Claytonia virginica var. *hammondiae*

Hammond's Yellow Spring Beauty

Montiaceae

Claytonia virginica var. *hammondiae* by Jeff Burian, 2020

***Claytonia virginica* var. *hammondiae* Rare Plant Profile**

New Jersey Department of Environmental Protection
State Parks, Forests & Historic Sites
Forests & Natural Lands
Office of Natural Lands Management
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Life History

Claytonia virginica var. *hammondiae* (Hammond's Yellow Spring Beauty) is a low-growing perennial herb. *Claytonia* was traditionally placed in the Portulacaceae but recent evidence indicated that the family was not monophyletic; therefore, the genus has been transferred to Montiaceae (APG III 2009; Nyffeler and Eggli 2010).

The common Virginia Spring Beauty (*Claytonia virginica*) is a spring ephemeral, blooming in early spring before canopy leaf out, flowering and setting seed before dying back to its underground root structures. It does not produce bulbils or bulblets but does have globose tubers 10–200 mm in diameter (Miller 2020; Native Plant Trust 2024). *C. virginica* var. *hammondiae* has as similar life history but has characteristics that differentiate it markedly from Virginia Spring Beauty, and it is under review for elevated status as a distinct species (Snyder 1992, 2024).

Hammond's Yellow Spring Beauty is morphologically similar to Virginia Spring Beauty (Snyder 1992). *C. virginica* reaches 5–40 cm in height, its leaves and weak stem growing from underground tubers (Miller 2020). Each flowering stem typically has two opposite cauline leaves that are long, slender, and grasslike, reaching up to 10 cm long. Leaf width in var. *hammondiae* can range from 1–14 mm, with wider-leaved plants growing under dense canopy in wetter conditions (Snyder 1992). Leaves of *C. virginica* are simple and entire, smooth, green and somewhat thickened (Native Plant Trust 2024). Basal leaves are petiolate while cauline leaves are sessile (Miller 2020).

The flowers of var. *hammondiae* have five petals and two bracts (sepals) and are arranged in a terminal raceme with 5 to 26 flowers/stalk (Lobstein 2024; Schemske 1977). Flower size is similar to *C. virginica*, about 5–12 mm in diameter (Miller 2020). However, in contrast, the petals of var. *hammondiae* are entirely deep yellow orange with no pink striping, and the anthers are white, with yellow filaments. Petal veins are also yellow to yellow orange (Snyder 1992). It is not found growing among the more typical white/pink flowered Virginia Spring Beauty plants.

Additionally, the blooming period of var. *hammondiae* differs from *C. virginica*, blooming from late April to early June instead of earlier in the season. Hammond's Yellow Spring Beauty has also been observed flowering later in the summer, into the third week of August and beyond. However, it is not known whether those flowers were from late-blooming spring plants or developed on newly germinated seeds produced that spring. The leaves of some var. *hammondiae*, particularly those of plants growing in wetter, shaded headwater seeps, did not senesce until October (Snyder 1992).

The flowers of Virginia Spring Beauty are usually white, pinkish to rose, or white with pinkish stripes, pink anthers, and pink petal veins (Hilty 2020; Miller 2020). However, occasionally one can find individual plants with pale yellow flowers scattered among the pink and white-flowered plants in *Claytonia virginica* colonies. Although yellow, those blooms retain the pink petal striping and anther coloration. Some botanists consider the yellow petal/pink anther flower coloration to be a color form of *Claytonia virginica* (*Claytonia virginica* f. *lutea*) with populations occurring in Pennsylvania, Maryland, and now Readington Township, New Jersey, thanks to a more recent find in 2020 (Ling and Ling 2021). To date, var. *hammondiae* is only

known from one site in northwestern New Jersey and is considered a single-site endemic (Knapp 2024; Snyder 1992; Weakley et al. 2024; Wright 2019).

The flowers of Virginia Spring Beauty open on sunny days in early or mid-morning, closing by late afternoon. Flowers also remain closed when cloudy or rainy to protect the pollen (Hilty 2020; Lobstein 2024; Parker et al. 2017). When the flowers first open, the stamens are functional and release pollen. On the second day and for up to seven days thereafter the pistil is receptive to pollen (Lobstein 2024; Schemske 1977). *C. virginica* var. *hammondiae* blooms are likely similarly protandrous.

The fruit of *C. virginica* is an ovoid capsule enclosed by two sepals (Gleason and Cronquist 1963; Hilty 2020) that splits open when dry to expel the seeds up to two meters away (Lobstein 2024; Native Plant Trust 2024; Schemske 1977). Each capsule contains up to six seeds, with each seed 2–3 mm in diameter. Smooth and shiny, each seed has a fat body called an elaiosome (1–2 mm) attached at one end, which is attractive to ants (Handel et al. 1981; Handel and Beattie 1990). Var. *hammondiae* likely has a similar fruiting and seed dispersal characteristics, but more research is needed to confirm.

Left: Britton and Brown, 1913, courtesy USDA NRCS, 2024a. Right: Link M. Davis, 2021.

Pollinator Dynamics

Virginia Spring Beauty is one of the earliest blooming spring ephemerals in New Jersey and an important pollen and nectar source for early spring insect pollinators (Dailey and Scott 2006; Lobstein 2024). Those include the European Honey Bee (*Apis mellifera*), bumble bees (*Bombus* spp.), small carpenter bees (*Ceratina* spp.), mason bees (*Osmia* spp.), cuckoo bees (*Nomada* spp.), Halictid bees (*Agapostemon* spp., *Augochlorella* spp., *Halictus* spp., *Lasioglossum* spp.), and Andrenid bees (*Andrena* spp.) (Hilty 2020; Schemske 1977). Robertson (1929) recorded 58 species of bees visiting *C. virginica* near Carlinville, Illinois. There is a close relationship

between the plant species and one Andrenid bee, the Claytonia or Spring Beauty Bee (*Andrena erigeniae*), which only gathers pollen and nectar from two *Claytonia* species (Davis and LaBerge 1975; Hopwood 2015). With so many potential pollinators, the plant could sexually reproduce without visits from the Claytonia Bee, although it is the more efficient pollinator of this plant species (Motten et al. 1981; Parker et al. 2016). However, the converse is not true—the bee is oligolectic, relying solely on *Claytonia* spp. for pollen and nectar (Davis and LaBerge 1975; Fowler 2016a, b; Hopwood 2015). *A. erigeniae* typically forages between 10:00 a.m. and 2:30 p.m., with little to no foraging activity on cool or rainy days (Davis and LaBerge 1975; Raupp 2015).

Left: Claytonia Bee with var. *hammondiae* pollen, Jeff Burian 2020. Right: Jason Hafstad, 2017.

Claytonia flowers are also visited by a variety of fly species including Syrphid flies, the Giant Bee Fly (*Bombylius major*), flesh flies (Sarcophagidae), and Calliphorid flies. Butterflies and skippers also come in search of nectar (Hilty 2020; Schemske 1977), although none of those species are as effective at pollination as are native bees. [As an interesting aside, the Spring Beauty Bee is the dominant pollinator for northern populations of *Claytonia* studied in Pennsylvania and Maryland while the Giant Bee Fly is a primary pollinator in southern areas (e.g., North Carolina). This has resulted in variations in pollen production between those two "pollinator ecotypes", with northern *Claytonia virginica* populations typically producing more pollen (Parker et al. 2017)]. The Spring Beauty Bee (above) has also been observed on Hammond's Yellow Spring Beauty, which is likely visited and pollinated by the same groups of other insects as is *Claytonia virginica*, although it may attract some different pollinators with its later blooming period.

Research by Frey (2004) provides evidence that floral color in *C. virginica* is an indicator of susceptibility to both herbivory (e.g., Grey Garden Slug [*Agriolimax reticulatum*]) and subsequent infection by a fungal rust (*Puccinia mariae-wilsonii*), with whiter flowers being more resistant to both. This is due to the presence of two flavonoids that confer chemical protection to leaves and plants while also producing a whiter bloom. In contrast, redder/pinker flowers may be more visible to pollinators especially when the Virginia Spring Beauty is growing among other white-flowered early spring ephemerals in bloom at the same time. Those pinker spring beauty flowers are better pollinated and produce more seeds than white flowers. Flower constancy is exhibited when a bee visits only one species of plant to gather pollen during its forays. It is usually optimal for plants as it ensures cross pollination within species, preventing pollen clogging that happens with incompatible (e.g., different sized) pollen grains from other species (Frey 2004; Parker et al. 2016). However, the redder flower color may make the plants more vulnerable to slug herbivory and subsequent rust infection. Those differing selection pressures may account for the fact that there is a range of color forms in *Claytonia virginica* populations, from white to pink. *C. virginica* var. *hammondiae* is known to contain flavonoid compounds (Snyder 1992), but it is not known whether those compounds are the same ones that confer protection against slug herbivory or fungal rust infections as in *C. virginica*. Yellow colored flowers are also quite visible to pollinating bees, so there may not be similar selective pressure for flower color in var. *hammondiae.*

Seed Dispersal

Claytonia virginica seeds are small, shiny and black with 25 to 30 contained in an ovoid or triangular capsule. Each seed is 2–3 mm and has an attached appendage called an elaiosome, which contains fats and nutrients that are attractive to ants. When the seed capsule dries out, about ten days after fertilization, seeds are expelled, and some of those will be picked up and carried by ants back to their nest. Once brought underground, the ants feed on the elaiosomes and discard the seeds. Those actions serve to disperse the *Claytonia* seeds to potentially better germination sites—distant from competition with the parent plant, protected from above ground seed predators, fertilized by ant colony waste, and usually in locations less susceptible to flooding if in wetland areas—a win-win relationship between ant and plant called myrmecochory (Handel et al. 1981; Handel and Beattie 1990; Lobstein 2024; Michaelson 2024). Ants typically only move seeds an average of one to two meters (Handel and Beattie 1990). K. Walz (2024) observed Hammond's Yellow Spring Beauty plants growing in hoofprints along deer trails throughout the wetland suggesting that deer movement might contribute to some seed dispersal within the population.

Claytonia virginica is primarily spread by reseeding (with the assistance of ant dispersal), with some vegetative spread via underground tubers to create loose colonies (Hilty 2020). To break dormancy, *C. virginica* seeds require multiple periods of cold stratification over a two-to-four-year period (HSA 2019; Vermont Wildflower Farm 2024). Otherwise, Virginia Spring Beauty is easy to cultivate, especially by planting tubers, and it will self-seed and naturalize; however, neither mechanism allows for widespread dispersal. Hammond's Yellow Spring Beauty seed germination requirements may differ, as the population is located in a sphagnous seepage

wetland. It may be that some seeds produced in the spring germinate that same year to produce flowers; other seeds may overwinter (Snyder 1992).

There was no information readily available in the literature about seed viability and seed bank longevity for *Claytonia virginica* or the var. *hammondiae*. However, the requirement for stratification over a two-to-four-year period suggests that some seeds of *Claytonia virginica* do remain in the soil for at least that time. Additionally, the seed collecting activity of ants that results in the burial of seeds in and around ant nests also creates dispersed seed banks of a kind. More research is needed about seed viability and seed bank longevity as it relates to *C. virginica* var. *hammondiae* reproduction and population persistence.

Habitat

While Virginia Spring Beauty is tolerant of many site conditions, favoring wetter sites yet also thriving in moist deciduous forests, woodland edges and meadows, and occasionally in wet lawns (Native Plant Trust 2024), Hammond's Yellow Spring Beauty is exacting in its habitat requirements. The only known location for this species is an extensive acidic seepage wetland complex with a shallow organic soil underlain by clay fragipan, itself a critically imperiled G1 community, the *Deschampsia – Claytonia virginica* var. *hammondiae* Seepage Meadow. In addition to var. *hammondiae*, some associated species at the site include *Deschampsia caespitosa, Carex bromoides, Carex atlantica ssp. atlantica,* and *Cerastium velutinum* (a native and uncommon species in New Jersey, confused in the past with a nonnative European species) (NatureServe 2024; NJNHP 2024; Snyder 2024; Weakley et al. 2024). The soils are classified as an extremely stony loam with a pH of 4.5–4.7 in the open wetlands and a pH of 3.5 measured in one of the forested sites (Breden et al. 2001; Snyder 1992).

The main population is found on a shrubby southeast-facing slope of the Kittatinny Mountains with areas of open sphagnous fen and tussocky wetland, and cold spring seeps surrounded by a *Tsuga canadensis*/*Rhododendron maximum* woods (NJNHP 2024). Other canopy trees in the surrounding forest included *Tsuga canandensis*, *Pinus strobus, Betula alleghaniensis,* and *Acer rubrum* with scattered shrubs of *Lindera benzoin* and *Hamamelis virginiana*. There are many seeps onsite with a relatively constant groundwater flow. At times, especially in the spring, plants may be inundated or surrounded by standing water yet can flower and set seed under those conditions, in either forested or open portions of the wetland communities (Snyder 1992).

With a heliophily rank of 4, var. *hammondiae* has a relatively "broad ability" to grow and reproduce in shady or sunny environments (Weakley et al. 2024), demonstrated by the fact that plants were found growing in the open fen along a feeder stream, in either full sun or dense shade. Range wide, *Claytonia virginica* has been found up to 305 m (1,000 ft) in elevation (Miller 2020), the var. *hammondiae* population is found at a similar altitude 305–335 m (Snyder 1992).

Wang and Qiu (2006) did not report any mycorrhizal associations for *Claytoni*a spp. in their literature survey of mycorrhizal occurrences among plant species. Similarly, research on the mycorrhizal associations of some early spring ephemerals in Ohio found that *Claytonia virginica* in that location did not have any vesicular-arbuscular mycorrhizal associations. DeMars (1996)

conjectured that *C. virginica's* "ruderal life history" and the presence of flavonoids, glucosinolates, and other protective chemicals found in the leaves and flowers of the plant may act as a deterrent to the establishment of mycorrhizal relationships. Frey (2004) observed that whiter flowers of Virginia Spring Beauty, which contained higher levels of defensive phytochemicals, were less affected by rust fungi, supporting the idea that those deterrent chemicals might affect the growth of other fungi, including the formation of mycorrhizal fungal associations in that species, although this has not been experimentally demonstrated. It is not known whether the var. *hammondiae* contains those same flavonoids.

Wetland Indicator Status

Claytonia virginica is a facultative upland species, meaning that it usually occurs in nonwetlands but may occur in wetlands. The variety *hammondiae* has not been ranked independently (U. S. Army Corps of Engineers 2020); however, it is likely an obligate wetland species given its strict hydrological requirements.

USDA Plants Code (USDA, NRCS 2024b)

CLVIH

Coefficient of Conservancy (Walz et al. 2020)

CoC = 10. 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 map in Figure 1 depicts the global extent of *Claytonia virginica* var. *hammondiae*. The variety is only known from a single location in Sussex County, New Jersey (NJNHP 2024; Snyder 1992; USDA NRCS 2024b).

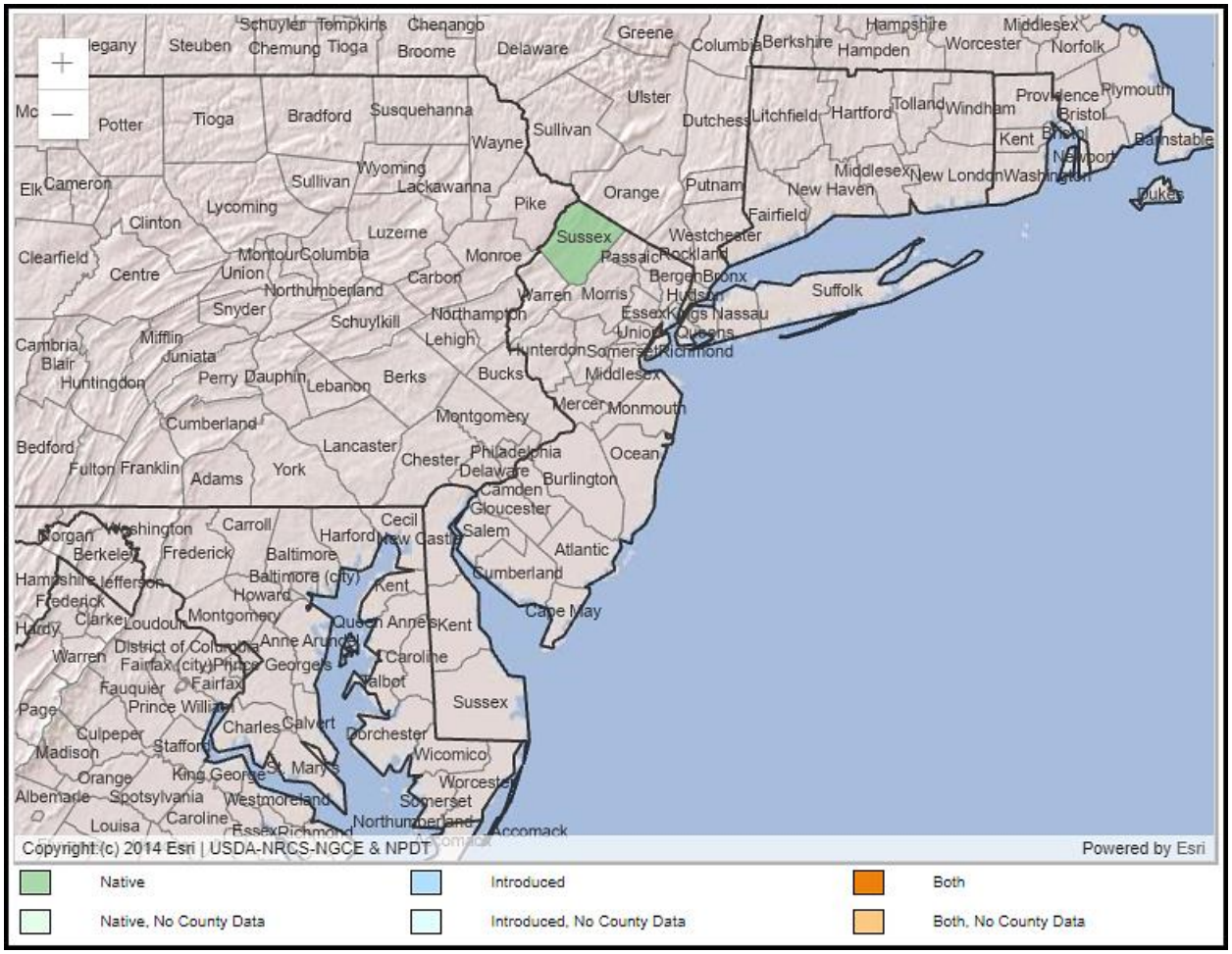

Figure 1. Global distribution of C. virginica var. hammondiae (USDA NRCS 2024b).

Conservation Status

Claytonia virginica var. *hammondiae* has a global rank of G5T1. G5 indicates that the species as a whole is globally secure while T1 means that the variety is critically imperiled. The critically imperiled status signifies that the variety is at very high risk of global extinction or collapse due to a very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors (NatureServe 2024). The map below (Figure 2) illustrates the conservation status of *C. virginica var. hammondiae* throughout its range.

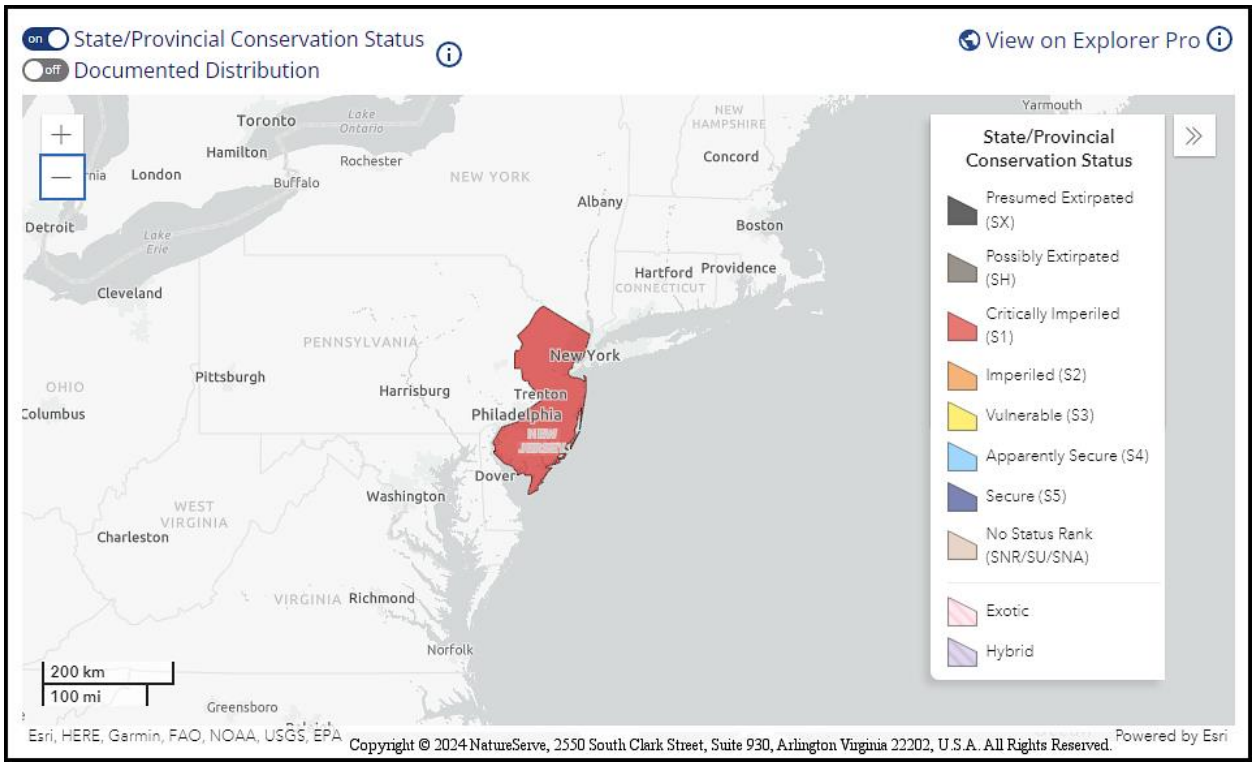

Figure 2. Conservation status of C. virginica var. hammondiae in North America (NatureServe 2024).

Claytonia virginica var. *hammondiae* is ranked S1.1 in New Jersey (NJNHP 2024), 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. Hammond's Yellow Spring Beauty 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).

Threats

Hammond's Yellow Spring Beauty is restricted to one location globally and has exacting hydrological requirements in its unique habitat. Disruption of the existing hydrologic regime, whether changes to precipitation patterns, altered stream and seep flow, or flooding from upslope runoff is the primary threat to this population. Beaver (*Castor canadensis*) activity altered site conditions at one subpopulation, completely flooding that area (NJNHP 2024).

Maintaining water quality and the low pH characteristic of the inland acidic seep plant community as well as the var. *hammondiae* population is also important. Runoff containing pollutants from adjacent roads or upslope properties may alter site chemistry, especially at

roadside subpopulations, as would the introduction of invasive plant species that might alter soil chemistry once established (NJNHP 2024).

Invasive species may also affect site conditions with effects on the tree canopy. Although var. *hammondiae* is relatively tolerant of sunny or shady conditions, further opening of the tree canopy due to tree death caused by feeding activity of the Hemlock Woolly Adelgid (*Adelges tsugae*) could open the way to encroachment by other non-native invasive species. A general decline was observed in a significant portion of the var. *hammondiae* population in 2004 after the death of many Eastern Hemlocks (*Tsuga canadensis*) created gaps in the canopy (NJNHP 2024).

Human activity on site or on adjacent properties is another threat to the species. Logging impacts from proposed forest management activity off site may create problems in the wetland complex such as erosion and soil compaction from the use of heavy machinery. Similarly, trampling by humans would harm plants directly or affect them indirectly through soil compaction that alters water flow in the highly saturated soil. Another serious concern is plant poaching, something that has been suspect since a series of holes were found in 2022 from which plants may have been removed (NJNHP 2024). In addition to site trampling, human access would increase the potential for non-native species encroachment into the population via seed transmission, with negative effects on habitat integrity.

Although White Tailed Deer (*Odocoileus virginianus*) have been reported to only minimally browse on Virginia Spring Beauty (Augustine 1997; Frankland 2000), herbivory is always a potential threat if deer are at high density. Small rodents such as Eastern Chipmunk (*Tamias striatus*) and White-footed Mice (*Peromyscus leucopus*) do feed on the underground tubers (Hilty 2020; Martin et al. 1951; Wrazen and Svendsen 1978) and slugs (e.g., *Agriolimax reticulatum*) have been mentioned in the literature as grazing on the leaves of *Claytonia virginica* populations elsewhere (Frey 2004). Deam (1940) even noted "a small bird greedily eating the flowers of *Claytonia virginica*." Each of those herbivores may impact var. *hammondiae*.

While this population of Hammond's Yellow Spring Beauty has been known since 1961 (NJNHP 2024), it likely has existed far longer than that. To date, there has been no evidence of any serious disease affecting this population, nor have other diseases been identified that affect *Claytonia virginica* other than fungal rusts (Frey 2004; Missouri Botanical Garden Plant Finder 2022). There is little information about the genetics of this population as it affects population persistence and health.

Climate Change Vulnerability

Information from the references cited in this profile was used to evaluate the vulnerability of New Jersey's *Claytonia virginica* var. *hammondiae* population to climate change. The species was assigned a rank from NatureServe's Climate Change Vulnerability Index using the associated tool (Version 3.02) to estimate its exposure, sensitivity, and adaptive capacity to changing climactic conditions in accordance with the guidelines described by Young et al. (2016) and the state climactic computations by Ring et al. (2013). Based on available data, Hammond's Yellow Spring Beauty was assessed as Extremely Vulnerable, meaning that climate change is expected to have a notable detrimental impact on its extent in New Jersey by 2050.

This conclusion was reached with very high confidence, based on information regarding the species' strict hydrological requirements, its limited dispersal capacity, and the fact that it is a single-site endemic; however, many site- and variety-specific knowledge gaps remain.

New Jersey is the fastest warming state in the Northeast and third fastest in the country (Howard 2024). Virginia Spring Beauty seeds require multiple periods of cold stratification to germinate and var. *hammondiae* may as well. Warmer winters that lack sufficient periods of cold temperatures may result in poor seed germination. Climate change in New Jersey is also projected to lead to altered precipitation patterns with summer droughts becoming more common (Hill et al. 2020). Those warmer temperatures and altered precipitation patterns will affect hydrologic conditions and may change the timing of the annual groundwater recharge cycle with potential disruptions to spring flow (Pallis et al. 2022). Hammond's Yellow Spring Beauty is highly dependent upon consistently wet site conditions such that any drying of spring/seep flow will critically threaten the long-term persistence of the natural community and the var. *hammondiae* population.

Changes in future climatic conditions may also increase the threat of new invasive plant species encroachment into the state (Bellard et al. 2013; Coville et al. 2021; O'Uhuru 2022; Salva and Bradley 2023) as plant ranges shift in response to altered abiotic conditions. This could further reduce habitat suitability if any of those species become established in the vicinity of the *C. virginica* var. *hammondiae* population, especially if that site becomes drier in future years.

Claytonia virginica seeds are predominantly ant dispersed. Ant foraging activity is affected by temperature and changing climatic conditions may affect the phenology of ant activity as well as foraging behavior (Parr and Bishop 2022). It is likely that var. *hammondiae* seeds are also dispersed by ants. However, because there are potentially a number of ant species dispersing seeds at the var. *hammondiae* site, with varying tolerances to climatic conditions, it is not known whether or how ant foraging activity will be affected and whether there will be a related impact on seed dispersal and germination in var. *hammondiae* in future years. While it may be that ant species of temperate zones will find ways to cope with warming temperatures and might even benefit from them, it is not known how they will respond to other associated abiotic changes (Michaelson 2024; Parr and Bishop 2022).

Management Summary and Recommendations

Due to the rarity of this species, regular monitoring of the population to detect new threats and address any existing threats is critical. Additional survey work to search for potential new subpopulations might also be worthwhile, although extensive surveys have been conducted over the years.

To help ensure that hydrologic conditions remain intact, it would be important to work with adjacent landowners (e.g., the National Park Service) so that any actions taken on those properties do not impede onsite water flow or cause upslope erosion on steeper slopes. Monitoring of forest management planning and harvest on adjacent lands would help reduce any potential negative impacts of forest cutting activity in or near the wetland habitat (NJNHP 2024). Regular monitoring of invasive species would also be helpful to detect invasions before they

become problematic. Any invasive species control should be implemented with care to not affect the *Claytonia virginica var. hammondiae* plants directly by trampling or the application of toxic chemicals or indirectly through hydrologic alterations such as soil compaction and subsequent ponding. Beaver activity in an adjacent woodland swamp resulted in the flooding of one var. *hammondiae* subpopulation (NJNHP 2024). Any future beaver activity in proximity to other subpopulations should be monitored with dam or animal removal considered. Public access to the site should be managed to minimize trampling and influx of invasive species seeds. While herbivory has not been noted to date onsite, regular monitoring will help ensure that protective actions can be taken should deer or other browsers start to become a problem.

Many information gaps exist in relation to var. *hammondiae* life history and habitat requirements. Taxonomic genetic assessment is underway; however, additional research is needed to determine the level of genetic diversity as it relates to population persistence over time for this single-site endemic species. Other potential research questions include: While early season pollinators may be the same as for *C. virginica*, are there other important pollinators active during the later blooming season of var. *hammondiae*? Are var. *hammondiae* flowers protandrous as are those of *C. virginica*? Are the seeds ant dispersed as in *C. virginica*? If so, what ant species are found at the site? What proportion of seeds are moved by ants vs. remain in proximity to the parent plant after being jettisoned by the seed capsule? Are seeds spread by the flowing seepage water in the wetland? What is known about var. *hammondiae* germination requirements, seed viability, and seed bank longevity? Although not known in other *Claytonia* species, are there any possible mycorrhizal associations for this taxon?

Site monitoring and management for this population will need to be ongoing, due to the Hammond's Yellow Spring Beauty's status as a single-site endemic. To further assist in its long-term conservation, ex-situ conservation measures can also be considered.

Synonyms

The accepted botanical name of the species is *Claytonia virginica* L. var. *hammondiae* (Kalmbacher) Doyle, W. H. Lewis & Snyder. Orthographic variants, synonyms, and common names are listed below (Kartesz 2015; NatureServe 2024; USDA NRCS 2024b; Weakley et al. 2024). Some sources (ITIS 2024; Miller 2020; POWO 2024) do not recognize the variety.

Botanical Synonyms	Common Names
Claytonia virginica f. *hammondiae* Kalmb.	Hammond's Yellow Spring Beauty Hammond's Claytonia

References

APG (Angiosperm Phylogeny Group) III. 2009. An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 161: 105–121.

Augustine, D. J. 1997. Grazing patterns and impacts of White-Tailed Deer in a fragmented forest ecosystem. Master's Thesis, University of Minnesota, Minneapolis, MN.

Bellard, C., W. Thuiller, B. Leroy, P. Genovesi, M. Bakkenes, and F. Courchamp. 2013. Will climate change promote future invasions? Global Change Biology 19(12): 3740–3748.

Breden, T. F., Y. R. Alger, K. Strakosch Walz, and A. G. Windisch. 2001. Classification of Vegetation Communities of New Jersey: Second iteration. Association for Biodiversity Information and New Jersey Natural Heritage Program, Office of Natural Lands Management, Division of Parks and Forestry, NJ Department of Environmental Protection, Trenton, NJ. 230 pp.

Burian, Jeff. 2020. Cover photo of *Claytonia virginica* var. *hammondiae* and photo of Claytonia Bee (*Andrena erigeniae*). Used with permission.

Coville, W., B. J. Griffin, and B. A. Bradley. 2021. Identifying high-impact invasive plants likely to shift into northern New England with climate change. Invasive Plant Science and Management 14(2): 57–63.

Dailey, T. B. and P. E. Scott. 2006. Spring nectar sources for solitary bees and flies in a landscape of deciduous forest and agricultural fields: Production, variability, and consumption. Torrey Botanical Society 133(4): 535–547.

Davis, Link M. 2021. Photo of *Claytonia virginica* var. *hammondiae*. Shared via iNaturalist at https://uk.inaturalist.org/observations/75687242, licensed by https://creativecommons.org/licenses/by-nc/4.0/

Davis, L. R., Jr. and W. E. LaBerge. 1975. The nest biology of the bee *Andrena* (Ptilandrena) *erigeniae* Robertson (Hymenoptera: Andrenidae). Biological Notes No. 95. Illinois Natural History Survey, Urbana, Il. pp 1–16.

Deam, C. C. 1940. *Claytonia virginica*. Flora of Indiana, Consortium of Midwest Herbaria. Accessed October 9, 2024 at https://midwestherbaria.org/portal/taxa/index.php?taxon=Claytonia+virginica&formsubmit=Search+Terms

DeMars, B. G. 1996. Vesicular-arbuscular mycorrhizal status of spring ephemerals in two Ohio forests. Brief Note. Ohio Journal of Science 96(4/5): 97–99.

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

Fowler, J. 2016a. Specialist bees of the Mid-Atlantic: Host plants and habitat conservation. The Maryland Entomologist, 6(4): 2–40.

_____ 2016b. Specialist bees of the Northeast: Host plants and habitat conservation. Northeastern Naturalist 23(2): 305–320.

Frankland, F. 2000. Impacts of white-tailed deer grazing on spring wildflower communities. Master's Thesis 1568. Eastern Illinois University, Charleston, IL. 45 pp.

Frey, F. M. 2004. Opposing natural selection from herbivores and pathogens may maintain floral-color variation in *Claytonia virginica* (Portulacaceae). Evolution 58(11): 2426–2437.

Gleason, H. A. and A. Cronquist. 1963. Manual of Vascular Plants of the Northeastern United States and Adjacent Canada. Willard Grant Press, Boston, MA. 810 pp.

Hafstad, Jason. 2017. Photo of *Claytonia virginica* var. *hammondiae*. Used with permission.

Handel, S. N. and A. J. Beattie. 1990. Seed dispersal by ants. Scientific American 263(2): 76–83A.

Handel, S. N., S. B. Fisch, and G. E. Schatz. 1981. Ants disperse a majority of herbs in a mesic forest community in New York State. Bulletin of the Torrey Botanical Club 108(4): 430–437.

HSA (Herb Society of America). 2019. Notable Native Herb 2020-*Claytonia virginica* L., Spring beauty. Accessed August 22, 2024 at https://www.herbsociety.org/explore/notable-native-herbsprofiles.html

Hill, R., M. M. Rutkowski, L. A. Lester, H. Genievich, and N. A. Procopio (eds.). 2020. New Jersey Scientific Report on Climate Change, Version 1.0. New Jersey Department of Environmental Protection, Trenton, NJ. 184 pp.

Hilty, J. 2020. *Claytonia virginica*. Illinois Wildflowers. Accessed August 12, 2024 at https://www.illinoiswildflowers.info/woodland/plants/spring_beauty.htm

Hopwood, J. 2015. Wildflowers, harbingers of spring. The Xerces Society. Accessed August 26, 2024 at https://xerces.org/blog/wildflowers-harbingers-of-spring

Howard, H. 2024. "New Jersey Is One of America's Fastest-Warming States, Data Shows." *New York Times*, August 15, 2024. Accessed 3 August 2024 at https://www.nytimes.com/2024/07/03/nyregion/new-jersey-warming-climate-change.html#:~:text=By%20Hilary%20Howard,as%20worsening%20storms%20and%20floods.

ITIS (Integrated Taxonomic Information System). Accessed March 16, 2024 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)].

Knapp, W. 2024. Personal communication. October 21, 2024. Wesley Knapp is the chief botanist for NatureServe and can be reached at Wesley_Knapp@natureserve.org

Ling, M. and H. Ling. 2021. *Claytonia virginica forma lutea*. Awesome Native Plants. Accessed August 7, 2024 at https://awesomenativeplants.info/photo_galleries/photo_pages/claytonia_virginica_forma_lutea.html#start

Lobstein, M. B. 2024. Spring Beauty (*Claytonia virginica*). Prince William Wildflower Society. Accessed August 21, 2024 at https://vnps.org/princewilliamwildflowersociety/botanizing-with-marion/spring-beauty-claytonia-virginica/

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American Wildlife and Plants – a Guide to Wildlife Food Habits. Dover Publications, Inc. 500 pp.

Michaelson, J. 2024. Myrmecochory: How ants shape plant communities. Xerces Society Blog. Accessed September 3, 2024 at https://xerces.org/blog/myrmecochory-how-ants-shape-plant-communities.

Miller, J. M. Page updated November 5, 2020. *Claytonia virginica* Linnaeus. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 22+ vols. New York and Oxford. Accessed January 2, 2024 at http://floranorthamerica.org/Claytonia_virginica

Missouri Botanical Garden Plant Finder. 2022. *Claytonia virginica.* Accessed August 21, 2024 at https://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=j800

Motten, A. F., D. R. Campbell, D. E. Alexander, and H. L. Miller. 1981. Pollination effectiveness of specialist and generalist visitors to a North Carolina population of *Claytonia virginica*. Ecology 62(5): 1278–1287.

Native Plant Trust. 2024. *Claytonia virginica* – Virginia spring-beauty. Accessed February 13, 2024 at https://gobotany.nativeplanttrust.org/species/claytonia/virginica/

NatureServe. 2024. NatureServe Explorer [web application]. NatureServe, Arlington, VA. Accessed March 16, 2024 at https://explorer.natureserve.org/ https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.687806/Deschampsia_cespitosa_-_Claytonia_virginica_var_hammondiae_Seepage_Meadow

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). 2024. Biotics 5 Database. NatureServe, Arlington, VA. Accessed March 15, 2024.

Nyffeler, R. and U. Eggli. 2010. Disintegrating Portulacaceae: A new familial classification of the suborder Portulacineae (Caryophyllales) based on molecular and morphological data. Taxon 59(1): 227–240.

O'Uhuru, A. C. 2022. Identifying New Invasives in the Face of Climate Change: A Focus On Sleeper Populations. Master's Thesis, University of Massachusetts, Amherst, MA. 32 pp.

Pallis, T., S. E. Domber, R. Bousenberry, R. Filo, K. Strakosch Walz, B. Henning, Y. Acosta Caraballo, M. Wu. 2022. Springs of New Jersey, New Jersey Geological Survey Open File Report No. 21-3, New Jersey Department of Environmental Protection, Water Resources Management, New Jersey Geological and Water Supply. 285 pages.

Parker, A. J., N. M. Williams, and J. D. Thomson. 2016. Specialist pollinators deplete pollen in the spring ephemeral wildflower *Claytonia virginica*. Ecology and Evolution 6(15): 5169–5177.

_____ 2017. Geographic patterns and pollination ecotypes in *Claytonia virginica*. Evolution 72(1): 202–210.

Parr, C. L. and T. R. Bishop. 2022. The response of ants to climate change. Global Change Biology 28(10): 3188–3205.

POWO. 2024. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Accessed March 16, 2024 at http://www.plantsoftheworldonline.org/

Raupp, M. J. 2015. Spring Beauties: Mining Bees, *Andrena erigeniae*. Bug of the Week. Accessed August 26, 2024 at https://bugoftheweek.com/blog/2015/5/4/spring-beauties-mining-bees-iandrena-erigeniaei

Ring, R. M., E. A. Spencer, and K. Strakosch Walz. 2013. Vulnerability of 70 Plant Species of Greatest Conservation Need to Climate Change in New Jersey. New York Natural Heritage Program, Albany, NY and New Jersey Natural Heritage Program, Department of Environmental Protection, Office of Natural Lands Management, Trenton, NJ, for NatureServe #DDCF-0F-001a, Arlington, VA. 38 pp.

Robertson, C. 1929. Flowers and Insects. Science Press, Lancaster, PA. 221 pp.

Salva, J. D. and B. A. Bradley. 2023. High-impact invasive plants expanding into mid-Atlantic states: Identifying priority range-shifting species for monitoring in light of climate change. Invasive Plant Science and Management 16: 197–206.

Schemske, D. W. 1977. Flowering phenology and seed set in *Claytonia virginica* (Portulacaceae). Bulletin of the Torrey Botanical Society 104(3): 254–263.

Snyder, D. B. 1992. A new status for New Jersey's Yellow Spring Beauty. Bartonia 57: 39–49.

Snyder, D. B. 2024. Personal communication. June 26, 2024. David Snyder is the retired New Jersey Natural Heritage Program State Botanist.

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). 2024a. *Claytonia virginica* 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). 2024b. PLANTS profile for *Claytonia virginica* var. *hammondiae* (Hammond's Claytonia). The PLANTS Database, National Plant Data Team, Greensboro, NC. Accessed March 16, 2024 at http://plants.usda.gov

Vermont Wildflower Farm. 2024. Spring Beauty Seeds (*Claytonia virginica*). Accessed August 21, 2024 at https://www.vermontwildflowerfarm.com/products/spring-beauty-seeds

Walz, K. S. 2024. Personal communication. June 25, 2024. Kathleen Walz is the New Jersey Natural Heritage Program Ecologist and can be reached at Kathleen.Walz@dep.nj.gov

Walz, K. S., J. L. Hafstad, L. Kelly, and K. 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.

Wang, B. and Y.-L. Qiu. Phylogenetic distribution and evolution of mycorrhizas in land plants. Mycorrhiza 16: 299–363.

Weakley, A. S., and Southeastern Flora Team. 2024. Flora of the southeastern United States Web App. University of North Carolina Herbarium, North Carolina Botanical Garden, Chapel Hill, U.S.A. Accessed July 12, 2024 at https://fsus.ncbg.unc.edu/main.php?pg=show-taxon.php&plantname=claytonia+virginica+var.+hammondiae

Wrazen, J. and G. E. Svendsen. 1978. Feeding ecology of a population of Eastern Chipmunks (*Tamias striatus*) in southeast Ohio. American Midland Naturalist 100(1): 190–201.

Wright, J. 2019. Celebrating Hammond's Spring Beauty. Accessed 10 February 2024 at https://www.celeryfarm.net/2019/05/celebrating-hammonds-spring-beauty.html]

Young, B. E., E. Byers, G. Hammerson, A. Frances, L. Oliver, and A. Treher. 2016. Guidelines for Using the NatureServe Climate Change Vulnerability Index, Release 3.02, 1 June 2016. NatureServe, Arlington, VA. 65 pp.