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Plant Health
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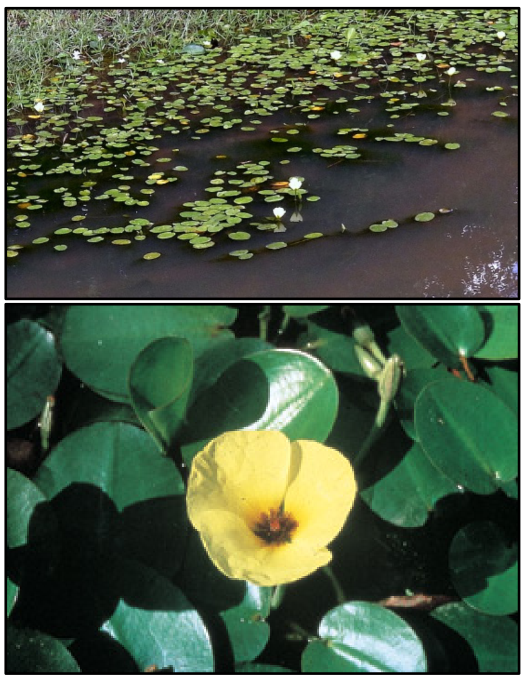
Version 1

Weed Risk Assessment for *Hydrocleys nymphoides* (Alismataceae)



Top: *Hydrocleys nymphoides* population in Brazil (Popovkin, 2013);
bottom: *H. nymphoides* in bloom in New Zealand (Auckland Regional Council, 2020)

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Executive Summary

The result of the weed risk assessment for *Hydrocleys nymphoides* is High Risk of spreading or causing harm in the United States. *Hydrocleys nymphoides* is a perennial aquatic herb that can be a weed of natural areas and a nuisance in drains and waterways. It is naturalized in seven counties in Florida and Texas and possibly one county in Louisiana, and it is a causal alien in Hawaii. The species has also been observed in Puerto Rico, where its status is unclear. It is on a watch list in Texas but is not regulated by any state. The plant produces seed in its native range but has only been observed to reproduce vegetatively in its exotic range. Small fragments can grow into new plants, and vegetative plantlets detach at the end of the growing season. The species is spreading in New Zealand and is under eradication there. It can be moved on boats and equipment and can also be introduced to new areas through aquarium dumping. The leaves can form dense mats on the water surface, which completely block light to submerged vegetation and deplete oxygen in the water. It displaces native species and interferes with water recreation. In anthropogenic systems, it also clogs drains and canals. We estimate that 6 to 17 percent of the United States is climatically suitable for the species to establish. It is most likely to spread as an escape from cultivation or through disposal into natural waterways.

Plant Information and Background

PLANT SPECIES: *Hydrocleys nymphoides* (Humb. & Bonpl. ex Willd.) Buchenau (Alismataceae) (NPGS, 2020)

SYNONYMS: Basionym: *Stratiotes nymphoides* Humb. & Bonpl. ex Willd (NPGS, 2020). Synonym: *Limnocharis humboldtii* (Rich.) Endl. (Randall, 2007). The name is sometimes spelled as *Hydrocleis nymphoides* in trade (Champion et al., 2008). Several additional synonyms are provided by The Plant List (2013).

COMMON NAMES: Water poppy (MBG, 2020)

BOTANICAL DESCRIPTION: *Hydrocleys nymphoides* is a rooted, aquatic, perennial herb that can grow up to 50 cm tall (Haynes and Holm-Nielsen, 1992; MBG, 2020; VRO, 2020). Mature leaves float on the water surface and are dark green, thick, and shiny, with heart-shaped bases (MBG, 2020). Seedlings, however, produce linear leaves, and the plant can revert to that leaf shape when submerged or otherwise stressed (Aston and Jacobs, 1980). Yellow, three-petaled flowers are produced on floating stems. Each flower lasts only one day, but a population will stay in bloom throughout the summer by producing many flowers in succession (MBG, 2020). Fruits are pods that measure about 10-14 cm long, 2-3.5 mm wide, with a beak 3.5-5.5 mm long. Each contains several dozen seeds, which are less than 1 mm long, oval shaped, and covered with glandular hairs (Haynes and Holm-Nielsen, 1992).

INITIATION: Due to potential concern with the potential invasiveness of *H. nymphoides* in the United States, the PPQ Weeds Cross-Functional Working Group requested that this species be evaluated with a weed risk assessment.

WRA AREA[1]: United States and Territories

FOREIGN DISTRIBUTION: *Hydrocleys nymphoides* is native to much of South America and to the Netherlands Antilles and Trinidad and Tobago (NPGS, 2020). It is naturalized in Australia and New Zealand (Howell and Sawyer, 2006; NPGS, 2020; Randall, 2007). It is considered invasive in New Zealand (Brunel, 2009; MPI, n.d.), where it has been spreading since 1912 (Thomson, 1922). In Australia, it is recommended for a watch list (Champion et al., 2008), but it is not a noxious weed (Brunel, 2009). It is also considered invasive in China (Wang et al., 2016), and Ugarte (2011) lists it as introduced in Chile. In 2009, a population was found at a dam in South Africa, and by 2013, this species had covered 30 percent of the surface. It has since been recommended for eradication (Nxumalo et al., 2016). Williams and Champion (2008) report that it has spread to Japan, Fiji, and the United Kingdom in the aquarium trade, but we found no evidence of its presence in Fiji or the

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

United Kingdom. Aston and Jacobs (1980) listed it as naturalized in Japan, but Kadono (2004) indicates that it may be a waif. It was probably planted intentionally and is not expected to spread (Kadono, 2004). European and Mediterranean countries occasionally import it as an ornamental; the European and Mediterranean Plant Protection Organization considers it a low risk, though monitoring is recommended (Brunel, 2009). In Zimbabwe and Kenya, it is planted as an ornamental and used in wetlands for wastewater treatment, but it has not escaped or naturalized (Nxumalo et al., 2016). It is also grown as an ornamental in South Korea (Cho et al., 2018). The species is under eradication in New Zealand (Champion et al., 2014), where it is prohibited from sale, distribution, and propagation (ENV BOP, 2004). Aston and Jacobs (1980) indicated that it is not likely to be a problem weed in Australia, but they recommended against planting it in the wild or importing additional material. The plant has not been observed to set seed in Australia or New Zealand; the populations may be self-incompatible clones. The importation of new plants could allow cross-pollination and seed production (Aston and Jacobs, 1980). *Hydrocleys nymphoides* is prohibited in South Africa (South Africa Department of Environmental Affairs, 2016), but it is not listed as a harmful organism by any country (PCIT, 2020).

U.S. DISTRIBUTION AND STATUS: *Hydrocleys nymphoides* is present outside of cultivation in Florida, Texas, Louisiana, and possibly Puerto Rico (EDDMapS, 2020; Kartesz, 2015; NRCS, 2020). It is exotic in the continental United States (Acevedo-Rodriguez and Strong, 2005; EDDMapS, 2020; Gordon et al., 2012; MacRoberts and MacRoberts, 2010; MBG, 2020; NPGS, 2020; NRCS, 2020; POWO, 2020; Weakley, 2015; Williams and Champion, 2008), but the status of the species in Puerto Rico is unclear. The National Plant Germplasm System (NPGS, 2020) lists it as native to Puerto Rico, while other references describe it as present but introduced (Acevedo-Rodriguez and Strong, 2005; NRCS, 2020). Pfingsten (2020) indicates that it is native to Puerto Rico but may be extirpated there. It is naturalized in four counties in Florida and three in Texas (EDDMapS, 2020; Gordon et al., 2012; NRCS, 2020). In Louisiana, it was observed to be growing in a ditch at a park in 2010 (MacRoberts and MacRoberts, 2010), but we did not find information to indicate whether it is naturalized. It has been introduced as an ornamental to Hawaii, where it is a casual exotic (Wester, 1992). It is widely grown as an ornamental and traded among gardeners (Cox, 2006; Dave's Garden, 2020; GardenWeb, 2020; Pond Informer, 2019) and readily available for purchase (LilyBlooms, 2020; Lilypons, 2020; Springdale, 2020; William Tricker, 2020). The species is considered a mild invader in Florida and Texas. It has been in the United States for over 100 years without causing major problems, but it may be a sleeper weed and may become a concern in the future (Gordon et al., 2012). The Texas Non-Native Plants Group (2010) lists it as an F2 species, which means it is abundant in fewer than 10 counties and invasive in disturbed areas, but it is not a particular problem in natural areas. It is on their watch list and recommended for control and eradication (Texas Non-Native Plants Group, 2010), but it is currently legal to plant in Texas gardens (Earth-Kind Landscaping, 2020). Lilypons (2020) indicates that shipment of *H. nymphoides* to Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming is prohibited, but we found no other indication that the species is regulated by any state (NPB, 2020). Furthermore, APHIS does not regulate it (APHIS, 2020).

Analysis

ESTABLISHMENT/SPREAD POTENTIAL: *Hydrocleys nymphoides* is an aquatic plant that can form dense populations (MBG, 2020; Sullivan and Hutchison, 2010). It produces seed in its native range (Kodela and Jobson, 2018), but it has not been observed to do so in its introduced range (Dave's Garden, 2020; Nxumalo et al., 2016; Sullivan and Hutchison, 2010). It is a perennial and can also reproduce vegetatively (MBG, 2020) with plantlets detaching from the parent plant at the end of the growing season (Kodela and Jobson, 2018). The plant can also regenerate from fragments (Nxumalo et al., 2016); consequently, attempts at mechanical control are more likely to further disperse the species than to eliminate it (Sullivan and Hutchison, 2010). *Hydrocleys nymphoides* is spreading in New Zealand (MPI, n.d.; Thomson, 1922) and can be dispersed by boats and machinery (Kodela and Jobson, 2018) and by dumping of aquarium contents into waterways (Weakley, 2015). We had average uncertainty for this risk element.

Risk score = 10.0   Uncertainty index = 0.16

IMPACT POTENTIAL: *Hydrocleys nymphoides* is a weed of natural and anthropogenic systems; it is under eradiation in New Zealand (Champion et al., 2008). Sullivan and Hutchison (2010) calculate that the cost of managing the plant would be less than the cost of economic losses due to its impact. Its long stalks can interfere with the movement of aquatic animals, and it can cover the water surface and block light to submerged vegetation (Nxumalo et al., 2016). Agriculture Victoria (VRO, 2020) reports that when it forms a monoculture, no other vegetation layers are present. It can outcompete and displace native species (MPI, 2012; Nxumalo et al., 2016). In New Zealand, it decreases water quality (ARC, 2004), and Nxumalo et al. (2016) report that it can deplete oxygen if it covers the water surface. *Hydrocleys nymphoides* also clogs drains and canals (Sullivan and Hutchison, 2010) and causes flooding (MPI, 2012). It has been reported to block dams in New South Wales, Australia (Hosking et al., 2011). It interferes with fishing, boating, and swimming in New Zealand (Sullivan and Hutchison, 2010) , and Agriculture Victoria (VRO, 2020) in Australia has reported on visitor complaints and a reduction in visitors to infested areas. Hosking et al. (2011) list it as having moderate weed potential since it has become established in Australia. We had average uncertainty for this risk element.

Risk score = 2.9   Uncertainty index = 0.13

RISK MODEL RESULTS

Model Probabilities: P(Major Invader) = 49.2%
P(Minor Invader) = 47.8%
P(Non-Invader) = 3.0%

Risk Result = High Risk
Risk Result after Secondary Screening = Not Applicable

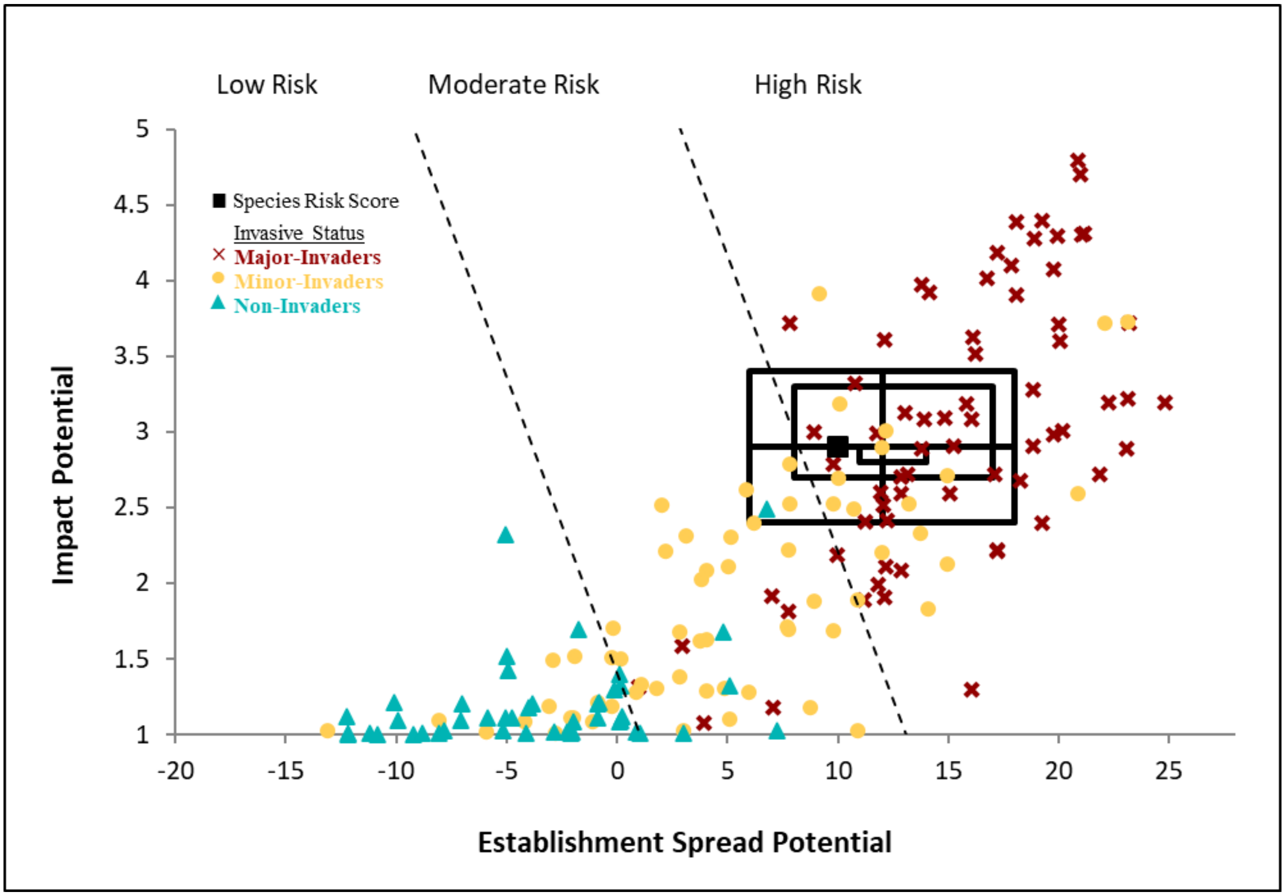

Figure 1. Risk and uncertainty results for *Hydrocleys nymphoides*. The risk score for this species (solid black symbol) is plotted relative to the risk scores of the species used to develop and validate the PPQ WRA model (Koop et al., 2012). The results from the uncertainty analysis are plotted around the risk score for *H. nymphoides*. The smallest, black box contains 50 percent of the simulated risk scores, the second 95 percent, and the largest 99 percent. The black vertical and horizontal lines in the middle of the boxes represent the medians of the simulated risk scores (N=5000). For additional information on the uncertainty analysis used, see Caton et al. (2018).

GEOGRAPHIC POTENTIAL: Using the PPQ climate-matching model for weeds (Magarey et al., 2017), we estimate that about 6 to 17 percent of the United States is suitable for the establishment of *H. nymphoides* (Fig. 2). The larger area 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, humid subtropical, and marine west coast (Appendix). The area of the United States shown to be climatically suitable was determined using only these three climatic variables. Other factors, such as soil, hydrology, disturbance regime, and species interactions may alter the areas in which this species is likely to establish. *Hydrocleys nymphoides* is an aquatic plant found in streams, lakes, ponds, canals, and farm dams (ENV BOP, 2004; Weakley, 2015). It grows best in tropical and subtropical environments, but it can tolerate cooltemperate climates (Williams and Champion, 2008). Gardening websites and suppliers recommend it for PHZ 9, 10, and sometimes 11 (Dave's Garden, 2020; LilyBlooms, 2020; Lilypons, 2020).

ENTRY POTENTIAL: We did not assess the entry potential of *H. nymphoides* because it is already present in the United States (Gordon et al., 2012; MacRoberts and MacRoberts, 2010; NRCS, 2020) (Fig. 2).

Discussion

The result of the weed risk assessment for *Hydrocleys nymphoides* is High Risk of spreading or causing harm in the United States. Since it is an aquatic plant (MBG, 2020), it is not likely to be an agricultural contaminant. We found no records of interception at U.S. ports of entry (AQAS, 2020). The species is, however, widely grown as an ornamental and sold for that purpose (Dave's Garden, 2020; Earth-Kind Landscaping, 2020; LilyBlooms, 2020; Lilypons, 2020). It can easily be introduced to new areas through disposal of aquatic plants into natural waterways (Weakley, 2015). Once established in a waterway, it can be dispersed by currents (Kodela and Jobson, 2018). Kodela and Jobson (2018) also list birds as possible dispersal vectors, but we did not find supporting evidence to confirm this. We found evidence of a seed bank for the congener *H. parviflora* (Bao et al., 2018) but no evidence for *H. nymphoides*, though it is native to the same region (Tomas and Salis, 2000). *Hydrocleys nymphoides* is a weed of natural areas (Champion et al., 2014) and has some impact on canals and farm dams (Hosking et al., 2011; Sullivan and Hutchison, 2010). In Texas, it is primarily invasive in disturbed areas (Texas Non-Native Plants Group, 2010), but we found no evidence of its impact. It is also listed as a weed of rice fields in Argentina (Lallana, 2005), but no impact is described; furthermore, we found no other evidence of its effect on agriculture. Our risk model results are almost evenly divided between predicting that the species would be a major invader (49.2 percent) and that it would be a minor invader (47.8 percent). This indicates that although it is likely to have an impact, it is unlikely to become a significantly serious invasive. The uncertainty analysis indicates that changes to our answers would most likely increase the risk score; consequently, new evidence may show that *H. nymphoides* poses a greater risk than we can currently demonstrate.

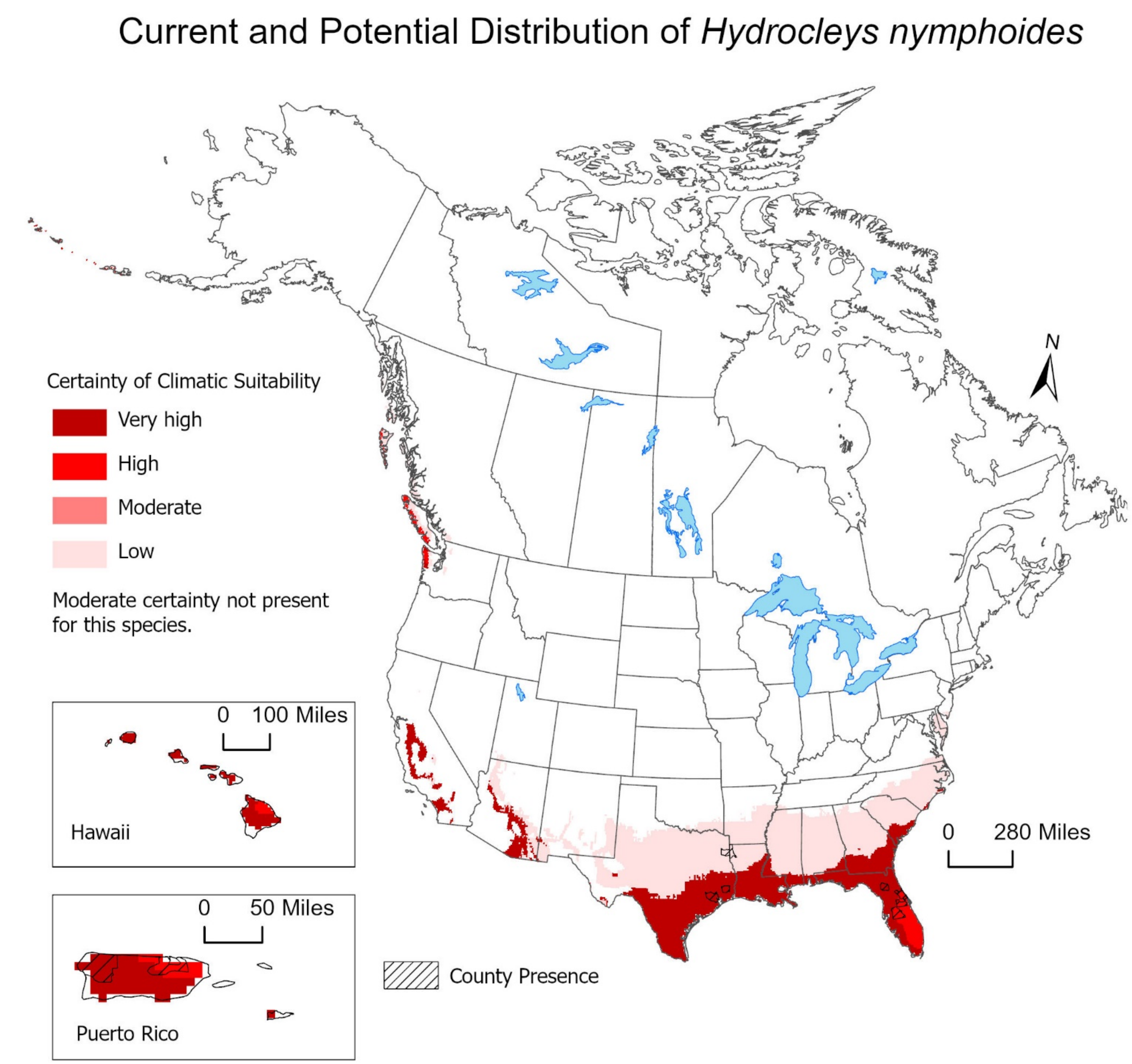

Figure 2. Current and potential distribution of *Hydrocleys nymphoides* in the United States. Climatic suitability was determined using the APHIS-PPQ climate matching tool for invasive plants (Magarey et al., 2017). The known distribution of *H. nymphoides* was based on county distribution records from online databases and other sources (see text). Map components are shown at different scales.

Suggested Citation

PPQ. 2020. Weed risk assessment for *Hydrocleys nymphoides* (Humb. & Bonpl. ex Willd.) Buchenau (Alismataceae) – Water poppy. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC. 21 pp.

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Appendix A. Weed risk assessment for *Hydrocleys nymphoides* (Humb. & Bonpl. ex Willd.) Buchenau (Alismataceae)

The following table lists the evidence and associated references used to evaluate the risk potential of this taxon. We include the answer, uncertainty rating, and score for each question.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - low	5	*Hydrocleys nymphoides* is native to the Netherlands Antilles, Trinidad and Tobago, and much of South America (MBG, 2020; NPGS, 2020). It is naturalized in Australia, New Zealand, Chile, South Africa, and China (Hill and Coetzee, 2017; Howell and Sawyer, 2006; NPGS, 2020; Nxumalo et al., 2016; Randall, 2007; Ugarte et al., 2011; Wang et al., 2016). It is invasive in New Zealand (MPI, n.d.) and was observed to be spreading from intentional plantings in 1912 (Thomson, 1922). We answered "f" because it is spreading in New Zealand. Our alternate answers were both "e."
ES-2 (Is the species highly domesticated)	n - low	0	It is grown as an ornamental (Brunel, 2009; Haynes and Holm-Nielsen, 1992; Wester, 1992), but we found no evidence of breeding for traits that would reduce weed potential.
ES-3 (Significant weedy congeners)	n - low	0	The genus *Hydrocleys* includes five species (Mabberley, 2008). We found no evidence that any congeners are weedy or invasive.
ES-4 (Shade tolerant at some stage of its life cycle)	n - mod	0	It grows in well-lit bodies of water (MPI, 2012). A few sources indicate that it requires full sun (Dave's Garden, 2020; MBG, 2020). One aquatic plant vendor, however, indicates that it prefers full sun but can tolerate shade (LilyBlooms, 2020), and another source describes it as needing full to partial sun (Lilypons, 2020). Agriculture Victoria (VRO, 2020) indicates that it prefers sun but can tolerate shade and may establish under leaf litter or a partial tree canopy. Since none of the sources indicate a tolerance for deep shade, we answered "no" but with moderate uncertainty.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	The leaves float on the water (MBG, 2020). They do not form basal rosettes.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	It forms dense mats on the surface of water in New Zealand (MPI, 2012; Sullivan and Hutchison, 2010). Aston and Jacobs (1980) reported a densely massed population in Australia. According to the Missouri Botanical Garden (MBG, 2020), the plant provides good surface cover on the water.
ES-7 (Aquatic)	y - negl	1	Yes, it is an aquatic plant (Randall, 2017).
ES-8 (Grass)	n - negl	0	It is in the family Alismataceae (MBG, 2020) and is not a grass.
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that it fixes nitrogen; it is not a member of a family known to include nitrogen-fixing species (Santi et al., 2013).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Plants may be grown from seed (MBG, 2020). It has not been observed to produce viable seed in New Zealand, Australia, or South Africa (Nxumalo et al., 2016; Sullivan and Hutchison, 2010; Williams and Champion, 2008). A popular gardening website also indicates that it does not set seed (Dave's Garden, 2020). It does, however, produce seed in its native range (Kodela and Jobson, 2018).
ES-11 (Self-compatible or apomictic)	n - high	-1	The lack of seed production in New Zealand and Australia is believed to be due to self-incompatibility (Williams and Champion, 2008). Aston and Jacobs (1980) suggested that all the plants in Australia and New Zealand may be clones from a single original introduction to New Zealand (Aston and Jacobs, 1980).The congener *H. martii* has been demonstrated to be self-incompatible (Carvalho and Schlindwein, 2011). Our uncertainty is high since we do not have experimental data from *H. nymphoides* itself.
ES-12 (Requires specialist pollinators)	n - negl	0	The style and anthers are close together, suggesting that generalist pollinators or wind could transfer pollen within a flower (Kodela and Jobson, 2018). Carvalho et al. (2014) report that it is pollinated by generalist bees of several genera. Fagundez and Caccavari (2006) found *H. nymphoides* pollen in 21 percent of samples of honey from European honey bees in Argentina. Therefore, the species is not likely to require specialist pollinators.

Question ID	Answer - Uncertainty	Score	Notes (and references)
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	It is a perennial and also reproduces vegetatively (MBG, 2020). Vegetative plantlets are produced and detach at the end of the growing season (Kodela and Jobson, 2018). Agriculture Victoria (VRO, 2020) reports that plantlets become separate individuals in one to two years. We found several sites describing *H. nymphoides* as an ornamental, and none of these indicate that it takes more than one year to flower (Barnett, 2020; Dave's Garden, 2020; GardenWeb, 2020; Pond Informer, 2019). Therefore, we answered "b," with "c" for both alternatives.
ES-14 (Prolific seed producer)	n - high	-1	Martinez and Franceschini (2018) found a leaf density of about 54/m^2. Aston and Jacobs (1980) reported that flowers are solitary in the leaf axils, which suggests one flower per leaf. These do not bloom all at the same time since each flower only lasts for a day, but flowers are produced throughout the summer (Barnett, 2020). To meet the 5000 seeds/m^2 threshold for prolific seed production, each seed pod would then need to contain 92.5 seeds with 100 percent germination. Each fruit contains several dozen seeds (Haynes and Holm-Nielsen, 1992), which most likely means 30 to 60 rather than 92 or 93. Our uncertainty, however, is high since we had to estimate the density of flowers and make an assumption on the meaning of "several dozen."
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - low	1	Kodela and Jobson (2018) indicate that boats and machinery are likely dispersal vectors. Weakley (2015) reports that the species is spread by aquarium dumping.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - low	-1	We found no evidence that *H. nymphoides* is an agricultural contaminant. It has not been intercepted at U.S. ports of entry (AQAS, 2020).
ES-17 (Number of natural dispersal vectors)	1	-2	Fruits are pods about 10-14 cm long and 2-3.5 mm wide, with a beak 3.5-5.5 mm long. Each contains several dozen seeds, which are less than 1 mm long, oval shaped, and covered with glandular hairs (Haynes and Holm-Nielsen, 1992).
ES-17a (Wind dispersal)	n - low		We found no evidence for this dispersal method.
ES-17b (Water dispersal)	y - negl		It can be moved on water after human introduction to an area (MPI, n.d.). Staples et al. (2000) and Kodela and Jobson (2018) list water as a means of dispersal.
ES-17c (Bird dispersal)	? - max		Unknown; Kodela and Jobson (2018) indicate that birds are likely dispersal vectors, but we found no direct evidence to confirm this.
ES-17d (Animal external dispersal)	n - low		We found no evidence for this dispersal method.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17e (Animal internal dispersal)	n - mod		The marsh deer (*Blastocerus dichotomus*) in Brazil eats the leaves of *H. nymphoides* (Tomas and Salis, 2000), but we found no evidence that it disperses the seeds.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	Unknown. Bao et al. (2018) found the congener *H. parviflora* in the seed bank in Brazil through seedling emergence experiments, which suggests that *H. nymphoides* may also be able to form a seed bank. The soil, however, was collected from the Pantanal wetland, where *H. nymphoides* is also native (Tomas and Salis, 2000); consequently, its absence in the experiment may indicate that it does not form a seed bank. We found no evidence specific to *H. nymphoides*.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - low	1	It can regenerate from fragments (Nxumalo et al., 2016). Sullivan and Hutchison (2010) report that attempts at mechanical control are more likely to spread the species.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - negl	0	We found no evidence of herbicide resistance for *H. nymphoides*. It is not listed in the International Herbicide-Resistant Weeds Database (Heap, 2020).
ES-21 (Number of cold hardiness zones suitable for its survival)	7	0	
ES-22 (Number of climate types suitable for its survival)	7	2	
ES-23 (Number of precipitation bands suitable for its survival)	11	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - mod	0	We found no evidence that the species is allelopathic; however, it is relatively poorly studied.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that *H. nymphoides* is parasitic, and it does not belong to a family known to include parasitic species (Heide-Jorgensen, 2008).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	y - low	0.4	It decreases water quality in New Zealand (ARC, 2004). When it covers the whole surface of a body of water, it can deplete oxygen (Nxumalo et al., 2016).
Imp-N2 (Changes habitat structure)	y – negl	0.2	It can completely smother bodies of water (MPI, 2012). Long stalks can interfere with the movement of aquatic animals, and it can cover the water surface and block light to submerged vegetation (Nxumalo et al., 2016). Agriculture Victoria (VRO, 2020) reports that when it forms a monoculture, no other vegetation layers are present.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N3 (Changes species diversity)	y – negl	0.2	It displaces native species in New Zealand (ARC, 2004; MPI, 2012; Sullivan and Hutchison, 2010). It can outcompete native plants (Nxumalo et al., 2016).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y – high	0.1	*Hydrocleys nymphoides* affects native species in natural areas (MPI, 2012; Nxumalo et al., 2016); therefore, it could potentially impact threatened or endangered species in the United States. It has, however, been present in the United States for over 100 years and is only a minor invader in Florida and Texas, though it may be a sleeper weed (Gordon et al., 2012). Therefore, we have high uncertainty.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - mod	0	The climatically suitable area for *H. nymphoides* in the United States includes globally significant ecoregions (Ricketts et al., 1999). Since the plant has been a mere minor invader in the United States for 100 years (Gordon et al., 2012), it is unlikely to have a major impact on these areas.
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	c - negl	0.6	It is a weed of the natural environment in Australia (Randall, 2007). It is under eradication in the Bay of Plenty and Auckland regions of New Zealand (ARC, 2004; ENV BOP, 2004) and in the country as a whole (Champion et al., 2014). Our alternative answers for the uncertainty simulation were both "b."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	y - negl	0.1	It clogs drains and canals (Sullivan and Hutchison, 2010; Thomson, 1922) and causes flooding (MPI, 2012). It has been reported to block dams in New South Wales, Australia (Hosking et al., 2011).
Imp-A2 (Changes or limits recreational use of an area)	y - negl	0.1	It interferes with access to water in New Zealand (ARC, 2004), preventing recreational uses such as fishing, boating, and swimming (Sullivan and Hutchison, 2010). Agriculture Victoria (VRO, 2020) reports visitor complaints about the weed and reductions in visitors to infested areas.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - low	0	We found no evidence of this impact. It is also not mentioned as a garden weed on popular gardening forums (Dave's Garden, 2020; GardenWeb, 2020).
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]	b - mod	0.1	It is listed in the National Plant Pest Accord in New Zealand (MPI, 2012). Sullivan and Hutchinson (2010) calculate that the cost of managing *H. nymphoides* would likely be less than the economic loss due to its unimpeded ability to spread. Hosking et al. (2011) list it as having moderate weed potential since becoming naturalized in Australia. In Texas, it is listed as an F2 species: abundant in fewer than 10 counties

Question ID	Answer - Uncertainty	Score	Notes (and references)
			and invasive in disturbed areas but not particularly in natural areas. It is on a watch list and recommended for control and attempted eradication (Texas Non-Native Plants Group, 2010). Since we did not find direct evidence of control in anthropogenic systems, we answered "b." Our alternate choices for the uncertainty simulation were "c" and "a."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - low	0	We found no evidence of this impact.
Imp-P2 (Lowers commodity value)	n - low	0	We found no evidence of this impact.
Imp-P3 (Is it likely to impact trade?)	n - low	0	*Hydrocleys nymphoides* is prohibited from sale, propagation, and distribution in New Zealand (ENV BOP, 2004). It is prohibited in South Africa (South Africa Department of Environmental Affairs, 2016). It is not, however, listed as a harmful organism by any country (PCIT, 2020), and it has not been intercepted at U.S. ports of entry (AQAS, 2020). Therefore, it is unlikely to impact trade.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	y - high	0.1	Victoria Agriculture (VRO, 2020) reports that it may restrict access to irrigation water or displace water by causing flooding, but this is likely to be a mild effect with less than five percent impact on yield. Since we found no other evidence, we answered “yes” with high uncertainty.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - negl	0	It is not listed as a toxic plant by Burrows and Tyr (2013) or by Bruneton (1999). We found no evidence that it is toxic to animals.
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 - high	0	It is listed as a weed in rice fields of Argentina (Lallana, 2005), but no impact is described. We found no other evidence; therefore, we answered "a" with high uncertainty. Our alternative 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 Secretariat, 2019).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence of presence in this zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence of presence in this zone.
Geo-Z3 (Zone 3)	n - low	N/A	We found no evidence of presence in this zone.
Geo-Z4 (Zone 4)	n - high	N/A	1 point in Russia
Geo-Z5 (Zone 5)	n - high	N/A	We found no evidence of presence in this zone.
Geo-Z6 (Zone 6)	n - high	N/A	1 point in the United States (Connecticut), but this is in an aquatic collections tank at a university and may be climate-controlled.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z7 (Zone 7)	y - high	N/A	2 points in the United States (DC) but these are cultivated
Geo-Z8 (Zone 8)	y - high	N/A	1 point in the United States (Texas), South Korea, and Australia; the point in Australia represents a cultivated plant.
Geo-Z9 (Zone 9)	y - negl	N/A	Some points in Argentina; a few in Australia and New Zealand; 3 in the United States (Florida and Texas) and Japan; 1 in Uruguay, Brazil, Mexico, and South Africa. It is recommended for cultivation in Zones 9-11 (LilyBlooms, 2020).
Geo-Z10 (Zone 10)	y - negl	N/A	Many points in Argentina and Paraguay; a few in Brazil and New Zealand; 9 in Australia; 1 in Zimbabwe, China, and Taiwan. It is recommended for cultivation in Zones 9-11 (LilyBlooms, 2020).
Geo-Z11 (Zone 11)	y - negl	N/A	Many points in Brazil, some in New Zealand. It is recommended for cultivation in Zones 9-11 (LilyBlooms, 2020).
Geo-Z12 (Zone 12)	y - negl	N/A	Many points in Brazil; 2 in Colombia, Ecuador, and Taiwan; 1 in Guyana
Geo-Z13 (Zone 13)	y - negl	N/A	A few points in Brazil, 5 in Guyana, 3 in Colombia, 2 in Venezuela and Ecuador
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Some points in Brazil, 3 in Guyana, 2 in Australia and Colombia
Geo-C2 (Tropical savanna)	y - negl	N/A	Many points in Brazil, 7 in Paraguay, 2 in Colombia and Venezuela, 1 in Australia and Ecuador
Geo-C3 (Steppe)	y - negl	N/A	Many points in Brazil, 2 in Ecuador, 1 in Zimbabwe
Geo-C4 (Desert)	n - negl	N/A	We found no evidence of presence in this climate class.
Geo-C5 (Mediterranean)	n - mod	N/A	We found no evidence of presence in this climate class, but we have moderate uncertainty since the Mediterranean climate is similar to marine west coast.
Geo-C6 (Humid subtropical)	y - negl	N/A	Many points in Australia, Paraguay, and Argentina; 6 in the United States (Florida, Texas, and DC) and Brazil; 3 in Taiwan and Japan; 2 in China; 1 in Mexico
Geo-C7 (Marine west coast)	y - negl	N/A	Many points in New Zealand; 5 in Australia; 1 in South Africa, Ecuador, Colombia, Brazil, and Uruguay
Geo-C8 (Humid cont. warm sum.)	n - high	N/A	1 point in South Korea
Geo-C9 (Humid cont. cool sum.)	n - high	N/A	1 point in Russia and the United States (Connecticut); the point in the United States represents a cultivated plant.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence of presence in this climate class.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence of presence in this climate class.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence of presence in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - high	N/A	2 points in Brazil
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Some points in Brazil; 1 in Paraguay, Colombia, and Zimbabwe
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Many points in Brazil, 5 in Paraguay and Australia, 2 in Argentina, 1 in New Zealand
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Some points in Paraguay and Australia, a few in Brazil, 7 in Argentina, 1 in Russia and Zimbabwe
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Some points in New Zealand, a few in Argentina and Paraguay, 8 in Brazil, 7 in Australia, 4 in the United States (Texas, Connecticut, and DC), 1 in Uruguay
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Some points in New Zealand; few in Argentina; 3 in Brazil; 2 in Australia; 1 in Guyana and the United States (Texas)
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	8 points in Brazil; 7 in New Zealand; 2 in Venezuela, the United States (Florida), and Japan; 1 in Taiwan
Geo-R8 (70-80 inches; 178-203 cm)	y - low	N/A	8 points in Brazil; 1 in Guyana, Colombia, Mexico, and Taiwan
Geo-R9 (80-90 inches; 203-229 cm)	y - low	N/A	1 point in Ecuador, Japan, and China
Geo-R10 (90-100 inches; 229-254 cm)	y - low	N/A	3 points in Brazil and Guyana
Geo-R11 (100+ inches; 254+ cm)	y - low	N/A	3 points in Colombia and Ecuador, 2 in Brazil, 1 in China and Taiwan

ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	*Hydrocleys nymphoides* is naturalized in Florida and Texas (Gordon et al., 2012); it has been observed in Louisiana (MacRoberts and MacRoberts, 2010). It is also widely cultivated as an ornamental (Dave's Garden, 2020; GardenWeb, 2020) and readily available for purchase (LilyBlooms, 2020; Lilypons, 2020). Therefore, we did not evaluate its entry potential.
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
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	-	N/A	

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