

European Waterclover (*Marsilea quadrifolia*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, January 2024

Revised, September 2024

Web Version, 8/25/2026

Organism Type: Fern

Overall Risk Assessment Category: Uncertain



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1 Native Range and Status in the United States

Native Range

From Corli (2021):

“*M. quadrifolia* has a widespread distribution, occurring throughout central-southern Europe and extending from Eurasia to tropical and temperate areas of eastern Asia [...]”

From USGS (2026):

“Found in Caucasia, western Siberia, Afghanistan, southwest India, China, Japan [...]”

From POWO (2023):

“Native to: Austria, Bulgaria, Canary Is., China North-Central, China Southeast, Czechoslovakia [Czechia, Slovakia], East European Russia, France, Hungary, Inner Mongolia, Iran, Italy, Japan, Kazakhstan, Korea, Manchuria [northeast China], Netherlands, Northwest European [Russia], Portugal, Qinghai [central China], Romania, Transcaucasus [Armenia, Azerbaijan, Georgia], Turkey, Ukraine, Uzbekistan, Yugoslavia [Bosnia and Herzegovina, Croatia, Kosovo, Macedonia, Montenegro, Serbia, Slovenia]”

Status in the United States

From Corli (2021):

“It was first recorded in Connecticut in 1862 as an ornamental aquatic plant.”

From USGS (2026):

“It has escaped cultivation and is well established in much of the Northeastern U.S. west to Iowa and Missouri for over 100 years.”

USGS (2026) lists nonindigenous occurrences with a status of ‘established’ in Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Missouri, New Jersey, New York, and Pennsylvania; nonindigenous occurrences with a status of ‘collected’ in Washington, D.C. and North Carolina; and nonindigenous occurrences with an unknown status in Minnesota, Ohio, South Carolina, and Washington.

From Simpson and Crank (2008):

“*Marsilea quadrifolia* L., European Waterclover Fern, was discovered for the first time in Arkansas during a preliminary survey of the summer shore and aquatic macrophytes flora found along the lower 6 km of the Little Maumelle River, where it empties into the Arkansas River, just west of the City of Little Rock in western Pulaski County, Arkansas.”

Marsilea quadrifolia is in trade within the United States (e.g., Pond Plants Online 2023).

Regulations

Marsilea quadrifolia is regulated in Connecticut (Connecticut General Statutes 2021), New Hampshire (NHEDS 2022), Ohio (ODA 2023), and Oklahoma (ODWC 2023). 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 Les and Mehrhoff (1999):

“*Marsilea quadrifolia* from Bantam Lake, CT was introduced to the Harvard Botanical Garden (Cambridge, MA) prior to 1868 (Johnson 1986).”

“At least four 20th century reports document intentional introductions. A 1985 specimen collected from Mill River, Northampton, MA (Hampshire Co.) originated at Smith College ‘where it escaped from the greenhouse pond ca. 10 years ago’ (see also Burk et al. 1976).”

“Aquatic birds may have facilitated its post-introduction dispersal, because waterfowl do consume the sporocarps (Martin and Uhler 1939).”

From USGS (2026):

“1925, deliberate release, Lake Ontario drainage (U.S. EPA 2008). Ornamental deliberate release. Many of the localities from which it is known at present are artificial bodies of water. This may indicate intentional introduction of the plant as a curiosity.”

Remarks

From USGS (2026):

“*Marsilea minuta* and *M. mutica* are often mistaken for *M. quadrifolia*, all three being glabrous, soft and fleshy when fresh. Nevertheless, the two newly documented exotic species appear better suited to the warmer climate of the Southeast, while more than a century after its initial introduction *M. quadrifolia* has not extended south of Maryland, Kentucky or Missouri (Henry 1983, Johnson 1993, Jacono & Johnson 2006).”

Due to morphological plasticity of *Marsilea* species (Corli 2021), misidentifications and disagreement over identifications have occurred and have resulted in errors in reported distribution, particularly regarding potential introductions (e.g., Jefferson 2003, Brazil; Simpson and Crank 2008, Arkansas reports prior to 2008; Schaefer et al. 2011, Canary Islands).

From Corli (2021):

“Despite its wide distribution, in its home range [*Marsilea quadrifolia* L.] is threatened with extinction and has already been locally extirpated in several European countries. As a result, it is listed as “Vulnerable” in the European Union Red List due to its scattered distribution and declining population.”

Mention of commercial products in this Ecological Risk Screening Summary does not entail endorsement by the U.S. Federal Government.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Polypodiophytina
Class Polypodiopsida
Subclass Polypodiidae
Order Salviniaceae
Family Marsileaceae
Genus *Marsilea*
Species *Marsilea quadrifolia* L.

According to World Flora Online (2023), *Marsilea quadrifolia* L. is the current valid name for this species.

Size, Weight, and Age Range

From USGS (2026):

“Size: max. 20 cm”

Environment

From USGS (2026):

“*Marsilea quadrifolia* requires moist soils and can be found in shallow, slow-moving waters environments: rivers, streams, ponds, shorelines, and ditches (Benson et al. 2004, Campbell et al. 2010). This plant prefers sandy and loamy soils. It can grow in semi-shade or no shade.”

From Corli (2021):

“Bolpagni and Pino (2017) found that growth peaked in slightly eutrophic waters, and persisted, though inhibited, under elevated nutrient levels. It does not tolerate high concentrations of nutrients and pollutants, even though it has been demonstrated to be able to remove nitrites from contaminated waters (Rawat et al., 2012). [...] It prefers soft waters, frequently measured as deficient in calcium carbonate (Oberdorfer, 2001).”

“The plastic response of the leaves to the environment contributes to the ability of *M. quadrifolia* to occupy a continuum of habitats, ranging from terrestrial soils to continuously flooded substrates (Wu & Kao, 2011).”

“Experimental studies demonstrated that *M. quadrifolia* can tolerate concentrations up to 450 and 4 µM of ammonium and phosphate respectively in sediment pore [sic] water (Bolpagni & Pino, 2017) and low to medium salinity levels (Schneider-Binder, 2014 but also 0.76 mS/cm, Estrelles et al., [2001]).”

Climate

From POWO (2023):

“It [...] grows primarily in the temperate biome.”

From Cao and Berent (2024):

“[...] the cold temperate *M. quadrifolia* [...]. In eastern North America, *M. quadrifolia* remains restricted to the more humid range of the cold temperate north.”

From Corli (2021):

“The species grows best in areas where annual daytime temperatures are within the range of 20-28°C but it can tolerate temperatures between 14-32°C. When dormant, the plant can survive to temperatures of -15°C, but young shoots can be severely damaged at 0°C.”

Distribution Outside the United States

Native

From Corli (2021):

“*M. quadrifolia* has a widespread distribution, occurring throughout central-southern Europe and extending from Eurasia to tropical and temperate areas of eastern Asia [...].”

From USGS (2026):

“Found in Caucasia, western Siberia, Afghanistan, southwest India, China, Japan [...].”

From POWO (2023):

“Native to: Austria, Bulgaria, Canary Is., China North-Central, China Southeast, Czechoslovakia [Czechia, Slovakia], East European Russia, France, Hungary, Inner Mongolia, Iran, Italy, Japan, Kazakhstan, Korea, Manchuria [northeast China], Netherlands, Northwest European [Russia], Portugal, Qinghai [central China], Romania, Transcaucasus [Armenia, Azerbaijan, Georgia], Turkey, Ukraine, Uzbekistan, Yugoslavia [Bosnia and Herzegovina, Croatia, Kosovo, Macedonia, Montenegro, Serbia, Slovenia]”

Introduced

From POWO (2023):

“Introduced into: [...] Cuba, [...] Ontario [Canada], [...].”

Means of Introduction Outside the United States

No information on means of introduction outside the United States was found.

Short Description

From USGS (2026):

“It has thin green stalk-bearing downy fiddleheads (furled leaflets) which will open to reveal four wedge-shaped leaflets (Benson et al. 2004, Connecticut Aquatic 2006, MIPN.org 2008). These 1.5—4 cm leaflets will float along the water’s surface or be slightly emerged (Benson et al. 2004, Campbell et al. 2010).”

“*Marsilea quadrifolia* produces thick sporocarps (spore-producing tissues) on 1—12 mm stalks near the petiole; they are oval and hairy in appearance (Benson et al. 2004, Campbell et al. 2010).”

“From creeping rhizomes, thin green stalks rise to the water surface, each stalk bearing a single leaf with four wedge-shaped leaflets (Connecticut Aquatic 2006). When the leaves float on or just below the water surface, the leaflets have an elongated shape (Liu 1984). However in very shallow water, the stalks often are able emerge above the water’s surface and produce the characteristic four-leaf clover shape (Liu 1984).”

Biology

From USGS (2026):

“The rhizomal structure of *M. quadrifolia* enables this species to reproduce vegetatively (Campbell et al. 2010). This plant also produces sporocarps (spore-producing tissues); male and female spores germinate and cross-fertilize to produce new plants (Benson et al. 2004). The sporocarps also be dispersed by waterfowl and/or remain dormant in the soil for decades (Benson et al. 2004, Campbell et al. 2010)”

From Corli (2021):

“Gametophyte generation is completed within 24 hours, and the first roots and shoots appear within three days [...] Spore germination occurs between June and September (Marchetti, 2004) after the rupture of the sporocarp wall, a structure that allows the sporocarp contents to be hydrated.”

“Sexual reproduction occurs in the water and the release of spores, fertilization and development of the embryo takes approximately 48 hours (Schneider & Pryer, 2002). Within three months a young sporophyte develops into a mature plant producing sporocarps (Johnson, 1986).”

Human Uses

From Corli (2021):

“In India, it has been used in the local Ayurvedic medicine by the *Vaidyas* (people who practice Ayurveda) for thousands of years (Joy et al., 2019).”

“As a food, *M. quadrifolia* has a relatively high nutritional value and is important for food security in times of drought or poor harvest (Tanaka, 1976).”

“*M. quadrifolia* has an economic value for wetland restoration thanks to its phytoremediation properties (Miranda et al., 2014; Jiang et al., 2018). Specifically, the species is used for nutrient uptake from freshwater lakes (Khan and Shah, 2010) and for phytoremediation against heavy metals such as vanadium, arsenic, cadmium, chromium, mercury, and lead in the sediments and waters of mining areas (Jiang et al., 2018).”

From Ripa et al. (2009):

“The present study indicated that the chloroform and ethyl acetate extracts of the aerial part of *M. quadrifolia* have got profound antibacterial, cytotoxic and antioxidant effect and may have potential use in medicine.”

From Subrmanian et al. (2019):

“Overall, this study indicated that *M. quadrifolia* ameliorated MSG-induced neurotoxicity. Future investigations are required to explore the neuroprotective mechanism of *M. quadrifolia* and its active constituents, which will provide exciting insights in the therapeutic management of neurological disorders.”

From Gini and Jothi (2015):

“The results indicated that *Marsilea quadrifolia* extracts has antimicrobial activity and could be source of alternative antimicrobial drugs for treatment of diseases caused by the pathogens tested in this study.”

From Agarwal et al. (2018):

“The nutritional values of *Marsilea quadrifolia* has given the plant a special natural medicinal flavor, which can be linked with the dessert making cottage industry to provide nutrition to population as well as generate alternative livelihood.”

From Cao and Berent (2024):

“European waterclover is commonly used in water gardens and aquariums (Campbell et al. 2010).”

Diseases

From CABI (2010):

“Padwick (1950) refers to *T[richoconiella] padwickii* causing spots on the leaves of an unspecified wild grass [...] This fungus has also been reported [...] on the invasive weed, *Marsilea quadrifolia* (Sarbhoy et al., 1971).”

From Corli (2021):

“*M. quadrifolia* is one of the hosts of the North European aphid *Rhopalosiphum nymphaeae* Linnaeus (Albrecht, 2015) and the North polyphagous aphid *Myzus persicae* Sulzer.”

Threat to Humans

No information was found on threats to humans from *Marsilea quadrifolia*.

3 Impacts of Introductions

From Cao and Berent (2024):

“*Marsilea quadrifolia* is capable of outcompeting native aquatic and moist terrestrial species and creating monotypic vegetative stands (Benson et al 2004, Illinois Department 2013). These monospecific stands can also persist throughout the winter seasons because of the underground rhizomes (Benson et al. 2004).”

“Other sources report that *M. quadrifolia* does not spread aggressively and poses a low ecological threat (Benson et al. 2004, Connecticut Aquatic 2006). In a survey by Henry and Myers (1983), *M. quadrifolia* only migrated 151 feet per year Spring Creek (Illinois); for a total range expansion of 1 mile downstream in 35 years.”

The following information pertains to *potential* impacts from introduction of *Marsilea quadrifolia*.

From USGS (2026):

“*Marsilea quadrifolia* may out-compete native wetland plants by forming dense stands, although direct evidence of competition or habitat alteration is lacking.”

From Cao and Berent (2024):

“During the growing season, *M. quadrifolia* plants are able to adjust the angle of the floating leaflets to optimize access to sunlight and the ability to photosynthesize (Kao and Lin 2010). This ability could allow this species to outcompete neighboring species for sunlight.”

Marsilea quadrifolia is regulated in Connecticut (Connecticut General Statutes 2021), New Hampshire (NHEDS 2022), Ohio (ODA 2023), and Oklahoma (ODWC 2023). See section 1.

4 History of Invasiveness

The History of Invasiveness for *Marsilea quadrifolia* is classified as Data Deficient. This species was introduced to North America over one hundred years ago through ornamental plantings. It has since established in many Northeastern and Midwestern States in the United States as well as in Ontario, Canada. *Marsilea quadrifolia* is available in trade in the United States as an ornamental plant but is regulated in several states. However, there is little available information on impacts from those introductions. Within the information that is available, different sources give conflicting reports regarding the impacts of the species.

5 Global Distribution

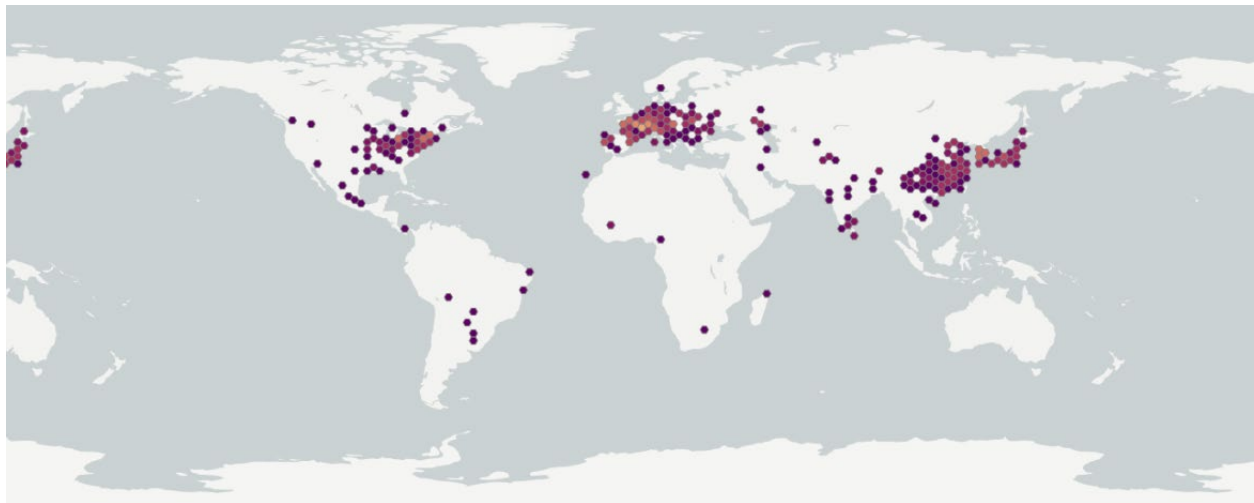


Figure 1. Reported global distribution of *Marsilea quadrifolia*. Map from GBIF Secretariat (2023). Observations are reported from the United States, Europe, and Asia. Points in Africa, South America, the western United States, Central America, and Norway likely do not represent established populations and were not used to select source points for the climate matching analysis (Section 7).

6 Distribution Within the United States

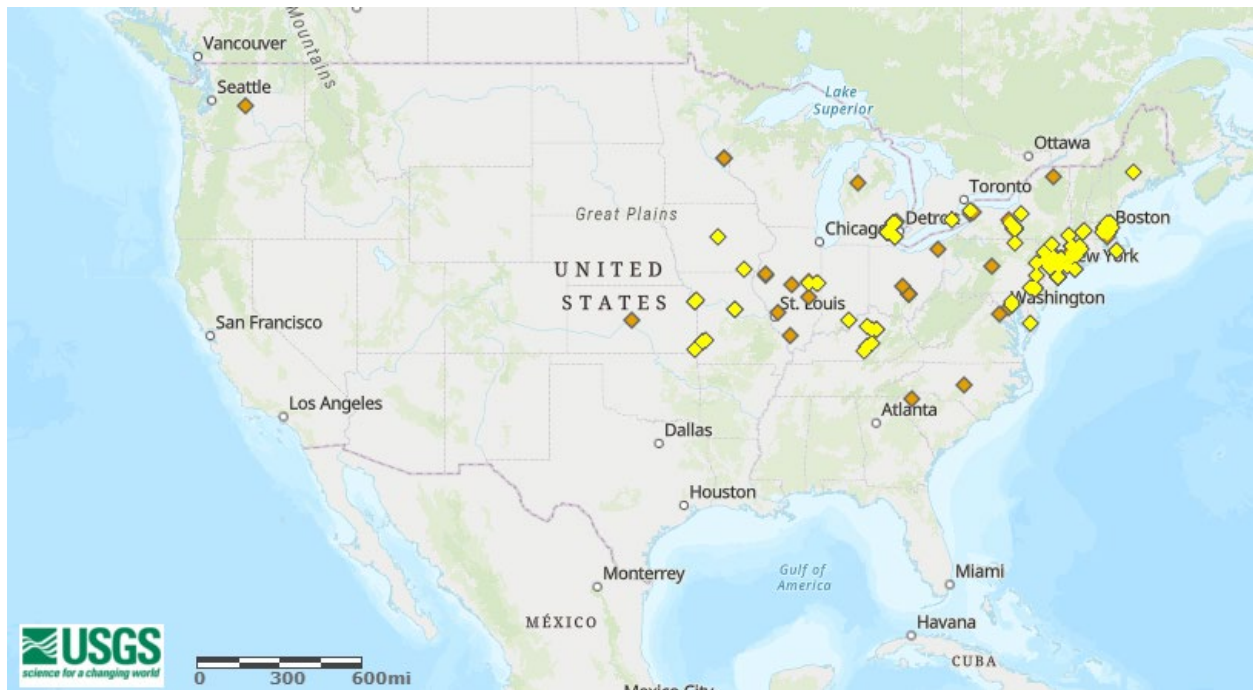


Figure 2. Reported distribution of *Marsilea quadrifolia* in the United States. Map from USGS (2026). Yellow points represent established populations. Orange points are observations with statuses other than ‘established’ and records of established populations at the state level and were not used for the climate matching analysis.

Simpson and Crank (2008) reported an established population of *Marsilea quadrifolia* in Pulaski County, Arkansas. The observation was used in the climate matching analysis.

7 Climate Matching

Summary of Climate Matching Analysis

The contiguous United States had a high climate match for *Marsilea quadrifolia*. Areas of high match included the Northeast and Mid-Atlantic west to Iowa and Missouri. Medium climate match was found in in most of the Southeast, Central Plains, Colorado Plateau, Great Basin, and Western Mountains. There were small areas of low climate match, principally areas along the Sierra-Nevada Range and the Olympic Peninsula in Washington. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.976 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 *Marsilea quadrifolia* (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.

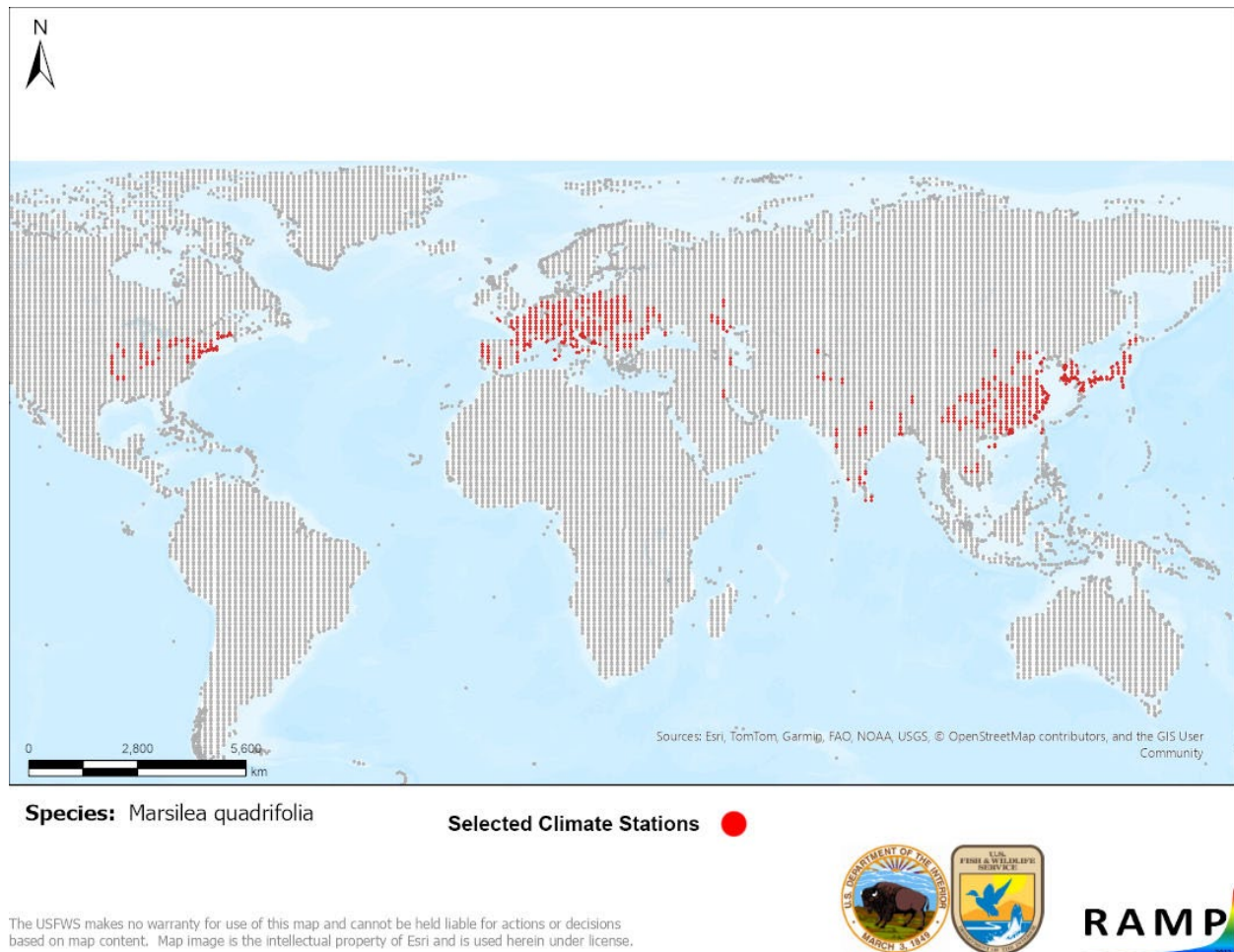


Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in the world selected as source locations (red; United States, Asia, and Europe) and non-source locations (gray) for *Marsilea quadrifolia* climate matching. Source locations from Simpson and Crank (2008) and GBIF Secretariat (2023). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

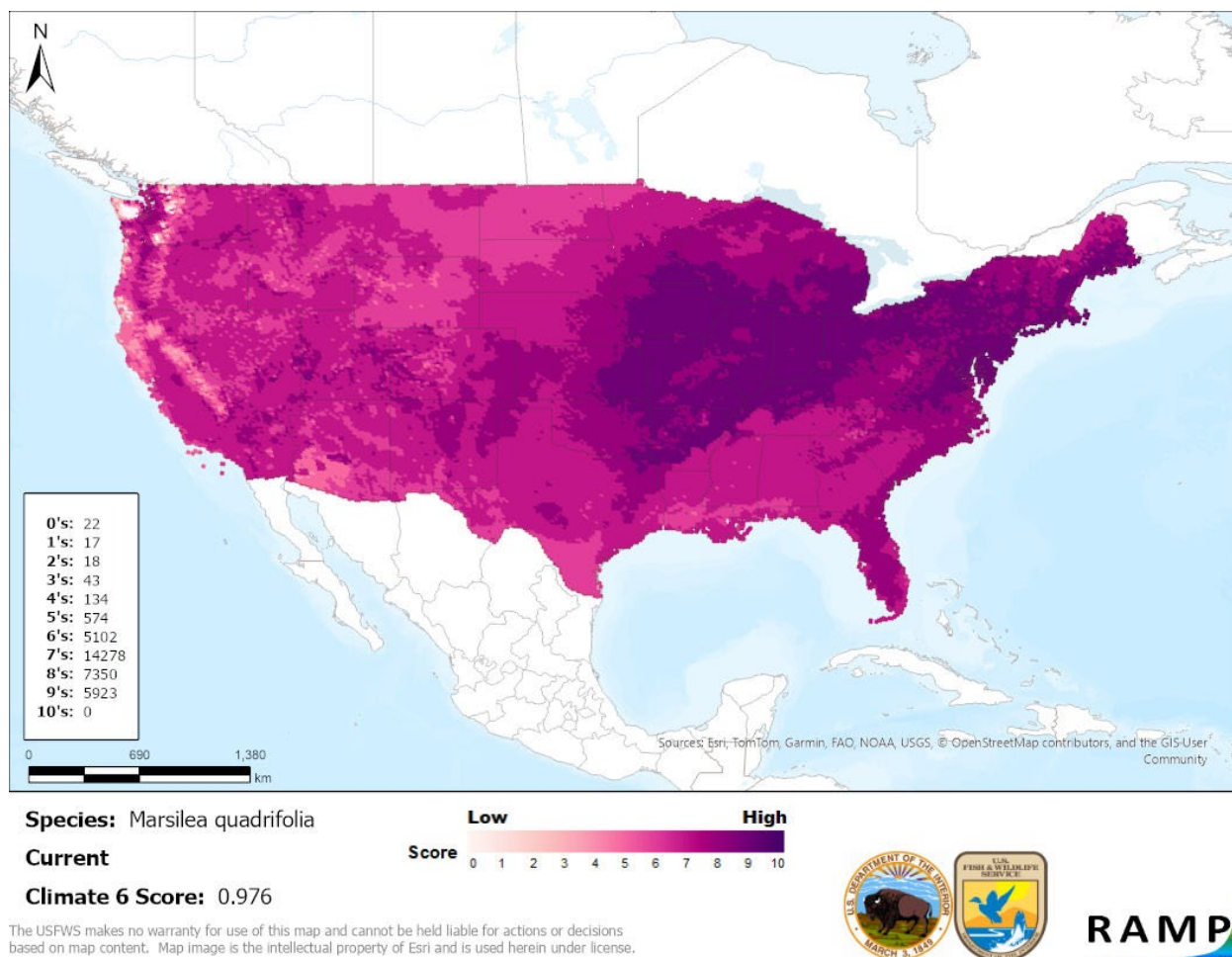


Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Marsilea quadrifolia* in the contiguous United States based on source locations reported by Simpson and Crank (2008) and GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Marsilea quadrifolia* is classified as Low. Information is available regarding the species biology, ecology, and distribution. A complete understanding of the species' distribution is complicated by misidentifications. Information about the impacts of introduction is limited and inconsistent.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Marsilea quadrifolia, European Watercress, is a semi-aquatic fern that is native to Europe and Asia. This species grows in temperate climates and can reproduce vegetatively and sexually. *M. quadrifolia* has a long history of human use in medicine and as a food source. It was introduced as an ornamental in the Northeastern United States during the 19th century and escaped cultivation. *Marsilea quadrifolia* is regulated in Connecticut, New Hampshire,

Oklahoma, and Ohio. There is little known about impacts of introduction. The History of Invasiveness for *Marsilea quadrifolia* is classified as Data Deficient due to the limited and inconsistent information about impacts of introduction. The climate matching analysis for the contiguous United States indicates establishment concern for this species. Areas of high climate match were found from Missouri and Iowa east to the Mid-Atlantic and Northeast. The Certainty of Assessment for this ERSS is classified as Low due to misidentifications impacting the understanding of the distribution and a lack of information regarding impacts from introductions. The Overall Risk Assessment Category for *Marsilea quadrifolia* in the contiguous United States is Uncertain.

Assessment Elements

- **History of Invasiveness (see Section 4): Data Deficient**
- **Establishment Concern (see Section 7): Yes**
- **Certainty of Assessment (see Section 8): Low**
- **Remarks, Important additional information: None**
- **Overall Risk Assessment Category: Uncertain**

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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11 Literature Cited in Quoted Material

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

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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 Simpson and Crank (2008) and GBIF Secretariat (2023).

Under the future climate scenarios (figure A1), on average, high climate match for *Marsilea quadrifolia* was projected to occur in the Appalachian Range, Great Lakes, Mid-Atlantic, and Northeast regions of the contiguous United States. These areas of high match are most prominent at the 2055 time step in both SSP3 and SSP5 and are reduced in time step 2085, particularly under SSP5. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.763 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.977 (model: GFDL-ESM4, SSP3, 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 (0.976, figure 4) 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, the most extreme climate change scenario. Under one or more time step and climate scenarios, areas within the Colorado Plateau, Northeast, Southwest, and Western Mountains 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 Mid-Atlantic, Northeast, and Southeast saw a large decrease in the climate match relative to current conditions. Additionally, areas within the Appalachian Range, California, Colorado Plateau, Great Basin, Great Lakes, Gulf Coast, Northern Pacific Coast, Northern Plains, Southern Atlantic Coast, Southern Florida, Southern Plains, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. The magnitude of change from current conditions was more pronounced in time step 2085 than in time step 2055, particularly under SSP5. Additional very small areas of large or moderate change may be visible on the maps (figure A3).

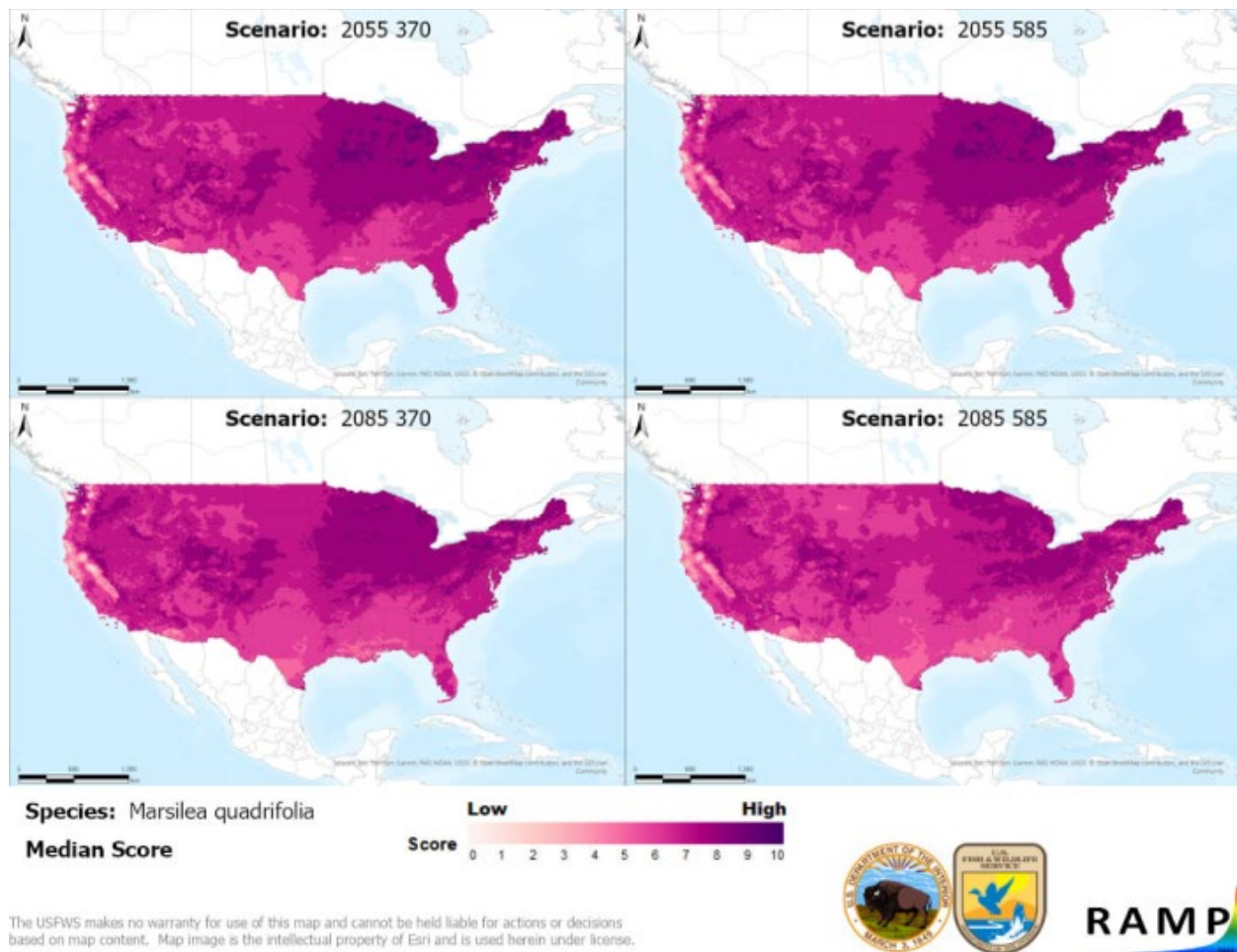


Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Marsilea quadrifolia* in the contiguous United States. Climate matching is based on source locations reported by Simpson and Crank (2008) and 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.

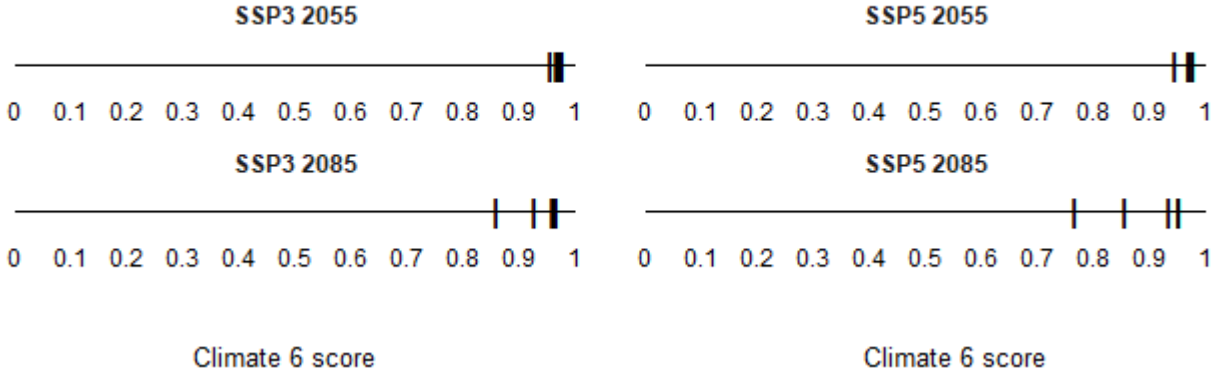


Figure A2. Comparison of projected future Climate 6 scores for *Marsilea quadrifolia* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018;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

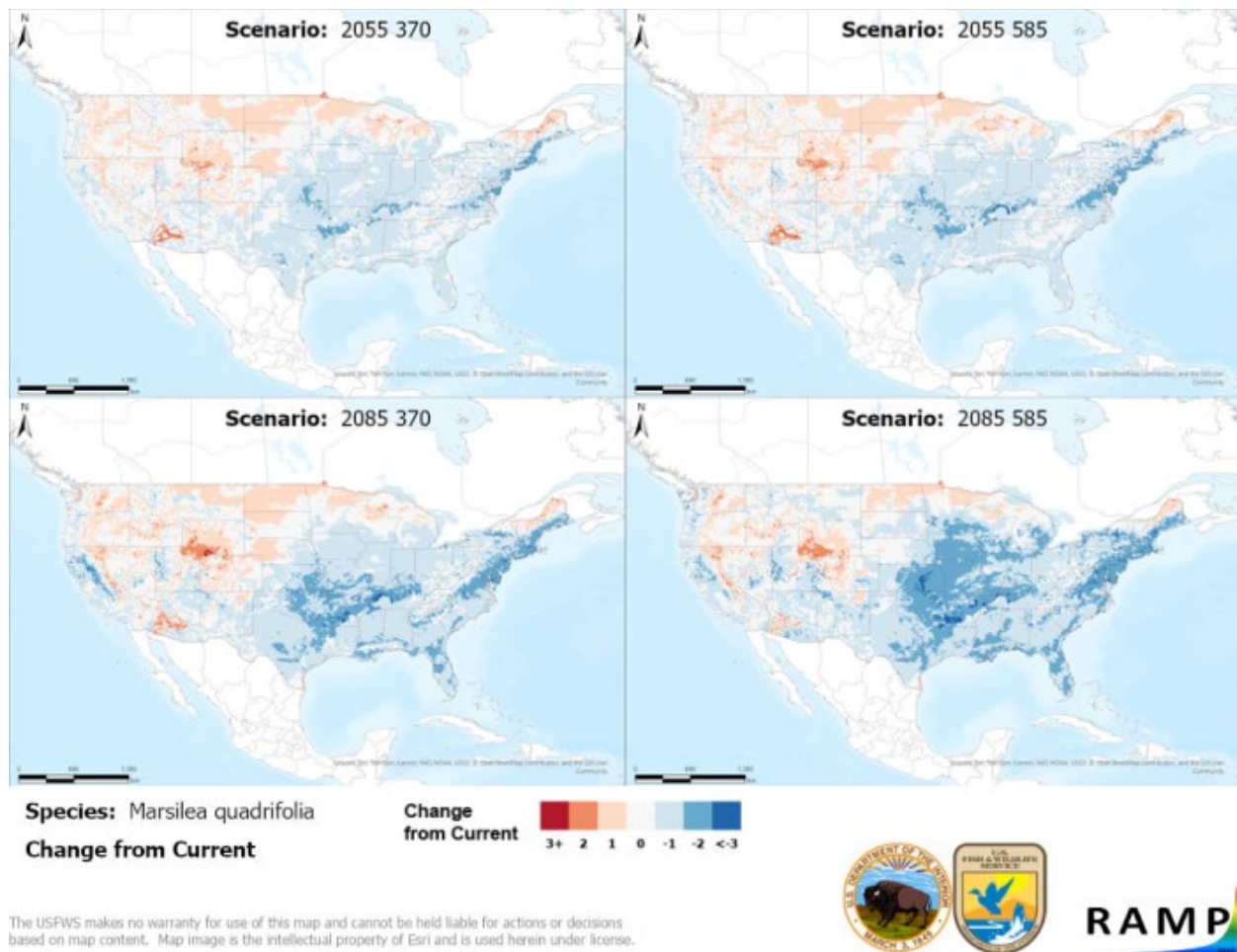


Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Marsilea quadrifolia* based on source locations reported by Simpson and Crank (2008) and 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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