

Carex polymorpha Muhl.

Variable Sedge
Cyperaceae



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Carex polymorpha Rare Plant Profile

New Jersey Department of Environmental Protection
Division of Parks and Forestry
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New Jersey Natural Heritage Program

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Life History

Carex polymorpha, known colloquially as variable sedge, is a globally rare (G3), rhizomatous, herbaceous perennial member of the sedge family, Cyperaceae. The species is described as having firm, flat stem leaves that are 3-5mm wide, bracts with conspicuous loose sheaths, and ovate pistillate scales that are much shorter than the perigynia with purplish brown sides and conspicuous green centers (Gleason and Britton 1974). *C. polymorpha* is distinguished by its long beaked perigynia, densely flowered female spikes, and bladeless basal leaves. All leaves are a pastel green color in early summer and tawny yellow by mid-September (Maine Department of Agriculture Conservation and Forestry 2013). The species has a sympodial growth form, similar to most rhizomatous species of *Carex*, which consists of a rhizome and a terminal shoot that produces roots at the nodes and has buds in the axils of basal leaves. This growth form results in clusters of connected shoots produced by short rhizomes, dispersed at the ends of long rhizome segments (Standley and Dudley 1991). The flowering stalk is normally stiffly erect, 30-50cm tall, and contains a cluster of male flowers at the top as well as one to three spikes of female flowers below. Flowering stems first appear in May and remain intact through the summer with the fruits persisting in place (Pennsylvania Natural Heritage Program 2017).

Similar Species

Carex polymorpha is in Section Paniceae, along with *C. meadii*, *C. tetanica*, *C. livida*, and *C. woodii*. Together, this group exhibits 1) a strong rhizomatous growth form, 2) bracts with well-developed sheaths, 3) purple-brown or red-brown pistillate scales, and 4) ovoid to obovoid perigynia which are green, glabrous, and inflated (NatureServe 2019). However, other members of this Section in New Jersey occupy different habitats than *C. polymorpha*, either more wet or calcareous. Morphologically, *C. polymorpha* is distinguished from other New Jersey species in this Section by having a distinct beak (1.0-2.2 mm long) as opposed to being beakless or having a beak less than 0.5 mm (Weakley 2015).

In New Jersey, *Carex polymorpha* can be confused with *Carex vestita* (of Section Paludosae), with which it often grows, but *C. polymorpha* has smooth, hairless perigynia while *C. vestita* densely pubescent perigynia (Arsenault et al. 2013). Vegetatively, the length of the bladeless sheath leaves is 5 cm in *C. polymorpha* and 8-10 cm in *C. vestita*. The apex of the bladeless sheath is broadly acute in *C. polymorpha* and sharply acute in *C. vestita*. Also, the abaxial surface of the foliage leaf is papillose, rough, and appears white or dull in *C. polymorpha*, whereas it is smooth, shiny, and dark green in *C. vestita* (NatureServe 2019).

Pollination Dynamics

Like other species in the sedge family, *Carex polymorpha* is wind-pollinated. Plants of *C. polymorpha* are protogynous –the initial pistillate phase spans less than a week, the intermediate hermaphroditic phase continues for one to two days, and the final staminate phase lasts from one to several days. Although these stages occur at different times, the overlap in flowering potentially allows self-pollination to occur (Standley and Dudley 1991).

Studies have been conducted to determine whether the species' rarity is associated with its reproductive characteristics. Controlled breeding experiments showed that seed set rates for hand-pollinated plants are comparable to those for open-pollinated plants in the most favorable open habitats. These results demonstrated that *C. polymorpha* is self-compatible and that in open habitats the ability to reproduce is not limited by pollen availability (Standley and Dudley 1991).

Additionally, comparisons were made to the more common *Carex vestita*, which is similar in morphology and reproductive strategies to *Carex polymorpha*. *C. vestita* has a significantly higher reproductive potential due to its prevalence but has a lower number of flowering shoots and seed sets. Populations of *C. vestita*, even in open, favorable habitats, had lower fertility rates than populations of *C. polymorpha* in similar favorable sites. These results indicated that there were no significant differences from common or widely distributed species. Rarity in *C. polymorpha*, does not appear to be caused by reduced sexual reproduction, but rather appears to be the result of embryo abortion controlled by extraneous environmental factors such as resource limitation (Standley and Dudley 1991).

Seed Dispersal

The seeds of *Carex polymorpha* are brown and inconspicuous. Perigynia are tightly pressed, ascending, on stiff peduncles, ovoid 4.2-5.5mm long, with minute, smooth bumps and have 2 prominent marginal veins. The beak is long, straight, purplish at the tip and up to 1.8mm long. Achenes are 2.2-2.8mm long and 1.4-2.3mm wide (Arsenault et al. 2013).

The main way *Carex* species disperse seeds is gravity, although seeds may be also transported by wind, water, or animals – either externally by attaching to larger mammals or internally by ingestion. Some forest species are also dispersed by ants. Often, a combination of these different methods of seed dispersal can be observed in a single given species (Żukowski et al. 2010). Although limited research has been done on *Carex polymorpha*, these processes are common in this lineage.

Light seems to be a limiting resource in the development of achenes. Studies in Maine and Massachusetts showed that the highest incidence of flowering in *C. polymorpha* occurred where canopy cover was less than 50% and decreased to zero in areas where the canopy cover was greater than 80% (Standley and Dudley 1991). Shoot production was found to be 1.5% in open canopy, and less than 1% or absent in closed canopy sites. Spike production per stem ranged from 1 to 2 with 16-40 perigynia. Seed set varied greatly between shaded and unshaded sites, ranging from fewer than 2 achenes per spike in shaded sites to 30 achenes per spike in unshaded sites (NatureServe 2019). By extension, it may be that only in populations where light levels are sufficient enough to trigger the production of flowering shoots and development of achenes, can seeds disperse and colonize new sites to establish new populations.

Habitat

Throughout its range *Carex polymorpha* is known to grow in open, disturbed, mesic, sandy habitats, such as woodland edges, borrow pits, and open corridors (Arsenault et al. 2013), dry open woods, mostly in acidic soils (Gleason and Cronquist 1991), and thin woods and barrens in sandy-peaty soils (Rhoads and Block 2007). It is also noted to primarily be an upland species, but frequently occurs in upland-wetland ecotones and occasionally in *Sphagnum* wetlands. The sedge requires acidic, friable soils to permit the spread of its rhizomes (NatureServe 2019).

In Maine, an upland-wetland ecotone where *C. polymorpha* is found lies between a downslope dominated by *Equisetum sylvaticum* and *Carex crinita*, and an upslope forest of mixed *Quercus* and *Gaylussacia baccata*. In Pennsylvania, the species is frequently associated with *Lygodium palmatum*, a plant comparably dependent on acidic conditions. A Rhode Island population is found in very acidic soils at the ecotone of an upland grazed wooded area with a *Dennstaedtia punctilobula* understory, and a sloping *Sphagnum* wetland with *Scirpus expansus* and *Carex atlantica*. In Pennsylvania, all but one extant population occur on Clymer series soils, which are highly weathered, leached, and dystrophic. Another characteristic of *C. polymorpha* soils is that they are very low in natural fertility as nearly none of the sedge's associated plant species are particularly nutrient-demanding (NatureServe 2019).

One New Jersey population occurs in an open second growth forest. The forest is dominated by *Quercus rubra* and *Quercus alba* with a sparse *Sassafras albidum* understory and sparse shrub layer comprised of *Rhododendron periclymenoides*, *Gaylussacia frondosa*, *Vaccinium stamineum*, and *Kalmia angustifolia*. The herbaceous layer is also sparse with sedges and grasses. A second New Jersey population occurs in two closely associated habitats along an abandoned railroad; one within a mixed *Quercus* forest, and the other in a wooded *Acer rubrum* swamp. Other species associated with this population are *Osmunda cinnamomea*, *Pteridium aquilinum*, *Chimaphila maculata*, *Monotropa uniflora*, *Hamamelis virginiana*, *Geranium maculatum*, *Sassafras albidum*, *Scirpus hattorianus*, *Rubus hispidus*, *Aster divaricatus*, *Potentilla simplex*, *Prunus serotina*, *Solidago bicolor*, *Vaccinium vacillans* (= *Vaccinium pallidum*), and *Cornus florida* (NatureServe 2019).

In addition to disturbed habitats, a study conducted by Standley and Dudley points out that this species also appears to be adapted to or characteristic of habitats with frequent fires. The types of habitats in which the authors found *C. polymorpha* had sandy, low-nutrient soils that became very dry in late summer. Those habitats are susceptible to fire and had canopy species such as *Quercus* and *Pinus rigida* which are known to be fire-tolerant. Fires reduce the density of the canopy and increase the amount of light available to *C. polymorpha* for growth and reproduction, and may also function to remove the litter layer, facilitating seed germination. Furthermore, the underground rhizomes and meristems could survive a cool ground fire and rapidly re-sprout (Standley and Dudley 1991).

Wetland Indicator Status

According to the US Army Corps of Engineers National Wetland Plant List Indicator Definitions, *Carex polymorpha* is facultative upland (FACU), meaning that it usually occurs in non-wetlands, but may sometimes occur in wetlands (USDA 2020).

It can also be noted that although this sedge is an upland species, it has been found to occur in wetland ecotones and occasionally *Sphagnum*. The wetlands that support this sedge are seasonally saturated which contributes to the formation of a thick topsoil rich in organic material (NatureServe 2019).

USDA Plants Code

CAP04; USDA Plant Code for *Carex polymorpha* Muhl.

Coefficient of Conservatism

CoC = 8; Native with a narrow range of ecological tolerances and typically associated with a stable community (Walz et al. 2018).

Distribution and Range

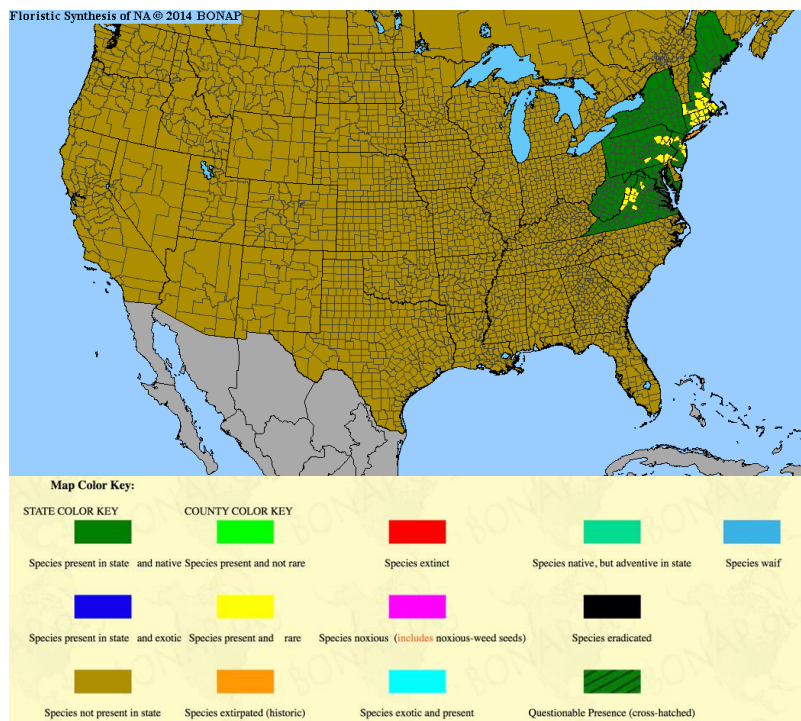


Figure 1. Distribution of *Carex polymorpha* in North America (Kartesz 2015).

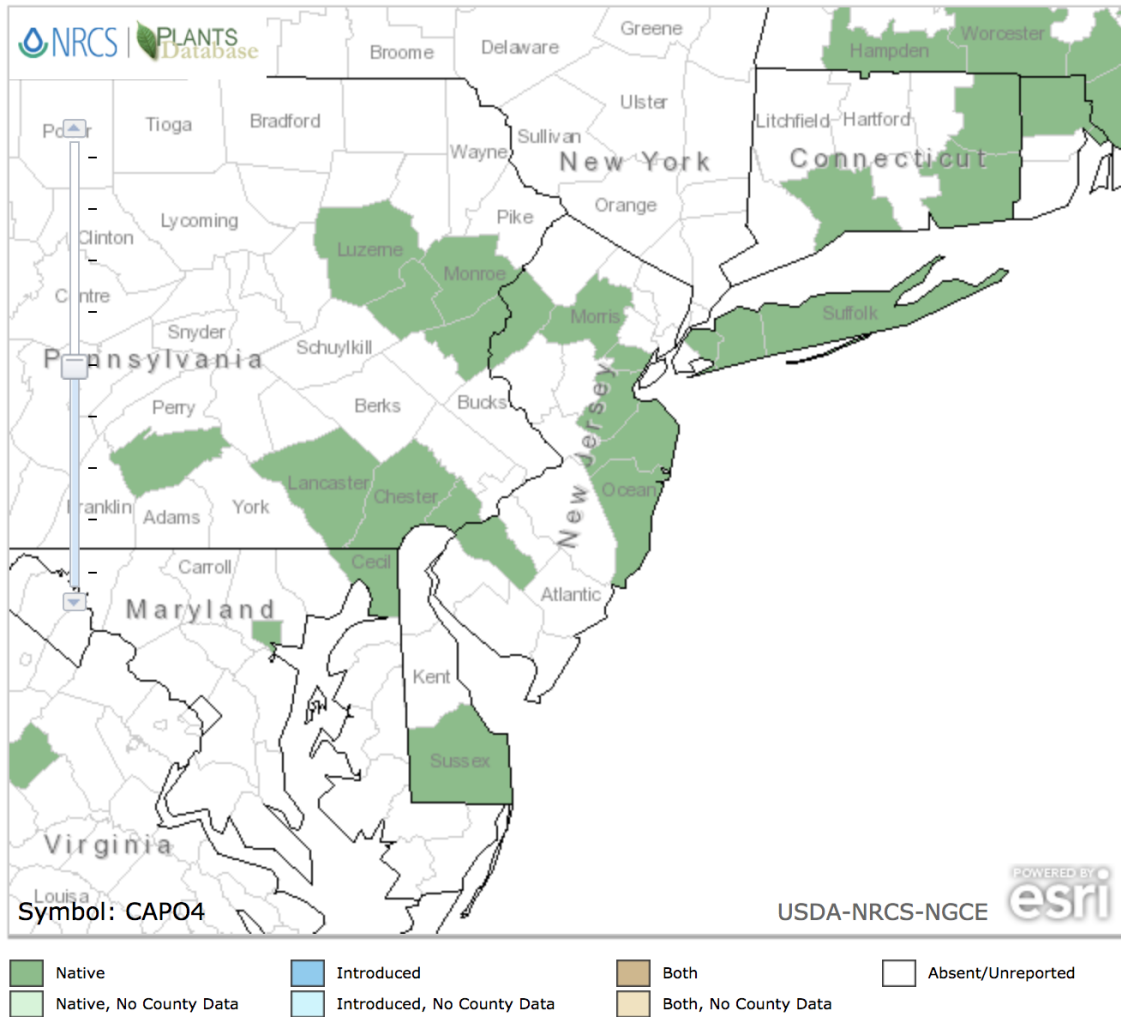


Figure 2. Distribution of *Carex polymorpha* in New Jersey (USDA 2020).

Carex polymorpha is locally distributed in the northeastern United States, occurring in a narrow band stretching from Maine to Virginia. Figure 1 illustrates the distribution of the species, with dark green shaded regions indicating states where the species is native, yellow shaded regions where the species is present and rare, and orange shaded regions where the species is extirpated (Kartesz 2015). In New Jersey, the shaded regions in Figure 2 indicate that the species is native to Gloucester, Ocean, Monmouth, Middlesex, Union, Morris, and Warren county, with two extant occurrences in Morris county (USDA 2020).

The distribution of *Carex polymorpha* populations throughout this relatively large geographic area from Maine to Virginia suggests that this species is not of recent origin. Studies on the pattern of genetic variation found within *C. polymorpha* also suggest that it has not undergone recent bottlenecks. Variations in population size are buffered by clonal reproduction and the ability to persist through adverse conditions such as disturbance or changing resource availability. Data shows that rarity does not appear to be a cause nor a consequence of reduced genetic variation as this species is rare in spite of high levels of genetic variation (Standley et al. 1991).

Conservation Status

Carex polymorpha is a rare sedge with fewer than 30 remaining populations from Maine to West Virginia. The species is listed as rare in each of the states in which it is known to occur or to have occurred. Listed as globally rare and found locally throughout its range (G3) environmental factors and other threats make *C. polymorpha* vulnerable to extinction. Furthermore, the species is critically imperiled in New Jersey (S1) with 8 historic occurrences and fewer than 5 remaining occurrences in restricted habitats throughout the state (New Jersey Natural Heritage Program 2016).

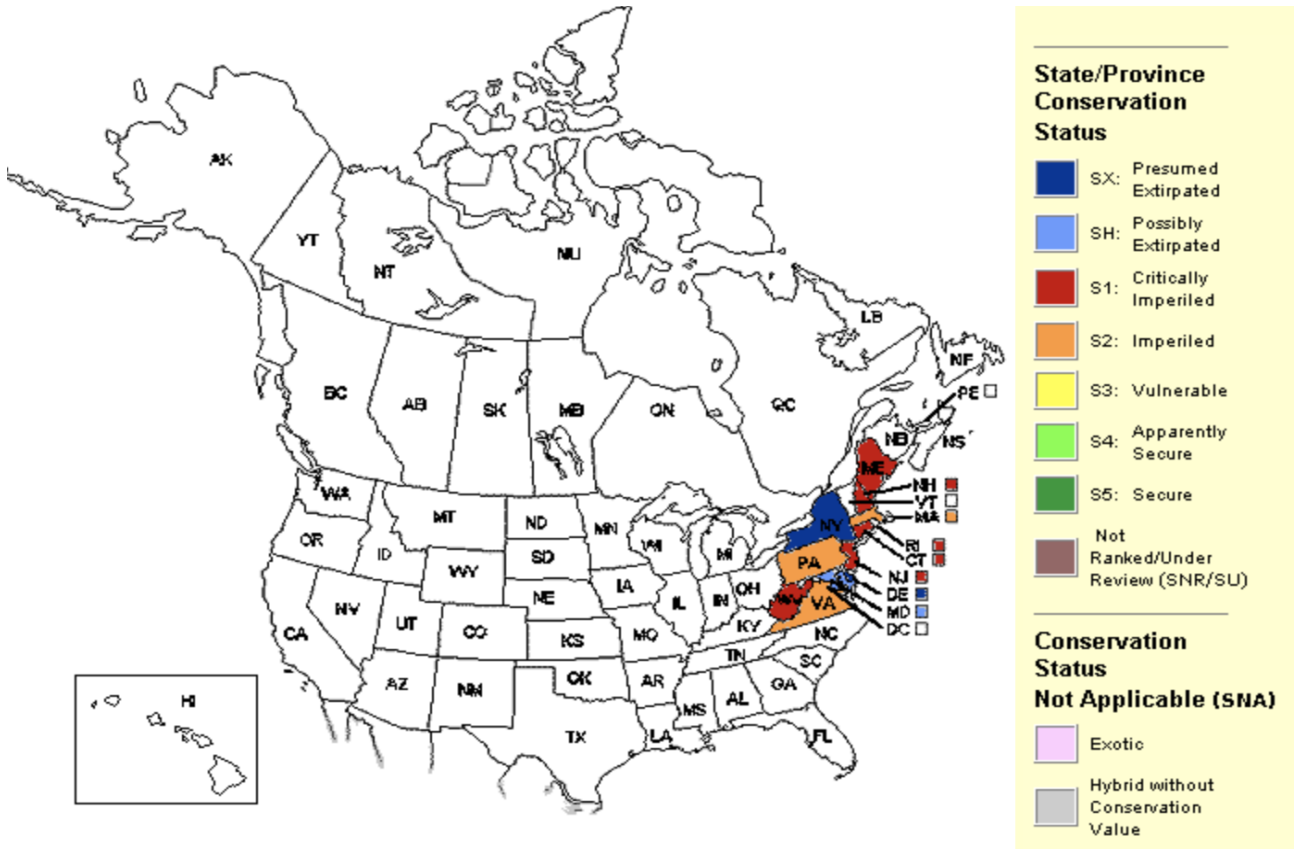


Figure 3. Conservation Status of *Carex polymorpha* (NatureServe 2019).

Figure 3 illustrates the combined data on conservation statuses of *C. polymorpha* synthesized by the reports of individual natural heritage programs for each state. Throughout its range, the species is listed as imperiled (S2), critically imperiled (S1), as well as possibly and presumably extirpated (SH, SX).

The New Jersey List of Endangered Plant Species and Plant Species of Concern also indicates that *C. polymorpha* is listed as State Endangered (E), listed by the Pinelands Commission as endangered or threatened within their legal jurisdiction (LP), and (HL) protected by the

Highlands Water Protection and Planning Act within the jurisdiction of the Highlands Preservation Area (New Jersey Natural Heritage Program 2016).

Threats

The most imminent threat to *Carex polymorpha* seems to be habitat destruction, as much of the species' habitat has been destroyed throughout its range. In historical New York sites, the species is considered extirpated due to habitat alteration and destruction as the result of urbanization (New York Natural Heritage Program 2020). In other states where it formerly occurred, many historic localities have been destroyed by sand and gravel mining as well as residential development. In Pennsylvania, many acres of suitable habitat have been stripped for topsoil, and more recently in Maine, new houses have encroached upon two known populations –one of which was the state's largest population. In southeastern Massachusetts there have been tremendous pressures to develop lowland areas where known populations occur for cranberry production. And although some populations at The Nature Conservancy's Panther Knob Preserve in West Virginia are under little threat, other remote sites in West Virginia are also at risk of development (NatureServe 2019).

Though the locations of these populations are known to regulatory agencies and The Nature Conservancy, very few state laws or regulations are actually available to protect this rare species. The upland habitats and buffer zones in which this sedge grows are areas generally not protected from development by federal or state wetland protection statutes. The sandy substrates preferred by this species will continue to be altered by sand and gravel removal operations. Several populations occur on railroad or utility rights of way or easements where vegetation management through use of herbicides may also pose a threat. Unless placed under protective ownership, all known localities must be regarded as under severe risk of development or alteration that would eliminate habitat suitable for *C. polymorpha*. Even within protected areas, habitat management may be necessary to maintain optimal conditions for vegetative growth and sexual reproduction necessary for the long-term viability of this species (Standley and Dudley 1991).

Management Summary and Recommendations

A reasonable goal for this species going forward would be to maintain and protect the few extant populations remaining throughout its range, with the intent to augment populations where possible by optimizing habitat and resource conditions. There is also potential to discover new populations in the states in which the species still occurs. Land protection is imperative to protect *C. polymorpha* from development, which has evidently been the biggest threat for this sedge.

There is no reliable method for germinating achenes of this species, although it may be possible to utilize vegetative propagation techniques to increase the size of existing populations and even establish new populations. Feasibility of vegetative propagation was demonstrated in Maine, when the successful transplantation of *C. polymorpha* in mats or as individual plants was achieved when a population was threatened by construction (Everett 2001). Larger populations are the primary reservoir for genetic diversity within the species and may serve as a source

population to colonize new sites (Standley et al 1991). However, propagation and outplanting at the site of natural populations or to create new populations remains a controversial proposition, particularly for rare plant species. Any such proposals should be thoroughly researched and reviewed by multiple agencies before implementation.

Being that the rarity of *C. polymorpha* appears to be the result of embryo abortion controlled by extraneous environmental factors, additional research should be conducted on resource limitations for this species. Further research should be conducted in greenhouse experiments to determine the optimal amount of sunlight that stimulates sexual reproduction, as well as soil and resource requirements for optimal embryo success rates. Other studies suggest that a reduction in shrub competition and canopy cover by prescribed burning could stimulate growth of the species (Howard 2015).

Synonyms

Botanical Name	<i>Carex polymorpha</i> Muhl.
Common Name	Variable sedge

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