

New England Plant Conservation Program
Conservation and Research Plan

Castilleja coccinea (L.) Sprengel
Indian Paintbrush

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SUMMARY

Indian paintbrush, *Castilleja coccinea* (L.) Sprengel (Scrophulariaceae), is an annual terrestrial herb found in moist meadows and open woods with typically sandy and subacid to slightly alkaline soils. There are 60 element occurrence records for Indian paintbrush in New England. This number includes 51 records from Maine, Massachusetts, New Hampshire, and Rhode Island, all of which are now historic. The remaining nine records are for locations in Connecticut, of which only five are now considered extant. In the last ten years, plants have been observed at only four of these sites and one of these observations was of only three plants in 1990. The most viable of the remaining populations are found in Fairfield and Litchfield Counties. The primary threat at these sites is shading.

Indian paintbrush does not compete well in the shade of other plants and open sites need to be actively maintained if the species is to persist. In addition, it is a hemiparasite (acquiring certain resources through haustorial connections with other plants but meeting part of its resource requirements through autonomous photosynthesis) and grows vigorously only in the presence of a host. The latter requirement might be eased by the fact that Indian paintbrush seems to have a reasonably broad host range.

The primary conservation actions recommended for Indian paintbrush are to:

- protect extant occurrences
- conduct surveys at recently reported but untracked sites
- identify limiting factors
- reintroduce plants to historic sites

The actions necessary to protect the viability of existing populations of Indian paintbrush include maintaining current open habitat at extant sites and re-establishing favorable conditions at selected historic sites. In each case, working with owners that are cooperative with conservation goals will be paramount.

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) 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.

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I. BACKGROUND

INTRODUCTION

Indian paintbrush, *Castilleja coccinea* (L.) Sprengel (Scrophulariaceae), is a small to intermediate-sized, terrestrial, hemiparasitic, flowering herb that grows in bogs, open wet meadows and open woods with moist, subacid to alkaline sandy soils (Pennell 1935) across the eastern half of the United States. Its range extends west across the Missouri River into parts of Kansas and Oklahoma and north into portions of the adjacent Canadian provinces, Manitoba, Ontario, and Saskatchewan (Pennell 1935).

Indian paintbrush is considered extirpated from all New England states, except Connecticut where it carries a state rank of S1. It has a global rank of G5 (apparently stable). It is vulnerable to local extinction due to succession (Sorrie 1987), the most important consequence of which is probably shading (Leslie Mehrhoff, University of Connecticut, personal communication). It is especially threatened on extant sites by the canopy-forming invasive species *Rosa multiflora* (William Moorhead, consultant, personal communication).

This conservation plan summarizes what is known about the biology and ecology of Indian paintbrush as well as the threats to its continued survival. The plan also recommends actions that will promote the conservation and recovery of the species in New England.

DESCRIPTION

Indian paintbrush is an annual or biennial hemiparasitic herb (Pennell 1935, Gleason and Cronquist 1991). Stems are usually simple, 2.0-4.0 dm tall, with or without pubescence, and bear leaves that may be variously entire to three-lobed. Flowers are born in a dense 4.0-6.0 cm terminal spike (which elongates in fruit to 1.0-2.0 dm) and are subtended by scarlet bracts which are commonly three-lobed. These bracts make up much of the floral display that attracts pollinators. The calyx is 17.0-25.0 mm long, often scarlet, thin, and is divided into lateral halves which are widened distally and bear a broadly rounded, truncate, or barely emarginate summit. The corolla is a little longer than the calyx (21-27 mm) and typically greenish yellow. In New England, flowering takes place mostly from late May to the middle of June. The fruit is a small ovoid capsule (0.4-1.0cm) with hundreds of minute seeds (Malcolm 1962a).

The only other species of *Castilleja* that occurs in New England is *C. septentrionalis*. *Castilleja coccinea* is easily distinguished from *C. septentrionalis*. *C. coccinea* is an annual with simple stems and mostly lobed bracteal and foliage leaves, while *C. septentrionalis* is perennial, often has branched stems, and has mostly entire bracteal and foliage leaves. When in

flower, *C. septentrionalis* has bracts that are yellow to pale white, while those of *C. coccinea* are mostly scarlet. The habitat of *C. septentrionalis* is montane in damp rocky soil, while *C. coccinea* is found in wet meadows at lower elevations (Pennell 1935). Finally, *C. septentrionalis* typically flowers later (July and August according to Gleason and Cronquist 1991) than *C. coccinea*, which typically flowers from May to June.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Indian paintbrush was first described as a new species in 1737 by Linnaeus who gave it the name *Bartsia coccinea* in honor of Johannes Bartsch. In 1818, Nuttall transferred the species into *Euchroma*. It was transferred by Sprengel to the genus *Castilleja* in 1825 (Pennell 1935) where it presently remains.

In their recent work, Judd et al. (1999) transferred this genus as well as all other hemiparasitic members of the family Scrophulariaceae into the family Orobanchaceae. While this treatment is consistent with some recent molecular work (cited in Judd et al. 1999), the regional vascular floras we are aware of (which are the most likely authorities used by agencies and individuals executing this plan) recognize *Castilleja* as a member of the Scrophulariaceae family. Consequently, we chose to retain this treatment in writing the current plan.

SPECIES BIOLOGY

Indian paintbrush has perfect flowers. Gleason and Cronquist (1991) suggest flowering occurs from April to August. Pennell (1935) points out that the actual phenology in any locality is probably much shorter and associated with latitude. This is consistent with our own observations. In New England, flowering appears to peak from late May through mid June, although flowering is indeterminate and can extend into August (according to data from herbarium records). Robertson (1891) recorded a hummingbird visit to *C. coccinea* in Illinois. From this isolated observation, Pennell (1935) surmises it is pollinated by hummingbirds. Hummingbirds are present in Connecticut (Colwell 1994).

Seeds are minute, number in the hundreds (Malcolm, 1962a), and have no apparent adaptations for dispersal. However, one landowner has observed that the extant population in his Connecticut hay meadow migrates in the hay meadow every year according to the direction the hay is raked. This landowner has observed the same pattern of population migration for several decades, during which time seed production and seedling recruitment have been sufficient to maintain an essentially stable population size. This suggests that pollinator availability is not a limiting factor at least in this population.

Indian paintbrush is a root hemiparasite (Malcolm 1962a, Malcolm 1962b), deriving part of its nourishment from the tissues of its host species through haustorial root connections

and also producing some photosynthates autonomously. Like other members of this genus (Mills and Kummerow 1988, Heckard 1962), *C. coccinea* can form haustoria with a variety of host species and does not appear to exhibit a great deal of host specificity (Malcolm 1962a, Malcolm 1962b).

HABITAT/ECOLOGY

Pennell (1935) lists soils as being moist, sandy and subacid to alkaline. Where the species is extant in Connecticut, it is associated with calcareous seeps (William Moorhead, personal communication). However, Leslie Mehrhoff (personal communication) finds the plant more generally associated with rich sites, based on observations of both extant and historic occurrences. In Virginia, the species is found in mafic seeps and mafic and dolomitic glades and prairies (Tom Rawinski, Massachusetts Audubon Society, personal communication). Pennell (1935) also describes the plant's habitat as open. Rodger (1998) characterizes the species as preferring open habitats with high light. This is consistent with the physical characteristics of the two most vigorous extant occurrences in New England. One site has long been an open hay meadow and the other has long been a pasture.

As mentioned above, *Castilleja coccinea* is a hemiparasite known to form haustorial connections with a variety of hosts. Malcolm (1962a, 1962b) tested the following 17 species that are found in close proximity to *Castilleja coccinea* in Michigan to determine whether haustorial connections would develop: *Achillea millefolium*, *Alnus rugosa*, *Antennaria neglecta*, *Chrysanthemum leucanthemum*, *Danthonia spicata*, *Fragaria virginiana*, *Hieracium aurantiacum*, *Krigia biflora*, *Lactuca canadensis*, *Lobelia spicata*, *Panicum sphaeroides*, *Populus deltoides*, *Rubus hispidus*, *Rudbeckia hirta*, *Solidago graminifolia*, *Solidago juncea*, and *Solidago rugosa*. Of these, all except *Populus deltoides*, *Alnus rugosa*, and *Rubus hispidus* supported growth of Indian paintbrush. We observed the following species associated with one Connecticut population, but made no determinations with respect to whether *C. coccinea* was parasitizing them: *Carex* spp., *Erigeron* sp., *Gallium mollugo*, *Geranium maculatum*, *Lilium* sp., *Lobelia spicata*, *Medicago* sp., *Onoclea sensibilis*, *Phalaris arundinacea*, *Phleum pratense*, *Plantago lanceolata*, *Potentilla simplex*, *Prunella vulgaris*, *Rosa multiflora*, *Rudbeckia hirta*, *Solidago* sp., *Sisyrinchium* sp., and *Trifolium pratense*.

While Malcolm (1962a, 1962b) was looking specifically for evidence of host preference by *C. coccinea* and found none, he did not evaluate the effects of various hosts on lifetime reproductive fitness. When exploring this aspect of host utilization in *C. wightii*, Marvier (1998) found that hosts differed in quality as sources of nutrition and defensive secondary compounds. Moreover, a diverse host assemblage simultaneously improved both reproductive performance and herbivore resistance. While *C. coccinea* does not seem to be strictly dependent on a single host species, it is possible that it performs better on some hosts than others or that the population performs better when a diversity of hosts is present

THREATS TO TAXON

Sorrie (1987) and a handful of site reports list succession as the main factor contributing to population declines at sites in New England. At CT .004 (Sherman), the hay meadow has remained open for at least 33 years as a result of annual mowing. At CT .009 (New Milford), a long history of grazing was only recently interrupted following a change in ownership. At this site, *Rosa multiflora* is encroaching at an accelerating rate (William Moorhead, personal communication). All other extant occurrences that have been recently surveyed supported significantly smaller populations and showed signs of increasing light competition from woody species.

At probably the best extant population in Connecticut (CT .004), haying operations have been preventing the development of a canopy for several decades (and possibly for two or more centuries). However, the owner indicated that this practice will soon cease because the farmer (not the same person) who operates the equipment is contemplating retirement. At the second most viable population (CT .009), *Rosa multiflora* is rapidly replacing the grassland over much of the site and threatens to shade out the Indian paintbrush population. All other extant sites are similarly threatened with canopy growth as a result of management practices that do not retain an open canopy.

While mowing seems to be working well at CT .004 as a means to prohibit canopy formation, other means of maintaining open sites may have been important in the past. For instance, Rodger (1998) suggests that *C. coccinea* may benefit from fire. In a recovery plan for another species of paintbrush in the western United States, the decline in fire frequency as a force maintaining open prairie habitats is listed as one of the factors potentially contributing to the species' endangerment (U.S. Fish and Wildlife Service 1999). The impacts of grazing and herbicide use in and around Indian paintbrush habitat are unknown. However, grazing does not appear to have been detrimental at CT .009 (William Moorhead, personal communication).

DISTRIBUTION AND STATUS

General Status

Indian paintbrush is found in bogs and wet meadows of eastern North America mostly east of the Missouri River. Its range extends west across the Missouri River just into southeastern Kansas and the eastern edge of Oklahoma and north into southern Manitoba, Ontario, and Saskatchewan and the northernmost states of the northeastern United States except Vermont (see Figure 1). The only known record from Nova Scotia is thought to be introduced (Renfrew and Bird 1983). Historically, its distribution encompassed all New

England states except Vermont (Figures 2 and 3), although it was most frequently encountered in Connecticut, Massachusetts and Rhode Island. Only a single occurrence was ever recorded from Maine and two from New Hampshire. It is now considered extant only in Connecticut (Figure 2).

Castilleja coccinea has a global rank of G5 (apparently stable), and Canadian and U. S. national ranks of N? (Natureserve 2000). *Castilleja coccinea* appears to be generally more stable in the western part of the range as can be seen in Table 1. In the brief communication we had with other heritage programs, it seemed that the areas with the greatest abundance of the species were areas with more open sites.

Table 1. Occurrence and status of *Castilleja coccinea* 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)
Alabama (S1): 4 extant element occurrences	Illinois (S?): “plentiful” where found	Arkansas (SR): widespread and abundant	Maine (SX): 1 historic occurrence from unknown collecting location
Connecticut (S1): 4 extant element occurrences	Iowa (S3)	Indiana (SR): some protected populations; previously considered for listing	Massachusetts: SX; 45 historic occurrences in Bristol, Essex, Hampden, Hampshire, Middlesex, Norfolk, Plymouth and Worcester Counties
Georgia (S2?): no element occurrence records	Kansas (S3)	Minnesota (SR)	New Hampshire: SX; 2 historic occurrences in Londonberry, Windham
Louisiana (S1): no element occurrence records	Manitoba (S5): occurs in southern 2/3 of province; less common in eastern portion of range; estimate 101+ occurrences and 10,000+ individuals	Missouri (SR)	Rhode Island (SH): 3 historic occurrences, one each from Providence, Adamsville, and Johnston.
Kentucky (S1): state endangered; 11 element occurrence records dating from 1840 to 1997.	Michigan (S?)	Ohio (SR): widespread and abundant	
Maryland (S1): state-listed as endangered.	North Carolina (S3): uncommon in mountains and piedmont and rare in coastal plain	Oklahoma (SR)	
Mississippi (S1): 4 element occurrence records 1838 -1976; 2	Ontario (S5)	Tennessee (S3)	

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OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
are historic.			
New Jersey (S2): 6 of 40 occurrences are extant	Nova Scotia (SE): thought to be introduced	Wisconsin (SR): uncommon	
New York (S1): state-listed as endangered; 5 extant populations	Virginia (S3): watch-listed; greater than 6 extant occurrences; estimate another 20-40 occurrences may yet be discovered		
Saskatchewan (S1)	West Virginia (S?)		
South Carolina (S2): 10 element occurrences			

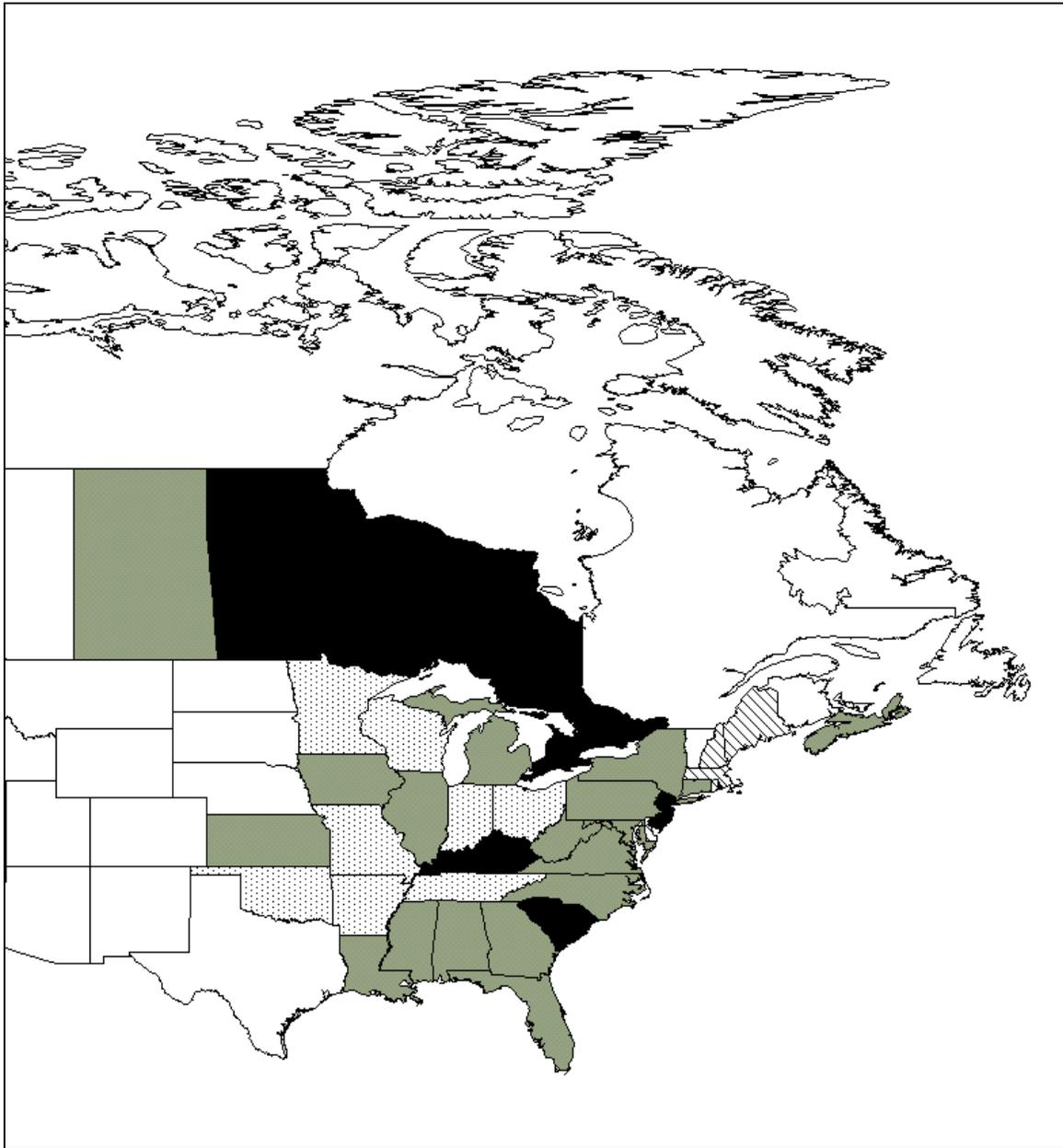


Figure 1. Occurrences of *Castilleja coccinea* in North America. States and provinces shaded in gray have 1-5 confirmed occurrences of the taxon. States and provinces shaded in black have more than 5 extant occurrences. States with diagonal hatching are ranked "SH" or "SX" (see Appendix for definitions), where the taxon no longer occurs. States with stippling are ranked "SR" by the Association for Biodiversity Information (see Appendix).

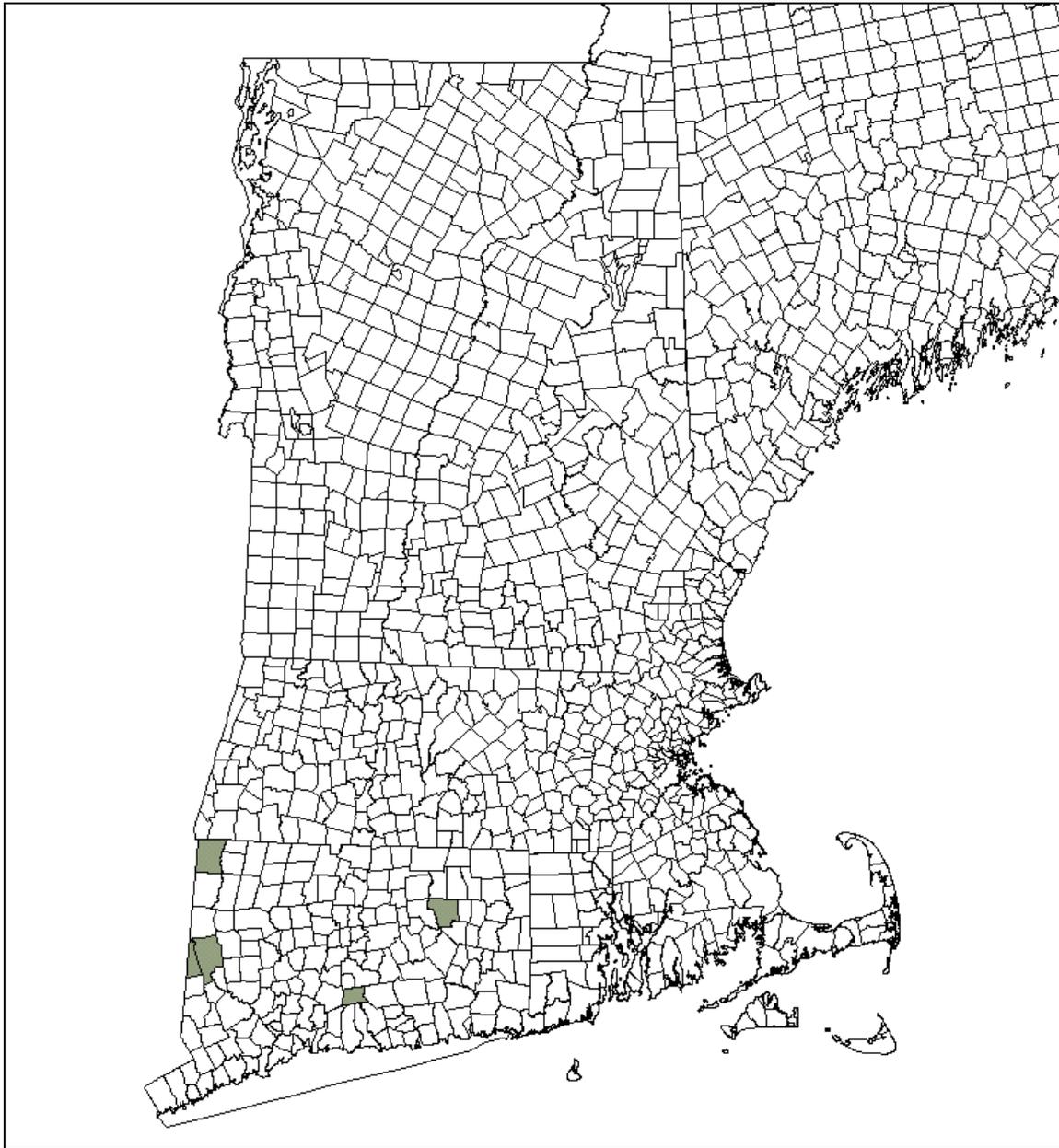


Figure 2. Extant occurrences of *Castilleja coccinea* in New England. Town boundaries for New England states are shown. Towns with shading have 1-5 current occurrences.

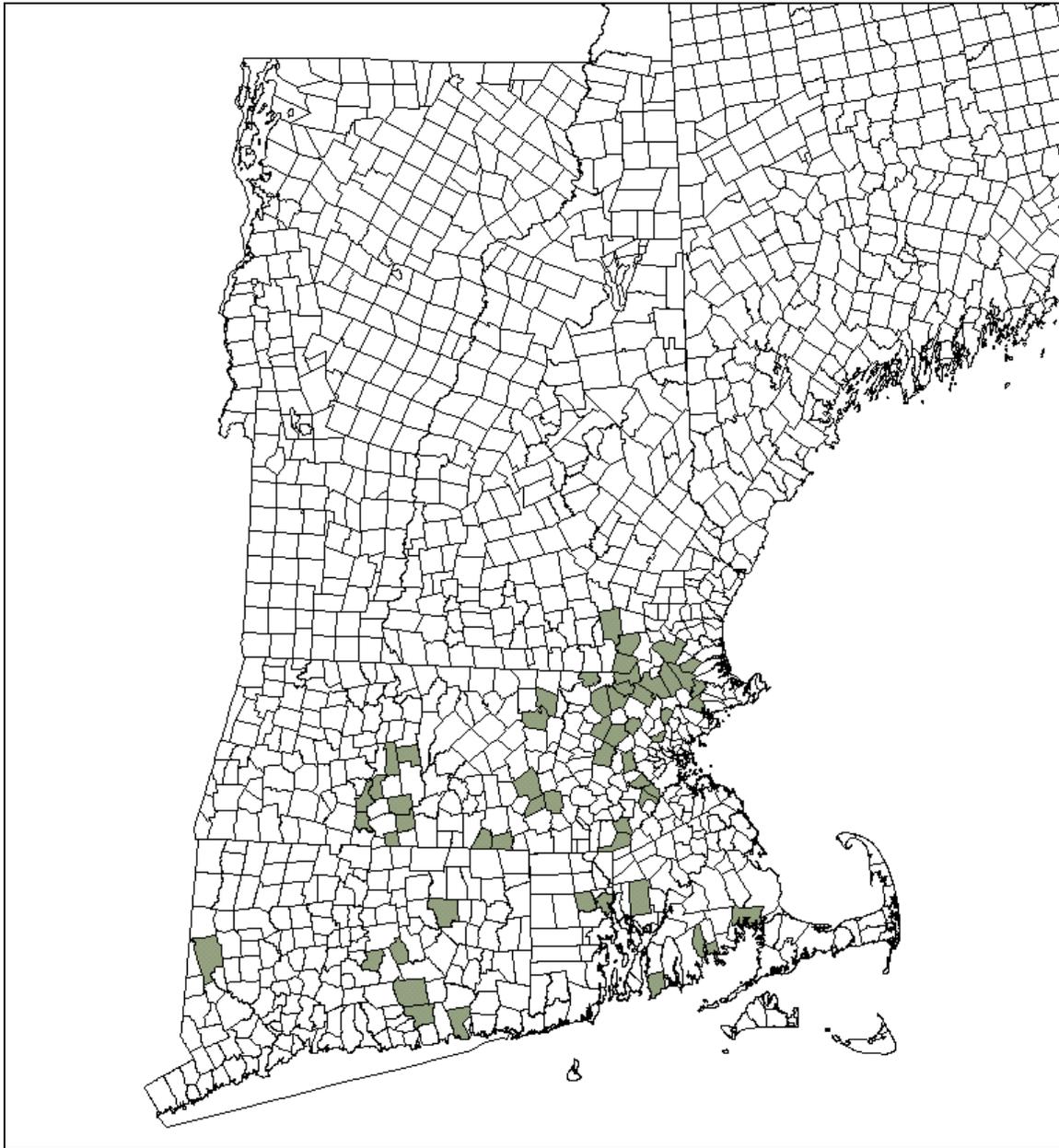


Figure 3. Historic occurrences of *Castilleja coccinea* in New England. Town boundaries for New England states are shown. Towns with shading have 1-5 historic records for the taxon.

Table 2. New England Occurrence Records for *Castilleja coccinea*. Shaded occurrences are considered extant.

State	Element Occurrence Number	County	Town
ME	.001	no information	no information
NH	.001	Rockingham	Windham/ Pelham
NH	.002	Rockingham	Londonderry
MA	.001	Worcester	Dudley
MA	.002	Hampden	West Springfield
MA	.003	Hampden	Ludlow
MA	.004	Bristol	New Bedford
MA	.005	Essex	Ipswich
MA	.006	Essex	Danvers
MA	.007	Bristol	Rehoboth
MA	.008	Essex	Topsfield
MA	.009	Essex	North Andover
MA	.010	Hampden	Holyoke
MA	.011	Hampden	East Longmeadow
MA	.012	Hampden	Wilbraham
MA	.013	Middlesex	Bedford
MA	.014	Hampshire	Pelham
MA	.015	Middlesex	Lowell
MA	.016	Middlesex	Dracut
MA	.017	Middlesex	Dunstable
MA	.018	Middlesex	Chelmsford
MA	.019	Middlesex	Reading

Table 2. New England Occurrence Records for *Castilleja coccinea*. Shaded occurrences are considered extant.

State	Element Occurrence Number	County	Town
MA	.020	Middlesex	Winchester
MA	.021	Middlesex	Tewksbury
MA	.022	Middlesex	Westford
MA	.023	Middlesex	Weston
MA	.024	Plymouth	Wareham
MA	.025	Worcester	Grafton
MA	.026	Worcester	Leominster
MA	.027	Worcester	Lunenburg
MA	.028	Worcester	Millbury
MA	.029	Worcester	Southbridge
MA	.030	Essex	Boxford
MA	.031	Worcester	Worcester
MA	.032	Hampshire	South Hadley
MA	.033	Middlesex	Acton
MA	.034	Hampshire	Amherst
MA	.035	Norfolk	Dedham, Westwood
MA	.036	Middlesex	Concord
MA	.037	Middlesex	Sudbury
MA	.038	Essex	Andover
MA	.039	Essex	Georgetown
MA	.040	Norfolk	Wrentham
MA	.041	Norfolk	Needham
MA	.042	Bristol	Fairhaven

Table 2. New England Occurrence Records for *Castilleja coccinea*. Shaded occurrences are considered extant.

State	Element Occurrence Number	County	Town
MA	.043	Essex	Haverhill
MA	.044	Essex	Haverhill
MA	.045	Norfolk	Norfolk
RI	.001	Providence	Providence
RI	.002	Newport	Little Compton/ Adamsville
RI	.003	Providence	Johnston
CT	.001	Litchfield	Salisbury
CT	.002	Middlesex	East Haddam
CT	.003	Tolland	Mansfield
CT	.004	Fairfield	Sherman
CT	.005	Middlesex	Durham
CT	.006	New London	Lyme
CT	.007	New London	Waterford
CT	.008	Middlesex	Portland
CT	.009	Litchfield	New Milford
CT	NA	Litchfield	New Milford
CT	NA	Hartford	Marlborough
CT	NA	Tolland	Mansfield

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Indian paintbrush is regionally rare in New England (Brumback and Mehrhoff et al. 1996). It is apparently secure range-wide with a global rank of G5, although some Natural Heritage programs elsewhere in the plant's range list it as rare. The primary conservation goals are to protect extant populations and identify new sites where we can reintroduce plants.

In communication with ecologists in other parts of the range, it was determined that the plant was most abundant at open sites such as road rights-of-way. It seems highly probable, therefore, that the persistence of CT .004 (Sherman) is attributable to the practice of mowing. The occurrence CT .009 (New Milford) has not been tracked for long enough to determine whether the plants here have persisted as a result of grazing or in spite of it. However, it does appear that the latter site has been open for at least the last several decades so it should be maintained as an open site.

At CT .004, the plants were producing abundant seed when we visited in 2000 and the population has remained stable for several decades. Consequently, we don't consider studying the plant's pollination biology as a high priority conservation action at this site, although it may be important in other extant populations. Considering the current status relative to the historic status of the species in New England and uncertainties about availability of sites for reintroduction, we have chosen not to provide specific numeric goals for recovery of the species. Protecting extant populations is the most immediate task but identifying sites where populations may be reintroduced is also important.

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Appendix 1. 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 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.