Spiranthes ovalis var. *erostellata*

Lesser Ladies'-tresses

Orchidaceae

Spiranthes ovalis var. *erostellata* courtesy Alan Cressler, Lady Bird Johnson Wildflower Center

***Spiranthes ovalis* var. *erostellata* 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

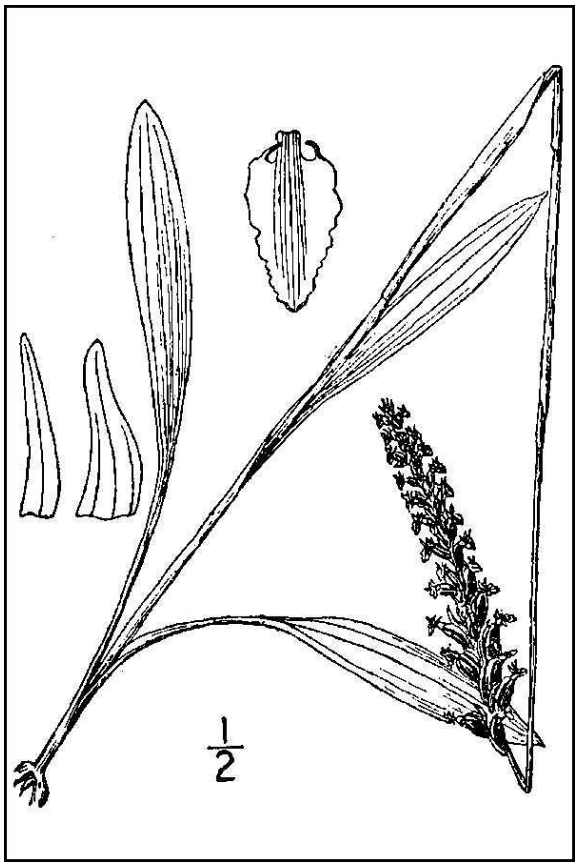
October, 2023

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. 2023. *Spiranthes ovalis* var. *erostellata* 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. 16 pp.

Life History

Spiranthes ovalis var. *erostellata* (Lesser Ladies'-tresses) is a perennial orchid with fleshy roots. Two or three basal or near-basal leaves are present at the time of flowering and some smaller bractlike leaves may be present on the stem. *S. ovalis* leaves are oblanceolate in shape, 3–15 cm long, and 0.5–1.5 cm wide. The leaves and lower part of the stem are smooth but the upper portion of the stem and inflorescence are pubescent. The stems are generally under 40 cm in height. The inflorescence is a dense, spirally arranged spike of 20–40 white flowers that are subtended by green bracts and usually form three discernible rows. Each flower is about 6 mm long: The sepals are 3.5–5 mm long and separate to the base, the petals are lance-shaped, and the lip is ovate with a wavy margin. (See Fernald 1950, Gleason and Cronquist 1991, Homoya 1993, Fowler 2005, Sheviak and Brown 2020).



Left: Courtesy Alan Cressler, Lady Bird Johnson Wildflower Center. Right: Britton and Brown 1913, courtesy USDA NRCS 2023a. The illustration depicts *Spiranthes ovalis* and predates the recognition of varieties in the species.

Daniel and Johnson (2017) referred to *Spiranthes ovalis* var. *erostellata* as the latest-blooming *Spiranthes* in the northeast. Throughout its range the orchid may flower from August through November (Weakley et al. 2022) but September or October are typical in northeastern states (Ames 1906, Rhoads and Block 2007). Not all of the plants in a colony bloom simultaneously. Observations of *S. ovalis* var. *erostellata* populations with plants in various stages of bud, flower, and fruit have been made during mid-September in New Jersey (NJNHP 2022) and early October

in New York (Daniel and Johnson 2017). Argus et al. (1987) noted that *S. ovalis* var. *erostellata* can be readily distinguished from most fall flowering *Spiranthes* by the size of its flowers—those of the other ladies'-tresses are generally 2–3 times larger. Some *Spiranthes* species occasionally remain below the ground for a year but can still flower upon emergence the following season (Rasmussen 1995).

In his original description of *Spiranthes ovalis*, Lindley (1840) remarked that it was "a very distinct and apparently rare plant." Perhaps because the species was relatively uncommon, nearly a century and a half passed before anyone noticed that there were two discrete varieties of *S. ovalis*. The two forms are identical in most respects but have a critical difference in floral structure as described by Catling (1983). Most orchid flowers have a rostellum (a little beak-like structure that extends from the upper edge of the stigma and prevents contact between the anthers and the stigma) and a viscidium (a sticky structure on the pollinia that attaches them to visiting insects). *Spiranthes ovalis* var. *erostellata* flowers lacks both a rostellum and a viscidium, although both are fully developed in *S. ovalis* var. *ovalis*. *S. ovalis* var. *ovalis* also has slightly longer sepals. *S. ovalis* var. *ovalis* is mostly limited to the gulf coast states but var. *erostellata* has a much broader range so *S. ovalis* plants growing north of Arkansas are likely to be the latter variety (Sheviak and Brown 2020, NAOCC 2022, Weakley et al. 2022).

Care must be taken with the identification of *Spiranthes* plants. Hybridization and polyploidy have been documented in the genus and many North American species have overlapping morphological traits. Conflicting results have been reported from molecular studies that have attempted to resolve taxonomic relationships within *Spiranthes*, and new species are still being described (Dueck and Cameron 2007, Dueck et al. 2005 & 2014, Pace and Cameron 2017, Hough and Young 2021). At least twelve kinds of *Spiranthes* have been found in New Jersey—including one recently described by Pace and Cameron (2017)—and half of them are listed as species of concern in the state (Kartesz 2015, NJNHP 2022).

Pollinator Dynamics

The majority of *Spiranthes* species are bee-pollinated (Argue 2012, Pace 2020) and *S. ovalis* var. *ovalis* is thought to be fertilized by bumblebees (*Bombus* spp.) (NAOCC 2022). However, the unique structure of *Spiranthes ovalis* var. *erostellata* more or less precludes insect pollination so its flowers are almost entirely self-pollinated (Catling 1983). Catling observed that pollen germinated on the flowers' stigmatic surfaces before they had even opened. In fact, the flowers of *S. ovalis* var. *erostellata* seldom expand fully and even while they are in bloom the ovaries are often visibly swollen because the fruits are already developing (Homoya 1993, Fowler 2005, Sheviak and Brown 2020). Nevertheless, Catling (1983) suggested that because the flowers do open the possibility of occasional cross-fertilization cannot be ruled out.

Seed Dispersal and Establishment

Spiranthes fruits are erect capsules (Britton and Brown 1913). Orchids produce numerous tiny, dustlike seeds that consist mainly of an embryo surrounded by a loose, papery coating (Dressler

1981). Some *Spiranthes* have polyembryonic seeds but those of *S. ovalis* var. *erostellata* contain a single embryo (Sheviak and Brown 2020). Approximately 69% of a typical *Spiranthes* seed consists of internal air space, which allows the wind-dispersed propagules to remain afloat in the air for long periods. Many orchid seeds also have a water-resistant outer surface that—together with the internal air space—permits flotation, allowing some movement of seeds via surface water. The seeds of a number of *Spiranthes* species have been reported to float when wet. The general characteristics of orchid seeds also allow them to be transported by adherence to birds or animals (Arditti and Ghani 2000).

Rasmussen (1995) reported that the seeds of North American *Spiranthes* could remain viable for up to three years when refrigerated but the best results were obtained from sowing fresh seed. Because their seeds lack endosperm, orchids must form associations with appropriate fungi in order to germinate and develop (Dressler 1981). *Spiranthes* seeds often germinate near mature plants where suitable fungi are likely to be present in the soil (Ames 1921). However established *Spiranthes* plants are not fully dependent on mycorrhizae and some species develop fungal associations seasonally, particularly during the fall and winter months (Rasmussen 1995). Certain members of the genus can be grown on artificial media without fungi but survival rates are poor (Zettler 1996). Brooks and Zettler (2000) studied *Spiranthes ovalis* var. *erostellata* and found the species difficult to germinate. After they isolated a fungus (*Ceratorhiza* sp.) from a mature plant they successfully germinated seeds by inoculating their culture medium with the fungus. Even then, the *S. ovalis* var. *erostellata* seeds took more than five months to sprout and only had an 18% germination rate. Furthermore, few of the seedlings lived long enough to produce leaves. According to Zale et al. (2022), seeds of *S. ovalis* var. *erostellata* that were sterilized in calcium hypochlorite have been germinated without fungi in a laboratory setting.

Other members of the genus usually germinate more rapidly and they display a typical orchid developmental pattern, first forming protocorms and then producing small leaves and roots (Zettler and McInnis 1993, Zettler et al. 1995). Ames (1921) indicated that *Spiranthes cernua* could produce slender, few-flowered racemes during the first growing season after germination and more typical inflorescences by the second year, although he noted that most orchids require a longer period of development before they can bloom. Some cultivated species of *Spiranthes* have also been known to flower within two years of germination (Zettler et al. 1995).

Habitat

Spiranthes ovalis var. *erostellata* has been reported in a wide variety of habitats, primarily at elevations of 0–900 meters above sea level (Sheviak and Brown 2020). Some early habitat descriptions preceded delineation of the varieties but were likely to apply to var. *erostellata* based on location. For example, Ames (1906) reported the habitat of *Spiranthes ovalis* as shady, moist woods on high hills for plants occurring from "Georgia westward to Indian Territory; Tennessee, and northward to Missouri and Illinois," Barksdale (1933) described the habitat of North Carolina plants as dry wooded hills, and Parr (1984) characterized Tennessee habitat as rich, shady woods. Natural habitats reported more recently for *S. ovalis* var. *erostellata* show the orchid's tolerance for a broad array of moisture conditions, including swamps and floodplains,

mesic prairies and damp forests, and dry upland sites (Homoya 1993, Fowler 2005, Rhoads and Block 2007, NJNHP 2022, Weakley et al. 2022).

The soils in places where *Spiranthes ovalis* var. *erostellata* occurs may be loamy, sandy, silty, gravelly, or clayey mixtures (Argus et al. 1987, McGrath 2001, Hubini et al. 2017). The substrate is frequently calcareous but the species has also been found on acidic sites (Homoya 1993). *S. ovalis* var. *erostellata* seldom grows in full sun: It is most likely to be found in sites with moderate light levels but occasionally has been reported in heavy shade (Homoya 1993, Fowler 2005, Catchpole 2012, Carter and Pace 2013). The canopy is often deciduous (eg. Parr 1984, Carter and Pace 2013, NJNHP 2022) but may be mixed with *Juniperus* or *Pinus* spp. (Homoya 1993, McGrath 2001). Many of the woodland habitats that support populations of Lesser Ladies'-tresses have been characterized as early successional sites or second-growth forest (Parr 1984, Homoya 1993, Bennett and Course 1996, Catchpole 2012, Carter and Pace 2013, Hubini et al. 2017).

Spiranthes ovalis var. *erostellata* has frequently been found along the edges of trails or roadways (Homoya 1993, Bennett and Course 1996, Carter and Pace 2013), as was the New Jersey occurrence (NJNHP 2022). The New York population became established on calcareous clay fill from a dredge spoil (Daniel and Johnson 2017), and in Indiana the orchid was growing in a lawn (Prast et al. 2013). Additional examples of disturbed habitats where *S. ovalis* var. *erostellata* has been collected include campgrounds, cemeteries, parks, and railway corridors, and one Virginia site was described as a recently thinned and burned hardwood-pine stand (Mid-Atlantic Herbaria 2023). *Spiranthes ovalis* var. *erostellata* seems to be increasingly making use of early successional habitats and disturbed sites and it may be becoming better adapted to establishing in such locations (Argus et al. 1987, Homoya 1993). The apparent trend could be a consequence of its reproductive strategy. Self-fertilized orchids often have a broader distribution than their outcrossing relatives and that pattern is displayed by *S. ovalis* var. *erostellata* and *S. ovalis* var. *ovalis* (Catling and Bennett 2007). Sun (1996, 1997) studied *S. hongkongensis*, which has a self-pollination mechanism similar to that of *S. ovalis* var. *erostellata*, and pointed out that the two *Spiranthes* species are also alike in that they are good colonizers and frequently establish in successional, disturbed, or newly created habitats.

Wetland Indicator Status

Spiranthes ovalis is a facultative species, meaning that it occurs in both wetlands and nonwetlands (U. S. Army Corps of Engineers 2020).

USDA Plants Code (USDA, NRCS 2023b)

SPOVE

Coefficient of Conservancy (Walz et al. 2020)

CoC = 4. Criteria for a value of 3 to 5: Native with an intermediate range of ecological tolerances and may typify a stable native community, but may also persist under some anthropogenic disturbance (Faber-Langendoen 2018).

Distribution and Range

The global range of *Spiranthes ovalis* var. *erostellata* is restricted to the United States and Canada (POWO 2023). The map in Figure 1 shows the extent of the species in North America. New Jersey and New York are not included on the map because the orchid was only documented in those states recently. *S. ovalis* var. *erostellata* was found in New York during 2015 (Daniel and Johnson 2017) and in New Jersey during 2020 (NJNHP 2022).

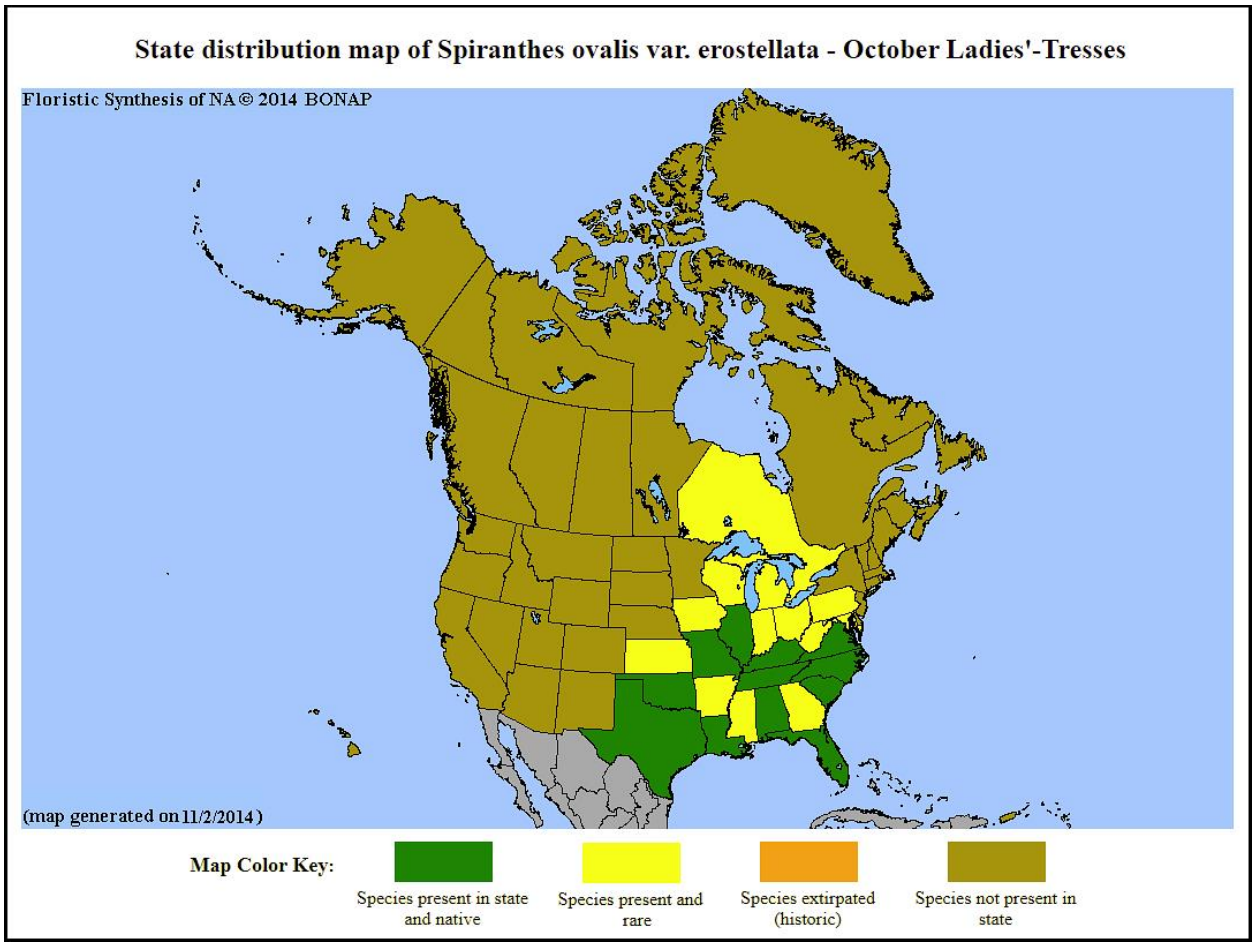


Figure 1. Distribution of S. ovalis var. erostellata in North America, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2022) does not include any New Jersey county records for the species because, as noted above, *S. ovalis* var. *erostellata* is a very recent addition to the state's

flora (Figure 2). The only documented occurrence in the state is located in Warren County (NJNHP 2022).

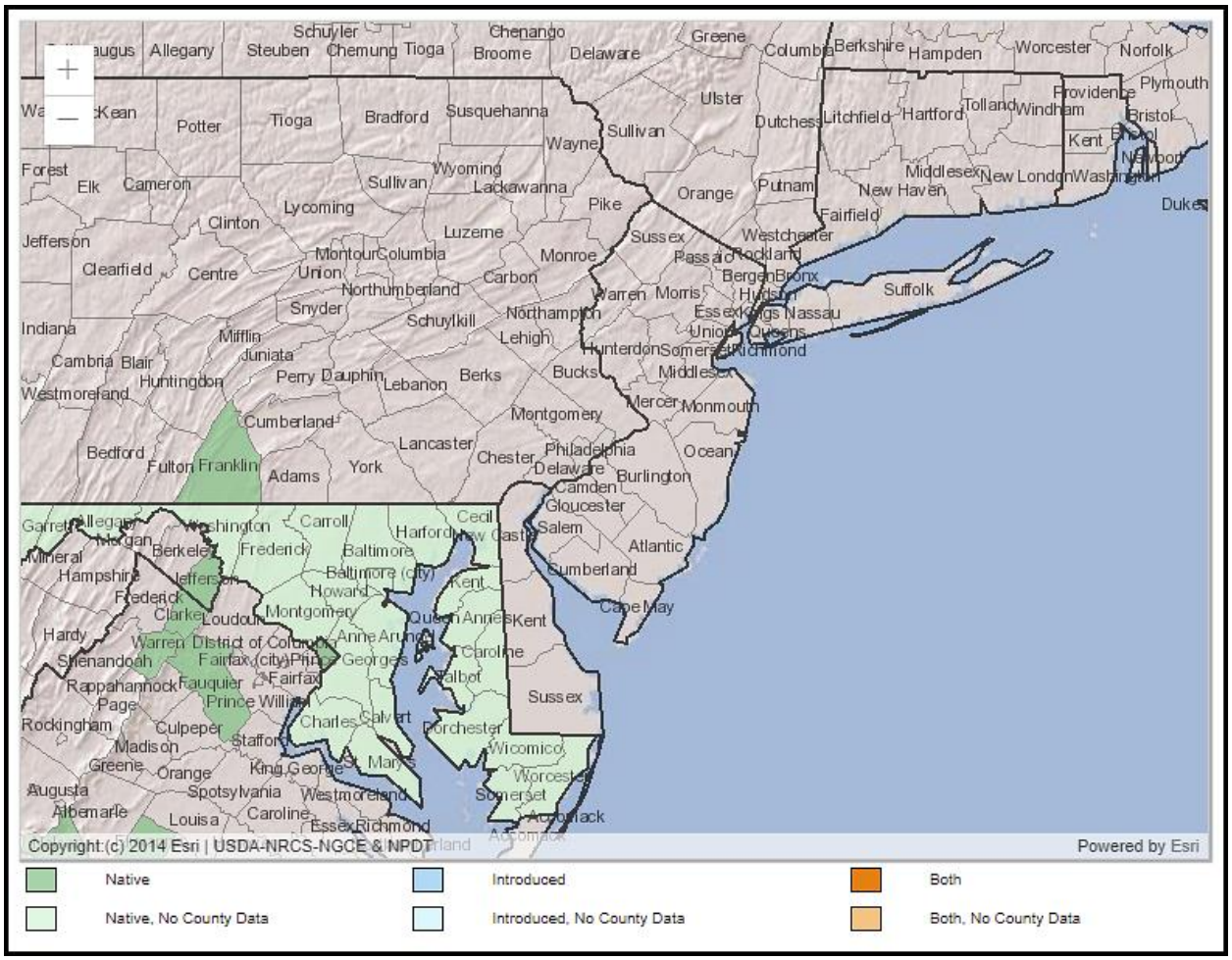


Figure 2. Records of S. ovalis var. erostellata in the vicinity of New Jersey (USDA NRCS 2023b).

Conservation Status

The global status of *Spiranthes ovalis* var. *erostellata* is in need of review (MacBryde 2000). The rank is currently listed as G5?T4?, with the question marks denoting some uncertainty regarding the status of both the species and the subtaxon. The G5? rank means the species appears to have 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, and the T4? rank means the variety appears have a fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, although there is some cause for concern as a result of recent local declines, threats, or other factors (NatureServe 2023).

The map below (Figure 3) illustrates the conservation status of *S. ovalis* var. *erostellata* throughout its range. The variety is vulnerable (moderate risk of extinction) in one state, imperiled (high risk of extinction) in one province and three states, and critically imperiled (very

high risk of extinction) in six states. There are several other states where the orchid has been listed at the species level so it does not appear on the varietal conservation map (eg. Illinois, Iowa, Michigan, and Pennsylvania). *S. ovalis* var. *erostellata* is presently unranked in a number of the states where it occurs, although it was noted to be on watchlists in Indiana (Prast et al. 2013) and in Ohio (Hubini et al. 2017).

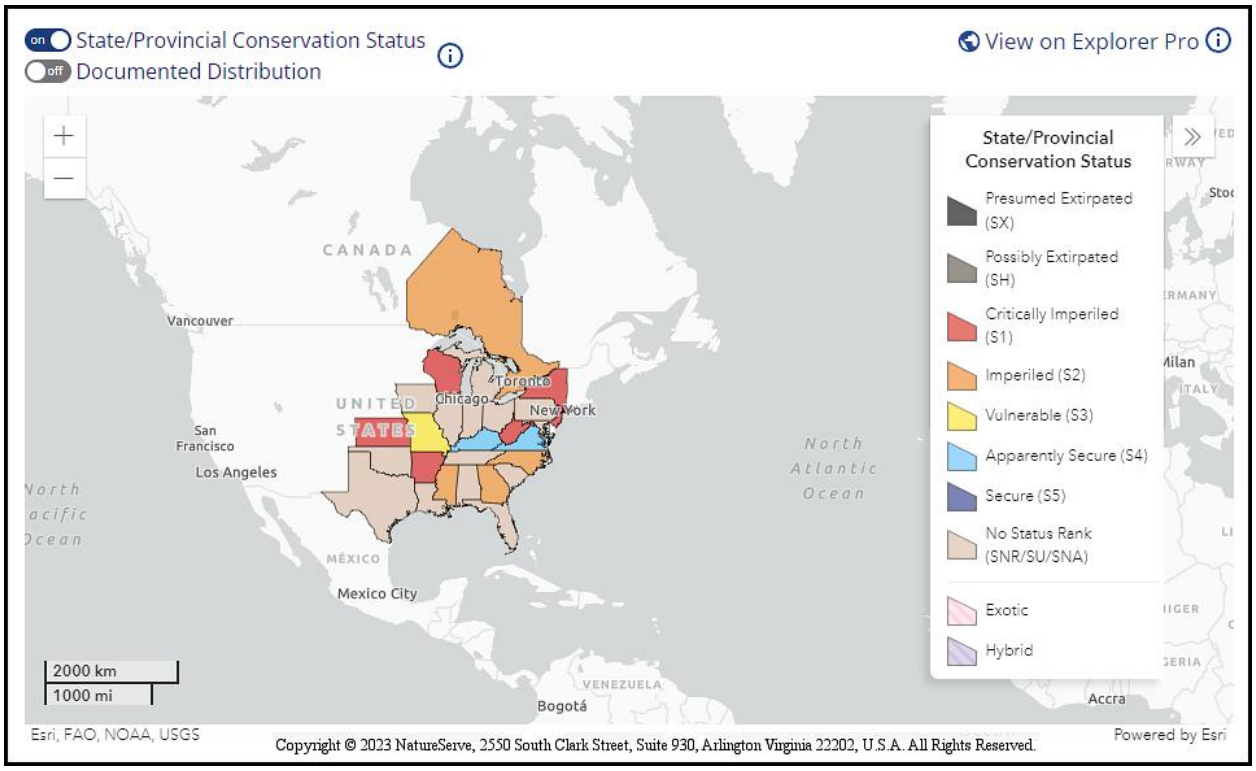


Figure 3. Conservation status of S. ovalis var. erostellata in North America (NatureServe 2023).

Spiranthes ovalis var. *erostellata* is ranked S1.1 in New Jersey (NJNHP 2022), meaning that it is critically imperiled due to extreme rarity. A species with an S1.1 rank has only ever been documented at a single location in the state. Lesser Ladies'-tresses 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).

Pace (2020) observed that there is an overall declining trend in North American orchids, but *Spiranthes ovalis* var. *erostellata* may be an exception. Although Lesser Ladies'-tresses is generally infrequent in the places where it occurs (MacBryde 2000) it appears to be increasing in abundance in the northern part of its range. In addition to the recent appearance of the orchid in New Jersey and New York, new occurrences and possible range expansions have been noted in Illinois, Indiana, Ohio, Wisconsin, and Ontario (Argus et al. 1987, Homoya 1993, Bennett and Course 1996, Catchpole 2012, Carter and Pace 2013).

Threats

New Jersey's newly discovered population of *Spiranthes ovalis* var. *erostellata* was assigned a viability ranking of Fair. The orchids were scattered singly or in small clusters along the edges of a trail that is popular with hikers and equestrians, making the plants vulnerable to trampling. Numerous non-native plant species were noted in the vicinity, including *Microstegium vimineum, Elaeagnus umbellata, Rosa multiflora, Lonicera japonica, Berberis thunbergii, Rubus phoenicolasius,* and *Alliaria petiolata* (NJNHP 2022). All of those species are highly invasive in New Jersey and are considered significant threats to native plant communities in the state (Van Clef 2009, FoHVOS 2022).

Although no reports of herbivory on *Spiranthes ovalis* var. *erostellata* were found the orchid may experience some losses in that manner. Studies of other *Spiranthes* species have shown that herbivory can significantly reduce reproduction and cause a decline in plant vigor. One investigation found that slugs and snails damaged leaves of *S. casei* var. *casei* and sometimes consumed entire plants, and that deer preferentially browsed on the flowering stems (Reddoch and Reddoch 2008). The consumption of floral stalks by vertebrates (eg. deer, rabbits) has also been reported for other *Spiranthes* species, primarily while the plants were still in bud (Wonkka 2010). Mammalian browsing of up to 46% of reproductive stalks was observed during another two-year study—some losses also occurred due to insect herbivory, primarily by grasshoppers and moth larvae, but the majority of invertebrate damage was limited to foliage (Nally 2016).

Shifting climactic conditions in New Jersey are resulting in higher temperatures, more frequent and intense precipitation events, and increasing periods of drought (Hill et al. 2020). Based on the information currently available for *Spiranthes ovalis* var. *erostellata* there is no indication that the changes will pose a significant threat to the orchid in the state. Because *S. ovalis* var. *erostellata* flowers are self-fertilized the species is likely to have limited genetic variability throughout its range, which would be expected to make the plants less adaptable and thus more susceptible to climate change (Schierenbeck 2017). However, it seems that the self-pollinated variety of *S. ovalis* is able to utilize a wider selection of habitats now than in the past (Argus et al. 1987, Homoya 1993) and is also expanding its northward distribution as discussed in the previous section. Catling and Kostiuk (2020) identified *S. ovalis* var. *erostellata* as a species that is likely to spread even farther north as the climate continues to change.

Management Summary and Recommendations

Regular monitoring of New Jersey's extant *Spiranthes ovalis* var. *erostellata* population is recommended since it is the only documented occurrence in the state. Future site visits can be used to determine whether the population is stable, increasing, or decreasing and to evaluate the need for active management to address concerns that have already been identified. Consultation with land managers might be appropriate in order to assure that the adjacent trail is maintained in a way that will not harm the population.

There is a reasonable potential for the discovery of new occurrences in the state. The small stature of *S. ovalis* var. *erostellata* plants can make them inconspicuous, particularly in places

where they are concealed by taller vegetation (MacBryde 2000, Daniel and Johnson). Additional populations might also become established in the state if the species continues to expand its range.

Brooks and Zettler (2000) recommended further research on the germination requirements of *Spiranthes ovalis* var. *erostellata*. Other topics suggested for study include the effects of competition, particularly with non-native plant species, and responses to fire. It would also be useful to know whether changing climactic conditions are facilitating the apparent northward expansion of Lesser Ladies'-tresses.

Synonyms

The accepted botanical name of the species is *Spiranthes ovalis* var. *erostellata* Catling. Orthographic variants, synonyms, and common names are listed below. Although there are no synonyms for the variety, prior to the recognition of varieties in *Spiranthes ovalis* the species itself was known by several other names including *Gyrostachys ovalis* (Lindl.) Kuntze, *Ibidium ovale* (Lindl.) House, and *Triorchis ovalis* (Lindl.) Nieuwl. (ITIS 2021, POWO 2023, USDA NRCS 2023b).

Botanical Synonyms	**Common Names**
	Lesser Ladies'-tresses
	October Ladies'-tresses
	Northern Oval Ladies'-tresses

References

Ames, Oakes. 1906. *Spiranthes ovalis*. Rhodora 8: 15–16.

Ames, Oakes. 1921. Notes on New England orchids - I. *Spiranthes*. Rhodora 23(268): 73–85.

Arditti, Joseph and Abdul Karim Abdul Ghani. 2000. Numerical and physical properties of orchid seeds and their biological implications. New Phytologist 145: 367–421.

Argue, Charles L. 2012. The Pollination Biology of North American Orchids North of Florida and Mexico. Volume 2. Springer, New York, NY. 202 pp.

Argus, George W., Kathleen M. Pryer, David J. White, and Catherine J. Keddy. 1987. Atlas of the Rare Vascular Plants of Ontario. Pt. 1-4. National Museum of Natural Sciences, Ottawa, Ontario. 650 pp.

Barksdale, Lane. 1933. Orchid hunting in Guilford County. The High School Journal 16(6): 232–235, 237, 239, & 241.

Bennett, James P. and Jennifer E. J. Course. 1996. The vascular flora of Hopewell Culture National Historical Park, Ross County, Ohio. Rhodora 98(894): 146–167.

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.

Brooks, Melissa M. and Lawrence W. Zettler. 2000. Symbiotic seed germination of the Northern Oval Ladies'-tresses, *Spiranthes ovalis* Lindley var. *erostellata* Catling (Orchidaceae). Abstracts of Papers from the 61st Annual Meeting. ASB Bulletin 47(2): 147.

Carter, Daniel L. and Matthew Pace. 2013. Noteworthy collection: *Spiranthes ovalis* var. *erostellata*. The Michigan Botanist 52: 105–108.

Catchpole, Floyd. 2012. Oval Ladies' Tresses Orchid appearing in northern Illinois. The Harbinger 29(4): 7.

Catling, P. M. 1983. *Spiranthes ovalis* var. *erostellata* (Orchidaceae), a new autogamous variety from the eastern United States. Brittonia 35: 120–125.

Catling, Paul M. and Bruce A. Bennett. 2007. Discovery of a possibly relict outbreeding morphotype of Sparrow's-egg Lady's-slipper Orchid, *Cypripedium passerinum*, in southwestern Yukon. The Canadian Field Naturalist 181(3): 295–298.

Catling, Paul and Brenda Kostiuk. 2020. Orchids of the Bruce Peninsula. Part III. Is the Bruce orchid flora changing? Native Orchid Conference Journal 17(1): 32–41.

Cressler, Alan. 2012. Two photos of *Spiranthes ovalis* var. *erostellata*. Courtesy of the Lady Bird Johnson Wildflower Center, https://www.wildflower.org/. Used with permission.

Daniel, S. and A. Johnson. 2017. *Spiranthes ovalis* var. *erostellata* (Orchidaceae) new to New York. Phytoneuron 72: 1–5.

Dressler, Robert L. 1981. The Orchids: Natural History and Classification. Smithsonian Institution. Harvard University Press, Cambridge, MA. 332 pp.

Dueck, Lucy A. and Kenneth M. Cameron. 2007. Sequencing re-defines *Spiranthes* relationships, with implications for rare and endangered taxa. Lankesteriana 7(1–2): 190–195.

Dueck, Lucy A., James A. Fowler, Cris S. Hagen, and Travis C. Glenn. 2005. Genetic discrimination of *Spiranthes cernua* species complex in South Carolina. Selbyana 26(1/2): 145–154.

Dueck, Lucy A., Deniz Aygoren, and Kenneth M. Cameron. 2014. A molecular framework for understanding the phylogeny of *Spiranthes* (Orchidaceae), a cosmopolitan genus with a North American center of diversity. American Journal of Botany 101(9): 1551–1571.

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

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

FoHVOS (Friends of Hopewell Valley Open Space). 2022. New Jersey Invasive Species Strike Team. Invasive species list with control recommendations. Available online at https://www.fohvos.info/invasive-species-strike-team/info-center/

Fowler, James Alexander. 2005. Wild Orchids of South Carolina: A Popular Natural History. University of South Carolina, Columbia, SC. 242 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.

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.

Homoya, Michael A. 1993. Orchids of Indiana. Indiana University Press, Bloomington, IN. 276 pp.

Hough, Michael, and Matthew A. Young. 2021. A systematic survey of the *Spiranthes cernua* complex (Orchidaceae) in New York. Native Orchid Society Journal 18(3): 22–56.

Hubini, Ahmed Mousa H., Donald G. Ruch, Megan E. Crecelius, John E. Taylor, and Kemuel S. Badger. 2017. Floristic inventory of the Cooper Woods-Skinner Woods complex, Ball State University, Delaware County, Indiana. Proceedings of the Indiana Academy of Science 126(1): 72–93.

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

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

Lindley, John. 1840. The General and Species of Orchidaceous Plants. Ridgways, Piccadilly. London. 553 pp.

MacBryde, Bruce. 2000. *Spiranthes ovalis* var. *erostellata* conservation status factors. NatureServe, Arlington, VA. Accessed October 24, 2023 at https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.142479/Spiranthes_ovalis_var_erostellata

McGrath, Lawrence K. 2001. Native orchids of Oklahoma. Oklahoma Native Plant Record 1(1): 39–66.

Mid-Atlantic Herbaria. 2023. Accessed at https://midatlanticherbaria.org/portal/index.php on October 24, 2023.

Nally, Deseri Dawn. 2016. Growth, development and vertebrate and invertebrate herbivory of the federally endangered *Spiranthes parksii* Correll and sympatric cogener *Spiranthes cernua*. Master's Thesis, Texas A&M University, College Station, TX. 68 pp.

NAOCC (North American Orchid Conservation Center). 2022. Species profile for *Spiranthes ovalis*. Available at https://goorchids.northamericanorchidcenter.org/species/spiranthes/ovalis/

NatureServe. 2023. NatureServe Explorer [web application]. NatureServe, Arlington, VA. Accessed October 24, 2023 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). 2022. Biotics 5 Database. NatureServe, Arlington, VA. Accessed February 1, 2022.

Pace, Matthew C. 2020. The Orchidaceae of northeastern North America: Systematics, evolution, diversity, and conservation. Memoirs of the Torrey Botanical Society 29: 156–189.

Pace, Matthew C. and Kenneth M. Cameron. 2017. The systematics of the *Spiranthes cernua* species complex (Orchidaceae): Untangling the gordian knot. Systematic Botany 42(4): 640–669.

Parr, Patricia Dreyer. 1984. Endangered and threatened plant species on the Department of Energy Oak Ridge Reservation—an update. Journal of the Tennessee Academy of Science 59(4): 65–68.

POWO. 2023. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Accessed October 25, 2023 at http://www.plantsoftheworldonline.org/

Prast, Zachary B., Donald G. Ruch, David LeBlanc, Michael Russell and Kemuel S. Badger. 2013. The vascular flora and vegetation communities of Munsee Woods Nature Preserve, Delaware County, Indiana. Proceedings of the Indiana Academy of Science 122(2): 93–117.

Rasmussen, Hanne N. 1995. Terrestrial Orchids: From Seed to Mycotrophic Plant. Cambridge University Press, New York, NY. 460 pp.

Reddoch, Joyce M. and Allan H. Reddoch. 2008. Phenology, population dynamics, and flowering dynamics of Case's Ladies'-tresses, *Spiranthes casei* var. *casei* (Orchidaceae), in Ottawa, Ontario. Canadian Field Naturalist 123(1): 19–31.

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

Schierenbeck, Kristina A. 2017. Population-level genetic variation and climate change in a biodiversity hotspot. Annals of Botany 119: 215–228.

Sheviak, Charles J. and Paul Martin Brown. Page updated November 5, 2020. *Spiranthes ovalis* var. *erostellata* Catling. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 22+ vols. New York and Oxford. Accessed October 24, 2023 at http://floranorthamerica.org/Spiranthes_ovalis_var._erostellata

Sun, Mei. 1996. The allopolyploid origin of *Spiranthes hongkongensis* (Orchidaceae). American Journal of Botany 8(2): 252–260.

Sun, Mei. 1997. Genetic diversity in three colonizing orchids with contrasting mating systems. American Journal of Botany 84(2): 224–232.

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). 2023a. *Spiranthes ovalis* 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). 2023b. PLANTS profile for *Spiranthes ovalis* var. *erostellata* (October Lady's Tresses). The PLANTS Database, National Plant Data Team, Greensboro, NC. Accessed October 24, 2023 at http://plants.usda.gov

Van Clef, M. 2009. New Jersey Strategic Management Plan for Invasive Species: The Recommendations of the New Jersey Invasive Species Council to Governor Jon S. Corzine, Pursuant to New Jersey Executive Order #97. 220 pp. Appendix II, Prioritized Listing of New Jersey's Nonindigenous Plant Species, prepared by David Snyder.

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

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

Wonkka, Carissa Lyn. 2010. Large herbivore impacts on demographic characteristics and population dynamics of an endangered orchid (*Spiranthes parksii* Correll). Master's Thesis, Texas A&M University, College Station, TX. 70 pp.

Zale, Peter J., Ashley Clayton, John Nix, and Matt Taylor. 2022. Asymbiotic in vitro seed germination, in vitro seedling development, and ex vitro acclimatization of *Spiranthes*. Applications in Plant Sciences 10: e11494.

Zettler, Lawrence W. 1996. Symbiotic seed germination of terrestrial orchids in North America during the last decade - A progress report. In Carol Allen (ed.). 1996. North American Native Terrestrial Orchids: Propagation and Production. Conference Proceedings, March 16 & 17, 1996. North American Native Terrestrial Orchid Conference, Germantown, MD. 132 pp.

Zettler, Lawrence W. and Thomas M. McInnis, Jr. 1993. Symbiotic seed germination and development of *Spiranthes cernua* and *Goodyera pubescens* (Orchidaceae: Spiranthoideae). Lindleyana 8(3): 155–162.

Zettler, Lawrence H., Felicity V. Barrington, and Thomas M. McInnis, Jr. 1995. Developmental morphology of *Spiranthes odorata* seedlings in symbiotic culture. Lindleyana 10(3): 211–216.