Stenanthium leimanthoides

Pine Barrens Death Camas

Liliaceae

Stenanthium leimanthoides by R. Bartgis, 2016

***Stenanthium leimanthoides* 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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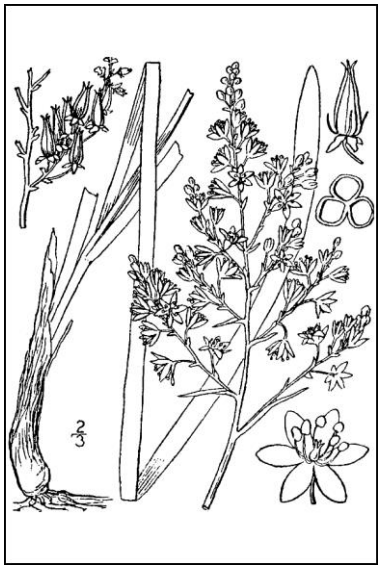
Life History

The taxonomic history of *Stenanthium leimanthoides* (Pine Barrens Death Camas) has been characterized by turbulence and still remains unsettled in some quarters (see Synonyms and Taxonomy section). Consequently, it is difficult to ascertain how much of the information from previous studies can be directly applied to this recently redefined species (Les 2020). Despite the multitude of nomenclatural issues, however, the identity of *S. leimanthoides* in New Jersey is not in question.

Stenanthium leimanthoides is a non-rhizomatous perennial monocot. The solitary plants arise from narrow bulbs that are conspicuously fibrous. The slender, grasslike leaves are primarily basal or alternate and mainly located near the base of the stems: They are 1–6 dm long and 3–11 mm wide (mean width 7.7 mm). The leaves are not keeled although they may be longitudinally pleated. The average height of stems is slightly over 7 dm but they can range from 5–25 dm. The inflorescence of *Stenanthium leimanthoides* is a once-branched panicle with a smooth axis. The flowers develop on pedicels that are 5–12 mm long and subtended by shorter bracts. Each of the six floral tepals has a patch of glandular tissue at the base that can sometimes be difficult to detect. The flowers are white when fresh but as they age the color changes to a dull olive or pale apple green. The lower flowers on an inflorescence are bisexual and fertile but those near the top are usually staminate. The fruits are erect, three-parted capsules around 1 cm in length. (See Small 1903, Britton and Brown 1913, Fernald 1950, Godfrey and Wooton 1981, Gleason and Cronquist 1991, Zomlefer 1997, Sorrie and Weakley 2017, Taft 2017, Weakley et al. 2022).



Left: Britton and Brown 1913, courtesy USDA NRCS 2023a. Right: R. Bartgis, 2016.

Taylor (1915) noted that *Stenanthium leimanthoides* occurred in regions where a typical growing season lasted for 175–182 days. Throughout its range, flowering can take place from mid-June through August and fruit may be present from August through October (Stone 1911, Hough 1983, McDonald 2015, Ring 2022, LeGrand et al. 2023). The plants do not flower every year (NJNHP 2022). A population observed by Taft (2017) included approximately 250 plants: Four of them were in flower and two others had the remnants of seed stalks from the previous year.

Stenanthium densum dies back to the ground during the winter and produces fresh leaves in the spring (NCCE 2023), and it seems likely that *S. leimanthoides* has a similar seasonal cycle.

Stenanthium leimanthoides is assumed to be poisonous based on information from related taxa although no analysis of compounds derived from this particular species was found. Many melanthoid plants, including various species of *Amianthium*, *Anticlea*, *Stenanthium*, *Toxicoscordion*, *Veratrum*, and *Zigadenus*, produce one or more toxic alkaloids that can be fatal to mammals including humans, although alkaloid combinations and concentrations vary from one species to the next (Zomlefer 1997, Patel et al. 2013, Stegelmeyer et al. 2020). Toxins may be found in all parts of the plants, including bulbs, leaves, and flowers, and they can become especially concentrated in dried tissue like that of capsules and seeds (Schwartz 2020).

Pollinator Dynamics

Stenanthium densum inflorescences start to bloom at the base and then work their way upwards (NCCE 2023). Photos of *S. leimanthoides* plants in New Jersey taken during early July at the beginning of the blooming period showed that those flowers also open from the bottom to the top of the inflorescences (Teegate 2016, 2017). For the latter species, that means that the bisexual fertile flowers might mature before the staminate blossoms open above them. In related species with perfect flowers, the anthers typically release their pollen prior to the time when the stigmas become receptive. Available information indicates that *S. leimanthoides* is likely to be self-incompatible and reliant on insects for pollination (Zomlefer 1997).

The specific pollinators of *Stenanthium leimanthoides* are not known. Related species are reportedly cross-pollinated by various insects such as bees, wasps, flies, beetles, and butterflies. Some species change color after fertilization, although it is uncertain whether the color shift in *S. leimanthoides* serves as a pollinator signal (Zomlefer 1997). In some other melanthoid species, toxic alkaloids in the pollen deter generalist pollinators and specialist bees are needed to fertilize the flowers (Irwin et al. 2014, Cane et al. 2020). There is a sawfly (*Rhadinoceraea sodsensis*) that lays its eggs on flowering *S. leimanthoides* plants (Smith and Barrows 1995) but it is not clear whether the insect has any role in pollination.

Seed Dispersal

Stenanthium leimanthoides produces a few narrow, angled seeds in each of the three capsule chambers (Small 1903, Zomlefer 1997). Small described the seeds as "winged at the apex." No particular dispersal methods have been reported for the species but the slightly winged seeds and the fact that the fruits remain on standing stalks for a long time after senescence suggest that local dispersal probably occurs as the propagules are shaken out of the capsules by wind.

Germination has been studied in two closely related species: *Stenanthium densum* and *S. texanum* (Baskin et al. 1993). The seeds of both species were dormant at maturity and required a period of cold stratification prior to germination. Because *S. densum* and *S. texanum* flower early in the spring (Sorrie and Weakley 2017) their seeds are exposed to sequential periods of

warm and cold stratification in natural settings, but the research demonstrated that only the cold stratification was a prerequisite for germination (Baskin et al. 1993, Baskin and Baskin 2004). All of the *Stenanthium* seeds that germinated during a greenhouse study did so during the first season, and the lack of subsequent germination suggested that the species were unlikely to form persistent seed banks (Baskin et al. 1993).

Habitat

Nearly a century ago Fernald (1931) noted the disjunct distribution of *Stenanthium leimanthoides* populations along the coastal plain and on the high tablelands of North Carolina. Even within the more restricted extent of the species as recently recognized by Sorrie and Weakley (2017) *S. leimanthoides* continues to be known from disparate habitats in different parts of its range. In the north it is restricted to lowland habitats on the coastal plain but southern populations have been found as much as 1829 meters above sea level (Les 2020).

In New Jersey *Stenanthium leimanthoides* has been found in wetland habitats described as bogs, swamps, wet pine woods and thickets, or Pine Barren savannas (Keller and Brown 1905, Fables 1957, Hough 1983, Johnson and Walz 2013). Extant occurrences in the state are situated in Pine Barren savannas and in open, swampy gaps along utility right-of-ways (NJNHP 2022). *S. leimanthoides* populations in New York, Maryland, and West Virginia have also been associated with wetlands. Taft (2017) noted that the recently discovered occurrence on Long Island was growing "in an area that remained damp but would have been considerably wetter in a normal year" and Maryland's sole documented occurrence was located in a freshwater seepage area over terraced gravel deposits (Knapp et al. 2011). In West Virginia reported habitats included boggy areas associated with ponds or riversides (Gibson 1970, McDonald 2015); Bartgis et al. (2015) described typical *S. leimanthoides* habitat in that state as acidic, nutrient-poor fens dominated by peat and haircap mosses.

In contrast, Belden et al. (2003) reported an anomalous occurrence of *S. leimanthoides* that was located in ultramafic woodland habitat in xeric uplands of Virginia. Characteristic habitats in North Carolina are high-elevation rocky outcrops and balds dominated by ericaceous shrubs (Schafale and Weakley 1990, Newell and Peet 1998). Most North Carolina populations are associated with acidic soils, and some occur in seepage areas (LeGrand et al. 2023).

Wetland Indicator Status

The U. S. Army Corps of Engineers divided the country into a number of regions for use with the National Wetlands Plant List and portions of New Jersey fall into three different regions (Figure 1). *Stenanthium leimanthoides* has more than one wetland indicator status within the state. In the Atlantic and Gulf Coastal Plain region, *S. leimanthoides* is a facultative wetland species, meaning that it usually occurs in wetlands but may occur in nonwetlands. In the rest of the state *S. leimanthoides* is an obligate wetland species, meaning that it almost always occurs in wetlands (U. S. Army Corps of Engineers 2020).

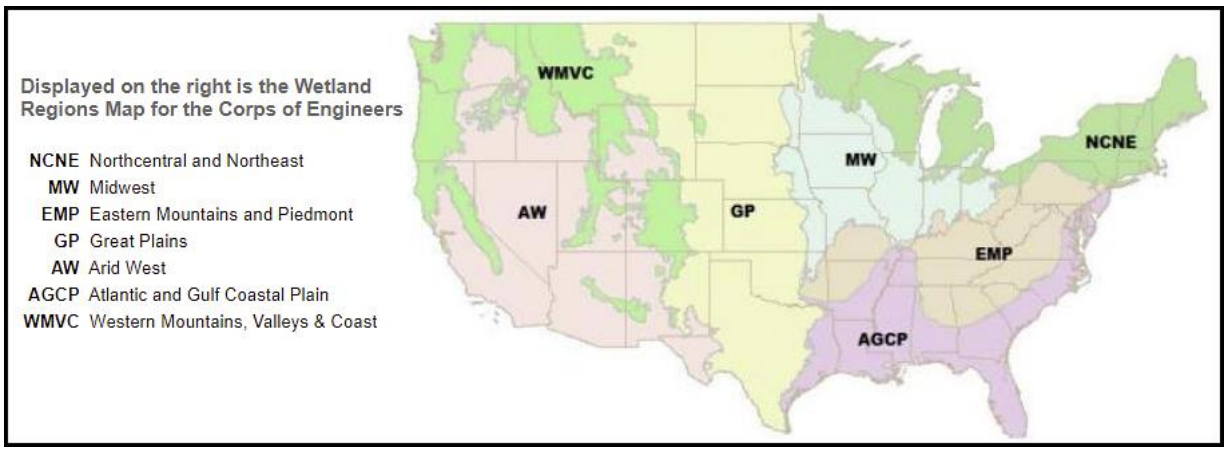


Figure 1. Mainland U. S. wetland regions, adapted from U. S. Army Corps of Engineers (2020).

USDA Plants Code (USDA, NRCS 2023b)

The USDA code for *Stenanthium leimanthoides* is STLE14. The USDA uses the synonym *Zigadenus leimanthoides* (code ZILE) to identify the species.

Coefficient of Conservancy (Walz et al. 2020)

CoC = 8. Criteria for a value of 6 to 8: Native with a narrow range of ecological tolerances and typically associated with a stable community (Faber-Langendoen 2018).

Distribution and Range

The worldwide range of *Stenanthium leimanthoides* is limited to a small portion of the eastern United States (Sorrie and Weakley 2017, POWO 2023). The map in Figure 2 depicts the global extent of three species previously included in *Stenanthium leimanthoides* (see Synonyms and Taxonomy section). *S. leimanthoides* as recognized herein does not occur in Kentucky, Tennessee, or along the Gulf Coast. However Weakley et al. (2022) included northern Georgia in the species' range.

The USDA PLANTS Database (2023b) shows records of *Stenanthium leimanthoides* in eight New Jersey counties: Burlington, Camden, Cumberland, Gloucester, Mercer, Middlesex, Monmouth, and Ocean (Figure 3). The data include historic observations and do not reflect the current distribution of the species.

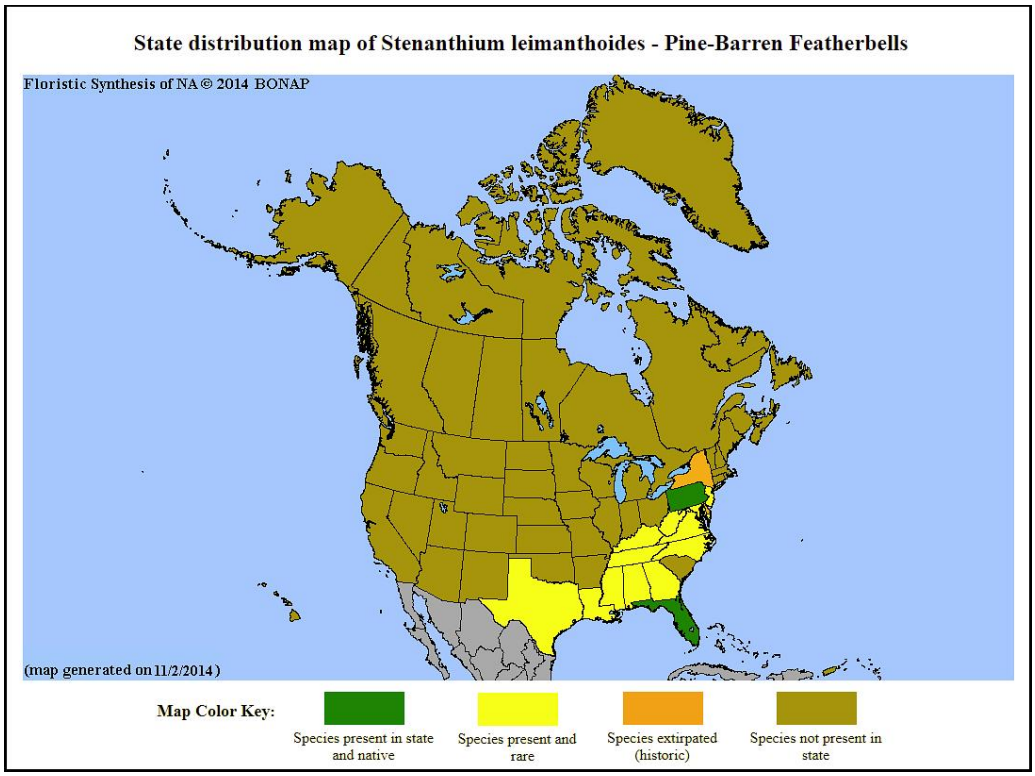


Figure 2. Distribution of S. leimanthoides in North America, adapted from BONAP (Kartesz 2015), but see text regarding recent modifications.

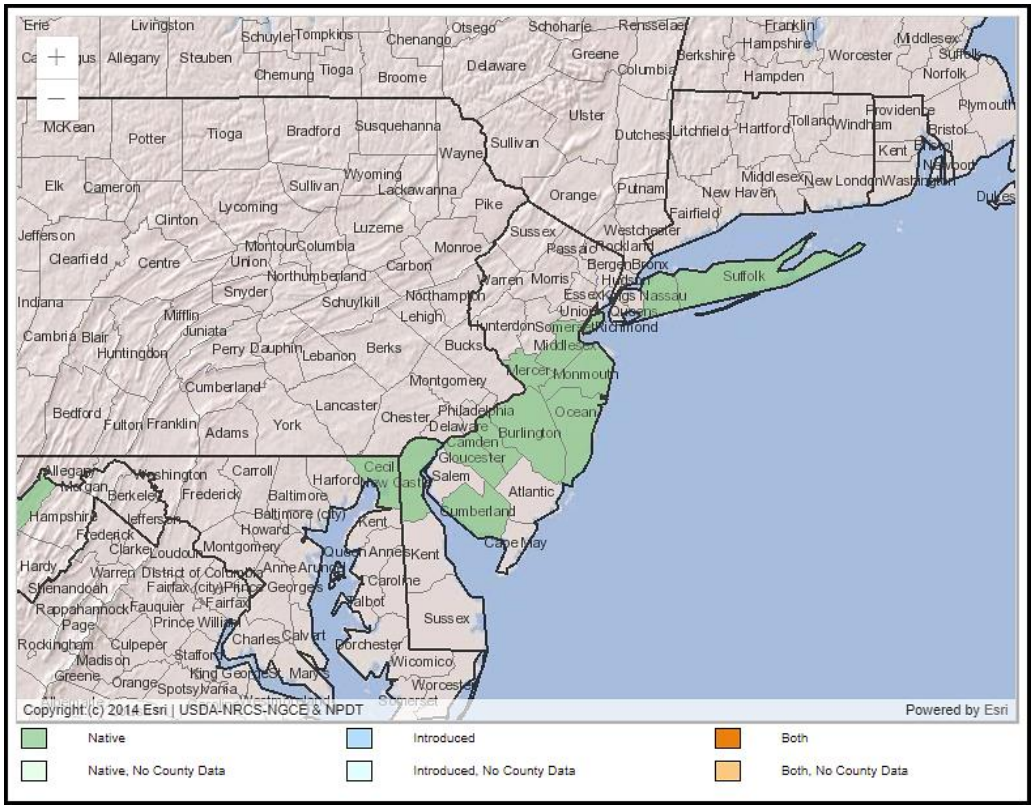


Figure 3. County records of S. leimanthoides in New Jersey and vicinity (USDA NRCS 2023b).

Conservation Status

Stenanthium leimanthoides is globally imperiled. The G2 rank means the species faces a high risk of extinction or collapse due to a restricted range, few populations or occurrences, steep declines, severe threats, or other factors (NatureServe 2023). The map below (Figure 4) illustrates the known extent of *S. leimanthoides* but does not reflect the species' current status in each state. Pine Barrens Death Camas is not considered secure anywhere in its range. The species is most abundant in West Virginia but even there it is ranked as imperiled, signifying a high risk of extinction (WVNHP 2020). *S. leimanthoides* was previously thought to be extirpated in New York but a new population was recently discovered (Taft 2017, Young 2017). It is now listed as critically imperiled (very high risk of extinction) in that state (Ring 2022) and likewise in New Jersey, in Virginia, and in Maryland—where it was just documented for the first time (Knapp et al. 2011, NJNHP 2022, MDDNR 2023, Townsend 2023). The species is also ranked as critically imperiled in North Carolina but a downgrade to imperiled may be warranted in that state (LeGrand et al. 2023). In Delaware *S. leimanthoides* is considered historical (McAvoy and Bennett 2023).

At the continental level, *Stenanthium leimanthoides* has been identified as a plant species of highest conservation priority for the North Atlantic region, which includes four Canadian provinces and twelve U. S. states. The species has a regional rank of R1 (critically imperiled), signifying a very high risk of extinction (Frances 2017).

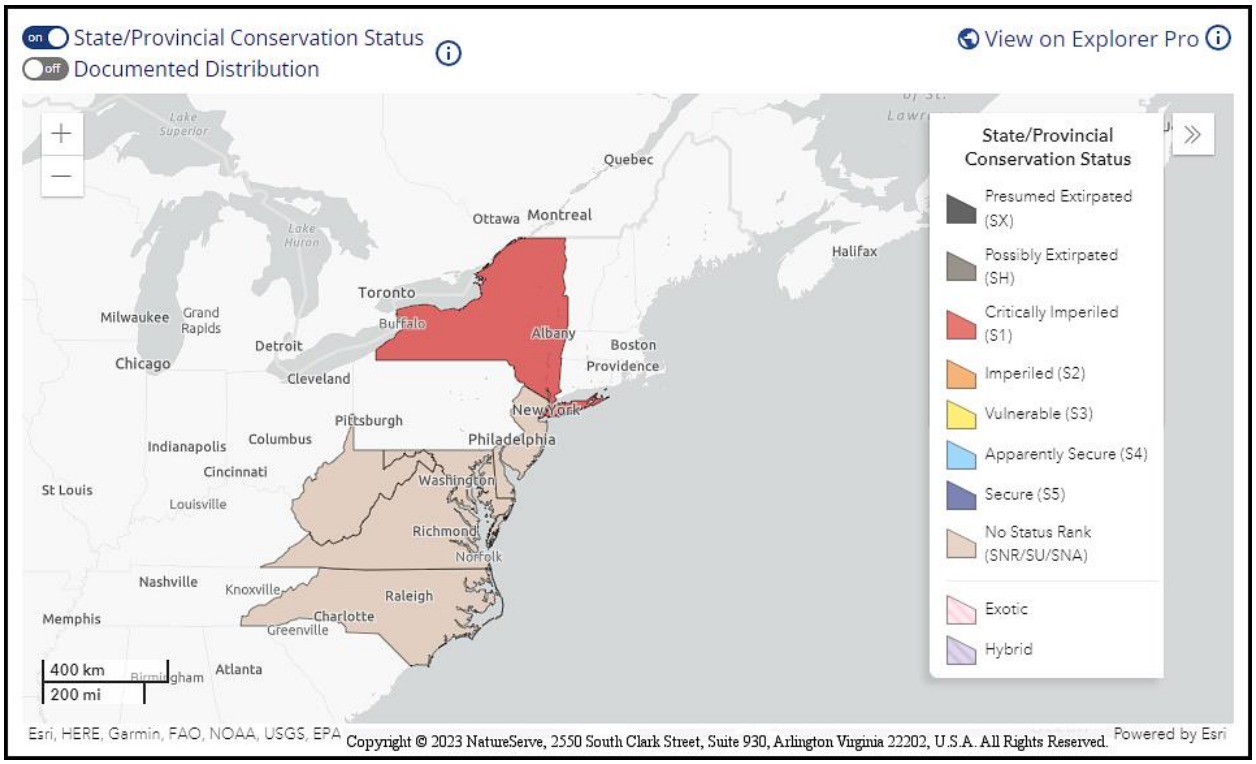


Figure 4. Conservation status of S. leimanthoides in North America (NatureServe 2023). The species appears to be unranked in most of the states where it occurs due to a recent revision in nomenclature (see text).

As noted above, *Stenanthium leimanthoides* is critically imperiled (S1) in New Jersey (NJNHP 2022). The rank signifies five or fewer occurrences in the state. A species with an S1 rank is typically either restricted to specialized habitats, geographically limited to a small area of the state, or significantly reduced in number from its previous status. *S. leimanthoides* 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. Pine Barrens Death Camas 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).

Numerous collections of *Stenanthium leimanthoides* were made throughout southern and central New Jersey during the late 1800s and early 1900s although the species was frequently noted as being rather rare in the state (Willis 1874, Britton 1881 and 1889, Keller and Brown 1905, Stone 1911, Taylor 1915). Only one population was still known to be extant when a new occurrence was discovered by Vincent Abraitys in 1960 (Snyder 1984). Calazza and Fairbrothers (1980) listed the species' New Jersey status as Undetermined. Three extant populations were reported by Breden et al. (2006) and a total of five, located in Burlington, Middlesex, and Ocean counties, are presently considered extant (NJNHP 2022). Unfortunately, the vast majority of occurrences tracked by the Natural Heritage Program are ranked as historical (20) or extirpated (3).

Threats

Habitat loss and degradation threaten populations of *Stenanthium leimanthoides* throughout the species' range (Eberly 2022). Rentch and Anderson (2006) cited *S. leimanthoides* as an example of a species that could tolerate some low-level disturbance but was likely to decline when subjected to frequent or intense disruptions. The Pine Barren Savanna communities in which *S. leimanthoides* naturally occurs in southern New Jersey were historically affected by commercial endeavors associated with resource extraction or agriculture. Current threats to savanna habitat include changes in natural hydrologic or fire regimes, reductions in water quality resulting from offsite agricultural practices, and direct damage from foot traffic and/or off-road vehicles (Johnson and Walz 2013). Potential threats to populations in utility right-of-ways may depend on the methods used for corridor maintenance.

Pine Barrens Death Camas favors open habitats and may be vulnerable to competition. One New Jersey population of *S. leimanthoides* that was subsequently destroyed by development had already been declining as a result of natural succession by woody vegetation (NJNHP 2022). In a West Virginia peatland *S. leimanthoides* became more abundant following the removal of Broadleaf Cattail (*Typha latifolia*), which had been forming dense stands to the detriment of other native species (Bartgis et al. 2015). Occasional disturbances may help to maintain the open character of riverside savanna habitats and serve as an advantage for the rare plants that thrive in those communities. In at least one New Jersey savanna periodic flooding has been credited with preventing the establishment of woody vegetation to the benefit of *S. leimanthoides* (NJNHP 2022). *Stenanthium densum* reportedly favors sites that have been subject to periodic burns (NCCE 2023).

Although *Stenanthium leimanthoides* can tolerate short-term flooding, extended periods of inundation may be problematic. The prior flooding of a savanna habitat by beavers may have reduced the vigor of an extant New Jersey population (NJNHP 2022). Bonner (2005) found that rare plant species such as *S. leimanthoides* can decline in the short term following beaver activity but may benefit from the creation of new habitat in the long term. However, *S. leimanthoides* does not appear to maintain a seed bank so the species' ability to re-establish following beaver-initiated disturbances may depend on its dispersal capabilities, which are currently unknown.

Studies of related plant species indicate that *Stenanthium leimanthoides* is likely to produce toxic alkaloids that could serve as a deterrent to herbivores. However, certain insects are resistant to melanthoid toxins, particularly sawflies in the genus *Rhadinoceraea*. For example, *Rhadinoceraea nodicornis* can sequester compounds from *Veratrum album*, allowing the insect to consume the foliage and also possibly aiding in predator deterrence (Shaffner et al. 1994). Two *Rhadinoceraea* species discovered during the 1990s are specialists on *Stenanthium*. Smith and McDearman (1990) first described *Rhadinoceraea zigadenusae* from observations on *Stenanthium* spp. in Mississippi (currently known as *S. densum* and *S. texanum*). *R. zigadenusae* females laid eggs in the inflorescences and the developing larvae fed on stamens, pistils, and other floral parts. Although the herbivory did not result in defoliation or plant mortality an evident decrease in seed production was reported. In fact, the authors observed that "literally all flowers were consumed in the majority of the host populations." Sawfly larvae observed on inflorescences of *Stenanthium leimanthoides* in West Virginia were first assumed to be *R. zigadenusae* but subsequent investigations determined that they were a different species—*Rhadinoceraea sodsensis* (Smith and Barrows 1995). The flight times of the two sawfly species differ but coincide with the blooming periods of their host plants.

New Jersey populations of *Stenanthium leimanthoides* have been identified as moderately vulnerable to climate change, signifying that the species' extent and range within the state is likely to decrease by 2050 (Ring et al. 2013). As the climate continues to warm, plant communities in New Jersey are increasingly exposed to higher temperatures and shifting precipitation patterns are increasing the frequency and intensity of both droughts and floods (Hill et al. 2020). Based on the broad range of habitats reported for *S. leimanthoides* it is difficult to predict how populations might respond to changes in local hydrologic conditions, but the species' apparent lack of long-distance dispersal mechanisms could limit its potential to establish at new sites if existing locations become unsuitable.

Management Summary and Recommendations

The globally imperiled status of *Stenanthium leimanthoides* makes it a conservation priority, both in New Jersey and elsewhere in its range. Protection of extant populations in New Jersey might include some woody species management in savanna habitats or the development of cooperative conservation agreements with landowners and/or utility companies for occurrences that are located along right-of-ways. Regular monitoring of known sites is recommended in order to identify and address any developing threats originating from anthropogenic or beaver activity.

Eberly (2022) identified the necessity for updated assessments of historical *Stenanthium leimanthoides* occurrences throughout the species' range. Twenty sites in New Jersey have been ranked as historical based on the potential presence of suitable habitat but have not been searched since the early 1900s or, in some cases, the late 1800s (NJNHP 2022). The recent circumscription of *S. leimanthoides* has elevated the importance of establishing a clear understanding of its current extent and status.

Les (2020) pointed out that the latest revision of *Stenanthium leimanthoides* has created a need for a complete reevaluation of the species' life history. Suggested topics for research on *S. leimanthoides* include a thorough description of development from seedling to mature reproductive plant; a species-specific analysis of alkaloids and toxicity in various parts of the plant; the identification of pollinators, seed dispersal mechanisms, and establishment requirements; and studies of competition and fire effects. Further information regarding the range and distribution of *Rhadinoceraea sodsensis*, the sawfly that specializes on *S. leimanthoides*, is needed in order to evaluate potential impacts on plant populations outside of West Virginia. Marked differences in the habitats occupied by southern and northern populations of Pine Barren Death Camas may be indicative of genetic ecotypes or varieties that have adapted to local conditions and that topic is also worthy of investigation. Ex-situ propagation of *Stenanthium leimanthoides* could be appropriate due to its global rarity. Techniques for the long-term storage of seeds and for growing the plants in controlled settings should be evaluated by qualified investigators with relevant horticultural experience.

Synonyms and Taxonomy

The accepted botanical name of the species is *Stenanthium leimanthoides* (A. Gray) Zomlefer & Judd. Orthographic variants, synonyms, and common names are listed below (Zomlefer and Judd 2002, ITIS 2023, POWO 2023).

Botanical Synonyms	**Common Names**
Amianthium leimanthoides A. Gray	Pine Barrens Death Camas
Oceanorus leimanthoides (A. Gray) Small	Coastal Deathcamas
Zigadenus leimanthoides A. Gray	Coastal Zygadene
Zygadenus leimanthoides A. Gray	Pine-barren Featherbells

Schlosser (2008) observed that a literature search on Pine Barrens Death Camas "revealed a taxonomic maze with bewildering twists, turns, and dead-ends" and Les (2020) noted that "the taxonomy of *Stenanthium* is nothing short of confusing." *Stenanthium leimanthoides* belongs to a cluster of morphologically similar monocots that have alternately been segregated as a single family (Melanthiaceae), divided into multiple families, or treated as a subgroup of the Liliaceae. Gates (1918) took a broad view of the North American Melanthiaceae, including in it 21 genera, but later authors rolled those back into the lily family (eg. Fernald 1950, Gleason and Cronquist 1991). The APGIII (2009) reinstated Melanthiaceae with 16 genera included (Pellicer et al. 2014). *Stenanthium* was identified as a core genus in the family and one of seven included in the Melanthiaceae Tribe Melanthieae by Zomlefer et al. (2001, 2006). Utech (2020) retained the

group in Liliaceae, noting that there was strong evidence supporting division of the family but a lack of consensus regarding the best way to do so.

For much of the 20th century *Stenanthium leimanthoides* was included in the genus *Zigadenus* and the synonym *Z. leimanthoides* is still in use by some sources (eg. Schwartz 2020, USDA NRCS 2023b). Rydberg (1903) put forth a early argument for subdividing the genus, pointing out that some related genera were "separated by rather trifling characters, while in *Zygadenus* are included species of no closer relationship." Zomlefer (1997) noted that the genus *Zigadenus* consisted of a heterogeneous assembly of species that lacked defining characteristics and set out to resolve the issue. Subsequent genetic analyses confirmed that *Zigadenus* was not monophyletic, which resulted in the transfer of previously included species to other genera, and the species previously recognized as *Z. densum* and *Z. leimanthoides* were moved to *Stenanthium*. Possible defining features identified for *Stenanthium* included slender bulbs, obscure or absent tepal glands, and chromosome number (Zomlefer et al. 2001). When *S. leimanthoides* was formally transferred from *Zigadenus* to *Stenanthium*, Durand's 1837 specimen from New Jersey was designated as the lectotype (Zomlefer and Judd 2002).

The two species most closely related to *Stenanthium leimanthoides* are *S. densum* and *S. graminium*. Those three species share a chromosome number (1n=10) that sets them apart from other melanthoid taxa (Zomlefer and Smith 2002, Pellicer et al. 2014). McDearman (1984) viewed *S. densum* and *S. leimanthoides* as conspecific and Schwartz (2020) concurred, treating *S. leimanthoides* as a synonym of the former species. An alternate viewpoint was taken by Zomlefer (1997), who pointed out that *S. densum* differs in having smooth bulbs and unbranched inflorescences of perfect flowers. *S. leimanthoides* and *S. densum* also bloom at different times (NCCE 2023). Sorrie and Weakley (2017) not only identified consistent differences between the two species but took it a step further and subdivided the taxon previously described as *S. leimanthoides* into three species which do not overlap geographically. Populations from North Carolina and northward retain the name *Stenanthium leimanthoides* while those in Tennessee are now recognized as *S. tennesseense*. Gulf coast populations formerly identified as *S. leimanthoides* have been transferred to *S. texanum*, and the range of that species overlaps with that of *S. densum* (Sorrie and Weakley 2017, Weakley et al. 2018).

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