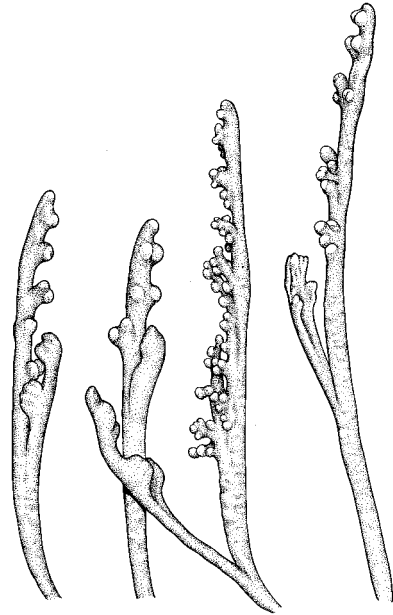


***Conservation Assessment***  
***For***  
***Botrychium mormo (Little Goblin Moonwort)***



*Photo © Steve Mortensen*



*Illustration provided by USDA Forest Service*

***USDA Forest Service, Eastern Region***  
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*This Conservation Assessment was prepared to compile the published and unpublished information on the subject species or community. 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 310 Wisconsin Avenue, Milwaukee, Wisconsin 53203.*

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## EXECUTIVE SUMMARY

*Botrychium mormo* (little goblin moonwort) is a very small moonwort fern that occurs only in the rich deciduous forests of northern Minnesota, Wisconsin, and Michigan. One site is also reported from Quebec. It is listed as state endangered in Wisconsin, state threatened in Michigan, state special concern in Minnesota, a Regional Forester's sensitive species for Region 9 of the USDA Forest Service, and a U.S. Fish and Wildlife Service "species of concern" (Casson et al. 2000). *B. mormo* is usually associated with a thick surface organic (litter) horizon and dense shade, characteristics easily altered through timber management activity. However, the primary long-term threat to population viability is probably the effect of exotic earthworms, which are spreading throughout the Great Lakes region. These earthworms can completely consume the organic horizon, thus eliminating *B. mormo* habitat and populations. Monitoring *B. mormo* is difficult due to its small size and tendency to not appear aboveground consistently every year (and aboveground plants are usually absent during drought years). Research and monitoring needs are listed for the species based on the recommendations of an expert panel. The recommendations are generally centered on the underground biology of *B. mormo*, population monitoring, and identifying primary threats to the species. Two documents, Berlin et al. (1998) and Casson et al. (2000) were extensively used in this assessment and should be consulted for further information.

## INTRODUCTION/OBJECTIVES

One of the conservation practices of the USDA Forest Service is designation of Regional Forester's sensitive species. The Eastern Region (R9) of the Forest Service updated its Sensitive Species list on February 29, 2000. Part of that process included identification of priority species for Conservation Assessments and Strategies. A group of *Botrychium* species (Ophioglossaceae; Adder's-Tongue Family) was one of those priorities.

The objectives of this document are to:

1. Provide an overview of current scientific knowledge for *Botrychium mormo*.
2. Provide a summary of the distribution and status of *Botrychium mormo*, both rangewide and within the Eastern Region of the USDA Forest Service.
3. Provide the available background information needed to prepare a subsequent Conservation Strategy. In the case of *B. mormo*, a Conservation Strategy is already being prepared, the draft (Casson et al. 2000) was a primary source for the information contained in this document.

The genus *Botrychium*, family Ophioglossaceae, are small ferns that are typically divided into three subgenera in North America (Lellinger 1985). One subgenus, *Osmundopteris*, is only represented in our area by *B. virginianum*, the rattlesnake fern, which is common around the world (Wagner 1998). Subgenus *Sceptridium* is the grapeferns, medium-sized plants and decidedly evergreen. Subgenus *Botrychium*, the moonworts, contains numerous species of often rare, local, and very small plants that are difficult to find and positively identify.

North America is a center of diversity for moonworts (Wagner and Wagner 1994) and the upper Great Lakes region, along with the northwestern U.S. and nearby Canada, are two of the richest areas

(Wagner and Wagner 1990, Wagner 1998). Twenty-three species of North American moonworts are now recognized (Wagner and Wagner 1994) compared to an earlier interpretation of only six (Clausen 1938). The problems in distinguishing moonwort species are considerable (Wagner and Wagner 1990), including the tendency for different species of moonworts to co-occur at a single site, the natural variation in plant-form due to microhabitat variability, their small size, and the difficulty of making good herbarium specimens. However, decades of work, primarily by Dr. Herb Wagner and associates, have clarified the taxonomy of the group, habitat preferences, and the ranges of individual species. Several rare species of subgenus *Botrychium* are now recognized in the Upper Great Lakes region.

*Botrychium mormo* (little goblin moonwort) is an extremely small fern endemic to northern Minnesota, northern Wisconsin, and northern Michigan. It has also been reported from one site in Quebec (NatureServe 2001, see note in Appendix A). *B. mormo* is the smallest known moonwort in North America (Lellinger 1985). It was long thought to be a variety of *B. simplex* until described as a separate species by Wagner and Wagner (1981) after years of study. Notable characteristics of *B. mormo* include a highly reduced succulent habit, a tendency for the gametophytes to persist at the bases of plants, a habitat primarily in rich northern hardwood forests, and a tendency to not emerge aboveground consistently every year, especially during years of drought (Wagner and Wagner 1981).

## NOMENCLATURE AND TAXONOMY

<b>Scientific Name:</b>	<i>Botrychium mormo</i> W.H. Wagner
<b>Family:</b>	Ophioglossaceae; Adder's-Tongue Family
<b>Common Name:</b>	Little goblin moonwort, Goblin Moonwort
<b>Synonymy:</b>	(none)

## DESCRIPTION OF SPECIES

### General Description and Identification Notes

*Botrychium mormo* is succulent and tiny, to only 8-10 cm in height (often smaller), and highly reduced in comparison to other moonworts. The plants are a satiny or shiny yellowish-green color. The stem terminates in a blunt to somewhat elongate fertile segment embedded with fleshy sporangia. The sterile leaf blade is variable; more mature or larger plants may have 2–3 pairs of small blunt lobes (pinnae), while the leaf blade may be virtually absent in smaller individuals. *B. mormo* may not appear aboveground during drought years, and due to the plant's small stature, it often fails to emerge from the leaf litter. The small stature of *B. mormo* also means that the plant is easily overlooked. Plants underneath the litter layer are usually whitish and lack chlorophyll (Wagner and Wagner 1981). The plant first emerges from the leaf litter in June or July and can often be identified into October.

*B. mormo* is most similar to *B. simplex* (least moonwort) and was long thought to be a variety of that species, but most subspecies or varieties of *B. simplex* do not typically share the mesic, northern hardwood habitat characteristic of *B. mormo*. *B. simplex* also has a less fleshy appearance, a duller and

greener color, and a higher attachment point for the leaf blade (Wagner and Wagner 1981). The sterile segment of *B. mormo* also has lower divisions about equal to those above, while in *B. simplex* these are enlarged. Additionally, the tip of the *B. mormo* sterile segment is usually toothed to deeply cleft, unlike the mainly undivided and entire tip of *B. simplex* (Wagner and Wagner 1981). *B. mormo* has been reported to be very closely related to the western species *B. montanum* based on allozyme evidence, possibly forming two varieties of one species with *B. mormo* forming a peripheral population in the Great Lakes States (D. Farrar, pers. comm. reported in Johnson-Groh 1999).

There are a number of useful references for identifying members of this genus. The treatment in Volume 2 of the Flora of North America (Wagner and Wagner 1993) is the most current published guide to all but the most recently described species (for example, since the release of Volume 2, a new species, *Botrychium lineare*, has been described by Wagner and Wagner [1994]). Lellinger (1985) includes descriptions and color photographs of many moonwort species. Cody and Britton (1989) provide descriptions and distribution maps of *Botrychium* species known to that time in Canada.

### **Technical Description**

Wagner and Wagner (1981) described *Botrychium mormo* as follows: “Gametophyte commonly persisting at the bases of even the largest plants; leaf averaging 8.6 (7-12.5) cm tall, very succulent, yellow-green, shiny; the common stalk making up 50 (20-70)% of the total length; sterile segment linear, 2 (1.3-4.1) cm long, 5 (3-7) cm wide, the stalk 1 (0.5-1.6) cm long; lobes 2 (1-3) pairs, round-pointed to truncate, the distal margins entire or shallowly crenate, not sharply dentate or irregularly lacerate, and with no tendency for exaggerated basal lobes; the tip usually with 2-4 angular triangular or squarish lobes; fertile segment 4.5 (2.4-7.5) cm tall, commonly branched in the lower third, the branches 1/3 to 2/3 as long as the main axis; sporangia large, sunken, not opening until late September and October, the aperture narrow, only 15-30 degrees; spores 49 (45-53)  $\mu\text{m}$  in diameter; chromosomes  $2n=90$ .”

### **LIFE HISTORY**

*Botrychium mormo* belongs to subgenus *Botrychium* (moonworts). In North America there are also subgenus *Osmundopteris* (rattlesnake ferns) and subgenus *Sceptridium* (grapeferns) (Lellinger 1985, Wagner and Wagner 1993). The life-cycle of all three subgenera is similar (Lesica and Ahlenslager 1996). Moonworts are generally smaller than rattlesnake ferns and grapeferns and the leaves have both a trophophore (vegetative segment) and a sporophore (fertile segment). Grapefern trophophores are present during the winter, while moonwort and rattlesnake fern leaves die-back by winter.

Like all ferns, moonworts are characterized by alternation of generations between sporophytes and gametophytes. The sporophyte, the diploid (2N) generation of the plant, begins its life after fertilization of an egg by a sperm within the archegonium of the gametophyte. Embryology of moonwort species has been little studied due to the difficulty of obtaining suitable material (Gifford and Foster 1989, Mason and Farrar 1989). Early morphological studies (e.g., Campbell 1922) described a diversity of patterns of embryo development among moonworts. For example, *Botrychium simplex* has a relatively large cotyledon and rapid development, perhaps capable of maturing a small aboveground fertile frond in its first year, while *B. lunaria* has a relatively small cotyledon, and may take as much as seven years to produce an emergent frond.

Vegetative reproduction was not thought to occur in *Botrychium* (Wagner et al. 1985), but Farrar and Johnson-Groh (1990) documented underground gemmae (bud-like structures) in a few species of moonwort. They speculated that asexual reproduction may have evolved as an adaptation to the dry habitat that some of these moonwort species were found in. *B. mormo* was not listed as a species they examined. Wagner and Wagner (1993) do not report that *B. mormo* reproduces through gemma production. In the absence of vegetative reproduction, the primary mode of reproduction would be sexually through spores.

Reproduction in *Botrychium mormo* is not totally understood and there is some question whether the sporangia open to produce wind-disseminated spores. Some reports say that the sporangia do not open normally (Wagner et al. 1985, Wagner and Wagner 1993, NatureServe 2001), while others suggest that the sporangia do open slightly, with an aperture of 15–30 degrees (Wagner and Wagner 1981, Tans and Watermolen 1997). Tans and Watermolen (1997) directly observed spore dispersal when the plants were bumped. Spores of *Botrychium* have been measured to disperse by wind about one meter as cited in Hoefflerle (1999), but potentially travel much less, perhaps only a few centimeters (Casson et al. 1998). While most spores could be expected to land near the parent plant, some may travel considerable distances (Wagner and Smith 1993, Briggs and Walters 1997). Peck et al. (1990) found that *B. virginianum* spores landed within 3 meters of the source if the plant was above the herbaceous layer, but much less when the sporophore was within the herbaceous layer. Peck (1980) reports that the *B. mormo* releases spores in October.

The succulent nature of the plant, the questionable spore dispersal mechanism, and the very thick spore walls (Wagner 1998) that could help spores to pass through an animal's gut, have suggested to some that herbivores, such as small mammals, may be involved in dispersal (Wagner et al. 1985, Wagner and Wagner 1993). The sporangia may also simply rot in the ground, thereby dispersing their spores (NatureServe 2001). It's uncertain how long *Botrychium* spores will remain viable (Lesica and Ahlenslager 1996).

After the spores are released, they infiltrate into the soil and may germinate. Infiltration and subsequent germination may take up to 5 years, although some germinate immediately (Casson et al. 1998). Spore germination requires darkness (Whittier 1972, Whittier 1973, Wagner et al. 1985), a requirement that is not surprising given the subterranean habitat of the gametophyte and the need for the gametophyte to be infected by an endophytic fungus in an obligate association (Whittier 1973). Details of this host/fungus interaction can be found in Schmid and Oberwinkler (1994). It has been suggested that *Botrychium* gametophytes may even delay growth until they are infected with the fungus (Campbell 1911, Whittier 1973, Whittier 1996). Essentially the *Botrychium* gametophyte becomes a parasite of the mycorrhizal fungus (Casson et al. 1998, Whittier 2000). The underground gametophyte (subg. *Sceptribidium*) is generally less than 0.3 cm in longest diameter, cylindrical or cushion shaped, moderately hairy, and light to dark brown-brown (Wagner et al. 1985).

The gametophyte produces male and female gametangia, fertilization of eggs occurs via free-swimming sperm under wet conditions (Lesica and Ahlenslager 1996). Development and fertilization of the gametophyte probably takes 2–4 years (Casson et al. 1998). Most fertilizations are likely due to inbreeding (Farrar 1998), since the antheridia and archegonia are nearby and enzyme electrophoresis indicates a lack of genetic variability (Farrar and Wendel 1996a). However, there is no reason that

cross-fertilization should not occur, especially in consideration of the existence of interspecific hybrids (Wagner et al. 1985, Wagner 1998).

After fertilization, the resultant sporophyte develops underground for several years (Casson et al. 1998), also depending primarily on a mycorrhizal association for nutrients (Farrar and Johnson-Groh 1990, Wagner 1998, Johnson-Groh 1998). The fungus involved is believed to be a vesicular arbuscular mycorrhizae (USDA Forest Service 2000), which penetrates inside the plant cells of both the roots and the gametophytes in the case of *Botrychium*. Nutrients and sugars are then transferred between the fungi and the host plant (Brady and Weil 1999). The species of mycorrhizae fungus involved with *Botrychium* is unknown (Casson et al. 2000).

All *Botrychium* species are believed to be obligately dependent on mycorrhizal relationships in both the gametophyte (Bower 1926, Campbell 1922, Gifford and Foster 1989, Scagel et al. 1966, Schmid and Oberwinkler 1994) and sporophyte generations (Bower 1926, Gifford and Foster 1989, Wagner and Wagner 1981). The gametophyte is subterranean and achlorophyllous, depending on an endophytic fungus for carbohydrate nutrition, while the roots of the sporophyte lack root hairs and probably depend on the fungus for absorption of water and minerals (Gifford and Foster 1989). *Botrychium* gametophytes were formerly considered saprophytic (Bower 1926), but are now thought to obtain carbohydrates fixed by neighboring plants and transported by shared mycorrhizal fungi (Camacho 1996); they are thus better classified as myco-heterotrophic (Leake 1994).

A fungal associate is present within the plant at the earliest stages of development of the gametophyte and sporophyte (Bower 1926). There are no reports of successful completion of the lifecycle by *Botrychium* species without fungal infection, however, the degree of infection may vary between species and age of plants (Bower 1926, Campbell 1922). Little is known about the mycorrhizal fungi associated with *Botrychium* species other than their presence within the gametophyte and roots of the sporophyte (Camacho 1996). *Botrychium* mycorrhizae have been described as the vesicular-arbuscular (VAM) type by Berch and Kendrick (1982) and Schmid and Oberwinkler (1994).

The mycotrophic condition is important to the ecology of *Botrychium* species in several ways. Nutrition supplied through a fungal symbiont may allow the ferns to withstand repeated herbivory, prolonged dormancy, or growth in dense shade (Kelly 1994, Montgomery 1990). The fungal/fern relationship has implications for the occurrence of genus communities, the distribution of the species across the landscape, and associations with particular vascular plants. Mycorrhizal links may explain the often observed close associations between certain moonworts and strawberries (*Fragaria* spp.; Zika 1992, 1994) and between grapeferns (*Botrychium* subgenus *Sceptridium*) and Rosaceous fruit trees (Lellinger 1985). Due to the occurrence of heterotrophic life-stages, moonworts share many of the morphological and habitat characteristics of myco-heterotrophic plants such as orchids (reviewed by Leake 1994) and in many respects behave much like mushrooms (Zika 1994).

The juvenile sporophyte initially develops roots, which must be infected with the mycorrhizal fungi at an early stage (Casson et al. 1998). It appears that it may take several years for the juvenile sporophyte to produce an apex and emerge aboveground (Peck 1980, Casson et al. 1998, Johnson-Groh 1999). An upright rhizome develops belowground with fleshy, slightly branched roots without root hairs (Wagner 1998) and a terminal bud with up to five previously formed leaves (Johnson-Groh 1999). When the sporophyte eventually emerges, a sterile leafy blade (trophophore) and a fertile segment (sporophore)



will develop. One leaf will typically emerge every growing season but plants can go dormant during periods of stress, such as drought, and not produce an aerial sporophyte (Wagner and Wagner 1981).

Most plants do not produce aboveground sporophytes more than two consecutive years (Johnson-Groh 1998) and there may be gaps as long as 6 years, although 1–3 years is more typical (Johnson-Groh 1998, Tans and Watermolen 1997). *B. mormo*, unlike other *Botrychium*, may produce more than one sporophyte from the same gametophyte within one growing season (Casson et al. 1998).

Several factors likely determine the size of the plant and how many spores it is capable of producing (Casson et al. 1998). These include the health of the plant and the associated fungi, climatic conditions, plant age, predators, and other factors. About 5–10% of aboveground plants will develop into larger plants with 20 to 50 sporangia (spore-bearing tissues) each (Casson et al. 1998).

Roughly half of all individuals retain the gametophyte at their bases (NatureServe 2001). The reason for this is unclear (Wagner and Wagner 1981).

Plants emerge from the ground in late July and frequently persist into the winter if mammals do not eat them (NatureServe 2001). The loss of plants to herbivory, fire and collection do not seem to affect the return of the plant in later years (Johnson-Groh 1998, 1999). This suggests that *B. mormo* depends little on photosynthesis, and mycorrhizae alone appear to supply a significant amount of the plant's nutrients and energy (Johnson-Groh 1999, Casson 2000).

Available information (Montgomery 1990, Muller 1993, Kelly 1994, Lesica and Ahlenslager 1996) indicates that members of *Botrychium* subgenus *Botrychium* (moonworts) are short-lived perennials while subgenus *Sceptridium* (grapeferns) are more long-lived. Estimated half-life times for various grapeferns were 43.2 years (Montgomery 1990) and 11.2 years (Kelly 1994), while moonwort half-lives were 1.3 years (Muller 1993) and 3 years or less (Lesica and Ahlenslager 1996).

Numerous hybrids between different species of moonworts have been found (Wagner et al. 1985; Wagner 1991, 1993). No hybrids involving *B. mormo* are recognized (Wagner 1993). Hybrids possessed abortive spores and were intermediate in characteristics between the presumed parents. All 23 taxa of moonworts have chromosome numbers based on 45, half the members are tetraploids, and one is a hexaploid (Wagner 1993). *B. mormo* has  $n=90$ . Chromosome number has been useful in recognizing the distinctness of a new species; additionally, some species may have arisen through allopolyploids of interspecific hybrids (Wagner 1993). Farrar and Wendel (1996a, b) have applied enzyme electrophoresis to the genetic relationships of eastern moonworts and have also suggested some relationships for moonwort species and hybrids.

## **HABITAT**

*B. mormo* is a species endemic to the northern forests of Minnesota, Wisconsin, and Michigan, with one Quebec site reported (see note in Appendix A). Plants are typically found in mid-age or older northern hardwood forests with deep leaf mold or duff. The forest canopy is relatively closed (Wagner and Wagner 1993, Tans and Watermolen 1997, Casson et al. 1998). Mycorrhizal fungi are influenced by their soil environment (Allen 1991), thus *B. mormo* may be dependent on the deep organic layer found in these forests habitats (Casson et al. 2000). The strong association of a rich duff layer with *B. mormo*

habitat has been often recognized (Wagner and Wagner 1981, Casson et al. 1998, Tans and Watermolen 1997, Almendinger and Hanson 1998). When Almendinger (1995) examined 248 plots from the Chippewa National Forest he found seven plots with *B. mormo*. All of the plots with *B. mormo* had O horizons greater than 3 inches thick, while only 12% of the other plots had organic horizons of similar or greater thickness.

Soil profiles below the overlaying duff layer are also usually similar, with a humus-rich mineral soil of intermediate drainage (Casson et al. 2000, 1998). Loamy or silty surface textures and a shallow horizon (mean depth 16 inch) of heavy clay or loam underlie the typical rich hardwood forest where *B. mormo* usually occurs (Casson et al. 2000). Since this layer somewhat restricts drainage (Almendinger and Hanson 1998), the overall effect is an increase in soil moisture in the upper soil horizons, which contributes to an accumulation of organic material on the ground surface.

The Wisconsin DNR (2001) associate the AH, AViO, ATD, AFD habitat types and a northern mesic forest type (without hemlock) with *B. mormo*. Also in Wisconsin, Peck (NatureServe 2001) found plants growing in ‘pure’ sugar maple woodlands. One site was characterized as having a wind-throw swell/swale relief. Very little woody understory occurred at the site. Habitats are reported to be typically north-facing hillsides, with moist, mineral-rich soils (NatureServe 2001), but Casson et al. (1998) report most occurrences are on flat terrain and only occasionally on a moderate slope. Pit and mound microtopography is often mentioned in occurrence records.

The Michigan Natural Features Inventory (MNFI 2001) described the habitat of *B. mormo* similarly, with typical habitats described as humus-rich northern hardwood forests. MNFI also reported plants of *B. mormo* in somewhat disturbed, relatively young, second-growth stands. They list a number of dominant trees and common groundcover associates (Table 1). In the eastern Upper Peninsula of Michigan, plants are usually associated with areas underlain by limestone (Chadde 1999).

**Table 1.** Dominant trees and common groundcover plants associated with *B. mormo* in northern Michigan (Michigan Natural Features Inventory 2001).

Species	Common name
<i>Acer saccharum</i>	Sugar maple
<i>Betula alleghaniensis</i>	Yellow birch
<i>Fraxinus americana</i>	White ash
<i>Fagus grandifolia</i> (east of Marquette, MI)	American beech
<i>Spring ephemerals</i>	various
<i>Trillium Grandiflorum</i>	Large-flowered trillium
<i>Asarum canadense</i>	Wild ginger
<i>Actaea pachypoda</i>	Doll’s eyes
<i>Thalictrum dioicum</i>	Early meadow-rue
<i>Athyrium filix-femina</i>	Lady fern
<i>Dryopteris spp.</i>	Woodferns
<i>Osmorhiza claytonii</i>	Sweet cicely
<i>Aralia nudicaulis</i>	Wild sarsaparilla
<i>Trientalis borealis</i>	Starflower

In Minnesota, Almendinger (2000) evaluated *B. mormo* occurrence in relation to forest type using Minnesota Department of Natural Resources ecological community sampling plots (Almendinger and Hanson 1998). He found that *B. mormo* was most likely to occur in a Rich Hardwood Forest type (22% or 30 occurrences in 135 plots) followed by the Mesic Northern Hardwood Forest type (9% or 26 occurrences in 302 plots). The types are described by Almendinger and Hanson (1998) as follows:

Mesic Northern Hardwood Forest: Fire-sensitive, all-aged, open, maple/ basswood/ ironwood/birch forests of well- to moderately-well drained loamy soils over clayey/loamy soils, undulating to moderately rolling habitats.

Rich Hardwood Forest: Fire-sensitive, all-aged, open, maple/basswood/ ironwood/yellow birch forests of well- to moderately-well drained silty/loamy soils over clayey soils, undulating to moderately rolling habitats.

Almendinger (2000) further commented that he believed that *B. mormo* is best defined by the Rich Hardwood Forest with occurrences in the Mesic Northern Hardwood Forest type due to the intergradation of the two communities and the presence of richer microhabitats within the Mesic Northern Hardwood Forest type.

Almendinger (2000) also identified plants that were either strongly positive (Table 2) or negative (Table 3) indicators for the presence of *B. mormo* within the Northern Drift and Lake Plains Section of Minnesota (Minnesota Department of Natural Resources 2000).

**Table 2.** Top 15 potential plant indicators for the presence of *B. mormo* within the Northern Drift and Lake Plains Section of Minnesota (Almendinger 2000)

Species	Common name	Fidelity	Presence
<i>Tilia americana</i>	Basswood seedlings/saplings	64.21	93.85
<i>Acer saccharum</i>	Sugar maple seedlings/saplings	61.39	95.38
<i>Acer saccharum</i>	Sugar maple trees	63.44	90.77
<i>Carex pensylvanica</i>	Pennsylvania sedge	65.52	87.69
<i>Polygonatum pubescens</i>	Solomon's seal	65.52	87.69
<i>Uvularia grandiflora</i>	Large-flowered bellwort	62.11	90.77
<i>Botrychium virginianum</i>	Rattlesnake fern	65.88	86.15
<i>Tilia americana</i>	Basswood trees	68.35	83.08
<i>Osmorhiza claytonii</i>	Clayton's sweet cicely	63.22	84.62
<i>Prunus virginiana</i>	Chokecherry	66.23	78.46
<i>Aralia nudicaulis</i>	Wild sarsaparilla	62.96	78.46
<i>Oryzopsis asperifolia</i>	Mountain rice-grass	62.96	78.46
<i>Athyrium filix-femina</i>	Lady fern	64.10	76.92
<i>Ostrya virginiana</i>	Ironwood	64.86	73.85
<i>Botrychium mormo</i>	Little goblin moonwort	100.00	36.92

**Table 3.** Top 10 potential plant indicators for the absence of *B. mormo* within the Northern Drift and Lake Plains Section of Minnesota (Almendinger 2000).

Species	Common name	Fidelity	Presence
<i>Acer rubrum</i>	Red maple seedlings/saplings	61.54	38.10
<i>Impatiens capensis</i>	Spotted touch-me-not	69.23	21.43
<i>Betula alleghaniensis</i>	Yellow birch trees	59.09	30.95
<i>Lathyrus ochroleucus</i>	Pale pea	60.00	28.57
<i>Polygonatum commutatum</i>	Giant Solomon's seal	71.43	11.90
<i>Ranunculus abortivus</i>	Kidney-leaf buttercup	71.43	11.90
<i>Amphicarpa bracteata</i>	Hog-peanut	61.54	19.05
<i>Betula alleghaniensis</i>	Yellow birch seedlings and saplings	55.56	23.81
<i>Carex arctata</i>	Drooping wood-sedge	52.63	23.81
<i>Acer rubrum</i>	Red maple trees	58.33	16.67

At least three *B. mormo* collections have been made in somewhat atypical habitats (Casson et al. 2000). *B. mormo* was collected in a mesic deciduous forest on loamy sand at the Pictured Rocks National Lakeshore in Upper Michigan. It was also found on the Chippewa NF under northern white cedar litter in a stand with maple, basswood, and upland white cedar. In the McCormick Wilderness, Ottawa NF, Chadde (2000) discovered a *B. mormo* population with most plants growing in the litter-free mineral soil of ephemeral runoff channels; the surrounding forest was a mature stand of sugar maple and yellow birch.

Species of *Botrychium* tend to form genus communities (Wagner and Wagner 1983), where several species of the same genus are found together in a similar habitat. *B. mormo* is found most commonly with *B. virginianum* and *B. minganense*, and more rarely with *B. lunaria*, *B. lanceolatum*, *B. matricariifolium*, *B. dissectum*, and *B. multifidum* (Wagner and Wagner 1981).

## **DISTRIBUTION, ABUNDANCE, AND STATUS**

*Botrychium mormo* (little goblin moonwort) is an extremely small fern endemic to northern Minnesota, northern Wisconsin, and northern Michigan. It has also been reported from one site in Quebec (NatureServe 2001, see note in Appendix A).



**North American range of *Botrychium mormo* (Wagner and Wagner 1993).**

Global and state rankings were obtained from NatureServe ([www.natureserve.org](http://www.natureserve.org)), a comprehensive online database of information on plants, plant communities, and animals. Conservation status ranks are defined in Appendix C.

**U.S. and Canada State/Province Distribution**

Minnesota, Wisconsin, and Michigan (also reported from Quebec, Canada).

Global Conservation Status Rank: G3

Rounded Global Conservation Status Rank: G3

Global Conservation Status Rank Reasons:

Known from scattered sites in Minnesota, Wisconsin, and Michigan (also reported from Quebec, Canada). Due to the small stature and periodic emergence of this species, it is easily overlooked. However, recent inventories (1995) have turned up over 40 occurrences in Minnesota and many new occurrences in Wisconsin (NatureServe 2001). Previous destruction of this species' mature hardwood forest habitat has probably destroyed many sites; logging or other physical disruptions are likely to be detrimental (NatureServe 2001).

**United States**

National Conservation Status Rank: N3 (06 Dec. 1995)

**Canada**

National Conservation Status Rank: N1 (19 Oct. 2000)

**U.S. and Canada State/Province Conservation Status Ranks**

Michigan (S1S2), Minnesota (S3), Wisconsin (S2), Quebec (S1)

Global Range Comments: Species apparently endemic to the Upper Midwest states of Michigan, Wisconsin and Minnesota; also reported from Quebec, Canada.

In a survey of sites up to 1997, the Distribution and Status Working Group (Berlin et al. 1998) identified 191 recorded Little goblin moonwort sites rangewide. Of these, 51 sites were considered

“stable.” Of these about 75% were from Forest Service land, and they considered this majority representation to be both due to the habitat present and the ongoing search effort.

## EO SUMMARY

### GREAT LAKES STATES–NUMBER OF ELEMENT OCCURRENCES

State	No. of EOs	State Rank	Status	Comments
Minnesota	162	S3	T	State threatened
Wisconsin	74	S2	E	State endangered
Michigan	12	S1S2	T	State threatened
Quebec	1	S1		
Total	249			

### STATE and NATIONAL FORESTS - SUMMARY OF ELEMENT OCCURRENCES

National Forest	No. of EOs
Minnesota	162
Chippewa National Forest	133
Superior National Forest	1
Michigan	13
Ottawa National Forest	3
Hiawatha National Forest	3
Huron-Manistee National Forest	0
Wisconsin	74
Chequamegon-Nicolet National Forest	47
Total State EOs	249
Total National Forest EOs	187
NF as % of EOs in MN, WI, MI	76%

The Michigan Natural Features Inventory (2001) lists 12 occurrences in Michigan but do not specify how many are historic occurrences that have not be recently relocated (an additional site was located in the McCormick Wilderness in 2000). They emphasize, as have others, that many new sites have been found rangewide during the last several years and the species may be more widespread than previously thought. Therefore, the number of occurrences may increase as additional surveys are conducted. However, impacts to populations from factors discussed below may lead to loss of individual populations.

## POPULATION BIOLOGY AND VIABILITY

Since *Botrychium mormo* is a mycorrhizal species, it is extremely dependent upon moisture availability, going through cycles of “boom or bust” years (NatureServe 2001). Years with good snowfall, followed by spring and summer rains, will often result in abundant numbers of *B. mormo*. In any given year, plants may push their way through the leaf litter or lie dormant, depending upon seasonal moisture availability (Wagner and Wagner 1981). Often, very small plants will dominate a population. In drought years, even the large plants will fail to send up a leaf, or they appear whitish (achlorophyllous) beneath the forest litter. In Michigan, Wagner (NatureServe 2001) stated that he had only observed three individuals of the species in the last decade due to prolonged drought conditions. Populations fluctuate independently among plots at any given site, some local populations may be increasing while others are decreasing; (Johnson-Groh 1999). These variations reflect microsite differences such as soil moisture, herbivory, or mycorrhizae (Johnson-Groh 1999).

In surveying *B. mormo* populations Johnson-Groh (1999) concluded that mycorrhizae are the most limiting factor for *Botrychium* establishment, distribution and abundance. Environmental factors that may affect mycorrhizae, like reductions in water resources, are then also likely to have significant impacts on *B. mormo*, whereas the repeated removal of leaf tissue may have little effect (Johnson-Groh 1999). Standard assumptions about the population biology of other, more ‘normal’ plants may be irrelevant to *Botrychium* because of this obligate relationship (Johnson-Groh 1999).

Since there is considerable variation in the numbers of aboveground sporophytes due to weather conditions, a measurement of only sporophytes does not completely indicate population numbers. Johnson-Groh (1998) developed a method to extract *Botrychium* gametophytes and belowground sporophytes from soil samples. Up to 7000 gametophytes and 250 non-emergent sporophytes per square meter of soil have been recovered, although an unknown number of these may be the common *B. virginianum* (Johnson-Groh 1998). Bierhorst (1958) reported finding 20 to 50 gametophytes of *B. dissectum* beneath each surface square foot. These findings suggests that a single emergent sporophyte may indicate a self-sustaining population at that site (Casson et al. 1998).

A population model for *B. mormo* has been developed by a working group within the Population and Habitat Viability Assessment effort (Berlin et al. 1998). This model used a variety of input variables such as number of spores in the soil, number of soil gametophytes, frequency of catastrophes, etc. They authors concluded that populations subjected to increased levels of annual environmental variation are at greater risk of population decline and extinction, although a single catastrophic year has relatively little long-term effect on simulated populations.

Michigan Natural Features Inventory records (2001) report that *B. mormo* has been sometimes found in somewhat disturbed, second-growth woods. They state that some level of disturbance may benefit colonization and establishment, although Sather et al. (1998) report that documentation to support this is lacking and that the species does not appear to require disturbance.

Farrar (1998) has investigated the population genetics of a number of moonwort taxa, including *B. mormo*. He determined that these species have low genetic variability due to the predominance of inbreeding, but does not believe that low genetic variability is a significant negative factor at either the population or the species level.

## POTENTIAL THREATS AND MONITORING

Potential threats to *B. mormo* plants and habitat have been ranked by the “Threats and Working Group Report of the Population and Habitat Viability Assessment” (Sather et al. 1998). Some threats, like global warming or acid rain, were considered to be beyond the scope of their assessment since the changes would be gradual and over a long time scale. Factors that would be detrimental to *B. mormo* or its habitat (Sather et al. 1998), regardless of cause were:

- Soil compaction
- Loss of soil nutrients
- Loss of duff layer (O horizon)
- Loss of shade provided by the duff layer or forest canopy
- Changes in moisture regime (drying, such as by canopy removal, or flooding)
- Changes in soil characteristics (pH, aeration, structure)
- Inhibition of spore dispersal

Casson et al. (2000) recognized that these threats can result from both human and natural activities and grouped them into four categories:

**Direct threats:** Activities that would directly remove plants or habitat like road construction, housing developments, or mines.

**Habitat changes:** Activities resulting in habitat changes resulting in a degraded or unsuitable habitat for *B. mormo*.

**Direct human activity:** These activities may impact plants or soil but leave the habitat intact; examples include collecting of plants, off-road vehicle use, and dispersed recreation.

**Other:** Natural and unnatural threats to *B. mormo* and its habitat such as drought or herbivory.

The Nature Conservancy (NatureServe 2001) identified a number of threats to *B. mormo* including logging of the species’ preferred habitats of mature maple-basswood or maple-basswood-beech forests. They also speculated that any activity that would open the canopy is likely to be detrimental to the species. Grazing, herbicide applications, or forestry activities were also considered threats.

A variety of threats were evaluated by Sather et al. (1998). The most serious threats were considered to be:

- exotic earthworms,
- a number of forestry practices,
- the lack of biological knowledge.

### **Threat from exotic earthworms**

Native earthworms were eliminated from the Lake States during the last ice age. Natural recolonization from the unglaciated south has been extremely slow, with reported distances of less than 100 miles in the centuries since glacial retreat (James 1990, Berlinger 2000, Conover 2000). European earthworms were introduced into North America with European settlement and then spread through the use of earthworms for fishing bait, gardening, and inadvertent human transport (Kalisz and Wood 1995,



Berlinger 2000). Logging machinery and other forest vehicles can transport cocoons and hatchlings, thereby dispersing earthworms widely into forests (Marinissen and van den Bosch 1992, Dymond et al. 1997). More remote forests in our region still lack earthworms, but as humans move through the landscape the probability of colonization is increasing (Casson et al. 2000).

One of the earliest studies of non-native earthworms in forested habitats documented a disappearance of the organic surface horizon, an increase in the depth and character of the A layer, and a decrease in the depth of the B horizon (Langmaid 1964). Another study stated that earthworms “eliminated the forest floor” (Groffman et al. 2000). Alban and Berry (1994) provided the first detailed documentation of earthworm effects in Minnesota forest soils where they dramatically reduced the litter and duff layers, eliminated the E-layer, and increased the A horizon. Earthworms also can make the soil more permeable to water (Peterson and Dixon 1971), potentially altering water relations, especially near the soil surface.

Leaf litter can be completely broken down in as little as 4 weeks by earthworms (Knollenberg et al. 1985). In a natural forest ecosystem lacking earthworms, it has been estimated that it might take 3–5 years for decomposition (Mortensen and Mortensen 1998). Earthworms introduced into mine spoil banks have been seen to have dramatic effects on the litter layer, burying or consuming 5 metric tons of leaf litter/ha within 2 years (Vimmerstedt and Finney 1973).

The evidence suggests that the several species of exotic earthworms now colonizing the Lake States region will have considerable impact on native plants including *B. mormo*. A comparison of 6 plots with earthworms compared to 6 plots without earthworms (albeit a low sample size) in the Chippewa NF found that 70% of the plant species were adversely affected by earthworms and 25 species, or 50% of all the species present in the undisturbed plots and including *B. mormo*, were apparently eliminated by worm activity (Almendinger 1998). Others have also reported decreased diversity in the herbaceous understory (Nielsen and Hole 1963, 1964; Nixon 1995; Cothrel et al. 1997). It has been suggested that European earthworms may be incompatible with the survival of many North American hardwood understory species (Hale et al. 1999), although some species have been reported to increase in numbers after worm invasion (Almendinger 1998, Berlinger 2000).

On the Chippewa NF, an ongoing monitoring study (Johnson-Groh 1999) demonstrated significant declines in *B. mormo* numbers where plots were infested with earthworms. However, she cautioned that, while the earthworms likely had fatally affected the plants, all other populations also showed decreases during that dry period. She also observed that it is normal for moonwort populations to fluctuate widely and that population crashes may be due to a population exceeding the carrying capacity of a site. Another monitoring study in the same area (reported by Casson et al. 2000) also showed negative effects on soil properties and a dramatic reduction in the *B. mormo* population after invasion by exotic earthworms.

The loss of the soil organic layer may affect *B. mormo* through its obligate association with mycorrhizal fungi. The fungi may perish with the loss of the forest floor (Nixon 1995) or may also be eaten by sowbugs, which, in at least one instance seem to be invading sites with exotic earthworms (Wolff et al. 1997). Large decreases in mycorrhizal fungi have occurred following earthworm invasion in deciduous hardwood forests (Nielsen and Hole 1963, 1964; Cothrel et al. 1997, Nixon 1995). Since most

mycorrhizal activity occurs in the interface between the O and A horizons (Read 1994), the concurrent action of exotic earthworms in the same area can be expected to have dramatic effects.

### **Forestry threats**

Forest management direction and other decisions concerning natural resources policy on public forest land in the Lake States often have worked against maintenance or development of forest habitat suitable for *B. mormo* (Casson et al. 2000). A policy emphasis on aspen monoculture in certain areas is an example (Sather et al. 1998).

Forestry activities have been identified as a significant threat to *B. mormo* populations (Sather et al. 1998) due to a variety of associated effects. The most permanent activities such as construction of roads, skid trails, and landings obviously have the most severe effects, but are less extensive than other effects, such as widespread canopy removal. Even temporary roads or landings cause soil compaction, erosion, and other changes that may persist for years (Brady and Weil 1999). Sather et al. (1998) evaluated the spectrum of silvicultural options and potential impacts on *B. mormo* populations. They recognized that while clearcutting pure stands of aspen may not represent a loss in *B. mormo* habitat, *B. mormo* habitat would be compromised in clearcutting mixed stands of aspen, maple, and basswood, a forest type where *B. mormo* has been frequently found. In single tree or group-selection methods, the removal of trees may simulate natural gap-forming processes, but the ground impacts would not simulate natural disturbances (Casson et al. 2000). Forestry activities such as the planting of monocultural pine plantations or ground-layer herbicide application are other threats to *B. mormo*.

In some cases, restoration activities that aim to regenerate tree species that were more common in the past may impact *B. mormo* habitat by disturbing the organic layer and soil (Sather et al. 1998). However Casson et al. (2000) reported that this may improve long-term habitat conditions by restoring species such as white pine, hemlock, paper birch, and yellow birch which are components of forest habitats suitable for *B. mormo*.

Casson et al. (2000) detailed five informal reports from seven timber harvest sites in areas with a known *B. mormo* population:

Ottertail Peninsula, Minnesota: About 100 plants of *B. mormo* were observed at a site that had been clearcut 17 years earlier. The plants were at the edge of the clearcut and extended into an adjacent uncut area. Earthworms subsequently invaded and reduced the soil organic layer and no *B. mormo* plants have been found since. In a nearby similar area of aspen regeneration one plant was found.

Langlade County, Wisconsin: A stand containing 15 *B. mormo* plants was winter thinned. The site was revisited 1 and 3 years later, and no plants of *B. mormo* were located.

Minisogama Lake, Minnesota: A stand containing 10 *B. mormo* plants was clearcut during the winter. No plants were relocated during 3 return visits within the following 5 years.

Bello Lake, Minnesota: A stand containing 3 *B. mormo* plants was clearcut, no plants were relocated during several years of subsequent visits.

Langlade and Forest County, Wisconsin: Observations on three selectively cut sites showed that plants were apparently unaffected by the activity (as long as they were not directly damaged).

Forest County, Wisconsin: A stand containing 34 *B. mormo* plants was thinned, five years later 12 plants were relocated.

Casson et al. (2000) concluded that timber harvest presents a threat to *B. mormo* and that populations are less tolerant of clearcutting than partial removals. They reported an ongoing study in the Chippewa National Forest (Little Goblin Moonwort Administrative Study), where an intermediate harvest-level treatment will occur in the same area as an uncut control area, both areas having *B. mormo* populations.

### **Stewardship overview and population viability concerns**

*Botrychium mormo* depends on a thick organic layer in rich deciduous forests and prospers under full or nearly full shade. The potential of exotic earthworms to destroy the organic layer range-wide is an extremely serious threat to the viability of *B. mormo* as a species, although it is a threat that land managers can do little about at the present time, other than to institute educational or other measures to limit the rate of colonization and spread. Since the earthworm threat is so serious, existing *B. mormo* populations and habitats need to be vigorously protected (Casson et al. 2000).

The maintenance of mature maple, maple-basswood and maple-basswood-beech forests along the eastern deciduous/northern hardwood forest ecotone is a primary need to protect *B. mormo* habitats (NatureServe 2001). Adequate buffers should be acquired to protect existing *B. mormo* populations from outside influences (herbicide drift, development, road openings, various effects of logging, etc.). Logging of areas containing high-quality *B. mormo* populations should not be undertaken (NatureServe 2001). Extensive deforestation or physical disruption of surface soil layers will be detrimental to *B. mormo*.

Since there is little genetic differentiation between *B. mormo* populations (Farrar 1997), no inter-population dynamics may be required for species viability (Casson et al. 1998), indicating that collaboration with landowners outside of the Forest Service is not necessary to maintain the viability of *B. mormo* on National Forest land (Casson et al. 2000). Although, in consideration of the earthworm threat, the protection of worm-free sites outside of Forest Service may help preclude ultimate Federal listing of the species under the Endangered Species Act (Casson et al. 2000).

A “Population Viability Assessment” meeting held in Duluth, Minnesota in January, 2000 was unable to determine the number of populations needed to maintain viability of *B. mormo* across the planning area (USDA Forest Service 2000). Casson et al. (2000) also discussed the short- and long-term viability of *B. mormo* on National Forests in the Lake States. Since the Superior, Hiawatha, and Ottawa National Forests each have less than three known populations (now four on the Ottawa NF), they concluded that there is an insufficient number of known populations to insure future viability in those forests. They consider the larger populations on the Chippewa and the Chequamegon National Forests potentially viable in the short-term but questionable over the long-term due to the exotic earthworm threat.

### **Research and monitoring requirements**

The “Population and Habitat Viability Assessment for the Little Goblin Moonwort” (Berlin et al. 1998) details a number of recommendations from each working group. Many of the recommendations relate to research needs concerning habitat, *B. mormo* biology, and potential threats from exotic earthworms and forestry practices.

Casson et al. (2000) strongly recommended the following monitoring and research actions:

- Study and compare the underground biology of *B. mormo* in normal and disturbed communities. An abundance of underground gametophytes and sporophytes has been documented (Johnson-Groh 1998). Do they persist in sites disturbed by earthworms or forestry practices?
- Study the impacts of earthworms on the viability of *B. mormo* and its habitat. Since earthworms present such a serious threat to *B. mormo*, information is needed on the distribution of the various exotic earthworm species and their effect on the forest soil. Additionally, little is known about the ability of *B. mormo* to sustain itself in the kind of habitats that will remain after invasion. Can methods be developed to control earthworms?
- Monitor *B. mormo* populations in areas undergoing timber harvests with permanent plots.
- Investigate the mycorrhizal components of population dynamics such as the presence or absence of mycorrhizae in relationship to various habitat types or disturbances.

Casson et al. (2000) also recognized other monitoring and research needs including:

- Continue searching for *B. mormo* occurrences including less likely sites.
- Continue monitoring past, current, and potential sites to refine data on various population factors.
- Study spore dispersal strategy
- Conduct transplant experiments with *B. mormo*.
- Investigate ecophysiology and the contribution of photosynthesis to the overall energy budget.
- Evaluate the importance of *B. mormo* to the ecological community including other *Botrychium* spp.
- Are there feasible timber harvesting methods that do not negatively impact *B. mormo* habitat factors?
- Coordinate and share ongoing monitoring information.
- How do the soils of various forest habitats differ in their susceptibility to exotic earthworms?

The Nature Conservancy (NatureServe 2001) recommended further inventory work, particularly in Michigan. They considered the species' ecological requirements and stewardship needs to be poorly known. The effects of forest management regimes should be assessed, and methodologies should be developed for monitoring the condition of extant populations (NatureServe 2001).

### **Management programs**

A "Conservation Strategy for the Little Goblin Moonwort, *Botrychium mormo* W. H. Wagner" is being developed for the USDA Forest Service, Eastern Region (Casson et al. 2000). The draft version recommended a number of management actions needed to help protect *B. mormo* populations and habitats. The authors emphasized that exotic earthworms could virtually eliminate the thick organic surface horizon necessary for *B. mormo*. Expanding earthworm colonization of the region's forests could threaten the continued existence of *B. mormo* (and many other herbaceous forest species). In recognition of this threat, Casson et al. (2000) recommended that any additional threats to *B. mormo* be minimized when practicable. Berlin et al. (1998) also make a number of management recommendations.

## Research programs

Robert Preston, Don Drife, and until his death in 2000, Dr. Herb Wagner, of Alpena Community College, Detroit metro area, and University of Michigan, respectively, are currently working on publication of the pteridophyte (ferns and fern-allies) flora of the Upper Great Lakes region (NatureServe 2001).

Warren Hauk, a doctoral candidate under Dr. Chris Haufler, University of Kansas, is currently working on the systematics of *Botrychium* subgenus *Botrychium*, which includes *B. mormo* (NatureServe 2001). Contact: Warren Hauk or Dr. Chris Haufler, Department of Botany, Haworth Hall, University of Kansas, Lawrence, Kansas 66045. Telephone No. (913) 864-3255. Francisco Comacho, a graduate student in Oregon is reported to be working on identifying the mycorrhizae associated with *Botrychium* (Sather et al. 1998).

On the Chippewa National Forest an intermediate harvest will occur in the same area as an uncut control area, both with a *B. mormo* population (Little Goblin Moonwort Administrative Study reported in Sather et al. 2000).

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Michigan: <http://www.dnr.state.mi.us/wildlife/heritage/mnfi/>

Minnesota: [http://www.dnr.state.mn.us/ecological\\_services/nhnrp/index.html](http://www.dnr.state.mn.us/ecological_services/nhnrp/index.html)

Wisconsin: <http://www.dnr.state.wi.us/org/land/er/nhi/nhi.htm>

Illinois: <http://dnr.state.il.us/>

Indiana: <http://www.ai.org/dnr/naturepr/index.htm>

Iowa: <http://www.state.ia.us/dnr/organiza/ppd/nai.htm>

Ohio: <http://www.dnr.state.oh.us/odnr/dnap/dnap.html>

North Dakota: <http://www.abi.org/nhp/us/nd/index.html>

#### CANADA

Ontario: <http://www.mnr.gov.on.ca/MNR/nhic/nhic.html>

Quebec: <http://www.menv.gouv.qc.ca/biodiversite/centre.htm>

## APPENDICES

### APPENDIX A. *BOTRYCHIUM MORMO* ELEMENT OCCURRENCE RECORDS

Jacques Labrecque from the Quebec Natural Heritage Data Center reports that the Quebec occurrence of *B. mormo* is known from one collection made by fern experts Herb and Florence Wagner in 1990, but this site was not reported in their treatment of *Botrychium* in the Flora of North America (Wagner and Wagner 1993).

The following information was obtained from natural heritage programs in Michigan, Minnesota, Wisconsin, and adjacent states (U.S.) and provinces (Canada). National Forests within the Great Lakes region also provided survey data on species occurrences within each Forest.

Element occurrence summary:

Michigan	13
Minnesota	162
Wisconsin	74

#### MICHIGAN

Location: Michigan, Alger County

Ownership: USDA Forest Service (Hiawatha NF, Munising RD)

Abundance: Not listed

Habitat: Moist upland

Source of information: Hiawatha NF

Location: Michigan, Alger County

Ownership: USDA Forest Service (Hiawatha NF, Munising RD)

Abundance: Not listed

Habitat: Not listed.

Source of information: Hiawatha NF survey form

Location: Michigan, Alger County

Ownership: Pictured Rocks National Lakeshore.

Abundance: Not listed.

Habitat: In sand at foot of lee slope of sand dunes; in woods along sandy trail; in mixed woods.

Comments: No population data.

Source of information: Hiawatha NF

Location: Michigan, Baraga County

Ownership: USDA Forest Service (Ottawa NF, McCormick Wilderness)

Abundance: 34 plants.

Habitat: Most plants growing in mineral soil of ephemeral runoff channels; the surrounding forest was a mature stand of sugar maple and yellow birch.

Source of information: Chadde (2000).

Location: Michigan, Cheboygan County  
Ownership: private  
Abundance: Not listed.  
Habitat: Reported from dry northern forest and much of area is red pine plantation and degraded jackpine barrens. No *B. mormo* found during last field visit in 1997.  
Comments: No population data.  
Source of information: Michigan Natural Features Inventory Element Occurrence Record

Location: Michigan, Cheboygan County  
Ownership: private  
Abundance: Not listed.  
Habitat: Mesic northern forest of second-growth *Fagus*, *Tilia*, *Acer saccharinum*, *Ostrya*. Several cm of leaf litter over loamy soils. No *B. mormo* found during last field visit in 1997.  
Comments: No population data.  
Source of information: Michigan Natural Features Inventory Element Occurrence Record

Location: Michigan, Chippewa County  
Ownership: USDA Forest Service (Hiawatha NF, Sault Ste Marie RD).  
Abundance: Not listed.  
Habitat: 1953: Rocky woods. 1954: Maple woods on limestone hill.  
Comments: No population data.  
Source of information: Michigan Natural Features Inventory Element Occurrence Record

Location: Michigan, Delta County  
Ownership: private  
Abundance: Not listed.  
Habitat: Mesic northern forest, along margins of swamp.  
Comments: No population data.  
Source of information: Michigan Natural Features Inventory Element Occurrence Record

Location: Michigan, Dickinson County  
Ownership: Copper Country State Forest, private  
Abundance: Not listed.  
Habitat: Shallow ravine in woods below limestone bluffs and highlands. Area rich in broken limestone.  
Comments: No population data.  
Source of information: Michigan Natural Features Inventory Element Occurrence Record

Location: Michigan, Gogebic County  
Ownership: USDA Forest Service (Ottawa NF, Watersmeet RD)  
Abundance: 13 plants.  
Habitat: Sugar maple forest with *Tilia* and *Abies* on north-facing slope, soil sandy loam; plants growing on an old decayed log in swale. Other species include *Lonicera canadensis*, *Trientalis borealis*, *Maianthemum canadense*, *Aralia nudicaulis*, *Dryopteris carthusiana*.  
Source of information: Ottawa NF survey form

Location: Michigan, Gogebic County

Ownership: USDA Forest Service (Ottawa NF, Watersmeet RD)

Abundance: 13 plants.

Habitat: Sugar maple forest with *Tilia* and *Abies* on north-facing slope, soil sandy loam; plants growing on an old decayed log in swale. Other species include *Lonicera canadensis*, *Trientalis borealis*, *Maianthemum canadense*, *Aralia nudicaulis*, *Dryopteris carthusiana*.

Source of information: Ottawa NF survey form

Location: Michigan, Otsego County

Ownership: private

Abundance: Not listed.

Habitat: Old roadway and shaded clearings in a dry-mesic northern forest.

Comments: No population data.

Source of information: Michigan Natural Features Inventory Element Occurrence Record

Location: Michigan, Mackinac County

Ownership: Lake Superior State Forest, private.

Abundance: Not listed.

Habitat: In woods on top of small limestone bluff, near open quarry. 1996: 1 hour survey - lots of *Botrychium virginianum* but no *B. mormo*.

Comments: No population data.

Source of information: Michigan Natural Features Inventory Element Occurrence Record

## Minnesota

Location: Minnesota, Aitkin County

Ownership: Unknown

Abundance: 3 plants

Habitat: Maple-basswood ridge around small forest pool in concentration of white cedar and yellow birch within maple-basswood forest. *Botrychium lanceolatum*, *B. matricariifolium* and *B. oneidense* also found at site. Plants found at base of white cedar with *Aralia nudicaulis*, *Maianthemum canadense*, *Acer saccharum*, *Trientalis borealis*, and *Carex pensylvanica*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: USFWS

Abundance: 3 plants

Habitat: In a low lying maple-basswood forest. Associated with *Botrychium virginianum*, *Aster macrophyllum*, *Aralia nudicaulis*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: USFWS

Abundance: 1 plants

Habitat: In rich maple-basswood forest on esker. On gradual east-facing slope of 50 ft high north-south trending esker. Canopy of mature *Tilia americana* with *Acer saccharum* predominant in understory. Rich dark mesic loam. Associated with *Osmorhiza claytonii*, *Caulophyllum thalictroides*, *Athyrium filix-femina*, *Thalictrum dioicum*, *Uvularia grandiflora*, *Acer saccharum* seedlings.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: County

Abundance: 7 plants

Habitat: Maple-basswood ridge south of hay lake. Associated with *Caulophyllum thalictroides*, *Allium tricoccum*, *Acer saccharum* seedlings, *Sanguinaria canadensis*, *Arisaema triphyllum*, *Botrychium virginianum* and *Botrychium matricariifolium*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: State and con-con

Abundance: 7 plants

Habitat: In maple-basswood forest, associated with *Aralia nudicaulis*, *Uvularia grandiflora*, *Acer saccharum* seedlings and *Osmorhiza claytonii*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: State

Abundance: 2 plants

Habitat: Mature maple-basswood forest.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: Unknown

Abundance: Several plants

Habitat: In a low moist area of maple and ash near a beaver pond.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: USFWS

Abundance: 2 plants

Habitat: In a small steep sided kettle depression on a hardwood ridge dominated by *Acer saccharum* and *Tilia americana*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: Unknown

Abundance: A dozen or more plants, but very scattered

Habitat: Maple-basswood forest with a generous quantity of mature aspen in the mix.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: County

Abundance: 16 plants, two populations (4 and 12)

Habitat: Mildly rolling ground in maple-basswood for transition into black ash wetland. Patchy leaf litter of ~1 in deep with abund small, woody debris. Scatt sugar maple saps, *Osmorhiza claytonii*, *Aralia nudicaulis* and *Arisaema triphyllum*. Fluffy leaf litter 2 in deep among woody debris.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: County

Abundance: < 10 plants

Habitat: Growing in a one acre patch of northern hardwood forest at the base of a north-facing slope, adjacent to a hardwood swamp. Surrounding uplands are young oak/aspen forest. Less than 10 plants. With *Acer saccharum*, *Gymnocarpium dryopteris*, *Asarum canadense* and *Carex rosea*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Aitkin County

Ownership: County

Abundance: Four shoots found in cluster and 10 shoots seen about 100m away in same habitat.

Habitat: Growing in a large lowland forest dominated by *Thuja occidentalis* and *Acer saccharum*. In shade under *Acer*, sparse woody understory. With *Asarum canadense*, *Uvularia sessilifolia*, *Botrychium virginianum*, *Carex pedunculata* and *Mitella diphylla*. Comments: 1998 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: Native American land

Abundance: Not listed.

Habitat: Not listed.

Comments: 1973 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: Unknown

Abundance: > 50 plants



Habitat: Northern hardwood stand, several age classes represented from 20 yr old maple thru about 90 yr old maple and white cedar. Closed canopy, thick leaf mold. Another occurrence of this species is found in another "40" within this stand.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: Unknown

Abundance: 1995: 14 plants obs. 1996: 104 plants obs. 1997 and 1998: population steadily decreased

Habitat: Candidate old-growth complex. 1+ plants found under mixed northern hardwoods.

Comments: 1998 listing, introduced earthworms may be altering soil and impacting *Botrychium*.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: Unknown

Abundance: 2 plants

Habitat: Mixed northern hardwoods with white spruce, white pine, and balsam fir, strong aspen component. Maple overstory where little goblin moonworts were located. *Hepatica*, *Uvularia*, leatherwood, beaked hazel on the ground and understory. Regenerating clearcut (approx 10 years old) approx 120 feet to the south.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service

Abundance: > 15 plants

Habitat: Northern hardwood stand on boundary between two managed stands. Very little ground vegetation present. Paper birch common.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: Unknown

Abundance: 3 plants

Habitat: 3 plants located in an area of large diameter maple and basswood, eastern aspect of low slope. Heavy leaf mold, few forbs or grasses present. Crown cover within stand was heavy, low light conditions underneath. Forest stand is typed as aspen, but has appearance of northern hardwood community.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service

Abundance: 15 plants

Habitat: northern hardwoods

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service

Abundance: 15+ plants

Habitat: Habitat dominated by aspen, maple, basswood, and balsam fir. Associated species includes hazel, maple seedlings, *Viola* spp., twisted stalk, *Thalictrum dioicum*, *Carex* spp., and *Hepatica americana*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service

Abundance: 90+ plants

Habitat: Habitat dominated by sugar, maple-basswood with some ironwood. Associated species include *Acer* seedlings, *Aralia nudicaulis*, *Carex* spp., *Thalictrum dioicum*, *Hepatica americana*, *Viola* spp., *Botrychium virginianum* and *Osmorhiza claytonii*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service

Abundance: 15+ plants

Habitat: Habitat dominated by maple, basswood, and paper birch. Associated species include maple seedlings, *Thalictrum dioicum*, *Viola* spp., *Aralia nudicaulis*, ferns, and *Botrychium virginianum*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service

Abundance: 20 plants

Habitat: Habitat dominated by aspen, oak, paper birch ironwood, ash, maple, and basswood. Associated species include *Aralia nudicaulis*, *Carex* spp., *Maianthemum canadense*, bloodroot, *B. virginianum*, *Thalictrum dioicum* and *Hepatica americana*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service

Abundance: 3 plants

Habitat: Located in habitat of ash, oak stand with hazel understory.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County

Ownership: USDA Forest Service  
Abundance: 5 plants  
Habitat: Habitat contains maple-basswood and aspen.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County  
Ownership: USDA Forest Service  
Abundance: 1 plants  
Habitat: Not listed  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County  
Ownership: USDA Forest Service  
Abundance: 50+ individuals  
Habitat: Maple-basswood-cedar stand, on a low rise above the lake. In scattered clusters with *Botrychium minganense*, Associated with *Caulophyllum thalictroides*, *Pyrola rotundifolia*, *Gymnocarpium dryopteris*, *Carex pedunculata*, *Arisaema triphyllum*.  
Comments: Plants unusually robust, to 3 inches tall. Earthworms invading from western 3/4 of stand  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County  
Ownership: USDA Forest Service  
Abundance: 2 plants  
Habitat: Maple-basswood in a narrow corridor between a logging road and clearcut. In 2-3cm duff with *Acer saccharum* seedlings, *Uvularia grandiflora*, *Streptopus roseus*, *Osmorhiza claytonii*, *Thalictrum dioicum*, *Ostrya virginiana*, *Botrychium matricariifolium*.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County  
Ownership: USDA Forest Service  
Abundance: 4 plants  
Habitat: Mature sugar maple-basswood forest on level ground; rich soils, closed canopy. Six *B. matricariifolium* plants also found. *Botrychium virginianum* in abundance, *Dirca palustris*, *Ostrya virginia* prolific  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Beltrami County  
Ownership: Unknown  
Abundance: Not listed  
Habitat: Not listed  
Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: Unknown

Abundance: Not listed

Habitat: Not listed

Comments: 1975 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Several colonies of few individuals. 4 very tall, slender plants (8 cm above leaf litter) observed

Habitat: Plants growing in mature deciduous forest dominated by *Acer saccharum* and *Tilia americana*, with *Abies balsamea*, *Ostrya virginiana* and *Dirca palustris*. Associates include *Uvularia grandiflora*, *Aralia nudicalis*, *A. racemosa* and *Athyrium filix-femina*. Several colonies of few individuals. 4 very tall, slender plants (8 cm above leaf litter) observed

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 1 plant

Habitat: Plants growing in a mature deciduous forest dominated by *Acer saccharum* and *Tilia americana*. Sparse herb layer with substantial leaf mold. Assoc. species include: *Athyrium filix-femina*, *Uvularia grandiflora*, *Botrychium virginianum*, and *Thalictrum dioicum*

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Not listed

Habitat: Plants occur in leaf litter along the edge of a log in an upland with *Thuja occidentalis*, *Acer saccharum*, *Betula alleghaniensis*, *Tilia americana*, and *Ulmus americana*. Assoc. species include: *Athyrium filix-femina*, *Thalictrum dioicum*, *Arisaema triphyllum*, *Streptopus roseus*, *Gymnocarpium dryopteris*, and small *Acer* seedlings.

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Not listed

Habitat: Plants observed on both sides of the road in a mature regrowth forest of *Acer saccharum*, *Tilia americana*, *Betula alleghaniensis*, *Thuja occidentalis*, *Ostrya virginiana* and *Dirca palustris*. Moderate herb layer of *Aralia racemosa*, *Uvularia grandiflora*, *Botrychium virginianum*, *Taxus canadensis*, and *Athyrium filix-femina*.

Comments: 1992 listing, Often only spore capsules visible above deep leaf litter.  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 150 plants  
Habitat: Upland area with *Acer saccharum*, *Tilia americana*, upland *Thuja occidentalis*, *Betula alleghaniensis* with limited understory and sparse herb layer of *Uvularia grandiflora*, *Aralia racemosa*, *B. virginianum* and *Athyrium filix-femina*.  
Comments: 1998 listing, 1992-1998: pop monitored by Johnson-Groh. Population experienced increase each year 1992-1996 and decreased each year 1996-1998. Decrease possibly caused by earthworm invasion.  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: Many small plants at this location, as well as some large specimens  
Habitat: Plants occur in a border between dense lakeshore vegetation and a sea of *Laportea canadensis* beneath very widely spaced mature *Acer saccharum*. Border of herbs include: *Athyrium filix-femina*, *Uvularia grandiflora*, *Streptopus roseus*, and *Aralia racemosa*.  
Comments: 1992 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 1994: 85 plants obs (35 new) by Johnson-Groh. 1995: 115 (33 new) obs by J-Groh. 1996: 229 (95 new) obs by J-Groh.  
Habitat: Plants occur in sloping and level areas with *Acer sacchar*, *Tilia amer* and lesser amnts *Abies balsam*. Associated spp: *Uvularia grandiflora*, *Aralia racemosa*, *Botrychium virginianum*, *B. matricariifolium* and *Athyrium filix-femina*. 1 plant observed in faint deer trail, others at base of slope.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: Several small, tight colonies of very large plants obs in deep leaf litter  
Habitat: Plants occur in a level, deciduous forest dom by *Acer saccharum* and *Tilia americana*. Bright yellow-green color of sporophore contrasts with light brown of crust of leaf litter making plants more visible, despite appearance of only portion of plant above leaf mold.  
Comments: 1992 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service

Abundance: A few very large individuals (with spore capsules numbering over 75) observed at this location, as well as small and average-sized specimens.

Habitat: Plants occur in deep leaf litter with *Acer saccharum*, *Tilia americana*, and *Thuja occidentalis*. Assoc. species include: *Botrychium minganense*, *B. virginianum*, *Aralia racemosa*, *Uvularia grandiflora*, and *Dirca palustris*.

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Some of the plants observed are extremely tiny.

Habitat: Forested with *Acer saccharum*, *Tilia americana*, and occasional *Thuja occidentalis*. Plants are growing in very deep shade, in a slightly lower, moist area of thin leaf litter and woody debris. Herb layer is very sparse.

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 100+ plants observed in brief search.

Habitat: Plants occur in a deciduous forest dom by *Acer saccharum* and *Tilia americana* with *Botrychium minganense*, *B. matricariifolium*, and *B. virginianum*. growing singly, in pairs, and in loose groupings of a few plants scattered through stand

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: Private

Abundance: 100+ plants observed in brief search.

Habitat: Maple-basswood forest

Comments: 1998 listing, Plants 1st appeared in 1994. 1995: population monitoring plot #1 established by Johnson-Groh. Pop decreased in 1995, increased in 1996, decreased in 1997 to only 11 plants and none were present in 1998. Possible cause of decrease is earthworm invasion.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 25+ plants observed in a 100 x 50 meter area in very brief search

Habitat: Deciduous forest dominated by *Acer saccharum* and *Tilia americana* with *Acer* understory of 4-5" dbh trees.

Comments: 1997 listing. Exotic earthworms in area

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Very rarely observed at this site despite much potential habitat

Habitat: Plants occur in a deciduous forest dominated by *Acer saccharum* and *Tilia americana* with *Acer* understory also.

Comments: 1994 listing.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 5 plants observed in brief search

Habitat: Deciduous forest dominated by *Acer saccharum* and *Tilia americana* with *Botrychium matricariifolium* and *B. virginianum*.

Comments: 1994 listing.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 8 plants

Habitat: Seasonal drainage ditch in deciduous forest with *Tilia americana*, *Acer saccharum*, *Betula papyrifera* and *Ostrya virginiana*. Associated species: *Uvularia grandiflora*, *U. sessilifolia*, *Maianthemum canadense*, *Osmorhiza claytonii*, *Asarum canadense*, *Pyrola* and *Botrychium virginianum*.

Comments: 1995 listing.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 11 plants

Habitat: Maple-basswood with yellow birch. With *Carex pedunculata*, *Aralia racemosa*, *Uvularia grandiflora*, *Tilia* seedlings, *Aralia nudicaulis*, *Polygonatum pubescens*. Plants located just north of planted red pine along gravel road

Comments: 1994 listing.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: Native American land

Abundance: 1995: large pop; bndry not firmly established. 485+ stems, more nearby in unsurveyed area

Habitat: Rich maple-basswood, some logging evidence. Dense *Acer saccharum* canopy. Assoc: *Uvularia grandiflorum*, *Allium tricoccum*, *Hydrophyllum*, *Sanguinaria*, *Laportea*. Leaf litter matted, light brown.

Comments: 1997 listing. 1997: exotic earthworm infestation moving through site, duff partially destroyed.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: Native American land

Abundance: 23 plants

Habitat: Rich, old-growth maple-basswood forest. Slight slope down to nw. Canopy dominated by *Acer saccharum*, with *Tilia americana*, *Fraxinus nigra*, *Quercus macrocarpa*; herbs - *Uvularia grandiflora*, *Hydrophyllum virginianum*, *Sanguinaria canadensis*, *Arisaema triphyllum*. *Erythronium albidum* found in area in 1994

Comments: 1995 listing.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 20 plants

Habitat: Maple-dominant forest with basswood and birch. Associated spp: *Thalictrum* spp., large-flowered bellwort, small regenerating ironwood, and *Carex* sp.

Comments: 1996 listing.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Not listed

Habitat: Not listed

Comments: 1997: Plants are an extension of a larger occurrence

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Not listed

Habitat: Habitat contains sugar maple, ironwood, bur oak, and ash in process of die back,

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 32 plants

Habitat: Habitat is sugar maple/basswood stand

Comments: 1996 listing, some plants may be *B. matricariifolium*.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: Unknown

Abundance: 6 plants

Habitat: In 2 areas north of large wetland. One site in hazel brush, second site further west in cinnamon fern. North boundary of wetland dominated by cinnamon fern. Maple-basswood stand type with Solomon's seal abundant. Other Associated spp: sarsaparilla, large-leaf aster and hazel.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County



Ownership: Unknown  
Abundance: 20+ plants located in 2 areas  
Habitat: Habitat is old-growth maple-basswood, yellow birch, and cedar. Some understory growth of sugar maple. Associated spp: Solomon's seal jack-in-the-pulpit and ginger. Site is mostly flat with very rich, wet soil.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: Private  
Abundance: 1 plant  
Habitat: One plant found in aspen regeneration (approx 22 yrs old).  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: Not listed  
Habitat: Not listed  
Comments: Part of larger population  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: Unknown  
Abundance: 100+ plants observed in 100 x 100 meter area  
Habitat: Deciduous forest dom by *Acer saccharum* and *Tilia americana*. Associated with *Athyrium filix-femina*, *Ulmus americana*, *Uvularia grandiflora*. Understory 2-4" dbh *Acer* and *Ulmus* thicket; past cutting.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 2 plants  
Habitat: Maple-basswood forest. Other plants present include jack-in-the pulpit, wild lily-of-the valley, numerous *Botrychium matricariifolium*, also spruce and yellow birch.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 20 plants  
Habitat: Maple-basswood with sparse shrub layer. Other species present include jack-in-the pulpit, ginger, bloodroot.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: Not listed  
Habitat: Canopy dominated by *Acer saccharum* and *Tilia americana*, with *Quercus macrocarpa* and *Betula papyrifera*. Associated with *Uvularia grandiflora*, *Aralia nudicaulis* and *Botrychium virginianum*. No exotic earthworms found. Possibly some logging in past 50 years.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: Unknown  
Abundance: 3 plants  
Habitat: Habitat is aspen stand with basswood, oak and birch mixed in. Well shaded area with flat slope and rich, wet soil. Associated spp: large-leaf aster, Solomon's seal, young oaks with many mosses and poison ivy.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: Private  
Abundance: Not listed  
Habitat: Not listed  
Comments: 1997 listing, area heavily infested by earthworms  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 100's of plants  
Habitat: Not listed  
Comments: 1997 listing, exotic earthworms present.  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: Unknown  
Abundance: 1 plant  
Habitat: Habitat is maple-basswood stand with occasional oak and pine. Site is shaded, with flat slope and very wet, rich organic soil. Associated spp: Solomon's seal, cinnamon fern and large-leafed aster.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: Native American land  
Abundance: Not listed

Habitat: Northern hardwood forest dom by *Acer saccharum*, *Tilia americana*. Site of timber stand improvement in past. Large *Tilia* and *Betula alleghaniensis* (30-36 in dbh) observed. Associated spp incl usual herbaceous plants including *B. virginianum*.

Comments: 1996 listing, Land across road to south also surveyed and found to be lacking duff layer due to exotic earthworms. *B. mormo* likely to be lost to infestation in future.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 25+ plants

Habitat: Maple-basswood with areas of ash. Open understory, thick organic layer. Level topography. Associated spp: *Botrychium virginianum*, *B. matricariifolium*, *B. multifidum*, *B. lanceolatum*, jack-in-the pulpit, seal-seal, ostrich fern, wild ginger.

Comments: 1998 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: Private

Abundance: 15 plants

Habitat: Maple-basswood with jack-in-the-pulpit, blue cohosh, red baneberry, lopseed and *Sanguinaria canadensis*.

Comments: 1998 listing. Much of the area along this peninsula is heavily infested with earthworms. Area where plants are found is last of habitat with intact duff and litter layer.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: Private

Abundance: 100's of plants

Habitat: Not listed

Comments: 1997 listing. Area heavily infested with earthworms

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: Not listed

Habitat: Not listed

Comments: 1997 listing, part of larger population

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County

Ownership: USDA Forest Service

Abundance: 100's of plants in area

Habitat: Not listed

Comments: 1997 listing, exotic earthworms present

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: State and con-con land  
Abundance: 100's of plants in area  
Habitat: Not listed  
Comments: 1997 listing, exotic earthworms present, part of larger population  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 4 plants  
Habitat: Open leaf litter, in mature maple-basswood forest. Open understory, herb layer dominated by nettles and rattlesnake fern  
Comments: 1999 listing, exotic earthworms present, part of larger population  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 3 plants  
Habitat: Mature maple-basswood forest. Understory mostly open, northern white cedar nearby.  
Associated spp: *Aralia nudicaulis*, *Dirca palustris*, *Urtica dioica*, *Botrychium virginianum*.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 4 plants  
Habitat: Open leaf litter in mature hardwoods. Understory crowded with maple saplings.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 12 plants  
Habitat: Mature maple-basswood stand with open understory, thick leaf litter. 2 *B. matricariifolium* plants also found.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 100+ plants found on 15 July, Over 500 plants were observed when site was re-visited on 8/30/1999.  
Habitat: Mature maple-basswood canopy with wet pockets of black ash. Northern white cedar along edges of black spruce swamps in northern part of stand.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 3 plants.  
Habitat: Mature maple-basswood stand; understory open, floor dominated by maple seedlings. *B. virginianum* abundant.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: approx 100 plants  
Habitat: Mature maple-basswood forest with aspen and large yellow birch. Understory mostly open.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Mature maple-basswood forest with rich organic layer  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 2 plants  
Habitat: Stand of primarily balsam fir, with maple-basswood and scattered cedar. Understory open.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 7 plants  
Habitat: Mature maple-basswood forest, at edge of temporary pool. Associated with *Corylus cornuta*, *Dirca palustris*, *Uvularia grandiflora*, *Thalictrum dioicum*, *Botrychium virginianum*, *Viola* spp., *Streptopus roseus*, *Anemone quinquefolia*, *Rubus pubescens*.  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 3 plants  
Habitat: Mature maple-basswood forest with rich soil  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 10+ plants  
Habitat: Maple-basswood forest with rich soil  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Cass County  
Ownership: USDA Forest Service  
Abundance: 50+ plants  
Habitat: Mature maple-basswood forest with yellow birch; very rich soil  
Comments: 1999 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Clearwater County  
Ownership: State  
Abundance: infrequent  
Habitat: Hardwood forest  
Comments: 1973 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Clearwater County  
Ownership: State  
Abundance: Not listed  
Habitat: Not listed  
Comments: 1973 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Clearwater County  
Ownership: County  
Abundance: Not listed  
Habitat: Not listed  
Comments: 1973 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Crow Wing County  
Ownership: Unknown  
Abundance: Dozens of plants seen  
Habitat: Near the edge of a small pool in an old-growth maple-basswood forest.  
Comments: 1998 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Crow Wing County  
Ownership: Unknown  
Abundance: about 30 indiv

Habitat: Forested moraine. Open canopy dominated by bur oak with closed subcanopy of sugar maple. Level to gently sloping with slight depressions. Deep mull humus to 7cm depth. Leaf litter to 3cm. Rooting in dense fibrous mat. E-horizon light gray silt. Associated spp: *Streptopus roseus*, *Thalictrum dioicum*, *Trillium cernuum*, *Ribes cynosbati*, *Cornus alternifolia*, *Adiantum pedatum*.

Comments: 1998 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Crow Wing County

Ownership: State

Abundance: about 10 indiv

Habitat: Found in a white cedar swamp under a continuous canopy of *Thuja occid.* Sub-canopy dominated by *Abies balsamea*. Associated with *Acer spicatum*, *Coptis groenlandicum*, *Mitella nuda*, *Smilacina trifolia*, *Arisaema triphyllum*, and *Carex trisperma*. Mosses diverse and continuous.

Comments: 1998 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 3 plants

Habitat: Mature maple-basswood forest on toe of s slope in heavy leaf litter with little ground cover. Associated spp include: black ash, white cedar, aspen, balsam fir, sedges and bracken ferns

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 2 plants

Habitat: Mature maple-basswood forest on a s slope with heavy leaf litter and little ground cover. 2 species of horsetail also observed in vicinity.

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 6-7 plants observed

Habitat: Plants occur in red oak litter in transition from maple-basswood forest to marshy lakeshore, with *Botrychium: minganense*, *matricariifolium* and *virginianum*. Assoc: *Thalictrum dioicum*, *Lathyrus venosus*, *Ostrya*, and *Equisetum*.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: Very rare at this site

Habitat: Plants occur in a deciduous forest dominated by *Acer saccharum* and *Tilia americana*; growing in a thin, fibrous layer oak and maple leaf litter with some woody debris

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 12 plants in 2 areas

Habitat: Plants occur below a low understory of sugar maple saplings in a deciduous forest dom by *Acer saccharum* and *Tilia americana*.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 1 plant

Habitat: Deciduous forest dominated by *Acer saccharum* and *Tilia americana* in an area of denser herb layer.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 10+ within 1m

Habitat: Microsite under an overstory of aspen, white spruce and black ash. Stand as a whole contains mainly aspen, paper birch, basswood, and sugar maple.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 1 plant

Habitat: Found in heavy leaf mold, under large diameter red maple/basswood overstory with closed canopy.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 3 plants

Habitat: 73 year old stand typed as paper birch, 3 Little goblin moonworts observed within sugar maple inclusion. Heavy leaf mold with few forbs or grasses on ground. Hepatica present. Plants were found within 2 chains (132 feet) of clearcut completed summer '94. Crown closure at site nearly complete, very dark.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record



Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 2 plants

Habitat: Found under an overstory of black ash, white cedar, basswood, paper birch, white spruce, sugar maple. Overstory relatively open to the south and east of the plants. Large leaf aster, *Uvularia*, *Clintonia*, *Hepatica*, *Carex* and black ash seedlings for ground cover. Soil appears clayey.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 1 plant

Habitat: Mixed northern hardwood community, strong maple/ basswood component in overstory with aspen. Thick leaf mold, generally sparse ground cover. *Hepatica*, *Uvularia* on the ground. Closed canopy, no recent harvests.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 2 plants

Habitat: 2 Little goblin moonworts observed within a closed canopy maple inclusion within a predominantly aspen forest stand. Heavy leaf mold with little ground vegetation at site.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: not listed

Habitat: Northern hardwood stand, closed canopy, component of large aspen. *Hepatica*, *Uvularia*, leatherwood on ground. Moderately hilly with vernal pools in low areas.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: not listed

Habitat: Forest stand typed as aspen, heavy component of northern hardwoods including sugar maple and basswood. Thick leaf mold with maple and basswood seedlings, *Uvularia*, club fungi, mosses.

Comments: 1994 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service  
Abundance: 5 plants  
Habitat: Within an aspen, maple stand at edge of small ash inclusion. Associated with *Populus tremuloides*, *Fraxinus nigra*, *Cornus canadensis*, *Rubus pubescens*, *Asarum canadense*, *Matteuccia struthiopteris*.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 25+ plants  
Habitat: Found at base of basswood and balsam on edge of ash stand. Associated with *Botrychium virginianum*, *Rubus pubescens*, *Maianthemum canadense*, *Tilia americana*, *Abies balsamea*.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 28+ plants in two populations  
Habitat: Habitat dom by aspen, maple and basswood. Associated spp: *Botrychium virginianum*, *Maianthemum canadense*, *Uvularia grandiflora* and *Acer* seedlings. 7 plants observed in stand 20.  
Habitat dominated by aspen and maple overstory. Associated spp: large leaf aster, leatherwood, *Thalictrum dioicum*, *Osmorhiza claytonii* and *Aralia nudicaulis*.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 13 plants  
Habitat: Aspen, hardwood habitat. Located in mixed stand near bottom of slope north-aspect.  
Comments: 1995 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Not listed  
Comments: 1995 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: Not listed  
Habitat: Found in low area with *Thuja*, *Abies*, and ash.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 3 plants  
Habitat: Habitat contains maple-basswood with fir understory. Associated species include *B. matricariifolium* and *B. virginianum*.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Habitat contains aspen, hazel, and birch.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 24 plants  
Habitat: Habitat contains maple-basswood, oak, and balsam. Associated species includes *B. matricariifolium*.  
Comments: 1996 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 2 plants  
Habitat: Hardwood forest.  
Comments: 1992 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Hardwood forest.  
Comments: 1994 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: Unknown  
Abundance: 2 plants  
Habitat: Habitat has mature aspen, younger ash and some young spruce. Associated spp: Solomon's seal and rattlesnake fern.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 9 plants

Habitat: Habitat was predominantly green ash with ironwood, aspen, birch and maple stand typed as small aspen. Open understory. Associated spp: wild ginger, Clintonia, wild sarsaparilla, meadow rue, bunchberry and rattlesnake fern. Located in damp, poorly-drained soil on flat slope.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 10+ plants

Habitat: Habitat is a birch/ maple mix surrounded by wet lowland saturated soil. Area is heavily shaded and has very little forb cover and 1-2" of duff. Associated spp: rattlesnake fern and *B. matricariifolium*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: Unknown

Abundance: 50+ plants

Habitat: Habitat is mature sugar maple, basswood with open understory and thick leaf litter. Associated spp: wild sarsaparilla, trillium and rattlesnake fern. Located in shaded area, flat slope, unknown soils.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 1 plant on north facing slope

Habitat: There are 3 maple trees banded with orange paint around site. Associated species: *Acer saccharum*, *Tilia americana*, *Ostrya virginiana*, *Streptopus roseus*, *Aralia racemosa*, *Botrychium virginianum*, *Galium triflorum*, *Equisetum scirpoides*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 100+ plants found throughout the stand

Habitat: Associated species: *Tilia americana*, *Acer saccharum*, *Thuja occidentalis*, *Gymnocarpium robertianum*, *Botrychium virginianum*, *Aralia racemosa*, *Circaea lutetiana*, *Galium triflorum*, *Streptopus roseus*, *Lycopodium lucidulum*, *Asarum canadensis*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Aspen-birch-maple-basswood with wild sarsaparilla, wild ginger, rattlesnake fern, maple seedlings and trillium.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Found in maple-basswood and birch stand with maple saplings in the understory.  
Associated species: *Tilia americana*, *Betula papyrifera*, *Ostrya virginiana*, *Uvularia grandiflora*, *Viola pubescens*, *Streptopus roseus*, *Equisetum scirpoides*  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Maple-basswood stand with maple, and aspen understory. Associated species: *Acer saccharum*, *Betula papyrifera*, *Streptopus roseus* and *Carex* spp.  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 2 plants  
Habitat: Maple-basswood and birch stand. Maple seedlings and saplings in the understory  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 2 plants  
Habitat: Maple-basswood and birch stand. Maple seedlings and saplings in the understory  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 2 plants  
Habitat: Found in maple-basswood stand at base of basswood. Maple seedlings and saplings found in understory  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Found in maple-basswood stand with maple seedlings underneath. Plant was found at the base of a large aspen  
Comments: 1997 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: Unknown  
Abundance: 1 plant  
Habitat: Old-growth maple-basswood forest  
Comments: 1998 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 6 plants  
Habitat: Plants occur in *Acer saccharum*, *Tilia americana*, *Thuja occidentalis*, *Streptopus roseus*, *Botrychium virginianum*, *Asarum americana*, *Rubus pubescens*, and *Anemone quinquefolia*  
Comments: 1998 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 14 plants  
Habitat: Not listed  
Comments: 1998 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 7 plants  
Habitat: Mixed stand of aspen, balsam, basswood. Plants found at base of 20 ft basswood. Associated with *Abies balsamea*, *Populus tremuloides*, *Aralia nudicaulis*, *Clintonia borealis*, *Mitella nuda*, *Asarum canadense*, *Rubus pubescens*, *Viburnum rafinesquianum*.  
Comments: 1998 listing  
Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County  
Ownership: USDA Forest Service  
Abundance: 1 plant  
Habitat: Located under *Acer saccharum*, *Abies balsamea*, *Fraxinus nigra*, *Tilia americana*, with *Maianthemum canadense*, *Rubus pubescens*, *Hepatica americana*, *Aralia nudicaulis* and *Uvularia grandiflora*.  
Comments: 1998 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 1 plant

Habitat: Plant occurs in an aspen stand with *Acer saccharum*, *Betula papyrifera*, *Cornus* spp., *Uvularia grandiflora*, *Rubus pubescens*, *Aralia nudicaulis*, *Osmorhiza claytonii*.

Comments: 1998 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: Not listed

Habitat: Not listed

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: Not listed

Habitat: Plants located on eastern border, approx 80m north of sw corner of section. Stand is aspen, ash and maple-basswood.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 5 plants

Habitat: Acer-Tilia stand on ridge. 90% canopy, shrubs <10%, *Acer* seedlings 90%. Also *Ulmus*, *Acer spicatum*, *Prunus virginiana*, *Lonicera canadensis*. Forbs: *Asarum canadense*, *Botrychium virginianum*, *Botrychium minganense*, *Cystopteris fragilis*, *Hepatica americana*, *Carex pennsylvanica*.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 10 plants

Habitat: Mature maple-basswood forest with rich organic layer

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 30+ plants

Habitat: Located on n-facing slope, adjacent to flooded ash swamp. Leaf litter 1-2cm thick, canopy 75% of green and black ash, birch and basswood. Associated spp: *Carex pedunculata*, *Cystopteris fragilis*, *Asarum canadense*, *Phryma leptostachya*, *Trillium cernuum*, *Aster macrophyllus*.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 5 plants

Habitat: Maple-basswood stand, on a hill adjacent to a cedar swamp. With *Dirca palustris*, *Acer seedlings*, *Caulophyllum thalictroides*, *Asarum canadense*, *Actaea rubra*, *Aralia racemosa*.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 20 plants

Habitat: Bottom of slope next to a wetland. Maple-basswood forest with thick duff layer.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 1 plant

Habitat: Maple-basswood stand, with open understory. Associated spp: *Hepatica americana*, *Uvularia grandiflora*, *Prunus* spp., *Aralia nudicaulis*, *Carex pensylvanica*.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 2 plants

Habitat: Maple-basswood stand, with pockets of ash, birch and balsam fir.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 15 plants

Habitat: Located at the bottom of a shallow ravine, growing under non-*Botrychium* ferns. In mature maple-basswood, with thick leaf litter.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service



Abundance: 11 plants

Habitat: Maple-basswood with maple saplings and seedlings in under-story. Associated spp: *Hepatica americana*, *Lycopodium obscurum*, *Streptopus roseus*, *Anemone canadensis*, *Betula papyrifera*, *Acer rubrum*, *Populus tremuloides*.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 1 plant

Habitat: Mature maple-basswood forest.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Itasca County

Ownership: USDA Forest Service

Abundance: 2 plant

Habitat: Mature maple-basswood forest.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Mahnommen County

Ownership: Private

Abundance: Few plants

Habitat: At edge of low area (probably seasonally flooded) in fairly deep maple litter around 2 inches, clavaria fungi nearby. Little other forb cover. Area approx 6 meters nw of wide forest trail in fairly mature maple forest in a to ab condition.

Comments: 1995 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Mahnommen County

Ownership: Private

Abundance: 3 plants

Habitat: Under *Tilia*, *Acer sac*, in bare litter; no forbs in association but dom forbs in stand are *Anemone quinquefolium*, *Uvularia grandiflorum*, *Thalictrum dioicum*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Mille lacs County

Ownership: State

Abundance: uncommon

Habitat: Lowland hardwood forest on silty loam over mottled clay loam. Interrupted canopy dominated by *Tilia americana* and *Acer saccharum*; *Hepatica americana*, *Maianthemum canadense*, *Trillium grandiflorum*, and *Carex pensylvanica* common below. Local topography gently undulating within a larger terminal moraine landscape

Comments: 1998 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Mille lacs County

Ownership: State

Abundance: 10 plants

Habitat: Maple-basswood forest with a thick, spongy duff layer. Level ground moraine topography at nearly the same elevation as nearby wetlands. Assoc: *Osmunda claytoniana*, *Hepatica*, *Geranium*, *Uvularia sessilifolia*, *Trillium grandiflora*, *Carex pedunculata*.

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Mille lacs County

Ownership: State

Abundance: few plants

Habitat: A few plants among 40+ small *Botrychium matricariifolium* located on a high ridge of the microtopography following an ephemeral drainage channel. Mesic forest with continuous canopy of *Acer saccharum*, *Tilia americana*, *Quercus rubra*, *Fraxinus pensylvanica*. Assoc: *Hepatica acutiloba*, *Geranium maculatum*, *Anemone quinquefolia*, *Sanicula marilandica*. 1-2 degree southerly aspect. Silt loam over silt clay

Comments: 1999 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Polk County

Ownership: USFWS

Abundance: 1993: 12 and 23 plants seen at two different times during the year

Habitat: On narrow point between 2 semipermanent ponds. Under *Acer saccharum*, dead *Betula papyrifera*, *Abies*. With much *Clavaria* fungus, *B. virginianum*, *Rhus radicans*.

Comments: 1998 listing, 1995: population monitored by C. Johnson-Groh. Plants appeared in 1996: pop increased, then remained steady, then decreased in 1998.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Polk County

Ownership: USFWS

Abundance: 1993: 23 plants seen

Habitat: 23 plants seen in 4 or 5 patches (2-3m apart) on narrow point between 2 semipermanent wetlands. Under *Acer saccharum*, dead birch and fir. In duff with abundant fungi, especially *Clavaria*. Much deadfall. Ground layer mainly litter, abundant *Botrychium virginianum*.

Comments: 1996 listing, 1995: plot 2 established by Johnson-Groh, 27 plants observed. 1996: 64 plants observed by Johnson-Groh.

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, St. Louis County

Ownership: USDA Forest Service

Abundance: 1992: 15 plants. 1994: 12 plants. 1995: 14 plants. 1996: 28 plants

Habitat: Near base of n-facing slope in 80 year old red maple stand. With *Actaea pachypoda*.

Comments: 1996 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, St. Louis County

Ownership: Unknown

Abundance: Not listed

Habitat: Plants scattered, generally on side and base of hill. Dom species red maple with paper birch, balsam fir and arborvitae. Closed canopy, open forest floor. Deep humus soil with thick leaf litter.

Comments: 1992 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Location: Minnesota, Stearns County

Ownership: State

Abundance: 25 plants in 5 x 10m area

Habitat: Mesic oak forest. on mid and upper portion of rather steep, 40ft, northeast-facing slope. Rolling terrain. Sandy-loam soil with dark organic layer and thick leaf litter. Canopy locally *Tilia americana*, *Populus tremuloides* and *Acer rubrum*. Dense *A. saccharum* understory. Sparsely-vegetated herb layer. Associates include *Caulophyllum thalictroides*, *Athyrium filix-femina*, *Arisaema triphyllum*.

Comments: 1997 listing

Source of information: Minnesota Natural Heritage Program Element Occurrence Record

Wisconsin

Location: Wisconsin, Ashland County

Ownership: USDA Forest Service

Abundance: 1979: Over 1000 plants. 1983: Species present. 1989 One plant. 1991 One plant. 1993: 23 plants, plant observed since 1991 present in July. 1996: 10 plants, plant monitored since 1991 no longer present. 1997: 2 plants.

Habitat: 1979: Associated with *Fraxinus Americana*, *Betula alleghaniensis*, *Prunus serotina*, *Tilia americana*, and *Quercus rubra*. 1983?: Open second-growth *Acer Saccharum* woods, understory conspicuously open with much *Carex pensylvanica* and leaf mold in groundlayer. Tip-up mound topography. In this forest no one has ever found this species in a stand that did not have basswood, it has also not been found in oak stands. Individual sites on the forest have never had more than 25 individuals.

Comments: Species is very inconspicuous, many plants do not protrude above leaf litter.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Ashland County

Ownership: Not listed

Abundance: 1979: Species collected. 1981: Species collected. 1990: Not found in short search. 1993-08: A total of 18 plants on both sides of a road, 17 on one side (N). 1993-09: 1 plant. 1993-10: 1 plant

Habitat: 1992: Sugar maple forest with other moonworts, wood ferns, etc., 0-1% slope, S exposure, moderate light levels, moist loamy soil. 1993: Site is dominated by *Acer saccharum* with some

*Fraxinus americana* and *Tilia americana*. *B. matricariifolium*, *B. virginianum*, *B. lanceolatum*, *B. minganense* (?) also present. Plants on the south side of road were in a tip-up mound depression.

Comments: Grazed plant present, mice?

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Ashland County

Ownership: USDA Forest Service

Abundance: 1993-08: 8 plants with several others (?) observed, 10% emerging, 90% in fruit. 1993-09: 4 plants. 1993-10: 3 plants, one visible, 1 green, 1 dried up.

Habitat: Maple–basswood forest (60–75 yrs. old) with many tip-up mounds. Black cherry and aspen also present with a sparse shrub component and dense *Carex pensylvanica*. *B. simplex*, *B. minganense*, *B. lanceolatum*, *B. matricariifolium*, *B. virginianum*, *B. multifidum*, and *B. dissectum* present. Other associates include *Aralia nudicaulis*, *Trientalis borealis*, *Viola* sp. and *Osmorhiza claytonii*.

Comments: Timber sale planned, ATV use present in stand.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Ashland County

Ownership: USDA Forest Service

Abundance: 1992: 20+ fertile plants observed.

Habitat: Second growth sugar maple and basswood. Understory of ferns, young maple, sedges, etc. *B. lanceolatum* var. *lanceolatum*, *B. lanceolatum* var. *angustisegmentum*, and *B. matricariifolium* present. W exposure, moderate light and soil moisture levels, < 5% slope. Many tip-up mounds.

Comments: Stand was part of the biological evaluation process prior to “manipulation”.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County

Ownership: USDA Forest Service

Abundance: 1995: 34 plants.

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County

Ownership: USDA Forest Service

Abundance: 1995-08: 2 plants. 1997-07 30 fertile plants

Habitat: 1997: Plants in thick leaf litter on an old tip-up mound under pole sized maple. Sugar maple dominated with scattered basswood, black cherry, and aspen. Sparse groundlayer of *Osmorhiza claytonii*, sugar maple seedlings, *Maianthemum canadense*, *Viola* sp., and *Athyrium filix-femina*. 1995: Sparse understory with *Dryopteris intermedia*, *Trientalis borealis*, *Gymnocarpium dryopteris*, and *Osmorhiza claytonii*. Relatively level, full canopy shade, NNW exposure, rich loamy soils. Selectively logged 8-12 years ago.

Comments: Research Natural Area

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County

Ownership: USDA Forest Service

Abundance: 1995-08: 4 plants. 1997-07 2 subpopulations, 7 and 50+  
Habitat: Most plants are in very thick leaf litter under a large basswood. Sugar maple dominated with scattered basswood, black cherry, and aspen. Sparse understory with *Dryopteris intermedia*, *Trientalis borealis*, *Gymnocarpium dryopteris*, and *Osmorhiza claytonii*. Relatively level, full canopy shade, NNW exposure, rich loamy soils. Selectively logged 8-12 years ago.  
Comments: Research Natural Area. Near previous record.  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County  
Ownership: USDA Forest Service  
Abundance: 1995-08-14: 123 plants. 1995-08-31: 6 plants  
Habitat: --  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County  
Ownership: USDA Forest Service  
Abundance: 1995: 2 plants.  
Habitat: --  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County  
Ownership: USDA Forest Service  
Abundance: 1995: 3 plants.  
Habitat: --  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County  
Ownership: USDA Forest Service  
Abundance: 1995: 34 plants.  
Habitat: --  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County  
Ownership: USDA Forest Service  
Abundance: 1995: 17 plants.  
Habitat: --  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County  
Ownership: Not listed  
Abundance: 1995: 5 plants.  
Habitat: --  
Comments:  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Florence County

Ownership: USDA Forest Service  
Abundance: 1996: 13 fruiting plants in a very small area  
Habitat: Northern mesic forest, sugar maple stand with basswood and scattered paper birch. Closed canopy, thick leaf litter with some sparse sedge growth. Area slopes gently NE. Associates include *Carex pensylvanica*, *Athyrium filix-femina*, *Osmorhiza claytonii*, *Actaea sp.*, *Viola canadensis*, *Phryma leptostachya*, *Dirca palustris*, and *Aralia nudicaulis*.  
Comments: Plants in a stand of actively managed hardwood. A wide ranging search was not made.  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1995: 4 plants  
Habitat: --  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1996: 2 small fruiting plants  
Habitat: Northern mesic forest, sugar maple stand. Has been select cut in past, but has a closed canopy and intact groundlayer. Well-drained silty soil. Associates include *Galium triflorum*, *Acer saccharum* seedlings, *Osmorhiza claytonii*, and *Viola sp.*  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1996: 16 fruiting stems in 2 separate clumps  
Habitat: N wet-mesic forest, rich sugar maple hardwoods. Significant component of large trees. Closed canopy under a large double-stemmed basswood. Thick, moist leaf litter on silt loam soils. Associates include *Polygonatum pubescens*, *Osmorhiza claytonii*, *Corallorhiza trifida*, and *Maianthemum canadense*.  
Comments: Stand select-cut in past  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1996: 6 stems, 1 was very small, all appeared to be in early stage of senescence.  
Habitat: Moist N hardwood forest with sugar maple and basswood. Fairly heavy leaf litter. Drumlinized moraine topography. Associates include *Dryopteris intermedia*, *Osmorhiza claytonii*, *Caulophyllum thalictroides*, *Matteuccia struthiopteris*, *Laportea canadensis*, *Viola sp.*, and *Carex spp.*  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1994/1995 (year not specified): 25 plants  
Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1994/1995 (year not specified): 1 plant

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 34 plants

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 40 plants

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 1 plant.

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 11 plants

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 17 plants 1997: About 20 fertile plants

Habitat: Near top of hill in rich northern mesic forest, habitat type AVIO. The canopy is sugar maple, hemlock, and basswood. Associated species include *Acer saccharum* seedlings, *Maianthemum canadense*, *Osmorhiza claytonii*, *Dryopteris intermedia*, and *Allium tricoccum*. Moist rich soil with deep leaf litter.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 2 plants

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1997: 2 subpopulations, 3 fertile plants and 31 fertile plants.  
Habitat: Northern mesic forest with sugar maple–basswood–ash overstory. Groundlayer of *Gymnocarpium dryopteris*, *Prunus serotina* seedlings, sugar maple seedlings, ash seedlings, *Sanguinaria canadensis*, *Adiantum pedatum*, *B. lanceolatum*, and *B. matricariifolium*.  
Comments: Site is an actively managed hardwood stand.  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: Not listed  
Abundance: 1951: Species collected. 1993: Not found.  
Habitat: 1993: Sugar maple and basswood forest with many ferns and typical forbs. Tip-up mound topography present.  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1995: 9 fertile plants with good vigor observed.  
Habitat: Maple–basswood cover type with scattered hemlock, yellow birch, and white cedar. Level, open understory, lots of maple leaf litter. Associates include *Schizachne purpurescens*, *Lycopodium obscurum*, *Hepatica americana*, *Trientalis borealis*, and *Clintonia borealis*.  
Comments: Timber sale proposed in area.  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1995: 7 plants.  
Habitat: --  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 1995: 60 plants. 2000: 20 plants  
Habitat: 6–12” sugar maple forest with some yellow birch, basswood, and a few *Abies* seedlings. *B. matricariifolium* nearby.  
Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County  
Ownership: USDA Forest Service  
Abundance: 2000: About 3 fertile plants  
Habitat: Northern mesic forest, rich sugar maple hardwoods with strong basswood component, locally common beech, scattered ash. Other tree species include black cherry and yellow birch. Well-developed leaf litter and duff layers, soil moist and well-drained, in complete shade. Plants usually in parts where basswood was co-dominant with sugar maple. Associates include *B. simplex*,



*B. matricariifolium*, *B. lanceolatum*, *Carex plantaginea*, *C. intumescens*, *C. pensylvanica*, *Ostrya seedlings*, *Caulophyllum*, *Polygonatum*, sugar maple seedlings, *Allium tricoccum*, *Adiantum*, *Osmorhiza*, *Athyrium filix-femina*, *Viola canadensis*, and *Ribes triste*.

Comments: Area under consideration for logging

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 2000: About 3 fertile plants

Habitat: Sugar maple dominated forest (but nearest trees were white ash). At crest of slope in thick leaf litter under sapling sugar maples. Associates include *Osmorhiza claytonii*, *Aralia nudicaulis*, *Uvularia grandiflora*, *Viola* sp., *Maianthemum*, *Sanguinaria*, *Polygonatum pubescens*, *Botrychium lanceolatum*, *Corylus cornuta*, and *Adiantum*.

Comments: Area under consideration for logging

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 2000: 238 fertile plants in 6 subpopulations, largest was 220 plants.

Habitat: Sugar maple dominated woods with basswood and ash common. Plants tend to occur where basswood and ash are dominant. In thick leaf litter under the complete shade of a closed canopy. Soils moist and well-drained. Plants tend to occur on shallow slopes on sides of small drumlins. Associates include *B. matricariifolium*, *B. lanceolatum*, *Maianthemum*, *Caulophyllum*, *Polygonatum*, *Streptopus roseus*, and *Osmorhiza claytonii*.

Comments: Area proposed for logging

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 2000: 1 plant

Habitat: Sugar maple dominated forest, scattered beech, common basswood. In thick leaf litter and duff. Complete shade under closed canopy.

Comments: Area under consideration for logging

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 2000: 22 fertile plants in 9 subpopulations

Habitat: Northern mesic forest, rich sugar maple hardwoods with strong basswood component, locally common beech, scattered ash. Other tree species include black cherry and yellow birch. Well-developed leaf litter and duff layers, soil moist and well-drained, in complete shade. Plants usually in parts where basswood was co-dominant with sugar maple. Associates include *B. simplex*, *B. matricariifolium*, *B. lanceolatum*, *Carex plantaginea*, *C. intumescens*, *C. pensylvanica*, *Ostrya seedlings*, *Caulophyllum*, *Polygonatum*, sugar maple seedlings, *Allium tricoccum*, *Adiantum*, *Osmorhiza*, *Athyrium filix-femina*, *Viola canadensis*, and *Ribes triste*.

Comments: Area under consideration for logging

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 2000: 1 plant

Habitat: Sugar maple dominated forest with common basswood, scattered ash and beech. In thick leaf litter and duff. Complete shade under closed canopy. Under multi-stemmed basswoods. *B. oneidense* also present.

Comments: Area under consideration for logging

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 2000: 2 fertile plants

Habitat: Rich, sugar maple dominated stands with basswood and ash scattered throughout. Plants were typically near basswood clumps in areas with thick leaf litter and duff layers. Under closed canopy in well-drained, moist soils. With tree seedlings, *Dryopteris intermedia*, *Viola* sp., and *Osmorhiza claytonii*.

Comments: Area proposed for logging

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 2000: 33 fertile plants

Habitat: Rich, sugar maple dominated stands with basswood and ash scattered throughout. Plants were typically near basswood clumps in areas with thick leaf litter and duff layers. Under closed canopy in well-drained, moist soils. With tree seedlings, *Dryopteris intermedia*, *Viola* sp., and *Osmorhiza claytonii*.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 2 fertile plants.

Habitat: AVIO habitat type. Maple-basswood cover type with dead elm, lots of *Osmorhiza* and *Allium tricoccum*, and a few scattered *Panax quinquefolius*. Lots of leaf litter, gentle slope near top of drumlin, rich silt loam soil.

Comments: Timber sale proposed

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1997-08: 13 plants in two subpopulations (11,2)

Habitat: AVIO habitat type. Northern mesic forest of sugar maple, first site is next to a large basswood. Second site is under sugar maple and basswood poles. An unusual site, most of stand is dominated by mature aspen with small pockets of sugar maple. Both sites are within 30' of cleared gas pipeline ROW but in full shade. Moist with thick leaf litter.

Comments: Part of stand proposed for aspen removal.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Not listed

Abundance: 1994: Two subpopulations, 4 plants at SE site, 15 plants at NW site. 1995: SE 3 plants, NW 19 plants. 1996: SE up to 6 plants, NW up to 66 plants.

Habitat: Northern mesic forest with heavy canopy of *Acer saccharum* with *Betula alleghaniensis*, *Tilia americana*, *Fraxinus americana*. Sparse understory and groundlayer. Associates include *Polygonatum pubescens*, *Uvularia grandiflora*, and *Viola canadensis*, with a few *Aster macrophyllus* in the area. One *Ribes cynosbati* observed. *B. matricariifolium* is common.

Comments: Plants are permanently marked.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Not listed

Abundance: 1994: 4 fertile plants

Habitat: Northern mesic forest dominated by sugar maple with basswood and some *Betula papyrifera*. There is a sparse understory and groundlayer with a conspicuous leaf mold layer. On the upper portion of a relatively steep slope.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Not listed

Abundance: 1994-09: 20 fertile plants. 1995: 20 plants 1995-96: Up to 43 plants observed.

Habitat: Northern mesic forest of mostly *Acer Saccharum* with *Tilia americana*, *Fraxinus americana*, and a sparse understory and groundlayer. The understory contains *Sambucus pubens* and the groundlayer includes *Athyrium filix-femina*, *Viola canadensis*, *Carex pensylvanica*, *Carex* sp. (*C. arctata?*), *Adiantum pedatum*, *Polygonatum pubescens*, *Fraxinus* seedlings, *Caulophyllum thalictroides*, and *Uvularia grandiflora*.

Comments: Plants are permanently marked.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Private

Abundance: 1994: 3 fertile plants

Habitat: Northern mesic forest of mostly sugar maple with *Tilia americana* and a sparse understory and groundlayer. Associates include *Oryzopsis asperifolia*, *Hydrophyllum virginianum*, *Dicentra* sp., *Claytonia caroliniana*, *Mitella diphylla*, *Dentaria diphylla*, *D. laciniata*, *Osmorhiza claytonii*, *Carex pensylvanica*, *Polygonatum pubescens*, and *Fraxinus* seedlings.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Private

Abundance: 1994-08: 16 fertile plants. 1994-09 2 fertile plants. 1995 no plants

Habitat: Northern mesic forest of mostly sugar maple with *Tilia americana*, *Betula Alleghaniensis*, *Fraxinus americana*, and a sparse understory and groundlayer. Unusual site in that few hemlock were present. Close associates (within 1m) include *Athyrium filix-femina*, *Osmorhiza claytonii*, *Carex pensylvanica*, *Polygonatum pubescens*, and *Acer saccharum* seedlings. Within 3m are *Oryzopsis asperifolia*, *Cornus alternifolia* seedlings, and *Fraxinus* seedlings. Conspicuous leaf mold layer present. Plants are mostly associated with a rotted log which is so far decayed as to be nearly indiscernible.

Comments: 1994 plants were well marked and site relocated in 1995 but still nothing found.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Private

Abundance: 1994-08-22: 23 fertile plants. 1994-08-29: 5 fertile plants.

Habitat: Northern mesic forest with a closed canopy of sugar maple with *Tilia americana*, *Betula alleghaniensis*, *Fraxinus americana*, and a sparse understory and groundlayer. Associates within 1m include *Athyrium filix-femina*, *Carex pensylvanica*, *Polygonatum pubescens*, *Dryopteris intermedia*, *Viola canadensis*, *Ostrya virginiana*, *Galium triflorum*, *Aralia nudicaulis*, *Trientalis borealis*, *Oryzopsis asperifolia*, and *Acer saccharum* seedlings. *Osmorhiza claytonii*, *Streptopus roseus*, *B. matricariifolium* and *B. lanceolatum* are present. Conspicuous leaf mold layer present.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Not listed

Abundance: 1994: 1 fertile plants.

Habitat: Northern mesic forest dominated by sugar maple with *Tilia americana*, *Betula alleghaniensis*, and a sparse understory and groundlayer. Associates include *Athyrium filix-femina*, *Galium lanceolatum*, *Carex stricta* (?), *Maianthemum canadense*, *Osmorhiza claytonii*, *Polygonatum pubescens*, and *Fraxinus* seedlings.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1994: 4 fertile plants.

Habitat: Mesic forest of mostly small diameter *Acer saccharum* with a sparse understory and groundlayer. *Prunus serotina* is prominent in this forest, *Carex assiniboinensis* found nearby. Conspicuous leaf mold layer present.

Comments: Canopy is more open and the habitat is more disturbed than most *B. mormo* sites, due to logging.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1994: 5 fertile plants.

Habitat: Mesic forest of mostly small diameter *Acer saccharum* with a sparse understory and groundlayer. *B. matricariifolium* is very common in this forest. Numerous fruiting scapes of *Allium tricoccum* could be seen, and *Carex plantaginea* was obvious. Conspicuous leaf mold layer present.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1997-09: 6 fertile stems

Habitat: In thick leaf litter on moderate slope. Habitat type AviO. northern mesic forest with overstory of sugar maple, basswood, and occasional beech. Groundlayer dominated by sugar maple seedlings, *Maianthemum canadense*, *Carex pensylvanica*, *Sanguinaria canadensis*, and *Uvularia grandiflora*. Hummocky topography.

Comments: An actively managed hardwood stand.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1994: 3 fertile plants.

Habitat: Mesic forest of mostly small diameter *Acer saccharum* with a sparse understory and groundlayer. Conspicuous leaf mold layer present.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: Not listed

Abundance: 1994: 5 plants.

Habitat: Mesic forest of mostly *Acer saccharum*.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Forest County

Ownership: USDA Forest Service

Abundance: 1995: 4 plants.

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Iron County

Ownership: Private

Abundance: 1938: Species collected. 1993: Not found.

Habitat: 1938: Leafy humus deep (?), shady ...(?), maple woods—label unclear. 1993: Mesic woods in area with lots of topography. The original collection site may now be a golf course.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Langlade County

Ownership: County

Abundance: 1994: 11 fertile plants

Habitat: Closed canopy northern mesic forest of sugar maple with *Tilia americana*, a sparse understory and groundlayer. Rich soil with a conspicuous leaf mold layer. Associates include *Athyrium filix-femina*, *Viola pubescens*, *B. matricariifolium*, *B. lanceolatum*, *Oryzopsis asperifolia*, *Dentaria diphylla*, *D. laciniata*, *Claytonia caroliniana*, *Carex pensylvanica*, *Polygonatum pubescens*, *Maianthemum canadense*, and *Streptopus roseus*.

Comments: Plants are permanently marked.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Langlade County

Ownership: USDA Forest Service

Abundance: 1997-08: 4 fertile stems

Habitat: In thick leaf litter under complete shade. Northern mesic forest with sugar maple and basswood canopy. AH/AviO habitat type. *B. virginianum* and *B. matricariifolium* are in the vicinity. Other associates include *Aralia nudicaulis*, *Osmorhiza claytonii*, *Acer saccharum* seedlings, and *Mitella diphylla*.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Langlade County

Ownership: Not listed

Abundance: 1995: 10 plants.

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Marinette County

Ownership: Not listed

Abundance: 1995: 1 plant.

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Marinette County

Ownership: Not listed

Abundance: 1995: 1 plant.

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Oconto County

Ownership: USDA Forest Service

Abundance: 1995: 2 plants

Habitat: --

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Oconto County

Ownership: USDA Forest Service

Abundance: 1997-07: 5 fertile stems

Habitat: In thick leaf litter on a mound near a large basswood. Northern mesic forest dominated by large red oak, basswood, and white ash. Smaller trees mostly sugar maple. Significant paper birch component. Areas immediately around plants dominated by basswood. Rich well-drained soil. Habitat type AviO.

Comments: Early in growing season, more plants may be present

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Oconto County

Ownership: USDA Forest Service

Abundance: 1997-08: 3-4 stems at 3 separate locations.

Habitat: In thick leaf litter under or near large basswood trees under a closed canopy. Northern mesic forest with basswood, beech and sugar maple. Rich groundlayer includes *Smilacina racemosa*, *Polygonatum pubescens*, *Uvularia grandiflora*, *Hepatica acutiloba*, *Sanguinaria canadensis*, *Acer saccharum* seedlings, *Viburnum acerifolium*, *Adiantum pedatum*, *Maianthemum canadense*, *Trientalis borealis*, and *Fagus grandifolia* seedlings.

Comments: Research Natural Area

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Oconto County

Ownership: USDA Forest Service

Abundance: 1997-08: 1-2 stems

Habitat: In thick leaf litter under or near large basswood trees under a closed canopy. Northern mesic forest with basswood, beech and sugar maple. Rich groundlayer includes *Smilacina racemosa*, *Polygonatum pubescens*, *Uvularia grandiflora*, *Hepatica acutiloba*, *Sanguinaria canadensis*, *Acer Saccharum* seedlings, *Viburnum acerifolium*, *Adiantum pedatum*, *Maianthemum canadense*, *Trientalis borealis*, and *Fagus grandifolia* seedlings.

Comments: Research Natural Area

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Sawyer County

Ownership: USDA Forest Service

Abundance: 1997-08: 20 fertile stems. 2000: 18 fertile plants 1000' from 1998 (?) population.

Habitat: 1997: Older second growth on a rolling morainal hill. Top of slope, moist rich soil, full canopy shade. Sugar maple, basswood, white ash with no shrub layer and sparse herb layer. *B. matricariifolium*, *B. dissectum*, *B. virginianum*, and *B. multifidum* are also present. 2000: Shaded mesic woods of sugar maple, basswood, and white ash with deep leaf litter, N aspect, 3-5 % slope, well developed tip-up mounds, sandy loam soils. Associated with *Adiantum pedatum*, *Viola pubescens*, *Caulophyllum thalictroides*, *B. matricariifolium*, *B. lanceolatum*, *B. virginianum*, and *Carex pedunculata*.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Taylor County

Ownership: USDA Forest Service

Abundance: 1997: About 23 fertile plants at 4 locations

Habitat: Sugar maple-basswood northern mesic forest (10-16" DBH). White ash, red oak, and occasional hemlock also present. Old tip-up mounds common. Habitat type probably AvIO. Associates include *Aralia nudicaulis*, *Caulophyllum thalictroides*, *Dryopteris intermedia*, *Osmorhiza claytonii*, *Galium triflorum*, *Hepatica acutiloba*, *B. virginianum*, *Sanguinaria canadensis*, white ash, and sugar maple seedlings.

Comments: Considered for Research Natural Area

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Taylor County

Ownership: USDA Forest Service

Abundance: 1997: About 12 fertile plants at 5 locations

Habitat: Northern mesic forest (10–16" DBH). Basswood and sugar maple co-dominate with occasional white ash and red oak. Tree sizes up to 29" DBH but most were much smaller, 10–16" DBH on average. White spruce common in understory, seeds from nearby plantation. Habitat type rich ATM. Associates include *Aralia nudicaulis*, *A. racemosa*, *Streptopus roseus*, *B. virginianum*, *B. matricariifolium*, *B. lanceolatum*, *Oryzopsis asperifolia*, *Uvularia grandiflora*, *Maianthemum canadense*, *Hepatica acutiloba*, and *Sanguinaria canadensis*.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Taylor County

Ownership: USDA Forest Service

Abundance: 1998: About 5 fertile plants

Habitat: Maple–basswood closed canopy forest. Habitat type ATD/AviO. Sparse shrub layer, ground flora moderately dense. *B. virginianum*, *B. matricariifolium*, *B. lanceolatum*, *B. multifidum*, *Oryzopsis asperifolia*, *Aralia nudicaulis*, *Trillium*, *Adiantum pedatum* and maple seedlings. Rich mesic soil.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Taylor County

Ownership: USDA Forest Service

Abundance: 1994: 1 fruiting plant.

Habitat: Mesic northern hardwoods with sugar maple and basswood, ATM habitat type. No shrub layer and sparse herb layer.

Comments: Area will likely be protected from logging.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Taylor County

Ownership: USDA Forest Service

Abundance: 1993-07: 4 fruiting plants. 1993-08: 4 plants, two were reclining and light colored. 1993-09: 1 plant. 1993-10: 1 plant.

Habitat: AVIO grading to AH habitat type. Closed canopy sugar maple–basswood forest with sedges, wood ferns, *B. virginianum*, maidenhair fern. Fairly open understory. Silt cap over sandy loam with well-drained ridges and moister lower areas. 3-4% E slope. Sugar maple and basswood dominant with white ash and a dead black walnut nearby. Associates include *Sanguinaria canadensis*, *Trillium grandiflorum*, *Uvularia grandiflora*, *U. sessilifolia*, ash seedlings, *Viburnum acerifolium*, and *Carex pedunculata*.

Comments: Site proposed for timber activity.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Taylor County

Ownership: USDA Forest Service

Abundance: 1995: 8 or 9 plants, one stem grazed and couldn't be positively identified.

Habitat: ATO/AVIO habitat type. Northern mesic forest with a sugar maple and basswood overstory. Sparse shrub layer of leatherwood, American honeysuckle, and hazel. Relatively rich herb layer including, *Carex pedunculata* and *Dryopteris intermedia*. Deep leaf litter, numerous tip-



up mounds, deep shade and a moist rich soil. Slope of about 5% facing WNW. Low numbers (<10) of *B. matricariifolium*, *B. lanceolatum* var. *angustisegmentum*, *B. dissectum*, and *B. virginianum*.  
Comments: Proposed for logging.

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

Location: Wisconsin, Wood County

Ownership: County

Abundance: 1915: Species collected. 1993: Not found. 1999 Not found. 2000 Two plants, one fruiting.

Habitat: 1915: Hilly deciduous woods. 1993: Area is a steep hill with scattered area of exposed rock and is rather mesic. Tree cover is sugar maple, red oak, basswood, white ash, and bitternut hickory. Herbs present include *Allium tricoccum*, bloodroot, *Actaea alba*, and *Caulophyllum thalictroides*. Ferns present are *B. virginianum*, *Camptosaurus rhizophyllus*, and *Polypodium*. The ground layer seems dense for *B. mormo* with very little area not covered by a dense growth of *Solidago flexicaulis*, blue cohosh, *Thalictrum dioicum*, *Smilacina stellata*, *S. racemosa*, *Smilax herbacea*, and others. *Monotropa uniflora*, *Conopholis americana*, and many spp. of mushrooms were present. 2000: N facing slope in southern mesic hardwoods.

Comments: 2000: proposed timber sale postponed

Source of information: Wisconsin Natural Heritage Program Element Occurrence Record

## APPENDIX B. *BOTRYCHIUM* STATUS AND THREATS SUMMARY

Three tables are presented below. Table 1 summarizes the state, national, and global status of each *Botrychium* taxon. Table 2 summarizes range, population, and habitat features. Table 3 ranks the degree of threat to populations of each taxon from various factors. The assigned rankings are intended as general guidelines based on information presented in each conservation assessment. For many taxa, detailed ecological information is lacking.

Table 1. *Botrychium* status.

	<b>minnesota</b>	<b>michigan</b>	<b>wisconsin</b>	<b>global/ national</b>
<i>B. campestre</i>	SC (S3)	T (S2)	E (S1)	G3/N3
<i>B. dissectum</i>	(not listed) SU	(not listed) S?	(not listed) SR	G5/N5
<i>B. hesperium</i> ( <i>B. michiganense</i> )	(not listed)	T (S1S2)	(absent)	G3/N2
<i>B. lanceolatum</i> <i>var.</i> <i>angustisegmentum</i>	T (SR)	(not listed) S4	(not listed) S3	G5/N4
<i>B. lunaria</i>	T (S2)	(not listed) S?	E (S1)	G5/N4?
<i>B. minganense</i>	SC (S3)	(not listed) S?	SC (S2)	G4/N?
<i>B. mormo</i>	SC (S3)	T (S1S2)	E (S2)	G3/N3
<i>B. oneidense</i>	E (S1)	(not listed) S?	SC (S2)	G4Q/N4
<i>B. pallidum</i>	E (S1)	SC (S3)	(absent)	G2G3/N2N3
<i>B. pseudopinnatum</i>	(not listed) S?	(absent)	(not listed)	G1/N1
<i>B. rugulosum</i>	T (S2)	(not listed) S3	SC (S2)	G3/N3
<i>B. simplex</i>	SC (S3)	(not listed) S?	(not listed) S?	G5/N5
<i>B. spathulatum</i>	(not listed) S?	(not listed) S3	SC (S1)	G3/N3

### Key

#### Status:

E = state endangered

T = state threatened

SC = state special concern

S1 = state rankings (see Appendix B)

absent = taxon not known from state

not listed = taxon not tracked by state natural heritage program.

Global/National–worldwide or United States ranking provided by NatureServe (2001, see Appendix B. for definitions).

**Table 2.** *Botrychium* range, population, and habitat features.

	range	habitat amplitude	pop trend	habitat integrity	vulnerability
<i>B. campestre</i>	wide, disjunct	intermediate	unknown	fair	medium
<i>B. dissectum</i>	wide	broad	increasing	fair	low
<i>B. hesperium</i> ( <i>B. michiganense</i> )	endemic	intermediate	stable	fair	medium
<i>B. lanceolatum</i> var. <i>angustisegmentum</i>	wide	intermediate	increasing	fair	low
<i>B. lunaria</i>	wide	broad	stable	fair	medium
<i>B. minganense</i>	wide	broad	increasing	good	low
<i>B. mormo</i>	endemic	narrow	decreasing	fair	high
<i>B. oneidense</i>	wide	intermediate	unknown	fair	medium
<i>B. pallidum</i>	narrow	broad	stable	fair	low
<i>B.pseudopinnatum</i>	endemic	narrow	unknown	poor	high
<i>B. rugulosum</i>	narrow	intermediate	stable	fair	low
<i>B. simplex</i>	wide	broad	increasing	good	low
<i>B. spathulatum</i>	narrow	intermediate	unknown	fair	medium

**Key**

range: wide (occurs across much of North America), narrow (e.g. Lake States), endemic (restricted to Lake States), disjunct (separated from main population).

amplitude: broad (tolerates a variety of habitats and conditions), intermediate, narrow (very specific requirements).

estimated population trend: increasing, stable, decreasing, unknown (insufficient information to estimate trend).

habitat integrity: good (most habitats/sites protected, not commonly impacted by management), fair, poor (most sites degraded, unoccupied habitat subject to numerous impacts), unknown.

vulnerability: high (populations generally not resilient or are intolerant of habitat changes), medium, low (populations resilient and/or resistant to change), unknown.

Table 3. Major threats to *Botrychium*.

	threat					
	exotic earthworms	exotic plants	canopy thinning	succession to closed canopy	disturbance	
					major	minor
<i>B. campestre</i>	low	medium	low	high	medium	low
<i>B. dissectum</i>	medium	medium	medium	low	high	medium
<i>B. hesperium</i> ( <i>B. michiganense</i> )	medium (forested sites) low (other sites)	medium-high	low	low-medium	medium	low
<i>B. lanceolatum</i> var. <i>angustisegmentum</i>	high	medium	medium	low	medium	low
<i>B. lunaria</i>	low	medium	low	medium	medium	low
<i>B. minganense</i>	high	medium	medium	low	medium	medium
<i>B. mormo</i>	high	low	high	low	high	medium
<i>B. oneidense</i>	high	medium	medium-high	low	high	medium-high
<i>B. pallidum</i>	low	high	low	high	medium	low
<i>B. pseudopinnatum</i>	low	high	low	high	medium	low
<i>B. rugulosum</i>	low	medium	low	high	high	medium
<i>B. simplex</i>	medium	medium	low	medium	medium	low
<i>B. spathulatum</i>	low	high	low	high	medium	low

Key

High, medium, or low are used to indicate the estimated degree of impact of a specific threat to a *Botrychium* population.

## **APPENDIX C. GLOBAL, NATIONAL, AND SUBNATIONAL CONSERVATION STATUS RANKS (FROM NATURESERVE, WWW.NATURESERVE.ORG).**

NatureServe reports the relative imperilment, or conservation status, of plants, animals, and ecological communities (elements) on a global, national, and subnational (state/provincial) level. Based on the conservation status ranking system developed by The Nature Conservancy and the Natural Heritage Network, conservation status ranks are assigned, reviewed, and revised according to standard criteria. Assessing the conservation status of species and ecological communities is the cornerstone of Natural Heritage work. It allows Natural Heritage programs and their cooperators to target the most at-risk elements for inventory, protection, management, and research.

### Global, National, and Subnational Conservation Status Ranks

An element is assigned one global rank (called a G-rank), which applies across its entire range; a national rank (N-rank) for each nation in its range; and a subnational rank (S-rank) for each state, province, or other subnational jurisdiction in its range (e.g. Yukon Territory). In general, Association for Biodiversity Information (ABI) scientists assign global, U.S., and Canadian national ranks. ABI scientists receive guidance from subnational data centers, especially for endemic elements, and from experts on particular taxonomic groups. Local data centers assign subnational ranks for elements in their respective jurisdictions and contribute information for national and global ranks. New information provided by field surveys, monitoring activities, consultation, and literature review, improves accuracy and keeps ranks current. Including an annual data exchange with local data centers, ABI's central databases are updated continually with revisions, corrections, and information on ranked elements.

### What the Ranks Mean

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, in other words, 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). Other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate

uncertainty. See the lists of conservation status rank definitions for complete descriptions of ranks and qualifiers.

### Rank Definitions

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 is in conservation priority.) On the other hand, it is possible for an element to be 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 which should receive priority for research and conservation in a jurisdiction. Highest priority should be given to elements that are most vulnerable to extinction—that is, those ranked G1, G2, or G3. And, according to the rules of ranking, these must have equally high or higher national and subnational ranks. Elements vulnerable to national or subnational extirpation (ranks N1, N2, N3, or S1, S2, S3) with global ranks of G4 or G5 should be considered next.

### Assessment Criteria

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 ABI 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, which function as guidelines rather than arithmetic rules. The ranker's overall knowledge of the element allows him or her to weigh each factor in relation to the others and to consider all pertinent information for a particular element. The factors considered in ranking species and communities are similar, but the relative weight given to the factors differs.

For species elements, the following factors are considered in assigning a rank:

- total number and condition of occurrences
- population size
- range extent and area of occupancy
- short- and long-term trends in the foregoing factors
- threats
- fragility.

Secondary factors include the geographic range over which the element occurs, threats to occurrences, and viability of the occurrences. However, it is often necessary to establish

preliminary ranks for communities when information on these factors is not complete. This is particularly true for communities that have not been well described. In practice, a preliminary assessment of a community's range-wide global rank is often based on the following:

geographic range over which the element occurs

long-term trend of the element across this range

short-term trend (i.e., threats)

degree of site/environmental specificity exhibited by the element

rarity across the range as indicated by subnational ranks assigned by Heritage data centers.

#### Global Heritage Status Rank Definitions

Rank	Definition
GX	Presumed Extinct—Believed to be extinct throughout its range. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
GH	Possibly Extinct (species)—Known from only historical occurrences, but may nevertheless still be extant; further searching needed.
G1	Critically Imperiled—Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000).
G2	Imperiled—Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000).
G3	Vulnerable—Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.
G4	Apparently Secure—Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.
G5	Secure—Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

#### National (N) and Subnational\* (S) Heritage Status Rank Definitions

\* Subnational indicates jurisdictions at the state or provincial level (e.g. California, Ontario).

Rank	Definition
NX SX	Presumed Extirpated—Element is believed to be extirpated from the nation or subnation*. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
NH SH	Possibly Extirpated (Historical)—Element occurred historically in the nation or subnation*, and there is some expectation that it may be rediscovered. Its presence may not have been verified in the past 20 years. An element would become NH or SH without such a 20-year delay if the only known occurrences in a nation or subnation were destroyed or if it had been extensively and unsuccessfully looked for. Upon verification of an extant occurrence, NH or SH-ranked elements would typically receive an N1 or S1 rank. The NH or SH rank should be reserved for elements for which some effort has been made to relocate occurrences, rather than simply using this rank for all elements not known from verified extant occurrences.
N1 S1	Critically Imperiled—Critically imperiled in the nation or subnation* because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the subnation. Typically 5 or fewer occurrences or very few remaining individuals (<1,000).
N2 S2	Imperiled—Imperiled in the nation or subnation* because of rarity or because of some factor(s) making it very vulnerable to extirpation from the nation or subnation. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000).
N3 S3	Vulnerable—Vulnerable in the nation or subnation* either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.
N4 S4	Apparently Secure—Uncommon but not rare, and usually widespread in the nation or subnation*. Possible cause of long-term concern. Usually more than 100 occurrences and more than 10,000 individuals.
N5 S5	Secure—Common, widespread, and abundant in the nation or subnation*. Essentially ineradicable under present conditions. Typically with considerably more than 100 occurrences and more than 10,000 individuals.
N? S?	Unranked—Nation or subnation* rank not yet assessed.



## APPENDIX D. CONTRACTOR QUALIFICATIONS AND EXPERIENCE

The conservation assessment was prepared by Steve W. Chadde and Dr. Greg Kudray. Mr. Chadde holds an M.S. degree in Plant Ecology from Montana State University and a B.S. degree in Agriculture from the University of Wyoming. He has conducted numerous botanical and ecological surveys and research studies in both the Great Lakes (Michigan, Minnesota, Wisconsin) and Rocky Mountain regions. Mr. Chadde's primary areas of expertise are endangered, threatened, and sensitive plant surveys, plant community characterization studies, natural areas evaluations, and wetlands inventory, delineation, and mapping. Dr. Kudray holds a Ph.D. in Wetland Ecology from Michigan Technological University. He has extensive experience in ecosystem characterization and mapping, vegetation inventory and monitoring, and forest analysis. Additional information for each author is provided below.

### Contact Information

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Statement of Qualifications–Steve W. Chadde

### Recent Experience

Consulting Botanist  
Ottawa National Forest, Lake Superior Land Co., Central Lake Superior Watershed Partnership, U.P. Engineers and Architects, Michigan (partial list only).  
Conducted field surveys for endangered, threatened, and rare plant species, and various wetland and other ecological studies.

Botanist, USDA Forest Service  
Ottawa National Forest and Hiawatha National Forest, Michigan  
Conducted field surveys for endangered, threatened, and rare plant species on national forest lands in Michigan's Upper Peninsula.

Biologist, US Geological Survey  
Great Lakes Science Center, Ann Arbor, Michigan  
Vegetation scientist for a large wetland restoration project at Seney National Wildlife Refuge in Michigan's Upper Peninsula.

Natural Areas Ecologist, USDA Forest Service/The Nature Conservancy  
Northern Region USDA Forest Service, Missoula, Montana  
Responsible for identifying and establishing research natural areas (RNAs) and botanical areas on national forests in northern Idaho, Montana, and North and South Dakota. Performed field surveys and baseline inventories of wetlands and natural areas. Conducted field surveys for rare plants and plant communities.

#### Education

Michigan Technological University—Coursework in the Scientific and Technical Communication program.  
M.S. Range Ecology—Montana State University, 1985  
B.S. Agriculture (Honors)—University of Wyoming, 1983

#### Publications

Chadde, Steve. 2000. Natural Features Survey, Lake Superior Shoreline, Marquette County, Michigan. Contract report prepared for Central Lake Superior Watershed Partnership, Marquette.

Chadde, Steve. 1999. A Forester's Field Guide to the Endangered and Threatened Plants of Michigan's Upper Peninsula. Contract report prepared for Mead Corporation, Champion International Corporation, and Shelter Bay Forests.

Chadde, Steve. 1998. A Great Lakes Wetland Flora - A Complete, Illustrated Guide to the Aquatic and Wetland Plants of the Upper Midwest. PocketFlora Press, Calumet, MI. 584 p.

Chadde, Steve, and others. 1998. Peatlands on National Forests of the Northern Rocky Mountains: Ecology and Conservation. USDA Forest Service, Rocky Mountain Research Station General Technical Report RMRS-GTR-11. Ogden, UT.

Chadde, Steve. 1996. Plants of the Copper Country - An Illustrated Guide to the Vascular Plants of Houghton and Keweenaw Counties, Michigan, and Isle Royale National Park. PocketFlora Press, Calumet, MI. 112 p.

Chadde, Steve. 1996. Plants of Pictured Rocks National Lakeshore—A Complete, Illustrated Guide to the Plant's of America's First National Lakeshore. PocketFlora Press, Calumet, MI. 103 p.

Chadde, Steve. 1995. Ecological Evaluation - Findlayson Property, Chippewa County, Michigan. Contract report prepared for Michigan Chapter, The Nature Conservancy.

Chadde, Steve. 1995. Research Natural Areas of the Northern Region: Status and Needs Assessment. USDA Forest Service, Northern Region, Missoula, MT. 164 p.

Rabe, Fred, and Steve Chadde. 1995. Aquatic Features of Research Natural Areas of the Kootenai and Flathead National Forests, Montana. USDA Forest Service, Northern Region, Missoula, MT. 66 p. plus appendices.

Rabe, Fred, and Steve Chadde. 1994. Classification of Aquatic and Semiaquatic Wetland Natural Areas in Idaho and Western Montana. *Natural Areas Journal* 14(3): 175-187.

## Statement of Qualifications–Dr. Greg Kudray

### Recent Experience

Ecological Inventory and Analysis, Chassell, MI. Established company in June 1999 to conduct ecological consulting work for individuals, corporations, and government agencies. Contracted with the Hiawatha National Forest to do ecosystem mapping, the correlation of ecosystem types to soil types, and the training of Hiawatha personnel in ecosystem inventory and mapping. Contracted with the USGS to do wetland vegetation monitoring in the Seney National Wildlife Refuge. Other experience includes teaching wetland plant workshops, evaluation and mapping of exotic plant infestations, vegetation inventory, bryophyte identification, and aquatic plant monitoring. Six seasonal employees in 1999.

Michigan Technological University, Department of Forestry and Wood Products, Houghton, MI. Employed as a research scientist with primary responsibilities involving ecosystem classification and mapping with related database management and data analysis for the Hiawatha National Forest. Wetland mapping was based on a key and field guide developed during my doctoral research and continually refined through multivariate data analysis. In this position I trained and supervised a seasonal crew of biologists (8 in 1996, 9 in 1995, 3 in 1994) to conduct field mapping integrating vegetation, soil, and hydrological data. I also trained and coordinated four employees from the USDA Natural Resources Conservation Service (former USDA Soil Conservation Service) during the 1995 season and USDA Forest Service personnel throughout the project. Accomplishments include the fine-scale mapping of approximately 300,000 acres in the western half of the Hiawatha National Forest and the development of a database with detailed soil characterizations, hydrological data, and vascular and bryophyte plant information from 4000 plot records. In addition to this work I was an instructor in the 1994 Wetland Ecology course (FW 451), taught a 2 day Clear Lake Conference wetlands plant workshop, and also taught the wetland ecology section during a USDA Forest Service silvicultural certification workshop offered by our department. (1994 to Nov. 1996)

Michigan Department of Natural Resources, Forest Management Division, Baraga Field Office. Assistant area forester supervising two forest technicians. Primarily responsible for the operations inventory and timber sale programs on the 135,000 acre Baraga area state forest. Conducted and supervised stand exam, type mapping, timber volume estimates, stumpage appraisal, and timber sale contract compliance. Other duties included Commercial Forest Act administration, insect surveys, wildfire suppression, road layout, and forest regeneration activities. Overall performance appraisal rating term for 1989 was "exceptional". Received 1989 DNR District One award for overall excellence. (1984 to 1990)

### EDUCATION

Michigan Technological University, Houghton, Michigan. Ph.D. in Wetland Ecology. 1999. Research project involved the development of a ecosystem classification system for the wetlands of the Hiawatha National Forest. Attended University of Michigan Biological Station 1991 summer session with classes in Bryology and Aquatic Plants. Other areas of specialization include soil science, hydrology, forest and landscape ecology, vegetation science, statistics, and

remote sensing/GIS applications in land management. Overall GPA of 4.0. (1990 to 1994, Nov. 1996 to June 1999). Published book chapter on the relationship of peatland types and vegetation to water chemistry, other publications in review.

Michigan State University, East Lansing, Michigan. MS specializing in Forest Genetics. 1979. Masters thesis was an evaluation of a spruce hybrid breeding program. Work as a research assistant included controlled pollinations, greenhouse propagation, and plantation establishment. Initiated a computerized record keeping system for a breeding arboretum. Published scientific article based on my research. Overall GPA of 3.6. (1977 to 1979)

Michigan State University, East Lansing, Michigan. BS in Forestry. 1976. Graduated with high honor including Honors College membership. Also a member of Alpha Zeta, Beta Beta Beta, and Phi Kappa Phi honorary societies. Overall GPA of 3.8. (1972 to 1976)