

*Conservation Assessment
for
Limestone Oak Fern (*Gymnocarpium robertianum*)*



USDA Forest Service, Eastern Region

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Jan Schultz
Hiawatha National Forest
2727 N Lincoln Road
Escanaba, MI 49829
906-786-4062



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EXECUTIVE SUMMARY

Gymnocarpium robertianum is most frequent in the Canadian provinces of Ontario and Quebec, but even there it occurs in small populations. In the Great Lakes States it occurs in even smaller populations than in Canada. One Wisconsin site listed between 50-100 individuals, but most sites did not give an indication as to number of individuals. On the Hiawatha National Forest in Michigan one site has over twenty individuals but this site by itself will likely not be enough to maintain a viable population. *Gymnocarpium robertianum* occurs on calcareous substrates, usually on the north or sometimes the west side of bluffs or talus slopes, in addition to cedar swamps.

NOMENCLATURE AND TAXONOMY

This Conservation Assessment is a review of the distribution, habitat, ecology, and population *m* and *G. appalachianum*. This hybrid (*G. x heterosporum*) is apparently extirpated from the one county in Pennsylvania where it had been collected (Pryer 1992). *G. appalachianum*, which is confined to the Appalachian region, was formerly included with *G. dryopteris*. [Wagner (1966) had previously discussed the existence of the hybrid *G. x heterosporum*, a cross between *G. dryopteris* and *G. robertianum*.] *G. x achriosporum* Sarvela is a “putative tetraploid hybrid” between *G. robertianum* and *G. dryopteris*, and is only known to occur in Quebec and Sweden (Pryer 1993). Robert Preston (pers. comm., 2001) suggests that this hybrid (*G. x achriosporum*) has been found in Michigan’s Marquette County as well. Pryer (pers. comm. 2002) thought it was more likely it would be *G. x intermedium*.

Gymnocarpium x intermedium Sarvela hybrids occur between *G. jessoense* subsp. *parvulum* and *G. dryopteris*, and are “particularly abundant” in the Great Lakes area (Pryer 1993). In the past, these hybrids have been called *G. x heterosporum*. *G. x heterosporum* now refers to hybrids between *G. robertianum* and *G. appalachianum*, as described in the previous paragraph.

As the most recent treatment for *Gymnocarpium* (Pryer 1993) considers *Gymnocarpium robertianum* and *G. jessoense* subsp. *parvulum* two distinct taxa, they are treated as separate taxa in this Conservation Assessment as well. *G. jessoense* subsp. *parvulum* is also considered a separate taxon in Michigan from *G. robertianum* and is listed as State Endangered. As many floras do not recognize *G. jessoense* subsp. *parvulum* as a separate taxon from *G. robertianum*, their descriptions for *G. robertianum* may contain characteristics of *G. jessoense* subsp. *parvulum* and are not used here in the species description for *G. robertianum*. See Pryer (1993) for a thorough description of *Gymnocarpium robertianum* and p. 259 in Pryer (1993), Figures 2 and 3 (on pp. 424 & 425) in Sarvela *et al.* (1981) and Figure 1 (pg. 192) in Pryer (1990) for helpful illustrations and silhouettes.

(The following information was obtained from: Pryer 1993, Sarvela *et al.* 1981, Pryer 1990)

- Fronde:** Perennial, herbaceous forb/herb., 10-52 cm long, texture firm.
- Blades:** Broadly deltate, widely triangular to widely trullate (trowel-shaped), 2-3 pinnate-pinnatifid, up to 19 cm long and 26 cm wide, tripartite, acute to broadly acute at the apex; blades moderately glandular on both surfaces.
- Rachis:** Densely glandular
- Pinnae:** Basal pinnae always stalked 0.5-1(2) cm, basal pinnules usually shorter than second basal pinnules; ultimate segments oblong, up to 9 mm long, margins mostly recurved, entire to crenate. Aspect of pinnules mostly perpendicular and form an angle of 90° with the rachis of the pinnae.
- Stipes:** Sparingly scaly with numerous glandular hairs distally
- Scales:** 2-4 mm the scales brown, ovate, appressed
- Sori:** Round, submarginal; indusia absent
- Rhizome:** Black, 1-1.5 mm thick, sparingly scaly

Species Identification Notes:

Gymnocarpium may be differentiated from the genus *Dryopteris* in various ways. *Gymnocarpium* has a stipe base with two vascular bundles while *Dryopteris* has more than three vascular bundles (Montgomery & Wagner 1993). *Gymnocarpium* also lacks an indusium [(*Gymnos* in Greek means naked and *karpos* means fruit (Cobb 1984)]. According to Lellinger (1985), *Gymnocarpium* differs from *Dryopteris* by having a “small, delicate, tripartite lamina with long-stalked basal pinnae.” *Gymnocarpium* has long, creeping rhizomes, thus fronds appear singly; *Dryopteris* has shorter rhizomes so fronds are more closely spaced and often form a vase-shaped cluster (Lellinger 1985).

Five species of *Gymnocarpium* and several hybrids are listed for North America (Pryer 1993). Identification of species and hybrids in this genus may be difficult. “Hybrids between the glabrous species, and also between the glabrous and glandular species, have played a significant role in obscuring species boundaries in *Gymnocarpium*” (Pryer & Haufler 1993).

Both *Gymnocarpium dryopteris* (common oak fern) and *G. jessoense* subsp. *parvulum* (Nahanni oak fern or northern oak fern) have ranges that overlap with *G. robertianum*. There are two major complexes. *G. robertianum* and *G. jessoense* subsp. *parvulum* are part of the

G. robertianum complex, while *G. dryopteris* is the most widespread species in the *G. dryopteris* complex (Pryer & Haufler 1993). *G. robertianum* and *G. jessoense* subsp. *parvulum* have an “indument of minute (0.1 mm) glands on their leaves”; members of the *G. dryopteris* complex do not (Pryer 1990)--*G. dryopteris* may have a few glandular hairs on the distal part of the petiole or on the abaxial (underside) surface of the blade (Pryer 1993). Young or “ecologically depauperated” plants of *G. robertianum* may tend to mimic *G. dryopteris*, but the glandularity of *G. robertianum* is “evidently always a dependable character” (Wagner 1966).

Pryer (1990) compares various aspects of morphology and ecology of *G. dryopteris*, *G. robertianum*, and *G. jessoense* subsp. *parvulum*. The following chart of comparisons was adapted from that article.

Characters	<i>G. dryopteris</i>	<i>G. robertianum</i>	<i>G. jessoense</i> ssp. <i>parvulum</i>
Fronde appearance	Ternate	Obscurely ternate	Obscurely ternate
Fronde outline	Widely triangular	Widely triangular to trullate (trowel-like)	Narrowly triangular
Fronde texture	Lax and delicate	Firm and robust	Either firm or lax
Glandularity (rachis, lower and upper blade)	Essentially glabrous	Densely to moderately glandular	Rachis and lower surface moderately glandular; upper surface glabrous
Aspect of basal pinnae	More or less perpendicular	More or less perpendicular	Strongly curved towards tip of frond
Second basal pinnae	Usually sessile; basal pinnules and second basal pinnules equal	Usually stalked; basal pinnules often shorter than 2 nd pinnules	Usually sessile; basal pinnules and second basal pinnules equal

The adaxial (upper) surface of *G. jessoense* subsp. *parvulum* has no glands and is moderately glandular in *G. robertianum*. The abaxial (lower) surface of *Gymnocarpium robertianum* is moderately to densely glandular and moderately glandular in *G. jessoense* subsp. *parvulum* (Pryer 1993). According to Sarvela *et al.* (1981), *G. robertianum* has longer glands (including stalks) than *G. jessoense*. subsp. *parvulum* Sarvela *et al.* (1981) note the rule that “the distance between the glands of *G. robertianum* is shorter than the glands, whereas in *G. jessoense* subsp. *parvulum* the distance is longer than the glands.”

In addition to gland differences, Pryer (1993) distinguishes *Gymnocarpium robertianum* from *G. jessoense* subsp. *parvulum* by the orientation of the “proximal pinnae” (=lowermost pinnae) and “basiscopic pinnules of proximal pinnae” (=lower pinnules on the lowermost pinnae). [The illustrations/silhouettes on p. 259 in Pryer (1993), Figures 2 and 3 (on pp. 424 & 425) in Sarvela *et al.* (1981), and Figure 1 (pg. 192) in Pryer (1990) are useful in following this description.] In *G. robertianum*, these “proximal pinnae and basiscopic pinnules of proximal pinnae” are “± perpendicular to rachis and costa, respectively” and in *G. jessoense* subsp. *parvulum*, these curve “toward apex of leaf and apex of pinna, respectively.” In addition, in *G. robertianum* the “pinnae of 2d pair are usually stalked, or if sessile with basal

pinnules shorter than adjacent pinnules” and in *G. jessoense* subsp. *parvulum* the “pinnae of 2d pair are almost always sessile with basal pinnules \pm equal in length to adjacent pinnules” (Pryer 1993).

Penskar and Higman, while stressing that *Gymnocarpium dryopteris* (common oak fern) can be distinguished by its lack of glandular hairs on the petiole and blade, also noted that common oak fern tends to be smaller in size and lacks the pronounced, extended tips of the main leaf segments that are evident in well-developed fronds of *G. robertianum* (Choberka *et al.* 2001).

The spores of *Gymnocarpium robertianum* are a deeper brown color than the tan or brownish “glassy” color that is characteristic of spores of *G. jessoense* subsp. *parvulum* (Sarvela *et al.* 1981). Pryer (1990) did not note differing spore color between *G. dryopteris*, *G. robertianum*, and *G. jessoense* ssp. *parvulum*; all were noted as light brown and kidney-shaped. Perhaps the difference that Sarvela noted was a locally occurring characteristic.

Gymnocarpium robertianum is usually found on calcareous substrates such as limestone pavements; *G. jessoense* subsp. *parvulum* prefers granite cliffs and cool talus slopes (Pryer 1990). Additional differences in the habitats of *Gymnocarpium robertianum* and *G. jessoense* subsp. *parvulum* are discussed more thoroughly in the Habitat/Ecology section.

HABITAT AND ECOLOGY

Europe

Within a karst area of France, *Gymnocarpium robertianum* occurs in “cool to moist sites, at the foot of limestone boulders, cliffs, screes, and lapiaz crevices up to 2000 m in elevation” (W-1). In Wales, it is found in deep crevices (grikes) of limestone pavement that provide a humid environment and offer protection from grazing animals (W-2).

Canada

Sarvela (1978) presented a significant revision of the limestone oak fern. Sarvela (1978) segregated the species into two taxa: *G. robertianum* was restricted in distribution to the east; it was known from Newfoundland, New Brunswick, Quebec, Ontario, and a few states in the Great Lakes Region. *G. jessoense* ssp. *parvulum* Sarvela (Nahanni oak fern) occurred westward from Ontario to Alaska. *Gymnocarpium robertianum* was later confirmed from Manitoba making this the most western locality for this species in North America (Pryer 1990). Its habitat was rock crevices in limestone cliffs. Although quite rare this far west, there are numerous localities in eastern Canada especially Ontario and Quebec. However, populations at these verified sites are quite small (Pryer 1990).

North America/Great Lakes Region

Many of the occurrences of *G. robertianum* in North America are on calcareous substrates (cliffs, limestone pavement, outcrops), as well as in *Thuja occidentalis* swamps (Pryer 1993). [Habitats listed in floras [such as Tryon (1980), Lellinger (1985) and Gleason & Cronquist (1991)], where *G. robertianum* was treated in a broad sense and included the *G. jessoense* subsp. *parvulum* taxon, are not included.] *G. robertianum*, in the Great Lakes region, is a forest, or at least flat land (*i.e.*, semi-forested limestone pavement) species (Tony Reznicek, pers. comm., 2001).

In the Great Lakes area, within Michigan's Upper Peninsula and the Canadian Province of Ontario, many occurrences of *Gymnocarpium robertianum* are found along the Niagara Escarpment (Morton & Venn 1984). On Manitoulin Island (Ontario), for example, *Gymnocarpium robertianum* usually occurs on damp humus slopes in forests on limestone and dolomitic limestone (Morton & Venn 1984). Ten species of ferns are largely restricted to the Mixedwoods Plains Ecozone of the Niagara Escarpment. Other ferns species, in addition to *Gymnocarpium robertianum*, occurring in the Mixedwoods Plains Ecozone of the Niagara Escarpment, include *Dryopteris filix-mas* (male fern), *Pellaea atropurpurea* (purple cliffbrake), *Asplenium trichomanes-ramosum* (green spleenwort), *Asplenium scolopendrium* var. *americanum* (hart's-tongue fern), and *Cystopteris laurentiana* (laurentian fern) (W-3).

Northwest of Thunder Bay in Ontario, Canada, *Gymnocarpium robertianum* is found in two canyons in *Pyrola grandiflora* communities. The ground and talus are often covered with a thick spongy moss mat of over 90% *Aulacomnium acuminatum*. *Pyrola grandiflora*, *Equisetum scirpoides*, and *Woodsia ilvensis* are the most frequent vascular species. Other species besides *Gymnocarpium robertianum* include: *Arenaria humifusa*, *Carex media*, *Ledum groenlandicum*, *Mitella nuda*, *Polygonum viviparum*, *Saxifraga aizoon*, and *Viola palustris* along with the shrubs *Salix myrtilifolia*, and *Salix rigida* (Given & Soper 1981).

Element occurrence records for *Gymnocarpium robertianum* from Illinois, Michigan, Minnesota, and Wisconsin are shown in Appendix A and include approximate number of occurrences, associated species, and habitats.

Michigan

In Michigan, probably the most common habitats for *Gymnocarpium robertianum* are calcareous cedar swamps (Tony Reznicek, pers. comm., 2001); it is "associated with *Thuja*, over 90% of the time" (Robert Preston, pers. comm., 2001). In the Upper Peninsula, *Gymnocarpium robertianum* is found in cedar (*Thuja occidentalis*) swamps with calcareous substrates. In cedar swamps it grows in cool, wet substrates, particularly in organic soils and in areas of thick moss cover (Choberka *et al.* 2001). It also grows on wet forest slopes in limestone (dolomite) and in rich deciduous forests characterized by alkaline sites with limestone association (MNFI 1999a). On Drummond Island (Chippewa County) it was found growing on a vertical cliff face in small crevices along with *Cystopteris fragilis* (fragile fern) (Hiltunen 1962).

Marquette Counties in the Upper Peninsula, and Cheboygan and St. Claire Counties in the Lower Peninsula

It has also been found in Mackinac County on the Hiawatha National Forest (MNFI 1999), and Montmorency County in the Lower Peninsula (MNFI 2002).

Gymnocarpium robertianum can be found growing with the more common *Gymnocarpium* (*G. dryopteris*) in Michigan as well as elsewhere in the Great Lakes area (Wagner 1966; MNFI 1999a). These two fern species often grow together in moist, rich, and shaded swamps in the northern Lower Peninsula of Michigan, where they “develop to the maximum size” (Wagner 1966).

In North America, *Gymnocarpium jessoense* subsp. *parvulum* occurs in “cool northern rock crevices” and tends to avoid dolomitic limestone (Sarvela *et al.* 1981). Tony Reznicek (pers. comm., 2001) noted that he has seen *G. jessoense* subsp. *parvulum*, in Ontario, Canada, occurring on cliffs and ledges, in habitat that is quite open, and often totally sunny and fairly dry. In Michigan, *G. jessoense* subsp. *parvulum* occurs in Marquette County within the Marquette highlands on igneous/metamorphic rock (Robert Preston, pers. comm., 2001). According to Robert Preston (pers. comm., 2001), there is only a “slim possibility” that *G. robertianum* and *G. jessoense* subsp. *parvulum* would occur in this same area unless a nearby cedar swamp was alkaline enough and had suitable habitat for *G. robertianum*.

Minnesota

In Minnesota, *Gymnocarpium robertianum* occurs on “shaded talus slope and calcareous shale; within forests on clay soil; perched rootmass of cedar (*Thuja*) swamps” (USDA 2000b). The “clay soil” is probably “calcareous soils of loamy texture” according to Wisconsin/Minnesota PVA (2000). In Chippewa National Forest, the three occurrences of this species are all on mossy ground in cedar swamps (Ian Shackleford, pers. comm., 2000). Elsewhere in the state, it occurs in spruce-fir forests (Ian Shackleford, pers. comm., 2000; citing Minnesota Bell herbarium specimens from northern Minnesota). One collection from Cook County was from a granitic, possibly acidic, cliff (Tryon 1980).

Illinois

In Illinois, *Gymnocarpium robertianum* is listed as State Endangered. It has been found at one site in extreme NW Illinois (Carroll County), on a NW-facing limestone bluff (Ken Robertson, pers. comm., 2001). Even the more common oak fern (*Gymnocarpium dryopteris*) is rare in Illinois, and known historically (1885) from rocky woods in Ogle County (Mohlenbrock, 1981).

Iowa

Cold air drainage on a north-facing bluff along a river or creek is listed as the most common habitat for many specimens, especially from Allamakee County. “Under *Taxus canadensis* on cool, mossy limestone talus of algific slopes” is the stated habitat for several specimens from Clayton County. Both sandstone, and limestone (more frequently) bedrocks are listed (State University of Iowa Herbarium 2001).

Wisconsin

In Wisconsin, the habitat for *Gymnocarpium robertianum* includes bluffs, limestone talus slopes, and cedar swamps (WSH 2001). Northwestern Wisconsin sites in Bayfield County are shaded, moss-covered sandstone (Spickerman and Janke, pers. comm., 2001). In southwestern Wisconsin, many of the occurrences are near the Mississippi River on limestone talus (WI NHP 2001).

According to Steve Spickerman (pers. comm., 2001), there are no occurrences of *G. robertianum* in the Chequamegon-Nicolet National Forest (one occurrence is off the Forest by just a township). Emmet Judziewicz, according to Spickerman (pers. comm., 2001), does not think that habitat exists on the Chequamegon side of the Forest for this fern species, although habitat may exist on the Nicolet side as part of the Niagara Escarpment is there.

Substrate type

Although *Gymnocarpium robertianum* often occurs on rocky calcareous substrates, it also grows on non-rocky substrates of cedar swamps in Michigan, Minnesota, and Wisconsin. The various habitats within cedar swamps are listed below (Appendix A, WI/MN PVA 2000).

- mossy ground (Minnesota, Chippewa National Forest)
- in perched rootmass of cedar in swamps (Minnesota)
- on and near top (driest part) of 1 ½ ft. high hummock (Michigan, Hiawatha Natl. For.)
- on moss (Wisconsin, Door County)
- Sphagnum* hummock (Wisconsin, Door County)

In some cases, the soils may be calcareous (WI/MN PVA 2000) or perhaps the limestone bedrock or rock may be just below the surface at these sites.

DISTRIBUTION AND ABUNDANCE

Cobb (1984) states that *Gymnocarpium robertianum* is more common in the British Isles and Europe than in the Americas; it also occurs in Asia, but only in the Caucasus (Sarvela *et al.* 1981). In Canada, *G. robertianum* occurs in many sites in eastern Canada, especially in Quebec and Ontario, where although distributed over a wide area, populations are small (Pryer 1993). Elsewhere in Canada, it occurs in Manitoba, Newfoundland, and New Brunswick. In the United States, populations are often metapopulation in distribution (USDA 1999). It occurs in Michigan, Iowa, Minnesota, and Wisconsin (Pryer 1993). It is not listed as occurring in Illinois by Pryer (1993). In Illinois there is one occurrence in Carroll County on private land (Ken Robertson pers. comm. 2001); it is listed as endangered for Illinois.

It could be that some herbarium specimens of *Gymnocarpium robertianum* from Minnesota, Wisconsin, and Michigan may be misidentified or filed in folders of synonyms. In some cases, *G. jessoense* ssp. *parvulum*, which was considered as part of the *G. robertianum* taxon in the past, may still be filed with *G. robertianum* specimens. Ideally, all herbaria containing specimens of *Gymnocarpium* from Wisconsin, Minnesota, and Michigan should have those

specimens annotated. This reexamination has been done at major U.S. herbaria fairly recently. For example, in the spring of 2001, Robert Preston (pers. comm., 2001) looked at every collection of *Gymnocarpium* (mounted, unmounted, accessioned, unaccessioned) at the University of Michigan's herbarium (MICH); see appendix for more details. Copies of four labels of *G. robertianum* herbarium specimens from Herbarium WIS showed that three specimens had been annotated by Kathleen Pryer (in 1984) and one by the Wisconsin Natural Heritage Program (in 1998). Kathleen Pryer (pers. comm. 2002) noted that she had annotated 7 Wisconsin herbarium specimens from Door and Lafayette Counties from various herbariums.

Illinois

The one occurrence in Illinois is in a privately owned camp (Ken Robertson, pers. comm., 2001). Peck (1982) cited a voucher at Southern Illinois University (Pryer pers. comm. 2002). However, there is some confusion as to whether the voucher ever made it into the herbarium. At any rate it is either very rare within Illinois possibly not known at all since the voucher has not been documented by a pteridologist.

Iowa

In Iowa there are 19 occurrences documented at the State University of Iowa Herbarium. Both Clayton County and Allamakee had 6 occurrences each. Other counties with occurrences include: Dubuque, Winneshiek, and Delaware. Kathleen Pryer (pers. comm. 2002) indicated that she had annotated 39 specimens from Iowa from various herbarium. Woody rocky bluffs were the dominant habitat (State University of Iowa Herbarium, 2001).

Michigan

In Michigan, there are 24 occurrences of *Gymnocarpium robertianum* (E. Schools pers. comm. 2002). On the Hiawatha National Forest, *G. robertianum* is documented from four locations (MNFI 1999a) [1 in Delta County and 3 (MNFI considers 2 EOs) in Mackinac County]. These sites have ranks of BC (MNFI 1999b). Another site, discovered in 2001, is also in Mackinac County (MNFI 2001a).

In addition, there has been some confusion over the reporting of *Gymnocarpium robertianum*. Billington (1952) had a distribution map indicated this species occurred in Houghton and Keweenaw Counties. It was also listed for these two counties as well in Plants of the Copper Country (Chadde 1996). Chadde (pers. comm., 2001) said that Billington's map is incorrect and that *G. robertianum* actually does not occur in either Houghton nor Keweenaw County. The only potential habitat for it in either of these counties is on Limestone Mountain, in Houghton County, although it has not been found there.

MNFI (2001b) lists 23 element occurrences for Michigan, which include the following Upper Peninsula counties: Chippewa, Delta, Mackinac, and Marquette (historical, near rocky shore of Presque Isle). Mark Jaunzems, (pers. comm. 2001) a seasonal botanist on the Hiawatha National Forest, found a clump of 25 shoots covering an approximately five foot square area in Mackinac County in 2001. *G. robertianum* is also listed as occurring in the Lower

Peninsula counties of Cheboygan, Montmorency, and St. Clair (MNFI 2001b). Wagner (1966) reported this species for Presque Isle County as well.

Minnesota

Gymnocarpium robertianum is not listed as an endangered, threatened, or special concern plant in Minnesota, and is not tracked by the Minnesota Natural Heritage Information System. Tryon (1980) stated that “it is infrequent in Lake and Cook counties and rare southward.” According to Ian Shackelford (pers. comm., 2000), Minnesota has 13 documented occurrences of *Gymnocarpium robertianum*, with three occurrences on the Chippewa National Forest. Fifteen specimens of this species are from six counties (Beltrami, Clearwater, Cook, Filmore, St. Louis, and Winona) are housed in the University of Minnesota herbarium (W-4). The distribution map in Tryon (1980) shows four additional counties (Carlton, Itasca, Lake, and Pine) where this species apparently had been collected. Winona County is not marked on Tryon’s map, although one collection is housed at the University of Minnesota Herbarium (W-4). Also inconsistent are two distribution maps for *Gymnocarpium robertianum* in Minnesota (Tryon 1980; Ownbey & Morley 1991). Pryer (pers. comm. 2002) felt that it was likely these apparent discrepancies might be due to confusion with *G. jessoense* subsp. *parvulum*.

Pennsylvania

Historically there were several specimens originally labeled as *Gymnocarpium robertianum* that were collected presumably at a single site in Blair County, Pennsylvania. The first of these specimens was redetermined by Wagner in 1970 to be *G. x heterosporum* W.H. Wagner. The other specimens from this group were redetermined in 1989 by Kathleen Pryer to be *G. x heterosporum*. The eventual destruction of this site due to highway expansion represented the only site at which this taxon was documented. It is unlikely *Gymnocarpium robertianum* ever existed in Pennsylvania (S. Grund pers. comm. 2001).

Wisconsin

Gymnocarpium robertianum is a Special Concern species in Wisconsin. There are 13 specimens of this species, collected in six counties, accessioned in various herbaria in Wisconsin (WSH 2001). Populations in Wisconsin range from a few plants to over 100 plants (WSH 2001). Some of the specimens are from the same locality (WSH 2001). A distribution map from the Wisconsin Floristic Atlas Project (W-5), which looked at specimens in the Wisconsin State Herbarium plus evidently in other herbaria, shows it present in two additional counties (Jackson and Ashland).

There is a possibility that an Ashland County specimen was collected in the Chequamegon-Nicolet National Forest. Steve Spickerman checked various herbaria to see if he could locate any from Ashland County, and if so, if the specimen had been collected in the Forest. According to Steve Spickerman (pers. comm., 2001), the WI State Herbarium does not have a specimen from Ashland County, nor do several other herbaria (Milwaukee Natural History Museum, UW—Green Bay) that he checked. Without a herbarium specimen it is not possible to verify the Ashland County occurrence.

The hybrid (*G. x intermedium*) has been collected from three counties, including Bayfield County, in the northwestern part of Wisconsin; *G. jessoense* subsp. *parvulum* has been collected from Bayfield County (W-5). Since *G. robertianum* is known from Bayfield County as well, there could be the potential for mistaken identification (W-5). A closer look at voucher specimens by someone familiar with this species is needed.

STATUS

Currently, the official status of *Gymnocarpium robertianum* with respect to Global, Federal and State Conservation status is:

U.S. Fish and Wildlife Service: Not listed (None)

U.S. Forest Service: Region 9 Sensitive on Hiawatha and Chippewa National Forests in Michigan and Minnesota

POTENTIAL THREATS

The Chippewa National Forest gave the following basis for listing as an R9 species: “*Gymnocarpium robertianum* is rare on the Chippewa, known from only three locations. Habitat for the species is generally calcareous rocks, which is absent from the Chippewa. This fern is often found in cedar swamp. However, cedar swamp habitat is in jeopardy from a lack of cedar regeneration, and other potential habitats such as tamarack and black spruce are vulnerable to forest management activities. The species is uncommon in Minnesota (13 documented occurrences)” (USDA 2000c).

The Hiawatha National Forest gave the following basis for listing *Gymnocarpium robertianum* as an R9 species: It is a State Threatened listed plant, known from 24 occurrences in Michigan, and only 4 occurrences on the Hiawatha National Forest. In Michigan its habitat is both cedar swamp and shaded limestone talus slope (MNFI 2002).

Although this species is likely rare where it is listed as endangered, threatened, or special concern, it could also be that it has sometimes been mistaken for *Gymnocarpium dryopteris*. However, Mark Jaunzems (pers. comm., 2001) commented that the plants of *G. robertianum* that he found in a Mackinac County (Michigan) cedar swamp were distinct in their paler dustier gray tone and different shape than *G. dryopteris* and that the glandular hairs were visible with the naked eye; his comment, “No way would you walk by it.”

In North America, *Gymnocarpium robertianum* is apparently most secure in Newfoundland and Quebec where it is listed as a S3 species.

Global Conservation Status Rank: G5 Common, widespread and abundant globally (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in

more than 100 occurrences and more than 10,000 individuals. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

National Conservation Status Rank: United States: N?

Canada: N3

N?: Unranked-National rank not yet assessed.

N3: Rare or local throughout its range.

United States: NatureServe, W-6

Illinois ¹	S1	Endangered	Minnesota	SR	Not listed
Iowa	S2	Not listed	Wisconsin	S2	Special concern
Michigan	S2	Threatened			

1. Illinois site appears to be lacking a herbarium voucher (Pryer pers. comm. 2002).

Canadian Provinces: NatureServe, W-6

Manitoba	S1	Ontario	S2
New Brunswick	S1	Quebec	S3
Newfoundland	S3	Saskatchewan ²	S?
Newfoundland Island	S2		

2. Pryer (pers. comm. 2002) was not aware of any specimens from Saskatchewan

Key to State Ranks:

S1: Critically imperiled because of extreme rarity (often known from 5 or fewer extant occurrences).

S2: Imperiled in state/province because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state/province.

S3: Rare or local throughout its range (usually 21-100 occurrences)

SR: Reported, not assessed

LIFE HISTORY

Little is documented regarding the life history of *Gymnocarpium robertianum*. It is a perennial fern and is not evergreen—the leaves die back in winter (Cobb 1984). Upper Michigan sites for this rare fern occur under a mature canopy layer (D. LeBlanc pers. comm. 2000). *Gymnocarpium robertianum* is recognizable whenever its foliage is well developed, conservatively from mid-June through September with July and August being the best periods to reliably identify this species (Choberka *et al.* 2001).

Sori of *Gymnocarpium robertianum* are round, submarginal and have no indusia (Pryer

1993). The spores of *G. robertianum* in North America are not distinguishable from other *Gymnocarpium* species (Pryer & Britton 1983a). Spores of *G. robertianum* are bilateral and dispersed in the summer (Pryer 1993); in Michigan sori are produced from June through August (Choberka *et al.* 2001).

One study (Kirkpatrick *et al.* 1990) looked at various aspects of the mating system of another *Gymnocarpium* (*G. dryopteris* ssp. *disjunctum*). [Although *G. robertianum* was not discussed it might be that some of the findings could apply to this species as well. Research done specifically on *G. robertianum* would be necessary to confirm similarities.]

Outcrossing (*i.e.*, spores from two different fern individuals germinate, each producing a gametophyte, followed by cross-fertilization of the gametophytes) was found to be the most common mating system in the 15 populations of *G. dryopteris* ssp. *disjunctum* analyzed (Kirkpatrick *et al.* 1990). Both intragametophytic (*i.e.*, fertilization occurring within the same gametophyte) and intergametophytic selfing (*i.e.*, cross-fertilization of two gametophytes that are produced by spores from the same individual) were rare in this species (Kirkpatrick *et al.* 1990). Although *G. robertianum* was not studied, outcrossing may also be the most common mating system for this species as well. Research on this species is needed to confirm this.

Antheridiogens are hormones that may result in unisexual gametophytes being formed, thus preventing intragametophytic selfing from occurring (Kirkpatrick *et al.* 1990). It is likely that *G. dryopteris* ssp. *disjunctum* (and possibly *G. robertianum*?) possesses an antheridiogen system which accounts in part for the high degree of intergametophytic outcrossing in this species. Inbreeding depression may also promote intergametophytic outcrossing as well.

Referring to *Dryopteris filix-mas*, Korpelainen (1994) noted that some degree of intragametophytic selfing is useful, such as during colonization and when population sizes are down. Intragametophytic selfing is rare in *G. dryopteris* ssp. *disjunctum*, according to Kirkpatrick (1990). If further research shows this characteristic to be true of *Gymnocarpium robertianum* as well, then *G. robertianum* would not be successful during colonization and when population numbers are reduced. Perhaps small populations would persist vegetatively by continued rhizomatous growth, if they were not able to reproduce sexually through intergametophytic crossing.

POPULATION BIOLOGY AND VIABILITY

Populations of *Gymnocarpium robertianum* in Michigan, Minnesota, and Wisconsin appear “viable but small and vulnerable” according to USDA (2000b). A panel studying viability suggested that in cedar swamps a viable population for 10 years or more would contain about 100 individuals of this species (USDA 2000b). No National Forests in Michigan, Minnesota, and Wisconsin have populations of this size.

One Michigan site in Mackinac County supports over twenty plants in two metapopulations (MNFI 1999a). This site should not be assumed to be viable long-term given deer herbivory conditions within the southern regions of the Upper Peninsula, climate factors, and

environmental stochastic conditions. MNFI (1999b) ranked this site (and the Delta County site as well) with a BC rating, which indicates short term viability, but questionable long-term viability. There may be other, as yet undiscovered sites on the Hiawatha National Forest and adjacent lands, which could contribute to the long-term viability of this species.

Many changes in nomenclature/taxonomy have been made within the *Gymnocarpium* genus and for *G. robertianum* (see synonym list and discussion in Nomenclature/Taxonomy section), thus all prior collections not already verified by Kathleen Pryer need to be rechecked to assure proper identification. Emmet Judziewicz (USDA 1999) expressed concern that many of the collections in the Lake Superior region that are identified as *G. robertianum*, may be some other species or hybrids.

POTENTIAL THREATS

Research is needed to document what the current threats are to the survival of *Gymnocarpium robertianum* in Michigan, Minnesota, and Wisconsin. Possible threats to *G. robertianum* include changes in canopy closure or habitat alteration due to natural causes or timber harvesting (D. LeBlanc, pers. comm., 2001). If exotic plant species become established in disturbed areas, such as haul roads constructed during timber harvest these plants could pose a threat to *G. robertianum* (Deb LeBlanc, pers. comm., 2001). Anything that disrupted the hydrology of cedar swamps, such as flooding by beaver, blowdowns, etc. could threaten *G. robertianum* plants in those habitats (USDA 2000b). As this species was originally considered a *Dryopteris* species (Fernald 1950), early settlement data is too sketchy to determine its actual rarity and therefore changes in rarity.

The three known occurrences of *G. robertianum* in Minnesota's Chippewa National Forest are from cedar swamps, which are "generally protected from forest activities" (USDA 2000c). "The known Mackinac County Forest locations are under general threat of canopy removal related to harvesting operations associated with Forest timber management; therefore, this species was provided a 200 foot buffer in a Hiawatha National Forest logging operation (J. Schultz, pers. comm., 2001)".

Thuja occidentalis is still typically harvested on private and State-owned forest lands in Wisconsin and Michigan including swamp forest (Spickerman and Janke, pers. comm., 2001; Martin Nelson, pers. comm., 2001). According to Jeff Stampfly (pers. comm., 2001), at least in the Shingleton Management Unit of Michigan's Department of Natural Resources, cedar is harvested infrequently because it provides thermal cover for deer and because of problems due to regeneration.

Long-term viability for *Gymnocarpium robertianum* may be dependent on maintaining potential habitat and known occupied habitat on public lands. The opportunity exists to create and maintain refugia for rare species within Federal and State lands.

Conservation/Management

To conserve this species, it is necessary to maintain its habitat. In the northern United States, maintenance of the hydrologic cycle of northern white cedar swamps is very important, as

well as providing an intact canopy. The effects of timber harvesting in cedar swamps is poorly known, but even road building or dragging logs could effect the hydrology and result in habitat degradation. Beaver activity in swamps could be an important factor in determining where populations occur; this needs to be studied more thoroughly. In areas where *G. robertianum* grows on ledges and cliffs, it may be vulnerable to recreational activities such as rock climbing.

General information about *Gymnocarpium robertianum* is sparse. There is confusion on identification due to taxonomic changes. Verification of all herbarium specimens is needed in order to develop baseline information on *G. robertianum*. Emmet Judziewicz expressed concern that many of the collections in the Lake Superior region are not *G. robertianum*, but may be some other species or hybrid (USDA 1999). According to MNFI (2001a), *G. robertianum* occurs in fewer Michigan counties than is shown on the distribution map in Billington (1952) for this species. In Minnesota, Tryon's (1980) distribution map differs considerably from Ownbey & Morley's (1991). In Wisconsin, the University of Wisconsin herbarium web site (W-5) shows two maps for this species that differ considerably (Spickerman and Janke, pers. comm., 2001). One possible explanation is confusion with other species such as *G. jessoense* subsp. *parvulum* and hybrids.

Ian Shackleford (pers. comm., 2001) suggested that "limestone oak fern," the common name of *Gymnocarpium robertianum*, may actually be a misnomer in the northern United States since *Gymnocarpium robertianum* inhabits cedar swamps in addition to limestone habitats (eg., outcrops, pavements, etc.). In Canada, the common name of limestone oak fern seems to describe the preferred habitat better (Pryer 1993). In fact, most of the occurrences in Michigan are from cedar swamps (Tony Reznicek, pers. comm., 2001). Three occurrences in the Chippewa National Forest in Minnesota were growing on mossy ground in cedar swamps (Ian Shackleford, pers. comm., 2000). At other sites in Minnesota, within cedar swamps, this fern species grew on perched rootmass of cedar (Wisconsin/Minnesota 2000).

RESEARCH AND MONITORING

The habitat for *Gymnocarpium robertianum* at its southern edge (northern United States) is poorly understood. According to Root (1962), this species has been collected in swamps, where no rocks are present. What are the similarities between sites where this species occurs on limestone substrate and those that occur on non-rocky substrates in cedar swamps? Is limestone bedrock just under the surface of some of the cedar swamp sites? When the species is not growing on rock, is it in especially calcareous soils? Where *G. robertianum* occurs on *Sphagnum* hummocks, is there little or no soil? Although the ecology and habitat requirements for *Gymnocarpium robertianum* in Michigan, Wisconsin, and Minnesota are known to some extent, more research is needed, including tolerance levels to disturbance, overstory canopy opening, climatic influences (drought, etc.), and deer herbivory.

More inventory work is needed to locate new sites and relocate known sites of *Gymnocarpium robertianum*. Monitoring at known Forest sites and off-Forest locations is needed in order to analyze effects associated with management actions and answer

management questions. MNFI suggests that demographic work on populations and life history studies could assist land managers to best conserve this rare fern (Choberka *et al.* 2001). Results of monitoring and research could provide managers with data to develop a Conservation Approach. This could include developing goals for maintaining viability of the species, writing management prescriptions for known sites, and public education or outreach in efforts to protect populations and habitat of *Gymnocarpium robertianum*.

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WEB SITES

W-1. *Gymnocarpium robertianum*

<http://www.com-nature.com/~fougere...rnpagesGBtext/robertianumpelGB.htm>

(no longer at above address)

W-2. Limestone pavement

<http://www.ccw.gov.uk/biodiv/limeston.htm>

W-3. Pteridophytes from Assessment of species diversity in the mixedwood plains ecozone

<http://www.cciw.ca/eman-temp/reports/publications/Mixedwood/ferns/ferns3.htm>

W-4. University of Minnesota Herbarium

<http://wildflowers.umn.edu/public/results.asp?search=countychk&id=1578>

W-5. Wisconsin State Herbarium

<http://wiscinfo.doit.wisc.edu/herbarium/hand/GYMROB.gif>

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<http://www.natureserve.org>

CONTACTS

National Forests

Chequamegon-Nicolet National Forest, Wisconsin: Steven Spickerman, Plant Ecologist

(715) 764-2511; Steve Janke, Plant Ecologist (715) 276-6333; Linda Parker, Forest Ecologist (715) 762-5169

Hiawatha National Forest, Michigan: Jan Schultz, Forest Plant Ecologist (906) 228-8491;

Deb LeBlanc, West Unit, Ecologist (906) 387-2512

Ottawa National Forest, Michigan: Ian Shackelford, Forest Botanist ishackelford@fs.fed.us
(formerly at Chippewa National Forest, Minnesota)

Eastern Region (R9), Milwaukee, Wisconsin: Nancy L. Berlin (218) 335-8673

Library Services, North Central Research Station: Laura Hutchinson Lhutchinson@fs.fed.us

Others

Black, Merel: University of Wisconsin at Madison, Botany Dept., Herbarium
mblack@facstaff.wi

Chadde, Steve: botanist, PocketFlora Press, Calumet, Michigan schadde@up.net

Grund, Steve: botanist, Western Pennsylvania Conservancy, Pittsburgh, Pennsylvania
Sgrund@paconserve.org

Judziwicz, Emmet: Associate Professor of Botany, U/W at Stevens Point (formerly with Wisconsin DNR, Bureau of Endangered Species)

Nelson, Martin: MI DNR, Baraga: 906-353-6651

Preston, Robert (Bob): pteridologist, co-authoring MI pteridophytes book with the late Herb Wagner; (989)354-2593; bpreston@freeway.net

Pryer, Kathleen: pteridologist (author of *Gymnocarpium* in Flora of North America)
pryer@duke.edu

Penskar, Mike: botanist, Michigan Natural Features Inventory (MNFI), Lansing, MI
penskarm@michigan.gov

Reznicek, Tony: botanist, University of Michigan Herbarium reznicek@umich.edu

Robertson, Ken: botanist, Illinois Natural History Survey (217) 244-2171;
krrobert@uiuc.edu

Schools, Ed: Michigan Natural Features Inventory (MNFI), Lansing, MI
schoolse@michigan.gov

Stampfly, Jeff: MI DNR, Shingleton Management Unit: 906-452-6227

APPENDICES

Appendix A. *Gymnocarpium robertianum* Element Occurrences

The following element occurrence information was obtained from natural heritage programs, national forests, etc. in Illinois, Iowa, Michigan, Minnesota, and Wisconsin.

Element Occurrence Summary:

Illinois (1) Ken Robertson, Illinois Natural History Survey (pers. comm., 2001)
Iowa (19) State University of Iowa Herbarium Kathleen Pryer (pers. comm. 2002) has annotated 39 herbarium specimens from Iowa from the following herbarium: US, WIS, OS, GH, IA, ISTC, CM, VPI, PH, PENN
Michigan [24] (E. Schools pers. comm. 2002)
Hiawatha National Forest [4] (MNFI lists as 3)
Some differences between University of Michigan Herbarium and MNFI
Kathleen Pryer (pers. comm. 2002) annotated 18 Michigan herbarium specimens
Minnesota [13 documented occurrences) Univ. of Minnesota Herbarium]
Chippewa National Forest (3) (Ian Shackelford, pers. comm., 2000)
Kathleen Pryer (pers. comm. 2002) annotated 8 Minn. herbarium specimens
Wisconsin [13 specimens of *G. robertianum* are accessioned in various herbaria in Wisconsin (WSH 2001). Some of the specimens are from the same locality.]
Kathleen Pryer (pers. comm. 2002) annotated 7 Wisconsin herbarium specimens

Note: Specimens located after 1993 would not have been annotated by Pryer.

ILLINOIS

Location:	Illinois, Carroll County
Habitat:	“NW-facing limestone bluff.”
Source of Information:	Ken Robertson, Illinois Natural History Survey (pers. comm., 2001).
Note:	Confusion as to whether voucher specimen exists at Southern Illinois University (Pryer, pers. comm. 2002).

IOWA

Location:	Iowa, Clayton County
Date:	June 24, 1991
Habitat:	“Rare in cold, mossy limestone talus on eastern end of large algific slope along creek.”
Comments:	Associates included <i>Carex deweyana</i> , <i>Rosa acicularis</i> , <i>Aconitum noveboracense</i>
Source of Information:	R.V. Drexler Herbarium, Coe College, Cedar Rapids, IA.
Location:	Iowa, Allamakee County

Date:	Sept. 6, 1958
Habitat:	“Mossy cold air drainage area on north-facing bluff along river.”
Source of Information:	State University of Iowa Herbarium

Location:	Iowa, Dubuque County
Date:	Historical, 1901
Comments:	Examined by Iowa Natural Areas Inventory in 1983
Source of Information:	State University of Iowa Herbarium

Location:	Iowa, Allamakee County
Date:	Historical, 1920
Habitat:	“Wooded, rocky bluff.”
Comments:	Examined by Iowa Natural Areas Inventory in 1983
Source of Information:	State University of Iowa Herbarium

Location:	Iowa, Allamakee County
Date:	Historical, 1927
Habitat:	“Wooded, rocky bluff.”
Comments:	Examined by Iowa Natural Areas Inventory in 1983
Source of Information:	State University of Iowa Herbarium

Location:	Iowa, Clayton County
Date:	Historical, 1927
Habitat:	“Ledge of sandstone.”
Comments:	Examined by Iowa Natural Areas Inventory in 1995
Source of Information:	State University of Iowa Herbarium

Location:	Iowa, Allamakee County
Date:	Historical, 1929
Habitat:	“Wooded, canyon above bluff.”
Comments:	Examined by Duke University Herbarium 1995
Source of Information:	State University of Iowa Herbarium

Location:	Iowa, Clayton County
Date:	June 24, 1991
Habitat:	“Under <i>Taxus</i> on cool, mossy limestone talus on algific slope.”
Comments:	Associates include <i>Rhamnus alnifolia</i> , <i>Ribes hudsonianum</i> , <i>Circaea alpina</i> , <i>Chrysosplenium iowense</i>
Source of Information:	R.V. Drexler Herbarium, Coe College, Cedar Rapids, IA

Location:	Iowa, Clayton County
Ownership:	Bixby State Park

Date: August 30, 1960
Habitat: "Cold, mossy, limestone talus slope on north-facing bluff bordering Bear Creek."
Comments: Examined by Iowa Natural Areas Inventory in 1983
Source of Information: State University of Iowa Herbarium

Location: Iowa, Winneshiek County
Date: June 1, 1960
Habitat: "Cold, mossy, limestone talus slope on north-facing bluff."
Comments: Examined by Iowa Natural Areas Inventory in 1983
Source of Information: State University of Iowa Herbarium

Location: Iowa, Dubuque County
Ownership: White Pine Hollow State Forest
Date: May 18, 1957
Habitat: "North facing limestone talus slope with cold air drainage."
Comments: Examined by Iowa Natural Areas Inventory in 1983
Source of Information: State University of Iowa Herbarium

Location: Iowa, Winneshiek County
Date: August 22, 1952
Habitat: "North-facing bluff along south side of river."
Comments: Examined by Iowa Natural Areas Inventory in 1983
Source of Information: State University of Iowa Herbarium

Location: Iowa, Allamakee County
Date: June 10, 1953
Habitat: "Cool, moss covered limestone talus, north-facing bluff along river."
Comments: Examined by Iowa Natural Areas Inventory in 1983
Source of Information: State University of Iowa Herbarium

Location: Iowa, Garnavillo Township
Date: August 26, 1959
Habitat: "Cold, mossy, limestone talus slope on wooded bluff bordering creek."
Comments: Examined by Iowa Natural Areas Inventory in 1983
Source of Information: State University of Iowa Herbarium

Location: Iowa, Clayton County
Date: July 15, 1960
Ownership: Bixby State Park
Habitat: "Steep, north-facing wooded bluff, above creek."
Source of Information: State University of Iowa Herbarium

Location:	Iowa, Allamakee County
Date:	May 17, 1991
Habitat:	“Cold limestone talus on algific slope along creek.”
Comments:	Associates included <i>Pyrola secunda</i> , <i>Potentilla fruticosa</i> , <i>Equisetum scirpoides</i>
Source of Information:	R.V. Drexler Herbarium, Coe College, Cedar Rapids, IA

Location:	Iowa, Winneshiek County
Date:	August 8, 1986
Ownership:	Twin Springs Park
Habitat:	“On lower portion (6 ft) on north-facing, algific, limestone talus slope.”
Comments:	Associated with <i>Cystopteris bulbifera</i>
Source of information:	State University of Iowa Herbarium

Location:	Iowa, Delaware County
Date:	June 18, 1991
Habitat:	“Cold, mossy, limestone talus of open algific slope.”
Comments:	Associates include <i>Cystopteris fragilis</i> var. <i>fragilis</i> , <i>Rosa acicularis</i> , <i>Aconitum nobeboracense</i> .
Source of Information:	R.V. Drexler Herbarium, Coe College, Cedar Rapids, IA

Location:	Iowa, Clayton County
Date:	June 12, 1991
Habitat:	“Cold mossy limestone talus in northwest facing opening on algific Slope.”
Comments:	Associates included <i>Rosa acicularis</i> , <i>Saxifraga forbesii</i> , <i>Rhamnus alnifolia</i>
Source of information:	R.V. Drexler Herbarium, Coe College, Cedar Rapids, IA

MICHIGAN

Location:	Michigan, Mackinac County
Ownership:	Hiawatha National Forest

Abundance:2001:	25 plants, in 4-5 square ft. area
Habitat: in cedar swamp,	“Surrounding habitat was a relatively open and closed canopy cedar swamp”; on and near top (driest part) of 1 ½ ft. high hummock.”
Comments:	Associates included <i>Larix laricina</i> , <i>Populus balsamifera</i> , <i>Abies balsamea</i> , <i>Lonicera villosa</i> , <i>Rubus pubescens</i> , <i>Carex eburnea</i> , <i>C. vaginata</i> , <i>C. disperma</i> , <i>Hylocomium splendens</i> , <i>Trientalis borealis</i> , <i>Mitella nuda</i> , <i>Maianthemum canadense</i> , <i>Smilacina trifolia</i>
Source of Information:	Michigan Natural Features Inventory special plant survey form

Location:	Michigan, Delta County
Ownership:	Hiawatha National Forest
Abundance:	Occasional
Habitat:	“ <i>Thuja</i> swamp.”
Comments:	Associates included <i>Coptis trifolia</i> , <i>Gymnocarpium dryopteris</i> , and typical cedar swamp flora
Source of Information:	Michigan Natural Features Inventory, 1993 report

NOTE: Represents 2 sites about 1 mile away from each other (MNFI considers 1 EO)

Location:	Michigan, Mackinac County
Ownership:	Hiawatha National Forest
Abundance:	22 plants in two meta-populations
Habitat:	“Rich Conifer Swamp; <i>Thuja</i> on dolomitic boulders.”
Comments:	Associates included <i>Carex pedunculata</i> , <i>C. eburnea</i> , <i>Asplenium viride</i> , <i>Mitella nuda</i> , <i>Viola renifolia</i> , <i>Lycopodium lucidulum</i>
Source of Information:	White Water Associates 1992 Report, Three Point Timber Sale

Location:	Michigan, Alger County (1989)
Habitat:	“Rich conifer swamp.”
Ownership:	Hiawatha National Forest
Source of Information:	MNFI (Mike Penskar)

Location:	Michigan, Cheboygan County (1948)
Habitat:	“Bog near Burt Lake.”
Ownership:	University of Michigan Biological Station
Source of Information:	MNFI (Rogers McVaugh)

Location:	Michigan, Cheboygan County (1955)
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Habitat:	“Shady swamp.”
Comments:	Near Route 33
Source of Information:	Univ. of Mich. (Hagenah)
Location:	Michigan, Cheboygan County (1927)
Habitat:	“As (<i>Phegopteris robertiana</i>) near openings along trail in Thuja swamp.”
Source of information:	Preston (MICH) (2002)
Location:	Michigan, Cheboygan County (1955)
Habitat:	“Shady cedar swamp.”
Source of Information:	University of Michigan Herbarium (MICH) (2002)
Location:	Michigan, Cheboygan County (1948)
Habitat:	“Near old corduroy road in cedar swamp.”
Source of Information:	University of Michigan Herbarium (MICH) (2002)
Location:	Michigan, Chippewa County (1961)
Habitat:	“Vertical cliff face in small crevices.”
Comments:	With <i>Cystopteris fragilis</i>
Ownership:	Lake Superior State Forest
Source of Information:	Hiltunen (1962)
Location:	Michigan, Chippewa County (1961)
Habitat:	“Vertical cliff face in small crevices.”
Comments:	With <i>Cystopteris fragilis</i>
Ownership:	Lake Superior State Forest (different range/section from above)
Source of Information:	Hiltunen (1962)
Location:	Michigan, Chippewa County (Drummond Island) (1950)
Habitat:	“Cut-over coniferous woods.”
Comments:	locally abundant
Source of information:	MNFI (Rogers McVaugh)
Location:	Michigan, Chippewa County (1994)
Habitat:	“Cedar swamp.”
Comments:	Adjacent to dolomite pavement dipping into lake
Ownership:	Lake Superior State Forest
Source of Information:	MNFI (Pat Comer)
Location:	Michigan, Delta County (1983-1989)
Habitat:	“3 specimens growing in semi-open cedar swamp.”
Source of information:	Preston (MICH) (2002)

Location: Michigan, Delta County (1934)
Habitat: "2 specimens as (*Thelypteris robertiana*); talus of limestone Cliff."
Source of Information: Preston (MICH) (2002)

Location: Michigan, Delta County (1949)
Habitat: "Abundant on shaded limestone talus slopes."
Source of Information: University of Michigan Herbarium (MICH) (2002)

Location: Michigan, Mackinac County (Aug. 10, 1997)
Habitat: "*Thuja* swamp in shade with some *Huperzia lucidula*."
Comment: less than 2 MI SSE of Hiawatha National Forest boundary
Source of Information: Preston (MICH) (2002)

Location: Michigan, Marquette County (1906)
Habitat: "As (*Phegopteris dryopteris*) in protected crevices of promontory rock; toward shore."
Source of Information: Preston (MICH) and MNFI(2002)

Location: Michigan, Marquette County (date not given)
Habitat: "Shaded N & W cliffs."
Source of Information: Preston (MICH) (2002)

Location: Michigan, Montmorency County (Aug. 30, 1989)
Habitat: "As (*Dryopteris robertiana*) in deep shade of mature *Thuja* Shamp."
Ownership: Mackinaw State Forest
Source of Information: Preston (MICH) (2002)

Location: Michigan, St. Clair County (June 10, 1888) (verified by Ed Voss)
Habitat: "As (*Phegopteris dryopteris*) often abundant in rich woods
Comments: C.K. Dodge (Dodge was a collector who transplanted plants so it might represent a naturalized site)."
Source of Information: Preston (MICH) (2002)

MINNESOTA

Location: Minnesota
Ownership: Chippewa National Forest

Habitat: "White-cedar (*Thuja occidentalis*) swamp; mossy ground."
Source of Information: Ian Shackleford, pers. comm., 2001

Location: Minnesota
Ownership: Chippewa National Forest
Habitat: "White-cedar swamp; mossy ground."
Source of Information: Ian Shackleford, pers. comm., 2001

Location: Minnesota
Ownership: Chippewa National Forest
Habitat: "White-cedar swamp; mossy ground."
Source of Information: Ian Shackleford, pers. comm., 2001

Location: Minnesota, Cook County
Habitat: "Granitic, possibly acidic, cliff."
Source of Information: Tryon (1980)

WISCONSIN

Location: Wisconsin, Bayfield County
Habitat: "North-facing bluff with seepage."
Source of Information: University of Wisconsin database, 4 Dec. 2001

Location: Wisconsin, Bayfield County
Habitat: "Sandstone."
Source of Information: University of Wisconsin database, 4 Dec. 2001

Location: Wisconsin, Brown County
Abundance: Only a few hundred individuals
Habitat: "Stable, limestone talus slope facing W; in deep shade of *Thuja*, *Betula papyrifera*, and *Tsuga*; humus thin."
Comments: Collected 5 June 1979; examined by WI Natural Heritage Program in 1998
Source of Information: University of Wisconsin database, 4 Dec. 2001

Location: Wisconsin, Door County
Abundance: Rare
Habitat: "On moss in white cedar swamp."
Source of Information: University of Wisconsin database, 4 Dec. 2001

Location: Wisconsin, Door County

Habitat:	“Sphagnum hummock in white cedar swamp
Comments:	Collected 18 July 1940; annotated by K. Pryer in 1984 and Others.”
Source of Information:	University of Wisconsin database, 4 Dec. 2001

LOCATION WISCONSIN, LA CROSSE COUNTY

Habitat:	“White pine topped sandstone bluff; <i>Taxus</i> slope above seepage bog.”
Source of information:	University of Wisconsin database, 4 Dec. 2001

Location:	Wisconsin, Lafayette County
Habitat:	“Limestone RR cut; deep shade.”
Comments:	With <i>Cystopteris bulbifera</i> , <i>Pellaea glabella</i> ; collected 18 July 1972; annotated by K. Pryer in 1984 and others
Source of Information:	University of Wisconsin database, 4 Dec. 2001

Location:	Wisconsin, Vernon County
Abundance:	50-100 fronds
Habitat:	“Growing on damp moss and liverwort covered limestone.”
Source of Information:	University of Wisconsin database, 4 Dec. 2001