Water Spinach (*Ipomoea aquatica*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, January 2023
Revised, June 2023, January 2025
Web Version, 3/14/2025

Organism Type: Flowering Plant
Overall Risk Assessment Category: High

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1 Native Range and Status in the United States

Native Range

From Howard (2024):

"Native Range: Central and south China, India, Sri, Lanka, and Thailand."

Status in the United States

From USDA APHIS (2020):

"Ipomoea aquatica is naturalized in Florida, Guam, Hawaii, and Puerto Rico (Anderson, 2019 [Florida Department of Agriculture and Consumer Services, personal communication]; IRC, 2016; Snyder et al., 1981; Sosa, 2019 [Supervisory PPQ Officer, Puerto Rico, personal communication]; Stone, 1970; Young, 2019 [USDA-PPQ Pest Survey Specialist, personal communication]). There are additional references reporting it from other areas of the United States (BONAP, 2019; USDA NRCS, 2019), however, many of these citations refer to cultivated plants or transient populations. South Carolina confirms that *I. aquatica* was detected in the state. Action was taken and there are no known escaped or naturalized populations in the state (Lightfoot, 2019 [South Carolina State Plant Health Director, personal communication]). […] *Ipomoea aquatica* is also present on Midway Atoll, where it was introduced for cultivation (Starr et al., 2008)."

According to Howard (2024), nonindigenous occurrences of *Ipomoea aquatica* have been reported in the following U.S. states, with range of observation years, number of watersheds, and population status where reported (one or more watersheds) in parentheses:

- California (2001-2003; 1; collected)
- Florida (1986-2016; 13; established)
- Hawaii (1927-2005; 3; unknown)
- Puerto Rico (1937; 1; extirpated)
- Texas (2012; 1; unknown)
- Washington (2002; 1; established)

Dueñas-López (2023) lists *Ipomoea aquatica* as introduced to the U.S. Virgin Islands, Northern Mariana Islands, and U.S. Minor Outlying Islands.

From Dueñas-López (2023):

"In the USA, this species is cultivated in California, Texas and the US Virgin Islands (Van and Madeira, 1998; Harwood and Sytsma, 2003)."

"After 20 to 30 years of commercial production, this species has established outside cultivation areas in only small stands in California and Florida (Chilton, 2017)."

"Since the late 1970s, the Florida Department of Natural Resources has eradicated over 20 small infestations of I. aquatica that escaped from illegal plantings (Westbrooks, 1989)."

This species is available for sale online in the United States as it is commonly sold for food (e.g., Amazon.com 2023).

Regulations

Ipomoea aquatica is listed as a Federal Noxious Weed (USDA 2016). Some states adopt the federal noxious weed list as their own regulations. In addition, either *Ipomoea aquatica* or genus

Ipomoea is explicitly named in regulation text in Arkansas (Arkansas Department of Agriculture 2022), California (CDFA 2021), Florida (FDACS 2010), Illinois (Illinois DNR 2015), Indiana (Indiana DNR 2022), Louisiana (LDAF 2022), Massachusetts (MDAR 2022), North Carolina (North Carolina DEQ 2022), New Hampshire (NHDES 2022), Oklahoma (ODWC 2022), South Carolina (SCDNR 2010), Texas (TPDW 2022), Virginia (VDACS 2022), Wisconsin (Wisconsin DNR 2022), and West Virginia (WVDA 2022). 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 Howard (2024):

"Infestations may be intentional or accidental, resulting from seed or vegetative fragments escaping cultivation or contaminated agricultural crops like rice, jute, cocoa, peanuts (Holm et al. 1997)."

From Dueñas-López (2023):

"The seeds have been intercepted as contaminants of *Ipomoea cairica* seeds, *Citrus* sp. seeds, rice seeds, *Sesamum indicum* seeds, *Cucumis* sp., *Pittosporum* sp. leaves, *Cuminum* sp. seeds and tractor trailer debris (Interceptions Records, USDA, Animal and Plant Health Inspection Service, Riverdale, Maryland, USA)."

Remarks

From Dueñas-López (2023):

"*Ipomoea aquatica* is native to southern Asia (Li, 1970; Van and Madeira, 1998). More recently, Langeland and Burks (1998) indicate China as its native range, but Van (1998) suggests India and China. The origin of this species is currently debatable, and there is doubt as to whether this species is native in Africa and North Australia (Austin, 2007)."

From USDA APHIS (2020):

"*Ipomoea aquatica* is regulated by Guatemala and Honduras (USDA PCIT, 2019)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

Kingdom Plantae
  Subkingdom Viridiplantae
    Infrakingdom Streptophyta
      Superdivision Embryophyta
        Division Tracheophyta
          Subdivision Spermatophytina
            Class Magnoliopsida
              Superorder Asteranae
                Order Solanales
                  Family Convolvulaceae
                    Genus *Ipomoea*
                      Species *Ipomoea aquatica* Forssk

According to WFO (2023), *Ipomoea aquatica* is the current valid name for this species.

Size, Weight, and Age Range

From Howard (2023):

"[…] perennial vine with stems that reach lengths up to 4 meters […] Leaves are variable, but typically are 3-15 cm long, and 1-10 cm wide […] Petioles are long, ranging from 3-20 cm. The showy morning-glory-like flowers are up to 5 cm wide […]"

Environment

From Dueñas-López (2023):

"Marshy lands and waterlogged soils are ideal for growth of *I. aquatica*. Shallow ponds, ditches, peripheries of deep ponds, tanks, and slopes of wet soils are also suitable. It is adapted to a wide range of soil conditions, with clay soils (heavy or silty) being generally suitable. Soils with a high percentage of organic matter are preferred. The optimum pH range for growth is 5.3-8.5 (Tiwari and Chandra, 1985; Westphal, 1992)."

"*I. aquatica* is not tolerant of brackish or salt water (Backer and Van den Brink, 1965)."

"Nitrogen and phosphorus are important growth factors in this species. *I. aquatica* shows a high absorption capacity for ammonium-nitrogen. Potassium and calcium were relatively high, whereas magnesium and sodium were low in the habitats studied (Chin and Fong, 1978)."

Climate

From Dueñas-López (2023):

"It is primarily a plant of the humid tropical lowlands, requires short-day conditions and a warm, wet climate to flourish. Mean temperature has to be above approximately 25°C […]"

"It grows poorly in cold weather but can tolerate light frost that affects only the outer leaves (Snyder et al., 1981). The seeds can withstand some freezing (Gilbert, 1984). Huang (1981) observed that it does not grow at day/night temperatures below 20/15°C."

Distribution Outside the United States

Native

From Howard (2024):

"Native Range: Central and south China, India, Sri, Lanka, and Thailand."

Introduced

From Dueñas-López (2023):

"In Africa, it occurs from Mauritania and Senegal, east to Eritrea and Somalia, and south to South Africa; it is also found on some Indian Ocean islands (PROTA, 2018; WCSP, 2018). It is distributed throughout Australia except in the south west (Atlas of Living Australia, 2018), and in the Pacific Islands, tropical South America, Central America, the Caribbean (Cuba […]"

Dueñas-López (2023) lists *Ipomoea aquatica* as introduced in Africa (Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, the Democratic Republic of the Congo, Côte d'Ivoire, Egypt, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mauritania, Mayotte, Mozambique, Nigeria, Réunion, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Tanzania, Tunisia, Uganda, Zambia, Zimbabwe), Asia (Bangladesh, Bhutan, Brunei, Cambodia, Cocos Islands, Hong Kong, West Bengal (India), Indonesia, Israel, Japan, Laos, Malaysia, North Korea, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka, Taiwan, Thailand, Turkey, Vietnam, Yemen), North America (Belize, Costa Rica, Cuba, Dominican Republic, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago), Oceania (Christmas Island, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Kiribati, Marshall Islands, Nauru, New Caledonia, Norfolk Island, Palau, Samoa, Tonga, Vanuatu, Wallis and Fortuna), and South America (Brazil, Colombia, French Guiana, Guyana, Peru, and Suriname).

Dueñas-López (2023) lists *Ipomoea aquatica* as present without indication of native or introduced status in Canada, Ecuador, Mauritius, Myanmar, Namibia, Nepal, Papua New Guinea, Solomon Islands, and South Africa.

Means of Introduction Outside the United States

From Dueñas-López (2023):

"*Ipomoea aquatica* was introduced in tropical Asian countries from China through trade around the second century BC and introduced in Africa from China in the 14th century (Austin, 2007). The first record of it on a Pacific island was in Samoa in 1956 (Parham,1972); […]"

From USDA APHIS (2020):

"[…] long history as a cultivated vegetable […]"

Short Description

From USDA APHIS (2020):

"*Ipomoea aquatica* is a freshwater, semiaquatic herbaceous plant that floats on the water surface. Adventitious roots hang freely from stem nodes, which provide the primary means of dispersal when these nodes break free from the main plant."

"The leaves are alternate and are either heart- or arrowhead-shaped (Snyder et al., 1981)."

"The seed capsule has four valves containing one to four, frequently hairy, seeds (Langeland and Burks, 1998; Patnaik, 1976)."

From Dueñas-López (2023):

"*I. aquatica* is a sprawling vine, annual or perennial, creeping on mud or floating on water; stems terete, branched, hollow and succulent when floating, otherwise solid and firm, up to 3 m long, to 1 cm in diameter. Leaves emersed, glabrous, alternate; petioles succulent when grown in water, 3-20 cm long; blades greenish-brown, triangular, ovate, lanceolate, or linear, entire to dentate, 3-15 cm long, 1-12 cm across, bases truncate, cordate, hastate, or sagittate, lobes rounded to acute, entire to dentate. Inflorescences axillary cymes, with one to a few flowers; peduncles 0.5-18 cm long. Flowers perfect, hypogenous, large and showy; pedicels 1-6.5 cm long, with minute bracts at base; sepals glabrous, unawned, ovate, the inner slightly longer than outer, 7-10 mm long; corolla funnel shaped, glabrous, pink, often with darker eye, sometimes white or cream, 2.5-5.5 cm long, 2-4 cm wide; stamens included, shorter than corolla, adnate with petals above the base, filaments hairy at the base, anthers dehiscing longitudinally; carpels glabrous, locules mostly 2, style included, shorter than corolla, ovules mostly 4."

Biology

From Howard (2023):

"Reproduction via seed and vegetative fragments (Holm et al. 1997, Wagner et al 2005)."

From Dueñas-López (2023):

“Reproduction is also by seed, mostly during the dry season, when it grows on temporary flooded land. Fresh, mature seeds display primary dormancy within 15 days after harvest. Natural germination occurs following an after-ripening period and scarification of the seed coat. Dormancy can be broken by various methods of scarification, such as naturally occurring abrasion by soil particles, prolonged microbial attack, or ingestion by animals (Datta and Biswas, 1970). Germination rates of *I. aquatica* seeds are usually less than 60%, with black-seeded types showing higher germination rates than light-coloured seeds. Two to three weeks after sowing, the plants start developing strong lateral branches. After this, the main axis and both lateral branches produce about one leaf every 2-3 days. Flowering starts 48-63 days after sowing (Westphal, 1992).”

“Although flowering and fruiting in India occur during the rainy season, generally flowering is observed throughout the year (Flora of Pakistan, 2018; India Biodiversity Portal, 2018). Under good conditions, *I. aquatica* can produce 190,000 kg fresh weight biomass per ha in 9 months. It flowers in the warm months and produces 175-245 seeds per plant during the peak season (Langeland and Burks, 1998).”

“*Ipomoea aquatica* can behave as an aquatic, semi-aquatic or as a terrestrial plant with reduced leaves and stems in dry months. When soil moisture is lacking, it may appear to be in hibernation (Holm et al., 1997). Under dry land conditions, *I. aquatica* will grow as an erect herb (Edie and Ho, 1969). It can then become an annual plant, when the dry conditions do not allow its survival.”

Human Uses

From Dueñas-López (2023):

“The young tops or plants (stem and leaves) are cooked like spinach or lightly fried in oil and eaten as a vegetable in various dishes. A small portion of the production is canned. The vines are used as fodder for cattle and pigs.”

“A plant that is presumed to be *I. aquatica* was being used as a food plant during the Chin Dynasty in China as early as 290 AD (Edie and Ho, 1969). Today, it is grown as a vegetable crop in many tropical countries and was suggested as a potential vegetable crop for south Florida by Ochse (1951).”

“According to various sources, *I. aquatica* has been used extensively as a medicinal plant: as a mild laxative in India (Subramanyam, 1962); in the treatment of ringworm (Anonymous, 1959); and as a poultice in febrile delirium (Anonymous, 1959).”

“This plant may be useful in removing nitrates from contaminated water, such as farm drainage and municipal waste (Snyder et al., 1981).”

Diseases

From Dueñas-López (2023):

"*Ipomoea aquatica* is a host of the root-knot nematode *Meloidogyne javanica* in north-west Nigeria (Salawu et al., 1991), *Meloidogyne hapla* in Taiwan (Ruelo, 1980) and *Paratrophurus sp*. that occurs in the Ryukyu Islands [Japan] (Teruya, 1979)."

"Blister rust caused by *Albugo ipomoeae-panduratae* has been recorded on I. aquatica in Brunei where it is grown as a crop (Peregrine, 1974). White rust caused by *Albugo ipomoeae-aquaticae* has been reported wherever *I. aquatica* has been planted (e.g. China (Hong Kong, Fuzhou), India, Philippines, Singapore, Taiwan, Thailand, northern Australia, Irian Jaya) (Sawada, 1922; Safeeulla and Thrumalachar, 1953; Ho and Edie, 1969; Gao et al., 1985; Giri et al., 1989; Austin, 2007; Yu et al., 2015)."

"Fungi affecting *I. aquatica* include *Phyllosticta ipomoeae*, *Cercospora ipomoeae* [*Passalora bataticola*] and *Pseudomonas syringae* pv. *syringae*, which were observed in commercial greenhouses in Ontario and California during the 1990s (Cerkauskas et al., 2006); *Stagonosporopsis cucurbitacearum* (spot blight) in China (Liu et al., 2017); *Myrothecium roridum* (leaf spot) in China (Wang et al., 2017) and *Ectophoma multirostrata* (leaf spot) in Korea (Lee et al., 2022). Other species of fungi reported on *I. aquatica* include *Colletotrichum* sp., *Fusarium* sp., *Phomopsis* sp. (Suryanarayanan et al., 2018), *Pseudocercosporella bakeri* (David, 2000), *Discosporella phaeochlorina* and *Mycosphaerella* sp. (Ling, 1948)."

"In China, *Xanthomonas perforans* [*Xanthomonas euvesicatoria* pv. *perforans*] has been identified as the causal agent of bacterial leaf canker in *I. aquatica*, with *Pantoea ananatis* as a companion pathogen responsible for yellowing and brown rot of leaves (Hu et al., 2021)."

From USDA APHIS (2020):

"South Carolina regulates all *Ipomoea* spp. due to its risk of spreading *Cylas formicarius*, sweet potato weevil (Lightfoot, 2019 [personal communication])."

Threat to Humans

From Dueñas-López (2023):

"In Thailand, *I. aquatica* and several other aquatic weeds are hosts of snails (*Segmentina spp*.) which transmit the parasite of humans*, Fasciolopsis burki* (Johannes, 1972)."

3 Impacts of Introductions

From Dueñas-López (2023):

"*I. aquatica* grows very rapidly and becomes a weed in some habitats (Parham, 1958; Varshney and Rzoska, 1976). The long floating stems form a dense network across bodies of fresh water. This network supports leaves and flowers, which rise above the water surface and may impede

water flow and navigation (Ashton, 1973). *I. aquatica* is also a major broadleaved aquatic weed of dry-seeded wetland rice (Raju and Reddy, 1986; Jena and Patro, 1990)."

"In Florida (USA), where the flat landscape permits sheet flow of water during periods of heavy rain, *I. aquatica* is considered a serious threat to flood control. Since the late 1970s, the Florida Department of Natural Resources has eradicated over 20 small infestations of *I. aquatica* that escaped from illegal plantings. It is considered a significant threat to Florida's waterways and wetlands (Westbrooks, 1989)."

"In natural settings, such as rivers and lakes, *I. aquatica* may outcompete native vegetation and limit the use of these waters. […] In a Florida study, *I. aquatica* left unattended in a tank with several other species protruded up through a dense mat of *Hydrilla verticillata* and then grew over the remaining species (Gilbert, 1984)."

"Canals used for irrigation in the Sudan are conducive to the spread of aquatic weeds. Among the most prevalent species are *Cyperus rotundus*, *I. aquatica* and *Panicum repens* on canal banks, and *Chara globularis*, *Najas pectinata*, *Ottelia alismoides* and *Potamogeton spp*. anchored in the canal mud."

From Howard (2023):

"This weedy species infests up to 20 crops world-wide and many of its impacts are similar to other well known aquatic weeds like *Eichhornia*, *Pistia* and *Salvinia*. Intertwined stems form dense mats on water surfaces, shading out native submersed aquatics and competing with emergent species which may be important for fish and wildlife (PIER 2008). These masses of tangled vegetation can slow water flow in drainage and flood control canals (Holm et al. 1997). Stagnant water resulting from infestations of water spinach may become breeding grounds for mosquitoes and in its native range of Thailand *I. aquatica* is known to provide habitat for snails that are vectors for human diseases (Holm et al. 1997, ISSG 2006)."

This species is federally listed as a noxious weed and is also regulated by 16 states: Arkansas, California, Florida, Illinois, Indiana, Louisiana, Massachusetts, North Carolina, New Hampshire, Oklahoma, South Carolina, Texas, Virginia, Wisconsin, and West Virginia. See Section 1 for more information.

4 History of Invasiveness

The History of Invasiveness for *Ipomoea aquatica* is classified as High. This species is listed as invasive in much of its introduced range. In the United States, it is Federally listed as a Noxious Weed and importation and interstate movement is prohibited due to its invasiveness. This species is also regulated in 16 states. Its ability to adapt to different environments, and fast reproduction outcompete native vegetation and create monocultures, negatively impacting the overall biodiversity where it establishes. This species can also cause issues to navigation within waterways.

5 Global Distribution

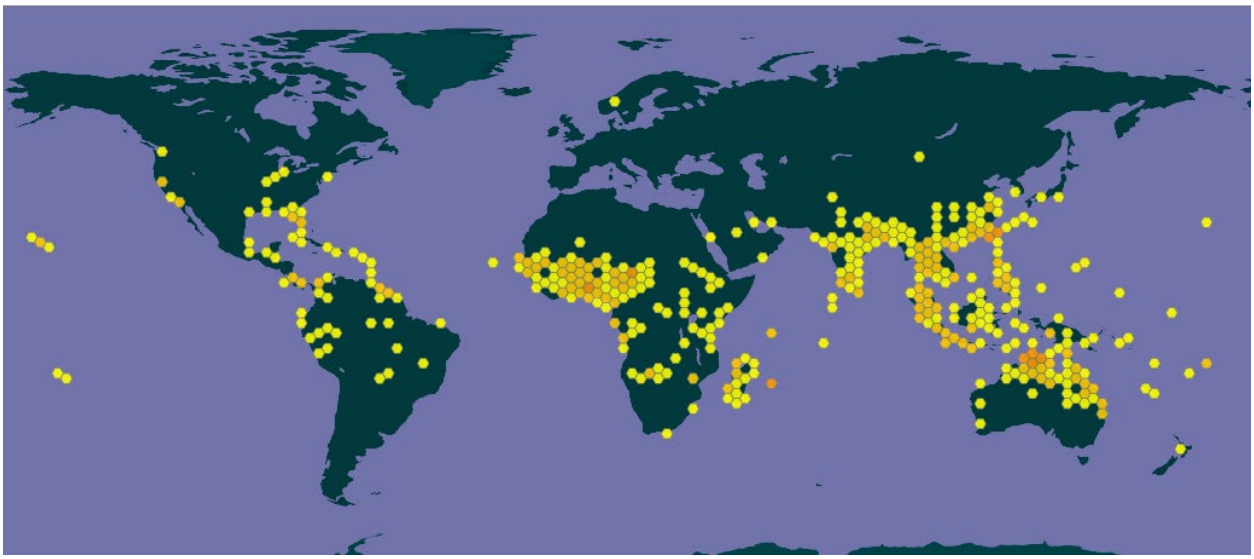

Figure 1. Reported global distribution of *Ipomoea aquatica*. Map from GBIF Secretariat (2023). Observations are reported from all continents other than Antarctica and most Islands in the Pacific, Caribbean, and Indian oceans. Observations in Norway, the northern and western contiguous United States, Mongolia, and New Zealand do not represent established wild populations and were not used to select source points for the climate matching analysis.

6 Distribution Within the United States

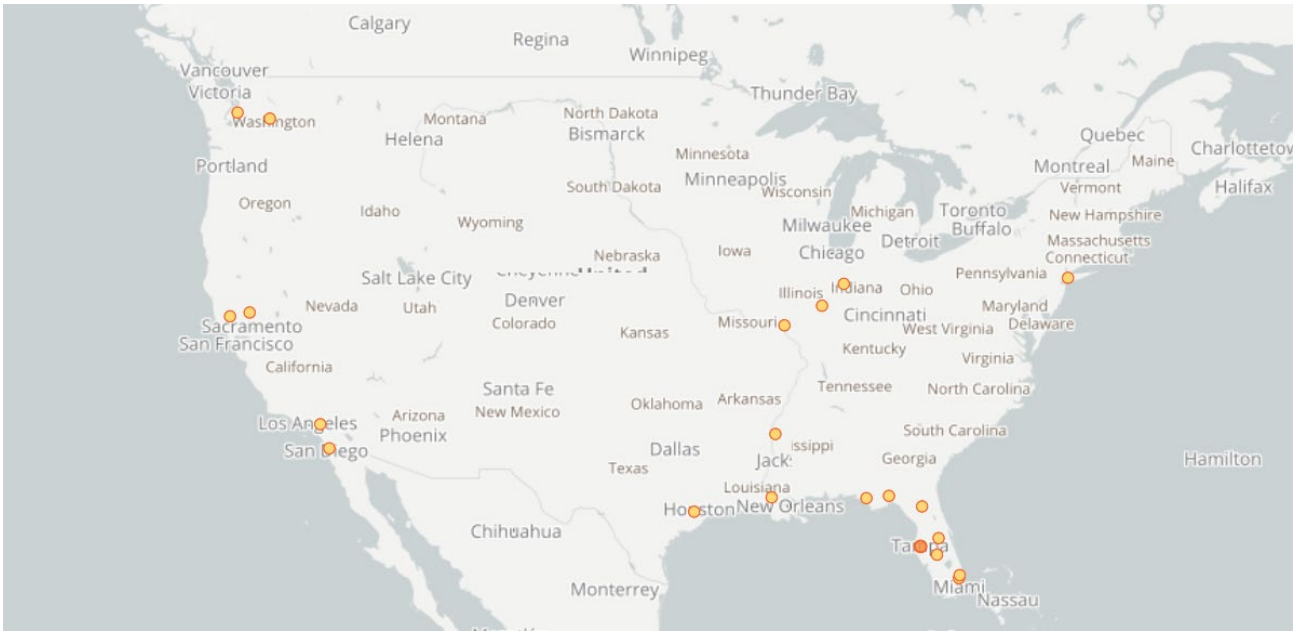

Figure 2. Reported distribution of *Ipomoea aquatica* in the United States. Map from GBIF-US (2023). Observations are reported from Florida, Texas, California, Louisiana, Illinois, Indiana, Missouri, New York, Washington, and Mississippi. Points in Washington were centroid data without specific location information or market specimens and therefore were not used in the climate matching analysis. The points in California, Mississippi, Illinois, Indiana, and New York are cultivated plants or bought from food markets and were therefore removed from climate matching analysis.

Figure 3. Reported distribution of *Ipomoea aquatica* in Puerto Rico. Map from GBIF-US (2023). Observations are reported on the west coast of the main island.

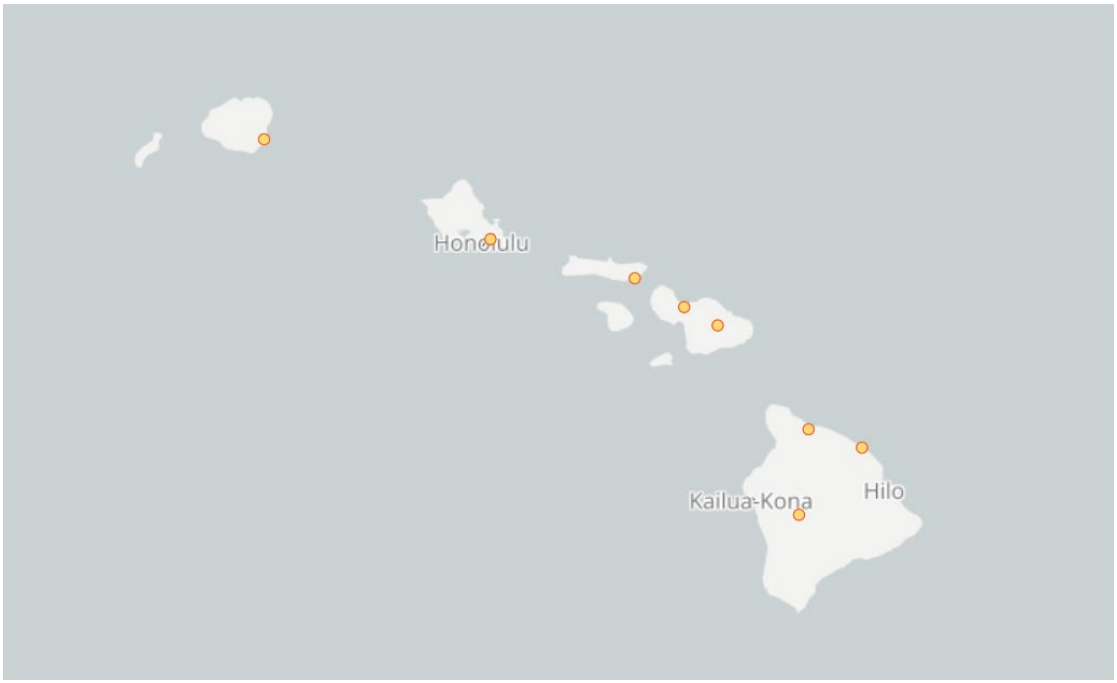

Figure 4. Reported distribution of *Ipomoea aquatica* in Hawaii. Map from GBIF-US (2023). Observations are reported throughout the islands.

Figure 5. Reported distribution of *Ipomoea aquatica* in Guam. Map from GBIF-US (2023). Observations are reported in the central and southern part of the island.

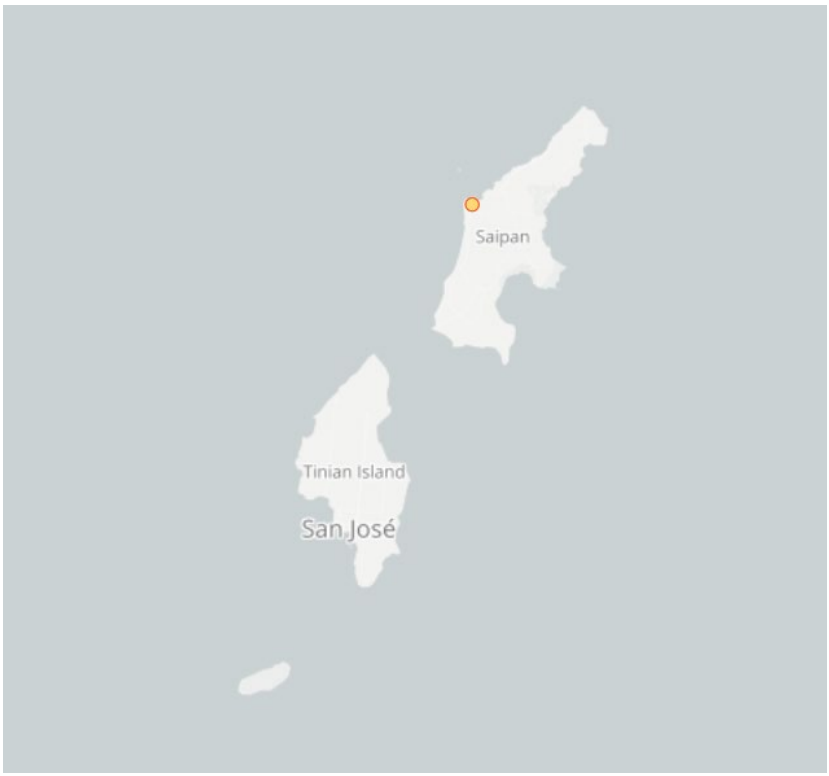

Figure 6. Reported distribution of *Ipomoea aquatica* in the Mariana Islands. Map from GBIF-US (2023). Observation reported on the west coast of the island of Saipan.

7 Climate Matching

Summary of Climate Matching Analysis

The climate matching analysis for *Ipomoea aquatica* found high climate match from the Mid-Atlantic region south to Florida and from Florida west to southern California. Medium matches were found in most of the southern Midwest states. Areas in the Western Mountains, northern Midwest, and New England had lower matches. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.476, 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 *Ipomoea aquatica* (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.

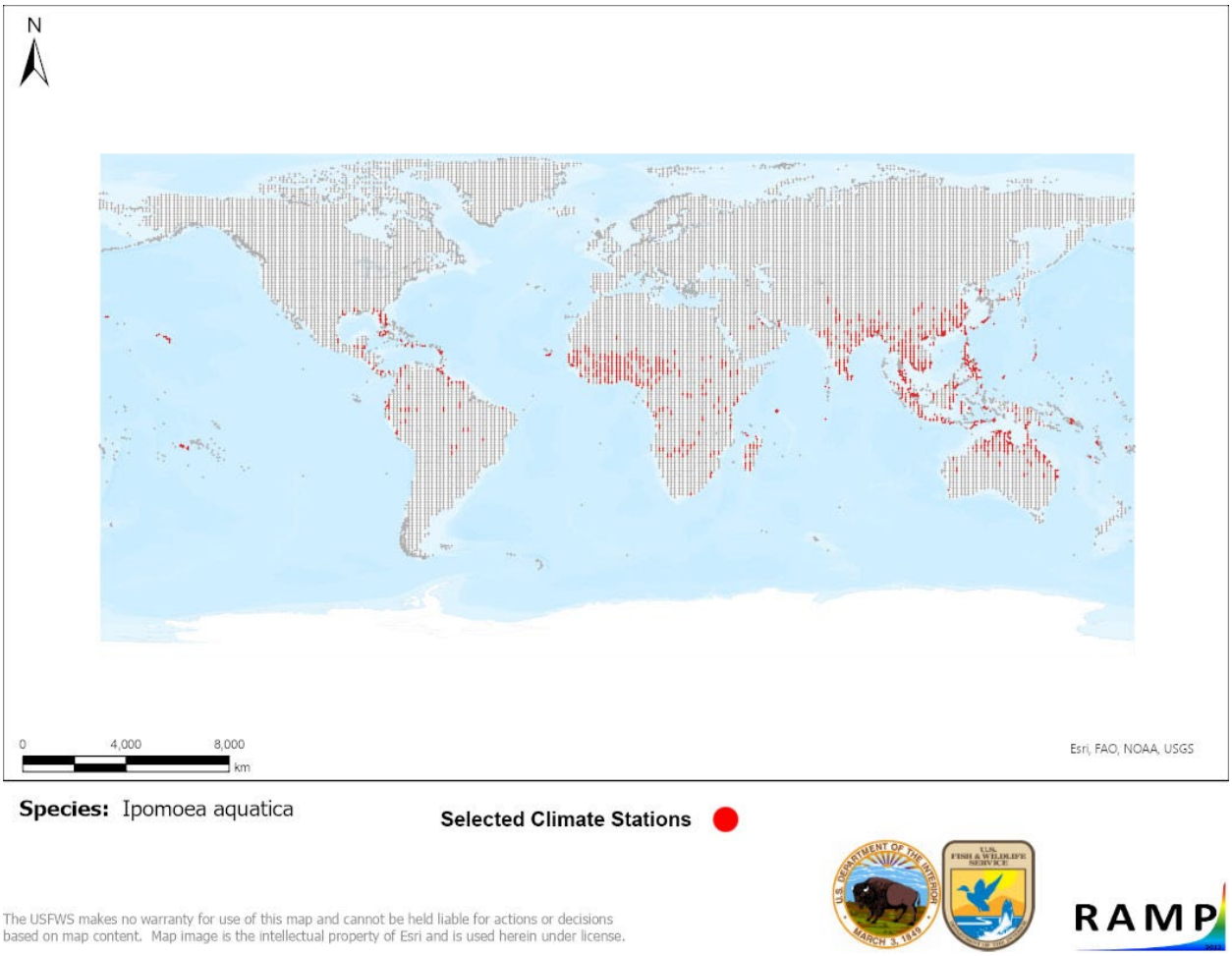

Figure 7. RAMP (Sanders et al. 2023) source map showing weather stations in almost all tropical and subtropical regions throughout the world selected as source locations (red; many Pacific Islands and subtropical and tropical regions from all continents excluding Antarctica) and non-source locations (gray) for *Ipomoea aquatica* climate matching. Source locations from GBIF Secretariat (2023). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

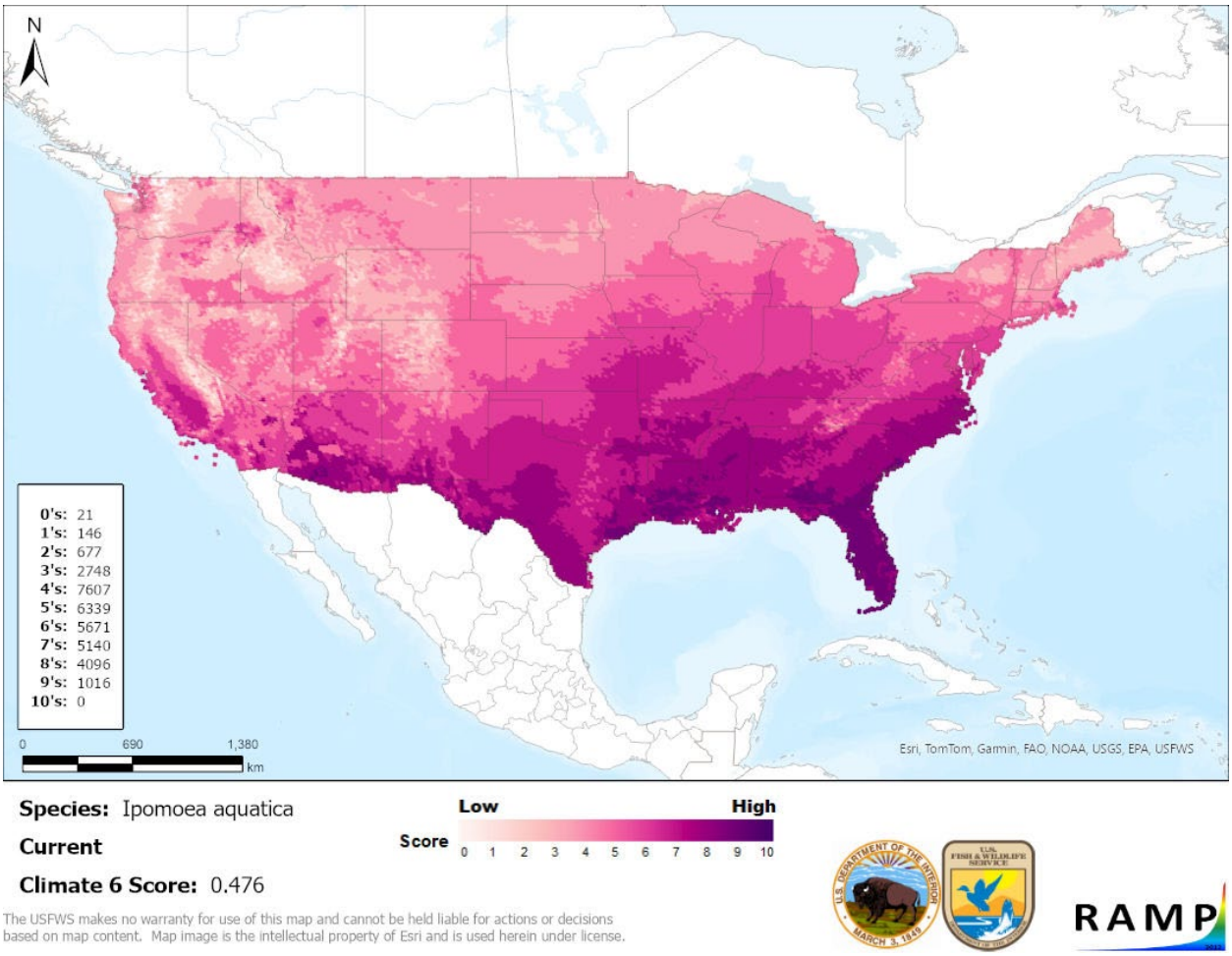

Figure 8. Map of RAMP (Sanders et al. 2023) climate matches for *Ipomoea aquatica* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Ipomoea aquatica* is classified as High. General biological information as well as information on the distribution of the species was available. There were records of introduction and establishment of nonnative populations as well as ample data available documenting the negative effects of this species from around the world.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Ipomoea aquatica, water spinach, is a flowering plant that is native to southern Asia. This species is fast growing and can reproduce via seeds and fragments. It does not grow well in cooler climates but grows at a high rate when climate conditions are optimal. Water spinach is cultivated for consumption around the world and is readily available on the open market. This species has been introduced to both South and North America and is listed as a Federal Noxious

Weed in the United States because of its ability to create monocultures in areas where it is introduced. In addition to being federally listed, 16 U.S. states also regulate this species at the species or genus level. This species is associated with a snail that can transmit a parasite to humans. The History of Invasiveness for *Ipomoea aquatica* is classified as High due to being introduced and established in many areas across the world, with documented negative impacts. The climate matching analysis for the contiguous United States indicates establishment concern for this species. Areas of high match were found in southern areas of the contiguous United States from southern California to Florida and North Carolina. The Certainty of Assessment for this ERSS is classified as High due to the ample information available, particularly regarding the history of invasiveness. The Overall Risk Assessment Category for *Ipomoea aquatica* 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: Federally listed as a Noxious Weed. Habitat for snails that can transmit disease to humans.**
- **Overall Risk Assessment Category: High**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.

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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 (2023).

Under the future climate scenarios (figure A1), on average, high climate match for *Ipomoea aquatica* was projected to occur in the Gulf Coast, Mid-Atlantic, Southeast, Southern Atlantic Coast, and Southern Florida regions of the contiguous United States. There were also consistent patches of low match throughout the Western Mountains. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.505 (model: MPI-ESM1-2-HR, SSP5, 2085) to a high of 0.725 (model: UKESM1-0-LL, SSP5, 2085). 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 (0.476, figure 8) falls below the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under one or more time step and climate scenarios, areas within the Northeast saw a large increase in the climate match relative to current conditions. The areas of large increase were concentrated along the northern Atlantic Coast and eastern Lake Ontario region. The area of increase was larger in time step 2085 under both SSPs. Additionally, areas within the Appalachian Range, California, Colorado Plateau, Great Basin, Great Lakes, Mid-Atlantic, Northern Pacific Coast, Northern Plains, Southern Plains, Southwest, and Western Mountains saw a moderate increase in the climate match relative to current conditions. Under one or more time step and climate scenarios, areas within the Southwest saw a large decrease in the climate match relative to current conditions. Additionally, areas within the Gulf Coast, Southeast, Southern Atlantic Coast, and Southern Florida saw a moderate decrease in the climate match relative to current conditions. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

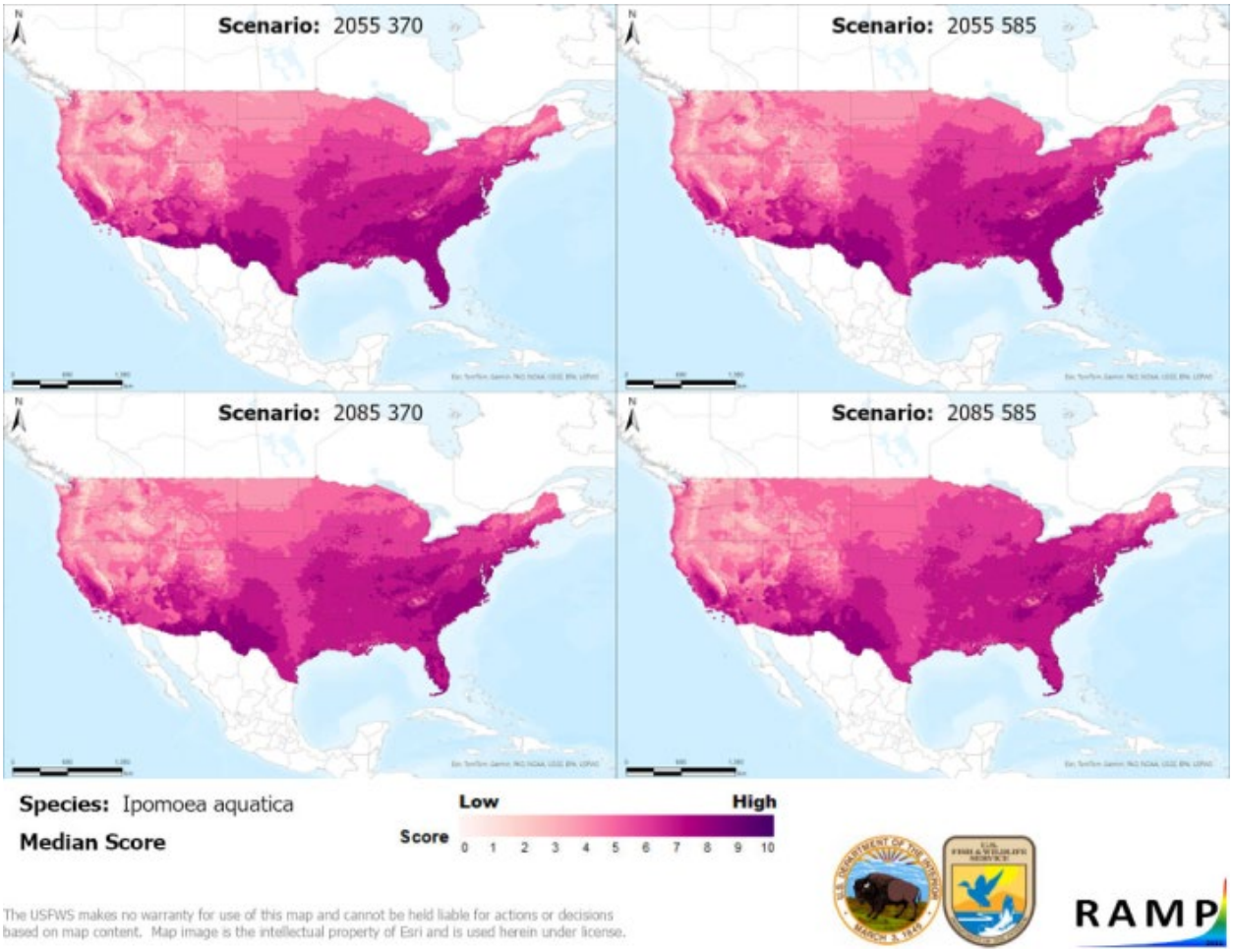

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Ipomoea aquatica* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic 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.

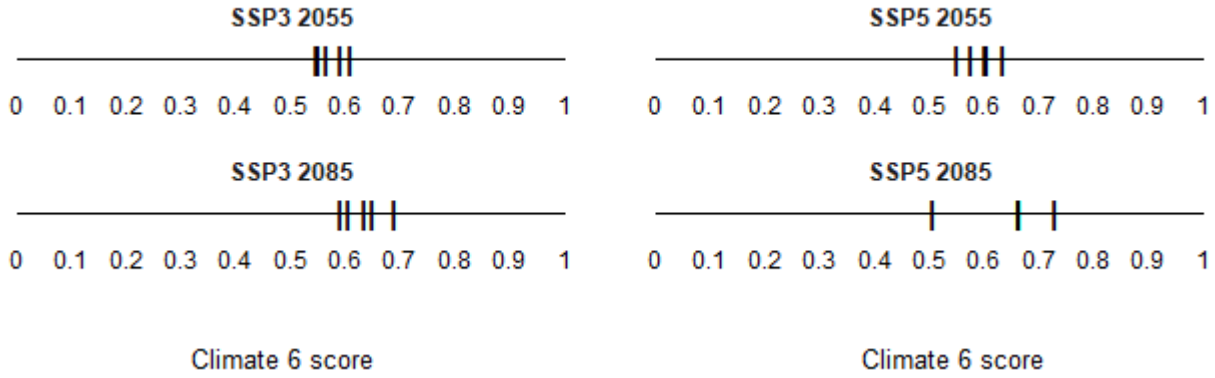

Figure A2. Comparison of projected future Climate 6 scores for *Ipomoea aquatica* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 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.

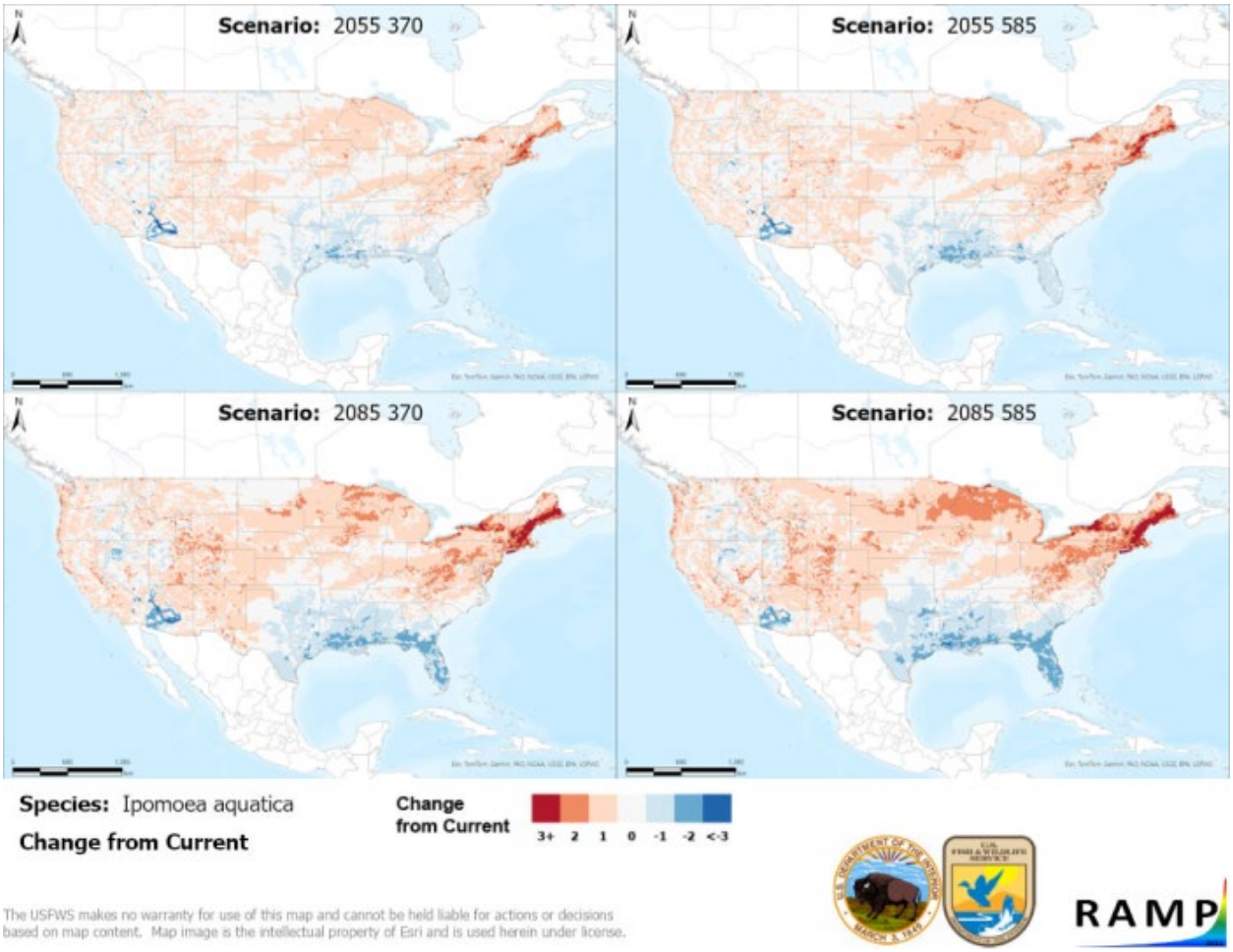

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 8) and the median target point score for future climate scenarios (figure A1) for *Ipomoea aquatica* based on source locations reported by GBIF Secretariat (2023). 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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