Large-flower Primrose-willow (*Ludwigia grandiflora*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, February 2023
Revised, July 2023
Web Version, 3/24/2025

Organism Type: Flowering Plant
Overall Risk Assessment Category: High

Photo: US Army Corps of Engineers. Public Domain. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=253 (June 2023).

1 Native Range and Status in the United States

Native Range

From Mikulyuk (2009):

"*L. grandiflora* is a productive emergent perennial native to South and Central America and parts of the USA."

Status in the United States

Pfingsten and Reaver (2021) list nonindigenous occurrences of *Ludwigia grandiflora* in Alabama, Arkansas, California, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

From Pfingsten et al. (2021; under the name *Ludwigia hexapetala*):

"There is questions [sic] if the species is native to the southeastern US. Its earliest records date to South Carolina in 1844 and Georgia in 1864; its [sic] unclear if these records reflect a lack of early collections or introductions (Jacono 2014)."

Simpson et al. (2022) lists *Ludwigia grandiflora* as a "widespread invasive (category E)" in the lower 48 States, which is defined as a species that is "invasive with individuals dispersing, surviving and reproducing at multiple sites across a spectrum of habitats and geographic range."

According to Mikulyuk (2009), *Ludwigia grandiflora* is present in the water garden trade.

Regulations

Ludwigia grandiflora is regulated in California (CFDA 2021; under the synonym *L. hexapetala*), New York (NYDEC 2022; under the synonym *L. hexapetala*), North Carolina (North Carolina DEQ 2023; under the synonym *L. hexapetala*), Oregon (ODA 2022), Pennsylvania (PDA 2022; under *Ludwigia grandiflora* ssp. *hexapetala*), South Carolina (SCDNR 2010; under the synonym *L. hexapetala*), and Washington (Washington State NWCB 2023; under the synonym *L. hexapetala*). 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 Pfingsten and Reaver (2021):

"The primary introduction pathway is through the ornamental plant trade (Jacono 2014). Secondarily *L. grandiflora* is dispersed as stem fragments carried by water and waterfowl (Les 2018)."

Remarks

A previous version of this ERSS was published in 2018. Revisions were done to incorporate new information and conform to updated standards.

L. grandiflora was previously considered part of the *L. uruguayensis* species complex (Zardini et al. 1991a). Recent taxonomic work on that complex has split it in two primary ways: two distinct species, *L. grandiflora* and *L. hexapetala*, or a single species, *L. grandiflora*, with two subspecies, *L. grandiflora* subsp. *grandiflora* and *L. grandiflora* subsp. *hexapetala* (e.g., Zardini

et al. 1991a; Barloy et al. 2024). This screening follows the treatment found in World Flora Online (WFO 2023) where *L. hexapetala* is considered a valid subspecies of *L. grandiflora*. See additional information below.

From Mikulyuk (2009):

"*L. grandiflora* was originally listed along with closely-related *Ludwigia hexapetala* as separate species *Ludwigia uruguayensis*, which was at the time understood to be one of the most variable members of sect. *Oligospermum*. Evidence from Zardini et al. (1991[b]), however, revealed that in fact, *L. uruguayensis* included two chromosomal variants: a hexaploid (n = 24) and a decaploid (n = 40) form. This observation formed the basis of splitting *L. uruguayensis* to *L. hexapetala* and *L. grandiflora*. However, Nesom and Kartesz (2000) argue for treating the two species as subspecies (*L. grandiflora* subsp. *grandiflora* and *L. grandiflora* subsp. *hexapetala*, comb. et stat. nov.), and both treatments can be found in recent literature (cf Okada et al., 2009; Ruaux et al., 2009)."

Information searches for this screening were conducted using the name *Ludwigia grandiflora* and the synonyms *L. uruguayensis* and *Jussiaea grandiflora*. Information pertaining to the two recognized subspecies, *L. grandiflora* subsp. *grandiflora* and *L. grandiflora* subsp. *hexapetala*, was also included in this screening. When appropriate, the focal subspecies is indicated for included information.

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 Rosanae
Order Myrtales
Family Onagraceae
Genus *Ludwigia*
Species *Ludwigia grandiflora* (Michx.) Greuter & Burdet

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

Size, Weight, and Age Range

From Pfingsten and Reaver (2021):

"[…] pedicels 1-5 cm, […] acute sepals, 10-12 mm, pubescent on the outside; corolla of 5, sometimes 6, bright yellow, rounded petals, 1-2 cm long and wide; stamens 8-12, twice the amount of sepals/petal"

"[…] fruit a pubescent, cylindric capsule 1-2.5 cm long, 3-4mm wide"

From Mikulyuk (2009):

"[…] stems become pubescent and can grow up to 1 m tall (USACE-ERDC, 2009)."

Environment

From Thouvenot et al. (2013):

"*L. grandiflora* inhabits marshes, swamps, ponds, lakes, ditches, channels and slow-running rivers, as well as wet meadows (Lambert et al., 2010)"

From Okada et al. (2009):

"The emergent aquatic perennial plants are found in slow-flowing rivers, at lake and reservoir margins, and in the shallow waters of canals and floodplains."

From Billet et al. (2017):

"Several localities of the French Atlantic coast are now being invaded by terrestrial form, where it is continuously expanding […]"

"Aquatic and terrestrial environments differ greatly in terms of oxygen availability and have likely contributed shaping the aquatic and terrestrial morphological types (morphotypes) of *L. grandiflora*."

From Pfingsten and Reaver (2021):

"Tolerances: fresh to brackish (0-3.5 ppt salinity); pH 6.1-7.3; depths to 2.4 m; elevations to 102 m; poorly drained muck and sandy clay; fire-, flood-, graze-, and mow- tolerant over short periods (Les 2018)"

Climate

From Vanderhoeven (2013):

"The species is found in temperate, Atlantic and Mediterranean climates (Dutartre et al., 2007). There is an evident lack of specific data on the cold tolerance of *L. grandiflora*. Although

emergent parts of the plant are killed by frost, submerged, buried parts of the plants and rhizomes are reported to survive the wintertime if they are not enclosed in ice."

Distribution Outside the United States

Native

From Mikulyuk (2009):

"*L. grandiflora* is a productive emergent perennial native to South and Central America […]"

From POWO (2023):

"Native to: […], Argentina Northeast, Argentina Northwest, […], Bolivia, Brazil South, […], Cuba, […], Guatemala, […], Paraguay, […], Uruguay, […]"

Introduced

From POWO (2023):

"Introduced into: Belgium, France, Greece, Spain"

From Hussner et al. (2016):

"In Germany, a first population was found in an oxbow lake of the River Leda in Lower Saxony, north-western Germany, in 2004."

From Armitage et al. (2013):

"*L. grandiflora* subsp. *hexapetala* became naturalised [in France] first after it was introduced to the Lez river, Montpellier, in about 1830. However, in the southern part of France, this taxon has been displaced by *L. peploides* during the twentieth century (Dandelot et al., 2005)."

"The first record of a non-native *Ludwigia* [*L. grandiflora* subsp. *hexapetala*] growing outside gardens in the UK is from 1998 when a plant was reported from Barn Elms in Barnes, London (Burton, 1999). This was followed in 1999 by records from two ponds on Barton on Sea golf course, South Hampshire (Clement, 2001). Subsequent reports have been scattered over a wide range from Dorset to Yorkshire and have shown a steady increase in frequency over time."

From Fried et al. (2015):

"*L. grandiflora* is widespread and invasive in the South and West of France but its distribution is still very limited in the North and East of France, as well as in Belgium, Germany, Ireland, Italy, the Netherlands, Spain and the UK where invasion is at an early stage."

"Note: the species has been eradicated from Switzerland."

"Introduced Range: […] Africa: Kenya (Thendi, 1996 in DEFRA, 2008)."

From NIES (2025):

“Subsp. of this species (*L. grandiflora ssp.grandiflora*) are established in Hyogo pref, Shiga pref and Wakayama pref. [Japan]”

Means of Introduction Outside the United States

From Nehring and Kolthoff (2010):

“[…] was intentionally released in 1830 in southern France […]”

From Mikulyuk (2009):

“Humans may be the primary vector of transmission. *L. grandiflora* has been historically valued as an ornamental; ornamental plantings likely explain its introduction to Europe (Ruaux et al., 2009). Due to its presence in the horticultural trade, it is likely that propagules of this plant are occasionally present as hitchhikers, and included in orders of non-target species. It is possible that this plant may unintentionally be introduced in mixed-species planting orders.”

Short Description

From EDDMapS (2023):

“The leaves *L. grandiflora* [sic] attach alternately to the pubescent stems. In early growth stages the leaves usually have a rounded shape growing rosette-like around the villous stem. Once *L. grandiflora* begins to flower, the leaves lengthen, becoming much more lanceolate to elliptic in shape. Leaves are pilose.”

“*L. grandiflora* has large yellow flowers that arise from the leaf axils. Each flower has 5-6 petals. Flowers are about 1-2 inches (2-5 cm) in diameter. The floral tube is noticeably shorter than the pedicel.”

“The fruit of *L. grandiflora* is a cylindrical capsule that is divided into 5 chambers. Fruits have a woody endocarp (inner layer). The seeds are embedded in the endocarp.”

Biology

From Pfingsten and Reaver (2021):

“Life history: self-compatible flowers will self-fertilize; most reproduction is through vegatative fragmentation of stems; flowers from April to September; seeds remain embedded in woody capsules (Okada et al. 2009; Les 2018)”

“Community interactions: pollinated by generalists (bees, butterflies, and flowerflies); waterfowl consume the seeds of *L. grandiflora*; *Lysathia ludoviciana* leaf beetles consume the foliage of *L. grandiflora* (Les 2018)”

From EDDMapS (2023):

“It grows quickly, covers large areas and forms very dense mats.”

“Estimates put seed production at 10,000 seeds for every square meter of *L. grandiflora*. *L. grandiflora* also reproduces from plant fragments. The fragments float and are easily spread by the current or wind blowing along the surface of the water.”

Human Uses

From Mikulyuk (2009):

“The bright yellow, rather showy flowers of *L. grandiflora* make it an interesting specimen for aquaculture.”

“This plant is still offered for sale through internet horticultural distributors.”

“*L. grandiflora* has been historically valued as an ornamental.”

From Oku et al. (2020):

“[…] *L. grandiflora* could be partially used as alternative roughage for ruminants.”

From Fried et al. (2015):

“According to a recent study analyzing the identity and quantity of aquatic plants imported in 10 EPPO countries between 2005 and 2007 (Brunel, 2009), *L. grandiflora* has been imported as an ornamental plant in France during the sole month of April 2006 from Indonesia (100 units) and from Singapore (170 units). In Austria, the species has been imported from Malaysia (750 units) for the whole year 2006, and in Latvia from Thailand (250 units) from January 2005 until April 2007.”

Diseases

From Mikulyuk (2009):

“Wild host of: *Pomacea maculata*; *Xylella fastidiosa* (Pierce's disease of grapevines)”

Threat to Humans

No information was found on threats to humans from *Ludwigia grandiflora*.

3 Impacts of Introductions

From Mikulyuk (2009):

"The species possesses an allelopathic activity that changes water quality throughout the year and can lead to impoverished flora by decreasing seedling survival of vulnerable native taxa (Dandelot et al., 2008)."

"*L. grandiflora* has been shown to cause severe hypoxia or even anoxia during summer months as well as leading to reduced sulphate and nitrate levels and increased sulphide and phosphate concentrations, leading to what Dandelot et al. (2005) refer to as 'a dystrophic crisis' and an intoxicated ecosystem."

From Stiers et al. (2014):

"*L. grandiflora* increased the floral display in a community and attracted pollinators to the area which than [sic] also visited the native *L. salicaria*."

From Stiers et al. (2011):

"Our research on 32 ponds in Belgium indicated that the reduction in the native plant species richness was a common pattern to invasion."

"On average, the impact of *H. ranunuloides* and *L. grandiflora* was stronger (decrease [in native plant species] of about 70%) compared to a 57% decrease for *M. aquaticum* from uninvaded A plots to heavily invaded C plots."

"Mean invertebrate taxa richness, mean invertebrate abundance and the diversity index were slightly higher in the uninvaded ponds and lowest in the *L. grandiflora* invaded ponds, but no significant differences were found among the four types of vegetation ($P > 0.05$)."

"Species compositions in heavily invaded plots by *H. ranunculoides* and *L. grandiflora* were significantly different from species compositions in uninvaded plots."

From Stiers and Triest (2017):

"In particular, large cladocerans and littoral taxa were absent when the cover of invasive species was high. This is possibly due to low dissolved oxygen concentrations, physical obstruction and a putative allelopathic property of the invasive plants."

From Vanderhoeven (2013):

"In several ponds in the Landes region (South-West of France), decreases of *Potamogeton natans*, *Myriophyllum spicatum*, *Iris pseudacorus* and *Ludwigia palustris* have been observed as a consequence of competition with *L. grandiflora* and *Lagarosiphon major* (Dutartre, 2002). Based on floristic analyses in different areas of a marsh colonized by *L. grandiflora* in Brittany, Haury et al. (2009) showed that, in similar conditions, *L. grandiflora*

outcompetes *Phalaris arundinacea*, *Glyceria maxima*, *Phragmites australis* and *Polygonum hydropiper*. They also recorded an overall reduced number of species."

"Besides competition with other plant species, the presence of *L. grandiflora* has been associated in some ecosystems with a reduction of macroinvertebrates and fish (Grillas et al., 1992; Dutartre et al., 1997; Dandelot 2004). One reason might be that dense populations of *Ludwigia spp*. constitute a barrier for the movement of the fish (Legrand, 2002) and may promote hypoxic conditions inducing fish kills and loss of invertebrate diversity (van de Meutter, personal communication 2013)."

"First, the high biomass production leads to reduced water flow (Dutartre, 1988) in channels, ditches and shallow rivers. This causes increased sedimentation, which leads to higher flood risk. Plant and animal communities change, including fish disappearing from dense beds (Dutartre [et al.], 2007). In standing open waters, the slow litter decomposition induces shallowing and succession to swamp and marsh vegetation. The allelopathic compounds released in the water contribute to alter ecosystem processes and are expected to affect different kinds of organisms (Dandelot et al., 2008; Dutartre [et al.], 2007)."

"A decrease in pH is also commonly observed due to the lack of photosynthesis below the water surface (Dandelot et al., 2005[…])."

"[…] *Ludwigia* species […] are problematic in irrigation channels, dams/reservoirs and canals and rivers (Non Native Species Secretariat, 2011). The floating mats can be colonised by other plants (sedges, grasses and later shrubs and trees). Floating islands can be created which could pose serious flood risk issues in the man-made landscapes (Dandelot, 2004)."

"In California, the cost of mechanical removal from two wetlands varied between US$3017 and US$ 9682 per ha according to the habitat type while the cost of chemical control varied between US$1313 and US$4377 per ha (McNabb and Meisler 2006)."

"Stands of *Ludwigia spp.* can be very dense, forming several metres long floating islands preventing activities such as angling, boating or hunting (Menozzi, 2005)."

From Okada et al. (2009):

"Dense stands have degraded natural communities, reduced water quality and flood water retention, and prevented effective mosquito control."

Ludwigia grandiflora is regulated in California, New York, North Carolina, Oregon, Pennsylvania, South Carolina, and Washington. See section 1.

4 History of Invasiveness

The History of Invasiveness for *Ludwigia grandiflora* is classified as High. *Ludwigia grandiflora* is established outside its native range. Impacts from the established nonnative populations have included changes to water chemistry, changes in species abundance and richness across taxa groups, and changes to water flows and accessibility.

5 Global Distribution

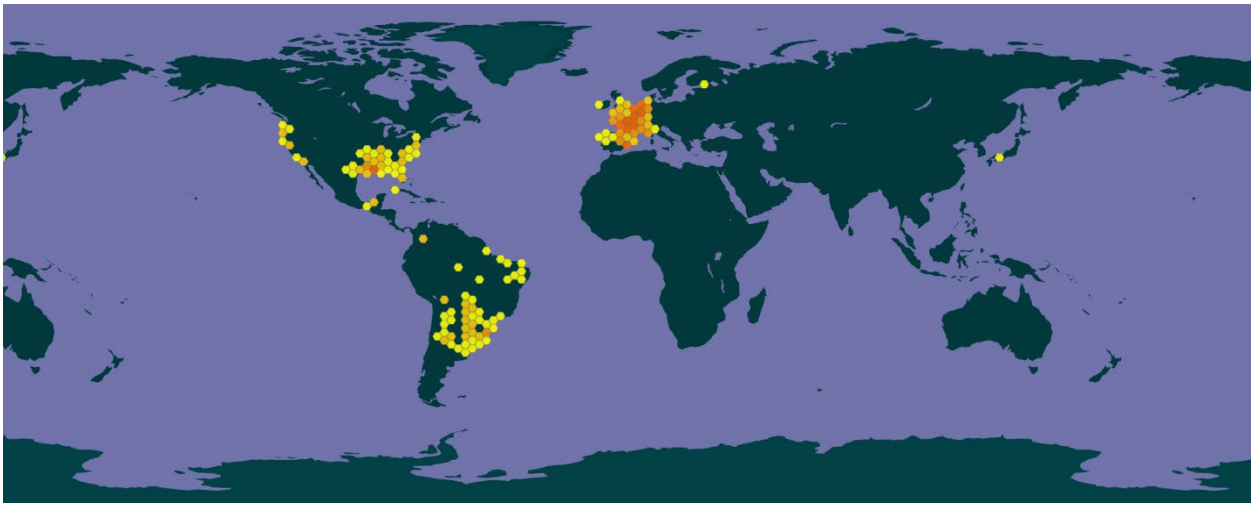

Figure 1. Reported global distribution of *Ludwigia grandiflora*. Map from GBIF Secretariat (2022). Observations are reported from North America, South America, Europe, and Japan. No information was found confirming a population in Finland, therefore, that observation was not used to select source points for the climate matching analysis.

No specific georeferenced observations were found for the reported introduced range in Kenya (Fried et al. 2015).

6 Distribution Within the United States

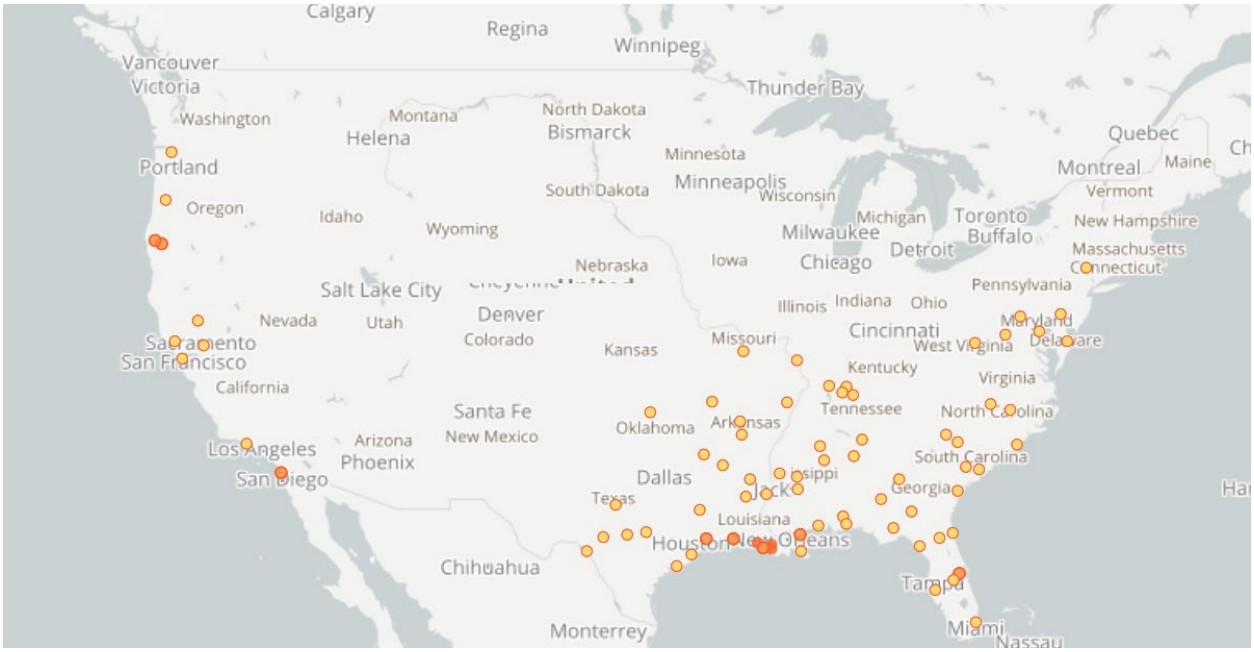

Figure 2. Reported distribution of *Ludwigia grandiflora* in the United States. Map from GBIF-US (2023).

7 Climate Matching

Summary of Climate Matching Analysis

The contiguous United States had generally high climate match for *Ludwigia grandiflora*. Areas of high match were recorded along the Gulf and Atlantic Coasts and into the southern Midwest as well as along the Pacific Coast and in patches in the Western Mountains. Areas with low climate match were found in the Northern Plains, and in patches in both the Colorado Plateau and the Northern Pacific Coast region. The overall Climate 6 score (Sanders et al. 2021; 16 climate variables; Euclidean distance) for the contiguous United States was 0.871, 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 *Ludwigia grandiflora* (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.

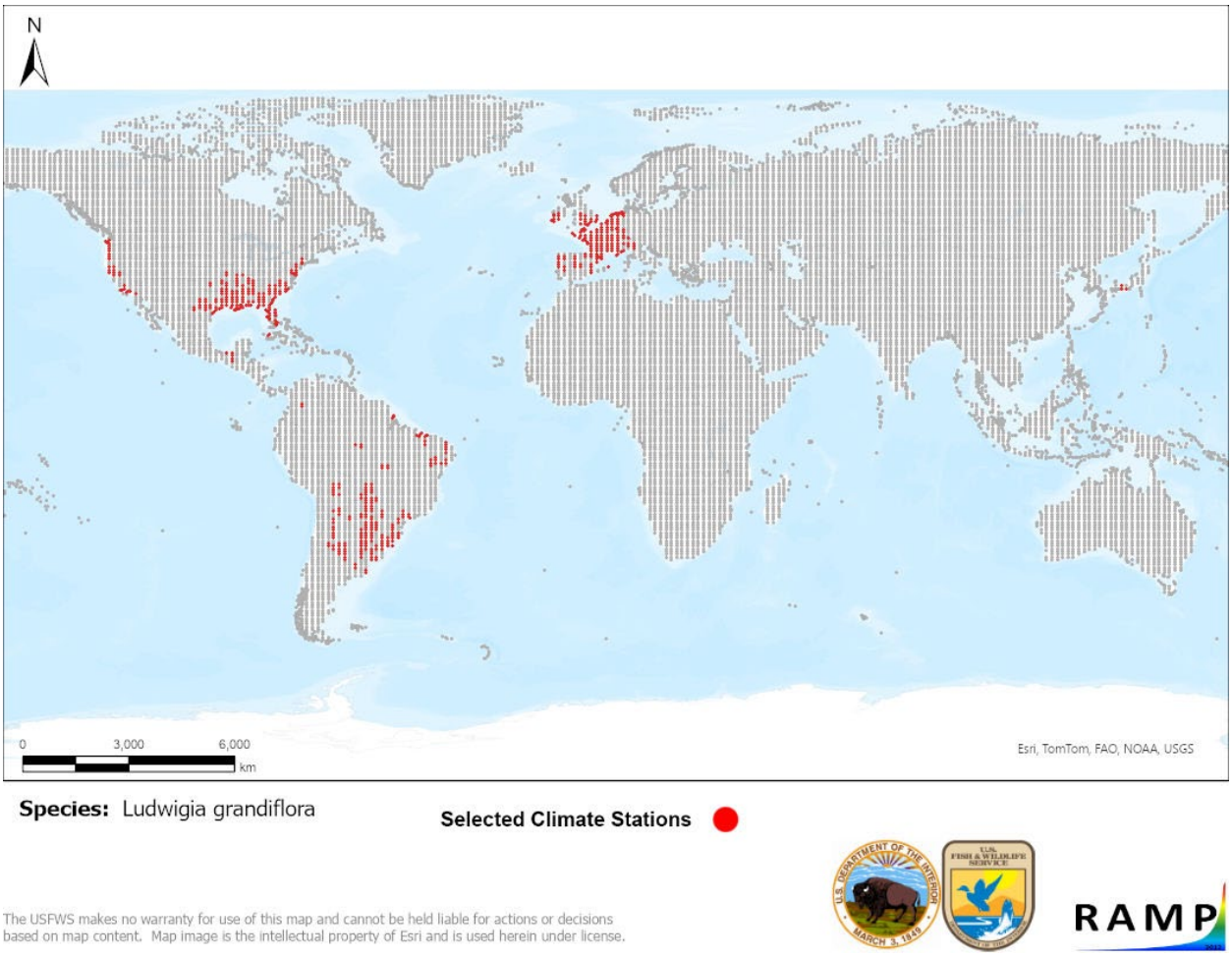

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in the world selected as source locations (red; United States of America; Belgium, France, United Kingdom of Great Britain and Northern Ireland, Japan, Italy; Ireland, Germany, Spain, Greece; Switzerland, the Netherlands, Brazil, Argentina, Uruguay, Colombia, Paraguay, and Mexico) and non-source locations (gray) for *Ludwigia grandiflora* 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.

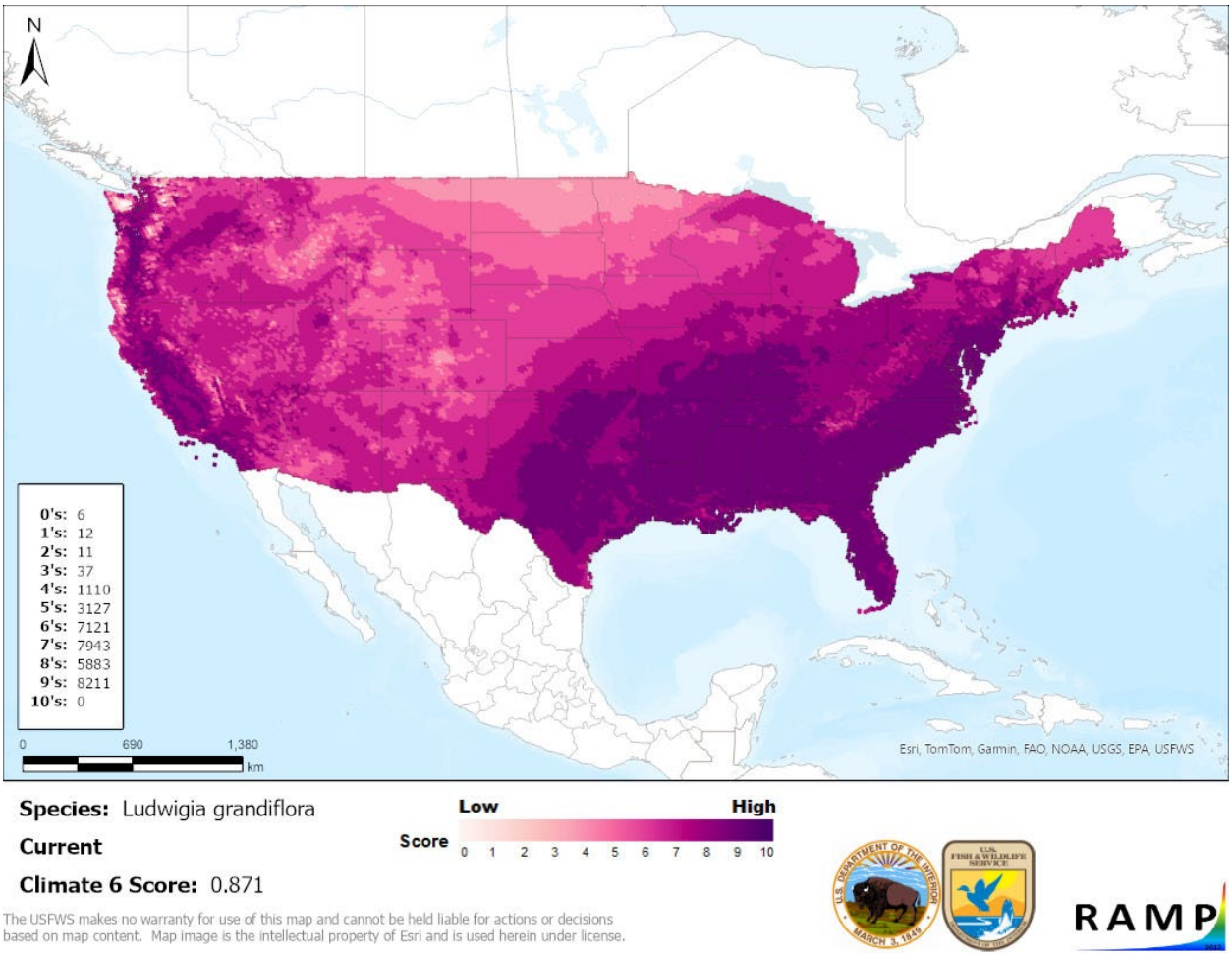

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Ludwigia grandiflora* in the contiguous United States based on source locations reported by GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Ludwigia grandiflora* is classified as High. Abundant, clear, and convincing information is available about *Ludwigia grandiflora*'s biology, distribution, introductions, and negative impacts of introduction from peer-reviewed scientific literature.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Ludwigia grandiflora, large-flower primrose-willow, is a flowering plant that is native to South and Central America and possibly parts of the United States. *Ludwigia* grandiflora grows quickly, covers large areas and forms dense mats, leading to negative impacts on water quality, native biodiversity, human and fish navigation, and recreational activities. Within the United States, *L. grandiflora* is regulated in seven states. The History of Invasiveness for *Ludwigia grandiflora* is classified as High due to *L. grandiflora* being established outside its

native range and a plethora of clear, convincing, and reliable documentation of negative impacts of introduction. The climate matching analysis for the contiguous United States indicates establishment concern for this species. Areas with the highest climate match were located in the Southeast, Northeast, southern Midwest, and along the Pacific coast. The Certainty of Assessment is classified as High due to the abundant, clear, and convincing information available about *Ludwigia grandiflora*'s distribution and negative impacts of introduction from peer-reviewed scientific literature. The Overall Risk Assessment Category for *Ludwigia grandiflora* 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: None**
- **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 (2022).

Under the future climate scenarios (figure A1), on average, high climate match for *Ludwigia grandiflora* was projected to occur in the Appalachian Range, California, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Southeast, Southern Atlantic Coast, Southern Florida, and Southern Plains regions of the contiguous United States. Areas of medium match were found in the extreme Northern Plains with larger areas occurring under time step 2085. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.859 (model: MPI-ESM1-2-HR, SSP5, 2085) to a high of 0.968 (model: GFDL-ESM4, 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 (0.871, 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, Great Lakes, Northeast, and Northern Plains 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 California saw a large decrease in the climate match relative to current conditions. Additionally, areas within the Appalachian Range, Great Basin, Gulf Coast, Mid-Atlantic, Northern Pacific Coast, Southeast, Southern Atlantic Coast, Southern Florida, Southern Plains, Southwest, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. The extent of the areas of moderate decrease were larger under time step 2085 than 2055 for both SSP3 and SPP5. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

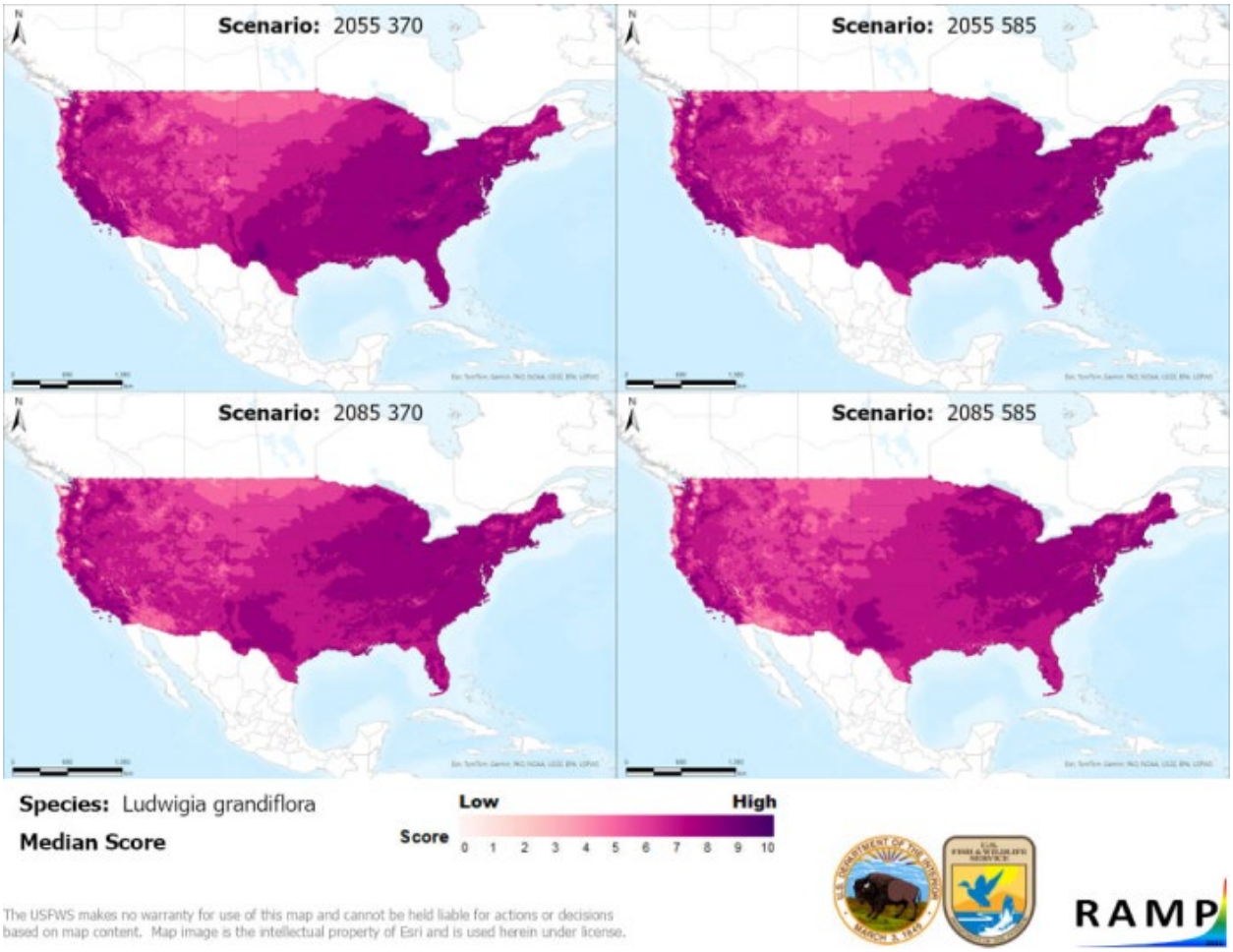

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Ludwigia grandiflora* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2022). Shared 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.

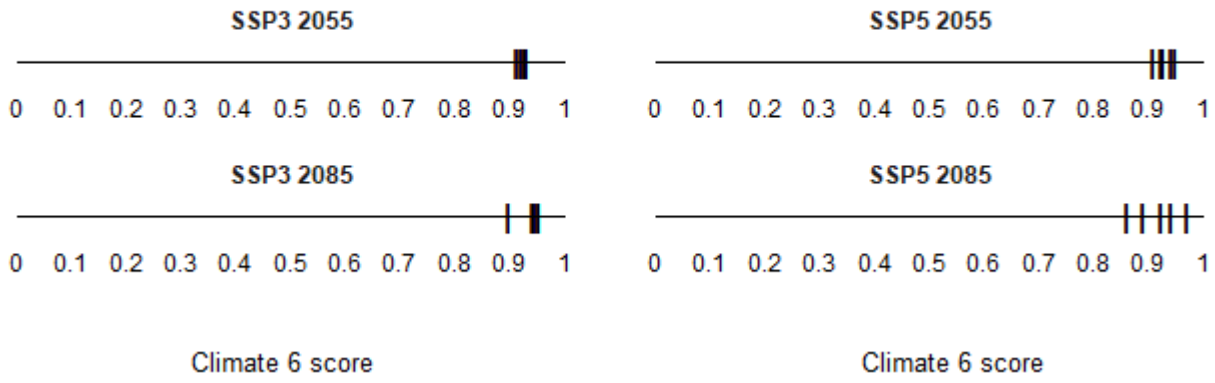

Figure A2. Comparison of projected future Climate 6 scores for *Ludwigia grandiflora* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018;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

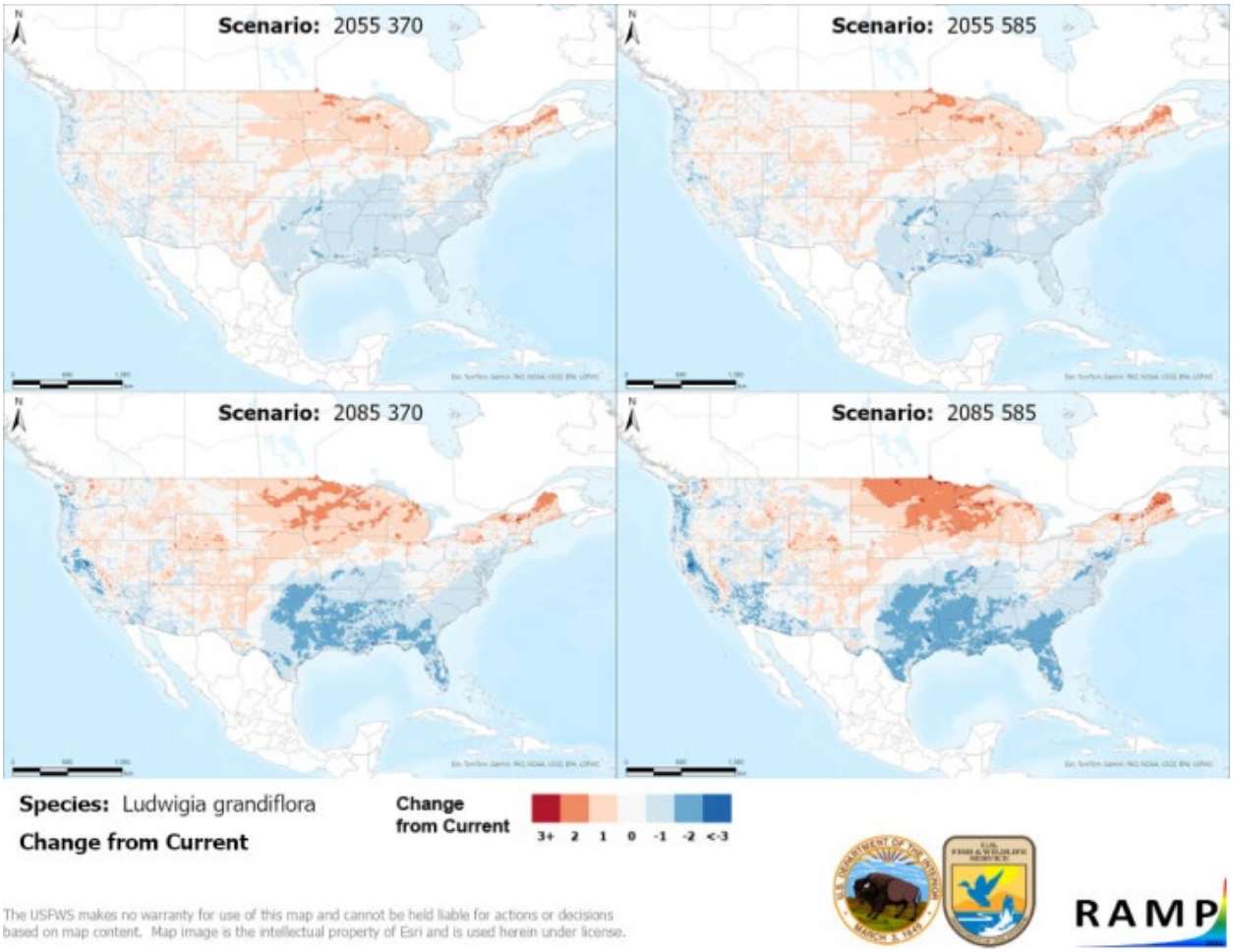

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Ludwigia grandiflora* based on source locations reported by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