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Conservation Assessment

for

Bradley's Spleenwort

(*Asplenium bradleyi* D.C. Eaton)

Steven R. Hill

Center for Biodiversity
Technical Report 2003 (1)

Illinois Natural History Survey
607 East Peabody Drive
Champaign, Illinois 61820

Prepared for:
U.S.D.A., Forest Service
Vienna Ranger District
Shawnee National Forest
P. O. Box 37
Vienna, IL 62995

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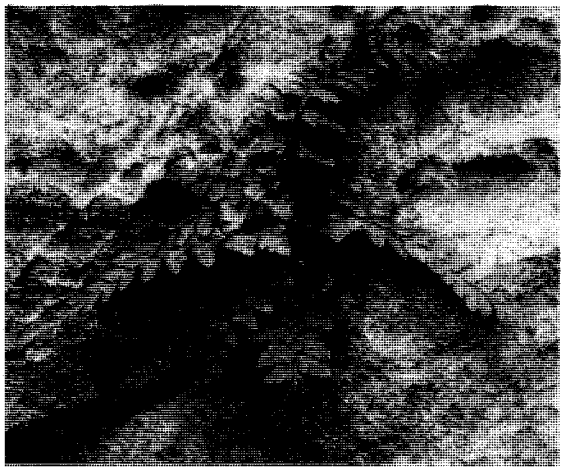

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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for 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 Bradley's spleenwort, *Asplenium bradleyi* D.C. Eaton, throughout the United States, and in the U.S.D.A. Forest Service lands, Eastern Region (Region 9), in particular. This document also serves to update knowledge about the status, potential threats, and conservation efforts regarding Bradley's spleenwort to date. Bradley's spleenwort is a small tufted evergreen fern, a perennial herb, that is found only in the United States, and it is known to occur historically in eighteen midwestern and eastern states, namely, AL, AR, GA, IL, IN, KY, MD, MO, NJ, NY, NC, OH, OK, PA, SC, TN, VA, and WV. This fern has been shown to be the fertile offspring of a cross between the Mountain spleenwort (*Asplenium montanum*) and the Ebony spleenwort (*Asplenium platyneuron*). It is found rooted in crevices on acidic rock outcrops, particularly on steep sandstone cliffs, in exposed, barren areas, sometimes in full sun. The populations are isolated partly because of infrequent suitable habitat and the number of individual plants at each site is small. Globally, its ranking is G4 (apparently secure world-wide, but factors exist to cause some concern). Though not truly common anywhere, Bradley's spleenwort is most often found in the Ozark region, and, in Illinois it is found primarily within the Shawnee National Forest. The species has been included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest, where no populations are known. It is vulnerable in Illinois where it is listed as Endangered, and it has also been listed as Endangered in Indiana, New Jersey, New York, and Pennsylvania, as Threatened in Ohio, and as Extirpated in Maryland. It faces several risks that could result in its extirpation throughout its range if it is not properly managed.

In additional to species listed as endangered or threatened under the Endangered Species Act (ESA), or species of Concern by U.S. Fish and Wildlife Service, the Forest Service lists species that are Sensitive within each region (RFSS). The National Forest Management Act and U.S. Forest Service policy require that National Forest System land 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.

The objectives of this document are to:

-Provide an overview of the current scientific knowledge on the species.

-Provide a summary of the distribution and status on the species range-wide and within the Eastern Region of the Forest Service, in particular.

-Provide the available background information needed to prepare a subsequent Conservation Approach.

NOMENCLATURE AND TAXONOMY

Scientific Name:	*Asplenium bradleyi* D.C. Eaton
Common Names:	Bradley's spleenwort; Cliff spleenwort
Synonymy:	*Asplenium stotleri* Wherry
Class:	Filicopsida (Ferns)
Family:	Aspleniaceae (the Spleenwort family)
Plants Code:	ASBR2 (USDA NRCS plant database, W-2) http://plants.usda.gov/cgi_bin/topics.cgi

There are approximately 42 species of spleenworts (*Asplenium*) in North America north of Mexico depending upon differing interpretations. A significant number of the recognized species are of hybrid origin, and 16 of the 42 are sterile hybrids, leaving 26 fertile species. This species is considered to be a close relative of the other Appalachian - Ozarkian spleenworts, and it has been demonstrated that it is a derivative (allopolyploid) of a hybrid between *Asplenium montanum* Willd. and *Asplenium platyneuron* (L.) Oakes ex Eat. (*i.e.*, its parental taxa; see Wagner 1954, Smith & Levin 1963, Werth *et al.* 1985). It is a true fern, a vascular plant that reproduces by spores.

DESCRIPTION OF SPECIES

Asplenium bradleyi is a small tufted evergreen perennial fern, a morphologically variable species. Its leaves (fronds) are 4.5-25 (30) cm long, and their dark reddish-brown shiny stalks are 1-10 cm of that length. At the base of the leaf rosette, brown, narrowly lanceolate scales can be found that grade into hairs. The leaf blades (laminae) are narrowly-oblong or linear-lanceolate, shiny green when fresh, 1-5 cm wide, pinnate-pinnatifid to twice pinnate, truncate (not tapered) at the base though the basal pinnae (blade divisions) are often somewhat reduced in size, acute at the apex, with (5-) 8-15 (-20) pairs of alternate or sub-opposite very short-stalked pinnae that are also ovate-oblong to linear-lanceolate, nearly equilateral, and often with a slightly enlarged basal lobe; the pinnae margins are toothed, but leaf veins are barely evident; the sori are 1-2 mm long with opaque entire indusia (description primarily from Gleason & Cronquist 1991, Lellinger 1985, Wagner *et al.* 1993).

Bradley's spleenwort apparently arose independently through hybridization at several different places and times from its parents, *A . montanum* and *A. platyneuron*, based upon isozyme studies (Werth *et al.* 1985b). The sterile diploid form of *A . bradleyi* has been collected only twice in nature (Wagner *et al.* 1973).

HABITAT AND ECOLOGY

Asplenium bradleyi is normally found in a very distinctive and limited habitat (see Mohlenbrock 1978). Typically, the plants grow tightly rooted in ('wedged into') vertical or horizontal crevices on hard, well-weathered vertical sandstone cliffs and other highly exposed bedrock. These areas are often near rock shelters or rock houses (Francis *et al.* 1993) because people have used the more protected sites within these areas as protection from the weather since prehistoric times. In addition to sandstone, it also grows on granite, chert, or other acidic rocks (Lellinger 1985). The cliffs where it grows are normally devoid of other vascular plants, and the crevices where it is rooted are too small for many other fern or flowering plant species (W-3). A limited number of lichens and mosses as well as the closely related ferns *Asplenium montanum*, *Asplenium pinnatifidum*, and *Asplenium platyneuron* are occasional associates nearby. Skorepa (1973) suggested that while the general aspect of the lichen, moss, and vascular plant vegetation on the sandstone outcrops could lead one to believe that succession is taking place, the lichens and mosses on the exposed rocks actually represent a stable climax. Winterringer and Vestal (1956) likewise saw little evidence of succession on sandstone bluffs in southern Illinois.

Bradley's spleenwort has also been characterized as growing on shaded but dry cliffs, or in dry shaded crevices of cliffs. It does not grow on ledges or other microsites where other plants could overwhelm it, nor does it grow in dense shade. The margins of the bluffs above are forested with species tolerant of drought conditions, and these help to prevent soil erosion from above and may also add small amounts of nutrient and organic material to the sand caught in the crevices where the ferns grow. The plant community surrounding or at the summit of the cliffs is generally a dry upland forest (White & Madany 1978). The habitat exposure is generally western to southern, and the plants can be exposed to direct sunlight for at least part of the day.

The sparse soils on which the plants grow are composed of sandy residuum from the weathered rock face as well as organic materials from decomposing plant materials, mostly from the old fronds of the fern itself. The roots appear to fill the crevices and anchor the plants firmly within them. The soil pH is thought to be acidic because soils normally formed from such outcrops are typically so. The fern does not appear to tolerate limestone, though it has been found infrequently on cherty (acidic) inclusions within limestone outcrops (W-3) . The normally thin soil is well-drained, but it is normally moist or wet in the winter and spring during the plant's growing and reproductive season. The plants are well adapted to the drying of their habitat in the summer at which time they may lose a few of their more fragile, fibrous leaves, which normally provide humus to the plant. Some biologists might consider the species to be a pioneer species because of the occasionally eroding and fragmenting habitat. However, the tough but short rhizome and numerous roots appear to effectively store nutrients and moisture during the plant's dormancy and the individual plants appear to persist for many years. Plants in this sort of exposed habitat generally utilize moisture from fogs and dew to supplement the meager rainfall during dry seasons, and characteristically have a dense root mass to assist in absorption.

The species is well adapted to this unusual harsh and somewhat scarce habitat, and there are generally few other plants that are able to grow with it. Therefore, there is little competition from other plant species and Bradley's spleenwort often grows alone in crevices on bare rock. This fern does not appear to be able to compete well with other plants. In addition, while this habitat type is sometimes plentiful in certain areas of some states, occurrences of the species are very few. It has not been successfully cultivated, as far as it is known, and this supports its designation as a specialist species with narrow habitat tolerances.

DISTRIBUTION AND ABUNDANCE

Asplenium bradleyi is limited in range to an area south of the glacial boundary and it is known to occur historically in eighteen midwestern and eastern states, namely, AL, AR, GA, IL, IN, KY, MD, MO, NJ, NY, NC, OH, OK, PA, SC, TN, VA, and WV (W-2, W-3). Wagner *et al.* (1993) did not record it in Indiana but it is known from the state. One source (W-2) mapped the species in Louisiana, but a definitive atlas of the state's flora (Thomas & Allen 1993) did not include it there and that information appears to be erroneous. Its distribution is not continuous, but is quite spotty or discontinuous, with notable disjunctions. Additional details on the distribution of Bradley's spleenwort can be found in Chester *et al.* (1993), Mohlenbrock (1986), Mohlenbrock and Ladd (1978), Kartesz and Meacham (1999), Reed (1953), Smith (1988), and Yatskievych (1999) and several Internet sites (*e.g.*, W-2, W-3). *Asplenium bradleyi* occurs only rarely to locally in the Appalachian region and where it overlaps with both progenitor species, but it is fairly frequent in the Ozark and Ouachita regions where one of them, *Asplenium montanum*, is absent.

Bradley's spleenwort is at its southern limit of distribution in the Cumberland Plateau and just south in northeastern Alabama and northwestern Georgia. Its western limit is in extreme southeastern Oklahoma, from which it continues northeast into the Ouachita and Ozark mountains and barely into southwestern Illinois. It is in the somewhat isolated Shawnee Hills and plateau of extreme southern Indiana and a portion of west central Kentucky, then in the Appalachians from Tennessee and North Carolina north to northwestern New Jersey and in adjoining New York where it reaches its northern limit. According to the Nature Conservancy (W-3) two historic populations were known in New York, in the Shawangunk Mountains and in the vicinity of Newburgh, in Ulster and Orange Counties, respectively, but there are no known extant populations remaining in the state. In Maryland, the species may also be extirpated (W-2). Representative specimens have been listed in Appendix 1. A summary of the distribution of Bradley's spleenwort has been presented in Appendix 2.

Within the U.S. Forest Service Eastern Region (Region 9) *Asplenium bradleyi* has been confirmed to be present within the Shawnee National Forest in Illinois, where there are three populations; it has not been found on the Hoosier National Forest in Indiana although suitable habitat is present.

In Indiana, only a single *Asplenium bradleyi* population is known, in Dubois County, and this contained 15-20 plants in 1984 (Indiana Heritage Data Center 2001).

In Illinois, where it is listed as Endangered, the species has been reported historically in Jackson, Randolph, Saline, and Union Counties (Herkert *et al.* 1991, Illinois Endangered Species Protection Board [IESPB] 1999). These sites fall within the Central Section of the Ozark Natural Division and the Greater Shawnee Hills Section of the Shawnee Hill Natural Division of Illinois (Schwegman *et al.* 1973) just south of the glacial boundary. Mohlenbrock (1957) has discussed the significance of the Ozarkian flora in Illinois, and Bradley's spleenwort was specifically mentioned as a component of this flora.

All populations in Illinois and elsewhere are individually small, generally with only about 10-50 plants present. In Illinois, records indicate population sizes of 11-15 individuals in Randolph County, 50 plants in Saline County, and 12 plants in Union County, but these were somewhat casual observations. Interestingly, there were 9 specimen sheets at the Southern Illinois University herbarium from Illinois, with more than 9 individuals total. This amount of collecting can certainly adversely affect this species. These ferns can be local or widely scattered over the cliff face. Furthermore, the populations are isolated from one another because of its specific requirements for an uncommon and discrete habitat and intolerance of competition. In terms of numbers of individuals, it is possible that the entire number of individuals currently alive may be in the low thousands globally. There is little specific data in this regard other than the data available in state Natural Heritage databases, which suggests these low remaining numbers. It could as easily be surmised that the species was never common.

PROTECTION STATUS

The Nature Conservancy ranking for *Asplenium bradleyi* is G4 (apparently secure world-wide, but factors exist to cause some concern; W-3, Appendix 3). In the United States the species is given the National Heritage status rank of N4 with a similar meaning. The state rankings vary, but it has been designated as Endangered in Illinois, Indiana, Maryland (or Extirpated), New Jersey, New York (or Extirpated), and Pennsylvania, and Threatened in Ohio. While it is tracked and acknowledged to be very uncommon in most states, it is not protected in Alabama ('listed without rank'), Arkansas, Georgia ('Watch List'), Kentucky, Missouri ('stable'), North Carolina ('Significantly Rare-Peripheral'), Oklahoma ('rare'), South Carolina ('of concern - regional'), Tennessee, Virginia ('Rare'), or West Virginia. Despite some sources, Bradley's spleenwort apparently does not occur in Louisiana.

Asplenium bradleyi is listed on the U.S. Forest Service's Regional Forester Sensitive Species (RFSS) list for the Shawnee National Forest, Region 9.

Protection for this fern and other plants with non-showy individuals is currently more dependent on habitat protection, and so its survival will probably depend more on this than on species

protection. *Asplenium bradleyi* appears to be restricted to a specialized and scarce habitat and high quality examples of this habitat (Sandstone overhang, Sandstone cliff) have been given a priority for protection in some states including Indiana (see W-6).

Table 1 lists the official state rank assigned by each state's Natural Heritage program according to the Nature Conservancy at their Internet site (W-3). Appendix 3 explains the meanings of the acronyms used (W-4). A summary of the current official protection status for Bradley's spleenwort follows:

U.S. Fish and Wildlife Service:	Not listed (None)
U.S. Forest Service:	Region 9, Sensitive (Illinois)
Global Heritage Status Rank:	G4
U.S. National Heritage Status Rank:	N4

Table 1: S-ranks for *Asplenium bradleyi* [element PPASP02050]

State	Heritage S-rank	State	Heritage S-rank
Alabama	S2	New York	SH
Arkansas	SR	North Carolina	S1
Georgia	S3?	Ohio	S2
Illinois	S1	Oklahoma	S1
Indiana	S1	Pennsylvania	S1
Kentucky	S3S4	South Carolina	S1
Louisiana	SR	Tennessee	S2S3
Maryland	SH	Virginia	S2
Missouri	SR	West Virginia	S?
New Jersey	S1		

LIFE HISTORY

Asplenium bradleyi is a tufted evergreen fern, a perennial herb, but its average life-span is not known. Growth is very slow and some individuals may be very long-lived. Like its relatives, it can produce a few additional rosettes from the same rhizome in age, but these do not spread the plant naturally, they merely help insure an individual's survival and increase reproductive potential through additional fertility. Plant growth and size is limited by characteristics of its

immediate habitat (microhabitat), including such factors as crevice size, degree of exposure, and soil and nutrient availability, and there may be long periods of dormancy of individual plants in some populations in dry, hot, or cold periods.

Plants begin growth in early spring. It appears that about 5-10 leaves are on a plant at any given time, and few new ones are produced each year. Apparently, new fronds are produced as old ones die. The ferns reproduce by means of spores that are produced in sporangia (spore cases) borne on the undersides of the mature leaves in clusters called sori that are usually protected by a covering called an indusium (Lellinger 1985). The dust like spores are dispersed into the air when mature, and they may be present and shed all year because the leaves are evergreen in this species. Most mature and fall in mid- to late summer. As is typical in the ferns, the spores grow into small heart-shaped flat green thalli (gametophytes) 0.5 cm long or less, and new spore-producing fern plants (sporophytes) are produced only if eggs on these gametophytes are fertilized by free-swimming sperms whereupon they can grow into a new rooted plant. The eggs are only fertilized when there is a film of water available on the gametophyte because the sperm must swim to the egg. Therefore, the spore must first disperse to a suitable moist or wet crevice in the rock with sufficient soil for a vascular plant to grow, and it must not dry out before a sturdy young sporophyte has formed. The plant is not secure until it has developed a large root mass that can withstand drought. These conditions are rarely met in this harsh cliff habitat; few spores can grow into mature plants and so the plants are rare.

Spores probably do not survive or persist for long after being shed. Instead, it appears that the presence of the tough root mass and its protected rhizome is crucial to the species' survival, and that the production of many spores per plant allows sporophyte establishment in favorable years only.

Under favorable conditions during the gametophyte stage, gametes from neighboring gametophytes of other related species can occasionally fertilize the eggs of Bradley's fern. Sterile hybrids with *Asplenium pinnatifidum* (named *Asplenium* × *gravesii*), *Asplenium montanum* (named *Asplenium* × *wherryi*), and *Asplenium platyneuron* are all known from nature (see Wagner 1954, Smith & Levin 1963, Wagner *et al.* 1973, Wagner *et al.* 1993).

POPULATION BIOLOGY AND VIABILITY

In the previous section, the complex life history of *Asplenium bradleyi* was briefly presented. While mature individuals appear to be sturdy and, perhaps, long-lived the success of establishment and growth of individuals to maturity is very difficult and can depend on local conditions and on suitable years. It is likely that in this habitat each plant may produce only a single successful offspring during its lifetime because of the limited amount of microhabitat (suitable moist crevices on cliff faces) available. It is not known how far the spores can travel, but the few colonies extant and their local nature may suggest that they cannot travel long distances or that there is little additional suitable habitat available for the species even if they can.

Asplenium bradleyi is an allopolyploid species with a high chromosome number ($2n = 144$). Its parental species, *A. montanum* and *A. platyneuron*, each have chromosome numbers of $2n = 72$ (Wagner 1954). As a derived species, it follows that Bradley's spleenwort is also a younger species and it is not able to compete well with its parents or with other plants for space. It has a narrowly defined habitat in which it cannot develop large populations. Therefore, its viability depends entirely upon its persistence at its currently known sites and the protection of its habitat.

It is unlikely that the species would be able to re-establish itself at a site from which it has been extirpated even though fern spores are light and can disperse on wind. The distances between populations are too great, and the numbers of reproductive individuals are too small. The species has been given a relatively secure rank of G4 because, historically and based upon herbarium collections, a significant number of populations have been found over a large part of the country. However, some of these populations are now gone, and the loss of a few populations can eliminate the fern from an entire state (*e.g.*, Maryland and New York). In states where it is not being actively monitored, it is not known how many populations or individuals still exist. The plants grow in generally inaccessible sites. When they are visited, fewer plants are found each time. However, the species is considered to be somewhat stable and still viable in parts of its range at this time, and many of the populations are protected within conservation areas or national forests (W-3). It is also thought that recreational activities and over-collecting have eliminated some populations of the plant, and that this may continue (Shimp, pers. com.; Shawnee National Forest 2001).

In Illinois and Indiana, suitable habitat for the species occurs only along a narrow band in the area of the Shawnee Hills where there appears to be additional suitable habitat for the plant available. While it is thought that most significant sized populations have been found because the habitat is a very popular one among hikers (and botanists to some extent), additional searches are suggested. With proper habitat management, the current populations should persist.

POTENTIAL THREATS

Overall, Bradley's spleenwort is locally secure because of the inaccessibility of most of the individuals in a population. However, its habitat is not common and this fern cannot stand some types of disturbance. An obvious threat to the species is quarrying or strip mining of its habitat, particularly in the Cumberland Plateau region of Kentucky and Tennessee (W-3). The other threats to the species include physical damage from trampling by rock climbers, from over-zealous collecting, and from degradation of the environment. Pollutants and herbicides applied at the top of cliffs could eliminate the species from toxic runoff from above. The elimination of vegetation cover on the bluffs above may also reduce the soil and nutrients available to the plants in the crevices below decreasing reproductive potential. These plants may be dependent on seasonal drainage patterns on the cliffs of which we are not aware. The growth of vines, such as Japanese honeysuckle and Virginia creeper among others, onto the cliff faces may produce too much shade for the ferns to persist as well. The growth of trees may also shade some populations

and cause them to decline, but if woody debris from cutting is left against the cliff faces, it could also decline or disappear (W-3). If prolonged drought occurs, the populations would also be expected to decline or even disappear (Herkert *et al.* 1991).

Botanists generally believe that most native plants have reached the limit to which they can travel under present conditions of climate (that is, temperature and rainfall), substrate, dispersal mechanism, and other pertinent factors. In other words, species are in balance with their environment as long as the environment is stable. In many biological simulations, ecological extremes are more important than the means in controlling plant distribution (Webb *et al.* 1975). An obvious example is that of frost tolerance (temperature extremes). A plant species completely intolerant of freezing can persist in a site indefinitely until the first time extreme temperatures cause it to freeze. One such freeze in a century may be enough to eliminate a species entirely from a wide area of its range, and changes in climate historically have caused the greatest changes in plant distributions.

In the case of *Asplenium bradleyi*, current distribution appears to be dependent primarily on historical factors (lack of glaciation within its current range, resulting in a 'relict' distribution), substrate and bedrock type, and the age of the surrounding forest (as measured by the degree of canopy closure) rather than from temperature extremes. With limited opportunity for spore dispersal, it may also be unable to increase its range very quickly. The climatic factor of winter and spring moisture appears to be crucial for this fern as it is for the desert ferns world-wide, along with a stability of soil and a lack of competition. Under natural conditions, these habitats are stable, but if the habitat becomes shaded, if it becomes too dry, if nutrient and soil accumulation changes, or if human traffic increases, the fragile habitat balance can be destroyed and the populations can be lost. Some plants are known to have been killed by extreme drought conditions (Schwegman, see W-3) but this is not unusual in this habitat. The use of fire as a management tool does not appear to be a beneficial factor for this species; the cliffs actually provide protection from natural fires and a combustible component is not part of its immediate environment. Burning of the surrounding forest or that forest on the bluffs above might be detrimental by increasing drying and erosion, but hard data is lacking (W-3). It is just as likely that a burned forest could add nutrient to its microhabitat.

It is also generally believed among biologists that habitat fragmentation can have profound effects on the success and persistence of local populations. Any activities that result in barriers to dispersal, such as developments, clearcuts, road/utility line corridors, and mined areas limit the possibility of population expansion and genetic exchange in many species. Deleterious effects of fragmentation could possibly go unnoticed for a long period of time, making the short term effects 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 (Barrett & Kohn 1991). When one is considering populations that are already naturally isolated, as in the case of Bradley's spleenwort,

random genetic drift may have already occurred. In fact, this may have been a driving force in its evolution as a distinct species.

Some of the best-known colonies of the plant occur near well-used trails and it is thought that this has had negative effects on them. A population growing along a township road in Ohio was extirpated within 10 years of the opening of the road, but the exact cause of the loss is not known (W-3). Restricted access to the sites, relocation of the trails, and elimination of rock climbing where it grows would be indicated as a means to ensure the species' survival and viability, as in the case of other species with a similar habitat (Shawnee National Forest 2001, W-3). These activities are currently illegal where this species grows in the Shawnee National Forest. This fern is rather popular among researchers and educators because of its well publicized origins and because it is evergreen, so botanists tend to collect it when they see it. While this does not normally affect most plant populations, because the population sizes of this species are so small, elimination of a few reproductive individuals could endanger the continued existence of a small local population. Some of the generally used guidelines for plant collecting are presented in Hill (1995).

Certainly, quarrying and stripmining of the cliffs and their vicinity could easily eliminate a population. The construction of any buildings on the bluffs immediately above the ferns would likely create a very definite threat to their survival. For this plant and others in its habitat, protection for the upland and surrounding forest is necessary to buffer sites from the effects of erosion and drying and to preserve conditions which may influence long-term viability.

At the current time, it does not appear that the populations of *Asplenium bradleyi* in the Shawnee National Forest are immediately threatened with elimination because of habitat loss. However, in the absence of future management of the forest and sandstone and other acidic cliffs for this species, it could decrease or be eliminated.

RESEARCH AND MONITORING

There has been a considerable amount of research on the genetics of this species, and on the variability between populations, thanks to the work of Wagner (1954), Smith & Levin (1963), and Werth *et al.* (1985). There has not been as much research on its establishment, viability, and population dynamics. The techniques for these and other aspects of monitoring and studying rare plant species are explained well in Collins *et al.* (2001), Philippi *et al.* (2001), and Imm *et al.* (2001).

Bradley's spleenwort is being monitored by some botanists working on behalf of the state Natural Heritage programs and other organizations in the areas where it is listed as rare, threatened, or of special concern (W-3). However, a continuing problem is that there is neither sufficient funding nor are there enough botanists available to survey the immense area that needs to be covered in the monitoring of the large numbers of sensitive plants, including this one (Hill

2002). There is the potential of additional suitable habitat in extreme southern Illinois as well as in southern Indiana where *Asplenium bradleyi* could exist, and continued searches for the species should be conducted. It is important not to collect an entire plant, and only rarely should leaves be taken (W-5). Photographs are a less damaging means to document this species, but the species must be positively identified for any data to be of use and so vouchers may be required.

Of particular importance is the monitoring of the known populations over time to determine population dynamics (W-3). More research is needed particularly on the longevity of individuals and the establishment of sporophytes. Particular attention must be shown to avoid invasive monitoring (trampling, scraping, removal of soil, breaking of substrate) within the sites. It might be useful to enclose some colonies within a newly devised protective fencing to investigate the effectiveness of this kind of protection that would still allow monitoring. Protection of the cliff face habitat on which *Asplenium bradleyi* lives is the primary management need according to the Nature Conservancy (W-3).

Research is needed concerning the propagation of this plant. While gametophytes of this and most other ferns can be grown rather easily under controlled conditions, the production of sporophytes may not be so easy, and the subsequent acclimation and introduction of these young plants into a natural environment may or may not be possible. As far as known, it has not been attempted.

The Hoosier National Forest has instituted an agreement with the Indiana Department of Natural Resources, Division of Nature Preserves, to conduct surveys of rare and exotic plants in special areas (Day 2000). The populations of rare plants are to be documented, former sites revisited, new sites are to be found, and plot information collected, and each exact location is to be noted with Global Positioning System technology. This should be encouraged at sites in all of the states where this scarce plant occurs.

RESTORATION

The recovery potential for *Asplenium bradleyi* is probably poor (W-5).

There are no known restoration efforts being conducted on *Asplenium bradleyi* anywhere in its range. Most research on the species has been conducted to determine its genetic relationships. This matter appears to have been settled, and some limited monitoring has been instituted only in relatively recent times. More data is needed on this species and its listing in the RFSS list should help in this regard. The National Forests are one of the greatest hopes for the protection of this rather narrowly distributed and isolated United States endemic plant.

As mentioned above, this species of fern is not commercially available, and it is not generally cultivated (Lellinger 1985). Restorations of any native plant species are recommended using only nursery propagated material grown from native, local populations to avoid interbreeding

with genotypes not adapted to the local conditions and to avoid compromising the local gene pool. If this rule is not followed, the result is generally the loss of plants because they are not competitive under local conditions or the result could be the success of a plant or plants that can not be considered truly native (considered by some to be a plant community reconstruction rather than a restoration). Research has already demonstrated that this species arose in different places at different times from genetically different parents (Werth *et al.* 1985), and these genetically distinct populations probably should be kept separate. The propagation of Bradley's spleenwort in Illinois from unknown spore sources would not be encouraged in a restoration effort. Local plants should, instead, be propagated for planting in such an effort. Ferns are considered to be rather easily grown from spores under controlled conditions. However, it is yet to be determined if Bradley's spleenwort can be successfully grown and restored to its habitat in this way.

SUMMARY

Bradley's spleenwort is a small tufted evergreen fern native exclusively in the United States that has been documented in only eighteen midwestern and eastern states. This fern has been shown to be the fertile offspring of a cross between the Mountain spleenwort (*Asplenium montanum*) and the Ebony spleenwort (*Asplenium platyneuron*). It is found rooted in crevices on acidic rock outcrops, particularly on steep sandstone cliffs, in exposed, barren areas, sometimes in full sun. The populations are isolated partly because of infrequent suitable habitat and the number of individual plants at each site is small. Globally, its ranking is G4 (apparently secure world-wide, but factors exist to cause some concern). Though not truly common anywhere, Bradley's spleenwort is most often found in the Ozark region, and, in Illinois it is found primarily within the Shawnee National Forest. The species has been included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest, where no populations are known. It is vulnerable in Illinois where it is listed as Endangered, and it has also been listed as Endangered in Indiana, New Jersey, New York, and Pennsylvania, as Threatened in Ohio, and as Extirpated in Maryland. It faces several risks that could result in its extirpation throughout its range if it is not properly managed. These risks include quarrying and mining, recreational rock climbing, over zealous collecting, and drying and erosion from modification of the surrounding habitat. Casual access to the vicinity of the populations should be limited. Continued population monitoring is needed and searches should be conducted for additional populations in far southern parts of both Illinois and Indiana in suitable habitat. Management through protection of its habitat and through possible exclosures may be needed for it to persist at its present locations, which are currently thought to be secure.

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CONTACTS

Shawnee National Forest; 50 Highway 145 South, Harrisburg, IL 62946 (618) 253-7114

Elizabeth L. Shimp	(618) 253-7114; e-mail: eshimp@fs.fed.us
Steve Widowski	(618) 658-2111; e-mail: swidowski@fs.fed.us

Hoosier National Forest; 811 Constitution Avenue, Bedford, IN 47421 (812) 275-5987

Steven D. Olson (719) 553-1400; e-mail: solson01@fs.fed.us
currently: Pike-San Isabel National Forests,
Cimarron-Comanche National Grasslands,
Kachina Drive, Pueblo, CO 81008

Illinois Natural History Survey; 607 E. Peabody Drive, Champaign, IL 61820

Dr. Steven R. Hill	(217) 244-8452; e-mail: srhill@mail.inhs.uiuc.edu
Dr. L. Richard Phillippe	(217) 244-2181; e-mail: rickp@mail.inhs.uiuc.edu
Dr. John B. Taft	(217) 244-5046; e-mail: taft@mail.inhs.uiuc.edu

Illinois Endangered Species Board

Dr. John E. Ebinger (217) 345-3815; e-mail: cfjee@eiu.edu

Biological Consultant

John E. Schwegman (618) 543-9429; e-mail: botany@midwest.net

Missouri Department of Conservation

Dr. George A. Yatskievych (314) 577-9522; e-mail: george.yatskievych@mobot.org

Tim E. Smith (573) 751-4115 ext. 3200; e-mail: smith2@mdc.st

Ohio Department of Conservation, Natural Heritage Program

Marilyn Ortt (614) 373-3372. Has begun monitoring programs on Bradley's spleenwort.

APPENDIX 1

Representative specimens of *Asplenium bradleyi* examined or cited in the literature

Herbaria:

ILLS = Illinois Natural History Survey Herbarium, Champaign. SIU = Southern Illinois University Herbarium, Carbondale. WIS = University of Wisconsin Herbarium, Madison.

ALABAMA: JACKSON CO., growing on sandstone cliffs, Long Island, May 1917, *Graves 458* (WIS)

ARKANSAS: CONWAY CO., 5 Jun 1973, *Taylor 944, 950, 958* (SIU); MADISON CO., 19 March 1974, *Taylor 2004* (SIU); NEWTON CO., 13 Jun 1975, *Taylor 2699* (SIU); POPE CO., 24 Jun 1973, *Taylor 1216* (SIU); STONE CO., 28 Sep 1975, *Taylor 2902* (SIU)

GEORGIA: DADE CO., on sandstone cliffs, 1917, *Graves 25* (WIS)

ILLINOIS: JACKSON CO., Piney Creek Ravine Nature Preserve, ca. 5 mi NE of Rockwood, *Mohlenbrock 5629* (SIU); 12 Mar 1955, *Mohlenbrock 8601* (SIU); RANDOLPH CO., Rockcastle Creek, 3 mi S of Steeleville, 22 May 1954, *Mohlenbrock & Voigt 2491* (SIU); 15 Jul 1969, *Wunderle s.n.* (SIU); 7 Aug 1954, *Mohlenbrock 4629* (SIU); 13 Nov 1954, *Mohlenbrock 4948* (SIU); 3 Apr 1955, *Mohlenbrock 4994* (SIU); 26 May 1970, *Faulkner 270* (SIU); SALINE CO., crevice in sandstone cliff, Garden of the Gods, south of Derby, 29 Jun 1966, *Evers 87715* (ILLS); sandstone cliff in dry upland forest, Cave Hill, 1 Jun 1986, *Olson 264* (ILLS); UNION CO., sandstone cliff, Panther Den area north of Lick Creek, 15 Sep 1964, *Evers 81488* (ILLS); La Rue - Pine Hills Research Natural Area, 28 Jul 1969, *Wunderle s.n.* (SIU)

MISSOURI: COUNTY ?, 1 Aug 1954, *Mohlenbrock 4503* (SIU)

TENNESSEE: eastern Tennessee, s.d., ex herb. *D.C.Eaton.*[herbarium of Wellesley College 329, canceled] (WIS)

VIRGINIA: GILES CO., S end Peters Mountain, sandstone outcrops, Allegheny Mountains, 17 Aug 1962, *Gersh s.n.* (WIS)

APPENDIX 2.

The Distribution of *Asplenium bradleyi* in the United States.
Information from herbarium specimens and the literature. Incomplete.

STATE	COUNTIES	NOTES
Alabama	Jackson; possibly Cherokee, Cleburne, DeKalb	? may be in Talladega National Forest
Arkansas	26 counties, primarily northwestern	see Smith 1988, W-2; includes Ozark and Ouachita National Forests
Georgia	Cobb, Dade, De Kalb, Floyd, Lincoln, Rabun, Stephens, Upson, Walker	see W-2; includes Chattahoochee National Forest
Illinois	Jackson, Randolph, Saline, Union	includes Shawnee National Forest
Indiana	Dubois	1 population
Kentucky	22 counties, west-central and eastern areas	see W-2; includes Daniel Boone National Forest
Maryland	Baltimore, Carroll, Harford, Howard	historic; extirpated ?
Missouri	20 counties, southeastern and southwestern areas	see W-2, Yatskievych 1999; includes Mark Twain National Forest
New Jersey	Sussex, Warren [extreme northwestern]	
New York	Orange, Ulster	historic; extirpated
North Carolina	Burke, Cleveland, Gaston	see W-2
Ohio	Athens, Fairfield, Pike, Washington	see W-5
Oklahoma	McCurtain	includes Ouachita National Forest
Pennsylvania	[extreme southeastern]	
South Carolina	Chesterfield, York	see W-2
Tennessee	Fentress, Grainger, Grundy, Hamilton, Marion, Polk, Rhea, Sequatchie, Van Buren	see Chester *et al.* 1993; includes Cherokee National Forest
Virginia	15 counties, piedmont and mountains	see W-2
West Virginia	Fayette, Grant, Jefferson, Kanawha	see W-2

APPENDIX 3.

Natural Diversity Database Element Ranking System

modified from: http://www.cnpsci.org/html/PlantInfo/Definitions2.htm [W-6]

Global Ranking (G)

G1
Critically imperiled world-wide. Less than 6 viable elements occurrences (populations for species) OR less than 1,000 individuals OR less than 809.4 hectares (ha) (2,000 acres [ac]) known on the planet.

G2
Imperiled world-wide. 6 to 20 element occurrences OR 809.4 to 4,047 ha (2,000 to 10,000 ac) known on the planet.

G3
Vulnerable world-wide. 21 to 100 element occurrences OR 3,000 to 10,000 individuals OR 4,047 to 20,235 ha (10,000 to 50,000 ac) known on the planet.

G4
Apparently secure world-wide. This rank is clearly more secure than **G3** but factors exist to cause some concern (i.e. there is some threat, or somewhat narrow habitat).

G5
Secure globally. Numerous populations exist and there is no danger overall to the security of the element.

GH
All sites are historic. The element has not been seen for at least 20 years, but suitable habitat still exists.

GX
All sites are extirpated. This element is extinct in the wild.

GXC
Extinct in the wild. Exists only in cultivation.

G1Q
Classification uncertain. The element is very rare, but there is a taxonomic question associated with it.

National Heritage Ranking (N)

The rank of an element (species) can be assigned at the national level. The **N-rank** uses the same suffixes (clarifiers) as the global ranking system above.

Subspecies Level Ranking (T)

Subspecies receive a **T-rank** attached to the G-rank. With the subspecies, the G-rank reflects the condition of the entire species, whereas the T-rank reflects the global situation of just the subspecies or variety.

For example: *Chorizanthe robusta* var. *hartwegii*. This plant is ranked **G2T1**. The G-rank refers to the whole species range (*i.e.*, *Chorizanthe robusta*, whereas the T-rank refers only to the global condition of var. *hartwegii*. Otherwise, the variation in the clarifiers that can be used match those of the G-rank.

State Ranking (S)

S1
Critically imperiled. Less than 6 element occurrences OR less than 1,000 individuals OR less than 809.4 ha (2,000 ac). **S1.1** = very threatened; **S1.2** = threatened; **S1.3** = no current threats known.

S2
Imperiled. 6 to 20 element occurrences OR 3,000 individuals OR 809.4 to 4,047 ha (2,000 to 10,000 ac). **S2.1** = very threatened; **S2.2** = threatened; **S2.3** = no current threats known.

S3
Vulnerable. 21 to 100 element occurrences OR 3,000 to 10,000 individuals OR 4,047 to 20,235 ha (10,000 to 50,000 ac). **S3.1** = very threatened; **S3.2** = threatened; **S3.3** = no current threats known.

S4
Apparently Secure. This rank is clearly lower than S3 but factors exist to cause some concern (*i.e.*, there is some threat, or somewhat narrow habitat).

S5
Secure. Demonstrably secure to ineradicable in the state.

SH
All state sites are historic; the element has not been seen for at least 20 years, but suitable habitat still exists. Possibly extirpated.

SR
Reported to occur in the state. Otherwise not ranked.

SX
All state sites are extirpated; this element is extinct in the wild. Presumed extirpated.

Notes:

1. Other considerations used when ranking a species or natural community include the pattern of distribution of the element on the landscape, fragmentation of the population/stands, and historical extent as compared to its modern range. It is important to take a bird's eye or aerial view when ranking sensitive elements rather than simply counting element occurrences.

2. Uncertainty about the rank of an element is expressed in two major ways: by expressing the rank as a range of values (*e.g.*, **S2S3** means the rank is somewhere between S2 and S3), and by adding a '?' to the rank (*e.g.* S2?). This represents more certainty than S2S3, but less than S2.