

New England Plant Conservation Program

Lycopodiella alopecuroides (L.) Cranfill
Foxtail bog-clubmoss

Conservation and Research Plan
for New England

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SUMMARY

Foxtail bog-clubmoss, *Lycopodiella alopecuroides* (L.) Cranfill (Lycopodiaceae), is a common plant on the coastal plain of the southeastern United States and the Atlantic seaboard, reaching its historical northern limit of range on Nantucket and Cape Cod. The *Flora Conservanda: New England* lists it as regionally rare. Currently, there are sites for it in Maine, Massachusetts, Rhode Island, and Connecticut, although several sites are only known historically. It appears to be colonizing slightly more northerly sites; it has been recently discovered in Maine, and unusual inland occurrences in Rhode Island and in central Massachusetts have also been recently discovered.

Lycopodiella alopecuroides is a non-flowering plant remotely related to ferns. Bog-clubmosses reproduce by minute, single-celled spores that, when dispersed to suitable sites, germinate to form small plants, the gametophytes, which produce eggs and sperms. Upon fertilization, the resulting embryos grow into the larger spore-producing plants – the sporophytes – which are the plants observed in nature.

The species is restricted in New England to damp or wet microsites with saturated, typically sandy soils that have no organic layer or only a minimal organic layer, and to boggy (peaty) areas; one old Connecticut record was from the landward edge of a salt marsh. It is a pioneer species of open sites with little competition from other plants. However, it may persist as a more mature community develops; in the south, it occurs in boggy peatlands. Alternatively, although information is lacking, it may be able to directly colonize boggy peatlands; that is, gametophytes may be able to thrive on an organic substrate.

The local rarity of this species is enigmatic. The species is probably not sufficiently cold-hardy to successfully colonize more than a narrow strip along New England's coast-line; still, there are suitable sites that have not been colonized. For most spore-dispersed plants, availability and dispersal of propagules is not considered limiting, and the recent range extension of this species indicates this to be true. However, closely related species such as common bog clubmoss (*L. inundata*) are common in the same or similar habitats, which suggests that spore availability may be a limiting factor for foxtail bog-clubmoss.

The main conservation objective is to increase the number of populations to four each in Massachusetts, Maine, Rhode Island, and Connecticut (for a regional total of 800 plants), a goal that the apparently recent colonization of new areas makes seem reasonable. Current conservation efforts for foxtail bog-clubmoss are limited, although some of the few known sites are monitored and actions have been taken by private individuals and governmental authorities to protect them. Future efforts are to be encouraged along these same lines. Since the species is likely to be easily cultivated from vegetative divisions and possibly from spores, *ex situ* efforts may also be possible in abandoned commercial cranberry bogs, if the species in future is seen to be in danger of regional extirpation.

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Because they contain sensitive information, full plans 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.

NEPCoP is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

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

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

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection. If you require additional information on the distribution of this rare plant species in your town, please contact your state’s Natural Heritage Program.

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I. BACKGROUND

INTRODUCTION

A suite of New England-rare species occurs primarily on the coastal plain, the narrow strip of low-lying land not far from the ocean that includes the coast of Connecticut and Rhode Island, Nantucket, Martha's Vineyard and Cape Cod in Massachusetts, and marshes and bogs northward to Maine. Some of these rare plants are at the northern periphery of their natural range in this zone, being common elements of the flora further south, where the coastal plain is much wider. One such species is foxtail bog-clubmoss, *Lycopodiella alopecuroides* (L.) Cranfill (Lycopodiaceae), a plant of damp to wet, often peaty, areas of sandy, nutrient-poor soils. Although globally secure (ranked G5; NatureServe 2003), it is listed by *Flora Conservanda: New England* (Brumback and Mehrhoff et al. 1996) as a Division 2, regionally rare, species. Division 2 includes, among others, "taxa which are rare throughout their range in all of New England as well as taxa that reach the edge of their distributional range in our region" (Brumback and Mehrhoff et al. 1986: 243). *Lycopodiella alopecuroides* is both rare wherever it occurs in New England and at the edge of its natural range. *Flora Conservanda* continues, "it is important to conserve these edge-of-range occurrences as part of New England's natural heritage as well as to avoid further shrinkage of these species' entire range" (Brumback and Mehrhoff et al. 1996: 243). This conservation and research plan aims to address the question of the species' rarity in further detail and to suggest strategies that would prevent losses of existing colonies and increase the population base in New England.

Foxtail bog-clubmoss is frequently associated with two closely related species, appressed bog-clubmoss (*L. appressa* (Sm.) Cranfill) and common bog-clubmoss (*L. inundata* (L.) Cranfill), and sometimes forms hybrids with them. Why it should be so rare, while those species are not, is puzzling, and is probably to be explained by a combination of edaphic (soil-related) and climatic factors. A comparative regional paucity of spores vs. the abundant spores of the other species, may partially explain both the overall rarity of foxtail bog-clubmoss (expressed as number of colonies) and the common occurrence of hybrids, since in a new mixed colony, egg cells of the rare species would be more likely to be fertilized by sperm from other species than its own. Such a phenomenon of hybrid exclusion has been shown, for example, to structure regional populations in the spore-dispersed spleenwort ferns (*Asplenium* spp.) in Europe (Vogel et al. 1999).

However, foxtail bog-clubmoss is apparently extending its range further northward, as evidenced by recent discoveries of new stations in Maine, in central Massachusetts, and at a site in western Rhode Island; the latter two sites are unusual in being well away from the coastal plain. It was previously recorded only along the immediate coast and only as far north as Cape Cod. The causes of this apparent range expansion are not known, and what it means for conservation purposes is not known. Perhaps it means that the species is becoming less rare.

The species has received some attention from regulatory authorities and is listed as Endangered in Massachusetts, Endangered in Rhode Island, and of Special Concern (although likely extirpated) in Connecticut. It is also listed as of Special Concern in Maine.

Current conservation measures specifically for foxtail bog-clubmoss are minimal and depend on a few knowledgeable botanists who have taken a particular interest in the species. These individuals have promoted the species by managing habitats at known sites on a limited scale. The main conservation objective is to increase the number of populations to four each in Massachusetts, Maine, Rhode Island, and Connecticut (for a regional total of 800 plants), a goal that expands the number of known populations and the size of those populations. This will be primarily achieved through management and protection of existing populations and searches for historic and new occurrences. Because foxtail bog-clubmoss is a species that is easy to cultivate, and because there is likely to be plenty of suitable, but not occupied, habitat on the coastal New England landscape, *ex situ* propagation and introduction to new sites would probably be successful, and may be warranted in the future if the species is viewed as regionally imperiled.

DESCRIPTION

Foxtail bog-clubmoss is a perennial, spore-dispersed vascular plant with microphyllous leaves. It has shoots of two kinds, horizontal and upright. The horizontal shoots are barren (i.e. not spore-bearing), and are arching to looping, only distally rooting, 5-30 cm long. They bear numerous leaves in no apparent phyllotaxy, that are very narrowly triangular, 0.5×5 mm, with 3-7 teeth per side, and a long-acuminate, filiform tip. The character of leaf dentition can be troublesome, as it is also expressed in hybrids; it is possible also that New England plants, which are smaller than individuals from further south, may be difficult to identify on this character alone.

The distal tips of the horizontal shoots root on contact with soil, becoming foreshortened and starch-filled in autumn. These tips are the perennating organs of the plant and remain green over winter; the proximal shoots senesce and die during the winter (in the south, they remain green). The upright shoots are typically 1-3, proximally barren but distally spore-bearing. The proximal leaves are similar to those of horizontal shoots, but the distal leaves bear sporangia in their axils and are termed sporophylls. They differ in size and shape from others, being longer and more linear-filiform, each side 1-3 toothed, spreading widely from the axis, and with membranous wings near their base that partially enclose the sporangia. Taken together, the sporophylls form a distinct strobilus or cone. The sporangia are very numerous, each borne singly in the axil of a sporophyll. The spores are globose-tetrahedral, ca. 0.04 – 0.05 mm in diameter, and yellowish. Gametophytes are independent, chlorophyllous, surficial (i.e., not subterranean), and partly saprophytic.

Foxtail bog-clubmoss is so called because its upright shoots have a "bushy" tip (i.e., the strobilus) like that of the "foxtail grass" (*Alopecurus*, although the common name "foxtail grass" is now used for another genus, *Setaria*, which also resembles foxtail bog-clubmoss). It is typically taller and more robust than other bog-clubmosses, although in New England it is sometimes represented by plants of rather reduced stature (Arthur Haines, New England Wild Flower Society, personal communication). It can normally be identified by the combination of very toothed leaves on both horizontal and upright shoots, long sporophores, and arched (i.e., not prostrate) horizontal stems. A possible source of confusion in New England is hybridization with two sympatric species, *L. appressa* and *L. inundata*. Hybrids with these are *L. × copelandii* (Eiger) Cranfill and *L. × robusta* (R. J. Eaton) A. Haines, respectively. These hybrids are homoploid, form well-formed spores and, presumably, are fertile (Wagner and Beitel 1993). In the absence of unequivocal markers of their hybrid nature, such as abortive spores, they are best identified by their intermediate morphologies. Characters best suited for study to differentiate between the species and hybrids are the nature of the toothing of the upright shoots, length/width ratio of the sporophylls, average number of upright shoots per horizontal shoot, the widely spreading sporophylls (vs. appressed in *L. appressa*), and the arching nature of the horizontal stems. Details are available in recent literature, which should be consulted by conservation personnel (Haines 2001, Haines 2003).

Illustrations Available for the Species

- **Tryon and Moran** (1997: 240) published a photo, taken ca. 1940, of a colony of *L. alopecuroides* near Hyannis, Massachusetts. Taken early in the year, this shows immature development of the upright shoots, but diagnostic arching of the horizontal shoots.
- **Haines** (2003: 57, 59), Figures 55, 56, and 57, habitat and diagnostic photos of plants from Maine.
- **Wagner and Beitel** (1993: 35), shoot, leaf, and portion of upright stem.
- **Snyder and Bruce** (1986: 190 *et seq.*) illustrated the species and its hybrids with diagnostic photographs.
- **Stuckey** (1977), photo of plant from Jamestown, Rhode Island.
- **Images** at <http://www.arthurhaines.com>
- **Images** at <http://plantatlas.usf.edu>

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

The genus *Lycopodiella* was segregated from the more broadly circumscribed clubmoss genus *Lycopodium* in 1964 (Holub 1964), a segregation that had been discussed previously (Boivin 1950). Despite some initial reservations (Wilce 1972), it has become widely accepted by the botanical community (Øllgaard 1990, Wagner and Beitel 1992,

1993, Tryon and Moran 1997, Haines 2003). It differs from *Lycopodium* (and other recent generic segregates) in several important characters, notably in its chlorophyllous (only partially mycotrophic), surficial gametophytes (vs. saprophytic, subterranean gametophytes), its deciduous habit (its leafy stems senesce in cold weather), and its fidelity to damp or wet habitats. It has a different base chromosome number ($2n = 156$ vs. $2n = 46, 68, 70, 136, 136$ in other segregate genera). Its position as a separate genus is also supported by molecular (DNA) data, which indicate that it has been distinct from the remainder of the group for an estimated 208 million years or more (Wikström 2001).

The species *L. alopecuroides* was originally described (as *Lycopodium*) by Linnaeus in 1753. It was later considered a variety of *L. inundata* by Tuckerman in 1843, but except for previous transfers to the genera *Plananthus* P. de Beauv. (1805) and *Lepidotis* Rothmaler (1943), and its more recent transfer to *Lycopodiella* (Cranfill 1981), it has enjoyed a stable continuity of nomenclature. The name was based on a type specimen collected by Kalm in Virginia (LINN 1257.7, *n.v.*), so it necessarily denotes the United States plants. Close relatives in the Caribbean and in South America have been referred to this species, *sensu lato*. For example, Nessel (1939) listed ten South American varieties, but according to Øllgaard (1992), in the strict sense, the species occurs only as far south as Cuba. One mostly South American variety, (*Lycopodium*) *alopecuroides* var. *spinulosum* Spring, was credited to New Jersey (Nessel 1939); it was said to be smaller than *L. alopecuroides*, and may have been based on a small plant or a hybrid. No modern systematist has recognized this doubtful variety.

As noted above, foxtail bog-clubmoss, like other members of the genus, readily forms hybrids with other species. These hybrids can be common in some regions, leading to confusion in identifications, in turn leading to sometimes erroneous conclusions about the species' presence or absence in an area. However, taxonomists have not seriously questioned the validity of the taxon as a species *per se*.

SPECIES BIOLOGY

For this and the following section (Habitat/Ecology), little species-specific information has been found. Some information, however, can be inferred from studies on the closely related species, common bog clubmoss (*Lycopodiella inundata*).

Like all members of the genus, *Lycopodiella alopecuroides* is a perennial species adapted to wet habitats. In the south, it is nearly evergreen, but in the north, the growing tip of the horizontal shoot becomes filled with starch and serves as a sort of temporary (one-season) overwintering storage organ, sometimes called a "turion." Except for the tip of the shoot, the previous season's growth senesces and dies, and is essentially abandoned. In the spring, growth recommences at the tip of the horizontal shoot and continues throughout the season. Little is known about the induction of the upright, sporogenous shoots. Their development begins soon after growth of the horizontal shoot recommences; that is, the upright shoots branch proximally on the horizontal shoot (personal observation). The induction of sporogenesis may be related to day length or to

available food reserves. Growth occurs throughout the warmer months, with spore release typically in September. Plants produce many thousands of light, single-celled spores, which are dispersed probably by both wind and water.

Light is required for spore germination (Whittier 1998). Because the gametophytes are chlorophyllous and only partially saprophytic, the necessity of a mycorrhizal association for successful development is not understood, but the association is typically formed (for *L. inundata*, Campbell 1918). In *L. inundata*, gametophytes develop rapidly, from one to three months after spores reach suitable habitat, and have been found at all seasons in New Jersey (Koster 1941). They may overwinter (Bruce 1972), but it is unknown if a cold period (vernalization) is significant in their physiology.

Little is also known of the breeding system in this species (indeed, in the genus). Given the readiness with which hybrids are formed, it is likely that *L. alopecuroides* is an outcrossing species. However, it should also be noted that single spores landing in new or unoccupied habitats at some distance from their origin can form plants capable of intra-gametophytic fertilization. By this mechanism, the species is similar to a seed plant in its ability to invade new terrain; however, the mechanism is similar to selfing or cleistogamy in flowering plants, and results in a completely homozygous sporophyte. This may partition variability among populations across the landscape; additional colonization may be necessary to produce a fully integrated regional population, i.e., a population capable of genetic interchange. The phenomenon of hybrid exclusion may also be important. If a spore lands in a habitat dominated by other bog-clubmoss species, its gametophyte is likely to be fertilized by sperm of another species, resulting in hybrid formation, as is noted in many colonies of *L. alopecuroides*. However, back-cross or introgressive hybrids have not been widely reported and the species may be, once established, effectively protected against swamping by unknown genetic factors.

As with many spore-dispersed plants (which have no need of pollinators, and no fruits), biological interactions of clubmosses with other species are somewhat limited compared to higher plants. Several fungi are known to infest related genera, i.e., *Diphasiastrum* Holub, *Huperzia* Willd., and *Lycopodium* L. (Gregor, 1938), and the author has collected a fungus tentatively identified as a species of *Cladosporium* infesting *L. inundata* (Gilman 2002). The gametophyte is typically mycorrhizal, but mycorrhizal associations in the sporophytes have not been documented, although they were hypothesized for *L. inundata* by Pickering and Wigston (1990) based on nutrient status of the substratum. Vascular plants growing on nutrient-poor soils are frequently mycorrhizal, but one study (Moteetee et al. 1996) that included three lycopods, including one from a “peaty bank on sandstone” in Africa, showed these species to be free of such associations (in living roots).

No literature records have been found on predation by insects, although it is noted that herbarium pests, including certain beetles (Coleoptera) and possibly booklice (Hemiptera), sometimes eat lycopod spores in the herbarium (personal observation), presumably because they are oil-rich. Perhaps this occurs in nature as well. No other biological associations or interactions are documented.

HABITAT/ECOLOGY

Lycopodiella alopecuroides is adapted to damp or wet habitats. Haines (2001) noted that the species is most frequent on saturated sand, an observation consistent with other New England reports. Page (1997: 406) noted that *L. inundata* “demand[s] moist, peaty, sandy or muddy sites, which are almost competition-free.” Certainly, freedom from competition is likely a major factor in colonization, although persistence in natural, stable habitats (e.g., *Sphagnum*-dominated systems) is probable as well. Most observed locales are peaty, or at least have a shallow, peaty surface horizon overlying sand, and they are probably acidic in reaction. Wherry (1961) noted a preference for “intensely acid” soil – a normal situation on the Atlantic coastal plain where this species is centered. Lellinger (1985) also noted its occurrence on “strongly acidic soil,” as did Snyder and Bruce (1986).

In the south, and for some New England occurrences, the common habitat is bogs or poor (acidic, nutrient-limited) fens. Other New England occurrences are, or were, on shores of ponds on the terminal glacial moraine. Such ponds typically have seasonally fluctuating water levels, or experience low water levels in some years and high water levels in other years. One pondshore (MA .001 [Nantucket]) may have some marine influence as well, although the extent of this in relation to the bog-clubmoss population (which is extirpated) is not known. One Connecticut population (collected by Eames in 1908; see Mehrhoff 1996, 1999) was noted to occur at the edge of a salt marsh, indicating some tolerance of salt, although it is not noted in other literature as a regular component of salt marshes. Maine populations are not associated with pondshores or bogs, but are on areas disturbed by human activities – utility corridors and borrow areas. One Rhode Island occurrence (RI .002 [North Kingstown]) is in an abandoned gravel pit excavated to the water table, and another (RI .004 [Coventry]) is on an area of scraped soil in an old field where topsoil was removed some years ago, exposing a damp subsoil.

Habitats that have been disturbed by earth-moving in the recent to mid-term past, e.g., access roads in utility corridors, borrow pits, and areas where topsoil was removed, seem to be common across the region (although large-scale disturbances of wetlands are now limited by legal protections afforded to these habitats, especially disturbances where soils are allowed to remain exposed). Nevertheless, species such as *Lycopodiella inundata* and *L. appressa* have no difficulty in finding suitable sites to colonize, and it is something of a mystery why *L. alopecuroides* does not seem to colonize more such sites. As with other pteridophytes, disturbances need not be large in scale; small microsites that can be colonized may be available within larger habitats. The suitability of a particular site is likely determined by several synchronous factors involving lack of competition (see above), soil texture, moisture, and pH. *Lycopodiella inundata* was considered by Pickering and Wigston (1990) to be a ‘pioneer species’ on bare soils.

Frequent associates in its typically sandy, acidic, nutrient-poor habitats are sundews (*Drosera rotundifolia*), lance-leaved violet (*Viola lanceolata*), one-seeded muhly grass (*Muhlenbergia uniflora*), beak-rushes (*Rhynchospora capitellata*, *R. alba*), and bartonia (*Bartonia paniculata*). Large cranberry (*Vaccinium macrocarpon*) has been

noted as an associate in both Massachusetts and Rhode Island, and the species was noted to colonize abandoned cranberry bogs in New Jersey (Montgomery and Fairbrothers 1992). The soil type (“high organic matter sands, preferably coarse sands”) and moisture regime (intermittently flooded but with good drainage in the root zone) necessary for cranberry cultivation may be similar to the requirements of foxtail bog-clubmoss (Peter Lockwood, Field Biologist, personal communication).

Lady’s-tresses orchid (*Spiranthes cernua*), and Canada bluejoint grass (*Calamagrostis canadensis*) have also been noted as associates in Rhode Island. On Nantucket, a somewhat different suite of species is associated with the one extant occurrence, including bushy bluestem (*Andropogon glomeratus*), reed-grass (*Calamagrostis cinnoides*), and Mattamuskeet panic-grass (*Dichanthelium dichotomum* ssp. *mattamuskeetense*); also associated are nodding ladies’-tresses (*Spiranthes cernua*) and white fringed orchis (*Platanthera blephariglottis*). The most seaward plants may be associated with saltmarsh species, e.g., cordgrass (*Spartina* spp.), sea-lavender (*Limonium carolinianum*), etc. *Sphagnum* is a frequent associate. In some or most occurrences, other bog-clubmoss species and/or hybrids are also associated.

This species does not appear to be significantly cold-hardy and is limited to the warmer zones of New England and southward. In New England, it is strongly associated with a maritime climate, most populations being on the narrow coastal plain or islands.

Given the rarity of *L. alopecuroides* in New England, colonization may be limited by spore availability. Spores are abundantly produced, but dispersal is probably leptokurtic, i.e., most spores probably fall near the parent. Genetic swamping may also be a factor (see below).

THREATS TO TAXON

Individuals are perennial, although populations may be relatively short-lived due to competition from other species and overshadowing. As disturbed sites become stabilized with graminoid, forb, or woody vegetation, initial colonizers such as *Lycopodiella* can be excluded (personal observation). Natural succession has been identified as a threat at some of the sites, e.g., ME .002 (Falmouth), MA .003 (Nantucket), RI .001 (Jamestown), and CT .v (Killingworth). This phenomenon may not be operative in naturally open or semi-open sites, such as bogs, edges of salt-marshes, etc. However, swamping of plants by *Sphagnum* may also be a potential problem or, alternatively, full cover by *Sphagnum* may close sites to colonization.

Physical perturbation by machinery, off-road vehicles, etc. may pose threats; one Maine (ME .001 [Topsham]) occurrence is in a power line corridor that experiences some damaging vehicular traffic that has been identified as a threat (Haines 2001). On the other hand, maintaining an open site, including some limited soil disturbance, may be beneficial to populations (as at ME .002 [Falmouth]). The Winchendon, Massachusetts site (MA .004) may be at risk from extension of gravel quarrying or logging operations

on adjacent lands (Paul Somers, Massachusetts Natural Heritage and Endangered Species Program, personal communication); another Massachusetts site (MA .003 [Nantucket]) may be threatened by various landowner operations if regulatory safeguards fail. Examples include inappropriate mowing or other activities related to maintenance of a facility on the site. For instance, electrical wires were recently buried adjacent to this population (Paul Somers, Massachusetts Natural Heritage and Endangered Species Program, personal communication). Any population located in a gravel pit, or abandoned gravel pit (e.g., RI .002 [North Kingstown]), would be at risk from further activity. The populations that have been reported at the edges of salt marshes (Connecticut) would be potentially at risk from any activity (e.g., fill, dredge), that would alter the morphology of this landform or its hydrology.

No biological threats have been identified from pests or disease. If, in fact, the regional population is increasing, as suggested by recent discoveries of populations in new areas, threats from genetic isolation may be decreasing.

DISTRIBUTION AND STATUS

General Status

Foxtail bog-clubmoss is, essentially, a common species centered on the Atlantic coastal plain, with the majority of populations in the southeastern United States. It also occurs northward, sporadically, to New England, westerly to Texas, and north in the Mississippi River Valley to Tennessee and Arkansas (Figure 1). It also occurs, *sensu stricto*, in Cuba, where its conservation status is “indeterminate” (Villaverde and Galuff 1997). Reports from elsewhere, in the West Indies and South America, probably represent another taxon (Øllgaard 1992). It has a global rank of G5, i.e., globally secure (NatureServe 2003).

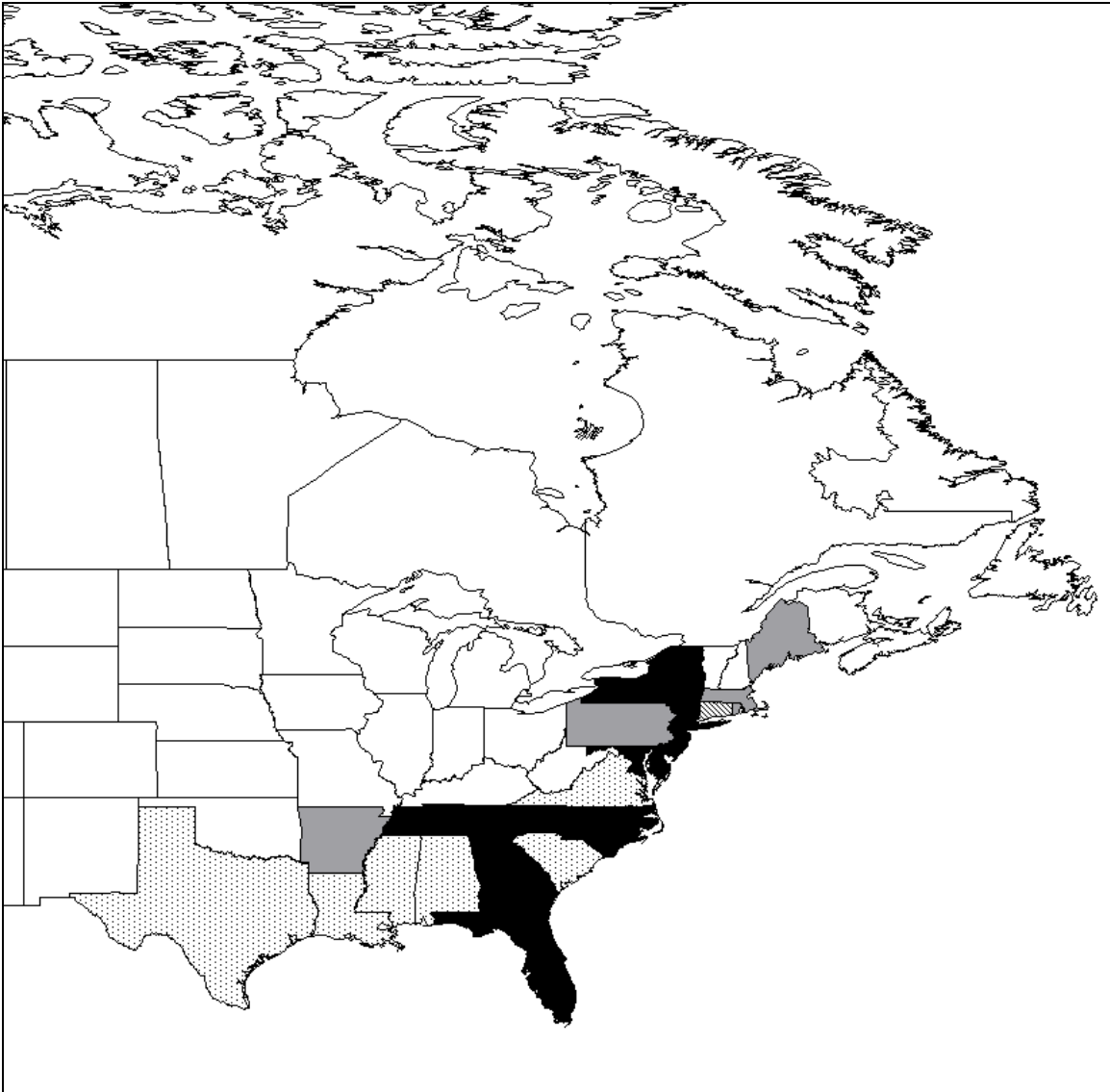


Figure 1. North American occurrences of *Lycopodiella alopecuroides*. States and provinces shaded in black have more than five confirmed, extant occurrences of the taxon. Areas shaded in gray have listed the taxon as S1, *or* have an unspecified (perhaps numerous) number of occurrences. The state (Connecticut) with diagonal hatching is ranked “historic” or “presumed extirpated,” where the taxon no longer occurs, but this appears to be in error (see text). Areas with stippling have been ranked “SR” (“Reported” with no further information). See Appendix for explanation of state ranks.

Table 1. Occurrence and status of <i>Lycopodiella alopecuroides</i> in the United States and Canada based on information from Natural Heritage Programs and other sources.			
OCCURS & LISTED (AS S1, S2, OR T & E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Maine (S1): Two recent sites known, but one may not still be extant	New Jersey (S5): Noted to be “common in the pinelands and along the coast, scattered [elsewhere]” (Montgomery and Fairbrothers 1992: 78)	New York (SR): in Suffolk, Nassau and Kings counties (NYFA 2003)	Connecticut (SH): This rank is apparently in error, as at least one site may be extant (see CT .v)
Massachusetts (S1, E): Two extant, three historic occurrences	Maryland (S4)	Virginia (SR)	
Rhode Island (S1, E): 2 extant, 1 extirpated population	Delaware (S3)	South Carolina (SR): “chiefly coast plain” (Radford et al. 1968)	
Pennsylvania (S1)	North Carolina (S4): “chiefly coast plain” (Radford et al. 1968.	Georgia (SR): ‘Throughout the Lower Coastal Plain, in much of the Upper Coastal Plain, and in a few counties of the Piedmont’ (Snyder and Bruce 1986: 190)	
District of Columbia (S1)		Florida (SR): “Common” (Wunderlin and Hansen 2000)	
Arkansas (S1)		Alabama (SR)	
Tennessee (S2)		Mississippi (SR)	
		Louisiana (SR)	
		Texas (SR)	

Status of All New England Occurrences — Current and Historical

In New England, *Lycopodiella alopecuroides* is a Division 2, regionally rare, species under the *Flora Conservanda* ranking scheme (Brumback and Mehrhoff et al. 1996), and individual New England states where it occurs rank it primarily as S1. Lately, this species seems to be extending its range northward. Not only are there new records from inland Massachusetts (e.g., MA .004 [Winchendon]) and Rhode Island (RI .003 [Coventry]) but it has been found in Maine only within the past decade (Haines 2001; Figures 2 and 3). It does not occur, as far as known, in New Hampshire (Dan Sperduto, New Hampshire Natural Heritage Bureau, personal communication) or Vermont.

Interestingly, a range extension has recently been found with a related clubmoss, Carolina clubmoss, *Pseudolycopodiella caroliniana* (L.) Holub, which has recently been reported on Long Island (Lamont and Fitzgerald 2001) and in upstate New York (Corey 1998). This may or may not be a general trend, and ought not to be relied upon as a phenomenon that would obviate the need for conservation until, minimally, such time as the conservation goals set out below are achieved.

In some instances, correlation of Element Occurrence (EO) numbers with data supplied to the author may not be exact due to confusion of herbarium labels, old published reports, etc. Every attempt has been made to define discrete EOs, but it is possible that some should be combined or, conversely, segregated. This is most likely to affect the historic Massachusetts and Connecticut occurrences. Also note that occurrences that are not listed as numbered EOs by the individual Natural Heritage Programs are listed here with lower case Roman numerals (.i, .ii, etc.).

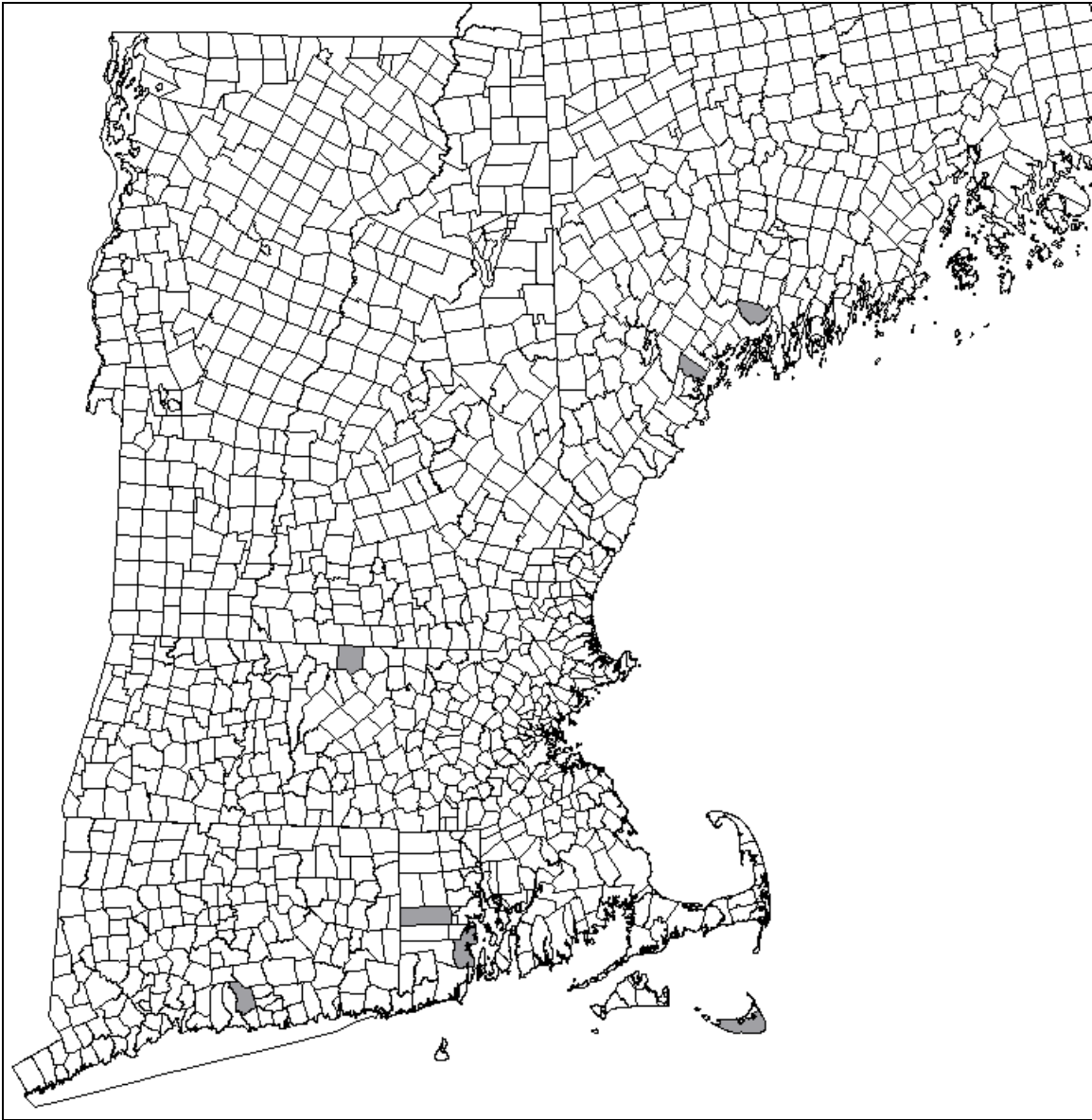


Figure 2. Extant occurrences of *Lycopodiella alopecuroides* in New England. Town boundaries for New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

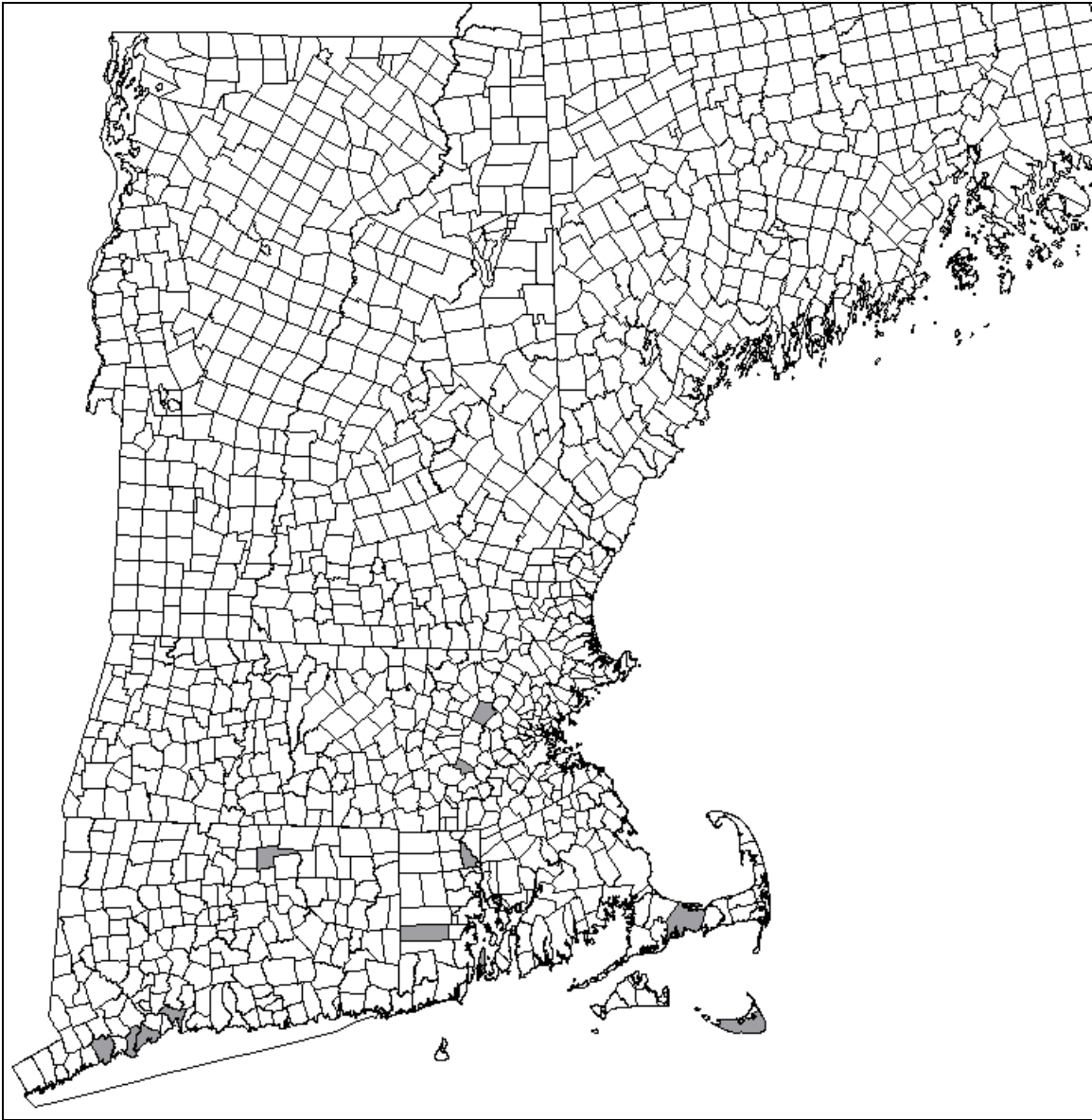


Figure 3. Historical occurrences of *Lycopodiella alopecuroides* in New England. Towns shaded in gray have one to five historical records of the taxon.

Table 2. New England Occurrence Records for <i>Lycopodiella alopecuroides</i>. Bold occurrences are considered extant.			
State	EO #	County	Town
ME.	.001	Sagadahoc	Topsham
ME.	.002	Cumberland	Falmouth
MA	.001	Nantucket	Nantucket
MA	.002	Nantucket	Nantucket
MA	.003	Nantucket	Nantucket
MA	.004	Worcester	Winchendon
MA	.i	Barnstable	Hyannis
MA	.ii	Middlesex	Concord
MA	.iii	Middlesex	Ashland
MA	.iv	Nantucket	Nantucket
MA	.v	Nantucket	Nantucket
RI	.001	Newport	Jamestown
RI	.002	Washington	North Kingstown
RI	.003	Kent	Coventry
RI	.i		West Greenwich
RI	.ii		Lincoln
CT	.001	New Haven	New Haven
CT	.002	Fairfield	Unknown
CT	.i	Fairfield	Fairfield
CT	.ii	Fairfield	Fairfield
CT	.iii	Fairfield	Stratford
CT	.iv	Tolland	Ellington
CT	.v	Middlesex	Killingworth

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

With very few known locales in New England, but with an apparent expansion of range within the area, now may be an appropriate time to increase the numbers and sizes of populations of *L. alopecuroides* on a regional basis. To that end, the following goals are enumerated:

- 1) At least four populations in each of four states: Maine, Massachusetts, Rhode Island, and Connecticut.
- 2) A total of *at least* 800 plants (i.e., 4 states \times 4 sites \times 5 clones \times 10 upright stems per clone = 800) overall for New England is recommended. Because no data are available on minimum viable populations sizes for this taxon, these numbers are provisional. Current populations consist of 10 to several hundred stems (clones are not always specified in surveys). Overall, this goal will be a level far more secure than the current tenuous hold the species has on the region.
- 3) Each population would ideally consist of several to numerous ($>$ five) clones, and consist of tens to hundreds of strobili (sporulating upright shoots) each year. The purpose of these numbers is to attain genetic diversity (i.e., as measured by number of clones) and adequate spore production to colonize colonizable habitat patches without hybrid exclusion.

Efforts should be concentrated on maintaining and enlarging existing populations, and on discovering and establishing new populations. Coastal areas and protected lands are especially recommended for conservation efforts, although private lands could be suitable as well. Habitats should be maintained in such a manner as to provide colonizable sites as well as mature plants.

- ***In situ* efforts.** Most of the existing populations are small and occur in habitats that are not intrinsically self-maintaining. Therefore, maintenance of the habitats against succession is of first concern. This may require removal of competing vegetation (including *Sphagnum*) and physical perturbation of the soil (“scalping”) to provide colonizable sites on an ongoing basis. Because introgression is probably not a factor, congeners should not be removed from these sites.

Landowners and land managers should be educated about the species and its needs. However, questions about long-term persistence of small, more or less unstable habitats — which are not necessarily located within larger habitat matrices of conservation concern — may make expenditures for land acquisition difficult to justify.

- ***Ex situ* efforts.** The bog-clubmoss group is readily cultivated (Montgomery and Fairbrothers 1992) under proper conditions of wet, acidic soils. Although propagation by spores may be problematic (Whittier 1998), vegetative propagation by division or offsets is feasible. However, due to general concerns about the utility of introduction, genetic consequences of mixing populations, and poor record of success for many transplantation efforts, introduction or reintroduction is not contemplated at this time, especially because *Lycopodiella alopecuroides* may be expanding its range in the region. Future researchers and managers may contemplate these actions based on the following two considerations: 1) is the regional population so small that such actions are warranted to prevent extirpation? and 2) is the regional population so large that concerns about maintaining genetic isolation are overcome?

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IV. APPENDICES

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

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