

Conservation Assessment
for
Laurentian brittle fern (Cystopteris laurentiana) (Weatherby) Blasdell



USDA Forest Service, Eastern Region
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This document is undergoing peer review, comments welcome

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

This conservation assessment is a review of the distribution, habitat, ecology and population biology of *Cystopteris laurentiana* (Weatherby) Blasdell (laurentian brittle fern). This species is listed as Special Concern in the State of Michigan with a global G3 ranking; (G3: Vulnerable-vulnerable globally either because very rare or local throughout its range (W-1, NatureServe). It has a Regional Forester Sensitive Species (RFSS) ranking only on the Hiawatha National Forest in Michigan's Upper Peninsula (USDA 2000). This fern species also occurs in the western Upper Peninsula near but outside the Ottawa National Forest's proclamation boundary (Sue Trull, pers. comm., 2001).

In the western part of Michigan's Upper Peninsula, *Cystopteris laurentiana* is likely rare, in part, due to the scarcity of calcareous rock, typical habitat for this species.

One of the major threats to the survival of *Cystopteris laurentiana* in the east unit of the Hiawatha National Forest is timber harvesting creating alteration of habitat by canopy removal and thereby decreasing shade and humidity within the Niagara Escarpment Community Type (Evans 1997). In some instances, logging occurs on the Hiawatha National Forest within the area of Niagara Escarpment boulders (J. Schultz pers. comm. 2001).

The opportunities for research and/or monitoring of *Cystopteris laurentiana* include general life history, habitat requirements, and threats to viability. Research and/or monitoring of known populations are needed to analyze potential impacts from proposed forest management actions. Additional inventory work is needed to locate new sites and relocate known sites of this species.

INTRODUCTION/OBJECTIVES

This Conservation Assessment was prepared to compile the published and unpublished information about *Cystopteris laurentiana* (laurentian brittle fern). This is an administrative study only and does not represent a management decision or direction by the U.S. Forest Service. Though the best scientific information available was gathered and reported in preparation of this document, then subsequently reviewed by subject experts, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if the reader has 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.

One of the conservation practices of the USDA Forest Service is the designation of Regional Forester Sensitive Species (RFSS). The Eastern Region (R9) of the Forest Service updated its Sensitive Species list on February 29, 2000 (USDA 2000). Part of that process included identification of priority species for Conservation Assessments and Conservation Approaches. *Cystopteris laurentiana* (laurentian brittle fern) was one of those priorities.

The objectives of this document are to:

- Provide an overview of the current scientific knowledge
- Provide a summary of the distribution and status both range-wide and within the Eastern Region of the Forest Service
- Provide the available background information needed to prepare a subsequent Conservation Approach

The National Forest Management Act and U.S. Forest Service policy requires that Forest Service lands be managed to maintain viable populations of all native plant and animal species. A viable population is one that has the estimated numbers and distribution of reproductive individuals to ensure the continued existence of the species throughout its range within a given planning area (FSM 2670.5.22).

NOMENCLATURE AND TAXONOMY (Haufler et al., 1993; Kartesz 1994)

Scientific name: *Cystopteris laurentiana* (Weatherby) Blasdell

Family: Dryopteridaceae

Common names: laurentian brittle fern, laurentian bladder fern,
laurentian fragile fern

USDA plant code: CYLA4

Synonymy: *Cystopteris fragilis* (L.) Bernh. var. *huteri* (Hausman) Luerss.
Cystopteris fragilis (L.) Bernh. var. *laurentiana* Weatherby

Common names: Choosing an appropriate common name for this species is quite troublesome. Florence Wagner (pers. comm. 2002) felt that laurentian fragile fern was a poor choice since *C. fragilis* is one of its parents and the consensus is this is a separate species. On the other hand, *C. laurentiana* looks more like *C. fragilis* than *C. bulbifera*. Laurentian bladder fern emphasizes a common characteristic of its other parent; whereas, the bulblets in *C. laurentiana* are abortive so this name can also be confusing. The name laurentian brittle fern at least does not favor one parent over the other.

Taxonomy note: A monograph of the *Cystopteris* genus was published by Blasdell (1963). See the diagram on p. 263 of Haufler et al. (1993) which illustrates the relationships among various *Cystopteris* species, some of which are diploid and others allopolyploids. The diploid *Cystopteris* species are “relatively distinct from one another,” however, there is a lot of overlapping, especially with leaf characteristics, which makes identification difficult in all species in this genus (Haufler et al. 1993). Especially troublesome is the polymorphic species *C. fragilis* and its close relatives. *Cystopteris laurentiana* is a fertile allohexaploid (6n) hybrid which arose from a cross between the tetraploid (4n) *C. fragilis* and the diploid (2n) *C. bulbifera* (Haufler et al. 1993). Where *C. laurentiana* and *C. fragilis* are in the same geographic region, pentaploid (5n), infertile hybrids of these two species sometimes occur.

DESCRIPTION OF SPECIES (Gleason & Cronquist 1991; Haufler et al. 1993)

Fronds: Monomorphic, perennial

Blade: 2-pinnate to 2 pinnate-pinnatifid; widest part is usually above the base; tip is short-attenuate

Pinnae: “Typically perpendicular to rachis, not curving toward blade apex, margins serrate; proximal pinnae pinnate-pinnatifid to pinnatifid, equilateral, basiscopic pinnules not enlarged, basal basiscopic pinnules sessile to short-stalked” (Haufler et al. 1993)

Bulblets: Rachises and costae sometimes with poorly-developed, scaly bulblets.

- Stipe:** Base usually dark and with sparse scales; lighter, straw-colored higher up stipe
- Stems:** Creeping, the old stipe bases very close to each other
- Indusia:** Cup-like, apex square at end, often with sparse one-celled, gland-tipped hairs.
- Spores:** Spiny, usually 49-60 μm

Identification notes: *Cystopteris laurentiana* and other *Cystopteris* species and hybrids may be very difficult to distinguish from each other. (See the first part of the Distribution and Abundance section for further discussion about this difficulty.) Several specimens at the University of Michigan Herbarium (2002) were originally identified as *C. fragilis* then later identified as *C. x laurentiana*. Haufler et al. (1993) made several suggestions to follow when collecting and identifying *Cystopteris* species. Since hybridization often occurs whenever two or more *Cystopteris* species grow in the same area, fertile plants are important to collect so that spore characteristics can be examined (hybrids usually have spores that are deformed and shriveled). In addition, plants growing in stressful situations may be stunted and lack the usual stem and leaf characteristics which aid in distinguishing among *Cystopteris* species (Haufler et al. 1993).

Cystopteris laurentiana is a hybrid of *C. bulbifera* and *C. fragilis*. *C. laurentiana* and *C. bulbifera* differ from each other as follows (Haufler et al. 1993):

- usually a dense covering of hairs with gland tips on the rachises, costae, indusia, and midribs of the last segments of *C. bulbifera*; gland-tipped hairs are usually sparse in *C. laurentiana*
- rachises/costae of *C. bulbifera* frequently have bulblets; the occasional bulblets of *C. laurentiana* are often deformed
- blades of *C. laurentiana* are usually widest above the base while those of *C. bulbifera* are usually widest at the base; the pinnae of *C. bulbifera* tend to be longer narrow triangles with longer tips than either of the other two species (F. Wagner pers. comm. 2002)
- apex is less attenuated in *C. laurentiana* than in *C. bulbifera*
- spores are larger in *C. laurentiana* (usually 49-60 μm) than in *C. bulbifera* (usually 33-38 μm)
- Florence Wagner (pers. comm. 2002) considers the wide basal pinnae and bulblets to be diagnostic for *C. laurentiana*

C. laurentiana and *C. fragilis* differ from each other as follows (Haufler et al. 1993):

- rachises/costae of *C. fragilis* have no bulblets; *C. laurentiana* has occasional, often deformed, bulblets
- no glandular hairs on the rachises, costae, indusia, and midribs of the last segments in *C. fragilis*; *C. laurentiana* usually has sparse gland-tipped hairs
- C. laurentiana* plants (in Canada) are of larger stature than *C. fragilis* plants (Cody & Britton 1989).
- C. fragilis* never has a trailing tip, and the lowest pinnae are always shorter than the next pair above. If you have a specimen with a trailing tip and basal pinnae shorter

than the pair above, chances are it is *C. laurentiana*. Or a specimen that has basal pinnae almost as long as the pair above but no trailing tip, it is most likely *C. laurentiana* (F. Wagner pers. comm. 2002)

Note: Most element occurrences are based on herbarium specimens. After they have aged they have likely lost any spore cases they may have had. Element Occurrence records are most often based on herbarium specimens. Florence Wagner's comment (pers. comm. 2002) describes this dilemma "I am at a loss to define the characters separating *C. fragilis* and *C. laurentiana*, especially in herbarium specimens; they look so much alike".

Peck et al. (1989) noted that the abortive, misshapen bulblets of *Cystopteris laurentiana* do not easily abscise, which distinguishes it from its parents. (Presumably *C. bulbifera* as *C. fragilis* does not have bulblets.) To distinguish *C. laurentiana* from its parent plants, Hinds (2000), in the Flora of New Brunswick, suggests looking for "pointed glandular indusia and bulblets scattered or lacking."

HABITAT AND ECOLOGY

Element occurrence records for *Cystopteris* are shown in Appendix A and include approximate number of occurrences, associated species, habitats, etc.

In North America, *Cystopteris laurentiana* occurs on cliff ledges and in fissures, and frequently grows on calcareous substrates (Haufler et al. 1993).

Illinois

In Illinois, *Cystopteris laurentiana* has been reported from a cliff (Ken Robertson, pers. comm., 2002).

Iowa

In Iowa, *Cystopteris laurentiana* occurs with other *Cystopteris* species (*C. bulbifera*, *C. fragilis*, *C. protrusa*, and *C. tenuis*) and grows on "algific and north-facing, moist sandstone outcrops" (Peck et al. 1989). Christopher Haufler (pers. comm., 2002) noted that "the most amazing *C. laurentiana* I collected was at the mouth of an ice cave in Iowa, some hundreds of miles distant from the closest location of other *C. laurentiana* plants. These ice caves maintain a moist, cool microhabitat around their mouths through the hot, dry mid-western summers. So, it made sense for this fern to be there, but it was unexpected nonetheless."

Michigan

In Michigan's Upper Peninsula and the Canadian Province of Ontario, *Cystopteris laurentiana* is found largely along the Niagara Escarpment (Evans 1997, Cox & Larson 1993). Ten species of ferns, including *C. laurentiana*, are largely restricted to the Mixedwoods Plains Ecozone of the Niagara Escarpment (W-2, Pteridophytes). Other species occurring in the Mixedwoods Plains Ecozone include *Dryopteris filix-mas* (male fern), *Pellaea atropurpurea* (purple cliffbrake), *Asplenium trichomanes-ramosum* (green

spleenwort), *Asplenium scolopendrium* (hart's-tongue fern), and *Gymnocarpium robertianum* (limestone fern) (W-2, Pteridophytes). Also both parent species show an affinity for talus slopes along the Niagara Escarpment in Canada with abundance where present mean values (= total abundance divided by number of quadrants in which the species was present) of 2.6 for *C. fragilis* and 8.9 for *C. bulbifera* (Cox & Larson (1993).

The two known Hiawatha National Forest (HNF) sites of *Cystopteris laurentiana*, located in the eastern part of Michigan's Upper Peninsula, are found within the Niagara Escarpment community type. *C. laurentiana* grows in the shade of mixed northern hardwood forests on moist limestone ledges or boulders (MNFI 1999a). In the HNF sites, plant species associated with *C. laurentiana* include an overstory of *Acer saccharum*, *Fagus grandifolia*, *Populus grandidentata*, *Abies balsamea*, and *Corylus cornuta* (MNFI 1999a). Sugar maple and beech commonly occur as co-dominants in the eastern Upper Peninsula thriving on heavy-textured soils such as silt loam or clay loam. Sugar maple, yellow birch, and basswood all enhance the soil with their nutrient rich leaf-fall if left undisturbed (Cohen 1996). Understory species include *Maianthemum canadense*, *Trientalis borealis*, *Streptopus roseus*, and *Viola pubescens*; and the fern species *Asplenium rhizophyllum* (MNFI 1999a). At one site *C. fragilis* was present; at the other site both *C. fragilis* and *C. bulbifera* were present.

A possible third HNF site was reported by Bob Preston (pers. comm. 2002) of the University of Michigan, he reports a good sized population in Alger County west of Munising on the limestone base of a fenced-in building; MNFI was not able to confirm this site. However, Mike Penskar (MNFI, pers. comm. 2002) stated that he considered the Michigan database to be very incomplete for this species (6 occurrences, E. Schools pers. comm.), since *C. laurentiana* is so similar to *C. fragilis*.

In a study by Evans (1997) on several species of *Asplenium* of the Niagara Escarpment in the east unit of Michigan's Hiawatha National Forest, *C. laurentiana* was found to be significantly correlated with *Asplenium trichomanes-ramosum* at the <0.05 level. *C. laurentiana* was found on 13 out of 27 rocks with other ferns and only 4 out of 25 rocks without other ferns. Another fern species typically found on these boulders was *Dryopteris intermedia* (Evans 1997).

In the western part of Michigan's Upper Peninsula, there is much less calcareous substrate available. However, one collection of *Cystopteris laurentiana* was discovered on a sandy, limestone escarpment (MNFI 1999a). A site, located in the central part of the Upper Peninsula, was on wet seepy rocks above a creek in an old-growth northern hardwoods forest (MNFI 1993). Another site in Michiganamme Township in Marquette County is growing on igneous bedrock (B. Preston, pers. comm. 2002).

Minnesota

On the north shore of Minnesota, *Cystopteris laurentiana* has been found growing under a shady, moist, diabase ledge and in rock crevices along the shore (Jack Greenlee, pers. comm., 2002 citing Bell Herbarium herbarium specimen label information).

Pennsylvania

In one site in Pennsylvania, *Cystopteris laurentiana* grows on dolomitic limestone on a low, west-facing outcrop cut by a stream (Steve Grund, pers. comm., 2002). Nearness to the stream keeps the habitat moist. Associates included *Cystopteris bulbifera*, *C. fragilis*, *Sanguinaria canadensis*, *Asarum canadense*, and *Erigeron pulchellus*. Another occurrence may be on the same stream, and the habitat is probably very similar.

Vermont

Cystopteris laurentiana has been found in Vermont at high elevations and also at a cold lowland site (Robert Popp, pers. comm., 2002).

Wisconsin

In Wisconsin, *Cystopteris laurentiana* occurs on limestone ledges, sandstone outcrop/rock, trap rock, and even in masonry of an overlook (Wisconsin State Herbarium 2001).

Canada—Atlantic Canada (Newfoundland, Labrador, Prince Edward Island, New Brunswick, Nova Scotia)

In Atlantic Canada, *Cystopteris laurentiana* is restricted to calcareous cliffs and slopes (mostly limestone or gypsum) (Sean Blaney, pers. comm., 2002). In Nova Scotia, it occurs on dolomitic ledges, damp sinkholes in plaster, shady ledges, and conglomerate substrates (Roland & Smith 1969).

Canada—Quebec

One site of *Cystopteris laurentiana* in Quebec's Bic region was on a calcareous cliff (Jacques Labrecque, pers. comm., 2002).

DISTRIBUTION AND ABUNDANCE

Distinguishing various *Cystopteris* species in the field (such as *C. laurentiana*, *C. fragilis*, and *C. bulbifera*) may be difficult since many of the characteristics are not necessarily clear-cut [e.g., bulblets are frequent in *C. bulbifera* and occasional in *C. laurentiana*; usually densely covered by gland-tipped hairs in *C. bulbifera* and usually sparsely covered by glandular hairs in *C. laurentiana* (Haufler et al. 1993).] Steve Grund (pers. comm., 2002), a botanist for the Western Pennsylvania Conservancy/Pennsylvania Natural Diversity Inventory—Western Office, noted that “they did not feel confident about field identification” at two Centre County sites in Pennsylvania where hundreds of *Cystopteris* plants occur together. Specimens of *C. laurentiana*, *C. bulbifera*, and *C. fragilis* have been verified from the two sites by Jim Parks (Millersville University). Steve Grund hopes to return to those sites (with Jim Parks) to obtain, in part, more accurate counts for each species.

Botanists from the Minnesota County Biological Survey, according to Jack Greenlee (pers. comm., 2002) said they have seen plants that could be *C. laurentiana*; however, they are not comfortable making the definitive identification. Emmet Judziewicz, an associate Professor

at the University of Wisconsin, Stevens Point feels that this species, as well as the *Cystopteris* in general, are really difficult to tell apart; he has a well-known pteridologist (Carl Taylor) identify his *Cystopteris* specimens (Steve Spickerman/Steve Janke pers. comm. 2001). Even if collections of suspected *Cystopteris laurentiana* are made and brought back to the lab, those that are incomplete and without fertile fronds (thus spores) may be difficult to distinguish from other species (Haufler et al. 1993).

Ideally, all herbarium specimens of *Cystopteris laurentiana* and similar species should be annotated. This has been done to a great extent by Christopher Haufler (pers. comm., 2002) in preparation for the Flora of North America's treatment of *Cystopteris*. He annotated over 8000 sheets that he had borrowed (and returned) from 22 herbaria in the United States and Canada. See Appendix for a list of most of the herbarium consulted.

Because of the difficulty in identification of *Cystopteris laurentiana*, both in the field and from herbarium specimens, it may be that current information about distribution and abundance is not accurate for this species. In Canada, *C. laurentiana* is thought of as a rare plant, but frequently it is just lumped into the *C. fragilis* taxon (Cody & Britton 1989). In Ontario (Canada), this species is "easily overlooked and probably more common than records indicates" (Oldham 1999). However, according to Sean Blaney (pers. comm., 2002), referring to Atlantic Canada, *C. laurentiana* is "legitimately rare (rather than simply overlooked)" and it does not occur even in areas of suitable habitat.

North America

According to Haufler et al. (1993), *Cystopteris laurentiana* occurs in the United States in Illinois, Iowa, Massachusetts, Michigan, Minnesota, Pennsylvania, Vermont, and Wisconsin; and in Canada, in New Brunswick, Newfoundland, Nova Scotia, Ontario, and Quebec. It also is listed for New Hampshire (W-1, NatureServe). Occurrences are usually scattered and apparently not frequent, however, in some areas it is considered locally abundant such as on Ontario's Manitoulin Island and in the Driftless area in the mid-western United States (W-1, NatureServe).

Illinois

Cystopteris laurentiana, listed as endangered in Illinois, has one entry in the Natural Heritage database for Illinois (Ken Robertson, pers. comm., 2002). Two herbarium specimens (one or two locations?) were collected from Lee County, Illinois.

Iowa

In Iowa, *Cystopteris laurentiana* occurs with other *Cystopteris* species (*C. bulbifera*, *C. fragilis*, *C. protrusa*, and *C. tenuis*) and grows on "algific and north-facing, moist sandstone outcrops" (Peck et al. 1989).

Massachusetts

Although Massachusetts has an “SR” (reported, but not assessed) designation for *Cystopteris* (W-1, NatureServe), according to Paul Somers (pers. comm., 2002), to his knowledge, Massachusetts only has *C. fragilis* (var. *fragilis*), *C. tenuis*, and *C. bulbifera*.

Michigan

By 1952, *Cystopteris fragilis* var. *laurentiana* (= *C. laurentiana*) had not been recognized in Michigan, but it was known from Ontario’s Bruce Peninsula, Wisconsin, and Minnesota (Billington 1952). This fertile hybrid was first reported in Michigan in a serpentine belt NW of Ishpeming (Hagenah 1963). This fern was not documented on the Hiawatha National Forest until 1993 (MNFI 1999a).

Six occurrences (Ed Schools, pers. comm., 2002) of *Cystopteris laurentiana* are documented by the Michigan Natural Features Inventory from six counties (Baraga, Chippewa, Dickinson, Houghton, Mackinac, and Marquette) [MNFI 2001], all of which are located in the Upper Peninsula. Robert Preston (pers. comm., 2002) said that he had seen a University of Michigan (MICH) specimens from Alpena and Alger Counties as well. Other specimens not listed with MNFI are available for Delta, Ontonagon, and Keweenaw Counties at the University of Michigan Herbarium (2002). Documented sites for this species have been found in the East Unit of the Hiawatha National Forest (HNF) at two sites, one in Chippewa County and the other in Mackinac County. The number of plants are unknown at both HNF sites. The Chippewa County site has a B ranking (MNFI 1999b). *C. laurentiana* occurs in Houghton County, outside but near the proclamation boundary of the Ottawa National Forest (Sue Trull, pers. comm., 2001). A Marquette site is located east, and outside the proclamation boundary, of the Ottawa National Forest (MNFI 1993; Sue Trull, pers. comm., 2001).

In Michigan, the distribution of *Cystopteris bulbifera* seems to be more limited in the Upper Peninsula than *C. fragilis*, *C. laurentiana*’s other parent (Billington 1952). Both parents occur in rocky habitats, but *C. bulbifera* is more site specific growing on wet, calcareous rocks (Billington 1952). Up-to-date mapping of the two parent species in Michigan could give additional insight to likely occurrences for *C. laurentiana*.

Minnesota

In Minnesota, there are ten documented specimens of the fertile hybrid *C. laurentiana* from at least seven counties (W-3, Univ. of Minnesota Herbarium). Four specimens are from the north shore of Lake Superior, three of which are from state parks. Two of these collections (Cook County) were made within the proclamation boundary of Superior National Forest, but they are on state park land (Jack Greenlee, pers. comm., 2002). The other two north shore collections (Lake County) were outside the proclamation boundary of the Superior National Forest. This species, although not on the Superior National Forest is on that Forest’s Species of Concern list, an informal watch list (Jack Greenlee, pers. comm., 2002).

The NE Minnesota populations in Cook and Lake Counties were recorded as isolated, stable and known to be a hybrid (Mary Shedd, pers. comm., 2000). The Dorer Memorial Hardwood State Forest has an additional three occurrences (W-3, Univ. of Minnesota Herbarium).

New Hampshire

Cystopteris laurentiana occurs in New Hampshire but is not tracked by the New Hampshire Heritage Inventory (Sara Cairns, pers. comm., 2002). The list of tracked species in New Hampshire is being reviewed, currently *C. laurentiana* is on a list of species that requires additional information for assessment.

Pennsylvania

There are two extant occurrences of *Cystopteris laurentiana* in Pennsylvania (Steve Grund, pers. comm., 2002), both located in Centre County, as well four vague historic records (two in Centre County, one each in Butler County and Pike County). One or two of the Centre County historic records may represent the same Centre County localities as the extant occurrences. There are probably hundreds of *Cystopteris* plants in the two extant Centre County sites; however, it is unknown how many of those plants are *C. laurentiana*.

Vermont

Cystopteris laurentiana is not listed in Vermont, although it is considered rare in the state (Bob Popp, pers. comm., 2002). It is known from only three locations, all of which are in Chittenden County. Since *C. laurentiana* has only recently been split off from *C. fragilis*, the Vermont Nongame and Natural Heritage Program does not have specific information on this species.

Wisconsin

In Wisconsin, there are over 20 locations of *C. laurentiana* in seven counties (W-4, Wisconsin State Herbarium). Most of these occurrences were in the northwestern part of Wisconsin as well as in Door County (W-4, Wisconsin State Herbarium). This hybrid fern is listed as uncommon in the Apostle Islands, but it does occur on cliffs of three of the islands (Judziewicz & Koch 1993). In Wisconsin, the distribution of the parent *Cystopteris fragilis* appears to be a limiting factor, with occurrences of the hybrid found where the distribution of both ferns overlap (Maps (2001) on Wisconsin State Herbarium site, W-4).

Canada—Atlantic Canada (Newfoundland, Labrador, Prince Edward Island, New Brunswick, Nova Scotia)

In Newfoundland, *Cystopteris laurentiana* has been documented from at least two recent locations and eight historic locations (Sean Blaney, pers. comm., 2002). Many historic sites, according to Sean Blaney, may still be extant (historic means that no one has looked for the species at the site for many years). In New Brunswick, this species is known from four locations (Sean Blaney, pers. comm., 2002). It is considered extremely rare in New Brunswick, occurring occasionally where its parent species (*C. fragilis* and *C. bulbifera*)

grow nearby (Hinds 2000). In Nova Scotia, there are four historic, but probably still extant, locations for *C. laurentiana* (Sean Blaney, pers. comm., 2002). In Labrador and Prince Edward Island, it is not known and not likely to be present.

Canada—Ontario

In Ontario, *Cystopteris laurentiana* occurs in 11 counties, seven of which have records within the past 20 years and four which have records that are from more than 20 years ago (Oldham 1999). On Manitoulin Island, *C. laurentiana* is abundant (Cody & Britton 1989).

Canada—Quebec

Jacques Labrecque (pers. comm., 2002) estimated the number of occurrences of *Cystopteris laurentiana* in Quebec as approximately 10. It is known in Quebec mostly from the Gaspé Peninsula and the Lower St. Lawrence. A few isolated individuals occurred in the Bic region of Quebec as well (Jacques Labrecque, pers. comm., 2001).

STATUS (Protection) (W-1, NatureServe)

Currently, the official status of *Cystopteris laurentiana* with respect to Global, Federal and State Conservation Status is:

U.S. Fish and Wildlife Service: Not listed

U.S. Forest Service: Region 9 Sensitive on Hiawatha NF

The Regional Forester has identified it as a species for which viability is a concern on Hiawatha National Forest as evidenced by: **a)** significant current or predicted downward trends in population numbers or density, and or **b)** significant current or predicted downward trends in habitat capability that would reduce its existing distribution (FSM 2670.5.19).

Cystopteris laurentiana was listed on the Hiawatha as an R9 species because of its G3 ranking and its documented presence on the Hiawatha National Forest.

Cystopteris laurentiana is not listed as an R9 species on the Superior National Forest because there are no documented occurrences in that Forest, and although it is known from Lake Superior's north shore, there is a low probability that it would occur in Superior National Forest (Jack Greenlee, pers. comm., 2002 citing a discussion at a USFS subregional meeting).

Global Heritage Status Rank: G3 (14 August 2000)

National Heritage Status Rank: United States: N2N3 (11 Aug. 2000)
Canada: N3? (Jan. 1997)

United States: (W-1, NatureServe)

Illinois	S1; endangered	New Hampshire	SR
Iowa	Hybrid	Pennsylvania	S1; tentatively undetermined; proposed endangered
Massachusetts	SR	Vermont	SR
Michigan	S1S2; special concern	Wisconsin	SR (not tracked)
Minnesota	SR (not tracked)		

Canadian Provinces: (W-1, NatureServe)

New Brunswick	S1	Ontario	S2S3
Newfoundland Island (Newfoundland)	S1S2	Quebec	S?
Nova Scotia	S1?		

S1: Critically imperiled in the state/province because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation in the state/province.

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, but not assessed

S? = Unknown, not enough information

LIFE HISTORY

Little is documented about the life history of *Cystopteris laurentiana*. *C. laurentiana* is a fertile allohexaploid hybrid with *C. bulbifera* as one parent (2n) and *C. fragilis* as the other (4n) (Haufler et al. 1993). *C. laurentiana* is a perennial, herbaceous fern; its leaves are monomorphic, dying back in winter. It releases its spores summer through fall. *Cystopteris* is epipetric growing in moist to wet places.

In a study of seven members of the genus *Cystopteris*, including *C. fragilis* and *C. bulbifera*, Blasdell (1963) reported that antheridia in the gametophytes were formed before archegonia and that there were not any significant differences in gametophytic characteristics amongst those *Cystopteris* species. In contrast to Blasdell's findings, Haufler & Ranker (1985) noted that three *Cystopteris* species (*C. bulbifera*, *C. protusa*, and their allopolyploid hybrid *C. tennesseensis*) produced archegonia before antheridia and showed significant interspecies differences such as their response to the hormone antheridiogen. Some of the differences brought about by addition of antheridiogen are described below.

After culture on antheridiogen-enriched agar plates, “in *C. protrusa* cultures, a majority (62.5%) of the sexually active gametophytes was functionally unisexual (either male or female) after 34 days. In contrast, only 29.1% of the *C. tennesseensis* gametophytes and 42.9% of the *C. bulbifera* gametophytes were unisexual”. From this it may be predicted that *C. bulbifera* and *C. tennesseensis* are more inbreeding than *C. protrusa* (Haufler & Ranker 1985). Since *C. bulbifera* is one of *C. laurentiana* parents it is possible *C. laurentiana* might behave similarly.

Haufler & Ranker (1985) determined that when *Cystopteris protrusa* was cultured on antheridiogen-enriched agar plates, those sexually active gametophytes produced that were unisexual, were mostly male. However, when cultured with antheridiogen, the unisexual gametophytes produced by *C. bulbifera* were all female. The different responses of *Cystopteris* species to antheridiogen, “may dictate variation in the types of breeding systems within species and may play a role in promoting hybridization between species” such as *C. protrusa* and *C. bulbifera*.

Although the antheridiogen responses in *Cystopteris fragilis* and *C. laurentiana* were not studied, it may be that *C. fragilis* would respond to antheridiogen in a similar fashion as did *C. protrusa* with outcrossing being promoted. In addition, antheridiogen may be a factor in promoting hybridization between *C. fragilis* and *C. bulbifera*. Research specific to *C. fragilis* and *C. laurentiana* is needed.

POPULATION BIOLOGY AND VIABILITY

Little is known about spore dispersal [other than *Cystopteris laurentiana* sporulates summer-fall (Haufler et al. 1993)], germination requirements, or distance of dispersal. Similarly, little is known about the genetic diversity of this species.

Because of few known sites, it is anticipated there are either no viable long-term populations or potential for a viable long-term population on National Forest system lands in Michigan. Over the short term, the Hiawatha National Forest site in Chippewa County with a “bunch of healthy plants” (MNFI 1999a) might be considered viable; however, a more precise assessment is needed. Additional inventory for this species may reveal new occurrences of this species within the Hiawatha National Forest and elsewhere.

POTENTIAL THREATS

Several threats or limiting factors which can significantly impact population viability of *Cystopteris laurentiana*, in addition to habitat changes, are climatic factors which include loss of protective snow pack during cold winters (D. LeBlanc pers. comm. 2001). The most serious threat is a change in canopy closure (loss of shade cover) or habitat alteration due to timber harvesting activities, conversion of northern hardwoods to other cover types, and blowdowns (Evans 1997). MNFI lists 59 documented occurrences of mesic northern forest; but only 8 of those occurrences, constituting just over 56,000 acres, are considered high quality representations of this community type. The best stands of northern mesic forest occur in the Porcupine Mountains, the Sylvania Wilderness, and the Huron Mountains (Cohen 1996); little of this area has the limestone bedrock that this fern appears to favor.

Timber harvesting on the east unit of Hiawatha National Forest, within the Niagara Escarpment, has resulted in degradation of habitat for rare epipetric ferns and an increase in weedy non-native species on the large limestone boulders (Jan Schultz, pers. comm., 2001).

In those occurrences of *Cystopteris laurentiana* in northeastern Minnesota, the overall threat is probably low because it occurs on cliffs (Jack Greenlee, pers. comm., 2002). Possible threats are collecting and recreation. In general, the best management prescription for mesic northern hardwoods is to leave large tracts unharvested and allow natural processes of growth, senescence, windthrow, fire, disease, and insect infestation to operate unhindered (Cohen 1996). Johnson and Van Wagner (1985) suggested that a landscape fragment should be at least twice the size of the largest disturbance event. When managing tracts of mesic northern forest for timber harvest, care should be taken to minimize fragmentation caused by logging roads, preserve the forest matrix, and maintain a range of canopy closure comparable to pre-harvest conditions (Cohen 1996).

RESEARCH AND MONITORING

Thorough mapping of the distribution of both of *Cystopteris laurentiana* parents could give insight as to where the hybrid might be expected. It is possible that individuals are being mistaken as *C. fragilis* since the hybrid is similar in form to its parent. “Specimens with ovate leaves having unusually large spores and growing on moist cliffs should be checked carefully for occasional glandular hairs,” which would distinguish *C. laurentiana* from *C. fragilis* (Haufler et al. 1993). (See the Identification Notes part of the Description of Species section for differences between these two species as well as between *C. laurentiana* and *C. bulbifera*.)

Monitoring at known Forest sites and off Forest locations is needed in order to analyze effects associated with management actions such as timber harvest. Results of monitoring and research may provide managers with data to develop a Conservation Approach for this species. This could include developing goals for maintaining viability of this species, writing management prescriptions for known sites, along with public education and outreach in efforts to protect this rare fern’s habitat.

SUMMARY

Cystopteris laurentiana is a fertile hybrid between *C. fragilis* and *C. bulbifera*. *Cystopteris* is a genus that was not described by a monographic work on the genus until 1963 (Blasdel 1963). Preferred habitat for *C. laurentiana* is limestone or calcareous rock, especially along the Niagara Escarpment; the species is epipetric. In the Great Lakes states, this fern species occurs in the Upper Peninsula of Michigan, in northern Wisconsin, and in the northeast section of Minnesota. Michigan lists this hybrid fern as Special Concern. Florence Wagner (pers. comm. 2002) notes that there is no question about its status as a separate species; she also comments that this is a difficult species to evaluate because it is both rare and hard to identify. Since this hybrid looks similar to its parent *C. fragilis* in particular, and to a lesser degree *C. bulbifera*, its presence is probably overlooked, thus numbers are possibly underestimated. Especially difficult is the process of differentiating previously collected specimens, since its hybrid status was fairly recently separated from *C. fragilis* (Blasdel

1963). Florence Wagner (pers. comm. 2002) commented that “it is difficult to separate *C. fragilis* and *C. laurentiana*, especially in herbarium specimens, since they look so much alike”.

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W-3. University of Minnesota Herbarium
<http://wildflowers.umn.edu/public/results.asp?search+countychk&id=2038>

W-4. Wisconsin State Herbarium
<http://wisinfo.doit.wisc.edu/herbarium/hand/CYSLAU.gif>

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APPENDIX A. CYSTOPTERIS LAURENTIANA ELEMENT OCCURRENCES

Ideally, all herbarium specimens of *Cystopteris laurentiana* and similar species should be checked and annotated. Christopher Haufler (pers. comm., 2002) in preparation for the Flora of North America's treatment of *Cystopteris* annotated over 8000 sheets that he had borrowed (and returned) from 22 herbaria in the United States and Canada. Many of these herbaria are listed below:

COLO (University of Colorado)	MO (Missouri Botanical Garden)
DAO (Agriculture & Agri-Food Canada)	NY (New York Botanical Garden)
GH (Harvard University)	OAC (University of Guelph)
ILLS (Illinois Natural History Survey)	OS (Ohio State University)
IND (Indiana University)	SIU (Southern Illinois University)
KANU (University of Kansas)	TENN (University of Tennessee)
KE (Kent State University)	UARK (University of Arkansas)
KY (University of Kentucky)	US (Smithsonian Institution)
MICH (University of Michigan)	WIS (University of Wisconsin)
MIL (Milwaukee Public Museum)	

After Haufler's review in 1993 some states have been diligent in updating their element occurrence information for this species; other states are behind in this process. Therefore the information that you get from various state heritage program may not reflect the current understanding for this species.

Some occurrence totals for a particular state may be higher than indicated below; data from herbaria are rarely computerized and often this data is not automatically given to heritage programs. If the heritage program has not had the personnel to send to the various herbaria within their state then they frequently only show records where the botanist filled out one of their special forms and sent the specimen to the University herbarium. Many times the botanist recognizes the species as a possible find but isn't sure. Once it is verified, the form for the natural heritage program is not filled out. Thus data from a state heritage program may only give a partial understanding.

The following element occurrence information for *Cystopteris laurentiana* was obtained from natural heritage programs, National Forests, etc. in the United States. Because this species is poorly understood or element occurrences still lumped with *C. fragilis*, this list is not complete. This species also occurs in New Hampshire and various Canadian provinces as well.

Element occurrence summary:

Illinois (1; possibly 2?) Ken Robertson (pers. comm., 2002) said that are two herbarium specimens known of this species in Illinois, both from Lee County.

Iowa (1?) (Christioher Haufler, pers. comm., 2002)

Michigan [6 (Ed Schools, pers. comm., 2002)]
Hiawatha National Forest (2)
University of Michigan Herbarium 2002 (5 more recent EO, 3 historical) Florence
Wagner pers. comm. 2002.

University of Michigan Herbarium has one specimen for Keweenaw, Houghton,
Mackinac, and Marquette counties; two specimens for Chippewa and Dickinson
Counties, and three for Delta and Ontonagon Counties or 14 specimens for 8 counties.

Minnesota [10 herbarium specimens representing approximately 10 or fewer occurrences
(W-3, Univ. of Minnesota Herbarium)]

Pennsylvania [4-6; 2 extant and 2-4 historical records; Steve Grund (pers. comm., 2002)]

Vermont [3; Robert Popp (pers. comm., 2002)]

Wisconsin [9 herbarium specimens representing approximately 9 or fewer occurrences
(Wisconsin State Herbarium 2001)]

Ontario [10 herbarium specimens at the University of Michigan]; presumably others in
Canadian herbarium (F. Wagner pers. comm. 2002).

ILLINOIS

location: Illinois, Lee County

abundance: 1981-08-30 (approx. 10 plants; site needs verification); 1969 (plants observed)

habitat: cliff

comments: this is the only entry in the Natural Heritage database for Illinois

source of information: Todd Bittner according to Ken Robertson (pers. comm., 2002)

IOWA

location: Iowa

habitat: ice cave with moist, cool microhabitat

comments: hundreds of miles distant from nearest location of other *Cystopteris laurentiana*

source: Christopher Haufler (pers. comm., 2002)

MICHIGAN

Hiawatha National Forest:

location: Michigan, Chippewa County

ownership: Hiawatha National Forest

date last observed: 1 August 1993

abundance: a "bunch"

habitat: mesic northern hardwoods (Niagara Escarpment); along limestone ledges (most found midway up slope); in shade
comments: plants healthy; associated species included *Cystopteris fragilis*, *C. bulbifera*, *Acer saccharum*
source of information: Michigan Natural Features Inventory (1999a)

location: Michigan, Mackinac County
ownership: Hiawatha National Forest
date last observed: August 1996
habitat: northern hardwoods (Niagara Escarpment); on large (up to 10 ft. in size) limestone boulders in full shade of hardwoods
comments: Associated species include *Acer saccharum*, *Fagus grandifolia*, *Corylus cornuta*, *Abies balsamea*, *Maianthemum canadense*, *Trientalis borealis*, *Streptopus roseus*, *Viola pubescens*, *Cystopteris fragilis*, *Asplenium rhizophyllum*
source of information: (Evans 1997)

Other locations: (Michigan Natural Features Inventory database, 2002)

location: Michigan, Alger County (not in MNFI 2002)
ownership: near the proclamation boundary of the Hiawatha National Forest
date last observed: not given
habitat: limestone base of fenced-in building
source of information: Robert Preston, University of Michigan (pers. comm., 2002)

location: Michigan, Houghton County
ownership: outside but near the proclamation boundary of the Ottawa National Forest
date last observed: 22 June 1992
habitat: on sandy limestone escarpment; NW aspect
source of information: Michigan Natural Features Inventory (1999a); Sue Trull (pers. comm., 2001)

location: Michigan, Marquette County
ownership: Mead Paper Company (east of Ottawa National Forest; not within the proclamation boundary of that Forest)
date last observed: 17 June 1989
habitat: on wet seepy rocks above creek; associated with old-growth northern hardwoods
comments: general area may be logged by Mead Paper Company
source of information: Michigan Natural Features Inventory (1993); Sue Trull (pers. comm., 2001)

location: Michigan, Baraga County
ownership: Ottawa National Forest
date last observed: 1992-06-22
habitat: igneous bedrock
source of information: Don Henson); Sue Trull (pers. comm., 2001)

location: Michigan, Dickinson County
ownership: Rock Ridge Plant Preserve
date last observed: 1985-08
habitat: Outcrop of dry granite (south-facing) at the top of Rock Ridge where ridge is the steepest and least covered by canopy.
Source of information: Ballard, pers. comm to MNFI

Other Michigan element occurrences (University of Michigan Herbarium 2002)

location: Michigan, Delta County
ownership: State of Michigan
date last observed: 1935 & 1954 (Wagner)
habitat: limestone outcrops near Fayette
source of information: Wagner

location: Michigan, Delta County
ownership: St. Martin's Island
date last observed: 1989-07-11
habitat: north shore growing on low limestone cliff
source of information: Wells, Higman, Thompson

location: Michigan, Dickinson County
ownership: (east of Niagara, WI)
date last observed: 1990-06-09
habitat: north shore growing on low limestone cliff
source of information: Wells, Higman, Thompson

location: Michigan, Mackinac County
ownership: (east of Trout Lake)
date observed: 1935-07-17
habitat: limestone outcrop
source of information: Univ. of Michigan Herbarium

location: Michigan, Keweenaw County
ownership: not specified
date last observed: 1950-08-03
habitat: moist crevices in conglomerate cliff face
source of information: C. Richards

location: Michigan, Ontonagon County
ownership: not specified (NE Bergland)
date last observed: 1989-07-15
habitat: on or near rocks of mountain-like terrain
source of information: Henson

location: Michigan, Ontonagon County
ownership: (west branch of Ontonagon River)
date last observed: 1990-07-04
habitat: growing on shady north facing rocks
source of information: Henson

Minnesota

location: Minnesota, Cook County (North Shore)
ownership: Temperance River State Park
date collected: 15 August 1975
source of information: Jack Greenlee (pers. comm., 2002) citing Bell Herbarium
herbarium specimen label information

location: Minnesota, Cook County (North Shore)
ownership: Cascade River State Park
date collected: 2 August 1879
source of information: Jack Greenlee (pers. comm., 2002) citing Bell Herbarium
herbarium specimen label information

location: Minnesota, Lake County (North Shore)
ownership: George Crosby Manitou State Park
date collected: 28 August 1947
habitat: growing under a diabase ledge, damp, very shaded
source of information: Jack Greenlee (pers. comm., 2002) citing Bell Herbarium
herbarium specimen label information

location: Minnesota, Lake County (North Shore)
date collected: 23 August 1943
habitat: in rock crevices on shore
source of information: Jack Greenlee (pers. comm., 2002) citing Bell Herbarium
herbarium specimen label information

Note: In addition to listed records, the University of Minnesota, and one specimen from Goodhue County.

Pennsylvania

Both of the two sites below are owned by the state (Pennsylvania State University and the Department of Corrections). The Pennsylvania State University site was visited most recently in 1990 and the Department of Corrections site in 1997.

location: Pennsylvania, Centre County
ownership: see above
date last observed: see above

abundance: hundreds of *Cystopteris* plants; *C. laurentiana* occurs with *C. bulbifera* and *C. fragilis* and “we did not feel confident about field identification” (Steve Grund, pers. comm., 2002); [Steve Grund (and others) will return to site with Jim Parks, who works with *Cystopteris* at Millersville University]

habitat: dolomitic limestone on a low, west-facing outcrop cut by a stream; stream is close enough to keep site moist

comments: associated species included *Cystopteris bulbifera*, *C. fragilis*, *Sanguinaria canadensis*, *Asarum canadense*, and *Erigeron pulchellus*

source of information: Steve Grund (pers. comm., 2002)

location: Pennsylvania, Centre County

ownership: see above

date last observed: see above

abundance: : hundreds of *Cystopteris* plants; *C. laurentiana* occurs with *C. bulbifera* and *C. fragilis* and “we did not feel confident about field identification” (Steve Grund, pers. comm., 2002); [Steve Grund (and others) will return to site with Jim Parks, who works with *Cystopteris* at Millersville University]

habitat: similar to habitat of occurrence listed above

source of information: Steve Grund (pers. comm., 2002)

Vermont

location: Vermont, Chittenden County, Green Mountains

habitat: high elevations

source of information: Robert Popp (pers. comm., 2002)

location: Vermont, Chittenden County

habitat: high elevations

source of information: Robert Popp (pers. comm., 2002)

location: Vermont, Chittenden County

habitat: cold lowland site

source of information: Robert Bopp (pers. comm., 2002)

Wisconsin (Note: Some sites below may represent the same occurrence; WSH = Wisconsin State Herbarium)

location: Wisconsin, Ashland

habitat: N end of island

source of information: WSH (2001)

location: Wisconsin, Ashland County

habitat: trap rock

source of information: WSH (2001)

location: Wisconsin, Bayfield County
habitat: sandstone rock
source of information: WSH (2001)

location: Wisconsin, Crawford County
habitat: along face of limestone ledge
source of information: WSH (2001)

location: Wisconsin, Douglas County
abundance: estimated 60 plants (fronds not all from the same plant)
habitat: in masonry of overlook
source of information: WSH (2001)

location: Wisconsin, Douglas County
habitat: rock outcrop below falls
source of information: WSH (2001)

location: Wisconsin, Douglas County
habitat: trap rock
source of information: WSH (2001)

location: Wisconsin, Waupaca County
habitat: down the face of a ledge
source of information: WSH (2001)

Canada

The following specimen information was from the University of Michigan. Definitely more specimens would be housed in Canadian herbarium. However even these few specimens may be helpful to assess the preferred habitat.

Ontario

location: Algoma District (2 specimens)
habitat: moist rich humus under alders in a ravine
source of information: F. Wagner (pers. comm. 2002)

location: Bruce County
habitat: Limestone outcropping at edge of cleared pasture
source of information: F. Wagner (pers. comm. 2002)

location: Grey County
habitat: not indicated
source of information: F. Wagner (pers. comm. 2002)

location: Fitzwilliam Island
habitat: ledge of limestone cliff
source of information: F. Wagner (pers. comm. 2002)

location: Manitoulin Island
habitat: rock crevices on face of limestone escarpment
source of information: F. Wagner (pers. comm. 2002)

location: Manitoulin Island
habitat: talus of Gibraltar cliff
source of information: F. Wagner (pers. comm. 2002)

location: Manitoulin Island (3 specimens)
habitat: limestone cliffs
source of information: F. Wagner (pers. comm. 2002)

location: Thunder Bay District (2 specimens)
habitat: On ledges and crevices along shaded cliff crevice, west aspect
source of information: F. Wagner (pers. comm. 2002)

Newfoundland

location: Bay of Islands
habitat: crevices in shaded damp rocks near sea level
source of information: F. Wagner (pers. comm. 2002)