U.S. Fish & Wildlife Service

Water Hyacinth (*Pontederia crassipes*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, August 2023
Revised, September 2023
Web Version, 4/8/2025

Organism Type: Flowering Plant
Overall Risk Assessment Category: High

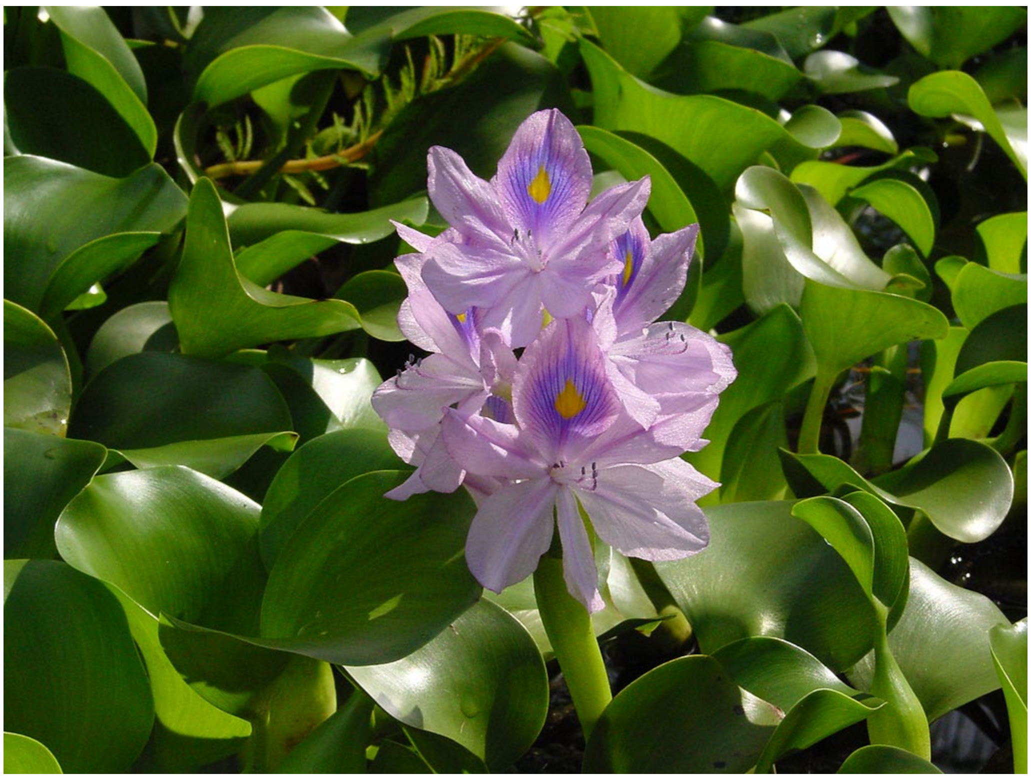

Photo: Hagens W. Public Domain. Available: https://en.wikipedia.org/wiki/Pontederia_crassipes#/media/File:Eichhornia_crassipes_C.jpg (March 2023).

1 Native Range and Status in the United States

Native Range

From USDA (2023):

"NORTHERN SOUTH AMERICA: **French Guiana, Guyana, Suriname, Venezuela**
BRAZIL: **Brazil** (n.e.)"

From Coetzee et al. (2017):

"*Eichhornia crassipes* [synonym for *Pontederia crassipes*] is indigenous to tropical South America, first described from Brazil in 1823 by C.F.P. Martius. Its centre of origin is Amazonia, Brazil, […]"

Status in the United States

From Coetzee et al. (2017):

"The first authentic record of *E. crassipes* outside South America was from a trade fair in New Orleans in 1884 (Penfound and Earle 1948). Visitors to the cotton exposition were given plants as souvenirs by Japanese delegates, and many of these plants found their way into the waters of Louisiana, Texas, and Florida (Klorer 1909). A particularly troublesome invasion was on the St Johns River in Florida in 1895, when gale force winds blew the plant 160 km up and down the river, creating expansive floating mats up to 40 km long. Thereafter, *E. crassipes* plants spread around the U.S.A., remaining most problematic in the southern States as well as California."

From Pfingsten et al. (2024):

"Populations in the southeastern (North Carolina to Texas) and southwestern (California and Arizona) US remain established (including Guam, Hawaii, Puerto Rico, and the Virgin Islands), while those in northern states (Washington to Colorado to New York) likely do not overwinter."

According to Pfingsten et al. (2024), *Pontederia crassipes* has also been reported as established in the following U.S. States and territories: Alabama, Arkansas, Florida, Georgia**,** Louisiana**,** Maryland, Mississippi, South Carolina, Tennessee.

According to Pfingsten et al. (2024), establishment status has not been determined for *Pontederia crassipes* reported in the following U.S. States: Connecticut, District of Columbia, Delaware, Illinois, Indiana, Kansas, Kentucky, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, New Mexico, Ohio, Oregon, Pennsylvania, Rhode Island, Virginia, Wisconsin.

According to Pfingsten et al. (2024), all occurrences of *Pontederia crassipes* in New Hampshire have been extirpated.

Coetzee et al. (2017) lists *Pontederia crassipes* as having invaded the Northern Mariana Islands.

From Jacono et al (2018):

"*Eichhornia crassipes* is sold at aquarium stores and is sold in the Great Lakes. This species is a popular aquarium plant and is available for purchase in the Great Lakes region. […] In a survey of aquarium stores near Lakes Erie and Ontario, *E. crassipes* was available for purchase in 30% of the stores (Rixon et al. 2005)."

From Pond Plants Online (2022):

"Water Hyacinth | Eichornia [sic] crassipes $ 4.50"

"Cannot ship to: AL, AR, AZ, CA, LA, FL, ID, IL-City of Chicago, PR, MS, NE, SC, TX, WI. If ordered where illegal, will be substituted with similar floating plants of equal or greater value."

Regulations

Pontederia crassipes is regulated under the name *Eichhornia crassipes* in Alabama (Alabama Department of Agriculture and Industries 2006), Arizona (AZDA 2022), Delaware (Delaware Code 2022), Idaho (IDDA 2022), Minnesota (Minnesota DNR 2022), North Carolina (North Carolina DEQ 2022), South Carolina (South Carolina DNR 2010), Texas (TPDW 2022), and Wisconsin (Wisconsin DNR 2022). It is regulated at the genus level, under the name *Eichhornia*, in Florida (Florida Department of Agriculture and Consumer Services 2010). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

From Coetzee et al. (2017):

"The first authentic record of *E. crassipes* outside South America was from a trade fair in New Orleans in 1884 (Penfound and Earle 1948). Visitors to the cotton exposition were given plants as souvenirs by Japanese delegates, and many of these plants found their way into the waters of Louisiana, Texas, and Florida (Klorer 1909). A particularly troublesome invasion was on the St Johns River in Florida in 1895, when gale force winds blew the plant 160 km up and down the river, creating expansive floating mats up to 40 km long."

From Pfingsten et al. (2024):

"Sold as an ornamental for fish ponds; sometimes escapes or is intentionally introduced into larger water bodies such as lakes and reservoirs."

Remarks

This ERSS was previously published in September 2018. Revisions were completed to incorporate new information and conform to updated standards.

Based on morphological and molecular data, Pellegrini et al. (2018) consider *Eichhornia* to be a sub-genus of *Pontederia* and promote the use of *Pontederia crassipes*. Despite this recent work, most information in this ERSS was found from sources still using the former valid scientific name *E. crassipes*. This assessment follows World Flora Online (WFO 2023) in treating *P. crassipes* as the accepted name. However, literature searches using the synonym *E. crassipes* were included in the research for the ERSS.

From GISD (2017):

"Early in 1974, a first law (decreto-lei 165/74 de 22 Abril) [in Portugal] recognized water-hyacinth (*Eichhornia crassipes*) as an invasive species, forbidding its importation, culture, selling, transport or possession."

From U.S. Forest Service (2015):

"A declared noxious weed in Western Australia, the Northern Territory and Queensland [Australia] (Smith, 2002; p. 82). A Class A (eradicate) noxious weed in New Zealand."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to WFO (2023), *Pontederia crassipes* is the current accepted name for this species.

From ITIS (2024):

Kingdom Plantae
  Subkingdom Viridaeplantae
    Infrakingdom Streptophyta
      Division Embryophyta
        Subdivision Tracheophyta
          Infradivision Spermatophytina
            Class Magnolipsida
              Superorder Lilianae
                Order Commelinales
                  Family Pontederiaceae
                    Genus *Pontederia* L.
                      Subgenus *Pontederia* (*Oshunae*) M. Pell. & C.N. Horn
                      Species *Pontederia crassipes* Mart.

Size, Weight, and Age Range

From Rojas-Sandoval and Acevedo-Rodriguez (2013):

"The plant is very variable in size, seedlings having leaves that are only a few centimetres across or high, whereas mature plants with good nutrient supply may reach 1 m in height."

"Leaves consist of petiole (often swollen, 2-5 cm thick) and blade (roughly round, ovoid or kidney-shaped, up to 15 cm across). The base of the petiole and any subsequent leaf is enclosed in a stipule up to 6 cm long."

"Roots develop at the base of each leaf and form a dense mass: usually 20-60 cm long, though they can extend to 300 cm."

"Each [inflorescence] spike, up to 50 cm high […] Each flower has a perianth tube 1.5 cm long, expanding into six mauve or purple lobes up to 4 cm long."

Environment

From U.S. Forest Service (2015):

"Freshwater lakes, ponds, marshes, ditches, canals, slow-moving streams."

From Coetzee et al. (2017):

"*Eichhornia crassipes* invades still and slow-moving water bodies, […] It also thrives in fresh to brackish waters (up to 4 ppt) but is limited by very high salinity in coastal estuaries where concentrations between 6 and 8 ppt are lethal (de Casabianca and Laugier 1995; Muramoto, Aoyama, and Oki 1991), although there are reports that the plant may adapt its tolerance to higher salinities (de Casabianca and Laugier 1995)."

From Téllez et al. (2008):

"Also, growth stops if the water temperature falls below 10°C or rises above 40°C (François 1970)."

"Another determining factor for the growth of *E. crassipes* is pH. This has to be between 6 and 8. When the values move outside this interval, the plant can regulate pH of the medium within this range with its growth frequently resulting in the alkalinization of the water. Maximum growth (number of plants and dry weight) is at pH 7, with pH 3.2–4.2 being very toxic for the plant, 4.2–4.3 inhibitory, and 4.3–4.5 possibly inhibitory (Berg 1961)."

"Maximum growth of *E. crassipes* has been observed at N:21 mg/L, P:62 mg/L, and Fe:0.6 mg/L. Deficiency of N or P has less adverse effect than that of Ca. A lack of Ca prevents the plant's vegetative reproduction (Desougi 1984), the minimum concentration necessary being Ca:5 mg/L (Oki et al. 1978), with this element being essential for seed formation (Talatala 1974). Nitrates are the main nutrient responsible for the growth of this invading plant. Their concentration in the River Guadiana in 2005 varied between 19.63 to 23.52 mg/L in the zones of greatest infestation. Phosphate concentrations were between 0.02 to 3.31 mg/L."

Climate

From Coetzee et al. (2017):

"Its distribution is largely restricted by cold winter temperatures to between 40°N and S, while it occurs abundantly in tropical freshwater bodies around the world (Figure 3 [in source material])."

"The distribution of *E. crassipes* is largely pantropical, with optimal growth occurring between 28°C and 30°C, while cold winter temperatures and frost events limit its spread (Owens and Madsen 1995). […] *Eichhornia crassipes* can withstand near-freezing temperatures for a limited period of time but exhibits a steady decline in regrowth potential under these conditions (Owens and Madsen 1995)."

"For these reasons, *E. crassipes* invasive range is restricted to the warmer Mediterranean regions in Europe, in Portugal, Spain, Italy and Corsica (France)."

From Villamagna and Murphy (2009):

"Water hyacinth has invaded freshwater systems in over 50 countries on five continents and, according to recent climate change models, its distribution may expand into higher latitudes as temperatures rise (Rodrıguez-Gallego *et al*. 2004, Hellmann *et al*. 2008, Rahel and Olden 2008). […] It is prevalent in tropical and sub-tropical waterbodies […]."

From Téllez et al. (2008):

"The northernmost limit of the area of distribution of *E. crassipes* is where the mean January temperature is 1°C, the mean annual temperature is 13°C, and the average lowest temperature in the year is -3°C (Ueki et al. 1976). The optimal mean temperature for plant growth is between 25°C and 27°C (François 1970)."

Distribution Outside the United States

Native

From USDA (2023):

"NORTHERN SOUTH AMERICA: **French Guiana, Guyana, Suriname, Venezuela**
BRAZIL: **Brazil** (n.e.)"

From Coetzee et al. (2017):

"*Eichhornia crassipes* is indigenous to tropical South America, first described from Brazil in 1823 by C.F.P. Martius. Its centre of origin is Amazonia, Brazil, […]"

Introduced

From NNSS (2017):

"Water hyacinth is one of the worlds most invasive and troublesome aquatic weeds of tropical regions. It has been widely planted for ornament outside the tropics but has rarely established due to frost sensitivity."

From Coetzee et al. (2017):

"[…] anthropogenic spread [of *Pontederia crassipes*] to areas such as Argentina, Venezuela and central South America and the Caribbean islands (Barrett and Forno 1982; Edwards and Musil 1975; Penfound and Earle 1948)."

"*Eichhornia crassipes* has also been reported in ephemeral summer and autumn populations on the border of southern Canada (Ontario Province, tributaries to the southern side of Lake St. Clair and the Detroit River) (Adebayo et al. 2011). It is assumed that the finding of water hyacinth in these locations is due to repeated re-invasion from anthropogenic release by humans, rather than propagation by seed."

From Coetzee et al. (2009):

"Even though the first introduction of *E. crassipes* to the African continent was made in Egypt between 1879 and 1892 (Edwards and Musil 1975), many invasions in Africa were first noticed only in the 1980s and it continues to invade many waterways of Africa, even though regional bans have been placed on its transport, and numerous control efforts have been implemented (Navarro and Phiri 2000)."

From GISD (2017):

"Water hyacinth currently occurs along the east coast of Australia from Kiama in NSW to southern Cape York Peninsula in Queensland. In the early 1900s dominant infestations in northern coastal rivers of NSW were a major hindrance to river navigation. In inland NSW, water hyacinth was identified on the Gingham Watercourse near Moree in 1955. By 1976 it had become a major infestation covering 7000 hectares, threatening the Murray-Darling system. These infestations are now under control but require annual monitoring and maintenance. Populations are also known to occur in Darwin, Perth, and the Mitchell River on western Cape York Peninsula, Mt Isa and Georgetown in Queensland. Infestations in Victoria and South Australia have been eradicated. It has never been found in the wild in Tasmania."

"Water hyacinth, *Eichhornia crassipes* is found in freshwater habitats, it is reported upland coastal habitats [in Bermuda] (Bermuda Natural History Museum, undated in Varnham, 2006)."

"*Eichhornia crassipes* has been introduced to other parts of Brazil beyond its native distribution in the Amazon Basin."

"Water hyacinth, *Eichhornia crassipes* probably introduced as an ornamental and possibly naturalised does not appear to thrive in the wild in the Cayman Islands (Burton, 2003 in Varnham, 2006)."

"Water hyacinth was introduced into China in the early 1900s. As an ornamental plant, it was first introduced into Taiwan in 1903 from Southeast Asia. In the 1930s it was introduced to the mainland (Diao 1989, in Jianqing et al. 2001). But the first scientific record appeared for the mainland in 1954 in the book, 'Taxonomy Catalogue for China's Plants: Families and Genera' (Anon. 1954, in Jianqing et al. 2001). In the 1950s and 1960s, water hyacinth was distributed widely into almost all provinces for animal food."

"Water hyacinth is now distributed naturally in 17 provinces or cities in China. In several other provinces water hyacinth is still utilised but cannot overwinter."

“Proliferation of *Echhornia crassipes* have been reported in Lakes Victoria [Tanzania, Uganda, Kenya] and Naivasha [Kenya] (Gang P. Society for Protection of Environment in Kenya, pers. comm., July 2003).”

“There is an enormous presence of water hyacinth in some of these lakes and rivers of one the most important National Parks in the West of Madagascar, Ankarafantsika (Gerardo García, Durrell Wildlife Conservation Trust (DWCT) pers. comm., April 2003.”

“*E. crassipes* has mostly been found in Northland and Auckland [New Zealand], with some sites as far south as Wellington. Many of the known sites of water hyacinth are now considered historical, having been clear of the plant for at least 20 years. The seed of water hyacinth may remain viable for up to twenty years and in New Zealand plants have been found at a site previously clear for seven years.”

“Classed as one of the worst and most aggressive invasive plant species present in Portugal [sic] *E. crassipes* was introduced as an ornamental and now invades water courses and lagoons in the country.”

“Different stretches of freshwater in coastal zones [of Reunion] are overgrown to a greater or lesser degree by water hyacinth and water lettuce (*Pistia stratiotes*). In February 2006, an analysis done on l Etang du Gol (16ha) showed it to be 100% overgrown, 40% of it due to water hyacinth. Even though major climatic events (hurricanes or tropical storms) result in evacuation of floating aquatic plants to the sea, recolonization of the surface of the pond is ensured from remaining seeds and fragments (Le Bourgeois, 2006).”

“Tropical water weeds *E. crassipes* and *Pistia stratiodes* have lately been found in many ponds and rivers of Moscow [Russia] and its neighborhood. Both of the species are grown as ornamental and escape summertime cultivation, the first is suggested for use in wastewater treatment, too. These plants are regarded as invasive weeds in many tropical and subtropical countries.”

“Despite the fact that they can sometimes can form large floating mats during hot summers (even under Moscow climatic conditions), the first frosts in October kill them completely. *E. crassipes* and *Pistia stratiodes* can hardly become established in natural systems of the middle European Russia, although they may be potentially hazardous for southern regions of the country.”

“Water hyacinth entered Sri Lanka in 1904 and spread rapidly to cause major environmental problems. Water hyacinth was introduced into the Botanical Gardens in Colombo in 1904 and by 1909 it was seen as such a significant pest that the Water Hyacinth Ordinance was proclaimed (Jepson 1933, Kotalawala 1976, in Room and Fernando 1992). Despite several expensive eradication campaigns, the weed was found throughout the lowlands by 1922 and 338 infestations were reported in 1933 (Jepson 1933, in Room and Fernando 1992). Infestations remained widespread, numerous and flourishing throughout the 1980s.”

From Téllez et al. (2008):

"In Spain, the first documented cases date from 1989, appearing only sparsely and more or less sporadically between parallels 36° and 43°N, forming small localized populations that disappeared when the ponds or wetlands in which they had been detected dried out, or because of the salinity of the habitat (GIC 2006)."

"The greatest damage due to its fast expansion has been in the middle reaches of the River Guadiana in the SW Iberian Peninsula. Detected in the Autumn of 2004, it underwent a marked recession during the winter but in April 2005 there occurred a strong regeneration of the fragments that had been left on the banks. By October and November it occupied an area of approximately 200 ha, covering 75 km of river […]"

In addition to the areas mentioned above, GISD (2017) lists *Pontederia crassipes* as alien and established in Bahamas, Bangladesh, Benin, Brunei, Burkina Faso, Burundi, Cambodia, Cameroon, Chile, China (Dianchi Lake, Fujian, Guangdong, Wenzhou, Yunnan, and Zhejiang), Christmas Island, Colombia, Republic of the Congo, The Democratic Republic of the Congo (Zaire), Cook Islands (Mangaia and Rarotonga islands), Costa Rica, Cote d'Ivoire, Cuba, Dominican Republic, Ecuador, Equatorial Guinea, Ethiopia, Fiji (Viti Levu Island), French Polynesia (Raiatea, Tahiti, and Ua Pou islands), Gabon, Ghana, Guadeloupe, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, Hong Kong, India, Indonesia (Papua (Irian Jaya)), Jamaica, Japan, Lao People's Democratic Republic, Liberia, Malawi, Malaysia, Maldives, Marshall Islands (Kwajalein and Majuro islands), Martinique, Mauritius, Mexico, Micronesia (Chuuk, Kosrae, Pohnpei, and Yap islands), Mozambique, Myanmar (Burma), Nauru, New Caledonia, Nicaragua, Nigeria, Nile River, Palau (Babeldaob, Koror, and Ngerekebesang islands), Panama, Papua New Guinea, Peru, Philippines, Rwanda, Saint Lucia, Samoa (Upolu Island), Senegal, Sierra Leone, Singapore, Solomon Islands, South Africa, Sudan, Swaziland, Thailand, Togo, Vanuatu, Vietnam, British Virgin Islands (Beef Island), Zambia, and Zimbabwe (Lake Chivero). It is listed as invasive but eradicated in parts of Australia (South Australia and Victoria). It is listed as alien and status uncertain in Occupied Palestinian Territory and the Syrian Arab Republic.

Additionally, the U.S. Forest Service (2015) lists *Pontederia crassipes* as introduced in French Polynesia (Tetiaroa Atoll), Marshall Islands (Arno and Majuro atolls), and Seychelles. Coetzee et al. (2017) lists *P. crassipes* as having invaded South Korea, Central African Republic, Côte d'Ivoire, and Mauritania.

In addition to the countries already listed above, Rojas-Sandoval and Acevedo-Rodriguez (2013) lists *Eichhornia crassipes* as introduced with a restricted distribution in Angola, Bhutan, Czech Republic (not considered invasive), France (not considered invasive), Mali, Niger, and Pakistan; invasive and present in few locations in Israel; present in Antigua and Barbuda, Aruba, Barbados, Belize, Botswana, Canada, Dominica, El Salvador, Jordan, Korea, Lebanon, Morocco, Rodriguez Island, Romania, Saint Vincent and the Grenadines, Trinidad and Tobago, and Turkey; and introduced but not established in Belgium, and Hungary.

According to NOBANIS (2023), *Eichhornia crasspies* was introduced to the Netherlands in 1917, it did not become established in the wild.

Means of Introduction Outside the United States

From Villamagna and Murphy (2009):

"There is not a clear record of how, why and when water hyacinth was introduced to waterbodies outside of its native range, but many populations are well established and persistent despite control efforts. Introductions to non-native waterbodies have been accidental and intentional; intentional introductions to ponds are common as water hyacinth is an ornamental plant that reduces nutrient concentrations and algae blooms."

From GISD (2017):

"In the 1950s and 1960s, water hyacinth was distributed widely into almost all provinces in China for animal food. After artificial transplanting and mass rearing and breeding, water hyacinth was distributed to further areas in the 1970s (Jianqing et al. 2001). Water hyacinth has an attractive purple flower which has made it a favourite amongst ornamental pond and botanical garden enthusiasts. As a result humans have spread it widely and due to its fast growth rate it now flourishes in all continents but Europe. Most spread can be attributed to deliberate planting of water hyacinth in ponds or dams as an ornamental, or use in aquariums. Unwanted plant material is discarded into creeks, rivers and dams is a major mode of dispersal (Burton 2005). […] Seeds are translocated by machinery (Burton 2005)."

Short Description

From U.S. Forest Service (2013):

"A perennial aquatic **herb**; stems short, floating or rooting in mud, rhizomatous or stoloniferous, rooting from the nodes; **roots** long, sometimes dark because of their purple anthocyanin, pendant; **leaves** in a rosette; petioles spongy, in young specimens short and with a one-sided swelling or inflation but up to 30 cm long when older, tapering and narrowing from the bulbous base to the point of attachment with the lamina; **lamina** circular to kidney-shaped, glossy smooth, 4 to 15 cm long and wide, acting as a sail in the wind; **inflorescence** in spikes with about eight flowers, long peduncled, bibracteate, the lower bract with long sheath and small lamina, the upper almost entirely included within the sheath of the lower one, tubular with a small pointed tip (apiculate); flower-bearing part of the rachis up to 15 cm or less long; entire scape may be 30 cm; perianth six-lobed, united below into a narrow tube, lilac, bluish purple or white, the upper lobe bearing a violet blotch with yellow center; stamens six, three long, three shorter, attached to the tube; **capsule** membranous, three-locular, dehiscent, many-seeded, as many as 50 or so per capsule; **seed** ovoid, ribbed, 0.5 to 1 mm. The species is distinguished by the almost one-sided swelling or inflation of the petiole, its long peduncled bibracteate spike, and its upper perianth blotched with yellow at the center" (Holm *et al*. 1977, p. 72)."

"Rooted only at flowering time by long slender roots; otherwise floating, with thick, fleshy, more or less horizontal **roots**; **leaves** clustered, on bulbously inflated petioles, blades rounded or oblong, up to 3-4 inches wide; **flowers** showy, pale violet with a spot of bright yellow on the large upper lobe, some forms with pink and yellow flowers, all parts edible" (Stone 1970, p. 116)."

From GISD (2017):

"As much as 50% of a single water hyacinth's biomass can be roots. Roots are adventitious and fibrous, 10-300cm in length. As many as 70 lateral roots percm give the roots a feathery appearance. They are dark violet to bluish or pinkish violet (though whitish if grown in total darkness) and contain soluble pigments, including anthocyanins that may protect the root from herbivory (Gopal 1987, in Batcher Undated)."

"Flowers are borne terminally on a lavender spike on an elongated peduncle and are subtended by two bracts. The lower bract has a distinct blade. Each spike has 4-25 flowers (maximum 35) with 8-15 being the most common. The perianth tube is 1.5-1.75cm long with a green base and pale top. Tepals are ovate to oblong, thin, lilac and up to 4cm long. The posterior tepal (labellum) has a central bright yellow diamond-shaped region surrounded by a deep blue border with bright red radiating lines. When young, this labellum has a green spot. There are six stamens (sometimes 5 or 7) having curved filaments with glandular hairs. Three are small and close to the perianth tube. Anthers are violet and measure 1.4-2.2mm long (Gopal 1987, in Batcher Undated)."

"The fruit is a thin-walled capsule enclosed in a relatively thick-walled hypanthium developed from the perianth tube. Mature seeds can number 450 per capsule, are 4 x 1mm, with an oval base and tapering apex. The coat has 12-15 longitudinal ridges (Gopal 1987, in Batcher Undated)."

Biology

From Indian River Lagoon Species Inventory (2023):

"Water hyacinth mats are capable of attaining incredibly high plant density and biomass. A single hectare of dense *E. crassipes* mat can contain more than 360 metric tons of plant biomass."

"Water hyacinth is capable of sexual and asexual reproduction and both modes are important to the species' success as a pernicious aquatic invader. In mild climates, plants can flower year-round, and from early spring to late fall elsewhere. They can produce an abundance of seeds (Flora of North America 2003, Langeland and Burks 1998). A study by Barrett (1980b) confirmed that tropical *E. crassipes* populations produced twice as many seeds as did temperate populations and attributed the difference to higher rates of pollinating insect visitation in the tropics. Seed germination tends to occur when water levels are down and the seedlings can grow in saturated soils."

"Vegetative reproduction occurs via the breaking off of rosettes of clonal individuals. The stolons (horizontal shoots capable of forming new shoots and adventitious roots from nodes) are easily broken by wind or wave action and floating clonal plants and mats are readily transported via wind or water movement (Barrett 1980a, Langeland and Burks 1998)."

From GISD (2017):

“Maximum fruiting occurs in 90% humidity and at 22.5°C to 35°C (Gopal 1987, in Batcher Undated). Several species of bee pollinate the flowers and several researchers report a highlvel [sic] of self-compatibility (Batcher Undated). High light intensity and altering high and low temperatures (5°C to 40°C) favour germination (Batcher Undated).”

From Pfingsten et al. (2024):

“In the absence of sustained freeze, the plant grows as a perennial. In its northern range, the plant grows as an annual, where it is either re-introduced or germinates from seed. Long-term exposures (2-4 weeks) to temperatures at or near freezing are required to significantly reduce *E. crassipes* populations (Owens and Madsen 1995; Russell 1942).”

Human Uses

From Villamagna and Murphy (2009):

“[…] water hyacinth is an ornamental plant that reduces nutrient concentrations and algae blooms.”

“In California (U.S.A.), water hyacinth leaf tissue was found to have the same mercury concentration as the sediment beneath, suggesting that plant harvesting could help mediate mercury contamination if disposed of properly (Greenfield et al., 2007). On a similar note, water hyacinth’s capacity to absorb nutrients makes it a potential biological alternative to secondary and tertiary treatment for wastewater (Ho & Wong, 1994; Cossu et al., 2001).”

From GISD (2017):

“There has been some use of *E. crassipes* for the removal of nutrients and heavy metals from sewage and sludge ponds (bioremediation) (Vietmeyer 1975, in Batcher Undated). In Kenya the experimental use of water hyacinth as an organic fertiliser and animal feed has been undertaken in places such as flower farms (The Nation Nairobi 2004). However there is some controversy as to the effect of the fertiliser on the soil due to its highly alkaline PH value (>9).”

“In China the weed was widely used as animal food from the 1950s to the 1970s. As at that time, the economy in rural areas was very depressed and there was great shortage of food for animals. It was also used for fertiliser in a few areas. Since the end of 1980s the use of water hyacinth has fallen greatly and its sole use now is for feeding ducks and as a test plant for the purification of polluted water (Jianqing et al. 2001).”

From U.S. Forest Service (2015):

“Can be used for pig feed [in Australia], but this may aid in its spread.”

From Rojas-Sandoval and Acevedo-Rodriguez (2013):

"It can be used as a mulch, for making compost, fuel bricks, paper or board, for generating methane biogas, and for removing nutrients and toxic chemicals from water. Recent work on composting includes Montoya et al. (2013) who found that a large-scale composting system using water hyacinth as a primary feedstock reached high enough temperatures to inactivate seeds and other propagules, and thus that the plant can be composted without the potential danger of spread."

"Work on utilization includes use as an organic manure in Bangladesh (Nasima et al., 1997); as a compost to suppress nematodes in India (Verma et al., 1997); for water purification (Ayade, 1998); for biogas production (Rodriguez et al., 1997; Sarkar and Banergee, 2013)); [sic] for feeding buffaloes in India (Mitra et al., 1997); and as a mulch to suppress weeds in Indonesia (Lamid and Wahab, 1996). Masto et al. (2013) explored the conversion of *E. crassipes* to biochar for improvement of soil quality. There are many recent studies on utilizing *E. crassipes* for bioenergy. Hussain et al. (2013) converted *E. crassipes* biomass into liquid hydrocarbon fuel using catalytic pyrolysis. Bergier et al. (2012) suggest that biomass from water hyacinth in the Panatanal of South America could be managed for production of biofuels. Sudhakar et al. (2013) assess bioelectricity production using water hyacinth biomass. Anaerobic co-digestion with poultry litter for biogas production is considered by Patil et al. (2013), while Zhang et al. (2013) report on hydrothermal liquefaction. Biogas production from water hyacinth polluting water bodies in Nigeria is studied by Adeleye et al. (2013)."

From Jacono et al (2018):

"*Eichhornia crassipes* is sold at aquarium stores and is sold in the Great Lakes. This species is a popular aquarium plant and is available for purchase in the Great Lakes region. […] In a survey of aquarium stores near Lakes Erie and Ontario, *E. crassipes* was available for purchase in 30% of the stores (Rixon et al. 2005)."

Diseases

Rojas-Sandoval and Acevedo-Rodriguez (2013) list *Acremonium zonatum, Alternaria alternata, Alternaria eichhorniae, Cercospera rodmanii, Cercospora piaropi, Cercospora rodmanii, Cochliobolus lunatus, Cochliobolus sativus, Cochliobolus spicifer, Fusarium chlamydosporum, Gibberella intricans, Gibberella zeae, Haematonectria haematococca, Myrothrcium roridum, Penicillium oxalicum, Phoma sorghina, Thanatephorus cucumeris,* and *Uredo eichhorniae* as pathogens of *Eichhornia crassipes*.

Poelen et al. (2014) list *Paracles affinis, Erastroides curvifascia, Argyractis subornata, Donacoscaptes infusellus, Samea multiplicalis, Leptosphaeria eichhorniae, Rhinotrichum depauperatum, Rhizoctonia solani, Paracles fusca,* waterlettuce moth (*Spodoptera pectinicornis*), *Sameodes albiguttalis, Xubida infusellus, Trigona fulviventris, Bellura densa, Spodoptera litura*, *Pericallia ricini, Kalopolynema* sp., *Anagrus* sp., *and Aprostocetus* sp. as additional parasites of *Eichhornia crassipes.*

Threat to Humans

From Rojas-Sandoval and Acevedo-Rodriguez (2013):

"The same authors refer to the recent increase in water hyacinth infestations in West Africa which are resulting in serious disruption of the socio-economic structure, food supply and health of several million people."

"*E. crassipes* may reduce water quality in various ways and encourage mosquitoes, snails and other organisms associated with human illnesses, including malaria, schistosomiasis, encephalitis, filariasis and cholera (Gopal, 1987). Harley et al. (1996) comment that people in Papua New Guinea have died through a combination of reduced nutrition, degraded water, increased disease vectors and generally reduced health, directly related to the degrading effect of water hyacinth on the environment. Dense mats greatly hinder boating by fishermen and may prevent fishing altogether, thus denying the locals their main source of protein and sometimes forcing people to relocate. In extreme cases of competition between *E. crassipes* and rice crops, fields have been abandoned. In the Lake Victoria Basin, the main negative social impact were identified by interviewees as an increase in certain diseases, difficulties associated with clean water availability and migration of communities (Mailu, 2001)."

3 Impacts of Introductions

From Coetzee et al. (2009):

"*Eichhornia crassipes* is recognized as the world's worst aquatic weed, because of the significant ecological impacts it has on the environment, and the associated cascading socioeconomic effects. Dense impenetrable mats restrict access to water, negatively impacting fisheries and related commercial activities, the effectiveness of irrigation canals, navigation and transport, hydroelectric programs, and tourism (Navarro and Phiri 2000). Other problems include property damage during floods as a result of *E. crassipes* building up against bridges, fences, walls, obstructing water flow, and increasing flood levels. Arguably, the most affected are poverty-stricken communities in rural Africa, where the extent of these effects are yet to be fully measured. *Eichhornia crassipes* alters the livelihoods of any community with high dependence on freshwater waterways for food (subsistence or commercial), transport, and clean water. Ecologically, benthic and littoral diversity is reduced (Masifwa et al. 2001; Toft et al. 2003; Midgley et al. 2006). For example, Midgley et al. (2006) found that the benthic invertebrate community beneath *E. crassipes* mats was significantly less diverse than the community in open water on New Years Dam, South Africa, and similarly Masifwa et al. (2001) found a decrease in littoral macroinvertebrate diversity beneath dense *E. crassipes* mats on Lake Victoria in Uganda. Increases in the populations of vectors of human and animal diseases, such as *Eichhornia crassipes* 187 bilharzia, malaria, and cholera, are also associated with *E. crassipes* infestation because these plants interfere with pesticide application (Harley et al. 1996). Because of its rapid growth rate whereby it can double in number in suitable habitat every 11 to 18 days (Edwards and Musil 1975), *E. crassipes* is able to outcompete native aquatic plants by utilizing the available nutrients in the water, and by successfully competing for space and sunlight (Cilliers 1991)."

From GISD (2017):

“Ethnobotanic investigations estimate the losses for fishing, arboriculture and vegetable gardening at more than 20 million francs CFA per annum, that is approximately $US 35,000 to 40,000. Currently the water hyacinth invasion threatens the three largest sources of water in Burkina Faso, the Kompienga (20,000 ha) located in the basin of Niger, the Bagré (25,000 ha) and the Bougouriba which belongs to the basin of Volta (Lompo-Ouedraogo, Z., pers.comm., 2005).”

“Boat traffic on several rivers [in Florida] was halted; hundreds of lakes and ponds were covered from shore to shore with up to 200 tons of water hyacinths per acre.”

“The total infested area is estimated to be 487 km2 covering most of the drainage and irrigation canals in different governorates of Egypt, and about 151 km2 covering lakes (Fayad et al. 2001). The water hyacinth problem is particularly severe in the Nile Delta and the irrigation systems (Shabana et al. 2001).”

From U.S. Forest Service (2015):

“"High growth rates mean populations can quickly form thick mats on the water surface. This makes passage by boats difficult, chokes irrigation channels, pollutes water and provides breeding grounds for disease-carrying insects. The natural beauty of areas is also degraded as native plants, birds and fish are displaced." (Smith, 2002; p. 82).”

From Villamagna and Murphy (2009):

“The most commonly documented effects are lower phytoplankton productivity and dissolved oxygen concentrations beneath these mats (Rommens et al., 2003; Mangas-Ramirez & Elias-Gutierrez, 2004; Perna & Burrows, 2005). Other water quality effects include higher sedimentation rates within the plant’s complex root structure and higher evapotranspiration rates from water hyacinth leaves when compared to evaporation rates from open water (Gopal, 1987). Water hyacinth also has been found to stabilise pH levels and temperature within lotic systems, increasing mixing within the water column and potentially preventing stratification (Giraldo & Garzon, 2002). Water hyacinth mats decrease dissolved oxygen concentrations beneath mats by preventing the transfer of oxygen from the air to the water’s surface (Hunt & Christiansen, 2000) and by blocking light used for photosynthesis by phytoplankton and submersed vegetation.”

“Water hyacinth was found to selectively inhibit planktonic green algae in a shallow Portuguese lake (Almeida et al., 2006), yet phytoplankton density in littoral sites with water hyacinth in Lake Chivero (Uganda) was 10–30 times higher than littoral sites without water hyacinth (Brendonck et al., 2003). Water hyacinth can trap phytoplankton and detritus, thereby increasing, at least temporarily, phytoplankton densities beneath mats (Brendonck et al., 2003).”

“The effects of water hyacinth on zooplankton reported in the literature are inconsistent (Table 2 [in source material]), suggesting that factors such as algal concentrations and physiochemical conditions at the time of sampling, the time of day at which zooplankton was sampled, the presence of predators, the effects of water hyacinth on potential predators and the spatial configuration of water hyacinth may be influencing zooplankton response."

"Researchers in Florida took an experimental approach to determine the effects of water hyacinth mats on the macroinvertebrate and fish communities associated with native submersed vegetation *Sagittaria kurziana* Glück. Epiphytic macroinvertebrate abundance within the submersed vegetation initially decreased with the addition of a water hyacinth canopy, but total macroinvertebrate abundance did not differ. Total macroinvertebrate abundance within sites with water hyacinth and *S. kurziana* was significantly greater than sites without water hyacinth during the autumn and winter, starting approximately 80 days after the introduction of water hyacinth. Taxa richness was consistently greater at sites with water hyacinth and *S. kurziana* and community composition differed between the plants as well (Bartodziej & Leslie, 1998). Together these studies support the conclusion that water hyacinth can enhance macroinvertebrate abundance and richness through the provision of additional, and in some cases novel, habitat."

"Brendonck et al. (2003) found that fish diversity in Lake Chivero (Zimbabwe) was higher at littoral sites with water hyacinth than without, although confidence in this result was dampened by variability associated with sampling techniques. On the St Marks River in Florida (U.S.A.), total fish abundance and biomass were similar within submersed vegetation in areas with and without a water hyacinth canopy, but species richness was significantly higher in areas with the water hyacinth canopy. Community composition differed between sites with and without water hyacinth; notable differences included the presence of two insectivorous fish species only found at sites with water hyacinth (Bartodziej & Leslie, 1998). After mechanical control of water hyacinth in a Mexican reservoir three common species (*Cyprinus carpio* L., *Poecilia sphenops* Valenciennes, and *Heterandria jonesii* Günther) disappeared."

From Pfingsten et al. (2024):

"Since its introduction, *E. crassipes* has notoriously interfered with navigation, triggering the 55th Congress, through the Rivers and Harbors Act of 1899, to authorize the U.S. Army Corps of Engineers to address the problem (Schardt 1997) after commercial commerce was impeded by *E. crassipes* on the St. Johns River (Webber 1897). In one instance, 65 feet of a railroad trussel across Rice Creek near Palatka, FL was destroyed in 1894 by build-up of waterhyacinth."

From Rojas-Sandoval and Acevedo-Rodriguez (2013):

"Annual costs of control or removal have, in the past, amounted to millions of dollars on the Panama Canal, on the Nile in Sudan, on the Congo and have been as much as $35 million in southern USA. Costs of controlling water hyacinth in Malaysia have been estimated at M$ 10 million per year ([Mohamed] et al., 1992), while Harley et al. (1996) quoting this figure, state that present actual costs are believed to be much higher. In recent years, the operation of Port Bell, Uganda, on Lake Victoria has been seriously threatened and costs have involved $1 million for a mechanical harvester, as well as the loss of trade at times when the port was completely blocked (Hill, 1999). Infestations are also increasing in Ethiopia, creating a range of problems including restricted access (Aweke, 1994). Harley et al. (1996) refer to 'devastating effects' on socio-economic structure and on the environment in the lower flood plain of the Sepik river in

Papua New Guinea resulting from problems of access to subsistence gardens, hunting and fishing areas, and markets. The same authors refer to the recent increase in water hyacinth infestations in West Africa which are resulting in serious disruption of the socio-economic structure, food supply and health of several million people. In Nigeria, Alimi and Akinyemiju (1991) showed that costs of fuel and repairs to boats on infested waterways was approximately three times that on uninfested waterways. The problem has also been increasing recently in Mali (Dembele et al., 2000). Economic losses also result from interference with recreational uses of water bodies (for example, Gopal, 1987; Aweke, 1994; Cilliers et al., 1996)."

"Interference with fishing. This effect is most acute for small-scale fishing communities. Apart from the problems of access to fishing grounds and interference with the spreading or retrieval of nets or with landing their catch, there can be serious effects on fish stocks and fish breeding. Although a sparse cover of water hyacinth may not reduce fish and may even be used to advantage in some fishing techniques (Gopal, 1987), a dense infestation can lead to de-oxygenation and kill-off fish or reduce fish stocks. Gopal (1987) refers to heavy losses of fish production in the Congo, Nile and other rivers and in Pakistan and to losses amounting to 45 million kg in West Bengal, India in the 1950s and reductions of 70% in fish production in the USA as a result of a cover of only 25%, presumably due to reduction of phosphorus levels and phytoplankton. The shallow water of lake edges can be especially important spawning areas for fish and a dense cover of water hyacinth can interfere severely with fish breeding. Hill (1999) refers to this phenomenon on Lake Victoria where the estimated 10,000 ha of the weed includes an almost continuous fringe along the shoreline extending to at least 10 m. Labrada (1996) quotes fuel costs increased by a factor of 2-3 and fish catches down 50-75% on parts of Lake Victoria. Fishermen affected by another relatively new infestation, in the Shire river in Malawi, report reduced catches which are not confirmed by the locally available statistics but there is no doubt fishermen are being troubled by a reduced range of fish species, loss of nets and impeded access (Terry, 1996)."

"Risks of mechanical damage to hydro-electric installations and other structures such as bridges. Expensive barriers or mechanical harvesters may be needed to minimize these risks, for example, to the Owen Falls Dam on Lake Victoria (Hill, 1999). Elsewhere, there are similar concerns in South Africa (Harley et al., 1996), Brazil (Pitelli, 2000), New Zealand (Clayton, 2000) and Ethiopia (Aweke, 1994)."

"Reduced irrigation flow can indirectly cause crop loss but there can also be direct interference and competition from water hyacinth where it occurs in flooded rice. Such losses have been estimated at many million dollars in West Bengal, India and as significant in many other countries including Sri Lanka, Bangladesh, Burma, Malaysia, Indonesia, Thailand, Philippines, Japan and Portugal (Gopal, 1987)."

"Restricting water flow in rivers, irrigation and drainage channels, thus reducing irrigation water and/or leading to greater risk of flooding. Gopal (1987) refers to water flow being reduced by 40-95% in irrigation channels, sometimes leading to flooding in Malaysia and Guyana."

4 History of Invasiveness

Pontederia crassipes is a widespread invasive plant with a long history of introduction through its use as an ornamental plant. Peer-reviewed studies demonstrated that *P. crassipes* has severe negative ecological as well as socioeconomic impacts. *P. crassipes* has been introduced and found to be established outside of its native range. *P. crassipes* is found nearly globally, with the exception of establishment in polar climates. Due to the clearly documented impacts of introduction of *P. crassipes*, as well as its broad invasive range, the history of invasiveness of *Pontederia crassipes* is classified as High.

5 Global Distribution

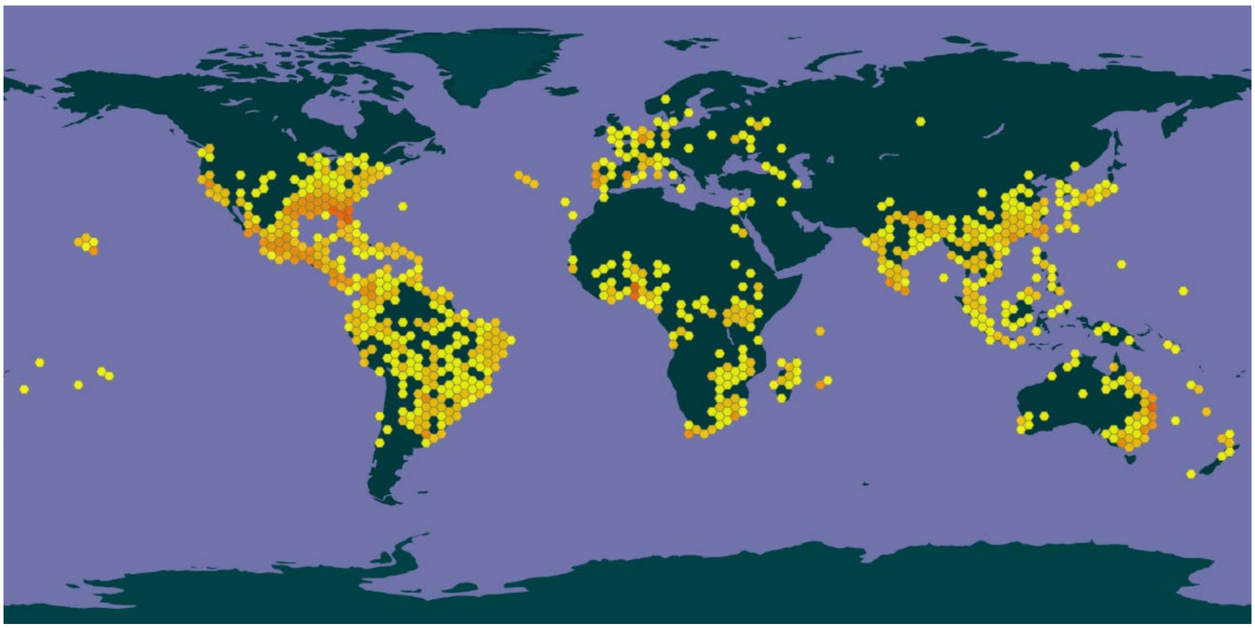

Figure 1. Reported global distribution of *Pontederia crassipes*. Map from GBIF Secretariat (2022). Observations are reported from North America, South America, Africa, Europe, Asia, Oceania and various surrounding islands. Observations reported from moist continental mid-latitude and polar climates do not represent currently established populations of *Pontederia crassipes* and therefore they were not used to select source points for the climate matching analysis. Observations in areas where *Pontederia crassipes* is not known to be established such as Iran and Georgia were not used to select source points for the climate matching analysis.

6 Distribution Within the United States

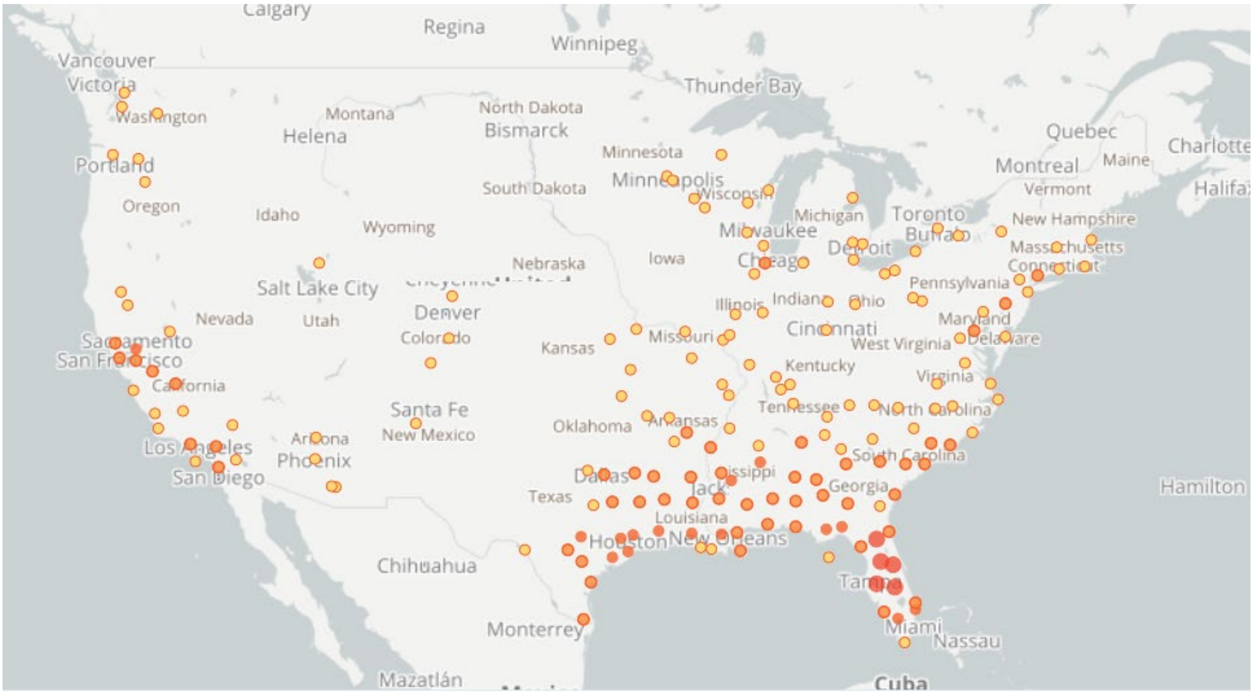

Figure 2. Reported distribution of *Pontederia crassipes* in the contiguous United States. Map from GBIF-US (2024). Observations are reported throughout the United States, with the exception of the northern Great Plains and northern Rocky Mountains. Observations outside the described established range in the southeast and southwest portions of the contiguous United States do not represent currently established populations of *Pontederia crassipes* and therefore they were not used for the climate matching analysis.

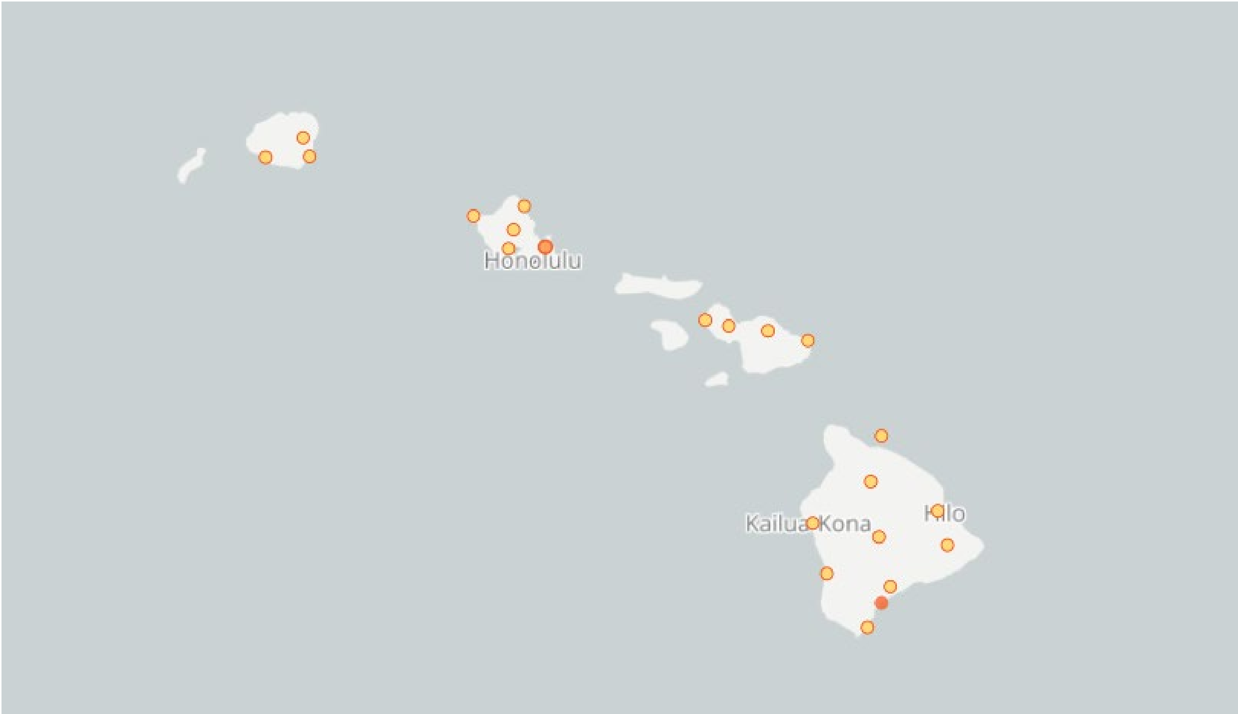

Figure 3. Reported distribution of *Pontederia crassipes* in Hawaii. Map from GBIF-US (2024).

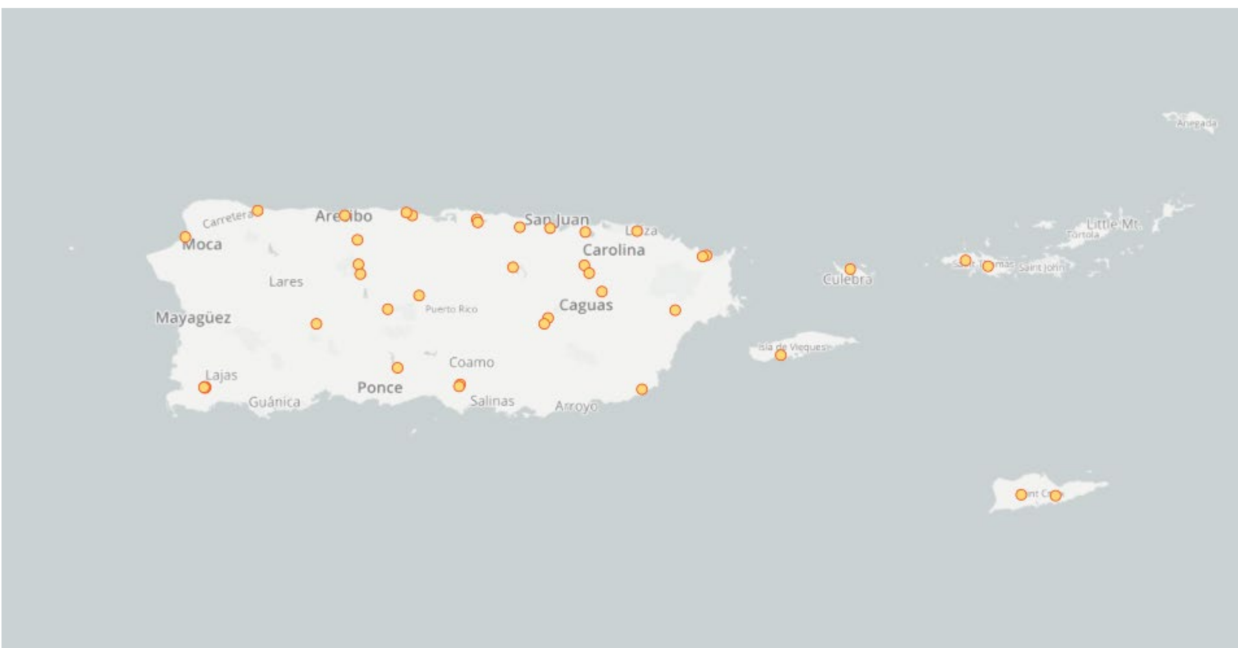

Figure 4. Reported distribution of *Pontederia crassipes* in Puerto Rico and the U.S. Virgin Islands. Map from GBIF-US (2024).

Figure 5. Reported distribution of *Pontederia crassipes* in Guam. Map from GBIF-US (2024).

Figure 6. Reported distribution of *Pontederia crassipes* in American Samoa. Map from GBIF-US (2024).

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Pontederia crassipes* was generally high for the contiguous United States. Areas of high match were found in the Southwest, Southeast, and Mid Atlantic regions. Northern New England, the northern Great Lakes, and Colorado Plateau had areas of medium match. Small patches of low match were found in the Pacific Northwest. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.971, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Pontederia crassipes* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

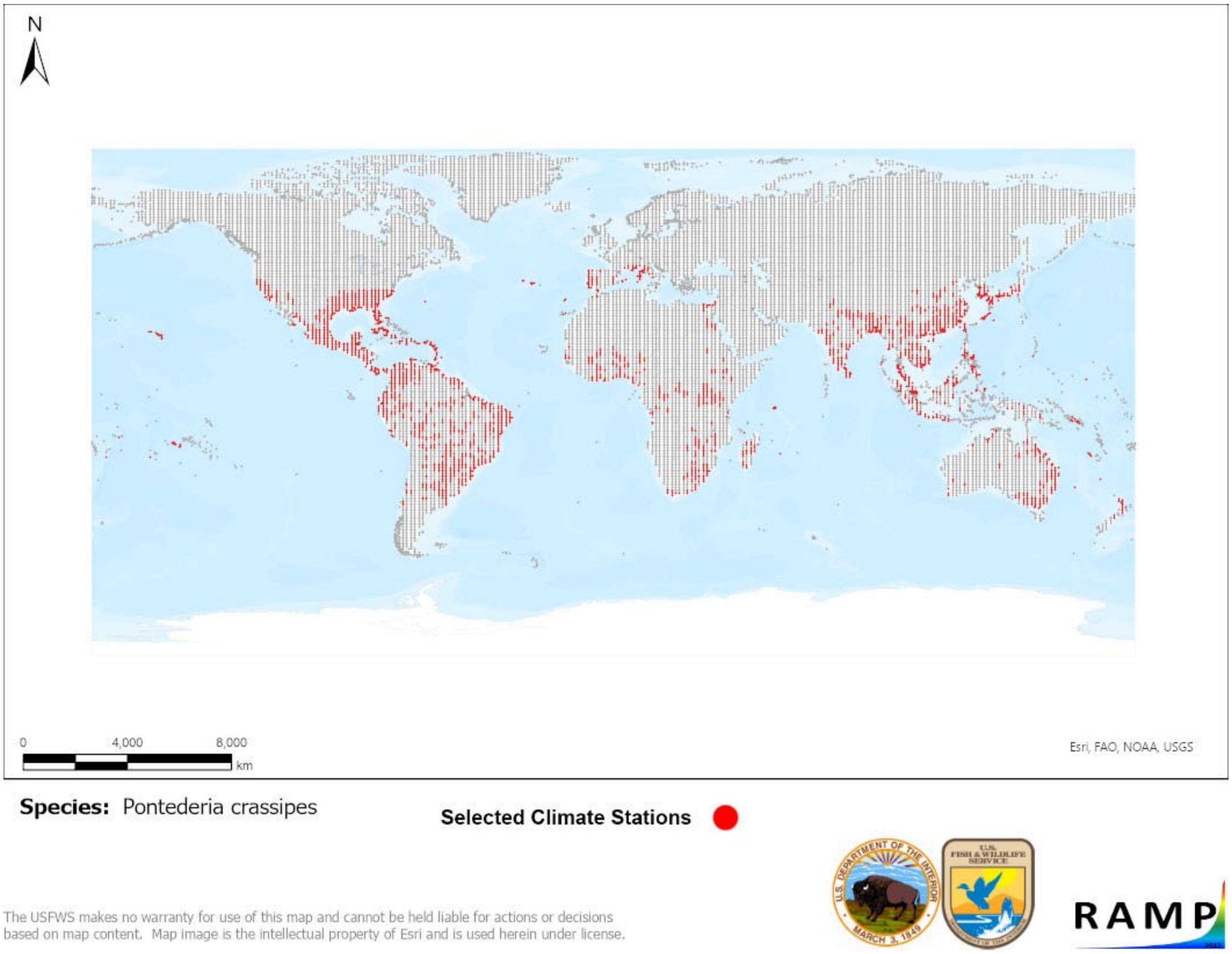

Figure 7. RAMP (Sanders et al. 2023) source map showing weather stations throughout the globe as source locations (red; North America, South America, Africa, Europe, Asia, Oceania and various surrounding islands) and non-source locations (gray) for *Pontederia crassipes* climate matching. Source locations from GBIF Secretariat (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

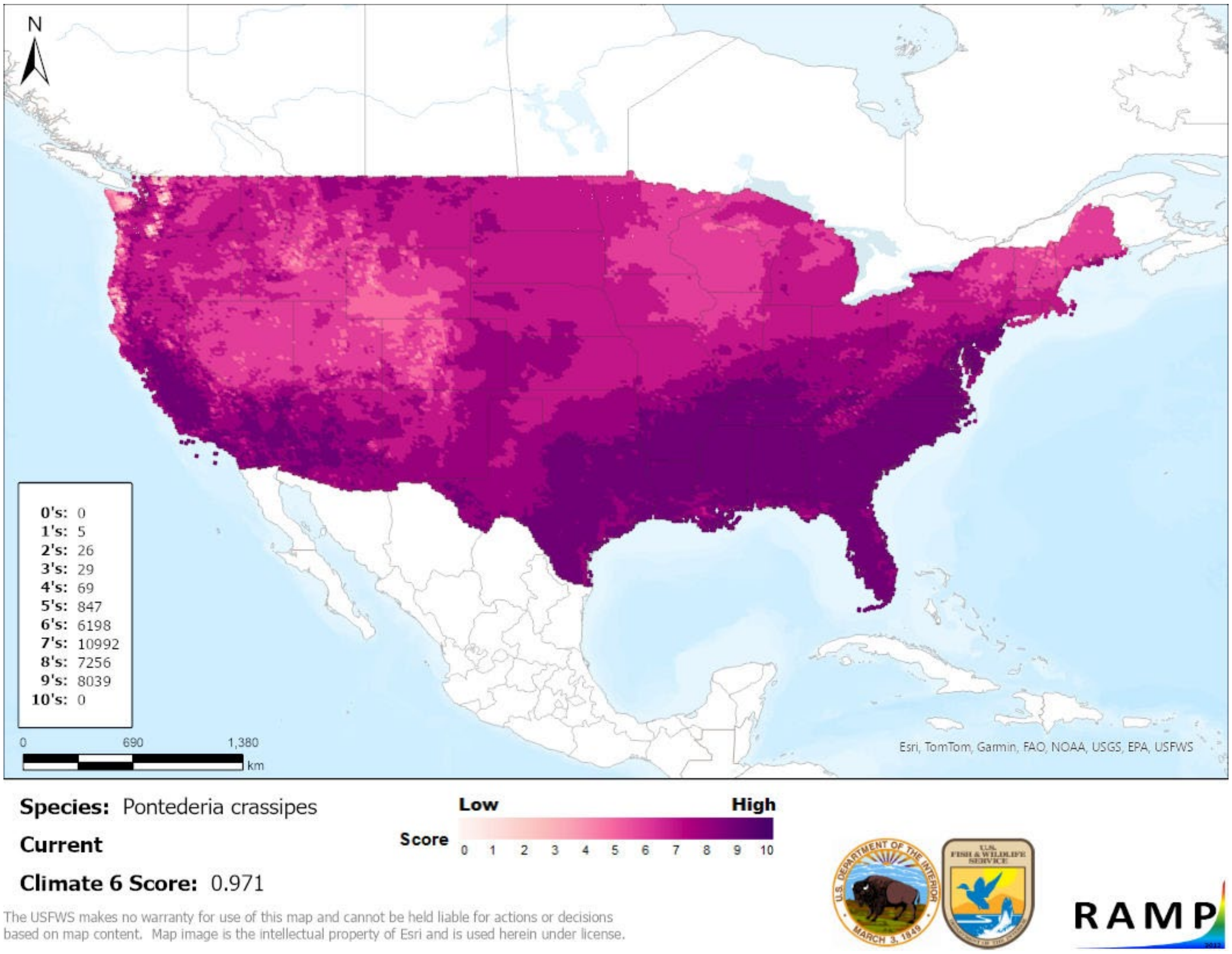

Figure 8. Map of RAMP (Sanders et al. 2023) climate matches for *Pontederia crassipes* in the contiguous United States based on source locations reported by GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

Certainty of assessment for *Pontederia crassipes* is High. High quality information on the biology, invasion history, and impacts of this species were available. Records of introduction were found outside of *P. crassipes* native range. Evidence was found of *P. crassipes* causing negative ecological and socioeconomic impacts in the areas where it was introduced. This species is one of the most well studied invasive species, with a plethora of information regarding documented harmful impacts.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Pontederia crassipes, water hyacinth, is an aquatic plant that is native to tropical South America. This species has likely spread worldwide either incidentally or purposefully as an ornamental plant. Substantial peer reviewed literature is available documenting adverse impacts caused by this species. *P. crassipes* has been found to directly impact both the ecology as well as the socioeconomic aspects of the regions it is found to be established. For those reasons the history of invasiveness is High. The climate matching analysis for the contiguous United States indicates establishment concern for this species. Areas of highest match were found in the Southwest, Southeast, and Mid-Atlantic regions. The Certainty of Assessment is High because of the abundant reliable information available for *P. crassipes*. The Overall Risk Assessment Category for *Pontederia crassipes* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): High**
- **Remarks, Important additional information:** *Pontederia crassipes* already has a wide distribution within the United States. Human deaths in Papua New Guinea have been attributed to the negative impacts of *P. crassipes* introductions.
- **Overall Risk Assessment Category: High**

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2022).

Under the future climate scenarios (figure A1), on average, high climate match for *Pontederia crassipes* was projected to occur in the Appalachian Range, California, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Southeast, Southern Atlantic Coast, Southern Florida, Southern Plains, and Southwest regions of the contiguous United States. A few small areas of low match were projected in the Pacific Northwest in all scenarios. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.937 (model: MPI-ESM1-2-HR, SSP5, 2085) to a high of 0.992 (model: IPSL-CM6A-LR, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.971, figure 8) falls within the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085. Under one or more time step and climate scenarios, areas within the Colorado Plateau, Great Lakes, and Northeast saw a moderate increase in the climate match relative to current conditions. No large increases were observed regardless of time step and climate scenarios. Under one or more time step and climate scenarios, areas within the Appalachian Range, California, Gulf Coast, Mid-Atlantic, Northern Plains, Southeast, Southern Atlantic Coast, Southern Florida, Southern Plains, Southwest, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. No large decreases were observed regardless of time step and climate scenarios. The magnitude and extent of both positive and negative change increased with time and from SSP3 to SSP5. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

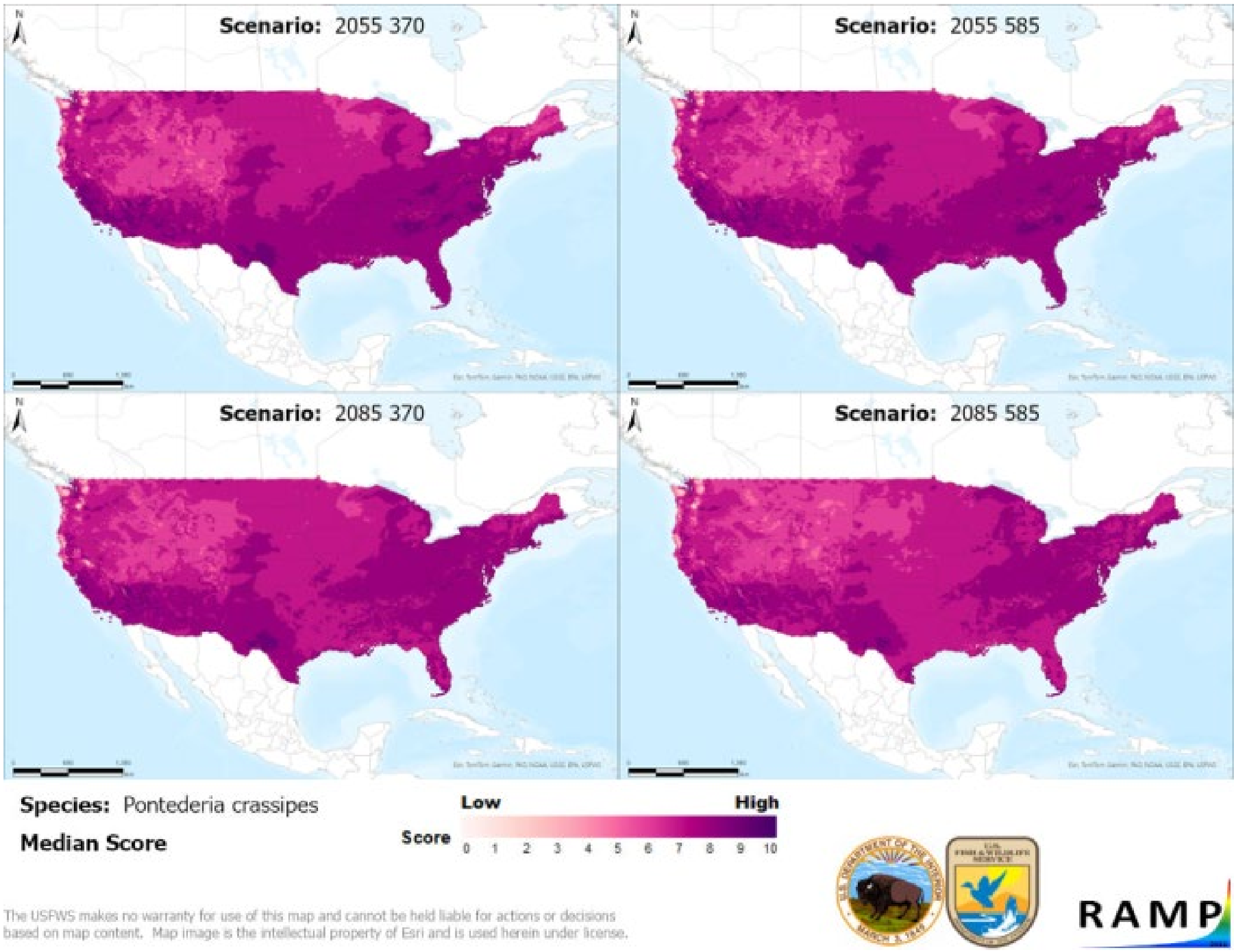

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Pontederia crassipes* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

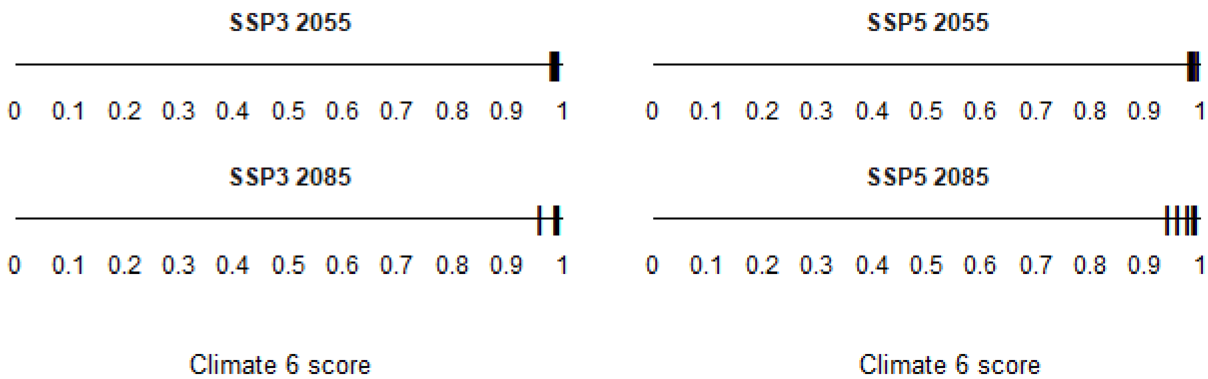

Figure A2. Comparison of projected future Climate 6 scores for *Pontederia crassipes* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

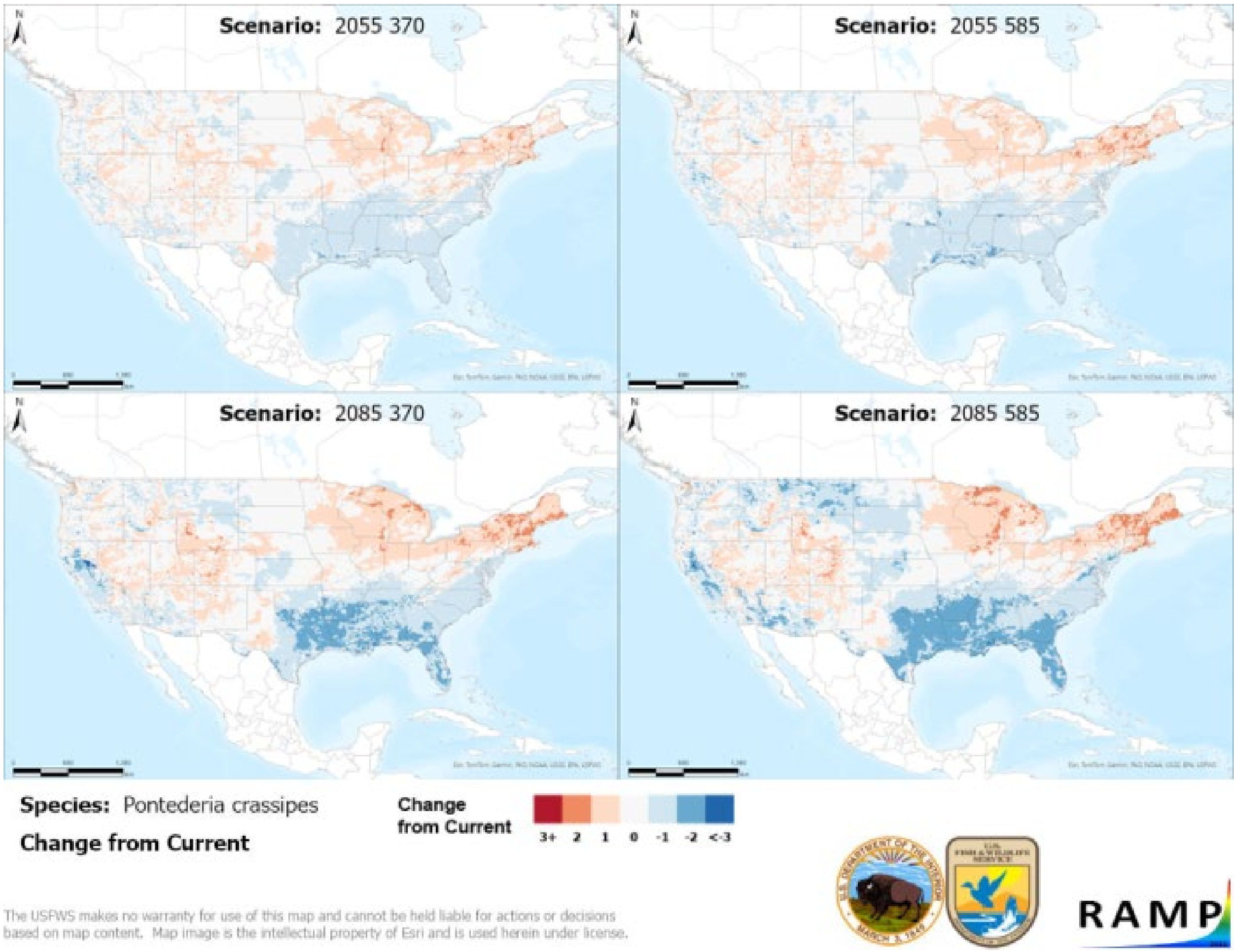

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 8) and the median target point score for future climate scenarios (figure A1) for *Pontederia crassipes* based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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