

New England Plant Conservation Program

Chamaelirium luteum (L.) A. Gray
Devil's Bit

Conservation and Research Plan
for New England

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SUMMARY

Chamaelirium luteum (L.) A. Gray is a dioecious perennial in the Liliaceae, and is the only species in its genus. It occurs in 24 eastern states and was once known from southern Ontario. It is common near the center of its range, but rare on its western and northern boundaries. In New England, it occurs in Connecticut and Massachusetts, where it is at the northern edge of its range. At one time more commonplace, now only 11 populations in the two states remain, and several of these have very few individuals.

Chamaelirium luteum has a basal rosette of leaves and a single flowering stalk with either male or female flowers. Flowers are white or greenish white; male flowers fade to yellow. Occasional plants can be found with a few perfect flowers at the base of the male inflorescence, a condition called polygamo-monoecy.

Although it has a wide habitat tolerance, *Chamaelirium luteum* typically grows on slopes of any aspect in open, mesic, rich hardwood forests, or in wet meadows. It requires partially open conditions in order to flower, but persists for years as vegetative rosettes in more shaded situations.

An interesting feature of *C. luteum* is that it shows strong differentiation in life history and ecological characteristics between male and female plants. In any growing season, more male than female plants will flower. The sex ratio in populations is also biased toward males. This has been shown to be due to lower longevity and higher mortality rates of female plants.

Chamaelirium luteum is used both medicinally and ornamentally, and thus it is potentially threatened in New England by collection from the wild. Documented threats in New England include habitat loss, competition from invasive species, shading, damage from all-terrain vehicles, and deer herbivory of flowering stalks.

The primary conservation objective for *C. luteum* in New England is the maintenance of healthy, viable populations of the species at its remaining 11 extant sites. In order to achieve this, land acquisition of several sites may be necessary, followed by active management to reduce canopy cover and competition from invasive shrubs. Annual monitoring will be essential until populations recover. Augmentation of the smaller populations may be necessary. Because *C. luteum* does not flower in shaded situations and since rosettes are more difficult to notice in the wild, more populations may be present in New England, especially in western Connecticut. A search for these populations is a secondary conservation objective.

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.

The New England Plant Conservation Program (NEPCoP) of the New England Wild Flower Society 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.

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I. BACKGROUND

INTRODUCTION

Chamaelirium luteum (L.) Gray, a plant in the Liliaceae, is commonly known as Devil's-bit or Fairy Wand. It occurs in 24 eastern states from Massachusetts to Florida and west to Louisiana, Arkansas, Illinois and Michigan, and is known historically from southern Ontario. While it is common in the center of its range, it becomes rare on the periphery of its range. In New England, it persists only in Connecticut and Massachusetts at 11 sites, although its historic range was more extensive. Across its range, it occurs in a variety of habitats, but tends to occupy slopes in mesic deciduous forests or wet meadows.

Each *Chamaelirium luteum* plant consists of a stout rhizome, a basal rosette of leaves, and under optimal growing conditions, a single flowering stalk. The species biology of *C. luteum* is complex. It is mainly dioecious, and male and female plants have different life histories and ecological characteristics. They vary in frequency of flowering, microhabitat preference, and relative abundance within a population (Meagher 1978). A small number of male plants in studied populations are known to have a few perfect flowers at the base of the male inflorescence (Silliman 1957, Radford et al. 1968, Zomlefer 1997). *Chamaelirium luteum* is insect-pollinated, and seeds are dispersed up to 10 m from the springy infructescence by wind or forced ejection from the loculidical capsules when animals brush up against the stalk (Meagher 1986, Meagher and Thompson 1987).

Known threats to *Chamaelirium luteum* include habitat loss, competition from invasive species, shading, damage from all-terrain vehicles, and deer herbivory. A potential threat is overcollection by herbalists. Because of the rarity of *Chamaelirium luteum* in New England and because the species usually requires active management for its survival, a conservation plan is needed to pinpoint actions essential to maintenance of viable populations. This plan summarizes existing knowledge of its taxonomy, species biology and habitat requirements, identifies knowledge gaps, and proposes conservation actions necessary to maintain New England populations. These actions include land acquisition, site inventory and monitoring, landowner contact, computer simulation of minimum viable population size, augmentation of some populations, and habitat management.

DESCRIPTION

Chamaelirium luteum has a number of different common names, including Devil's bit, Fairy Wand, Blazing Star, Drooping Starwort, Rattlesnake-root, Squirrel Tails, and False Unicorn (Moser 1917, Carrolan 1982, Blau and Venezia 1983).

The following description of *Chamaelirium luteum* is compiled from several taxonomic sources (Fernald 1950, Radford et al. 1968, Gleason and Cronquist 1991, Zomlefer 1997, Magee and Ahles 1999, Flora of North America Editorial Committee 2002). Of these sources, Zomlefer (1997) contains the most complete description. Measurements given for plant parts are taken mainly from Gleason and Cronquist (1991). Since there appears to be a trend toward shorter leaves and shorter flowering stalks in more northerly regions, measurements in this manual are more appropriate for New England.

Chamaelirium luteum is a dioecious or occasionally polygamo-monoecious (see below) perennial with a short, stout rhizome. Plants are glabrous and have a basal rosette of spatulate to obovate leaves that are 8-15 cm long. Leaves have five to seven parallel veins and smaller veins that are somewhat netted, unusual in a monocot (Silliman 1957). Leaves are described as evergreen or persistent in the southern part of the range (Radford et al. 1968, Zomlefer 1997). In both sexes, flowers occur in dense, spike-like racemes; flowering stalks contain alternate, cauline leaves that become progressively shorter and narrower up the stalk. Flowering staminate plants range in height from 3 to 7 dm, while flowering pistillate plants are taller (up to 12 dm). Staminate plants have fewer leaves on the flowering stalk than do pistillate plants.

Both the male and female flowers of *Chamaelirium luteum* are bractless and contain six, one-nerved tepals. Each female flower is white to greenish and contains staminodes (sterile stamens) and three sessile stigmas. Male flowers are white, drying yellowish, with six stamens, the white anthers facing outward (extrorse), and with filaments of about the same length as the tepals. The staminate raceme is the more showy of the two. It is 4 to 12 cm long and 10 to 15 mm wide, with spreading pedicels, and often nods at the tip. The pistillate spike is slender, stiff, and has erect to ascending pedicels. Pistillate racemes are 1.5-4 cm long at the start of anthesis, elongating to 3.5 dm within a week or two. The flowering stalk of male plants withers and disappears soon after flowering, while the female stalk persists for up to three years.

The fruit consists of an ellipsoid to somewhat obovoid, loculicidal, three-valved capsule containing eight to 12 seeds in each locule. Female plants in North Carolina populations produced between 25 and 46 capsules (Meagher and Antonovics 1982). Each capsule is 7-14 mm long, and the seeds are 3-5 mm long, reddish-brown, and have a wing-like, membranous aril.

In addition to size variability, *Chamaelirium luteum* is also quite variable in flowering characteristics. Several sources mention that the species is sometimes polygamo-monoecious (a single plant has both perfect and unisexual flowers) rather than dioecious (Silliman 1957, Radford et al. 1968, Blau and Venezia 1983, Zomlefer 1997). This trait has been seen in both North Carolina (Silliman 1957) and New York (Blau and Venezia 1983) populations. Flowering stalks of North Carolina plants that were polygamo-monoecious were intermediate in

size and persistence between those of purely pistillate or staminate plants (Silliman 1957). There is nothing in the literature that reports on whether or not the polygamo-monoecious plants are capable of self-pollination.

There are no other species of plants occurring in New England that are likely to be confused with *Chamaelirium luteum* by the serious botanist. The flowering stalks of *Saururus cernuus* bear a vague resemblance to those of *C. luteum* in that they consist of a nodding, spike-like raceme of white flowers, but the flowers of *S. cernuus* are perfect, its leaves are heart-shaped, and it grows in swamps. In vegetative condition, the basal leaves of *Clintonia borealis*, also in the Liliaceae, are somewhat similar in shape to those of *Chamaelirium luteum* and form a basal rosette, but leaves of this species are larger, fleshier, a darker green in color, and do not have any netted venation.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Chamaelirium is a monotypic genus in the Liliaceae. In taxonomic manuals that divide the Liliaceae into smaller family units, it is placed in the Melanthiaceae (*e.g.*, Magee and Ahles 1999). It and its east Asian disjunct, Arcto-Tertiary affiliate, *Coniographis*, have been treated as a separate tribe within the Melanthiaceae, the Coniographideae (Zomlefer 1997), or even as a separate family, the Coniographidaceae (Takhtajan 1997 as cited in Flora North America Editorial Committee 2002).

The taxonomic information in this and the following paragraph was taken from The Missouri Botanical Garden's TROPICOS World Wide Web site, unless otherwise noted (Missouri Botanical Garden 2002). *Chamaelirium luteum* was first described in 1753 by Linnaeus as *Veratrum luteum* in *Species Plantarum*. The genus name *Chamaelirium* was first published by von Willdenow in *Der Gesellschaft Naturforschender Freunde zu Berlin Magazin für die neuesten Entdeckungen in der Gesammten Naturkunde* in 1808, and he placed *Veratrum luteum* in this genus as *Chamaelirium carolinianum* in the same publication. The currently accepted name of *C. luteum* was published by Gray in 1848 in his *Manual of the Botany of the Northern United States*, the first edition of what is today known as *Gray's Manual of Botany* (Fernald 1950).

Between 1753 and 1848, several additional taxa were described that are now considered to be synonyms of *Chamaelirium luteum*, and it has been placed in four additional genera at various times during this period. *Chamaelirium obovale* Small was described as a new species in 1901 from West Virginia plants. In his 1903 taxonomic manual, Small maintained it as a separate species, with larger flowers than *C. luteum* and obovoid instead of oblong-ovoid capsules. More recent taxonomic manuals do not consider *C. obovale* to be distinct.

Information on these synonyms of *C. luteum* is available on several World Wide Web sites. The most complete listing is given by The Institute for Systematic Botany at the University of South Florida (Wunderlin and Hansen 2002).

Synonyms include:

- *Veratrum luteum* Linnaeus, 1753 (the basionym)
- *Melanthium luteum* (Linnaeus) Thunberg, 1784
- *Melanthium dioicum* Walter, 1788
- *Helonias pumila* Jacquin, 1789
- *Helonias lutea* (Linnaeus) Ker Gawler, 1807
- *Chamaelirium carolinianum* Willdenow, 1808
- *Helonias dioica* (Walter) Pursh, 1814
- *Ophiostachys virginica* Delile, 1815
- *Diclinotrys albiflorum* Rafinesque, 1825
- *Veratrum flavum* Schultes f., 1830
- *Chamaelirium obovale* Small, 1901

SPECIES BIOLOGY

Chamaelirium luteum is a dioecious or occasionally polygamo-monoecious perennial. It shows strong differentiation in life history and ecological characteristics between male and female plants.

Male and female plants flower synchronously (Zomlefer 1997) and are insect-pollinated (Carrolan 1982, Meagher 1986). Specific pollinators are not known. A longhorn beetle (Cerambycidae) was seen by surveyors in 2002 on top of one male flower at a Connecticut population (CT .005 [Bethel]), presumably collecting pollen.

The flowering period of *C. luteum* occurs earlier and fruiting occurs later in the southern part of the range. Radford et al. (1968) report flowering from March to May and fruiting from September to November for the Carolinas, while Gleason and Cronquist (1991) report June flowering for plants in the northeastern United States. Flowering in North Carolina takes place over a one-to-two week (Meagher 1986) or two-to-three week (Meagher and Thompson 1987) period. Blau and Venezia (1983) found that plants in two New York populations flowered in June and July. A field visit to two Connecticut sites in mid-June 2002 (CT .004 [New Milford], CT .005 [Bethel]) found male plants in flower (Allard, personal observation).

The flowering stalks of male plants wither and disappear after the flowers wilt, while the female flowering stalks continue to develop and elongate. Inflorescence length and number of leaves on a flowering stalk are positively correlated with flower number in both male and female

plants; male plants produce many more flowers than do female plants. In studied populations in North Carolina, males produced 180-450 flowers per inflorescence, whereas females produced 25-46 flowers (Meagher and Antonovics 1982, Smouse et al. 1999). Females rarely, if ever, flower two years in succession (Meagher 1981). In any given population, the number of plants in flower varies from year to year and is probably dependent upon yearly climate fluctuations, although the conditions that support a greater degree of flowering are unknown (Meagher 1978, Carrolan 1982).

Fruiting stalks are quite durable and can remain on a plant for two or three years (Meagher 1978). Fruit set in North Carolina populations was 97-100 per cent (Meagher 1991).

Carrolan (1982) reports that seed dispersal is by wind, while Meagher and Thompson (1987) state that seed dispersal has not been investigated. They surmise that since the flowering stalk of *C. luteum* is somewhat springy, seeds may be disengaged and thrown from the loculicidal capsules if the stalk is pulled back and released. Therefore, strong winds or animals brushing against plants might contribute to dispersal. The taller height of the female plants may be an adaptation to increase the distance to which seeds can be spread (Meagher 1978, Meagher and Antonovics 1982). Presumably, the wing-like arils on the seeds may also increase dispersal distance.

A genetic analysis of parentage in one mapped North Carolina population (Meagher and Thompson 1987) revealed that, for the plants whose female parentage could be determined (n=418), seed dispersal distances averaged 10.1 m. For plants whose male parentage was determined (n=313), pollen dispersal distances averaged 10.4 m.

In studies using seeds from Tennessee plants, the seeds of *Chamaelirium luteum* exhibited "nondeep simple morphophysiological dormancy" (Baskin et al. 2001). Seeds would not germinate unless 1) they had undergone a period of cold weather followed by warming temperatures, and 2) embryos grew to almost double their length at the time of shedding after cold stratification was complete and during the warming period (Baskin et al. 2001). In addition, light was required for germination. Meagher and Thompson (1987) found that seed of North Carolina plants stored at room temperature did not survive for more than one year. Cech (2002) reported that the viability of seed grown from cultivation can be extended to two years by storing them under refrigeration at low humidity. In seed viability studies done at the New England Wild Flower Society, seed stored in closed containers in a refrigerator maintained its viability for at least three years (W. Brumback, New England Wild Flower Society, personal communication).

A bit of conflicting evidence on seed dormancy is presented by a germination experiment conducted with seeds from a Connecticut population (CT .005 [Bethel]). According

to notes in Natural Diversity Database files, on September 20, 2000, D. Norris collected 16 seeds from a single plant of *C. luteum* and placed them in moist potting soil. Germination began on October 17 and continued until about fifty per cent of the seeds had germinated. This suggests that the seed dormancy shown in Tennessee plants may not be consistent throughout the range of the species. Immediate germination may be favored in northern populations for some proportion of the seed, or seeds that have dried completely (as was true of the Tennessee seeds) may become dormant and require pretreatment.

In their study of parentage analysis, Meagher and Thompson (1987) observed that most seedlings had germinated in areas with some kind of local disturbance that removed leaf litter, indicating a germination preference or requirement for either light or bare soil. This corresponds well with greenhouse studies by Baskin et al. (2001) that showed that light was needed for germination.

Meagher's studies, reported in part above, centered around a long-term monitoring study on the species biology of *Chamaelirium luteum* that was conducted in North Carolina. Meagher's field studies of *Chamaelirium* continued for a total of 17 years (Smouse et al. 1999). His research included studies of ecological differentiation between the sexes (Meagher 1978, Meagher 1980, Meagher and Burdick 1980), mechanisms controlling sex ratios (Meagher 1978, 1981, Meagher and Antonovics 1982), life history and population dynamics (Meagher 1978, Meagher 1982, Meagher and Antonovics 1982), resource allocation (Meagher 1978, Meagher and Antonovics 1982), and analysis of parentage (Meagher 1986, Meagher and Thompson 1987, Meagher 1991, Smouse and Meagher 1994, Smouse et al. 1999). Meagher did not include an investigation of polygamo-monoecy in his studies.

Meagher's initial doctoral research involved mapping, measuring, and assessing the sex of individuals in four large natural populations for four to five field seasons, as well as conducting growth studies in a phytotron (Meagher 1978). Populations contained between 450 and 2220 plants. After analyzing his field data, Meagher formed several conclusions. *Chamaelirium luteum* showed strong differentiation between the sexes in life history and ecological characteristics. Females were larger than males, flowered less frequently, had a higher mortality rate, and therefore were less common in the populations. The higher mortality rate was attributed to a greater resource depletion due to flowering in females relative to flowering in males, with a consequent lessening of resistance to environmental fluctuations (Meagher and Antonovics 1982).

The male-biased sex ratio in *Chamaelirium luteum* had been reported prior to Meagher's work (Silliman 1957, Radford et al. 1968), but he examined the phenomenon more intensively (Meagher 1978, 1981, Meagher and Antonovics 1982). Natural populations of *Chamaelirium luteum* consisted of male plants, female plants, and plants that were vegetative and therefore not able to be identified to sex. Meagher classified sex ratios of *C. luteum* and

other dioecious perennial species into three groups: 1) the seedling, or primary sex ratio; 2) the adult, or secondary sex ratio; and 3) the sex ratio among flowering plants in any given year, or ephemeral sex ratio. By planting seeds of *C. luteum* and following them to sexual maturity, he showed that the primary sex ratio was about one to one. After seven years of censusing, the cumulative sex ratio of adults in natural populations showed an excess of males, varying from 1.74 to 2.47 males to one female. In addition, the ephemeral sex ratio was even more strongly biased toward male plants, with a range of from 2.37 to 14.0 males to one female. The excess of males was due to higher mortality rates of females and a corresponding lower longevity. Since plants were tagged and tracked from year to year, the authors were able to determine that shifting between sexes did not occur. Population projection matrices for the North Carolina populations predicted that overall population sizes were stable (Meagher 1982).

Males and females in the North Carolina populations showed spatial segregation in their distribution in three out of four populations (Meagher 1980, Meagher and Burdick 1980). Nearest neighbor and Monte Carlo analysis showed that male plants were clustered with other male plants, and female plants were clustered with other female plants. Males occurred in denser clusters than did females. Meagher showed that this spatial segregation was, at least in part, due to differences in environmental requirements of the sexes. He did this by examining associated plant species at different quadrat scales and showing that male and female plants were distributed in different vegetation zones (Meagher 1978, Meagher 1980). Since the geographic extent of each *Chamaelirium* population was, on average, less than 0.1 hectare, differentiation among zones occurred at a very small scale.

Vegetative plants were smaller and had a higher mortality rate than either male or female plants. The higher mortality rate of vegetative plants was at least partly due to the fact that this category was dominated by seedlings and younger plants, and plants in these life stages are generally more vulnerable to mortality than older, well-established plants (Harper 1977). Size of rosettes in any given year was positively correlated with probability of flowering in the next year and size of inflorescence (Meagher and Antonovics 1982). Plant size not only influenced the probability of flowering, but was also influenced by flowering. In a year in which a plant flowered, the basal rosettes of both male and female plants were smaller than they were in the previous year, although the reduction in size was greater for female plants (Meagher 1978).

Number of years to sexual maturity was estimated by growing plants in a phytotron and inducing yearly growth cycles using changes in temperature and day length (Meagher and Antonovics 1982). The simulated age of first flowering of male plants, on average, was slightly less than that of female plants, although both male and female plants took about four induction cycles to achieve sexual maturation. In the field, the juvenile period was shown to last at least six years (Meagher 1981).

In addition to the North Carolina study, a series of researchers headed by J. Utter has

worked on a demographic study of several populations of *Chamaelirium luteum* in New York for nearly twenty years (Carrolan 1982, Blau and Venezia 1984, Utter and Hurst 1990; J. Utter, Purchase College, State University of New York, personal communication). These populations range in size from 1200 to 3600 individuals. The North Carolina and New York studies provide us with an understanding of the species biology of *Chamaelirium luteum* both at the center and at the northern edge of its range.

In the two New York populations in which it was initially studied, the sex ratio of flowering plants in 1983 was 3 males to one female in one population and 2.7 males to one female in the other (Blau and Venezia 1983). Since North Carolina populations showed an ephemeral sex ratio range of from 2.37 to 14.0 males to one female, the limited New York data indicate a greater relative production of female inflorescences within populations roughly comparable in size to the North Carolina populations, but because ratios vary from year to year, more data are needed to be certain of this.

Flowering and successful seed set may be less frequent in the climatic conditions present in the north, but not enough data have been published to make a clear determination. A smaller percentage of plants in New York populations flowered in the year studied than did plants averaged over several years in North Carolina populations. North Carolina populations had a ten to 20 per cent average annual flowering rate (Meagher 1978), while only five to eight per cent of New York populations flowered in 1983 (Blau and Venezia 1983).

Two additional notable differences between plants in the New York populations and the North Carolina populations have emerged from these studies. First, of the two, only the New York plants sometimes produce two or more rosettes from one rhizome (Blau and Venezia 1983). In North Carolina, more than 1000 plants were dug up in one population, and no subterranean connections were found between rosettes (Meagher 1978).

The production of multiple rosettes from one rhizome has been reported as a means of vegetative reproduction (Blau and Venezia 1983, Utter and Hurst 1990). In the strict sense, vegetative reproduction has not been shown. In order for successful vegetative reproduction to occur, there must be a means of separation of the rosettes from each other and spread of plants from the original plant into the surrounding areas. These clones must form their own independent root system with which to tap water and nutrients from the environment. This has not been demonstrated in the New York populations. Rhizomes of *C. luteum* are short and the rosettes of multiple-rosetted plants grow close together. A corresponding rhizome elongation has not been observed, and there is no obvious other means whereby ramets might be spread. Nonetheless, there may be some selective advantage to the formation of multiple rosettes from one rhizome. Perhaps multiple rosettes may increase the likelihood of survival of the plant should one or more of the rosettes succumb to disease or insect predation.

The presence of multiple rosettes from one rhizome was also reported in a two- year study of one site in Berkshire County, Massachusetts (MA .002 [Sheffield], Blau 1988, Dunn 1989). Each rosette of the plants with multiple rosettes was smaller than rosettes of single-rosetted plants. Seventeen percent and 12 percent of the plants in the Massachusetts study had multiple rosettes in 1988 and 1989, respectively. No plants were flowering.

The production of multiple rosettes from one rhizome may not be limited to populations at the northern edge of the range. Moser (1917), in a paper on the pharmacognosy of the species, reports two rhizome forms in material collected from the Baltimore, Maryland area: upright rhizomes with numerous leaf bases at the crown, suggesting a single rosette, and oblique rhizomes that show "one or more stem scars," implying the formation of more than one rosette from these rhizomes. In addition, an illustration of the roots, rhizome, and leaves of *Chamaelirium luteum* in Cech (2002), a book describing the cultivation of at-risk medicinal herbs, shows a branched rhizome supporting two crowns. Finally, although Meagher did not find multiple rosettes on plants in his North Carolina sites, some of the plants that he grew in the greenhouse from seeds collected in North Carolina produced multiple rosettes (T. Meagher, St. Andrews University, personal communication). This evidence suggests that multiple rosette production may be the norm, rather than the exception.

Another difference between North Carolina and New York populations is that although populations in both areas contain a small percentage of individuals that are polygamo-monoecious, only those in the New York populations produce seeds from flowers with both male and female parts (Utter and Hurst 1990; Utter, personal communication). It should not be assumed that this difference is unique to edge-of-range populations, that it is the consequence of genetic isolation, or that it developed due to greater environmental stresses at the edge of *C. luteum*'s range. The viability of the seeds of New York polygamo-monoecious plants is not known, and studies of populations that are geographically intermediate between New York and North Carolina have not been conducted.

HABITAT/ECOLOGY

Chamaelirium luteum is quite a generalist in its habitat preferences, but typically grows on slopes of any aspect in open, mesic, rich hardwood forests, or in wet meadows. Although researchers who have exclusively studied New York populations claim otherwise (Carrolan 1982, Blau and Venezia 1983, Utter and Hurst 1990), there is only a weak indication of a trend in habitat across its range. Forest types in which it occurs vary from south to north, but that is only because the forest types themselves do not extend across the entire geographic range of *C. luteum*. New York populations produce more flowers in a single year in more open habitats than in densely wooded ones, indicating that open sites are of higher quality for the species (Utter and Hurst 1990). Populations in North Carolina have a relatively high but

somewhat variable rate of yearly flowering in more shaded environments (Meagher 1978, Meagher and Antonovics 1982).

There is little information in the scientific literature on the preferred soil types of *Chamaelirium luteum*. A manual on the cultivation of medicinal herbs describes the soil conditions of natural populations as loam or sandy loam with a pH of 4.5 to 6, and suggests that the soils used for cultivation should be of high organic content and “on the acid side” (Cech 2002). This contrasts with the pH of 6.8 to 7.2 reported for the soils of a natural New York population (Carrolan 1982).

Taxonomic manuals list the habitat of *Chamaelirium luteum* as "meadows, thickets, and rich woods" in the central and northeastern United States and adjacent Canada (Fernald 1950), "moist woods and bogs" in the northeastern United States and adjacent Canada (Gleason and Cronquist 1991), "moist or dry-mesic woods" in New England and adjacent New York (Magee and Ahles 1999), "moist meadows and thickets" in West Virginia (Strausbaugh and Core 1978), "rich woods" in the Blue Ridge physiographic province (Georgia, North Carolina, South Carolina, Tennessee, and Virginia; Wofford 1989), an exposed limestone slope and woods dominated by beech and oak in southern Indiana (Deam 1940), "moist slopes, bottomlands, wet savannas" in North and South Carolina and Virginia (Weakley 2002), "rich, mesic wooded slopes and coves" in North and South Carolina (Radford et al. 1968), "rich woodlands, wooded slopes, coves, sometimes in dry open woods and meadows; in the southernmost part of the range sporadic in seasonally wet pine savannas and flatwoods" in the southeastern United States (Godfrey and Wooten 1979), "flatwoods and bluffs" in the Florida panhandle (Clewell 1985), and "moist thickets and meadows" in central Florida (Wunderlin 1982). There seems to be little trend in habitat preference across the range of the species, with open, moist, rich woods being the habitat of choice in most areas.

Two specific sites studied in New York include an open wet meadow flanked by trees and a drier wooded site, with both populations growing alongside trails (Blau and Venezia 1983). A list of many associated species is given with no indication of relative abundance and is too long to reproduce here. Soils at the wet meadow site are silt loam with a surface pH of 6.8 to 7.2 (Carrolan 1982). In a later paper, the wet meadow is referred to as an "old field" (Utter and Hurst 1990). A third site in the same general area is a moist hemlock ravine with exposed calcite rock (Carrolan 1982).

Sites where *Chamaelirium luteum* grows in the heart of its range in central North Carolina include 1) slopes in forests dominated by *Fagus grandifolia*, *Acer rubrum*, and *Liriodendron tulipifera*; 2) a drier, westwardly sloping site with *Pinus taeda*, *Liquidambar styraciflua*, and several *Quercus* species; and 3) two sites on northeast-facing slopes under *Carya tomentosa*, *Liriodendron tulipifera*, and several *Quercus* species (Meagher 1980). The most abundant shrub and herb species associated with *Chamaelirium luteum* at these

sites included *Desmodium nudiflorum*, *Iris cristata*, *Hexastylis* sp., *Euonymus americanus*, and *Polygonatum biflorum*.

Chamaelirium luteum once occurred in up to five sites in Ontario, and is known only from herbarium specimens (M. Oldham, Ontario Natural Heritage Information Centre, personal communication). Its habitat there, taken from specimen labels, included sandy brush, open grassland, swamps, and moist thicket.

The lack of flowering of *C. luteum* in sites that are now occupied by dense secondary forests may indicate a need for a more open forested condition, as does the fact that *C. luteum* often grows near trails where more light may be available. In two New York sites studied, *C. luteum* flowered more vigorously in a single year of study in the wet meadow site than in the forested site (Blau and Venezia 1983). Trees cut along a trail in the forested New York site enhanced flowering (R. Zaremba, Consulting Botanist, personal communication). One once-forested site where it is persisting and flowering is now a maintained power line right-of-way (CT .004 [New Milford]). Limited data from one site in Connecticut where the canopy above the population was thinned suggests that reducing canopy density may increase flowering (CT .005 [Bethel]). In a wooded Massachusetts population (MA .002 [Sheffield]), flowering was only observed in years following gypsy moth defoliation of canopy trees.

Carrolan (1982) surmises that the most likely sites to find *Chamaelirium luteum* in New York are calcareous wet meadows with 10-40 per cent shrub cover and containing some of the following species: *Myrica pensylvanica*, *Ceanothus americanus*, *Potentilla fruticosa*, *Gaylussacia baccata*, *Castilleja coccinea*, *Gentiana crinita*, *Parnassia glauca*. Three of these species (*Potentilla fruticosa*, *Castilleja coccinea*, *Parnassia glauca*) are also known from one of the Connecticut sites (CT .004 [New Milford]).

Habitats in extant sites for *Chamaelirium luteum* in Connecticut include the perimeter of oak and pine woods on a moist hillside (CT .001 [Salisbury]), a swamp border and a woods trail (CT .002 [Salisbury]), a wooded hillside (CT .003 [North Canaan]), an open power line (CT .004 [New Milford]), trailside in mixed deciduous woods with *Acer saccharum*, *Betula lenta*, and *Quercus rubra* (CT .005 [Bethel]), in the transition between a *Quercus/Viburnum* forest and *Acer rubrum-Fraxinus pennsylvanica* swamp forest (CT .013 [Meriden]), and trailside in a mesic streamside mixed forest of *Tsuga canadensis*, *Acer saccharum*, *Quercus rubra*, and *Betula alleghaniensis* (CT .014 [Salisbury]). In Massachusetts, extant populations occur in mixed oak-pine-chestnut woods (MA .002 [Sheffield]), a shaded dolomite ledge in *Fraxinus americana-Acer saccharum* forest (MA .007 [Sheffield]), a sloping forest of *Acer rubrum*, *A. saccharum*, *Tsuga canadensis*, and *Liriodendron tulipifera* on a peninsula extending into a marsh (MA .008 [Egremont]), and mid-slope in a forest of *Acer saccharum* and *Quercus rubra* over limestone (MA .009 [Great Barrington]). More detailed species associates for New England occurrences are given in the Distribution and Status section.

USES

Chamaelirium luteum is used both medicinally and as an ornamental plant. Called “helonias” in the medicinal and herbal literature, *C. luteum* was used by American Indians and by 1917 was considered one of the more widely used domestic drugs in North America (Moser 1917). Medicinal uses include treatment of colic, stomach ailments, indigestion, the expulsion of worms, stimulation of appetite, and a variety of ailments associated with both male and female reproductive organs (Foster and Duke 2000). *Chamaelirium luteum* contains estrogenic compounds (Zomlefer 1997). Dried *C. luteum* root and root extracts are widely available commercially (e.g. Mountain Rose Herbs 2002).

Chamaelirium luteum plants grown from cultivated seed are available for purchase from several commercial gardens, such as Sunshine Farm and Gardens in West Virginia (Glick 2002) and Niche Gardens in North Carolina (Niche Gardens 2002).

THREATS TO TAXON

Known threats to *Chamaelirium luteum* in New England consist of: habitat loss; habitat degradation from shading, competition from invasive species, and all-terrain vehicle damage; and deer herbivory. A potential threat is the collection of plants from the wild for medicinal or ornamental use.

Habitat Loss

Numerous historic records for *C. luteum* exist in New England, particularly in Connecticut. There are no known documented cases of extirpation of historic populations, and the lack of specific site information in historic records makes it difficult to determine if populations still exist where the plants were originally collected. It is assumed, however, that development has eliminated many populations through habitat loss or modification. Most of the habitats of *C. luteum* are suitable for housing or other forms of development.

Habitat Degradation

Because *Chamaelirium luteum* requires fairly open surroundings in order to flower, the increase in vegetation density that often follows human disturbance such as the intensive logging of mature forests may threaten populations. Such a situation probably is the case at MA .002 (Sheffield), where *C. luteum* barely persists under a dense forest of young oaks and pine. *Chamaelirium luteum* often occurs along trails in woodlands in New England (CT .002

[Salisbury], CT .005 [Bethel], CT .014 [Salisbury]), and trampling and erosion along the trails is a potential threat. This must be weighed against the potential benefits to the plant provided by a more open canopy, trail maintenance, and the possible dispersal of seeds by humans or other large animals moving along the trails and brushing up against fruiting stalks.

Competition from invasive species is possible at several Connecticut sites where *Chamaelirium luteum* occurs. These include CT .001 (Salisbury), possibly threatened by *Rosa multiflora*; CT .002 (Salisbury), possibly threatened by *Lonicera* sp.; and CT .004 (New Milford), possibly threatened by *Lonicera* sp.

Another type of habitat degradation that is known to have occurred at one population (CT .005 [Bethel]) and has the potential to occur at other sites with trails is destruction of plants and habitat by all-terrain vehicles (ATVs). ATVs can cause serious soil erosion, especially in wet weather.

Deer Herbivory

Deer herbivory is evidenced by a literature report from New York, notes in the Heritage files for CT .002 (Salisbury), and my own field observations in Connecticut (CT .004 [New Milford], CT .005 [Bethel]). As is often the case for other species of lilies and orchids, only the flowering stalk is eaten (Allard personal observation, Blau and Venezia 1983). Some insect herbivory on leaves has also been noted (CT .013 [Meriden]).

The extent of deer herbivory varies from population to population. In both the New York and in one Connecticut case, only a small percentage of the flowering stalks were eaten by deer. In the Connecticut population (.004 [New Milford]), only one stalk out of 20 had been eaten in 2002. This implies that either *C. luteum* is not particularly favored by deer, or that the deer population in the area is not dense enough to pose a serious threat. Nonetheless, when only a small proportion of the plants in a population will flower in any growing season, even the removal of a few inflorescences is a matter for concern.

In another Connecticut population (CT .005 [Bethel]), the inflorescences of three out of seven blooming plants had been eaten by deer in 2002. The deer population in this area may be more dense than it is in the New Milford site (CT .004), or deer may frequent the area more regularly. Of the two sites, only CT .005 (Bethel) is located along a trail. Deer often use existing footpaths for travel through forested terrain (Allard, personal observation); thus, the chances for deer to encounter *Chamaelirium luteum* plants at the Bethel site may be greater even if the deer population is not higher there.

Collection from the Wild

Since only the root of *Chamaelirium luteum* is used for medicinal purposes, collection from the wild destroys the plant. The USDA Forest Service treats *C. luteum* as a nontimber forest product and issues permits for its collection on some national forests, particularly in the southern Appalachians (Chamberlain et al. 2002). Collection of *C. luteum* from the wild for medicinal or ornamental uses is a potential threat to populations in New England.

DISTRIBUTION AND STATUS

General Status

Chamaelirium luteum is listed as a Division 2 species in *Flora Conservanda* (Brumback and Mehrhoff et al. 1996), which is defined as a regionally rare taxon with fewer than 20 occurrences within New England. Its global rank is G5, its U. S. national rank is N5, and its Canadian national rank is NX (NatureServe Explorer 2002).

Chamaelirium luteum has been documented in 24 states in the eastern United States and in Ontario, occurring from central Florida to southern Massachusetts and southern Ontario, and west to Louisiana, Arkansas, Illinois, and Michigan. It is less common at the western and northern edges of its range, and is rare in the southeastern Coastal Plain (Weakley 2002). It is known only historically from Ontario. NatureServe Explorer (2002) erroneously reports its presence in Maine (D. Cameron, Maine Natural Areas Program, personal communication). It is abundant in Pennsylvania, North Carolina, South Carolina, Tennessee, and Virginia.

The distribution and current state and sub-national ranks of *Chamaelirium luteum* are presented in Table 1. The North American distribution of *Chamaelirium luteum*, both historic and extant, is presented in Figure 1. The current distribution in New England is shown in Figure 2. Figure 3 depicts the historic New England distribution.

Status of all New England Occurrences — Current and Historical

Within New England, *Chamaelirium luteum* occurs in southwestern Massachusetts and western Connecticut. The Massachusetts Natural Heritage and Endangered Species Program database contains nine occurrences (four extant, five historic), while seven occurrences are reported in the Connecticut Natural History Survey database, all of which are extant. In addition to the seven Connecticut occurrences in the Element Occurrence database, notes on 15 herbarium specimens from the Connecticut Botanical Society are present in the Heritage files. These records have not been included in the Connecticut Element Occurrence data base,

but are included here, except for one specimen with no town information. A letter from L. Mehrhoff to T. Blau in the Connecticut Natural Diversity Data Base files indicates that there are seven historic records from Litchfield County, six from Fairfield County, two from Hartford County, three from New Haven County, one from Tolland County, and one from Middlesex County. None of these have been incorporated into the Connecticut Natural History Survey Element Occurrence database, but they are listed in Table 2 below.

Table 1. Occurrence and status of <i>Chamaelirium luteum</i> 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): seven extant and up to 27 historic occurrences	Arkansas (S3)	Alabama (SR)	Ontario (SH): up to five former occurrences in two counties (Oldham, personal communication)
Delaware (S1)	District of Columbia (S?)	Georgia (SR): throughout the state but rare in the Coastal Plain (Jones. and Coile 1988)	
Illinois (S1)	Florida (S?)	Mississippi (SR)	
Indiana (S1): four southern counties (Deam 1940)	Kentucky (S?): throughout the state except in the Bluegrass region (Browne and Athey 1992)	Ohio (SR)	
Louisiana (S2S3)	Maryland (S3)	South Carolina (SR)	
Massachusetts (S1): four extant, five historic	Michigan (S?)	Tennessee (SR)	
New York (S1S2): 11 extant and over 60 historical occurrences (Utter and Hurst 1990)	New Jersey (S3)	Virginia (SR): throughout the state but rare in the Coastal Plain (Harvill et al. 1986)	
	North Carolina (S5)		
	Pennsylvania (S?): throughout the state (Rhoads and Klein 1993)		
	West Virginia (S?)		

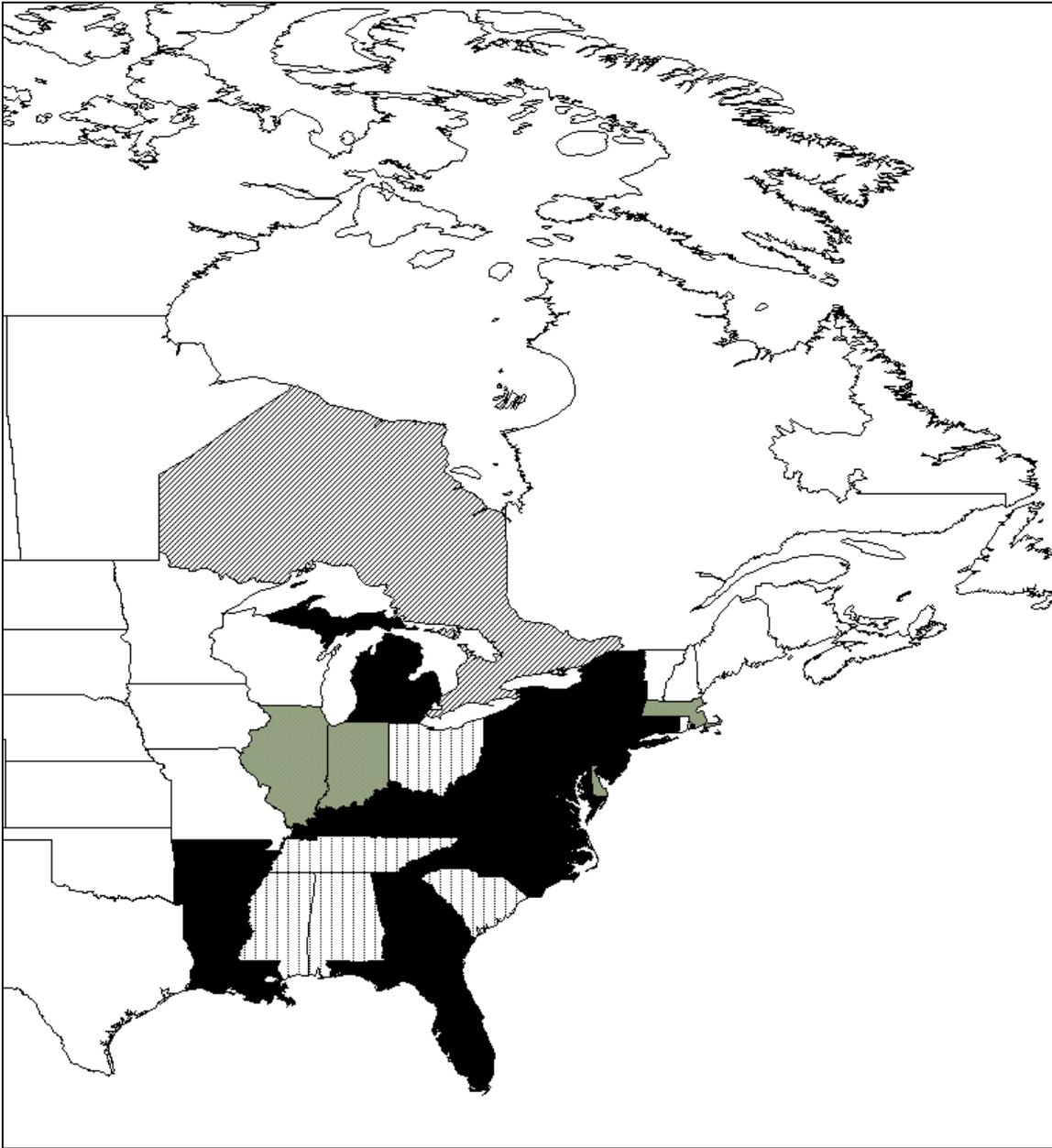


Figure 1. Occurrences of *Chamaelirium luteum* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. The province (Ontario) with diagonal hatching is designated "historic," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but without additional documentation). See Appendix for explanation of state ranks.

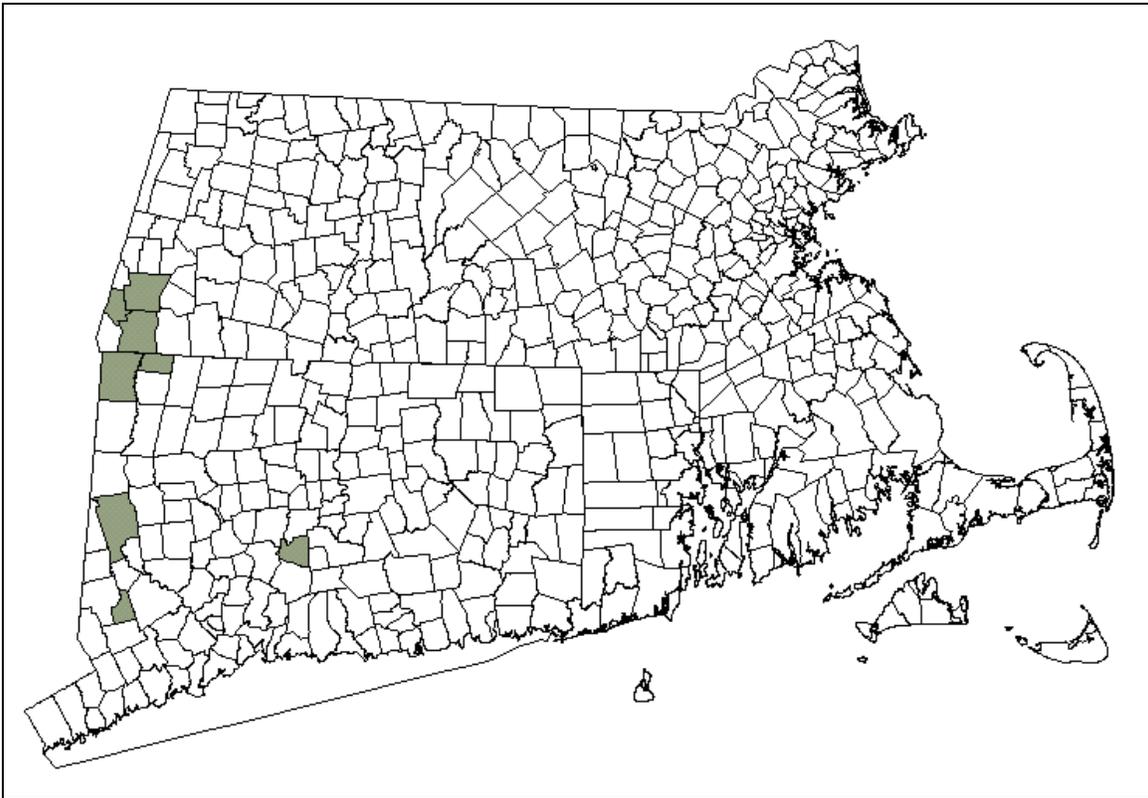


Figure 2. Extant occurrences of *Chamaelirium luteum* in New England. Town boundaries for southern New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

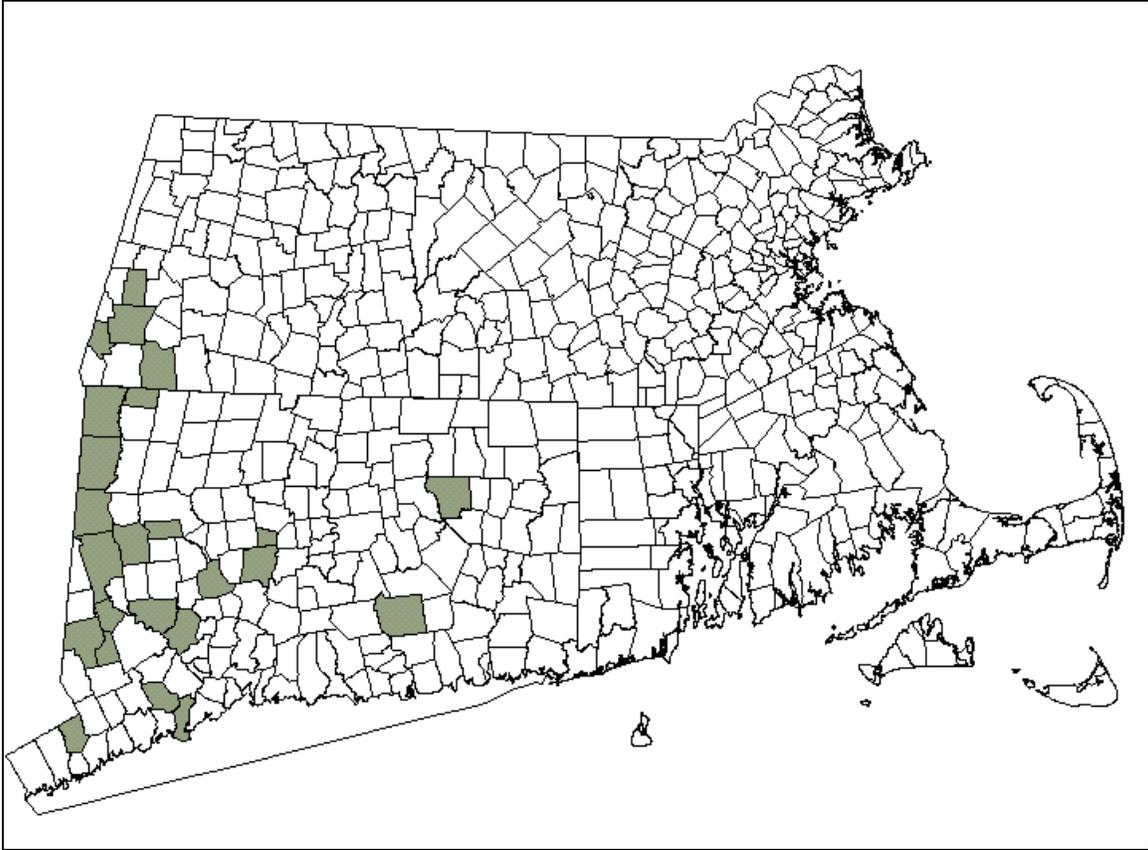


Figure 3. Historical occurrences of *Chamaelirium luteum* in New England. Towns shaded in gray have one to five historical records of the taxon.

Table 2. New England Occurrence Records for <i>Chamaelirium luteum</i>.			
Shaded occurrences are considered extant.			
State	EO #	County	Town
MA	.001	Berkshire	Great Barrington
MA	.002	Berkshire	Sheffield
MA	.003	Berkshire	Stockbridge
MA	.004	Berkshire	Stockbridge
MA	.005	Berkshire	New Marlborough
MA	.006	Berkshire	Egremont
MA	.007	Berkshire	Sheffield
MA	.008	Berkshire	Egremont
MA	.009	Berkshire	Great Barrington
CT	.001	Litchfield	Salisbury
CT	.002	Litchfield	Salisbury
CT	.003	Litchfield	North Canaan
CT	.004	Litchfield	New Milford
CT	.005	Fairfield	Bethel
CT	.013	New Haven	Meriden
CT	.014	Litchfield	Salisbury
CT	Historic	Fairfield	Bethel
CT	Historic	Fairfield	Brookfield
CT	Historic	Fairfield	Danbury
CT	Historic	Fairfield	New Canaan
CT	Historic	Fairfield	Stratford
CT	Historic	Fairfield	Trumbull
CT	Historic	Hartford	Plainville
CT	Historic	Hartford	Southington
CT	Historic	Hartford	Southington
CT	Historic	Litchfield	Kent
CT	Historic	Litchfield	Morris
CT	Historic	Litchfield	North Canaan
CT	Historic	Litchfield	New Milford
CT	Historic	Litchfield	Salisbury
CT	Historic	Litchfield	Salisbury
CT	Historic	Litchfield	Salisbury
CT	Historic	Litchfield	Salisbury

Table 2. New England Occurrence Records for <i>Chamaelirium luteum</i>.			
Shaded occurrences are considered extant.			
State	EO #	County	Town
CT	Historic	Litchfield	Salisbury
CT	Historic	Litchfield	Sharon
CT	Historic	Litchfield	Washington
CT	Historic	Middlesex	East Haddam
CT	Historic	New Haven	Oxford
CT	Historic	New Haven	Oxford
CT	Historic	New Haven	Southbury
CT	Historic	New Haven	Waterbury
T	Historic	New Haven	Waterbury
CT	Historic	Tolland	Mansfield

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Chamaelirium luteum is at the northern edge of its range in New England, where it occurs only in 11 extant occurrences in western Connecticut and southwestern Massachusetts. This is a decline from earlier times, as evidenced by numerous historic collections. Within its natural range in New England, its rarity is partially due to climatic factors that limit its abundance, but habitat loss, deer herbivory, and habitat degradation due to shading, competition from invasive species, and all-terrain vehicle usage have also played important roles. It is possible that collection of rhizomes for medicinal use played a part in early decimation of some populations, but this has not been documented.

The primary conservation objective for this species in New England is maintenance of populations at the known seven extant locations within Connecticut and up to four extant locations in Massachusetts. Several of the smaller populations are not viable in their current condition, and so augmentation is suggested.

At least five percent of the plants in each population should flower in any given year. Based upon monitoring data from North Carolina and New York, it is expected that about 30 percent of flowering individuals will be female. Populations growing in areas where dense vegetation has reduced or eliminated flowering are at greatest risk and therefore require the most immediate action. Deer herbivory is of concern in some sites, and may become more of an issue in future years.

With the exception of MA .002 (Sheffield), Massachusetts populations are all small, with six plants or fewer. In addition, MA .002 (Sheffield) has not been thoroughly surveyed since 1994 and may have declined. Populations of this size are not viable, due to the biased sex ratio and limited flowering capacity of this species. Because of this, it is recommended that the greatest amount of effort in Massachusetts be invested at increasing the vigor and numbers of plants in the MA .002 population. Once this population has recovered, propagules from MA .002 can be used to reintroduce the species at selected other sites if it no longer exists there, or to augment the populations if they are still small.

In order to set an informed conservation objective for the number of plants per population required for long-term population viability in Massachusetts and Connecticut, several issues must be considered. First, since some New York populations include more than 1000 individuals (Utter and Hurst 1990), it is not unreasonable to expect populations of the same size

to be attainable in New England. Currently, however, the largest populations in New England have far fewer plants.

In order for a population to be ranked "A" in Massachusetts, the Massachusetts Natural Heritage and Endangered Species Program recommends that a population contain at least 40 individuals (Appendix 3). Since 1) under more or less ideal conditions in New York, only between five and ten per cent of the population flowers in any given year, 2) populations have an average male sex bias of three to one, 3) sexually mature female plants cannot flower in successive years, 4) it takes up to six years for a plant to become sexually mature, and 5) natural seed banking is unlikely to occur, it seems doubtful that a population of 40 individuals will maintain itself for the long term. A viable population size will not be suggested here, but rather, a method for coming up with a reasonable size range is suggested as an action in the next section of this report.

A secondary conservation objective is to determine if historic populations still exist, and also to search for other, as yet undocumented, occurrences of the taxon. While information on most historic records is not specific enough to justify a search, a few specimens contain site information that may allow the original location to be pinpointed.

In addition to the historic sites, there is a reasonable chance that the species occurs in additional sites within its range, particularly in Connecticut. While in flower, *C. luteum* is showy and difficult to miss. At other times of the year and in populations that do not flower due to shading, the rather inconspicuous basal rosette may not be noticed unless care is taken. New populations have been discovered in Connecticut as recently as 2000. Botanists conducting research in western Connecticut should be familiar with the appearance of *C. luteum* and with its habitat so that they will be alert to the possibility of finding new populations.

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IV. APPENDICES

1. **State of Massachusetts Element Occurrence Ranking Specifications,**
Chamaelirium luteum
2. **An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

1. State of Massachusetts Element Occurrence Ranking Specifications, *Chamaelirium luteum*

A-Rank Specifications:

Condition: Vigorous, reproducing vegetatively and sexually, with both staminate and pistillate individuals in the population

Size: Greater than 40 individuals

Landscape: Within a community of high natural integrity, without invasive species; within a roadless block of greater than 500 acres

B-Rank Specifications:

Condition: Vigorous plants, at least reproducing vegetatively

Size: Between 20 and 40 individuals

Landscape: Within a plant community of high natural integrity, without invasive species; within a roadless block of greater than 200 acres

C-Rank Specifications:

Condition: Plants of at least fair vigor

Size: Between 5 and 20 individuals

D-Rank Specifications:

Condition: Plants of poor vigor

Size: Fewer than 5 individuals

Landscape: Within a degraded natural community or a highly fragmented landscape

Justification:

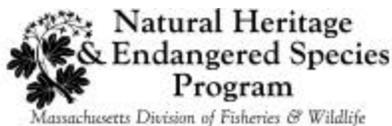
A-Rank Threshold: One population has remained consistently over 40 individuals in Massachusetts; several populations exist in high integrity natural communities in large roadless blocks of over 500 acres.

C-D Threshold: Populations with fewer than 5 individuals are more susceptible to stochastic events, and potentially to genetic consequences (e.g. drift) of small population size. Degraded natural communities may harbor invasive species or be subject to anthropogenic activities that may be detrimental to this species.

General Comments: Actual threats noted on Massachusetts field forms: succession (shade), invasive species (*Berberis thunbergii*), and changes to hydrology (beaver flooding). Potential threats include forest harvest and development.

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2. 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 or refine 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 been made for more than 20 years. An X rank is utilized for sites that are known to be extirpated. Not all EOs have received such ranks in all states, and ranks are not necessarily consistent among states as yet.