Euphorbia purpurea

Darlington's Glade Spurge

Euphorbiaceae

Euphorbia purpurea, courtesy Alan Cressler, Lady Bird Johnson Wildflower Center

***Euphorbia purpurea* 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

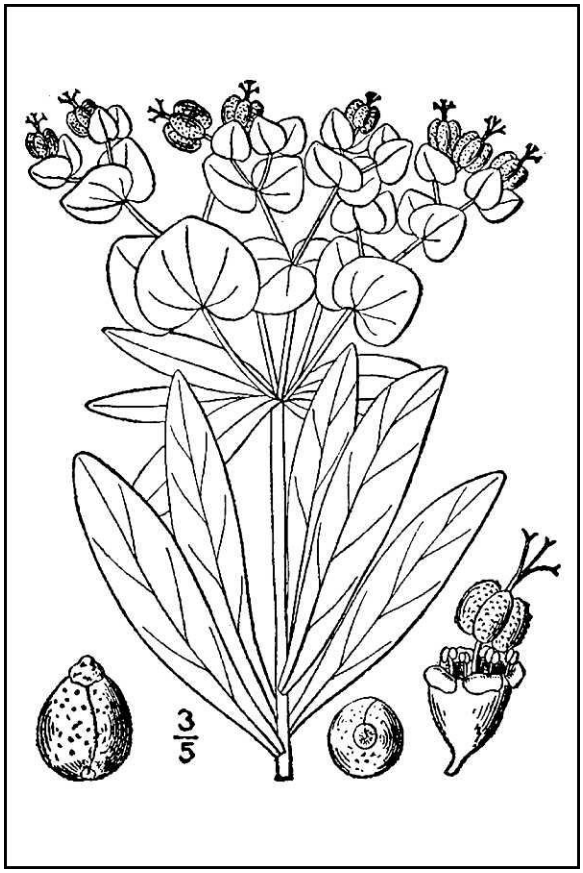
Euphorbia purpurea (Darlington's Glade Spurge) is a tall perennial herb in the Euphorbiaceae. Mature plants may approach two meters in height (Snyder 1986), and Darlington (1853) found it remarkable that botanists had failed to notice such a large plant earlier. The plants can reproduce vegetatively via short, thick rhizomes, and as many as 75 individual stems (ramets) may be associated with a single clone (Loeffler and Wegner 2000). Dark green, oblong, entire leaves that are 5–10 cm long and 1–3 cm wide are arranged alternately along the stout stems, with whorls of shorter, broader leaves at the bases of the terminal flower clusters. The terminal inflorescence is umbellate, usually having 5–8 stems that are further subdivided, and additional flowers may be produced on slender branches from the upper leaf axils. Flower structure in the genus *Euphorbia* is unique: What appears to be an individual flower is actually an inflorescence known as a cyathium. Each cyathium consists of a cuplike structure with glands on the rim and a single pistillate flower surrounded by multiple staminate flowers. Some species have petal-like appendages attached to the glands, but *E. purpurea* does not. Darlington's Glade Spurge has cyathia with 5 glands, 10–15 staminate flowers, and paired leafy bracts at the bases. As the fruits develop, the ovaries become somewhat warty with small, irregular projections. (See Darlington 1853, Britton and Brown 1913, Fernald 1950, Gleason and Cronquist 1991, Riina et al. 2020).


Left: Elizabeth Byers, 2020. Right: courtesy Alan Cressler (2012), Lady Bird Johnson Wildflower Center.

Throughout the range of *Euphorbia purpurea* the plants flower and fruit from spring through fall (Weakley 2015, Riina et al. 2020), but Hough (1983) reported blooming from early May to August in New Jersey and Stone (1911) indicated that the fruits mature by mid-June. A four-year study of several populations in Pennsylvania yielded more details about the seasonal cycle of *E. purpurea*. The plants began growth in early April and flowering took place throughout most of May, sometimes extending into early June. By the middle of June the stems had achieved most (85–100%) of their annual height, and senescence began in July following seed dispersal (Loeffler and Wegner 2000). Block and Rhoads (2013) noted that senescence can start earlier during dry years. From 1995–2000 *E. purpurea* plants produced more flowers and seeds every two years which resulted in high seedling crops during the intervening years, although the pattern may have been related to local weather conditions (Dabbs et al. 2001).

First-year seedlings of *E. purpurea* typically range from 10–20 cm in height (Loeffler and Wegner 2000). Seedlings may be distinguished by the two lowest leaves above the cotyledons which are opposite or near-opposite, as opposed to similarly-sized older plants that lack the cotyledons and have only alternate stem leaves (Loeffler, pers. comm.). Only the largest plants in a population flower, and due to slow growth rates most plants take many years to mature (Short et al. 2002). Sieretko et al. (2004) reported that 7-year-old plants averaged 30 cm in height but blooming seldom occurred until plants were over 90 cm tall, although it was noted that smaller ramets on multi-stemmed plants also occasionally developed flowers. Generally less than 5% of the plants in any *E. purpurea* population were large enough to produce seed (Wright and Loeffler 2005). A similar observation was made by Snyder (1986), who described a population of vigorous plants in which the majority were vegetative.

The survival rates of Darlington's Glade Spurge increase as the plants become larger. Survival is lowest at the seed to seedling stage, averaging between 8.5–15% (Loeffler and Wegner 2000). After the first year, survival rates for immature plants range from 31–66%, but upon reaching maturity the odds improve to 83–98% survival (Short et al. 2002). The maximum life span of a *Euphorbia purpurea* clone is not known.



Left: Britton and Brown 1913, courtesy USDA NRCS 2022a. Right: Jim Brighton, 2021.

Pollinator Dynamics

The specific pollinators of *Euphorbia purpurea* are currently unknown. A small yellow wasp has been observed visiting *E. purpurea* flowers in Pennsylvania and West Virginia, but its role as a pollinator has not been confirmed and the species has yet to be identified (C. Loeffler, pers. comm.). Insect pollination is typical in both the family and the genus, and a wide variety of insects including flies, bees, wasps, and butterflies are attracted to nectar produced by the floral glands (Block and Rhoads 2013, Riina et al. 2020). Zomlefer (1994) indicated that flies are particularly frequent pollinators of plants the Euphorbiaceae and Webster (1967) noted that pollination mechanisms within the genus *Euphorbia* are generally not specialized. The abundance of insect pollinators for *Euphorbia spp*. may be influenced by cyathium size (Ehrenfeld 1979) or high color contrast between the nectar glands and the surrounding vegetative organs (Asenbaum et al. 2021).

In a normal cyathium with both male and female flowers the female flowers mature first. In some *Euphorbia* species—particularly those that are perennial—only the male flowers develop in a number of the cyathia, and units with aborted pistillate flowers are likely to be situated in lower positions on the plants. The strategy could favor allocation of resources to the flowers that are most likely to be cross-fertilized (Narbona et al. 2002). Although unisexual cyathia have not been explicitly reported in *E. purpurea*, Loeffler and Wegner (2000) did observe that seed development was higher in the terminal inflorescences than on the side branches.

Seed Dispersal

The fruit of *Euphorbia purpurea* is a three-parted capsule with a single seed in each chamber (Gleason and Cronquist 1991). The seeds are smooth, ovoid to round, and mottled silver-brown in color (Riina et al. 2020). Loeffler and Wegner (2000) found that the fruits developed during late May and June and seeds were dispersed in late June or early July. As the capsules dried the seeds were released explosively with a noticeable pop. The majority of seeds observed landed 4–4.5 meters from the parent plants, although distances from 0.1–5.8 meters were recorded. While longer distance dispersal mechanisms remain undocumented for *E. purpurea*, Loeffler and Wegner (2000) raised the possibility that some seeds could be transported by adherence to mud on animals, and Knoop (1990) suggested that the species may have utilized rivers to migrate to new sites.

Most *E. purpurea* seeds germinate the year after dispersal, although a small number have persisted until the second year in both natural and experimental settings. There is no evidence of long-term seed banking in the species. Germination rates are highest at the soil surface but decrease with burial, and mycorrhizal associations are not required during the spurge's initial developmental period (Loeffler, pers. comm.).

Habitat

One of the earliest habitat notations for *Euphorbia purpurea* was "glades of Pennsylvania" (Fernald 1932), which probably gave rise to the species' common name of Glade Spurge. The dictionary defines glade as "an open space surrounded by woods" and further notes that the word was historically used to indicate a clearing that was filled with sunlight (Merriam-Webster 2022). While Darlington's Glade Spurge is most often associated with forested sites, the species has also been reported from shrublands, fens and pastures (Latham 2003, Rentch et al. 2008, Bartgis et al. 2015, Weakley 2015). Although the plants are able to tolerate a range of light conditions from full sun to shade (Ostlie et al. 2018), recent work in Pennsylvania indicates that higher light levels increase growth which ultimately leads to greater seed production (Loeffler, pers. comm.). It is worth noting that West Virginia's largest population of *E. purpurea* is located in an open, graminoid-dominated community with scattered shrubs (Bartgis et al. 2015).

In North Carolina, where the species is most abundant, *E. purpurea* is restricted to mountainous areas (LeGrand et al. 2022) but throughout its range it may occur at elevations of 50–1100 meters (Riina et al. 2020). Populations in New Jersey and Delaware are situated at low elevations on the coastal plain (McAvoy 2000), and in Virginia scattered colonies occur on the lower slopes and floodplains of a river gorge while the only population not in the gorge area is located approximately 900 meters higher on the crest of a mountain (Ogle 1989).

Euphorbia purpurea often occurs at sites that are situated over a calcareous substrate (Knoop 1990, Bartgis et al. 2015, Weakley 2015, Riina et al. 2020, LeGrand et al. 2022). Some colonies are positioned over mafic rock such as amphibolite which raises the pH of the soils that form above it (Weakley 2015, Chafin 2019). A preference for high pH soils is noted by LeGrand et al. (2022), but Davis (1993) described the substrate at one Pennsylvania site as "saturated to the surface for much of the year by pH-neutral water." While some *E. purpurea* habitats are nutrient rich (Davis 1993, Weakley 2015), the species has also been known to occur in serpentine habitats which are characteristically poor in nutrients (Latham 1993).

Most of the habitat types utilized by *E. purpurea* have reliably high levels of moisture available early in the growing season (Block and Rhoads 2013). The sites are typically kept wet by seepage or overland flow and frequently lack well-defined stream channels (Davis 1993, Rentch et al. 2015, Ostlie et al. 2018, Chafin 2019). In West Virginia, *E. purpurea* is primarily found in wetlands but also occurs in upland sites including bedrock outcroppings and well-drained hillside pastures (Bartgis et al. 2015).

The best-known *Euphorbia purpurea* occurrence in New Jersey was located in moist, dense woods (Mackenzie 1919) where the plants were found growing in open, mucky seeps adjacent to a small creek (Snyder 1986). The vegetation association where it occurred is called Cape May Lowland Swamp (*Acer rubrum—Nyssa sylvatica—Liquidambar styraciflua—Populus heterophylla* forest), a community that is critically imperiled (S1) in the state (Breden et al. 2001). According to the community description, such sites generally have high vegetative diversity and may include both acid-loving species and calciphiles.

Wetland Indicator Status

The U. S. Army Corps of Engineers (2020) 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). *Euphorbia purpurea* has more than one wetland indicator status within the state. In the Eastern Mountain and Piedmont region, *E. purpurea* is a facultative species, meaning that it occurs in both wetlands and nonwetlands but in the Atlantic and Gulf Coastal Plain region it is considered a facultative wetland species, meaning that it is more likely to occur in wetlands but may occur in nonwetlands. The range of Darlington's Glade Spurge does not extend into the Northcentral and Northeast region, and it has not been assigned a status in that area.

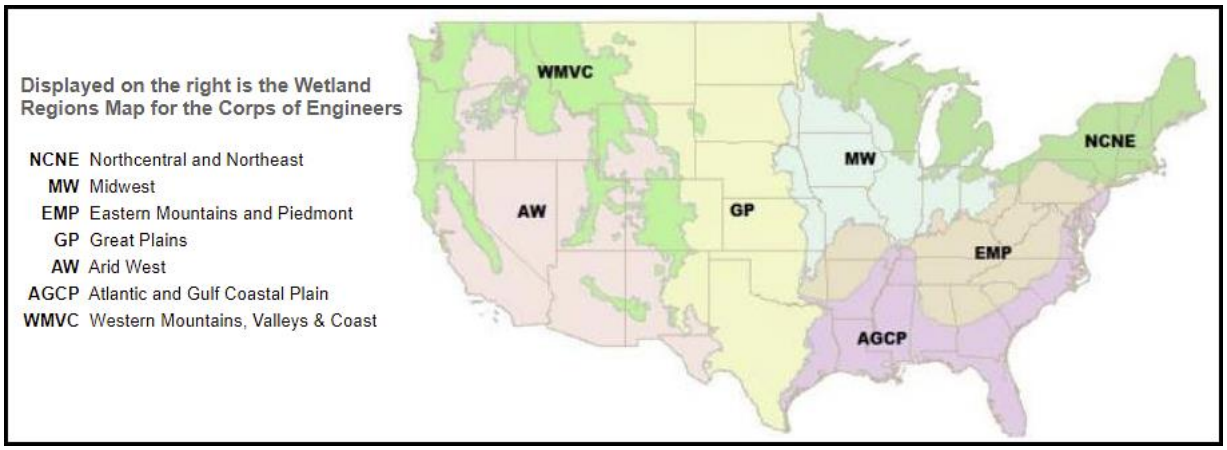


Figure 1. Mainland U. S. wetland regions, adapted from U. S. Army Corps of Engineers (2020).

USDA Plants Code (USDA, NRCS 2022b)

EUPU4

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

The global range of *Euphorbia purpurea* is restricted to the east central United States (POWO 2022). The map in Figure 2 (below) depicts the extent of the species in the North America.

The USDA PLANTS Database shows records of *Euphorbia purpurea* in three New Jersey counties: Cape May, Gloucester, and Salem (Figure 3). The data include historic observations and do not reflect the current distribution of the species. Outside of New Jersey, the only other place where *E. purpurea* has been reported on the Atlantic Coastal Plain is Delaware, where the

species was known from a single site and was thought to be historic prior to the discovery of a new population in 1997 (Clancy 1993, McAvoy 2000).

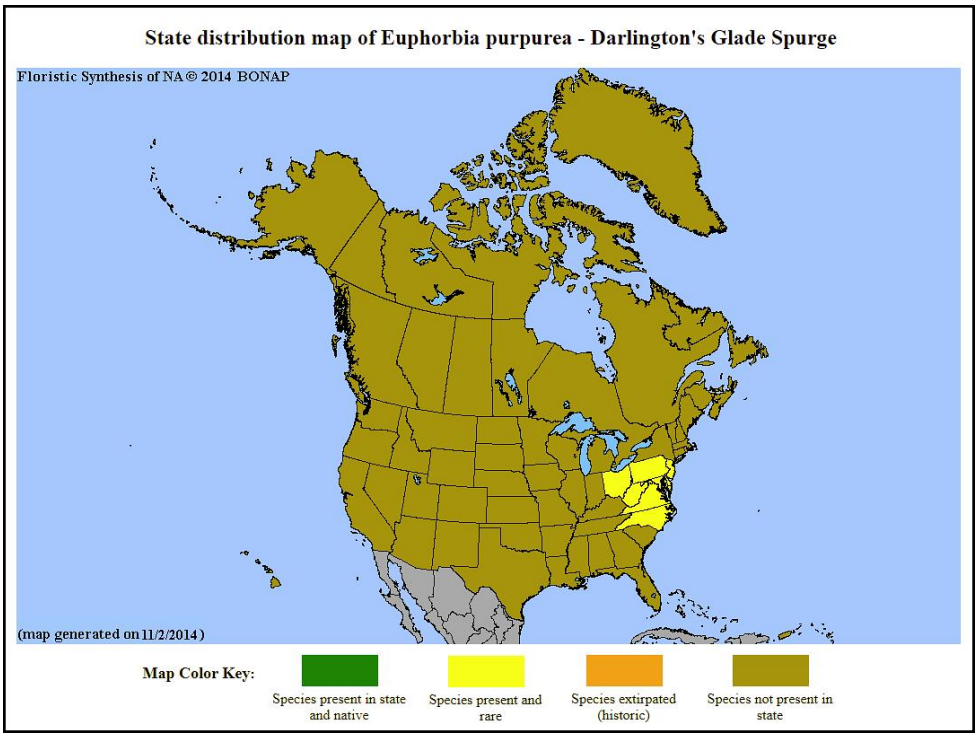


Figure 2. Distribution of E. purpurea in North America, adapted from BONAP (Kartesz 2015).

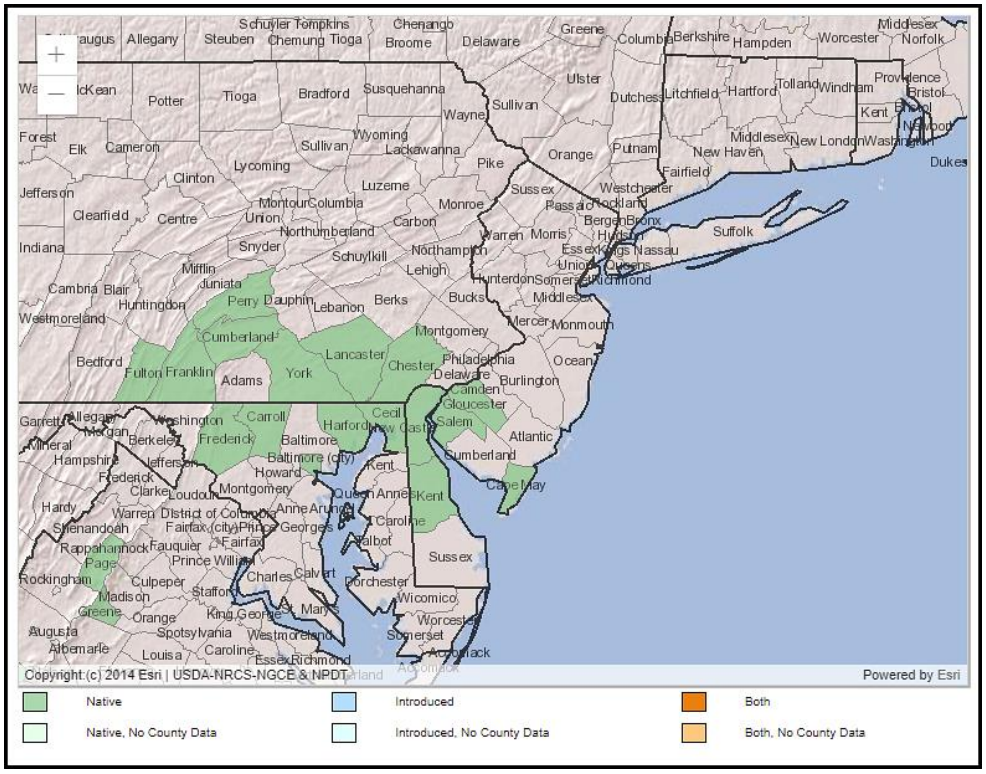


Figure 3. County records of E. purpurea in New Jersey and vicinity (USDA NRCS 2022b).

Conservation Status

Euphorbia purpurea is globally vulnerable. The G3 rank means the species has a moderate risk of extinction or collapse due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors (NatureServe 2022). In North America, *E. purpurea* has also 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 due to extreme rarity, very steep declines, or other factors (Frances 2017). The map in Figure 4 illustrates the conservation status of Darlington's Glade Spurge throughout its range. The spurge is ranked as critically imperiled (very high risk of extinction) in six states, imperiled (high risk of extinction) in two states, and vulnerable (moderate risk of extinction) in one state. *Euphorbia purpurea* is not considered secure anywhere in its range. However, it is not presently listed at the federal level. Tucker and Dill (1982) noted that *E. purpurea* had a federal designation as a Category 2 species, and the most current information available indicates that its status remains unchanged (USFWS 1993, 2022). The Category 2 designation indicates that while a proposed listing of the species may be appropriate, there is not sufficient information on biological vulnerability and threats available to make a determination.

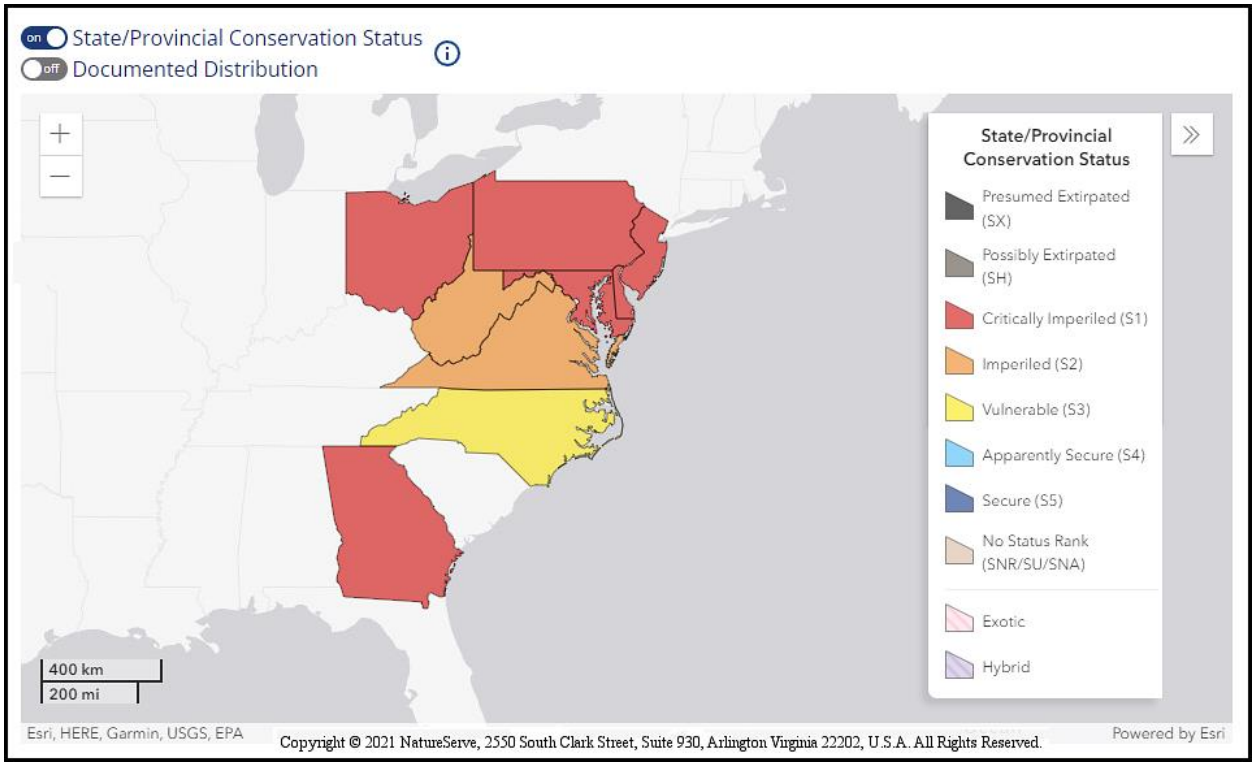


Figure 4. Conservation status of E. purpurea in North America (NatureServe 2022).

Euphorbia purpurea 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. *E. purpurea* 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).

Euphorbia purpurea was first documented in New Jersey in 1895 when it was collected at a site in Salem County (Stone 1911). Stone noted that the plants were very rare in the state, and Taylor (1915) added that the distribution of the species was poorly understood. A second population of *E. purpurea* was found in Cape May County in 1919 and a number of collections were made from the site (NJNHP 2022), where the plant was then reported to be "locally abundant" (Mackenzie 1919). Two other colonies were found in the Cape May area during the 1920s, but after the mid-1940s the species was not recorded in the state for several decades until the original Cape May occurrence was relocated in 1985 (Snyder 2000). The population was described as vigorous in 1986 and 1987 but subsequently disappeared, and numerous searches conducted between 2005–2018 failed to find any trace of the species (NJNHP 2022).

Threats

Like a lot of rare plants in the northeastern United States, *Euphorbia purpurea* is susceptible to habitat loss and disturbance—in many cases due to human activity. In the past the most significant impacts resulted from the draining and filling of wetlands, while current threats are attributable to development, resource harvesting and extraction, road and right-of-way construction, and an assortment of recreational activities including off-road vehicles, horseback riding, biking, and foot traffic (Ostlie et al. 2018). Habitat alterations resulting from natural processes also threaten *E. purpurea*. Hydrologic changes resulting from beaver activity were identified as a threat to large populations in West Virginia (Bartgis et al. 2015). Plant community succession also appears to be detrimental to Darlington's Glade Spurge. Wright and Loeffler (2005) initially reported a possible correlation between light availability and plant size, and ongoing studies of Pennsylvania populations have shown that selective canopy thinning can increase the height and reproductive capacity of the plants (Loeffler pers. comm.).

Plant demography research in Pennsylvania suggests that low reproduction threatens the long-term viability of *E. purpurea* populations. A series of studies showed that only a small percentage of any population typically flowered and mortality rates in both seedlings and immature plants were high (Dabbs et al. 2001, Short et al. 2002, Wright and Loeffler 2005). Despite the fact that *Euphorbia purpurea* plants are long-lived and able to reproduce vegetatively, the data indicated that Pennsylvania populations were not producing enough offspring to compensate for mortality (Wright and Loeffler 2005).

Herbivory by White-tailed Deer (*Odocoileus virginianus*) has been documented as a significant threat to *E. purpurea*. All species of *Euphorbia* produce abundant latex which can be highly caustic in some cases (Riina et al. 2020) and that may be what causes cattle to avoid eating *E. purpurea* when it grows in pastures (Ostlie et al. 2018). Unfortunately it does not seem to deter deer. Herbivory impacts to selected spurge populations in Pennsylvania were initially reported at

0–35% (Loeffler and Wegner 2000) but in areas with restricted hunting up to 80% of plants were subsequently affected by deer browse (Salvatore et al. 2003). Loeffler and Wegner (2000) observed that a preference was shown for the upper portion of the stems, which resulted in reproductive losses when mature plants were browsed. They also quantified the impacts on plant growth by measuring basal stem diameters, which correlated with ramet height and therefore served as a reasonable index of plant vigor. Results showed that browsed plants in the largest of three populations were 20% smaller than unbrowsed individuals, while the other two populations included in the study were too small to have statistically significant results. The authors also noted that in one of the smaller populations nearly all of the potential propagules were removed by browsing during one growing season. Continued reductions in size, flowering, fruiting, and seed production were reported at the study sites in subsequent years (Dabbs et al. 2001, Salvatore et al. 2003).

No studies focusing on the impact of competition were found for *Euphorbia purpurea*, although Loeffler and Wegner (2000) mentioned that young plants were sometimes pressed down into the mud by the wilting of nearby skunk cabbage (*Symplocarpus foetidus*) leaves. Because the growth of *E. purpurea* is facilitated by light, competition for that resource in the understory might account for the fact that survival rates are higher in larger plants. The presence of invasive flora has been cited as a threat to Darlington's Glade Spurge by Bartgis et al. (2015) and by Ostlie et al. (2018).

At one time there was concern that *E. purpurea* could be harmed by the non-native insect *Aphthona flava* (European flea beetle) which was introduced for the control of Leafy Spurge (often referred to as *Euphorbia esula* but more properly identified as *E. virgata* per Riina et al. 2020). However, Pemberton and Rees (1990) indicated that the threat was insignificant because *E. purpurea* proved to be unsuitable for larval development of the flea beetles. A negligible amount of insect damage has been seen in Darlington's Glade Spurge under natural conditions, mostly due to leaf-folding caterpillars, although a number of insect pests (thrips, whiteflies, aphids) were noted as problematic for plants experimentally grown ex situ. A powdery mildew was also observed on *E. purpurea* plants in both natural and greenhouse settings (Loeffler and Wegner 2000, Loeffler pers. comm.)

An assessment of climate change vulnerability for rare species in West Virginia classified *Euphorbia purpurea* as extremely vulnerable, signifying that the species is likely to substantially decrease or disappear in that state by 2050. Risk factors identified as contributing to the spurge's vulnerability included poor dispersal ability, predicted temperature sensitivity, predicted sensitivity to changes in precipitation, hydrology, and moisture regime, and habitat limitations (Byers and Norris 2011). A comparable level of vulnerability is also likely in New Jersey, where changing climactic conditions are contributing to rising temperatures and shifting precipitation patterns (Hill et al. 2020).

Management Summary and Recommendations

A significant level of effort may be required to conserve a species like Darlington's Glade Spurge that faces numerous challenges. After years of observing declines in Pennsylvania populations

of *Euphorbia purpurea*, researchers developed a multi-pronged management plan to address a number of factors that were threatening the local occurrences including browsing, competition, succession, and poor recruitment. Strategies utilized included the fencing of populations to deter herbivores, weeding around the spurge plants to reduce competition, targeted tree removal to increase light levels, and offsite propagation. *E. purpurea* plants grown from local seeds were reintroduced to the sites when they were large enough to assure a reasonable expectation of survival. To date, five populations have reversed course from declining to increasing, and similar efforts are underway at a sixth site (Loeffler, pers. comm.).

Some extant populations of *E. purpurea* may have different conservation requirements. In places where the species is threatened by hydrological changes, it may be necessary to maintain the integrity of its seepage habitats. Management of those populations could involve protection of the immediate community, the adjacent land, and the site's water source as discussed by Ostlie et al. (2018).

In New Jersey, efforts should focus on determining whether *E. purpurea* is still extant in the state. Since seeds of the species do not appear to persist for more than a year or two, repeated searches of sites where the plants have disappeared may not be productive. However, location of historic sites that have not been pinpointed or investigations of potentially suitable habitat in other places might turn up a new population, as exemplified by the 1997 discovery in Delaware (McAvoy 2000).

Synonyms

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

Botanical Synonyms	Common Names
Agaloma purpurea Raf.	Darlington's Glade Spurge
Euphorbia darlingtonii A. Gray	Darlington's Spurge
Euphorbia darlingtonii var. *glabra* Boiss.	Glade Spurge
Euphorbia discolor Shuttlew. ex Boiss.	Purple Spurge
Euphorbia nemoralis Darl.	Wolf's Milk
Euphorbia pilosa Pursh	
Galarhoeus darlingtonii (A. Gray) Small	
Keraselma ciliata Raf.	
Tithymalus darlingtonii (A. Gray) Small	

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Cressler, Alan. 2012. Closeup of developing fruit of *Euphorbia purpurea* from Georgia. Courtesy of the Lady Bird Johnson Wildflower Center, https://www.wildflower.org/. Used with permission.

Cressler, Alan. 2017. Cover photo of *Euphorbia purpurea*. Courtesy of the Lady Bird Johnson Wildflower Center, https://www.wildflower.org/. Used with permission.

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