Goodyera tesselata

Checkered Rattlesnake-plantain

Orchidaceae

Goodyera tesselata by Benoit Dorion, 2021

Goodyera tesselata 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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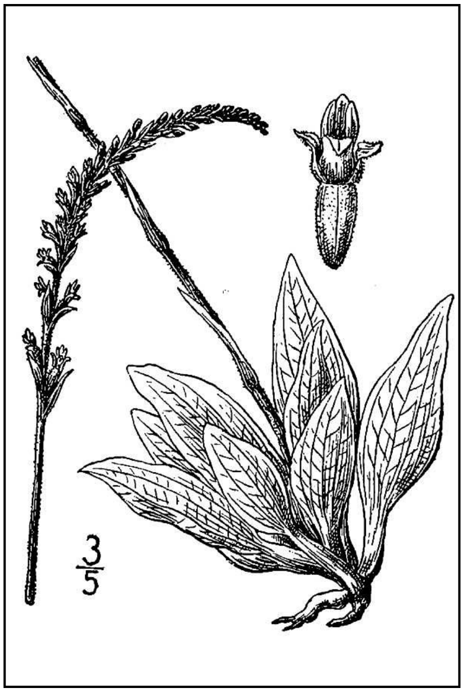
Life History

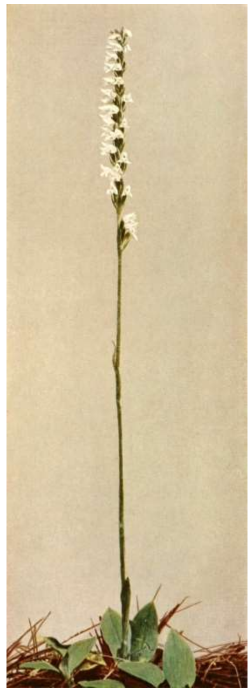
Four species of *Goodyera* occur in the United States but only two have been recorded in New Jersey (Kartesz 2015). *Goodyera tesselata* (Checkered Rattlesnake-plantain) is believed to have originated shortly after the last ice age as a hybrid of two North American species that do not occur in New Jersey, *G. oblongifolia* and *G. repens*, subsequently establishing in areas where one or both parents were absent (Kallunki 1976). Most early specimens of *G. tesselata* from New England were misidentified as one of the parent species (Fernald 1899). Kallunki (1976) observed that many *G. tesselata* plants were visually intermediate between the other two species and occasionally difficult to tell apart, and her cytologic analysis revealed that the diploid chromosome number was 30 for each of the parent species but 60 for *G. tesselata*. *Goodyera pubescens*, the second and more common rattlesnake-plantain that occurs in New Jersey, is not closely related to the other three species—it differs in chromosome number (2n = 26), floral morphology, and characteristic molecular compounds (Kallunki 2020). Nevertheless, when growing together any two of the four North American *Goodyera* species are able to form hybrids (Kallunki 1981).

Goodyera tesselata is a perennial orchid that can produce new clones via rhizomatous growth (Gleason and Cronquist 1991). The plants typically have 3–8 ovate, evergreen leaves that form a basal rosette (Davis 2018). The veins on the leaves are bordered by pale lines that are connected by additional horizontal or oblique lines, forming a pattern of irregular, somewhat rectangular markings (Fernald 1899). Broad white bands bordering the midrib of *G. pubescens* leaves will help to distinguish the species from *G. tesselata* (Weakley 2015). Checkered Rattlesnake-plantain may flower between mid-July and early September (Weakley 2015, Kallunki 2020) but most of the time it seems to occur during the early part of that window. Median flowering dates for four populations in Michigan ranged from July 22 to August 1 (Kallunki 1981), and one Ontario population had median dates of July 23 and August 5 during two different years (Barclay-Estrup et al. 1991). Plants in New Jersey populations have often finished blooming by mid-August (NJNHP 2022).

The inflorescence of *Goodyera tesselata* is a spike of 5–72 flowers borne on a pubescent scape 10–35 cm tall. Its flowers are typically arranged in a loose or dense spiral around the stem but occasionally appear to be all on one side. The flowers are small and white, with broad hoods and pouched lips that have elongated tips. (See Britton and Brown 1913, Fernald 1950, Gleason and Cronquist 1991). Andrews (1901) reported that the flowers have a sweet, pleasant smell and may occasionally have a pinkish tinge. *G. tesselata* fruits are capsules which split at three sites along their sides (Kallunki 2020), and the dried flower stalks can persist until the following growing season (Brackley 1985). Winter identification of *Goodyera* plants is facilitated by the evergreen leaves and persistent fruits (Levine 1995).

Most orchids in the subtribe Goodyerinae have leaves that are adorned with pale green, pink or silver lines on a darker background, causing the group to be known as the jewel orchids (Dressler 1981), but Brackley (1985) remarked that *Goodyera* plants are known as rattlesnake-plantains because the patterns on their leaves are reminiscent of snakeskins. In the original published description of *Goodyera tesselata*, Loddiges (1924) simply observed that the plant had beautifully marked leaves which remained green all winter.






Left: Britton and Brown 1913, courtesy USDA NRCS 2022a. Center: House et al. 1918 via Wikimedia Commons. Right: Peter M. Dziuk, 2012.

Flowers by Peter M. Dziuk, 2005.

Fruits by Katy Chayka, 2010.

Pollinator Dynamics

Goodyera tesselata is primarily pollinated by bumblebees (*Bombus spp*.), but halictid bees and syrphid flies may also play a role. The insects are attracted by nectar that is produced at the base of the orchid's lip (Kallunki 1976, Davis 2018, NAOCC 2022). Kallunki (1981) observed that the flowers of *G. tesselata* give off a noticeable scent which is stronger during the day than at night, and she also found that under ultraviolet light the lips of the flowers are highly fluorescent and display a bright yellow-green color.

Individual flowers on *Goodyera* plants are protandrous, meaning that the stamens develop before the pistils (Brackley 1985). The flowers of a *G. tesselata* inflorescence mature from bottom to top, so those near the lower end of a spike have receptive stigmas while the upper ones are still dispensing pollen. When bees visit the flowers they work their way from the bottom to the top of a flower spike so as they arrive their pollen load is deposited on the lower, receptive flowers while they access the nectar. The less developed flowers near the upper end of the spike which have not fully expanded cannot receive pollen but can still deposit their pollinia (pollen packets) on a bee's proboscis before it leaves to visit another flower (Brackley 1985, Davis 2018, NAOCC 2022). The developmental sequence promotes outcrossing.

Kallunki (1976, 1981) found that *G. tesselata* did not set seed when insects were excluded. However, she also reported that the species is highly self-compatible and fruit development is not inhibited when flowers are fertilized by pollen from another flower on the same stem or ramet in the same clone. Pollinator visits were highly correlated with successful fertilization, but insect activity varied with habitat conditions. During Kallunki's 1981 study, reduced pollination at certain locations was attributed to high levels of disturbance by humans or wind, and at one site a more diverse mix of flowering herbs was thought to cause competition for pollinators.

Seed Dispersal and Establishment

The seeds of orchids lack endosperm and consist mainly of an embryo surrounded by a loose, papery coating (Dressler 1981). Individual plants produce numerous tiny propagules that are often referred to as dust seeds: Millions per plant have been reported for some species (Romero-González et al. 2020). The minute seeds are wind-dispersed and most have (relatively) large internal air spaces that allow them to float in the air for long periods. Average measures of 2 µg in weight and 70% internal air space have been reported for the genus *Goodyera* (Arditti and Ghani 2000). Many orchid seeds also have a water-resistant outer surface that—together with the internal air space—permits flotation, allowing some movement of seeds via surface water after a rain. The seeds of *Goodyera tesselata* have been reported to float when wet (Arditti and Ghani 2000). Arditti and Ghani further noted that the general characteristics of orchid seeds also allow their transport by adherence to land animals and birds. Plants that disperse by dust seeds rarely become dominant in any community (Eriksson and Kainulainen 2011).

Dormancy in orchid seeds varies between species, ranging from 0–7 years (Eriksson and Kainulainen 2011). Dressler (1981) noted that the seeds of orchids may survive for long periods if they are cool and dry. When the seeds become hydrated, limited metabolic activity is initiated but germination requires appropriate physical conditions and, in nature, the right kind of fungi (Dressler 1981, Arditti and Ghani 2000). Some species, such as *Goodyera pubescens*, are able to germinate even when a suitable fungus is not present but a mycorrhizal association is required for further development (Rasmussen and Whigham 1993). When an orchid seed germinates the embryo swells into a mass of cells called a protocorm, and the lower portions initiate root hairs while the cells on the upper surface may eventually develop into a leafy shoot. Prior to leaf development, the seedlings are completely dependent on their fungal associate for nutrients (Dressler 1981).

Some types of orchids rely on mycorrhizae only during the establishment phase while others continue to need them throughout their lives (Eriksson and Kainulainen 2011). A species such as *Goodyera tesselata* with evergreen leaves might seem unlikely to remain dependent on fungi once it has established. However, many orchids continue to rely on their fungal associates for continued growth and survival (Pandey et al. 2013), and dormancy may be triggered when mycorrhizae are limited (McCormick et al. 2018). Zale et al. (2022) identified fungi from the root of a mature *G. tesselata* plant as an unnamed species of *Ceratobasidium*, and other species of *Goodyera* have also been reported to develop associations with *Ceratobasidium spp.* (Rasmussen 2002, Shefferson et al. 2010). Shefferson et al. (2010) reported a narrow specificity for *G. tesselata*, finding it associated with several fungi 'falling near *Ceratobasidium angustisporum*'. However, it is worth noting that some orchids utilize different fungal associates during germination and establishment (Li et al. 2022), some maintain associations with multiple types of fungi simultaneously (Pandey et al. 2013, McCormick et al. 2021), and some—including *Goodyera pubescens*—typically associate with a single fungus but are able to switch to another species during periods of stress (McCormick et al. 2006).

Habitat

Goodyera tesselata generally occurs at elevations of up to 300 meters in dry or moist upland woods, but it may occasionally be found in white cedar swamps or spruce-tamarack bogs (Kallunki 2020). The canopy type is usually reported as either coniferous or mixed deciduous-coniferous woods (Brackley 1985, Weakley 2015, Kallunki 2020), but conifers are often a substantial habitat component (PANHP 2019). Champlin (1976) cited the plants as preferentially growing under *Pinus sylvestris* in Rhode Island. Davis (2018) studied habitat use by *G. tesselata* in the Ontario area, where she found an extant population growing beneath *Abies balsamea*. Davis's review of habitat data from regional herbarium specimens showed that *G. tesselata* had been collected under *Picea mariana*, *Pinus banksiana*, and *Abies*; other records indicated mixed woods or did not show a forest type. In New Jersey, Checkered Rattlesnake-plantain has been found in several *Pinus resinosa* plantations with one additional occurrence in a *Pinus-Tsuga* forest (Wander and Wander 1985, NJNHP 2022). Zale (2022) noted that *G. tesselata* typically grows in a thick layer of forest duff under a canopy of *Pinus* or *Tsuga*. The orchid is most likely to be found in well-established stands: A study of post-burn regeneration in a boreal forest reported that *Goodyera tesselata* and *G. repens* did not appear in the understory until 74 years or more after the last fire (DeGrandpré et al. 1993).

An evaluation of some habitat characteristics of native orchids recorded a soil pH range of 3.7–5.2 at sites where *Goodyera tesselata* was growing (Stuckey 1967). Burgess-Conforti et al. (2019) found no significant difference between coniferous and deciduous forests in terms of soil pH but reported that the litter beneath coniferous stands was more acidic than deciduous litter. Characteristics of the duff layer, or of the conifers themselves, may govern the fungal composition of the community and therefore determine the rattlesnake-plantain's ability to germinate, establish, and thrive (Rasmussen 2002). Developing and mature orchids may obtain nutrients directly from fungi that are decomposers or secondarily from other plants by forming associations with their mycorrhizal fungi (Eriksson and Kainulainen 2011). Orchids that grow in environments where light is limited are especially likely to form and maintain connections with the fungal symbionts of neighboring trees (Bidartondo et al. 2004). Various types of *Ceratobasidium*, a fungal genus often associated with *Goodyera spp*., have been reported to function as both decomposers and conifer parasites (Rasmussen 2002). Forest successional stages and organic soil components can also affect the fungi that associate with orchids (McCormick et al. 2012). The ways in which the complex relationships between *Goodyera tesselata*, fungi, and overstory species influence habitat suitability for the orchid are nor fully understood.

Wetland Indicator Status

Goodyera tesselata is a facultative upland species, meaning that it usually occurs in nonwetlands but may occur in wetlands (U. S. Army Corps of Engineers 2020).

USDA Plants Code (USDA, NRCS 2022b)

GOTE

Coefficient of Conservatism (Walz et al. 2018)

CoC = 7. 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 *Goodyera tesselata* is limited to North America (POWO 2022). The map in Figure 1 shows the extent of Checkered Rattlesnake-plantain in the United States and Canada.

The USDA PLANTS Database (2022b) shows records of *Goodyera tesselata* in two New Jersey counties: Sussex and Warren (Figure 2). The data include historic observations and do not reflect the current distribution of the species.

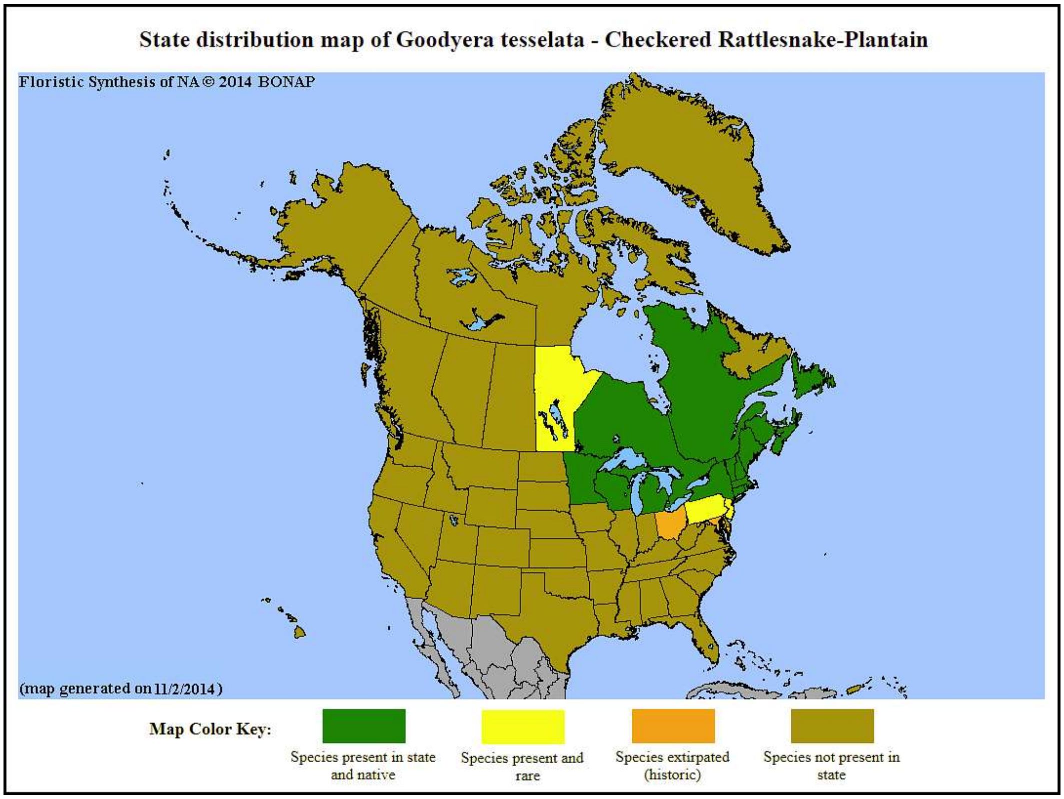


Figure 1. Distribution of G. tesselata in North America, adapted from BONAP (Kartesz 2015).

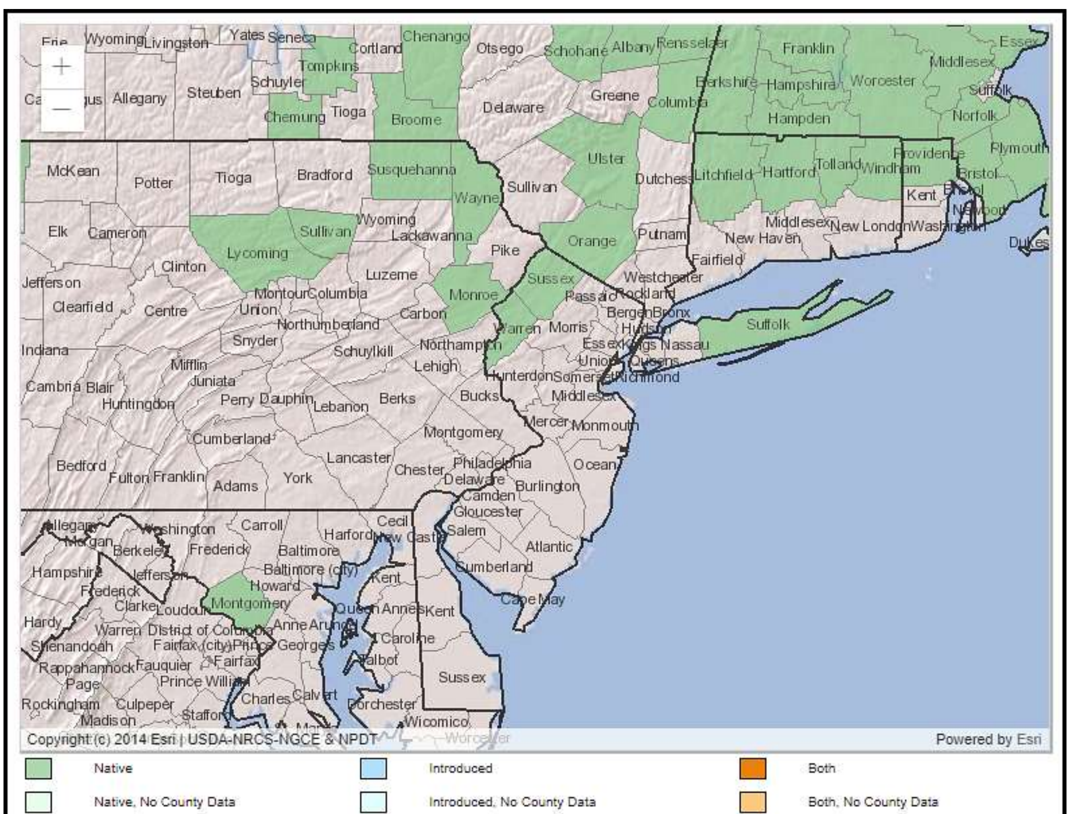


Figure 2. County records of G. tesselata in New Jersey and vicinity (USDA NRCS 2022b).

Conservation Status

Goodyera tesselata 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). The map below (Figure 3) illustrates the conservation status of *G. tesselata* throughout its range. Checkered Rattlesnake-plantain is critically imperiled (very high risk of extinction) in two states, imperiled (high risk of extinction) in two provinces and one state, vulnerable (moderate risk of extinction) in one province, and possibly extirpated in Maryland and Ohio. The species is secure, apparently secure, or unranked in the rest of its range.

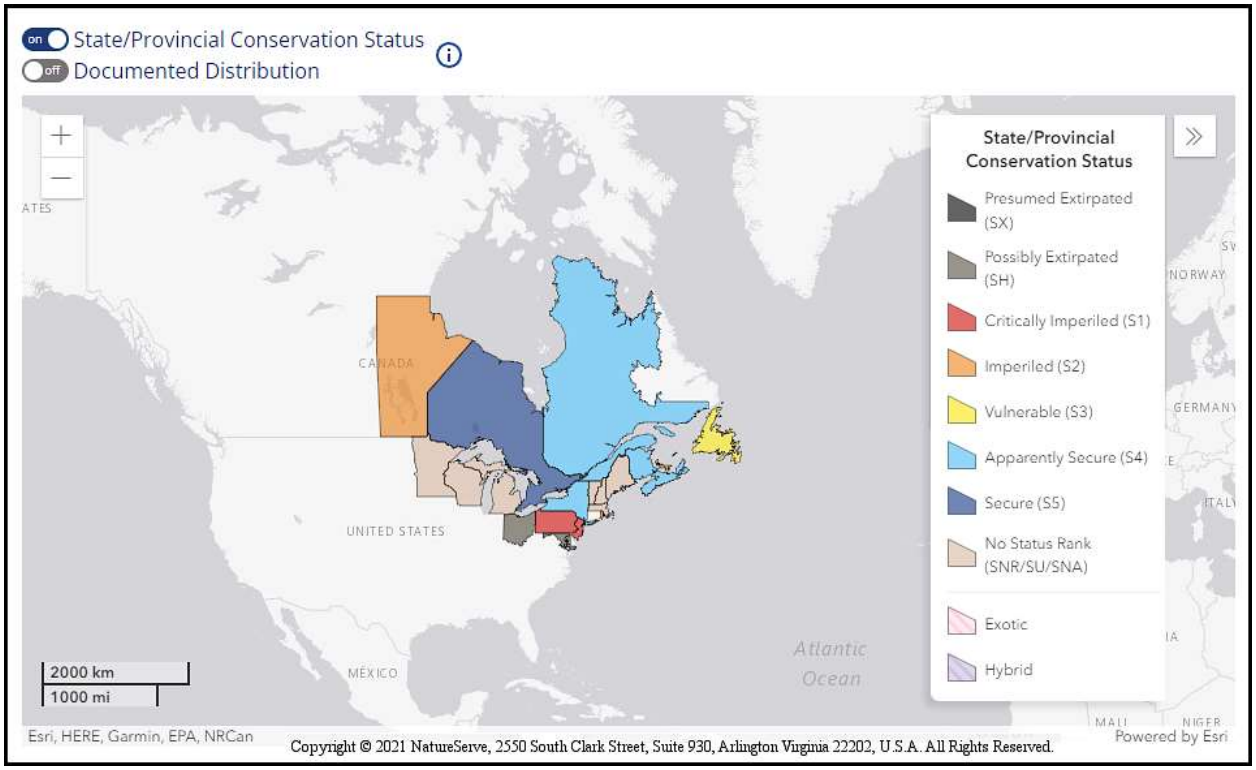


Figure 3. Conservation status of G. tesselata in North America (NatureServe 2022).

New Jersey is one of the two states where *Goodyera tesselata* is critically imperiled (NJNHP 2022). 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. *G. tesselata* also has a regional status code of HL, signifying that the species is eligible for protection under the jurisdictions of the Highlands Preservation Area (NJNHP 2010).

Goodyera tesselata was unknown in New Jersey until 1981, when a small population was discovered in Warren County (Wander and Wander 1985). The species was state-listed as S1.1 (critically imperiled and only known from a single location) for a number of years, but the site was subsequently destroyed and the orchid was reclassified from endangered to extirpated (NJ ONLM 1992, NJNHP 2014). The recent discovery of three new occurrences in Sussex County has re-established *G. tesselata* as extant but still critically imperiled in the state (NJNHP 2022).

Threats

As with most upland species in heavily developed regions, *Goodyera tesselata* can be threatened by habitat loss or degradation. New Jersey's original population was eradicated following the construction of a reservoir (NJNHP 2022). Davis (2018) searched locations in Ontario where *G. tesselata* had previously been documented and found that many of the sites had been paved over or showed signs of heavy human use, and the orchids were no longer present.

Threats from invasive plants have been reported at two of New Jersey's extant populations. *Microstegium vimineum*, *Berberis thunbergii*, and *Rosa multiflora* were identified as the species of concern (NJNHP 2022). Decaying leaves of *Berberis* can alter soil chemistry and decomposing *Microstegium* plants can raise soil pH (Kaufman and Kaufman 2007). Such changes could disrupt the composition of the fungal community upon which *G. tesselata* depends.

Overabundance of deer has been cited as a threat to many native orchids (Pace 2020), and excessive deer browse was noted as a potential threat to *Goodyera tesselata* in Pennsylvania (PANHP 2019). White-tailed Deer (*Odocoileus virginianus*) have caused extensive damage to populations of *Goodyera pubescens* in Quebec, consuming both the leaves and the inflorescences (Reddoch and Reddoch 2012).

Changing climactic conditions are causing temperatures to rise faster in New Jersey than in other parts of the northeast (Hill et al. 2020). Above average temperatures were cited as the possible cause for early blooming of both *Goodyera tesselata* and *G. repens* during the 1987 growing season (Barclay-Estrup et al. 1991). If plants and their pollinators do not respond to the warming climate in a synchronous manner, fertilization and seed set may be reduced. Severe weather can also harm individual occurrences; for example, damage from a severe hurricane and the subsequent cleanup eliminated a *Goodyera* population on Rhode Island (Bryan 1950). While tropical storms are usually most destructive in coastal areas, some inland portions of New Jersey experienced nearly complete tree toppling during Superstorm Sandy (Bilinski et al. 2015). Rising temperatures have already facilitated the northward expansion of the Southern Pine Beetle, *Dendroctonus frontalis*, (NJDEP 2010) and *Pinus spp*. in the canopy of *G. tesselata* habitats that have been weakened or killed by the beetles are more likely to fall. Extensive loss of pines to the beetles may also trigger successional changes that impact the fungal communities supporting Checkered Rattlesnake-plantain.

Management Summary and Recommendations

It is conceivable that *Goodyera tesselata* is expanding its range in New Jersey. *Pinus resinosa* was planted extensively by the Civilian Conservation Corps during the 1930s and early 1940s, and government-encouraged planting continued well into the 1960s (Butler 2018). The study of post-burn vegetation development in boreal forests by DeGrandpré et al. (1993) showed that *Goodyera* began to appear 74 years post-fire but the first age class where it was considered frequent on site was 143 years. The timing is not precise because the age classes of the study sites were unevenly spaced based on their fire history (26, 46, 74, 120, 143, 167, 174, and 230 years post-burn), but Red Pine plantations in New Jersey have reached an age range during which *G. tesselata* could be expected to colonize. Since several populations of Checkered Rattlesnake-plantain have been found in *P. resinosa* plantations, de novo surveys of comparable habitat might yield some new occurrences.

Comprehensive surveys of the three recently-discovered occurrences are recommended so that site-specific management plants can be developed. In addition to documenting the full extent of each population, monitoring visits can be used to evaluate whether there is a need to protect the *G. tesselata* plants from herbivory, intervene in the spread of invasive plants, or address other threats that may be noted at a particular site. Observations regarding stand age and other habitat characteristics may help to identify factors that make the sites suitable for the rare orchids, enabling more effective management of extant sites and focusing search efforts for additional populations.

NAOCC (2022) has underscored the need for research on North American orchids, noting that more than half of our native species are already listed as endangered or threatened. Some aspects of *Goodyera tesselata* have been examined, particularly around propagation. Starting with Loddiges' (1824) tips on how to maintain *G. tesselata* as a potted plant, cultivation studies have progressed to laboratory analyses of how substrate and fungi influence the species' germination, establishment, and growth (Arditti et al. 1981, Zale et al. 2022). However, there is still a great deal to be learned about how *G. tesselata* develops under natural circumstances; for example, the species' rate of growth, frequency of vegetative and sexual reproduction, and the length of time it may remain in a dormant state both as a seed and at maturity. While some headway has been made in identifying Checkered Rattlesnake-plantain's fungal associates, additional information is needed to determine whether those affiliations are narrow or flexible, whether connections remain stable or change as the plants develop, and the nature of its relationships (if any) with the canopy species. A better grasp on the complex inter-species bonds that support *G. tesselata* may explain the orchid's apparent affinity for conifer-dominated sites.

Synonyms

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

Botanical Synonyms	**Common Names**
Goodyera repens var. *tesselata* (G. Lodd.) B. Boivin	Checkered Rattlesnake-plantain
Peramium tesselatum (Lodd.) A. Heller	Tesselated Rattlesnake Plantain
Epipactis tesselata (G. Lodd.) A. A. Eaton	Loddiges' Rattlesnake Plantain
Orchiodes tesselatum (G. Lodd.) Kuntze	

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