Trillium grandiflorum

Large-flower Trillium

Liliaceae

Trillium grandiflorum by Katy Chayka, 2007

***Trillium grandiflorum* 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

Trillium grandiflorum (Large-flower Trillium) is one of North America's most charismatic spring wildflowers (Keeler 1916, Stritch undated, Chicago Botanic Garden 2022). New Jersey has four native species of *Trillium* that are easy to recognize and identify when in bloom, and the flowers of *T. grandiflorum* are particularly showy. Vegetative trillium plants look somewhat like nonflowering jack-in-the-pulpits (*Arisaema spp*.) but in the absence of flowers or fruits the two genera may be distinguished by leaf position and venation (Gracie 2012).

Trillium grandiflorum is an unbranched perennial herb with a whorl of three leaves at the summit of a thick, smooth stem (Case 2020). The leaves of *T. grandiflorum* lack petioles and are somewhat rounded or diamond-shaped in outline with an acuminate tip (Britton and Brown 1913). The roots form extensive mycorrhizal associations (Brundrett and Kendrick 1990). Although the species is rhizomatous, it does not reproduce clonally (Hanzawa and Kalisz 1993). Most *Trillium* rhizomes produce a single stem each year, but up to 15% of a population may produce two (or rarely three) stems (Gracie 2012).

The establishment and growth of a *T. grandiflorum* plant takes place very slowly. The seeds require several years to develop an aboveground presence. Following the first winter in the ground only a radical (embryonic root) is produced, and the primary shoot does not develop until the second spring (Baskin and Baskin 2004). A single leaf is produced during the third season, then another year or more is required until the plants transition to the three-leaf form (Hanzawa and Kalisz 1993). If the initial root emergence is delayed, the whole process can take an additional year (Oliver et al. 2019). Root growth takes place mainly during the summer months and is also very slow (Brundrett and Kendrick 1990). Because development occurs at such a leisurely pace and a large amount of energy is utilized for reproduction, a *Trillium grandiflorum* plant can sometimes take as long as 16–20 years to produce its first bloom (Hanzawa and Kalisz 1993, Gracie 2012). An average of 5–8 years from germination to maturity may be expected for cultivated plants (Bush 2004, Cornell Botanic Gardens undated).

A mature *T. grandiflorum* plant produces flowers with three large (4–8 cm) petals that are white when fresh but turn pink with age (Gleason and Cronquist 1991). A wholly pink morph, forma roseum, is frequent in the Blue Ridge Mountains but may occasionally occur elsewhere throughout the species' range (Case 2020). Unusual variations in the flowers are often observed including extra petals, green stripes, or other markings. In the past enthusiastic botanists were apt to describe the aberrations as new forms or varieties, but the differences are actually due to a bacterial (mycoplasma) infection (Fernald 1950, Stritch undated, Case 2020). Hall (1961) noticed that infected plants produced small amounts of pollen but no viable seeds, and Gracie (2012) reported that the infections can weaken and eventually kill the plants.

Trillium grandiflorum blooms during April or May (Weakley 2015), and the flowers remain open for a period of 17–21 days (Darling and Barrett 2011). The timing of flower production is more closely linked to photoperiod than to temperature (Sevenello et al. 2020). Hanzawa and Kalisz (1993) observed that *T. grandiflorum* plants which make a significant reproductive effort in one year have a lower probability of flowering in the subsequent year or years due to resource depletion. Nevertheless, a healthy plant should have plenty of opportunities to reproduce during

the course of a lifetime. Life spans for individual plants under favorable circumstances have been variously reported as 70+ years (Gracie 2012) and hundreds of years (Cornell Botanic Gardens undated).

Left: Britton and Brown 1913, courtesy USDA NRCS 2022a. Right: Wendel, 1868.

Color variation and woodland population by Chayka (2009, 2010).

Pollinator Dynamics

Many different types of insects have been reported visiting the flowers of *Trillium grandiflorum* including bees, flies, beetles, and butterflies, but their effectiveness as pollinators has not always been examined (Keeler 1916, Irwin 2000). Long-tongued bees, and particularly bumblebees (*Bombus spp*.), appear to play a critical role in cross-fertilization of *T. grandiflorum* (Darling and Barrett 2011, Hilty 2020). Fruit production and seed set in the species are limited by pollination (Griffin and Barrett 2002, Knight 2003a, Darling and Barrett 2011).

T. grandiflorum flowers appear to resist self-fertilization although it sometimes occurs, but the plants produce more successful fruits when they have been cross-fertilized (Irwin 2000, Sage et al. 2001). Both *T. grandiflorum* and *T. erectum* (Red Trillium) usually recognize and reject their own pollen when it starts to develop on their stigmas but the process is not 100% effective, a system that Sage et al. (2001) described as "*leaky self-incompatibility*." Gracie (2012) suggested that the flowers become more self-receptive toward the end of their life if they have not been adequately pollinated by insects.

Irwin (2000) observed that the flowers of *Trillium grandiflorum* received low numbers of pollinator visits in comparison to other spring wildflowers, and Darling and Barrett (2011) suggested that the species' lengthy flowering period may be a strategy to increase opportunities for fertilization when pollinators are scarce. Studies of pollinator limitation in *T. grandiflorum* have found that mid-sized populations have the highest percentages of cross-fertilization. Very small or widely scattered populations may fail to attract a sufficient number of insects (Knight 2003a), while flowers in very dense populations may compete for a limited number of pollinators (Steven et al. 2003).

Pollination is not the whole story though, because plant size also has a direct impact on female reproductive success (Irwin 2000). Griffin and Barrett (2002) found that even plants that were hand-pollinated to assure cross-fertilization did not always have 100% seed set per fruit, and that larger plants had higher seed:ovule ratios. The fertility of *T. grandiflorum* is therefore reduced when resources are limited.

Seed Dispersal

The many-seeded, berry-like fruits of *Trillium grandiflorum* mature in July and August (Case 2020, Weakley 2015). The fruits are green when ripe and typically drop to the ground where the seeds are exposed at the former point of attachment, and each of the seeds bears a fleshy appendage at one end (Gates 1940, Gracie 2012). Ant dispersal of *T. grandiflorum* was first reported by Gates (1940). After observing fallen fruits that had been emptied of their seeds overnight, Gates determined that ants were the culprit and followed them back to their nest where he found piles of *Trillium* seeds with their appendages (elaiosomes) removed. He subsequently documented the same process in other forest herbs, reporting seed removal by ants in the genera *Camponotus*, *Formica*, *Lasius*, *Myrmica*, and *Prenolepis* (Gates 1943).

Handel et al. (1981) underscored the importance of ant-dispersal for *T. grandiflorum* along with about a dozen other plant species, noting that ant abundance and behavior may play a significant role in structuring forest herb communities. However, ants can only disperse seeds at a limited distance from their plant of origin. A study of ant removal of *T. grandiflorum* seeds found that the majority of seeds (77-81%) were undispersed, ending up within 10 centimeters of the parent plants, and that average dispersal distances ranged from 0.5-2.4 meters with a maximum distance of 10 meters (Kalisz et al. 1999).

Turner and Frederickson (2013) studied the factors that attracted ants to the seeds and found that the elaiosomes of *T. grandiflorum* had less nutritive value and higher oleic acid content in comparison to those of *T. erectum* but were more frequently harvested. The preferential selection of *T. grandiflorum* was detrimental to the ants, thus highlighting the importance of the chemical signal in dispersal. Yellow jackets (*Vespula* spp.) have been reported as a dispersal vector for several other species of *Trillium* (Zettler et al. 2001). That may or may not be the case for *T. grandiflorum*, depending on whether the wasps are attracted by the same chemical signals that facilitate dispersal by ants.

A long-distance dispersal mechanism for *Trillium grandiflorum* via ingestion and defecation by white-tailed deer (*Odocoileus virginianus*) was documented by Vellend et al. (2003). However, the benefits of deer herbivory and subsequent dispersal may be outweighed by the disadvantages (Vellend et al. 2006). The costs of herbivory are further discussed in the Threats section of this paper. It is also worth noting that dispersal alone does not guarantee success: A study by Kalisz et al. (2001) noted that only 2% of *T. grandiflorum* seeds went on to establish as juvenile plants.

Habitat

Trillium grandiflorum typically grows in rich deciduous or mixed coniferous-deciduous upland woods but it may also occur on floodplains or roadsides (Oliver et al. 2019). Elevations range from 20–700 meters (Case 2020). In western Pennsylvania Large-flower Trillium is frequent in moist woods (Rhoads and Block 2007), and habitat in the southeastern U. S. has been described as rich coves and mesic slopes (Weakley 2015). Characteristic communities include *Acer saccharum–Fraxinus americana–Tilia americana* (Sugar Maple–White Ash–American Basswood) Forest Alliance and *Tsuga canadensis–Betula allegheniensis* (Eastern Hemlock–Yellow Birch) Forest Alliance (Breden et al. 2001).

T. grandiflorum is most likely to thrive in old-growth forests. Vellend (2004) found that Large-flower Trillium occurrences in secondary forests were less vigorous than those in primary forests at both the individual and population levels. Established *T. grandiflorum* plants may persist and even temporarily thrive in hedgerows, but poor recruitment in such habitats will result in long-term population declines (Schmucki and de Blois 2009).

Wetland Indicator Status

Trillium grandiflorum 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)

TRGR4

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 *Trillium grandiflorum* is limited to eastern North America (POWO 2022). The map in Figure 1 depicts the extent of the species in the United States and Canada.

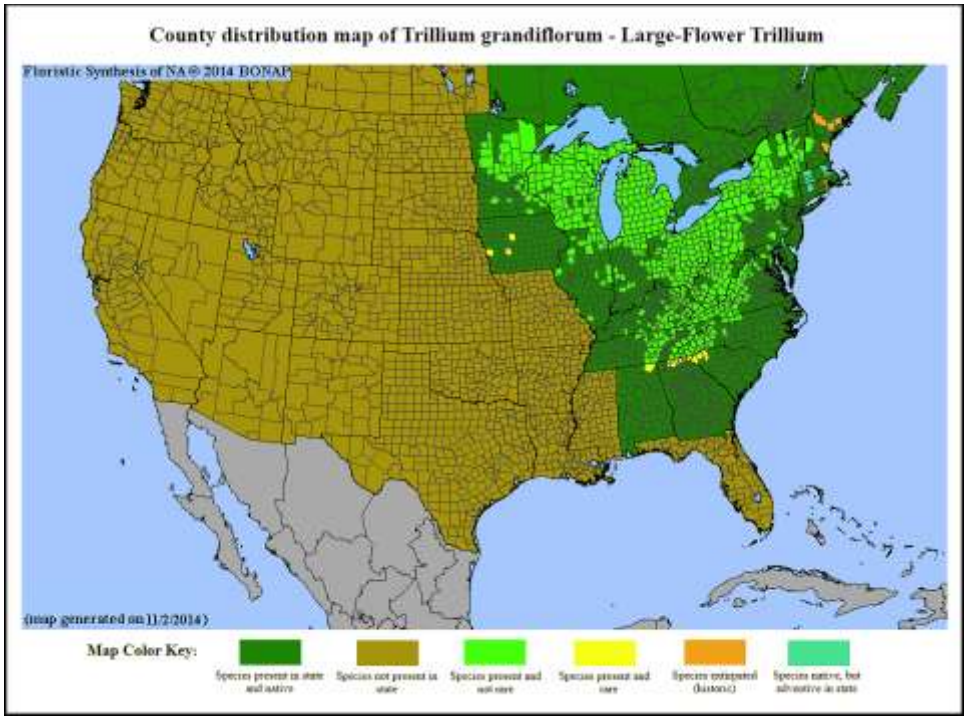

Figure 1. Distribution of T. grandiflorum in North America, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2022b) did not provide county level information for *Trillium grandiflorum* in New Jersey. The map in Figure 2 includes records for Cape May, Monmouth, and Sussex counties based on information from Mid-Atlantic Herbaria (2022) and the state biotics database (NJNHP 2022). One herbarium specimen from the early 1900s was labeled as "Morris or Sussex.". Historic observations do not reflect the current distribution of the species.

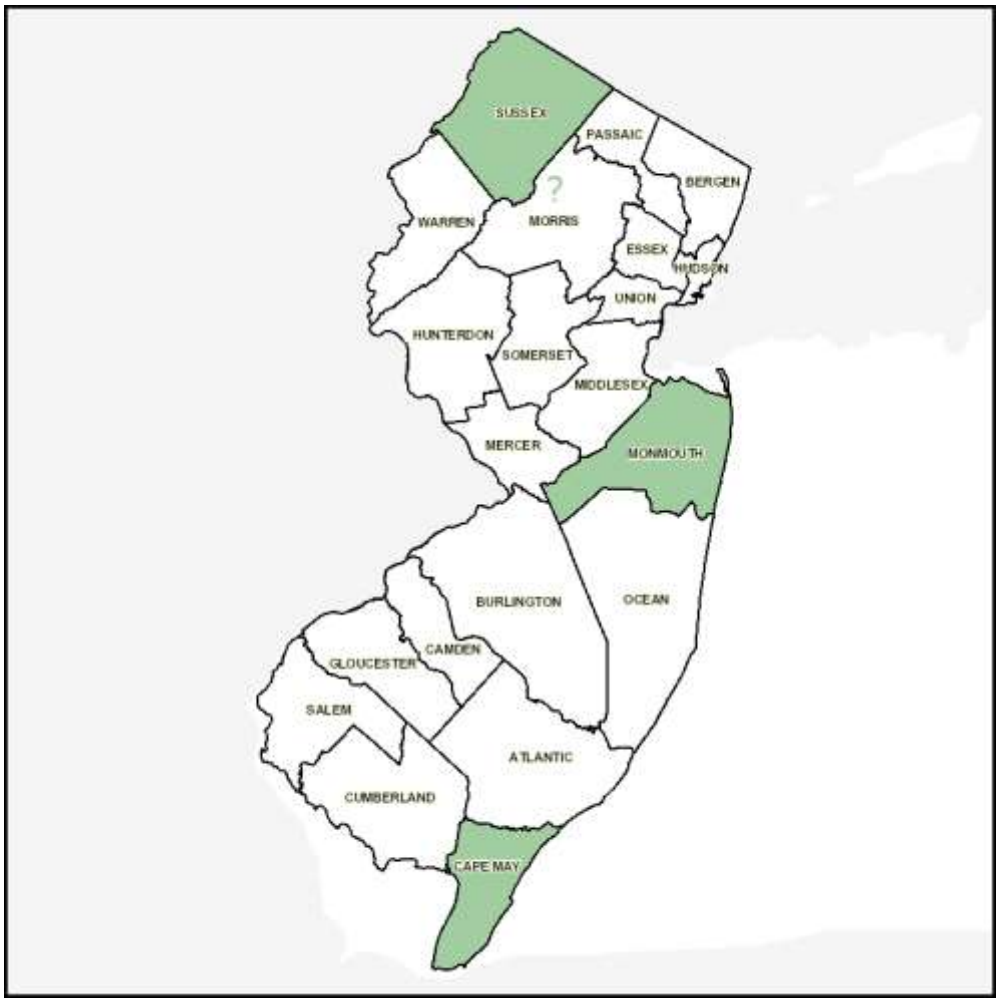

Figure 2. County records of T. grandiflorum in New Jersey.

Conservation Status

Trillium grandiflorum is presently ranked as 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). The IUCN (International Union for Conservation of Nature) has reported *T. grandiflorum* as a declining species, but it was still ranked as Least Concern by when last evaluated in 2018 (Meredith et al. 2020).

The map below (Figure 3) illustrates the conservation status of Large-flower Trillium throughout its range. *Trillium grandiflorum* is one of the most common and widespread trilliums in North

America (Oliver et al. 2019), and it is either unranked or considered secure/apparently secure in many areas. It has been ranked as critically imperiled (very high risk of extinction) in three states and one province, vulnerable (moderate risk of extinction) in two states and one province, and possibly extirpated in Maine.

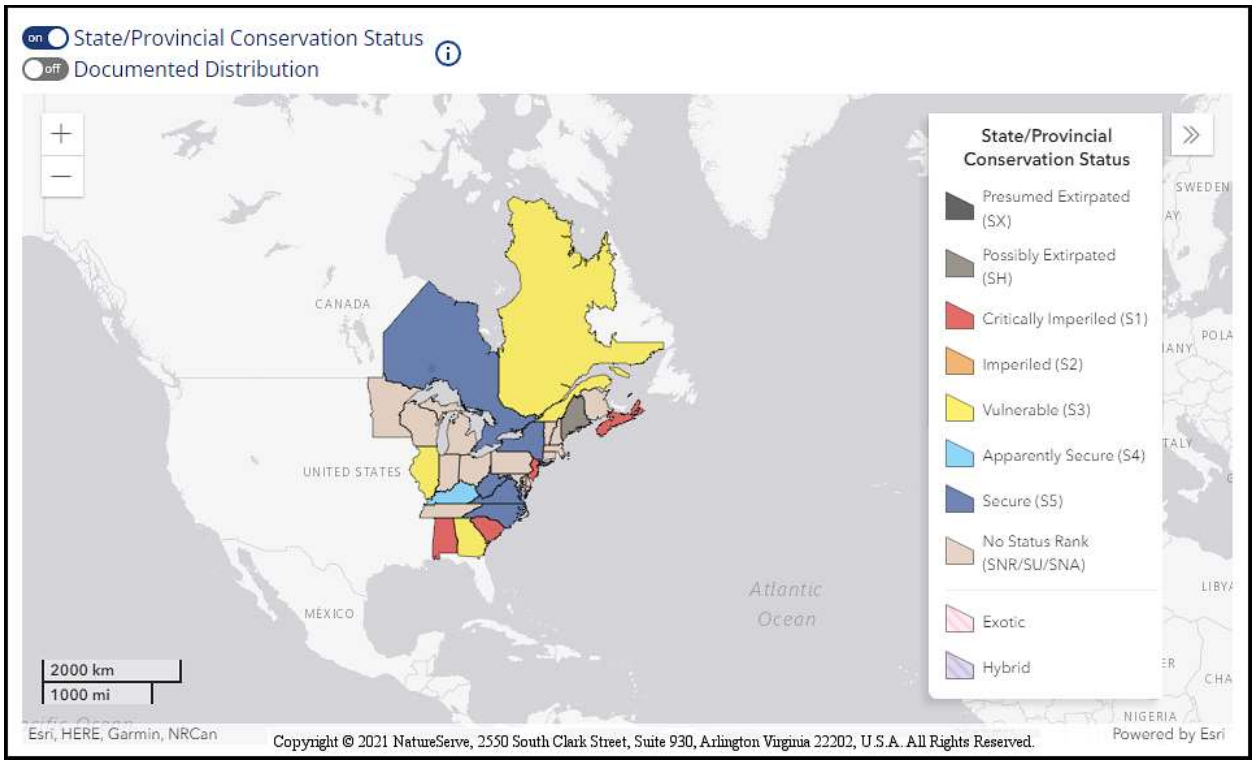

Figure 3. Conservation status of T. grandiflorum in North America (NatureServe 2022).

New Jersey is one of the states where *Trillium grandiflorum* is critically imperiled. The S1 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. *T. grandiflorum* 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 the trillium 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).

Only two occurrences of *Trillium grandiflorum* have been documented in New Jersey during the past half-century. One small, nonflowering population discovered in 2000 slowly declined and has not been seen since 2014, and the sole extant population is very small and has a viability rank of 'Fair' (NJNHP 2022).

Threats

The greatest range-wide threat to *Trillium grandiflorum* is habitat destruction for housing and commercial development (Oliver et al. 2019). In addition to direct loss of habitat, fragmentation of the landscape is also a concern. Jules (1998) studied the effects of habitat fragmentation on *Trillium ovatum* and found that edge effects reduced recruitment, which was similar to the response documented for *T. grandiflorum* in hedgerows by Schmucki and de Blois (2009). Forest fragmentation can increase the populations of small mammals such as mice and voles (Tallmon et al. 2003, Zwolak 2009). Mice and voles consume both seeds and rhizomes, and whole stands of *Trillium spp*. can be quickly eliminated by a colony of voles (Cullina 2002). Fragmented landscapes are also more favorable for deer (Augustine and Frelich 1998) and preferential foraging by deer on native herbs reduces their size and flowering status, resulting in the creation of open patches that may then be colonized by invasive plant species (Knight et al. 2009).

The detrimental effects of deer browsing on *Trillium grandiflorum* have been well-documented, and deer have been cited as the primary reason for the plant's decline in the northern part of its range (Meredith et al. 2020). Early studies simulating aboveground herbivory with leaf removal found a reduction in the amount of resources allocated to rhizomes (Lubbers and Lechowicz 1989). Deer selectively browse the largest plants in a colony which would otherwise be the best reproducers, accelerating local population declines (Anderson 1994, Augustine and Frelich 1998, Rooney and Gross 2003). Augustine and Frelich (1998) reported that deer browsing consistently resulted in a 50% decrease in reproduction during the growing season. Early season herbivory increases the probability of reproductive failure the following year (Knight 2007), and future reproduction is also impacted as populations becomes skewed toward smaller plants. Repeated browsing reduces photosynthetic capacity, depleting belowground resources and causing plants to become smaller and regress to nonreproductive stages (Anderson 1994, Knight 2003b). Smaller plants have higher mortality rates and lower recruitment, resulting in gradual population declines (Rooney and Millam 2006). A similar response to herbivory occurs in *Helonias bullata* (personal observation) and, as with *Helonias*, protection of the plants from herbivory results in increased leaf area and flowering rates (Augustine and Frelich 1998). Knight (2004) concluded that reproductive success in *T. grandiflorum* is reduced more by herbivory than by pollen limitation. Once the damage has been done the plant is slow to recover: Introduction of wolves to manage deer density had only a small positive impact on *T. grandiflorum* after more than a decade (Bouchard et al. 2013).

Another emerging threat to *Trillium grandiflorum* is the proliferation of non-native earthworms in northern forests. Introduced worms reduce the organic layer, alter the structure and nutrient cycling patterns of the soils, and disrupt mycorrhizal processes (Bohlen et al. 2004, Frelich et al. 2006, Hale et al. 2006). *T. grandiflorum* is one of the forest herbs that has been documented as declining as earthworm populations expand (Corio et al. 2009, Bohlen et al. 2004, Frelich et al. 2006). Hale et al. (2006) noted that when characteristic herbs of Sugar Maple-dominated forests disappear as a result of earthworm activity they are often replaced by non-mycorrhizal species such as *Carex pensylvanica* (Pennsylvania sedge). As earthworm populations expand northward, *Trillium grandiflorum* is reportedly disappearing from the forests of Ontario where it is the official flower of the province (Spears 2012).

T. grandiflorum is sometimes collected for the medicinal plant and horticulture trade (Oliver et al. 2019). Because the species grows so slowly, unscrupulous vendors sometimes dig up rhizomes from the wild (Chicago Botanic Garden 2022). Gracie (2012) also points out that *T. grandiflorum* plants infected with mycoplasma are often prized by horticulturalists due to their unusual appearance, which can result in spreading of the disease when the plants are transported to new locations.

A number of additional factors may interact with impacts from herbivores, worms, and humans to affect Large-flower Trillium in unpredictable ways. Extensive mortality of White Ash, a major component of typical *T. grandiflorum* habitat, has occurred as a result of the invasive insect Emerald Ash Borer (*Agrilus planipennis*), notably altering the composition of communities where the trees were previously abundant (Marshall 2020). Steep declines in populations of bumblebees—the primary pollinators of *Trillium grandiflorum*—have been widely documented (e.g. Colla and Packer 2008). Less direct impacts from broad environmental concerns such as pollution and acid rain have also been reported for the *T. grandiflorum* (Cox 1983, Oliver et al 2019, Meredith et al. 2020).

While the long term affects of climate change on the species are unknown, no particular threat to *Trillium grandiflorum* has been identified. One study found that both eastern forest herbs and pollinators responded to rising temperatures in a similar way so that their emergence continued to be synchronized (Sevenello et al. 2020), and despite *T. grandiflorum*'s apparent reliance on photoperiod for cues the plants reportedly bloomed an average of 3.5 days earlier over the period from 1986 to 2015 (Cornell Botanic Gardens, undated).

Management Summary and Recommendations

For high quality occurrences of *Trillium grandiflorum*, conservation efforts should prioritize land protection and habitat preservation. Undisturbed mature forests are not easily replaced, and studies have demonstrated that *T. grandiflorum* populations are less vigorous in secondary or fragmented habitats. The impact of *Fraxinus* loss on *T. grandiflorum* should be examined at sites where White Ash has been a significant component of the canopy.

Control of deer population density is critical for *Trillium grandiflorum* (Augustine and Frelich 1998). Deer are not the only problem facing the species but they may be one of the most manageable, and continuous herbivory reduces the plants' resources and thus their ability to cope with other challenges. Anderson (1994) reported that deer densities of 4–6 individuals per km^2 (247 acres) allow *Trillium* populations to remain stable. Rooney (2001) suggested the use of indicator plant species that increase or decrease in the face of overpopulation by deer to set a threshold for management, with ongoing monitoring of both forest herbs and deer populations to assure that a good balance is maintained. For small, imperiled populations the installation of deer-exclusion fencing might create an opportunity for the plants to regain some vigor and reproduce.

Introduction or reintroduction of the Large-leaf Trillium at suitable or historic sites is a possibility that could also be considered. Although slow to develop, the plant may be cultivated

from seed with relative ease (Leopold 2005, Bush 2004, Cullina 2002). Some work has also been done on outplanting *T. grandiflorum* that was propagated via tissue culture (Kitto and Frett 2001).

Synonyms

The accepted botanical name of the species is *Trillium grandiflorum* (Michaux) Salisbury. Orthographic variants, synonyms, and common names are listed below (ITIS 2021, USDA 2022b, POWO 2022).

Botanical Synonyms	Common Names
Trillium chandleri Farw. (includes 5 forms)	Large-flower Trillium
Trillium erythrocarpum Curtis	Snow Trillium
Trillium grandiflorum var. *minimum* N. Coleman	White Trillium
Trillium grandiflorum f. *chandleri* (Farw.) Vict.	Great White Trillium
Trillium grandiflorum f. *lirioides* (Raf.) Vict.	White Wakerobin
Trillium lirioides Raf. (includes 1 variety and 6 forms by Farw.)	
Trillium obcordatum Raf.	
Trillium rhomboideum var. *grandiflorum* Michx.	

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