Equisetum pratense

Meadow Horsetail

Equisetaceae

Equisetum pratense by Peter M. Dziuk, 2013

***Equisetum pratense* 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

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Life History

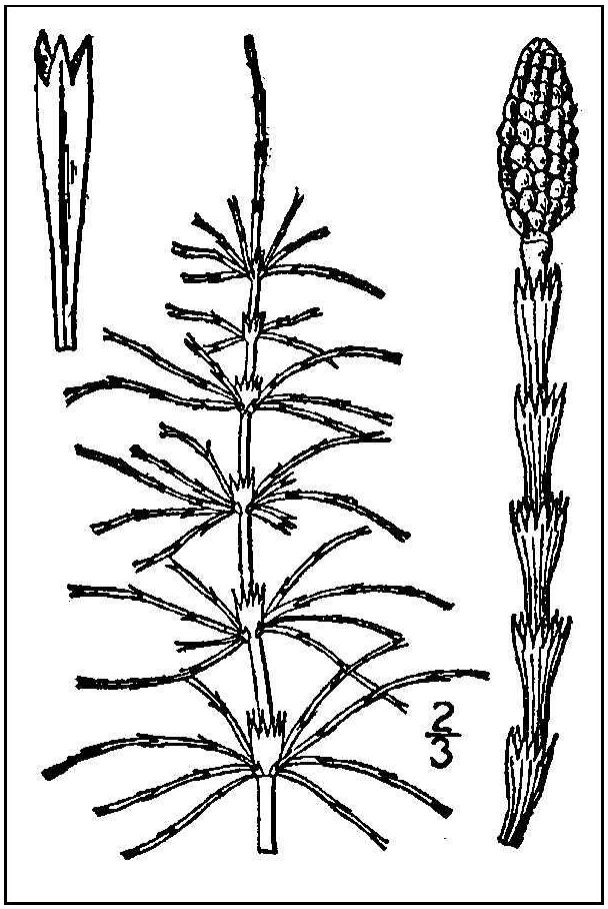
Equisetum pratense (Meadow Horsetail) belongs to the sole remaining genus from an ancient group of plants that originated during the Devonian period. The genus *Equisetum* is frequently divided into two subgenera—*Hippochaete* and *Equisetum*—with *E. pratense* included in the latter group. Like other pteridophytes, *Equisetum* has a life cycle with two independent generations. Spores produced by mature plants (sporophytes) develop into tiny free-living gametophytes that develop structures which produce male and female reproductive cells (gametes). Male gametes (sperm) develop in an antheridium and a female gamete (egg) develops in an archegonium. The gametophytes of *Equisetum* may be either bisexual or male. In bisexual gametophytes the eggs cells develop in advance of the sperm cells, increasing the chance of cross-fertilization. Fertilized female cells develop into the familiar horsetail plants that produce the spores for the next generation, and multiple sporophytes may arise from a single gametophyte (Raven et al. 1986).

Duckett (1985) noted that the wild gametophytes of *E. pratense* had never been described, but the developmental processes reported for species from both subgenera are similar. *Equisetum* gametophytes are flat and rounded or slightly lobed, typically ranging from 1–10 mm in diameter (Walker 1921, Duckett 1985). The gametophytes of subgenus *Hippochaete* can be larger than those of subgenus *Equisetum*, sometimes achieving diameters up to 35 mm (Husby 2013). Walker (1921) observed that the gametophytes of *E. laevigatum* were dull green with a brownish tint, making them inconspicuous on wet soil. The surface is covered by a membrane of photosynthetic cells, and the underside has abundant rhizoids that attach the tiny plants to the substrate (Duckett 1985, Knowlton 2012). This is a relatively short phase in the life of an *Equisetum* plant. A cultivation study of *E. hyemale* found that it took about two months for spores to develop into sexually mature gametophytes (Whittier 1996), and *E. laevigatum* spores placed on favorable substrate in June developed sporophytes by mid-September (Walker 1921).

Equisetum pratense sporophytes have perennial rhizomes that produce annual stems. Two kinds of stems are produced by Meadow Horsetail: The sterile stems are green and branched while the fertile stems are initially whitish-pink or brown, produce cone-like strobili at the tips, then become green and branched after the spores have been shed. Branches are produced in a whorl at each node and are typically spreading to drooping, and the sheaths of the hollow main stem have narrow teeth with white borders that equal or exceed the dark centers in width. (See Britton and Brown 1913, Fernald 1950, Gleason and Cronquist 1991, Montgomery and Fairbrothers 1992, Hauke 2020).

Both stem types originate from buds that were formed during the previous growing season. *Equisetum pratense* plants studied by Apple (1985) in Montana had basal buds present in November, by which time the stems from that year had completely died back. The fertile stems were quick to expand at the beginning of the growing season, and the sterile stems began to elongate when the fertile stems were releasing their spores. In New Jersey, strobili may be found from late April through July, and sometimes persist into September (Hough 1983). Vegetative propagation continues throughout the growing season as new roots and shoots are produced at the nodes of rhizomes (Apple 1985). Schaffner (1928) reported variability in a number of the characteristics of mature *Equisetum* plants, and Hauke (2020) noted that the aerial stems of

plants in the genus can vary considerably in height and branching habits in response to environmental conditions. Most horsetails, including *Equisetum pratense*, are able but not obligated to form mycorrhizal associations and the development of those relationships is thought to be dependent on unspecified habitat conditions (Dhillon 1993, Husby 2013).



Left: Britton and Brown 1913, courtesy USDA NRCS 2022a. Right: Stem sheath teeth by Peter M. Dziuk, 2014.

Equisetum pratense is most likely to be confused with *E. arvense* (Field Horsetail) and *E. sylvaticum* (Woodland Horsetail). Eaton (1904) offered some tips for distinguishing the species, asserting that the stem of *E. arvense* is smooth while *E. pratense* is covered with small spines which give it a grayish tinge, and that the compound branches of *E. sylvaticum* readily distinguish it from the other two species. Staniforth (2014) noted that the upper stem internodes of *E. pratense* were rough to the touch while those of *E. arvense* were smooth. The broad white margins of the stem teeth on *E. pratense* may also help to identify the species (Fernald 1950).

Pollinator Dynamics

Because *Equisetum pratense* is a non-flowering plant, pollination does not take place. Fertilization occurs on the gametophytes and is dependent on water, which allows the movement of the multi-flagellated sperm cells toward a receptive egg cell (Raven et al. 1986).

Seed Dispersal

Dispersal in *Equisetum pratense* is carried out by spores rather than seeds. An *Equisetum* strobilus contains a series of modified leaves bearing receptacles (sporangia) in which spores are formed. Each spore is surrounded by four spirally coiled bands with clubbed ends known as an elaters that expand and contract with variations in moisture (Newcombe 1888, Raven et al. 1986). After the sporangia split open, movement of the elaters may play a role in helping to fling the bright green spores from the plants (Knowlton 2012, Husby 2013), and their widened ends may also aid in wind transport (Newcombe 1888). Expanded elaters can become tangled so that clusters of spores are dispersed together, assuring that multiple gametophytes will develop in close proximity to one another and thus increasing the likelihood of cross-fertilization (Taylor et al. 2005). Once released, the spores may fall immediately or be carried in the air and eventually deposited in a new location. *Equisetum* spores do not float, but they are able to remain green in water for approximately 48 hours (Apple 1985).

Equisetum spores can germinate within 24 hours of release but they retain viability for only a short period, typically a few days but occasionally as many as 17 depending on humidity (Apple 1985, Whittier 1996, Husby 2013). The spores require both favorable substrate and light to germinate and develop into gametophytes (Hauke 1977, Raven et al. 1986). Even with adequate resources the young plants may face additional challenges. In some species of *Equisetum* subgenus *Equisetum* the sporophytes produce allelopathic compounds that may prevent the formation of gametophytes in the vicinity of mature plants. Even once established, *Equisetum* gametophytes may be unsuccessful because they compete poorly with bryophytes and vascular plants (Duckett 1985, Husby 2013).

Habitat

Unvegetated moist soil is required for the establishment of *Equisetum* gametophytes (Husby 2013). Recently flooded muddy ground that is rich in nutrients is favorable substrate for germination and development (Raven et al. 1986), and Walker (1921) reported finding *Equisetum* gametophytes primarily on mud banks along waterways of all sizes but also in a ditch where bare soil had recently been exposed by fire. Moist habitat is essential for the movement of sperm and hence for the development of sporophytes (Husby 2013).

The sexual expression of *Equisetum* gametophytes has been the subject much study and debate. It has long been thought that some environmental factors influenced the relative proportion of male and bisexual gametophytes in a given population (Walker 1921). Hauke (1977) reported that male gametophytes were shorter-lived than female or bisexual ones, and Duckett (1985) noted that gametophytes were less likely to develop as males when environmental conditions were favorable for growth. Recent work by Guillon and Fievet (2003) indicated that light availability influences the sex determination of *Equisetum* gametophytes but does not on its own account for female bias in natural populations.

Equisetum pratense sporophytes are usually associated with alluvial soil in meadows and wet woodlands at elevations from 0–2000 meters (Schaffner 1921, Hauke 2020). New Jersey habitat

has been characterized as rich and often calcareous soil in open, moist woodlands near streams (Fairbrothers and Hough 1973), floodplain forests (Montgomery 1982), stream banks, and springy moist woods (Montgomery and Fairbrothers 1992). Habitat for one extant occurrence in the state is described as a riverside site in very rich old growth woods with a sparse shrub canopy (NJNHP 2022). A vegetation survey in New York found *Equisetum pratense* in a glacial era floodplain wetland and also in a semi-open woodland with a moderately well-developed shrub layer and a well-developed sedge-dominated herbaceous layer (Wu and Kalma 2013). A study of understory composition in aspen (*Populus tremuloides*) stands in British Columbia found that *E. pratense* was strongly associated with highly productive sites, and that nutrient and moisture availability were the main variables driving site productivity (Chen et al. 2004).

Several specific community associations were identified during a study in Alberta, Canada (Timoney et al. 1997). *Equisetum pratense* was characteristic of Balsam Poplar forest (*Populus balsamifera*/*Alnus*/*Cornus stolonifera*/*Equisetum pratense* association). The horsetail became increasingly dominant in developing White Spruce forests and was a characteristic species at old growth sites (*Picea glauca*/*Alnus*/*Equisetum*/*Hylocomium* association). *E. pratense* was also identified as a dominant species in recently disturbed sites such as new clear-cut (*Rosa - Rubus pubescens - R. idaeus* association) and new burn (*Epilobium angustifolium*/moss association)

Data from British Columbia was used to calculate the species' microsite preferences such as elevation (0–2300 meters, average = 907 m) and slope gradient (0–205 percent, average = 7%) (Klinkenberg 2020). Klinkenberg also quantified the most favorable moisture regime as 5 (subhygric) on a scale of 0 (very xeric) to 8 (hydric) and identified the nutrient regime as D (rich). A more comprehensive description of the soil and moisture regimes is provided by the B. C. Ministry of Forests (1998). In a subhygric water regime the primary water source is precipitation and seepage. Water is removed slowly enough to keep soil wet for a significant part of the growing season but some temporary seepage and mottling is possible at depths below 20 centimeters. A rich nutrient regime, in which available nutrients are plentiful, is associated with sites at which the water pH generally falls between 6.5 and 7.4.

Based on a collective assessment of four *Equisetum* species including *E. pratense*, Marsh et al. (2000) found that the horsetails are highly efficient at acquiring and cycling nutrients and thus make a significant contribution to the communities in which they occur. *E. pratense* roots can extend as far as 2.5 meters below the surface and most other *Equisetum* plants are also deeply rooted, enabling them to retrieve nutrients from greater depths than many other species. In one community, horsetails representing 5% of the aboveground biomass contributed 29% of the phosphorus and 39% of the potassium in the leaf litter when they discarded their stems at the end of the season. The nutrients then became incorporated into higher soil horizons where they were available to other plants such as sedges (*Carex spp*.), willows (*Salix spp*.) and Sweetgale (*Myrica gale*). Mycorrhizae were not observed on any of the *Equisetum* species in the study.

Wetland Indicator Status

Equisetum pratense is a facultative wetland species, meaning that it usually occurs in wetlands but may occur in nonwetlands (U. S. Army Corps of Engineers 2020).

USDA Plants Code (USDA, NRCS 2022b)

EQPR

Coefficient of Conservatism (Walz et al. 2018)

CoC = 9. 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

Equisetum pratense is globally distributed throughout the subarctic and temperate Northern Hemisphere (POWO 2022). The map in Figure 1 illustrates the extent of the species in the United States and Canada.

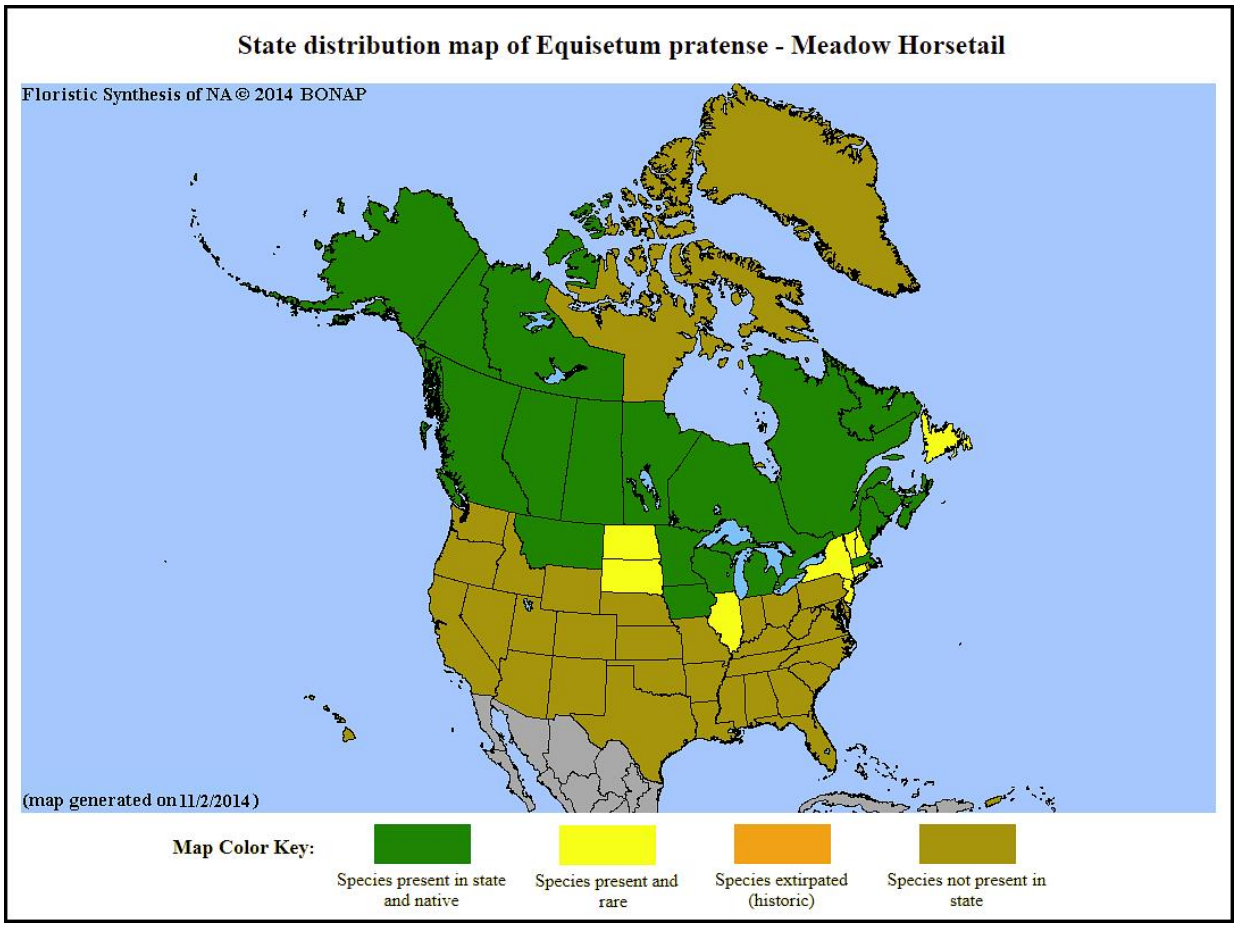


Figure 1. Distribution of E. pratense in North America, adapted from BONAP (Kartesz 2015).

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

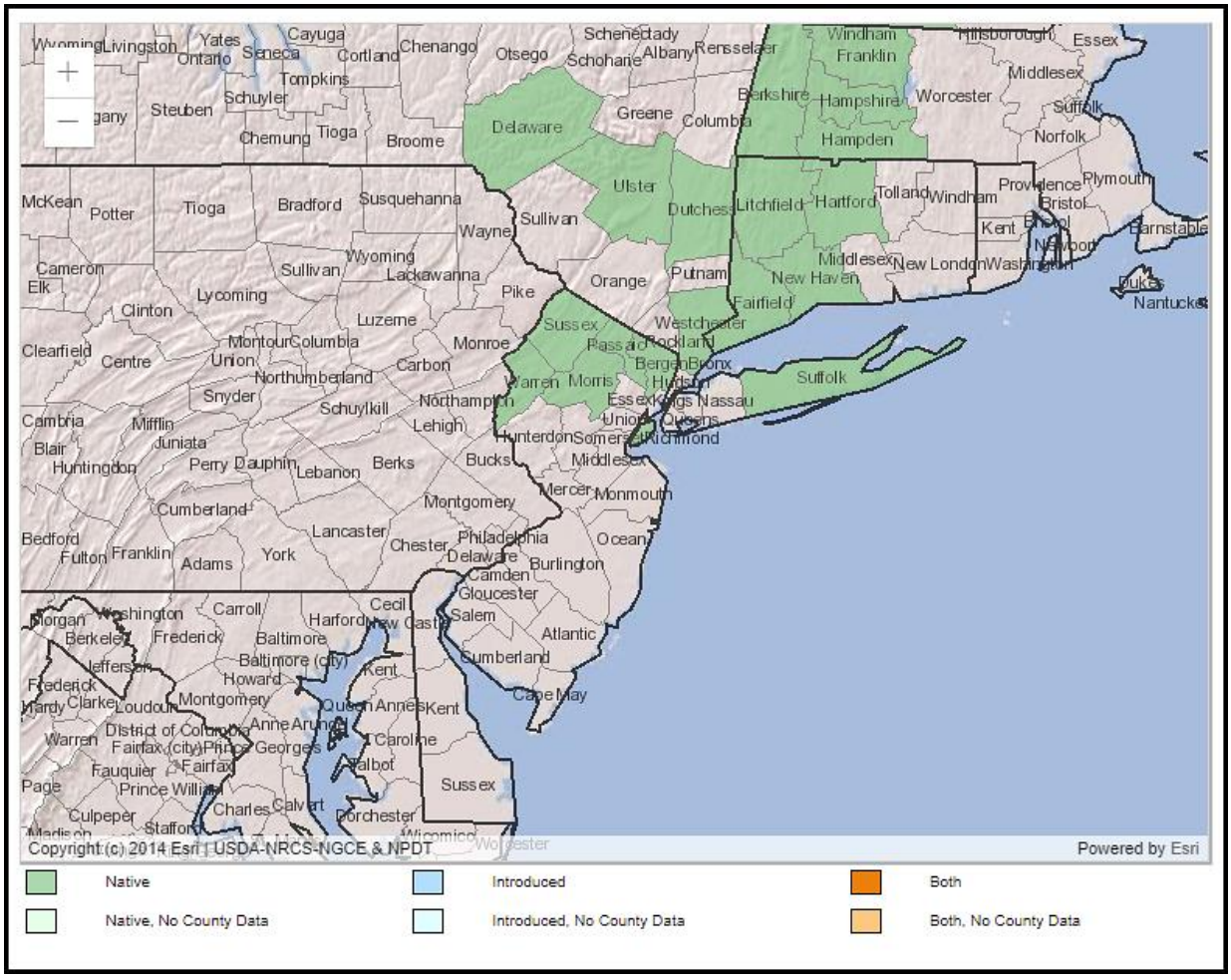


Figure 2. County records of E. pratense in New Jersey and vicinity (USDA NRCS 2022b).

Conservation Status

Equisetum pratense 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 2022). The map in Figure 3 (below) illustrates the conservation status of *E. pratense* in the United States and Canada. The species is listed as critically imperiled (very high risk of extinction) in three states, imperiled (high risk of extinction) in four states and one province, and vulnerable (moderate risk of extinction) in two provinces and two states. It is shown as secure, apparently secure, or unranked throughout the rest of its North American range.

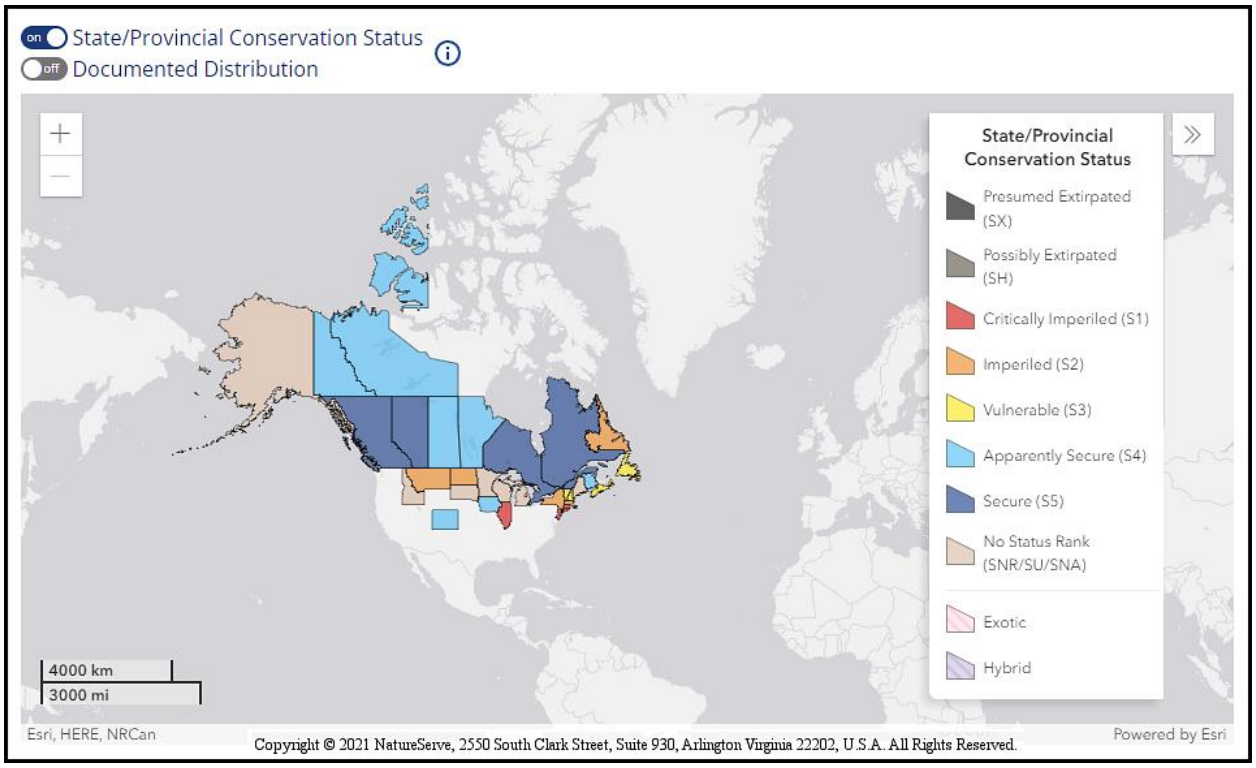


Figure 3. Conservation status of E. pratense in North America (NatureServe 2022).

New Jersey is one of the states where *Equisetum pratense* 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. Meadow Horsetail 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 plant 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 New Jersey, *Equisetum pratense* is at the southern edge of its geographical range and it has only been reported from sites that are north of the terminal moraine of the Wisconsin glacier (Taylor 1915, Hough 1983). Early state records of the species were from Bergen and Sussex Counties (Britton 1881, Taylor 1915). Fairbrothers and Hough (1973) identified the species as endangered in the state and noted that several occurrences had been eliminated by human activity, at which point Meadow Horsetail was known to be present in Morris, Passaic, and Sussex but no longer in Bergen County. Within the next two decades the species also disappeared from Passaic County (Montgomery and Fairbrothers 1992). Today, two populations remain extant in the state (NJNHP 2022).

Threats

Equisetum pratense requires a specific set of substrate, light, moisture and nutrient conditions in order to successfully establish a new population. In a study of forest plant dispersal along corridors, *E. pratense* was classified as a habitat specialist that did not disperse well (Liira and Paal 2013). Once established, however, the horsetail's deep roots and profuse vegetative reproduction allow it to persist for a long time. One New Jersey occurrence has been documented at the site for over 150 years (NJNHP 2022). Consequently, the greatest threat to extant populations is habitat loss. Two occurrences in New Jersey were extirpated as a result of habitat destruction for development, and nearby construction may have impacted habitat quality at another location (NJNHP 2022). In New York, reported threats to extant occurrences include habitat damage resulting from logging, improper roadside maintenance, foot traffic, erosion, and flooding (NYNHP 2022).

A potential threat from invasive plant species located just upstream was noted for one New Jersey occurrence (NJNHP 2022). Some of the identified species such as Japanese Barberry (*Berberis thunbergii*) and Garlic Mustard (*Alliaria petiolata*) can alter the soil chemistry after they become established, making it unsuitable for other species (Kaufman and Kaufman 2007). The proliferation of nonindigenous vegetation is a particular problem in New Jersey (NJDSR 2021) and many invasive plants can rapidly colonize disturbed ground, limiting the number of available germination sites for species like *Equisetum pratense* that have narrower habitat requirements.

Some herbivory has been reported but the extent of the threat to Meadow Horsetail is uncertain. *Equisetum* species are avoided by most insects—possibly due to high silicate content in stems or toxic compounds in the sap—but a few have formed obligate host associations with horsetails in the subgenus *Equisetum* (Poinar 2014). Reported insect herbivores include species of Coleoptera (Curculionidae, Chrysomelidae), Hymenoptera (Tenthridinidae), Hemiptera (Delphacidae, Cicadellidae, Aphidoidea) and Diptera (Agromyzidae). While some damage to horsetail plants may occur, none of the insects appear to pose a significant threat to any species of *Equisetum*. Young plants may be more vulnerable to pests. Walker (1921) reported slug herbivory on developing *E. laevigatum* sporophytes in a greenhouse. Hamilton and Lloyd (1991) studied the impacts of earthworms on establishment of the fern *Deparia acrostichoides* (Silvery spleenwort), and although the results showed that the presence of earthworms promoted the development of gametophytes the worms subsequently destroyed the young sporophytes.

In North American, *Equisetum pratense* is most vulnerable at the southern and eastern margins of its range, and threats to imperiled populations could be exacerbated by changing climactic conditions. Limited genetic variation would be expected for a species that relies heavily on clonal reproduction, and Huh et al. (2014) found that genetic diversity in *E. pratense* was lower than average for plants with similar life history traits. Low gene variability can reduce the probability of adaptation to shifting circumstances (Silvertown 1987). Nevertheless Knowlton (2012) reminds us that the genus *Equisetum* is derived from an ancient lineage that has already survived a period of global climate change.

Management Summary and Recommendations

In areas where *Equisetum pratense* is threatened or endangered, management efforts should focus on the preservation of extant populations. The long-lived species is likely to persist at locations where it is established as long as its habitat remains intact. Because many populations are closely associated with waterways and wetlands, some regulatory protections are available for Meadow Horsetail. Extant populations should be monitored periodically to assure that sites remain undisturbed. Consideration should be given to management of invasive plant species that directly threaten *E. pratense* occurrences or are establishing in the same watershed and occupy habitat which might otherwise be favorable for the establishment of gametophytes.

Because of its vigorous rhizomatous growth, *Equisetum pratense* appears to be a good candidate for transplantation or reintroduction to restored habitat if such actions are deemed necessary in the future. The species was successfully introduced and grown in a patch of low ground with running water emanating from a drain pipe at the Ohio State University Botanic Garden (Schaffner 1935). *E. pratense* also readily established in three communities where it had not been previously documented following the addition of flood-deposited sediments from a local stream (Baattrup-Pederson et al. 2012). Additional research on gametophyte establishment, the long-term success of transplants, and the impacts of invasive plant species would be beneficial.

Synonyms

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

Botanical Synonyms	Common Names
Equisetum arvense f. *macrostachyum* A. A. Eaton	Meadow Horsetail

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