

# Lesser Pond Sedge (*Carex acutiformis*)

## Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, January 2023  
Revised, February 2023  
Web Version, 7/23/2024

Organism Type: Flowering Plant  
Overall Risk Assessment Category: High



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[https://commons.wikimedia.org/wiki/File:Carex\\_acutiformis.jpg](https://commons.wikimedia.org/wiki/File:Carex_acutiformis.jpg) (January 2023).

## 1 Native Range and Status in the United States

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### Native Range

From Tropicos.org (2023):

“Distribution: Europe, Africa, Turkey, Caucasus, Iran, Siberia and southwards in C. Asia from Altai [southern Russia] to Afghanistan, Pakistan and Kashmir.”

From POWO (2023):

“Native to:

Afghanistan, Albania, Algeria, Altay [southern Russia], Austria, Baltic States, Belarus, Belgium, Bulgaria, Cape Provinces [South Africa], Central European Rus[sia], Corse [France], Czechoslovakia, Denmark, East European Russia, Eritrea, Ethiopia, Finland, France, Free State [South Africa], Germany, Great Britain, Greece, Hungary, Iran, Iraq, Ireland, Italy, Kazakhstan, Kirgizstan, Krym [Crimean Peninsula], KwaZulu-Natal [South Africa], Lebanon-Syria, Lesotho, Morocco, Netherlands, North Caucasus [southern Russia], North European Russia, Northern Provinces [South Africa], Northwest European R[ussia], Norway, Pakistan, Palestine, Poland, Romania, Sardana, Sicilia, South European Russia, Spain, Sweden, Switzerland, Tadjikistan, Tanzania, Transcaucasia [Georgia, Azerbaijan], Turkey, Turkmenistan, Uganda, Ukraine, Uzbekistan, West Himalaya [India, Pakistan], Yugoslavia”

## Status in the United States

According to Cao et al. (2023a), nonindigenous occurrences of *Carex acutiformis* have been reported in the following States. Range of observation years, watersheds, and populations status where reported (one or more watersheds) in parentheses.

- Connecticut (2008; New England Region; collected)
- Delaware (2008; Mid Atlantic Region; collected)
- Indiana (1951–2008; Ohio Region, St. Joseph; established)
- Maryland (2008; Mid Atlantic Region; collected)
- Massachusetts (1865–2008; New England Region; established)
- Michigan (1998–2014; Boardman-Charlevoix, Lake Michigan; established)
- New York (2008; Long Island; collected)
- Rhode Island (2008; New England Region; collected)

From Cao et al. (2023a):

“**Status:** Established [in the United States]”

From Cao et al. (2023b):

“Currently, there are few reported populations of *C. acutiformis* in the Great Lakes, suggesting that it is a relatively rare introduction. [...] In 1982, *C. acutiformis* was observed forming a near monoculture around the entirety of St. Joseph Lake, South Bend, IN.”

No records of *Carex acutiformis* in trade in the United States were found.

## Regulations

No species-specific regulations on possession or trade were found within the United States for *Carex acutiformis*.

## Means of Introductions within the United States

From Cao et al. (2023a):

“It is suspected that this plant [*Carex acutiformis*] was introduced through hay from Europe. There are concerns that it may spread from roadside ditches where it occurs. The seeds, rhizome and root masses of the plant may attach to animals or possibly road maintenance equipment/ vehicles passing through a stand of this plant.”

## Remarks

From Cao et al. (2023b):

“As of 1992, a total of 253 *Carex* hybrids have been reported in North America. This indicates that this genus is highly capable of hybridization, and invasive species, such as *C. acutiformis*, may be a genetic threat to native sedge species (Cayouette and Catling 1992).”

“However, the swamp sedge [*C. acutiformis*] is often misidentified as the native water sedge (*C. aquatilis*), which could limit its documentation.”

“Based on its competitive dominance in Stony Swamp, Ottawa, Ontario, *C. acutiformis* was identified as a high priority invasive plant by the Canada Botanical Association in 2004, ranking 14th overall among invasive plants (Catling 2005).”

## 2 Biology and Ecology

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### Taxonomic Hierarchy and Taxonomic Standing

According to WFO (2023), *Carex acutiformis* Ehrh. is the accepted name for this species.

From ITIS (2023):

Kingdom Plantae  
Subkingdom Viridiplantae  
Infrakingdom Streptophyta  
Superdivision Embryophyta  
Division Tracheophyta  
Subdivision Spermatophytina  
Class Magnoliopsida  
Superorder Lilianae  
Order Poales  
Family Cyperaceae  
Genus *Carex* L.  
Species *Carex acutiformis* Ehrh.

## Size, Weight, and Age Range

From Tropicos.org (2023):

“[...] perennial, 60-120 cm.”

## Environment

From Cao et al. (2023a):

“It is found in open swamps, wet, open thickets, marsh edges, sedge meadows, eutrophic fens, and along the shores of ponds, rivers, and lakes, 0–300 m from shoreline.”

According to CABI (2019), *Carex acutiformis* is associated with terrestrial and freshwater habitats.

## Climate

From Cao et al (2023a):

“Germination occurs at temperatures above 15°C, peak emergence is in early summer, and fruiting occurs June–August (Schütz 1998).”

From POWO (2023):

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

## Distribution Outside the United States

Native

From Tropicos.org (2023):

“Distribution: Europe, Africa, Turkey, Caucasus, Iran, Siberia and southwards in C. Asia from Altai [southern Russia] to Afghanistan, Pakistan and Kashmir.”

From POWO (2023):

“Native to:

Afghanistan, Albania, Algeria, Altay [southern Russia], Austria, Baltic States, Belarus, Belgium, Bulgaria, Cape Provinces [South Africa], Central European Rus[sia], Corse [France], Czechoslovakia, Denmark, East European Russia, Eritrea, Ethiopia, Finland, France, Free State [South Africa], Germany, Great Britain, Greece, Hungary, Iran, Iraq, Ireland, Italy, Kazakhstan, Kirgizstan, Krym [Crimean Peninsula], KwaZulu-Natal [South Africa], Lebanon-Syria, Lesotho, Morocco, Netherlands, North Caucasus [southern Russia], North European Russia, Northern Provinces [South Africa], Northwest European R[ussia], Norway, Pakistan, Palestine, Poland, Romania, Sardana, Sicilia, South European Russia, Spain, Sweden, Switzerland, Tadjikistan, Tanzania, Transcaucasia [Georgia, Azerbaijan], Turkey, Turkmenistan, Uganda, Ukraine, Uzbekistan, West Himalaya [India, Pakistan], Yugoslavia”

## Introduced

From POWO (2023):

“Introduced into: [...] Ontario”

## Means of Introduction Outside the United States

From Catling and Kostiuk (2003):

“It seems most likely that European Lake Sedge [*Carex acutiformis*] arrived at the Ottawa [Canada] site in hay from Europe. A number of farms existed in the immediate vicinity which may have introduced hay from Europe. [...] It is fruiting abundantly and it appears to be capable of spread of perigynia by both adhesion to a variety of mammals such as beaver and muskrat and ingestion by waterfowl. Since it occurs along a major road in the ditch and along the ditch banks, another potential method of spread is transport of root masses and rhizomes by road maintenance vehicles.”

## Short Description

From Cao et al. (2023a):

“Plants colonial; rhizomes long-creeping. Culms central, coarse, trigonous, 55–130 cm, scabrous-angled. Leaves: basal sheaths pale green to brownish or red tinged; ligules 5–14 mm; blades glaucous, M-shaped, (4.5–)5.5–12(–20) mm wide, glabrous. Inflorescences 15–35 cm; proximal 2–5 spikes pistillate, ascending; distal spikes erect; terminal 1–2(–3) spikes staminate. Pistillate scales lanceolate, acute to acuminate, glabrous, at least the proximal with scabrous awn to 3.5 mm. Perigynia ascending, ± glaucous, often strongly red dotted, ± strongly 12–18-veined, thin-walled, narrowly ovoid, flattened-trigonous, 3–4.5 × 1.4–2.1 mm, glabrous; beak 0.3–0.6 mm, emarginate to weakly bidentulate, teeth to 0.2 mm.  $2n = 78$ . Superficially resembles *C. aquatilis*, but is larger, has 3 stigmas, and has strongly veined perigynia 3–4.5 mm.”

## Biology

From Cao et al (2023a):

“*Carex acutiformis* is a monocotyledonous perennial with laterally extending rhizomes and, in its native range, is capable of forming dense stands up to 1 m high (Hirose et al. 1989). It is found in open swamps, wet, open thickets, marsh edges, sedge meadows, eutrophic fens, and along the shores of ponds, rivers, and lakes, 0–300 m from shoreline. In dense stands of *C. acutiformis*, individual plants tend to have greater leaf area and higher leaf nitrogen concentrations in the top-most leaves, maximizing individual photosynthetic capacity (Hirose et al. 1989, Schieving et al. 1992). However, *C. acutiformis* also has a high leaf area ratio in general relative to other fen sedges (Konings et al. 1992). It also has a relatively high efficiency in nitrogen (N) use, but is less efficient in phosphorus (P) use (Aerts and de Caluwe 1994, Konings et al. 1992).”

“Tall *Carex* species, such as *C. acutiformis*, may dominate fens that are rainwater fed and base-poor relative to short *Carex* species, which tend to dominate base-rich fens (Verhoeven and Arts

1992). In acidic waters (e.g., base-poor fens), the decomposition of cellulose in *C. acutiformis* [sic] plant matter may occur slowly, preventing the full release of nutrients until 3-4 years after death and immobilizing N and P for a longer period of time relative to other sedges (Aerts and de Caluwe 1997, Verhoeven and Arts 1992). However, because *C. acutiformis* produces more leaf litter than most sedges, it may actually facilitate a higher rate of nutrient cycling than what the other sedges attain (Aerts and de Caluwe 1997).”

“Germination occurs at temperatures above 15°C, peak emergence is in early summer, and fruiting occurs June–August (Schütz 1998). Percent emergence (from seed) is very low at shaded sites, possibly due to a relatively high minimum temperature requirement. In European populations, the production of viable seed in *C. acutiformis* is low relative to that of other sedges, suggesting that clonal reproduction is favored (Schütz 1998).”

## Human Uses

From Cao et al. (2023b):

“*Carex acutiformis* has been used in horizontal subsurface-flow constructed wetlands in Denmark, Slovenia, and Germany (Vymazal 2011). *Carex acutiformis* (in combination with *Spartina pectinata* and *Phragmites australis*) was successful in removing 91.6% of the ammonium concentration and 80.6% of organic nitrogen in a treatment wetland in Germany, which was developed to treat dairy farm wastewater (Vymazal and Kröpfelová 2008).”

## Diseases

No information was found on diseases associated with *Carex acutiformis*.

## Threat to Humans

No information was found on threats to humans from *Carex acutiformis*.

# 3 Impacts of Introductions

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From Catling and Kostiuk (2003):

“In 2003 we visited the site [in Ottawa, Ontario, Canada] to further evaluate its [*Carex acutiformis*] dominance. It dominated an area of approximately 6 acres of moist open marsh with scattered trees of Tamarack, Eastern White Cedar, White Birch, and American Elm. Along a 3 m wide transect 215 m in length, representing 645 m<sup>2</sup> quadrats, the sedge had a frequency of 100% and of its surface area (cover) was 100 to 500 % of the surface area of each quadrat, with an approximate average of 200%. The only other species present are listed in Table 1 [in source material]. These are all native and none contributes more than a fraction of a percentage of the cover. The very extreme dominance of European Lake Sedge is clear from the frequency and cover values of the native species. A general survey confirmed that the sampled area was representative of the 6 acre stand. In general native species were either trees or confined to more recent mounds produced by ants.”

“Although much of the area it dominates is relatively uniform as described above, the European Lake Sedge at the Stony Swamp site has a remarkable ecological amplitude. It grows in hummocks around open water up to 1 m deep. Here the rhizomes grow out into the water and extend the hummock. There is some evidence that European Lake Sedge may be controlled in wetlands by reduction in water level (Kazda 1995), but at the Stony Swamp site it grows in some relatively dry semi-open areas where the vegetation is dominated by an old field association of *Daucus carota* L. (Wild Carrot) and *Poa compressa* L. (Canada Blue Grass). In these areas the sedge is 100% cover or less, but still dominant up to the edge of the more diverse association.”

“European Lake Sedge is unusual among sedges in its high canopy and large amount of leaf area (Aerts & DeCaluwe 1994). This allows both photosynthetic carbon gain and suppression of other species in the competition for light. It is a highly productive species in its native range and is characteristic of eutrophic wetlands. Its leaf litter decomposes more slowly than that of other species of sedge (Aerts and DeCauwe 1997). The litter immobilizes more N and P for longer periods than the litter of other species (Corona and Verhoeven 1999). The characteristic dense cover of the current year growth as well as the dense accumulation of litter forming a dense subcanopy were characteristic of the Stony Swamp population. The extreme dominance of this introduced sedge may be attributable to a combination of successful competition for nutrients and competition for light as a result of both dense green cover and smothering by persisting dead leaves from the previous year. The effect of litter accumulation may be greater in base-poor waters (more acid waters over granite or sandstone) due to slower cellulose decay than occurs in base-rich waters (Verhoeven & Arts 1992).”

From Cao et al. (2023b):

“Currently, there are few reported populations of *C. acutiformis* in the Great Lakes, suggesting that it is a relatively rare introduction. However, the swamp sedge is often misidentified as the native water sedge (*C. aquatilis*), which could limit its documentation. It does not appear to disperse well across long distances, but where it establishes, it is capable of spreading locally via rhizomes and displacing native species (A. Reznicek, pers. comm.). In 1982, *C. acutiformis* was observed forming a near monoculture around the entirety of St. Joseph Lake, South Bend, IN. Similarly, *C. acutiformis* was discovered dominating a 6-acre open marsh area in the Stony Swamp Conservation Area near Ottawa, ON. In this conservation area, *C. acutiformis* co-existed with native trees but had displaced nearly all other native plants in both open water and some relatively dry areas (Catling and Kostiuk 2003). Thus, this species may be a very serious threat to native vegetation on a local geographic scale due to its ability to spread rapidly via vegetative growth and out-compete native species for nutrients and light (Catling and Kostiuk 2003; A. Reznicek, pers. comm.) It may also smother native plants via accumulation of its excess litter (Catling and Kostiuk 2003).”

“*Carex acutiformis* has been found to have a longer lifespan and create more above ground plant biomass than three of the native sedge species: *C. diandra*, *C. rostrata*, and *C. lasiocarpa* (Aerts and Caluwe 1995, Konings et al. 1989). *Carex acutiformis* was also the most efficient in nitrogen use relative to production of biomass (Konings et al. 1992).”

No species-specific regulations on possession or trade were found within the United States for *Carex acutiformis*.

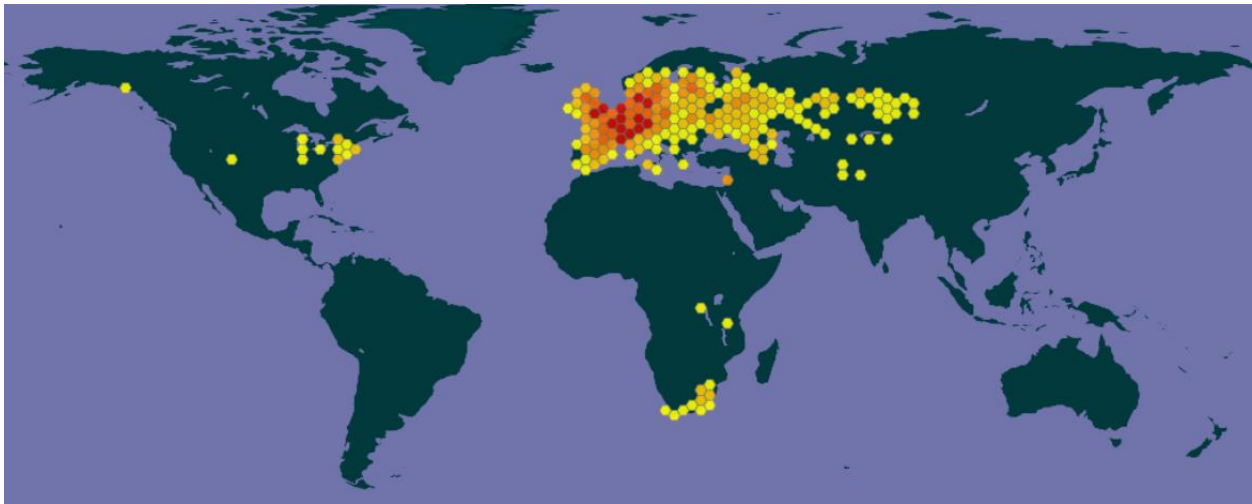
## 4 History of Invasiveness

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The History of Invasiveness for *Carex acutiformis* is classified as High. There are recorded nonnative introductions that have resulted in established populations of this species in North America. There is information on negative impacts of introductions, particularly in Ontario, Canada where *C. acutiformis* has displaced native vegetation creating dense monocultures. *C. acutiformis* is in trade within its native range and has been used in constructed wetlands. However, no information was available on trade volume or the occurrence of trade outside the native range.

## 5 Global Distribution

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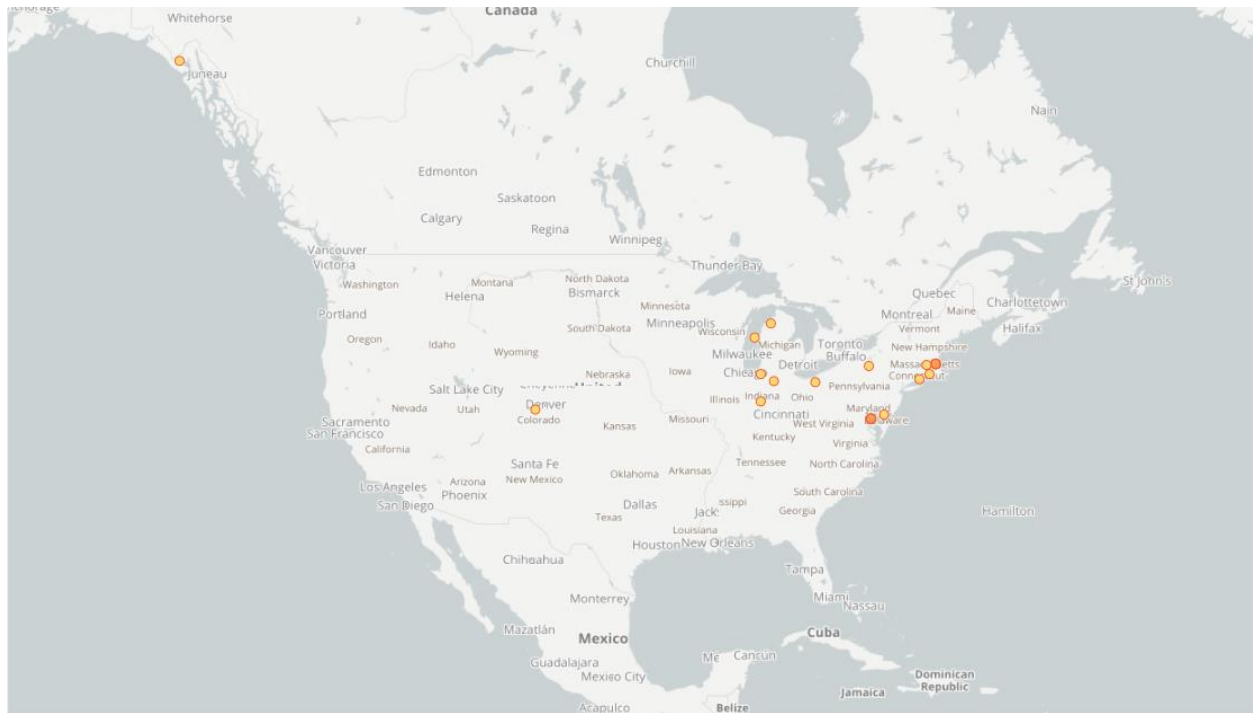


**Figure 1.** Reported global distribution of *Carex acutiformis*. Map from GBIF Secretariat (2023). Observations are reported from throughout Eurasia and in southern Africa, the United States, and Canada. Locations in Colorado and Alaska were not used in the climate matching analysis as they were not found to represent established populations.



## 6 Distribution Within the United States

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**Figure 2.** Reported distribution of *Carex acutiformis* in the United States. Map from GBIF-US (2023). Observations are reported from Connecticut, Indiana, Delaware, Massachusetts, Maryland, Michigan, Rhode Island, and New York. Locations in Colorado and Alaska were not used in the climate matching analysis as they were not found to represent established populations.

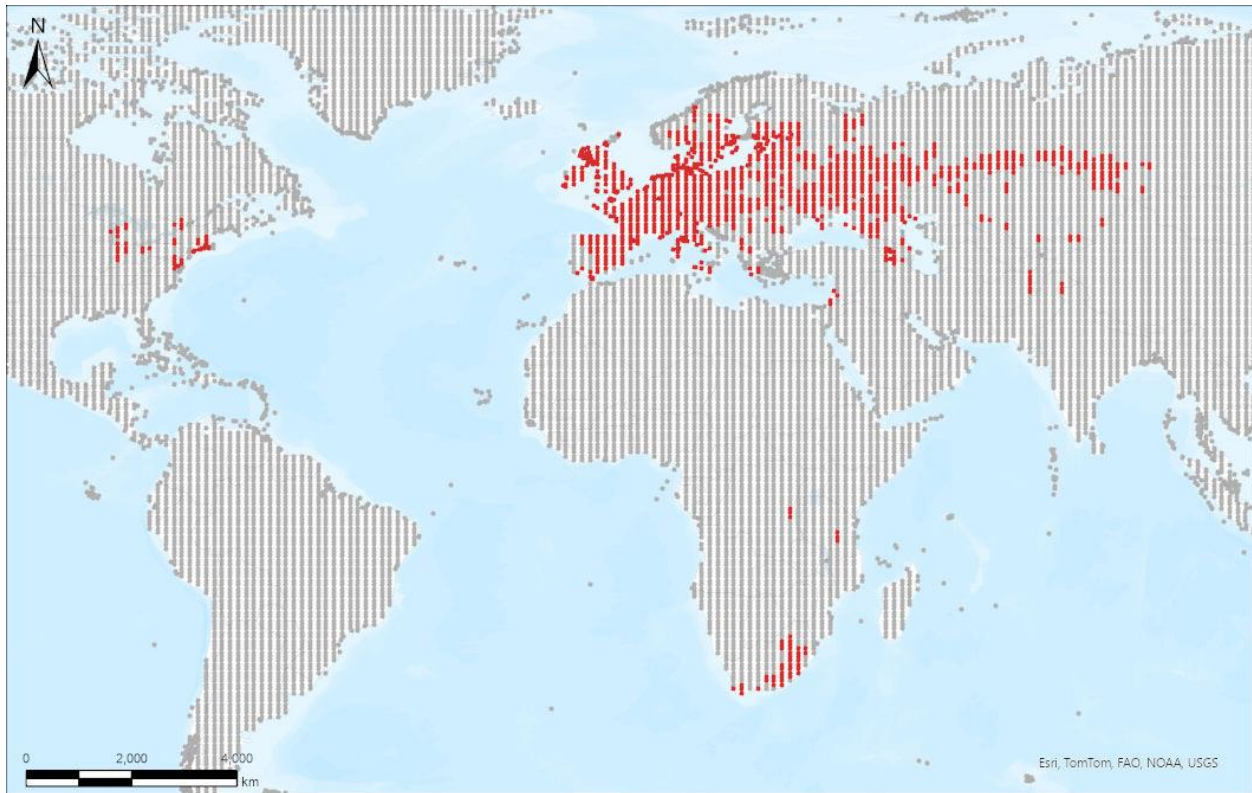
## 7 Climate Matching

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### Summary of Climate Matching Analysis

Most of the contiguous United States had a high climate match. Regions of particularly high match were reported from the Atlantic Coast, Great Lakes region, and portions of the Intermountain West. The only regions of low climate match scores were along the Gulf Coast, the Desert Southwest, and portions of the Pacific Northwest. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.946, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as:  $(\text{count of target points with scores} \geq 6) / (\text{count of all target points})$ . 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 *Carex acutiformis* (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.



Species: *Carex acutiformis*

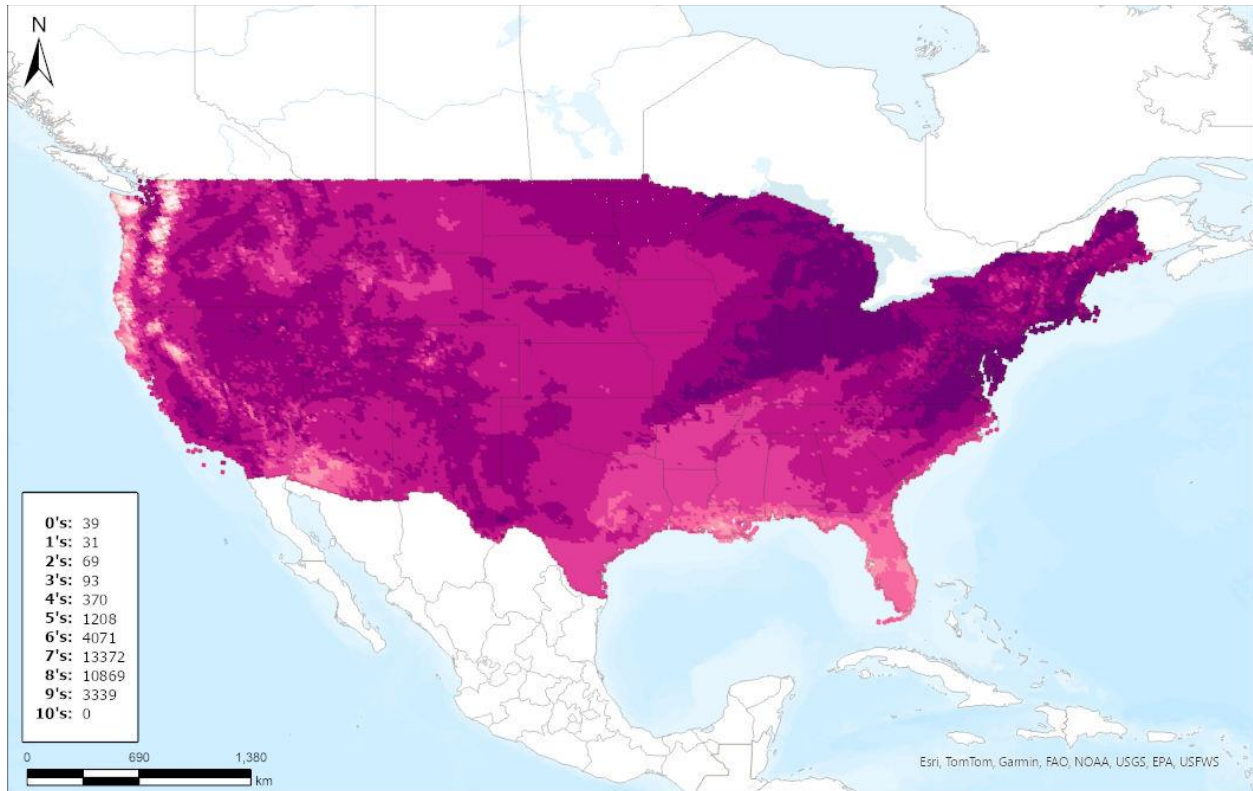
Selected Climate Stations ●



RAMP

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**Figure 3.** RAMP (Sanders et al. 2023) source map showing weather stations in North America, Europe, Asia, and Africa selected as source locations (red; southeastern Canada, northeastern United States, throughout Europe, western Asia, southern Africa) and non-source locations (gray) for *Carex acutiformis* 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.



Species: *Carex acutiformis*

Current

Climate 6 Score: 0.946



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**Figure 4.** Map of RAMP (Sanders et al. 2023) climate matches for *Carex acutiformis* 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 *Carex acutiformis* is classified as Medium. There is reasonably complete information regarding the biology and distribution of this species. Although *C. acutiformis* has been introduced to North America and is currently established in parts of the northeastern United States and southeastern Ontario, distribution in North America remains unclear due to its similarity to native sedges and ability to spread undetected. Negative impacts of introduction have been reported for *C. acutiformis*, primarily the near-total displacement of native plants in some locations. However, assessment of these impacts is currently limited to anecdotal accounts or gray literature reducing the Certainty of Assessment from High to Medium.

## 9 Risk Assessment

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### Summary of Risk to the Contiguous United States

*Carex acutiformis*, also known as the Lesser Pond Sedge, is native to Eurasia—north to Scandinavia and eastward to western China and central Siberia—and Africa. *C. acutiformis* is found in most wetlands and along a variety of water bodies where it can potentially form extensive monospecific stands. Likely introduced via European hay or other agricultural exports, *C. acutiformis* has been reported beyond its native range in Canada and the United States. Within the United States, introductions have occurred in the Northeast and Great Lakes regions. *C. acutiformis* does not appear to disperse well naturally across long distances, although its seeds, rhizome, and root masses could be transplanted via animals, equipment, or vehicles that have passed through established stands. The History of Invasiveness is classified as High as there was information on realized negative impacts of introductions, particularly in Ontario, Canada where *C. acutiformis* has displaced native vegetation creating dense monocultures. The climate matching analysis for the contiguous United States indicates establishment concern for this species. Regions of particularly high matches were reported from the Atlantic Coast, the Great Lakes region, and portions of the Intermountain West. The Certainty of Assessment for this ERSS is classified as Medium due to the information on impacts of introductions being from grey literature. The Overall Risk Assessment Category for *C. acutiformis* 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): Medium**
- **Remarks, Important additional information: None**
- **Overall Risk Assessment Category: High**

## 10 Literature Cited

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

[CABI] CABI International. 2019. *Carex acutiformis* (Swamp sedge) [original text by CABI] CABI Invasive Species Compendium. Wallingford, United Kingdom: CAB International. Available: <https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.112972#abstract> (February 2023).

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- [USFWS] U.S. Fish and Wildlife Service. 2024. Standard operating procedure: how to prepare an “Ecological Risk Screening Summary.” Version 3.
- [WFO] World Flora Online. 2023. World Flora Online – a project of the World Flora Online Consortium. Available: <http://www.worldfloraonline.org> (January 2023).

## 11 Literature Cited in Quoted Material

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**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.**

- Aerts R, De Caluwe H. 1994. Nitrogen use efficiency of *Carex* species in relation to nitrogen supply. *Ecology* 75:2362–2372.

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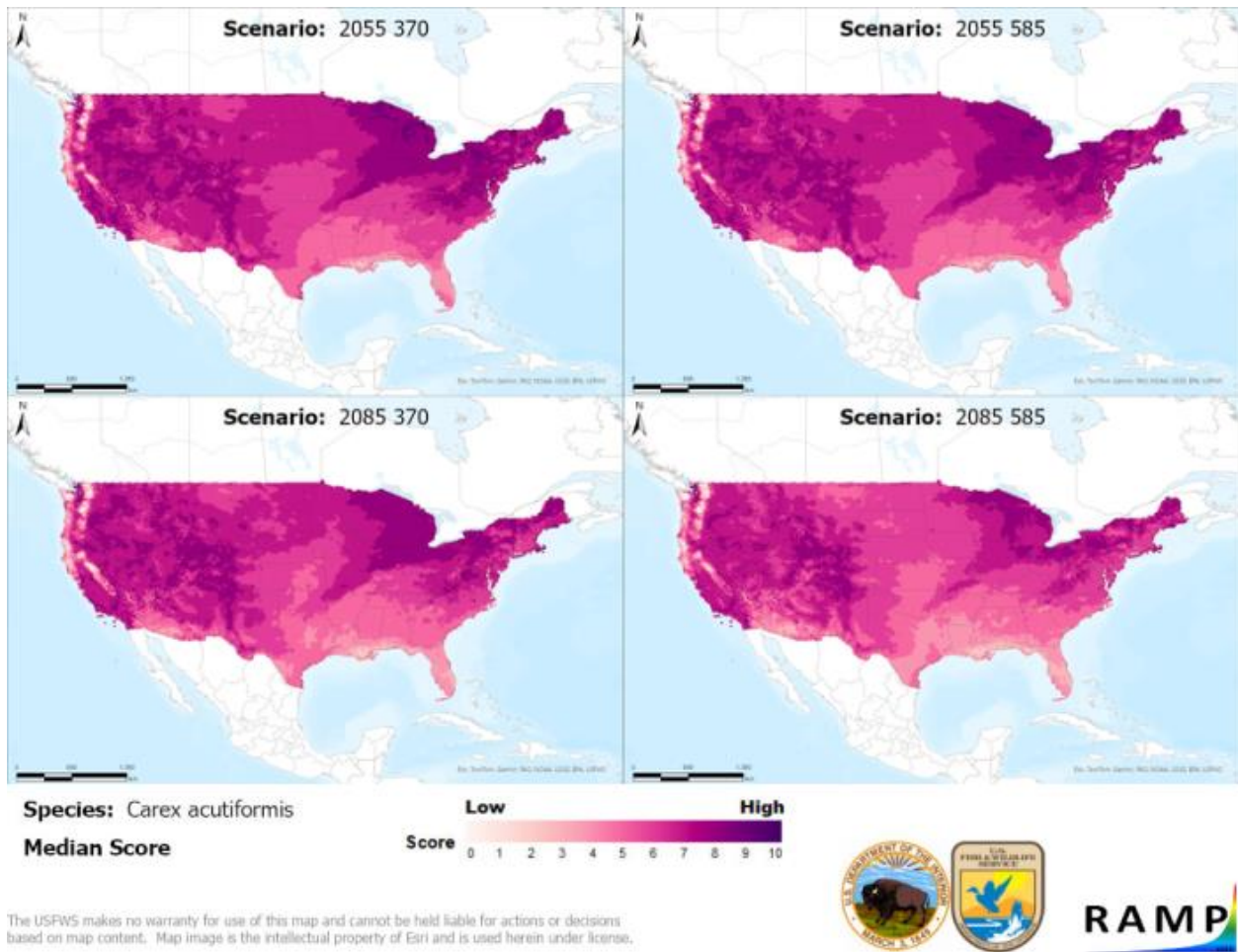
# Appendix

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## 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).

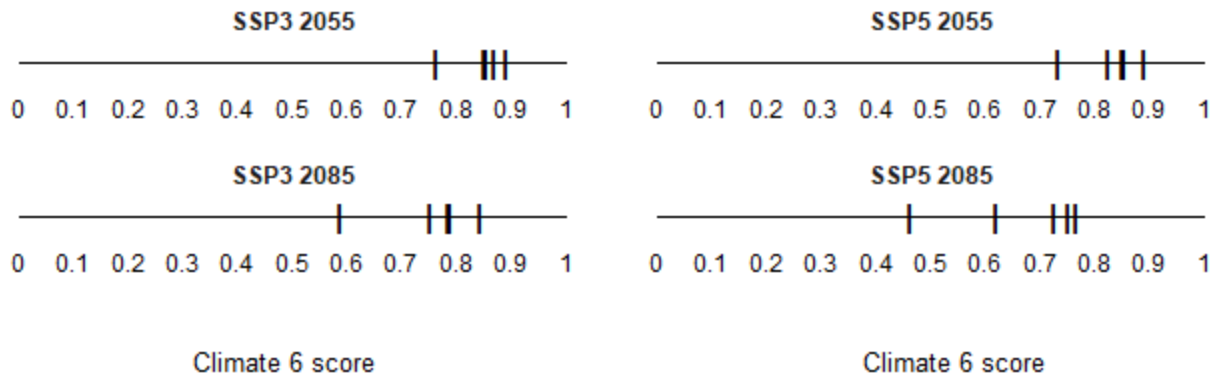
Under the future climate scenarios (figure A1), on average, high climate match for *Carex acutiformis* was projected to occur in California, the Colorado Plateau, Great Basin, Great Lakes, and Northeast regions of the contiguous United States. There were small patches of low match along the Pacific Coast and the Cascade-Sierra Range. In the 2085 time steps there was another area of low match along the Gulf Coast, extending further northward under SSP5 than SSP3. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.460 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.890 (model: MPI-ESM1-2-HR, 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 (0.946, figure 4) falls above 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 all time step and climate scenarios only minor or no increases in the climate match relative to the current match were observed. Under one or more time step and climate scenarios, areas within the Appalachian Range, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Southeast, Southern Atlantic Coast, and Southwest saw a large decrease in the climate match relative to current conditions. Additionally, areas within the California, Colorado Plateau, Great Basin, Northern Pacific Coast, Northern Plains, Southern Florida, Southern Plains, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. The areas of decrease increased in size greatly from 2055 to 2085 under both SSPs, as well as between SSP3 and SSP5 in the 2085 time step. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).



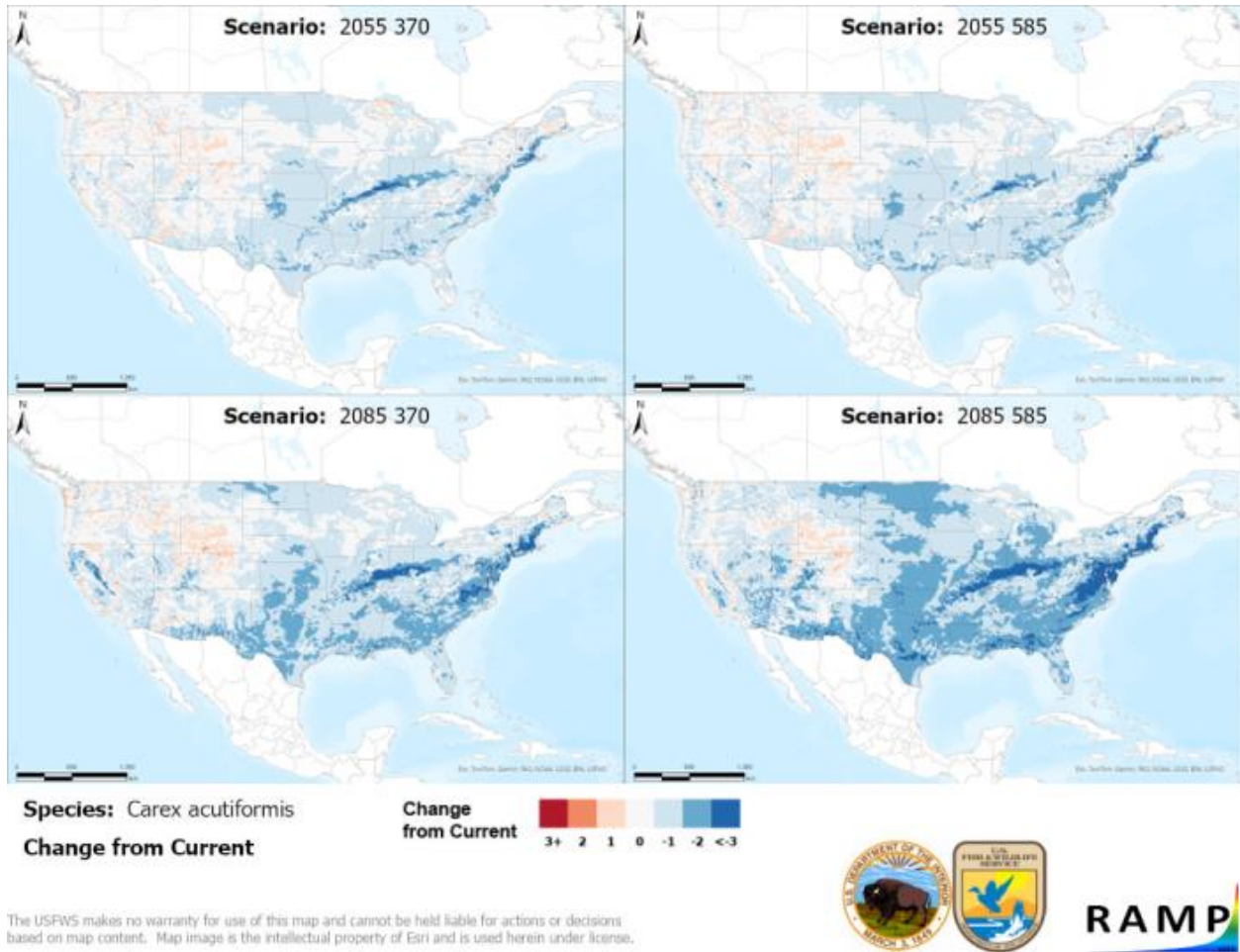
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**Figure A1.** Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Carex acutiformis* in the contiguous United States. Climate matching is based on source 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 *Carex acutiformis* 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.



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**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 *Carex acutiformis* 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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