New England Plant Conservation Program
Conservation and Research Plan

Trollius laxus Salisb.
Spreading Globeflower

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SUMMARY

Trollius laxus Salisb. (Ranunculaceae), Spreading Globeflower, the only representative of its genus in eastern North America, is rare throughout its fairly restricted range. There are approximately 40 known extant occurrences, many of which have less than 100 individuals and almost all less than 1000. A cluster of small populations in Litchfield County, Connecticut represents the northeastern limit of the species range, and these are the only New England occurrences. The greatest threat to these plants is loss or alteration of their sensitive wetland habitat. The number of occurrences in each of the five states in the species range has declined, often due to development and/or drainage of the fertile fens and swamps they inhabit. Conservation activity to date in New England includes protection of two occurrences, monitoring of most of the others, banking of seeds from three occurrences, and studies of *T. laxus* ecology, population genetics, and propagation. The taxon recently has been elevated to full species level, and is the only polyploid member of its genus.

The species is restricted to wetlands with cold, highly alkaline groundwater seepage, such as sloping fens and swamp margins. This appears to be an early- to mid-successional species, as populations may be suppressed by woody or herbaceous competitors. Flooding may enhance persistence of *T. laxus* in an area by opening up habitat and enabling dispersal. Maintenance of a natural hydrological regime is critical for the metapopulation dynamics that enable long-term persistence of small occurrences.

Trollius laxus will be reasonably secure in New England when it has approximately eight occurrences distributed among at least three metapopulations in different local watersheds. Within each metapopulation, at least the most viable occurrence must be fully protected, including upland buffer zones and avenues of seed dispersal to other sites.

The following conservation actions are needed:

- Search the limited appropriate habitat for new and historic occurrences.
- Characterize the size and structure of extant occurrences, and their potential for exchange of propagules.
- Protect at least one site that has the largest extant population in Connecticut.
- Study species biology, particularly competition and pollination relationships, *in situ* to dictate management strategy for individual occurrences.
- Determine hydrologic processes influencing vegetation composition and structure within wetlands supporting *T. laxus*.
- Develop seed stocks for possible augmentation of existing occurrences, or reintroduction to historic sites.
- Fully clarify the taxonomy of the North American species.
- Inform landowners and local citizens about this special plant and its conservation.

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Full plans with complete and sensitive information 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

Trollius laxus (Salisbury) is a rare and declining member of the buttercup family (Ranunculaceae). Belonging to the globeflower genus *Trollius*, most of whose members have rounded flowers, *T. laxus* has open flowers more like a typical buttercup; hence its puzzling common name, Spreading globeflower. It is one of only three *Trollius* species in North America (Parfitt 1997), including *T. riederianus*, an Asian species that extends to the western tips of Alaska, and *T. albiflorus*. The remainder of the approximately 30 species in this genus occur in Asia and Europe (Doroszewska 1974).

The species is restricted to wetlands with cold, highly alkaline groundwater seepage, such as sloping fens and swamp margins. *Trollius laxus* appears to be an early- to mid-successional species, as populations may be suppressed by woody or herbaceous competitors. A natural hydrological regime should be maintained to permit for the metapopulation dynamics that enable small occurrences to survive, and occasional flooding may facilitate the plant's dispersal and persistence at a site.

Trollius laxus will be more secure in New England when it has approximately eight occurrences distributed among at least three metapopulations in different local watersheds. Within each metapopulation, at least the most viable occurrence must be fully protected, including upland buffer zones and avenues of seed dispersal to other sites. To this end, appropriate habitats should be identified and searched for new and historic occurrences. The size and structure of extant occurrences, and their potential for exchanging propagules, should be assessed. At least one site, which has the largest extant population in Connecticut, should be protected. Species biology, particularly competition and pollination relationships, should be studied in the field to better inform management strategies for individual occurrences. Likewise, the natural hydrologic processes influencing vegetation composition and structure within known *Trollius laxus* wetlands should be better understood. Seed stocks should be developed to enable possible augmentation of existing occurrences, or reintroduction to historic sites. The taxonomy of the North American species needs to be clarified. Finally, landowners and local citizens should be informed and educated about this special plant.

DESCRIPTION

The *Trollius* genus is comprised of herbaceous perennials having palmately divided leaves with coarsely toothed margins. Multiple stems and basal leaves emanate from a central clump in mature plants, atop thick fibrous roots. Leaf size and stem height are quite variable

within *T. laxus*, with a maximum height of about 50 cm. The flowers are borne at the ends of the stems and are quite showy, up to five cm in diameter. The five to seven sepals are petal-like and broad, whereas the petals themselves are much reduced structures (sometimes referred to as staminodes) with nectar glands at the base. The fruit is an aggregate of follicles, typical of the Ranunculaceae.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

The occurrence of *Trollius* in North America was first reported by Muhlenberg in 1793, in a list of plants from the region around Lancaster, Pennsylvania (Doroszewska 1974). Muhlenberg gave the plant the name *Trollius americanus* N.S., but did not describe it. Salisbury (1807) described the species from the same region of Pennsylvania under the name *Trollius laxus* Salisb.

The two continental United States species of *Trollius*, *T. laxus* and *T. albiflorus*, are very similar morphologically. *Trollius albiflorus* is described as white-flowered (hence the name) whereas *T. laxus* has yellow flowers, but both are variable in shade and there is some overlap (Doroszewska 1974). There are some other minor differences (see the *Flora of North America* description of Parfitt [1997]), but the species are very difficult to differentiate in the field. One possible difference is that *T. laxus* flowers are typically solitary, but *T. albiflorus* in Colorado often has three or more flowers bunched at the tip of a stem (K. Jones, *personal observation*). Practically, the species are identified based on location, as *T. albiflorus* occurs only in the far western United States and Canada. Gray (1862) first described the western taxon as *T. laxus* var. *albiflorus*, and several other authors have treated the two as subspecies *laxus* and *albiflorus* of *T. laxus*.

Despite their morphological similarity, the two species are quite distinct in other ways, and the recent *Flora of North America* treatment (Parfitt 1997) leaves little doubt that they should be considered separate species. Notably, *T. laxus* is the only polyploid member of the genus (Pellmyr 1992). Parfitt (1997) indicates that *T. laxus* is tetraploid while *T. albiflorus* is diploid, based on the unpublished graduate work of G. Rhinehalt at Ohio University (B. Parfitt, Ohio State University, *personal communication*). Also, the habitat requirements are quite different, as *T. albiflorus* occurs in more acidic, montane to alpine wetlands rather than the alkaline seeps and fens of *T. laxus*. Together with their disjunct geographical distribution, the different habitat types and ploidy levels make it very unlikely that the two taxa could interbreed successfully; they appear to be independently evolving lineages.

SPECIES BIOLOGY

Phenology and reproduction

Like many associated species in swampy habitats, *T. laxus* emerges early and flowers from mid-April to early May, before the canopy trees reach full leaf (Bliss 1985). The seeds ripen by mid June in Connecticut, and are dispersed passively by gravity plus wind, rain and seasonally high water (Parsons and Yates 1984). Seeds of the related *T. europaeus* were capable of floating for several days and up to several months in beakers of water that were occasionally stirred (Danvind and Nilsson 1997). Seeds germinate readily in culture following a 90-day moist, cold period (Brumback 1983, Parsons and Yates 1984). At the New England Wild Flower Society in Framingham, Massachusetts, some plants flower as early as the second year, and most bloom by the third year (Brumback 1983). However, seedlings have rarely appeared in cultivation (Chris Mattrick, New England Wild Flower Society, *personal communication*).

Three Connecticut populations monitored by Michelle Zielinski all contained seedlings, larger vegetative plants, and at least a few plants that flowered; thus there appeared to be some successful reproduction (Zielinski 1993). Vegetative reproduction by offsets also occurs, resulting in a clumped distribution of plants (Rhinehalt 1990).

The nectar glands at the bases of the petals suggest animal pollination, but no pollinator observations are known for *T. laxus*. Many *Trollius* species have an associated fly species of the genus Chiastocheta (Anthomyiidae) that pollinates the host plant then lays eggs on the developing fruits. Some seeds are destroyed by the larvae but many more are left intact, so that the overall interaction is mutually beneficial (Pellmyr 1992). At least one species in the genus, *T. europaeus*, is thought to depend on the flies for reproduction (Jaeger and Despres 1998). There is no evidence of such an association in the North American *Trollius* species (Pellmyr 1992); however, the author observed small red-eyed flies apparently laying eggs on follicles of *T. albiflorus* in Colorado in 1999 (K. Jones, *personal observation*). No other visitors were observed, although there were many types of bees in the vicinity. Whether pollinators or seed predators are factors in the persistence of *T. laxus* populations is presently unknown.

The majority of plants marked by Zielinski in the three Connecticut populations were present each year from 1990 through 1993, indicating good survivorship over that period. Also, there is no indication of dormancy, either in adult plants that fail to emerge or in seeds, but this does not rule out the possibility of dormancy under poor conditions.

Population genetics

Zielinski (1993) also did a preliminary analysis of genetic variation in four Connecticut populations, using two polymorphic enzyme systems (aspartate aminotransferase and

peroxidase). Her results show no evidence of inbreeding and suggest that there is considerable gene flow between populations. Each population was polymorphic for the same two alleles at the Aat locus. The Per locus was more variable, with up to four alleles in a population. Heterozygosity did not differ from Hardy-Weinberg expectation for random mating in any of the populations.

Zielinski's calculations of Nei's coefficients of genetic diversity yielded much more variation within populations (Hs = 0.350) than between them (Dst = 0.037). Less than 10% of the total genetic variation at the two polymorphic loci came from differences between populations, compared to 22% for a broad survey of plant taxa (Hamrick and Godt 1989). This result is consistent with the close proximity and similar habitat types of the Connecticut populations. The population that is the most widely separated geographically (CT .001) was found to be most different from the others genetically.

Population dynamics

The distribution of occurrences in close proximity to each other, together with genetic similarity between populations, suggests that *T. laxus* occurrences in Connecticut may function as members of metapopulations (groups of interacting populations). This has important implications for population dynamics and viability, especially for rare plants with small individual populations (Menges 1991). Most notably, migration among populations may allow long-term persistence of metapopulations even when the individual populations are not viable by themselves (Menges 1990). Also, more isolated populations may have lower survival probabilities than partially connected ones, due to lower potential for re-colonization (Fahrig and Merriam 1985). Gene flow among members of a metapopulation can help maintain genetic variation in small member populations, but may limit total genetic variation in the larger group (Lacy 1987). Such a scenario seems to fit the profile of *T. laxus* quite well, given long-term persistence of the species in the same areas of Connecticut despite continued rarity and small population sizes, and given the finding of substantial genetic variation within but not between populations.

In a well-studied example, Furbish's lousewort (*Pedicularis furbishiae*) is subject to disturbance that extirpates whole populations at a time. These catastrophic events are more important to the overall population dynamics of the species than are processes operating within populations (Menges 1990). Conservation efforts for *P. furbishiae* therefore aim to provide conditions that favor a positive balance between establishment of new populations and local extinctions, for example by maintaining suitable hydrological conditions within the watersheds (Menges 1991). Disturbance regimes favoring *P. furbishiae* are more frequent and dynamic than those experienced by *Trollius laxus* (C. Caljouw, Botanist, *personal communication*), but the example serves to illustrate the importance of determining how *T. laxus* populations respond to disturbance and variation in hydrologic conditions.

HABITAT/ECOLOGY

Trollius laxus grows in open fens and swamp margins with highly alkaline groundwater seepage (Bliss 1985). Water pH at 17 *T. laxus* sites throughout the species range, including New England, varied from 7.2 to 8.0, with one Ohio population at 6.5 soon after a rain (Rhinehalt 1990). Soil pH at these sites ranged from 5.9 to 7.7. The soils had a very high lime index (often the maximum value of 70), available calcium (up to 80 to 90% saturation), and high but variable cation exchange capacity (Rhinehalt 1990). Rawinski (cited in Bliss 1985) considers *T. laxus* to be an obligate calcicole, requiring cold, alkaline groundwater under natural conditions. Where the water table drops significantly, *T. laxus* plants can be smaller, according to Andra Leimanis, a researcher who studied central New York populations in the 1990's (Leimanis 1994).

Most of the Connecticut sites are subject to flooding (W. Moorhead, Connecticut Natural Diversity Data Base, *personal communication*), often due to beaver activity. This disturbance may harm existing *Trollius laxus* populations, but also may aid dispersal and hinder competitors; the net effect on *T. laxus* is unknown. In sloping fens the populations can get quite large and dense, as in one current site in central New York. In these fens the *T. laxus* plants are concentrated on sedge tussocks somewhat above the saturated soils or on seepy mineral soil (Bliss 1985). In seepage swamps, the populations tend to be more sparse and patchy, with the plants growing along wet depressions or on sedge tussocks. In forested swamps, *T. laxus* can occur on mossy hummocks or moss-covered woody debris. Associated species in the two types of habitats are listed in Table 1, compiled from checklists provided by The Nature Conservancy.

Competition with other plants is thought to be a problem for *T. laxus*, and there is anecdotal evidence that they get “eventually shaded out” from swamp forests (Mitchell and Sheviak 1981). On the other hand, a study of the two extant Ohio populations found that shade seemed to benefit *Trollius* plants in a site subject to seasonal drying, but not at the other site where moisture is abundant and perennial (Rhinehalt 1990). Rhinehalt measured light intensity at several times of day and different points in the season for individual plants at the two sites, and looked for correlations with plant size and components of reproductive success. At one site larger plants (more ramets) occurred in places of lower afternoon light intensity, and more flowers were produced per plant where morning light intensity was lower. Overall, as average daily light intensity increased, plant height decreased. Light intensity was not correlated with any measures of plant size or reproductive effort at the other, wetter population, where there was much less flowering. Without experimental manipulation controlling for other variables it is difficult to establish that variation in light intensity causes changes in plant size and reproduction. Nonetheless, Rhinehalt’s conclusion that some canopy shading benefits *Trollius* plants in at least one site should be kept in mind when canopy reduction is under consideration as a management action for the taxon. Early records describe it as a native of “shady wet places” (Sims 1818). Lack of high shade due to beaver activity is listed as a threat at the most open Connecticut population, CT .001, where plants are noticeably smaller than other

populations and very few have bloomed in recent years. Brumback (1996) noted that trees and shrubs at this site were cut back two years earlier, and that the result was that the surrounding vegetation grew considerably and obscured the Trollius plants. Botanists familiar with *T. laxus* feel that it generally does better in the sun (Leslie Mehrhoff, Torrey Herbarium, *personal communication*; Robert Zaremba, The Nature Conservancy, *personal communication*; W. Moorhead, *personal communication*). Perhaps competition with other herbaceous species and woody shrubs restricts *T. laxus* to marginal, shady sites.

Table 1. Species associated with *Trollius laxus* in Connecticut.	
Open fens	**Seepage swamps**
Acer rubrum	*Acer rubrum*
Pinus strobus	*Carpinus caroliniana*
Cornus stolonifera	*Pinus strobus*
Hamamelis virginiana	*Tsuga canadensis*
Rhamnus alnifolia	*Ulmus americana*
Rubus pubescens	*Kalmia latifolia*
Vaccinium corymbosum	*Potentilla fruticosa*
Viburnum recognitum	*Rhamnus alnifolia*
Equisetum hyemale	*Spiraea latifolia*
Osmunda cinnamomea	*Toxicodendron radicans*
Thelypteris palustris	*Viburnum cassinoides*
Calamagrostis canadensis	*Osmunda cinnamomea*
Carex aquatilis	*Carex lacustris*
Carex flava	*Carex leptalea*
Carex interior	*Carex stricta*
Carex leptalea	*Angelica atropurpurea*
Cirsium muticum	*Caltha palustris*
Clematis virginiana	*Cicuta maculata*
Fragaria virginiana	*Cirsium muticum*
Iris versicolor	*Conioselium chinense*
Symplocarpus foetidus	*Geranium maculatum*
Zizia aurea	*Geum rivale*
	Mitella diphylla
	Mitella nuda
	Prunella vulgaris
	Ranunculus recurvatus
	Saxifraga pensylvanica
	Senecio aureus
	Solidago patula
	Symplocarpus foetidus
	Thalictrum polygamum
	Viola papilionacea
	Zizia aurea

There also is evidence of predation on leaves and stems in *T. laxus* populations in Connecticut (Hemingson 1993). Rawinski (1989) observed a slug in a *Trollius* flower and suspected it might be eating flower parts, and that slugs may affect reproduction when flowering occurs in rainy weather. He monitored one population in 1988 and found that only seven fruits were produced from 33 flowers on 13 plants that bloomed. Rawinski attributed the low fruit set to damaged or aborted flowers. Deer may also browse the plants (N. Proctor, Southern Connecticut State University, *personal communication*), particularly the taller flowering stems. A Colorado population of *T. albiflorus* had several tall stems clipped off at the top in a manner suggesting deer foraging (K. Jones, *personal observation*). Trampling may also be a problem, as several field notes indicate deer or beaver trails in or near Connecticut populations.

THREATS TO TAXON

The greatest threat to *Trollius laxus* throughout its range is loss or alteration of the sensitive calcareous wetland habitat (Bliss 1985). Development has extirpated many populations, particularly in New Jersey, New York, and Pennsylvania. More subtle alterations such as influxes of nutrients or silt from agricultural areas within the watershed, or changes in the local hydrology and drainage patterns may cause local declines or extinctions (Bliss 1985). The New England populations tend to occur in saturated areas at points of locally low topography, and so may be especially sensitive to such alterations in the watershed. Land use around the Connecticut populations includes agriculture, as the soils in the region are rich and fertile (Dowhan and Craig 1976).

An indirect effect of the loss of appropriate habitat is the formation of barriers to dispersal to new sites and restriction of migration among populations. Particularly for early- to mid-successional species, dispersal ability can be critical to long-term persistence in a region. If long-distance dispersal of *T. laxus* occurs primarily by water, as for a European relative (Danvind and Nilsson 1997), then artificial draining even some distance away may critically impede its ability to colonize new locations.

Logging in forested swamps would pose a threat to *T. laxus* populations at the swamp margins, by drastically altering the ecology of the sites and/or through direct destruction of plants, increases in soil compaction, and changes in surface hydrology. Grazing in these areas would cause similar problems. These attractive plants are also subject to collection from the wild.

Possible natural threats to extant populations include flooding from beaver dams and competition in the course of succession. Neither has been directly documented to harm *Trollius* (Bliss 1985) but both are frequently mentioned on field survey forms as potential threats. Beaver activity could cause changes in water quality as well as flow patterns, and rapid drawdown after flooding (as when dams are removed) can favor quick establishment of invasives (C. Caljouw, *personal communication*). Dowhan (quoted in Bliss 1985) noted that

forest encroachment contributing to the decline of *T. laxus* has not been documented, and that *T. laxus* is as much at home in swamp margins as in fens. Finally, as noted above, competition with other plant species, as well as herbivory on plants and predation on seeds, may threaten *Trollius laxus* at certain sites.

DISTRIBUTION AND STATUS

General status

Trollius laxus has a fairly narrow distribution, from northeastern Ohio east through northwestern Connecticut (Figure 1), and is restricted to sensitive wetland habitats throughout its range. Within New England, it currently is found only in the Northern Marble Valley region sof Litchfield County, Connecticut (Dowhan and Craig 1976; Figure 2). The historic range is similar (Figure 3); old records from New Hampshire, Maine, Michigan and Delaware are unsubstantiated and apparently erroneous (Eastman 1980, Crow 1982, Mohlenbrock 1983, Bliss 1985). Every state in the range has lost many or most of its occurrences (Bliss 1985). The Litchfield County, Connecticut populations represent the northeastern edge of the species range, both current and historic. There is at least one population within a few miles of the Connecticut border in New York, but it is considerably south and disjunct from the extant Connecticut populations.

Trollius laxus has a NEPCoP rank of Division 1 (Brumback and Mehrhoff *et al.* 1996), indicating that it is a globally rare taxon occurring in New England. The official global rank for *Trollius laxus* is G4 (according to The Nature Conservancy and The Association for Biodiversity Information, 1999), but this reflects the former practice of lumping *T. albiflorus*, a more abundant and widespread species of western North America, as a subspecies of *T. laxus* (*e.g.* Kartesz 1994). The 'subspecies' *laxus* is listed as "scarce, about T2, and declining" (according to The Nature Conservancy and The Association for Biodiversity Information 1999). The U. S. Fish and Wildlife Service has proposed *Trollius laxus* for the federal endangered species list in 1976, and has considered it repeatedly since then (Rhinehalt 1990). Several informal records at the Connecticut Department of Environmental Protection indicate its status as "U. S. Endangered." The individual state rank is S1 for Connecticut, Ohio, and Pennsylvania. New Jersey and New York have unknown ranks (S?) in the 1999 update, but both are listed as S2 in the 1984 Element Global Status summary.

Figure 1. Extant occurrences of *Trollius laxus* in North America. Gray-shaded states have 1-5 or an unspecified number of occurrences (see Table 2), while states in black (Connecticut) has more than 5 occurrences.

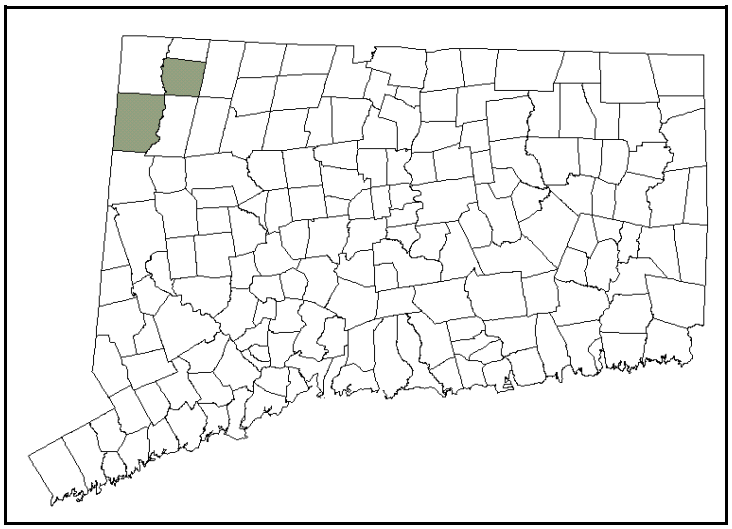

Figure 2. Extant occurrences of *Trollius laxus* in Connecticut (the only New England state in which it occurs). Towns shaded in gray have 1-5 occurrences.

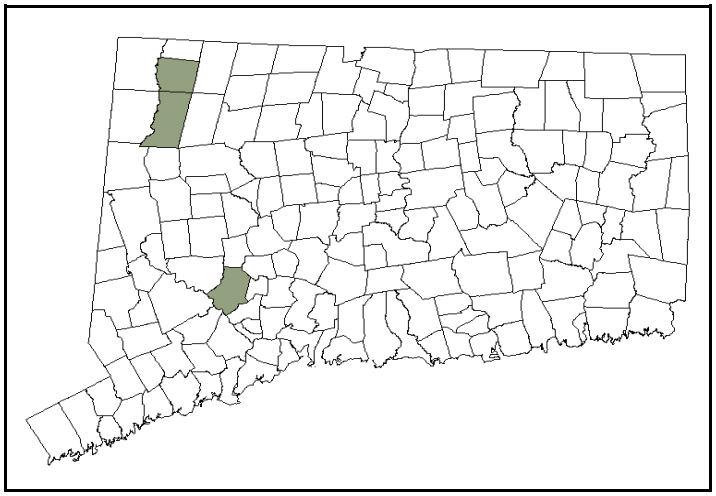

Figure 3. Historic occurrences of *Trollius laxus* in Connecticut. Towns shaded in gray have 1-5 occurrences.

Table 2. Occurrence and status of *Trollius laxus* 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 UNVERIFIED
Connecticut (S1): 6 extant occurrences, 3 historic occurrences	Western occurrences are now designated *Trollius albiflora*	Michigan (SR)
New Jersey (S1)	New York (S3)	
Ohio (S1)		
Pennsylvania (S1)		

Table 3. New England Occurrence Records for *Trollius laxus* based on data from State Natural Heritage Programs. Shaded occurrences are considered extant.

State	EO Number	County	Town
CT	**.001**	**Litchfield**	**Sharon**
CT	**.002**	**Litchfield**	**Canaan**
CT	**.003**	**Litchfield**	**Canaan**
CT	**.004**	**Litchfield**	**Cornwall**
CT	**.005**	**Litchfield**	**Canaan**
CT	**.006**	**Litchfield**	**Canaan**
CT	**.007**	**New Haven**	**Oxford**
CT	**.008**	**Litchfield**	**Canaan**
CT	**None Assigned**	**Litchfield**	**Canaan**

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

As the sole representative of the *Trollius* genus in eastern North America, *T. laxus* is an exciting and valuable evolutionary and ecological novelty. Morphological similarity to the western *T. albiflorus* suggests a recent evolutionary split, yet the two taxa occur in very different types of habitats, suggesting a capability for rapid evolution. New England populations are especially significant because they represent the northeastern limit of the species range and are characteristic of a very specialized and sensitive habitat.

A realistic goal for the conservation of *T. laxus* is a total of eight occurrences distributed among at least three metapopulations in different local watersheds in Connecticut. At least one occurrence in each metapopulation should be sufficiently large and reproductively active, a minimum of 100 flowering and fruiting individuals, to serve as a source population of propagules for less viable occurrences. The stated goal represents an expansion from the five known extant occurrences, some of which are alarmingly small. Nonetheless, it should be possible to achieve this goal within twenty years.

It is crucial to ensure the capacity for seed dispersal among occurrences within a metapopulation, to avoid extirpation of occurrences that may not be viable in isolation. Ideally this would be accomplished by protecting the entire watersheds and maintaining the natural hydrologic regimes, including occasional flooding.

Distribution among multiple watersheds is especially important, so that disturbance or deterioration of local habitat will not extirpate this wetland plant from the entire region. Five of the known extant occurrences are in close proximity in Canaan. Changes in the quality or hydrology of the Hollenbeck River, for example, could well affect most or all of these. The fifth extant occurrence is on the other side of the Housatonic River in Sharon, and thus its fate is more independent of the others. This occurrence, CT .001, is quite small and feeble, and merits special attention due to its isolation. An additional disjunct site, for example at an historic location in Cornwall, would greatly enhance the prospects for long-term persistence of *T. laxus* in New England.

Because the species apparently has never been found elsewhere in New England, despite intensive searching particularly in western Massachusetts (L. Mehrhoff, *personal communication*), there is little reason to attempt to expand its range beyond its historic northeastern limit in western Connecticut.

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Appendix I. An explanation of conservation ranks used by The Nature Conservancy and the Association for Biodiversity Information

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.