New England Plant Conservation Program

# *Solidago rigida* L.
# Stiff Goldenrod

## Conservation and Research Plan for New England

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# SUMMARY

*Solidago rigida* L. (Asteraceae) is an herbaceous fall-flowering perennial common in the prairie region of the United States and Canada, uncommon in eastern states. In Connecticut, the species occurs at only three sites; in Rhode Island and Massachusetts, it is historic. One of the Connecticut sites is in the northwest limestone region of the state, while the others are along the coast. The same disparity of habitats – from limestone to coastal – was found in the historic records, while the historic Rhode Island populations were found on inland sandy soil. Herbarium records give some indication, though infinitely debatable, that the species was at one time more widespread in Connecticut.

Three subspecies have been recognized, with all northeastern populations belonging to *Solidago rigida* ssp. *rigida.* There is considerable overlap in the Midwest between subspecies *rigida* and *Solidago rigida* ssp. *humilis*, and interpretation of the available ecological and species biology literature on *Solidago rigida* is made difficult by the fact that virtually all life history studies have been performed on midwestern populations with no designation as to subspecies. A large unknown, therefore, is whether subspecies *rigida* has different survival parameters from the other subspecies, but the author's limited observations of the species in Connecticut coincide with those made by researchers in the Midwest, indicating that at least some parameters are similar.

Available information on *Solidago rigida* indicates that across its range, the species grows in a wide variety of mesic to xeric soils, but that subspecies *rigida* shows calciphilic tendencies. *Solidago rigida* is a common component of native tallgrass and mixed grass prairie, but also grows along roadsides, in old fields, disturbed prairies, overgrazed range, open woods, and rocky outcrops. The species has proven easy to germinate and grows readily under cultivation in full sun to partial shade. *Solidago rigida* in the Midwest benefits from fire and grazing.

Threats to the species in Connecticut are shading, deer browse, human disturbance, and competition. The recommended conservation objective is reinvigoration of the inland site to a population of at least 20 flowering stems and maintenance of the shoreline populations at an average of 100 - 150 flowering stems per year over five years, realizing the possibility of fluctuation. The recommended conservation actions are regular surveys, searches for new populations, seed banking, site management, and landowner education. Site management for two of the three sites would be quite simple, consisting of manual control of competing vegetation.

# PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Because they contain sensitive information, full plans are made available to conservation organizations, government agencies and individuals with responsibility for rare plant conservation. This excerpt contains general information on the species biology, ecology, and distribution of rare plant species in New England.

NEPCoP is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

In 1996, NEPCoP published "*Flora Conservanda*: New England," which listed the plants in need of conservation in the region. NEPCoP regional plant Conservation Plans recommend actions that should lead to the conservation of Flora Conservanda species. These recommendations derive from a voluntary collaboration of planning partners, and their implementation is contingent on the commitment of federal, state, local, and private conservation organizations.

NEPCoP Conservation Plans do not necessarily represent the official position or approval of all state task forces or NEPCoP member organizations; they do, however, represent a consensus of NEPCoP's Regional Advisory Council. NEPCoP Conservation Plans are subject to modification as dictated by new findings, changes in species status, and the accomplishment of conservation actions.

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection. If you require additional information on the distribution of this rare plant species in your town, please contact your state's Natural Heritage Program.

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# I. BACKGROUND

## INTRODUCTION

*Solidago rigida* L. (Asteraceae) is an herbaceous perennial most often associated with native tall-grass and mixed-grass prairies. The most frequently used common name is stiff goldenrod, but other names in print are rigid goldenrod, stiff-leaved goldenrod, hard-leaved goldenrod (Peterson 1968, Newcomb 1977) or rigid-leaved goldenrod (Torrey 1843). *Solidago rigida* is common in the Midwest, but rare in the East. This document reports on the status of *Solidago rigida*, examines the factors that encourage or discourage the survival of the species, and makes recommendations for its conservation in New England.

## DESCRIPTION

*Solidago rigida* is easily distinguished from other goldenrods by its stiff, short, ovate leaves, its yellow flat-topped inflorescence, and its relatively large flower heads. Plants grow 2.5-15 dm high. The stem and leaves are covered with short spreading hairs, though this is not a salient feature of the plant. Basal leaves, when they are present, are firm, slightly toothed or entire, and vary in shape from elliptic to elliptic-ovate or broadly lanceolate to broadly ovate. The roundish to acute blade, 6-25 x 2-10 cm, is often exceeded in length by the petiole. The sessile cauline leaves are noticeably short, rounded and stiff. The corymboid inflorescence is 5-25 cm wide, and the heads are relatively large with the disk 5-10 mm wide and the involucre 5-9 mm wide. The striate bracts are firm and broadly rounded. Ray flowers, 3-5 mm long, number from 7-14, disk flowers 17-35. The turgid or angular achenes are 10-20-nerved (Gleason and Cronquist 1991).

## TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

*Solidago rigida* is a member of the Asteraceae, the Daisy Family, and was first described by Linnaeus. Small (1903) placed the species in the genus *Oligoneuron* Small, but *Solidago rigida* is the name currently in use. Heard and Semple (1988) defined three subspecies, based on morphology and geography: ssp. *rigida,* ssp. *humilis,* and ssp. *glabrata.* Subspecies *rigida,* with coarse pubescence and an open inflorescence, occurs from Connecticut to Tennessee, west to eastern Oklahoma, eastern Kansas and Iowa, southern Minnesota, Wisconsin and Michigan and southwestern Ontario. Subspecies *humilis,* which the authors consider the western prairie race, with fine pubescence and a compact inflorescence, overlaps in Minnesota, Wisconsin, Nebraska, Missouri, Oklahoma, Michigan, Illinois, Indiana, and Iowa. Subspecies *glabrata,* relatively glabrous, occurs mainly in the southeast, from northeast Texas to North Carolina, but overlaps in Tennessee, Virginia, Kentucky, and Ohio. The vast majority of the sources

consulted for this plan predate this work and, therefore, make no distinction among subspecies. Though the taxonomic sources that follow this work do recognize the subspecies, none of the later sources which touch on life history characteristics of *Solidago rigida* distinguish among the subspecies. This makes interpretation of some of the literature problematic. There is considerable geographical, habitat and morphological overlap in the Midwest of subspecies *rigida* and *humilis,* and a little overlap between subspecies *rigida* and *glabrata*. Most of the literature focuses on midwestern populations, and except in the few cases where the subspecies can be inferred by geography, there is no indication as to which subspecies was studied. If the subspecies being studied was *humilis*, there exists the possibility that observations on midwestern plants would not apply to northeastern populations.

The differences noted by Heard and Semple (1988) are mainly in the pubescence of the stem, leaves and phyllaries. They also note a difference in size, with subspecies *rigida*, interestingly, often being larger than subspecies *humilis*. They also note a difference in corolla depth, with *rigida* and *glabrata* having deeper corollas than *humilis*. This difference could have a bearing on pollinators.

Schmidt and Jurgenson (1999) and Samuels and Jurgenson (1999) performed DNA analysis on *Solidago rigida* specimens from different latitudinal zones of Iowa to determine the validity of current planting zones and to ascertain genetic mixing due to plantings. Their findings, which the authors emphasized were preliminary, showed little genetic variance within the state, suggesting considerable natural genetic mixing and negating the need for narrow planting zones. This study did not acknowledge the subspecies variation. Since the zones considered were latitudinal rather than longitudinal (the determining correlation with the distribution of subspecies), and since it is not clear which subspecies was being studied, this study is perhaps not relevant to New England populations, except perhaps to suggest that – at least in Iowa – pollinators are not restricted to a small geographical range.

## SPECIES BIOLOGY

Though *Solidago rigida* is mentioned in at least 60 scientific journal articles, the context is usually that of a species list from a prairie study plot. Few articles deal directly with the growth and survival parameters of the species individually. Similarly, though *Solidago rigida* is included in over 150 Web sites (as demonstrated by a search using www.AltaVista.com), again the context is often that of a species list for a natural area, or a seed list from a nursery specializing in native prairie species, with no detailed information on the species itself. However, many observations can be gleaned from both of the above venues, with the above subspecies issue in mind, and much can be inferred from observations on communities containing *Solidago rigida*. Some of the available information is contradictory, but enough exists to provide guidance in formulating a conservation plan.

### *General Growth Habit*

*Solidago rigida* is a perennial, but information on its longevity has not been found. In its first year, the plant produces a basal rosette; it has been found to produce a flowering stalk in the second or third year. Though an illustration of the plant's life cycle in Platt and Wies (1977) shows the basal leaves persisting at the time of flowering, this is inconsistent with the author's observations and with evidence from herbarium sheets, in which the flowering stems have no basal leaves. Whether this is due to withering by the time of flowering, or whether these stems never produce basal leaves is not clear.

Sperry (1935), examining plants in poorly drained and well-drained brown silt loams of Illinois, found the root system to be fibrous, extending to depths of about one to 1.4 meters, similar to those of many of its associates. Platt (1975), however, states that the roots of fugitive species (which he considers *Solidago rigida* to be) are "relatively shallow." Connecticut herbarium specimens show a thick caudex with numerous relatively thick parallel roots emanating along the caudex for a centimeter or two. Most of the roots appear to have broken in the collecting process, making it difficult to ascertain total root length. Since many Connecticut populations occur on extremely shallow soils, it is difficult to imagine deep fibrous root systems typical of prairie plants; needless to say, the author has not excavated plants to examine the roots. Overall, it appears that the root system is variable.

### *Reproduction*

*Solidago rigida* flowers in the late summer and autumn. Most wildflower guides list August through October as the flowering period, with some noting that it will flower till frost (Oak Prairie Farm 2001). Havercamp and Whitney (1983), studying Ohio populations, noted a flowering period of 30 to 39 days. In Connecticut, the author has noted a fairly short flowering period around mid-September. By October, the Connecticut flowers have withered.

Compared to other goldenrods, the flower heads and the flowers themselves are large and few. Havercamp and Whitney (1983) found a mean of 1,524 flowers per plant, while Platt (1975), in Iowa, found a mean of 450, compared to a mean of 9,700 flowers per stem for *Solidago canadensis*. Havercamp and Whitney (1983) consider *S. rigida* to be an obligate outcrosser, pollinated by a wide variety of insects. Though the latter conclusion is based on flower form rather than observation or testing, it is borne out by comments in prairie nursery literature that the species attracts many individuals and many species of insects including honey bees (Oak Prairie Farm 2001), ladybirds, lacewings, hoverflies (Gardenbed 2001) and butterflies (Lindgren et al. 1993, Michigan State University 1998, Wild Birds Unlimited 1998). In fact, *Solidago rigida* is recommended for plantings designed specifically to attract butterflies (Michigan State University 1998, Wild Birds Unlimited 1998). Steve Young, botanist with the New York Natural Heritage Program (personal communication), notes seeing "a lot of bumblebees pollinating the flowers" in one population. Anderson and Schelfhout (1980) found that, in a prairie

setting, interspecific competition for pollinators was reduced by the fact that morphologically similar flowers bloomed at different times. Though the author has never noticed large swarms of insects on the Connecticut flowers, this could be due just to chance or to unfocussed observation. There has been no quantification of seed set in local or Midwestern populations but two circumstances imply that seed set is adequate in New England populations. One is the fact that staff from New England Wildflower Society felt comfortable collecting 673 seeds from the inland population in 1996 (W. Brumback, New England Wildflower Society, personal communication). The other is the known persistence of the species at one coastal site for 119 years, perhaps the result of extremely long-lived plants, but probably also due to seed reproduction at some point.

A prairie nursery has measured an average of 41,000 seeds/ounce. These were lighter than those of 31 other prairie forbs offered for sale and lighter than all grass seeds offered, but heavier than those of 11 other forbs (Prairie Frontier 2001). Havercamp and Whitney (1983) compared seed weights of 46 prairie species and found *Solidago rigida* seeds, with a mean weight of 67 mg, to be a little over the mid-range of seed weight. Platt (1975) considers *Solidago rigida* to have relatively heavy seeds, as befits a xeric species which must penetrate dry soil. The pappus is smaller than that of other goldenrods. The seeds are presumed to spread by the wind, aided by the pappus (Platt 1975, Havercamp and Whitney 1983), but no studies were found of specific tests or observations. Platt (1975) considers the dispersal ability to be limited but does not present data to this effect. Sedivec and Barker (1997), working outside of the range of subspecies *rigida*, report that *Solidago rigida* seeds are eaten by songbirds and small rodents, but no information has been found as to whether seed predation is a significant factor in reproduction or dispersal.

The only information on germination in the wild is from Platt (1975), who found *Solidago rigida* to germinate readily on badger mounds, piles of dirt in an Iowa prairie created by badgers digging to capture ground squirrels. Several organizations and individuals, most of them in the Midwest, have performed germination tests in greenhouses, with mainly positive results. Chatfield (2000) reports that germination is "often poor," but most other workers have obtained 50 to 100% germination (Bezanson 1997, Oak Prairie Farm 2001, Ohio State University 2001, Brumback, personal communication). The fact that *Solidago rigida* seed is offered by so many (22 on www.AltaVista alone) nurseries and that it is recommended for ornamental uses (Chicago Botanical Garden), prairie restorations (Myers 2001), and highway roadside plantings (Schramm 1968) implies that germination is relatively uncomplicated. Though Ohio State University students obtained 70% germination in petri dishes with no cold treatment, rates were higher (100%) with cold treatment, and other sources (Bezanson 1997, Oak Prairie Farm 2001) state that cold stratification is required. Though again, we have no way of knowing which subspecies were tested in any of these trials, we do know that Brumback at the New England Wildflower Society achieved relatively good results with seed collected from Connecticut, presumably of subspecies *rigida*. These trials are discussed in greater detail in the section entitled "Current Conservation Measures in New England."

*Solidago rigida* reproduces vegetatively on a very limited scale with short, leafy shoots that emerge alongside the flowering stem from the caudex. The caudex can spread one to two inches per year, eventually dying in the center and leaving a bare area (Mueller 1941). The author has not observed this phenomenon in Connecticut populations, but this could be because of the rocky substrate on which most of them are found. Mueller (1941) also found adventitious buds rising from horizontal roots, but noted the plants spreading no more than .25 square feet (7.5 cm) in two years.

## HABITAT/ECOLOGY

### *Habitat and Soils*

*Solidago rigida* occupies a range of habitats. The following are among those cited in popular wildflower guides for the Midwest. In brackets are the state covered by the book and the subspecies found there. None of these sources distinguishes among subspecies.

- Prairies, dry open areas (Eisendrath 1978) [Missouri: *rigida*, *humilis*, *glabrata*]
- Prairies, roadsides (Moyle 1977) [Minnesota: *rigida*, *humilis*]
- Rocky soils (Wilson 1963) [Kansas: *rigida*, *humilis*]
- Dry prairies and plains (vanBruggen 1976) [Iowa: *rigida*, *humilis*]
- Dry to mesic prairies to moist prairies; also in open woods (Christiansen and Muller 1999) [Iowa: *rigida*, *humilis*]
- Dry prairies of the Calumet district (Peattie 1930) [Indiana: *rigida*, *humilis*]
- Sandy soil (Lomassen 1973) [Nebraska: *rigida*, *humilis*]

The scientific literature usually includes *Solidago rigida* as a component of prairies but also includes studies of the species growing in old fields (Wiegert and Evans 1964). Several currently recorded sites in New York State are old fields (Young, personal communication). Sources that cover a broad geographical range cite the following habitats:

- Sandy or gravelly woods (Newcomb 1977)
- Dry thickets, sandy soil, prairies (Peterson 1968)
- Prairies and other dry, open places, especially in sandy soil (Gleason and Cronquist 1991)

*Solidago rigida* has been cited as growing many kinds of soil from sandy and rocky to silty to heavy clay (Mueller 1941, Curtis and Partch 1948, Hardin 1988, Patton and Nyren 1998). The only type not mentioned is poorly drained soil. Gardeners and nursery operators have had success growing the species in a variety of soils (Gardenbed 2001, Oak Prairie Farm 2001). Chatfield (2000) states that *Solidago rigida* "will grow well in most soils."

Habitats cited for the northeastern states – presumably populations of subspecies *rigida* – include dry hillsides, usually in rocky places (Torrey 1843) and dry fields and open woods (Graves et al 1910). Habitats noted in New York State records include dry, rocky soil, limestone ledges, and old fields. Habitats noted on Connecticut herbarium specimens include: dry, sandy, and rocky soils; salt marsh margins; limestone ledges; and sandy or rocky woods (see Appendix 2). Of the current Connecticut populations, all occur on very dry sites: one on a steep, west-facing, limestone ledge, the others in sandy or rocky soil near the coast. The historic Massachusetts and Rhode Island sites included limestone ledges and sandy soils. In Virginia, *Solidago rigida* shows a decided preference for dry or clayey soils derived from magnesium-rich bedrock (Tom Rawinski, Massachusetts Audubon Society, personal communication). At such glades and barrens in Virginia, *Solidago rigida* often occurs with other rare species, including the globally rare *Tomanthera auriculata, Echinacea laevigata,* and *Clematis addisonii.*

Palmer and Steyermark (1935), in *The Flowering Plants of Missouri*, label the species "circumneutral to calciphile." Rhoads and Block (2000), in *The Plants of Pennsylvania,* note its habitat as "moist fields or thickets on calcareous soils." Heard and Semple (1988) identify the habitat of subspecies *rigida,* the northeastern race of the species, as "Glades, savannahs, dry open areas, especially on calcareous soil." Indeed, several northeastern occurrence records are from calcareous sites: two of the existing eleven New York State sites and one in Connecticut (a limestone ledge with a soil pH of 8.0 [Ken Metzler, Connecticut Natural Diversity Data Base, unpublished data]). One of the two historical sites in Massachusetts is in the town of Sheffield, in the Berkshire Mountains, a limestone area. It is also possible that sites not overtly calcareous might actually be so, perhaps on a very small scale. For instance, Robert Zaremba of The Nature Conservancy (personal communication) notes that one of the New York State sites – though at first glance looking like a typical old field – supports species such as *Gentiana crinita* and *Veronicastrum virginicum* "generally found on high pH soils." He speculates that rubble from a former farm on the site might be influencing the soil. The location of the other Connecticut populations, mainly on granite, which produces an acid soil, would flatly contradict the assertion of calciphily, but further investigation opens up some evidence for consideration. First, the soil at one of the sites is filled with clam shells, reportedly left by Native Americans. These could exert an alkaline influence. The soil at another site contains scattered shells, though not as concentrated as at the first. One of the sites is a beach made up of coarse sand, which also might have a high concentration of ground up shells (there is a possibility that this sand was imported to the site). All of these sites are near the shore of Long Island Sound, and Zaremba (personal communication) suggests that salt in the soil could alter the pH to favor a calciphilic species. If *Solidago rigida* ssp *rigida* is a strong calciphile, this could have important implications for reintroduction or for expected population levels.

### *Ecological Status*

Most popular wildflower guides for the midwestern states label the species as "common" in its habitat. The author noted the species in 1976 as growing "everywhere" in Illinois prairie sites. *Solidago rigida* is most often identified as a prairie plant, but some (Anonymous 1963, Weaver 1968) consider it an invader or a weed on rangelands.

Platt (1975), working in Iowa, considers *Solidago rigida* a fugitive species, one that establishes itself on bare soil. He includes *Solidago rigida* as one of a guild of five perennial species (*Mirablis hirsuta, Verbena stricta, Solidago rigida, Asclepias syriaca,* and *Apocynum sibiricum*) that regularly colonize badger mounds. In spite of its tendency to germinate in bare ground, he does not consider it a ruderal, for it persists in the prairie community once species typical of the mature prairie take hold. He notes that *Solidago rigida* grows faster than mature prairie species but more slowly than most ruderals. He considers it to be an intermediate successional species, while Havercamp and Whitney (1983) label *Solidago rigida* a "sedentary" species, an indicator of a true climax prairie.

### *Response to Competition*

Platt (1975) found that many growth parameters of *Solidago rigida* – root growth, number of leaves, time from germination to flowering, and seed production – were higher, as was overall survivorship, on badger mounds with no other plants than on occupied sites. This implies a poor response to competition. However, an EPA Web site (U.S. Environmental Protection Agency 1998) states that *Solidago rigida* can be "aggressive" in the home landscape and the Oak Prairie Nursery labels *Solidago rigida* as "very vigorous," a term which can be interpreted as a euphemism for invasive. It should be noted again that these studies are all from midwestern plants, of unknown subspecies.

### *Light Requirements*

Platt and Wies (1985) state that *Solidago rigida*, by inference as a member of the badger mound guild, is highly intolerant of shading. Hardin (1988) found that frequency and percent cover of *S. rigida* decreased in an Ohio prairie savanna as tree cover increased and that *Solidago rigida* recovered – with an "impressive" flowering display – when woody plants were cleared and lower tree limbs removed. The most frequently cited habitats for *S. rigida* are prairies, roadsides and open fields, implying a preference, if not a requirement, for full sun. However, open woods and thickets are also cited as habitat, and some of the prairie nurseries (Gardenbed 2001, Oak Prairie Farm 2001) recommend *S. rigida* for planting in sun or partial shade. Two of the Connecticut populations (CT .001[Kent] and CT 002c [Guilford]) occur in partial shade, though the population at CT .001 (Kent) seems to be in decline, perhaps because of the shade. The author concludes that *Solidago rigida* in New England grows better in full sun than in partial shade.

***Associated species***

As a plant with a large geographical range and a wide amplitude of habitats and soil types, *Solidago rigida* has many associates. A comprehensive list would include hundreds of species. Listing all of them here would be unproductive, but some generalizations can be made. As a prairie species, it grows with *Amorpha canescens*, *Andropogon gerardii, Aster ericoides, Echinacea pallida, Eryngium yuccifolium, Euphorbia corollata, Liatris* spp*., Petalostemon* spp*., Schizachyrium scoparium, Sorghastrum nutans,* and *Tradescantia ohioensis*, just to name a few (Curtis and Greene 1949, Weaver 1968). In disturbed prairies, it can occur with European grasses such as *Poa pratensis, Bromus inermis,* and *Agropyron repens*, interspersed with as many as 160 other species of grasses and other forbs (Patton et al.1998). Under certain conditions (Evans and Dahl 1955), *Solidago rigida* can become a dominant, still, however, sharing the ground with many other species.

In New England, too, *Solidago rigida* has many associates, varying considerably from site to site. The first cause of the variation is the difference in bedrock geology (limestone vs. granite) between CT .001 (Kent) and the shoreline sites, but even among the shoreline sites, there is little communality. Two of the sites support species typical of Connecticut rocky headlands, while another has more typical beach plants, and the last more weedy species. At CT .001 (Kent), the associated trees are mainly *Juniperus virginiana* and *Quercus muehlenbergii*, along with *Celtis occidentalis, Ostrya virginiana, Acer rubrum* and *Zanthoxylum americanum,* while the herbaceous layer includes *Eupatorium sessilifolium, Sorghastrum nutans, Aster patens,* and *Solidago nemoralis,* as well as a remarkable suite of rare species including *Liatris scariosa* var. *novae-angliae, Carex eburnea, Onosmodium virginianum, Polygala senega,* and *Pellaea atropurpurea.* At the shoreline sites, the most common nearby trees are *Juniperus virginiana, Celtis occidentalis, Tilia americana,* and *Quercus stellata,* but in the shrub and herbaceous layers there is considerable variation from site to site. Shrubs and woody vines include *Lonicera x morrowii, Cornus racemosa,* and *Rhus toxicodendron*, while herbaceous species include *Solidago sempervirens, Daucus carota, Helianthus divaricatus, Solidago canadensis*, *Lathyrus maritima* and *Cynanchum louiseae,* along with many others.

***Response to Grazing***

Dix (1940), studying thin-soil prairies in Wisconsin, found a slight decrease in *Solidago rigida* populations from grazing. However, his is the only source to report this. All others (Mueller 1941, Stevens 1950, Anonymous 1963, Weaver 1968, Sedevic and Barker 1997, North Dakota State University 1998) label *Solidago rigida* as an "increaser," a species that extends its cover under grazing, though the sources contradict each other as to what degree of grazing the species can tolerate. All sources rate the species fairly low in palatability. The increase comes about perhaps by virtue of the species' low palatability and concomitant elimination of competing plants, not, as is the case with some grassland plants, from growth stimulating substances in animals' saliva

(Weaver 1968). Sedevic and Barker (1997) report that in North Dakota and Minnesota, the foliage is consumed "to some extent" by white-tailed deer and some small mammals, also somewhat by sharp-tailed and ruffed grouse, less so by the prairie chicken. This report is consistent with the reports of low palatability of the species. In Connecticut, herbivory has been noted at two sites and is presumed to be caused by white-tailed deer. At one site, observers considered deer browse a major threat to the population; at another site, flowering stems that were browsed in midsummer produced lateral shoots which flowered at the normal time in the fall.

Grazing tolerance is relevant to conservation management in that mowing is often considered a mechanical equivalent, which can be used to maintain grazing-dependent species. Grazing tolerance also could perhaps predict tolerance for deer browsing.

### *Response to Fire*

As might be expected from a true prairie plant, *Solidago rigida* benefits from fire. Curtis and Partch (1948) carried out an eight-year study in Wisconsin with experimental plots subjected to various burning regimes (March, May, October, annual and biennial) and control plots unburned. The March burns were the most favorable for *Solidago rigida*, which increased from 2.5 plants per 100 square feet in 1940 to 30.5 in 1948. Tester (1996) also found an increase in *Solidago rigida* on burned plots in Minnesota, along with an increase in other prairie forbs.

The relevance of this information is discussed under "General conservation Actions."

### *Population Dynamics*

No long-term studies of *Solidago rigida* populations have been found. The author, in several years of monitoring local populations, has noticed a variation from year to year in numbers of rosettes versus numbers of flowering stems, but has never examined the situation carefully to determine if and when certain rosettes develop flowering stems or when the rosettes appear. Nor have I been able to ascertain seedling recruitment. I have also noted that population levels have fluctuated over the years (See Appendix 3), but have not discerned obvious patterns in these data. The only correlation that quickly suggests itself is with weather. In 1999, the driest summer in 30 years, the number of flowering stems declined; the next summer, which was very wet, was accompanied by an increase in the number of flowering stems. This apparent correlation has in no way been tested.

For conservation management considerations, the important parameters of the species ecology are the following:

1. *Solidago rigida* ssp *rigida* often occurs on calcareous sites and sites not overtly calcareous might actually be so. High magnesium content in the soil

may also be a critical edaphic factor. (Tom Rawinski, personal communication). Soil pH may be limiting.
2. Though *Solidago rigida* seems to grow best in full sun, partial survival in light shade is possible.
3. Based on information from the only source to have studied this parameter in the wild, competition could be a strongly limiting factor.

## THREATS TO *SOLIDAGO RIGIDA*

In the Midwestern states, *Solidago rigida* has certainly declined inasmuch as its prairie habitat has been destroyed on a vast scale by agriculture and development. However, it is still considered a common, if not weedy species, and is in no way threatened. Current threats to New England populations, described in greater detail in subsequent sections, include shade, competition, and white-tailed deer browse. At one site, where populations have noticeably declined, all of the above factors have been implicated, while competition seems the most likely factor at another site where the plant has disappeared. At the sites where the populations are stable or increasing, the proximity and vigor of nearby vegetation suggest a potential problem, though declines from competition have not yet been noted. Conversely, in sites subject to treatment by landscaping companies, as two are, there always exists the possibility of uncontrolled weed-whacking by unknowing and overzealous personnel. This is one form of human disturbance; the other is trampling, which could become a problem at one site but is not yet. An additional potential threat rises from *Solidago rigida's* presumed status as an obligate outcrosser (Havercamp and Whitney 1983). If genetic diversity is low in a small population, seed set and therefore reproduction could be diminished. It is not clear if this process is taking place in Connecticut populations.

## DISTRIBUTION AND STATUS

*Solidago rigida* is limited to the United States and Canada; within these bounds, range descriptions vary from source to source. Two sources (Gleason and Cronquist 1991, Natureserve 2001) cite Massachusetts as the northeastern limit of the species, but the Massachusetts records are historic. The current northeastern limit of its range is Connecticut. *Solidago rigida* does not grow in the Pacific Coast states, nor in the Rocky Mountains. Georgia is the southeastern limit of its range; New Mexico the southwestern. *Solidago rigida* also grows in the prairie regions of Ontario, Manitoba, Alberta and Saskatchewan.

Though common in the Midwest, *Solidago rigida* is not at all so in the northeast, as evidenced by its status of SH (historic) in Maryland and the District of Columbia, S2 (imperiled) in New York and S1 (critically imperiled) in Connecticut, New Jersey and Pennsylvania. In New York State, its distribution is curious, being reported only from the far western and the far eastern counties of the state.

***General Status***

Table 1 summarizes the distribution and subnational ranks for *Solidago rigida.* Figure 1 shows the North American distribution of the taxon.

**Table 1. Occurrence and status of *Solidago rigida* in the United States and Canada based on information from Natural Heritage Programs.**

| OCCURS & LISTED (AS S1, S2, OR T &E) | OCCURS & NOT LISTED (AS S1, S2, OR T & E) | OCCURRENCE REPORTED OR UNVERIFIED | HISTORIC (LIKELY EXTIRPATED) |
|---|---|---|---|
| Connecticut (S1): 6 current and unknown number of historic occurrences | Illinois (S?) | Arkansas (SR) | District of Columbia (SX) |
| New Jersey (S1) | Iowa (S4) | Colorado (SR) | Massachusetts (SX): 2 historic occurrences |
| Pennsylvania (S1) | Kentucky (S?) | Delaware (SU) | Maryland (SH) |
| South Carolina (S1) | Michigan (S?) | Georgia (SR) | Rhode Island (SH): 2 historic occurrences |
| | New York (S2) | Indiana (SR) | |
| | North Carolina (S2) | Kansas (SR) | |
| | West Virginia (S?) | Louisiana (SR) | |
| | Virginia (S2) | Minnesota (SR) | |
| | | Mississippi (SR) | |
| | | Missouri (SR) | |
| | | Montana (SR) | |
| | | Nebraska (SR) | |
| | | New Mexico (SR) | |
| | | North Dakota (SR) | |
| | | Tennessee (SR) | |
| | | Texas (SR) | |
| | | South Dakota (SR) | |
| | | Wisconsin (SR) | |
| | | Wyoming (SR) | |

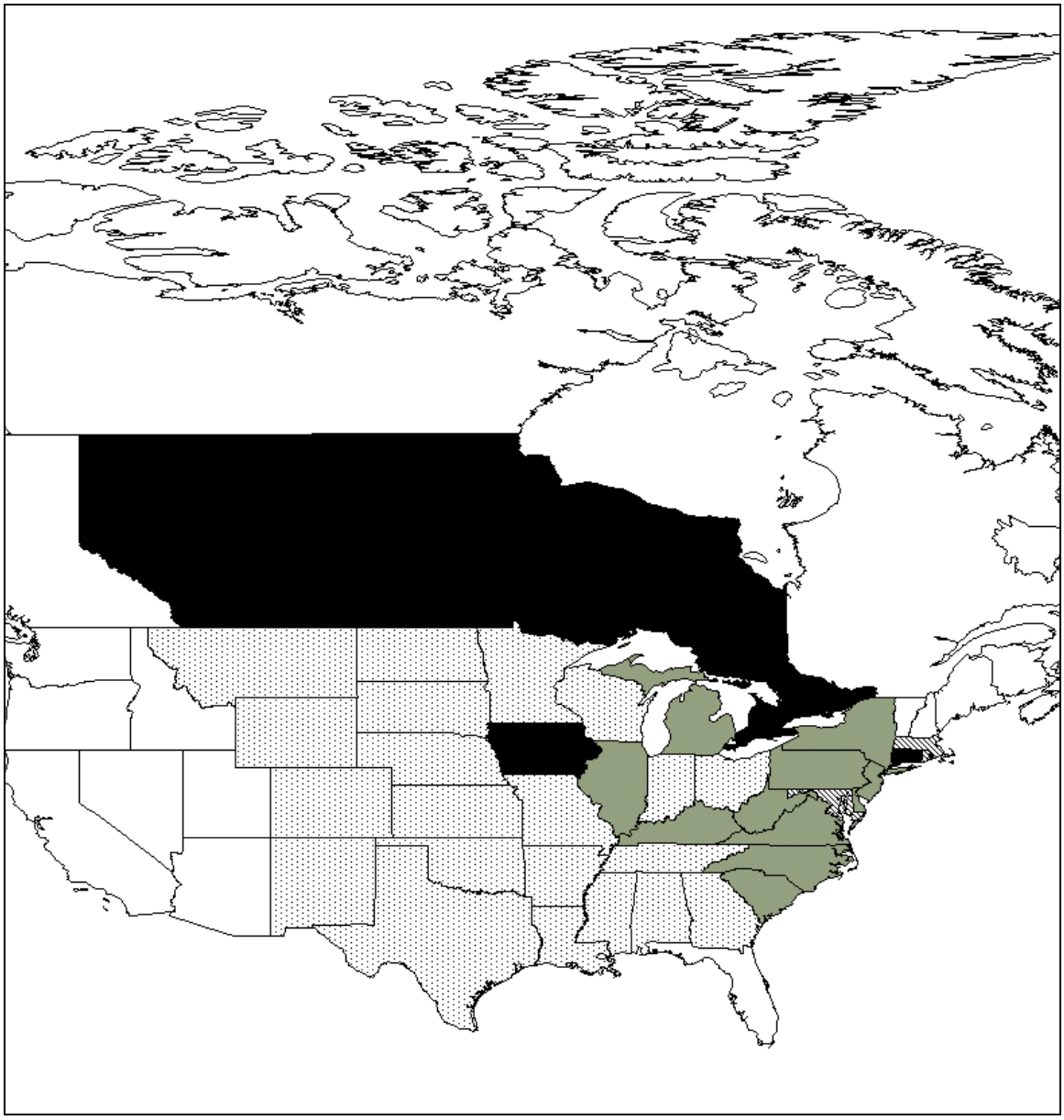

**Figure 1. Occurrences of *Solidago rigida* in North America.** States and provinces shaded in gray have one to five current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. States with diagonal hatching are designated "historic" or "presumed extirpated," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but not necessarily verified). See Appendix 4 for explanation of state ranks).

***Status of All New England Occurrences -- Current and Historical***

Currently, the only New England state where *Solidago rigida* is found is Connecticut. Three sites have been recorded, assigned Element Occurrence (EO) numbers, and surveyed with some regularity. Counting methods have not been entirely consistent, and some precision is unavoidably lacking. The author and most surveyors have followed the protocol of the Connecticut Natural Diversity Database field forms and used two measures: the number of flowering stems and the number of basal rosettes. The latter are sometimes difficult to count precisely, as the plant has a tillering growth form and it is sometimes difficult to ascertain where one rosette ends and another begins. Rosette counts are therefore usually approximate. Other surveying teams have counted genets and ramets or simply "plants in bud," not clarifying the presence, absence or quantity of rosettes. Some surveyors have checked the number categories (1-10, 11-50, 51-100) provided on the Natural Diversity Database forms without making precise counts. In spite of these inconsistencies, enough data exist to ascertain trends. The number of flowering stems, though not indicative of the overall status of a population, at least is an easily compared and easily counted quantity.

The internal demographics of *Solidago rigida* are not at all clear to the author, i.e. is there a relationship between the number of rosettes one year and the number of flowering stems the next or vice-versa? Are the rosettes first year plants? (The author has never noted seedlings, perhaps a function of poor observation rather than lack of seedlings). Does a decline in the number of rosettes mean that the plants have matured to flowering or does it mean low seedling recruitment, winter mortality, or herbivory? Does a large number of rosettes indicate a large number of young plants which will presumably grow to the flowering stage or does it indicate a population in jeopardy, unable to flower? These questions all bear attention.

A pertinent question, perhaps unanswerable, is whether *Solidago rigida* is declining in New England, i.e. whether it used to be more common. Examination of Connecticut herbarium specimens, not noted in NDDB files, is revealing. In the herbaria of the University of Connecticut (CONN), Yale University (YU) and the Connecticut Botanical Society (NCBS) are 53 sheets, representing probably 44 occurrences (See Appendix 2). The earliest specimen is from 1832; the most recent from 1992; most, as is typical of many herbaria, were collected in the early 20th century. What is especially noteworthy about these specimens, aside from their number, is their geographical spread. Twenty-two of the occurrences are from coastal towns, and four are in the northwestern part of the state: a distribution that mirrors what we see today. Other towns represented, however, include Avon, Durham, Columbia, Monroe, Pomfret, and Scotland. These towns are far from the coast, far from each other, and fall into several geological provinces of the state.

This information can be interpreted in many different ways. An initial conclusion, based simply on the number of occurrences, could be that the species was clearly more common, especially considering that some populations could have escaped the collectors' grasp. However, it must be remembered that these sheets span a time

period of 169 years. If one looks at a fifteen-year period, which is approximately the time frame for which current recorded data is available, one might reach a different conclusion. For instance, from 1900 –1915, the height of plant collecting, one finds 14 occurrences. The 1910 *Catalogue of the Flowering Plants and Ferns of Connecticut* (Graves et al. 1910*)* cites twelve stations, two of them inland. This is certainly more stations than are known today, but the authors still rated *Solidago rigida* as "rare or local." Given the existence of herbarium specimens also from Massachusetts and Rhode Island, a qualified answer is that the species was slightly more common, and, perhaps more important, that it had a wider range in the past. Whether this was an artifact of widespread forest clearing, and greater prevalence of open fields is of course another question; whether *Solidago rigida* was common in presettlement New England is beyond the scope of this document.

Figures 2 and 3 show the locations of extant and historic occurrences of *Solidago rigida* (respectively).

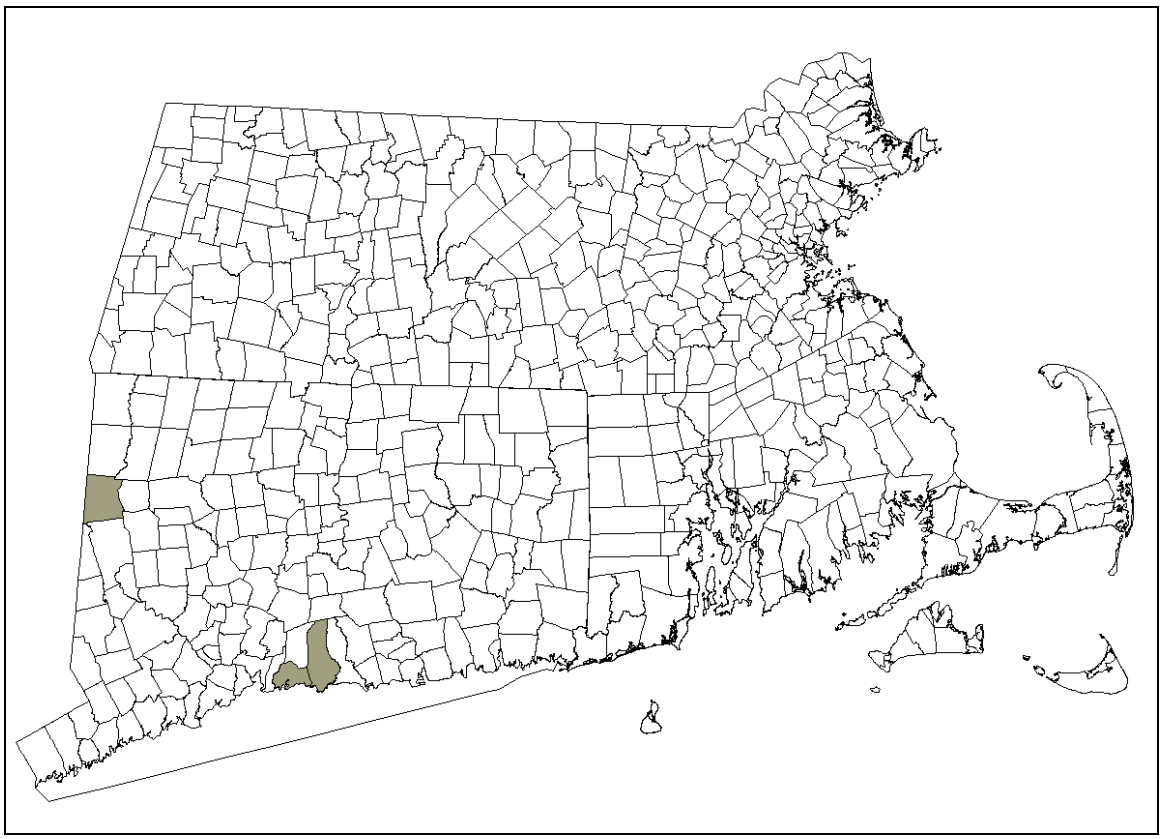

**Figure 2. Extant occurrences of *Solidago rigida* in New England.** Town boundaries for southern New England states are shown. Towns shaded in gray have one to five confirmed, current occurrences of the taxon.

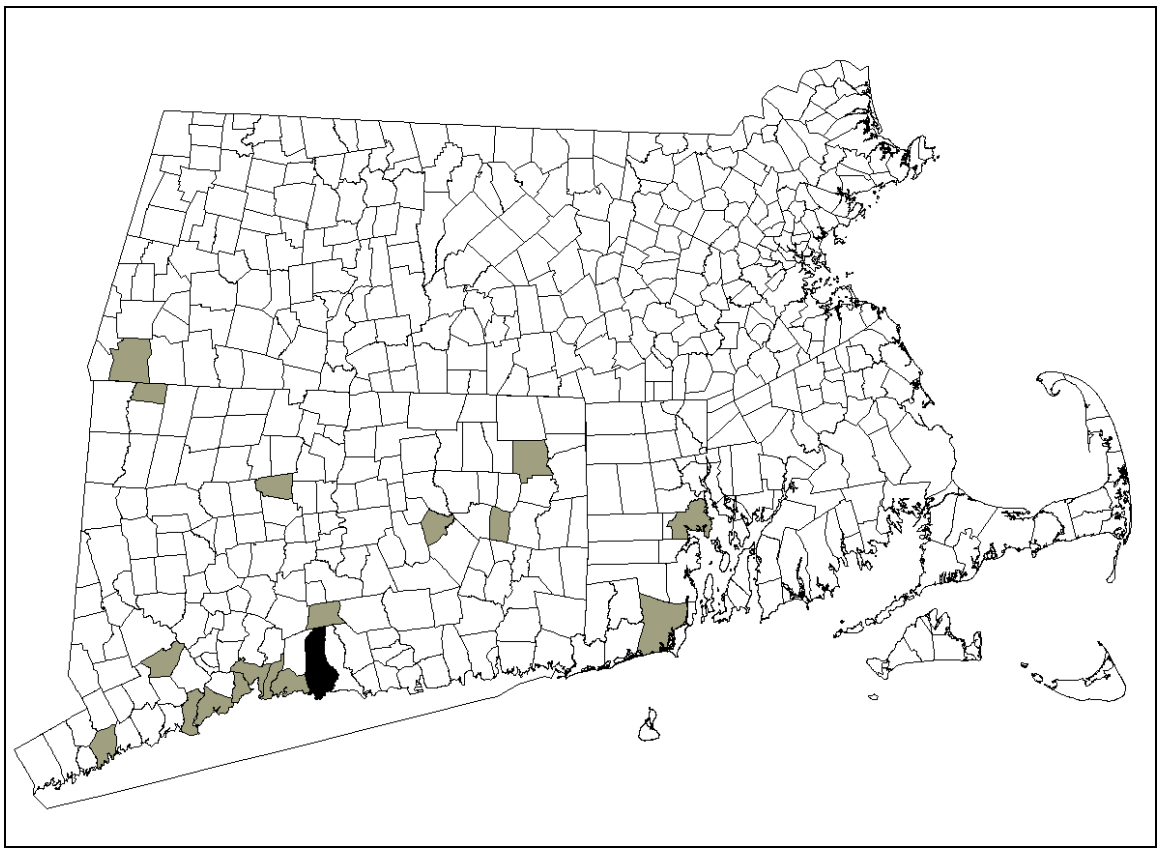

**Figure 3. Historic occurrences of *Solidago rigida* in New England.** Towns shaded in gray have one to five historic records of the taxon, while the town shaded in black (Guilford), has more than five historic records (see Appendix 2).

| Table 2. New England Occurrence Records for *Solidago rigida.* Shaded occurrences are considered extant. | | | |
|---|---|---|---|
| **State** | **EO #** | **County** | **Town** |
| **CT** | **.001** | **Litchfield** | **Kent** |
| **CT** | **.002a** | **New Haven** | **Branford** |
| **CT** | **.002b** | **New Haven** | **Guilford** |
| **CT** | **.002c** | **New Haven** | **Guilford** |
| **CT** | **.002d** | **New Haven** | **Branford** |
| **CT** | **.003** | **New Haven** | **Guilford** |
| RI | .001 | Washington | South Kingstown |
| RI | .001 | Kent | Warwick |
| MA | None | Hampshire | Not known |
| MA | None | Berkshire | Sheffield |
| MA | None | Nantucket | Nantucket |

## CURRENT CONSERVATION MEASURES IN NEW ENGLAND

### *Seed Collection*

William Brumback of the New England Wildflower Society collected 673 seeds in October 1996 from the Kent site (CT .001) and performed germination tests on 200 of these (personal communication). All seeds were dried, then 100 were sown in flats outside in January 1997, while the other 100 were subjected to cold stratification in a refrigerator for twelve weeks before sowing in May 1997. Of the seeds sown outdoors, germination was less than 15%, of those sown after refrigeration, germination averaged between 50 and 68%. The balance of the seeds are in the NEWFS seed bank.

Noble Proctor and Margrit Ardwin in 1996 collected 478 seeds from the Guilford site CT. 003; of these, 98 were tested, with half being sown in the refrigerator and 48 sown in the greenhouse. Germination rates were low and/or unreported for both treatments, suggesting that this population of seeds was of poor quality. Again, the remainder are in the NEWFS seed bank.

Brumback (personal communication) is encouraged by these results, noting that survival of the artificial drying is the first hurdle necessary for successful seed banking. He feels that *Solidago rigida* is a good candidate for seed banking. These tests are especially significant in that it can be assumed that the seeds were collected from subspecies *rigida*, unlike those of the many Midwestern trials, and indicate good germination potential of the northeastern subspecies.

Some of the seedlings resulting from these tests have been transplanted into sandy soil at the NEWFS Garden in the Woods and the plants have thrived.

### *Monitoring*

The author and others have monitored Connecticut sites since 1987 (see Table 2 and Appendix 3).

### *Landowner Education*

The owners of all sites have been notified by NEPCoP task force members, DEP staff, or the author, with the following results:

CT .001. (Kent) – Results of notification unknown.

CT.002a (Branford) – This site is owned by the local land trust, officers and directors of which change over time. Current directors are perhaps unaware of the previous existence of the species on this site.

CT .002b (Guilford) – The owner is aware of the existence of the plant, is completely sympathetic, and has no intention of any landscaping work or other activities that would harm the *Solidago rigida*.

CT .002c (Guilford) – The owner was notified of the existence and importance of the plant just as construction activities were starting nearby. The owner installed stakes and ribbons around the stand to protect it.

CT .002d (Branford) – The owner has been notified of the existence and importance of the plant and has given the author permission to clear competing vegetation.

CT .003 (Guilford) – The Town of Guilford Parks and Recreation Department was notified by NEPCoP task force members about the *Solidago rigida* population on the site and asked not to cut it down. This tactic, whether by accident or design, has apparently been successful, with the ironic unintended result, as described above, that competing vegetation is now overtaking the *S. rigida*.

# II. CONSERVATION

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## CONSERVATION OBJECTIVES FOR TAXON IN NEW ENGLAND

*Solidago rigida* is currently restricted to three sites in New England, one on the limestone ledges of northwestern Connecticut, the other two on the Connecticut shoreline. The first population is declining due to factors difficult to control while the other two seem stable and amenable to simple management. The existence of currently undocumented occurrences is quite likely.

The conservation objectives for *Solidago rigida* in New England are:

- Reinvigoration of the Kent site (CT .001) to a population of at least 20 flowering stems
- Maintenance of the shoreline populations. CT .002 (Branford/Guilford) should maintain an average of 150 flowering stems per year over five years, realizing the potential for fluctuation. CT .003 (Guilford), also likely to fluctuate, should maintain an average of 100 flowering stems per year.

Introduction, reintroduction and augmentation, being a "difficult and imperfect task," (Falk et al 1996) are not currently recommended, but seed banking from CT .002 (Branford/Guilford) is highly recommended in case these strategies become necessary – for instance, if an extreme storm or high tide were to kill these plants.

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# IV. APPENDICES

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1. **Herbarium Specimens of *Solidago rigida.***

2. ***Solidago rigida* populations at CT .002b (Guilford)**

3. **An explanation of conservation ranks used by The Nature Conservancy and NatureServe**

**1. Herbarium specimens of *Solidago rigida* in Connecticut.** Data from the Herbaria of the University of Connecticut (CONN), Yale University (YU), and the Connecticut Botanical Society (NCBS). Some of these specimens represent current EORs.

| Year | Date | Town and location | Habitat (*verbatim*) | Collector | Herbarium | Notes |
|---|---|---|---|---|---|---|
| 1832 | Not noted | Monroe | Not noted | H. C. Beardslee | YU | |
| 1857 | Not noted | New Haven | Not noted | Not noted | YU | |
| 1874 | Sept. 21 | New Haven | Near the seashore | F. W. Hall | CONN | This and the following are presumably duplicates. |
| 1874 | Sept. 21 | New Haven | | F. W. Hall | CONN | |
| 1884 | Oct. 2 | South End, East Haven | | A. L. Winton | YU | |
| 1888 | Sept. 1 | near Morris Cove, New Haven | dry soil | Alexander W. Evans | YU | |
| 1895 | Sept. 9 | Stratford | Sandy, dry woods, in openings. Very local. | E. H. Eames | CONN | |
| 1898 | Not noted | "near New Haven" | dry sandy soil | George E. Nichols | YU | |
| 1899 | Sept. 20 | Milford | Dry rocky ground near shore | C. H. Bissell | NCBS | This and the following are presumably duplicates |
| 1899 | Sept. 16 | Milford | dry rocky ground near shore | C. H. Bissell | YU | |
| 1899 | Sept. 20 | Orange | Dry rocky ground near sea shore | C. H. Bissell | CONN | |
| 1901 | August | Scotland | | Gerald Waldo | NCBS | |
| 1901 | Sept. 21 | Stratford | Dry woods near salt-meadows. Rays spreading 10 11/16 in. | E. H. Eames | CONN | |
| 1902 | Sept. | West Haven | | R. W. Woodward | NCBS | |
| 1902 | Aug. 29 | Woodmont, E. of Mervin's restaurant | Dry woods along shore | A. W. Driggs | CONN | |
| 1903 | Sept. 20 | City Point, New Haven | gravel bank | R. W. Woodward | NCBS | Specimen quite large |
| 1904 | Sept. 11 | Chaffinch Island, Guilford | | G. H. Bartlett | NCBS | |
| 1904 | July 1 | Chaffinch Island, Guilford | | William Russel Dudley | YU | |

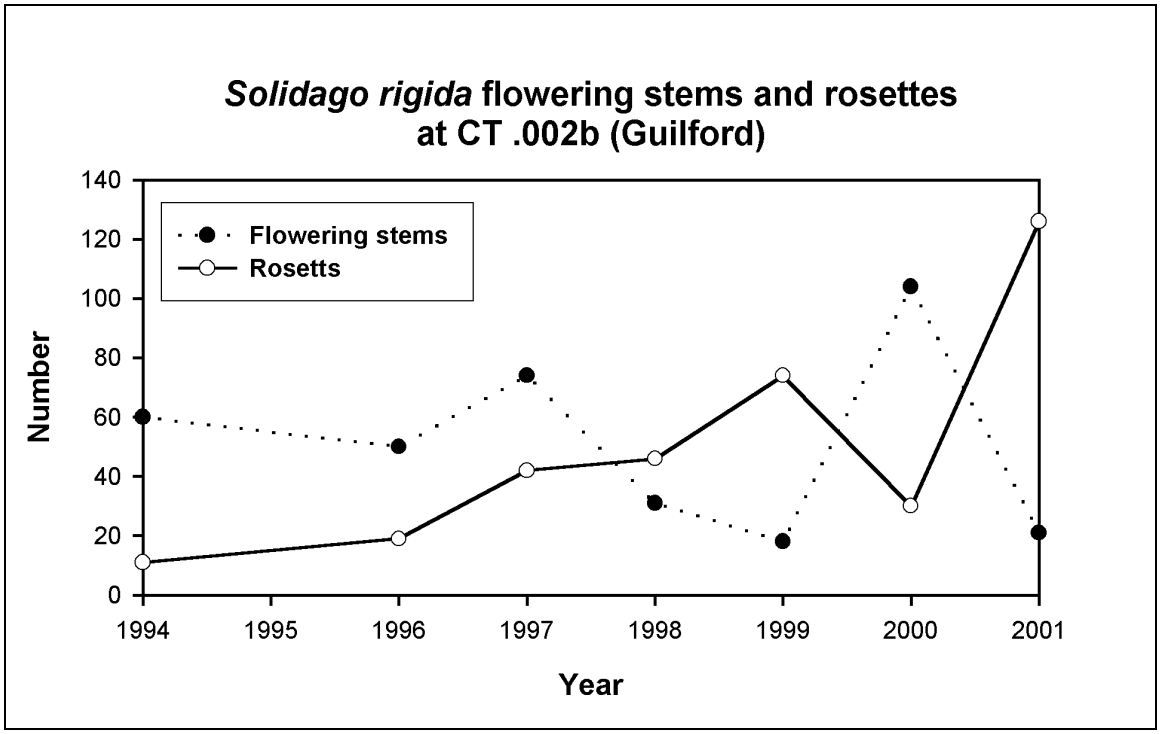
| Year | Date | Town and location | Habitat (*verbatim*) | Collector | Herbarium | Notes |
|---|---|---|---|---|---|---|
| 1905 | Sept. 16 | Stratford | dry sandy soil | Drs. Eames and Godfrey | YU | This and the following are presumably duplicates |
| 1905 | Sept. 16 | Stratford | dry sandy soil | Drs. Eames and Godfrey | YU | |
| 1906 | Sept. 9 | Guilford | | G. H. Bartlett | NCBS | |
| 1906 | Sept. 12 | Norwalk | Rocky woods | C. H. Bissell | NCBS | There is a good chance that Bissell and Harger, both of whom lived in other parts of the state, were together on a Connecticut Botanical Society field trip; therefore, this and the following are probably from the same location. |
| 1906 | Sept. 12 | Norwalk | Dry soil near shore | E. B. Harger | NCBS | This and the following are presumably duplicates |
| 1906 | Sept. 12 | Norwalk | Dry soil near shore | E. B. Harger | CONN | |
| 1907 | Sept. 1 | Guilford | Islands in salt meadow | William Russel Dudley | YU | |
| 1908 | Sept. 21 | Guilford, Chaffinch Island | Dry ground | E. B. Harger | CONN | |
| 1913 | Sept. 1 | Columbia | Railroad embankment | Mrs. C. S. Phelps | NCBS | |
| 1916 | July 23 | Branford, N. of Hotchkiss Grove | Wood margins | A. W. Driggs | CONN | A. W. Driggs also collected *Taenidia integerrima* from this same site. *Taenidia* also grows with *Solidago rigida* at CT .002c (Guilford). |
| 1917 | Sept. 3 | Guilford | Knolls on salt marsh | R. W. Woodward | NCBS | Woodward, Bissell and Harger were all members of the Connecticut Botanical Society. This specimen and the two following were likely collected on a Society field trip and are likely from the same location. |
| 1917 | Sept. 3 | Guilford | Dry rocky ground near sea shore | C. H. Bissell | NCBS | |

| Year | Date | Town and location | Habitat (*verbatim*) | Collector | Herbarium | Notes |
|---|---|---|---|---|---|---|
| 1917 | Sept. 3 | Chaffinch Island, Guilford | Dry open ground bordering salt marsh | E. B. Harger | NCBS | |
| 1920 | Sept. 12 | Milford | Edges of fields | Alexander W. Evans | YU | This and the following are presumably duplicates |
| 1920 | Sept. 12 | Milford | Edge of fields | A. W. Evans | CONN | |
| 1927 | Aug. 18 | North Canaan | Dry shrubby limestone ridge. Abundant at this station. (Very abundant also at a similar station in Sheffield, MA) | Edwin H. Eames | NCBS | Site sounds similar to Ct .001 (Kent); Sheffield station might be that represented in MA specimens. This and the following are presumably duplicates |
| 1927 | Aug. 18 | North Canaan | Dry shrubby limestone ridge. Plentiful at this station. | E. H. Eames | CONN | |
| 1927 | Sept. 9 | Brookfield | Dry gravelly knoll. Local | E. H. Eames | CONN | |
| 1927 | Sept. 21 | Kent | Dry soil along summit of limestone ridge | E. H. Eames | CONN | |
| 1931 | Sept. 29 | Westport | Dry open woods on coast, in gravelly soil | E. H. Eames | CONN | |
| 1932 | Sept. 16 | Westbrook, Grove Beach Point | Roadside plant | A. W. Driggs | CONN | |
| 1933 | Sept. 13 | Westbrook. Grove Beach | Dry sandy soil on coast. Locally common | E. H. Eames | CONN | |
| 1942 | Aug. 14 | Fort Hale, New Haven | large colony along path at edge of trap ridge | J. J. Neale | NCBS | Author visited this spot in September, 2000 and found mainly *Cynanchum louiseae*, no *Solidago rigida*. |
| 1950 | Aug. 27 | Guilford, Chaffinch Island | Border of thicket | Bradley, Neale and Torrey | CONN | |
| 1953 | Aug. 29 | Avon | Plentiful in sandy soil on hillside so-east of spruce bog | James J. Neale | CONN | |
| 1954 | Sept. 9 | Durham | | Mary I. Turner and Harry L. Johnson | NCBS | |
| 1955 | Sept. 17 | Pomfret | Dry field | Alan W. Upham | NCBS | |

| Year | Date | Town and location | Habitat (*verbatim*) | Collector | Herbarium | Notes |
|---|---|---|---|---|---|---|
| 1968 | Sept. 8 | Sandy area in Avon, Ct and planted in grassy area Farm | Sandy area in Avon, Ct and planted in grassy area Farm | Sterling Parker | CONN | |
| 1978 | Oct. 21 | Washburn property, Branford | stone roadway near shore | Lauren Brown | YU | |
| 1980 | Sept. 2 | Guilford, Chaffinch Island | Growing behind salt marsh near Sound | Leslie J. Mehrhoff | CONN | |
| 1985 | Sept. 20 | Branford, western edge of salt marsh, east of Stony Creek | | Leslie J. Mehrhoff | CONN | |
| 1987 | Sept. 1 | Kent East bank of Housatonic River, south of Bull's Bridge | Calcareous ledge | Leslie J. Mehrhoff | CONN | |
| 1992 | Oct. 6 | Branford, Yale Peabody Field Station Property, south of railroad adjacent to salt marsh | | Leslie J. Mehrhoff | CONN | The locality cited here is quite close to CT .002a. Perhaps this is a mistaken notation; if not, this represents a sub-population that has not persisted. More likely, however, this is CT.002a. |
| Not noted | Not noted | Avon | Not noted | J. J. Neale and Dorothy Wyman | NCBS | Collector was active in the 1960s |

| Year | Date | Town and location | Habitat (*verbatim*) | Collector | Herbarium | Notes |
|---|---|---|---|---|---|---|
| Not noted | Not noted | Stony Creek, Beattie's quarry | Not noted | J. A. Allen | NCBS | The locality information for this specimen is intriguing and confusing. Beattie's quarry is now the Old Quarry Association, where CT .002b and CT .002c have been found. However, Beattie's quarry was in Guilford, not Stony Creek, which is part of neighboring Branford. The quarry went out of business in 1918, so the specimen presumably was collected before then. However, the property lay vacant till 1950 so it might have been referred to by this name long after the demise of the business. The specimen was almost certainly collected before the current residential development was started in 1950. |

**2. *Solidago rigida* populations at CT .002b (Guilford)**




| YEAR | NUMBER OF FLOWERING STEMS | NUMBER OF ROSETTES | TOTAL | NOTES |
|---|---|---|---|---|
| 1994 | 60 | 11 | 77 | |
| 1996 | 50 | 19 | 69 | |
| 1997 | 74 | 42 | 116 | |
| 1998 | 31 | 46 | 77 | |
| 1999 | 18 | 74 | 96 | Summer drought – worst since 1964 |
| 2000 | 104 | 30 | 140 | Very rainy summer |
| 2001 | 21 | 126 | 147 | |

## 3. An explanation of conservation ranks used by The Nature Conservancy and NatureServe

The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G (Global), N (National), or S (Subnational) as appropriate. The numbers have the following meaning:

1 = critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

G1, for example, indicates critical imperilment on a range-wide basis — that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction — i.e., a great risk of extirpation of the element from that subnation, regardless of its status elsewhere. Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct). Certain other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty.

Elements that are imperiled or vulnerable everywhere they occur will have a global rank of G1, G2, or G3 and equally high or higher national and subnational ranks (the lower the number, the "higher" the rank, and therefore the conservation priority). On the other hand, it is possible for an element to be rarer or more vulnerable in a given nation or subnation than it is range-wide. In that case, it might be ranked N1, N2, or N3, or S1, S2, or S3 even though its global rank is G4 or G5. The three levels of the ranking system give a more complete picture of the conservation status of a species or community than either a range-wide or local rank by itself. They also make it easier to set appropriate conservation priorities in different places and at different geographic levels. In an effort to balance global and local conservation concerns, global as well as national and subnational (provincial or state) ranks are used to select the elements that should receive priority for research and conservation in a jurisdiction.

Use of standard ranking criteria and definitions makes Natural Heritage ranks comparable across element groups; thus, G1 has the same basic meaning whether applied to a salamander, a moss, or a forest community. Standardization also makes ranks comparable across jurisdictions, which in turn allows scientists to use the national and subnational ranks assigned by local data centers to determine and refine or reaffirm global ranks.

Ranking is a qualitative process: it takes into account several factors, including total number, range, and condition of element occurrences, population size, range extent and area of occupancy, short- and long-term trends in the foregoing factors, threats, environmental specificity, and fragility. These factors function as guidelines rather than arithmetic rules, and the relative weight given to the factors may differ among taxa. In some states, the taxon may receive a rank of SR (where the element is reported but has not yet been reviewed locally) or SRF (where a false, erroneous report exists and persists in the literature). A rank of S? denotes an uncertain or inexact numeric rank for the taxon at the state level.

Within states, individual occurrences of a taxon are sometimes assigned element occurrence ranks. Element occurrence (EO) ranks, which are an average of four separate evaluations of quality (size and productivity), condition, viability, and defensibility, are included in site descriptions to provide a general indication of site quality. Ranks range from: A (excellent) to D (poor); a rank of E is provided for element occurrences that are extant, but for which information is inadequate to provide a qualitative score. An EO rank of H is provided for sites for which no observations have made for more than 20 years. An X rank is utilized for sites that known to be extirpated. Not all EO's have received such ranks in all states, and ranks are not necessarily consistent among states as yet.