United States Department of Agriculture

Animal and Plant Health Inspection Service

October 17, 2013

Version 4

Weed Risk Assessment for *Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine (Hydrocharitaceae) – South American spongeplant

Limnobium laevigatum at a pond in Redding California. Source: Patrick Akers, California Department of Food and Agriculture.

Agency Contact:

Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science and Technology

Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

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 weed risk assessment (WRA)—specifically, the PPQ WRA model (Koop et al., 2012)—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.

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States or for any area within it. As part of this analysis, we use a stochastic simulation to evaluate how much the uncertainty associated with the analysis affects the model outcomes. We also use GIS overlays to evaluate those areas of the United States that may be suitable for the establishment of the plant. For more information on the PPQ WRA process, please refer to the document, *Background information on the PPQ Weed Risk Assessment*, which is available upon request.

Limnobium laevigatum (Humb. & Bonpl. ex Willd.) Heine – South American spongeplant

Species Information

Family: Hydrocharitaceae

Synonyms: *Limnobium spongia* subsp. *laevigatum* (Humb. & Bonpl. ex Willd.) Lowden [NGRP, 2013]

Initiation: Lars Anderson, University of California, Davis, requested on August 31, 2010, that the Animal and Plant Health Inspection Service assess the risk of *Limnobium laevigatum* because he has seen it spreading recently in California. On September 2, 2010, Al Tasker, the National Weeds Program Coordinator for Plant Protection and Quarantine (PPQ), reiterated that request. In addition, Patrick Akers, the Aquatic Weeds Program manager with the California Department of Food and Agriculture (CDFA), suggested that PPQ should add this species as a Federal Noxious Weed (Akers, 2010a).

Foreign distribution: This plant is native to Mexico, Central America, South America, and the Caribbean, including Puerto Rico (NGRP, 2013).

U.S. distribution and status: *Limnobium laevigatum* is present in 12 California counties (Calflora, 2010). After an initial quiet phase in California lasting about four years, this species recently began to spread quickly (Akers, 2010b). It was first detected in California in 2003 in two small, isolated locations, but in 2007, it was found in a river system. Since then it has appeared in several locations, despite active control efforts (Akers, 2010b). The PLANTS database lists this species as native to California and Puerto Rico (NRCS, 2010) but it is not native to California (NGRP, 2013), only to Puerto Rico (Acevedo-Rodriguez and Strong, 2005). In Puerto Rico *L. laevigatum* grows in shallow ponds, sluggish shaded rivers, and fresh-water ditches and swamps at or near sea level. It is grown and sold by the aquatic nursery plant trade under the common name of frogbit (Hrusa et al., 2002). It is now also regulated and subject to eradication efforts by the California Department of Food and Agriculture (CDFA) (Akers, 2010a; CDFA, 2010).

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

1. *Limnobium laevigatum* analysis

Establishment/Spread Potential *Limnobium laevigatum* established in California and within four years spread along several waterways in twelve counties (Akers, 2010b; Calflora, 2010). Because it reproduces sexually by seed and vegetatively through offshoots, this species can rapidly form dense mats on the water surface. Propagules are dispersed by water and birds, and as hitchhikers on watercraft (Akers, 2010b). This species appears to have a wide adaptive potential given its widespread distribution throughout Central and South America (NGRP, 2013). Uncertainty was high for this risk element because we found no information for several questions.
Risk score = 18 Uncertainty index = 0.28

Impact Potential *Limnobium laevigatum* is a weed that occurs in rivers, ponds, lakes, canals, and other aquatic habitats (Cook and Urmi-König, 1983). The CDFA lists it as a state Noxious Weed (List Q) and is currently trying to eradicate it (Calflora, 2010; DiTomaso, 2010). In its native range, this species is a weed for foresters because it blocks canals used for transporting timber (Fernández et al., 1990). In California, it reduces biodiversity, changes community structure, and limits access to water bodies (Akers, 2010a). Other impacts seem likely, but have not yet been documented for this species. We had a slightly above average amount of uncertainty with this risk element.
Risk score = 3.4 Uncertainty index = 0.24

Geographic Potential Based on three climatic variables, we estimated that about 29 percent of the United States suitable for the establishment of *L. laevigatum* (Fig. 1). That 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. laevigatum* represents the joint distribution of Plant Hardiness Zones 8-13, areas with 10-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, steppe, mediterranean, humid subtropical, and marine west coast.

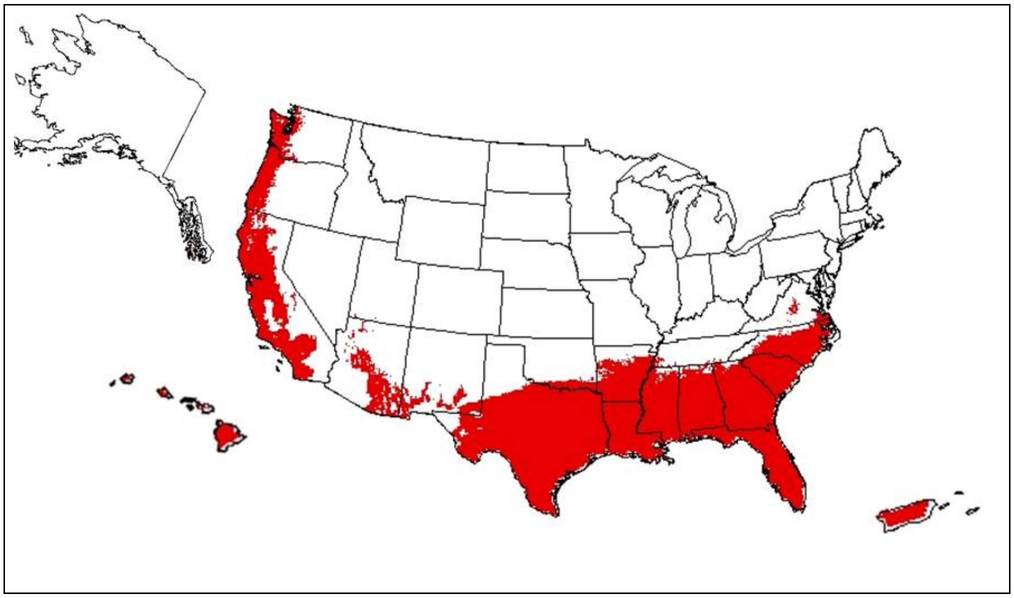
The area estimated likely represents a conservative estimate as it uses only three climatic variables. Other environmental variables, such habitat type, may further limit the areas in which this species is likely to establish. *Limnobium laevigatum* is generally a tropical or subtropical species (Cook and Urmi-König, 1983). It is widely distributed throughout Mexico, Central and South America, and the Caribbean (Cook and Urmi-König, 1983; NGRP, 2013). As an aquatic plant, precipitation is not a direct limiting factor, but cold temperatures are likely to limit its northerly distribution in the United States. We were uncertain whether it could occur in Plant Hardiness Zone 8, but we included it because we found one point occurrence for this zone (GBIF, 2010). Its occurrence in this zone may be 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).

protected microhabitat, or some other unusual situation.

Entry Potential We did not assess the entry potential of *L. laevigatum* because this species is already present in the United States (Calflora, 2010).

Figure 1. Predicted distribution of *Limnobium laevigatum* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale. Note this species is native to and occurs in Puerto Rico.



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 89.6%
P(Minor Invader) = 10.1%
P(Non-Invader) = 0.4%

Risk Result = High Risk
Secondary Screening = Not Applicable

Figure 2. *Limnobium laevigatum* 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.

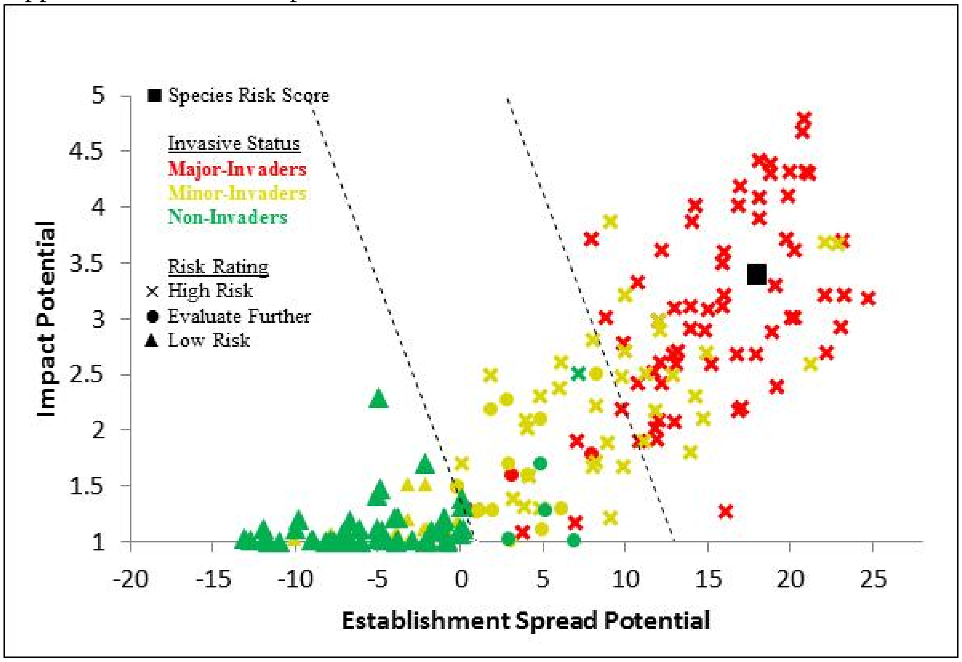
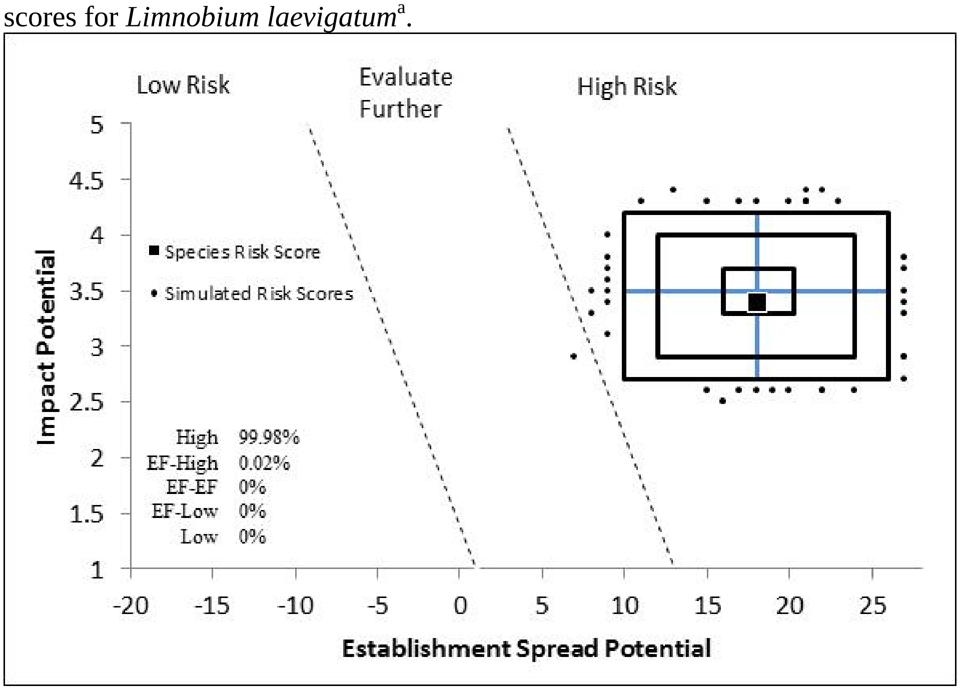


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Limnobium laevigatum*[a].



[a] The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Limnobium laevigatum* is High Risk (Fig. 2). Because *L. laevigatum* is a relatively recent invader in the United States, and little seems to be known about this species, our uncertainty with this assessment was greater than in other weed risk assessments. Still, we think we have sound justification for rating it High Risk, especially because all simulated risk scores in the uncertainty analysis resulted in the same conclusion (Fig. 3). It is clear that *L. laevigatum* has a high growth and spread potential, and that it forms thick vegetative mats on the water surface that exclude light, reduce biodiversity, and limit access (Akers, 2010b). Other impacts typically associated with these kinds of aquatic plant mats (Pieterse and Murphy, 1990) have not yet been documented for this species, perhaps because of the limited time that it has been in the United States. With respect to its habit, morphology, and general life history, *L. laevigatum* is very similar to *Eichhornia crassipes* (water hyacinth), which is widely recognized as a significant invader (Pieterse and Murphy, 1990). We think that its risk scores could increase as new information becomes available.

4. Literature Cited

7 U.S.C. § 1581-1610. 1939. The Federal Seed Act, Title 7 United States Code § 1581-1610.

7 U.S.C. § 7701-7786. 2000. Plant Protection Act, Title 7 United States Code § 7701-7786.

Acevedo-Rodriguez, P., and M. T. Strong. 2005. Monocotyledons and gymnosperms of Puerto Rico and the Virgin Islands. Contributions from the United States National Herbarium 52:1-415.

Akers, P. 2010a. Consider *Limnobium laevigatum* for the Federal Noxious Weed List. Personal communication to A. Tasker on October 12, 2010, from Patrick Akers, Aquatic Weeds Program Manager, California Department of Food and Agriculture, Sacremento, CA.

Akers, P. 2010b. Draft pest profile for *Limnobium laevigatum*. Unpublished Report. California Department of Food and Agriculture, Sacramento, CA.

ARS. 2010. Germplasm Resources Information Network, online database. United States Department of Agriculture, Agricultural Research Service (ARS), National Germplasm Resources Laboratory. http://www.ars-grin.gov/cgi-bin/npgs/html/paper.pl. (Archived at PERAL).

Burrows, G. E., and Tyrl. 2001. Toxic Plants of North America. Iowa State University Press, Ames, IA. 1342 pp.

Calflora. 2010. California flora database. Calflora. http://www.calflora.org/about-cf.html. (Archived at PERAL).

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

CDFA. 2010. Pest ratings of noxious weed species and noxious weed seed. California Department of Food and Agriculture (CDFA), Division of Plant Health and Pest Prevention Services, Sacramento, CA. 11 pp.

Cook, C. D. K., and K. Urmi-König. 1983. A revision of the genus *Limnobium* including *Hydromystria* (Hydrocharitaceae). Aquatic Botany 17(1):1-27.

Cooper, M. R., and A. W. Johnson. 1984. Poisonous Plants in Britain and Their

Effects on Animals and Man. Her Majesty's Stationery Office, London. 305 pp.
DavesGarden. 2010. Plant files database. Dave's Garden. http://davesgarden.com/guides/pf/go/1764/. (Archived at PERAL).
DiTomaso, J. M. 2010. Watch out for these Red Alert weeds! Cal IPC News 17(4):4-7.
Fernández, O. A., D. L. Sutton, V. H. Lallana, M. R. Sabbatini, and J. H. Irigoyen. 1990. Aquatic weed problems and management in South and Central America. Pages 406-425 *in* A. H. Pieterse and K. J. Murphy, (eds.). Aquatic Weeds: The Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, New York.
GBIF. 2010. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). http://data.gbif.org/welcome.htm. (Archived at PERAL).
Heap, I. 2010. The international survey of herbicide resistant weeds. Weed Science Society of America. www.weedscience.com. (Archived at PERAL).
Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Leiden, The Netherlands. 438 pp.
Hernandez-R, J., and J. O. Rangel-Ch. 2009. Vegetation of the wetland Jaboque (Bogota, D. C.). Caldasia 31(2):355-379.
Holm, L. G., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1979. A Geographical Atlas of World Weeds. Krieger Publishing Company, Malabar, FL. 391 pp.
Hrusa, F., B. Ertter, A. Sanders, G. Leppig, and E. Dean. 2002. Catalogue of non-native vascular plants occurring spontaneously in California beyond those addressed in The Jepson Manual: Part I. Madrono 49(2):61-98.
Hrusa, G. F. 1999. *Limnobium spongia* L. sensu lato. California Plant Pest and Disease Report 18(1-2):46-48.
IPPC. 2012. International Standards for Phytosanitary Measures No. 5: Glossary of Phytosanitary Terms. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy.
Kadono, Y. 2004. Alien aquatic plants naturalized in Japan: History and present status. Global Environmental Research 8(2):163-169.
Koop, A., L. Fowler, L. Newton, and B. Caton. 2012. Development and validation of a weed screening tool for the United States. Biological Invasions 14(2):273-294.
Les, D. H., and L. J. Mehrhoff. 1999. Introduction of nonindigenous aquatic vascular plants in Southern New England: a historical perspective. Biological Invasions 1(2/3):281-300.
Lowden, R. M. 1992. Floral variation and taxonomy of *Limnobium* Richard, L. C. (Hyrocharitaceae). Rhodora 94(878):111-134.
Madsen, J. D., C. S. Owens, and K. D. Getsinger. 1998. Evaluation of four herbicides for management of American frogbit (*Limnobium spongia*). Journal of Aquatic Plant Management 36:148-150.
Martin, P. G., and J. M. Dowd. 1990. A protein sequence study of the dicotyledons and its relevance to the evolution of the legumes and nitrogen fixation. Australian Systematic Botany 3:91-100.
NGRP. 2013. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program (NGRP). http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl?language=en. (Archived at PERAL).

Nickrent, D. 2009. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL. Last accessed June 12, 2009, http://www.parasiticplants.siu.edu/ListParasites.html.

NRCS. 2010. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. http://plants.usda.gov/cgi_bin/. (Archived at PERAL).

Parsons, W. T., and E. G. Cuthbertson. 2001. Noxious weeds of Australia (2nd edition). CSIRO Publishing, Collingwood, Victoria, Australia. 698 pp.

Pieterse, A. H., and K. J. Murphy. 1990. Aquatic Weeds: The Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, New York. 593 pp.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Elchbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. Terrestrial Ecoregions of North America: A Conservation Assessment. Island Press, Washington D.C. 485 pp.

Tanaka, N., K. Uehara, and A. Murata. 2004. Correlation between pollen morphology and pollination mechanisms in the Hydrocharitaceae. Journal of Plant Research 117(4):265-276.

Walker, R. 2009. Parasitic Plants Database. Rick Walker. http://www.omnisterra.com/bot/pp_home.cgi. (Archived at PERAL).

Appendix A. Weed risk assessment for *Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine (Hydrocharitaceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	f - negl	5	Introduced to Japan and occasionally found in the wild (but probably only temporary due to horticultural activities) (Kadono, 2004). Naturalized in Chile (in two administrative regions) (Castro et al., 2005) and California (Hrusa et al., 2002). Noted as an escape in West Java (citation in Akers, 2010b). After an initial quiet phase lasting about four years, this species recently began to spread quickly in California (Akers, 2010b). It was first detected in California in 2003 in two small, isolated locations, but in 2007, it was detected in a river system (Akers, 2010b). After that it has appeared in several locations, despite active control efforts (Akers, 2010b). Recognized as a California invader by a gardening website (DavesGarden, 2010). Alternate answers for the Monte Carlo simulation were both “e.”
ES-2 (Is the species highly domesticated)	n - mod	0	No evidence. Cultivated as an aquatic plant (DavesGarden, 2010; Kadono, 2004), but no evidence of domestication or selection of varieties with reduced weed traits.
ES-3 (Weedy congeners)	y - low		Unknown. There are two taxa within the genus *Limnobium*. Depending on the treatment, these taxa are either maintained as different species (*L. spongia* and *L. laevigatum*) or they are placed within one species, but as two different varieties (*L. spongia* var. *spongia*, and *L. spongia* var. *laevigatum*) (Acevedo-Rodriguez and Strong, 2005 vs. Cook and Urmi-König, 1983). With respect to this question, we are considering these two taxa as separate species. *Limnobium spongia*, the other taxon, is native to the eastern United States (Cook and Urmi-König, 1983) , and is listed in Holm's *A Geographical Atlas of World Weeds* as a weed of unknown status in the United States (Holm et al., 1979). *Limnobium spongia* is considered a weed and a potential threat to California (Hrusa, 1999). It is also listed as a State Noxious Weed in California (CDFA, 2010). *Limnobium spongia* “can produce extensive floating mats and create nuisance situations, such as blocking navigation, affecting water quality, fish and wildlife habitat, and recreational usage (Madsen et al., 1998).
ES-4 (Shade tolerant at some stage of its life cycle)	y - mod	1	Grows in shady streams in Puerto Rico (Acevedo-Rodriguez and Strong, 2005). Not using negligible uncertainty, because it also grows in full sun. Its performance across a range of light regimes has not been reported.
ES-5 (Climbing or smothering growth form)	n - low	0	Plant is an aquatic herb with floating and emergent leaves (Lowden, 1992).
ES-6 (Forms dense thickets)	y - negl	2	Plants are rosettes that stay interconnected via stolons. They form mats (Acevedo-Rodriguez and Strong, 2005). The genus (with either 1 or 2 species) forms dense floating or rooted mats near the water's edge (Cook and Urmi-König, 1983). Produces floating mats in its native range in Bogota (Hernandez-R and Rangel-Ch, 2009). In one place in California, there were 2500

Question ID	Answer - Uncertainty	Score	Notes (and references)
			plants per square meter (Akers, 2010b).
ES-7 (Aquatic)	y - negl	1	Plant is a free-floating or rooted aquatic with interconnected rosettes (Acevedo-Rodriguez and Strong, 2005). *Limnobium* seeds germinate underwater (Cook and Urmi-König, 1983).
ES-8 (Grass)	n - negl	0	Plant not a grass; it is in the Hydrocharitaceae (ARS, 2010; NRCS, 2010).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	Not in a plant family known to fix nitrogen (Martin and Dowd, 1990).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Produces seeds (Cook and Urmi-König, 1983). Reproduces by seeds in California (Akers, 2010b).
ES-11 (Self-compatible or apomictic)	y - low	1	Plants are monoecious, meaning separate male and female flowers on the same plant (Acevedo-Rodriguez and Strong, 2005). Flowers for *Limnobium* are unisexual, but male and female flowers developing on the same rosette or different rosettes (Cook and Urmi-König, 1983). Plants are autogamous (selfers) through geitonogamy (pollen from male flowers pollinating female flowers on the same plant) (Cook and Urmi-König, 1983).
ES-12 (Requires special pollinators)	n - negl	0	*Limnobium laevigatum* is wind pollinated (Tanaka et al., 2004). *Limnobium* (both species) is wind pollinated (Cook and Urmi-König, 1983). *Limnobium laevigatum* may be wind pollinated, but it may be more likely to be insect pollinated than *L. spondias*: the author has seen aphid nymphs crawling over flowers at the time of anthesis (Lowden, 1992).
ES-13 (Minimum generation time)	b - mod	1	Unknown for this species. *Limnobium laevigatum* is ecologically similar to water hyacinth, only smaller. Both are free-floating aquatics, have similar morphology, and reproduce vegetatively. Water hyacinth (*Eichhornia crassipes*) can double in population size in five days due to vegetative reproduction; furthermore, plants can begin blooming at three to four weeks of age (Parsons and Cuthbertson, 2001). Conservatively answering "b" for *L. laevigatum*, as it seems very likely that new offshoots can be produced, within a year. In fact, we suspect that there may be several generations of vegetative offshoots in a year, potentially supporting an "a" response. Using moderate uncertainty because of a lack of information for this species and because we had to rely information for a similar species. Alternate answers for the Monte Carlo simulation were "a" and "c."
ES-14 (Prolific reproduction)	? - max	0	Unknown. *Limnobium laevigatum* fruit contain up to 100 seeds (Cook and Urmi-König, 1983). Up to 2500 plants per square meter have been recorded (Akers, 2010b). If only 50 of these produced fruit, then we would have met our criteria for prolific reproduction for an herbaceous plant. However, without additional information, answering unknown.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - high	1	*Limnobium laevigatum* seeds and small seedlings could easily stick to watercraft (Akers, 2010b; Hrusa, 1999). Direct evidence isn't provided, but given these are two separate experts, answering yes with high uncertainty.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	? - max	0	Unknown. Some species of aquatic plants disperse in trade as contaminants of other aquatic plants, but it is unknown whether *L. laevigatum* is likely to disperse in this fashion.
ES-17 (Number of natural	2	0	Description of fruit and seed used to answer questions ES17a-

Question ID	Answer - Uncertainty	Score	Notes (and references)
dispersal vectors)			17e: Fruit a globose or ellipsoid, many-seeded berry. Fruits ellipsoid, 10-15 × 3.5 mm, with 3-6 protruding placentas; seeds 0.1-0.3 mm long, beaked and covered with minute trichomes. (Acevedo-Rodriguez and Strong, 2005). Fruit: berry-like capsule, beaked, elipsoidal to spherical, borne on a recurved pedicel, developing in mud or under water (Cook and Urmi-König, 1983).
ES-17a (Wind dispersal)	n - low		No evidence. Fruit is a berry that is 1-1.5 cm by .3-.5 cm wide (Lowden, 1992).
ES-17b (Water dispersal)	y - negl		After pollination the pedicel of female flowers (of *Limnobium* species) bends downward, forcing the fruit to develop in the water or in the mud (Cook and Urmi-König, 1983). Seeds are expelled in a mucilaginous mass. Thus either seeds, seedlings (which develop in water), or entire plants can disperse via water. Seedling propagules float (Lowden, 1992).
ES-17c (Bird dispersal)	y - high		When fruits rupture, seeds are released in a mucilaginous mass. According to one study, the seed dispersal mechanism has not been studied, but they are soft and unlikely to withstand crushing or digestion (Cook and Urmi-König, 1983). However, another study, focusing on the introduction of non-indigenous aquatic plants, provided evidence that *Limnobium spongia* var. *spongia* is sometimes consumed by waterfowl. And although they had no evidence indicating seeds survive gut passage, they believe it is the only explanation for the disjunct populations that appear outside of the species' native U.S. range (Les and Mehrhoff, 1999). A draft weed fact sheet for *L. laevigatum* in California states that seeds and very small seedlings could easily stick to birds and be moved by them (Akers, 2010b). Answering yes with high uncertainty.
ES-17d (Animal external dispersal)	? - max		Unknown. It is possible that the mucilaginous mass may stick to animals, but there is no evidence or even speculation of this.
ES-17e (Animal internal dispersal)	? - max		Unknown. When fruits rupture, seeds are released in a mucilaginous mass. Seed dispersal mechanism has not been studied but they are soft and unlikely to withstand crushing or digestion (Cook and Urmi-König, 1983). But some evidence from above suggests they may be able to survive digestion by birds. Answering unknown.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - high	1	"The survival time of seeds is not known, but at the Redding and other ponds, seedlings are still appearing although we have almost completely suppressed the populations for three years" (Akers, 2010b); this suggests there may be a seed bank. Using high uncertainty because it is not absolutely clear that the few remaining plants are contributing the seedlings.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	Unknown. No information available for this species. But it seems likely if connected plants (ramets in a genet) are broken up.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	Several herbicides control *L. laevigatum* (Akers, 2010b), as well as its congener, *L. spongia* (Madsen et al., 1998). Not listed as resistant to herbicides (Heap, 2010).
ES-21 (Number of cold hardiness zones suitable for its survival)	6	0	
ES-22 (Number of climate	6	2	

Question ID	Answer - Uncertainty	Score	Notes (and references)
types suitable for its survival)			
ES-23 (Number of precipitation bands suitable for its survival)	10	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - mod	0	No evidence.
Imp-G2 (Parasitic)	n - negl	0	No evidence. Not a member of family containing parasitic plants (e.g., Heide-Jorgensen, 2008; Nickrent, 2009; Walker, 2009).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	y - high	0.4	The massive floating mats this species forms (Akers, 2010a, 2010b) block light to the aquatic community below. A pest report from California where this species has already invaded suggests that the floating mats will alter many ecosystem processes such as carbon and nutrient cycling (Akers, 2010b). High organic inputs into water bodies will likely reduce oxygen levels in the systems (Akers, 2010b). Answering yes because at the very least the mats do block light. It seems likely they will also alter other ecosystems properties.
Imp-N2 (Change community structure)	y - mod	0.2	This species forms dense mats on the water surface (up to 2,500 plants per square meter). This dramatically changes habitat structure, including access by other species (e.g., some aquatic birds) (Akers, 2010b)
Imp-N3 (Change community composition)	y - low	0.2	Can dominate to the exclusion of all other aquatic species in California (Hrusa et al., 2002). The damage is caused because of the thick vegetative mat it forms over the water surface, excluding other species (Akers, 2010b).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	y - low	0.1	Given its ability to form thick vegetative mats (Akers, 2010b), this species is likely to affect Threatened and Endangered aquatic species.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	y - mod	0.1	Given its ability to form thick vegetative mats (Akers, 2010b) and possibly alter ecosystem processes, this species is likely to impact aquatic ecosystems in globally outstanding ecoregions in the United States (Ricketts et al., 1999).
Imp-N6 (Weed status in natural systems)	c - negl	0.6	Being controlled in natural areas in California (Hrusa et al., 2002). Regulated plant in California(CDFA, 2010). Occurs in natural waterways, ponds, and canals in California, and is subject to control and eradication efforts (Akers, 2010b). Control efforts indirectly damage other aquatic species (Hrusa et al., 2002).
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	y - mod	0.1	It blocks waterways (DiTomaso, 2010). Examination of photos sent by California workers (Akers, 2010a) strongly support this. "The mats move with the current and pile up wherever there is an obstruction. They therefore accumulate in infrastructure for moving water, and will likely jam weirs, dams, gates, and siphons, as well as being pulled into pumps where they will jam and damage the machinery. During high water, they may increase flood risk by piling against obstructions and clogging the channel" (Akers, 2010b). As a floating plant, this species could establish in concrete water delivery canals (Akers, 2010b). Because of their size, seeds and seedlings of *L.*

Question ID	Answer - Uncertainty	Score	Notes (and references)
			laevigatum appear to be able to bypass the measures taken to prevent the spread of water hyacinth in California (Akers, 2010b). In general aquatic weeds can cause physical damage to human structures and interfere with processes such as flood control (Fernández et al., 1990). Answering yes but with moderate uncertainty, because this invasion is probably too recent for this impact to have been reported or observed. However, based on the dense mats it is forming in California and impacts of the very similar water hyacinth, it is very likely that impacts for *L. laevigatum* will be similar.
Imp-A2 (Changes or limits recreational use of an area)	y - mod	0.1	It blocks waterways (DiTomaso, 2010). Examination of photos sent by California workers strongly support this (Akers, 2010a). Based on preliminary information from California, *L. laevigatum* mats are likely to affect navigation and recreational use of water bodies (Akers, 2010b). The U.S. native *L. spongia* affects navigation and recreational usage of an area (Madsen et al., 1998). *Eichhornia crassipes* (v. similar to *L. laevigatum*) makes navigation difficult in South America (Fernández et al., 1990). Answering yes because it is clear that blocked waterways will limit access. However, using moderate uncertainty because this impact has not been reported yet (i.e., its invasion is still too recent for this to be a recorded impact).
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	? - max		Unknown. Covering 1/4 acre of a pond in a cemetery in California (Hrusa et al., 2002). It seems likely that that this species will affect desirable aquatic plants and vegetation in U.S. cities, but there has been no evidence as of yet.
Imp-A4 (Weed status in anthropogenic systems)	c - low	0.4	Occurs in natural waterways, ponds, and canals in California, and is subject to control and eradication efforts (Akers, 2010b), including those in canals (Akers, 2010a).
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - mod	0	No evidence.
Imp-P2 (Lowers commodity value)	n - mod	0	No evidence.
Imp-P3 (Is it likely to impact trade)	? - max		This species is regulated in California (CDFA, 2010; Akers, 2010 #9649}). Because we are unsure whether this species can move in trade as a contaminant, answering unknown.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	? - max		Unknown. There is no direct evidence of this effect, but it seems likely. "Evidence for this is its presence in separate irrigation systems both east and west of Fresno, scattered over miles of canals" (Akers, 2010b). Other species of floating aquatic plants can block pumping machinery, culverts, etc. (Fernández et al., 1990).
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	No evidence. Neither species of *Limnobium* is listed as poisonous (Burrows and Tyrl, 2001; Cooper and Johnson, 1984)
Imp-P6 (Weed status in production systems)	b - mod	0.2	Along with other aquatic plants, it is considered a weed in South America where these species infest thousands of kilometers of drainage canals dug for forestry purposes (Fernández et al., 1990). Using moderate uncertainty because *L. laevigatum* is lumped together with a bunch of other weeds, and it is difficult to tell how important of a weed it is with respect to other species. No evidence of control in agricultural

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
			systems.
GEOGRAPHIC POTENTIAL			Unless otherwise noted, all evidence below represents point-occurrences obtained from GBIF (2010).
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	No evidence.
Geo-Z2 (Zone 2)	n - negl	N/A	No evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	No evidence.
Geo-Z4 (Zone 4)	n - negl	N/A	No evidence.
Geo-Z5 (Zone 5)	n - low	N/A	No evidence.
Geo-Z6 (Zone 6)	n - mod	N/A	No evidence.
Geo-Z7 (Zone 7)	n - high	N/A	No evidence.
Geo-Z8 (Zone 8)	y - high	N/A	One point at edge of this zone in Mexico and California (GBIF, 2010). Answering yes because aquatic plants are buffered somewhat from cold temperatures in the water.
Geo-Z9 (Zone 9)	y - negl	N/A	Mexico, California (GBIF, 2010)
Geo-Z10 (Zone 10)	y - negl	N/A	Mexico (GBIF, 2010); Argentina & Uruguay (Cook and Urmi-König, 1983).
Geo-Z11 (Zone 11)	y - negl	N/A	Bolivia (GBIF, 2010); Paraguay (Cook and Urmi-König, 1983).
Geo-Z12 (Zone 12)	y - negl	N/A	Bolivia, Ecuador, Peru, Costa Rica (GBIF, 2010).
Geo-Z13 (Zone 13)	y - negl	N/A	French Guiana, Suriname, Costa Rica (Cook and Urmi-König, 1983; GBIF, 2010).
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Brazil (GBIF, 2010). Species generally a tropical subtropical species (Cook and Urmi-König, 1983).
Geo-C2 (Tropical savanna)	y - negl	N/A	Brazil (GBIF, 2010). Species generally a tropical subtropical species (Cook and Urmi-König, 1983).
Geo-C3 (Steppe)	y - negl	N/A	Peru, California (GBIF, 2010). Also grows in Steppe regions with abundant rainfall in Venezuela (Cook and Urmi-König, 1983).
Geo-C4 (Desert)	? - max	N/A	Unknown. It is possible it could survive in warm deserts in areas where human activity has impounded water. When we estimated the portion of the Unites States suitable for its establishment, we assumed it could not occur in this climate class.
Geo-C5 (Mediterranean)	y - negl	N/A	California (GBIF, 2010).
Geo-C6 (Humid subtropical)	y - negl	N/A	Paraguay (GBIF, 2010); Uruguay & Argentina (Cook and Urmi-König, 1983). Species generally a tropical subtropical species (Cook and Urmi-König, 1983).
Geo-C7 (Marine west coast)	y - negl	N/A	Ecuador, Colombia, Mexico (GBIF, 2010).
Geo-C8 (Humid cont. warm sum.)	? - max	N/A	Unknown. When we estimated the portion of the Unites States suitable for its establishment, we assumed it could not occur in this climate class.
Geo-C9 (Humid cont. cool sum.)	n - mod	N/A	No evidence.
Geo-C10 (Subarctic)	n - negl	N/A	No evidence.
Geo-C11 (Tundra)	n - negl	N/A	No evidence.
Geo-C12 (Icecap)	n - negl	N/A	No evidence.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	? - max	N/A	Unknown. Possible it can survive in areas where humans have impounded water. When we estimated the portion of the

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Unites States suitable for its establishment, we assumed it could not occur in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	California (GBIF, 2010).
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Argentina, California (GBIF, 2010). Presence: Bolivia (GBIF, 2010).
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Mexico (GBIF, 2010).
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Brazil (GBIF, 2010).
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Brazil (GBIF, 2010).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	El Salvador (GBIF, 2010).
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Brazil (GBIF, 2010).
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Mexico (GBIF, 2010).
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Costa Rica (GBIF, 2010).
Geo-R11 (100+ inches; 254+ cm))	y - negl	N/A	French Guiana (GBIF, 2010).
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	Naturalized in California (Akers, 2010b; Hrusa et al., 2002).
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	In the aquatic nursery trade in California despite being regulated (Hrusa et al., 2002).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds for planting)	-	N/A	
Ent-4d (Contaminant of ballast water)	-	N/A	
Ent-4e (Contaminant of aquarium plants or other aquarium products)	-	N/A	
Ent-4f (Contaminant of landscape products)	-	N/A	
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	-	N/A	
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	-	N/A	

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
Ent-4i (Contaminant of some other pathway)	-	N/A	
Ent-5 (Likely to enter through natural dispersal)	-	N/A	