Conservation Assessment

for

Northern Appressed Club-moss

(Lycopodiella subappressa_ J. G. Bruce, W. H. Wagner, & Beitel)

and

Northern Prostrate Club-moss

(Lycopodiella margueritae J. G. Bruce, W. H. Wagner, & Beitel)

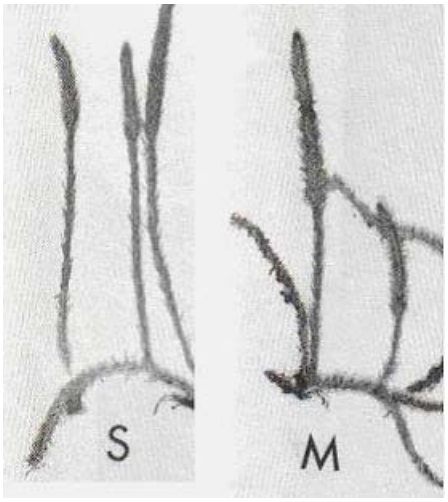

Photo from Bruce *et al*. (1991) from
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USDA Forest Service, Eastern Region

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Hiawatha National Forest

This conservation assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a conservation assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 626 East Wisconsin Avenue, Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

Lycopodiella margueritae J. G. Bruce, W. H. Wagner, & Beitel (northern prostrate club-moss) is designated as a regional forester sensitive species on the Hiawatha National Forest in the Eastern Region of the U.S. Forest Service. *Lycopodiella appressa* Chapm., Lloyd & Underw. is designated as a regional forester sensitive species on the Huron-Manistee National Forest also in the Eastern Region of the U.S. Forest Service. This occurrence has been re-assessed and is now identified as *L. subappressa* (Alix Cleveland pers. comm. 2002). Occurrences of *L. margueritae* or *L. subappressa* are not documented on any other national forest. The purpose of this document is to provide the background information necessary to prepare a "conservation strategy," the latter which will include management actions to conserve these species. Due to the difficulties in distinguishing *L. subappressa* and *L. margueritae,* these two species have been evaluated together in this conservation assessment.

Bruce *et al*. (1991) indicates that populations originally identified as *L. appressa* in Michigan are a combination of two new species: *L. subappressa* and *L. margueritae*. True *L. appressa* populations are believed to be restricted to southeastern United States (Wagner and Beitel 1993). Since 1991, most herbarium specimens of *L. appressa* in Michigan have been annotated as one of these two new species (Robert Preston pers. comm. 2002). Many documented occurrences, however, do not have voucher specimens and must be re-visited to determine their correct identification (Phyllis Higman pers. comm. 2002). In this document, populations originally classified as *L. appressa* that occur in Michigan that have not been re-evaluated since 1991 are assumed to be either *L. subappressa* or *L. margueritae*. Besides occurring in Michigan, *L. margueritae* has been located in Indiana, Ohio, Virginia, Pennsylvania, and Connecticut (PLANTS 2002). In addition to occurring in Michigan, *L. subappressa* has been located in Illinois, Indiana, and Ohio. Both of these species are ranked as "imperiled globally" (G2) (NatureServe Explorer 2001).

L. margueritae and *L. subappressa* are tetraploids, while other *Lycopodiella* species are diploids (Bruce 1975). Gametophytes of *Lycopodiella* species are small (3 mm), grow on the surface of the soil, and are partially photosynthetic (Gifford and Foster 1989). Species with photosynthetic gametophytes tend to have rapid spore germination and a weak relationship with endophytic fungi. The known habitats and ecology of *L. subappressa* and *L. margueritae* are currently indistinguishable. These species occur in open habitats with soil that is usually sandy, acidic, and moist or wet. Many of the known natural populations occur near Great Lakes in rare ecological communities such as coastal plain marshes, lakeplain wet prairies, and wetlands near dunes (Michigan Natural Features Inventory 2002). Many populations are also located in disturbed habitats such as borrow pits and ditches. Loss of natural habitat may be the greatest threat to these species. Loss of species identity due to hybridization may be another potential threat to these two species.

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Initial Draft: We are grateful to Ramona Shackleford, contract botanist, for her efforts in providing us with an original draft for this conservation assessment.

Herbarium and Heritage Data: We appreciate the sharing of occurrence information for this species from Heritage personnel both in the United States and Canada, along with the helpful assistance of Herbarium personnel. See Contacts section at end of report for a complete list.

Editorial Committee

- We thank Jan Schultz, of the Hiawatha National Forest, for her suggestions and patience through revisions.

- Also appreciated was the editorial assistance of the following contract employees working with the Hiawatha National Forest: Beverly Braden, contract botanist.

Literature Search

- We thank Laura Hutchinson of the North Central Research Library for performing initial species inquires and sending us relevant research articles.

- We thank Jan Schultz, of the Hiawatha National Forest, for use of her extensive library of materials to begin to compile information on this species.

- We thank Beverly Braden, a contract botanist, for additional literature searches at Northern Michigan University in Marquette, Michigan State University in East Lansing, and the University of Michigan in Ann Arbor.

- We also thank Ramona Shackleford, a contract botanist, for additional literature searches at the University of Wisconsin at Madison.

NOMENCLATURE AND TAXONOMY

Lycopodiaceae species along with other groups of primitive vascular plants are often referred to as "fern allies." Fern allies are vascular herbs with characteristics that are more primitive than true ferns such as simplistic organization of vascular tissue (usually protostelic vascular tissue) and leaves that have a single vein of vascular tissue (microphylls). Like ferns, species of Lycopodiaceae reproduce with spores, gametophytes live independently from sporophytes, and eggs are fertilized by flagellate sperms (Wagner & Smith 1993). Ferns and fern allies are often referred together as "pteridophytes" (Wagner & Smith 1993) or "vascular cryptogams" (Gleason & Cronquist 1991).

The organization of genera within the Lycopodiaceae has been somewhat controversial during at least the last 40 years (Gillespie 1962, Bruce 1975, Holub 1983, Øllgaard 1987). Until the early 1990's, however, *Lycopodium* was often the only genus recognized in North American field manuals. The only other genus that was recognized in the family, *Phylloglossum*, occurs exclusively in Australia (Gleason & Cronquist 1991). Øllgaard (1987) analyzed *Lycopodium* and recommended that it be split into three genera: *Lycopodium, Lycopodiella,* and *Huperzia*. Wagner and Beitel (1992), alternatively, analyzed characters of Lycopodiaceae species that occur in North America and supported splitting *Lycopodium* into seven genera. Wagner and Beitel's classification system split *Lycopodiella* as described by Øllgaard (1987) into three genera: *Lycopodiella*, *Pseudolycopodiella,* and *Palhinhaea*. *Lycopodium* as described by Øllgaard was divided into two genera, *Diphasiastrum* and *Lycopodium*; and *Huperzia* was also divided into two genera, *Phlegmariurus* and *Huperzia*. In 1993 Wagner and Beitel classified the Lycopodiaceae into these seven genera in the Flora of North America Volume 2.

The analysis of two sets of molecular data (DNA sequencing of the rbcL gene and trnL intron) supported grouping the family into the three genera recognized by Øllgaard instead of Wagner and Beitel's seven genera classification system (Wikström & Kenrick 2000). Currently three reputable databases classify Lycopodiaceae species of North America into three genera (Øllgaard's (1987) classification system): PLANTS database (2001), NatureServe explorer (2001), and ITIS (2001). In either Wagner and Beitel's (1993) classification system or Øllgaard's (1987) classification system, the species described in this paper maintain the same genus name, *Lycopodiella* (Table 1). Øllgaard (1987) grouped *Lycopodiella inundata,* a species closely related to *L. subappressa* and *L. margueritae,* in the *Lycopodiella* section of the *Lycopodiella* genus. This section classification has been maintained by Wikström and Kenrick (2000).

The genera *Lycopodium* and *Lycopodiella,* according to Øllgaard (1987), are "sister groups" as they share more characteristics than the more primitive genus, *Huperzia*. Most notably unlike *Huperzia,* sporophylls of these two genera are organized into strobili or terminal cones. *Lycopodium* and *Lycopodiella* are distinguished by the differing stem anatomy, spore exine, mucilage canal distribution, sporangium epidermis, gametophyte morphology, and recently gene sequences (Øllgaard 1987, Wikström and Kenrick 2000).

Table 1. Current taxonomic placement and nomenclature of *Lycopodiella margueritae* and *L. subappressa* (Wagner & Beitel 1993, PLANTS 2002).

Family:	**Lycopodiaceae**
Genus:	***Lycopodiella***
Section:	***Lycopodiella***
Scientific name:	*Lycopodiella margueritae* J.G. Bruce, W.H. Wagner, & Beitel
Common name:	Northern prostrate club-moss
USDA Symbol:	LYMA7
Synonyms:	*L. margueritiae, L. margueriteae* (NatureServe explorer 2001)
Scientific name:	*Lycopodiella subappressa* J.G. Bruce, W.H. Wagner, & Beitel
Common name:	Northern appressed club-moss
USDA Symbol:	LYSU2

The *Lycopodiella inundata* complex is a group of closely related species that hybridize readily and include *L. inundata*, *L. appressa*, *L. margueritae*, and *L. subappressa* in the Great Lakes region and eastern coastal states (Gillespie 1962, Bruce 1975, Lelligner 1985). The ranges and habitats of these species overlap. *Lycopodiella inundata*, for example, often occurs with *L. margueritae* and *L. subappressa* in Michigan (Appendix).

Distinguishing these four species can also be difficult. *Lycopodiella inundata* var. *bigelovii* Tuckerman is a synonym of *L. appressa* (Bruce 1975, Wagner & Beitel 1993); however, a few sources indicate that this variety may be distinct from *L. appressa* (Cody & Britton 1989, Robert Preston pers. comm. 2002). In addition, *L. subappressa* and *L. margueritae* are two new species that make up populations originally identified as *L. appressa* in southwestern Michigan (Bruce *et al.* 1991). *Lycopodiella subappressa* and *L. margueritae* are not only physically distinct from *L. appressa*, but they are also tetraploid instead of diploid like *L. appressa* (Bruce 1975, Bruce *et al.* 1991). All herbarium specimens of *L. appressa* from Michigan have been re-examined during the 1990s and have been annotated as either *L. subappressa* or *L. margueritae* (or were originally misidentified *L. inundata*) (Robert Preston pers. comm. 2002). Many documented occurrences, however, do not have voucher specimens and must be re-visited to determine their correct identification (Phyllis Higman pers. comm. 2002).

DESCRIPTION OF SPECIES

Like most Lycopodiaceae species, *Lycopodiella* species produce long rhizomes with aerial branches and adventitious roots (Figure 1, Wagner & Beitel 1993). Leaves are short and needle-like (< 2 cm), have no petiole, and are organized around the stem in spirals (Figure 2). Lycopodiaceae species are homosporous meaning that their spores have a single unisexual form that has the capacity to develop into bisexual gametophytes (Wagner & Beitel 1993). Each sporangium produces hundreds to thousands of spores and occurs singly in the axils of special leaves called sporophylls. In species of *Lycopodiella* and *Lycopodium*, sporangia and sporophylls are organized into a reproductive structure called a strobilus.

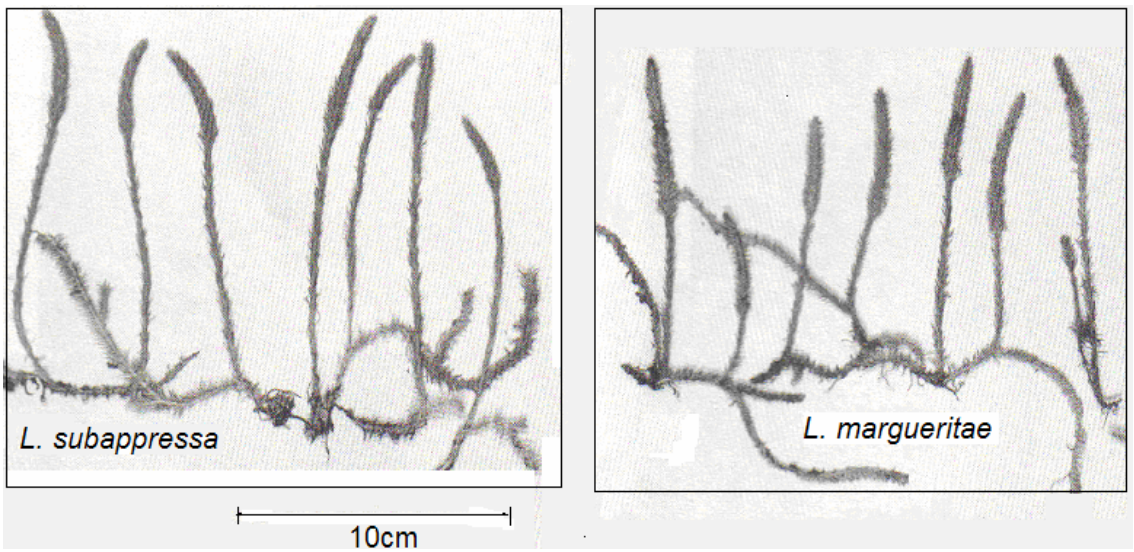


Figure 1. Dried specimens of *Lycopodiella subappressa* and *L. margueritae*. Photo from Bruce *et al*. (1991) printed in *The Michigan Botanist* (not copyrighted).

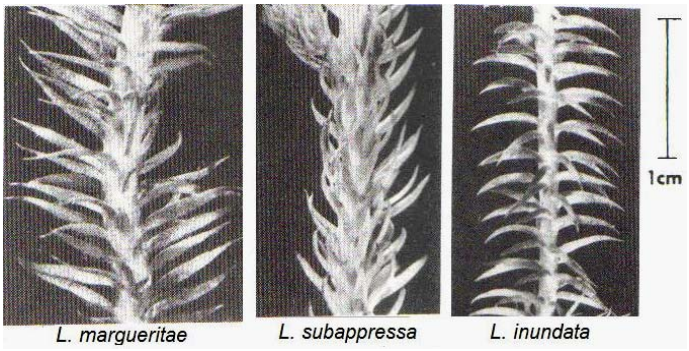
Lycopodiella subappressa, *L. margueritae*, *L. inundata*, and *L. appressa* share basic similarities. Rhizomes grow flat along the ground, unlike some species in the genus that have arching rhizomes (Figure 1, Wagner & Beitel 1993). Leaves of these species are of a similar size and shape (monomorphic) (Wagner & Beitel 1993). Vertical stems are unbranched and bear a single erect strobilus (Figure 1). Peduncles are leafy with similar sized leaves as the rhizomes and strobili. Spores have a wrinkled surface (rugulate), mature sporophylls are green, and sporangia are nearly spherical (Wagner & Beitel 1993).

Lycopodiella inundata has the most distinctive qualities compared to the other species. It tends to have shorter peduncles (3.5-6 cm tall), and its rhizomes (without leaves) have shorter diameters than the other three species (Figure 2a). In addition, sporophylls are spreading in *L. inundata*, while they are appressed in the three other species (Figure 2b).

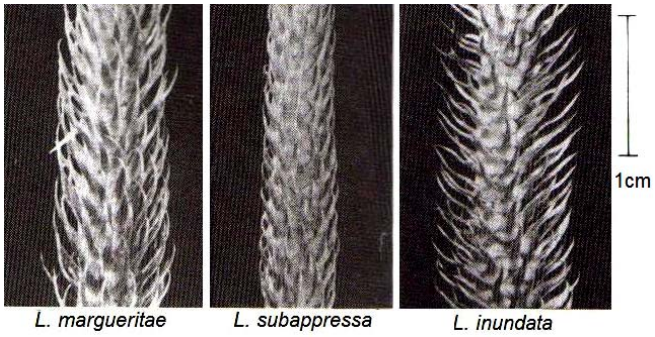
Lycopodiella appressa tends to have peduncles that are taller (13-40 cm tall) than those of *L. subappressa* or *L. margueritae* (Wagner & Beitel 1993). In turn, peduncles of *L. margueritae* tend to be taller than those of *L. subappressa*. *Lycopodiella margueritae* has thicker and longer strobili (relative to the peduncle) compared to *L. subappressa* or *L. appressa* (Figure 1, Wagner & Beitel 1993). *Lycopodiella appressa* has appressed leaves on all stems, while *L. margueritae* has spreading leaves on peduncles and rhizomes, and *L. subappressa* has leaves that ascend vertically on rhizomes (Wagner & Beitel 1993). Leaf lengths on rhizomes tend to be greater in *L. margueritae* than *L. subappressa* or *L. appressa*. *Lycopodiella margueritae* also has three to four teeth along rhizome leaves, while *L. subappressa* has no such teeth. The diameter of rhizomes is greater for *L. appressa* and *L. margueritae*, than for *L. subappressa*.

Table 2 displays the distinct characteristics of *Lycopodiella inundata*, *L. appressa*, *L. subappressa*, and *L. margueritae*. Plants have the greatest chance to be correctly distinguished if they are observed or sampled when they are mature, but not over mature

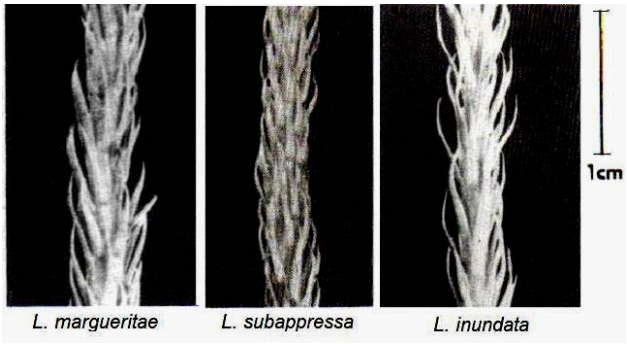
(August to late September) (Robert Preston pers. comm. 2002). *Lycopodiella subappressa*, *L. margueritae*, and *L. inundata* are known to readily hybridize (Bruce 1975, Bruce *et al.* 1991). Although hybrids between the diploid and tetraploid species are sterile, the sporophytes develop normally. Given the discreet morphological differences among these species, hybrids among species that occur together may make their identification difficult.



a) Rhizomes



b.) Strobili



c.) Leafy peduncles

Figure 2. Sections of living rhizomes (a), strobili (b), and leafy peduncles (c) from *Lycopodiella margueritae*, *L. subappressa*, and *L. inundata*. Photo from Bruce *et al*. (1991).

Table 2. Distinguishing characteristics of *Lycopodiella subappressa*, *L. margueritae*, *L. inundata*, and *L. appressa* as noted by Bruce *et al*. (1991) and Wagner & Beitel (1993). Characteristics in bold are used in keys to distinguish these species by one or both of these sources.

	L. subappressa	***L. margueritae***	***L. inundata***	***L. appressa***
Rhizome				
Length	4-17 cm	10-18 cm	3-12 cm	15-45 cm
Diameter*	**1-1.5 mm**	**1.8-2.2 mm**	**<1.0 mm**	**1.5-2.0 mm**
Leaf length	4-6 mm	6-13 mm	5-6 mm	5-7 mm
Leaf teeth	**absent**	**3-4**	**absent**	**0-7 ****
Leaf Orientation	vertically ascending	spreading (perpendicular)	spreading, upcurved	appressed
Fertile shoot				
Length	**(4) 9-14 cm**	**(7) 13-17 cm**	**3.5-6 cm**	**13-40**
Number/plant	1	1 (2)	1(2)	1-7
Peduncle				
Width	0.4-0.5 cm	0.3-0.7 cm	0.4-0.7 cm	0.3-0.4 cm
Leaf length	3.5-6 mm	5-6 mm	5-6 mm	3-5.3 mm
Leaf teeth	absent	0-2	rare	0-3
Leaf orientation	appressed	spreading (incurved tip)	spreading	appressed
Strobilus				
Length	2-4 (5) cm	5-8 cm	1.0-2.0 cm	2.5-6.0 cm
Width	4-8 mm	4-9 mm	2.5-5.5 mm	3-4 mm
Length relative to peduncle	1/5-1/3	1/3-1/2	1/3-1/2	1/6-1/3
Thickness relative to peduncle	**+ 0-2 mm**	**+(2) 3-6 mm**	**+(2) 3-6 mm**	**+ 0-2 mm**
Sporophyll				
Length	3-4 mm	4-6 mm	4.5-5.0 mm	3.5-5 mm
Width	0.2-0.5 mm	0.4-0.5 mm	0.5-0.9 mm	0.3 mm
Teeth	absent	absent	rare	absent
Leaf orientation	**appressed**	**appressed, incurved**	**spreading-ascending**	**appressed, incurved**
Chromosomes	2n=312	2n=312	2n = 156	2n = 156
Range	MI, OH, IN	MI, OH, IN, PA, VA, CT	Circumboreal	south and east coast of U.S.

*Diameter excluding the leaves.

***L. appressa* is keyed into the section described as "horizontal stem leaves with marginal teeth absent or sparse" Wagner and Beitel (1993).

LIFE HISTORY

The majority of the Lycopodiaceae are tropical species, many of which are epiphytes (Gifford and Foster 1989). Species adapted to temperate regions are primarily small terrestrial herbs. The Lycopodiaceae are descended from ancient plants of the Late Devonian period (381 million years ago [myr]) (Wikström & Kenrick 2000). *Lycopodium* and *Lycopodiella* are thought to have split into separate groups during the early Jurassic period, around 208 myr (Wikström & Kenrick 2000).

Reproduction

The basic life cycle of *Lycopodiella* is like that of all pteridophytes (Gifford and Foster 1989). The sporophytic phase of the life cycle (2N) produces spores through meiosis. Meiosis decreases the chromosome number by half (N). Spores disperse, germinate, and grow into free-living gametophytes. In diploid species, the spores and gametophytes are haploid. In tetraploid species, such as *L. margueritae* and *L. subappressa*, the spores and gametophytes are diploid. Homosporous plants, such as *Lycopodiella*, produce bisexual gametophytes. Sperm produced by antheridia of gametophytes can swim to fertilize eggs in archegonia (Gifford and Foster 1989). During fertilization the chromosomes from eggs and sperm are summed together, doubling the chromosome count. A sporophyte develops from the resulting zygote (Gifford and Foster 1989).

Unlike some Lycopodiaceae, *Lycopodiella* species do not reproduce asexually with gemmae or bulbils (Wagner & Beitel 1993). The sporophytes of species of *Lycopodiella* grow horizontal vegetative stems (rhizomes) with adventitious roots and vertical stems that develop strobili (Wagner & Beitel 1993). Roots develop from the tip of growing rhizomes. Both stems and roots branch dichotomously. Most Lycopodiaceae are evergreen, however stems (vertical and horizontal) of some *Lycopodiella* species, including *L. inundata*, are deciduous (Øllgaard 1979, Gifford and Foster 1989, Hitchock *et al*. 1977). Only the tips of swollen rhizomes overwinter and re-sprout in the spring in these species (Øllgaard 1979, Gifford and Foster 1989, Hitchock *et al*. 1977). Given that *L. inundata* is closely related to *L. subappressa* and *L. margueritae*, one might expect these species to die back in the fall. Robert Preston (pers. comm. 2002), however, indicated that he observed living rhizomes on *L. subappressa* and *L. margueritae* late in the fall.

Hundreds to thousands of microscopic spores ripen and disperse from openings in each sporangium during the late summer and fall (Gifford and Foster 1989). Spores from species with photosynthetic gametophytes, such as *Lycopodiella*, tend to germinate more rapidly than species with subterranean gametophytes (Whittier 1998). Species with subterranean gametophytes depend on a symbiotic relationship with endophytic fungi for development. In addition, they tend to be dependent on darkness for germination; therefore, they may need time to be buried before germinating (Whittier 1998). Such factors may inhibit rapid germination of spores. *Lycopodiella* gametophytes grow on the surface of the soil, are partially photosynthetic, and tend to have a weak relationship with endophytic fungi (Whittier 1998). Such factors may be related to the structure of the spore wall that allows rapid germination (Øllgaard 1987).

The conditions needed to germinate spores of Lycopodiaceae species are not well understood. Researchers can germinate a high percent of spores from other pteridophytes with mycorrhizal gametophytes within a few months (Whittier 1998). Whittier (1998) determined that even with optimal lab conditions, Lycopodiaceae gametophytes that are subterranean have a low percent of germination in one year. Although *L. appressa* has photosynthetic gametophytes, this species also had a poor rate of spore germination. Spores of *L. appressa* began germinating within one month of ripening; however, only 8.2% of spores germinated after one year (Whittier 1998). This species and one other known species with photosynthetic gametophytes had lower germination rates than some of the species with subterranean gametophytes (Whittier 1998).

Subterranean gametophytes may take ten or more years to mature (Gifford and Foster 1989). On the other hand, after spore germination *Lycopodiella* gametophytes tend to take 8 to 12 months to develop into mature gametophytes with both sex organs (Gifford and Foster 1989). Sex organs of *Lycopodiella* species tend to develop relatively close to each other near the base of aerial lobes. *Lycopodiella* gametophytes are difficult to locate as they can be less than 3 mm across and are shorter-lived than the subterranean gametophytes (Gifford and Foster 1989). They are ovoid to axial with short green aerial branches and colorless rhizoids (Gifford and Foster 1989).

Antheridia have a one cell thick covering that encloses spermatids. Spermatids develop into biflagellate sperm that exit the antheridia and swim across a thin film of water to reach archegonia of the same or neighboring gametophytes. Citric acid or salts of citric acid may attract sperm to the archegonia (Gifford and Foster 1989). Each archegonium has a neck with a path of canal cells that lead to the egg. The canal cells disintegrate forming the canal that the sperm swim down to reach the egg (Gifford and Foster 1989).

Cross-fertilization in the Lycopodiaceae may seem unlikely given that a small biflagellate sperm must swim across or through soil an unspecified distance to other randomly distributed gametophytes. Molecular data indicates, however, that Lycopodiaceae species cross-fertilize quite regularly (Gifford and Foster 1989, Haufler & Welling 1994). The common occurrence of hybrids within populations is additional evidence of frequent cross-fertilization. The mechanisms that promote cross-fertilization are poorly understood in Lycopodiaceae (Gifford and Foster 1989). Sperm from other pteridophytes have been documented as swimming 10 cm (Schneller 1988). In some fern species, cross-fertilization is promoted by pheromones produced by gametophytes with archegonia that induce neighboring gametophytes to develop only antheridia (Schneller 1988, Haufler & Welling 1994).

The embryo of *Lycopodiella* species develops into a “foot” that maintains a connection with the gametophyte (Gifford & Foster 1989). Subterranean gametophytes may produce more than one sporophyte over the course of their lifetime. However, the shorter lifespan of photosynthetic gametophytes may make it unlikely that they produce multiple sporophytes. Gametophytes may provide carbohydrates and nutrients to sporophytes through this connection, at least until photosynthetic leaves develop (Freeberg 1962).

Transfer cells develop a wall interface between the two stages that blocks passage of certain cell materials such as plasmodesmata (Peterson & Whittier 1991).

Related pteridophytes often hybridize. In most groups, hybrids have irregular meiosis and spores tend to be deformed (Wagner & Smith 1993). Species of *Lycopodiella* that hybridize with other species of the same ploidy level (*e.g*. diploids crossed with diploids or tetraploids crossed with tetraploids) produce offspring with normal-looking spores that may be fertile (Wagner & Smith 1993). These hybrids, nevertheless, do not appear to maintain themselves, as they usually are a minority of plants in populations (Wagner & Smith 1993). Species that cross with species of a different ploidy-level (*e.g* diploids crossed with tetraploids) produce hybrids that have irregular, inviable spores (Wagner & Beitel 1993). The diploid, *L. inundata*, for example, crossed with tetraploid species, *L. subappressa* or *L. margueritae*, produce triploid hybrids that have low fertility (Bruce *et al*. 1991).

Ecology

As mentioned in the "Reproduction" section, gametophytes of Lycopodiaceae typically have a symbiotic relationship with endophytic fungi. In subterranean species, this relationship may be obligate as gametophytes with six to eight spores stop development until they are infected (Gifford & Foster 1989). In the lab, however, gametophytes can be grown without a fungus infection. Species with photosynthetic gametophytes, like *Lycopodiella*, are less dependent on the fungus infection (Gifford & Foster 1989). Lycopodiaceae gametophytes have an increased growth rate with the fungus infection, suggesting that the fungus provides carbohydrates and nutrients to the gametophytes (Freeberg 1962).

Some species of ferns have been shown to have spore banks (Schneller 1988, Haufler & Welling 1994). In such species, spores accumulate in the soil and may be in a state of dormancy until certain conditions occur that initiate their germination. In some species, spores near the surface may germinate and produce a pheromone that promotes germination of spores in deeper soil (Haufler & Welling 1994). Such a mechanism has not been studied in Lycopodiaceae. Some Lycopodiaceae, especially species with subterranean gametophytes, have spores that do not germinate for years after dispersal (Gifford & Foster 1989), suggesting that they are in a state of dormancy. In addition, spore germination in the lab is very low for some species, such as *L. appressa* (Whittier 1998), suggesting that specific conditions are needed to initiate germination that have not yet been determined. Given that *L. subappressa* and *L. margueritae* have photosynthetic gametophytes, light is probably necessary for spore germination (Whittier 1998). If these species produce spore banks, germination may be initiated when spores are uncovered from a soil disturbance.

Dispersal/Migration

Direct evidence of pteridophyte spore-dispersal indicates that a majority of spores fall close to the parental sporophytes (Peck *et al*. 1990). Indirect evidence suggests that spores of pteridophytes can disperse long-distances by air convection due to their microscopic size (Lellinger 1985, Wagner & Smith 1993). Species, for example, have

been reported as occurring for short periods of time in locations distant from their normal range. These "accidental populations" are believed to be the result of the long-distance dispersal of spores and temporarily favorable conditions due to climate fluctuations (Lellinger 1985). In addition, many species have populations that are widely disjunct from the primary range of the species (Lellinger 1985). *Asplenium adiantum-nigrum*, for example, is a polyploid fern that occurs on isolated islands of the Hawaiian archipelago. Molecular isozyme evidence suggests that spores from the parental diploid species that occur exclusively in Europe dispersed to the islands between 3 and 17 times (Ranker *et al.* 1994, cited in Briggs & Walter 1997).

Growth requirements may limit the distribution and range of pteridophytes more than spore dispersal (Lellinger 1985). Specific conditions such as temperature, soil moisture, soil pH, and soil type affect spore germination, gametophyte development, and sporophyte development. In addition, species may be limited by competition from other plant species. Peck *et al.* (1990) indicates that long-distance establishment not only depends on long-distance dispersal and favorable conditions, but also the ability for isolated spores to produce gametophytes that can self-fertilize and produce healthy sporophytes.

HABITAT

Range-wide

The known habitats of *L. subappressa* and *L. margueritae* are generally indistinguishable. Differences in their habitats may become apparent as more populations are identified. In Flora of North America, Wagner and Beitel (1993, p. 540) describe the habitats of *L. subappressa* and *L. margueritae* as "wet, acidic ditches and borrow pits." Bruce (1975, p.82) indicates that species within the *L. inundata* complex in the western Great Lakes region (including *L. inundata*, *L. subappressa*, *L. margueritae*, and their three hybrids) occur in "sandy borrow pits, ditches, dune swales, pond margins, and occasionally bogs."

Michigan

With roughly 39 populations, Michigan has a majority of all of the known populations of *L. subappressa* and *L. margueritae* (many of which are still identified as *L. appressa*) (Appendix). Most populations occur near coasts of the Great Lakes. Nearly 70% of populations in Michigan are in counties bordering Lake Michigan, 13% are in counties bordering Lake Erie, Lake Huron, or Lake Superior, while less than 18% of populations are located in inland counties (Appendix). The soil is usually described as sandy and moist or intermittently wet. Populations that occur in natural habitats tend to occur in rare ecological communities including coastal plain marshes (five populations), lakeplain wet prairies (two populations), and dune habitats (six populations) such as interdunal wetlands (Appendix). These three ecological communities are listed by NatureServe Explorer (2001) as ranging from globally imperiled to vulnerable (ranked G2 to G3, see "Rangewide Status" for explanation of G-rankings). Other natural habitats include intermittent wetlands, sedge meadows, and bogs. Over half of the populations occur in disturbed areas such as old excavation pits or borrow pits, along roads or highways, and along a pipeline. A few of the populations in borrow pits are near or in disturbed lakeplain wet prairies, dunes, or coastal plain marshes.

In Michigan, any combination of *L. margueritae, L. subappressa, L. inundata,* and their hybrids may be found together. Jack pine (*Pinus banksiana)* is the only tree species that is mentioned as growing in the vicinity of a few populations. *Chamaedaphne calyculata* (leatherleaf) is the only shrub species mentioned as a dominant species in two of the populations. Graminoids are the most dominant and diverse group that are associated with these *Lycopodiella* populations. The most often mentioned species of graminoids are *Rhyncospora capitellata* (brown beak rush) and *Juncus* species (rush). *Polytrichum* moss was noted to occur in three populations. Below is a list of species associated with populations of L. *subappressa* and *L. margueritae* (listed as *L. appressa* in the Michigan Natural Features [MNFI] database 2002).

> Shrub species: *Chamaedaphne calyculata* (leatherleaf), *Salix* species (willow), *Ilex verticillata* (holly), *Rubus hispidus* (bristly blackberry), *Spirea tomentosa* (hardhack), *Vaccinium macrocarpon* (cranberry).
>
> Graminoid species: *Rhyncospora capitellata* (brown beak rush) and *Juncus* species (rush), *Rhynchospora fusca* (gray beak rush), *Calamograstis canadensis* (bluejoint), *Carex* species (sedges), *Cladium mariscoides* (twig-rush), *Fimbristylis* species (sedge), *Muhlenbergia uniflora* (muhly), *Scirpus cyperinus* (bull-rush), and *Xyris torta* (twisted yellow-eye).
>
> Non-graminoid herbaceous species: *Drosera rotundifolia* (round-leaved sundew), *Euthamia remota* (goldenrod), *Hypericum* species (St. John's wort), *Viola lanceolata* (lance-leaved violet), *Bartonia virgini*a (yellow screw-stem) *Drosera intermedia* (spoon-leaved sundew), *Eupatorium perfoliatum* (boneset), *Ludwigia* spp. (water-primrose), *Platanthera dilatata* (rein-orchid), *Rhexia virginica*, (Virginia meadow beauty), *Utricularia subulata* (slender bladderwort).

Other states

The five occurrences of *L. subappressa* and *L. margueritae* in Indiana are in wet or disturbed prairies and a bog: Four of the occurrences are in counties bordering Lake Michigan (Appendix). The single element occurrence of *L. margueritae* in Virginia occurs in the floodplain of a creek (Appendix, Virginia Department of Conservation and Recreation 2002). The population occurs near ponds that may be the result of sand excavations (borrow pits). The habitats of populations in Connecticut, Ohio, and Pennsylvania are not known.

National Forests

Huron-Manistee National Forest, Michigan

The *Lycopodiella* population on the Huron-Manistee National Forest that is listed as *L. appressa* by the MNFI, has recently been re-evaluated and is now identified as *L. subappressa* (Alix Cleveland pers. comm. 2002). The only description available of this population is that it occurs in three localized locations (Appendix, MNFI 2002).

Hiawatha National Forest, Michigan

The Hiawatha National Forest has one population of *L. margueritae* which occurs in a 10 x 12 ft square area (Appendix, MNFI 2002). The soil is moist (seasonally wet), sandy and calcareous. The habitat is open and somewhat disturbed as it occurs along an old pipeline. Associated species include *Scirpus cyperinus* (bull-rush), *Juncus* species (rush), *Hypericum perforatum* (St. John's wort), *Vaccinium macrocarpon* (cranberry), *Chamaedaphne calyculata* (leatherleaf), and *Calamograstis canadensis* (bluejoint) (Appendix, MNFI 2002).

DISTRIBUTION AND ABUNDANCE

Range-wide Distribution

Given that *L. margueritae* and *L. subappressa* have been described relatively recently, their known ranges are limited and may be incomplete. Currently *L. margueritae* is known to occur in the Midwestern states of Michigan, Indiana, and Ohio and disjunct locations occur in the eastern states of Virginia, Pennsylvania, and Connecticut (Table 3, PLANTS 2002). *Lycopodiella subappressa* is known to occur only in a limited area of the Midwest including Illinois, Indiana, Ohio, and Michigan (Table 3, PLANTS 2002).

Table 3. The number of occurrences of *L. subappressa* (LYSU2) and *L. margueritae* (LYMA7) in each state that these species are known to occur.

State	LYSU2 identified (without LYMA7)	LYMA7 identified (without LYSU2)	LYSU2 and LYMA7 present together	Occurrences identified as *L. appressa*	Total occurrences of LYSU2 or LYMA7
Illinois	1				1
Indiana	4	1			5
Michigan	7	4	5	23*	39
Ohio	8	3			11
Pennsylvania		1			1
Virginia		1			1
Connecticut		1			1
Total	20	11	5	23	59

Sources (See details in Appendix): MNFI 2002 (MI); Notes of Preston and Wagner 1998 (IL, IN, MI); Field notes of Wagner (IN, MI); Pennsylvania Natural Diversity Inventory 2002 (PA); Mehrhoff 1998(CT); Debbie Woischke, pers. com. (OH); Virginia Department of Conservation and Recreation 2002 (VA).

*Occurrences listed as *L. appressa* in Michigan need to be reassessed to determine their identification and are assumed to be a combination of *L. subappressa* and *L. margueritae*.

State and National Forest Distribution

The known ranges of *L. margueritae* and *L. subappressa* are within the boundaries of the Eastern Region of the U.S. Forest Service. Michigan, by far, has the most known locations of both species with potentially 39 occurrences (Table 3, Appendix).

Lycopodiella subappressa has been identified (without *L. margueritae*) in seven of these Michigan populations. *Lycopodiella margueritae* has been identified (without *L. subappressa*) in four populations. *Lycopodiella subappressa* and *L. margueritae* have been identified as occurring together in five of the Michigan populations. Twenty-three populations are still identified as *L. appressa*. Populations identified as *L. appressa* most likely consist of a combination of *L. subappressa* and *L. margueritae* plants and need to be re-evaluated. Given the difficulty in distinguishing *Lycopodiella* species, some of the populations of *L. appressa* that were identified in the field without submission of a voucher specimen could be misidentified populations of the more common *Lycopodiella* species, *L. inundata* (Robert Preston, pers. comm. 2002).

Outside Michigan occurrences of *L. subappressa* and *L. margueritae* are scarce and disjunct. Three occurrences of *L. margueritae* are known in three northern counties of Ohio (Geauga, Lake and Portage) (Ohio Division of Natural Areas and Preserves 2000). In addition, Virginia, Pennsylvania, Indiana and Connecticut each have one occurrence of *L. margueritae* (Table 3). Four populations of *L. subappressa* occur in the counties of Indiana that border Lake Michigan (Lake, La Porte, and Porter). Eight populations of *L. subappressa* occur in Lucas County in Ohio, and Illinois has a single historical population (Table 3, Appendix).

RANGE WIDE STATUS

The Nature Conservancy's Ranking

Range wide status can be assessed by a ranking system developed by The Nature Conservancy, NatureServe, and the Natural Heritage Network (NatureServe Explorer 2001). This ranking system uses information on species that are tracked by The Nature Conservancy and Natural Heritage Programs throughout the world. The global ranking (G-rank) gives the status of a species throughout its range. Each country where the species occurs has a national ranking (N-rank) that indicates the species vulnerability within that country. If the species occurs within the boundaries of provinces, states, or other divisions within a country, the species is given a subnational ranking (S-rank) for that area (NatureServe Explorer 2001).

The number or letter following G, N, or S is the ranking of current vulnerability of the species within the given geographical boundary (Nature Serve Explorer 2001). Numeral ratings range from 1 to 5. The more vulnerable a species is to extirpation within the given geographical boundary, the lower the numeral rating. If a letter or punctuation follows the G, N, or S, the current status has not been determined; the letter indicates what is known about the species (Nature Serve Explorer 2001).

L. margueritae has a global rank of "G2" (26 Jan. 1996) indicating that it is "imperiled" throughout most of its range (NatureServe Explorer 2001). The national rank in the United States is "imperiled" or "N2" (4 Dec. 1995). The status of *L. margueritae* is "critically imperiled" in Virginia and Ohio (S1) and "imperiled" in Michigan (S2, Table 4). The species is "under review" (SU) in Pennsylvania. Nature Serve Explorer (2001) does not list this species as occurring in any other state, however PLANTS (2001) and Mehrhoff (1998)

indicates that the species also occurs in Connecticut where its rarity is currently "unrankable" (SU).

Like *L. margueritae*, *L. subappressa* is ranked as "imperiled" globally (G2, 26 Jan. 1996) and "imperiled" in the United States (N2, 4 Dec. 1995). *Lycopodiella subappressa* is ranked as "critically imperiled" (S1) in Indiana and Ohio, and "imperiled" (S2) in Michigan (Table 4).

Table 4. Rarity status of (a.) *L. margueritae* and (b.) *L. subappressa* in each U.S. state that these species are known to occur. Species rarity within a given state is indicated by its subnational (S) ranking (S1 = critically imperiled, S2 = imperiled, SU =unrankable or under review). Natural Heritage rankings are given by Nature Serve Explorer (2001) except for Connecticut which is cited from Mehrhoff (1998). State listings are cited from state agencies including: Indiana (Indiana Division of Nature Preserves 2002), Michigan (MNFI 2001), Ohio (Ohio Division of Natural Areas and Preserves 2000), Pennsylvania (Pennsylvania Natural Diversity Inventory 2002), and Virginia (Townsend 2002).

a. ***Lycopodiella margueritae***

State	State Listing	Natural Heritage Rank
Connecticut	Not listed	SU
Michigan	Threatened	S2
Ohio	Endangered	S1
Pennsylvania	Proposed Endangered	SU
Virginia	Not listed, but tracked	S1

b. ***Lycopodiella subappressa***

State	State Listing	Natural Heritage Rank
Indiana	Endangered	S1
Michigan	Special Concern	S2
Ohio	Endangered	S1

Ranking by States and the U.S. Forest Service

Lycopodiella margueritae is listed by Michigan as "threatened" and Ohio as "endangered" (Table 4). Pennsylvania currently has not listed the species, but it has been proposed to be listed as "endangered." Virginia tracks *L. margueritae* due to its subnational ranking of S1 and includes it in a list of rare species (Table 4). The state, however, does not officially list the species as "endangered" or "threatened." (Only fifteen vascular plant species are listed officially by Virginia as rare species.) *Lycopodiella subappressa* has been listed by the states of Ohio and Indiana as "endangered." Michigan has listed this species as "special concern" (Table 4).

Lycopodiella margueritae is listed on the Hiawatha National Forest as a regional forester sensitive species, while Huron-Manistee National Forest has listed *L. appressa* as a

regional forester sensitive species on that Forest (USDA Forest Service 2003). The population on the Huron-Manistee National Forest has been recently re-identified as *L. subappressa* (Alix Cleveland, pers. comm. 2002). When the list of regional forester sensitive species from each national forest is next updated, the correct identification of this population will be included. In any case, these *Lycopodiella* populations that have been located, whatever their identification, are currently protected as regional forester sensitive species.

POPULATION BIOLOGY AND VIABILITY

Little information is available regarding the population biology of Lycopodiaceae species. Most research on this group has been directed towards understanding the difficult taxonomy of these plants. Population biology may be difficult to study due to the problems in following the complete life cycle of these species. Spores may not germinate for years and may be difficult to locate given their microscopic size. In addition, gametophytes are difficult to locate and slow to develop. Given the lack of knowledge regarding the population dynamics of *Lycopodiella* species, assessing the viability of populations is difficult. The viability of *L. subappressa* and *L. margueritae* populations may be especially difficult to ascertain as these species have been described quite recently. The correct identification of some populations has not been determined and new populations are still being located.

Despite the poor understanding of *Lycopodiella* population biology, a few interesting and unusual characteristics of populations are worth discussing. Despite being quite rare throughout their range, *L. subappressa* and *L. margueritae* often occur in quite disturbed locations such as borrow pits and ditches. For pteridophytes, disturbance-dependency is not that unusual as spores and gametophytes often need bare soil in order to germinate and develop (Wagner & Smith 1993). However, one might expect that a rare species would be located more often in naturally disturbed habitats or relatively mildly disturbed locations. By contrast, these species are often located in areas that are rather severely disturbed by human activities such as borrow pits where the soil has been excavated. If species can establish on such disturbed locations, one might expect that their populations would increase with the presence of humans. Such an increase in the size or number of populations has not been documented. Certain borrow pits may have qualities similar to some natural occurring disturbances. Borrow pits, like other disturbed locations may have less competition from other species. Sandy and acidic soil tends to be nutrient poor and stressful for many plant species. Such conditions may indicate that these *Lycopodiella* species are relatively stress tolerant. Species that are stress tolerant tend to be able to persist in resource-deprived locations and tend to be poor competitors (Barbour *et al*. 1987).

Another unusual characteristic of populations is that two or three *Lycopodiella* species often occur in the same location (Appendix). Given that many of these populations occur on areas disturbed by humans and the species seem dependent on the disturbed nature of the habitat, one would expect that the populations are relatively young. One might expect that the nearly simultaneous establishment of three different species, two of which are rare, in the same locations would be an uncommon, chance event. Lellinger (1985)

indicates, however, that because pteridophytes have very good spore dispersal, the establishment of pteridophytes is more limited by appropriate conditions than by their dispersal to a given location. Lellinger's description of spore dispersal suggests that any soil miles from established pteridophyte populations may have a mixture of microscopic spores from the local pteridophytes. Only spores that happen to fall in a suitable location ultimately germinate and have an opportunity to establish. If *L. subappressa*, *L. margueritae*, and *L. inundata* need very similar conditions to germinate and establish (wet, disturbed, and sandy soil), they may incidentally establish together quite regularly.

Establishment from a persistent spore bank could be another factor that allows multiple *Lycopodiella* species to establish together. Angiosperms adapted to habitats with unpredictable disturbances tend to have seed banks (Barbour *et al*. 1987). In fact, coastal plain marshes, a natural habitat in which *L. subappressa* and *L. margueritae* have been found, have a community of angiosperms that depend on seed banks for establishment (Kost 2000). In addition, certain pteridophytes can have persistent spore banks (Schneller 1988, Haufler & Welling 1994). However, Lycopodiaceae species with photosynthetic gametophytes, such as *Lycopodiella*, may be less likely to have spore banks than other Lycopodiaceae species (See "Life History-Ecology" section). If these species of *Lycopodiella* can have persistent spore banks, the disturbances may uncover spores that had been in the soil for many years. The conditions created by the disturbance may influence the spores to germinate.

Populations of *L. subappressa* and *L. margueritae*, in addition, tend to grow together within the same community where they readily hybridize and produce hybrids with normal-looking spores. In some cases, hybrids of species not present in a locality may also be found (Robert Preston pers. comm. 2002). Hybrids of most genera produce irregularly shaped spores that have very low viability, while spores of *Lycopodiella* hybrids appear to have normal meiosis and are suspected to be viable (Wagner & Smith 1993). The ability of plants to produce fertile hybrids brings up fundamental questions of how these species maintain their species identities. On the other hand, the fertility of *Lycopodiella* hybrids and their offspring has not been studied. The fact that hybrids tend not to establish their own populations, that backcrossing of hybrids has not been documented, and that hybrids do not expand their range without parental species (Wagner & Smith 1993) suggest that hybrids and their descendents are not as fertile as non-hybridized plants.

Possibly the establishment of these species together with their hybrids is partially related to unnatural disturbances. Disturbed habitats apparently can reduce the ecological isolation of two species (Briggs & Walters 1997, Futuyma 1986). Related species, for example, that usually do not co-occur due to habitat differences have been found together along with hybrids in disturbed habitats. Such an effect has been observed in other plant species such as *Geum* in Europe (Briggs & Walters 1997). Habitat differences are not known between *L. subappressa* and *L. margueritae*. From descriptions of known occurrences, it is difficult to determine if these species occur together even in the most natural conditions. Hybridization often occurs in "hybrid zones" where the range of two species overlaps. Usually the hybrid zone is a small portion of the species' range.

Contrary to this generalization, the known ranges of *L. margueritae* and *L. subappressa* apparently are centered in southwestern Michigan.

POTENTIAL THREATS

Rarity

The rarity of *L. margueritae* and *L. subappressa* is probably the greatest threat to these species. Only 59 known populations containing one or both of these species are currently known (Table 3). These species are listed as "imperiled" both globally and within the U.S. (See Range Wide Status). If current populations decline, these species could become extinct quickly.

Loss of Habitat

Loss of habitat may be a significant threat to populations. Populations that occur in natural habitats tend to occur in rare ecological communities including coastal plain marshes, lakeplain wet prairies, and dune habitats (Appendix). NatureServe (2001) and the MNFI (2002), in fact, list some of these ecological communities as vulnerable or imperiled. In Michigan, the plant community of coastal plain marshes is “very sensitive to hydrologic disturbance and may be severely degraded by shoreline development, draining, damming, dredging, or filling” (Kost 2000, p.1). In Michigan, lakeplain wet prairies have been “reduced so that today less than 1% of the original community remains” (Albert & Kost 1998, p.1). If these species are adapted to these habitats, occurrences of *L. margueritae* and *L. subappressa* may be limited by the quality and quantity of natural habitat.

Hybridization

Lycopodiella subappressa and *L. margueritae* co-occur in a number of locations in Michigan (Table 3; Appendix). Hybrids from these two species produce spores that appear normal and possibly are viable (Wagner & Smith 1993). If hybrids are fertile, the loss of species integrity due to hybridization may be a significant threat to these species. Such a process could be natural and difficult, if not illogical, to attempt to prevent. On the other hand, human influenced habitats, such as borrow pits, may be decreasing the influence of the ecological isolation that may have separated populations of these species prior to European colonization (Briggs & Walters 1997, Futuyma 1986). In addition, natural habitats where the species would be isolated from one another due to ecological differences may have declined or been lost. Currently these species appear physically distinct (Bruce *et al*. 1991). Evolution, however, is a slow process that cannot necessarily be evident at a given time. One would expect that if these two species have identical habitats, similar ranges, and fertile hybrids, their species integrity may be threatened. Research needs to be carried out to determine if hybrids and their descendents are fertile in order to know if this threat is significant (See Research Priorities).

Limited knowledge of how populations are established and maintained may delay management or lead to inappropriate management of populations. For example, maintaining human disturbed areas in which these rare *Lycopodiella* species occur together could increase hybridization between *L. subappressa* and *L. margueritae*. Such

hybridizing, in turn, may decrease the species integrity of these two species and may ultimately be threatening to these species. On the other hand, if these species occur together naturally and hybridization is not a threat to populations, all populations should be managed equally. Not managing locations that are in disturbed habitats could, in this case, be harmful to the species.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

Of the fourteen populations in Michigan that are known to occur on public land or lands that manage for rare plants, four occur in nature preserves managed by non-profit organizations, four occur in state parks, two occur in national forests, one occurs in a U.S. military reservation, and three occur in Critical Dune Areas (MNFI 2002). The nature preserves probably provide the greatest protection as they are primarily managed to protect rare plants and animals within their boundaries. Critical Dune Areas are areas that are protected by Michigan's Sand Dune Protection and Management Act (Michigan Department of Environmental Quality 2003). Permits must be obtained in order for development, recreation, or other uses of these lands. Due to the special listing of these species by the MNFI and national forests, management activities that occur on state and Forest Service lands would avoid disturbing known populations of *L. subappressa* or *L. margueritae*.

Nearly two-thirds of the *L. subappressa* and *L margueritae* populations in Michigan occur on land with private or unknown ownership (MNFI database 2002, Appendix). Local non-profit and government groups are working together to raise money to purchase the lakeplain wet prairie where one of these populations occurs (Button 2002). Three populations with uncertain ownership are close to highways, and therefore they may be managed by the Michigan Department of Transportation. Eight of the populations on land with unknown ownership were last visited in 1970 or earlier. Two of these were last visited in the 1880s making their persistence questionable. One of these historic populations was in an area that is now quite developed (MNFI 2002).

Two of the five populations of these *Lycopodiella* species in Indiana are in nature preserves and two other populations are on federal land. The population of *L. margueritae* in Virginia is on private land (Appendix). Given that the voucher specimen of *L. subappressa* in Illinois was collected in 1947 in the vicinity of Chicago, the persistence of this population is not likely. Land ownership in locations where *L. margueritae* occurs in Ohio, Pennsylvania and Connecticut is unknown.

RESEARCH AND MONITORING

Existing Surveys, Monitoring, and Research

The only research of *L. subappressa* and *L. margueritae* has been taxonomic studies by Bruce (1975) and Bruce *et al.* (1991). Bruce (1975) described theses two species and determined that they were both tetraploids. In 1991, Bruce *et al.* formally named these species. Since 1991, herbarium specimens of *L. appressa* in Michigan have been examined to determine if they are *L. subappressa* or *L. margueritae* (Robert Preston pers. comm. 2002). Due to their status as regional forester sensitive species, the Hiawatha and

the Huron-Manistee National Forests conduct surveys for *L. margueritae* and *L. subappressa* when management projects are proposed in potential habitats of these species.

Survey Protocol

1. The current populations of rare *Lycopodiella* species that occur on the Hiawatha National Forest and the Huron-Manistee National Forest should be located and thoroughly described. A thorough survey could finalize the identity of these populations. Well qualified botanists should be in charge of the surveys given the difficulty in distinguishing *Lycopodiella* species. If the populations are of an adequate size, a few representatives of each population should be sampled and sent to the University of Michigan Herbarium. A few important factors should be described in the populations such as the numbers of reproductive individuals, associated species, level of disturbance, soil moisture, soil type and soil pH.

2. Surveying for additional populations of *L. subappressa* and *L. margueritae* could be beneficial to the protection of these species. Given their global rarity, the persistence of these species may depend on protecting any populations that exist. Searches could be directed to the rare ecological communities that they have been found (interdunal wetlands, inland coastal marshes, and lakeplain wet prairies), in addition to borrow pits or other temporally wet and sandy locations that are somewhat disturbed. Due to the rarity of these species and the confusion in their identification, new populations would provide an important source of information. Site information from new populations would give clues regarding the optimal habitat of these species.

Research Priorities

Little is known about *L. subappressa* and *L. margueritae*. Research could be carried out regarding almost any aspect of their biology.

1) **Analyze habitat information**. The current habitat descriptions of *L. subappressa* and *L. margueritae* are virtually identical. Given that the hybrids of these species produce normal-looking spores and that they have nearly overlapping ranges, one would expect that ecological differences might isolate these species under natural conditions. Possibly these species occur together in certain habitats, but are never found together in other habitats. Thorough descriptions of each population's habitat might clarify habitat differences. Habitats could be classified by the degree that they have been disturbed by human impacts. One could then determine if the populations that have been least disturbed tend to have a single *Lycopodiella* species present. If species do occur in distinct undisturbed locations, it would be important to protect the most natural occurrences.

2) **Annual cycles of rhizome growth.** As discussed in the "Life History" section, some *Lycopodiella* species such as *L. inundata* have deciduous rhizomes that leave only a stem tuber that persists through the winter. Other *Lycopodiella* species have persistent rhizomes. Population dynamics may be different for these two different life history strategies. In addition, such a character might assist in distinguishing

Lycopodiella species. A simple study could determine if rhizomes are persistent during the winter for *L. subappressa* and *L. margueritae*. Individual plants could be labeled and observed monthly to track rhizomatous growth from spring to late fall.

3) **Transplantation.** If *L. subappressa* and *L. margueritae* can persist after being transplanted, populations or portions of populations could be moved before being destroyed by unavoidable disturbances. Development or construction projects in the area where a population occurs might include such an experiment as a condition of development or construction. Attempting to move a population should be avoided if possible as the likelihood of the successful establishment of a persistent new population is unknown and could be unlikely. First, a suitable location into which the plants could be transplanted into should be chosen. The new location should have a similar habitat and be in the general vicinity of the original location. In addition, it should be in an area that would be unlikely to be disturbed by humans. The location should be open with a similar soil pH, soil moisture, soil texture, and plant associations as the original location. A set of plants could be transplanted into a greenhouse or garden and transplanted a second time into the new population site once they are healthy. Such a technique may increase the probability that plants survive transplantation.

Gifford and Foster (1989, p.114) suggest three means by which Lycopodiaceae species can be sampled for propagation:

a) "Obtain a portion of the plant with intact roots"
b) "Use the upper portion of a shoot (since roots are initiated near the tip)"
c) "Secure a portion of the stem with arrested roots which emerge from the stem cortex on contact with a moist surface. Arrested roots may be identified as mounds on the underside of the stem of a prostrate form."

Rhizomes with intact roots (a) may be the most likely samples to survive as they do not have to develop new roots. A portion of rhizomes or stems without developed roots (b and c) could also be grown to test the survival of such samples. Given the care that samples without developed roots would need, they would have to be transplanted into a greenhouse until roots develop.

Propagation of ferns as described by the American Horticultural Society (1999) may be similar to that of fern allies such as Lycopodiaceae species. The American Horticultural Society suggests that transplantation of rhizomes from ferns should be carried out in early to mid spring to give the plants the entire growing season to establish. American Horticultural Society (1999) suggests that 5 to 8 cm of rhizome with a root system should be sampled. Ferns with surface rhizomes should not be buried very deeply, if at all. They could be pegged down or pressed into the soil. If they are grown in a greenhouse, they should be planted individually in soiless potting mix. If roots are attached, the rhizome should be set at the same level as it was before transplantation. The rhizomes should be kept moist until they start growing, which could be two to three months.

4) **Spore germination; gametophyte and sporophyte development.** One could determine the best conditions needed to germinate *L. appressa, L. inundata, L. margueritae*, and *L. subappressa* spores. Spores that germinate could be followed through development to the sporophyte stage. One could grow sets of each species under certain conditions to determine what conditions are optimal for each species. Conditions such as the soil moisture, pH, and nutrient level could vary for each set. Sporophytes that develop could be used for other research.

5) **Determine hybrid fertility.** The development of poorly formed spores is used as an indicator that hybrids of pteridophytes are sterile (Wagner & Smith 1993). The fact that hybrids of *L. subappressa* and *L. margueritae* produce normal-looking spores suggests that they are fertile. *Lycopodiella* is cited as one of two genera of Lycopodiaceae that produces fertile hybrids (Wagner & Smith 1993). To positively determine the fertility of hybrids, one would need to determine if spores from hybrids germinate and grow into gametophytes at a similar rate as parental species. To do this, one would put spores of *L. subappressa, L. margueritae*, and hybrids of these species under conditions to promote germination such is described by Whittier (1998). Given that these species have photosynthetic gametophytes, the spores may germinate soon after ripening (Whittier 1998). Such a study may seem straightforward; however, conditions needed to germinate Lycopodiaceae spores are not completely understood (Whittier 1998). Hybrid fertility not only is dependent on spore germination, but also the healthy development of gametophytes and the ability of gametophytes to produce healthy sporophytes that can also produce normal spores.

6) **Taxonomic study.** A molecular study of *Lycopodiella* species could determine the relations of the different species. Such a study could indicate how genetically distinct each species is. In addition, it could indicate how long species have been genetically isolated from one another. Such a study could also determine the parental diploid species that evolved into the tetraploid species.

7) **Spore origins.** Possibly *Lycopodiella* spores are within a spore bank in the soil and germinate after the soil is disturbed. Alternatively, spores may disperse into a site after the disturbance occurred given the capacity of spores to disperse long-distances. Although a study that would determine the origins of spores that establish new populations would be very interesting, it may be difficult to design. Spore banks could be determined by taking soil samples at various depths and putting the soil in optimal growing conditions. The depth of the spores should correlate with the length of time that they were dispersed. To carry out such a study, one could follow the methods of other studies of spore banks such as Schneller (1988) or Dyer and Lindsay (1992, cited in Haufler & Welling 1994). One problem for such a study is that the conditions to promote spore germination for *Lycopodiella* species are not well understood (Whittier 1998).

   Most studies on the distance of spore dispersal are based on indirect evidence such as the expectation that small spores should be capable of being carried long-distances and the number of disjunct populations that pteridophytes have compared to

angiosperms (Lellinger 1985, Haufler & Welling 1994). Direct evidence of spore dispersal has only indicated that many spores fall close to plants (Peck *et al*. 1990, see "Dispersal" section). Such studies have not detected the number of spores that are actually carried long-distances. Even if the proportion of spores that are carried long-distances is small, they have potential to establish new populations. To determine the actual spore-dispersal, one would have to design an innovative study that could track spores after their dispersal and determine the source from which they originated.

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APPENDIX

Element Occurrences of *Lycopodiella subappressa* and *L. margueritae*.
This appendix lists known element occurrences of *Lycopodiella subappressa* and *L. margueritae* in Illinois, Indiana, Michigan, and Virginia. Descriptions are in alphabetical order by location (U.S. state and county).

Sources of element occurrences are from the MNFI (2002), the Indiana Natural Heritage Data Center (2002), and the Virginia Department of Conservation and Recreation, Division of Natural Heritage (2002). An additional source for element occurrence information was from the field notebook of Warren H. Wagner, Jr. from 1986 to 1999 that was transcribed by Robert Preston on November 30, 2001. Another source is the notes from Robert Preston and Warren H. Wagner, Jr. from their examination of herbaria specimens from the University of Georgia Herbarium (September 18, 1998) and Morton Arboretum Herbarium (May 29, 1998). Occurrences listed as *L. appressa* from Michigan need to be re-evaluated, as they are most likely *L. subappressa*, *L. margueritae*, or *L. inundata*. The name given in parenthesis is the revised name as noted in the "Source of Information" section that may not yet be on the herbarium label.

Illinois

Identification:	*L. subappressa*
Location:	Cook County
Year(s) observed:	September 6, 1947
Source of Information:	Notes of Preston and Wagner 1998; voucher at Morton Arboretum Herbarium (MOR).

Indiana

Identification:	*L. marguaritae* (?), *L. inundata* X *subappressa*
Location:	Jasper County
Year(s) observed:	August 14, 1986
Ownership:	Nature preserve
Source of Information:	Notes of Preston and Wagner 1998; voucher at MOR

Identification:	*L. subappressa*
Location:	Lake County
Year(s) observed:	July 24, 1997
Ownership	Nature preserve
Habitat:	Wet meadow
Source of Information:	Field notebook of Warren H. Wagner

Identification:	*L. subappressa*
Location:	Lake County
Year(s) observed:	July 24, 1997
Ownership	Nature preserve

Source of Information:	Field notebook of Warren H. Wagner

Identification:	*L. subappressa*
Location:	La Porte County
Year(s) observed:	November 1, 1970
Habitat:	Floating in acid bog.
Source of Information:	Notes of Preston and Wagner 1998; voucher at MOR

Identification:	*Lycopodiella subappressa*
Location:	Porter County
Year(s) observed:	1994, 1995
Ownership:	U.S. Park Service
Population size:	"1995: approximately 1,001-10,000 mature individuals in leaf growing in a small colony or large carpet in an open 100 sq yd-2 acre…Reproduces sexually and asexually."
Habitat:	"1995: mesic to xeric sand and humus area that is on a flat to 0-10 degree bottom slope…This is a disturbed prairie."
Source of Information:	The Indiana Natural Heritage Data Center 2002, Field notebook of Warren H. Wagner

Michigan

Identification:	*Lycopodiella appressa*
Location:	Allegan County
Year(s) observed:	November 1970
Habitat:	"A roadside borrow pit of low, moist sand. Local in open places with *Lycopodium inudatum*."
Source of Information:	MNFI 2002, Occurrence 1

Identification:	*Lycopodiella appressa*
Location:	Allegan/Ottawa Counties
Year(s) observed:	May 1871
Ownership:	Unknown. Much residential development.
Source of Information:	MNFI 2002, Occurrence 7

Identification:	*Lycopodiella appressa*
Location:	Berrien County
Year(s) observed:	October 1960
Habitat:	"A moist interdunal swale."
Source of Information:	MNFI 2002, Occurrence 2

Identification:	*Lycopodiella appressa*
Location:	Berrien/Cass Counties
Year(s) observed:	August 1867
Source of Information:	MNFI 2002, Occurrence 3

Identification:	*Lycopodiella appressa*
Location:	Berrien County
Year(s) observed:	1976
Ownership:	Nature preserve.
Habitat:	"A bog."
Source of Information:	MNFI 2002, Occurrence 13

Identification:	*L. subappressa*
Location:	Berrien County
Year(s) observed:	September 28, 1974
Habitat:	Sphagnum mat of bog
Source of Information:	Notes of Preston and Wagner 1998, voucher at MOR, May be same as MNFI Occurrence 13.

Identification:	*Lycopodiella appressa* (probably *L. marguaritae* & *L. subappressa*, see next two occurrences)
Location:	Berrien County
Year(s) observed:	August 1986
Population size:	"Locally common as a few small colonies."
Ecological community:	"Disturbed coastal plain marsh."
Habitat:	"A former coastal plain marsh, now an old borrow area reverting again to native coastal plain vegetation. In one area next to (just outside) of a highway r-o-w, with *L. inundatum* and hybrids; in another area some distance back into the site, among *L. sp. nov.* [new unnamed species] and *L. inundatum* and 3 hybrids along an old drainage."
Source of Information:	MNFI 2002, Occurrence 17

Identification:	*L. marguaritae*
Location:	Berrien County
Year(s) observed:	September 19, 1994
Source of Information:	Field notebook of Warren H. Wagner; probably MNFI Occurrence 17

Identification:	*L. subappressa* and *L. marguaritae*
Location:	Berrien County
Year(s) observed:	August 28, 1993
Source of Information:	Notes of Preston and Wagner 1998; voucher at MOR; Probably MNFI Occurrence 17

Identification:	*Lycopodiella appressa*
Location:	Chippewa County
Year(s) observed:	September 1995
Ownership:	State
Ecological community:	"Intermittent wetland/coastal plain marsh"

Habitat:	"Scattered within patches of *Lycopodium inundata* in moist, calcareous, sandy, intermittent shoreline near lake access point".
Associated Species:	*Lycopodiella inundata, Rhyncospora capitellata, Juncus pelocarpus, Carex oligosperma, C. buxbaumii, Platanthera dilata, Rhexia virginica, Drosera rotundifolia*, and *Chamaedaphne calyculata*.
Source of Information:	MNFI 2002, Occurrence 25

Identification:	*Lycopodiella appressa*
Location:	Chippewa County
Year(s) observed:	September 1995
Ownership:	State
Ecological community:	"Sedge meadow."
Habitat:	"Scattered within patches of *Lycopodiella inundata* at edge of very shallow, moist, calcareous, sandy sedge meadow."
Associated Species:	Dominated by *Rhyncospora capitellata, Euthamia remota,* & *Muhlenbergia uniflora*.
Source of Information:	MNFI 2002, Occurrence 26

Identification:	*Lycopodiella appressa*
Location:	Crawford County
Year(s) observed:	October 1993
Ownership:	Federal
Population size:	"Very local…"
Habitat:	"Borrow pits, abandoned 2-track Occurring sparsely with mostly *Lycopodiella inundata* in moist borrow pits. Growing in Kinross muck, in borrow pits and abandoned 2-track."
Associated species	*Lycopodiella inundata, Muhlenbergia uniflora, Scirpus cyperinus, Juncus effusus, J. brachycephalus, J. brevicaudatus, Danthonia spicata, Drosera rotundifolia, Rubus hispidus.*
Source of Information:	MNFI 2002, Occurrence 24

Identification:	*Lycopodiella appressa*
Location:	Kalamazoo County
Year(s) observed:	September 1940
Population size:	"Very scarce."
Source of Information:	MNFI 2002, Occurrence 4

Identification:	*Lycopodiella appressa*
Location:	Kalamazoo County
Year(s) observed:	September 1940
Habitat:	"A lakeshore."
Source of Information:	MNFI 2002, Occurrence 5

Identification:	*Lycopodiella appressa*
Location:	Luce County
Year(s) observed:	October 1991
Ownership:	The Nature Conservancy
Population size:	"150-250 plants in two separate colonies…. Most plants had strobili."
Ecological community	"Edge of intermittent wetland."
Habitat:	"*Chamaedaphne calyculata* (leatherleaf) forming dense border along upland side. Scattered jack pine (*Pinus banksiana)* upland and in wetland."
Source of Information:	MNFI 2002, Occurrence 21

Identification:	*Lycopodiella appressa* (*L. margueritae*)
Location:	Mackinac County
Year(s) observed:	October 1990
Ownership:	Federal: Hiawatha National Forest
Population size:	"Colony restricted to 10' X 12' area…"
Habitat:	"Moist, calcareous, open, sandy microhabitat. In seasonally wet, sandy soil along old pipeline R.O.W. 30-40."
Associated species:	*Scirpus cyperinus* (bull-rush), *Juncus* species (rush), *Hypericum perforatum* (St. John's wort), *Vaccinium macrocarpon* (cranberry), *Chamaedaphne calyculata* (leatherleaf), and *Calamograstis canadensis* (bluejoint).
Source of Information:	MNFI 2002, Occurrence 22; New identity determined by Robert Preston, pers. comm, 2002

Identification:	*L. appressa (L. subappressa)*
Location:	Midland County
Year(s) observed:	September 18, 1971
Habitat:	Borrow pit
Source of Information:	Notes of Preston and Wagner 1998; voucher at GA (University of Georgia Herbarium)

Identification:	*L. appressa* (*L. subappressa*)
Location:	Midland County
Year(s) observed:	September 5, 1972
Habitat:	Borrow pit
Source of Information:	Notes of Preston and Wagner 1998; voucher at GA

Identification:	*L. marguaritae*
Location:	Midland County
Year(s) observed:	September 26, 1991
Habitat:	Borrow pit, bog
Source of Information:	Field notebook of Warren H. Wagner

Identification:	*Lycopodiella appressa*

Location:	Muskegon County
Year(s) observed:	October 1970
Habitat:	"A roadside borrow pit; moist sandy ground."
Associated species:	"Growing with *Lycopodiella inundata* and *L. sp. nov*.[new unnamed species]; the latter and this were much less frequent."
Source of Information:	MNFI 2002, Occurrence 6

Identification:	*Lycopodiella appressa*
Location:	Muskegon County
Year(s) observed:	October 1992
Population Size:	State
Ecological community:	Interdunal wetland
Habitat:	"Scattered somewhat sparsely at edge of large interdunal wetland in middle of dune complex, growing in moist sand by jack pine."
Associated species:	*Calamagrostis canadensis, Spirea tomentosa, Salix nigra, Ilex verticillata, Rhyncospora capitellata, Drosera rotundifolia, Utricularia subulata, Eupatorium perfoliatum.*
Source of Information:	MNFI 2002, Occurrence 23

Identification:	*Lycopodiella subappressa*
Location:	Muskegon County
Year(s) observed:	August 19, 1997
Source of Information:	Field notebook of Warren H. Wagner (within 1.5 mi of MNFI occurrence 8)

Identification:	*Lycopodiella appressa* (*L. subappressa*)
Location:	Newaygo County
Year(s) observed:	1990
Ownership	Federal: Huron-Manistee National Forest
Habitat:	"3 localized occurrences."
Source of Information:	MNFI 2002, Occurrence 19; New identity indicated by Alix Cleveland, pers. comm., 2002.

Identification:	*Lycopodiella appressa*
Location:	Ottawa County
Year(s) observed:	1970, August 1986
Population Size:	"Several hundred fertile shoots from runners over 1/8 - 1/4 acre."
Habitat:	"A freeway borrow pit. A low, moist sand flat. Herb-dominated with scattered shrubs. There was a groundcover of moss (*Polytrichum* species) nearly throughout on moist sand with little organic content."

Associated species:	"Forming a ground cover with *Polytrichum* and *L. inundatum*. Also frequent was *L. sp. nov*. [new unnamed species], all three hybridizing. Other species: *Cladium* species, *Carex flava, Juncus* species."
Source of Information:	MNFI 2002, Occurrence 8

Identification:	*Lycopodiella subappressa*
Location:	St. Clair County
Year(s) observed:	1995, August 1999
Ownership	State
Population size:	"Very local, consisting of a relatively small colony of *Lycopodiellas*."
Ecological community:	Lakeplain wet prairie
Habitat:	" ..at the edge of a former sand borrow pit site. Possibly part of a swarm of clubmosses composed of *Lycopodiella inundata*, *L. margueritae* and this taxon [*L. subappressa*], as well as potential backcrosses."
Source of Information:	MNFI 2002, Occurrence 1[1]

Identification:	*L. subappressa*
Location:	Van Buren County
Year(s) observed:	June 13, 1971
Habitat:	Borrow pit
Source of Information:	Notes of Preston and Wagner 1998, voucher at MOR

Identification:	*L. appressa*
Location:	Van Buren County
Year(s) observed:	June 23, 1973
Habitat:	Borrow pit
Source of Information:	Notes of Preston and Wagner 1998, voucher at GA, collected by Bruce (May be MNFI occurrence 16)

Identification:	*L. inundata* (*L. margueritae*)
Location:	Van Buren County
Year(s) observed:	October 3, 1973
Habitat:	Borrow pit
Source of Information:	Notes of Preston and Wagner 1998, voucher at GA, collected by Bruce

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Year(s) observed:	1983, August 1986
Ownership:	Non-profit preserve: Michigan Nature Association

[1] This is the only population listed by the MNFI as *Lycopodiella subappressa.*

Population size:	"Common with *Lycopodium inundatum* and hybridizing with it, in a 30' X 30' panne…"
Habitat:	Dune area. "Wet in spring, dry in summer; soil: sand with a crusty surface, pH 4.4, little organic content. Wet pannes surrounded by low dunes. Beech-maple-tulip tree-hemlock forest to the N; some ORV tracks on the upland."
Associated species	"Dominated by *Rhynchospora capitellata* Assoc.: *Rhynchospora fusca, Xyris difformis*."
Source of Information:	MNFI 2002, Occurrence 9

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Year(s) observed:	1983, August 1986
Ecological Community:	Coastal Plain Marsh
Population size:	"Local."
Habitat:	"A seasonally wet panne (dry when surveyed) in the *Rhynchospora capitellata* zone of the wet panne, associated with *Rhynchospora fusca*. Growing with *L. inundatum* (common) and *L. sp. nov*. [new unnamed species] (frequent), and all 3 hybridizing."
Associated species:	"With *Typha angustifolia* in the center, surrounded by *Fimbristylis*, then *Rhynchospora capitellata*, *Juncus canadensis* and *Solidago*[*Euthamia*] *remota*.
Source of Information:	MNFI 2002, Occurrence 10

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Year(s) observed:	August 1983
Population size:	"One good-sized colony…"
Ecological Community:	Coastal Plain Marsh
Habitat:	"In [a]…depression. Sandy flats with a series of shallow, moist depressions dominated by *Rhynchospora capitellata*."
Source of Information:	MNFI 2002, Occurrence 11

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Management:	Critical Dune Area.
Year(s) observed:	1983, August 1986
Habitat:	"A disturbed sandy wet panne w/ the N end dredged to create a permanent pond & beach."
Associated species:	"Common near *L. inundatum* & hybridizing w/ it."
Source of Information:	MNFI 2002, Occurrence 12

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Year(s) observed:	August 1983

Habitat:	"Moist depressions in sand flats."
Associated species	*Rhyncospora capitellata* , *Solidago remota* [*Euthamia remota*], *Juncus scirpoides*, *Viola lanceolata*, *Xyris torta*, *Spirea tomentosa*, *Salix glaucophylloides* [*S. myricoides*], *Hypericum* sp.
Source of Information:	MNFI 2002, Occurrence 14

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Year(s) observed:	August 1983
Management:	Critical Dune Area
Ecological community:	Coastal marsh
Habitat:	Dune area. "A sandy seepage panne surrounded by sand flats."
Associated species:	"Common with *Rhyncospora capitellata*, *Viola lanceolata*, *Solidago* [*Euthamia*] *remota*, *Xyris torta*, and *Juncus canadensis*."
Source of Information:	MNFI 2002, Occurrence 15

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Year(s) observed:	1973, August 1986
Management:	Critical Dune Area
Habitat:	"Large *Fimbristylis* flats surrounded by *Typha* & *Scirpus americanus*. This & *L. inundatum* more abundant than *L. sp. nov*. [new unnamed species] here. All 3 hybridizing."
Source of Information:	MNFI 2002, Occurrence 16

Identification:	*Lycopodiella appressa*
Location:	Van Buren County
Year(s) observed:	October 1986
Ownership:	The Nature Conservancy
Ecological community:	Coastal Plain Marsh
Population size:	"Colony about 50' x 100', locally abundant…"
Habitat:	"An old small dune swale covered at the bottom with heavy growth of *Polytrichium* moss, frequently saturated from seepage and fall rains, supporting several plant species of coastal plain affinity. …concentrated in lowest portion of swale where moisture is more constant…"
Associated species	"*Fimbristylis*, *Drosera intermedia*, *Bartonia viginicar*, *Cladium* spp, *Lycopodium inundata*, *L. species. nova* [new unnamed species], *Polytrichium* sp, *Rhynchospora capitellata* and *Ludwigia* spp."
Source of Information:	MNFI 2002, Occurrence 18

Identification:	*L. appressa* (possibly *L. subappressa* or *Lycopodiella* hybrid)
Location:	Van Buren County
Year(s) observed:	September 26, 1993
Habitat:	Borrow pit
Source of Information:	Notes of Preston and Wagner 1998, voucher at GA, collected by Bruce

Identification:	*L. inundata* (possibly *L. margueritae* and *L. inundata*)
Location:	Van Buren County
Year(s) observed:	September 26, 1993
Habitat:	Borrow pit
Source of Information:	Notes of Preston and Wagner 1998, voucher at GA, collected by Bruce

Identification:	*L. subappressa*, *L. marguaritae*, & hybrids
Location:	Van Buren County
Year(s) observed:	October 17, 1994
Habitat:	Borrow pit
Source of Information:	Field notebook of Warren H. Wagner, May be MNFI occurrence 18

Identification:	*L. appressa*
Location:	Van Buren County
Year(s) observed:	August 20, 1997
Source of Information:	Field notebook of Warren H. Wagner

Identification:	*L. subappressa*, *L. marguaritae*, & hybrids
Location:	Van Buren County
Year(s) observed:	September 27, 1997
Habitat:	Borrow pit
Source of Information:	Field notebook of Warren H. Wagner

Identification:	*Lycopodiella appressa*
Location:	Wayne County
Year(s) observed:	September 1991
Ownership:	Mostly private, efforts underway to purchase and preserve (Button 2002)
Population size:	"Very local, occurring in 1 small opening."
Ecological community	Lakeplain wet prairie.
Habitat:	"Possibly a sand borrow pit site, growing in seasonally moist sand."
Source of Information:	MNFI 2002, Occurrence 20

Identification:	L. subappressa
Location:	Wayne County

Year(s) observed:	September 29, 1991
Habitat:	Prairie
Source of Information:	Field notebook of Warren H. Wagner, May be MNFI occurrence 20

Virginia

Identification:	*Lycopodiella margueritae*
Location:	Bland County
Year(s) observed:	1994
Ownership:	Private
Population size:	"Dense, extensively creeping colonies with thousands of upright, fertile stems over ca. .25 acre. Plants with sporophylls developed but not yet shedding spores."
Habitat:	"Seepy, more or less barren, sandy soil in scraped area near ponds [not natural, possibly borrow pite] at upper edge of floodplain."
Source of Information:	Virginia Department of Conservation and Recreation, Division of Natural Heritage, 2002

LIST OF CONTACTS

Information Requests

Indiana: Ronald Hellmich, Division of Nature Preserves; Indiana Dept. of Natural Resources

Michigan: Robert Preston, University of Michigan Herbarium
Phyllis Higman; Michigan Natural Features Inventory
Alix Cleveland; Plant Ecologist; Huron-Manistee National Forests

Ohio: Debbie Woischke; Ohio Department of Natural Resources; Division of Natural Areas and Preserves; Columbus, OH

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Review Requests

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