Taxon: Sagittaria platyphylla **Family:** Alismataceae

Common Name(s): Broad-leaf arrowhead
delta arrowhead
delta duck-potato

Synonym(s): Sagittaria graminea var. platyphylla

Assessor: No Assessor **Status:** In Progress **End Date:** 29 Oct 2014

WRA Score: 28.0 **Designation:** H(HPWRA) **Rating:** High Risk

Keywords: Aquatic Weed, Ornamental Herb, Monoculture-Forming, Water-Dispersed, Spreads Vegetatively

Qsn #	Question	Answer Option	Answer
101	Is the species highly domesticated?	y=-3, n=0	n
102	Has the species become naturalized where grown?		
103	Does the species have weedy races?		
201	Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"	(0-low; 1-intermediate; 2-high) (See Appendix 2)	High
202	Quality of climate match data	(0-low; 1-intermediate; 2-high) (See Appendix 2)	High
203	Broad climate suitability (environmental versatility)		
204	Native or naturalized in regions with tropical or subtropical climates	y=1, n=0	y
205	Does the species have a history of repeated introductions outside its natural range?	y=-2, ?=-1, n=0	y
301	Naturalized beyond native range	y = 1*multiplier (see Appendix 2), n= question 205	y
302	Garden/amenity/disturbance weed	n=0, y = 1*multiplier (see Appendix 2)	n
303	Agricultural/forestry/horticultural weed	n=0, y = 2*multiplier (see Appendix 2)	y
304	Environmental weed	n=0, y = 2*multiplier (see Appendix 2)	y
305	Congeneric weed	n=0, y = 1*multiplier (see Appendix 2)	y
401	Produces spines, thorns or burrs	y=1, n=0	n
402	Allelopathic		
403	Parasitic	y=1, n=0	n
404	Unpalatable to grazing animals		
405	Toxic to animals	y=1, n=0	n
406	Host for recognized pests and pathogens		
407	Causes allergies or is otherwise toxic to humans	y=1, n=0	n
408	Creates a fire hazard in natural ecosystems	y=1, n=0	n

Qsn #	Question	Answer Option	Answer
409	Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	y
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)		
411	Climbing or smothering growth habit	y=1, n=0	n
412	Forms dense thickets	y=1, n=0	y
501	Aquatic	y=5, n=0	y
502	Grass	y=1, n=0	n
503	Nitrogen fixing woody plant	y=1, n=0	n
504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y=1, n=0	y
601	Evidence of substantial reproductive failure in native habitat	y=1, n=0	n
602	Produces viable seed	y=1, n=-1	y
603	Hybridizes naturally		
604	Self-compatible or apomictic		
605	Requires specialist pollinators	y=-1, n=0	n
606	Reproduction by vegetative fragmentation	y=1, n=-1	y
607	Minimum generative time (years)		
701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	y
702	Propagules dispersed intentionally by people	y=1, n=-1	y
703	Propagules likely to disperse as a produce contaminant		
704	Propagules adapted to wind dispersal	y=1, n=-1	n
705	Propagules water dispersed	y=1, n=-1	y
706	Propagules bird dispersed	y=1, n=-1	y
707	Propagules dispersed by other animals (externally)	y=1, n=-1	y
708	Propagules survive passage through the gut		
801	Prolific seed production (>1000/m2)	y=1, n=-1	y
802	Evidence that a persistent propagule bank is formed (>1 yr)		
803	Well controlled by herbicides	y=-1, n=1	n
804	Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	n
805	Effective natural enemies present locally (e.g. introduced biocontrol agents)		

Supporting Data:

Qsn #	Question	Answer
101	**Is the species highly domesticated?**	**n**
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	[No evidence] "Sagittaria platyphylla has been accepted at the variety level, i.e., Sagittaria graminea var. platyphylla (C. Bogin 1955; J. W. Wooten 1973; E. O. Beal et al. 1982). After studying dozens of populations in the field from much of its range and hundreds of herbarium specimens, we have concluded that this taxon should be recognized at the specific level instead, a conclusion supported by cladistic analyses of morphologic characters (R. M. Kortright 1998)"

102	Has the species become naturalized where grown?	
	Source(s)	**Notes**
	WRA Specialist. 2014. Personal Communication	NA

103	Does the species have weedy races?	
	Source(s)	**Notes**
	WRA Specialist. 2014. Personal Communication	NA

201	Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"	High
	Source(s)	**Notes**
	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/. [Accessed 29 Oct 2014]	"Native: NORTHERN AMERICA Northeastern U.S.A.: United States - Ohio, Pennsylvania, West Virginia North-Central U.S.A.: United States - Illinois, Missouri, Oklahoma Southeastern U.S.A.: United States - Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Tennessee South-Central U.S.A.: United States - Texas Northern Mexico: Mexico - Nuevo Leon Southern Mexico: Mexico - Michoacan SOUTHERN AMERICA Mesoamerica: Panama - Panama"

202	Quality of climate match data	High
	Source(s)	**Notes**
	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/. [Accessed 29 Oct 2014]	

Qsn #	Question	Answer
203	**Broad climate suitability (environmental versatility)**	
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"No quantitative data are available on the climatic requirements of S. platyphylla and S. calycina. In its native and introduced range, S. platyphylla has a broad ecological tolerance, but is generally restricted to warm-temperate regions. Frosts may kill or damage top growth, but regrowth occurs from submerged or subterranean organs."

204	**Native or naturalized in regions with tropical or subtropical climates**	**y**
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	[Naturally occurs in Mexico & Panama] "Streams and lakes; 0--900 m; Ala., Ark., Fla., Ga., Ill., Ky., La., Miss., Mo., Ohio, Okla., Pa., Tenn., Tex., W.Va.; Mexico (Nuevo León, sw Mexico); Central America (Panama)."

205	**Does the species have a history of repeated introductions outside its natural range?**	**y**
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"S. platyphylla is naturalized in the former USSR (Rubstov 1975), Indonesia (Rataj 1972a), Panama, where it is well established in the canal zone (Bogin 1955), and along the Gulf of Mexico coast. S. platyphylla was first recorded as naturalized in South Africa in KwaZulu Natal, and is now considered a new and emerging weed threat to aquatic ecosystems (P. Ivey personal communication 2011)."
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Sagittaria is native to the southern states of North America from an eastern limit in Missouri, west to Kansas and south to Texas, Louisiana, Mississippi and Alabama. It was most likely introduced into Australia for ornamental use. It is known to have been traded as an ornamental aquatic plant in Australia during the 1950's but it may have been present in Australia as early as the 1930's. The first naturalized infestation was detected in Australia in 1959 in Ekibin Creek in Brisbane. Infestations were first detected in Victoria in 1962, New South Wales in 1973 and Western Australia in 1999. It has also spread to South Australia. The most significant infestations occur in the northern Victoria and southern NSW sections of the Murray Darling Basin. It is becoming a problematic plant in the Sydney and NSW central coast regions."
	Frohlich, D.& Lau, A. 2014. New plant records for the Hawaiian Islands 2012–2013. Bishop Museum Occasional Papers 115: 7–17	"This perennial aquatic herb is native to southeastern North America and Central America, and is cultivated as an aquatic ornamental. it was first collected in Hawai'i in 1991, but has likely been in the aquarium trade here for some time before then."

301	**Naturalized beyond native range**	**y**
	Source(s)	**Notes**

Qsn #	Question	Answer
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"S. platyphylla is naturalized in the former USSR (Rubstov 1975), Indonesia (Rataj 1972a), Panama, where it is well established in the canal zone (Bogin 1955), and along the Gulf of Mexico coast. S. platyphylla was first recorded as naturalized in South Africa in KwaZulu Natal, and is now considered a new and emerging weed threat to aquatic ecosystems (P. Ivey personal communication 2011)."
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Sagittaria (Sagittaria platyphylla) is one of Australia's worst aquatic weeds. It causes significant impacts to irrigation channels, waterways and wetlands, particularly in the southern areas of the Murray Darling Basin. Severe infestations block irrigation channels, choke wetlands and can have detrimental impacts on recreation activities. Sagittaria is nationally significant because it has potential to become more widespread throughout Australia, threatens key aquatic assets and is difficult and expensive to control."
	Frohlich, D.& Lau, A. 2014. New plant records for the Hawaiian Islands 2012–2013. Bishop Museum Occasional Papers 115: 7–17	"This perennial aquatic herb is native to southeastern North America and Central America, and is cultivated as an aquatic ornamental. It was first collected in Hawai'i in 1991, but has likely been in the aquarium trade here for some time before then. it was collected from a lo'i kalo in Waihe'e, O'ahu, where it was occasionally occurring in high density "thickets" over multiple kalo (Colocasia esculenta) patches, and appeared to be competing for resources and significantly reducing fitness of the planted kalo. it is unclear how it came to occur in this site, though local farmers believe it may have been transferred accidentally as seed in soil when sharing huli from infested lo'i elsewhere. This species can be distinguished from the congener S. latifolia, the only other species known to be naturalized in Hawai'i, by its generally larger size (to 150 cm tall); emersed leaves with petioles 21–71 cm long, blades linear-ovate to ovate; submersed leaves present; and flowers with pubescent filaments (S. latifolia grows to about 45 cm tall; emersed leaves with petioles 6–51 cm long, blades sagittate or sometimes hastate; submersed leaves absent; and flower filaments glabrous) (Haynes & Hellquist 2000). Material examined. O'AHU: Windward O'ahu, Waihe'e, lowland cultivated taro patch, hundreds of individuals seen in patch, said to have been introduced from taro starters brought from Kaua'i, 20 Sep 2013, D. Frohlich, A. Lau & J. Beachy 2013092002."

302	Garden/amenity/disturbance weed	n
	Source(s)	**Notes**
	WRA Specialist. 2014. Personal Communication	An aquatic weed with detrimental impacts to agriculture (e.g. irrigation) and to the natural environment

303	Agricultural/forestry/horticultural weed	y
	Source(s)	**Notes**

Qsn #	Question	Answer
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"Agricultural impacts. The most significant impacts of S. platyphylla invasions arise from reduced flow paths in drains and channels, which cause increased water levels, particularly during periods of high flow or rainfall, and inefficiencies in water delivery. Infestations in irrigation channels affect the reliability of water delivery to farms, reducing capacity to deliver the right amount of water at the right time, which can lead to production losses or increased costs (Parsons and Cuthbertson 1992, Chapman and Dore 2009)."
	Frohlich, D.& Lau, A. 2014. New plant records for the Hawaiian Islands 2012–2013. Bishop Museum Occasional Papers 115: 7–17	"It was first collected in Hawai'i in 1991, but has likely been in the aquarium trade here for some time before then. it was collected from a lo'i kalo in Waihe'e, O'ahu, where it was occasionally occurring in high density "thickets" over multiple kalo (Colocasia esculenta) patches, and appeared to be competing for resources and significantly reducing fitness of the planted kalo."
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Severe infestations block irrigation channels and drains, leading to restricted flows and increased trapping of silt. It chokes wetlands and waterways, which adversely affects aquatic biodiversity. Infestations can also have detrimental impacts on recreational activities, such as boating, swimming and fishing, and reduce visual amenity of waterways. Sagittaria is also a difficult and expensive plant to control."

304	Environmental weed	y
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"Sagittaria platyphylla threatens native aquatic flora and fauna by invading shallow water bodies, where it competes with native species and reduces plant biodiversity (Chapman and Dore 2009). However, quantitative data demonstrating such impacts are lacking."
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"The continued spread of sagittaria threatens irrigation assets and aquatic biodiversity throughout the Murray Darling Basin, and other waterways in Australia within its potential range. Ramsar wetlands at immediate risk include Barmah National Park, Kerang Wetlands and Gunbower Forest in Victoria, and the Chowilla Floodplain in South Australia." ... "In 2012 sagittaria was named one of the additional twelve Weeds of National Significance. This strategic plan was developed in response to its WoNS listing and aims to provide a framework to eventually protect Australia's waterways from the severe impacts of this weed."

305	Congeneric weed	y
	Source(s)	**Notes**

Qsn #	Question	Answer
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"Four species of Sagittaria other than S. platyphylla and S. calycina are naturalized outside their native ranges and can threaten agricultural production or natural ecosystems. S. lancifolia, S. rigida Pursh and S. subulata are native to the New World, but are naturalized in Europe. S. trifolia is native to Europe, but is now naturalized in the southern Ukraine (Tutin et al. 1980). Endemic species, e.g. S. montevidensis, S. aginashi Makino, S. guayanensis Kunth, S. lancifolia L., S. pygmaea Miq. and S. trifolia L. (Bogin 1955, Rataj 1972b, Godfrey and Wooten 1979, Randall 2002), can also be problematic, particularly in rice production systems."
	Global Invasive Species Database. 2006. Sagittaria sagittifolia. http://www.issg.org/database/species/ecology.asp?si=858&fr=1&sts=tss&lang=EN. [Accessed 29 Oct 2014]	"Sagittaria sagittifolia is a very hardy aquatic plant that has become a general nuisance in the crops' irrigation systems, drains and waterways around the globe."

401	Produces spines, thorns or burrs	n
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	[No evidence] "Herbs, perennial, to 150 cm; rhizomes absent; stolons present; corms present. Leaves submersed and emersed; submersed sessile, phyllodial, flattened, to 26 ´ 0.5 cm; emersed with petiole ± triangular, 21--70.5 cm, blade linear-ovate to ovate, 4.6--16.4 ´ 0.7--6.1 cm. Inflorescences racemes, of 3--9 whorls, emersed, 2.5--10 ´ 2--4.5 cm; peduncles 22--60 cm; bracts connate more than ¼ total length, lanceolate, 3--5.5 mm, delicate, not papillose; fruiting pedicels spreading to recurved, cylindric, 0.5--3 cm."

402	Allelopathic	
	Source(s)	**Notes**
	WRA Specialist. 2014. Personal Communication	Unknown

403	Parasitic	n
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	[No evidence] "Herbs, perennial, to 150 cm; rhizomes absent; stolons present; corms present."

404	Unpalatable to grazing animals	
	Source(s)	**Notes**
	Keddy, P.A. 2000. Wetland Ecology: Principles and Conservation. Cambridge University Press, Cambridge, UK	[Palatable to nutria] "Table 6.2. The effects of Myocastor coypus on deltaic wetlands as illustrated by four 40 x 50 m exclosures and paired control areas." ... "Plants that were preferred food of M. coypus (e.g. Sagittaria platyphylla, S. latifolia) dominated exclosures, while species presumably less preferred (Justicia ovate, Leersia oryzoides) dominated the coastal sites."

Qsn #	Question	Answer
	Martin, A.C. & Uhler, F.M. 1939. Food of game ducks in the United States and Canada. Technical Bulletin No. 634. USDA, Washington, D.C.	[Tubers palatable to ducks] "Parts consumed - The tubers; the use of seeds (achenes) is slight." ... "The delta duckpotato is probably the only sagittaria of primary importance as a duck food. Its tubers ... are of moderate size and occur at shallow depths and hence are much used in their limited native habitat along the Gulf coast."

405	Toxic to animals	n
	Source(s)	**Notes**
	Victorian Resources Online. 2014. Impact Assessment - Delta arrowhead (Sagittaria platyphylla) in Victoria. http://vro.depi.vic.gov.au/dpi/vro/vrosite.nsf/pages/impact_delta_arrowhead. [Accessed 29 Oct 2014]	"Sagittaria species are eaten by ducks and sometimes humans, suggesting that they are not toxic either (Parson & Cuthberston, 1992)."
	Wagstaff, D.J. 2008. International poisonous plants checklist: an evidence-based reference. CRC Press, Boca Raton, FL	No evidence

406	Host for recognized pests and pathogens	
	Source(s)	**Notes**
	Victorian Resources Online. 2014. Impact Assessment - Delta arrowhead (Sagittaria platyphylla) in Victoria. http://vro.depi.vic.gov.au/dpi/vro/vrosite.nsf/pages/impact_delta_arrowhead. [Accessed 29 Oct 2014]	"Harbours several important plant viruses (Parsons & Cuthbertson, 1992)."
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"In North America, Sagittaria is an alternative host to the aster leaf hopper, Macrosteles fascifrons Stål, (Hemiptera: Cicadellidae), a vector of aster yellows phytoplasma, oat blue dwarf virus and clover phyllody virus. While the leaf hopper is not present in Australia, infestations of Sagittaria present a potential biosecurity risk to Australian agricultural and floricultural industries."

407	Causes allergies or is otherwise toxic to humans	n
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	[No evidence] "Throughout most of their range, Sagittaria spp. are utilized as a source of food. Tubers of several species are consumed baked, boiled, fried, ground into flour, sweetened or dried. Therefore, human activity has historically played a role in the distribution of Sagittaria (Rogers 1983)."
	Wagstaff, D.J. 2008. International poisonous plants checklist: an evidence-based reference. CRC Press, Boca Raton, FL	No evidence

408	Creates a fire hazard in natural ecosystems	n
	Source(s)	**Notes**

Qsn #	Question	Answer
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	[No evidence] "Both shallow water depth and slow flow are key requirements for establishment of sagittaria. It mostly inhabits waterways and/or irrigation channels in water less than 1m deep or on the waters edge, and prefers the muddy substrates associated with still or slow moving waterways. It can also survive in wet marshy soils near water. Fluctuating water levels can aid establishment as it provides favourable conditions for seed germination."

409	Is a shade tolerant plant at some stage of its life cycle	y
	Source(s)	**Notes**
	Weeds Australia. 2014. Weed Identification - Sagittaria platyphylla. http://www.weeds.org.au/cgi-bin/weedident.cgi?tpl=plant.tpl&state=tas&s=&region=twe&card=W13. [Accessed 29 Oct 2014]	"Shade tolerant. Forms dense patches, obstructing water flow and producing luxuriant growth in enriched conditions. Competes vigorously with native waterplants."

410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"Once established, populations trap more sediment, thereby increasing habitat availability. In North America, substrates high in potassium and organic matter were associated with S. platyphylla, suggesting specificity for certain soils amongst Sagittaria taxa (Wooten 1986)."
	GardenAway. 2013. Sagittaria platyphylla. http://gardenaway.com/search/plant_view/sagittaria-platyphylla. [Accessed 29 Oct 2014]	"Sagittaria platyphylla will grow best in wet soil moisture. This delta arrowhead will grow in all garden soil types. "

411	Climbing or smothering growth habit	n
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	"Herbs, perennial, to 150 cm; rhizomes absent; stolons present; corms present. Leaves submersed and emersed; submersed sessile, phyllodial, flattened, to 26 ´ 0.5 cm; emersed with petiole ± triangular, 21--70.5 cm, blade linear-ovate to ovate, 4.6--16.4 ´ 0.7--6.1 cm. Inflorescences racemes, of 3--9 whorls, emersed, 2.5--10 ´ 2--4.5 cm; peduncles 22--60 cm; bracts connate more than ¼ total length, lanceolate, 3--5.5 mm, delicate, not papillose; fruiting pedicels spreading to recurved, cylindric, 0.5--3 cm."

412	Forms dense thickets	y
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"It is a highly invasive and rapidly growing plant that forms dense monocultures in water bodies up to one metre in depth."

Qsn #	Question	Answer
	Frohlich, D.& Lau, A. 2014. New plant records for the Hawaiian Islands 2012–2013. Bishop Museum Occasional Papers 115: 7–17	"It was first collected in Hawai'i in 1991, but has likely been in the aquarium trade here for some time before then. it was collected from a lo'i kalo in Waihe'e, O'ahu, where it was occasionally occurring in high density "thickets" over multiple kalo (Colocasia esculenta) patches, and appeared to be competing for resources and significantly reducing fitness of the planted kalo."
	Lemke, D. E. 1989. Aquatic macrophytes of the upper San Marcos River, Hays Co., Texas. The Southwestern Naturalist 34(2): 289-291	"Twenty- three of the 31 species collected from the study area are native taxa, the most abundant being Potamogeton illinoensis Morong and Sagittaria platyphylla Engelm., both of which form extensive mat-like stands."

501	Aquatic	y
	Source(s)	**Notes**
	Mohlenbrock, R.H. 2006. The Illustrated Flora of Illinois - The Flowering Plants: Flowering Rush to Rushes. SIU Press, Carbondale, IL	"Habitat: Sloughs, ditches, around ponds, sometimes in standing water."
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	"Herbs, perennial, to 150 cm; rhizomes absent; stolons present; corms present. Leaves submersed and emersed." ... "Streams and lakes; 0--900 m"

502	Grass	n
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	"Herbs, perennial, to 150 cm" [Alismataceae]

503	Nitrogen fixing woody plant	n
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	"Herbs, perennial, to 150 cm" [Alismataceae]

504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y
	Source(s)	**Notes**
	Flora of North America Editorial Committee. 2000, Flora of North America: North of Mexico, Volume 22. Oxford University Press, Oxford, UK	"Herbs, perennial, to 150 cm; rhizomes absent; stolons present; corms present."

Qsn #	Question	Answer
601	**Evidence of substantial reproductive failure in native habitat**	**n**
	Source(s)	**Notes**
	WRA Specialist. 2014. Personal Communication	A plant with a broad native distribution, and a successful invader in Australia, with no evidence of reproductive failure in either the native or introduced ranges

602	Produces viable seed	y
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Sagittaria reproduces by both seeds and vegetative means, although seed production is only possible in emergent forms. They can be prolific seed producers with one healthy emergent plant capable of producing up to 20,000 seeds."

603	Hybridizes naturally	
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	[Possibly] "Hybridization occurs in Sagittaria, but is inadequately investigated. Plasticity of morphological characters and related taxonomic confusion makes recognition of hybrids difficult. Bogin (1955) suggests the origin of S. graminea var. platyphylla (= S. platyphylla) was hybridization between S. introgression with S. graminea. However, subsequent hybridization experiments do not strongly support this hypothesis. Crossing experiments show varieties of S. graminea (varieties graminea, weatherbiana, chapmanii) are highly interfertile with each other and with S. platyphylla, but S. platyphylla shows low crossability with S. fasiculata E.O.Beal and no fertile crosses were obtained when combined with S. isoetiformis J.G.Sm., S. rigida Pursh, S.cristata Engelm., S. teres S.Watson and S. montevidensis subsp. calycina (Wooten 1973)."

604	Self-compatible or apomictic	
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	[Possibly no] "Flowers of S. graminea sens. lat. excluded from access by pollinators do not produce seeds, indicating plants are not agamospermous (Wooten 1973) and are likely to be self-incompatible."

Qsn #	Question	Answer
605	**Requires specialist pollinators**	**n**
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"Pollination of Sagittaria is by flies, shorttongued bees, generalist bees, syrphids or other small insects that are attracted to nectar rewards (Lovell 1898, Rogers 1983, Muenchow and Delesalle 1994)."

606	**Reproduction by vegetative fragmentation**	**y**
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Both the emergent and rosette forms reproduce vegetatively through their underground stolons and tubers. These vegetative parts can survive over winter and allow infestations to rapidly regenerate in spring or following periods of stress. Tubers are round and fleshy organs produced by the root system and can remain viable in the soil for up to a year. They can be detached and dispersed downstream by strong water currents, although they do not tolerate desiccation."

607	**Minimum generative time (years)**	
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	[Time to first flowering not specified] "Regrowth from the rosettes, tubers and stolons can form new emergent plants in as little as 6-12 weeks post-treatment under suitable conditions."

701	**Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)**	**y**
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"The seeds can also be spread in mud attached to boats, vehicles or other equipment."

702	**Propagules dispersed intentionally by people**	**y**
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Its use as an ornamental plant by water garden and pond plant enthusiasts threatens to spread sagittaria to regions that are currently free of the weed. A national ban on its sale along with awareness programs will help reduce its ornamental use and limit this invasion pathway. Improving our understanding of sagittaria's invasion pathways and how these can be managed will also help to limit further spread."
	Frohlich, D.& Lau, A. 2014. New plant records for the Hawaiian Islands 2012–2013. Bishop Museum Occasional Papers 115: 7–17	"This perennial aquatic herb is native to southeastern North America and Central America, and is cultivated as an aquatic ornamental. it was first collected in Hawai'i in 1991, but has likely been in the aquarium trade here for some time before then."

Qsn #	Question	Answer
703	**Propagules likely to disperse as a produce contaminant**	
	Source(s)	**Notes**
	Frohlich, D.& Lau, A. 2014. New plant records for the Hawaiian Islands 2012–2013. Bishop Museum Occasional Papers 115: 7–17	[Possibly a contaminant with taro crops] "it is unclear how it came to occur in this site, though local farmers believe it may have been transferred accidentally as seed in soil when sharing huli from infested loʻi elsewhere."

704	Propagules adapted to wind dispersal	n
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Sagittaria reproduces by both seeds and vegetative means, although seed production is only possible in emergent forms. They can be prolific seed producers with one healthy emergent plant capable of producing up to 20,000 seeds. The small and buoyant seeds can float for up to three weeks and can be easily dispersed by relatively light water currents. Ducks, swans and swamp hens feed on sagittaria and appear to be another major vector for seed spread. The seeds can also be spread in mud attached to boats, vehicles or other equipment."

705	Propagules water dispersed	y
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"The small and buoyant seeds can float for up to three weeks and can be easily dispersed by relatively light water currents."

706	Propagules bird dispersed	y
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Ducks, swans and swamp hens feed on sagittaria and appear to be another major vector for seed spread."

707	Propagules dispersed by other animals (externally)	y
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	"Achenes of Sagittaria can adhere to animals via a sticky outer surface, or become attached to mud and machinery (Rogers 1983, Flower 2003)."

Qsn #	Question	Answer
708	**Propagules survive passage through the gut**	
	Source(s)	**Notes**
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	[Possibly Yes] "Most Sagittaria achenes drop within the infestation area, but some are eaten by ducks and are believed to be viable when excreted (Parsons and Cuthbertson 1992)."

801	**Prolific seed production (>1000/m2)**	**y**
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Sagittaria reproduces by both seeds and vegetative means, although seed production is only possible in emergent forms. They can be prolific seed producers with one healthy emergent plant capable of producing up to 20,000 seeds."

802	**Evidence that a persistent propagule bank is formed (>1 yr)**	
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"Tubers are round and fleshy organs produced by the root system and can remain viable in the soil for up to a year."
	Adair, R. J., Keener, B. R., Kwong, R. M., Sagliocco, J. L., & Flower, G. E. 2012. The Biology of Australian weeds 60.'Sagittaria platyphylla' (Engelmann) JG Smith and 'Sagittaria calycina' Engelmann. Plant Protection Quarterly, 27(2), 47-58	[Unknown] "In the laboratory, the optimal temperature for germination of S. platyphylla is 21°C. Achenes do not germinate in darkness, but remain viable (Flower 2004). The duration of viability of S. platyphylla achenes is undetermined."

803	**Well controlled by herbicides**	**n**
	Source(s)	**Notes**

Qsn #	Question	Answer
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	"At the time of publication no herbicides were registered for use against sagittaria in Australia. However, several herbicides, including glyphosate, dichlobenil, Arsenal ExpressTM (an imazapyr/glyphosate formulation) and 2,4-D can be used under minor use permits issued by the Australian Pesticides and Veterinary Medicines Authority for sagittaria control in specific areas. Herbicide control is often difficult and will often only provide limited and temporary control of sagittaria. Foliar applications of herbicides helps remove the standing biomass of emergent plants but the herbicides do not sufficiently translocate to the underground tubers or stolons, nor do they come into contact with the submerged rosettes. Regrowth from the rosettes, tubers and stolons can form new emergent plants in as little as 6-12 weeks post-treatment under suitable conditions. Herbicide control of emergent foliage prior to the plant flowering significantly reduces seed production and can be a useful method to help prevent further spread of established infestations. Spraying provides best results when water levels are low and plant growth is highest, which maximises the uptake of the herbicide. However, in irrigation districts spraying can be complicated as the plant's optimal growth rates occur in March and April, which coincides with the irrigation season when water levels in channels tend to be at their highest. Despite the above difficulties, herbicides still provide the most cost-effective means of controlling emergent sagittaria in irrigation channels and restoring channel flow. In addition, there are some promising herbicide strategies under development, which may provide improved suppression tools for infestations, including submerged rosettes, in irrigation channels."

804	Tolerates, or benefits from, mutilation, cultivation, or fire	n
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	[Can resprout unless all stem & root fragments are removed] "Physical removal involves either digging by hand or mechanical removal through use of machinery. It is best utilised where there is a need to quickly restore hydrological function of irrigation channels or drains. It is also used where herbicide applications are not suitable (such as near sensitive crops) or where the channels are in continual use and cannot be shut down for control. Viable plant fragments, such as tubers and stolons, often remain after mechanical excavation so follow up treatment is often required. Physical removal is a suitable tool for eradicating small infestations, providing all viable plant material can be removed. However, physical removal is costly and, in the case of mechanical removal risks damaging irrigation channels, potentially leading to ponding or leakage. It can also alter channel architecture, which may alter flow regimes. In addition, there is a high risk of spread associated with physical removal resulting from dislodgment of roots, tubers and stolon fragments and their movement downstream. Suitable hygiene and containment measures are required to ensure these plant fragments don't float downstream and cause new infestations."

805	Effective natural enemies present locally (e.g. introduced biocontrol agents)	

Qsn #	Question	Answer
	Source(s)	**Notes**
	Australian Weeds Committee. 2012. Weeds of National Significance, Sagittaria (Sagittaria platyphylla) Strategic Plan. Australian Weeds Committee, Canberra	[Unknown if any biological agents impact this plant in the Hawaiian Islands] "The Department of Primary Industries, Victoria, have completed a biological control feasibility study and a program is now underway to identify potential agents (insects and pathogens) in the native range of southern USA. A concurrent study of the genetic structure of Australian and USA sagittaria populations will determine the likely origins of Australian populations and aid in the sourcing of potential biocontrol agents. DPI Victoria are developing a submission to the Australian Weeds Committee to have Sagittaria spp. listed as targets for biological control. Biological control of Sagittaria spp. has potential in Australia because only five members of the Alismataceae are native to Australia (Sagliocco et al. 2007)."

Summary of Risk Traits:

High Risk / Undesirable Traits
• Can grow in warm temperate to tropical climates
• Naturalized in Australia, Oahu, Russia, Indonesia, South Africa & possibly elsewhere
• An agricultural weed (affecting irrigation) & an environmental weed (competing with native vegetation)
• Other Sagittaria species have become invasive
• Shade tolerant
• Forms dense thickets in aquatic habitats
• Can spread from tubers or seeds
• Dispersed intentionally & unintentionally by people
• Seeds & vegetative fragments dispersed by water, in soil, by birds & in mud stuck to animals & machinery
• Prolific seed production
• Seeds & vegetative fragments may persist in the soil
• Tolerates cutting & will resprout without complete removal of plant, or treatment with herbicides
• Herbicide control is difficult due to aquatic nature of plants and poor translocation of herbicides to tubers or stolons

Low Risk Traits
• Unarmed (no spines, thorns or burrs)
• Palatable to ducks & possibly other animals
• Non-toxic
• Ornamental