# *Sparganium natans*

**Small Burr-reed**

**Sparganiaceae**


*Sparganium natans* by Katy Chayka, 2019

## ***Sparganium natans* Rare Plant Profile**

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

501 E. State St.
PO Box 420
Trenton, NJ 08625-0420

Prepared by:
Jill S. Dodds
jsdodds@biostarassociates.com

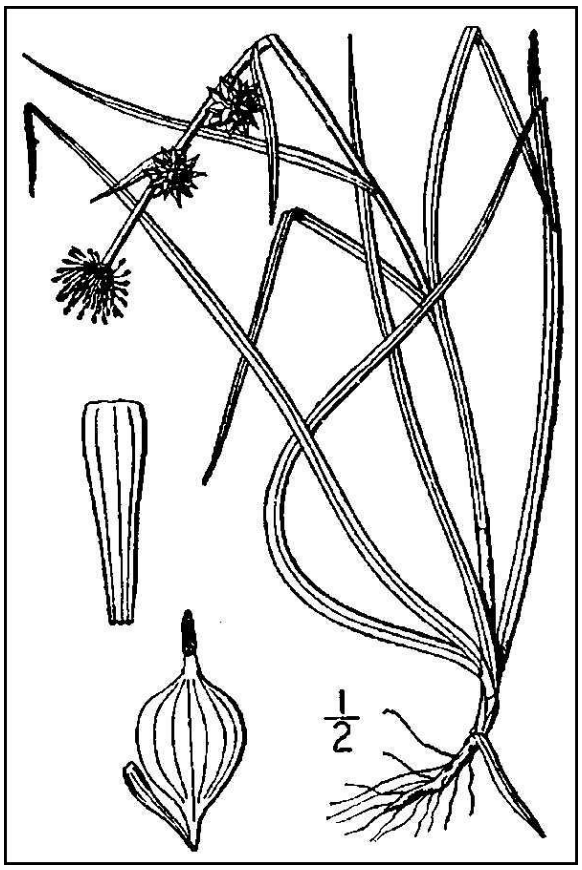
May, 2022

For:
New Jersey Department of Environmental Protection
Office of Natural Lands Management
New Jersey Natural Heritage Program
natlands@dep.nj.gov

This report should be cited as follows: Dodds, Jill S. 2022. *Sparganium natans* Rare Plant Profile. New Jersey Department of Environmental Protection, State Parks, Forests & Historic Sites, State Forest Fire Service & Forestry, Office of Natural Lands Management, New Jersey Natural Heritage Program, Trenton, NJ. 15 pp.

## Life History

*Sparganium natans* (Small Burr-reed) is a rooted perennial aquatic plant. The genus *Sparganium* has traditionally been placed in the monogenetic family Sparganiaceae but molecular-based classification systems are now including it in the Typhaceae (Sulman et al. 2013, Stevens 2017). The ribbonlike leaves of *Sparganium natans* are limp and unkeeled, typically ranging from 2–8 mm in width and extending up to about 6 dm in length (Kaul 2020). The leaves often float at or below the surface but they may also be erect, particularly when the plants are in very shallow water or stranded on mud. *S. natans* leaves are structurally designed for floating, with distinct upper and lower surfaces. The upper leaf surface has a dense layer of chlorophyll and abundant stomata (110/mm$^2$) while the lower surface has reduced chlorophyll and only scattered abortive stomata (Kaul 1972, 1976). The aquatic leaves of Small Burr-reed are dark green and somewhat translucent, while aerial leaves are likely to be deeper green, glossier, and shorter (Cook and Nicholls 1986).


Left: Peter M. Dziuk, 2013. Right: Britton and Brown 1913, courtesy USDA NRCS 2022a.

Flowering branches are typically produced from June to August in New Jersey (Hough 1983). *Sparganium* flowers are clustered in dense, round, unisexual heads. The inflorescence of *S. natans* is an unbranched stem with 1–3 pistillate heads near the base and a single staminate head in the uppermost position. Flower tepals are reduced to chaffy scales and are inconspicuous but remain attached to the developing fruit. In fruit, the pistillate heads are 8–12 mm in diameter and the achenes are a dull greenish brown. Mature achenes are 2–4 mm long and 1–1.5 mm

wide, tapering to a curved beak that is 0.5–1.5 mm in length. *Sparganium natans* can be distinguished from other floating-leaved burr-reeds in New Jersey by the single male inflorescence and the comparatively short beaks on the achenes. (See Britton and Brown 1913, Fernald 1950, Gleason and Cronquist 1991, Kaul 2020). The mature fruits needed for identification can usually be found in late summer or early fall (Hough 1983, Ring 2012). However, *S. natans* can sometimes form colonies that produce few flowering stems (Minnesota Wildflowers undated).

*Sparganium natans* is able to reproduce vegetatively via slender, creeping rhizomes but its rhizomatous growth is limited, averaging 3–5 internodes in a year (Cook and Nicholls 1986, Les 2020). Les (2020) also cited asexual reproduction via vegetative fragments. At the end of each growing season the leaves die off and the plants form small tuberous structures to overwinter which may also serve as vegetative dispersal units for young plants (Cook and Nicholls 1986, Belyakov and Lapirov 2019a).

## Pollinator Dynamics

All *Sparganium* species are pollinated by wind (Cook and Nicholls 1986, Sulman et al. 2013, Les 2020, Kaul 2020). Many characteristics that are typical of wind-pollinated aquatic plants can be seen in *S. natans*, including unisexual flowers, reduced perianths, a reduced number of ovules per flower, and a non-leafy inflorescence that is held above the water (Cook 1988). Kaul (1976) reported that in *S. natans*, one or more of the floating leaves will form a raft to aid in supporting the upright inflorescence above the surface.

No mechanisms to prevent self-fertilization have been reported for the genus *Sparganium* (Cook and Nicholls, 1986). Some species of *Sparganium* have been found to be self-compatible but in all burr-reeds the female flowers mature first, encouraging outcrossing (Les 2020).

## Seed Dispersal

Each pistillate flower in a *Sparganium natans* inflorescence produces a single seed (Sulman et al. 2013, Kaul 2020). The typical *S. natans* stem produces two pistillate flower clusters that bear an average of 73 fruits, 56 of which develop normally and the rest of which do not fully develop (Belyakov and Lapirov 2019b). *Sparganium* fruits have a water-repellant outer layer (exocarp), a spongy middle layer (mesocarp) and a stony inner layer (endocarp) (Cook and Nicholls 1986) and water is their primary means of dispersal (Kubitzki 1998, Les 2020). Under laboratory conditions *S. natans* fruits stayed afloat for 15 months with 97% of the embryos remaining viable (Belyakov and Lapirov 2019b) but in nature the fruits rarely float for more than 6 months (Cook and Nicholls 1986). Cook and Nicholls also observed that if a *Sparganium* fruit becomes trapped in ice the exocarp usually ruptures, the mesocarp soon decays, and the liberated endocarp then sinks.

The hydrophobic coating on *Sparganium* fruits allow them to readily stick to surfaces, facilitating transport by birds and aquatic mammals (Cook and Nicholls 1986). *Sparganium*

fruits, including those of *S. natans*, are eaten by numerous species of waterfowl and marsh birds, resulting in dispersal over longer distances (Fassett 1957, Cook and Nicholls 1986, Sulman et al. 2013, Green et al. 2018). Dispersal by fish is also a possibility. Pollux et al. (2007) reported a post-ingestion seed survival rate of 67% for *P. natans* seeds that were fed to common carp (*Cyprinus carpio*), although the frequency of *Sparganium* seed consumption by fish under natural conditions is unknown.

Kubitzki (1998) noted that a micropylar plug in the endocarp allows the germination of *Sparganium* seeds to be delayed for several years after maturity. Les (2020) reported that the seeds of *Sparganium* can experience extended dormancy and remain viable for decades, but removal of the plug results in rapid germination. Belyakov and Lapirov (2019b) observed that *Sparganium natans* germinated poorly under laboratory conditions, but Kubitzki (1998) asserted that *Sparganium* seeds germinate readily once the micropylar plug has decayed as long as sufficient water is available. Seedlings of all *Sparganium* species must be submerged in standing water in order to develop (Cook and Nicholls 1986).

## Habitat

Throughout its range, *Sparganium natans* has been found in a wide variety of habitats including bays, beaver ponds, bogs, brooks, depressions, ditches, fens, gravel pits, interdunal swales, kettle holes, lakes, marshes, wet meadows, mudflats, muskeg, oxbows, ponds, pools, slow streams, springs, and shrub or cedar swamps (Coddington and Field 1978, Fernald 1922, Kaul 2020, Les 2020, Minnesota Wildflowers undated, Ring 2012). Wetland habitats occur over a broad array of substrates at elevations from 0–3500 meters and the plants may grow in full sun or shade (Les 2020, Kaul 2020). In New Jersey, *S. natans* is known from calcareous sinkhole ponds and a freshwater emergent marsh with scattered shrubs (Johnson and Walz 2013, NJNHP 2022).

The aquatic habitats preferred by *S. natans* are generally described as clear, cool, quiet, still, and shallow (Ring 2012, Kaul 2020, Les 2020, Minnesota Wildflowers undated). Cook and Nicholls (1986) noted that the species was rare in flowing water and intolerant of wave action. Hellsten and Mjelde (2009) indicated that Small Burr-reed was not particularly sensitive to water level fluctuations. Water depths of up to a meter have been recorded, but *S. natans* is usually found at depths of less than 60 cm and flowers best in water 20–40 cm deep (Kaul 2020, Cook and Nicholls 1986). In deeper water the plants produce fewer inflorescences with less heads, while terrestrial forms seldom flower and rarely develop fruit (Cook and Nicholls 1986). Data from *Sparganium natans* habitats in New England showed a pH range of 6.5–8.5 (mean 7.3) and an alkalinity range of 3.5–69.5 milligrams/liter (mean 35.4 mg/l) (Crow and Hellquist 1981).

*Sparganium natans* readily colonized gaps in aquatic vegetation created by muskrats (*Ondatra zibethicus*) in Sweden. Danell (1977) noted that the patches of open water in otherwise closed stands of hydrophytes acted as traps for local plant propagules and also attracted waterfowl that were likely to disperse the seeds of *S. natans* and other aquatic flora. However, *Sparganium natans* is not limited to open habitat. In the aforementioned Swedish study the species was already present within dense stands of *Equisetum fluviatile* prior to the muskrat modifications. Cook and Nicholls (1986) reported that *S. natans* frequently grows with various pondweeds

(*Potamogeton spp.*) or in loose stands of tall upright species such as *Carex rostrata* and *Phragmites*. It can also coexist with other *Sparganiums* such as *S. emersum* or *S. angustifolium,* although habitat partitioning occurs when it grows with the latter species and Small Burr-reed preferentially utilizes the shallower, shadier portions of the site (Cook and Nicholls 1986).

## Wetland Indicator Status

*Sparganium natans* 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 2022b)

SPNA

## Coefficient of Conservatism (Walz et al. 2018)

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

*Sparganium natans* is widely distributed throughout the northern hemisphere including much of North America, Europe, and Asia (POWO 2022). The map in Figure 1 depicts the extent of the species in the United States and Canada.

The USDA PLANTS Database (2022b) shows records of *Sparganium natans* in three New Jersey counties: Morris, Sussex, and Warren (Figure 2). The data include historic observations and do not reflect the current distribution of the species.

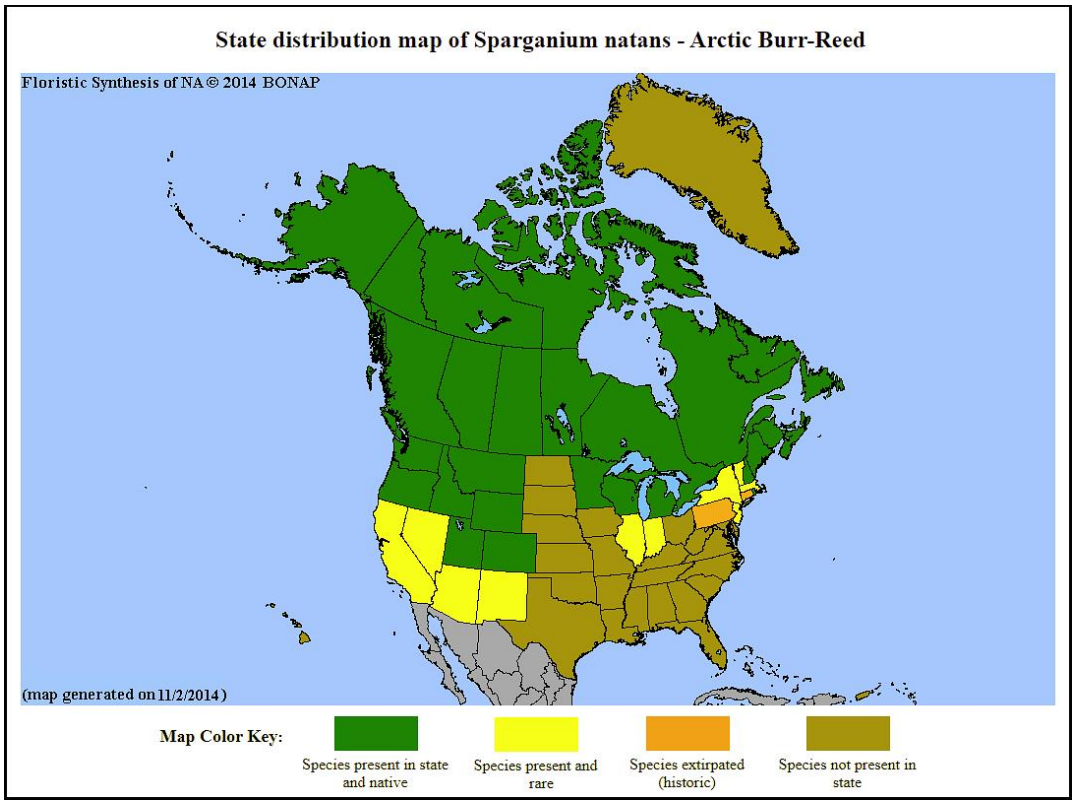



*Figure 1. Distribution of S. natans in North America, adapted from BONAP (Kartesz 2015).*

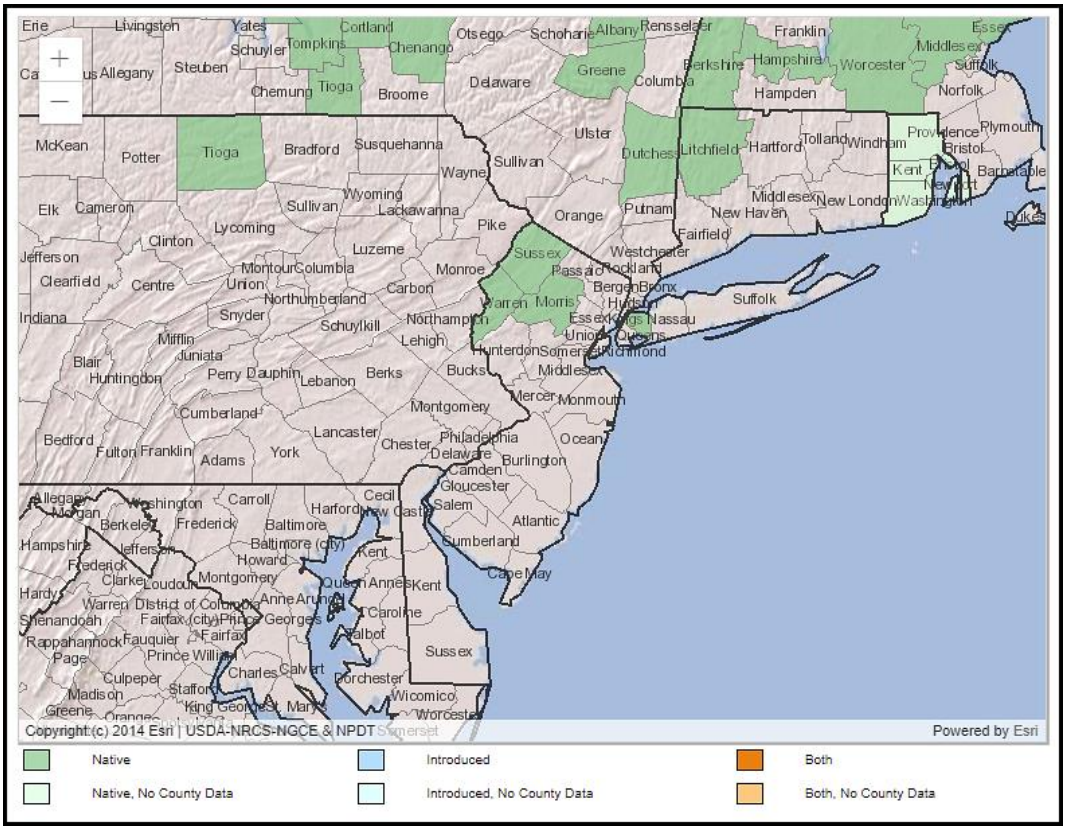



*Figure 2. County records of S. natans in New Jersey and vicinity (USDA NRCS 2022b).*

## Conservation Status

*Sparganium natans* is considered globally secure, although a decreasing population trend has been reported in Europe (Lansdown 2014). The G5 rank means the species has a very low risk of extinction or collapse due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats (NatureServe 2022). The map below (Figure 3) illustrates the conservation status of *S. natans* throughout its range. Small Burr-reed is critically imperiled (very high risk of extinction) in five states, imperiled (high risk of extinction) in three states and one province, vulnerable (moderate risk of extinction) in three states and four provinces, and presumed extirpated in Pennsylvania and Indiana. Throughout the rest of its North American range it is considered secure or apparently so, or is unranked.

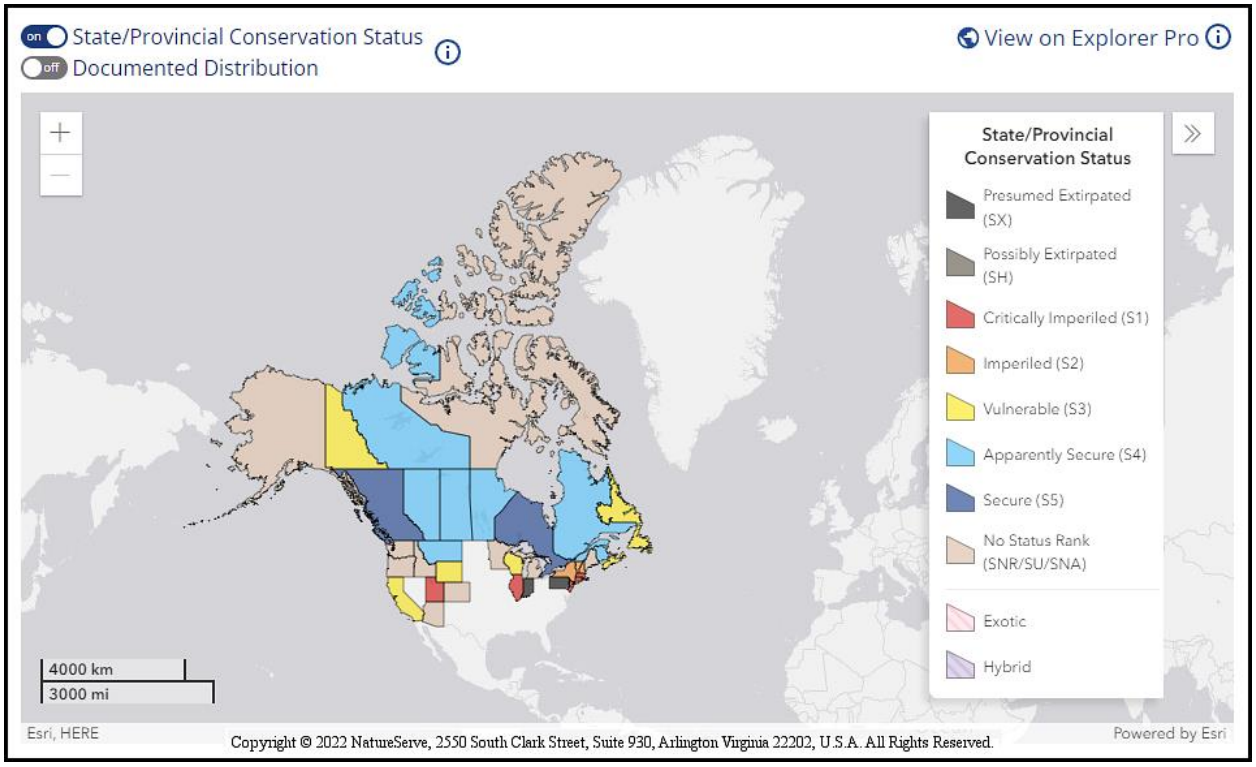



*Figure 3. Conservation status of S. natans in North America (NatureServe 2022).*

New Jersey is one of the states where *Sparganium natans* is critically imperiled (NJNHP 2022). The S1 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. *S. natans* is also listed as an endangered species (E) in New Jersey, meaning that without intervention it has a high likelihood of extinction in the state. Although the presence of endangered flora may restrict development in certain communities such as wetlands or coastal habitats, being listed does not currently provide broad statewide protection for the plants. Additional regional status codes assigned to the burr-reed signify that the species is eligible for protection under the jurisdictions of the Highlands Preservation Area (HL) and the New Jersey Pinelands (LP) (NJNHP 2010).

In the early 1900s, *Sparganium natans* was reported from a single New Jersey location in Morris County by Taylor (1915), who noted that the species was only found north of the terminal moraine of the Wisconsin glacier in the northeastern U. S. About 60 years later the original population had been extirpated—as had another in Sussex County—but an extant occurrence was reported in Warren County by Fairbrothers and Hough (1973) who categorized the species as endangered in the state. Snyder (2000) relocated the Warren County population and subsequently discovered two new occurrences in the general vicinity of the original New Jersey site, and those three colonies are still listed as extant (NJNHP 2022).

## Threats

*Sparganium natans* appears to be declining throughout its global range as a result of habitat loss and destruction. Eutrophication was cited as the likely cause of the species' disappearance from a number of sites in Germany (Steffen et al. 2013). *S. natans* is severely threatened in Ukraine, where regional ecological challenges include wetland loss and fragmentation, the eutrophication of aquatic ecosystems, the spread of invasive flora, and the further aggravation of anthropogenic impacts by climate change (Grokhovska et al. 2021). Loss of wetlands and eutrophication have also been cited as the cause of Small Burr-reed's decline in the United Kingdom by Lansdown (2014), who remarked that those issues are likely to impact the species throughout its range.

Lack of suitable habitat appears to be an obstacle to the success of *S. natans* in New Jersey. Calcareous ponds are rare throughout their range and in the state, where they are mostly limited to the northwestern part of the state. The fragile habitats are threatened by changes in hydrology, reduction in water quality, establishment of invasive species, and the destruction of flora by all-terrain vehicles, watercraft, or other recreational activities (Johnson and Walz 2013). One of New Jersey's few *Sparganium natans* populations is located in a limestone sink where its habitat has been compromised by the partial draining and filling of the pond (NJNHP 2022).

Because calcareous pond communities are dependent on stable hydrology and water chemistry, they are highly vulnerable to changes in climate (Johnson and Walz 2013). When evaluating the likely effects of climate change on selected flora, Ring et al. (2013) did not find sufficient information to rank Small Burr-reed's vulnerability. In New Jersey, the local effects of shifting climactic conditions include rising temperatures and increasingly heavy rainstorms (USEPA 2016). Both of those factors are likely to cause increased eutrophication of inland aquatic systems (Moss et al. 2011, Nazari-Sharabian et al. 2018), particularly those with limited water movement (Yang et al. 2008). Since eutrophication is now identified as a significant threat to *S. natans* at multiple locations around the world, it is reasonable to conclude that the species will prove to be sensitive to climate change.

Although herbivory has not been specifically noted at the New Jersey sites it could be a threat, particularly to small populations. Fassett (1957) reported that *Sparganium* plants were a preferred food of deer (*Odocoileus virginianus*), and also listed a number of burr-reed species that were known to be partially or fully consumed by muskrats.

## Management Summary and Recommendations

Although *Sparganium natans* can survive short-term fluctuations in water levels, the species appears to require clean, shallow water in order to reproduce and persist. Protection of an extant population requires both conservation of its wetland habitat and the establishment of a sufficient buffer to moderate changes in water depth and limit the amount of nutrients introduced into the system from the surrounding landscape. Monitoring of extant *S. natans* occurrences could include some evaluation of habitat integrity (e.g. measures of water depth and chemistry) in order to assure that conditions are still suitable or to raise awareness of a developing problem. The safeguarding of rare species populations that are located on private land can be particularly challenging and depends on the potential for establishing cooperative relationships with land owners or managers.

*Sparganium natans* has always been rare in the northeastern United States and perceptible gaps in its range were noted by Taylor (1909) and Fernald (1922), although the species was subsequently documented in areas where it was initially thought to be absent (Mid-Atlantic Herbaria 2022). Coddington and Field (1978) suggested that its apparent rarity in Massachusetts could be due to under-collection. Because Small Burr-reed does not appear to be limited by seed production and dispersal, identification of potentially suitable habitat and periodic searches for new occurrences could be fruitful.

The map in Figure 3 shows that *Sparganium natans* is particularly vulnerable all along the southeastern border of its range. However, the genotypes that have adapted to survive at the species' southern boundary may be particularly well-positioned to endure the consequences of rapid climate change (Rehm et al. 2015). In areas where *S. natans* is imperiled, propagation of plants from native material for use in restoration or reintroduction may be considered. If that is to be an option, some research is needed to fill gaps in knowledge about the germination and establishment requirements of the species both under natural circumstances and in cultivation. Although burr-reeds can be propagated from rootstock, both *Sparganium* in general and *S. natans* in particular have been reported as difficult to establish from seed (Martin and Uhler 1939, Belyakov and Lapirov 2019b). Nevertheless, the topic is worthy of investigation.

## Synonyms

The accepted botanical name of the species is *Sparganium natans* L. Orthographic variants, synonyms, and common names are listed below (ITIS 2021, USDA NRCS 2022b, POWO 2022).

| Botanical Synonyms | Common Names |
|---|---|
| *Sparganium minimum* (L.) Fr. | Small Burr-reed |
| *Sparganium minimum* Wallr. | Small Bur-reed |
| *Sparganium natans* var. *minimum* L. | Arctic Burr-reed |
| *Platanaria natans* (L.) Gray | |
| *Sparganium amplexicaulium* D. Yu | |
| *Sparganium axilare* Raf. | |

*Sparganium flaccidum* Meinsh.
*Sparganium gramineum* Wallr.
*Sparganium perpusillum* Meinsh.
*Sparganium ratis* Meinsh.
*Sparganium rostratum* Larss.
*Sparganium septentrionale* Meinsh.
*Sparganium tenuicaule* D. Yu & L. H.Liu

## References


Belyakov, E. A. and A. G. Lapirov. 2019a. Ontogenesis of the genets and ramets of some European species of the genus *Sparganium* subgenus *Xanthosparganium*. Regulatory Mechanisms in Biosystems 10(1): 136–146.

Belyakov, E. A. and A. G. Lapirov. 2019b. Seed productivity and peculiarities of floating of generative diaspores of some European species of the genus *Sparganium* L. Inland Water Biology 12(2): 542–548.

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.

Chayka, Katy. 2019. Cover photo of *Sparganium natans*. Image courtesy of Minnesota Wildflowers https://www.minnesotawildflowers.info/aquatic/small-bur-reed, licensed by https://creativecommons.org/licenses/by-nc-nd/3.0/.

Coddington, Jonathan and Katharine G. Field. 1978. Rare and endangered vascular plant species in Massachusetts. Report prepared by the New England Botanical Club, Cambridge, MA. 67 pp.

Cook, C. D. K. and M. S. Nicholls. 1986. A monographic study of the genus *Sparganium* (Sparganiaceae). Part 1. Subgenus *Xanthosparganium* Holmberg. Botanica Helvetica 96(2): 213–267.

Cook, Christopher D. K. 1988. Wind pollination in aquatic angiosperms. Annals of the Missouri Botanical Garden 75(3): 768–777.

Crow, G. E. and C. B. Hellquist. 1981. Aquatic vascular plants of New England. Pt. 2. Typhaceae and Sparganiaceae. New Hampshire Agricultural Experiment Station Bulletin 517: 1–21.

Danell, Kjell. 1977. Short-term plant successions following the colonization of a northern Swedish lake by the muskrat, *Ondatra zibethica*. Journal of Applied Ecology 14: 933–947.

Dziuk, Peter M. 2013. Labeled photo of *Sparganium natans* flowers. Image courtesy of Minnesota Wildflowers https://www.minnesotawildflowers.info/aquatic/small-bur-reed, licensed by https://creativecommons.org/licenses/by-nc-nd/3.0/.

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

Fairbrothers, David E. and Mary Y. Hough. 1973. Rare or Endangered Vascular Plants of New Jersey. Science Notes No. 14, New Jersey State Museum, Trenton, NJ. 53 pp.

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

Fernald, M. L. 1922. Notes on *Sparganium*. Rhodora 24(278): 26–34.

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

Green, Andy J., Merel Soons, Anne-Laure Brochet, and Erik Kleyheeg. 2016. Dispersal of plants by waterbirds. In Çagan H. Sekercioglu, Daniel G. Wenny, and Christopher J. Whelan (eds). Why Birds Matter: Avian Ecological Function and Ecosystem Services. University of Chicago Press, Chicago IL. 368 pp.

Grokhovska, Y., V. Volodymyrets, and S. Konontsev. 2021. Diversity and dynamics of hydrophilic flora of Lowland Polissya (on the example of the Sluch River basin). Biosystems Diversity 29(3): 303–310.

Hellsten, Seppo and Marit Mjelde. 2009. Macrophyte responses to water level fluctuation in Fennoscandinavian Lakes – Applying a common index. Verhandlungen des Internationalen Verein Limnologie 30(5): 765–769.

Hough, Mary Y. 1983. New Jersey Wild Plants. Harmony Press, Harmony, NJ. 414 pp.

ITIS (Integrated Taxonomic Information System). Accessed November 13, 2021 at http://www.itis.gov

Johnson, Elizabeth A. and Kathleen Strakosch Walz. 2013. Integrated Management Guidelines for Four Habitats and Associated State Endangered Plants and Wildlife Species of Greatest Conservation Need in the Skylands and Pinelands Landscape Conservation Zones of the New Jersey State Wildlife Action Plan. Report prepared for NatureServe #DDCF-0F-001a, Arlington, VA. 140 pp.

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)].

Kaul, Robert B. 1972. Adaptive leaf architecture in emergent and floating *Sparganium*. American Journal of Botany 59(3): 270–278.

Kaul, Robert B. 1976. Anatomical observations on floating leaves. Aquatic Botany 2: 215–234.

Kaul, Robert B. Page updated November 5, 2020. *Sparganium natans* Linnaeus. 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 7, 2022 at http://floranorthamerica.org/Sparganium_natans

Kubitzki, Klaus. 1998. Sparganiaceae. 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. 521 pp.

Lansdown, R. V. 2014. *Sparganium natans*. The IUCN Red List of Threatened Species 2014: e.T164166A42414281. Accessed May 6, 2022 at https://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T164166A42414281.en

Les, Donald H. 2020. Aquatic Monocotyledons of North America: Ecology, Life History and Systematics. CRC Press, Boca Raton, FL. 568 pp.

Martin, Alexander Campbell and Francis Morey Uhler. 1939. Food of game ducks in the United States and Canada. Technical Bulletin No. 634, USDA, Division of Wildlife Research, Washington, D. C. 156 pp.

Mid-Atlantic Herbaria. 2022. https://midatlanticherbaria.org/portal/index.php. Accessed on May 9, 2022.

Minnesota Wildflowers. Undated. *Sparganium natans* (Small Bur-reed). Available at https://www.minnesotawildflowers.info/aquatic/small-bur-reed

Moss, Brian, Sarian Kosten, Mariana Meerhoff, Richard W. Battarbee, Erik Jeppesen, Néstor Mazzeo, Karl Havens, Gissell Lacerot, Zhengwen Liu, Luc De Meester, Hans Paerl, and Marten Scheffer. 2011. Allied attack: climate change and eutrophication. Inland Waters 1(2): 101–105.

NatureServe. 2022. NatureServe Explorer [web application]. NatureServe, Arlington, VA. Accessed May 6, 2022 at https://explorer.natureserve.org/

Nazari-Sharabian, Mohannad, Sajjad Ahmad, and Moses Karakouzian. 2018. Climate change and eutrophication: A short review. Engineering, Technology and Applied Science Research 8(6): 3668–3672.

NJNHP (New Jersey Natural Heritage Program). 2010. Special Plants of NJ - Appendix I - Categories & Definitions. Site updated March 22, 2010. Available at https://nj.gov/dep/parksandforests/natural/docs/nhpcodes_2010.pdf

NJNHP (New Jersey Natural Heritage Program). 2022. Biotics 5 Database. NatureServe, Arlington, VA. Accessed February 1, 2022.

Pollux, B. J. A., N. J. Ouborg, J. M. VanGroenendael, and M. Klassen. 2007. Consequences of intraspecific seed-size variation in *Sparganium emersum* for dispersal by fish. Functional Ecology 21: 1084–1091.

POWO. 2022. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Retrieved December 19 2021 from http://www.plantsoftheworldonline.org/

Rehm, Evan M., Paulo Olivas, James Stroud, and Kenneth J. Feely. 2015. Losing your edge: climate change and the conservation value of range-edge populations. Ecology and Evolution 5(19): 4315–4326.

Ring, Richard M. 2012. New York Natural Heritage Program online conservation guide for *Sparganium natans*. Available at https://guides.nynhp.org/small-bur-reed/

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.

Snyder, David. 2000. One hundred lost plants found. Bartonia 60: 1–22.

Steffen, Kristina, Thomas Becker, Wolfgang Herr, and Christoph Leuscher. 2013. Diversity loss in the macrophyte vegetation of northwest German streams and rivers between the 1950s and 2010. Hydrobiologia 713: 1–17.

Stevens, P. F. 2017. Angiosperm Phylogeny Website. Version 14, July 2017. Accessed May 7, 2022 at http://www.mobot.org/MOBOT/research/APweb/

Sulman, Joshua D., Bryan T. Drew, Chloe Drummond, Eisuke Hayasaka, and Kenneth J. Sytsma. 2013. Systematics, biogeography, and character evolution of *Sparganium* (Typhaceae): Diversification of a widespread aquatic lineage. American Journal of Botany 100(10): 2023–2039.

Taylor, Norman. 1909. Local flora notes - I. Torreya 9(10): 203–208.

Taylor, Norman. 1915. Flora of the vicinity of New York - A contribution to plant geography. Memoirs of the New York Botanical Garden 5: 1–683.

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. 2022a. *Sparganium natans* 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. 2022b. PLANTS profile for *Sparganium natans* (Small Bur-reed). The PLANTS Database, National Plant Data Team, Greensboro, NC. Accessed May 6, 2022 at http://plants.usda.gov

USEPA (U. S. Environmental Protection Agency). 2016. What climate change means for New Jersey. EPA 430-F-16-032. Available at https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-nj.pdf

Walz, Kathleen S., Linda Kelly, Karl Anderson and Jason L. Hafstad. 2018. Floristic Quality Assessment Index for Vascular Plants of New Jersey: Coefficient of Conservativism (CoC) Values for Species and Genera. New Jersey Department of Environmental Protection, New Jersey Forest Service, Office of Natural Lands Management, Trenton, NJ. Submitted to United States Environmental Protection Agency, Region 2, for State Wetlands Protection Development Grant, Section 104(B)(3); CFDA No. 66.461, CD97225809.

Yang, Xiao-e, Xiang Wu, Hu-lin Hao, and Zhen-li He. 2008. Mechanisms and assessment of water eutrophication. Journal of Zhejiang University Science B 9(3): 197–209.