Conservation Assessment

for

Green Spleenwort (Asplenium trichomanes-ramosum) L.

Photo by: Arieh Tal

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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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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ABSTRACT

This conservation assessment provides information regarding *Asplenium trichomanes-ramosum* L. (green spleenwort) and its distribution, life history, habitat and range, status, and ecology. *Asplenium trichomanes-ramosum* occurs from Newfoundland to Alaska south to Vermont, northern New York, northern Michigan, Door Co., Wisconsin, Montana, South Dakota, Wyoming, Colorado, Utah, northeastern Nevada, Oregon, and northern California (Billington 1952). It is listed as Threatened in Michigan. This small, evergreen fern prefers a moist, shaded environment, sometimes in sheltered crevices on rocky limestone bluffs or talus slopes. It also occurs at alpine to middle elevations. Few Heritage Programs report large numbers of occurrences or large colonies; in most regions where green spleenwort is tracked, it is considered a very rare species, as indicated by numerous high state ranks (TNC 1993). Although this species has been long known as *Asplenium viride*, there is considerable argument that *Asplenium trichomanes-ramosum*, takes precedence.

INTRODUCTION/OBJECTIVES

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. 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, the Forest Service lists species that are Sensitive within each region (Regional Forester Sensitive). *Asplenium trichomanes-ramosum* is a Regional Forester Sensitive Species on the Hiawatha National Forest in Michigan and the Chequamegon-Nicolet National Forest in Wisconsin. It is also listed as a species of current viability concern for the Northern Hardwoods (04) ecosystem for the Northern Great Lakes (USDA FS 2001).

The objectives of management for sensitive 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.

The objectives of this conservation assessment are (1) to review and compile currently known information on the biology, status, and distribution of *Asplenium trichomanes-ramosum* and (2) to identify the information needed to develop a strategy to conserve this species.

NOMENCLATURE AND TAXONOMY

(USDA NRCS Plant Database, W-6)

Class: Pteridopsida (Filicopsida)

Subclass: Filicinae

Order: Aspleniales

Family: Aspleniaceae

USDA Plant Code: ASTR10

Scientific name: *Asplenium trichomanes-ramosum* L.

Common name: green spleenwort

Synonym: *Asplenium viride* Hudson

SPECIES DESCRIPTION

Asplenium trichomanes-ramosum is a small, delicate, tufted fern of rock crevices. It is most similar to the more common *A. trichomanes* (maidenhair spleenwort), a species with which it very commonly grows. *Asplenium trichomanes-ramosum* is characterized by its tufts of narrow fronds that grow up to 14 cm. (6 inches) in length. “The narrow blade is dissected into many

pairs of opposite egg-shaped pinnules which are tipped with rounded teeth" (Chadde 1999). Material for the following section adapted from Lellinger 1985, Chadde 1999.

Roots: Not proliferous.

Stems: Short-creeping or ascending frequently branched; scales dark reddish brown to blackish throughout, narrowly deltate, 2-4 x 0.2-0.4mm, and margins entire to undulate or with widely spaced shallow teeth.

Petiole: Reddish brown at base, green distally, lustrous; indument of dark reddish brown to black, narrowly deltate scales growing into glandular hairs.

Blade: Linear, 1 – pinnate throughout, 2-13 x 0.6-1.2 cm, thin, glabrous or with sparse minute hairs; base slightly tapering or truncate; apex acute but not rooting.

Pinnae: In 6-21 pairs, deltate to rhombic; medial pinnae 5-6 x 4-5mm; base obtuse and often inequilateral; distal margins crenate; apex rounded to acute.

Sori: 2-4 pairs per pinna, located on the underside of the blade segments near the faint midrib.

Spores: 64 per sporangium. 2n = 72

Identification notes:

Green spleenwort is superficially similar to the more common smooth woodsia (*Woodsia glabella*). However, green spleenwort can be distinguished by elongate sori which are attached along their side to the leaf segment; whereas the sori of smooth woodsia are round, and attached on the underside of leaf segments (Chadde 1999). Green spleenwort is also characterized by its green stripes and pinnate blade with opposite segments (Mickel 1979). Maidenhair spleenwort (*Asplenium trichomanes*) sometimes grows with green spleenwort, but has purple-brown stalks and more rounded evergreen pinnae (Mickel 1979, Chadde 1999, Pojar & MacKinnon 1994).

Hybrids

Hybridization between *Asplenium trichomanes-ramosum* and *A. trichomanes* produces the fertile allotetraploid *A. adulterinum*, which grows on Vancouver Island (Flora of North America Editorial Committee 1993).

GEOGRAPHIC DISTRIBUTION AND ABUNDANCE

A. trichomanes-ramosum is a circumboreal species that favors limestone rock. In subarctic areas it often occurs in cracks of lime-rich rock (North America Flora Committee 1993). In Britain and Ireland, green spleenwort occurs mainly in hilly upland districts and on mountains (to 1000 m) in cool habitats (Page 1997). In Europe, its distribution is primarily northern, but scattered populations occur in the mountains of the northern Mediterranean region; in Asia it is disjunct in central China, Japan, in the Himalayas and northern Africa (Tryon & Moran 1997).

A. trichomanes-ramosum is a fern found in two principal regions of North America, from northeastern Canada to northeastern United States, and disjunct in the Northwest concentrated in

the Canadian Rockies. In Ontario, Canada *A. trichomanes-ramosum* is widespread and not considered rare (Argus & White 1982). Cody and Britton (1989) show its distribution in northwestern North America as concentrated in the Canadian Rockies (in Saskatchewan and British Columbia) and scattered along the Pacific coast up to Alaska. It also occurs in southern Greenland and Iceland (Page 1997). In the western United States, often only one population per state is known with an average of 30-40 plants at a site. In Utah six populations are reported, but little is known about the size of populations (TNC 1993).

In the Northeast, *A. trichomanes-ramosum* ranges into Canada "including occurrences on Hudson Bay, James Bay, several populations around the Gaspe Peninsula, Nova Scotia, and Newfoundland" (TNC 1993). Throughout the Great Lakes region including Wisconsin, Michigan, and southern Ontario, *A. trichomanes-ramosum* is found on rock outcropping associated with the Niagara Escarpment silurian limestone formation (Evans 1997, Cody and Britton 1989). In Canada *A. trichomanes-ramosum* is less common than *A. trichomanes* (maidenhair spleenwort) (Cody and Britton 1989). This observation is borne out by similar findings in Michigan. "In the Northeast outside the Niagara Escarpment, green spleenwort is concentrated in Nova Scotia and Newfoundland, occurring as a rare species in New York, Vermont, and Maine" (TNC 1993). Sites in the eastern states are generally estimated at 100 to 200 individuals at a site. Maine and New York each have one population reported while Vermont has six populations (TNC 1993).

In Michigan this fern is best known from the limestone cliffs of the Niagara Escarpment. The earliest known Michigan collection was made near Pickford (1932) by N.C. Fassett (University of Wisconsin Herbarium). Apparently it was not collected again in Michigan until 1950, when R. McVaugh found it on Drummond Island, Chippewa County (University of Michigan Herbarium) (Billington 1952). The greatest number of occurrences of *A. trichomanes-ramosum* are found in Mackinac County; other Upper Peninsula counties include Chippewa, Houghton (non-specific location per M. Penskar pers. comm 2002), Marquette, and Schoolcraft and Leelanau County in the Lower Peninsula (MNFI 1999b, MNFI 2001b). About one-fifth (12 sites in Mackinac County) of the known occurrences for Michigan are found within the Hiawatha National Forest (MNFI 1999a). Hiawatha sites range from 10 plants to 500 plants; four sites have over 100 individuals.

In Wisconsin there are two major populations. One is within the planning area of the Brule River Research Natural Area of the Chequamegon-Nicolet National Forest. This site in Florence County contains 24 rosettes with 100% bearing sporangia (USDA FS 1997). An additional locality occurs on Washington Island in Door County (WI EOs 2001).

HABITAT AND ECOLOGY

Green spleenwort is a fern of circumboreal distribution. In North America it occurs in the West, Northwest, the upper Midwest, and the Northeast. "The habitat is typically shaded, moist, calcareous rock outcrops, such as limestone, dolomite, or shale cliffs, and talus slopes, escarpments, and boulder-strewn woodlands" (TNC 1993). This species usually requires a moist to seepy rock substrate, and thrives best under dense canopies of northern hardwoods (*Acer saccharum* or *A. saccharum/Fagus grandifolia/Betula alleghaniensis* / sugar maple or sugar-maple/beech/yellow birch) to mixed-hardwood conifer (*Picea abies/Picea glauca/Abies balsamea* / Norway spruce/white spruce/fir) forests (USDA FS 2001). It commonly occurs in association with dense, mixed beds of bryophytes, but has been reported growing in relatively

dry, unvegetated, exposed conditions. In one instance in Michigan, it has been documented on rotting logs of a mesic forest (TNC 1993). "Since it is usually restricted to alkaline substrates such as limestone and dolomite, there is presumably a requirement for high concentrations of metallic cations such as calcium and magnesium" (TNC 1993).

Throughout its North American range, *A. trichomanes-ramosum* is almost always epipetric (growing directly on and obligate to rock substrates) occurring in "moist crevices and concavities of calcareous rocks, cliffs, talus slopes, and other types of basic rock outcrops in locations that are usually partially or deeply shaded" (Pojar & MacKinnon 1994). In the western states, *A. trichomanes-ramosum* grows in cool crevices, vertical cracks, and the overhanging ledges of limestone outcrop areas at 7500 to 10,000 feet in elevation. It often occurs on north-facing limestone cliffs (TNC 1993). In the western states, *A. trichomanes-ramosum* is typically found at relatively high elevations (> 7000 feet) occurring within fir and spruce-fir forest types including *Picea engelmannii* (Engelmann spruce) and *Abies lasiocarpa* (subalpine fir). (Pojar & MacKinnon 1994).

In New York, the only known population of *A. trichomanes-ramosum* occurs within a shale cliff and talus community consisting of alternate layers of shale and limestone exposed on the steep-sided slopes of a gorge in a predominantly hemlock woods (Evans *et al.* 2000, TNC 1993, Reshcke 1990). Narrow sections of the gorge and its moist north-facing aspects support several hundred plants of this species (Evans *et al.* 2000). In both Maine and Vermont, *A. trichomanes-ramosum* occurs "on ledges and in the crevices of seepy to moist calcareous rock at higher elevations, in a cold, calcareous cliff community" (TNC 1993). In Maine it is known from two sites in Somerset County; one is a recent record, the other an historic record (Maine Dept. of Conservation 1999).

In the Great Lakes Region it is found almost exclusively on dolomite and limestone outcrops associated with the Niagara Escarpment geologic formation; habitat tends to be north-facing. "An analysis of limestone fern locations by soil series in the Upper Peninsula of Michigan (Evans and Seleen, unpublished) showed that these plants and outcrops were found in soil series that were defined as containing limestone rock only 50% of the time. The remaining 50% of the locations and rocky areas were at such a fine scale and/or scattered distribution that they were absorbed within the surrounding soil series" (Evans and Seleen, unpublished). *A. trichomanes-ramosum* occupies rocks of various sizes and is often found on low cliff faces (1 to 3m in height) (Evans 1997). It grows in both hardwood and coniferous forests in shaded conditions. However, there was statistically significantly lower canopy cover on the north side of rocks with green spleenwort 87 % vs. without 89 % (Evans 1997).

In a study on the geology of the Hiawatha National Forest in Michigan (Lindwall 1995) green spleenwort sites on outcrop or boulder faces often exhibited an irregular appearance with weathered, indented bedding planes. The boulder outcrops were predominately from the high purity Engadine Group. Many of the boulders exhibited chemical weathering where leaching produced "limey" flowers, and blotches on the dolostone surfaces. One site was associated with dolostones of the Manistique Group. Lindwall (1995) recommended searching for more green spleenwort sites by concentrating on a bedrock map of the Upper Peninsula, especially rocks outcrops of the upper Engadine in shady forest stands.

In Michigan, *A. trichomanes-ramosum* occurs primarily in limestone and dolomite outcrop areas of the Niagara Escarpment Landtype Association (LTA). On the Hiawatha National Forest,

populations typically occur on boulders and escarpments of Engadine dolomite and Manistique limestone (Doherty pers. comm. in TNC 1993). Doherty (1993) further notes that formations on which green spleenwort occur are generally Engadine dolostones (more than 50%). Natural communities in which this species occurs include rich conifer swamp, dry mesic northern forest, mesic northern forest, and boreal forest (Evans 1997, Chapman 1986). The microhabitat consists of moist, shaded crevices and cracks. In mesic and dry mesic northern forests, associates often include *Ribes lacustre* (gooseberry), *Maianthemum canadense* (Canada mayflower), *Actaea rubra* (red baneberry), *Aralia nudicaulis* (wild sarsaparilla), *Clintonia borealis* (bluebead lily), *Geranium robertianum* (herb robert), and several sedges, *Carex eburnea, C. pedunculata,* and *C. deweyana* (TNC 1993).

In Michigan, associated fern species include *Asplenium trichomanes* (maidenhair spleenwort), *Cystopteris fragilis* (fragile fern), *Cystopteris bulbifera* (bulblet fern), *Polypodium virginianum* (polypody), *Polystichum lonchitis* (northern holly fern), occasionally *Asplenium rhizophyllum* (walking fern) and the rare American Hart's-tongue fern *Asplenium scolopendrium* (Evans and Doherty pers. comm. in TNC 1993). In rich conifer swamps, typical associates include *Thuja occidentalis* (northern white cedar), *Carex eburnea* (sedge), *C. pedunculata* (sedge), *Mitella nuda* (naked miterwort), *Lycopodium lucidulum* (shining clubmoss), *Viola renifolia* (kidney-leaf violet), and *Gymnocarpium robertianum* (Robert's oak fern) (TNC 1993). In Marquette County, Michigan limestone formations within the Precambrian rock shield contain silica bands and provide a strong foot-hold for plants. Green spleenwort, along with *Cystopteris fragilis* (fragile fern), cling to these rock faces along these silica bands (Wahla 1984).

A population on South Manitou Island in northern Lake Michigan represents a markedly different type of habitat; a colony of 30 fronds grows on decaying logs within an old-growth white cedar forest on a sand dune (MNFI 1998). A similar habitat of mossy cedar logs supports both *A. trichomanes-ramosum* and *A. rhizophyllum* (walking fern) on Fox Islands in northern Lake Michigan (Hazlett & Hendricks 1986).

In Wisconsin green spleenwort was observed on shaded, moist, north-facing dolomitic cliffs of the Saunders formation and in the crevices of north-facing, shaded, moist Niagara limestone outcrops (Wisconsin DNR 1993). *Thuja occidentalis* (northern white cedar) is the dominant canopy species with *Acer spicatum* (mountain maple), *Abies balsamea* (balsam fir) and *Fraxinus nigra* (black ash). Other associated species include *Cryptogramma Stelleri* (slender cliffbrake), *Cystopteris bulbifera* (bulblet fern), and *Sambucus pubens* (red-berried elder) (TNC 1993). Four Wisconsin occurrences are known: one population of 24 rosettes occurs in the Chequamegon-Nicolet National Forest (USDA FS 1997) near the Brule River on a dolomite rockface of the Sander's Formation (Rill 1985, E. Judziewicz pers. comm. 2001), the other three are in Door County on Washington Island (WI EO's 2001). Fern associates at the Chequamegon-Nicolet National Forest include *Polypodium virginianum, Cystopteris fragilis,* and *Polystichum braunii* (USDA FS 1997).

Habitat patches vary in composition and configuration in the landscape; this fern is rare throughout its range in the United States though it may be very abundant in local patches (Maine Dept. of Conservation 1999). Species distribution is metapopulation, in disjunct local populations (USDA FS 2001). The occurrence of these patches is limited by the distribution of the calcareous rock substrate and is not predictably found in association with any one overstory type, soil series or suite of associated species (USDA FS 2000c).

PROTECTION STATUS

Currently, the official status for *Asplenium trichomanes-ramosum*, with respect to federal, and state Conservation status is:

U.S. Fish and Wildlife Rank: none
Global Heritage Status Rank: G4
4= Apparently secure, though it may be quite rare in parts of its range, especially at the periphery.

United States National Heritage Status Rank: N? (30 July 1993)
Canadian National Heritage Status Rank: N? (08 August 1993)

U.S. Forest Service, Regional 9 Forester Sensitive Species: on Hiawatha National Forest in Michigan (State Threatened) and Chequamegon-Nicolet National Forest in Wisconsin (State Endangered). This species in not known from Minnesota.

State Rank:

ALASKA	**S3**	NEW YORK	**S1**
CALIFORNIA	**S1.3**	OREGON	**S1**
COLORADO	**S1 S2**	SOUTH DAKOTA	**S2**
IDAHO	**S1**	UTAH	**S1**
MAINE	**S1**	VERMONT	**S1**
MICHIGAN	**S2 S3**	WASHINGTON	**SR**
MONTANA	**SU**	WISCONSIN	**S1**
NEVADA	**SR**	WYOMING	**S2**

Canadian Province Ranks:

ALBERTA	**S3**	NORTHWEST TERRITORIES	**SR**
BRITISH COLUMBIA	**S?**	NOVA SCOTIA	**S2**
LABRADOR (NEWFOUNDLAND)	**S1**	ONTARIO	**S4**
NEW BRUNSWICK	**S3**	PRINCE EDWARD ISLAND	**SU**
NEWFOUNDLAND	**S4S5**	QUEBEC	**S?**
NEWFOUNDLAND ISLAND	**SR**	YUKON TERRITORY	**SR**

Definitions of State/Provincial Ranks: (TNC)

S1 = Extremely rare; typically 5 or fewer known occurrences in the state; or only a few remaining individuals; may be especially vulnerable to extirpation.

S2 = Very rare; typically between 6 and 20 known occurrences; may susceptible to becoming extirpated.

S3 = Rare to uncommon; typically 21 to 50 known occurrences; S3 ranked species are not yet susceptible to becoming extirpated in the state but may be if additional populations are destroyed.

S4 = Common; apparently secure under present conditions; typically 51 or more known occurrences, but may be fewer with many large populations; usually not susceptible to immediate threats.

S5 = Very common; demonstrably secure under present conditions.

SU = Status uncertain; a species thought to be uncommon in the state, but there is inadequate data to determine rarity. Also includes uncommon species of uncertain nativity in the state and of questionable taxonomic standing.

SR = Reported from the state, but without persuasive documentation that would provide a basis for either accepting or rejecting the species.

S? = Species has not yet been ranked.

LIFE HISTORY

Asplenium trichomanes-ramosum is a diploid fern species which reproduces by spores that ripen June to September (Maine Dept. of Conservation 1999). Most diploid ferns strongly favor outbreeding in which two gametophytes produced by spores from different plants must be present for fertilization to occur. This breeding system results in slower local colonization rates (development of a sporophyte in a new site) and also greatly reduces chances of successful long distance dispersal. It may also account for relatively higher genetic variability when compared with other small, isolated fern populations. *Asplenium septentrionale* populations showed a small amount of genetic variability without gene flow among populations (Schneller & Holderregger 1996); similarly *Asplenium trichomanes* subsp. *quadrivalens* revealed low genetic variability within and among populations (Suter *et al.* 2000). In contrast, *Asplenium trichomanes-ramosum* showed substantial phenotypic variation within the population (Schneller & Holderregger 1996).

"Restoration potential for this species is largely unknown, owing to a lack of knowledge of specific habitat requirements and the optimal conditions for growth, maturation, and spore production" (TNC 1993). Lellinger (1985) notes that *A. trichomanes-ramosum* is not cultivated, which may infer that this species is difficult to propagate due to very specialized requirements for reproduction.

Spores mature in the summer; old stipes and leaf axes persist for years. The indusium is membranous, attached along the side of the sorus, delicate and tends to disappear as the sorus ripens. The spores located on the underside of fronds are ejected and either fall to the ground or are transported in water droplets to other sections of the same rock or close neighboring rocks, less frequently spores are carried to nearby landing sites on wind currents. Outbreeding, diploid

species have a much lower chance of successful long distance dispersal because two viable spores from different parent plants would need to land in the same distant suitable location (close enough for fertilization) (Vogel *et al.* 1999; Schneller 1995 *cf* USDA FS 2000c).

In studies of spore dispersal and biogeography of *Asplenium* species, it has been documented that most spores (approximately 95%) fall in the immediate vicinity (within 1 to 10 meters) of the parent plant (Schneller 1995 *cf*. USDA FS 2000c). Distribution patterns of *A. trichomanes-ramosum* within the outcrop areas studied in Michigan seem to support the notion that the expansion and maintenance of local colonies is likely achieved through short-distance dispersal mechanisms. The average distance between rocks was only 108 centimeters (Evans 1997). Spore dispersal mechanisms favor aggregated or continuous habitat patches (USDA FS 2001).

A. trichomanes-ramosum was consistently observed on northern exposures and in significantly higher numbers on the cooler, moister northeastern faces of the rocks, typically rooted in thick bryophyte mats (Evans 1997). Thus, it appears that dispersal and subsequent establishment is most successful when a) substrate is in close enough proximity that a number of spores reach safe sites and b) adequate moisture is available to the plants as they grow to reproductive age.

POTENTIAL THREATS

The habitat demands of *Asplenium trichomanes-ramosum* are particular; this species requires a rocky, cliff-like limestone and dolomite bedrock. Rocky outcrops in shady environments are ideal for *Asplenium trichomanes-ramosum.* Therefore, selective logging within or near green spleenwort colonies may have serious impacts. This species is susceptible to drought (localized changes in humidity and soil moisture) when overhead trees are cut, leaving the boulders exposed to repeated sunlight. Colonies are greatly threatened by land use activities such as mining, road building, and timber cutting, along with periodic defoliation of canopy (shade loss) by insect pests such as the gypsy moth,. In more remote and inaccessible locations, the principal management concerns are trail placement and the potential effects from recreationists such as rock climbers (TNC 1993).

Loss of habitat due to limestone mining and gravel pit extraction activities currently pose the greatest threat to this species (USDA FS 2001). Mining limestone involves the removal of overstory and understory vegetation as well as removal and displacement of the rock substrate on which the ferns grow. Since the species requires shaded limestone rock, this activity limits the opportunity for population expansion and establishment in new areas.

Both selective logging and clear-cutting result in exposure of rocks to higher degrees of sunlight, altering microclimatic conditions by increasing temperatures and decreasing moisture around the rocks. These changes can, and often do, result in changes in vegetation structure and composition**,** including loss of bryophyte cover. Logging around and within occupied habitat likely impacts species viability to a moderate degree over the short term as populations are eliminated or reduced in size and vigor (USDA FS 2000a).

Habitat fragmentation can also have profound effects on the success and persistence of local populations. Any activities that result in barriers to dispersal, such as clearcuts, road and utility line corridors and mined areas limit the possibility of population expansion and genetic exchange (USDA FS 2001). Deleterious effects of fragmentation could possibly go unnoticed for a period of time, making the short term effect on species viability less apparent. Over time, as populations

become increasingly more isolated, the effects of fragmentation can potentially be observed at the molecular level by reduced genetic frequencies caused by random drift (Evans 1997).

In Michigan the major existing and potential threats include overstory removal through logging activities, including the felling of logs onto boulders, and periodic defoliation of canopy vegetation by insect pests such as the gypsy moth (Evans pers. comm. in TNC 1993). Evans (1997) observed a small site on the Hiawatha National Forest where the overstory trees were completely removed, and plants of *A. trichomanes-ramosum* occupied only the areas along the bases of boulders, under the shade of *Rubus idaeus* (red raspberry). The best management practice would be "to leave large tracks unharvested and to allow natural processes (growth, senescence, windthrow, fire, and disease to operate unhindered" (Cohen 2000). When tracts are managed for timber, care should be taken to minimize fragmentation and maintain a canopy closure comparable to pre-harvest conditions (Cohen 2000).

Populations as listed by Michigan Natural Features Inventory vary from 10 plants to 500 plants; four element occurrences have plants numbering in the 100's (MNFI 1998). The population of over 500 plants has been rated as an A in terms of viability by Michigan Natural Features Inventory since this population has both good numbers and percentage of spore producing plants. Two other sites are rated as AB, and another two sites have been given B ratings indicating good long-term viability if not disturbed (MNFI 2001b).

At the site in the Chequamegon-Nicolet National Forest, the occurrence is isolated and occurs within a proposed Research Natural Area (RNA), which would provide good protection. However, there is concern that to ensure protection the adjacent northern mesic forest the cliff should also be incorporated into the RNA and not logged (Dobberpuhl pers. comm. in TNC 1993). In Wisconsin, *A. trichomanes-ramosum* is considered at risk in terms of distribution, abundance, habitat integrity, and population vulnerability (USDA FS 2000b) and it is known from only one site on federal land.

Size of Habitat Patches:
At a fine scale, an individual boulder or fractured ledge may be considered a habitat patch and be no larger than a square meter or two. However, in defining a patch as calcareous rock habitat with sufficient canopy cover to provide adequate shading, the functional minimum patch size is most likely an area containing an aggregate of boulders, a ledge, cliff or talus slope that is approximately a few thousand square meters to a hectare, depending on the 'intactness' of adjacent surrounding forest habitat (Evans 2001 pers. comm.). Evans further states that where the ultimate goal is population viability and protection, at least three levels or scales of habitat patches are important to consider; substrate or rock level (1-2m^2), stand or canopy level (1-10s hectares) and metapopulation level (10s – 1,000s hectares) (USDA FS 2000c).

POPULATION VIABILITY AND PROTECTION

"Most populations of *Asplenium trichomanes-ramosum* occur under at least partially shaded conditions. Where only partially shaded, colonies appear to be shielded from the most direct, intensive sunlight" (TNC 1993). Because many populations are relatively remote and/or exist in rugged terrain, they are often naturally protected.

Random drift towards homozygosity, or genetic drift has a more profound effect on smaller populations than large populations. More subdivided, inbred populations generally possess

smaller effective population sizes because as the population size decreases, the chance that copies of the same gene will combine and be passed on to the next generation increases. In the absence of mutation, a small population will eventually become homozygous, potentially affecting the long term viability of populations (Barrett and Kohn 1991, Ridley 1996). The magnitude of reduced fitness due to genetic drift on a species depends on the species tolerance to homozygosity. The effect of small population size and isolation in many cases is reduced genetic variability and a reduced overall ability to adapt to environmental conditions (Barrett & Kohn 1991).

Some species may have adapted reproductive strategies or breeding systems that help to moderate the effects of small population size. The predominantly outbreeding behavior of diploid fern species may be such an adaptation. Schneller and Holderegger (1996) studied one population of *A. trichomanes-ramosum* containing 31 individuals and found relatively high genetic variability. He attributed this finding to its diploid breeding system. Diploid ferns strongly favor outbreeding in which two gametophytes produced by spores from different plants sexually reproduce. This could potentially allow them to persist through longer periods of isolation (USDA FS 2000c).

Recreational traffic should be directed away from green spleenwort habitats; in some areas signage may be required to inform rock climbers about sensitive rare species habitats. It is also important for sites to include sufficient forested buffer areas which help maintain moisture conditions within the microhabitat, and to maintain connectivity between patches of both occupied and suitable unoccupied habitat. Since most populations occur in moist, shaded conditions, the maintenance or recovery of overstory vegetation is likely to be a primary objective in restoration (TNC 1993).

In Michigan several *A. trichomanes-ramosum* sites are protected in a nature preserve owned by the Michigan Nature Association, and the Sleeping Bear Dunes National Lakeshore on South Manitou Island. Of the more recent populations discovered in the 1990s on the Hiawatha National Forest, several colonies of *A. trichomanes-ramosum* are locally abundant with 100 to 500 individuals (MNFI 1998). A Wisconsin panel of fern experts considered populations of over 100 individuals as viable at least for the short to intermediate term (USDA FS 2000a Viability Panel). MNFI (2001) ranked a Michigan site with 500 individuals as an A (long term viable) since this population and habitat is large and there is a good number of spore producing plants. Two other sites are ranked as AB, and an additional two sites have been given B ratings (medium population size, and habitat quality, surrounding landscape in fair condition; unlikely population will drop below recovery threshold) (MNFI 2001b). Many smaller sites on the Hiawatha are ranked by MNFI as BC indicating reasonable short-term viability, but long-term viability could be at risk (plants could drop below threshold from which they could recover).

RESEARCH AND MONITORING

Research on virtually any aspect of this species' biology and ecology would provide information applicable to conservation. Especially helpful are studies that elucidate specific habitat requirements, such as optimal light levels, moisture requirements, the spatial and temporal distribution of plants with regard to canopy openings, nutrient and substrate requirements, substrate variation, and the role of natural and artificial disturbance (Evans 1997). The influence of bryophytes on the moisture regime at the microhabitat level may play a critical role in the

success of the germination of this species (USDA FS 2000c). Spore production and the conditions necessary for spore germination and gametophyte fertilization need investigation.

REASONS FOR ONGOING CONCERN/MANAGEMENT

Because there are virtually no known monitoring programs at present, population trends for *Asplenium trichomanes-ramosum* are poorly known. "Overall, green spleenwort colonies likely retain their best viability in relatively large areas managed as old-growth where logging was eliminated or carefully minimized. Logging in adjacent buffer areas should also be eliminated or restricted at least to selective cutting until the biology of this species is better understood with regard to light levels, forest canopy gaps, disturbance, and other factors" (TNC 1993). There are no formal management programs being conducted at this time for *Asplenium trichomanes-ramosum*. In Michigan, the Hiawatha National Forest is cataloging sites of this rare fern species in rock outcrop areas.

SUMMARY

Asplenium trichomanes-ramosum is a circumboreal species of subarctic and alpine areas in Canada and Eurasia. Green spleenwort is listed as Threatened in Michigan. In Michigan's Upper Peninsula and adjacent Canada its distribution is mostly limited to the Niagara Escarpment. Green spleenwort occurs on weathered dolostone boulder faces predominately of the Engadine Group. *Asplenium trichomanes-ramosum* is not limited to any one forest type and occurs in both conifer swamps and upland hardwood forests dominated by sugar maple and white birch. The known colonies mapped should be closely studied and monitored to learn more about the life history and biology of this species. Logging, recreational traffic, and trail use should be limited in forests that contain *A. trichomanes-ramosum.*

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Contacts

Hiawatha National Forest, Michigan: Jan Schultz, Forest Plant Ecologist (906) 228-8491
Chequamegon-Nicolet National Forest: Mariquita Sheehan, Plant Ecologist (715) 479-2827
Chequamegon-Nicolet National Forest: Steven Spickerman, West Zone Plant Ecologist, (715) 264-2511
Chequamegon-Nicolet National Forest: Steve Janke, East Zone Plant Ecologist, (715) 276-6333
Eastern Region (R9), Milwaukee, Wisconsin: Nancy L. Berlin (218) 335-8673
Library Services, North Central Research Station: Laura Hutchinson

lhutchinson@fs.fed.us
University of Wisconsin – Madison, Botany Dept. – Herbarium: Merel Black
mblack@facstaff.wi
New York Natural Heritage Program: Dorothy Evans, Associate Ecologist
(518) 402-9263
University of Wisconsin, Green Bay: Emmet Judziewicz
Michigan Natural Features Inventory: Mike Penskar (517) 373-1552