New England Plant Conservation Program

Conservation and Research Plan

Asclepias purpurascens L.
Purple milkweed

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SUMMARY

Purple milkweed (*Asclepias purpurascens* L., Asclepiadaceae) is a rare but widely distributed species currently recorded from 25 eastern and mid-western states and Ontario, with historic records from another four states. All extant New England populations are restricted to Connecticut and Massachusetts; the species is considered historic in Rhode Island and New Hampshire. Only a total of 5 occurrences have been seen since 1980, of 82 collected before that time. Of these, only two have been observed recently and one remains to be confirmed as *A. purpurascens*. Both confirmed populations are small (with fewer than 30 plants) and appear precarious.

The species is listed in the *Flora Conservanda* as Division I (Regionally Rare). *Asclepias purpurascens* is not federally listed and is a category G4G5 according to the Association for Biodiversity Information; thus, its status is not considered to be imperiled on a national or global scale. However, its population numbers are small throughout its range. Its precipitous recent decline in numbers in New England attests to the need for additional protective management to afford some level of habitat preservation and augmentation.

Asclepias purpurascens is most commonly found along woodland edges and roadsides in mesic to well-drained soils that are not high in organic material. Most common in oak-pine associations, the species occasionally occurs on seeps or wetland margins. The plant may also have affinities with circumneutral or calcium/magnesium-rich geologic parent material. Fruit production in this plant tends to be very low, and may be limited by inefficient pollination, self-incompatibility, interspecific pollen, isolation, selective abortion, parasitic fungi, and inbreeding depression. Other factors controlling fitness and survivorship need to be investigated.

Primary conservation objectives for *Asclepias purpurascens* in New England are to locate, protect, maintain, or establish at least twenty separate occurrences in Massachusetts and Connecticut over the next twenty years. At least ten of these populations should contain a minimum of 30 to 50 plants in order to maintain stable numbers and to increase the probability of successful pollination and fruit set. The majority of these populations should occur on protected land. To achieve these goals, historic sites should be reviewed and promising habitats resurveyed. Existing populations (especially a new Falmouth, Massachusetts site) must be protected from adverse effects of development, succession, erosion, and recreation. Consistent, quantitative monitoring should be undertaken at all known sites. Research studies on reproductive biology and habitat needs should take place at New England sites and selected populations outside the region to inform management decisions. Experimental hand-pollinations may be needed at some local sites to enhance seed set. *Ex-situ* cultivation and seed-banking should be pursued. The feasibility of population augmentation and reintroduction should be seriously explored.

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

The present status of purple milkweed, *Asclepias purpurascens* L., (Asclepiadaceae) in New England exemplifies a dilemma common to other rare species' recovery plans: a demonstrable decline in extant records (from 82 to five) with seemingly suitable habitat still existing throughout the region. This plan provides a broad-based overview of available information on *A. purpurascens* available in the literature, regional herbaria, and state Natural Heritage data bases. It renders a set of goals and actions required to meet the conservation objective of maintaining twenty viable populations of the plant in southern New England over the next two decades.

Asclepias purpurascens is found throughout the eastern and mid-western United States and Ontario. Connecticut and Massachusetts currently represent the northeastern edge of its range, although the species was formerly found in New Hampshire and Rhode Island, according to herbarium records. Throughout its range, the taxon occurs in widely-scattered, usually small populations, and has been undergoing general declines in abundance as reflected by its conservation ranks of S1-S3 or SH/SX in 17 of 35 states and provinces from which it is recorded. Although the taxon is most abundant in the midwestern and southeastern sectors of its range, it is described in most state floras as "infrequent" and characterized by small populations. *Asclepias purpurascens* is considered a Division 1 (Regionally Rare) taxon by the *Flora Conservanda*: New England (Brumback and Mehrhoff et al. 1996).

Exhibiting a broad ecological amplitude, *Asclepias purpurascens* typically inhabits semi-open margins of woodlands (often with *Pinus-Quercus* associations), roadsides, utility corridors, and old-fields on soil substrates ranging from dry to quite moist. Many of its populations in North America occur on calcium-rich parent material, indicating a loose affinity for richer soils with high cation exchange capacity. Although succession to forest, road maintenance, and development have negatively impacted these habitats, there is still ample area available to support the taxon range-wide. However, existing populations rarely produce fruit; therefore, population growth and range expansion proceed very slowly. Reasons for the decline of *Asclepias purpurascens* may include: major intrinsic limits to reproduction (including self-incompatibility); competition with other plant species; and other environmental factors that have yet to be identified.

With only two occurrences confirmed (and up to five known) in New England -- all totaling less than fifty plants -- the prospects for *Asclepias purpurascens* in the region appear grim unless concerted and immediate conservation actions are taken to bolster existing populations and to find new ones. These actions include:

- protecting all known occurrences from further decline;
- managing these habitats to promote population growth;
- searching historic localities and promising habitat for other occurrences;
- conducting field research on both New England and New York/New Jersey populations to determine limits to reproduction and recruitment;
- initiating *ex-situ* seed-banking and propagation trials;
- considering the feasibility of augmenting and eventually reintroducing populations to more sites within the current species range.

DESCRIPTION

Asclepias purpurascens is a slender, perennial herb growing to one meter in height. Like all members of the genus *Asclepias*, the corolla of *A. purpurascens* is deeply five-parted, with the divisions valvate in bud. Flowers are comparatively large (corolla lobes 7-10 mm long), and minutely hairy. The crown of five hooded bodies is seated on the tube of the stamens, with each containing a small appendage known as a *horn*. This appendage can be critical to correctly identifying certain species, including the target taxon. In *Asclepias purpurascens,* the incurved, flat horn is usually shorter than or barely exserted from the 5-7 mm long hoods (Gleason and Cronquist 1991). The hoods themselves have no lateral lobes and show little widening at the midpoint (Gleason and Cronquist 1991). Although the flowers bear a superficial resemblance to two other sister taxa -- *Asclepias syriaca* (Common milkweed, with more light-purple flowers) and *Asclepias incarnata* (Swamp milkweed, with smaller flowers) -- the corolla hoods and swept-back sepals are a unique and striking deep purple to reddish magenta. The flowering peduncles are usually terminal in *A. purpurascens*, with normally one or two tight, hemispherical umbels. Fruits are rarely produced by this species (Wilbur 1976, and personal observations of authors), but when they appear, they are smooth follicles (bearing no wart-like processes) and are perched on deflexed pedicels.

Vegetative characters can also be useful for distinguishing *Asclepias purpurascens* from its congeners. The plant surface is generally minutely downy, especially on the underside of the leaves and stem. The paired (not whorled), opposite 10-15 cm-long leaves are dark green and glabrate above, pale and densely puberulent below on petioles 0.5 to 2.5 cm long (Woodson 1954). The leaves are elliptic to ovate-oblong with an acuminate, not mucronate, tip and distinctive net venation in which secondary veins emanate from the mid-rib in a transverse or arcuate, not ascending pattern (Fernald 1950, Woodson 1954, Gleason and Cronquist 1991). The leaves are more acute and more strongly net-veined in *A. purpurascens* than in *A. syriaca* (Choberka et al. 2000). Primary cauline leaves of the voucher specimens at the NEBC and Harvard Herbaria measured by Mario DiGregorio displayed an average length-to-width ratio of about 3:1 (typically 15 cm x 5 cm). The two milkweed species that have often been confused with *A. purpurascens* have different leaf shapes and other ecological characteristics such as habitat preference that can be used in aiding field identification (summarized in Table 1). Other general characteristics of the *Asclepias* genus are seen in *A. purpurascens,* including milky sap and a stout root stock. *Asclepias purpurascens* does not appear to proliferate along rhizomes, unlike certain other milkweeds (Gleason and Cronquist 1991).

Misidentification in the field may have caused confusion of *A. purpurascens* with *Asclepias syriaca* or *A. incarnata*. Misidentification is evident in at least one voucher specimen at the Gray Herbarium (for example, VS #2, a putative *A. purpurascens* with unusually rounded leaves, is actually *A. syriaca*, as annotated later by Ahles).

Table 1: Comparison of informative characters of Purple, Common, and Swamp Milkweeds (compiled from Fernald 1950, Woodson 1954, Gleason and Cronquist 1991, and herbarium data)

A. purpurascens	***A. syriaca***	***A. incarnata***
5 cm (wide) x 15 cm (long) leaf	10 cm x 15-18 cm leaf	3-4 cm x 15-20 cm leaf
1-2 hemispherical umbels	2-6 spherical umbels	2-12 spherical umbels
Smooth follicle on deflexed pedicel; rarely fruiting	Downy follicle with many wart-like conical processes*	Minutely hairy follicles on ascending pedicels
Dry to moist wooded habitat. Native associated taxa	Dry to moist open fields often with non-native taxa	Moist to wet open soil with native taxa

* *A. syriaca* forma *inermis* lacks the warty follicle surface

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Asclepias purpurascens is a member of the milkweed family (Asclepiadaceae), Class Dicotyledoneae, Order Gentianales. This speciose, monophyletic family contains approximately 250 genera and 1,800 to 2,000 species, with centers of diversity in Africa and South America (Downie and Palmer 1992, Heywood 1993). Most Asclepiadaceae are tropical or sub-tropical, with relatively few representatives in temperate North America (Zomlefer 1994). The North American species of *Asclepias* form a "coherent alliance" (Woodson 1954: 26), separate from the African and South American clades. The genus *Asclepias* is classified under the subfamily Cynanchoideae in the tribe Asclepioideae, bearing pollen massed in pollinia (Heywood 1993).

Asclepias purpurascens, first named by Linnaeus (1753), is recognized as a distinct taxon with relatively stable, informative characters (Woodson 1954). Former synonyms include *Asclepias amoena* L., *A. compressa* Moench., *A. dasyypus* Raf., *A. lasiotis* Raf., and *A.*

gonialis Raf. (Woodson 1954). *Vincetoxicum purpurascens* C. Morren & Decaisne and *Asclepias purpurascens* Walter are considered homonyms (W3-Tropicos Database 2001).

Like many species in the *Asclepias* genus, *A. purpurascens* is apparently capable of hybridizing with the common milkweed, *A. syriaca*, with which it frequently co-occurs. Recent evidence of hybridization comes from analysis of flavonoid profiles among *A. purpurascens*, *A. syriaca*, and a putative *A. purpurascens* x *A. syriaca* hybrid (Wyatt and Hunt 1991), which also reinforces morphological evidence of hybridization among *Asclepias* species (Kephart et al. 1988). Woodson (1954), treating the North American *Asclepias*, did not observe hybridization between *A. purpurascens* and other taxa; neither did Moore (1946), who attempted cross-pollinations between *A. purpurascens* and *A. curassavica*. Although natural hybridization events may be infrequent, it is clear that *Asclepias* species are not as reproductively isolated as previously thought (Kephart and Henser 1980, Kephart 1987, Broyles 1992, Ivey 1998). As noted above, hybridization potentially poses problems for field identification, as characters can grade between *A. purpurascens* and *A. syriaca*. For example, the normally warty follicles of *A. syriaca* are sometimes smooth in forma *inermi*s, a feature shared with *A. purpurascens*. Bruce Sorrie, formerly with the Massachusetts Natural Heritage and Endangered Species Program, observed that hybridization may have led to confusion in the identity of *A. purpurascens* at one putative site in Agawam, Massachusetts (see below). However, in most cases, the habitat preference and general plant habit, including flower color and leaf morphology, leads to a solid species identification.

SPECIES BIOLOGY

Asclepias purpurascens is an iteroparous perennial (Gleason and Cronquist 1991), but its longevity in the wild is unknown. The plant typically grows from a stout root, but is not rhizomatous, and does not appear to allocate much of its photosynthetic resources to below-ground storage (at least to the extent that *A. syriaca* does). Thus, unlike other, more common milkweed species, expansion of *A. purpurascens* populations is heavily contingent on seed viability and dispersal. The small (<5 mm long), dry, wind-dispersed seeds of *A. purpurascens* are probably capable of entering dormancy (as has been demonstrated for *A. syriaca* and *A. tuberosa* (Oegma and Fletcher 1971, Baskin and Baskin 1977, National Seed Storage Laboratory 2001). However, it is unknown how long the seeds of *A. purpurascens* can remain viable either in the natural seed bank or in *ex situ* storage. Factors that reduce flower, fruit, and seed production are likely to fundamentally influence population viability and persistence of *A. purpurascens* and warrant detailed examination in the field.

Perhaps the most striking feature of *Asclepias purpurascens* -- and arguably the one most relevant to its conservation -- is its specialized sexual reproduction. The showy flowers of the milkweed family, their unusual pollinia (sacs comprised of multiple pollen grains), and their attractiveness to a wide array of floral visitors have made *Asclepias* species model systems for studying reproductive isolation and evolution of mating systems (e.g., Willson and Rathcke

1974, Wyatt and Broyles 1994, Fishbein 1996). Little research has specifically addressed *A. purpurascens* per se, but many hypotheses about its rarity can be gleaned from studies of reproductive ecology in its co-occurring congeners.

Asclepias purpurascens flowers in June and July in New England, and its fruits mature in late summer (Gleason and Cronquist 1991). Many *Asclepias* species are demonstrably self-incompatible (possibly showing ovarian self-incompatibility; reviewed in Wyatt and Broyles 1994) or exhibit very low rates of self-compatibility (Wyatt 1976, Lipow 1998). Thus, the taxon may rely almost entirely on outcrossing effected by insects in order to reproduce. The large, deep-purple flowers of *A. purpurascens* produce a nectar rich in simple sugars that draws many insects, some of which collect the sticky pollinia on their feet, mouthparts, and legs. Robertson (1887) reported five species of Lepidoptera, one Hemipteran (true bug) species, one Hymenopteran (bee) species, and one Dipteran (fly) species pollinating *A. purpurascens* in Missouri. Bumble bees (*Bombus* spp.) are common pollinators of *Asclepias syriaca* in New England (Morse and Fritz 1983), and are likely to be the most frequent visitors to *A. purpurascens* in areas where the two species overlap. Morgan-Thompson (1985) identified the following insects as important pollinators of *A. syriaca* and *A. incarnata* in Connecticut: *Apis mellifera*, *Bombus perplexus*, *Bombus griseocollis*, *Sphex pensylvanicus*, *Sphex ichneumoneus*, *Tachytes* sp., *Speyeria cybele*, *Danaus plexippus*, *Prionyx parkeri*, *Adopoea lineola*, and *Apis mellifera* (the latter two are introduced insect species to this region). During the summer of 2000, Mario DiGregorio documented both *Bombus* spp. and numerous flower-flies of the *Syrphidae* family (*Syrphus* spp.) feeding on the flowers of *A. purpurascens* in Falmouth, Massachusetts. Many of the foregoing species are generalist pollinators and probably do not show partitioning among various species of *Asclepias* (cf. Kephart 1983).

Insect pollinators vary widely in their efficiency for moving pollinia among plants, and rates of accidental self-pollination may be very high, exceeding 30% (Pleasants et al. 1990, Morse and Jennersten 1991, Pleasants 1991). In a self-incompatible species such as *A. purpurascens*, this incidental selfing may further depress reproductive output. If pollinia are sufficiently long-lived and tolerant of desiccation during flight, long-distance pollen dispersal can occur, enabling outcrossing of far-flung populations (Morse 1987, Wyatt and Broyles 1994). However, *Asclepias purpurascens*, which occurs in patchy, small populations separated by fifty miles or more in New England, may suffer low outcrossing rates and, consequently, low pollination success. Small, scattered plant populations tend to exhibit low genetic variability (e.g., Schaal and Smith 1980) as well as low allelic variation at the incompatibility locus (S-locus), reducing the frequency of cross-compatible mating combinations (e.g., Les et al. 1991, Demauro 1993, Byers 1995). Inbreeding depression would be further exacerbated if flowers or fruits are aborted as a means of selecting against "weak" pollen donors, as has been suggested by Bookman (1984); in small and inbred populations, vigorous paternal plants may be in short supply.

At sites where small populations of *Asclepias purpurascens* co-occur with other *Asclepias* species, the potential for accidental and often deleterious cross-pollination among taxa is great (see above observations by Sorrie regarding one Massachusetts site, for example). *Asclepias purpurascens* overlaps in flowering phenology with many of its co-occurring congeners in New England (Gleason and Cronquist 1991). Moreover, *Asclepias* species all have the same ploidy and base chromosome number (n = 11 [Woodson 1954]), further enhancing the chance of hybridization. Wyatt and Broyles (1994) report that hybrids between *A. exaltata* and *A. purpurascens* exhibited reduced pollen viability relative to parent plants. Likewise, studies of natural cross-fertilization between two sub-species of *Asclepias incarnata* (ssp. *pulchra* and ssp. *incarnata*) revealed lower pollen fertility in the hybrid generation (Ivey 1998). Two species that co-occur with *A. purpurascens, A. exaltata* and *A. syriaca,* have been shown to exchange alleles via interbreeding (Broyles 1992); such introgression could occur with *A. purpurascens*. *Asclepias purpurascens* flowers may be swamped by pollinia arriving from more common milkweed species, further dampening their reproductive success.

Fungal infection of nectar may also hinder reproduction. The common milkweed, *Asclepias syriaca*, produces nectar that is frequently infected by the yeast, *Metschnikowia reukaufii* Pitt et Miller (Eisikowitch et al. 1990, McLernon 1995). This yeast is capable of breaking down lipids and proteins that are constituents of pollen tubes; consequently, pollen germination does not occur in infected flowers. This yeast should be assayed for in *Asclepias purpurascens*; if it is particularly frequent on flowers of this species, it could potentially explain why exceedingly few fruits are even initiated by apparently healthy and highly-visited flowers. Another parasitic fungus, *Cercospora clavata* (Ger.) Cke. is noted to occur on *Asclepias purpurascens* in Wisconsin, but the effects of its presence on the plant are unknown (Greene 1952).

Another hypothesis explaining low fruit set (despite high pollinator activity) is resource limitation: lack of sufficient nutrients or light to produce mature fruits. Willson and Price (1980) demonstrated that fertilization with nutrients and enhanced light availability improved fruit production in *A. syriaca* and *A. verticillata* (the latter another rare milkweed in New England (Natureserve 2001). Queller (1985) similarly observed higher fruit set in fertilized *A. exaltata.* Flower production is positively correlated with the amount of stored above- and below-ground structural energy amassed by *Asclepias quadrifolia*, a woodland milkweed (Chaplin and Walker 1982). Without the benefit of a large rhizome, *Asclepias purpurascens* may not accumulate nutrient or water reserves as efficiently as other species, and may be outcompeted readily where resources become limiting. The perennial milkweed, *Asclepias tuberosa,* also shows low rates of seedling recruitment under conditions of chronically low productivity and drought (Klemow and Raynal 1986). However, *Asclepias tuberosa* grows faster and larger and produces more flowers when inoculated with vesicular-arbuscular myccorhizae, which both increase the efficiency of phosphorus assimilation and confers substantial drought tolerance to seedlings (Zajicek 1986). Milkweed pods are energetically costly to produce (Chaplin and Walker 1982), and populations of *A. purpurascens* on low-nutrient or dry sites may produce fewer fruits or abort a higher proportion of them. While this hypothesis needs to be tested in the field, and the mycorrhizal status of *A. purpurascens* should be explored, it is unlikely that *all* populations are nutrient-limited, and the range-wide rarity of the species is probably not attributable everywhere to lack of resources.

Interspecific competition for water, nutrients, or pollinators may also limit survivorship, growth, and fecundity of *Asclepias purpurascens*, especially when it co-occurs with the larger, rhizomatous congener, *Asclepias syriaca*, which is a strong competitor with other herbaceous species (Platt and Weis 1985). This phenomenon has not been studied in this species, but management to thin potential competitors could be treated as a controlled experiment to determine the importance of competition to the persistence of *A. purpurascens*.

Plant size and flower production appear to be lower in certain milkweeds that have been defoliated by herbivores (Willson and Price 1980, Chaplin and Walker 1992), but the importance of herbivory to *Asclepias purpurascens* is unknown. Wilbur (1976) found little evidence of herbivory on *A. purpurascens* in *Quercus-Carya* woodlands of Michigan. He documents one herbivore on *A. purpurascens* at that site: a curculionid beetle (*Ryssomates* sp.) that feeds on leaves and chews holes in stems. Intensity of insect herbivory in one growing season did not significantly reduce the probability of flowering in the next, according to Wilbur (1976). Milkweed species produce a host of secondary chemical defenses (most notably toxic cardiac glycosides) in their milky latex, and few insect species have evolved to overcome this defense (phylogenetic evidence of a co-evolutionary "arms race" between species-specific milkweed beetles and *Asclepias* species was developed, for example, by Farrell [1991]). By contrast, mammals are important herbivores on common milkweed (Hochwender 1997). Deer may eat stems to the ground, as noted by Polloni and colleagues for one Massachusetts site (see below), and should be watched carefully for their impacts on *A. purpurascens* range-wide. Resistance to herbivores is correlated with the nutrient status of the plant (Hochwender 1997).

HABITAT/ECOLOGY

Asclepias purpurascens displays a broad ecological amplitude throughout its range, generally occupying woodland edges and rural roadsides in generally well-drained to damp soil conditions. The species is designated a "facultative wetland" plant by the USDA PLANTS National Database (2001). Interestingly, habitat referenced in the literature for the northern part of its range in New England seems to indicate drier wood edges and roadsides, while lowland thickets and wetland edges are included among its preferred habitat types in the southern United States. Fernald (1950) describes typical habitat as being "dry to damp woods, thickets and openings." Seymour (1982) simply describes the habitat as "borders of woods," while Gleason and Cronquist (1991) state that its found in "dry soil." Voss (1996) describes the usual habitat as "dry woodland (especially oak) and thickets, shores, prairies." Woodson (1954) posits that *A purpurascens* segregates into two disjunct populations, referred to as "Ozarkian" and "Appalachian," where the species inhabits "woods, prairies and fields, often escaping to roadsides and railway embankments." An examination by Mario DiGregorio of fifty-four voucher specimens accessioned at the Gray and NEBC Herbaria at Harvard University, plus two unvouchered Barnstable County, Massachusetts records from Brewster and Falmouth, indicate the following habitat breakdown for New England occurrences (Table 2).

Table 2. Habitat categories for historic and extant Massachusetts occurrences
* Unless specified, this habitat may be too general to derive a dry-wet assessment

Dry* *(Upland to Facultative Upland)		***Damp to Wetland* *(Obligate to Facultative Wetland)***	
Roadsides	10	Roadsides	1
Woodlands	1	Woodlands	0
Woodland Edge	5	Woodland Edge	0
Open Field/Meadow	2	Open Field/Meadow	1
Thicket *	3	Thicket *	0
Other ('dry ground')	3	Other ('wet or low ground')	3
Total:	**24 = 83%**	**Total:**	**5=17%**

Extant or recently-observed New England populations occur in a wide variety of habitats including a woodland edge, an island heathland, a power line right-of-way, a mesic old-field, a former airport situated on a sandy outwash plain, and a successional sedge meadow. Appendix 2 lists numerous sources of information on the habitats of the taxon from outside New England, the majority of which are dry to mesic woodlands and forest "edges."

Inspection of habitat descriptions (Appendix Two) suggests that *Asclepias purpurascens* may be loosely associated with circumneutral soil types including: sandy, clayey, or rocky calcareous/gypseous soils of prairies and mid-western oak glades; limestone areas of the lower Illinois River valley (Turner 1936); wet soils derived from mafic bedrock in North Carolina (Bruce Sorrie, North Carolina Natural Heritage Program, personal communication); limestone formations in Tennessee (Paul Somers, Massachusetts Natural Heritage Program, personal communication); and soils overlying the New Haven arkose Formation and other circumneutral bedrock types in Connecticut. In part, a preference for soils rich in calcium or magnesium may explain the species' flexible tolerance for a range of moisture regimes, as has been noted with other calciphiles (Farnsworth 2001). Because its occurrences are few and far between, its association with particular parent materials is difficult to test without an active experiment examining growth in soils of differing nutrient status and cation exchange capacity. Not all New England populations appear to be found on circumneutral soils (e.g., Cape Cod and Nantucket occurrences), but precise soil status has not been determined for all the sites.

Asclepias purpurascens, unlike most of its related species, seems to be adapted to semi-open filtered shade and woodlands. Although it penetrates woodlands (unlike many of the congeners with which it co-occurs), the species may be relatively intolerant of shade and may flourish best at early to mid-successional sites (Illinois Plant Information Network 2001). Pruka (1997) points to this taxon as one of several indicator plant species of "recoverable" (healthy or restorable) oak savannas and open oak woodlands in southern Wisconsin. These savannas, as well as remnant prairies of Michigan and Ontario (Harvey 1922) and various sites in the outwash plain and islands of New England, may have been influenced by fire. Could *Asclepias purpurascens* benefit from fire, and be declining in part due to fire suppression? Given the broad ecological amplitude of *Asclepias purpurascens* (cf. Mitchell and Tucker 1994, for example), it is not appropriate to characterize it as a fire-dependent species. However, processes that maintain a relatively sparse canopy, such as fire, clearing for agriculture, and storm activity, could enhance performance of the taxon at certain sites (as long as they do not simultaneously promote growth and competition by *Asclepias syriaca* and other potential competitors).

Although reforestation of the New England landscape has been progressing since the early part of this century, early-successional habitat (roadside, railroad beds, and other edge habitats from which the species has been described since 1900, see Appendix Two) is not in particularly short supply in New England, nor elsewhere along the range of *Asclepias purpurascens* (although individual patches of appropriate habitat may be shrinking in size). Nevertheless, populations of the species are frequently described as small, sparse, infrequent, and rare across North America in references that span more than 70 years (Hus 1908, Bicknell 1915, Farwell 1928, Correll 1966, Wilbur 1976, Deam 1984). Counts of New England herbarium specimens from the previous century, by contrast, indicate that *A. purpurascens* was once moderately common and widespread (Table 3). Such a trend raises the question whether the rarity and decline of *A. purpurascens* is more likely due to either a recently evolving factor intrinsic to the species' biology (and/or a range-wide environmental factor such as air pollution) rather than a simple shrinkage in available habitat. Given the potential hindrances to reproduction discussed above, it may be plausible that small populations of the species have always suffered from pollen limitation or other reproductive impediments leading to reduced seed set, genetic bottlenecks, increasing incompatibility due to loss of S-alleles, and worsening inbreeding depression within increasingly isolated populations. Likewise, changing large-scale environmental conditions in the past century (such as acidic deposition, nitrogen deposition, and ozone pollution) could kill plants, shrink populations, and exacerbate inbreeding. Studies that systematically compare large and vigorous populations of *A. purpurascens* with smaller, more tenuous occurrences are needed to explore this hypothesis and to determine why the species is declining in many parts of North America.

Table 3. Trends in historic occurrence records for *Asclepias purpurascens* in New England (from survey of herbaria). The species has not been collected since 1987.

YEARS	***1800-1900***	***1900-1929***	***1930-1949***	***1950-1979***	***1980-Present***
Numbers of historic records collected in New England states	MA-18	MA-11	MA-4	MA-2	MA-3
	RI-2	RI-2	RI-0	RI-0	RI-0
	CT-10	CT-21	CT-5	CT-3	CT-2
	NH-1	NH-1	NH-2	NH-0	NH-0
TOTAL	**31**	**35**	**11**	**5**	**4**

THREATS TO TAXON

Historic habitat documentation of *Asclepias purpurascens* indicates that it was fairly common in the 1800's-early 1900's along roadsides and woodland edges. While presumably this habitat type is still commonly found in New England, the advent of modern highways and road improvements, herbicide treatments, and habitat conversion may have been major element in its decline, and set the stage for other stressors to extinguish populations. The following threats may impact *Asclepias purpurascens* singly or synergistically:

1. Road improvement, roadside herbiciding, and utility line easements have probably been responsible for extirpating many historic populations and for reducing available habitat throughout the region, especially around the metropolitan Boston and Hartford areas (Figure 3).

2. General habitat conversion for industrial and other development has directly impacted two Massachusetts sites within recent memory, and has destroyed other historic occurrences.

3. Succession from open wood edges to denser thickets has occurred throughout the region, probably shading plants and contributing to mortality. Plants are crowded by growth of woody vegetation and dense forbs at one site (Southbury, Connecticut), for example.

4. Invasive species proliferation, including common road-side invasive plants (some planted) may have excluded plants from their marginal habitats. Invasive species could threaten one occurrence at Southbury, Connecticut. Another species with exploding numbers should also receive attention, namely, deer, which are important herbivores at one site (Falmouth) and possibly others.

5. Increasing incompatibility and/or inbreeding depression in shrinking populations, leading to local extinctions. This is an overarching threat, and the most insidious one to address.

Inbreeding depression is likely depressing fruit set at all populations, and has undoubtedly hastened the demise of other populations. Due to self-incompatibility, reproductive constraints, and a specialized pollination system, *Asclepias purpurascens* may be inherently vulnerable to extinction once populations dip beneath a critical threshold. Related to this issue is the potential swamping of pollen by co-occurring, dominant congeners such as *Asclepias syriaca,* increasing the likelihood of reproductive failure or hybridization.

DISTRIBUTION AND STATUS

The historic North American range of *Asclepias purpurascens* encompasses a southeastern to mid-western distribution, with southern New England currently representing the northeastern edge of its range (it was formerly confirmed from New Hampshire). The species is described as ranging from southern New Hampshire to southern Ontario, Minnesota and South Dakota, south to North Carolina, Tennessee, Mississippi, Arkansas and Oklahoma (Fernald 1950, Natureserve 2001). Gleason and Cronquist (1991) truncate its southern distribution somewhat, describing it from southern New Hampshire to Virginia, west to Wisconsin, Iowa, Kansas and Oklahoma). Woodson (1954: 36) viewed the Appalachian populations as having "withdrawn almost completely from [their] putative refugium to the middle and northern Atlantic coast."

The Global conservation rank of *Asclepias purpurascens* is G4G5 (see Appendix 3 for explanation of ranks), indicating that although it is widespread and secure globally, its rarity at the periphery of its range may be of long-term concern (Natureserve 2001). The species' national classification is N?, meaning that its United States status has not been formally assessed as yet. The species is regarded as an N2 (imperiled) taxon in Canada, reflecting that it is found in few populations in a single province (Ontario). The *Flora Conservanda:* New England (Brumback and Mehrhoff et al.1996) designates *A. purpurascens* as Division 2 (Regionally Rare, with less than twenty occurrences in New England).

Although the taxon exhibits a wide distribution, state classifications indicate that it is uncommon throughout its range (Table 4; Natureserve 2001). The taxon is most often classified as SH (state historic), S1 (critically imperiled: 1-5 occurrences), S2 (Imperiled: 6-20 occurrences), SR (recorded in the state with little other documentation) or SU/S? (status uncertain). Only in Iowa, Michigan, New Jersey, and New York is *Asclepias purpurascens* listed as an S3 taxon, with more than 21 occurrences documented. Bruce Sorrie, Botanist for the North Carolina Natural Heritage Program, states that although it is listed as a Watch List species in North Carolina, it has not been seen in many years (personal communication). Figures 1, 2, and 3 show North American and New England distribution maps for the taxon.

Table 4. Occurrence and status of *Asclepias purpurascens* 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)
Delaware (S2)	Illinois (S?)	Arkansas (SR): but recorded by Hunter (1984)	Connecticut (SH): 43 historic records. *Rank should be updated to reflect new occurrences.*
Georgia (S1)	Iowa (S3)	Indiana (SR): but recorded by Deam (1984)	District of Columbia (SX)
Massachusetts (S2): 2 extant and 36 historic (plus 1 presumed extirpated) occurrences	Kentucky (S?)	Kansas (SR): but recorded by Stevens (1961)	New Hampshire (SH)
Mississippi (S1)	Michigan (S3)	Louisiana (SR)	Rhode Island (SH): 4 historic records
Nebraska (S1)	New Jersey (S3S4)	Maine (SR)	
North Carolina (S1?)	New York (S3)	Maryland (SU)	
Tennessee (S1)	Pennsylvania (S?)	Minnesota (SU)	
Virginia (S2?)	West Virginia (S?)	Missouri (SR): but recorded by Denison (1978)	
Wisconsin (S2)		Ohio (SR)	
Ontario (S2)		Oklahoma (SR): but recorded by McCoy (1987)	
		South Dakota (SR)	
		Texas (SR): but recorded by Correll (1966)	
		Vermont (SR)	

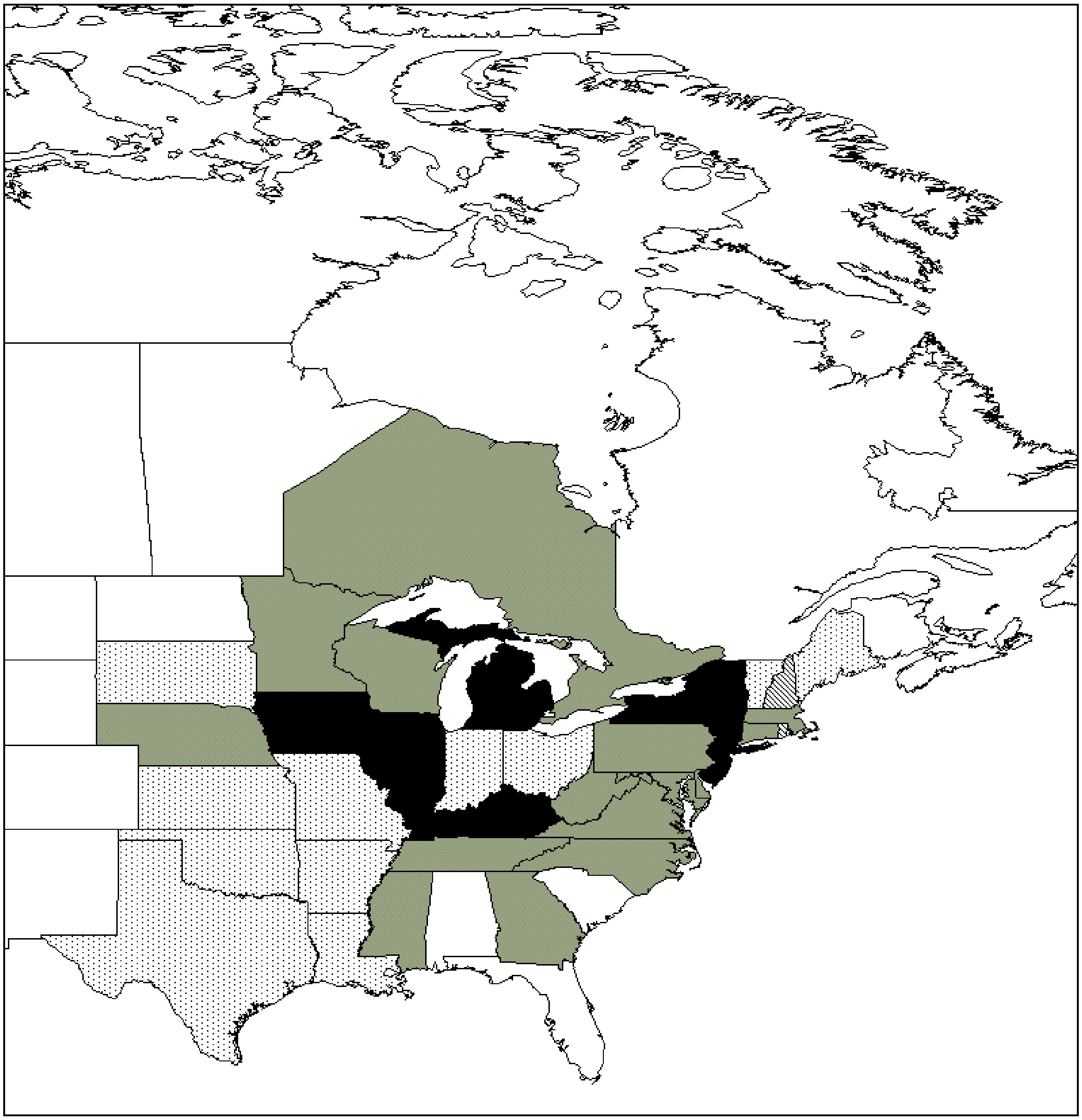

Figure 1. Occurrences of *Asclepias purpurascens* in North America. States and provinces shaded in gray have one to five current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. States with diagonal hatching are designated "historic" or "presumed extirpated," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but not necessarily verified). See Appendix 3 for explanation of state ranks).

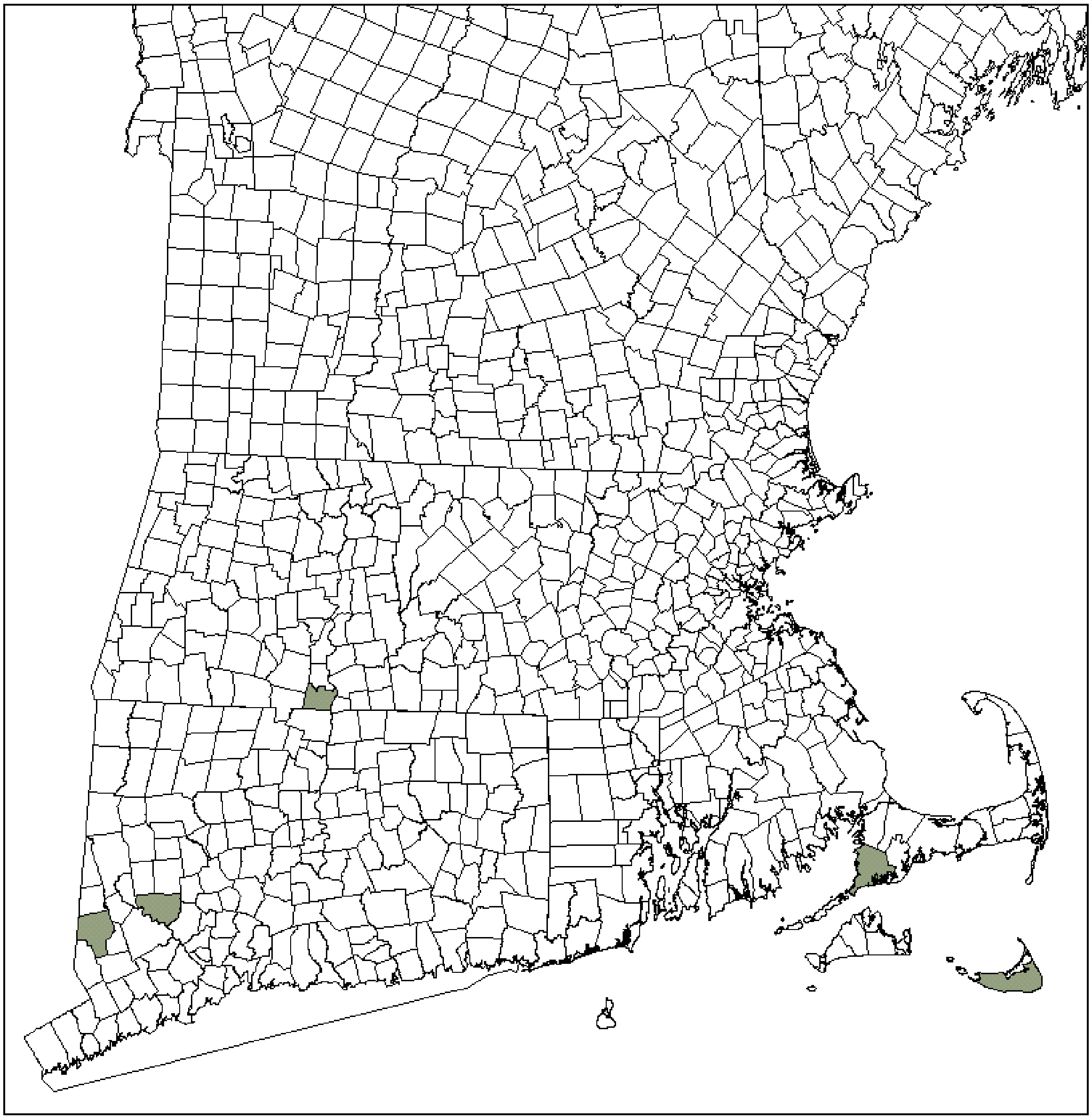

Figure 2. Extant occurrences of *Asclepias purpurascens* in New England. Town boundaries for southern New England states are shown. Towns shaded in gray have one to five occurrences of the taxon observed since 1980.

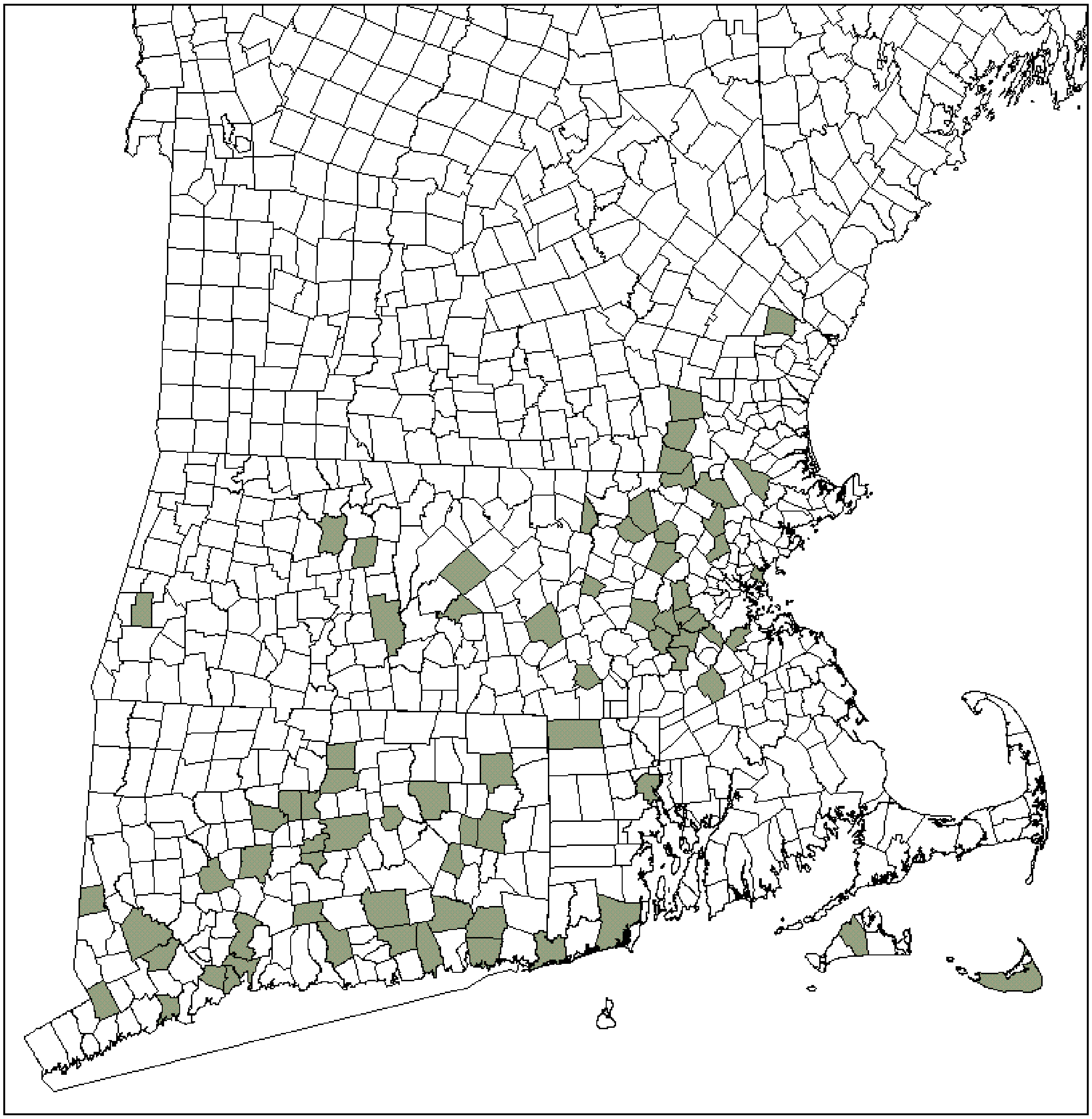

Figure 3. Historic occurrences of *Asclepias purpurascens* in New England. Towns shaded in gray have one to five historic records of the taxon.

Table 5. New England Occurrence Records for *Asclepias purpurascens*. Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
NH	.001	Strafford	Durham
NH	.002	Rockingham	Windham
NH	.003	Rockingham	Derry
NH	.004	Hillsborough	Pelham
MA	**.040**	**Barnstable**	**Falmouth**
MA	**.041**	**Nantucket**	**Nantucket**
MA	**None**	**Hamden**	**Agawam**
MA	.001	Nantucket	Nantucket
MA	.002	Dukes	West Tisbury
MA	.003	Worcester	Worcester
MA	.004	Middlesex	Woburn
MA	.005	Norfolk	Milton
MA	.006	Middlesex	Sherborn
MA	.007	Franklin	Deerfield
MA	.008	Suffolk	Revere
MA	.010	Norfolk	Medfield
MA	.011	Worcester	Berlin
MA	.012	Worcester	Northbridge
MA	.013	Berkshire	Stockbridge
MA	.014	Franklin	Leverett
MA	.015	Middlesex	Shirley
MA	.016	Norfolk	Dedham
MA	.017	Norfolk	Wellesley
MA	.018	Norfolk	Needham
MA	.019	Middlesex	Concord
MA	.020	Norfolk	Milton
MA	.021	Essex	Boxford
MA	.022	Middlesex	Carlisle
MA	.023	Middlesex	Dracut
MA	.024	Middlesex	Weston
MA	.025	Middlesex	Natick
MA	.026	Middlesex	Framingham
MA	.027	Middlesex	Littleton
MA	.028	Middlesex	Wilmington
MA	.029	Norfolk	Braintree
MA	.030	Norfolk	Dover
MA	.031	Norfolk	Sharon
MA	.032	Middlesex	Westford
MA	.034	Worcester	Barre
MA	.035	Hampshire	Belchertown
MA	.036	Norfolk	Dedham

Table 5. New England Occurrence Records for *Asclepias purpurascens*. Shaded occurrences are considered extant.

State	EO #	County	Town
MA	.037	Barnstable	Brewster
MA	.038	Essex	Andover
RI	None	Providence	Providence
RI	None	Washington	Westerly
RI	None	Providence	Burrillville
RI	None	Washington	South Kingstown
CT	.001	New London	Groton
CT	**.002**	**Fairfield**	**Danbury**
CT	**None**	**New Haven**	**Southbury**
CT	.003	New London	Ledyard
CT	.004	Fairfield	Bridgeport
CT	.005	Fairfield	Fairfield
CT	.006	Middlesex	East Haddam
CT	.007	Tolland	Mansfield
CT	.008	New London	Montville
CT	.009	Hartford	Hartford
CT	.010	Hartford	Rocky Hill
CT	.011	Middlesex	Cromwell
CT	.013	Middlesex	Durham
CT	.014	Hartford	South Windsor
CT	.015	Tolland	Mansfield
CT	.016	New London	East Lyme
CT	.017	Hartford	Farmington
CT	.018	Windham	Scotland
CT	.019	Windham	Pomfret
CT	.020	Tolland	Andover
CT	.022	Hartford	East Windsor
CT	.023	Hartford	Southington
CT	.024	New Haven	Hamden
CT	.025	New Haven	Orange
CT	.026	New Haven	Waterbury
CT	.028	Fairfield	Newtown
CT	.030	New Haven	New Haven
CT	.033	Hartford	Farmington
CT	.034	New London	Franklin
CT	.035	Windham	Canterbury
CT	.036	Fairfield	Monroe
CT	.037	Fairfield	Wilton
CT	.039	New Haven	Hamden
CT	.040	New Haven	Orange
CT	.042	Hartford	Glastonbury
CT	.043	Middlesex	Killingworth

Table 5. New England Occurrence Records for *Asclepias purpurascens*. Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
CT	.044	New London	Lyme
CT	.045	Hartford	Southington
CT	.046	Hartford	Southington
CT	.047	Hartford	West Hartford
CT	.048	New Haven	West Haven

CURRENT CONSERVATION MEASURES IN NEW ENGLAND

Increased work to protect the plants at the Falmouth, Massachusetts site is imperative, as construction activities continue apace from the east and west of the population. Sedimentation due to recreational traffic has occurred within fifty feet of the plants. In 2001, for the first time, deer had browsed the stems to ground level. With the hunting season cancelled in 2001 nearby, the deer population is expected to expand, and the threat will increase. Thus, there are multiple serious stresses on this population that must be addressed immediately.

The potentially extant population in Nantucket is under the ownership of the Nantucket Land Bank and is presumably secure (although the NLB has proposed an expansion of the Miacomet golf course near, but not on, the site near Mioxes Pond). It is unknown whether *Asclepias purpurascens* could still exist at the Agawam, Massachusetts site.

The conservation status of the Danbury, Connecticut population appears precarious (C. Mangels, personal communication). The Connecticut Natural Diversity Database and State Botanist are aware of the population and familiar with the problems at the site, but management is not currently underway (Ken Metzler, CT Natural Diversity Database, personal communication). The putative Southbury population is in excellent hands at the Audubon preserve, provided an appropriate mowing regime can be devised to keep the area open without damaging the existing plants. The Center Manager is very interested in cooperatively devising a feasible management strategy for the population, which may be the largest in New England.

The New England Wild Flower Society (NEWFS) has grown *Asclepias purpurascens* under cultivation at the Garden in the Woods in Framingham, Massachusetts. Plants out-planted to the rock garden area did not survive beyond a few years, however, and other seed storage and cultivation studies have not been undertaken. Other botanical gardens (e.g., the Chicago Botanic Garden) in North America have plants of *Asclepias purpurascens* in cultivation (William Brumback, NEWFS, personal communication), and some horticultural outlets market the species for attractive garden plantings (e.g., The Milkweed Farm, http://www.milkweedfarm.com/). Seed appears to be in very short supply around the entire region (Bill Cullina, NEWFS, personal communication).

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

The primary conservation objective for *Asclepias purpurascens* is to find, protect, maintain, or establish at least twenty separate occurrences in Massachusetts and Connecticut over the next 20 years. The majority of occurrences should be on land under conservation protection, and pairs or groups of sites should occur in close enough proximity to permit at least occasional gene flow via insect vectors . At least ten of these populations should contain a minimum of 30 to 50 plants in order to maintain stable numbers and to increase the probability of successful pollination and fruit set.

These quantitative goals are extremely conservative, reflecting the magnitude of the challenge we face in recovery efforts given the very small populations (at most three known) that we have to start with in the region. A collection of twenty viable populations represents less than thirty percent of the original number of populations present in the 1800's that are recorded in New England herbaria. However, an ultimate minimum goal of twenty populations is necessary to promote outcrossing among demes by and to bet-hedge against local extinction events. We focus initially on Connecticut and Massachusetts because the only known extant New England populations occur in these states. One measure of success in species recovery in the long run will be the natural establishment of populations throughout the historic range encompassing Rhode Island and New Hampshire. Likewise, there is no reliable "formula" for deriving a theoretical minimum viable population size of 30 to 50 plants (MVP *sensu* Shaffer 1987). Rather, most conservation biologists have had to derive empirical estimates for MVP based upon long-term demographic modeling and evaluation of Allee effects (e.g., Damman and Cain 1998, Hackney and McGraw 2001). We base this initial goal on the observation that *A. purpurascens* populations of this magnitude at other North American sites apparently can remain stable for many years (Wilbur 1976).

Currently, there are less than thirty plants known to exist in the entire region. If we wish to sustain *Asclepias purpurascens* as a viable component of the flora of New England, we must at a minimum, increase these numbers to over 300 individuals (and preferably more) over the next two decades. However, it is important to recognize that the species as a whole may be inherently "sparse" (sensu Rabinowitz 1981, Kunin and Gaston 1993), and may never be "common" on the landscape. Recommendations for both minimum population size and numbers of populations will have to be adjusted iteratively as we gain a better understanding of the ecology and genetics of *Asclepias purpurascens*, particularly through monitoring data that indicate that populations are stable or expanding through adequate seedling recruitment.

The existing tiny populations are showing unambiguous signs of reproductive failure, with extremely low rates of fruit set. Each of these widely-separated populations are also likely to be genetically homogeneous, with low levels of heterozygosity and S-allele diversity (Brussard and Gilpin 1989, Barrett and Kohn 1991, DeMauro 1993, Byers 1995). At the same time, these populations may be quite genetically distinct from each other (and from other populations in North America) due to founder effects, genetic drift, and increasing reproductive isolation -- a phenomenon noted for other plant populations undergoing severe evolutionary bottlenecks (e.g., Nei 1975, Schaal and Smith 1980, Watterson 1984, Polans and Allard 1989). While maintaining genetic diversity across populations is important, it will be paramount to expand the numbers and genetic diversity of viable individuals within populations to alleviate depressed reproduction brought on by erosion of S-allele diversity and inbreeding depression associated with high fruit abortion. Like other rare plants undergoing severe evolutionary bottlenecks, *A. purpurascens* may be under strong selection to evolve self-compatibility (Barrett et al. 1989, Reinhartz and Les 1994). Genetic polymorphism allowing for the dissolution of self-incompatibility may only be regained by promoting gene exchange among these small populations.

During the 19th and early 20th century, *Asclepias purpurascens* was much more common in New England than it is today. The reasons for its precipitous decline from over eighty historic populations to only five remains a mystery, as a great deal of suitable habitat still exists. Certainly, the plants' traditional habitat of open fields, undisturbed rural roadsides and woodland 'edges' has been substantially altered as roads are paved and widened, power and phone lines are installed, and farms and clearings have succeeded to closed-canopy forest. Frequent mowing and the liberal use of herbicides along roadsides may have eliminated many former locations of this taxon. Additionally, the twin threats of succession and fire suppression may have eliminated suitable habitat. The species may also, unlike the closely related *A. syriaca*, lack strong competitive abilities against invasive species, such as *Celastrus orbiculatus*, that are proliferating along roadsides and edges. As populations shrink and become increasingly isolated due to these factors, they become extremely vulnerable to extinction because of the many limitations to reproduction that are intrinsic to the species (inefficient vectors, accidental interspecific and self-pollination, selective fruit abortion, and low capacity for sequestering and allocating nutrients for reproduction).

Asclepias purpurascens is relatively rare and sparsely distributed throughout its range, and is in imminent danger of extirpation from New England. Its prognosis is extremely pessimistic here unless substantial conservation action is taken. The feasibility and costs of such action must be weighed against the urgency of decline and the probability of success (Holsinger 1992). The need is great and the prospect of success good. Its tenuous hold on its New England range, together with its range-wide decline, are the primary reasons that potentially labor-intensive conservation efforts should be directed at this taxon, if we do not want to witness its demise in North America. Widespread availability of potential habitat raises the probability that *A. purpurascens* will persist if such efforts are successful, an important criterion for setting conservation priorities (Holsinger 1992). Furthermore, actions taken in this region to better understand its biology and to protect and foster growth of its populations can inform range-wide efforts as well as programs to conserve other "sparse" taxa with similar forms and magnitudes of rarity (Rabinowitz 1981).

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IV. APPENDICES

1. Habitats of *Asclepias purpurascens* throughout its North American range.

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

1. Habitats of *Asclepias purpurascens* throughout its North American range.

State	Habitat	Citation
Arkansas	Rocky ground, roadsides, and open areas	Hunter 1984
Delaware	Dry woods and fields	Phillips 1978
Illinois	Open woods, sandy soil	Jones 1971
Illinois	"woodland borders, wet meadows in valleys, upland dry ridgetops, thickets undergoing fairly rapid ecological succession"	Illinois Plant Information Network 2001
Indiana	"Infequent throughout state...plants found in ones and twos." Rather dry, sandy soil in open woodland and along roadsides. Also damp, open woodland near swamps and lakes and even tamarack bogs.	Deam 1984
Kansas	Regarded as among "the best indicators of former savannas and open woodlands because they tend to be limited to partial canopy conditions"	Pruka 1997
Kansas	"Rocky open woods and thickets in east seventh and Wallace County"	Stevens 1961: 180
Kentucky	Woodland borders and thickets	Wharton and Barbour 1971
Kentucky	In "Taylor's fern ravine," Campbell County	Braun 1934
Maryland	Dry to moist fields or open woods throughout Maryland. "Frequent in Piedmont and northern coastal plain, infrequent elsewhere"	Brown and Brown 1984: 752
Massachusetts	A group of 11 plants in full flower found on July 10, 1912, growing "about midway on the face of a bluff or high bank on the west side of pond...also clothed with the common milkweed also in bloom"	Bicknell 1915: 36
Michigan	In dry, "baked" soils (influenced by fire) associated with *Pinus banksiana, Quercus rubra, Q. alba,* and species of *Viburnum, Cornus, Amelanchier, Crataegus,* and *Prunus*	Harvey 1922
Michigan	"Rare and local" distribution in *Quercus-Carya* woodlands. at ecotone of moist wood and southwest swamp	Wilbur 1976
Michigan	Prairie near Saginaw bay shore on sandbars and spits	Davis 1898
Michigan	"dry soils in prairies, including lakeplain prairies, and within open woodlands (especially oak and oak-pine), shrub thickets, and on shores."	Choberka et al. 2000
Michigan	"Rare" along roadsides near Temperance	Farwell 1928

1. Habitats of *Asclepias purpurascens* throughout its North American range.

State	**Habitat**	**Citation**
Missouri	"Isolated individuals" in oak deciduous forests dominated by *Quercus coccinea tinctoria, Q. imbricaria, Q. Muhlenbergii, Carya alba,* and *Carya tomentosa* with 8-10% light penetration beneath tree canopy; also dry bottom along railroad tracks	Hus 1908
Missouri	"Rocky open woods, meadows, along roads and ditches statewide except southeast lowlands"	Denison 1978: 197
New Jersey	"Frequent in dry ground of the northern counties and rare southward"	Stone 1973: 648
New Jersey	Limestone region of Warren County, near swamp with limestone outcrops, with rich grasses, sedges, orchids and other herbaceous species; observed in mid-June 1961	Fables 1961
New York	Virgin and old-growth forest in southern Adirondack Mountains	Mitchell and Tucker 1994
New York	Knob-and-kettle topography on mesic stony loam, with *Quercus borealis* var. *maxima, Q. velutina, Cornus florida, Acer rubrum, Liriodendron tulipifera, Betula lenta* on Long Island	Greller 1977
New York	With *Asclepias syriaca*, on moderate to steep slopes at 450-550 meters elevation (Helderberg Plateau region)	Russell 1958
Oklahoma	"Dry fields and meadows or open woods in a few eastern counties"	McCoy 1987: 73
Ontario	"Uncommon. Wet prairies and savannas"	Pratt 1999
Texas	"Infrequent" along ravine in woods and along fences and old field in Texarkana	Correll 1966
Virginia	Roadside opening	Wyatt and Hunt 1991
Wisconsin	Prairie remnants with fire influence	Curtis 1959
Wisconsin	"Open oak woods edges and roadsides over a range of soil moisture conditions" in oak woodland, oak opening, and wet-mesic prairie	Wisconsin Division of Natural Resources 2001

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.