

# *Jeffersonia diphylla*

**Twinleaf**

**Berberidaceae**



*Jeffersonia diphylla* by Peter M. Dziuk, 2007

## ***Jeffersonia diphylla* 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**

In 1792, the species now recognized as *Jeffersonia diphylla* (Twinleaf) was known from a limited number of locations in the United States, and early observers often identified it as a species of *Podophyllum* (may-apple) or *Sanguinaria* (bloodroot) according to Barton (1793). Following a period of fruitlessly searching for the plant in Pennsylvania, Barton was finally able to examine the species after the French botanist Andrew Michaux sent a root to William Bartram who then successfully cultivated it in his garden. Having inspected a living specimen firsthand, Barton acknowledged a close resemblance to *Podophyllum* but felt the plant was worthy of a distinct generic designation and proposed the name *Jeffersonia* in honor of the then Secretary of State Thomas Jefferson. He was explicit about the reasons for his choice: "*I beg leave to observe to you, in this place, that in imposing upon this genus the name of Mr. Jefferson, I have had no reference to his political character, or to his reputation for general science, and for literature. My business was with his knowledge of natural history. In the various departments of this science, but especially in botany and in zoology, the information of this gentleman is equalled by that of few persons in the United-States*" (Barton 1793).

The genus name has also been applied to an east Asian plant (Weakley 2015) but is presently in use for a single species (POWO 2022). *Jeffersonia diphylla* is currently placed in the Berberidaceae, along with *Podophyllum*. At first glance the flowers resemble those of our native *Sanguinaria* (Papaveraceae) but the leaves are quite distinct: *Sanguinaria* leaves are palmately 5–9 lobed while the leaves of *Jeffersonia* are deeply bisected into two parts that are narrowly joined at the center (Britton and Brown 1913).

Twinleaf is a perennial species with matted, fibrous roots (Fernald 1950). The plants also have short rhizomes (George 2020) which sometimes branch and produce one or two additional ramets (Smith et al. 1986). Individual ramets produce a few (4–8) long-petioled basal leaves (Gleason and Cronquist 1991). The species flowers early in the season, blooming in March or April and fruiting in May (Weakley 2015). Onset of flowering is influenced by late winter and early spring temperatures (Smith et al. 1986). The white flowers are solitary on naked scapes, and are typically 1–3 cm wide with four sepals and eight petals (Rhoads and Block 2007). Floral parts occasionally occur in threes or fives (Fernald 1950), and Sims (1812) illustrated the plant from a specimen with nine petals and stamens although he noted that eight was the usual number. The sepals are rapidly discarded as the flower bud develops and the petals only remain on the flower for a few days (1–3 per Gracie 2012, 2–6 per Smith et al. 1986). During that time the flowers open during the day and close at night (Graenicher 1906). Smith et al. (1986) reported that the flowering period of an entire population lasts for 10–14 days. Initially the flowers are taller than the leaves, but the leaves continue to elongate and expand following anthesis (Gleason and Cronquist 1991). The fruit is a capsule with a transverse or oblique dehiscence that causes the top to form a reflexed lid (George 2021). Fruits develop during May and release their seeds in early June (Weakley 2015, Smith et al. 1989). The distinctive leaves of *Jeffersonia* plants persist throughout the summer months, and by the time they begin to senesce in September the buds for the following year's growth are forming just beneath the soil surface (Gracie 2012).



Illustration by Britton and Brown 1913, courtesy USDA NRCS 2022a.



Emerging plants, Tom Potterfield, 2011.



Fruit, J. S. Dodds, 2013.

## **Pollinator Dynamics**

The flowers of *Jeffersonia diphylla* are pollinated by an assortment of bees, both long-tongued and short-tongued. Graenicher (1906) recorded nine different bee species pollinating Twinleaf, and also observed that a Syrphid fly would visit but not pollinate the flowers. Smith et al. (1986) noted sweat bees (Halictidae) and honeybees (Apidae) as the primary pollinators. Hilty (2020) reviewed and reported records of numerous insect visitors to *Jeffersonia* flowers, further explaining while the bees usually collected pollen the flies and beetles would feed on pollen and explore the flowers in vain for nectar. Although the flowers lack nectar, they produce a slight aroma and copious amounts of pollen that may aid in the attraction of insects (Smith et al. 1986). Like a number of other white-flowered spring ephemerals, *Jeffersonia* petals contain flavonoids that may function in pollinator attraction by absorbing of ultraviolet light and creating color patterns that are visible to insects (Schilling and Calie 1982).

*Jeffersonia* plants are also capable of self-fertilization. Graenicher (1906) first surmised that after watching the flowers close at the end of each day, and Smith et al. (1986) further elaborated that after two or three days the stamens begin bending toward the pistil until the anthers are brought into contact with the stigma. Because *J. diphylla* flowers early, and in an environment that provides unpredictable pollinator activity, the delayed self-fertilization mechanism can boost reproduction for plants that have not been cross-pollinated (Fenster and Martén-Rodriguez 2007).

## **Seed Dispersal and Development**

Each *Jeffersonia diphylla* capsule contains 10–25 seeds, which are red with a white appendage (George 2020). The appendages are elaiosomes, clusters of cells that are rich in fatty acids and diglycerides (Heithaus 1981). Seed set in the species is typically around 90%, but may be significantly reduced if temperatures drop below freezing while the plants are flowering or fruits are developing (Smith et al. 1986). When the fruits mature, the capsule lid opens and the peduncle bends, dropping the seeds on the ground (Smith et al. 1989).

*Jeffersonia diphylla* is locally dispersed by ants, which collect the seeds and carry them back to their nests in order to consume the nutritional elaiosomes (Heithaus 1981). Once the elaiosomes have been removed, the ants transfer the undamaged seeds to underground refuse piles in the nest (Smith et al. 1989). *Aphaenogaster rudis* is an ant species frequently reported as a vector for *Jeffersonia* seeds (Connell et al. 2016) and Heithaus (1981) named eight additional species known to carry elaiosome-laden seed, all but one of which are found in New Jersey (BugGuide 2022).

*Jeffersonia* seeds are often eaten by rodents before ants have an opportunity to collect them. The most common predator identified by Heithaus (1981) was the White-footed Mouse (*Peromyscus leucopus*), an abundant species in New Jersey. Heithaus (1981) reported that 54% of seed capsules at a West Virginia study site were opened by predators prior to dehiscence, resulting in the destruction of all seeds in each damaged capsule. Smith et al. (1986) observed that capsule predation was highest during the two week period prior to seed release, and found that almost



90% of capsules were lost in two of the populations they studied. The same study also documented high (76%) predation on mature seeds after they had dropped from their capsules, most of which took place during the first night post-release. Smith et al. (1986) found that seed predation rates were considerably lower in small populations, but that up to 95% of seeds produced in a large population could be lost to predators. Seed predation by mice is unlikely to promote dispersal for *Jeffersonia*. Damage frequently occurs while seeds are still in the capsule and are not completely mature. Mouse dispersal of fully developed seeds is equally improbable, as the seeds are completely digested following consumption (Heithaus et al. 1980).

Ant dispersal is often thought to place seeds in more favorable locations for development, but examination of the soils beneath *Jeffersonia* plants and those near ant nests where seeds are dispersed found some differences in soil processes but no resulting enhancement of seed germination (Connell et al. 2016). The advantage of ant-dispersal in *J. diphylla* may be predator avoidance that results in higher survival rates for seeds (Heithaus 1981, Smith et al. 1989).

Climactic influences on the germination of *Jeffersonia diphylla* seeds were studied by Baskin and Baskin (1989). The process occurs in stages that have different temperature requirements. High summer temperatures are initially needed as a trigger for the embryos to complete their development inside the seeds, a process which continues throughout the autumn months. Exposure to low temperatures is then required to break dormancy in preparation for germination the following spring. Dormancy beyond the first year was not reported. Bierzychudek (1982) observed that temperate forest herbs typically do not have extended dormancy periods, although *Jeffersonia* was not included in the study.

### **Habitat**

Characteristic habitat for *Jeffersonia diphylla* is moist, nutrient-rich hardwood forest over limestone or other calcareous rock, where the plants are often found on steep, rocky slopes (Boetsch 2000, Weakley 2015). Young (1877) described a zone of growth on the upper portion of hillsides starting at the middle and extending halfway to the top, puzzling over the species absence from lower parts of the hill that appeared to offer comparable habitat. George (2020) cites an elevation range of 100–800 meters. Twinleaf has also been found growing in floodplain forests (Michigan State University, undated). Favorable light regimes for the species have been described as shade, light shade, or partial sun (Shetler 1999, Leopold 2005).

### **Wetland Indicator Status**

*Jeffersonia diphylla* is not included on the National Wetlands Plant List (NWPL). Any species not on the NWPL is considered to be Upland (UPL) in all regions where it occurs. The UPL designation means that it almost never occurs in wetlands (U. S. Army Corps of Engineers 2020).

## USDA Plants Code (USDA, NRCS 2022b)

JEDI

## Coefficient of Conservatism (Walz et al., 2018)

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 global range of Twinleaf is restricted to the United States and Canada (POWO 2022). The map in Figure 1 depicts the extent of *Jeffersonia diphylla* in the North America.

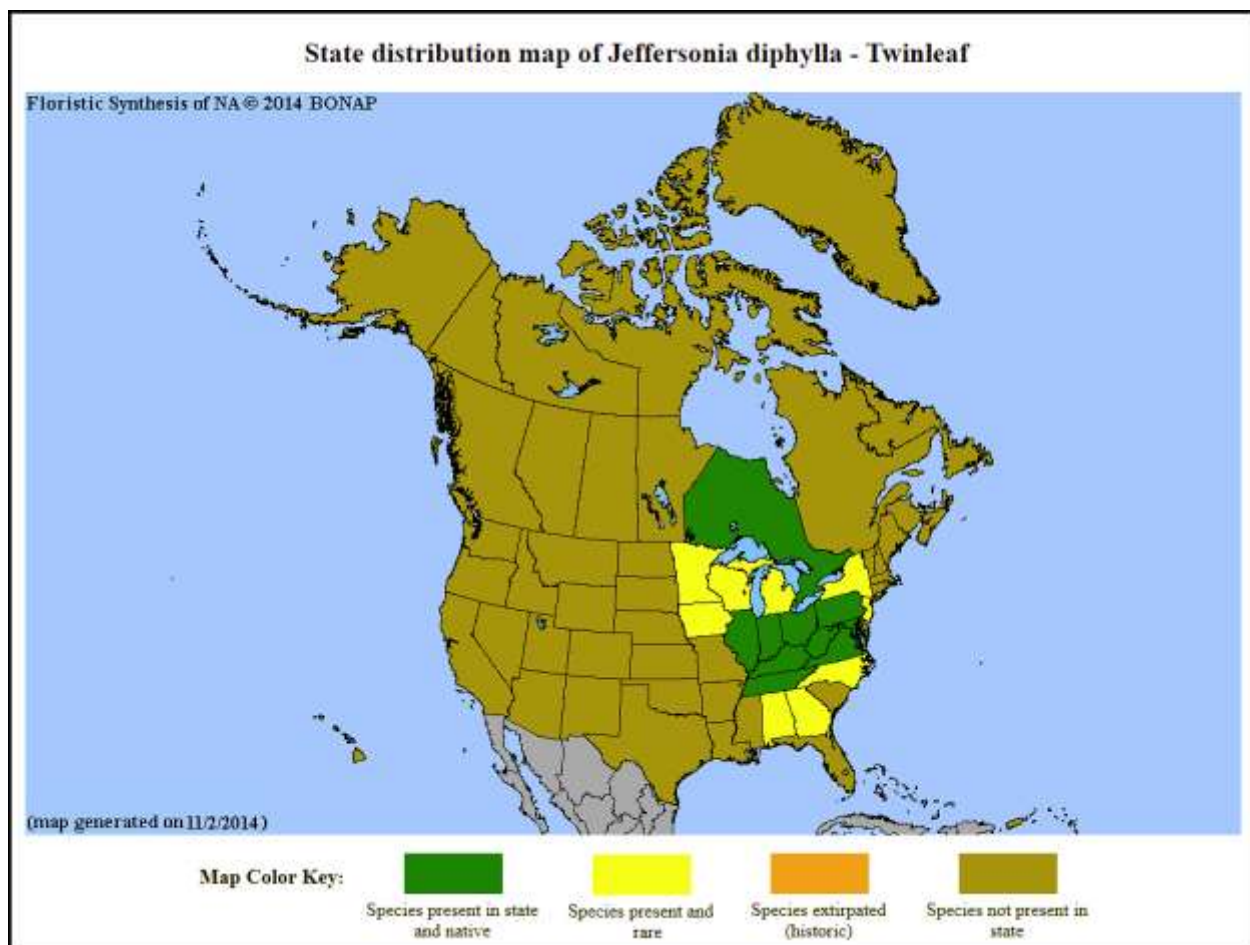


Figure 1. Distribution of *J. diphylla* in North America, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2022b) shows records of *Jeffersonia diphylla* in five New Jersey counties: Hudson, Hunterdon, Mercer, Ocean and Warren (Figure 2). The data include historic observations and do not reflect the current distribution of the species.

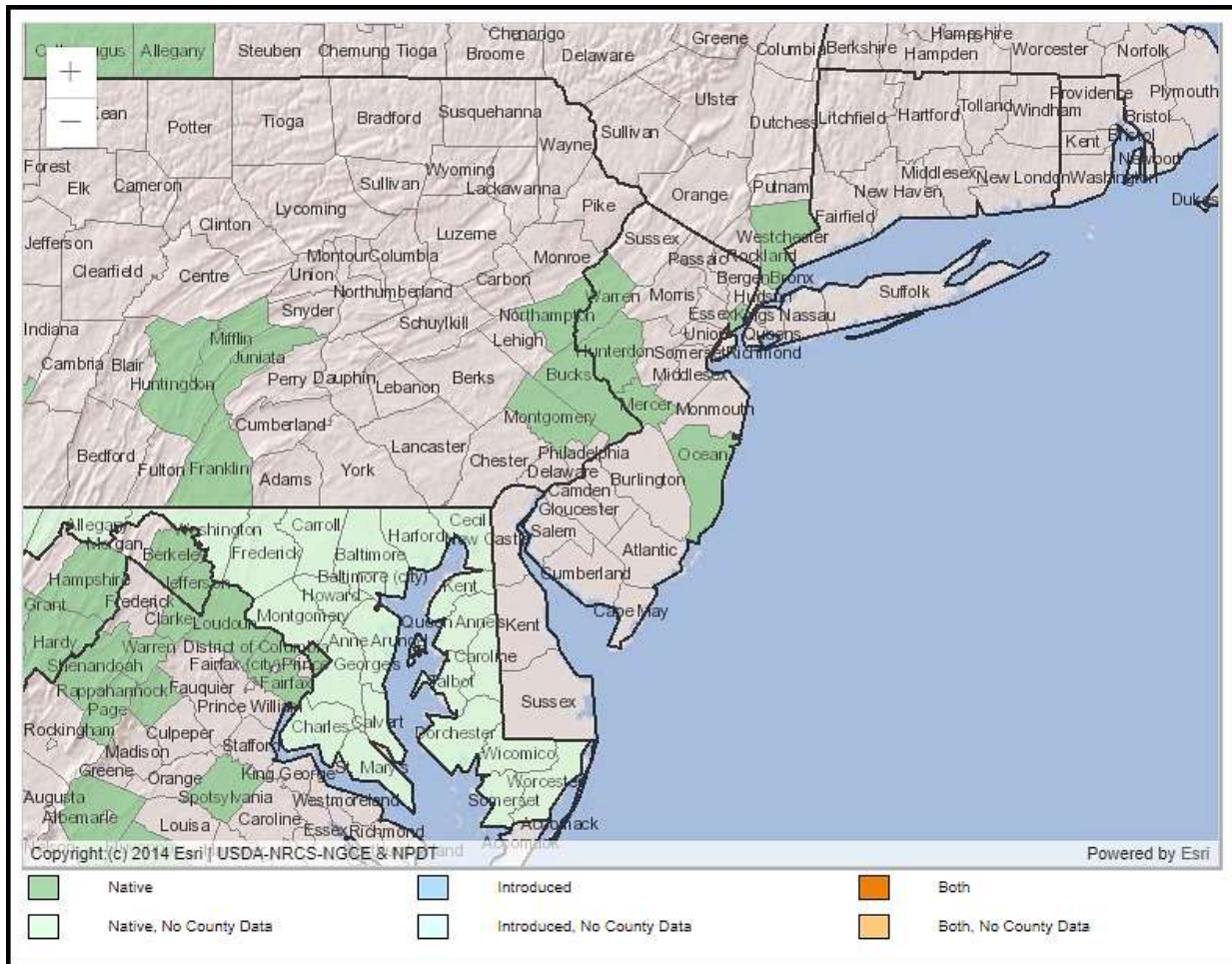


Figure 2. County records of *J. diphylla* in New Jersey and vicinity (USDA NRCS 2022b).

### Conservation Status

*Jeffersonia diphylla* 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). However, the fragility of the species is noted as moderately vulnerable because it only tolerates low levels of disturbance (Boetsch 2000). The map below (Figure 3) from NatureServe Explorer (2022) shows the state or provincial conservation ranks for Twinleaf. *Jeffersonia* is critically imperiled (very high risk of extinction) in four states, imperiled (high risk of extinction) in two states, and vulnerable (moderate risk of extinction) in three states. Throughout the remainder of its range it is secure, apparently secure, or is unranked.



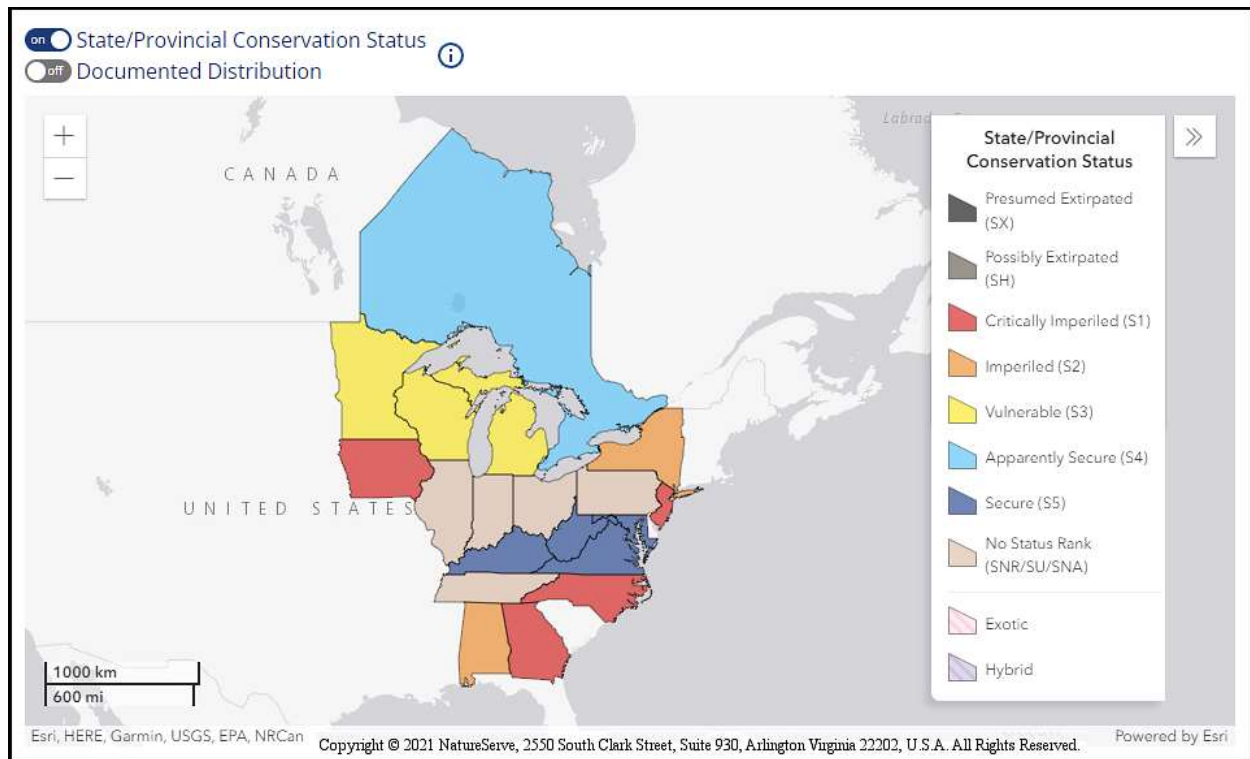


Figure 3. Conservation status of *J. diphylla* in North America (NatureServe 2021).

In New Jersey, *Jeffersonia diphylla* is critically imperiled (S1) (NJNHP 2022). The rank signifies five or fewer occurrences in the state. A species assigned 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. *Jeffersonia* 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, being listed does not currently provide broad statewide protection for the plants. Additional regional status codes assigned to *J. diphylla* signify that the species is eligible for protection under the jurisdictions of the Highlands Preservation Area (HL) and in the New Jersey Pinelands (LP) (NJNHP 2010).

It seems that Twinleaf has always been an elusive species in New Jersey. It was not included in Britton's early flora of the state (Britton 1889), and Keller and Brown's (1905) report of species in the greater Philadelphia area included only a single record from the Pennsylvania side of the Delaware River. Keeler (1916) described *Jeffersonia*'s range as "*western New York to Wisconsin, and south to Virginia and Tennessee.*" The first New Jersey specimen was collected by David Fables in 1936, but the Ocean County site where he found the plant was destroyed two years later (Snyder 2000). In 1964 Vincent Abraitys reported a new population in Warren County (Snyder 1984) but shortly after that Fairbrothers and Hough (1973) said that the only current location was in Hunterdon, so the Warren occurrence must have disappeared shortly after its discovery. Today *Jeffersonia diphylla* is extant at only two locations in the state, one with an occurrence viability rank of 'Good or Fair' and the other with a rank of 'Poor' (NJNHP 2022).

## **Threats**

Habitat loss is one of the most widely reported threats to *Jeffersonia diphylla* throughout its range. As noted above, the original New Jersey population was lost to development within two years of its discovery. Range-wide removal of forests for construction, agriculture, pasture, logging, quarrying, and pine plantations has eliminated sites that once supported *Jeffersonia* (Boetsch 2000, Chafin 2007, Minnesota DNR 2021).

Another significant range-wide threat to *J. diphylla* is the proliferation of invasive species (Boetsch 2000, Chafin 2007, Chapman et al. 2015, Minnesota DNR 2021). Habitat degradation resulting from the incursion of an assortment of exotic plants has caused a significant decline in both of New Jersey's remaining Twinleaf populations (NJNHP 2022). Even when the land supporting a rare plant population has been preserved, fragmentation of the surrounding landscape facilitates the spread of invasive species and allows them to penetrate further into the interior of forested sites (Chapman et al. 2015). Throughout the northeast—and specifically at the site of at least one New Jersey *Jeffersonia* population—the rapid loss of ash (*Fraxinus* spp.) tree cover to an introduced insect (Emerald Ash Borer, *Agrilus planipennis*) has increased light levels on the forest floor and exacerbated the invasive plant problem (NJNHP 2022).

Loss of seeds to rodent herbivory was discussed earlier (see Seed Dispersal and Development), and one of New Jersey's *Jeffersonia* populations lost nearly 100% of its fruit crop in that manner during 2018 (NJNHP 2022). Rockwood and Lobstein (1994) studied the potential effects of foliage herbivory on several forest herbs including *J. diphylla*. Partially defoliated plants replaced their leaves and showed no impacts during the first year, but were less likely to produce multiple fruits in the year that followed. While mature *Jeffersonia* plants can recover from both fruit and foliage herbivory, reduced reproductive success can have detrimental long-term effects on the population as a whole.

Some traditional forest management practices may be detrimental to forest herbs. Changes in habitat structure can directly and indirectly alter levels of light, moisture, and temperature; and Willems et al. (2021) found that the ensuing changes could delay the flowering period of understory species by up to two weeks. Forest management practices that open canopy gaps or disturb soil have been identified as a threat to *Jeffersonia diphylla* in Minnesota (Minnesota DNR 2021). Another form of human interference—plant poaching—has also been reported as a threat to the species in Georgia (Chafin 2007).

## **Management Summary and Recommendations**

Ideally, management of *Jeffersonia diphylla* should focus on the preservation of its mature forest habitat at sites where the species occurs (Chafin 2007, Michigan State University undated, Minnesota DNR 2021). The importance of conserving large tracts is discussed by Chapman et al. (2015) who pointed out that while small patches of habitat in a fragmented landscape play a critical role in maintaining biodiversity their greater edge to interior ratio makes them more susceptible to changes in soil moisture, temperature, light, wind exposure, and the introduction of pollutants or invasive species.

Invasive species control is probably the most urgent management need in order to assure the survival of the remaining *Jeffersonia diphylla* occurrences in New Jersey (NJNHP 2022). The significant and burgeoning threat from nonindigenous plants is recognized throughout the state, where the problem has been exacerbated by high human population density and intense development (NJ Division of Science and Research 2021). As with management plans for rare occurrences, site-specific planning is the most effective way to approach invasive species control. Considerations to be made in the development of a plan include the ecology and needs of rare species on site, the biology and population dynamics of the invasive species, size and topography of the target habitat, and long-range maintenance (Eppinga et al. 2021, Flory and Clay 2009, Kaufman and Kaufman 2007, Kettenring and Adams 2011).

Searches for additional populations in suitable habitat may be fruitful. Fairbrothers and Hough (1973) noted that *Jeffersonia* may have been overlooked at some locations due to its short flowering time, and Boetsch (2000) recommended a targeted, systematic habitat inventory throughout the range of the species.

Bellemare (2010) characterized *Jeffersonia diphylla* as a locally dispersed plant with limited potential for migration and colonization of new habitats, and raised the possibility that some human intervention or 'assisted colonization' may be needed to help the species keep up with shifting environmental conditions brought on by modern climate change. Preparations for that eventuality could include identification of suitable habitat at locations where the species does not presently occur and research on propagation and introduction of the plants. It seems that the species is relatively easy to propagate by rhizome division (Leopold 2005, Shetler 1999), and Boetsch (2000) reports that the plant is already in small-scale cultivation commercially. Propagation by an experienced horticulturalist using native stock is recommended if restoration efforts are considered.

## **Synonyms**

The accepted botanical name of the species is *Jeffersonia diphylla* (L.) Pers. Orthographic variants, synonyms, and common names are listed below (Gracie 2012, ITIS 2021, POWO 2022, USDA 2022b).

### **Botanical Synonyms**

*Jeffersonia bartonis* Michx..  
*Jeffersonia binata* W. Bartram  
*Jeffersonia lobata* Nutt.  
*Jeffersonia odorata* Raf.  
*Podophyllum diphyllum* L.  
*Vindicta begoniifolia* Raf.

### **Common Names**

Twinleaf  
Rheumatism-root  
Helmet-pod

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