New England Plant Conservation Program

Aplectrum hyemale (Muhl. *ex* Willd.) Nutt.
Puttyroot

Conservation and Research Plan
for New England

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SUMMARY

Commonly known as Puttyroot or Adam and Eve, *Aplectrum hyemale* (Muhl. *ex* Willd.) Nutt. (Orchidaceae) is a perennial terrestrial orchid occurring in eastern deciduous forests. In New England, it prefers rich mesic woods and is often associated with sugar maple (*Acer saccharum*) and beech (*Fagus grandifolia*). New England occurrences are generally located near small (intermittent or tributary) streams or pools in soils that are imperfectly drained, but not saturated. A single, plaited, blue-green leaf emerges in the early fall from a pair of corms. After overwintering (often under snow), the leaf withers in the spring and a single stalk with 8-15 pale green or yellow flowers may emerge. The common name of Puttyroot is due to the mucilaginous substrate found in its corms, which was historically used to mend crockery. Each individual *A. hyemale* has two corms attached by a small rhizome, which contributed to its other common name of Adam and Eve. These corms were worn as amulets in the southern United States and, when dropped in water, were used to tell fortunes.

Aplectrum hyemale (Muhl. *ex* Willd.) Nutt. is listed as a Division 2 (Regionally Rare) taxon in The New England Plant Conservation Program's *Flora Conservanda:* New England. Although considered globally secure (G5), this species is rare throughout much of its range from southern Canada (Quebec and Ontario), to Georgia, and west to Oklahoma and Minnesota, with only Virginia and North Carolina listing the species as secure. In New England, the species is known from five current occurrences (one in Vermont, four in Massachusetts) with populations generally consisting of only a few individuals. *Aplectrum hyemale* is presumed extirpated from at least one state, Connecticut, and is listed as critically imperiled (S1) in Vermont, Massachusetts, New York, New Jersey, Mississippi, and Oklahoma.

Loss of habitat and inadvertent destruction are the major threats to *A. hyemale* in New England. This species is difficult to find due to its life history, inconspicuous flowers, and its generally small populations. Genetic variability in the species is likely to be low, not only among the New England populations, but throughout its entire range. Little is known about the biology and habitat requirements of *A. hyemale*, specifically its mycorrhizal associations, pollinators, and means of reproduction, as well as its preferences for light, soil chemistry, and soil moisture content.

To maintain the species in New England, all five current populations need to be monitored and protected. Habitat management and/or possibly augmentation at some of these sites may be critical to increasing the population sizes, but studies on the effects of canopy thinning and other activities should be done on larger and more secure populations prior to treating populations with less than ten individuals. Therefore, research into habitat preferences and the species' biology may necessarily have to be conducted outside of New England in states with large, secure populations. Also, by identifying potential habitat and carefully searching these areas, additional populations (new or historical) may be located in New England.

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Full plans with complete and sensitive information are made available to conservation organizations, government agencies, and individuals with responsibility for rare plant conservation. This excerpt contains general information on the species biology, ecology, and distribution of rare plant species in New England.

The New England Plant Conservation Program (NEPCoP) of the New England Wild Flower Society is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

In 1996, NEPCoP published "*Flora Conservanda*: New England." which listed the plants in need of conservation in the region. NEPCoP regional plant Conservation Plans recommend actions that should lead to the conservation of *Flora Conservanda* species. These recommendations derive from a voluntary collaboration of planning partners, and their implementation is contingent on the commitment of federal, state, local, and private conservation organizations.

NEPCoP Conservation Plans do not necessarily represent the official position or approval of all state task forces or NEPCoP member organizations; they do, however, represent a consensus of NEPCoP's Regional Advisory Council. NEPCoP Conservation Plans are subject to modification as dictated by new findings, changes in species status, and the accomplishment of conservation actions.

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

Aplectrum hyemale (Muhl. *ex* Willd.) Nutt. (Orchidaceae), Puttyroot or Adam and Eve, is a perennial terrestrial orchid occurring in eastern deciduous forests. It is found throughout the eastern United States and southeastern Canada from Quebec to Georgia, west to Oklahoma, Minnesota, and Ontario. Although secure globally, this species is rare throughout the majority of its range and is considered a Division 2 taxon (Regionally Rare) in The New England Plant Conservation Program's *Flora Conservanda:* New England (Brumback and Mehrhoff et al. 1996). Massachusetts lists it as a state-Endangered species; while Vermont lists it as Threatened (these are the only New England states with extant populations). Populations of *A. hyemale* are commonly only a few individuals, though in some parts of its range populations are much larger. *Aplectrum* is a monotypic genus and is closely related to *Corallorhiza.* The two are differentiated by underground structure (corm in *Aplectrum*, coralloid root in *Corallorhiza*) and by leaves (*Aplectrum* has a single green leaf, while *Corallorhiza* has none or a few reduced, achlorophyllous leaves).

The common name of Puttyroot is due to the mucilaginous substrate found in its corms, which was historically used to mend crockery (Baldwin 1894, Koopowitz 2001). Each individual *A. hyemale* has two corms attached by a small rhizome, which contributed to its other common name of Adam and Eve. These corms were worn as amulets in the southern United States and, when dropped in water, were used to tell fortunes (Baldwin 1894, Gibson 1905). The generic name, *Aplectrum,* is derived from the Greek term meaning "spurless," distinguishing it from orchids with spurred flowers such as *Tipularia*. The specific, *hyemale*, is the Latin for "winter" in reference to the overwintering habit of its single leaf.

Puttyroot prefers rich mesic woods in New England and is often associated with sugar maple (*Acer saccharum*) and beech (*Fagus grandifolia*) (Case 1964). It often occurs in moist, but not saturated soils near small streams or pools. Loss of habitat and inadvertent destruction are the major threats to *Aplectrum hyemale* in New England. This species is easily overlooked due to its life history (a single basal leaf that emerges in the fall and overwinters before withering in the spring), infrequent and inconspicuous flowers (on a slender scape that emerges in the spring after the leaf withers), and generally small populations. Therefore, populations in some areas may not yet be identified.

The purpose of this plan is to summarize what is known about *Aplectrum hyemale* in New England including its phenology, reproductive biology, and ecological interactions as well as its conservation status and current and predicted threats to its long term survival. The plan then outlines actions necessary to preserve the species in its native habitat as well as a vision for its abundance and extent within New England for the next several decades. To secure the existence of *Aplectrum hyemale* in New England for

the next twenty years, it is imperative to increase the sizes and numbers of existing populations, and to ensure that viable occurrences remain (or are relocated) in Vermont, Massachusetts, and Connecticut.

DESCRIPTION

The description below was compiled from Fernald (1950), Gleason (1952), Radford et al. (1968), Gleason and Cronquist (1991), Magee and Ahles (1999), and Voss (1972). Individuals of *Aplectrum hyemale* grow from stout corms (often 2.5 cm in diameter), usually two, though occasionally three, attached by a short (3 cm) rhizome. Each corm lasts two years, with a new one produced each year. A solitary, basal leaf grows from the oldest corm in late summer and lasts throughout the winter. The single basal leaf blade is petiolled, elliptic, 10-20 cm long, and dark green or bluish green with whitish or silvery veins. The leaf has a plaited or corrugated appearance, even after it shrivels in the early spring before the scape (flowering stalk) appears.

An achlorophyllous, bracteate scape may be produced by the older corm the spring following the growth of the single basal leaf, after the leaf has withered. The 30-60 cm scape has a few linear-oblong, sheathing, nongreen bracts. The 7-15 pedicelled flowers (each about 1 cm long) are in a loose terminal raceme. The flowers are greenish, yellowish, or whitish marked with purple. Sepals are 10-15 mm long, purplish toward the base, and brown toward the summit. The petals are similarly colored, shorter, and arch over the column. The lip is white or nearly so, sparingly marked with magenta, broadly obovate, with 3 low parallel ridges near the center, its lateral lobes upcurved. The column is slender, 7 mm long, flattened, and bears a terminal anther with 4 pollinia. There is one minor variant, var. *pallidum*, described by House in 1903 from specimens collected in Onondaga County, New York that varies in flower color only. Capsules are ellipsoid and pendant, 15-30 mm long.

This monotypic genus is closely related to *Corallorhiza*, but can be differentiated from that genus by having a corm instead of a coralloid root. Case (1964) reports that *Aplectrum hyemale* can produce a coralloid rather than cormose root when growing in a rotten log pile, suggesting a tendency of *A. hyemale* toward a saprophytic habit similar to the coralroots. This coralloid root may be only a temporary form though that precedes the more typical cormose root (Correll 1950). In addition, unlike *Corallorhiza* species, *A. hyemale* has a green leaf (although it is often withered and gone by flowering time). Outside of New England, *A. hyemale* may be confused with the cranefly orchid *Tipularia discolor*, which has a similar habit but can be distinguished from *Aplectrum* by not having the corrugated leaf with raised whitish veins and by having a spurred flower. Although *T. discolor* occurs in Massachusetts, its range within the state does not overlap that of *A. hyemale*.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Aplectrum is a monotypic genus, although an extremely similar species (*Oreorchis patens* Lindley, included within *Aplectrum* in some treatments) is found in Japan (Hapeman 1996). Dressler (1981) lists *Aplectrum* as one of three orchid genera (along with *Pogonia* and *Tipularia*) that have disjunct transoceanic distributions in Asia and North America. He suggests that these three genera represent long-distance dispersal during the mid-Tertiary geologic period.

Within the Orchidaceae, there are several divisions known as subfamilies, tribes, and subtribes. Dressler (1981) places *Aplectrum* in subtribe Corallorhizinae along with *Corallorhiza*, *Cremastra*, *Dactylostalix*, *Didiciea*, *Ephippianthus*, *Govenia*, *Oreorchis*, and *Tipularia*. Sheviak and Catling (2002) in *The Flora of North America* list *Aplectrum* in subfamily Epidendroideae, tribe Cymbidieae, subtribe Corallorhizinae. Previous synonyms for *Aplectrum hyemale* (Muhl. ex Willd) Nutt. 1818 included in Luer (1975) are:

- *Cymbidium hyemale* Muhl. ex. Willd. 1805
- *Corallorhiza hiemalis* (Muhl. ex Willd.) Nutt. 1818
- *Aplectra elatior* Rafinesque 1824
- *Aplectrum spicatum* Britton Sterns & Poggenberg 1888
- *Aplectrum shortii* Rydberg in Britton 1901.

In addition, the synonyms *Aplectrum hyemale* (Muhl.) Torr. 1826 (Fernald 1950, Gleason 1952, Voss 1972, Gleason and Cronquist 1991) and *Aplectrum hyemale* (Muhl. ex Willd.) Torr. 1826 (Kartez 1994, Magee and Ahles 1999) have been used. One variety has also been described which is known as *Aplectrum hyemale* (Muhl. ex Willd.) Torrey var. *pallidum* (House) Barnhart 1904 (previously listed as *Aplectrum spicatum* Britton Sterns and Poggenberg, var. *pallidum* House 1903). The type locality for *A. hyemale* is Pennsylvania (Jones and Fuller 1955, Luer 1975).

SPECIES BIOLOGY

Aplectrum hyemale has an interesting life history, one which makes it difficult to find in the wild. Although it flowers in May or early June (there is a three-week difference between northern and southern populations [Auclair 1972]), it has no leaves at that time (although the previous year's withered leaf may be identifiable). Mature plants grow a solitary leaf in the late summer or early fall, well after the time of flowering. The leaf then overwinters, often under snow, and will wither the next spring before flowering occurs. Along with *A. hyemale*, *Calypso bulbosa* and *Tipularia discolor* (both North American orchids) similarly have single deciduous winter leaves. Like many orchid species, an individual *A. hyemale* will not flower every year. In fact, flowering is often described as sparse and only occurs under favorable conditions (Baldwin 1894, Case 1964, Sheviak 1974), perhaps one flower stalk among a dozen or more individuals (Correll 1950, Buker 1954, Luer 1975). Why some individuals flower and others do not is unknown, although Hogan (1983) suggests that an individual may need to reach a

minimum size before flowering. He found that the product of leaf width by leaf length is much greater in flowering than in non-flowering plants of *A. hyemale*. Auclair (1972) reports that 18-20 weeks are needed to complete development of the flower, from floral bud to mature fruit. Prior to flowering, the corms enlarge greatly (Stevens and Dill 1942), perhaps indicating an increase of carbohydrates and possible storage of water which may be necessary to produce flowers. Although a flower may not be produced each year, a new corm is produced (Orchid Society of Royal Botanical Gardens 2003). In addition to not flowering every year, individuals of some orchid species may not produce above-ground stems or leaves every year (thus remaining dormant in the soil for one or more years). This pattern of dormancy has not been described explicitly for *A. hyemale*, although it has been found in other New England orchid species.

The life-cycle of *Aplectrum hyemale* is closely synchronized with the seasonal periodicity of the deciduous forest canopy (Auclair 1972). Its overwintering leaf takes advantage of higher light levels available before trees leaf out to generate food stores for flowering and fruiting. In addition to providing stores for flowering, the large corms serve to retain photosynthates as starch during the summer when it is dormant. These reserves remain, despite relatively warm above-ground temperatures (Auclair 1972), and support shoot (leaf) and root development in the fall. In addition, starch stored in the corms is converted to sugars in the fall that are retained during the winter, conferring considerable frost-hardiness (Auclair 1972). The overwintering leaf permits photosynthesis during favorable temperatures in the fall, winter, and spring, especially in the more southern parts of its range where snow cover is minimal. Adams (1970) observed that even at 2° C, *A. hyemale* was able to photosynthesize at 15% of its absolute maximum rate. This capacity to photosynthesize and grow during the period of tree dormancy not only allows *A. hyemale* to take advantage of high light intensity, but also abundant soil moisture and high nutrient levels (made available by litter decomposition in the fall and spring) (Auclair 1972).

Adams (1970) studied the effect of temperature on photosynthesis in *Aplectrum hyemale* and the effect of preconditioning to a certain temperature range. He found that maximum net photosynthesis of plants that overwintered under snow occurred at a low temperature (15°C). Rates for plants maintained at warm temperatures over the winter (in a greenhouse or lab) were highest at warm temperatures (20-25°C). Plants from under the snow that were maintained in a cold environment (once collected) were more efficient at low temperatures (based on the amount of carbon fixed and on the percent of the maximum photosynthetic rate attained) than plants that were preconditioned to warm temperatures. Therefore, *A. hyemale* appears to be adapted for maximum productivity under cool conditions. The rapid activation of photosynthesis at temperatures as low as 5°C and at moderate light intensity provides evidence that populations of this species are capable of relatively high photosynthetic rates following the melting of snow in the spring, even before air temperatures have increased much above 5-10°C. Photosynthesis is decreased below 2°C; thus, it is unlikely that positive net photosynthesis is appreciable under the snow cover during winter. Therefore, most of the net positive photosynthesis occurs in early spring from the time that the snow melts until the canopy closes.

In addition to taking advantage of more light in the understory, early spring ephemerals also may take advantage of an excess of pollinators while competition for them is minimal. Although *Aplectrum hyemale* flowers early in the growing season, it is later than some spring ephemerals and therefore may lose potential pollinators to more attractive species. Perhaps its flowering phenology is limited by its need to accumulate carbohydrates immediately before flowering. In addition, Hogan (1983) found that most individuals of *A. hyemale* lacked nectar and therefore may not attract as many pollinators. Auclair (1972) reports that the successive anthesis of flowers on the scape may serve to lengthen the total flowering period, thereby assuring pollination in solitary individuals, but it appears that pollen transfer between plants of *A. hyemale* is an infrequent occurrence. Research on specific pollinators (or types of pollinators) of *A. hyemale* is lacking. Hogan (1983) suggests that *A. hyemale* is regularly autogamous (self-fertilizing) and perhaps agamospermous (producing seed without fertilization). An autogamous habit may nearly always result in high seed set without the problems associated with pollination (Hogan 1983). If this species is truly autogamous, then there is likely to be little genetic variability in the species (Hogan 1983).

Most orchids rely on mycorrhizal associates (Koopowitz 2001). MacDougal and Dufrenoy (1944) looked into mycorrhizal associations with *Aplectrum hyemale*. They found that from the base of each corm, 12-20 thick roots emerge and bear a crop of large root-hairs. When looking at several *A. hyemale* individuals, they found the outer walls of the root epidermis and the root-hairs contained dense clumps of fungal hyphae. MacDougal and Dufrenoy (1944) believed that they observed at least two species of fungi, one of which was identified as *Rhizoctonia neottiae* Wolff. Auclair (1972) suggests that *A. hyemale* does not have specific mycorrhizal associates, but rather can associate with a variety of species depending on microhabitat. Researchers at the Smithsonian Environmental Research Center have isolated a mycorrhizal fungus from *A. hyemale*, but have not been able to grow it in the lab for further germination experiments (Dennis Whigham, Smithsonian Environmental Research Center, personal communication). Rasmussen (1995) notes that some fungi that occur on the roots of oaks and maples have also been found on the roots of *A. hyemale* plants growing close to those trees.

Several individuals appear to have good success growing *Aplectrum hyemale* in gardens. Several commercial orchid growers may sell this species for gardens, such as Paul Christian in Britain (Christian 2003), Munchkin Nursery in Indiana (Bush 2000), and Sunshine Farm and Gardens in West Virginia (Glick 2003). Propagation techniques include division of the two connected corms to form two individuals and from the great amount of seeds shed (Christian 2003, GardenBed 2003, Glick 2003). Cold stratification may be important to breaking the dormancy of *A. hyemale* seeds (Rasmussen 1995). Wherry (in Correll 1950) and McAdoo (Consulting Botanist, personal communication) report that *A. hyemale* can be easily transplanted into suitable habitat. Current research on germination and development of seedlings is being done at the Smithsonian Environmental Research Center, although there has been little success to date with growing this species from seed (Whigham, personal communication).

HABITAT/ECOLOGY

Throughout its range, *Aplectrum hyemale* is found in rich, mostly mesic, deciduous woodlands and the lower slopes of moist ravines. Sugar maple and beech are common associates (Bingham 1939, Case 1964). It is occasionally found in drier upland areas, but there are often small pools or other imperfectly drained soils nearby (Morris and Eames 1929, Sheviak 1974, Gupton and Swope 1986). Although it seems to have a preference for drier areas than wet swamps, there are some references to it occurring in swampy woods of low ground and the mucky wet soil of wooded floodplains, peat bogs and tamarack swamps (Correll 1950, Voss 1972, Godfrey and Wooten 1979). It is most commonly found on alluvial terraces along small streams; this is where most of the extant populations in Massachusetts are found. It avoids extensive bottomland forests and floodplains of larger rivers, suggesting that it does not withstand severe flooding. Sorrie (1987) mentions that the habitat is often rocky. Case (1964: 102) describes the desired habitat as "a pocket of deep humus on the edge of a 'cradle hole' thrown up by the uprooting of some ancient tree, or the edge of the crumbling remains of an old log pile."

Aplectrum hyemale occurs across the distribution of grey-brown podzolic, humus-containing, soils in eastern North America (Auclair 1972). It appears to have no specific geologic or mineral requirement, although neutral soils are preferred. It is tolerant of slight acidity, but flowering occurs only with favorable, more neutral conditions. In general, the species seems to prefer humus-rich mesic woodland loam on well-drained sites. In germination experiments with a variety of media Oliva and Arditti (1984) had difficulty germinating seeds of *A. hyemale*, but generally had better success on media containing urea, which suggests that it may require or at least benefit from nitrogen in this form.

Auclair (1972) discusses temperature as a possible factor influencing where *Aplectrum hyemale* occurs. He looked at the occurrence of frost and found that the length of the growing season (> 5 months) coincides with the distribution of the species, whereas precipitation is not significantly correlated. He mentions that the occurrence of frost is also indicative of other temperature-related processes such as duration of snow, phenology of tree canopy and understory vegetation, and net photosynthetic rates. Regional topography is also an important factor, as it influences average local temperatures. The species seems to be excluded from the high mountains of the northeast (too cold) and the southern coastal plain and Mississippi River valley (too hot), but has been found in a range of elevations from near sea-level in the mid-Atlantic states, up to 4,000 feet in the Smoky Mountains (Correll 1950).

Aplectrum hyemale is found throughout the range of the eastern deciduous forest. The most common species associated with this taxon are shade-tolerant deciduous trees. Forest types (from Braun's 1950 classification) include mixed and western mesophytic forests, oak-hickory, oak-chestnut, beech-maple and maple-basswood. It has been found in some areas of coniferous or mixed deciduous-coniferous woods in parts of its range

(including New England). *Acer saccharum* is one of the most frequently listed associates, along with *Fagus grandifolia*. Other associates appear in Table 1.

Throughout its range, *Aplectrum hyemale* generally occurs in scattered, small populations (usually colonies of 5-20 plants) although it may be locally common in some areas. In the more northern or mountainous counties in Georgia, it is considered locally frequent in mostly undisturbed, rich, cove-hardwoods (Tom Patrick, Georgia Natural Heritage Program, personal communication). In the Piedmont and Blue Ridge of North Carolina and Virginia, *A. hyemale* is one of the three most common orchids, although it is still seldom found in colonies of more than 20 individuals (Alan Weakley, University of North Carolina, personal communication). Porcher and Rayner (2001), describing this species in South Carolina, also report small colonies and that they occur in a variety of habitats in the mountains, including cove forests, moist oak-hickory forests, and the upper margins of floodplains. *Aplectrum hyemale* also occurs in Illinois, the Ozarks of Arkansas, and in Ontario and Quebec, Canada, again though never in great abundance (John Ebinger, Eastern Illinois University, personal communication; Theo Witsell, Arkansas Natural Heritage Commission, personal communication, Reddoch and Reddoch 1997). Unlike the previously mentioned states, it has been reported to occur as large colonies in the southeastern mountains of Kentucky (McAdoo, personal communication).

Table 1. Common associates of *Aplectrum hyemale*, from Sheviak (1974)

Trees	Shrubs	Herbs
Acer saccharum	*Asimina triloba*	*Arisaema triphyllum*
Carya tomentosa	*Carpinus caroliniana*	*Asarum canadense*
Fagus grandifolia	*Corylus americana*	*Dentaria laciniata*
Fraxinus americana	*Hydrangea arborescens*	*Dicentra cucullaria*
Juglans nigra	*Parthenocissus quinquefolia*	*Erythronium albidum*
Liriodendron tulipifera	*Ptelea trifoliata*	*Hydrophyllum canadense*
Magnolia acuminate		*Impatiens biflora*
Platanus occidentalis		*Laportea canadensis*
Quercus alba		*Panax quinquefolius*
Q. rubra		*Polystichum acrostichoides*
Tilia americana		*Smilacina racemosa*
Ulmus americana		*Solidago caesia*
U. rubra		*Trillium recurvatum*

Note: Not all species in table occur in New England.

THREATS TO TAXON

The majority of extant occurrences of *Aplectrum hyemale* in New England are not threatened by development or imminent destruction of the habitat, as at least three out of five known occurrences are on protected land. The taxon is more immediately threatened by a multitude of events that could negatively impact one or more individuals in extremely small populations. These populations could be irreparably damaged by any small stochastic event or by changes to their habitat (such as an increase in evergreen cover or a decrease in moisture) due to climate change, acid rain, or invasive species.

Case (1964) reports that individual *A. hyemale* plants are often damaged by slugs and snails. Deer and small mammal browse have also been suggested as threatening some individual populations (McAdoo, personal communication; Steve Young, New York Natural Heritage Program, personal communication), although this has not been recorded for any of the New England occurrences. Human activities, including off-road vehicle use, timber harvesting, and even hiking, may also negatively impact individuals or entire populations of this species. *Aplectrum hyemale* apparently responds negatively to disturbance and disturbed sites (Auclair 1972, Sheviak 1974). Disturbance often results in more open, xeric conditions suitable for aggressive, pioneer and weedy species that could easily out-compete *A. hyemale* for water and light. White et al. (1982) suggest that its decline in Ontario is partially due to the decreasing area of deciduous woodland habitat in that province. Auclair (1972) further explains the decrease in abundance of this species as being "largely the result of disturbance of virgin forest by man," a sentiment suggested by Morris and Eames (1929) forty years earlier. This raises the question of whether *A. hyemale* is a relict species dependent upon the undisturbed forest that has been in decline since European settlement changed the stature and composition of our forests.

In New England, specimens of *A. hyemale* were collected during the end of the 19th century and the beginning of the 20th century. Most herbarium records from Vermont, Massachusetts, and Connecticut are dated from 1880-1910. Even in Wisconsin, herbarium records are mainly from the late 1800's through the first half of the 20th century, with several records in the 1980's (Wisconsin State Herbarium 2003). Unfortunately, these records do not include estimates of population sizes, so we do not know if population sizes were larger in the past than they are today. Many written records suggest that population sizes have always been small (usually less than 20, often only a handful of individuals), although in some instances *Aplectrum hyemale* was described as "occasionally carpeting portions of the forest floor" (Sheviak 1974). With population sizes very small, botanical collecting may also pose an additional threat.

DISTRIBUTION AND STATUS

General Status

Aplectrum hyemale occurs throughout the eastern deciduous forest from southern Canada (Ontario and Quebec) through the Appalachian Mountains to Georgia, west to Oklahoma, Iowa, and Minnesota. Although one occurrence is listed from Arizona, Auclair (1972) believes that this population, although possible due to other eastern disjuncts in the Santa Rita Mountains, is probably a misidentification. Coleman (2002) agrees, explicitly stating that *Aplectrum* does not occur in the wild in Arizona. It has been falsely reported from several other localities, such as Florida and Nebraska, and there are many unconfirmed reports from other states within its broad range (such as by Stevens and Dill [1942] for Kansas). Auclair (1972) lists three general subdivisions for its range: 1) the Great Lakes-St. Lawrence River region, 2) the Midwest United States including the Missouri, Mississippi, and Ohio River basins, and 3) a central distribution

including the southern Appalachians, the Piedmont of North Carolina and Virginia, and the northeastern U. S. except Maine. In the northeastern portion of the latter distribution including New England, New York, Pennsylvania, New Jersey, and Delaware, it is state-listed (Endangered, Threatened, or Special Concern), or unconfirmed (except in Maine and Rhode Island where it is unreported). It is considered a Division 2 taxon (regionally rare) in The New England Plant Conservation Program's *Flora Conservanda:* New England (Brumback and Mehrhoff et al. 1996). The only states that report secure populations are Virginia and North Carolina. Connecticut's populations are all historical, in spite of attempts to relocate this species in that state. *Aplectrum hyemale* has a globally secure rank (G5), although it is rare throughout most of the eastern United States (N?) and Canada (N2).

Table 2. Occurrence and status of *Aplectrum hyemale* in the United States and Canada based on information from Natural Heritage Programs.

OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Alabama (S2)	Arkansas (S3)	Arizona (SR)	Connecticut (SH, SC*): extirpated. 4 historic occurrences
Delaware (S2)	Georgia (S3)	Florida (SRF)	
Massachusetts (S1, E): 4 extant and 7 historic occurrences	Illinois (S3S4)	Kansas (SR)	
Mississippi (S1)	Indiana (S?)	Maryland (SR)	
New Jersey (S1)	Iowa (S3)	Minnesota (SR)	
New York (S1)	Kentucky (S?)	Missouri (SR)	
Oklahoma (S1)	Michigan (S?)	Nebraska (SRF)	
Vermont (S1, T): 1 extant and 6 historic occurrences	North Carolina (S4)	New Hampshire (SR): not known to occur (Cairns, NHNHB, personal communication)	
Ontario (S2)	Pennsylvania (S3)	Ohio (SR)	
Quebec (S1)	Virginia (S4S5)	South Carolina (SR)	
	West Virginia (S?)	Tennessee (SR)	
	Saskatchewan (S?)	Wisconsin (SR)	
		Manitoba (SRF)	

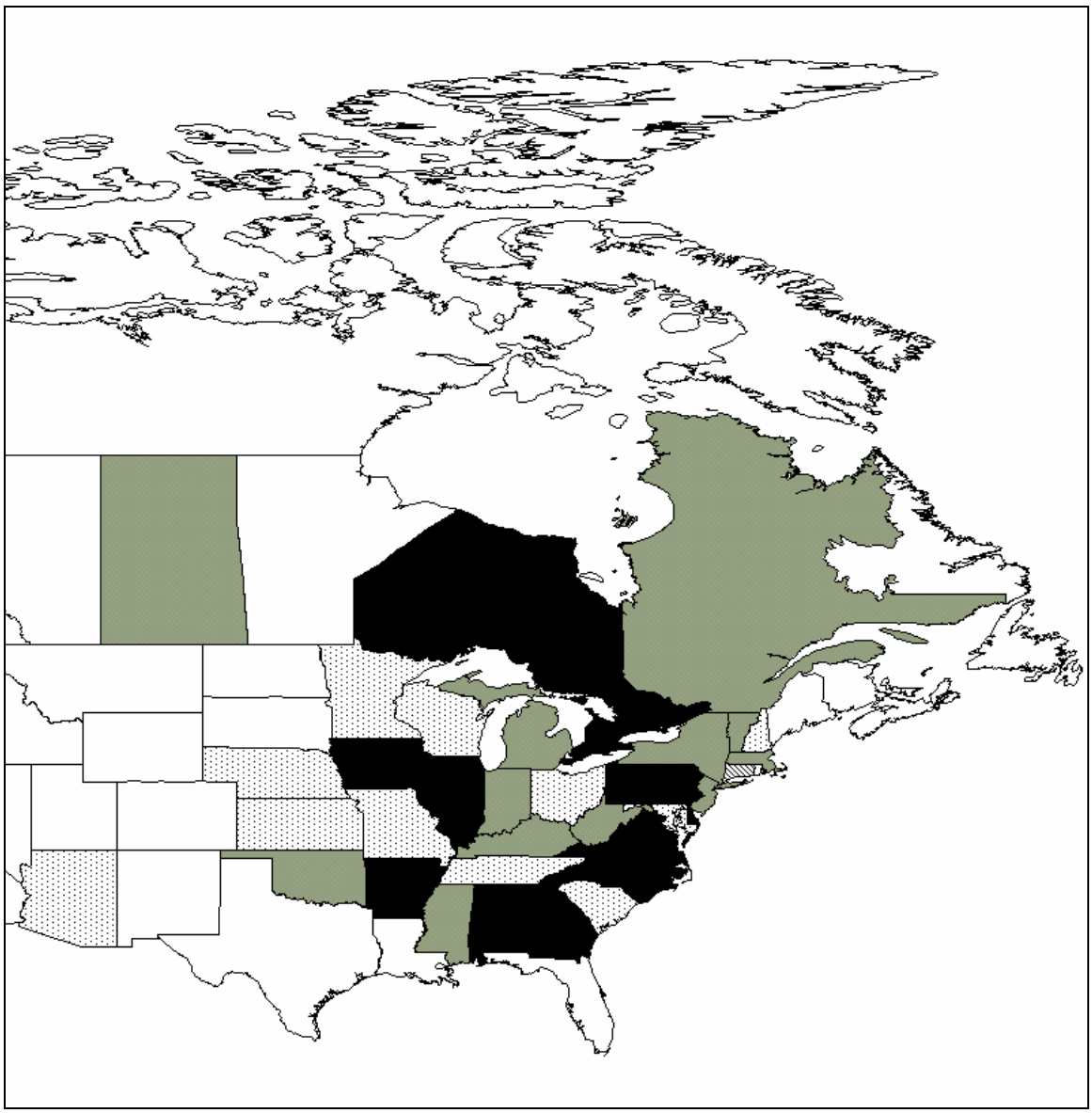

Figure 1. Occurrences of *Aplectrum hyemale* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. Areas shaded in black have more than five confirmed occurrences. The state (Connecticut) with diagonal hatching is designated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

Status of All New England Occurrences — Current and Historical

Only five populations of *Aplectrum hyemale* are known to be extant in New England: four in Massachusetts and one in Vermont (Figure 2, Figure 3, Table 3). Several herbarium specimens (all historic occurrences) from the University of Massachusetts – Amherst do not appear in the Natural Heritage lists of Element Occurrences for Massachusetts, Vermont, and Connecticut. These specimens, along with several additional specimens from other herbaria, are listed in Appendix 2. Additional specimens may be located at other regional and state herbaria, such as the collections of the New England Botanical Club. Although there is a reported occurrence for *Aplectrum hyemale* in New Hampshire (SR), this report has not been documented and the New Hampshire Natural Heritage Bureau does not consider this taxon to occur in that state (Cairns, New Hampshire Natural Heritage Bureau, personal communication).

Table 3. New England Occurrence Records for *Aplectrum hyemale.* Shaded occurrences are considered extant.

State	EO #	County	Town
VT	**.001**	**Addison**	**Addison**
VT	.002	Addison	New Haven
VT	.003	Addison	Middlebury
VT	.004	Addison	Middlebury
VT	.005	Chittenden	Charlotte
VT	.006	Chittenden	Charlotte
VT	.007	Rutland	Rutland
MA	.001	Hampshire	Amherst
MA	.002	Franklin	Charlemont
MA	.003	Hampshire	Amherst
MA	**.004**	**Franklin**	**Gill**
MA	.005	Hampshire	South Hadley
MA	**.006**	**Franklin**	**Gill**
MA	.007	Franklin	Buckland
MA	.008	Franklin	Conway
MA	.009	Hampshire	Granby
MA	**.011**	**Franklin**	**Sunderland**
MA	**.012**	**Hampshire**	**Granby**
CT	.001	Hartford	Farmington
CT	.002	New Haven	New Haven
CT	.003	Hartford	Windsor
CT	.004	Fairfield	Danbury

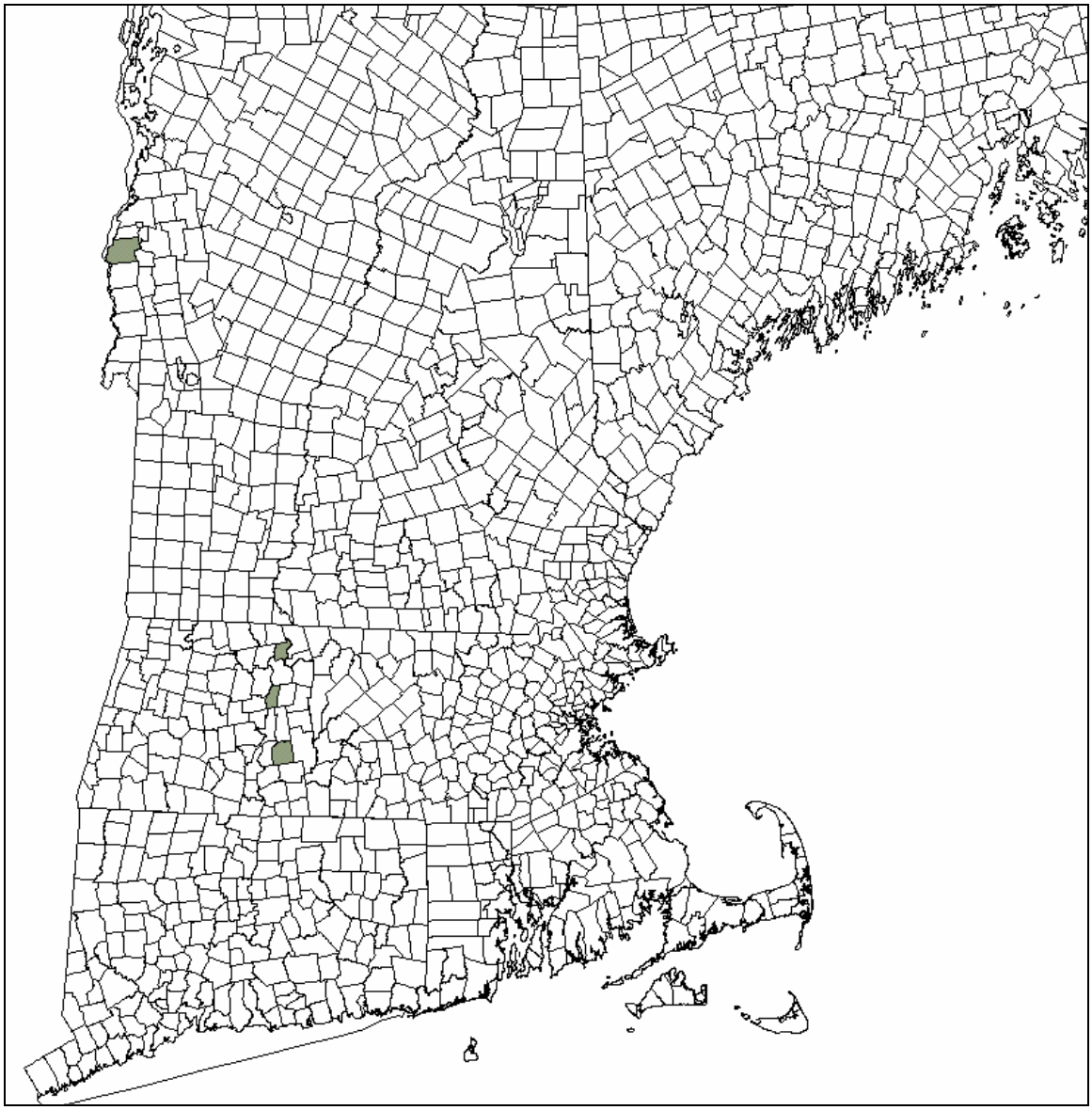

Figure 2. Extant occurrences of *Aplectrum hyemale* in New England. Town boundaries for New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

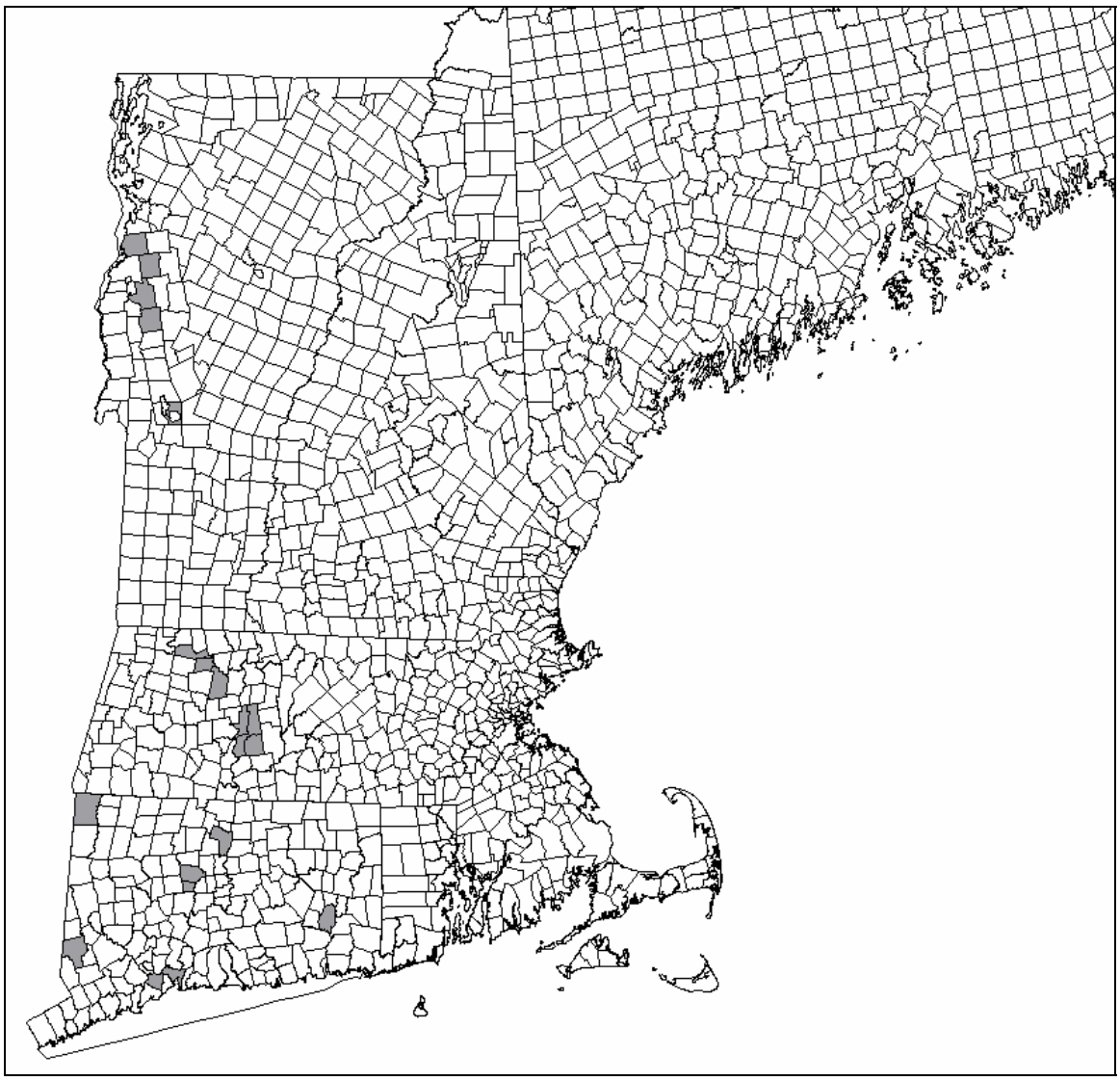

Figure 3. Historical occurrences of *Aplectrum hyemale* in New England. Towns shaded in gray have one to five historical records of the taxon.

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

To secure the existence of *Aplectrum hyemale* in New England for the next twenty years, it is imperative to increase the sizes and numbers of existing populations. Increasing the size of a population will help ensure its continued presence even if a random event (such as a fallen tree branch or small mammal activity) removes one or a few individuals from the population. There are only three occurrences of *A. hyemale* in New England that have been observed during the last 5 years (MA .006 [Gill], MA .011 [Sunderland], MA .012 [Granby]), and only one has flowered during that time (MA .012 [Granby]). To consider this taxon secure, the number of occurrences should be at least 10 (approximately ½ the number of current and historical occurrences) with each population consisting of more than 10 individuals. Throughout its range, populations of this size are common and, with at minimum of 10 individuals, it is hoped that at least one will flower in any given year. Populations should occur in Massachusetts and Vermont, although suitable habitat is likely present in Connecticut as well where it is considered extirpated. The species is reported from New Hampshire, although the report has not been confirmed (NatureServe 2002).

Gathering additional biological and ecological information to understand the apparent decline of *Aplectrum hyemale* in New England should be a top priority for achieving the objectives outlined above. This information will also provide an insight into the species' habitat requirements, which can advise efforts to locate or restore suitable habitat, and may identify additional potential threats. Further actions to achieve the objective of securing this taxon in New England include 1) monitoring existing populations to prevent further decline, 2) relocating historical populations, and 3) conducting *de novo* searches for new populations within suitable habitat. Unprotected lands hosting existing populations or suitable habitat need to be protected both through conservation ownership and by appropriate site management. Finally, increasing the sizes of existing populations may require augmentation or habitat management, the possibility of both requiring additional study prior to implementation.

III. LITERATURE CITED

Adams, M. S. 1970. Adaptations of *Aplectrum hyemale* to the environment: effects of preconditioning temperature on net photosynthesis. *Bulletin of the Torrey Botanical Club* 97: 219-224.

Auclair, A. N. 1972. Comparative ecology of the orchids *Aplectrum hyemale* and *Orchis spectabilis*. *Bulletin of the Torrey Botanical Club* 99: 1-10.

Baldwin, H. 1894. *The Orchids of New England: A Popular Monograph*. John Wiley and Sons, New York, New York, USA.

Bingham, M. T. 1939. *Orchids of Michigan*. Bulletin 15, Cranbrook Institute of Science, Bloomfield Hills, Michigan, USA.

Brumback W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. *Flora Conservanda*: New England. The New England Plant Conservation Program (NEPCoP) list of plants in need of conservation. *Rhodora* 98: 233-361.

Buker, W. E. 1954. Putty-root and lesser celandine in western Pennsylvania. *Rhodora* 56: 23-24.

Bush, G. 2000. Munchkin Nursery and Gardens: catalog. Available at www.munchkinnursery.com/catalog/ (accessed: November 15, 2003).

Case, F. W., Jr. 1964. *Orchids of the Western Great Lakes Region*. Bulletin 48, Cranbrook Institute of Science, Bloomfield Hills, Michigan, USA.

Christian, P. 2003. Rare Plants: *Aplectrum*. Available at http://www.rareplants.net/aplectrum (accessed: August 6, 2003).

Coleman, R.A. 2002. *The Wild Orchids of Arizona and New Mexico*. Cornell University Press, Ithaca, New York, USA.

Correll, D.A. 1950. *Native Orchids of North America North of Mexico*. Chronica Botanica Company, Waltham, Massachusetts, USA.

Dressler, R. L. 1981. *The Orchids: Natural History and Classification*. Harvard University Press, Cambridge, Massachusetts, USA.

Fernald, M. L. 1950. *Gray's Manual of Botany*. Eighth Edition. Dioscorides Press, Portland, Oregon, USA.

GardenBed. 2003. *Aplectrum hyemale* cultivation notes. Available at http://www.gardenbed.com/ (accessed: August 6, 2003).

Gibson, W. H. 1905. *Our Native Orchids: A Series of Drawings from Nature of All the Species Found in the Northeastern United States*. Doubleday, Page and Company, New York, New York, USA.

Gleason, H. A. 1952. *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada*. Hafner Press, New York, New York, USA.

Gleason, H. A. and A. Cronquist. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. Second Edition. The New York Botanical Garden, Bronx, New York, USA.

Glick, B. 2003. Sunshine Farm and Gardens: uncommonly rare and exceptional plants for the discriminating gardener and collector. Available at www.sunfarm.com (accessed: August 6, 2003).

Godfrey, R. K. and J. W. Wooten. 1979. *Aquatic and Wetland Plants of the Southeastern U.S.: Monocotyledons*. The University of Georgia Press. Athens, Georgia, USA.

Gupton, O. W. and F. C. Swope. 1986. *Wild Orchids of the Middle Atlantic States*. The University of Tennessee Press, Knoxville, Tennessee, USA.

Hapeman, J. 1996. Orchids of Wisconsin: an interactive flora. Available at http://www.botany.wisc.edu/Orchids/Orchids_of_Wisconsin.html (accessed: August 6, 2003).

Hogan, K. P. 1983. The pollination biology and breeding system of *Aplectrum hyemale* (Orchidaceae). *Canadian Journal of Botany* 61: 1906-1910

Jones, G. N. and G. D. Fuller. 1955. *Vascular Plants of Illinois*. University of Illinois Press, Urbana, Illinois and the Illinois State Museum, Springfield, Illinois, USA.

Kartesz, J. T. 1994. *A Synonymized Checklist of the Vascular Flora of the U.S., Canada, and Greenland*. Second Edition. Timber Press, Portland, Oregon, USA.

Koopowitz, H. 2001. *Orchids and Their Conservation*. Timber Press, Inc., Portland, Oregon, USA.

Luer, C. A. 1975. *The Native Orchids of the United States and Canada*. The New York Botanical Garden, Bronx, New York, USA.

MacDougal, D. T. and J. Dufrenoy. 1944. Mycorrhizal symbiosis in *Aplectrum*, *Corallorhiza* and *Pinus*. *Plant Physiology* 19: 440-465.

Magee, D. W. and H. E. Ahles. 1999. *Flora of the Northeast. A Manual of the Vascular Flora of New England and Adjacent New York.* University of Massachusetts Press, Amherst, Massachusetts, USA.

Morris, F. and E. A. Eames. 1929. *Our Wild Orchids: Trails and Portraits*. Charles Scribner's Sons, New York, New York, USA.

NatureServe Explorer: An online encyclopedia of life [web application]. 2002. Version 1.7. Arlington, Virginia, USA: NatureServe. Available at http://www.natureserve.org/ (accessed February 4, 2003).

Oliva, A. P. and J. Arditti. 1984. Seed germination of North American Orchids. II. Native California and related species of *Aplectrum, Cypripedium,* and *Spiranthes*. *Botanical Gazette* 145: 495-501.

Orchid Society of Royal Botanical Gardens. 2003. Native orchids of Canada. Available at http://www.osrbg.ca/orchid_native.html (accessed: August 6, 2003).

Porcher, R.D. and D.A. Rayner. 2001. *A Guide to the Wildflowers of South Carolina*. University of South Carolina Press, Columbia, South Carolina, USA.

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. *Manual of the Vascular Flora of the Carolinas*. University of North Carolina Press, Chapel Hill, North Carolina, USA.

Rasmussen, H.N. 1995. *Terrestrial Orchids from Seed to Mycotrophic Plant*. Cambridge University Press, New York, New York, USA.

Reddoch, J. M. and A. H. Reddoch. 1997. The orchids in the Ottawa District: floristics, phytogeography, population studies and historical review. *The Canadian Field-Naturalist* 111: 1-185.

Sheviak, C. J. 1974. An introduction to the ecology of the Illinois Orchidaceae. Illinois State Museum Scientific Papers 14. Illinois State Museum, Springfield, Illinois, USA.

Sheviak, C. J. and P. M. Catling. 2002. *Aplectrum*. Page 632 in Flora of North America Editorial Committee (Editors), *Flora of North America Volume 26: Magnoliophyta: Liliiadae: Liliales and Orchidales.* Oxford University Press, New York, New York, USA.

Sorrie, B. A. 1987. Notes on the rare flora of Massachusetts. *Rhodora* 89: 113-196.

Stevens, W.C. and F. E. Dill. 1942. *Aplectrum spicatum* in a Kansas woodland. *Transactions of the Kansas Academy of Science* 45:138-151.

Voss, E. G. 1972. *Michigan Flora*. *Part I: Gymnosperms and Monocots.* Cranbrook Institute of Science and University of Michigan Herbarium, Bloomfield Hills, Michigan, USA.

White, D. J., R. V. Maher, P. M. Catling, and R. E. Whiting. 1982. *Aplectrum hyemale* (Muhl. ex Willd.) Nutt. One page in G.W Argus and D.J. White (Editors) *Atlas of the Rare Vascular Plants of Ontario* Part 1. National Museum of Natural Sciences, Ottawa, Ontario, Canada. (Looseleaf).

Wisconsin State Herbarium. 2003. Wisconsin Herbaria Plant Specimen Database (WISCOMP). Available at http://www.botany.wisc.edu/wisflora/wiscompsearch.asp (accessed August 5, 2003).

IV. APPENDICES

1. **Voucher Specimens at the University of Massachusetts and Select Occurrences from Other Herbaria Not Included in State Occurrence Databases.**

2. **An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

1. Voucher Specimens at the University of Massachusetts and Select Occurrences from Other Herbaria Not Included in State Occurrence Databases.

Information gathered by J. A. Richburg 2003						
State	**Town/county**	**Collector**	**Date**	**Herbarium**	**Habitat/location**	**Comments**
MA	Conway	Hitchcock		UMASS		
MA	Amherst	F. R. Allen	6/2/1881	UMASS	At the Notch	Flower
MA	Amherst		May 1873	UMASS	"Garden of Eden", at the Notch	Flower & leaf
MA	Hadley/S. Hadley		6/4/1873	UMASS	Mt. Holyoke	Flower & leaf
MA	Hadley/S. Hadley			UMASS	Mt. Holyoke	Flower & leaf
MA	Amherst/ Granby			UMASS	Mt. Norwottuck	Flower & leaf
MA	Hadley/S. Hadley	Elwell	5/12/1899	UMASS	Mt. Holyoke	Leaf
MA	Hadley/S. Hadley	Elwell	6/2/1899	UMASS	Mt. Holyoke	Flower & leaf
MA	Amherst?	Elwell	5/19/1899	UMASS	Notch	Seed capsules
CT	New Haven Co.			UMASS		Flower, leaf, & seed capsule
CT	No data	Beardsler		UMASS		Flower & leaf
VT	Monkton		5/28/1877	UMASS		Flower & leaf
VT	Rutland		6/8/1905	UMASS	Center Rutland	Flower & leaf
Information provided by CT Natural Diversity Data Base						
State	**Town/county**	**Collector**	**Date**	**Herbarium**	**Habitat/location**	**Comments**
CT	Salisbury	O.A. Phelps	6/6/1905	CONN	Moist rocky woods	
CT	Plainville	C.H. Bissell	5/31/1913	NCBS	Rocky woods in rich soil	
CT	Danbury	C.H. Bissell	6/10/1914	NCBS	Rich woods	
CT	Danbury	G.L. Northrop	10/15/1905	CONN	Thin leaf-mold on mossy rocks	
CT	New Haven Co.		6/8/1885	YU	Maltby Park	
CT	Orange	D.C. Eaton	6/4/1868	YU	Westfield Woods	
CT	New Haven	D.C. Eaton	6/7/1867	YU	Westfield Woods	
CT	Norwich	J. Trumbull	6/4/1905	CC	Yantic woods	

UMASS = University of Massachusetts at Amherst, CONN = G. Stafford Torrey Herbarium of the University of Connecticut, NCBS = Connecticut Botanical Society, YU = Yale University, CC = ?

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.