Bolboschoenus novae-angliae

New England Bulrush

Cyperaceae

Bolboschoenus novae-angliae by Howard Horne, 2014

***Bolboschoenus novae-angliae* Rare Plant Profile**

New Jersey Department of Environmental Protection
State Parks, Forests & Historic Sites
Forests & Natural Lands
Office of Natural Lands Management
New Jersey Natural Heritage Program

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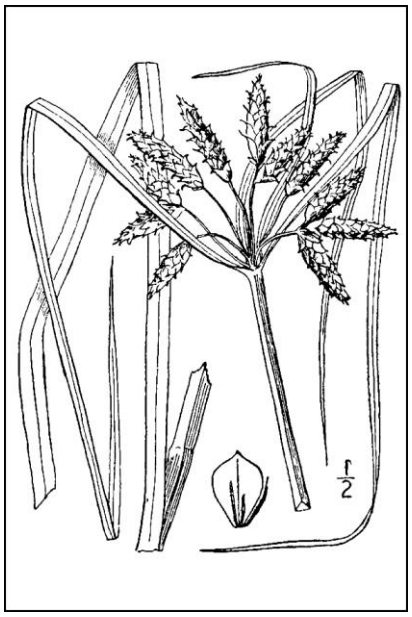
Life History

Bolboschoenus novae-angliae (New England Bulrush) is a robust, rhizomatous, perennial sedge. The genus name means bulb-bearing rush, a reference to the corms that are present at the base of the plants. Other species native to New Jersey include *B. fluviatilis*, *B. robustus*, and *B. maritimus* var. *paludosus*. The large, leafy plants are structurally similar to some species of *Scirpus* but can be distinguished by their larger spikelets and achenes and by their floral scales, which are both notched and prominently awned at the tips (Arsenault et al. 2013, Smith 2020). *Bolboschoenus novae-angliae* probably developed as a result of hybridization between *B. fluviatilis* and *B. robustus*: It is morphologically and ecologically intermediate between those two species (Browning et al. 1995, Smith 2020, Weakley et al. 2024). Beetle (1942) viewed *B. novae-angliae* as a subspecies of *B. robustus* but Fernald (1943) disagreed, characterizing the latter species as "beautifully distinct."



Left: Britton and Brown 1913, courtesy USDA NRCS 2024a. Right: Wayne Longbottom, 2020.

The culms of *Bolboschoenus novae-angliae* can be up to 1.5 meters tall and 1 cm in diameter. Four to nine leaves may be present on the stems: They are up to 7 dm in length and 6–13 mm wide with sheaths that are convex and papery at the top. The inflorescence of *B. novae-angliae* is a terminal cluster of 10–40 narrowly ovoid spikelets, the majority of which are on elongated branches. In both *B. maritimus* and *B. robustus* most of the spikelets are sessile. *B. novae-angliae* spikelets are 1.5–4 cm long, 5–6 mm wide, and reddish or orange-brown in color—they may be solitary or arranged in groups of 2–7 on the branches. Mature fruits are needed for positive identification and multiple achenes from the same plant should be examined. The achenes of *B. robustus* are a glossy dark brown and those of *B. fluviatilis* are a dull gray-brown whereas *B. novae-angliae* fruits are variable in color and shine, usually exhibiting characteristics of both parents (and sometimes even on the same achene). They are 3–4.3 mm long and 2.3–3.1 mm wide with short (0.1–0.5 mm) beaks. The achenes of *B. fluviatilis* are uniformly trigonous and the bristles remain firmly attached, often extending beyond the tip of the fruit. *B. novae-angliae* achenes are more likely to be somewhat compressed or even lenticular and the bristles

are weakly persistent and usually equal to or shorter than the achenes in length. The bristles of *S. robustus* and *S. maritima* are typically half the length of the achenes and the majority are not persistent. (See Britton and Brown 1913, Schuyler 1975, Gleason and Cronquist 1991, Strong 1994, Browning et al. 1995, Arsenault et al. 2013, Smith 2020).

Bolboschoenus novae-angliae generally flowers during late June or July and fruits from July through September (Strong 1994, NYNHP 2008, Weakley et al. 2024). Occasionally fruits can persist into October (MENAP 2021). Data collected in Massachusetts from 1910–1913 showed that *B. novae-angliae* plants were beginning to form spikes on June 10, still developing on June 20, in full flower on July 4, and had mature fruit on September 2 (Bicknell 1917). During 2020 seed-dispersing plants were observed in New Jersey on September 22 (NJNHP 2024).

Pollinator Dynamics

The majority of species in the Cyperaceae are pollinated by wind, and while there are a few notable exceptions no alternative pollination mechanisms have been reported in *Bolboschoenus* or related genera (eg. *Schoenoplectus*, *Scirpus*). In nearly all sedges the female flowers develop before the male flowers, which is thought to be a means of increasing the probability of cross-fertilization (Goetghebeur 1998). No information was found regarding self-compatibility in *Bolboschoenus*. Some species are known to hybridize but the offspring are often sterile (Smith 2020).

Seed Dispersal and Establishment

Bolboschoenus novae-angliae seeds are probably dispersed by both water and birds. The propagules of strongly halophytic *Bolboschoenus* species are reportedly able to float for many days but those of freshwater species usually sink rapidly (Leck and Schütz 2005). *B. robustus* seeds are lighter that water while those of *B. fluviatilis* are heavier. As with other features of *B. novae-angliae*, its seeds are intermediate relative to those of its parent species so some can float for a day or more but others sink fairly quickly (Browning et al. 1995). Avian species consume the achenes of many aquatic sedges and disperse viable seeds (Leck and Schütz 2005). *B. fluviatilis* has often been noted as an important source of food for waterfowl (Fassett 1957) and that likely applies to *B. novae-angliae* as well. Some vegetative dispersal may also occur. *B. fluviatilis* can spread by clonal growth and is capable of establishing at new sites via rhizome fragments (Leck and Schütz 2005).

Seed banking has been reported in both *Bolboschoenus fluviatilis* and *B. robustus* (Engel 1983, Baldwin et al. 2001, Leck and Schütz 2005). Studies of germination in *B. fluviatilis* found that seedling emergence was highest when the substrate was not flooded (Baldwin et al. 2001) and when seeds had been exposed to alternating temperatures of 20^{o} for 16 hours and 30^{o}C for 8 hours to simulate daily cycles (Geary 2023). *Bolboschoenus fluviatilis* and *B. robustus* both form mycorrhizal associations (Cooke and Lefor 1994), although it is not clear whether they are necessary for seedling establishment.

Habitat

Throughout its range, *Bolboschoenus novae-angliae* can be found growing at sea level in slightly brackish, tidally influenced wetlands such as marshes, shores, and estuaries (Fernald 1939, Strong and Kelloff 1994, NYNHP 2008, Gordon 2011, Arsenault et al. 2013, Smith 2020, MENAP 2021, NJNHP 2024). The sturdy rhizomes and corms support the plants and also help to stabilize the substrate and prevent erosion in the places where the sedge has become well-established (Naczi et al. 2018). Examination of the species' distribution in a Connecticut wetland showed that *B. novae-angliae* was most often situated on creek banks or levees and less frequently in the interior marsh (Moorehead et al. 2009). Ferren and Schuyler (1980) indicated that they had often observed *B. novae-angliae* along road embankments or other high areas in marshes that had been created by anthropogenic activities. New England Bulrush is nearly always located in open, sunny habitats (Weakley et al. 2024).

Bolboschoenus novae-angliae occupies a narrow ecological niche that is intermediate relative to those of its putative parents. *B. fluviatilis* is generally associated with fresh water and *B. robustus* favors more saline environments. *B. novae-angliae* is mainly located in the brackish transitional areas, where it may overlap with either of the other species near the edges of its preferred zone (Schuyler 1975, Ferren and Schuyler 1980, Strong 1994, Naczi et al. 2018). Kiviat et al. (2015) ranked a tidal wetland habitat from 1 (lower intertidal) to 3 (upper intertidal) and found *B. novae-angliae* in Zones 2 and 3. Salinity ranges recorded for the three species by Naczi et al. (2018) were 0.078–2.0 ppt (mean 0.10) for *B. fluviatilis*, 1.8–8.0 ppt (mean 3.3) for *B. novae-angliae*, and 4.9–16.0 ppt (mean 8.0) for *B. robustus*.

Ferren and Schuyler (1980) noted that while occurrences of *Bolboschoenus novae-angliae* were rare the sedge could sometimes become locally abundant. A similar observation was made by Moorehead et al. (2009), who observed that the bulrush was usually a minor associate in study plots where it was found but sometimes formed large patches several meters wide in which it was the dominant species. Reported associates of *B. novae-angliae* include *Amaranthus cannabinus, Cyperus bipartitus, Hibiscus moscheutos, Juncus gerardii, Peltandra virginica, Persicaria punctata, Pontederia cordata, Schoenoplectus americanus, Spartina* spp., and *Typha angustifolia* (Moorehead et al. 2009, Naczi et al. 2018, NJNHP 2024).

Wetland Indicator Status

Bolboschoenus novae-angliae is an obligate wetland species, meaning that it almost always occurs in wetlands (U. S. Army Corps of Engineers 2020).

USDA Plants Code (USDA, NRCS 2024b)

BONO

Coefficient of Conservancy (Walz et al. 2020)

CoC = 10. Criteria for a value of 9 to 10: Native with a narrow range of ecological tolerances, high fidelity to particular habitat conditions, and sensitive to anthropogenic disturbance (Faber-Langendoen 2018).

Distribution and Range

The global range of *Bolboschoenus novae-angliae* is restricted to the eastern United States (POWO 2024). The map in Figure 1 depicts the extent of the species in North America.

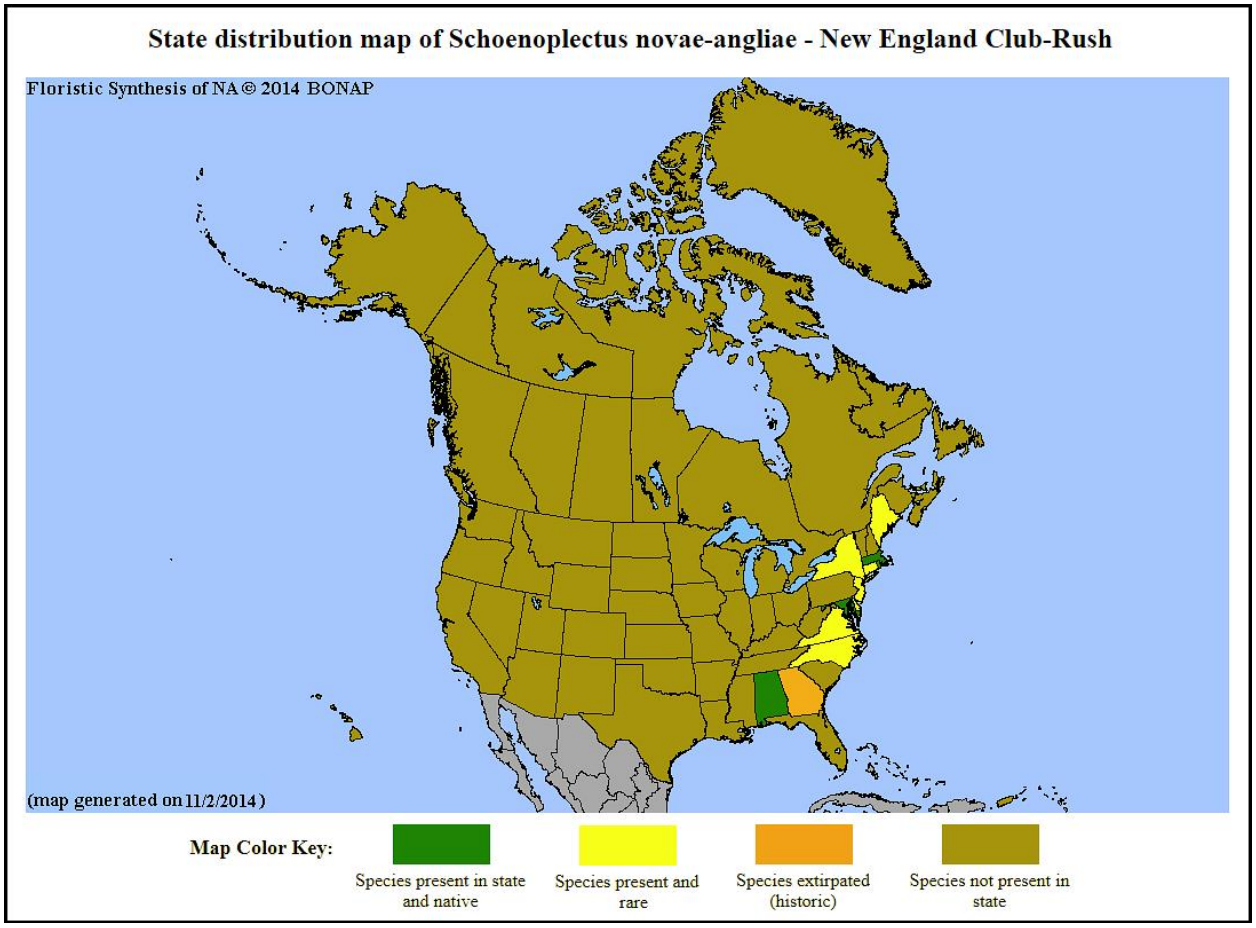


Figure 1. Distribution of B. novae-angliae in North America, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2024b) shows records of *Bolboschoenus novae-angliae* in three New Jersey counties: Burlington, Middlesex, and Salem (Figure 2 below). Herbarium records also exist for Atlantic, Bergen, Cape May, Cumberland, and Hudson counties (Schuyler 1975, Mid-Atlantic Herbaria 2024, NJNHP 2024). The data include historic observations and do not reflect the current distribution of the species.

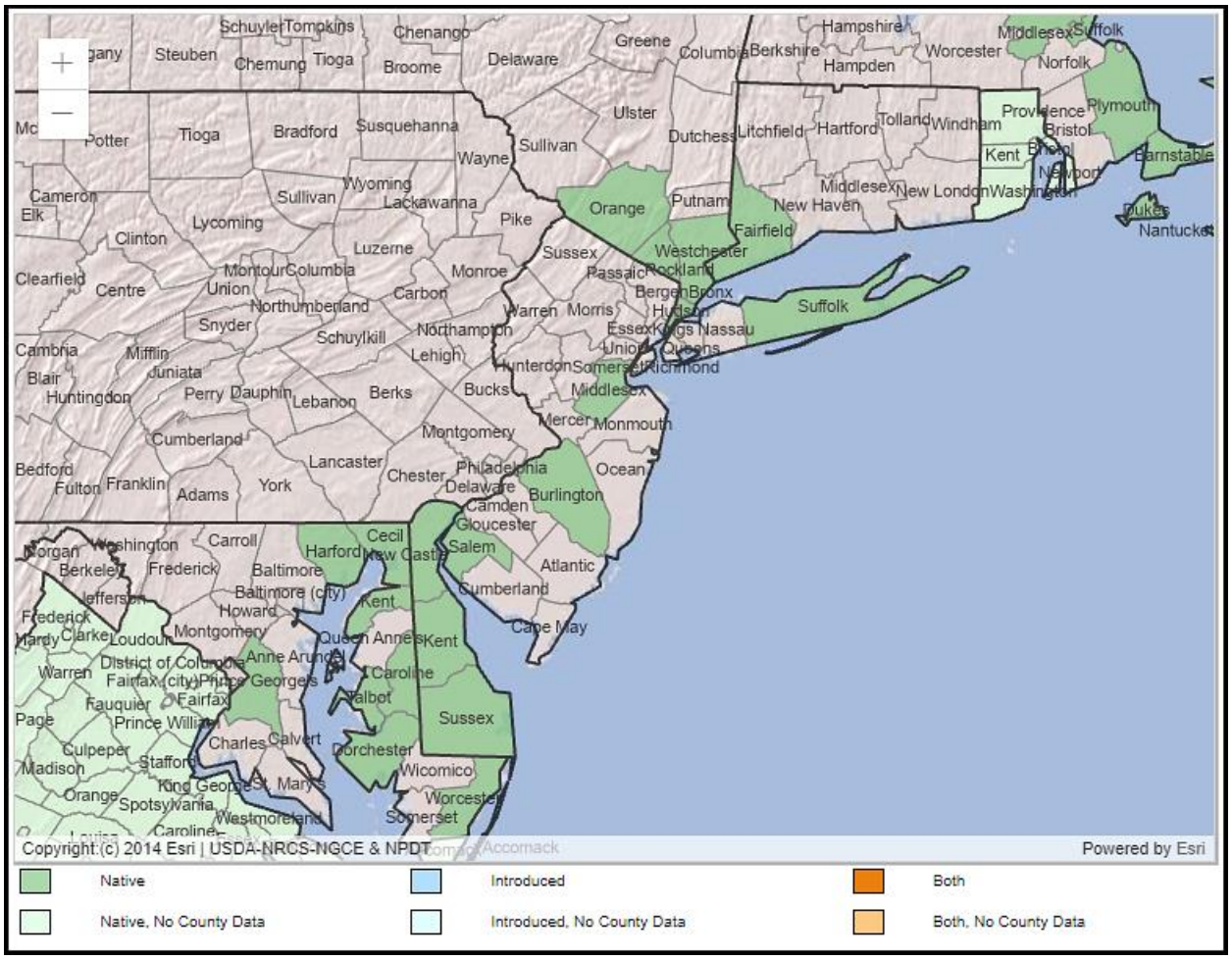


Figure 2. County records of B. novae-angliae in New Jersey and vicinity (USDA NRCS 2024b).

Conservation Status

Bolboschoenus novae-angliae is globally vulnerable. The G3 rank means the species has a moderate risk of extinction or collapse due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors (NatureServe 2024). The map below (Figure 3) illustrates the conservation status of *B. novae-angliae* throughout its range. The sedge is vulnerable (moderate risk of extinction) in two states, imperiled (high risk of extinction) in two states, critically imperiled (very high risk of extinction) in four states, and likely extirpated in North Carolina and Georgia. The species has not been ranked in New Hampshire or Rhode Island—Brumback et al. (2013) indicated that *B. novae-angliae* was not known from either of those states but a specimen from Rhode Island was examined by Browning et al. (1995) during their study and Angelo and Boufford (2007) marked Block Island as part of its range. *B. novae-angliae* was also included in a recent flora of Alabama (Kral et al. 2011), although it may be introduced in that state (Wernerehl 2022).

Bolboschoenus novae-angliae has been identified as a plant species of highest conservation priority for the North Atlantic region, which includes four Canadian provinces and twelve U. S.

states. The species was ranked as R3 (vulnerable), signifying a moderate risk of regional extinction (Frances 2017). A 2015 evaluation of *B. novae-angliae* for The IUCN Red List of Threatened Species concluded that there was not sufficient information available to make an adequate assessment of the species' conservation status (Lansdown 2016).

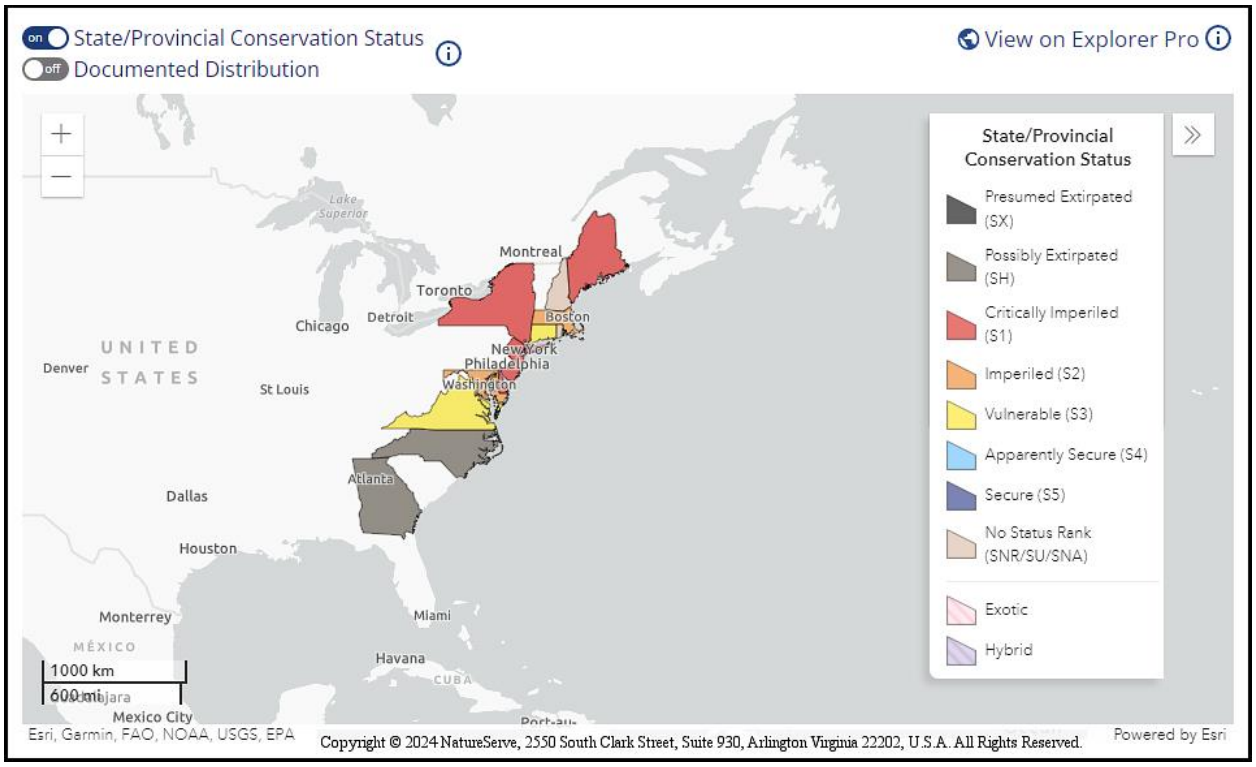


Figure 3. Conservation status of B. novae-angliae in North America (NatureServe 2024).

Bolboschoenus novae-angliae is critically imperiled (S1) in New Jersey (NJNHP 2024). The rank signifies five or fewer occurrences in the state. A species with an S1 rank is typically either restricted to specialized habitats, geographically limited to a small area of the state, or significantly reduced in number from its previous status. New England Bulrush has also been assigned a regional status code of HL, signifying that the sedge is eligible for protection under the jurisdiction of the Highlands Preservation Area (NJNHP 2010).

Bolboschoenus novae-angliae was first documented in New Jersey in 1894 when Thomas Seal collected a specimen from Hudson County (Schuyler 1975, Mid-Atlantic Herbaria 2024), although the first description of the species was not published until 1898 (Fernald 1943). Collections were made from more than 20 locations in the state during the 1900s (NJNHP 2024). *B. novae-angliae* was first listed as an S2 species around the turn of the century, and within 20 years it was downgraded to an S1 (NJNHP 2001, 2021). Two populations have been observed in New Jersey during the past two decades and 21 others are ranked as historical (Gordon 2011, NJNHP 2024).

Threats

Domestic geese have been noted as a threat to one of New Jersey's *Bolboschoenus novae-angliae* populations (NJNHP 2024). Geese feed both by uprooting and consuming plant tubers and rhizomes (grubbing) and by grazing on aboveground vegetation. Grubbing can reduce plant productivity and sexual reproduction (Gaultier et al. 2006). Frequent grazing can also cause a decline in plant vigor, particularly when it occurs early in the growing season (Buitendijk and Nolet 2023).

Habitat degradation is a more widespread concern for *Bolboschoenus novae-angliae*. Ferren and Schuyler (1980) observed that some sites had been lost due to the damming of tributaries or dumping in marshes, and alteration of hydrology was noted as a potential concern for populations in Maine (MENAP 2021). A frequently reported cause of habitat destruction has been the introduction of pollutants that alter the water chemistry and result in eutrophication (NYNHP 2008, Naczi et al. 2018, Treher 2021).

The most significant threat facing *Bolboschoenus novae-angliae* is competition with invasive plants. A study along the lower Hudson River found that *B. novae-angliae* could sometimes be outcompeted by *Acorus calamus, Iris pseudacorus*, or *Lythrum salicaria* but its most serious competitors were *Phragmites australis* ssp. *australis* and *Typha* (Kiviat et al. 2015). *Typha angustifolia* is the most salt-tolerant of the northeastern cattails and it frequently occurs in the same habitat as *B. novae-angliae*. *T. angustifolia* may be native along the North American coast, although it has become widely introduced and invasive further inland during the past century (Shih and Finkelstein 2008, Bansal et al. 2019): Its status in the northeast is presently considered uncertain (Weakley et al. 2024). The threat to native plant communities from *Phragmites* is well-documented and that species has frequently been identified as a cause of concern for New England Bulrush (NYNHP 2008, Moorehead et al. 2009, Treher 2021, NJNHP 2024). Naczi et al. (2018) documented declines in two occurrences of *B. novae-angliae* following the establishment of *Phragmites* and noted that Giant Reed was actively invading and overwhelming the majority of bulrush populations they had observed. A related threat to *B. novae-angliae* is the broad application herbicides used for *Phragmites* control (Treher 2021).

Climate Change Vulnerability

Information from the references cited in this profile was used to evaluate the vulnerability of New Jersey's *Bolboschoenus novae-angliae* populations to climate change. The species was assigned a rank from NatureServe's Climate Change Vulnerability Index using the associated tool (Version 3.02) to estimate its exposure, sensitivity, and adaptive capacity to changing climactic conditions in accordance with the guidelines described by Young et al. (2016) and the state climactic computations by Ring et al. (2013). Based on available data *B. novae-angliae* was assessed as Moderately Vulnerable, meaning that it is likely to show some decrease in abundance or range extent in New Jersey by 2050. An assessment of the species' susceptibility to climate change in Maine also concluded that the bulrush was moderately vulnerable (Whitman et al. 2013).

Because populations of *Bolboschoenus novae-angliae* are restricted to tidal habitats they will be directly affected by rising sea levels as the climate continues to warm. In New Jersey, as elsewhere, the sites utilized by the species are likely to become increasingly saline and experience more frequent flooding (Naczi et al. 2018, Treher 2021, NJNHP 2024). Other local changes resulting from shifting climactic conditions, such as rising temperatures and altered precipitation patterns (Hill et al. 2020), may also affect New England Bulrush although the impacts are harder to project due to gaps in information regarding the species' environmental tolerances. Climate change is likely to significantly exacerbate the existing threat from *Phragmites australis* ssp. *australis*—the invasive grass is expected to spread further and become even more competitive as a result of higher temperatures, greater concentrations of CO_2, and drought-induced opportunities for the colonization of new sites (Mozdzer and Megonigal 2012, Tougas-Tellier et al. 2015, Eller et al. 2017).

Management Summary and Recommendations

The management of invasive species, particularly *Phragmites australis* ssp. *australis*, is probably essential for the survival of *Bolboschoenus novae-angliae*. Based on their observations, Naczi et al. (2018) predicted that the majority of New England Bulrush occurrences in the Hudson River estuary would be lost to competition with *Phragmites* within a decade. Established stands of *Phragmites australis* are difficult to eradicate, particularly without collateral damage to nearby sensitive species, but there are some strategies that can be helpful in controlling its spread. Mozdzer and Megonigal (2012) suggested that limiting the introduction of nutrients into wetlands might counter some of the advantages that *Phragmites* is likely to gain as a result of climate change. The pros and cons of other potential management techniques for *P. australis* have been reviewed by OMNR (2011) and Hazelton et al. (2014), and investigations of new techniques for dealing with the invasive grass are ongoing (eg. Great Lakes Phragmites Collaborative 2024).

If future monitoring of *Bolboschoenus novae-angliae* populations indicates that geese continue to be a concern in New Jersey some techniques could be employed to discourage the birds from foraging in that location. Titchenell and Lynch (2010) reviewed an assortment of techniques that have been utilized as goose deterrents in different settings and recommended the incorporation of multiple strategies when developing a site-specific plan.

Naczi et al. (2018) pointed out that knowledge is somewhat limited regarding *Bolboschoenus novae-angliae* and other members of the genus that reside in tidal wetlands. Research on New England Bulrush could provide greater understanding of the factors that contribute to the success or failure of seedling establishment, sexual and vegetative reproduction, and persistence throughout its range. An updated inventory of historic occurrences is also needed on a range-wide basis to evaluate the current global status of the species (Treher 2021). There are 21 *B. novae-angliae* populations in New Jersey that have been ranked as historical and some could still be extant—six of the occurrences have already been identified as survey priorities (NJNHP 2024).

Synonyms and Taxonomy

The accepted botanical name of the species is *Bolboschoenus novae-angliae* (Britton) S. G. Smith. Orthographic variants, synonyms, and common names are listed below (ITIS 2024, POWO 2024, USDA NRCS 2024b). The first synonym on the list is still in use by some sources (eg. Kartesz 2015, U. S. Army Corps of Engineers 2020).

Botanical Synonyms	**Common Names**
Schoenoplectus novae-angliae (Britton) M. T. Strong	New England Bulrush
Scirpus cylindricus (Torr.) Britton	New England Tuber-bulrush
Scirpus novae-angliae Britton	
Scirpus robustus Pursh var. *novae-angliae* (Britton) Beetle	
Scirpus subterminalis Torr. var. *cylindricus* (Torr.) T. Koyama	

Prior to the much-needed clarification provided by Schuyler (1975) there was a great deal of confusion regarding the taxonomy and distribution of *Bolboschoenus novae-angliae* and related species in the northeastern United States. *Scirpus novae-angliae* Britton was identified as a synonym for *Scirpus campestris* var. *novae-angliae* (Britton) Fernald (Fernald 1906) and *Scirpus maritimus* var. *fernaldi* (Bickn.) Beetle (Cappel 1954, Fernald 1950), but those taxons reported ranges extending into western New York or Canada so they probably included portions of other species as well. The longstanding uncertainty regarding *Bolboschoenus* is attributable to overlapping morphological characteristics and variability within individual taxa (Schuyler 1975, Browning et al. 1995).

References

Angelo, Ray and David E. Boufford. 2007. Atlas of the Flora of New England: Cyperaceae. Rhodora 109: 237–360.

Arsenault Matt, Glen H. Mittelhauser, Don Cameron, Alison C. Dibble, Arthur Haines, Sally C. Rooney, and Jill E. Weber. 2013. Sedges of Maine: A Field Guide to Cyperaceae. University of Maine Press, Orono, ME. 712 pp.

Baldwin, Andrew H., Michael S. Egnotovich, and Ernest Clarke. 2001. Hydrologic change and vegetation of tidal freshwater marshes: Field, greenhouse, and seed-bank experiments. Wetlands 21(4): 519–531.

Bansal, Sheel, Shane C. Lishawa, Sue Newman, Brian A. Tangen, Douglas Wilcox, Dennis Albert, Michael J. Anteau, Michael J. Chimney, Ryann L. Cressey, Edward DeKeyser, Kenneth J. Elgersma, Sarah A. Finkelstein, Joanna Freeland, Richard Grosshans, Page E. Klug, Daniel J. Larkin, Beth A. Lawrence, George Linz, Joy Marburger, Gregory Noe, Clint Otto, Nicholas Reo, Jennifer Richards, Curtis Richardson, LeRoy Rodgers, Amy J. Schrank, Dan Svedarsky, Steven Travis, Nancy Tuchman, and Lisamarie Windham-Myers. 2019. *Typha* (Cattail) invasion in

North American wetlands: Biology, regional problems, impacts, ecosystem services, and management. Wetlands 39: 645–684.

Beetle, Alan A. 1942. Studies in the genus *Scirpus* L. IV. The section *Bolboschoenus* Palla. American Journal of Botany 29(1): 82–88.

Bicknell, Eugene P. 1917. The ferns and flowering plants of Nantucket - XVIII. Bulletin of the Torrey Botanical Society 44(8): 369–387.

Britton, N. L. and A. Brown. 1913. An Illustrated Flora of the Northern United States and Canada in three volumes: Volume I (Ferns to Buckwheat). Second Edition. Reissued (unabridged and unaltered) in 1970 by Dover Publications, New York, NY. 680 pp.

Browning, J., K. D. Gordon-Gray, and S. G. Smith. 1995. Achene structure and taxonomy of North American *Bolboschoenus* (Cyperaceae). Brittonia 47(4): 433–445.

Brumback, William E., Leslie J. Mehrhoff, Richard W. Enser, Susan C. Gawler, Robert J. Popp, Paul Somers, Daniel P. Sperduto, William D. Countryman, and C. Barre Hellquist. 2013. Flora Conservanda: New England. The New England Plant Conservation Program (NEPCoP) List of Plants in Need of Conservation. 70 pp.

Buitendijk, Nelleke H. and Bart A. Nolet. 2023. Timing and intensity of goose grazing: Implications for grass height and first harvest. Agriculture, Ecosystems & Environment 357: 108681.

Cappel, E. Dan. 1954. The genus *Scirpus* in North Carolina. Journal of the Elisha Mitchell Scientific Society 70(1): 75–91.

Cooke, John C. and Michael William Lefor. 1994. Wetland Mitigation: Mycorrhizal associations in some Connecticut wetland plants. Volume Three of Six. Report JHR 94-288, prepared for the Connecticut Department of Transportation, Rocky Hill, CT. 73 pp.

Eller, Franziska, Hana Skálová, Joshua S. Caplan, Ganesh P. Bhattarai, Melissa K. Burger, James T. Cronin, Wen-Yong Guo, Xiao Guo, Eric L. G. Hazelton, Karin M. Kettenring, Carla Lambertini, Melissa K. McCormick, Laura A. Meyerson, Thomas J. Mozdzer, Petr Pyšek, Brian K. Sorrell, Dennis F. Whigham, and Hans Brix. 2017. Cosmopolitan species As models for ecophysiological responses to global change: The Common Reed *Phragmites australis*. Frontiers in Plant Science 8: Article 1833.

Engel, Jean L. 1983. The Ecology of the Seed Banks of the Upland – Salt Marsh Transition Zone. Final report to Brigantine National Wildlife Refuge for Special Use Permit 80-BR-7. 80 pp.

Faber-Langendoen, D. 2018. Northeast Regional Floristic Quality Assessment Tools for Wetland Assessments. NatureServe, Arlington, VA. 52 pp.

Fassett, Norman C. 1957. A Manual of Aquatic Plants. Second Edition. University of Wisconsin Press, Madison, WI. 405 pp.

Fernald, M. L. 1906. Some new or little known Cyperaceae of North America. Rhodora 8: 161–167.

Fernald, M. L. 1939. Last survivors in the flora of tidewater Virginia (continued). Rhodora 41(491): 529–559.

Fernald, M. L. 1943. Contributions from the Gray Herbarium of Harvard University--No. CXLVIII (continued). V. Studies in the North American species of *Scirpus*. Rhodora 45: 279–303).

Fernald, M. L. 1950. Gray's Manual of Botany. Dioscorides Press, Portland, OR. 1632 pp.

Ferren, Wayne R. Jr. and Alfred E. Schuyler. 1980. Intertidal vascular plants of river systems near Philadelphia. Proceedings of the Academy of Natural Sciences of Philadelphia 132: 86–120.

Frances, Anne (Principal Investigator). 2017. Prioritization and Conservation Status of Rare Plants in the North Atlantic - Final Report. Report prepared for NatureServe by the North Atlantic Landscape Conservation Cooperative, Hadley, MA. Available at https://www.natureserve.org/publications/prioritization-and-conservation-status-rare-plants-north-atlantic-final-report

Gauthier, Gilles, Jean-Francois Giroux, and Line Rochefort. 2006. The impact of goose grazing on arctic and temperate wetlands. Acta Zoological Sinica 52(Supplement): 108–111.

Geary, Rachel. 2023. Identifying Optimum Germination Temperatures and Analysis Weights in Seed Testing for Stiff Goldenrod (*Solidago rigida*) and River Bulrush (*Bolboschoenus fluviatilis*). Master's Thesis, South Dakota State University, Brookings, SD. 46 pp.

Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Second Edition. The New York Botanical Garden, Bronx, NY. 910 pp.

Goetghebeur, P. 1998. Cyperaceae. In Klaus Kubitzki and T. Stuzel (eds). The Families and Genera of Vascular Plants, Volume 4: Flowering Plants, Monocotyledons: Alismatanae and Commelinanae (Except Gramineae). Springer-Verlag, Berlin. 521 pp.

Gordon, Ted. 2011. 2007–2008 field trips. Bartonia 65: 126–147.

Great Lakes *Phragmites* Collaborative. 2024. Current approaches to *Phragmites* control. Accessed May 26, 2024 at https://www.greatlakesphragmites.net/management/

Hazelton, Eric L. G., Thomas J. Mozdzer, David M. Burdick, Karin M. Kettenring, and Dennis F. Whigham. 2014. *Phragmites australis* management in the United States: 40 years of methods and outcomes. AoB PLANTS 6: doi:10.1093/aobpla/plu001

Hill, Rebecca, Megan M. Rutkowski, Lori A. Lester, Heather Genievich, and Nicholas A. Procopio (eds.). 2020. New Jersey Scientific Report on Climate Change, Version 1.0. New Jersey Department of Environmental Protection, Trenton, NJ. 184 pp.

Horne, Howard. 2014. Cover photo of *Bolboschoenus novae-angliae* from Alabama. Shared via iNaturalist at https://www.inaturalist.org/observations/16634322, licensed by https://creativecommons.org/licenses/by-nc/4.0/

ITIS (Integrated Taxonomic Information System). Accessed May 26, 2024 at http://www.itis.gov

Kartesz, J. T. 2015. The Biota of North America Program (BONAP). Taxonomic Data Center. (http://www.bonap.net/tdc). Chapel Hill, NC. [Maps generated from Kartesz, J. T. 2015. Floristic Synthesis of North America, Version 1.0. Biota of North America Program (BONAP) (in press)].

Kiviat, Erik, Chris Graham, and Gretchen Stevens. 2015. Invasive Species Threats to Rare Plants in the Hudson River Tidal Wetlands: Analysis and Recommendations. Report to the Lower Hudson Partnership in Regional Invasive Species Management, Mahwah, NJ. 35 pp.

Kral, Robert, Alvin R. Diamond Jr., Steven L. Ginzbarg, Curtis J. Hansen, Robert R. Haynes, Brian R. Keener, Michel G. Lelong, Daniel D. Spaulding, and Michael Woods. 2011. Annotated Checklist of the Vascular Plants of Alabama. Botanical Research Institute of Texas, Fort Worth, TX. 113 pp.

Lansdown, R.V. 2016. *Bolboschoenus novae-angliae*. The IUCN Red List of Threatened Species 2016: e.T64264486A67728593. Accessed May 26, 2024 at https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T64264486A67728593.en.

Leck, Mary Allessio and Wolfgang Schütz. 2005. Regeneration of Cyperaceae, with particular reference to seed ecology and seed banks. Perspectives in Plant Ecology, Evolution and Systematics 7: 95–133.

Longbottom, Wayne. 2020. Photo of *Bolboschoenus novae-angliae* from Maryland. Shared via iNaturalist at https://www.inaturalist.org/observations/49604550, licensed by https://creativecommons.org/licenses/by-nc/4.0/

MENAP (Maine Natural Areas Program). 2021. *Bolboschoenus novae-angliae*. Maine Department of Agriculture, Conservancy and Forestry, Augusta, ME. Accessed March 7, 2024 at https://www.maine.gov/dacf/mnap/features/bolnov.htm

Mid-Atlantic Herbaria. 2024. Accessed at https://midatlanticherbaria.org/portal/index.php on May 26, 2024.

Moorehead, William H. III, Cary Chadwick, Sandy Prisloe, Juliana Barrett, and Nels Barrett. 2009. Vegetation Mosaic of Ragged Rock Creek Brackish Tidal Marsh, Connecticut River, Old Saybrook, CT. Report prepared for the Connecticut Department of Environmental Protection, Hartford, CT. 39 pp.

Mozdzer, Thomas J. and J. Patrick Megonigal. 2012. Jack-and-master trait responses to elevated CO_2 and N: A comparison of native and introduced *Phragmites australis*. PLoS ONE 7(10): e42794.

Naczi, Robert F. C., Scottie L. Sheaffer, David A. Werier, and Charles J. Zimmerman. 2018. Geographic distribution, habitat characterization, and conservation status of *Bolboschoenus* bulrushes (Cyperaceae) in the Hudson River Estuary, USA. Brittonia 70: 289–305.

NatureServe. 2024. NatureServe Explorer [web application]. NatureServe, Arlington, VA. Accessed May 26, 2024 at https://explorer.natureserve.org/

NJNHP (New Jersey Natural Heritage Program). 2001 and 2021. List of Endangered Plant Species and Plant Species of Concern. Biotics Database. NatureServe, Arlington, Virginia. Lists created September 2001 and January 2021.

NJNHP (New Jersey Natural Heritage Program). 2010. Explanation of Codes Used in Natural Heritage Reports. Updated March 2010. Available at https://nj.gov/dep/parksandforests/natural/docs/nhpcodes_2010.pdf

NJNHP (New Jersey Natural Heritage Program). 2024. Biotics 5 Database. NatureServe, Arlington, VA. Accessed March 15, 2024.

NYNHP (New York Natural Heritage Program). 2008. Online Conservation Guide for *Bolboschoenus novae-angliae*. Accessed March 7, 2024 at https://guides.nynhp.org/saltmarsh-bulrush/

OMNR (Ontario Ministry of Natural Resources). 2011. Invasive Phragmites – Best Management Practices. Ontario Ministry of Natural Resources, Peterborough, Ontario. Version 2011. 17 pp.

POWO. 2024. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Accessed May 26, 2024 at http://www.plantsoftheworldonline.org/

Ring, Richard M., Elizabeth A. Spencer, and Kathleen Strakosch Walz. 2013. Vulnerability of 70 Plant Species of Greatest Conservation Need to Climate Change in New Jersey. New York Natural Heritage Program, Albany, NY and New Jersey Natural Heritage Program, Department of Environmental Protection, Office of Natural Lands Management, Trenton, NJ, for NatureServe #DDCF-0F-001a, Arlington, VA. 38 pp.

Schuyler, Alfred E. 1975. *Scirpus cylindricus*: An ecologically restricted eastern North American tuberous bulrush. Bartonia 43: 29–37.

Shih, Jessica G. and Sarah A. Finkelstein. 2008. Range dynamics and invasive tendencies in *Typha latifolia* and *Typha angustifolia* in eastern North America derived from herbarium and pollen records. Wetlands 28(1): 1–16.

Smith, S. Galen. Page updated November 5, 2020. *Bolboschoenus novae-angliae* (Britton) S. G. Smith. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 22+ vols. New York and Oxford. Accessed May 27, 2024 at http://floranorthamerica.org/Bolboschoenus_novae-angliae

Strong, Mark T. 1994. Taxonomy of *Scirpus*, *Trichophorum*, and *Schoenoplectus* (Cyperaceae) in Virginia. Bartonia 58: 29–68.

Strong, Mark T. and Carol L. Kelloff. 1994. Intertidal vascular plants of Brent Marsh, Potomac River, Stafford County, Virginia. Castanea 59(4): 354–366.

Titchenell, Marne A. and William E. Lynch, Jr. 2010. Coping with Canada Geese: Conflict management and damage prevention strategies. Agriculture and Natural Resources Fact Sheet W-3-10, Ohio State University Extension, Columbus, OH. 8 pp.

Tougas-Tellier, Marie-Andrée, Jean Morin, Daniel Hatin, and Claude Lavoie. 2015. Freshwater wetlands: Fertile grounds for the invasive *Phragmites australis* in a climate change context. Ecology and Evolution 5(16): 3421–3435.

Treher, A. 2021. *Bolboschoenus novae-angliae* conservation status factors. NatureServe, Arlington, VA. Accessed March 7, 2024 at https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.150405/Bolboschoenus_novae-angliae

U. S. Army Corps of Engineers. 2020. National Wetland Plant List, version 3.5. https://cwbi-app.sec.usace.army.mil/nwpl_static/v34/home/home.html U. S. Army Corps of Engineers Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, NH.

USDA, NRCS (U. S. Dept. of Agriculture, Natural Resources Conservation Service). 2024a. *Bolboschoenus novae-angliae* illustration from Britton, N. L. and A. Brown, 1913, An illustrated flora of the northern United States, Canada and the British Possessions, 3 vols., Kentucky Native Plant Society, New York, Scanned By Omnitek Inc. Image courtesy of The PLANTS Database (http://plants.usda.gov). National Plant Data Team, Greensboro, NC.

USDA, NRCS (U. S. Dept. of Agriculture, Natural Resources Conservation Service). 2024b. PLANTS profile for *Bolboschoenus novae-angliae* (New England Bulrush). The PLANTS Database, National Plant Data Team, Greensboro, NC. Accessed May 26, 2024 at http://plants.usda.gov

Walz, Kathleen S., Jason L. Hafstad, Linda Kelly, and Karl Anderson. 2020. Floristic Quality Assessment Index for Vascular Plants of New Jersey: Coefficient of Conservancy (CoC) Values for Species and Genera (update to 2017 list). New Jersey Department of Environmental Protection, New Jersey Forest Service, Office of Natural Lands Management, Trenton, NJ.

Weakley, A. S. and Southeastern Flora Team. 2024. Flora of the Southeastern United States. Edition of March 4, 2024. University of North Carolina Herbarium, North Carolina Botanical Garden, Chapel Hill, NC. 2023 pp.

Wernerehl, Robert. 2022. Comment on Alabama record of *B. novae-angliae*. Accessed May 26, 2024 at https://www.inaturalist.org/observations/16634322

Whitman, A., A. Cutko, P. deMaynadier, S. Walker, B. Vickery, S. Stockwell, and R. Houston. 2013. Climate Change and Biodiversity in Maine: Vulnerability of Habitats and Priority Species. Manomet Center for Conservation Sciences (in collaboration with Maine Beginning with Habitat Climate Change Working Group) Report SEI-2013-03, Brunswick, ME. 96 pp.

Young, Bruce E., Elizabeth Byers, Geoff Hammerson, Anne Frances, Leah Oliver, and Amanda Treher. 2016. Guidelines for Using the NatureServe Climate Change Vulnerability Index, Release 3.02, 1 June 2016. NatureServe, Arlington, VA. 65 pp.