

Solidago squarrosa

Stout Ragged Goldenrod

Asteraceae



Solidago squarrosa by Tom Norton, 2021

***Solidago squarrosa* 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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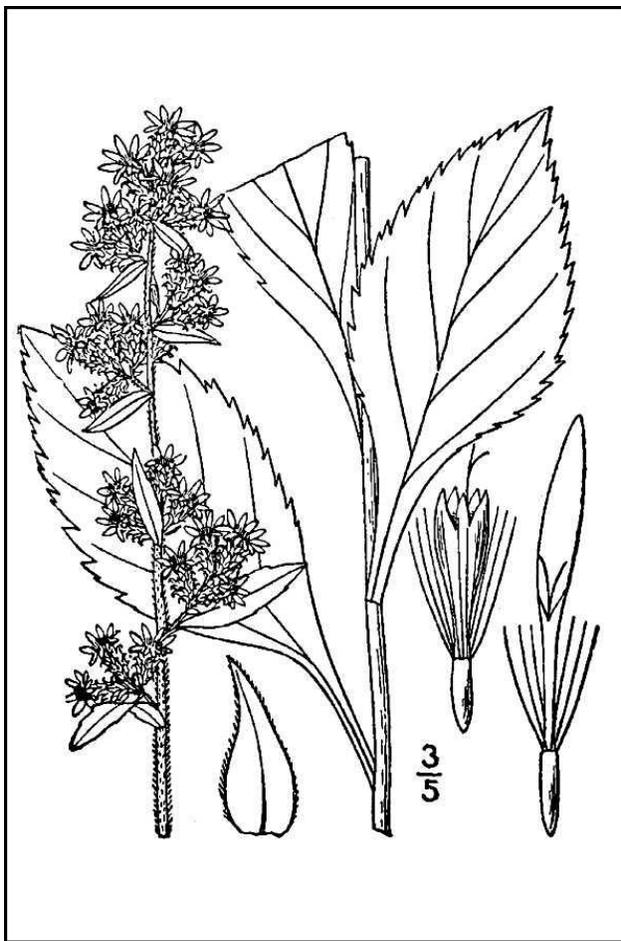
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Life History

Stout Ragged Goldenrod (*Solidago squarrosa*) is a native perennial forb that is a member of the Aster/Composite Family (Asteraceae). Plants grow 30–150 cm in height, with 1–5+ erect, simple, or rarely branched stems. The alternate stem leaves are “very unequal”, with the lowest being much larger than the upper ones (Britton and Brown 1913; Gleason and Cronquist 1963; Semple and Cook 2020; Strausbaugh and Core 1978). The upper leaves are sessile, 30–100 mm by 8–35 mm in size, oblong or acute oblanceolate, and mostly entire. Basal and lower leaf blades are ovate or broadly spatulate 30 or 50–200 mm in length and 8 or 20–100 mm wide and taper quickly to long, slightly winged petioles with ciliate margins (Britton and Brown 1913; Gleason and Cronquist 1963; Semple and Cook 2020; Strausbaugh and Core 1978). Sharply dentate, the upper side of the leaf lacks hairs, while the underside may be slightly pubescent especially along the veins.



Left: Britton and Brown 1913, courtesy USDA NRCS 2023a. Right: Mary Emily Eaton 1918, courtesy New York Botanical Garden.

There are 20–200 flower heads arranged close to the stem in axillary or terminal racemiform non-secund clusters; the inflorescence stem is pubescent. The involucre height is 5–9 mm with green and usually strongly recurved involucre bracts (phyllaries) that are distinctive and give the flower a “ragged appearance” (Britton and Brown 1913; Gleason and Cronquist 1963; Semple

and Cook 2020; Strausbaugh and Core 1978; Weakley et al. 2022). The flower heads are yellow with 15–30 tubular disk florets and 10–16 ray florets (Semple and Cook 2020).

Stout Ragged Goldenrod blooms in late summer and fall, August through September (Hough 1983; Semple and Cook 2020; Strausbaugh and Core 1978). The single-seeded fruits (cypselae) are glabrous, 1.5–2 mm, with 3–4.3 mm bristles (pappi) that help spread the wind-dispersed seeds (Semple and Cook 2020).

Pollinator Dynamics

Most goldenrod species are self-incompatible and require outcrossing by pollinators (Eastman 2003; Hilty 2020). While many believe that goldenrod pollen is the main cause of hay fever, in fact goldenrod pollen grains are relatively large, heavy, and spiny (Eastman 2003; Pollen Library 2023), which makes them cling better to pollinators. In comparison Common Ragweed (*Ambrosia artemisiifolia*) and other ragweed species that bloom at the same time as goldenrods are the primary culprits. Ragweed pollen is small (≤ 15 microns) and light, produced in great quantities, wind dispersed, and able to travel long distances (Scheppergrell 1917).

Goldenrods are considered of “special value” to native bees (Mader et al. 2011) as *Solidago* is a primary host plant genus for many specialist bees (Fowler 2016a, b). A diverse array of nectar and pollen-feeding insects visit goldenrods. Examples include Honey Bees (*Apis mellifera*), bumble bees (*Bombus* spp.), small carpenter bees (*Ceratina* spp.) and the Eastern Carpenter Bee (*Xylocopa virginica*), Halictid bees (*Halictus* spp.), and plasterer bees (*Colletes* spp.). Although each individual goldenrod floret is small and doesn’t contain much pollen or nectar, the aggregation of so many florets together in one inflorescence provides sufficient resources to make them an important pollinator resource, especially for bumble bees (Heinrich 2004). Wasps will also serve as inadvertent pollinators as they search for nectar for themselves or for insects to feed to their young. Additional visitors to goldenrod include beetles such as soldier beetles (*Chauliognathus pennsylvanicus*), lightning bugs (*Ellychnia* spp.), and locust borers (*Megacyllene robineae*); and assorted flies including Syrphid flies (e.g., *Toxomerus marginatus*), Tachinid, and blowflies (Calliphoridae). Many butterfly and moth species also pollinate goldenrod; examples include Common Sulphur (*Colias philodice*), American Copper (*Lycaena phlaeas*), Monarch (*Danaus plexippus*), swallowtail butterflies (*Papilio* spp.), Gray Hairstreak (*Strymon melinus*), and skippers (*Polites* spp.). Selected visiting moths include the Black-and-yellow Lichen Moth (*Lycomorpha pholus*), Virginia Ctenucha (*Ctenucha virginica*), Ailanthus Webworm (*Atteva aurea*), and Goldenrod Stowaway (*Cirrhophanus triangulifer*) (Eastman 2003; see also Hilty 2020. While specific information is not available for *S. squarrosa*, Hilty does provide flower-visiting insect lists for many other goldenrod species). In addition to pollinators, many goldenrod species are hosts to gall insects. Gagné (1968) lists *S. squarrosa* as a host for *Asteromyia carbonifera*, a gall-forming midge in the Cecidomyiidae (Diptera family).

Interestingly, *Solidago squarrosa* has extrafloral nectaries located on the flower bracts below the flower head and, according to Montreal Space for Life (2023), it is the only North American goldenrod species to have them. Extrafloral nectaries are nectar-producing glands found on any plant tissue apart from the flower or roots, for example, on leaves, petioles, stipules, or bracts.

They are typically used by the plant to attract insects or parasitoids that indirectly aid in plant defense against herbivores (Becerra and Venable 1989; Heil 2011). Carter (1892) observed numerous insects (e.g., Honey Bees, bumble bees, wasps and other small Hymenoptera, flies, beetles, and butterflies) visiting *Solidago squarrosa* in the fall *after* the flowers had withered and found the insects feeding from extrafloral nectaries. She noted that in some tropical plant species with extrafloral nectaries, ants were attracted to the nectar and their presence and activity helped protect the plant from insect herbivores. However, she did not observe many ants on the *S. squarrosa* involucres at that time. She also noted that insects continued to visit those extrafloral nectaries for at least two weeks after the flowers were gone, until cold weather.

Seed Dispersal

Seed dispersal in all goldenrods, including *S. squarrosa*, is by wind. Each fruit produces only a single seed 1.5–2 mm in length with a 3–4.3 mm plume of fine white bristles that readily catch the wind (Gleason and Cronquist 1963; Native Plant Trust 2023; Semple and Cook 2020; Strausbaugh and Core 1978). Fruiting occurs in September and October (ODNR 2020). Research on the related Canada Goldenrod (*Solidago canadensis*) in Ohio found that an average of 3,070 seeds were produced per plant and were dispersed up to 0.6 m (2 ft) away (at wind speed 5 mph) from the parent plant (OSU 2023). However, on windier days it is likely that seeds would disperse much farther. Seed production and dissemination in *Solidago squarrosa* would differ somewhat given the difference in the size and structure of its inflorescence and the fact that *S. canadensis* typically grows in expansive colonies in open fields (vs. in the less open forested habitat favored by *S. squarrosa*).

Goldenrod seeds are fed upon by game birds such as Ruffed Grouse (*Bonasa umbellus*), as well as passerines including American Goldfinch (*Carduelis tristis*), Northern Junco (*Junco hyemalis*), Pine Siskin (*Carduelis pinus*), Swamp and Tree Sparrows (*Melospiza georgiana* and *Spizella arborea*, respectively), and mammals such as meadow mice (*Microtus* spp.) (Martin et al. 1951). Those seed-eating animals may also help disperse seeds either by carrying any seeds that become tangled in their fur or feathers or by defecating ingested seeds in a new location post consumption.

Little information about germination was found specifically for *S. squarrosa*; however, the seeds of related *S. altissima*, *S. gigantea*, and *S. graminifolia* were found to germinate readily on many different soil types (Weber 2001) and *S. squarrosa* may exhibit the same capacity. Seeds of *S. canadensis* requires light to germinate and should be surface sown (ORGHPS 2023). Similarly, some plant propagators have found that *S. squarrosa* seeds also require surface sowing and 60 days cold, moist stratification (Beaux Arbres Native Plants 2023), but more research is needed. While many goldenrod species have rhizomes and spread vegetatively once established, there is no indication that *S. squarrosa* does the same. Instead, *S. squarrosa* has an underground caudex from which new growth emerges (Native Plant Trust 2023).

Allelopathy has also been reported in some goldenrod species as the plants contain diterpenoid alkaloid compounds that may contribute to an inhibitory effect on germination of nearby plant species (Eastman 2003). Although some allelopathic effect has been demonstrated in the lab, the

degree to which those chemicals affect plant community structure in nature is variable and dependent on multiple factors. Such factors may include weather conditions, soil community composition, and/or the presence of insect herbivores. Another factor may be whether the goldenrod is growing in its native range as the allelopathic effect has been found to be much stronger in populations of North American goldenrod species that were introduced to Europe (Pisula and Meiners 2010).

Habitat

Throughout its range, Stout Ragged Goldenrod is found on dry to mesic rocky wooded hillsides, mountain slopes, rocky bluffs, and along shaded forest edges (Hough 1983; LeGrand et al. 2023; Native Plant Trust 2023; Semple and Cook 2020; Strausbaugh and Core 1978; Weakley et al. 2022). It is also found in anthropogenic habitats—along trail edges, roadsides, open banks, or in clearings, fields, and meadows (Native Plant Trust 2023; Semple and Cook 2020). Plants have been found growing to 610 m (2,000 ft) in the Catskills (Britton and Brown 1913) and up to 1,000 m + (3,280 ft) in elevation elsewhere (Semple and Cook 2020).

In Indiana, at the western edge of the goldenrod's range, Deam (1940) reported *S. squarrosa* from only one location. At that site, the plants were scattered from top to bottom along the north facing slope of a 46 m (150 ft) deep forested hollow. Associated species at the top of the rise included Virginia Pine (*Pinus virginiana*), Chestnut Oak (*Quercus montana*), Black Oak (*Q. velutina*), and *Vaccinium* spp.

In New Jersey, one population occurs along exposed red shale bluffs in dry, thin soil and in rock crevices. Overstory trees noted at that location included Chestnut Oak, Scarlet Oak (*Q. coccinea*), and American Beech (*Fagus grandifolia*). Other New Jersey *S. squarrosa* populations have been found on traprock, one on a hillside in open woods and another in an area of scattered boulders just below a rocky outcrop. Plants have also been found on limestone substrate in three different microhabitats— at the edge of a small lake, in moist soil along a trail through an Eastern Hemlock (*Tsuga canadensis*) grove, and along an open ledge on a steeply sloping hillside (NJNHP 2022).

Most land plant species have mycorrhizal associations that aid them in nutrient uptake (Wang and Qiu 2006) and goldenrods are no exception. A review of the literature by those authors identified seven species of *Solidago* (*S. altissima*, *canadensis*, *chilenensis*, *gigantea*, *graminifolia*, *litoralis*, and *virgaurea*) that had an association with arbuscular mycorrhizae. Although no information about *Solidago squarrosa* was found during the review, it is likely that this species has a similar relationship with mycorrhizal fungi.

Wetland Indicator Status

Solidago squarrosa is not included on the National Wetlands Plant List (NWPL). Any species not on the NWPL is considered 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 2023b)

SOSQ

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 global range of *Solidago squarrosa* is restricted to the eastern United States and Canada (POWO 2023). The map in Figure 1 depicts the extent of Stout Ragged Goldenrod in North America.

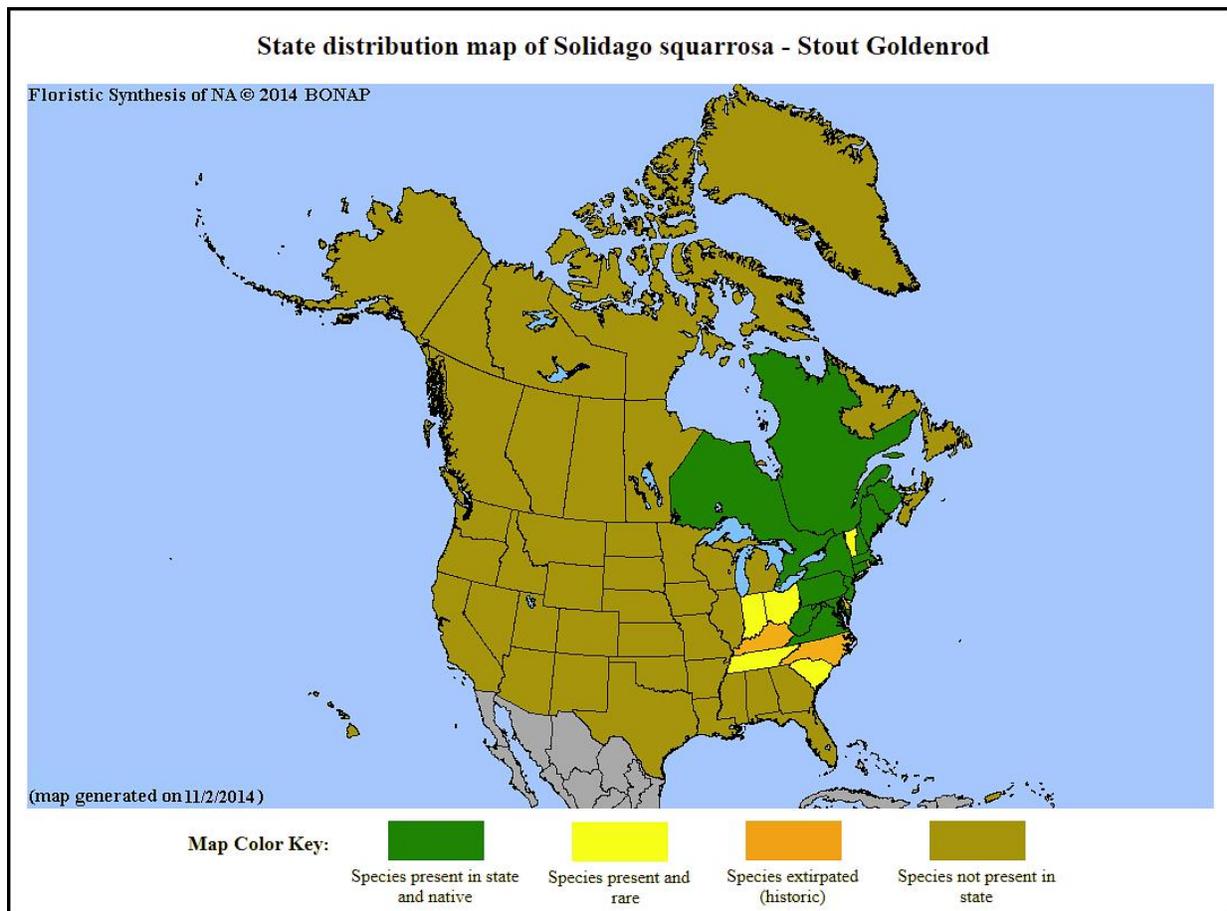


Figure 1. Distribution of *S. squarrosa* in North America, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2023b) shows records of *Solidago squarrosa* in eight New Jersey counties: Bergen, Hunterdon, Middlesex, Morris, Somerset, Sussex, Union, and Warren

(Figure 2). The data include historic observations and do not reflect the current distribution of the species.

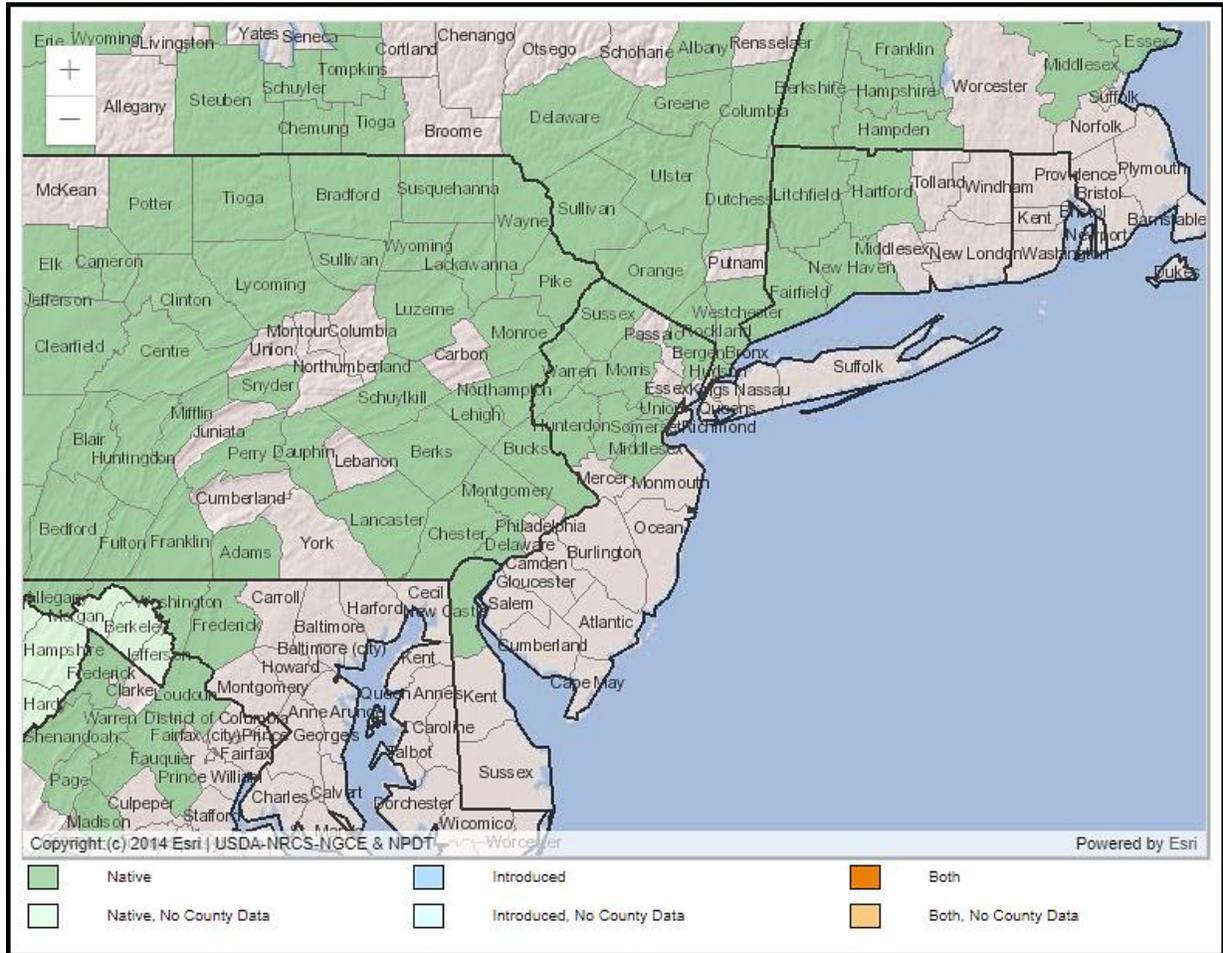


Figure 2. County records of *S. squarrosa* in New Jersey and vicinity (USDA NRCS 2023b).

Conservation Status

Solidago squarrosa has a global rank of G4G5, meaning there is some uncertainty as to whether it should be considered apparently secure or secure. A G4 species has a fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, although there is some cause for concern as a result of local recent declines, threats, or other factors. A G5 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). The map below (Figure 3) illustrates the conservation status of *S. squarrosa* throughout its range. Stout Ragged Goldenrod is vulnerable (moderate risk of extinction) in one state and one province, imperiled (high risk of extinction) in two states, critically imperiled (very high risk of extinction) in three states, and possibly extirpated in Delaware and Kentucky. In other parts of its range the species is secure, apparently secure, or unranked. It is reported to be common in the Laurentian Mountains and found north to Abitibi, Quebec, Canada (Montreal

Space for Life 2023). However, the exact location of the northern range extent in Canada and *S. squarrosa*'s distribution in some other locations at the southern edge of range need additional evaluation (Semple 2022).

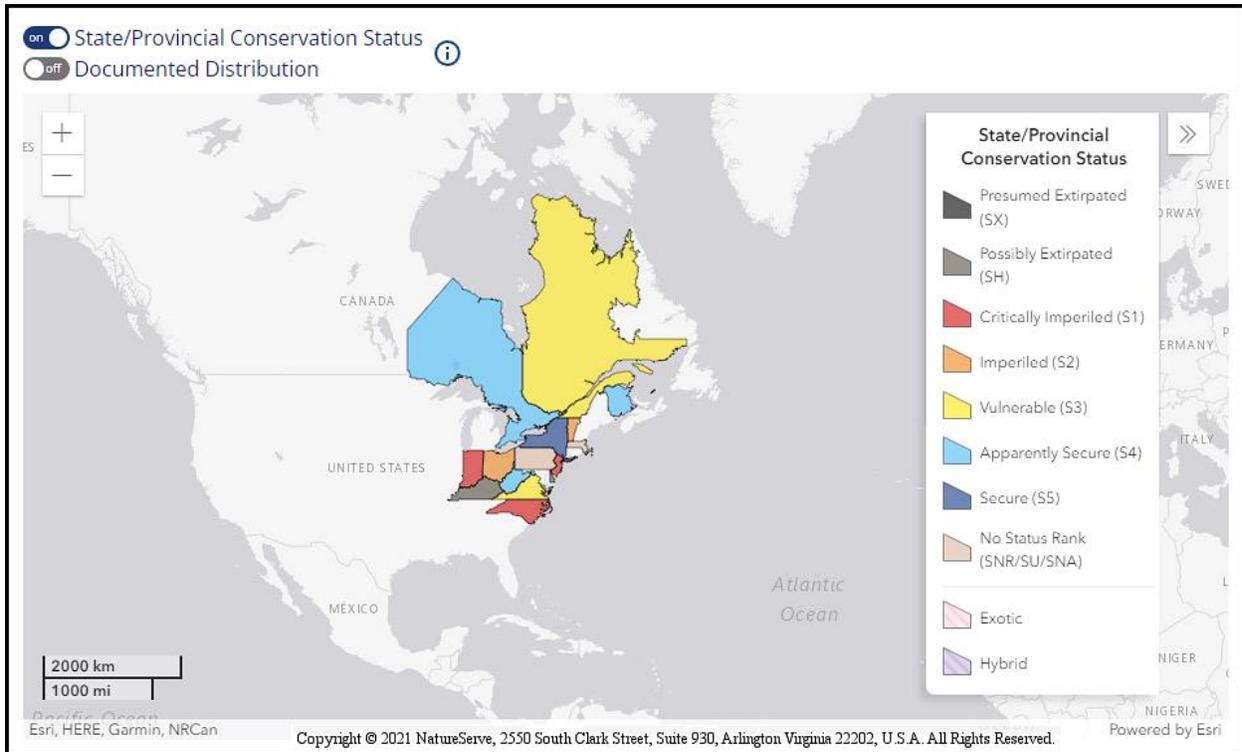


Figure 3. Conservation status of *S. squarrosa* in North America (NatureServe 2023).

New Jersey is one of the states where *Solidago squarrosa* 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. *S. squarrosa* has also been assigned a regional status code of HL, signifying that the species is eligible for protection under the jurisdiction of the Highlands Preservation Area (NJNHP 2010).

During the late 1800s and early 1900s, *Solidago squarrosa* was not particularly rare in the northern and central regions of New Jersey (Britton 1889; Keller and Brown 1905; Taylor 1915). However, over the past few decades the state status of the goldenrod has been rapidly upgraded from somewhat vulnerable (S3S4) to imperiled (S2) to critically imperiled (S1) (e.g., NJNHP 2001, 2010, 2019). Of six known occurrences, the species is presently considered extant at four locations in three counties, with one occurrence ranked as “failed to find” and the other as “possibly extirpated” (NJNHP 2022).

Threats

Solidago squarrosa populations in New Jersey are threatened by invasive plant species and deer herbivory. The presence of invasive plant species was noted at three New Jersey occurrences and

while the only species specifically named at one site was Autumn Olive (*Elaeagnus umbellata*), other invasive plants are likely present (NJNHP 2022). A resurvey of New Jersey occurrences would clarify which invasive species are most threatening and help to prioritize management needs. Deer herbivory was so extensive at two occurrences that any remaining *S. squarrosa* plants were restricted to mostly inaccessible locations on the steep cliff face. Another threat identified at some New Jersey sites was habitat erosion caused by deer use and human recreational exploration, especially of the steep slope and cliff sites (NJNHP 2022).

In addition to non-native invasive species, the Ohio Department of Natural Resources (ODNR 2020) include grazing and “over-shading by woody species” resulting from succession as threats to Ohio populations. Range wide, there is no mention of disease or habitat fragmentation as current threats, although there are populations of Stout Ragged Goldenrod that are quite isolated.

Climate change is a threat to all populations of *S. squarrosa*. Climate migration models for *S. squarrosa* show a northward spread of the range boundary well into central Quebec with a contraction of the southern boundary out of New Jersey over the coming decades (Natural Resources Canada 2023). New Jersey is projected to become warmer and wetter with altered precipitation patterns that may lead to hotter drier summers and periods of summer drought (NJDEP 2020). While *S. squarrosa* can be found in mesic to dry sites, it seems to be found more often in drier upland forests and ridges with thin soil; those populations on drier, more exposed slopes may become stressed in the coming years.

Management Summary and Recommendations

In Ohio, the ODNR (2020) suggests that *S. squarrosa* may respond favorably to canopy thinning in response to forest succession and that planting/restoring plants to its native habitat may be a useful management tool. Preventing grazing in forests that may harbor *S. squarrosa* as well as controlling invasive plant species is also recommended.

In New Jersey, the three sites last visited in 2008 (ranked as “failed to find”, “possibly extirpated”, and “poor viability”) should be revisited for a more definitive assessment of population status and EO rank. The other three sites were last visited in 2012 and warrant a revisit to confirm rank and assess the ongoing impact of invasive species encroachment, deer herbivory, and recreational use in and adjacent to the occurrences. Depending on the results of new site monitoring, management activities such as invasive species removal and deer management (whether population control or fencing on site), trail rerouting, and/or stabilization of steeper ridges supporting goldenrod may be needed to support the continued persistence and possible expansion of those Stout Ragged Goldenrod populations.

In addition to specific management needs, as mentioned above in Conservation Status a more detailed evaluation about the exact southern and northern range extent of *S. squarrosa*’s distribution (Semple 2022) would be helpful. Additional research about the optimal germination requirements for *S. squarrosa* as to whether seeds do require light and surface sowing and/or cold stratification to germinate would be beneficial to conservation efforts. It would also be

important to better understand how readily *S. squarrosa* can colonize new habitat, since it does not appear to spread vegetatively.

The future effects of climate change on remaining *Solidago squarrosa* element occurrences in New Jersey are not clear. Given the shift to a drier summer climate, the persistence of *S. squarrosa* on drier upland and ridgetop sites with thinner soil even if partially shaded, may be in question. In more mesic habitats, such as the hemlock grove occurrence, population persistence may be possible for a time. The best management may be to reduce other threats to *S. squarrosa* at its remaining sites as much as possible.

Synonyms

The accepted botanical name of the species is *Solidago squarrosa* Nutt. Orthographic variants, synonyms, and common names are listed below (ITIS 2021; Montreal Space for Life 2023; Natural Resources Canada 2023; ODNR 2020; POWO 2023; Semple and Cook 2020; USDA NRCS 2023b).

Botanical Synonyms

Aster muehlenbergianus Kuntze
Solidago confertiflora Nutt.
Solidago squarrosa var. *ramosa* Peck
Solidago squarrosa f. *ramosa* (Peck) House
Solidago squamosa Nuttall ex Hooker

Common Names

Stout Ragged Goldenrod
Stout Goldenrod
Squarrose Goldenrod
Leafy Goldenrod
Rugged Goldenrod
Bracted Goldenrod

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