New England Plant Conservation Program

Conservation and Research Plan

Hackelia deflexa var. *americana* (A. Gray) Fern. & I. M. Johnston
Northern Stickseed

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SUMMARY

Northern stickseed (*Hackelia deflexa* var. *americana*) is a widely distributed annual or biennial of the Borage family (Boraginaceae) restricted to dry, open, calcareous habitats. Natural communities supporting this species share a relatively high frequency of natural disturbance events, such as downslope movement of rocky substrate (in cobble-strewn woodlands) and bedrock erosion (on calcareous cliffs and bluffs). While *Hackelia deflexa* is circumboreal, the plants considered here (var. *americana*) occur in the northern portion of North America. The plant is uncommon at the southern limit of its range in New England, having been documented at three stations in Maine, one in New Hampshire, and 19 in Vermont. Field surveys in 2000 led to discovery of two new Maine occurrences, and confirmed only 50% (6 of 12) of visited Vermont stations. Despite the new records for Maine, the species seems to be declining in New England, primarily due to habitat loss in the populous Champlain Valley of western Vermont.

The primary conservation objective for this taxon in New England is to maintain at least 15 stable populations. Ideally, the Maine and New Hampshire stations would be included in this number in order to capture the full longitudinal range of the plant in New England. Other conservation objectives are to continue protection of the plant on three public properties where it occurs, survey all stations not visited in 2000, reduce threats to populations on private lands through communication with landowners, and to study demographics and ecology of the species.

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 individuals and 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

Northern stickseed (*Hackelia deflexa* var. *americana* (A. Gray) Fern. & I. M. Johnston) is an herbaceous annual or biennial found in sunny areas on soils derived from calcareous bedrock, including rocky woodlands and temperate calcareous bluffs and cliffs. Northern stickseed habitat is characterized by moderate to high levels of natural disturbance, which includes processes such as cliff weathering, downslope movement of boulders and cobble, and windthrow.

During its first growing season, northern stickseed persists as an inconspicuous rosette of leaves. Plants may be exposed to full sun at the start of the growing season, but are shaded by canopy trees and understory herbaceous growth by late summer. In its second season (or at the end of the first, in annual populations), the plant produces few or no basal leaves, but sends up a leafy stem. In June and early July, helicoid cymes bearing many small, blue or white flowers are produced. The pollination biology of northern stickseed has not been studied, but plants observed in 2000 had a high degree of fruiting success. Each fruit is composed of four spiny nutlets similar to those produced by other members of the Boraginaceae. The plant is adapted to passive dispersal by animals, as the spines readily cling to fur and hair. These spines are useful characters in distinguishing northern stickseed from the closely related and sympatric Virginia stickseed (*Hackelia virginiana* (L.) I. M. Johnston). Other aspects of the plant's ecology, such as its interactions with herbivores, have not been studied.

Hackelia deflexa is circumboreal, occurring in northern regions throughout the world. The variety considered here (var. *americana)* is widespread in northern North America, occurring from the Gaspé peninsula and Maine west to British Columbia and Washington state, and as far South as southern Vermont, Iowa, and Colorado (Jenkins 1981, Maine Critical Areas Program 1981, Gleason and Cronquist 1991, Magee and Ahles 1999, NatureServe 2000, Wisconsin State Herbarium 2000). It has the rank of S1 in Maine and New Hampshire, and S2S3 in Vermont, and is a state- and province-listed rare species in some of the other places it occurs (see Table 1). Northern stickseed populations experience a variety of threats, including logging, residential development, recreational activities, limestone quarrying, secondary succession, and herbivory.

The intent of this Conservation Plan is to summarize existing information on the status of northern stickseed in New England, and to recommend actions to protect and restore the species in an area that represents the southeastern edge of its historic range.

DESCRIPTION

Northern stickseed is a slender herbaceous annual or biennial of open, rocky woods, bluffs, and cliffs in calcareous regions (Fernald 1950, Gentry and Carr 1976, Gleason and Cronquist 1991, Voss 1996). It is more phenotypically plastic than most other species of *Hackelia*, occasionally varying greatly in size of leaves, stems, flowers, and fruit (Gentry and Carr 1976). First-year plants are inconspicuous rosettes of basal leaves. Flowering plants produce a leafy stem 10-90 cm in height. The alternate, sparsely toothed leaves are lanceolate to elliptic, with the base tapered to the petiole. Leaves are largest near the base of the stem, and grade into bracts of the inflorescence above. Vegetative parts are rough-hairy throughout (Gentry and Carr 1976, Gleason and Cronquist 1991). The inflorescence is a helicoid cyme, and an individual plant produces 200-750 flowers on several to many cymes (L. Richardson, personal observation). The small, perfect flowers (2-3 mm wide) are borne on short, ascendant pedicels that recurve downward in fruit. The calyx lobes are hairy and unfused. The corolla is salverform, its five blue or white petals fused. The throat of the corolla tube is partially obstructed by tiny, hairy appendages, or fornices. Stamens and style are included in the corolla. Like many members of the Boraginaceae, northern stickseed may have a nectar-secreting disk at the base of the ovary (Zomlefer 1994). The fruit is a schizocarp composed of four mericarps or "nutlets." These nutlets are attached basally to a receptacle, and apically to each other. The inner faces of the nutlets are smooth. The sharp edges of the nutlets are armed with recurved spines, but their dorsal faces (the broad area facing out) are unarmed, or have only a few spines. The usually smooth dorsal faces of the nutlets of this species distinguish it from the similar Virginia stickseed (*Hackelia virginiana*), as discussed below.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

There are 45 species of *Hackelia* distributed across North and South America and Eurasia (Gentry and Carr 1976, Mabberley 1987). Most species are found in north-temperate areas, and the center of diversity for the genus is Western North America (Gleason 1952, Gentry and Carr 1976). The genus *Hackelia* was historically treated as a division of *Lappula* (Gentry and Carr 1976). Often reported as circumboreal (e.g., Gentry and Carr 1976), *Hackelia deflexa* occurs in northern and upland temperate locations throughout the world. In the Old World it has been collected as far south as Spain (Polunin and Smythies 1973) and western Pakistan (Stewart 1972).

Hackelia deflexa var. *americana* was first recognized by Fernald and Johnston (1924), and, as the genus is presently understood, it is the only variety to occur in North America. However, because its taxonomy is complex, and because specimens of *Hackelia* are often misidentified (Gentry and Carr 1976), our understanding of the distribution of this species may change in the future. This North American variety occurs from New Brunswick (Fernald 1950) west through Québec (Rousseau 1974), Ontario (Soper et al. 1989), Manitoba, Alberta

(Moss 1983), and British Columbia (Porsild and Cody 1980), and as far south as Maine (Campbell and Eastman 1980, Maine Critical Areas Program 1981), Vermont (Dole et al. 1937, Jenkins 1981), New York (Mitchell 1986), Michigan (Voss 1996; E. Schools, Michigan Natural Features Inventory, personal communication), Wisconsin (Wisconsin State Herbarium 2000), Minnesota (K. Cieminski, Ecologist, personal communication), Iowa, Kansas (Fernald 1950), Colorado (Gleason and Cronquist 1991), and the Pacific Northwest (Gleason 1952, Hitchcock and Cronquist 1973, Gentry and Carr 1976). It seems to be absent from Alaska.

Synonyms for *Hackelia deflexa* var. *americana* include *Echinospermum deflexum* var. *americanum*, *Lappula deflexa*, *L. deflexa* subsp. *americana*, *L. deflexa* var. *americana*, *L. americana*, *Hackelia americana*, and *Rochelia deflexa.*

Northern stickseed closely resembles Virginia stickseed (*Hackelia virginiana*), with which it is sympatric in New England. Although the latter is usually taller with larger leaves, the two species may not be reliably distinguished unless flowers or fruits are present. The flowers of northern stickseed have slightly larger pedicel, calyx, corolla, and anther dimensions than those of Virginia stickseed (Gentry and Carr 1976). The dorsal faces of nutlets of northern stickseed are glabrous, or rarely have 2-12 prickles, while those of Virginia stickseed always have 15-25 prickles (Gentry and Carr 1976, Gleason and Cronquist 1991). In New England, northern stickseed is usually restricted to rocky, open sites whose soils are influenced by limestone bedrock, while Virginia stickseed is found in a variety of wooded situations (L. Richardson, personal observation). There is, therefore, some overlap in habitat preferences between the two species.

Northern stickseed could also be confused with bristly stickseed (*Lappula squarrosa*), an exotic plant rarely encountered in New England (B. Popp, Vermont Nongame and Natural Heritage Program, personal communication). Although the two have a similar overall appearance, a number of characters serve to distinguish them. Bristly stickseed has a leafy bract associated with each flower of the inflorescence, while northern stickseed has only a few bracts in the lower portion of the inflorescence. The fruits of northern stickseed are deflexed or drooping, while those of bristly stickseed remain erect. Northern stickseed nutlets are attached to the gynobase by a broad medial areola or pad, while those of bristly stickseed are attached by a long, narrow ventral keel (Gentry and Carr 1976).

SPECIES BIOLOGY

Northern stickseed life history is not well understood. Most authors (e.g., Gleason and Cronquist 1991) consider it a biennial, but Gentry and Carr (1976) describe as either annual or biennial. No rigorous studies examining this aspect of the plant's life history have been published. In Vermont, individual plants probably live at least two growing seasons—small vegetative rosettes of leaves are sometimes found near flowering and fruiting individuals (L. Richardson, personal observation); It should be noted, however, that vegetative individuals are

difficult to distinguish from those of Virginia stickseed or other members of the Boraginaceae). Gentry and Carr (1976) report that many species of *Hackelia* have taproots that readily split into longitudinal cords when buried by shifting talus and rocks, which allows the genetic individual to persist as two or more separate plants (this trait has not been confirmed for northern stickseed; see discussion below). This observation obscures the question of how long individuals live, and how timing of fruiting and senescence are related to plant age. We do know that northern stickseed dies after flowering and fruiting (L. Richardson, personal observation).

Flowering is usually in June and July, but an analysis of herbarium specimens shows that flowering times vary greatly, perhaps in response to genetic or year-to-year weather differences. As in other members of the Boraginaceae, pollination is probably accomplished by small insects that visit the flowers in search of nectar (Zomlefer 1994). Most flowers observed in 2000 matured 2-4 of 4 possible seeds, and an individual plant produced approximately 1,000-1,500 (and as many as 2,200) seeds when it flowered (L. Richardson, personal observation). It is not known whether the plants self-pollinate (It should be noted, however, that many plant species that disperse great distances to small patches of habitat are capable of self-pollination). Northern stickseed may flower alongside Virginia stickseed (L. Richardson, personal observation). There are no reports of hybridizing between the two species, but Gentry and Carr (1976) considered them to be closely related.

Seed dispersal, dormancy, and timing of germination have not been formally studied. Newly-formed seeds readily disperse as the plant senesces in late summer, but many seeds also persist on the dead stems until the following growing season (L. Richardson, personal observation). New England Wild Flower Society staff who propagated northern stickseed found that the seed germinated best after several months of cold treatment (Chris Mattrick, New England Wild Flower Society, personal communication). As discussed above, in some cases first-year rosettes are found at the bases of the previous year's dead stems, suggesting that seeds may fall to the ground and germinate at the base of their parent plant. The hooked spines of the nutlets are interpreted as adaptations for animal-mediated dispersal (van der Pijl 1969, Gentry and Carr 1976, Bullock and Primack 1977), but precisely how often this occurs is not known.

Northern stickseed is attacked by several herbivores. At VT .019 (Milton), two species of Lepidoptera larvae skeletonized plant leaves in 2000. An Hemipteran nymph was found walking on one individual, and likely fed there. A single mass of white insect eggs encrusted leaves of the same plant. It is not known whether these represent opportunistic or specialized relationships with herbivores. At VT .004 (South Hero), a large population of white-tailed deer had browsed nearly all herbaceous understory plants, and may eat northern stickseed, if it still occurs there.

Life history attributes of northern stickseed must be more thoroughly understood if we are to secure long-term protection for the species in New England.

HABITAT/ECOLOGY

Nearly all extant populations of the plant in New England are found at low elevation in sunny, dry open spots at the base of cliffs, on ledges, or on talus and cobble in open woods. Soils are usually very shallow, and enriched by calcareous bedrock. Unusual occurrences include a station in the dark understory of a northern white cedar forest (VT .003 [Charlotte]), and a roadside collection now considered historic (VT .007 [Derby]). In other parts of its range northern stickseed is reported from thickets, clearings, banks, dunes, moist woods, roadsides, and ditches, at elevations ranging from 300 to 5000 feet (100 to 1500 m; Fernald 1950, Gleason 1952, Hitchcock and Cronquist 1973, Rousseau 1974, Porsild and Cody 1980, Moss 1983).

New England sites supporting this species have a relatively high frequency of natural disturbance events, such as downslope movement of rocky substrate (in cobble-strewn woodlands) and bedrock erosion (on calcareous cliffs and bluffs), but floras referencing northern stickseed seldom mention the role of disturbance in creation of its habitat. In our area northern stickseed is found in the following natural community types: Rich Northern Hardwood Forest, Northern Hardwood Talus Woodland, Limestone Bluff Cedar-Pine Forest, Mesic Maple-Ash-Hickory-Oak Forest, Northern White Cedar Forest, Temperate Calcareous Outcrop, and Temperate Calcareous Cliff (Vermont Nongame and Natural Heritage Program Biological Conservation Database 2000, Thompson and Sorenson 2000, L. Richardson, personal observation). While fire may play a role in structuring some of these communities; it is not known whether it has had an effect on northern stickseed distribution.

Gentry and Carr (1976) studied cytology of 21 species of *Hackelia*, and report that all are either diploid (2*n*=24) or tetraploid (2n=48). This distinction has important bearing on several aspects of the plants' ecology. Some of the western diploid taxa (e.g., pink stickseed (*H. mundula*), Sierran stickseed (*H. nervosa*), and velvet stickseed (*H. velutina*)) have large, complex perennating buds composed of numerous leaf primordia, while the tetraploids tend to have simple buds with very few leaf primordia. Diploid taxa tend to grow on stabilized substrates such as level forest understory and sage brush flats, while most tetraploid species occupy more dynamic habitats, such as rock slides, talus, banks, and cliffs. The tendency of taproots to divide during substrate disturbance events is largely confined to the tetraploid species. Also, most tetraploids require moderate to strongly alkaline soils, while diploids have broader habitat preferences. Unfortunately, these workers did not study the cytology of northern stickseed, but they report that its closest relative, Virginia stickseed, is diploid. It is thus most parsimonious to conclude that northern stickseed is a diploid. Like the tetraploids, however, northern stickseed occurs almost exclusively in dynamic, highly calcareous habitats. An examination of the cytology and evolutionary relationships of northern stickseed might help us understand its rarity and distribution.

Northern stickseed may exhibit a metapopulation structure in New England and in other parts of its range. A metapopulation is essentially a population composed of subpopulations, or a species range composed of more or less geographically isolated populations connected through rare or occasional gene flow events. Subpopulations are often small and genetically isolated from each other, making them relatively more susceptible to the vagaries of genetic, demographic, and environmental stochasticity (Giles and Goudet 1997). Although this concept has more often been applied to animals, it is common in plants that disperse their pollen and seeds over long distances, and experience frequent local extinction and recolonization events (Given 1994). This pattern of small-scale subpopulation extinction events within the context of a globally stable population is common in many plant species that have been described as metapopulations (e.g., Giles and Goudet 1997; Valverde and Silvertown 1997).

Subpopulations within a metapopulation experience "founder effects" when one or a few individuals disperse to new patches of habitat (Barrett and Kohn 1991, McCauley et al. 1995). With relatively low genetic diversity and small number of reproducing individuals these populations are susceptible to extinction through genetic factors such as inbreeding depression and genetic drift (Shaffer 1987, Fisher and Matties 1997), demographic factors such as highly skewed sex ratios (Shaffer 1987), unpredictable or absent ecological interactions with pollinators and other mutualists (Mustajarvik et al. 2001), and catastrophic environmental disturbance events (Shaffer 1987). A subpopulation may occasionally be enriched (and may be made more resistant to extinction) by gene flow in the form of pollen, seeds, or vegetative propagules from other populations.

Much effort has been devoted to determining minimum viable population size (MVP)—the smallest number of individuals necessary for long term persistence in the face of the genetic, demographic, and ecological complications discussed above. Estimates vary widely, and most authors acknowledge that the MVP will vary from species to species. Minimum viable population size estimates for plants range from 50-500 for genetic factors, 50-100 or more for demographic factors, and 1,000 to 1,000,000 or more for environmental factors (Shaffer 1987, Menges 1991, Given 1994).

While the New England occurrences of northern stickseed exhibit some of the characteristics of a metapopulation, this study has by no means determined that such a demographic exists. And from a conservation perspective, one would not want to argue that any of the New England occurrences were dispensable as temporary subpopulations, especially because the plant may be in decline at the regional (i.e., metapopulation) level. Despite these caveats, it would be very instructive for us to study northern stickseed from the perspective of metapopulation science. In particular, understanding the degree of genetic differentiation among the occurrences, and rates and modes of gene flow between them would help us to conserve northern stickseed in New England.

THREATS TO TAXON

In a broad sense, northern stickseed is threatened by habitat destruction. Most of the occurrences in New England are in the increasingly densely populated Champlain Valley of Vermont. Northern stickseed occurs on some of the most desirable property in the area -- calcareous lakeshore bluffs along Lake Champlain -- and it is thus vulnerable to residential development. Below, we discuss several modes of habitat destruction that are endangering the taxon in New England. We also discuss a less obvious, though no less significant, threat to the taxon -- local extinction due to small population size and the likely low rate of gene flow between many of the populations.

Lakeshore and Residential Development

Fourteen of 16 stations recently visited in Vermont are privately owned. Many of these are prestigious lakeshore residential properties managed primarily to maintain privacy, scenic beauty, and recreational opportunities. At sites visited in 2000, land management activities included clearing of understory vegetation, depositing of yard wastes in northern stickseed habitat, selective timber harvest, trail maintenance, and bluff modification for beach access. One station had been extensively modified by subdivision and construction of a neighborhood of single-family homes. In most cases, owners are probably not aware of the northern stickseed populations on their properties, and will therefore not take measures to protect it.

Secondary Succession

The two most important habitat requirements of Northern stickseed are aridity and calcium-rich bedrock (Rousseau 1974; Gentry and Carr 1976; Jenkins 1981; Gleason and Cronquist 1991; Voss 1996), but it also requires a high level of light exposure (Gentry and Carr 1976; Jenkins 1981; Zika 1983). All but one (VT .003 [Charlotte]) of the known New England populations of this plant occur in open, sunny places, such as cliffs, bluffs, and forests with sparse canopies. Where northern stickseed occurs in open forests (e.g., VT .009 [Shelburne]) or on small rock outcrops surrounded by forest (e.g., VT .010 [Shelburne] and VT .019 [Milton]), it may be vulnerable to extirpation through secondary succession. As these forests mature, their understory becomes increasingly shaded, and individual populations of the plant could go extinct. In the mature presettlement forest, however, northern stickseed populations probably established on suitable substrate in tree fall gaps, then "jumped" to new patches of open habitat over time as the forest canopy closed. In fact, this pattern of plant distribution is common in species that exhibit a metapopulation structure (Cain et al. 2000; and see discussion above). Thus, in large tracts of intact forest -- which may contain many small patches of calcareous cliff, outcrop, and rocky cobble substrate -- microsite extinction of northern stickseed due to secondary succession would not lead to regional extinction. Unfortunately, many of the known New England occurrences of this plant are in very small

patches of forest surrounded by expanses of human settlement and agricultural land; these plants may not be able to colonize new patches of habitat before shading destroys the habitat patch they currently occupy.

Invasive Species

Invasive understory shrubs such as buckthorn (*Rhamnus cathartica*) and honeysuckle (*Lonicera morrowii, L. tartarica*) sometimes accompany secondary succession in New England forests, and these may rob herbaceous plants of light. Northern stickseed generally occurs in open, well-lit areas, and might not be able to persist under a dense shrub layer. In particular, these invasive plants appear to pose a threat to northern stickseed at VT .003 (Charlotte), VT .004 (South Hero), and VT .016 (Georgia Plains). Mullein (*Verbascum thapsus*), an herbaceous biennial weed, was common at ME .003 (West Paris) in 2000. It is not known whether this affected the northern stickseed population.

Logging and Woodlot Management

While northern stickseed requires some degree of disturbance, large-scale mechanized tree harvest is probably a cause of decline for the species. On the other hand, some modes of tree harvest may benefit the species, if they mimic the natural disturbances that favor the plant. The effects of different logging practices on northern stickseed need further investigation before generalized conclusions can be drawn. Seven of eight privately-owned stations visited in 2000 showed evidence of recent logging or tree removal. (One station visited in 2000, VT .011 [Milton], had recently been clear-cut, apparently leaving little or no northern stickseed habitat.)

Limestone Quarrying

One station (VT .010 [Shelburne]) is owned by a large limestone mining corporation. The mine currently sits 1000 meters from the ledges where northern stickseed grows, and does not directly threaten the population. Mining activities will likely encroach on this area as more rock is needed in the future, however. The owners log the surrounding forest at present.

Herbivory

A large population of white-tailed deer has severely browsed herbaceous understory plants on one island station (VT .004 [South Hero]). Where northern stickseed is accessible it may be eaten by these animals; wild comfrey (*Cynoglossum boreale*), a related species, is browsed by deer at this station (B. Popp, personal communication) and at one in New Hampshire (B. Engstrom, personal communication). A variety of insect herbivores (described

above) were observed on plants at another site (VT .019 [Milton]). It is not known if insect herbivory affects northern stickseed reproductive success or other aspects of life history.

Mass Wasting of Cliffs

As described above, many northern stickseed populations occur at sites characterized by active erosion of cliffs and bluffs. This form of natural disturbance creates new habitat for northern stickseed, but, at its extreme, could also cause local extinction of the plant. As some populations are small and restricted to just a few square feet of area on cliffs (e.g., see descriptions of VT .010 [Shelburne], VT .019 [Milton]), they could be destroyed by such mass wasting of cliffs. This has not been documented for northern stickseed, but it should be considered a potential cause of local extinction where the plant occurs on or at the base of cliffs.

Population Ecology

Northern stickseed may be vulnerable to local extinction via processes associated with metapopulation demography (see discussion above). In particular, the small number of individuals observed flowering and fruiting at most sites (usually fewer than 50) suggests that individual populations could suffer from genetic impoverishment, random demographic skew, or catastrophic disturbance events. These processes could be intensified by fragmentation of the matrix forest in which northern stickseed habitat occurs, or impacts to individual plants by deer, heavy use of trails, etc.

DISTRIBUTION AND STATUS

General Status

As noted above, *Hackelia deflexa* is a wide-ranging species found in the north-temperate regions of the world. Our plants (var. *americana*) occur across much of Canada and as far south as Maine, Vermont, Michigan, Wisconsin, Minnesota, Iowa, Colorado, and the Pacific Northwest (see citations above). The plant is considered uncommon in all of its North American range, except in Ontario and Manitoba (see Table 1). It has been collected from at least 22 stations in northern New England, most of these in the Champlain Valley of Vermont (Table 1). Because it is at the southern edge of its distributional range in New England, northern stickseed is listed as "regionally rare" (Division 2) in the New England Wildflower Society's Flora Conservanda (Brumback and Mehrhoff et al. 1996). Most current populations are small (5-100 individuals) and separated from each other by open, anthropogenic landscapes. As the species is fairly cryptic, and difficult to identify unless in flower and fruit, additional unknown populations may exist where habitat is suitable. The United States and New England

distributions of northern stickseed are presented in Figures 1 and 2. The current state and provincial ranks of *Hackelia deflexa* var. *americana* are given in Table 1.

Status of All New England Occurrences-Current and Historic

Fourteen of the 23 known New England stations for northern stickseed were visited in 2000 (note that two of the three sites in Maine were visited by Don Cameron of the Maine Natural Areas Program). The plant was located at eight of these 14 sites. Table 2 describes the extant and historic northern stickseed stations, or Element Occurrences (EOs). The sites are also described below in narrative form. Each station is described by the EO number assigned to it by state Natural Heritage Programs and the name of the town in which it occurs. Each was previously given an EO rank by Natural Heritage staff, a qualitative approximation of the quality of an occurrence (a function of number of individuals, population viability, area of habitat, successional status, etc.) and the degree to which it is threatened. Ranks range from "A" to "D", where a rank of "A" indicates a high quality EO that is little threatened, and "D" describes an EO that is of poor quality and threatened. A rank of "E" is given to occurrences about which existing information is insufficient to provide a qualitative score. An "H" indicates a site where no observations have been made for more than 25 years, and "X" indicates a site known to be extirpated. For extant sites that were not visited, the points are those mapped in the Vermont Nongame and Natural Heritage Program's Biological Conservation Database. Coordinates are not available for New Hampshire and Maine Occurrences.

Table 1. Occurrence and status of *Hackelia deflexa* var. *americana* in the United States and Canada based on information from Natural Heritage Programs and Natureserve (2000).

OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Illinois (S1)	Wyoming (S3)	Colorado (SR)	Ohio (SX)
Maine (S1): 3 EOs	Alberta (S3)	Idaho (SR)	
New Hampshire (S1): 1 EO	Manitoba (S5)	Iowa (SR)	
New York (S1)	Ontario (S5)	Kansas (SU)	
Vermont (S2S3): 19 EOs		Michigan (SR): (S4S5; E. Schools, personal communication)	
New Brunswick (S1)		Minnesota (SR): S4S5; 46+ EOs; K. Cieminski, personal communication)	
		Montana (SR)	
		Nebraska (SR)	
		North Dakota (SR)	
		South Dakota (SR)	
		Utah (SRF)	
		Washington (SR)	
		Wisconsin (SR)	
		British Columbia (SR)	
		District of Mackenzie (Northwest Territories) (SR)	
		Quebec (SR)	
		Saskatchewan (S?)	

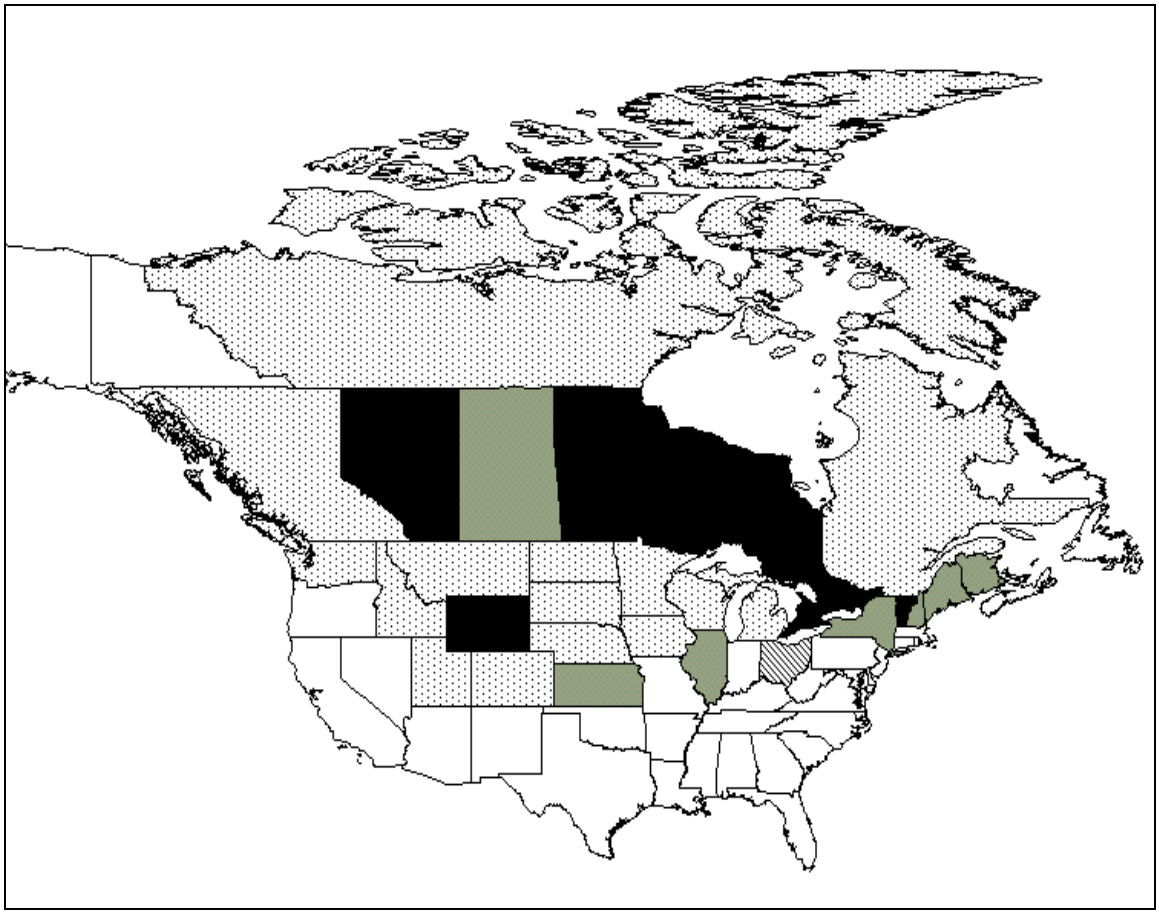

Figure 1. Occurrences of *Hackelia deflexa* var. *americana* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. Areas shaded in black have more than five confirmed occurrences. The state with diagonal hatching (Ohio) is designated "presumed extirpated," where the taxon no longer occurs. States and provinces with stippling are ranked "SR" (status "reported" but not necessarily verified). See Appendix for explanation of state ranks.

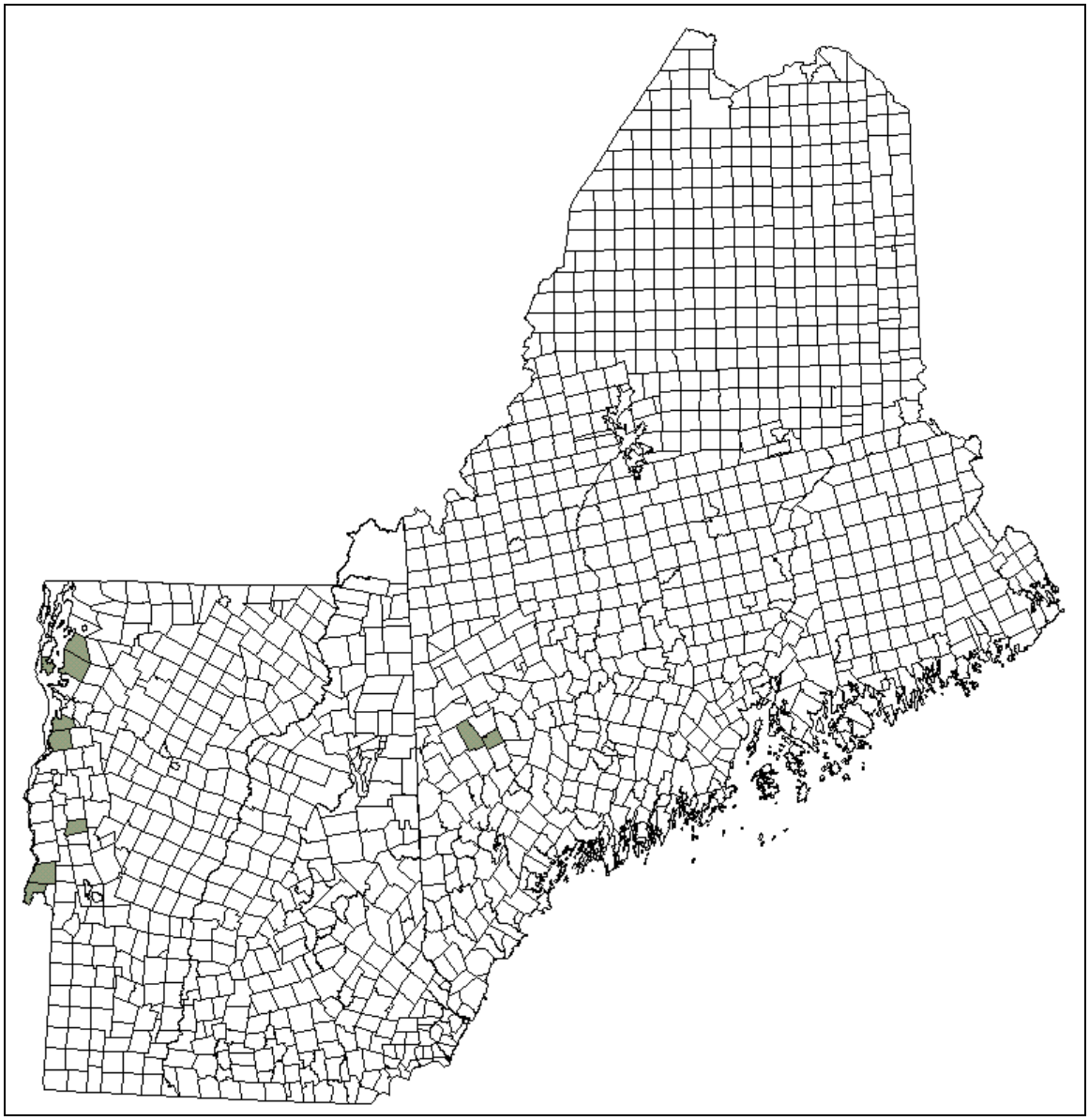

Figure 2. Extant occurrences of *Hackelia deflexa* var. *americana* in New England. Town boundaries for northern New England states are shown. Towns shaded in gray have one to five confirmed, current occurrences of the taxon.

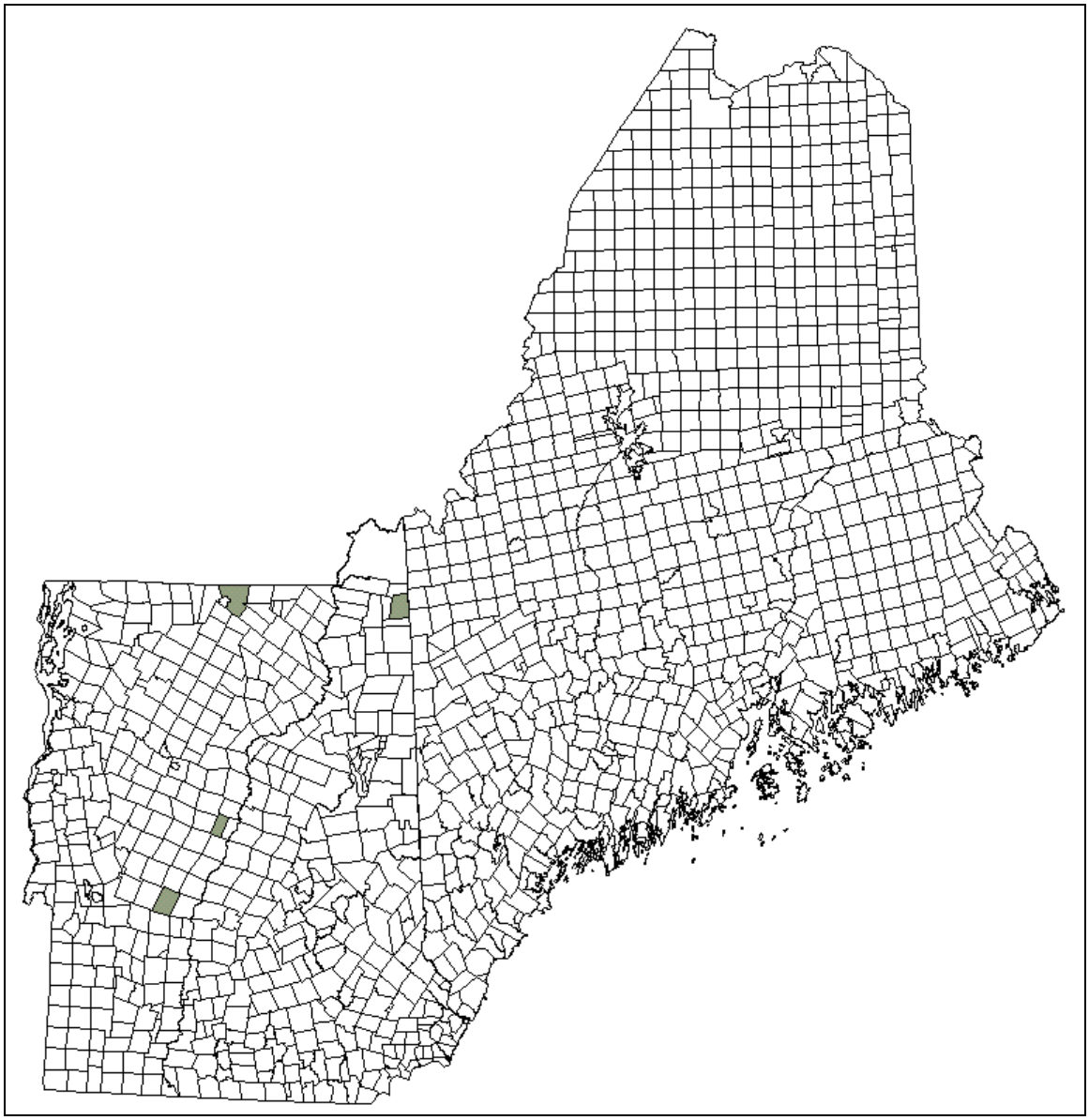

Figure 3. Historic occurrences of *Hackelia deflexa* var. *americana* in New England. Towns shaded in gray have one to five historic records of the taxon.

CURRENT CONSERVATION MEASURES IN NEW ENGLAND

Northern stickseed is a state-listed endangered species (S1) in Maine (Maine Revised Statutes Annotated 5 MSRA C, 383. sub C III, articles 1-A) and New Hampshire (State Law RSA 217–A:3, III). In Maine, an endangered species is one that is in danger of extirpation throughout all or a significant part of its range in the state, or one already designated by the federal Endangered Species Act. In New Hampshire, a plant species is legally endangered if three or fewer occurrences have been documented in the state in the last 50 years, or, if more than three occurrences are known, if specialists believe it is especially vulnerable to extirpation. In Vermont, it is state-listed as threatened (Vermont Endangered Species Law 10 V.S.A. Chapter 123) and tracked as S2S3 by the Nongame and Natural Heritage Program. Species considered threatened in Vermont are those that appear likely to become endangered in the near future, as well as those federally listed as threatened (Brumback and Mehrhoff et al. 1996).

Northern stickseed occurrences are protected at three publicly owned sites in Vermont (VT .009 [Shelburne], VT .015 [Charlotte], and VT .019 [Milton]). Populations of the plant were located at all of these sites in 2000. While natural processes will likely be allowed to persist at the sites, none of them are explicitly managed to protect or restore populations of northern stickseed. This management may be necessary if the small observed populations are to persist.

Northern stickseed has been propagated at New England Wild Flower's Garden in the Woods since 1992 (C. Mattrick, personal communication). A collection of 242 seeds from three parent plants was made by Bill Brumback on July 7, 1992 at VT .002. A portion of these seeds was placed in a freezer at –20 degrees Centigrade for long-term storage. Other seeds were placed in a germination trial after over-wintering under the following four experimental conditions: 1) fresh seed stored in warm sand, 2) fresh seed stored in refrigerated sand, 3) oven-dried seed stored in warm sand, and 4) oven-dried seed stored in refrigerated stand. Refrigerated seed had the highest germination rate, regardless of whether the seed was dried before sowing. Plants were grown to maturity in the Rare Plant Garden in 1995 and 1999, and seeds were collected from these plants. The seed collection now numbers at least 600.

We found little evidence of *Hackelia*-minded conservation initiatives on private lands, although several landowners expressed interest in preserving the plant (see site descriptions, above).

Table 2. New England Occurrence Records for *Hackelia deflexa* var. *americana.* Shaded occurrences are considered extant.

State	EO #	County	Town
ME	**.001**	**Oxford**	**Greenwood**
ME	**.002**	**Oxford**	**Greenwood**
ME	**.003**	**Oxford**	**West Paris**
NH	.001	Coos	Second College Grant
VT	**.001**	**Rutland**	**Benson**
VT	**.002**	**Rutland**	**West Haven**
VT	**.003**	**Chittenden**	**Charlotte**
VT	**.004**	**Grand Isle**	**South Hero**
VT	**.005**	**Addison**	**Salisbury**
VT	.006	Orange	Fairlee
VT	.007	Orleans	Derby
VT	.008	Windsor	Woodstock
VT	**.009**	**Chittenden**	**Shelburne**
VT	**.010**	**Chittenden**	**Shelburne**
VT	**.011**	**Chittenden**	**Milton**
VT	**.012**	**Chittenden**	**Charlotte**
VT	**.013**	**Chittenden**	**Charlotte**
VT	**.014**	**Chittenden**	**Charlotte**
VT	**.015**	**Chittenden**	**Charlotte**
VT	**.016**	**Franklin**	**Georgia Plains**
VT	**.017**	**Franklin**	**Georgia**
VT	**.018**	**Franklin**	**Georgia**
VT	**.019**	**Chittenden**	**Milton**

II. CONSERVATION

\CONSERVATION OBJECTIVES FOR TAXON IN NEW ENGLAND

Northern stickseed is threatened in New England, presently occurring at as few as eight (and possibly at as many as 17) of its 23 known stations. Several populations not found in 2000 are presumed to have disappeared in the last ten years. At some of the stations confirmed in 2000, the population is threatened by development, mining, or woodlot management. Low genetic diversity and inbreeding depression may also be threats to northern stickseed: with small populations (less than 100 individuals at all stations) scattered widely across an anthropogenic landscape, gene flow between populations via pollen and seeds is expected to be minimal. If this plant is to persist in New England at its present level of abundance, we believe that conservation actions must be taken.

The primary conservation objective for this taxon in New England is to secure long-term persistence for no fewer than 15 stations, including representatives from across its geographic range from Vermont to Maine.

Because it is not known how many occurrences of this plant should be protected in order to ensure long-term persistence in New England, we have chosen an arbitrary target of 15, which probably represents most or all of the extant populations (i.e., those confirmed by this study, as well as those not yet confirmed). We suggest protection of stations across the range of the plant in New England because, in the absence of detailed population and genetic information for this species, we feel this is this approach will conserve the highest level of genetic diversity and local adaptation possible. If 15 stations are to receive long term protection, workers obviously need to confirm at least seven more (and probably a greater number than this) stations as extant. Ideally, all "protected" sites would be owned by a public or private entity dedicated to rare species conservation; however, this is probably not a realistic goal. Instead, we envision long-term protection of northern stickseed sites to include easement acquisition, landowner education and cooperation, periodic monitoring, and land acquisition where feasible. Until this primary goal of conserving 15 northern stickseed occurrences is achieved, workers should concentrate on protecting the highest quality occurrences that are known to be extant (including those listed below in General Conservation Action #3). This will require reappraising quality ranks of confirmed occurrences, then working towards acceptable levels of protection of those occurrences.

The general conservation actions outlined below are intended to serve the primary onservation objective. The conservation actions are listed in the order we suggest they be

performed, which is not necessarily priority order—while action #3 is probably the most important, it must be preceded by the work prescribed in actions #1 and #2.

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IV. APPENDICES

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1. An explanation of conservation ranks used by The Nature Conservancy and Natureserve.

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 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 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.