Conservation Assessment
for
Braun's Holly Fern (Polystichum braunii)

photo credit: Eric J. Epstein

USDA Forest Service, Eastern Region

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This Conservation Assessment was prepared to compile the published and unpublished information on Polystichum braunii. 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, 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 this species, please contact the Eastern Region of the Forest Service – Threatened and Endangered Species Program at 310 Wisconsin Avenue Milwaukee, Wisconsin 53202.

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EXECUTIVE SUMMARY

Polystichum braunii (Braun's holly fern) is designated as a Regional Forester Sensitive species on the Chequamegon-Nicolet Forest in the Eastern Region of the Forest Service (Region 9). The species is documented but not designated as sensitive on the Ottawa, Hiawatha, Superior and Green Mountain National Forests. The purpose of this document is to provide the background information necessary to prepare a Conservation Approach that will include management actions to conserve the species.

This Conservation Assessment provides a review of currently known information regarding the distribution, habitat, ecology, and conservation status of Braun's holly fern within its North American range. Special emphasis is given to Wisconsin and Minnesota and particularly the Chequamegon-Nicolet and Superior National Forests within these states. This assessment may also be applicable in other states and provinces where this species occurs and is listed.

The range of Braun's holly fern is circumboreal and within this broad range it is considered "secure." However, it is listed as *endangered*, *threatened*, or *special concern* in several U. S. states and Canadian provinces, especially where it occurs toward the periphery of its range. The species is typically found along rocky streams and in boulder-strewn seepy places within nutrient-rich, cool, shady hardwood forest, though there are exceptions to this general habitat pattern. Populations of this semi-evergreen fern are generally small, consisting of one to 100 individual scattered plants. Potential threats include habitat loss or alteration due to logging and recreational activities, invasive non-native species, poaching, and climate change. These threats are perhaps all exacerbated by the small size of most local populations. Research regarding *P. braunii* population dynamics, habitat requirements, reproduction biology, and management needs is suggested.

NatureServe (2002), an online database covering Natural Heritage Programs in the U.S. and Canada, lists approximately 70 occurrences of this species in the areas where it is listed as rare and tracked. Of these, relatively few receive habitat protection by a management decision to maintain the site in a natural state. Further monitoring and possibly the design of a Conservation Approach is warranted along the edge of Braun's holly fern's range.

INTRODUCTION

The National Forest Management Act and U.S. Forest Service policy require 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).

In addition to those species listed as endangered or threatened under the Endangered Species Act, or Species of Concern by the U.S. Fish and Wildlife Service, the Forest Service recognizes the need to implement special management direction for other rare species on the lands it administers. Such species are designated within each region as *Regional Forester Sensitive Species*. The Eastern Region

(Region 9) of the Forest Service updated its Sensitive Species list in 2000. Part of the update process included identification of priority species for conservation assessments and strategies. Braun's holly fern was included on the Regional Forester's Sensitive Species List for the Eastern Region for the Chequamegon-Nicolet National Forest on which it occurs and in the Northern Region (Region 1) (see definition of Regional Forester's Sensitive Species in Status section).

The objectives of management for such species are to ensure their continued viability throughout their range on National Forest lands, and to ensure that they do not become threatened or endangered because of Forest Service actions (FSM 2670.22). In the National Forest System, this fern occurs only in the Eastern Region, in the northern part of Idaho in the Northern Region, and in southern Alaska (Region 10).

NOMENCLATURE AND TAXONOMY:

Scientific name:	*Polystichum braunii* (Spenner) Fée*
Common names:	Braun's Holly Fern; Braun's Sword-fern
Family:	Dryopteridaceae
Synonymy:	*Polystichum braunii* (Spenner) Fée *ssp. purshii* (Fern.) Calder & Taylor *Polystichum braunii* (Spenner) Fée *var. purshii* (Fern.) *Dryopteris braunii* (Spenner) Underw. *Aspidium braunii* Spenner in 1825
Taxon codes:	POBR4 (NRCS); PPDRY0R040 (NatureServe 2002)

*Wagner (1993) and Cody and Britton (1989) as well as others now refer to this species as *Polystichum braunii* (Spenner) Fée. Older works often used *P. braunii* (Spenner) Fée var. *purshii*; the name ascribed to differentiate this species from the European populations (var. *braunii*). But, according to Wagner (1979, 1993), the only consistent difference between the two varieties (sometimes considered subspecies) seems to be an increased proportion of broad to filiform microscales in var. *purshii*. Cody and Britton (1989) agree, stating that this difference is difficult to distinguish, "…serves no useful purpose and should be dropped."

SPECIES DESCRIPTION

Polystichum braunii is a very distinctive and handsome fern. It was named "holly" fern because the sharp spinules on the margins of the fronds reminded some imaginative botanist of holly. As ferns go, this species is fairly easy to identify in the field. Its dark, semi-evergreen fronds stand erect, arching slightly from a circular "crown" where the rhizome protrudes from the ground. The rachis and stipe are dense with scales giving this fern an over-all "shaggy" appearance (Brzeskiewicz, pers. obs.).

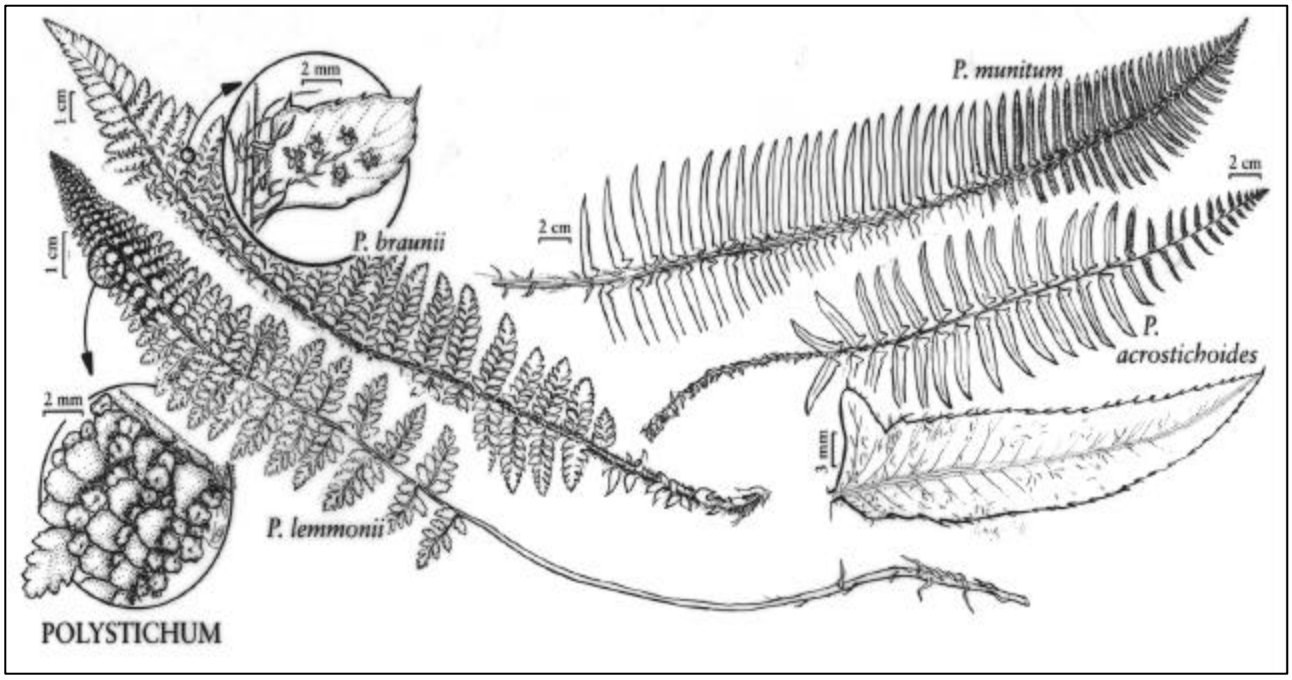
Fronds: Somewhat leathery, 3-10 dm tall. Stipe (petiole) persistently chaffy, 4-18 cm in length. Overall shape of frond is broadly lanceolate, tapering conspicuously at the base and tip, widest at the middle (7-17 cm). Semi-evergreen. Fiddleheads very wooly; cinnamon-brown.

Pinnae: Alternate; slenderly lanceolate; un-stalked; 20-40 pairs, graduating in length from 2-4 cm at the base to 4-10 cm at the middle; lower pinnae straight-sided, abruptly tapering to the apex.

Pinnules: Usually petiolate; dentate-margined with slender incurved bristles and a broadly acute apex.

Rachis: Stalk is stout, slightly flattened, pale brown, covered with bronze-colored scales which are wider near the base and become narrow toward the distal end. (Cobb 1963; Wagner 1979; Gleason & Cronquist 1991; Idaho Fish & Game 2001).

Fig. 1. Comparison of *Polystichum braunii* and some other members of the genus. (Flora of North America Editorial Committee, eds. 1993)



In eastern North America the range of Braun's holly fern overlaps that of *P. acrostichoides,* but confusion between the two is unlikely since the latter species is only once pinnate (Fig. 1). In northwestern North America, *P. braunii* might be confused with *P. andersonii,* and *P. scopulinum* (not shown). But the former has bulblets (proliferous buds) on the rachis, while the latter is a much smaller plant (Idaho Fish & Game 2001). *P. munitum* and *P. lonchitis* are also found in the northwest, but both are once pinnate, hence easily distinguished from *P. braunii*. *P. lonchitis* occurs in the western Great Lakes region as well, within the range of *P. braunii*.

Polystichum braunii is a tetraploid (2n=164), thought to be of ancient origin since no diploid ancestors have been found (Wagner 1979, 1993). It is known to hybridize with *P. acrostichoides* to form the sterile *P.* x *potteri* Barrington, which may be found wherever the ranges of the two species overlap. Because it superficially resembles *P. braunii*, the hybrid was frequently overlooked and misidentified in the past and may actually be fairly common, at least in the northeastern U.S. (Barrington 1986; Stein and Barrington 1990). Barrington (1986) lists numerous structural features that may be used to separate *P. braunii* from *P. x potteri* . *P. braunii* also crosses with *P. lonchitis* in southeastern Alaska (and perhaps elsewhere) forming *P. x meyeri*. The mating system of the genus *Polystichum* is highly outcrossing and sterile hybrids are frequent where two or more species occur (Wagner 1993; Mullenniex et al. 1999).

LIFE HISTORY

Braun's holly fern reproduces by means of spores which can be carried on the wind. The spore dispersal period is from July to October (Sato and Sakai 1981). As in most ferns, when a spore lands on a suitable substrate it germinates and forms a tiny gametophyte plant that has both male (antheridium) and female (archegonium) sex organs. Given suitable moisture conditions, the egg is fertilized by an antherozoid from either the same or a nearby gametophyte, forming a zygote which develops into a juvenile fern plant—the sporophyte generation. This young plant in many fern species does not resemble the parent, being smaller and having leaves either less or more divided (Lellinger 1985).

P. braunii does not reproduce by creeping rhizomes or stolons, hence, does not form clones, but instead typically occurs as individual plants scattered here and there (Fig. 3) within suitable habitat. Because it is often found in pockets of soil within talus and on rock, reliance on vegetative reproduction might be a poor ecological adaptation (Brzeskiewicz, pers. obs.)

The cells of fern leaves, or fronds, actively divide and grow during maturation, unlike many of the cells in flowering plant leaves which are pre-formed and simply expand as the leaves mature (Lellinger 1985). This could explain why ferns often have different-looking fronds within the same species since environmental factors such as available moisture, nutrients, and sunlight can easily affect the development of the leaf. Mechanical injury can also cause malformation. Braun's holly fern does not display much variation in frond morphology so is less likely to cause confusion in identification (Brzeskiewicz, pers. obs.).

The leaves of *P. braunii* are best termed "semi-evergreen"; in relatively mild climates they may stay green through the winter while in colder parts of its range they are deciduous (Mütter et al.1997).

Sato (1990) devised a method for estimating the age of semi-evergreen ferns. Working with a population of *P. braunii* in the southern part of its range in Japan, he found that the mean age for sporophyte maturation was 7.6 years. Maturation age was dependent on environmental conditions, however, and may be much longer at high altitudes and in colder parts of its range. (For what it is worth, the junior author has seen reference to a Russian study that found sporophyte maturation age for *P. braunii* to be 15-20 years in Siberia. No citation available.)

Sporophytes of *P. braunii* are quite hardy, the leaves tolerating temperatures of -20° C. and the rhizomes -15° C. The gametophytes are even hardier, surviving cold in excess of -40° C. (Sato and Sakai 1981).

P. braunii is an "occasional" species throughout its range, never found in colonies. Sue Trull, Forest Botanist for the Ottawa National Forest in Michigan, describes its occurrence as "not as common as lady fern or *Dryopteris intermedia* but more on the level of *Osmunda regalis"* (Trull 2002). In Wisconsin, it might represent one to three percent of the fern community at known sites (Brzeskiewicz, pers. obs.).

GEOGRAPHICAL DISTRIBUTION

Polystichum braunii is circumboreal in distribution. In eastern North America it ranges from Newfoundland and Labrador south to New York and west to northeastern

Minnesota (Fig. 2). Much of this portion of its range falls within the Laurentian Mixed Forest Province, according to the Ecological Classification System (ECS) National Hierarchy of Ecological units (Bailey 1994). In western North America the range of *P. braunii* extends from the westernmost Aleutian Islands along the southwest coast of Alaska to southern British Columbia, with an outlier population in the Idaho panhandle and adjacent Washington state and British Columbia. (see Table 1 for a listing of states and provinces). In the Old World the range extends through most of Europe, Siberia, and into Japan and

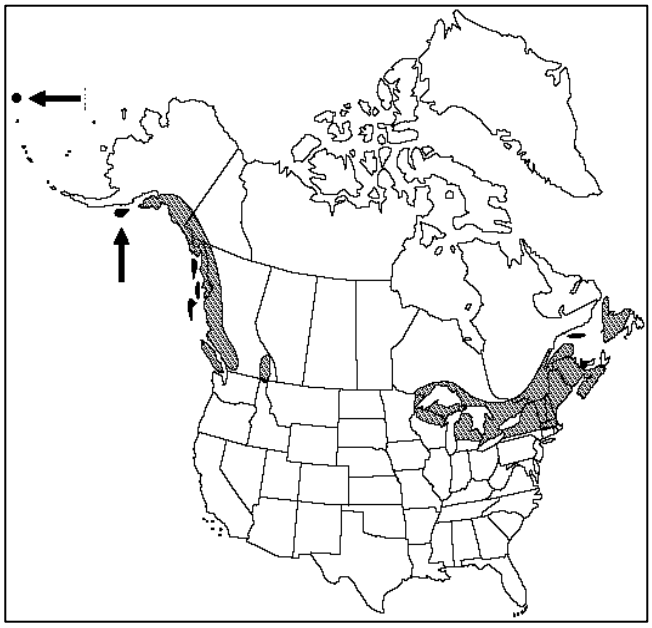


Fig. 2. Approximate range of *Polystichum braunii* in North America (adapted from Flora of North America Editorial Committee, eds. 1993).

China (USDA/ARS 2002; Flora of North America Editorial Committee, eds. 1993), though it is apparently absent from the British Isles (Mütter et al. 1997). Fairly recently, *P. braunii* was documented in India, at an altitude of 4,000m (Pande and Bhandari 1994).

HABITAT AND ECOLOGY

Polystichum braunii is a denizen of cool, moist northern forests. Most occurrence records place the species in rocky environments: in soil pockets and fissures in rock outcrops, at the bases of cliffs, among talus, along boulder-strewn water courses, or in rocky woods. But others note that it sometimes occurs in environments that may be relatively rock-free, such as floodplain forests and woods with deep loamy soil.

Microhabitat seems to be crucial in providing the cooler temperatures needed by this northern species. It is very often found in erosion channels where the banks are steeply cut and cool air drains and settles, providing cool and moist conditions throughout the day (Grund 2002). Shade, either of steep-sided ravines and gorges, north-facing slopes, or provided by a mature forest canopy—or at least a shrub thicket, seems to be a constant. In addition, *P. braunii* is very often found near waterfalls or along streams or seeps, suggesting a need for high humidity and a steady supply of moisture. Winter snow cover may also be an important environmental factor (Mütter et al. 1997).

P. braunii typically occurs in rich, humusy soils and likely reaches its best development in that type of substrate. But, as mentioned, the species is frequently found in rock fissures and in small pockets of soil on cliff ledges (Fig. 3). Preferred soil pH, at least in cultivation, is reported to be 6.0-7.5 (Birdseye and Birdseye 1951) and many North American sources mention circumneutral soil. For instance, the habitat description in Gleason and Conquist (1991) reads: "Upland woods and rock ledges in circumneutral soil." However, a Norwegian study noted a pH range of 4.84-5.45 (Mütter et al. 1997) and many occurrences in the western Great Lakes region are on rock that may be iron-rich and not especially basic. Good drainage appears to be important; only a few occurrence records mention wet or swampy conditions.

Braun's holly fern is somewhat of a loner. Plants are found within suitable habitat growing singly or a few in the same general area but not in thick clumps or clones. One occurrence record in Wisconsin described a population as "one plant here, another over there." Populations are on the order of a few to 50 individuals, rarely more than 100 (Labrecque 2002; S. Spickerman, personal conversation). Most field guides list it as "occasional" with populations being local and small.

A range-wide habitat survey gleaned from element occurrence records, reports from knowledgeable individuals, and published sources follows:

In Minnesota, *P. braunii* is known only from the vicinity of the north shore of Lake Superior. It was first discovered in 1966 in a river gorge where a small number of plants grow above the spring water line on small ledges and in cracks in the nearly vertical rock walls (Coffin and Pfannmuller 1988). Subsequent populations were found in similar if somewhat less extreme situations, often in a stream

gorge, ravine, or rocky wooded slope. Overstory trees usually include sugar maple, with yellow birch, white spruce, white-cedar, balsam fir, and white birch also present at various sites (Minnesota Natural Heritage records). Minnesota populations tend to be small and isolated from each other and the species is listed as endangered in the state.

Braun's holly fern is less rare in Wisconsin (though still listed as threatened), but suitable habitat that combines the components of rock, cool, moist and shady conditions, and mature forest limits the species to the northern third of the state. Natural Heritage data indicate that plants are usually found on north or northeast-facing slopes with a rock substrate consisting of exposed iron-rich bedrock from ancient eroded and glaciated mountains—part of the Canadian Shield. This is a great upland area of Precambrian rock extending from Maritime Canada to central Northern Wisconsin and northeast Minnesota and referred to in Wisconsin as the Northern Highlands (Martin 1965).

Where *P. braunii* occurs in Wisconsin, the forest overstory is typically dominated by mature sugar maple, with yellow birch, basswood, eastern hemlock, and white-cedar as frequent associates. Associated understory and groundlayer species often include numerous other ferns, sparse shrub cover (*Ribes* spp., *Taxus,* and *Acer spicatum*), and forbs typically found in nutrient-rich soil (*Caulophyllum thalictroides, Allium, Trillium, Claytonia* and *Osmorhiza*). (See the Appendix for a list of common associates.) Several EORs from Minnesota and Wisconsin noted successful reproduction (young plants) (Hahn 1999). The Chequamegon-Nicolet National Forest has roughly 60,000 acres that may contain suitable habitat, mainly in the Penokee Range, an area of the Northern Highlands which in places rises several hundred feet above the surrounding area and is composed of rock which is resistant to weathering (Fig. 3).

Fig. 3. *Polystichum braunii* growing in rock crevices on a vertical wall of an old mine shaft in Wisconsin's Penokee Range. *Dryopteris filix-mas* and *Asplenium trichomanes* also occur at this site. (photo by Steven Spickerman)

In the Upper Peninsula of Michigan, *P. braunii* typically occurs as scattered plants near streams in richer, boulder-strewn hardwood forests, on non-acid cliffs, and on talus slopes of calcareous sandstone escarpments. Though more common than in Wisconsin, the species is still limited by the availability of suitable habitat (Trull 2002; Schultz 2002). Here, and throughout its range in eastern North America, many occurrences are near waterfalls (Read 1975).
As in Minnesota, the majority of Ontario occurrences are fairly close to the Great Lakes, with most being in the vicinity of Sault Ste. Marie (Oldham 2002) Habitat follows the western Great Lakes pattern of moist, shady conditions of deep woods, rocky ravines or talus slopes, and humusy soils, with many streamside occurrences. (Ontario Natural Heritage Information Center 2002). The species is fairly frequent in Ontario, hence occurrences are not actively tracked. For Canada as a whole, Scoggan (1978) describes the habitat thus: "Rocky woods, shaded talus, and ravines."

P. braunii reaches the southernmost limit of its eastern North American range in northeastern Pennsylvania. The species is known from just four sites, all with similar site conditions: rocks or talus on lower slopes of relatively steep ravines; cool, moist, and shaded by hemlock and northern hardwoods; and relatively undisturbed. Two are near waterfalls (Grund 2002). Braun's holly fern is listed as endangered in Pennsylvania.

Element occurrence habitat information is not available for New York, since *P. braunii* occurs frequently enough not to be tracked. In his *Adirondack Upland Flora*, Kudish (1992) observed that the species is uncommon, but when found is often around ledges or boulder talus. He noted an exception on Kate Mountain, where it grows on "not especially stony," deep till, under northern hardwoods.

For New England, Seymour (1969) describes the habitat simply as "rich, damp woods." Jenkins (1982) provides more detail for Vermont: "fertile woodland soils with humus, generally on limestone, usually in ravines or other moist sheltered situations ….generally restricted to mountain woods. Most characteristically a plant of eastern Vermont, and found most frequently in the areas where the Devonian limestones of the Connecticut Valley have been pushed up onto the eastern flank of the Green Mountains."

Neither Maine nor New Hampshire actively track Braun's holly fern, but Chute (2002) notes that it is uncommon in New Hampshire, typically occurring in richer soils above 1700 feet in elevation. The Massachusetts Natural Heritage and Endangered Species Program lists five occurrences of *P. braunii*, all in Berkshire County, and all in cool, moist locations, either on steep slopes or on talus, and often near streams or seeps. Populations are very small, ranging from one to five plants. Massachusetts lists the species as endangered.

P. braunii is not tracked in the Canadian Maritime Provinces of New Brunswick , Nova Scotia, and Newfoundland. However, Sean Blaney (2000a; 2002b) of the Atlantic Canada Conservation Data Centre observes that in the cool, moist climate of these provinces, the species is not as restricted to rocky places as is some other parts of its eastern North American range, often occurring in alluvial soils

in deep ravines and on steep slopes with loamy soil. This is especially true in northern New Brunswick where the species is "consistently present in floodplain forests along major rivers where forests were some combination of white spruce, eastern white-cedar, black ash, and balsam poplar." Published floras of New Brunswick (Hinds 2000) and Nova Scotia (Roland and Smith 1969), depict *P. braunii'*s habitat as "rich woods, mostly calcareous soils" and "rich woods, ravines, and seepy hillsides," respectively.

A very small population (> 5 plants) is known from one site on Prince Edward Island. The habitat there is described by Blaney (2002b) as a silty sand river bank in a mature mixed forest of sugar maple, yellow birch, red spruce, and white spruce. In Newfoundland, the majority of occurrences are in the western third of the island, while Labrador appears to have but one known site for the species (Cody and Britton 1989). Finally, in Quebec *P. braunii* favors cool woods and ravines. Populations are typically local and small—less than 100 individuals—but known occurrences in this large province are fairly numerous and the species is not tracked (Labrecque 2002).

Braun's holly fern also occurs in extreme northern Idaho and adjacent Washington and is a Regional Forester Sensitive species in Region 1. The habitat is similar to the east in that plants are often found along streams among granitic boulders. However, some also occur on sandy-silty alluvial terraces or in adjacent very moist forest. None of the occurrences are in full sun and all have at least 50% canopy cover. Surrounding forests are often old-growth western red cedar and associated species include those with coastal or boreal affinities. The species is often associated with *P. munitum* and *P. andersonii* (Penny 2002). Habitat in British Columbia includes mesic to wet alluvial forests, coniferous forests, and talus and lava flows in the lowland to sub-alpine zones (Donovan 2002).

P. braunii 's forest habitat in Alaska is described by Stensvold (2002), FS Regional Botanist, as vegetated talus slopes with well-drained soil. In flat places the soil may be heavy, but drainage is good due to subsurface rocks and boulders. It is found frequently under a canopy of *Rubus* spp., *Ribes* spp. and alder brush surrounded by forest of *Tsuga heterophylla* and *Picea sitchensis*. Herbaceous species present include *Tiarella trifoliata*, *P. andersonii*, and mosses. Welsh (1974) lists the habitat as "woods and thickets" and leaves it at that. The species is also known from the Aleutian Islands; no habitat information available.

CONSERVATION STATUS

The current official status of *Polystichum braunii* with respect to federal, state and private agencies follows: (Rank, followed by rank definition [NatureServe 2002 web page unless otherwise indicated].)

U.S. Fish and Wildlife Service: none

The Nature Conservancy Global rank: G5 (The rank across its entire range.)

Definition of G5: Secure – Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

The Nature Conservancy National rank (U.S.): N? (The rank for each nation in its range.)

Definition of **N?**: Unranked – Nation or subnation rank not yet assessed.

The Nature Conservancy (Canada): N?_ (9 Aug 1993)

U.S. Forest Service: Regional Forester Sensitive (Regions 1 and 9**)**

Definition: The Regional Forester has identified it as a species for which viability is a concern 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).

Polystichum braunii is known to occur within the Eastern Region, Northern Region, and Alaska Region in the United States. It is Regional Forester Sensitive (R1) in the Eastern Region and the Northern Region (Northern Idaho and Montana). It is not listed in Alaska. Table 2 summarizes National Forest occurrences.

States & Provinces: (S-rank is for each *subnational* jurisdiction in its range)

Definitions:
S1: Critically imperiled 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 from the subnation.
S2: Imperiled because of rarity (6-20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the subnation.
S3: Vulnerable in the subnation either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences.
S4: Apparently secure, uncommon but not rare, and usually widespread in the subnation. Possible cause for long-term concern. Usually more than 100 occurrences and more than 10,000 individuals.
S5: Secure, common, widespread, and abundant in the subnation. Essentially ineradicable under present conditions. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

S?: Rank not yet assessed. Unlikely that it is tracked by the Natural Heritage Program.
SR: Reported to occur in the subnation but without a basis for either accepting or rejecting the report, or the report not yet reviewed locally. Some of these are very recent discoveries for which the program hasn't yet received first-hand information: others are old, obscure reports.

Table 1. Conservation status of *Polystichum braunii* in U.S. states and Canadian provinces.

Status	State	# EOs	Province	# EOs
S1	**Idaho** **Minnesota** **Massachusetts** **Pennsylvania**	4 12 5 4	**Labrador** **Prince Edward Island**	no report 1
S3	**Wisconsin**	44	**New Brunswick** **Ontario**	38+ 25 (est.)
S3S4	**Vermont***	occasional	**British Columbia*** **Newfoundland**** **Nova Scotia**	20+ 5 48+
S?	**Michigan**	common		
SR	**Alaska** **Maine** **New Hampshire** **New York** **Washington**	common common uncommon common 2?	**Quebec** **Yukon Territory**	40+ no report

(* Information on rank for VT and BC from contact with Natural Heritage Program botanist or Database manager, 2002.)
(** Number based on EOs in the Atlantic Canada Conservation Data Centre's database. Cody and Britton [1989] show at least 16 locations for Newfoundland island on their dot map.)

Notes: **New Jersey** – The NRCS PLANTS database and NatureServe erroneously list *P. braunii* as occurring in New Jersey. David Snyder, botanist for the New Jersey Natural Heritage Program, reports no records for the state and it is not reported in Britton's catalog or New Jersey fern books (Chrysler and Edwards 1947; Montgomery and Fairbrothers 1992). The error likely came from an early draft by Kartesz. While it's not impossible for *P. braunii* to occur in the state, it is unlikely that a regionally rare species would have been overlooked (Snyder 2002).

Connecticut – *P. braunii* is also listed in NatureServe for this state. Karen Zyko, database manager for NHP reports no records for Connecticut (Zyko 2002).

Table 2. Element Occurrences on National Forest Lands for *Polystichum braunii*.

National Forest	St	# EOs	RFSS listed?	Justification for listing or not
Chequamegon-Nicolet	WI	20	yes R9	restricted range/habitat, S2
Ottawa	MI	many	no	well w/in range, not listed in MI
Hiawatha	MI	many	no	well w/in range, not listed in MI
Huron-Manistee	MI	many	no	?
Superior	MN	0	no	three EOs within proclamation boundary, but none yet found on NF land*
Chippewa	MN	0		
White Mountain	NH	many	no	
Green Mountain	VT	many	no	secure in state, resilient, S3S4
Finger Lakes	NY	many	no	
Allegheny	PA	0		
Hoosier	IN	0		
Wayne	OH	0		
Idaho Panhandle	ID WA	4 2?	yes R1	only EOs in state are on NF land
Chugach-Tongass	AK	many		common, not listed in state

(* Will be added to Regional Forester Sensitive Species list during maintenance update in 2003 [Greenlee 2002].)

POTENTIAL THREATS

Potential threats to the viability of *Polystichum braunii* include habitat loss or alteration, mechanical damage, competition from invasive non-native species, collecting, and small population sizes. These threats may be naturally occurring or man-made. The forests that exist today within the range of this species are very different from those of the 1700's due to development, changes in forest composition, and climate change, leaving little undisturbed forest (Albert 1995). Activities that significantly alter the habitat can destroy present populations and eliminate options for future colonization.

Habitat Alteration or Loss

Timber production activity, with its associated ground disturbance, is a concern. Clear-cutting and heavy thinning open up the forest canopy, causing more sunlight to reach the ground and dry the soil. Element occurrence data from throughout its range indicate that Braun's holly fern requires at least partial canopy cover and, in most areas, a heavy canopy of 70-90 percent cover. Even nearby logging has the potential to change microclimates to the detriment of the species. In the Snake Trail Cliffs area of the Chequamegon-Nicolet National Forest in Wisconsin, for instance, a clear-cut within about 8-15 m of a population of *P. braunii* appears to have had a negative effect on both the number of individuals and the health of surviving plants (as indicated by leaf yellowing). After ten years the population had still

not recovered to pre-clear-cut numbers (Spickerman 2002). This case offers a clue as to the size of buffers needed to protect occurrences. And though known sites in the Chequamegon-Nicolet NF are currently deferred from logging, the same can not be said for potential habitat.

The responses of *P. braunii* to disturbance regimes are not well understood. Loss of the fronds in a given year may not kill the plant but repeated destruction of the above-ground portion would deplete nutrient stores in the rhizome, causing the death of the individual. Braun's holly fern plants that are in close proximity to recreation areas are at risk for such disturbance. An example is Morgan Falls, an increasingly popular recreational site on the Chequamegon-Nicolet. A recent population crash there is most likely due to trampling by recreational users (Spickerman 2002).

Habitat alteration is not always directly caused by humans (though human activity may be indirectly responsible). For instance, the death of trees and subsequent canopy loss can be due to insects or disease. Examples are the hemlock adelgid and sugar maple decline in the eastern U.S. (Grund 2002). Such threats may be especially important to a species such as *P. braunii,* which often occurs locally and in small numbers.

Collecting and Harvesting

Little is known about the extent of poaching and legal collection of wild ferns. Braun's holly fern is very attractive and makes a nice addition to woodland gardens. It is available commercially through numerous nurseries and on the internet for about $5-$9 each, yet plants are likely still collected in the wild.

Because of its rarity and habit of growing in rather inaccessible places, it is unlikely that fronds of *P. braunii* are harvested for florist's greenery in Wisconsin, Minnesota, or Michigan. Such activity, were it to occur, could reduce reproductive potential and even wipe out entire populations in a short time. Unlike some other types of plants, wild-growing ferns are subject to severe nutrient stress when overharvested (Milton 1987). For instance, *Matteuccia struthiopteris*, an edible fern, is killed within one year when repeatedly harvested (Van Aderkas 1984).

Exotic Species

The threat of competition by invasive non-native plants is not well researched. Non-native species such as garlic mustard (*Alliaria petiolata*), buckthorn (*Rhamnus cathartica* and *R. frangula*) and Asian honeysuckles (*Lonicera morrowii* and others) are known to invade mesic hardwood forests (Hoffman and Kearns 1997). These species are aggressive growers, leaf out early, and tend to shade out native plant species. Natural systems invaded by non-native plants become less species-rich, threatening biodiversity and habitat quality (FICMNEW 1998).

Though no evidence specific to *P. braunii* has been presented, exotic earthworms which consume the detritus layer in hardwood forests may be a cause for concern. The Great Lakes states are thought to have lost all of their native earthworms following the last glacial period. European earthworms were

introduced intentionally and accidentally and have spread rapidly. Eggs, cocoons, and adult earthworms are spread in soil on machinery, all-terrain vehicles, through river systems, and by the release of unwanted fishing bait (Conover 2000).

Following the introduction of earthworms, the upper organic soil layers in northern forest soils can disappear within a very short time (Langmaid 1963). According to Sauer (1998), earthworms consume the litter layer five times faster than the fungi which normally dominate in northern forest soils. They create an environment that stimulates the bacteria that convert ammonium to nitrate, as in grasslands. Nitrates are easily leached out of forest soils, leaving many native old-growth species starved for nutrients while allowing the rapid spread of early successional species and fast-growing exotics. In natural forests nitrogen is stored as ammonium and made available to plants much more slowly. Fungi also tend to promote the acid soil conditions that many woodland species favor.

Evidence suggests that colonization by several species of earthworms may be incompatible with the survival of many North American hardwood forest understory species (Hale et al. 2002; Conover 2000). For instance, Gundale (2002) found that populations of the rare fern *Botrychium mormo* often disappeared after the loss of the upper soil horizons due to the introduction of the earthworm *Lumbricus rubellus*. He also suggested that roads, even small utility roads, are important starting places for invasions of exotic earthworms. Remote forest areas still lack earthworms but their spread seems inevitable.

Herbivory

Most ferns are unpalatable to herbivores and ferns generally are not especially subject to insect attack (Lellinger 1985). This is probably due to the presence of tannins and a number of other compounds that are thought to be toxic or reduce digestibility. At least some of these compounds are at their highest levels early in the season when the young fronds are especially high in protein—as much as 26% dry weight — and would otherwise be very attractive as food. (Ottosson and Anderson 1983).

A related species, *Polystichum acrostichoides*, is an important winter food plant for ruffed grouse in the southern Appalachians (Stafford 1979). However, in the northern U.S. and Canada, aspen buds are the primary winter food for grouse, and evergreen ferns are probably minor food items, if they are consumed at all.

Global Warming

Various models have tried to predict the effects of global warming and some hypothesize that "mid-latitude to high-latitude regions in the Northern Hemisphere? areas such as the Continental United States, Canada, and Siberia? will likely warm the most. These regions could exceed mean global warming by as much as 40 percent" (Weier 2002). Clearly, an extreme temperature increase could pose a threat to mid-latitude species that thrive in cool microhabitats, as does *Polystichum braunii*. Given enough time, such species might be able to migrate northward, assuming other environmental requirements could be met. For instance, at least in eastern North America *P. braunii* appears to

prefer a rich, circumneutral soil. However, would pockets of the required soil types be available north of its present range, and how intense might competition for them be? Should warming predictions turn out to be correct, it is possible that the range of *P. braunii* will shrink considerably.

In past periods of climate change many species were able to migrate to newly-suitable habitat. However, this time around, the rapidity of change is likely to exceed the dispersal ability of most plants (Malcolm and Markham 2000). Greatly compounding the problem is habitat fragmentation and other human-caused barriers to migration.

Small Populations

P. braunii typically occurs locally and in small numbers. In locales where the species is tracked by Heritage programs or other entities, the majority of element occurrences consist of one or a very few individuals. Even where the species is more common and not tracked, populations of more than 100 are apparently unusual. In this context, potential threats perhaps take on more importance in that even a small-scale disturbance has the potential of eliminating an entire local population. Braun's holly fern is no different than many other rare plant species in this respect.

Perhaps lack of knowledge is as big a threat as any to sensitive species. Management decisions need to consider the best available information and be based on sound science, whenever possible. Public education is another important aspect in rare species management as habitat quality and size continues to dwindle. It may become the duty of public land stewards to educate private landholders on the needs of rare species. Private and public landowners, working together, can maintain critical habitat for Braun's holly fern where it is a rare species.

VIABILITY AND PROTECTION

Its preferred habitat in Minnesota, Wisconsin and elsewhere—steep slopes, ravines, streamsides, rocky areas—affords *P. braunii* a degree a protection from logging and some recreational activities. Hence, loggers using best management practices would not have a direct impact on most populations (Hahn 1999), but surrounding areas could still be degraded, possibly altering the needed microclimate.

In reports written for the Chequamegon-Nicolet National Forest, Alverson and Solheim (1981) and Judziewicz (1983) recommended no-cut buffers of up to 200 yards or more be established along riparian corridors and ravines supporting populations of *P. braunii*. Furthermore, trails should be rerouted to avoid damage to plants and nature trails should not draw attention to this nor other rare species.

Long-term viability of this species in Wisconsin may be dependent upon maintaining habitat on public lands. While private landowners may be sympathetic to sensitive species, in many cases they are under no obligation to protect even federally listed plants on their own land. Listed plants are protected, however, on federal lands and indeed both the U.S. Forest Service and Bureau of Land Management

have policies to maintain viable populations of all native plant species. Opportunity exists, therefore, to create and maintain havens for rare species on public land, including state and county land.

Almost half of all the known occurrences of this plant in Wisconsin are on National Forest lands. Currently on the Chequamegon-Nicolet, the management protocol is to protect known occurrences by maintaining the existing forest canopy conditions and deferring the entire stand from any activity.

RESEARCH AND MONITORING

There are many unanswered questions when it comes to this rare species. The lack of adequate monitoring and research of fern populations prevents development of beneficial management methods. It is assumed that maintaining the forest canopy at known sites is critical, but how large does the site need to be? General life history information is sorely lacking. For instance, little longevity research has been done. How long does an individual fern plant survive? The authors are aware of no research currently in progress relating specifically to the conservation of *P. braunii*.

Research and Monitoring needs

Participants in an expert panel (USDA FS 2000) recently convened by the Forest Service considered the population viability of a number of sensitive species, including *P. braunii*, in Minnesota and Wisconsin National Forests. The panel felt that more information was needed on its breeding system (inbreeding versus outbreeding), reproductive success, and demography. It was also suggested that attempts be made to introduce the species into apparently unoccupied habitat in Minnesota.

Monitoring of known sites in Wisconsin will be necessary to obtain baseline information. Populations and individuals should be monitored, especially those near recreation areas and along trails. This would give some indication of Braun's holly fern's ability to recover from disturbance and record its faithfulness to a particular site. It may be that the species comes and goes, with individuals dying and others replacing them. Sato's (1990) method of estimating the age for sporophyte maturation could be useful in any future studies. More information is needed in the following areas:

- Identification of critical habitat in southern reaches of the range, habitat necessary to maintain the cool temperatures required by Braun's holly fern.
- Population dynamics, reproductive limitations, lifespan of individuals.
- Conditions favorable for spore production, germination, and establishment, such as habitat requirements, soil chemistry, soil nutrients, and moisture needs.
- Effects of non-native invading species, including earthworms.
- Effects of long-term climate change on the species.

Available evidence suggests that *P. braunii* may be in need of protection in the western Great Lakes states and perhaps in other areas on the fringes of its range. Habitat in Wisconsin is mostly restricted to the Penokee Range, in the northern part of the state, where rocky ravines and closed canopy forest provide suitable microclimates. In Wisconsin the species appears to be relatively stable, but increased surveying in recent years may account for that impression. In Minnesota, the small, far-flung populations are significantly isolated from each other and from the main population to the east (Greenlee 2002), and numbers seem to be decreasing (Hahn 1999).

A Conservation Approach would help provide for the long-term conservation of *Polystichum braunii*, maintain management options for the future, and minimize conflict with other resource activities. Initiating an Approach would involve developing goals for maintaining viability of the species and writing management prescriptions for known sites as well as other suitable habitat. Results of monitoring and research should provide managers with data to develop a strategy for its conservation. Public education and outreach may be critical elements in efforts to protect this and other rare species.
Braun's holly fern is an "occasional" species and is considered secure in a global context. It becomes rare at the periphery of its range and it is here that it is most threatened by habitat alteration, forest fragmentation and possibly competition from invasive non-native plant species, and a general lack of understanding of conservation needs. Species at the edge of their range are often particularly vulnerable to changes. *Polystichum braunii* exists on this periphery due to microclimate conditions available within a restricted geographic range.

The Chequamegon-Nicolet National Forest in Wisconsin supports half of the known occurrences of this species in that state. In Idaho, all four element occurrences are on National Forest land. In the Upper Peninsula of Michigan many occurrences are on National Forest lands and consideration should be given to treating *P. braunii* as a Sensitive Species. It is apparent that public lands, particularly National Forest lands, are extremely important to the conservation of this species in the western Great Lakes region and perhaps elsewhere. To maintain its viability, we should protect occurrences, provide suitable habitat on public lands, and educate the public on plant conservation. In addition, more research and monitoring should be done on *Polystichum braunii*, and such monitoring should be long term. A Conservation Approach initiated now may precipitate this needed study.

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APPENDIX

Description of Habitats and Plant Associates of *Polystichum braunii* (compiled from a sampling of known occurrences across its range)

Wisconsin: Habitat descriptors from EO records: perennial stream; just below falls; groundwater seep at base of cliffs; in small, rocky creek bed; among boulders in rich, moist soil; in narrow ravine; mottled shade; deep shade; north-facing 3-10% slope; sparse mid-canopy or shrub layer; relatively undisturbed

Associate species for sites: (not all species on each site)

Trees:
Acer saccharum
Tilia americana
Tsuga canadensis
Betula allegheniensis
Abies balsamea
Fraxinus americana
Populus tremuloides

Shrubs:
Acer spicatum
Ribes cynosbati
Ribes glandulosum
Taxus canadensis
Lonicera canadensis
Rubus parviflorus
Sambucus racemosa

Ferns & allies:
Athyrium filix-femina
Matteuccia struthiopteris
Adiantum pedatum
Deparia acrostichoides
Dryopteris intermedia
Dryopteris expansa
Dryopteris fragrans
Dryopteris carthusiana
Phegopteris connectilus
Gymnocarpium dryopteris
Cystopteris fragilis
Osmunda claytoniana
Polypodium virginianum
Woodsia ilvensis

Forbs:
Aralia nudicaulis
Aralia racemosa
Arisaema atrorubens
Asarum canadensis
Caulophyllum thalictroides
Allium tricoccum
Circaea alpina
Phryma leptostachya
Polygonatum pubescens
Triantalis borealis
Trillium grandiflorum
Trillium cernuum
Claytonia caroliniana
Hydrophyllum virginianum
Uvularia grandiflora
Uvularia sessilifolia
Laportea canadensis
Clintonia borealis
Maianthemum canadensis
Mitella diphylla
Osmorhiza claytonii
Dicentra cucullaria
Viola pubescens
Oxalis montana

Minnesota:
Habitat descriptors from EO records: *intermittent stream; just below falls; ravine; mesic loam soil; sparse understory*

Associate species for Minnesota sites: (not all species on each site)

Trees:
Picea glauca
Thuja occidentalis
Betula allegheniensis
Betula papyrifera
Betula cordifolia
Abies balsamea
Populus tremuloides

Shrubs:
Rubus parviflorus
Acer spicatum
Corylus cornuta
Alnus incana
Prunus virginiana

Ferns & allies:
Athyrium filix-femina
Botrychium virginianum
Cryptogramma stelleri
Cystopteris bulbifera
Cystopteris fragilis
Dryopteris expansa
Dryopteris fragrans
Dryopteris intermedia
Matteuccia struthiopteris
Phegopteris connectilis
Woodsia alpina

Forbs:
Trillium cernuum
Claytonia caroliniana
Clintonia borealis
Dicentra cucullaria
Campanula rotundifolia
Aquilegia canadensis
Circaea alpina
Asarum canadense
Streptopus roseus
Anemone quinquefolia
Galium triflorum
Prenanthes alba
Phryma leptostachya

Michigan: Habitat descriptors from EO records: *talus slopes; calcareous soil; talus slopes of calcareous sandstone escarpments (Schultz, 2002); often in riparian areas*

Massachusetts: Habitat descriptors: *rock outcrop; ravine; talus schist with pockets of wallomsac; seepy slope; stream; filtered light (Massachusetts Natural Heritage Program 2002, Eos; 1985?)*

Associate species for Massachusetts sites: (not all species on each site)

Trees:
Picea rubens
Acer saccharum
Betula allegheniensis

Shrubs:
Acer spicatum
Viburnum alnifolius

Ferns:
Dryopteris intermedia
Polypodium virginianum

Forbs:
Tiarella cordifolia
Oxalis montana
Ageratina altissima
Aster acuminatus

Vermont: Habitat descriptors: *fertile woodland soils with humus; ravines and other moist situations; limestone soils in mountains* (USDA Forest Service - undated)

Idaho: Habitat descriptors: *moist places*; *old-growth western red cedar riparian or alluvial terrace habitats; low elevations* (Idaho Fish & Game 2001.

Associate species for Idaho sites: (not all species on each site)

Trees:
Thuja plicata
Tsuga heterophylla

Shrubs:
Cornus canadensis
Cornus sericea
Alnus incana
Rubus pedatus
Viburnum edule
Taxus brevifolia
Acer glabrum

Ferns & allies:
Gymnocarpium dryopteris
Botrychium virginianum
Dryopteris expansa
Athyrium filix-femina
Lycopodium clavatum

Forbs:
Smilacina stellata
Angelica arguta
Aralia nudicaulis
Viola glabella
Disporum hookeri
Clintonia uniflora
Epilobium minutum
Linnaea borealis
Adenocaulon bicolor
Tiarella trifoliate
Oplopanax horridum
Mitella brewerii

Alaska: Habitat descriptors: *vegetated talus slopes; active and inactive avalanche tracks; on alluvial substrates; soil with good drainage due to subsurface rocks; disturbance by rock slides*
Associate species for Alaska sites: (not all species on each site)

Trees:
Picea sitchensis
Tsuga heterophylla

Shrubs:
Alnus rubra
Alnus viridis spp. sinuata
Rubus spectabilis
Ribes spp.

Forbs:
Tiarella trifoliata
Polystichum andersonii
moss

Maritime Provinces, Canada: Habitat descriptors: *cooler than average microclimate; deeply shaded, older growth forests; soil slightly to strongly calcareous; on steeper slopes, small cliffs and shaded rock ledges; in floodplain forests with spruce, cedar, ash and balsam poplar*

Ontario, Canada: Habitat descriptors: *talus under maples, old hardwoods; sugar maple stand in a valley; closed canopy, very little understory; near a rocky, intermittent stream on a north facing slope; west facing slope; white pine plantation; damp, shady places in diabase talus; rocky ravine slope*

Associate species for Ontario sites:

Trees:	**Shrubs**:	**Forbs**:
Acer saccharum	*Acer spicatum*	*Thalictrum pubescens*
Pinus strobus		*Onoclea sensibilis*
		Matteuccia struthiopteris