced into Canada, where it is cultivated (Azan, 2011).
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)	? - max	N/A	Unknown. *Lilaeopsis brasiliensis* somewhat tolerates brackish water conditions (Windeløv, 2004).
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.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	n - mod	N/A	We found no evidence.
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	n - low	N/A	We found no evidence, and we think this pathway is unlikely.
Ent-4i (Contaminant of some other pathway)	a - high	N/A	We found no evidence.
Ent-5 (Likely to enter through natural dispersal)	n - mod	N/A	We found no evidence, and do not think this pathway is currently very likely, as the species is not known to be naturalized in a nearby region.