Pyrola chlorantha

Greenish-flower Wintergreen

Pyrolaceae

Pyrola chlorantha by Peter M. Dziuk, 2011

***Pyrola chlorantha* 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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January, 2023

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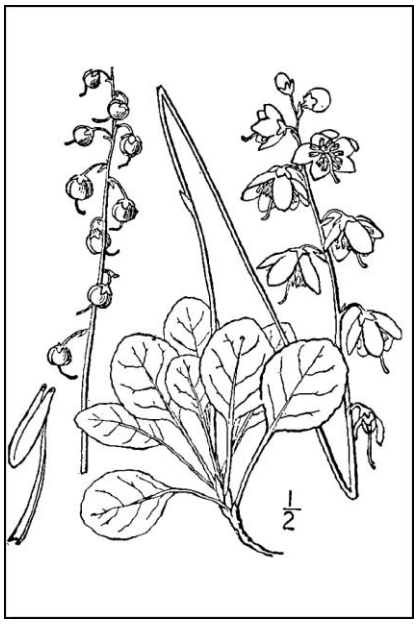
This report should be cited as follows: Dodds, Jill S. 2023. *Pyrola chlorantha* Rare Plant Profile. New Jersey Department of Environmental Protection, State Parks, Forests & Historic Sites, State Forest Fire Service & Forestry, Office of Natural Lands Management, New Jersey Natural Heritage Program, Trenton, NJ. 18 pp.

Life History

Pyrola chlorantha is a perennial, rhizomatous subshrub. *Pyrola* and closely related genera have traditionally been placed in the wintergreen family (Pyrolaceae) but are now included in the Ericaceae, subfamily Monotropoideae (Kron et al. 2002, Kartesz 2015). The leaves of *Pyrola chlorantha* remain green year-round and may persist for several years without showing any sign of senescence (Lallemand et al. 2017).

Pyrola chlorantha has small, wiry roots but the horizontal rhizomes are thick and white. Aerial shoots may arise from either roots or rhizomes. The leaves are alternate but appear to be basal because they form a whorl close to the ground. The leaf blades are ovate to round, usually ranging from 18–28 mm in length and 10–30 mm in width, and they are generally shorter than their petioles which may be 8–60 mm in length. The blades are dark green above and lighter green to purplish below. Leafless forms of the plant are also known throughout the species' range. Floral scapes are 10–25 cm tall and typically bear 2–8 flowers. A single, flowerless bract is often present on the stem below the inflorescence. The flowers have 5 tiny green calyx lobes 1.2–1.7 mm long, 5 greenish-white or yellowish-white petals 4.5–9 mm long, 10 stamens with curved filaments, and a protruding style that bends at the tip. The floral pedicels are 3–8 mm long and have basal bracts that are frequently (but not always) shorter than the pedicels (See Britton and Brown 1913, Henderson 1919, Camp 1940, Copeland 1947, Fernald 1950, Haber 1988, Gleason and Cronquist 1991, Freeman 2020). Fernald (1920) noted that the leafless or few-leaved forms of the plant tended to have smaller flowers.


Images courtesy Alan Cressler, Lady Bird Johnson Wildflower Center.




Left: Britton and Brown 1913, courtesy USDA NRCS 2023a. Right: Katy Chayka, 2011.

Several related species with similar growth forms occur in New Jersey. *Orthilia secunda* has a distinctly one-sided inflorescence. The floral bracts of *Pyrola americana* equal or exceed the pedicels in length and its petals are white, pink, or purplish-red. The leaves of *P. elliptica* are larger than those of *P. chlorantha*, typically exceeding 3 cm in length and longer than their petioles (Fernald 1950, Freeman 2020, Weakley et al. 2022). Haber (1988) reported hybridization between *Pyrola chlorantha* and *P. minor* in western North America.

Pyrola chlorantha plants generally don't flower until they are two or more years old. The flower buds form during the autumn and emerge in the spring, a trait often found in winter-green forest herbs (Henderson 1919, Bierzychudek 1982). Pyykkö (1968) observed floral buds on *P. chlorantha* plants wintering in frozen ground beneath 30 cm of snow. The stems were already 1–2 cm long but they curved downward so that the buds were buried in a layer of mosses. In New Jersey, Greenish-flower Wintergreen may bloom from late May to July (Stone 1911, Hough 1983). A Massachusetts population monitored for several years by Bicknell (1914) was in bud during early June, fully flowering in mid-June, and past blooming by July 9.

Ilyina et al. (2022) indicated that *Pyrola chlorantha* relies heavily on vegetative reproduction. The authors conducted a multi-year study of 27 populations in two Russian nature preserves, noting that clonal growth resulted in a clumped distribution of plants within the habitats (annual site means ranged from 5.7–25.1 individuals per cluster), and recorded average population densities of 6.8–14.5 plants per square meter. They also examined the age structure of the populations, finding that 26.5–35.5% of the plants were pre-generative, 61.6–72.1 were mature and reproducing, and less than 3% were pre-senescent or senescent. They estimated the life span of a typical *P. chlorantha* plant at 10 years.

Pyrola chlorantha is a partial mycoheterotroph, meaning that the plants obtain some of their nutrients via fungal relationships but are also photosynthetic. *P. chlorantha* is able to associate with multiple types of fungi, often simultaneously (Tedersoo et al. 2007), and the fungi are not

host-specific (Selosse et al. 2007). Massicotte et al. (2008) observed that the colonization rate of individual *Pyrola* roots varied considerably. In typical mycorrhizal relationships plants that can fix atmospheric carbon (autotrophs) share it with a fungal partner in exchange for water or nutrients, but some species such as *P. chlorantha* meet a significant portion of their carbon requirements through their fungal networks (Leake 1994, Tedersoo et al. 2007, Zimmer et al. 2007, Johansson et al. 2015). Some of the fungi found in various *Pyrola* species have also been associated with nearby trees, which are likely to serve as at least one of the carbon sources utilized by the small subshrubs (Hashimoto et al. 2012). Lallemand et al. (2017) found that carbon enrichment in *P. chlorantha* continued at a steady rate throughout the growing season even when light availability varied significantly over the course of a year. Leake (1994) noted that when the plants are net consumers of carbon the benefits to the fungi are unclear.

Pollinator Dynamics

The anthers of *Pyrola chlorantha* terminate in relatively long (0.5–1.0 mm), projecting tubes (horns) that open at the tips (Henderson 1919, Pyykkö 1968, Freeman 2020). External manipulation is required in order to release the pollen. Although *P. chlorantha* does not produce nectar (Knudsen and Olesen 1993, Freeman 2020), Britton and Brown (1913) described the flowers as slightly odorous and some other species of *Pyrola* are known to be fragrant (Genders 1977). Knudsen and Olesen (1993) found no perceptible scent but determined that in ultraviolet light the stamens produce a strong contrast with the corolla which may serve as a signal to potential pollinators.

Greenish-flower Wintergreen is visited exclusively by pollen-buzzers, and primarily by bumblebee (*Bombus* spp.) workers and queens (Knudsen and Olesen 1993). Buzz pollination occurs when bees straddle one or more stamens and generate a rapid thoracic vibration to shake pollen out through the pores of the anthers. The vibrations result in the deposition of pollen on the bee's body, which can then be carried to the next flower visited by the insect (Pritchard and Vallejo-Marín 2020). When visiting *P. chlorantha*, the bees grasped and vibrated the bunch of anthers above the style (Knudson and Olesen 1993).

Pyrola chlorantha is also capable of self-fertilization, although it appears to be of secondary importance. Experiments carried out by Knudsen and Olesen (1993) showed that seed set in open-pollinated flowers was 85.9%. When insects were excluded, manual fertilization with related pollen demonstrated that the plants were self-compatible (71.5% seed set) but bagged flowers that were not hand-pollinated only achieved 5.7% seed set. The low rate of self-pollination in the absence of intervention suggests that *P. chlorantha* is highly dependent on bumblebees for sexual reproduction.

Seed Dispersal and Establishment

The five-lobed ovary of *Pyrola chlorantha* contains thousands of tiny ovules. Knudsen and Olesen (1993) reported an average of 6,025 ovules per flower (range 4,250–9,250). About 30% of developing seeds are aborted in *P. chlorantha*, resulting in a net production of around 3,000

viable seeds per capsule (Johansson et al. 2014). When the fruits are mature they become erect and the capsules split along the valves from the base upward (Henderson 1919).

Pyrola chlorantha seeds are fusiform, winged, and tiny—averaging 0.70 mm in length and 0.17 mm in width (Johansson and Eriksson 2013, Freeman 2020). The dustlike seeds of *Pyrola* species are buoyant in air or water, and are particularly well adapted for dispersal by wind (Leake 1994). Leake surmised that dispersal distances in *Pyrola* would be limited by low wind speeds in forested sites and the close proximity of the plants to the ground. The supposition was confirmed by Johansson et al. (2014), who studied seed dispersal in *P. chlorantha*. Their results showed that 82.5% of seeds were deposited within a meter of the source plants and 95.7% traveled no further than five meters.

Like the majority of plants with dust seeds, *Pyrola* species must associate with a fungus in order to germinate and develop (Johansson et al. 2015). *Pyrola chlorantha* seedlings are able to link up with a diverse array of fungi, sometimes with multiple species simultaneously (Hynson et al. 2013). Following fungal colonization, a *Pyrola* embryo elongates and forms a colorless root-like structure. It is not clear how much time passes before the seedlings establish a presence above ground. Germination studies of *P. chlorantha* and related species indicated that at the end of the first growing season the seedlings were typically about 2 cm long and subterranean (Hashimoto et al. 2012, Johansson and Eriksson 2013).

Proximity to mature *P. chlorantha* plants resulted in a small but significant increase in germination but had a negative effect on seedling size. Germination was not affected by soil pH or nutrient availability, but elevated levels of nitrogen were also associated with reduced seedling growth (Johansson and Eriksson 2013).

Habitat

In North America, *Pyrola chlorantha* is most frequently found in forested areas with relatively dry soil (Fernald 1920, Rhoads and Block 2007, Weakley et al. 2022). Elevations up to 3,700 meters have been reported (Freeman 2020). The tree canopy is often dominated by coniferous species but the plants can also occur in mixed or deciduous woods (Bicknell 1914, Hough 1983, Timoney et al. 1997, Freeman 2020). Wherry (1927) reported that *P. chlorantha* prefers slightly acidic soils with a pH ranging between 5.1–7.0. New Jersey's extant population was observed in typical habitat: Dry soil on wooded slope under a canopy of *Pinus strobus* (NJNHP 2022). One historic occurrence in the state grew in sandy loam on a slight knoll in woods alongside a creek (Long 1928).

Pyrola chlorantha utilizes similar habitats in Europe and Asia (Kelly and Connolly 2000, Johansson and Eriksson 2013, Klymenko et al. 2017, Ilyina et al. 2022). Characteristic site features have that been noted include warm, dry conditions, low rainfall, and sparse ground vegetation (Kelly and Connolly 2000, Johansson and Eriksson 2013). Specific plant communities reported by Ilyina et al. (2022) included lichen/green moss/pine forests, tallgrass/pine forests, pine forests, and oak forests.

Like most mycoheterotrophic species, *Pyrola chlorantha* thrives in deeply shaded sites that have insufficient light for the majority of autotrophic plants (Leake 1994, Hynson et al. 2012). Zimmer et al. (2007) found *P. chlorantha* growing in places where it only received 15% of available light. A few *P. chlorantha* plants observed out in the open by Bicknell (1914) were described as stunted in comparison to nearby plants growing beneath pines. In woodland communities favored by mycoheterotrophs the forest floor often has a thick litter layer, a minimal herb layer, and a microclimate characterized by high vapor pressure, low evapo-transpiration, and little diurnal temperature variation (Leake 1994).

Data from 3,145 sites in British Columbia was used to calculate the species' microsite preferences such as elevation (0–2500 meters, average = 1026 m) and slope gradient (0–220 percent, average = 17%) (Klinkenberg 2020). Klinkenberg also quantified the most favorable moisture regime as 3 (submesic) on a scale of 0 (very xeric) to 8 (hydric) and identified the nutrient regime as C (medium). A more comprehensive description of the soil and moisture regimes is provided by the B. C. Ministry of Forests (1998). In a submesic water regime the primary water source is precipitation. Water is removed readily relative to the supply, and is available for moderately short periods following precipitation. A medium nutrient regime, in which an average amount of nutrients are available, is associated with sites at which the soil pH is moderately acid to neutral.

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). *Pyrola chlorantha* has more than one wetland indicator status within the state. In the Northcentral and Northeast region *P. chlorantha* is a facultative upland species, meaning that it usually occurs in nonwetlands but may occur in wetlands. In other regions of the state it is an upland species, meaning that it almost never occurs in wetlands (U. S. Army Corps of Engineers 2020).

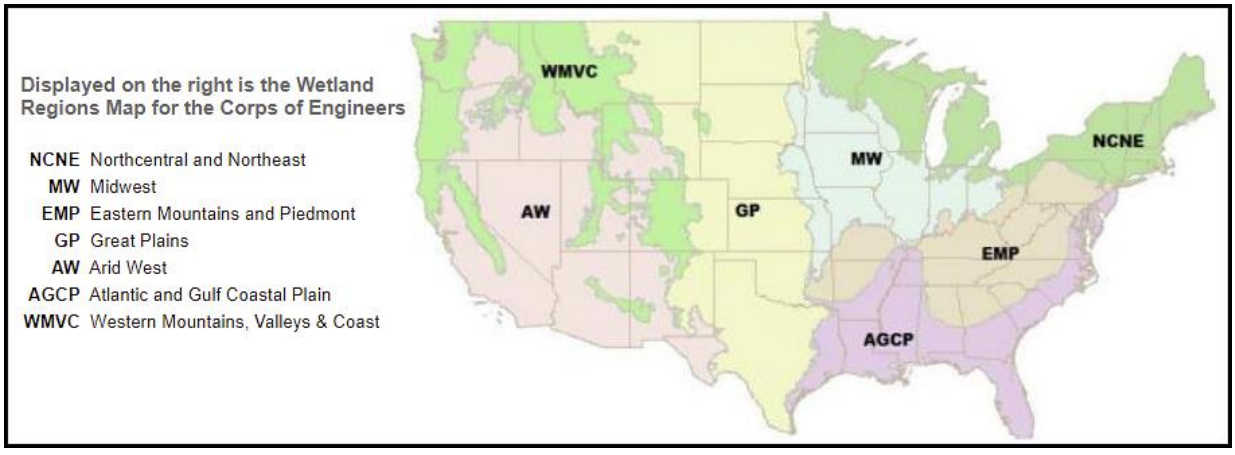


Figure 1. Mainland U. S. wetland regions, adapted from U. S. Army Corps of Engineers (2020).

USDA Plants Code (USDA, NRCS 2023b)

PYCH

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

Pyrola chlorantha is native throughout the subarctic and temperate parts of the Northern Hemisphere (POWO 2023). The map in Figure 2 depicts the extent of *P. chlorantha* in North America.

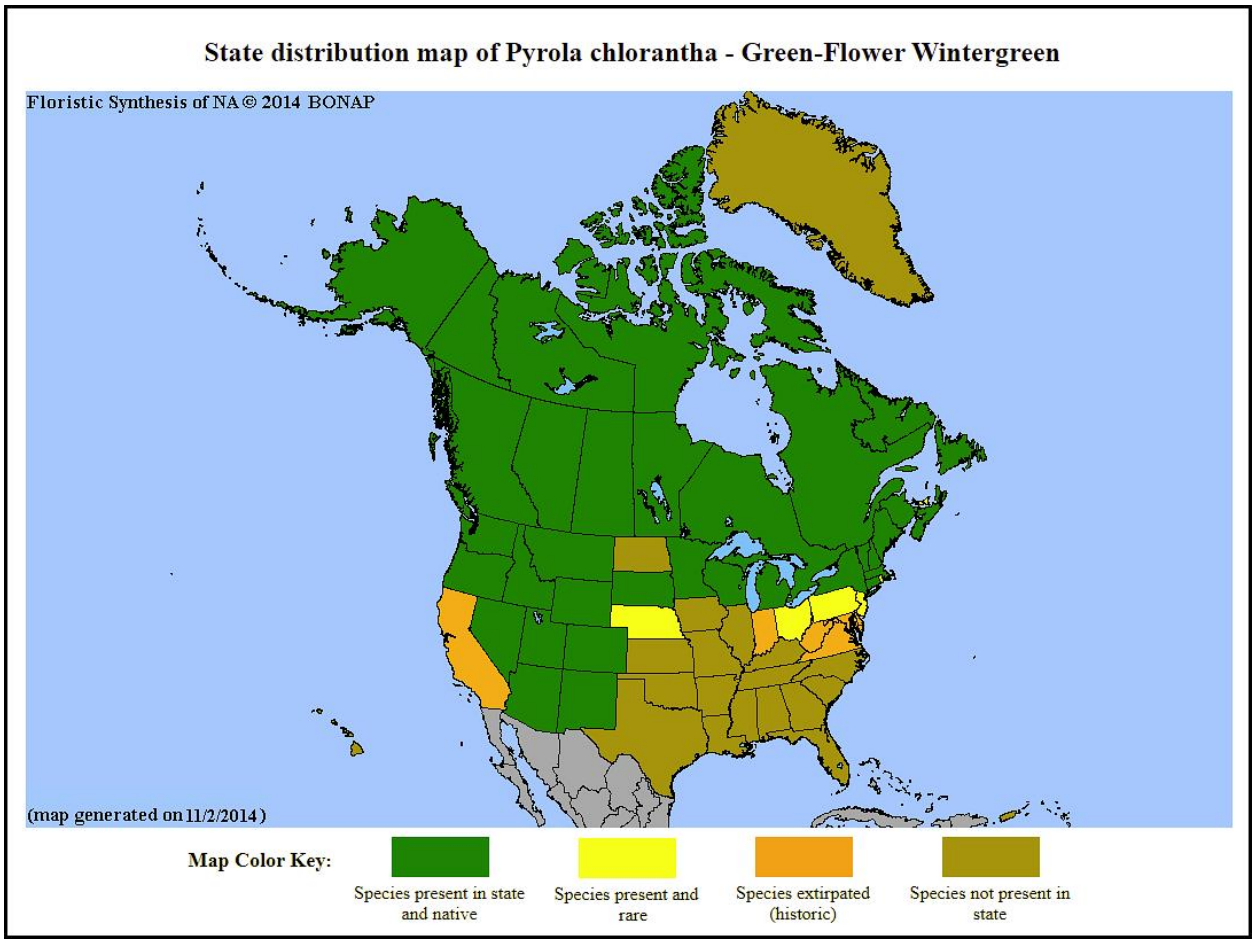


Figure 2. Distribution of P. chlorantha in North America, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2022b) shows records of *Pyrola chlorantha* in ten New Jersey counties: Atlantic, Bergen, Burlington, Camden, Cumberland, Gloucester, Monmouth, Morris,

Sussex, and Warren (Figure 3). The data include historic observations and do not reflect the current distribution of the species.

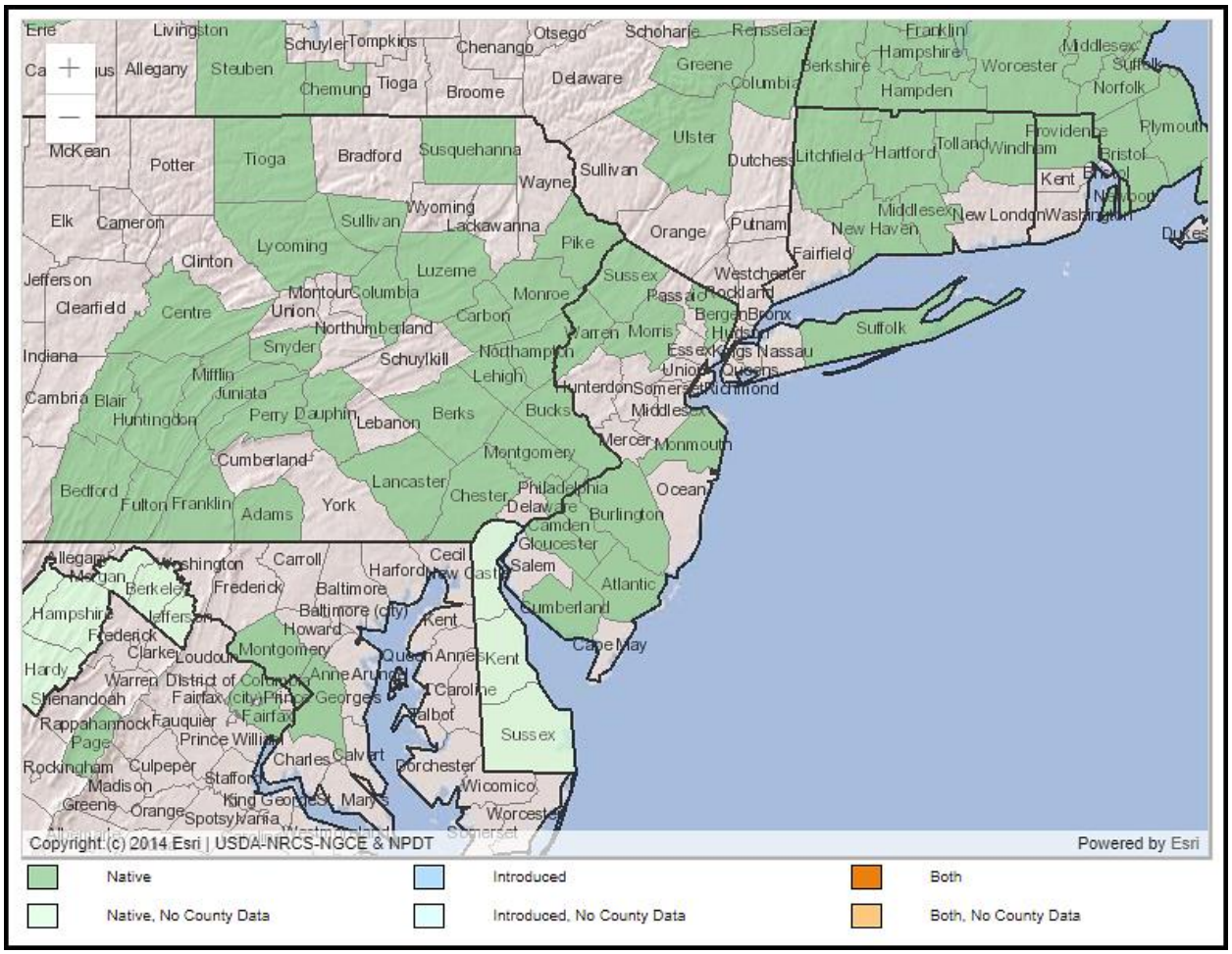


Figure 3. County records of P. chlorantha in New Jersey and vicinity (USDA NRCS 2023b).

Conservation Status

Pyrola chlorantha 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 2023). Even so, *P. chlorantha* is imperiled in some parts of the world: For example, the species is endangered in southwestern Poland (Fabiszewski and Kwiatkowski 2002), threatened in Russia (Ilyina et al. 2022), rare in Ukraine (Klymenko et al. 2017), and declining in Sweden (Johansson and Eriksson 2013).

The map below (Figure 4) illustrates the conservation status of *Pyrola chlorantha* throughout North America. Greenish-flower Wintergreen is vulnerable (moderate risk of extinction) in one state and one province, imperiled (high risk of extinction) in two provinces, critically imperiled (very high risk of extinction) in four states, possibly extirpated in four states, and likely

extirpated in Indiana. In other North American districts the species is secure, apparently secure, or unranked.

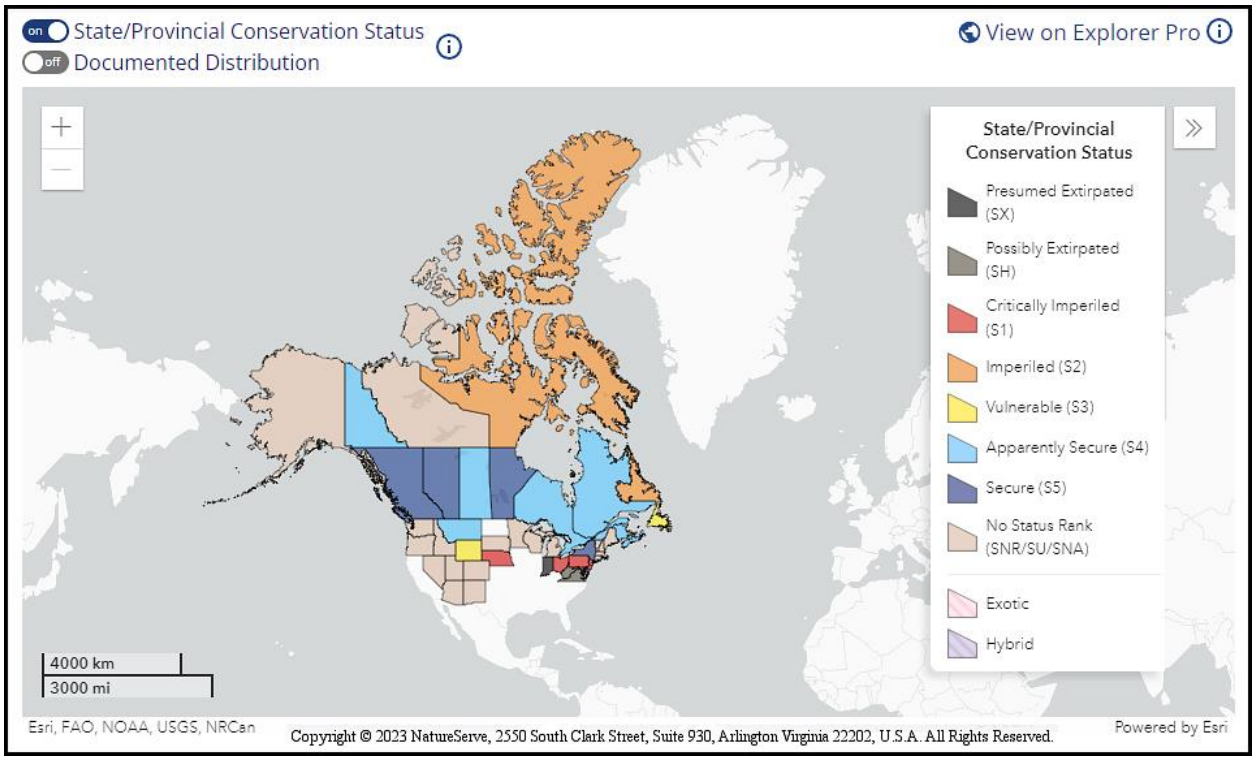


Figure 4. Conservation status of P. chlorantha in North America (NatureServe 2023).

Pyrola chlorantha 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. *P. chlorantha* 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 *P. chlorantha* 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).

During the latter part of the 1800s, *Pyrola chlorantha* was known from scattered locations throughout New Jersey (Britton 1889, Keller and Brown 1905). The plant was reportedly very rare in the Pine Barrens, rare and local in the central part of the state, and somewhat more frequent to the north although never abundant (Stone 1911, Taylor 1915). Over the years *P. chlorantha* was collected from more than 30 New Jersey sites, many of which were in the Delaware River watershed in parts of Burlington and Camden counties that were subsequently altered by urban sprawl (Snyder 1993). Numerous searches during the late 1900s revealed that Greenish-flower Wintergreen had disappeared from many of its former settings but a single population was rediscovered by David Snyder in 1989 (Snyder 1994, 2000). The small

population contained 16 plants, two of which were in flower, and that continues to be the sole occurrence of *P. chlorantha* presently known to be extant in the state (NJNHP 2022).

Threats

No specific threats have been identified for New Jersey's extant population of *Pyrola chlorantha*, although a significant amount of time has passed since the occurrence was last monitored (NJNHP 2022). Generally speaking, loss of upland habitat to development was the likely cause of the species' decline throughout the state (Snyder 1994). Even at sites that remain undeveloped, the habitat can be altered by human activities that make the sites less suitable for *P. chlorantha*. Trampling, canopy thinning, or increased nutrient inputs can directly harm the plants or significantly change the ecosystems upon which they depend (Drayton and Primack 1996, Johansson and Eriksson 2013). Drayton and Primack (1996) also noted more frequent ground fires as a threat to rare species like *P. chlorantha*. Ilyina et al. (2022) reported a decline in Greenish-flower Wintergreen following a series of fires, noting that burns reduced the number of individual plants, increased the distance between surviving colonies, and destroyed supporting fungal networks.

When extant habitat is altered or lost a number of factors can hamper the establishment of *Pyrola chlorantha* in new locations. The species is limited by the availability of suitable sites for germination (Johansson and Eriksson 2013) and appears to rely on clonal reproduction to maintain extant populations (Ilyina et al. 2022). Steep declines in populations of bumblebees—the primary pollinators of *Pyrola chlorantha*—have been widely documented (e.g. Colla and Packer 2008) and are likely to contribute to lower sexual reproduction in the plants. Some dipteran larvae may also cause the developing seeds of various *Pyrola* species to be aborted (Knudsen and Olesen 1993). Even when seed production is successful, the vast majority of *P. chlorantha* propagules are locally dispersed (Johansson et al. 2014) so the species may be severely restricted in its ability to colonize new sites in areas like New Jersey with highly fragmented landscapes.

Pyrola species are susceptible to some rust fungi in the genus *Chrysomyxa*. Inland spruce cone rust, *Chrysomyxa pirolata*, infects White Spruce but uses *Pyrola* species as an alternate host. Infected *Pyrola* plants can also transmit the rust directly to other related plants without an intermediate host (Alden 1985). *Chrysomyxa pyrolae*, a rust specific to the genus, was reported on *Pyrola chlorantha* by Anderson (1940). *C. pyrolae* overwinters in the rootstock and terminal bud of the host plants, producing a thick coat of bright orange spores on the undersurfaces of emerging leaves. Although the fungi can weaken the plants by depleting starches stored in the leaves, on the whole they do little damage to the hosts (Rice 1927).

Snyder (1994) suspected that shifting climactic conditions might be detrimentally affecting *Pyrola chlorantha* populations in New Jersey, and the observation is supported by the high concentration of states in the east-central United States where the species is extirpated or critically imperiled (see Figure 4). Although the effects of climate change on fungi are still being studied, there is evidence that significant modifications to subterranean communities are occurring as a result of changing temperatures, atmospheric carbon dioxide enrichment, nitrogen

deposition, and altered hydrologic patterns (Pickles et al. 2012, Cotton 2018). Rising temperatures have also facilitated the northward expansion of the Southern Pine Beetle, *Dendroctonus frontalis* (NJDEP 2010), and *Pinus* species that form the canopy in some *Pyrola chlorantha* habitats are frequently weakened or killed by the beetles. Mycoheterotrophic plants that thrive in shaded sites often compete poorly with autotrophic plants (Leake 1994), so a reduction in canopy cover could facilitate the establishment of understory species that are likely to replace *P. chlorantha*. An extensive loss of pines in a particular location may simultaneously trigger additional changes that affect the local fungal networks.

Management Summary and Recommendations

New Jersey's extant population of *Pyrola chlorantha* was last surveyed in 1989 (NJNHP 2022). Updated site monitoring is needed in order to assess the current status of the occurrence and identify potential threats. Searches conducted at the locations of many historical occurrences have been unsuccessful (Snyder 1994, 2000). Nevertheless, because the species was formerly distributed widely throughout the state, the identification of potential habitat for de novo surveys could still be worthwhile.

Due to its reliance on extant fungal networks *Pyrola chlorantha* is not a good candidate for offsite propagation and reintroduction, making the conservation of extant populations more urgent in areas where the species is imperiled. Management may require both the preservation of forested tracts where *P. chlorantha* occurs and protection of the habitat from foot traffic, off-road vehicles, and other recreational uses that could directly damage the plants. As the Southern Pine Beetle continues to expand its range into New England (Dodds et al. 2018), management of Greenish-flower Wintergreen in that region may also involve controlling the subsequent spread of invasive plant species in affected communities.

Long-term management planning for the Greenish-flower Wintergreen can become more effective with additional research. While bumblebees have been cited as the primary pollinators of *Pyrola chlorantha*, the particular species that visit the plants in the northeastern United States have not been identified. Some different types of bees such as carpenter bees and sweat bees are also capable of buzz pollination (Pritchard and Vallejo-Marin 2020), and it is important to understand whether other insects will be able to fill pollinator gaps caused by the decline in bumblebees. Although *P. chlorantha* is generally assumed to compete poorly with autotrophic plants in sites with more open canopies, the nature of that competition is not well understood. The complex relationships between plants, fungi, and environmental conditions are currently being investigated around the world and hopefully the results of some studies will provide information which can help protect the communities that support *Pyrola chlorantha*.

Synonyms

The accepted botanical name of the species is *Pyrola chlorantha* Swartz. Orthographic variants, synonyms, and common names are listed below (ITIS 2021, POWO 2023, USDA NRCS 2023b).

Botanical Synonyms

Pyrola chlorantha var. *convoluta* (W. P. C. Barton) Fernald
Pyrola chlorantha var. *paucifolia* Fernald
Pyrola chlorantha var. *revoluta* Jenn.
Pyrola convoluta W. P. C. Barton
Pyrola oxypetala Austin ex A. Gray
Pyrola solunica S. D. Zhao
Pyrola virens Schweigg. & Korte
Pyrola virens var. *convoluta* (W. P. C. Barton) Fernald
Pyrola virens var. *saximontana* Fernald
Thelaia chlorantha (Sw.) Alef.

Common Names

Greenish-flower Wintergreen
Green-flowered Wintergreen
Green-flowered Shinleaf
Pale-green Wintergreen

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