

***Conservation Assessment
for
Black-stem Spleenwort (*Asplenium resiliens*) Kunze***



Photo: Jerry Evans

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Steven R. Hill, Ph.D.
Illinois Natural History Survey
Center for Biodiversity
607 East Peabody Drive
Champaign, Illinois 61820



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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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

Table of Contents

ACKNOWLEDGMENTS4
EXECUTIVE SUMMARY4
NOMENCLATURE AND TAXONOMY5
DESCRIPTION OF SPECIES.....6
HABITAT AND ECOLOGY6
DISTRIBUTION AND ABUNDANCE.....8
PROTECTION STATUS9
LIFE HISTORY.....10
POPULATION BIOLOGY AND VIABILITY.....11
POTENTIAL THREATS12
RESEARCH AND MONITORING14
RESTORATION15
SUMMARY15
REFERENCES.....16
WEBSITES CONSULTED18
CONTACTS19
APPENDICES21

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EXECUTIVE SUMMARY

This Conservation Assessment is a review of the distribution, habitat, ecology, and population biology of Black-stem spleenwort, *Asplenium resiliens* Kunze, 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 Black-stem spleenwort to date. Black-stem spleenwort is a small tufted evergreen fern, a perennial herb, that is found in the United States south to Central and South America, and, in the United States, it is widespread and it has been found in twenty-six states, excluding only the westernmost and northernmost states. This fern has been shown to be an apogamous species, a fern in which the sporophyte is produced from a gametophyte without fertilization. It is found rooted in shaded crevices and on ledges of dolomite and limestone bluffs and boulders. The populations are scattered and isolated partly because of infrequent suitable habitat and the number of individual plants at each site is generally small. However, it is considered to be relatively common overall within its range. Globally, its ranking is G5 (secure globally). Black-stem spleenwort is most often found in the Cumberland Plateau, Tennessee Basin, and Ozark regions, and, in Illinois it is found only 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 both Illinois and Indiana where it is listed as Endangered, and it has also been listed as Endangered in Maryland and Pennsylvania, and it is listed as Presumed Extirpated in Louisiana and Possibly Extirpated in Ohio. It faces several risks that could result in its local extirpation in parts of its range if it is not properly managed.

In addition 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:	<i>Asplenium resiliens</i> Kunze
Common Names:	Black-stem spleenwort; Blackstem spleenwort; Black-stemmed spleenwort; Little ebony spleenwort
Synonymy:	<i>Asplenium parvulum</i> M. Martens & Galeotti, illegitimate name; <i>Chamaefilix resiliens</i> (Kunze) Farw.; <i>Asplenium lealii</i> Alston
Class:	Filicopsida (Ferns)
Family:	Aspleniaceae (the Spleenwort family)
Plants Code:	ASRE (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 far less common *Asplenium heterochroum* Kunze, a fern primarily of the Caribbean subtropics, with which it occasionally hybridizes (to produce *Asplenium X heteroresiliens* W.H. Wagner). It resembles the very common Ebony spleenwort (*Asplenium platyneuron* (L.) Britton *et al.*) but can be rather easily distinguished from it by its opposite, not alternate, pinnae, and the fact that its sterile and fertile fronds are about the same size (the fertile fronds are more erect and larger in Ebony spleenwort). There are habitat preference differences, as well as significant chromosomal and reproductive differences between the two species as well. It also resembles *Asplenium trichomanes* L., but the pinnae on that species are nearly oval and not much longer than wide, and the rare *Asplenium monanthes* L., which has a single sorus per pinna and is primarily tropical. It is a true fern, a vascular plant that reproduces by spores.

DESCRIPTION OF SPECIES

Asplenium resiliens is a small tufted evergreen perennial fern with a 1-2 mm thick compact erect rhizome. The black wiry roots spread to about the width of the fronds or wider when not confined. Its leaves (fronds) are 5-30 cm long, and their black shiny stalks are short, 1.5-5 cm of that length. The short wiry stalks are often persistent at the base of the plant. At the base of the leaf rosette, black narrowly lanceolate scales can be found. The leaf blades (laminae) are narrowly-oblong or linear-lanceolate, dull to bluish-green when fresh, normally 1-2.5 cm wide, once pinnate, tapered at base and apex, acute at the apex, with (5-)20-30(-40) pairs of opposite essentially sessile pinnae that are oblong to lanceolate (usually 3-5 times as long as wide), 6-10 mm long, and auriculate (with an enlarged basal lobe) but the lobes generally do not overlap the rachis (which is also black and shiny); the pinnae margins are slightly crenulate to nearly entire, the leaf veins are evident; the (2-)4-5(-10) sori are about 1 mm long (description primarily from Gleason & Cronquist 1991, Lellinger 1985, Wagner *et al.* 1993).

Black-stem spleenwort is considered to be an apogamous triploid species, and it produces 32 spores per sporangium (in contrast to the usual 64 produced in other spleenworts and true ferns) and it has a chromosome number of $2n = 108$. It is distinguished rather easily from most other spleenworts by the fact that its fronds are only once-pinnate, the pinnae are opposite, have crenate or nearly entire margins, and are about twice as long as wide, the rachis is nearly black, and the sterile and fertile fronds are not significantly different in size. The fresh fronds often appear to have a dull bluish cast when fresh.

HABITAT AND ECOLOGY

Asplenium resiliens is normally found in a distinctive and somewhat limited habitat (Lellinger 1985). Typically, the plants generally grow on moist shaded rock, particularly on limestone and dolomite or other basic rocks, on boulders, on cliffs, and in sinkholes. They can be found in crevices and pockets on the rock, or on horizontal surfaces such as ledges. The soil is generally thin and composed almost entirely of humus. These areas are often near streams or drainages where the limestone has been exposed by erosion. In this habitat the air is typically still and humid.

Black-stem spleenwort can grow in shade, and it is normally not found in areas exposed to full sun nor a very dense forest canopy. Its habitat is characterized by an open understory that allows a good supply of diffuse light. The plants are not crowded or overwhelmed by neighboring vascular plants primarily because much of the habitat in the vicinity of the ferns is bare rock.

Asplenium resiliens is tolerant of heat, and it occurs well into the tropics. It may not be tolerant of extreme cold, as surmised by its distribution. The areas surrounding the outcrops and boulders where it grows are generally forested with species somewhat tolerant of drought conditions and the forest plants help to add organic material to the surfaces and the rock crevices where the ferns grow. However, the plants must grow in areas where heavy leaf litter does not accumulate because they would be easily smothered and unable to photosynthesize during the crucial period from fall through spring. This fern is generally considered to belong to the Limestone Cliff natural community, and the plant community surrounding the outcrops or boulders is generally a dry mesic or mesic upland forest (White & Madany 1978) or sometimes a

mesic floodplain forest. The habitat exposure is often western, but it can be nearly any direction provided that canopy conditions are right for photosynthesis (eastern exposures may be as common). In North Carolina, *Asplenium resiliens* is considered to be a member of the Spray Cliff and Montane Acidic Cliff communities (see Gaddy 2002).

The outcrops where it grows are often vegetated by bryophytes, especially moss species of the genera *Anomodon*, *Brachythecium*, *Mnium*, and *Rhodobryum*. The other spleenworts *Asplenium platyneuron*, *Asplenium rhizophyllum*, and *Asplenium trichomanes* are occasional associates nearby. Other plants commonly associated with Black-stem spleenwort in its surrounding habitat generally include the trees *Acer saccharum*, *Celtis* sp., *Fraxinus* spp., *Juniperus virginiana*, *Tilia americana*, and *Ulmus* sp., the vines *Clematis* sp. and *Vitis* sp., the shrubs *Hydrangea arborescens*, *Rhus aromatica*, and *Staphylea trifolia*, the herbs *Aquilegia canadensis*, *Delphinium tricorne*, *Galium triflorum*, *Hepatica acutiloba*, *Pilea pumila*, and the additional ferns *Cystopteris bulbifera*, *Pellaea atropurpurea*, and *Polypodium virginianum*.

The thin soils on which the plants grow are composed of organic materials from decomposing plant materials (usually bryophytes) and often clayey or sandy residuum from the weathered rock surface as well. The roots spread to about the width of the fronds or wider and anchor the plants rather firmly. The soil pH is basic to nearly neutral because soils normally formed from such outcrops are typically so. The fern does not appear to tolerate acidic substrates. The normally thin soil is well drained but holds water well in the winter and spring during the plant's initial growing and reproductive season. The plants are 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. The leaves are capable of losing considerable water and wilting during dry periods, and then becoming hydrated again after a rain (personal observations). 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 sufficient nutrients and moisture during the plant's dormancy and the individual plants appear to persist for years. There are differing opinions on whether or not this habitat should be considered a pioneering rather than a mature habitat, some saying that there is no significant change in the habitat over time (Skorepa 1973). 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 bryophytes growing with the plants may assist in water collection for this species (personal observations).

The species is well adapted to this somewhat harsh and somewhat scarce habitat, and there are generally only a few other plants that are able to grow with it. Therefore, there is little competition from other plant species and Black-stem spleenwort often grows alone with bryophytes on bare shaded rock. This fern does not appear to be able to compete well with other plants. This habitat type is sometimes plentiful in certain areas of some states, and its tolerance for shade probably has increased its chances for survival. It has not been successfully cultivated for long periods, as far as it is known, and this supports its designation as a specialist species with rather narrow habitat tolerances. Some plants have been cultivated for 1-2 years, but they do not persist much longer than that (personal observations).

DISTRIBUTION AND ABUNDANCE

Asplenium resiliens is relatively widespread in range compared to some of the other spleenworts, and it has been found in an area mostly south of the glacial boundary in the southern states and further south. It is known to occur historically in twenty-six states, namely, AL, AR, AZ, CO, FL, GA, IL, IN, KS, KY, LA, MD, MO, MS, NC, NM, NV, OH, OK, PA, SC, TN, TX, UT, VA, and WV (W-2, W-3). From the United States, it continues south into Mexico, the West Indies, and Central America into western South America (Wagner *et al.* 1993). Wagner *et al.* (1993) did not record it in Colorado, Indiana, Ohio, or South Carolina, but it has been found in those states. Its distribution is not continuous but is spotty or discontinuous, with a few notable disjunctions. Additional details on the distribution of Black-stem spleenwort can be found in Barkley *et al.* (1977), Chester *et al.* (1993), Cranfill (1980), Mohlenbrock (1986), Mohlenbrock and Ladd (1978), Kartesz and Meacham (1999), Reed (1953), Smith (1988), Snyder and Bruce (1986), Taylor (1984), Thomas & Allen (1993), and Yatskievych (1999) and several Internet sites (*e.g.*, W-2, W-3). *Asplenium resiliens* occurs in the Appalachian region and it is fairly frequent in the Ozark and Ouachita regions.

Kartesz and Meacham (1999), Wagner *et al.* (1993) and major Internet sites (*e.g.* W-2, W-3) reported this spleenwort in Delaware, but this report appears to be erroneous. No specimens or records of the plant could be found in the herbarium at Dover, Delaware (Naczi, pers. comm.). The cited source of the record, Reed's "Ferns and fern-allies of Maryland and Delaware" (1953) specifically states "Known only on the limestone of the Hagerstown Valley, Washington County, Maryland" (where I have seen it, also). Kartesz and Meacham (1999) may have taken the map under the text to represent its distribution, which is actually represented on map 43 on a previous page of Reed's book and this fern does not appear to exist in Delaware.

Black-stem spleenwort is at its northern and eastern limits of distribution in Maryland and Pennsylvania, and at its western North American limits in southeastern Nevada and southwestern Arizona. It is in the somewhat isolated Ozarkian Shawnee Hills and plateau of extreme southern Indiana and Illinois. Representative specimens of the Black-stem spleenwort have been listed in Appendix 1. A summary of its distribution within the United States has been presented in Appendix 2.

Within the U.S. Forest Service Eastern Region (Region 9) *Asplenium resiliens* has been confirmed to be present within the Shawnee National Forest in Illinois, where there are one to three populations (depending upon interpretation). In fact, all known extant populations in Illinois are within the Shawnee National Forest. It has not been found on the Hoosier National Forest in Indiana although suitable habitat is present.

In Indiana, *Asplenium resiliens* is known from two counties, Clark and Harrison, east of the Hoosier National Forest (Indiana Heritage Data Center 2001, W-4). In Illinois, where it is listed as Endangered, the species has been reported historically in Alexander, Jackson, and Union Counties (Herkert *et al.* 1991, Illinois Endangered Species Protection Board [IESPB] 1999). At least one population has been extirpated by over collecting (Herkert *et al.* 1991). These sites fall within the Southern Section of the Ozark Natural Division of Illinois (Schwegman *et al.* 1973) just south of the glacial boundary. The distribution of this species in Illinois has been discussed

by Mohlenbrock and Engh (1964), Mohlenbrock and Voigt (1965), and Ozment (1967).

All populations in Illinois and elsewhere are individually small, generally with only about 5-50 plants present. In Illinois, records of population sizes were not indicated in the Natural Heritage database. Perhaps significantly, there were 10 specimen sheets from Illinois of this rare fern at the Southern Illinois University herbarium. This amount of collecting can certainly adversely affect this species. These ferns can be local or widely scattered over the substrate. Furthermore, the populations are isolated from one another because of the specific requirements for an uncommon habitat and an intolerance of aggressive competition. In terms of numbers of individuals, it is possible that the entire number of individuals in Illinois may be less than one hundred at this time. In the course of conversation, some botanists have told me that they believe there are far less than that remaining. There is little specific data in this regard but the limited number of remaining sites and typical population sizes for the species suggest this low number of survivors. It is known to have been somewhat more common in the past.

PROTECTION STATUS

The Nature Conservancy ranking for *Asplenium resiliens* is G5 (secure globally; W-3, Appendix 3). In the United States the species is given the National Heritage status rank of N5 with a similar meaning. The state rankings vary, but it has been designated as Endangered in Illinois, Indiana, Maryland, and Pennsylvania, and it has been designated as Presumed Extirpated in Louisiana and Possibly Extirpated in Ohio. While it is tracked and acknowledged to be uncommon in most states, it is not protected in most of the states where it grows.

Asplenium resiliens 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 relatively non-showy individuals is currently dependent on habitat protection, and so its survival will probably depend more on this than on species protection. *Asplenium resiliens* appears to be restricted to a specialized and scarce habitat and some of the best examples of this habitat (shaded limestone boulders and cliffs) have been given a priority for protection in some states including Indiana (see W-4).

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-5). A summary of the current official protection status for Black-stem spleenwort follows:

U.S. Fish and Wildlife Service:	Not listed (None)
U.S. Forest Service:	Region 9, Sensitive (Illinois)
Global Heritage Status Rank:	G5
U.S. National Heritage Status Rank:	N5

Table 1: S-ranks for *Asplenium resiliens* [Heritage Identifier number PPASP02170]

<u>State</u>	<u>Heritage S-rank</u>	<u>State</u>	<u>Heritage S-rank</u>
Alabama	SR	Missouri	SR
Arizona	SR	Nevada	SR
Arkansas	SR	New Mexico	SR
Colorado	S1	North Carolina	S2
[Delaware	SR] - erroneous report	Ohio	SH
Florida	SR	Oklahoma	SR
Georgia	SR	Pennsylvania	S1
Illinois	S1	South Carolina	S1S2
Indiana	S1	Tennessee	SR
Kansas	SR	Texas	SR
Kentucky	S4	Utah	S1
Louisiana	SX	Virginia	SR
Maryland	S1	West Virginia	S?
Mississippi	S1		

LIFE HISTORY

Asplenium resiliens is a tufted evergreen fern, a perennial herb, but its average life span is not known. Growth is slow and some individuals may be 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-)10-20 leaves are on a plant at any given time, though in most populations few are that robust, and a few new fronds are produced each year. 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 may grow into small heart-shaped flat green thalli (gametophytes) 0.5 cm long or less. In contrast to most ferns, however, the Black-stem spleenwort is an apogamous species. This means that the sporophyte (spore producing fern) develops directly from the gametophyte cells rather than from a fertilized egg. Fertilization and free-swimming gametes are not required. This species has a chromosome number of $n = 2n = 108$ chromosomes. It is considered to be a triploid species ($x = 36$) and its chromosomes cannot pair properly to form a zygote. This means that while a suitable moist environment is still needed for the gametophyte stage of the life cycle, and they do produce gametes, a film of water is not needed for the motile sperm and a dependence on chance for fertilization is not a problem. It also means that there is no introduction of new genetic

material and the plants are essentially genetically identical. Also because of this, hybridization is rare. Nevertheless, the offspring plant is not secure until it has developed a durable set of leaves and roots that can withstand drought. These conditions are infrequently met in this exposed habitat, but, with the elimination of the need for fertilization, species success is likely under stable environmental conditions and sufficient moisture for the gametophytes.

Spores probably do not survive or persist for long after being shed. Instead, it appears that the locally moist conditions needed for the growth of the gametophyte associated with the organic substrate is crucial to the species' survival. Sporophyte establishment may occur in favorable years only.

Under favorable conditions during the gametophyte stage, gametes from neighboring gametophytes of other related species can occasionally fertilize or be fertilized by this species. The only crosses known (Wagner 1954) are with the similar subtropical fern species *Asplenium heterochroum* Kunze ($n = 72$; $2n = 144$) with which it has hybridized to produce another apogamous species, the very rare *Asplenium X heteroresiliens* W.H. Wagner ($n = 2n = 180$).

POPULATION BIOLOGY AND VIABILITY

In the previous section, the unusual life history of *Asplenium resiliens* was briefly presented. While mature individuals appear to be sturdy and, perhaps, long-lived the success of establishment and growth of individuals to maturity on thin soils over outcrops is difficult and can depend on local conditions and on suitable years. It is possible that in this habitat each plant can produce more than one successful offspring during its lifetime because of the apogamous nature of its reproduction, but the habitat is limited. It is not known how far the spores can travel, but the local nature of the populations suggests that they cannot travel long distances or that there is little additional suitable habitat available for the species even if they can. The Black-stem spleenwort may not be able to compete well with other plants for space except in this specific habitat. Therefore, its viability depends entirely upon its persistence at its currently known sites and on habitat protection.

The Black-stem spleenwort may have difficulty re-establishing 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 generally too great, and the numbers of reproductive individuals are too small. In addition, the still and humid conditions where it grows are not conducive to air movement and spore dispersal for long distances. The species has been given a secure rank of G5 because, historically and based upon herbarium collections, a significant number of populations have been found over a large part of the country. However, an unknown number of these populations are now gone, and the loss of a few populations can eliminate the fern from an entire state (*e.g.*, Louisiana and Ohio). In states where it is not being actively monitored, it is not known how many populations or individuals still exist (see Table 1 "SR"]. At the margins of its range, fewer plants are found each time during a census. However, the species is considered to be somewhat stable and still viable in parts of its range at this time, and some of the populations are protected within conservation areas or national forests (W-3).

In southern Illinois and Indiana, suitable habitat for the species occurs along a narrow band in the

area of limestone hills east of the Mississippi River floodplain where there appears to be additional suitable habitat for the plant available. There are other limestone and dolomite outcrops that provide suitable habitat here and in other parts of Illinois, but the species has not been found north of the glacial boundary in the state. While it is thought that most significant sized populations have been discovered because the habitat is a very popular one among botanists (it is often considered to be very species-rich and distinct), additional searches are suggested. With proper habitat management, the current populations in Illinois may persist, but they are extremely vulnerable because of the small number of them remaining.

POTENTIAL THREATS

Through its entire range, Black-stem spleenwort is considered secure because of the large numbers of populations that have been recorded in a few key states. However, its habitat does not occur everywhere, it may not be cold tolerant, and this fern cannot tolerate 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). Limestone and dolomite in themselves are in great demand by the construction and agricultural industries. The other threats to the species include physical damage from trampling by rock climbers, hikers, and equestrians, from over-zealous collecting, and from degradation of the environment. The elimination of vegetation cover in the immediate vicinity of the fern colonies may not only cause the habitat to dry out beyond the fern's tolerance and ability to reproduce (by means of its gametophytes), but it may also reduce or eliminate the humus layer in which the plants grow. The ferns are particularly vulnerable to the growth of vines, such as the exotic Japanese honeysuckle and the native Virginia creeper among others, that can overwhelm the rock outcrops and that may produce too much shade for the ferns to persist. The growth of other understory species (particularly aggressive exotic species such as shrubby honeysuckles) may also shade some populations and cause them to decline (W-3). If prolonged drought occurs, the populations would also be expected to decline or even disappear. It has been reported that over-collecting has eliminated at least one population of the plant in Illinois (Herkert *et al.* 1991), and this may happen again. This threat has resulted from increased knowledge and interest in of the plant's unusual distribution and life history, its rarity, and because it is evergreen and easily found early and late in the year.

Botanists generally believe that most native plants have reached the limits 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 resiliens*, 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. Still, because this fern has tropical affinities and because it does not occur very far north, it may not be able to survive the colder conditions much farther north from its present distribution. It may also be unable to increase its range very quickly because of a limited opportunity for spore dispersal due to the stillness of the air in its environment. The climatic factor of winter and spring moisture appears to be crucial for this fern as it is for the bryophytes and spring ephemerals with which it grows, along with a stability of soil and a lack of competition. Under natural conditions, these habitats are stable, but if the habitat becomes too shaded, if it becomes too dry, if nutrient and soil accumulation changes, or if human or animal traffic increases, the fragile habitat balance can be destroyed and the populations can be lost. The use of fire as a management tool does not appear to be at all beneficial to this species; the outcrops and boulders actually provide some protection from natural fires and a combustible component is generally not part of its immediate environment. Burning of the surrounding forest would probably be very detrimental by increasing drying and erosion, but hard data is lacking (W-3).

Biologists also generally believe 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 constructed developments, clear cuts, 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 Black-stem spleenwort, random genetic drift may have already occurred. However, because this is an apogamous and not sexually reproducing species, the affects of isolation and random genetic drift may not apply, though chance mutation would still play a role.

Some of the best-known colonies of the plant in Illinois occur near well-used trails and have been visited regularly for class field trips, and it is thought that this has had negative effects on them. Restricted access to the sites, relocation of the trails, and the complete elimination of recreational activities or casual visitation to the remaining populations 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). Some of these activities are currently illegal where this species grows in the Shawnee National Forest. As stated above, this fern is rather popular among researchers and educators because of its well-publicized and unusual reproduction methods as well as because it is evergreen, and botanists tend to collect it when they see it. While this does not normally affect most species, because the population sizes of this fern 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 strip-mining of the cliffs and other outcrops in the vicinity of these ferns could quickly eliminate a population. Likewise, the construction of any buildings on or near outcrops in the vicinity of 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 that may influence long-term viability.

At the current time, it does appear that the populations of *Asplenium resiliens* in the Shawnee National Forest are immediately threatened with elimination because of potential or current activities described above. In the absence of restrictions on collecting and / or future management of the forest and limestone cliffs for this species, it could decrease or be eliminated in Illinois.

RESEARCH AND MONITORING

There has been a considerable amount of research on the genetics of this species thanks to the work of Wagner (1954). There has not been 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).

Black-stem 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 resiliens* 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-4). Photographs are a less damaging means to document this species, but the plant must be positively identified and so vouchers may be necessary.

Of particular importance is the monitoring of the known populations regularly 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 or all of the colonies within a newly devised protective fencing to investigate the effectiveness of this kind of protection that would still allow monitoring. Protection of the habitat in which *Asplenium resiliens* lives is the primary management need according to the Nature Conservancy (W-3).

Research is needed concerning the artificial establishment of this plant. While gametophytes of this and most other ferns can be grown rather easily under controlled conditions, and the production of sporophytes may not be a problem in this species because fertilization is not needed, the subsequent acclimation and introduction of these young ferns into a natural environment may or may not be possible. As far as known, it has not been attempted at a large scale.

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 located, 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 resiliens* in Illinois may be poor. The number of populations and individuals in the state is extremely low.

There are no known restoration efforts being conducted on *Asplenium resiliens* 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 years. 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 somewhat secure but declining United States fern, especially at the margins of its range. Black-stem spleenwort is occasionally available commercially, but it is not generally cultivated (Lellinger 1985). An Internet search found it for sale by Rock Island Wildflowers, Rock Island, Tennessee [<http://rockislandwildflowers.com/>] at a cost of \$ 3.90/plant, and by Country Arbors Nursery [<http://www.countryarbors.com/>] of Urbana, Illinois for \$ 5.95/plant. Restorations of any native plant species are recommended using only 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 cannot be considered truly native (considered by some to be a plant community reconstruction rather than a restoration). The propagation of Black-stem spleenwort in Illinois from unknown spore sources would not be encouraged in a restoration effort. Local plants should, instead, be carefully 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 Black-stem spleenwort can be successfully grown and restored to its habitat in this way.

SUMMARY

Black-stem spleenwort is a small tufted evergreen fern that is found in the United States south to Central and South America. In the United States, it is widespread and known to have been found historically in twenty-six states, excluding only the westernmost and northernmost states. This fern has been shown to be an apogamous species, a fern in which the sporophyte is produced from a gametophyte without fertilization. It is found rooted in shaded crevices and on seasonally moist ledges of dolomite and limestone bluffs and boulders. The populations are scattered and isolated partly because of infrequent suitable habitat and the number of individual plants at each site is generally small. However, it is considered to be relatively common overall within its range. Globally, its ranking is G5 (secure globally). Black-stem spleenwort is most often found in the Cumberland Plateau, Tennessee Basin, and Ozark regions, and, in Illinois it is found only 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 both Illinois and Indiana where it is listed as Endangered, and it has also been listed as Endangered in Maryland and Pennsylvania. It has been listed as Presumed Extirpated in Louisiana and Possibly Extirpated in Ohio.

The Black-stem spleenwort faces several risks that could result in its local extirpation in parts of its range if it is not properly managed. These risks include quarrying and mining, recreational activities, over-collecting, and drying and erosion of habitat from modification of its surroundings. Casual access to the vicinity of the populations in the Shawnee National Forest should be limited. Continued regular population monitoring is needed and searches should be conducted for additional populations in far southern parts of both Illinois and Indiana in suitable habitat. Strong management through protection of its habitat and through possible exclosures may be needed for it to persist at its present locations, which are few and not 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

Mike Homoya [Indiana DNR, see W-4 above]

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 Philippe (217) 244-2181; e-mail: rckp@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

APPENDICES

Appendix 1

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

Herbaria:

CLEMS = Clemson University Herbarium. GH = Harvard University Herbaria. ILLS = Illinois Natural History Survey Herbarium, Champaign. MARY = University of Maryland Herbarium. NCU = University of North Carolina Herbarium. NY = New York Botanical Garden Herbarium. SIU = Southern Illinois University Herbarium, Carbondale. VT = University of Vermont Herbarium. WIS = University of Wisconsin Herbarium, Madison.

ALABAMA: JACKSON CO., AL Rt. 65, 1.0 mi S of Princeton, along Paint Rock River, 13 Apr 1992, *Hill 22949* (CLEMS, NY)

ARKANSAS: BAXTER CO., limestone bluffs, partial shade, Cotter, 5 Sep 1918, *Palmer 14303* (WIS); 9 Sep 1973, *Taylor 1840* (SIU); 12 Jun 1975, *Taylor 2673* (SIU); 12 Jun 1975, *Taylor 2680* (SIU - 2 sheets); BENTON CO., Ozark Plateau, Boston Mountains foothills, Osage River valley, a tributary of the Illinois River, 15 Oct 1928, *Demaree 4615* (WIS); Ozark Plateau, Boston Mountains foothills, near Gentry, 16 mi WSW of Bentonville, 15 Oct 1927, *Demaree 4636* (WIS); LAWRENCE CO., 8 Sep 1973, *Taylor 1788* (SIU); NEWTON CO., 8 Nov 1974, *Demaree 69271, 69281* (SIU); 13 Jun 1975, *Taylor 2698* (SIU); SEARCY CO., 25 Jun 1973, *Taylor 1243* (SIU); 19 Aug 1974, *Taylor 2575* (SIU); STONE CO., 11 March 1951, *Stewart et al. s.n.* (SIU); 25 Jun 1973, *Taylor 1244, 1255* (SIU); 28 Sep 1975, *Taylor 2896* (SIU); WASHINGTON CO., cliffs along the White River, Goshen, 13 Jun 1938, *Fassett & Nielsen 19798* (WIS); limestone cliff, West Fork, 22 Apr 1935, *Fassett 17334* (WIS); limestone cliff, Illinois River, Savoy, 23 Apr 1935, *Fassett 17336* (WIS); 16 Jun 1973, *Taylor 1110* (SIU)

GEORGIA: DADE CO., SE of Trenton, Sitton Gulch Creek south of Canyon Park Drive, 8 Apr 2000, *Hill 32203* (VT)

ILLINOIS: ALEXANDER CO., 2 mi east of McClure, wooded bluffs, 10 Apr 1964, *Ozment & Windler 22* (SIU - 2 sheets); Gale, west-facing exposed limestone, 10 Sep 1969, *Wunderle s.n.* (SIU - 2 sheets); JACKSON CO., Devil's Bake Oven, top of limestone cliff, 29 Oct 1921, *Steagall s.n.* (SIU); on top of limestone cliffs, Grand Tower, 29 Oct 1921, *Steagall 12* (SIU); UNION CO., Pine Hills, east of Wolf Lake, 29 Jun 1940, *Gleason 9024* (GH); Pine Hills [Research Natural Area], east of LaRue, 14 Jun 1950, *Evers 23910B* (ILLS); 8 Oct 1949, *Hatcher s.n.* (SIU); NW part of county, limestone bluffs on west slope of Pine Hills, 21 Oct 1949, *Hatcher, et al. 922* (SIU); Pine Hills, limestone crevices, 21 Mar 1954, *Mohlenbrock s.n.* (SIU); 21 May 1967, *Ott C-96* (SIU); Fern Cove, Pine Hills, shaded, mesophytic limestone cove, 27 Jun 1969, *Wunderle s.n.* (SIU); Pine Hills #27, Hanging Rock # 34, Summer 1977, Homoya & Hutchinson (observation only ? - "Exterminated by collectors at Pine Hills site", IL Nature Preserves Commission notes)

MARYLAND: WASHINGTON CO., Potomac River at Sharpsburg, N of Rt. 34 bridge, 26 Aug

1981, *Hill 10710* (MARY)

MISSOURI: LAWRENCE CO., 26 Jun 1951, *Palmer 28165* (SIU); MCDONALD CO., on partially shaded limestone ledges near top of “Bob’s Knob” 1 mile south of Jane, 29 Jun 1957, *Palmer 65855* (WIS!); PHELPS CO., few plants on shaded dolomite cliff with *Pellaea atropurpurea*, 7 mi NW of Rolla, 7 Sep 1968, *Tans 202* (WIS); PULASKI CO., crevices of draw on west-facing lime bluff along Big Piney River, 4 mi SE of Tribune, 28 Aug 1937, *Steyermark 25506* (WIS)

NEW MEXICO: DONA ANA CO., Organ Mountains, Van Patten’s Camp, 3 Mar 1907, *Wooton 27032* (WIS)

NORTH CAROLINA: SWAIN CO. 20 Apr 1969, *Leonard & Cooper 2383* (SIU); Blowing Springs, Nantahala River Gorge on the east side of US 19, 20 Apr 1969, *Leonard & Cooper 2383* (NCU, WIS); CO.?, Warm Springs, 1878, *Vasey s.n.* (WIS - herb. Wellesley College canceled)

SOUTH CAROLINA: ORANGEBURG CO., Santee State Park NE of Rt. 6, Santee, 14 Jun 1988, *Hill 19573* (CLEMS)

TENNESSEE: ANDERSON CO., dissected bluff, south side of Clinch River I-75 bridge south of Lake City, 1 Apr 1983, *Sharp s.n.*(WIS); FRANKLIN CO., from Gen. E. Kirby Smith, Sewanee, ex herb. J.J.Davis, no date, *Smith s.n.* (WIS); HAMILTON CO., slopes of Middle Creek, N side Suck Creek Road, Signal Mountain area, 8 Apr 2000, *Hill 32174* (VT); MARION CO., growing on walls of sink hole near South Pittsburg, where hearts tongue grows, 1929, *Graves s.n.*(WIS); SEVIER CO., Little Pigeon River Valley, Great Smoky Mountains, May 1931, *Pepoon 207* (ILLS-2 sheets); CO. ?, Cliff Creek, Great Smoky Mountains, Aug 1931, *Pepoon 115* (ILLS-2 sheets);

VIRGINIA: GILES CO., with *Cystopteris bulbifera* (L.) Bernh. on limestone cliffs, entrance to Towley’s Cave along Sinking Creek, 1.7 mile NW of Newport. Allegheny Mountains, 22 Jul 1962, *Gersh s.n.* (WIS); CO. ?, Natural Tunnel, 4 Aug 1891, *Seymour 7* (WIS)

APPENDIX 2.

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

STATE	COUNTIES	NOTES
Alabama	northern counties, especially Jackson	see Wagner <i>et al.</i> 1993
Arizona	mostly southeastern	see Wagner <i>et al.</i> 1993
Arkansas	17 counties, primarily northwestern	see Smith 1988, Taylor 1984, W-2; apparently includes Ozark and Ouachita National Forests
Colorado	?	see Weber 1955

Florida	Gadsden, Suwannee	see W-2
Georgia	18 counties, concentrated in extreme northwest, but scattered	see W-2, Snyder & Bruce 1986; probably includes Chattahoochee National Forest
Illinois	Alexander, Jackson, Union	all in Shawnee National Forest
Indiana	Clark, Harrison	see W-4
Kansas	Bourbon, Chautauqua, Cherokee, Elk, Greenwood, Labette, Montgomery, Wilson, Woodson [all extreme southeast]	see W-2
Kentucky	30 counties, widely scattered	see W-2, Cranfill 1980; includes Daniel Boone National Forest
Louisiana	Winn	see Thomas & Allen 1993
Maryland	Washington	see Reed 1953
Mississippi	central portion of state ?	see Wagner <i>et al.</i> 1993
Missouri	39 counties, mostly Ozarks and southern third of state	see W-2, Yatskievych 1999; includes Mark Twain National Forest
Nevada	Clark	see Wagner <i>et al.</i> 1993
New Mexico	extreme southwestern	see Wagner <i>et al.</i> 1993
North Carolina	Craven, Jackson, Madison, McDowell, Stanly, Swain, Transylvania, Yadkin	see W-2, Gaddy 2002
Ohio	Adams	“This species has only been collected once in Ohio. There is a 1900 collection from Adams County.” see W-6
Oklahoma	14 counties, mostly south-central and northeast	see Barkley <i>et al.</i> 1977; possibly includes Ouachita National Forest
Pennsylvania	Franklin	see Wherry <i>et al.</i> 1979
South Carolina	Berkeley, Dorchester, Oconee, Orangeburg	South Carolina Dept. of Natural Resources, Heritage Program data
Tennessee	72 counties, nearly all of the eastern two-thirds of the state	see W-2, Chester <i>et al.</i> 1993; includes Cherokee National Forest
Texas	extreme west, central (Edward’s plateau), extreme southeast	see Wagner <i>et al.</i> 1993
Utah	San Juan, Washington - extreme southeastern and southwestern part of state	see W-2
Virginia	25 counties, piedmont and mountains	see W-2

West Virginia	12 counties, mostly southern and northeastern	see W-2
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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 worldwide. 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 worldwide. 6 to 20 element occurrences OR 809.4 to 4,047 ha (2,000 to 10,000 ac) known on the planet.

G3

Vulnerable worldwide. 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 worldwide. 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 variations 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.