Carex diandra

Lesser Panicled Sedge

Cyperaceae

Carex diandra by Peter M. Dziuk, 2016

***Carex diandra* 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

Carex diandra (Lesser Panicled Sedge) is a perennial sedge that grows in dense tufts. Early observers noted its close resemblance to *C. paniculata*, which is found throughout Europe (von Schrank 1781, Goodenough 1794). The specific name, *diandra*, means having two stamens and von Schrank (1781) originally noted that the male flowers were bi-staminate. However, a later illustration by Sturms et al. (1900) showed a tri-staminate male flower, and in their description of the species Gleason and Cronquist (1991) remarked "stamens 3, in spite of the name."

Lesser Panicled Sedge is included in *Carex* Section *Heleoglochin*. Some characteristics of sedges in that section include a tufted growth pattern, culms that are brown at the base, basal leaf sheaths with distinctive coloration, compound inflorescences with numerous spikes, spreading perigynia that turn brown at maturity, deciduous styles with two stigmas, and biconvex achenes. The culms of *Carex diandra* can reach up to 90 cm in height. The leaf blades are typically flat, 14–30 cm long, and 1–2.5 mm wide. The leaf sheaths are white with small but conspicuous red dots, and the sheaths continue past the base of the blades for several millimeters. The spikes of the inflorescence are bisexual, with the male flowers located above the female: They are usually somewhat crowded along the stem. The perigynia are dark and shiny at maturity and most of them extend beyond the ends of the yellowish-brown scales. The two-sided achenes are ovoid, 1.4–1.7 mm long, and 0.7–1.0 mm wide. (See Britton and Brown 1913, Fernald 1950, Gleason and Cronquist 1991, Arsenault et al. 2013, Cochrane 2020).

Left: Britton and Brown 1913, courtesy USDA NRCS 2024a. Center: Katy Chayka, 2016. Right: Hurd et al., courtesy USDA NRCS 2024b.

Only one other sedge in Section *Heleoglochin* is found in New Jersey, *Carex prairea*. Both *C. diandra* and *C. prairea* are rare in the state, and they can co-occur in the same habitat. The two species are closely related (Molina et al. 2015) and similar in appearance: In fact, Fernald (1908) initially viewed *C. prairea* as a variety of *Carex diandra*. Several characteristics can help to distinguish the two species—*C. prairea* has a coppery coloration at the top of the leaf sheaths and a more interrupted inflorescence; also the perigynia are not shiny and they are usually

concealed by the pistillate scales (Rhoads and Block 2007, Arsenault et al. 2012, Weakley et al. 2022). When immature, *Carex diandra* can also be confused with *C. stipata* (Weatherby and Blake 1939). *Carex diandra* has been known to hybridize with *C. secta* in New Zealand (Edgar 1964) and potential hybridization with *C. canescens* has also been reported in Europe (Cayouette and Catling 1992). No records of *C. diandra* hybrids in North America were found.

In New Jersey *Carex diandra* typically flowers and fruits from late May through August (Hough 1983, NJNHP 2024). In some parts of its range fruiting can continue into September (Cochrane 2020). Herriot (1916) observed that *C. diandra* plants in Ontario were well into bloom on June 20 and dispersing fruit on July 11. In New England, Bicknell (1917) reported that *C. prairea* was still in flower when *Carex diandra* was dispersing fruits on July 1, 1912. Some persistent fruits were observed in October 1997 at one New Jersey site, and at another location fruits clinging to culms during the last week of August 2007 were easily dislodged on contact (NJNHP 2024).

Pollinator Dynamics

Most sedges are pollinated by wind, although there are a few notable exceptions in scattered genera, including *Carex* (Goetghebeur 1998, Yano et al. 2015). Some adaptations to wind pollination in the family include large anthers, long filaments, and prominent stigmas (Zomlefer 1994).

In nearly all sedges, the female flowers develop before the male flowers (protogyny) and the lowest flowers on a spike are the first to mature (Goetghebeur 1998). Both strategies are typically viewed as means of promoting cross-pollination. However, experimentation to test that assumption showed that protogyny was not a particularly effective way of guaranteeing outcrossing in *Carex*, and the species in the study displayed a high degree of self-compatibility (Friedman and Barrett 2009). The authors concluded that protogyny gives wind-pollinated *Carex* species an opportunity to cross-fertilize while self-pollination assures reproductive success.

Seed Dispersal and Establishment

The fruit of a *Carex* plant is a single-seeded achene that forms in a sac-like perigynium in which it is eventually dispersed. A broad range of dispersal strategies have been reported in the genus, some of which were inferred from morphology (Leck and Schütz 2005). Mature *Carex diandra* fruits may remain on the culms until they are dislodged by wind or a passing animal. Gravity likely plays a role in local dispersal (Żukowski et al. 2010). *C. diandra* seeds are particularly buoyant, and their floating potential was rated as high in still water and very high in moving water (Van den Broek et al. 2005). Soomers et al. (2013) used measures of seed terminal velocity (falling speed in still air) to rule out the probability of wind dispersal in *C. diandra* and concluded that water was the dominant dispersal method for the species. However, they noted that opportunities for long-distance water dispersal can be limited by a lack of connectivity between suitable habitats. Distribution over long distances is probably facilitated by animals.

Mammals and birds, particularly waterfowl, eat the achenes of various *Carex* species (Fassett 1957) and that has been known to result in the dispersal of viable seed for other sedges (Leck and Schütz 2005). *Carex diandra* was identified as a component of the fall diet of Snow Geese (*Anser caerulescens*) and the birds appeared to feed on the sedge preferentially (Prevett et al. 1979).

Like many other sedges, *Carex diandra* is known to form a seed bank (Leck and Schütz 2005). *C. diandra* seeds are conditionally dormant at maturity and after that they have an absolute requirement for daytime temperatures with a minimal fluctuation of 2°C. In natural settings, *C. diandra* seeds overcome dormancy during the winter months so they are ready to germinate when diurnally alternating soil temperatures indicate that conditions are favorable (Fernández-Pascual et al. 2015). *Carex* seeds typically sprout underground, producing their first leaf 4–5 days after germination (Alexeev 1988). It is not clear whether *Carex diandra* forms any fungal associations: One other species in section *Heleoglochin* (*C. paniculata*) was examined and reported as non-mycorrhizal (Wang and Qiu 2006).

Habitat

Carex diandra thrives in wet places like bogs, marshes, swamps, and wet meadows (Ledingham and Fraser 1943, Hough 1983). Cochrane (2020) noted that the species often grows in shallow water and occasionally occurs in brackish conditions. It has been observed in low, wet swales between ridges or tussocks, on raised sphagnum bogs or sedge mats, and in floating fens (Raup 1931, Rigg 1940, Sims et al. 1997, Soomers et al. 2013). *C. diandra* is also frequently found in close proximity to water, establishing along banks and shorelines or on hummocks in bogs (Jordal 1951, Hellquist and Crow 2003, Rhoads and Block 2007). Based on a study of nearly 500 Canadian peatlands, microsite preferences identified for *Carex diandra* included a mean height of 13 (±11) cm above the water level and shade cover of 27 (±29) percent. A moderate range of pH (4.8–7.4, mean 6.3) was documented for the sedge but other measures of water chemistry varied widely (Gignac et al. 2004). Elevations where *C. diandra* has been recorded extend from 0–2800 meters above sea level (Cochrane 2020). In Pakistan the species generally grows at high elevations (eg. 1890 meters), where it tends to be abundant (Aslam et al. 2021).

Although it is frequently found in calcareous sites, *Carex diandra* is not a strict calcicole (Cochrane 2020, Weakley et al. 2022). However, New Jersey populations have typically been associated with limestone (Svenson and Rusk 1936, Johnson and Walz 2013, NJNHP 2024) and Lesser Panicled Sedge often occurs in fens in other parts of the United States as well (Sorrie 1987, Gage and Cooper 2006). In the Netherlands, *C. diandra* can become dominant in mesotrophic fens (Aerts and de Caluwe 1997) and it is usually one of the most abundant species in sedge-dominated fens in the British Isles (Wheeler 1980). An examination of successional stages in fens (*raft fen → quaking fen → rich fen*) found that germination and survival of *C. diandra* was significantly higher during the rich fen stage (Van den Broek and Beltman 2006). A number of other European studies were focused on the way *Carex diandra* obtains, allocates, and recycles nutrients in various fen habitats (eg. Pérez-Corona and Verhoeven 1996, Pérez-Corona et al. 1996, Aerts and de Caluwe 1997, Konings et al. 1989 & 1992).

At one location in New Jersey *Carex diandra* was reportedly sharing the habitat with at least a half dozen other graminoid species that are also rare in the state (NJNHP 2024). Typical associates noted in a Massachusetts fen included *Andromeda glaucophylla, Carex chordorrhiza, Potentilla palustris,* and *Salix pedicellaris* (Sorrie 1987). At the site of a Newfoundland *C. diandra* occurrence the typical flora included an assortment of sedges along with *Thalictrum pubescens, Betula pumila,* and *Larix laricina* (Bouchard and Hay 1976). During a recent fen restoration project in southeastern Quebec, *Carex diandra* established spontaneously in an area that had been planted with *Scirpus validus* (Bourgeois et al. 2018).

Wetland Indicator Status

Carex diandra 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 2024c)

CADI4

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

Carex diandra is native throughout the temperate northern hemisphere and also in New Zealand (POWO 2024). Molecular studies based on samples of *C. diandra* collected around the globe indicate that the sedge is about two hundred million years old and suggest that the species originated in North American before spreading across the northern hemisphere and down to Zealandia (Molina et al. 2015). The map in Figure 1 depicts the extent of *Carex diandra* in the United States and Canada.

The USDA PLANTS Database (2024c) shows records of *Carex diandra* in five New Jersey counties: Bergen, Morris, Sussex, Union, and Warren (Figure 2). Herbarium records indicate that the species was also collected in Somerset and Union counties (Mid-Atlantic Herbaria 2024). The data include historic observations and do not reflect the current distribution of the species.

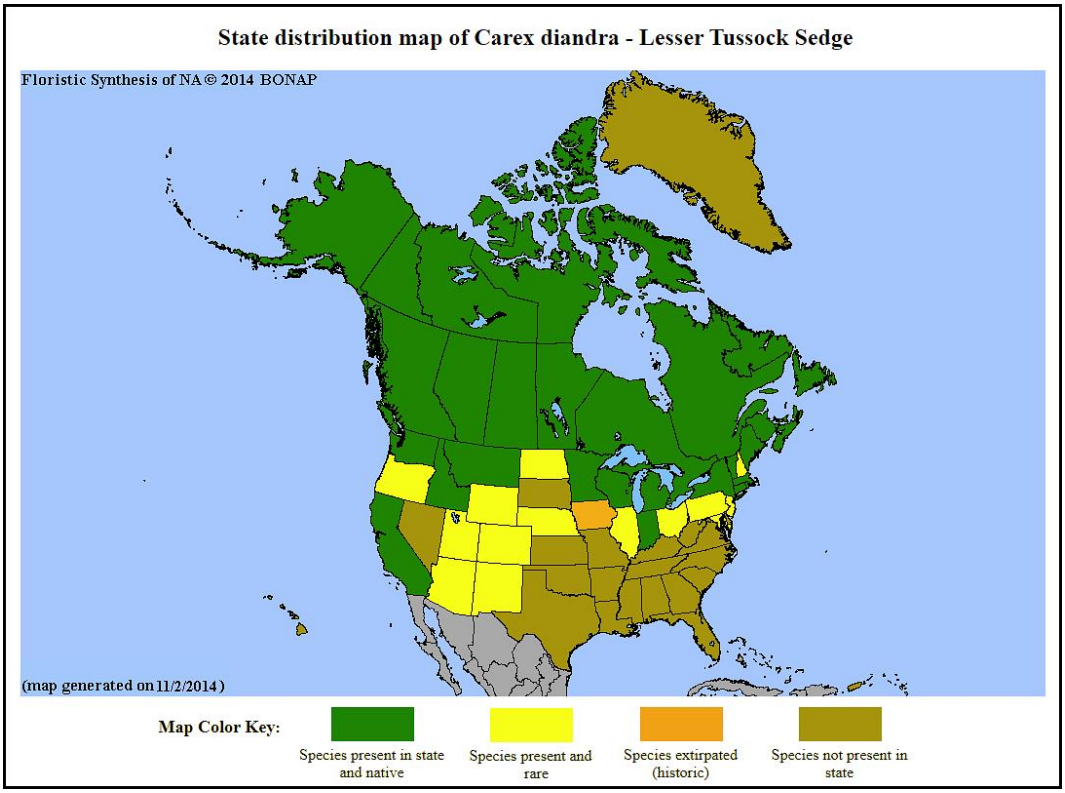

Figure 1. Distribution of C. diandra in North America, adapted from BONAP (Kartesz 2015).

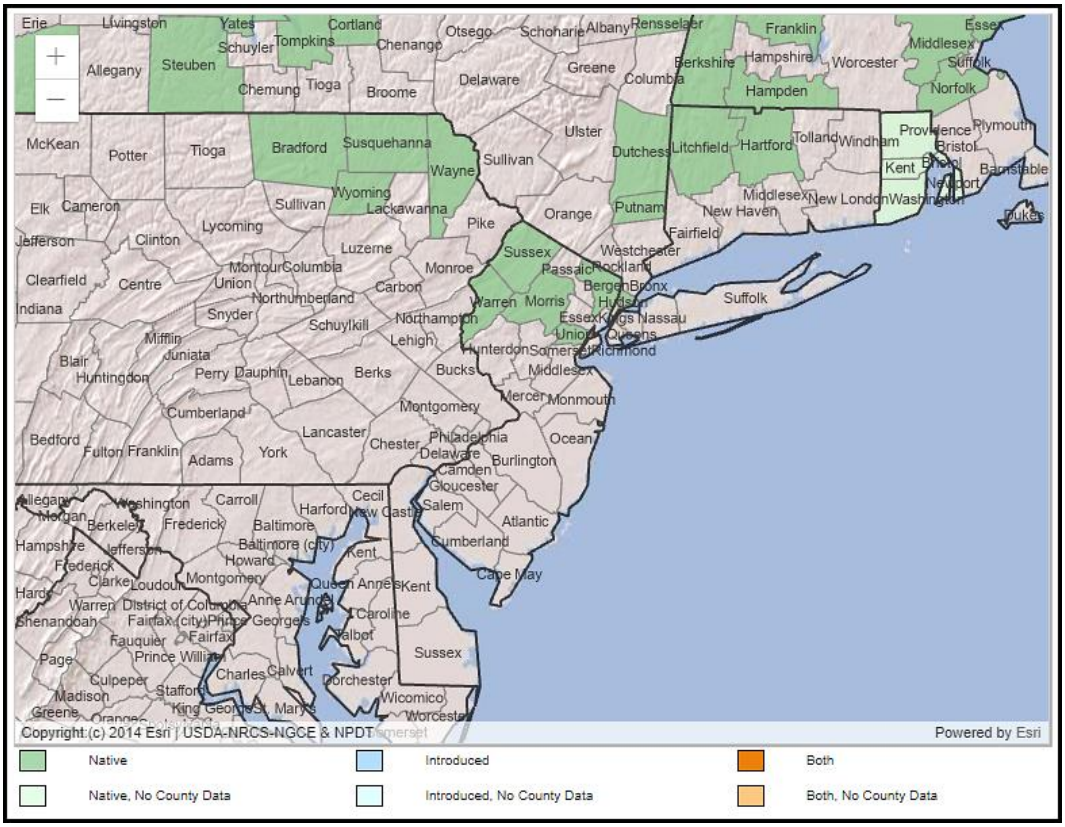

Figure 2. County records of C. diandra in New Jersey and vicinity (USDA NRCS 2024c).

Conservation Status

Carex diandra is considered globally secure. 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 2024). Cochrane (2020) noted that *C. diandra* is common throughout much of Canada but is more likely to be occasional or rare where it occurs in the United States. The species is vulnerable in the Netherlands (Soomers et al. 2013) but it has been characterized as invasive in Pakistan's rice fields (Molina et al. 2015).

The map below (Figure 3) illustrates the conservation status of Lesser Panicled Sedge in North America. *C. diandra* is vulnerable (moderate risk of extinction) in two states and one province, imperiled (high risk of extinction) in four states and one province, critically imperiled (very high risk of extinction) in seven states, and possibly extirpated in Iowa.

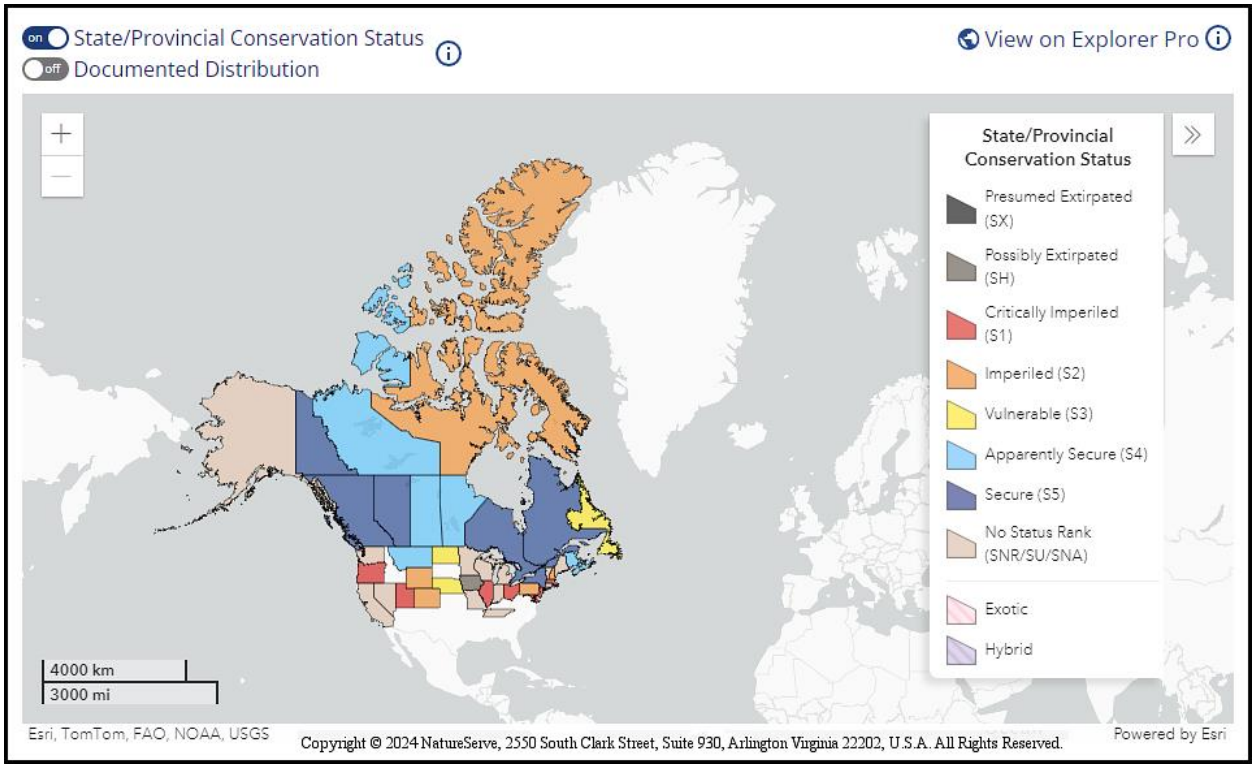

Figure 3. Conservation status of C. diandra in North America (NatureServe 2024).

New Jersey is one of the states where *Carex diandra* is critically imperiled (NJNHP 2024). 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. *C. diandra* has also been assigned a regional status code of HL, signifying that the species is eligible for protection under the jurisdiction of the Highlands Preservation Area (NJNHP 2010).

Carex diandra has been known in New Jersey since the mid 1800s. The sedge was first documented in Morris County, then subsequently reported in Bergen, Gloucester, Warren, and Sussex counties (Willis 1874, Britton 1881, Keller and Brown 1905). Some of the early records

were subsequently questioned—Taylor (1915) only reported the species in Sussex County and Hough (1983) noted that *C. diandra* was often confused with *C. prairea* and many of the older herbarium specimens had been misidentified. Two populations are currently thought to be extant in the state, one in Sussex County and one in Warren (NJNHP 2024).

Threats

Habitat fragmentation probably contributed to the decline of *Carex diandra* in the Netherlands (Soomers et al. 2013). In addition to being restricted to relatively small patches of suitable habitat within a highly developed landscape, plants that reside in New Jersey fens often face an array of anthropogenic threats including altered hydrology, degraded water quality, and damage from off-road vehicles. Any modifications to the sites' natural hydrologic or nutrient regimes can significantly change community composition by hastening successional processes or making the sites more habitable for invasive flora (Johnson and Walz 2013). Specific threats noted during visits to New Jersey's two extant populations of *C. diandra* were typical of those identified for the broader fen community—At one site the establishment of invasive plants was reported in the vicinity, while monitoring of the other site revealed that much of the previously available habitat had been flooded by beavers (NJNHP 2024). Maintenance of stable hydrology and the control of invasive species have also been identified as important considerations for the management of *C. diandra* in Pennsylvania (PANHP 2019).

Like many other sedges and grasses, *Carex diandra* can be utilized as a host by a number of potentially damaging fungi. Several species of rust fungi, including *Puccinia asterum, P. universalis,* and *P. urticata* have been documented on *C. diandra* (Kern 1917, Arthur 1927). *Anthracoidea (Cintractia) caricis* has also been reported on Lesser Panicled Sedge (Zundel 1939). *A. caricis* is a smut fungus that attacks the ovaries of multiple *Carex* species (FGBI 2024). Most fungal diseases can reduce reproduction or increase mortality, particularly when infections are intense or plant vigor has been depleted by other factors (Kranz 1990), and smut fungi that attack the floral parts of graminoid species generally destroy the seeds entirely (Fischer 1953).

Climate Change Vulnerability

As the climate becomes warmer plant communities in New Jersey are increasingly exposed to higher temperatures and a longer growing season, while shifting precipitation patterns are increasing the frequency and intensity of both droughts and floods (Hill et al. 2020). An evaluation by Ring et al. (2013) determined that *Carex diandra* was moderately vulnerable to climate change in New Jersey, and similar conclusions have been reached in Illinois (Molano-Flores et al. 2019) and in the northwestern United States (Gage and Cooper 2006). As previously noted, *Carex diandra* has never been particularly abundant in the United States. (Cochrane 2020) and many of the occurrences in the country are associated with fens—habitats which are highly sensitive to hydrological changes.

Sedges like *Carex diandra* might benefit from a longer growing season by having more time to develop, increasing the probability of producing healthy offspring (Antala et al. 2022). Unfortunately, any potential gains are likely to be overshadowed by negative impacts to the habitat. The combined effects of higher temperatures and lengthy summer droughts is predicted to significantly alter the composition of communities like those currently utilized by *C. diandra* (Moore 2002, Weltzin et al. 2003). A recent study of peatland flora in Germany found that plant species extinctions or declines were more frequent at low elevations where the impacts of higher temperatures and reduced water availability were greater (Sperle and Bruelheide 2021).

Management Summary and Recommendations

The calcareous fens that support *Carex diandra* are fragile habitats and they are relatively rare in New Jersey so conservation of those communities is the primary management consideration for the species. In addition to protecting the wetlands themselves, adequate buffers are needed to maintain the natural hydrology of the sites and to limit impacts from activities on adjacent land.

An updated onsite evaluation is recommended for one New Jersey population of *Carex diandra* that has not been observed since 1997. During the last visit a potential threat from the spread of invasive plant species was reported, and a new survey would provide an opportunity to assess both the status of the population and the severity of the threat. Depending on the outcome of the monitoring visit, it may be appropriate to develop a site-specific plan for invasive species control. Maintenance of the habitat could benefit *C. diandra* as well as a number of other rare species that also occur at the site. Due to the sensitive nature of the community, manual removal of problem species is suggested and if any herbicides are needed they should be applied directly to the target plants (Johnson and Walz 2013).

It would also be worthwhile to revisit New Jersey's other extant occurrence of *Carex diandra*. More than a decade has passed since the site was altered by beaver activity and the present condition of the sedge population is not known. The majority of Lesser Panicled Sedge occurrences tracked by the Natural Heritage Program in New Jersey are ranked as historical but suitable habitat may still be present at some of the sites (NJNHP 2024). Searches of the locations that can be identified would provide a more complete picture of the sedge's current status and future viability in the state.

Synonyms

The accepted botanical name of the species is *Carex diandra* Schrank. Selected orthographic variants, synonyms, and common names are listed below (ITIS 2024, POWO 2024, USDA NRCS 2024c). Goodenough (1794) described *Carex teretiuscula* in Great Britain and that name was applied to the species in North America until the early 1900s when it became known that the sedge had previously been published as *Carex diandra* in Germany by von Schrank (1781). Numerous forms and varieties have been described under *C. diandra* and *C. teretiuscula* but none are currently in use.

Botanical Synonyms

Carex bernardina Parish
Carex ehrhartiana Hoppe ex Boott
Carex paniculata var. *diandra* (Schrank) Fiori
Carex pseudoparadoxa S. Gibson
Carex teretiuscula Gooden.
Caricina teretiuscula (Gooden.) St.-Lag.
Physiglochis teretiuscula (Gooden.) Raf.
Vignea diandra (Schrank) Soják
Vignea teretiuscula (Gooden.) Rchb.

Common Names

Lesser Panicled Sedge
Lesser Tussock Sedge

References

Aerts, Rien and Hannie de Caluwe. 1997. Nutritional and plant-mediated controls on leaf litter decomposition of *Carex* species. Ecology 78(1): 244–260.

Alexeev, Yurii Evgeneevich. 1988. Ontogenesis in *Carex* species. Aquatic Botany 30(1–2): 39–48.

Antala, Michal, Radoslaw Juszczak, Christiaan van der Tol, and Anshu Rastogi. 2022. Impact of climate change-induced alterations in peatland vegetation phenology and composition on carbon balance. Science of the Total Environment 827: 154294.

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.

Arthur, Joseph Charles. 1927. Uredinales. Additions and corrections. North American Flora 7(12): 797–848.

Aslam, Sundas, Mansoor Hameed, and Muhammad Shahbaz. 2021. Distribution and ecology of some *Carex* L. species in sub-tropical pine and Himalayan moist temperate forests. Pakistan Journal of Botany 53(5): 1821–1829.

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

Bouchard, André and S. Hay. 1976. The vascular flora of the Gros-Morne National Park coastal plain in Newfoundland, Canada. Rhodora 78: 207–260.

Bourgeois, Berenger, Line Rochefort, Vicky Bérubé, and Monique Poulin. 2018. Response of plant diversity to moss, *Carex* or *Scirpus* revegetation strategies of wet depressions in restored fens. Aquatic Botany 151: 19–24.

Britton, N. L. 1881. A Preliminary Catalogue of the Flora of New Jersey. Geological Survey of New Jersey, Office of the Survey, Rutgers College, New Brunswick, NJ. 233 pp.

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.

Cayouette, J. and P. M. Catling. 1992. Hybridization in the genus *Carex* with special reference to North America. Botanical Review 58(4): 351–438.

Chayka, Katy. 2016. Photo of *Carex diandra*. Image courtesy of Minnesota Wildflowers, https://www.minnesotawildflowers.info/grass-sedge-rush/lesser-panicled-sedge licensed by https://creativecommons.org/licenses/by-nc-nd/3.0/.

Cochrane, Theodore S. Page updated November 5, 2020. *Carex diandra* Schrank. 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 1, 2024 at http://floranorthamerica.org/Carex_diandra

Dziuk, Peter M. 2016. Cover photo of *Carex diandra*. Image courtesy of Minnesota Wildflowers, https://www.minnesotawildflowers.info/grass-sedge-rush/lesser-panicled-sedge licensed by https://creativecommons.org/licenses/by-nc-nd/3.0/.

Edgar, Elizabeth. 1964. The natural sterile hybrid *Carex diandra* × *secta*. New Zealand Journal of Botany 2(3): 279–285.

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. 1908. Notes on some plants in northeastern America. Rhodora 10: 46–55.

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

Fernández-Pascual, Eduardo, Charlotte E. Seal, and Hugh W. Pritchard. 2015. Simulating the germination response to diurnally alternating temperatures under climate change scenarios: Comparative studies on *Carex diandra* seeds. Annals of Botany 115(2): 201–209.

FGBI (Fungi of Great Britain and Ireland). 2024. *Anthracoidea caricis*. Accessed May 3, 2024 at https://fungi.myspecies.info/all-fungi/anthracoidea-caricis

Fischer, George W. 1953. Smuts that parasitize grasses. USDA Yearbook of Agriculture 1953: 280–284.

Friedman, Jannice and Spencer H. C. Barrett. 2009. The consequences of monoecy and protogyny for mating in wind-pollinated *Carex*. New Phytologist 181: 489–987.

Gage, Edward, and David J. Cooper. 2006. *Carex diandra* Schrank (Lesser Panicled Sedge): A Technical Conservation Assessment. USDA Forest Service, Rocky Mountain Region, Species Conservation Project. 53 pp.

Gignac, L. D., R. Gauthier, L. Rochefort, and J. Bubier. 2004. Distribution and habitat niches of 37 peatland Cyperaceae species across a broad geographic range in Canada. Canadian Journal of Botany 82: 1292–1313.

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. 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.

Goodenough, Samuel. 1794. Observations on the British species of *Carex*. Transactions of the Linnean Society of London 2: 126–211.

Hellquist, C. Eric and Garrett E. Crow. 2003. The vascular flora of Mud Pond Peatland, Carroll County, New Hampshire. Rhodora 105(922): 153–177.

Herriot, W. 1916. Data on seed maturity of some Ontario plants. The Ottawa Naturalist 29(12): 151–157.

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.

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

ITIS (Integrated Taxonomic Information System). Accessed May 1, 2024 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.

Jordal, Louis H. 1951. Plants from the vicinity of Fairbanks, Alaska. Rhodora 53: 156–159.

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)].

Keller, Ida A. and Stewardson Brown. 1905. Handbook of the Flora of Philadelphia and Vicinity. Philadelphia Botanical Club, Philadelphia, PA. 360 pp.

Kern, Frank D. 1917. North American species of *Puccinia* on *Carex*. Mycologia 9(4): 205–238.

Konings, Henk, Edwin Koot and Anita Tijman-de Wolf. 1989. Growth characteristics, nutrient allocation and photosynthesis of *Carex* species from floating fens. Oecologia 80(1): 111–121.

Konings, Henk, Jos. T. A. Verhoeven, and Riny de Groot. 1992. Growth characteristics and seasonal allocation patterns of biomass and nutrients in *Carex* species growing in floating fens. Plant and Soil 147(2): 183–196.

Kranz, Jürgen. 1990. Tansley Review No. 28: Fungal diseases in multispecies plant communities. New Phytologist 116: 383–405.

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.

Ledingham, G. F. and W. P. Fraser. 1943. Notes on the Cyperaceae of Saskatchewan II. *Carex*. The American Midland Naturalist 29(1): 42–50.

Mid-Atlantic Herbaria. 2024. Accessed at https://midatlanticherbaria.org/portal/index.php on May 3, 2024.

Molano-Flores, Brenda, David N. Zaya, Jill Baty, and Greg Spyreas. 2019. An assessment of the vulnerability of Illinois' rarest plant species to climate change. Castanea 84(2): 115–127.

Molina, A., K. S. Chung, and A. L. Hipp. 2015. Molecular and morphological perspectives on the circumscription of *Carex* section *Heleoglochin* (Cyperaceae). Plant Systematics and Evolution 301(10): 2419–2439.

Moore, P. D. 2002. The future of cool temperate bogs. Environmental Conservation 29: 3-20.

NatureServe. 2024. NatureServe Explorer [web application]. NatureServe, Arlington, VA. Accessed May 1, 2024 at https://explorer.natureserve.org/

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.

PANHP (Pennsylvania Natural Heritage Program). 2019. Species and Natural Features List. Fact sheet for *Carex diandra* available at https://www.naturalheritage.state.pa.us/factsheets/15037.pdf

Pérez-Corona, M. Esther and Jos T. A. Verhoeven. 1996. Effects of soil P status on growth and P and N uptake of Carex species from fens differing in P-availability. Acta Botanica Neerlandica 45(3): 381–392.

Pérez-Corona, M. E., I. Van der Klundert, and J. T. A. Verhoeven. 1996. Availability of organic and inorganic phosphorus compounds as phosphorus sources for *Carex* species. New Phytologist 133: 225–231.

POWO. 2024. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Accessed May 1, 2024 at http://www.plantsoftheworldonline.org/

Prevett, J. Paul, Ian F. Marshall, and Vernon G. Thomas. 1979. Fall foods of Lesser Snow Geese in the James Bay region. The Journal of Wildlife Management 43(3): 736–742.

Raup, Hugh M. 1931. The formation of peat ridges on the shores of muskeg lakes in northern Alberta. Rhodora 33: 18–23.

Rhoads, Ann Fowler and Timothy A. Block. 2007. The Plants of Pennsylvania. University of Pennsylvania Press, Philadelphia, PA. 1042 pp.

Rigg, George B. 1940. Comparisons of the development of some *Sphagnum* bogs of the Atlantic coast, the interior, and the Pacific coast. American Journal of Botany 27(1): 1–14.

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.

Sims, R. A., G. M. Wickware, and Daryl W. Cowell. 1997. A study of coastal vegetation at a site on Hudson Bay near Winisk, Ontario. The Canadian Field-naturalist 101(3): 335–345.

Soomers, Hester, Derek Karssenberg, Jos T. A. Verhoeven, Pita A. Verweij, and Martin J. Wassen. 2013. The effect of habitat fragmentation and abiotic factors on fen plant occurrence. Biodiversity and Conservation 22: 405–424.

Sorrie, Bruce A. 1987. Notes on the rare flora of Massachusetts. Rhodora 89(858): 113–196.

Sperle, Thomas and Helge Bruelheide. 2021. Climate change aggravates bog species extinctions in the Black Forest (Germany). Diversity and Distributions 27(2): 282–295.

Sturms, J., E. Rob. Missbach, and Ernst H. L. Krause. 1900. Flora von Deutschland : in Abbildungen nach der Natur. Band 2. K. G. Lutz, Stuttgart, Germany.

Svenson, Henry K. and Hester W. Rusk. 1936. Field trips of the club. Torreya 36(5): 129–131.

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 (U. S. Dept. of Agriculture, Natural Resources Conservation Service). 2024a. *Carex diandra* 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. Photo of *Carex diandra* scales, perigynia, and achenes by Emerencia G. Hurd, N. L. Shaw, J. Mastrogiuseppe, L. C. Smithman, and S. Goodrich. Provided by USDA Forest Service RMRS Boise Aquatic Sciences Lab. 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). 2024c. PLANTS profile for *Carex diandra* (Lesser Panicled Sedge). The PLANTS Database, National Plant Data Team, Greensboro, NC. Accessed May 1, 2024 at http://plants.usda.gov

Van den Broek, Tom and Boudewijn Beltman. 2006. Germination and seedling survival in fens undergoing succession. Plant Ecology 185: 221–237.

Van den Broek, Tom, Rudy van Diggelen, and Roland Bobbink. 2005. Variation in seed buoyancy of species in wetland ecosystems with different flooding dynamics. Journal of Vegetation Science 16: 579–586.

von Schrank, Franz Paula. 1781. Eine Centurie Botanischer Anmerkungen zu des Ritters von Linne Species Plantarum. Erfurt, Germany.

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.

Wang, B., and Y. L. Qiu. 2006. Phylogenetic distribution and evolution of mycorrhizas in land plants. Mycorrhiza 16(5): 299–363.

Weakley, A. S. and Southeastern Flora Team. 2022. Flora of the Southeastern United States. University of North Carolina Herbarium, North Carolina Botanical Garden, Chapel Hill, NC. 2022 pp.

Weatherby, C. A. and S. F. Blake. 1939. On certain plant records from Hillsboro, New Hampshire. Rhodora 41: 28–34.

Weltzin, J. F., S. D. Bridgham, J. Pastor, J. Chen, and C. Harth. 2003. Potential effects of warming and drying on peatland plant community composition. Global Change Biology 9: 141–151.

Wheeler, B. D. 1980. Plant communities of rich-fen systems in England and Wales: II. Communities of calcareous mires. Journal of Ecology 68(2): 405–420.

Willis, O. 1874. Catalogue of Plants Growing in the State of New Jersey. J. W. Schermerhorn, New York, NY. 92 pp.

Yano, Okihito, Shizuka Fuse, Toshiyuki Fujikie, Minoru N. Tamura, Masaya Yago, Masahiro Sueyoshi, Yong-Ping Yang, and Hiroshi Ikeda. 2015. Insect pollination of *Carex* (Cyperaceae) from Yunnan, SW China. The Journal of Japanese Botany 90(6): 407–412.

Zomlefer, Wendy B. 1994. Guide to Flowering Plant Families. University of North Carolina Press, Chapel Hill, North Carolina. 430 pp.

Żukowski, Waldemar, Agnieszka M. Bogdanowicz, and Marlena Lembicz. 2010. Seed germination in sedges: A short review. Biodiversity Research and Conservation 19: 15–22.

Zundel, George L. 1939. Additions and corrections to Ustilaginales. North American Flora 7: 971–1030.