

Conservation Assessment
for
Barren Strawberry (Waldsteinia fragarioides ssp. fragarioides)
(Michx.) Tratt.



© Missouri Botanical Garden, February 2001

USDA Forest Service, Eastern Region

04 June 2003

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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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

ACKNOWLEDGMENTS	4
EXECUTIVE SUMMARY	4
NOMENCLATURE AND TAXONOMY	5
DESCRIPTION OF SPECIES.....	6
HABITAT AND ECOLOGY.....	7
DISTRIBUTION AND ABUNDANCE.....	10
PROTECTION STATUS	13
LIFE HISTORY.....	15
POPULATION BIOLOGY AND VIABILITY.....	15
POTENTIAL THREATS.....	16
RESEARCH AND MONITORING	19
RESTORATION	21
SUMMARY	22
REFERENCES.....	23
APPENDICES	28

ACKNOWLEDGMENTS

The staffs of the U.S.D.A. Forest Service, Shawnee and Hoosier National Forests have provided the opportunity to compile these conservation assessments and I thank them for their invaluable assistance with data and field opportunities. Mark Basinger, Stan McTaggart, Steve Olson, Beth Shimp, and Steve Widowski were particularly helpful in facilitating both the cost share agreement and fieldwork.

The staff of the Illinois Natural History Survey, Champaign, also provided assistance with logistics necessary to complete these reports. I especially thank John Taft for help in initiating these studies.

Several people assisted by contributing information on this rare herb. Ted Bradley provided information on some Virginia records, Allison Cusick assisted with information on Ohio occurrences, Steve Ginzburg provided information for Alabama populations, Steve Glenn provided information on New Jersey and New York records, Mike Homoya provided information on the plant in Indiana, and Rich Rabeler shared citations for Michigan specimens.

A special thanks to Ariane Hoard, my student at the University of Illinois during the summer of 2002, for her help in searching for information on the Internet and literature in support of several of these assessments (W-1), and to my assistant Sherry Weaver for her continuing assistance in database management and processing the plant specimen vouchers.

This material is based upon work supported by the U.S.D.A. Forest Service, Eastern Region, under Cost Share Award No. AG 01CS-11090804-032 (1-5-28861). Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the U.S.D.A. Forest Service, Eastern Region.

EXECUTIVE SUMMARY

This Conservation Assessment is a review of the distribution, habitat, ecology, and population biology of the Barren strawberry, *Waldsteinia fragarioides* (Michx.) Tratt. ssp. *fragarioides*, throughout the United States and Canada, 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 the Barren strawberry to date. Barren strawberry is a perennial evergreen rhizomatous herb with basal leaves that closely resemble those of the edible strawberry and with stalked clusters of small yellow flowers. Populations normally are local and clonal. The species is found in much of the eastern United States and Canada, in twenty-five states and three provinces, respectively, and it occurs in several different habitats. At its southern margin of range, it grows primarily in organically-rich soil on talus slopes in rocky, dry to mesic upland forests where its survival appears to depend on habitat protection. There is some disagreement by experts concerning the recognition of its two subspecies. Globally, its ranking is G5T5 (the subspecies is considered to be secure worldwide), and it is most frequent in northern latitudes, becoming scarce at the margins of its range. Barren strawberry is listed as Endangered in Illinois and Maine (Critically Imperiled in both), as Threatened in New Hampshire (Critically Imperiled), as Rare in Indiana (Imperiled), and of Special Concern in Connecticut, Massachusetts, and Minnesota. Barren strawberry is

included on the Regional Forester Sensitive Species list (RFSS) for both the Shawnee National Forest and the Hoosier National Forest within Forest Service Region 9. The Barren strawberry is now thought to be extirpated in Illinois.

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 entity 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: *Waldsteinia fragarioides* (Michx.) Tratt. ssp. *fragarioides* (1823)

Common Names: Barren strawberry (Barren-strawberry); Appalachian barren strawberry (Appalachian barren-strawberry)

Synonymy: basionym: *Dalibarda fragarioides* Michx. (1803)
Waldsteinia fragarioides (Michx.) Tratt. var. *fragarioides*

Class: Magnoliopsida (Flowering Plants - Dicotyledons)

Family: Rosaceae (the Rose family)

Plants Code: WAFRF (USDA NRCS plant database, W-2)
http://plants.usda.gov/cgi_bin/topics.cgi

The genus *Waldsteinia* contains 3 native species and one additional subspecies in North America north of Mexico, and there is one additional native species in Puerto Rico, according to Kartesz and Meacham (1999). One or two additional species occur in the eastern hemisphere, and one of these species from northern Asia and Europe, the Siberian barren strawberry (*Waldsteinia ternata* (Stephan) Fritsch), is very similar in appearance and is often grown for ornament in our range. It can usually be distinguished from the native plants by its larger flowers and hardier nature. While similar in appearance to the strawberry (genus *Fragaria*), *Waldsteinia* is

more closely related to *Geum* (Avens) according to Robertson (1974) and others.

Recognition of the subspecies of *Waldsteinia fragarioides* is somewhat controversial. Not all botanists recognize *Waldsteinia fragarioides* ssp. *doniana* (Tratt.) Teppner as distinct, and some would consider this to be an additional synonym for the species. If this name is considered to be a synonym, then no subspecies would be recognized and only the name *Waldsteinia fragarioides* (Michx.) Tratt. would be accepted for this plant. This Conservation Assessment does recognize the two subspecies as distinct, following Robertson (1974), Kartesz and Meacham (1999), and the USDA plant database (W-2). *Waldsteinia fragarioides* ssp. *doniana* is a plant that is more restricted in range (see Distribution and Abundance, below) and it can be distinguished by this fact and by its petals that are quite different from those of the typical subspecies (see next section). It has also been known as *Waldsteinia fragarioides* var. *parviflora* (Small) Fern., *Waldsteinia doniana* Tratt., and as *Waldsteinia parviflora* Small.

The common name varies only slightly in the literature. The Nature Conservancy lists both the species and subspecies as ‘Barren strawberry’ (W-3). Kartesz and Meacham (1999) and the USDA plant database list both as ‘Appalachian barren strawberry’ (or ‘Appalachian barren-strawberry’). The Illinois Endangered Species Protection Board (IESPB 1999) and most other references use the name ‘Barren strawberry’ (‘Barren-strawberry’) for the species overall and they do not note the subspecies epithets. The common name refers to the similarity of the plant’s appearance to that of the edible strawberry and also to the fact that the fruit is dry and often overlooked in contrast to the colorful and edible fruit of the true strawberry (*Fragaria*). The name *Waldsteinia* commemorates the Austrian botanist and military leader Count Franz de Paula Adam von Waldstein (1759-1823) and *fragarioides* means ‘strawberry-like’ in Latin.

DESCRIPTION OF SPECIES

Waldsteinia fragarioides ssp. *fragarioides* is a low perennial herb 10-20 cm tall with short to elongate slender tough and fibrous (sub-woody) shallow rhizomes that are generally crowded together and so the colony appears to be in a mat; the roots are mostly adventitious and develop in clusters at rhizome tips; the basal, normally evergreen leaves are also found at the end of the rhizomes, they resemble those of a strawberry, and they have 3 leaflets each at the top of an elongate (3-17 cm) hairy petiole; the leaflets are broadly cuneate-obovate, 2-8 cm long and 2-6 cm wide, only sparsely hairy, serrate and usually shallowly lobed, the lateral ones are asymmetrical and the middle leaflet is usually longer and wider than the lateral ones; the leaves generally turn somewhat bronze in the winter; stipules are adnate to the petiole or obsolete; the flowers are in a several-flowered loose cyme on a stalk that about equals the leaves in length. The small flowers are bracteate, yellow, the five petals are obovate to broadly elliptic and generally 5-10 mm long and 3-6 mm wide, and they are obtuse or rounded and longer than the five 2-7.5 mm long sepals. There are numerous stamens (50?) and 2-6 (-10?) separate pistils, each of which matures into a small hairy achene (dry, single seeded fruit) about 2 mm long. The chromosome number has been reported as both $2n = 14$ and $2n = 21$ and there may be two genetic races involved (adapted from Fernald 1950, Radford *et al.* 1968, Gleason and Cronquist 1991, Robertson 1974).

The two named subspecies differ from one another as follows:

ssp. *fragarioides*: petals obovate to broadly elliptic mostly 5-10 mm long and 3-6 mm wide, obtuse or rounded and evidently longer than the sepals; sepal lobes 2-7.5 mm long; widespread

ssp. *doniana*: petals lance-elliptic or narrowly elliptic mostly 2.5-4 mm long and 1-1.5 mm wide, often acute, and shorter than to barely longer than the sepals; sepal lobes 3-4.5 mm long; southern Appalachian Mountains and piedmont

With a little experience, one can distinguish *Waldsteinia* from similar genera rather easily even when it is not in flower. It does not have the surface stolons so obvious in the wild strawberry and so the colonies are generally more compact with individual rosettes close together, the leaves and petioles are generally not as soft (and mostly deciduous) as those of the wild strawberry, and it prefers shaded forest areas rather than more open fields. Its evergreen nature makes it relatively easy to find in the winter. Flowers are needed in order to determine the subspecies, though the specific location of collection can sometimes be a helpful indicator in this regard.

HABITAT AND ECOLOGY

Barren strawberry is easily grown in gardens, and its horticultural preferences help to reflect its preferences in the wild. In cultivation it tolerates full sun to part shade (W-4). It is tolerant of a wide variety of soils, but it prefers humus-rich, slightly acidic soils. The plants are generally intolerant of the heat and humidity of the deep South, and they do best in northern climates with cool summers. The plants are often grown as a groundcover.

In the wild, the Barren strawberry occurs in a variety of habitats. It has been found to grow primarily in 'rich woods', moist to dry deciduous upland forests, but it can also occur in thickets and clearings (Fernald 1950; Gleason and Cronquist 1991). It has been reported to grow on sandstone ledges, rocky wooded slopes (talus slopes), and in damp woods, both evergreen and deciduous. In the southern states it is normally restricted to the mountain and piedmont regions at locally higher altitudes or in shaded, moist habitats. The species is normally found at elevations of less than 2,500 feet. In some states it appears to show a definite preference for calcareous sites, as in Connecticut and Vermont, but it is not restricted to such sites, and its pH preferences even in calcareous areas appear to be less than pH 7.4 and greater than pH 5.5 (Jenkins 1981). However, this may explain, in part, its scarcity where predominantly very acid soils occur. While the Barren strawberry normally occurs in forested areas, many herbarium labels and descriptions of its habitat mention that it tends to prefer more open, well-lit areas, especially at forest margins rather than their darker interiors.

The Barren strawberry appears to be less habitat-specific towards the north. Herbarium labels on specimens at the University of Wisconsin Herbarium, Madison, for example, indicated a variable substrate of soil types, including gravel, clay, clay-loam, sand, and humus. These labels also indicated a wide range of environments in which this species grows in that state, including old fields, open dry places, secondary forests, bottomlands, stream banks, burned over forests, sand hills, and virgin forest. In Minnesota, it is located at the edge of the species range occurring most commonly in upland pine forests, with a canopy of mixed pines, an understory of

hardwood saplings and a hazel shrub layer.

In Wisconsin alone, *Waldsteinia fragarioides* ssp. *fragarioides* has been found in five described habitats (W-5), including **Boreal Forest, Bracken Grassland, Northern Lowland Forest, and Northern Upland Forest**. It is considered to be most characteristic of the mesic and dry-mesic Northern Upland Forest habitats, but its presence in other habitats appears to reflect the greater flexibility in the northern parts of its range. These Wisconsin habitats are described below because they demonstrate the great range of species associates and edaphic factors in which the Barren strawberry grows in northern climates. These habitats are abundant in cool and temperate portions of northeastern North America.

The **Boreal Forest** is an evergreen forest dominated by the trees White spruce (*Picea glauca*) and Balsam-fir (*Abies balsamea*) often mixed with White birch (*Betula papyrifera*), White cedar (*Thuja occidentalis*), White pine (*Pinus strobus*) and poplars (*Populus* spp.). Common understory herbs are large-leaved aster (*Aster macrophyllus*), bluebead (*Clintonia borealis*), Canada mayflower (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*) and bunchberry (*Cornus canadensis*).

The **Bracken Grassland** is made up of open upland areas often on sandy soils and they are dominated by bracken fern (*Pteridium aquilinum*), Penn sedge (*Carex pennsylvanica*), Kalm's bromegrass (*Bromus kalmii*), and Canada bluegrass (*Poa compressa*). There may be a high cover of low shrubs such as blueberries (*Vaccinium angustifolium* and *V. myrtilloides*), sweet fern (*Comptonia peregrina*), prairie willow (*Salix humilis*), and hazelnuts (*Corylus* spp.). Other common herbs include poverty oat-grass (*Danthonia spicata*), Lindley's aster (*Aster ciliolatus*), gray goldenrod (*Solidago nemoralis*), and common strawberry (*Fragaria virginiana*).

The **Northern Lowland Forest** includes a great variety of forested wetland types such as Northern Wet Forest (dominated by white cedar (*Thuja occidentalis*), Balsam fir (*Abies balsamea*), black ash (*Fraxinus nigra*), and spruces (*Picea glauca* and *P. mariana*) with an understory rich in sedges (such as *Carex disperma* and *C. trisperma*), orchids, and many wildflowers), Floodplain Forests (dominated by balsam-poplar (*Populus balsamifera*), box-elder (*Acer negundo*) and bur oak (*Quercus macrocarpa* Michx.), nettles (*Laportea canadensis* and *Urtica dioica*) and ostrich fern (*Matteuccia struthiopteris*)), and Mesic Floodplain Terraces (dominated by black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), basswood (*Tilia americana*), and sugar maple (*Acer saccharum*) with a diverse spring ephemeral flora including many southern species at their northern range limits).

The **Northern Upland Forest** ranges from dry to mesic sites that are nutrient-poor, and coniferous trees are usually dominant. These forests have a long history of fire. Dominant trees include jack and red pines (*Pinus banksiana* and *P. resinosa*) and Hill's oak (*Quercus ellipsoidalis*) along with white birch (*Betula papyrifera*) and/or quaking aspen (*Populus tremuloides*) in logged areas. Common understory shrubs are early blueberry (*Vaccinium angustifolium*) and brambles (*Rubus* spp.), common herbs include bracken fern (*Pteridium aquilinum*), starflower (*Trientalis borealis*), wild sarsaparilla (*Aralia nudicaulis*), barren-strawberry (*Waldsteinia fragarioides*), cow-wheat (*Melampyrum lineare*), trailing arbutus (*Epigaea repens*), and members of the shinleaf family (*Chimaphila umbellata*, *Pyrola* spp.). On rich sites, Northern Dry-Mesic Forests have pines mixed with red oak (*Quercus rubra*) and

red maple (*Acer rubrum*). In Northern Mesic Forests, dominants include the trees sugar maple (*Acer saccharum*) and eastern hemlock (*Tsuga canadensis*), with white pine (*Pinus strobus*), beech (*Fagus grandifolia*), yellow birch (*Betula allegheniensis*), and basswood (*Tilia americana*) also important. The ground layer of herbs varies from sparse (especially in pure hemlock stands) to rich and varied with fine spring ephemeral displays, but most commonly the dominants are woodferns (especially *Dryopteris intermedia*), bluebead (*Clintonia borealis*) and Canada mayflower (*Maianthemum canadense*).

Towards the southern portions of its range, *Waldsteinia fragarioides* grows mainly in upland mixed deciduous forests on slopes in humus-rich, rocky, often thin soils over sandstone outcrops, but the species is usually associated with creek valleys and even alluvial (floodplain) forests (Radford *et al.* 1968). The plants here are normally in partial shade on shaded, north-facing slopes or ledges. These habitats are often described as ‘rich woods’. Steyermark (1963) described its habitat as shaded, moist humus of steep wooded north-facing slopes and ledges near the base of or on the upper positions of bluffs of Roubidoux sandstone or cherty limestone exposures, along creeks. He described the substrate as acidic and recorded *Vaccinium vacillans* (= *V. pallidum*) as a characteristic associate.

In Arkansas, at its southwestern range limit, *Waldsteinia fragarioides* has been found on north-facing sandstone ledges and chert bluffs on talus (specimen collected by Hyatt, number 5319, at the Missouri Botanical Garden herbarium). Its associates at the site were recorded as the trees *Acer rubrum* L., *Cercis canadensis* L., *Hamamelis vernalis* Sarg., *Ostrya virginiana* (Mill.) K.Koch, and *Quercus alba* L., the shrub *Vaccinium* sp., the vines *Toxicodendron radicans* (L.) Kuntze and *Dioscorea quaternata* (Willd.) J.F.Gmel., the herbs *Aster* spp., *Desmodium nudiflorum* (L.) DC., *Galium* spp., *Iris cristata* Ait., *Pedicularis canadensis* L., *Smilacina racemosa* (L.) Desf., *Solidago flexicaulis* L., *Thalictrum thalictroides* (L.) Eames & Boivin, and the ferns *Polystichum acrostichoides* (Michx.) Schott and *Adiantum pedatum* L.

In Indiana, this species typically grows in thin, often rocky soil where the steep forested slope begins to level off at the high point of a slope. These sites are usually with a limestone substrate, but a few exist over sandstone. For whatever reason, perhaps a combination of gravity and wind, the sites commonly lack significant accumulations of leaf litter, and they are very well drained (dry-mesic). Some sites are on ledges of limestone cliffs. Aspect varies, but generally the slopes do not face south (Homoya, pers. comm.). Deam (1940) described the plant in Indiana as consistently growing in talus at the base of cliffs or on rocky ledges (often limestone) and slopes along creeks. A few associates of the plant include the soft-woody shrub *Hydrangea arborescens* L., the trailing shrub *Euonymus obovatus* Nutt., and herbs such as *Hepatica acutiloba* DC.

In Illinois, *Waldsteinia fragarioides* ssp. *fragarioides* was found in 1967 at a single site in Pope County on north-facing sandstone ledges above a creek in the Shawnee National Forest (Schwegman and Mohlenbrock 1968). It has not been relocated at that site and it is probably extirpated from the state (Schwegman, pers. comm.; Herkert and Ebinger 2002). This location is within the Greater Shawnee Hills section of the Shawnee Hills Natural Division of Illinois as described by Schwegman *et al.* (1973). Its habitat has been described as a dry-mesic upland forest dominated by sugar maple, oak, and hickory, as well as a marginal Sandstone Cliff

community (as defined by White and Madany 1978). This community is similar to that of *Silene ovata* Pursh as described by Basinger (1998, 2002) which is on moderate to steep slopes that are often very rocky, with cliffs and slide blocks common, with shallow loess-derived soils with rocky talus above sandstone rock, and a soil pH between 5.8-6.2. Associated species in this community include the dominant canopy trees *Acer saccharum* Marsh. *Carya cordiformis* (Wangenh.) K.Koch, *Carya glabra* (Miller) Sweet, *Carya texana* Buckl., *Celtis occidentalis* L., *Fraxinus americana* L., *Nyssa sylvatica* Marsh., *Quercus alba* L., *Quercus rubra* L., *Quercus velutina* Lam., *Sassafras albidum* (Nutt.) Nees, *Ulmus alata* Michx., and *Ulmus rubra* Muhl. along with the additional trees *Carya laciniosa* (Michx. f.) Loudon, *Carya ovata* (Miller) K.Koch, *Cornus florida* L., *Fagus grandifolia* Ehrh., *Juglans nigra* L., *Morus rubra* L., *Ostrya virginiana* (Mill.) K.Koch, and *Ulmus americana* L., the shrubs (or small trees) *Asimina triloba* (L.) Dunal, *Cercis canadensis* L., *Hydrangea arborescens* L., *Lindera benzoin* (L.) Blume, *Staphylea trifolia* L., and *Vaccinium pallidum* Aiton, the vines *Bignonia capreolata* L., *Lonicera japonica* Thunb. [exotic], *Parthenocissus quinquefolia* (L.) Planch., *Smilax* spp., *Toxicodendron radicans* (L.) Kuntze, and *Vitis* spp., the herbs *Antennaria plantaginifolia* (L.) Richards, *Arabis laevigata* (Muhl.) Poir., *Arisaema triphyllum* (L.) Schott, *Aster* spp., *Cunila origanoides* (L.) Britton, *Eupatorium rugosum* Houtt., *Galium aparine* L., *Geum canadense* Jacq., *Heuchera parviflora* Bartl., *Phryma leptostachya* L., *Pilea pumila* (L.) A.Gray, *Polygonum (Tovara) virginianum* L., *Prenanthes altissima* L., *Sanicula canadensis* L., *Sedum ternatum* Michx., *Solidago caesia* L., and *Tradescantia subaspera* Ker., the grasses *Bromus pubescens* Muhl., *Chasmanthium latifolium* (Michx.) Yates, *Danthonia spicata* (L.) Roem. & Schult., *Dichanthelium* spp., *Elymus* spp., and *Muhlenbergia sobolifera* (Muhl.) Trin., the sedges *Carex* spp., the rush *Luzula multiflora* (Retz.) Lej., and the ferns *Asplenium platyneuron* (L.) Oakes ex Eat., *Cystopteris bulbifera* (L.) Bernh., *Cystopteris protrusa* (Weatherby) Blasdell, *Polypodium virginianum* L., *Polystichum acrostichoides* (Michx.) Schott, and *Woodsia obtusa* (Spreng.) Torr. (Basinger 1998).

Botanists and ecologists have speculated on the original landscape in this part of Illinois based mostly upon land survey records and field observations (Ulaszek, pers. comm.). Evidence suggests that the original pre-settlement landscape was a 'barrens', a savanna or prairie-like community with scattered oak trees and oak brush, that was periodically burned by Native Americans. Moister areas were more heavily forested.

DISTRIBUTION AND ABUNDANCE

Waldsteinia fragarioides ssp. *fragarioides* is found in much of the eastern United States and Canada and it seems to prefer a cool temperate climate. It extends from New Brunswick, Quebec, and Ontario in Canada south to Arkansas, Alabama and Georgia both north and south of the glacial boundary. In the United States it has been reported to occur in twenty-five states from Maine west to Minnesota, and south to Arkansas and Georgia, excluding Delaware, Rhode Island, District of Columbia, Iowa, and Mississippi (W-2, W-3). Kartesz and Meacham (1999) and the USDA plants site (W-2) indicated that it has not been found in South Carolina, but this is in error (personal observations, W-6). The distribution of the species is said to show a disjunction in the Ozarks; viewed by state, however, there appears to be no clear break in its distribution from east to west except in its preference for specific cooler habitats. Within some states (e.g. Connecticut and Illinois) the species is known to occur at a single site, and the current

number of extant populations is not known. While once thought to have been extirpated in Connecticut, it was recently rediscovered there (W-7).

Waldsteinia fragarioides ssp. *fragarioides* is common in Quebec and Ontario in Canada, but it is critically imperiled in New Brunswick (W-3).

The other subspecies, *Waldsteinia fragarioides* ssp. *doniana*, is more restricted in range. It has been found only in the United States, from the mountains of Pennsylvania in the north, south to Alabama and Georgia, and west to Kentucky and Tennessee. Its entire known distribution includes Alabama, Georgia, Kentucky, North Carolina, Pennsylvania, South Carolina, Tennessee and Virginia.

In states where the two subspecies both occur, the identification of herbarium specimens to subspecies is somewhat questionable. For example, the Herbarium of the University of Alabama (UNA) has seven specimens of the species from Alabama (Ginzburg, pers. comm.). Four of these were examined and annotated by Caroline Douglass (see Douglass 1980) as being ssp. *doniana*. Douglass did not annotate the remaining three specimens, and the subspecies for those has not been determined. It may be that only ssp. *doniana* occurs in Alabama, but this has not been confirmed and current sources (*e.g.* Kartesz and Meacham 1999) include both subspecies within the state. A similar problem exists for the distribution in Georgia, where both subspecies have been reported. The two current atlases for the flora of Georgia do not distinguish the subspecies, and they present two very different state distributions - Jones and Coile (1988) report the species in 10 counties, and Mellinger (1984) report it in 52 counties, all in the northern third of the state.

Regarding the Barren strawberry's Missouri distribution (which can also apply to its distribution in Alabama, Arkansas, Illinois, and southern Indiana), Steyermark (1963) observed:

“Considering the long period in time during which this species has undoubtedly occupied the Ozark region, since at least before the last glacial advance, it is surprising that the colonies of plants are not more extensive in area occupied. Apparently a relict plant from a more northerly distributed range, it has survived in only a few choice situations where it has been able merely to survive to a limited degree where competition from other species is not too severe.”

Barren strawberry (ssp. *fragarioides*) has been reported within several national forests in Forest Regions 8 and 9 (Kartesz and Meacham 1999, W-2, W-3) and it has been included on at least two Regional Sensitive Species lists in Region 9. Records were found for the following national forests, and it undoubtedly occurs within additional national forests, as well.

In Region 9:

Waldsteinia fragarioides has been found in a single county in Illinois where one population (now considered to be extirpated) was located within the Shawnee National Forest. In Indiana, the plant has been located within the Hoosier National Forest. In Michigan, the Barren strawberry occurs in the Hiawatha National Forest (both east and west sections). Three populations are

known to occur in the Superior National Forest in Minnesota. It has been included on the list of plant and animal species of concern for the Mark Twain National Forest in Missouri. It occurs within the proclamation boundary of the Green Mountain National Forest in Vermont (Jenkins 1981). In Pennsylvania, the species has been found in the Allegheny National Forest and it is also known to occur in the Monongahela National Forest in West Virginia.

In Region 8:

The Barren strawberry has been reported in Arkansas, where it has been found in the Ozark National Forest. In Alabama, it has been found in the William B. Bankhead National Forest. According to David Taylor (pers. comm.) *Waldsteinia fragarioides* is locally abundant in southeastern Kentucky, but it does not occur in many places on the Daniel Boone National Forest, nor is it listed as a sensitive species on their RFSS listing. It has been found in Georgia in the Chattahoochee National Forest, in the Nantahala and Pisgah National Forests in North Carolina, in South Carolina in the Sumter National Forest, and in the Cherokee National Forest in Tennessee. In Virginia, the Barren strawberry occurs in the Jefferson and George Washington National Forests as well as within Shenandoah National Park. Great Smoky Mountains National Park in North Carolina and Tennessee has several populations of this species.

Representative specimens of this widely-distributed herb have been listed in Appendix 1. A summary of its known distribution in the United States has been presented in Appendix 2, and additional details on its distribution can be found in the references cited there.

The Barren strawberry was discovered in Illinois by John Schwegman who located a single population in Pope County within the Shawnee National Forest in 1967 (Schwegman and Mohlenbrock 1968). The population was considered to be disjunct in southern Illinois. However, the plant has not been seen in Illinois since 1987, and it may now be extirpated in the state. According to John Schwegman (pers. comm.):

“I was the original collector of [the] *Waldsteinia* [...] The only known *Waldsteinia* population is surely extirpated. Jody Shimp and I looked for it several years ago and I returned a year later by myself to look again in case it came up from a seed bank. I know exactly where it grew on a narrow ledge and just is not there any more. Must have fallen victim to the drought of '88.”

In Indiana, Deam (1940) reported the Barren strawberry in three counties, each at a single site, in addition to historical reports in two additional counties. The current and historic distribution for this plant in the state now includes 10 counties (Appendix 2). Currently, there are just fewer than 20 extant occurrences known in Indiana (Homoya, pers. comm.). Most occurrences are in southeast and south-central Indiana, with a couple in northern Indiana (Wabash County). Two of the occurrences are within the purchase boundaries of the Hoosier National Forest, but only one of those, near the Little Blue River near Grantsburg, is on land owned by the Forest. This population has been present since the 1930s but it is near an old railroad and it is susceptible to disturbance (Olson and Reynolds 2000; Homoya, pers. comm.).

Most native plants have reached the limits to which they can travel under present conditions of

climate (including 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 as well as in natural systems, however, ecological extremes are more important than the means in controlling plant distribution (Webb *et al.* 1975; Ode *et al.* 1980; Barnes *et al.* 1983). An obvious example is that of frost tolerance (or 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 (see Hill 2003).

In the case of *Waldsteinia fragarioides*, historical distribution appears to be dependent on hydrology (and humidity), substrate type (including pH), and slope as well as on temperature extremes. Its distribution and preferred habitat towards the south of its range suggest that the Barren strawberry is not adapted to extreme heat and that it also needs a well-lighted, but not fully open, exposure. A lack of data on its reproduction other than by vegetative means may suggest that the species may be unable to increase its current range, particularly at its southern sites where cooler habitats are scarce.

PROTECTION STATUS

The Nature Conservancy (TNC) currently lists *Waldsteinia fragarioides* ssp. *fragarioides* as a G5T5 plant indicating that the subspecies is secure world-wide (see Appendix 3; W-3). The species overall has been ranked G5 as well. In the United States, overall, the species and subspecies have been given the National Heritage rank of N? indicating that more information is needed before a rank can be assigned. The relatively large number of occurrences may suggest that a N5 rank might be appropriate but this cannot yet be supported because the status has not been reviewed in many of the states from which it has been reported.

Official protection for the species outside of Forest Service lands depends upon state and local laws because it is not listed as Federally threatened or endangered. The state rankings vary somewhat within and between the species and subspecies but the status of both has not been evaluated in most states. Barren strawberry is currently (2003) listed as Endangered in Illinois and Maine (Critically Imperiled in both), as Threatened in New Hampshire (Critically Imperiled), as Rare in Indiana (Imperiled), and of Special Concern in Connecticut and Massachusetts (possibly Extirpated, and Vulnerable, respectively) as well as in Minnesota (Vulnerable; W-3). It was recently rediscovered in Connecticut (W-7). This plant is also considered to be Vulnerable in Kentucky and North Carolina, but without official listing status in these states. In Missouri, *Waldsteinia fragarioides* was previously listed as endangered, but current law in the state only allows the listing of federally listed taxa as state endangered (Yatskievych, pers. comm.); however, it is tracked in the state as a S2 plant.

It is important to note that in fifteen of the twenty-five states in which it has been reported the status of the Barren strawberry remains undetermined (W-3). Seventeen of the twenty-five states have only the ssp. *fragarioides* present, and it might be assumed that the subspecies and species rankings in those states would be the same. A single state (Vermont) has concluded that the status of the Barren strawberry is apparently secure (S4).

According to Mike Homoya (pers. comm.), in Indiana, where *Waldsteinia fragarioides* is listed as Rare, there are just fewer than 20 extant occurrences (more than 20 extant occurrences will put the species off the Endangered, Threatened and Rare list into the watch-list category). Only one occurrence is known from federal land within the Hoosier National Forest.

The Barren strawberry is included on the Regional Forester Sensitive Species lists (RFSS) for both the Shawnee National Forest and the Hoosier National Forest.

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-8).

A summary of the current official protection status for the Barren strawberry follows:

U.S. Fish and Wildlife Service:	Not listed (None).
U.S. Forest Service:	Region 9, Sensitive (Shawnee National Forest, Hoosier National Forest).
Global Heritage Status Rank:	G5T5
U.S. National Heritage Status Rank:	N?
Canada National Heritage Status Rank:	N?

Table 1: S-ranks for *Waldsteinia fragarioides* [Heritage identifier: PDROS1S010] in the United States. The rank in brackets refers to the rank for the ssp. *fragarioides* [Heritage identifier: PDROS1S012]. In the states indicated by an asterisk (*) only the typical subspecies occurs.

State	Heritage S-rank	State	Heritage S-rank
Alabama	SR [SR]	New Hampshire	S1 [SR]*
Arkansas	S1 [SR]*	New Jersey	S? [S2]*
Connecticut	SH [SR]*	New York	SR [SR]*
Georgia	SR [SR]	North Carolina	S3 [S1]
Illinois	S1 [SR]*	Ohio	SR [SR]*
Indiana	S2 [SR]*	Pennsylvania	S? [SR]
Kentucky	S3? [S?]	South Carolina	SR [SR]
Maine	S1 [SR]*	Tennessee	SR [SR]
Maryland	SR [SR]*	Vermont	S4 [SR]*
Massachusetts	S3 [SR]*	Virginia	SR [SU]
Michigan	S? [SR]*	West Virginia	S? [SR]*
Minnesota	S3 [SR]*	Wisconsin	SR [SR]*
Missouri	S? [S2]*		

LIFE HISTORY

The Barren strawberry normally flowers in late April-May in Illinois and in much of its U.S. range (*e.g.* April 6-May in Missouri, Steyermark 1963). Herbarium records indicate that it may begin to flower by late March (or even late February) at the southern margins of its range, and as late as June (-July?) in the northern parts of its overall range. Mature fruits appear immediately afterwards. Rhoads and Block (2000) indicate that in Pennsylvania, this species flowers from April to July, and Radford *et al.* (1968) report that it flowers in the Carolinas from late March - May, and fruits from May-June in that region. Neither reference distinguished the subspecies, and both are reported in those states.

Very little experimental data is available on the life history of *Waldsteinia fragarioides*. It is thought to reproduce both sexually by means of seeds and asexually by means of rhizomes. No information has been found regarding its establishment from seed, but seeds are normally produced. However, no reference has been found on seedlings of the plant. It is not known how much time is needed to grow from seed to reproductive age. Flowers are perfect (bisexual) but whether they are self-compatible or not is not known. The pollinators are not known. It normally flowers every year, but its success in producing new individuals from seed is not yet clear. *Waldsteinia fragarioides* is known to be a perennial, but its longevity is unknown. It may live to a great age, or it may not. Colonies of the species are generally small, but several hundred plants can sometimes be found in an area only a few meters in length. Individual clumps are produced from the system of short creeping underground rhizomes. This could result in a colony of apparently separate, but genetically identical individuals as the rhizomes break. No information is available on how many stems in a colony may be of the same genotype ('genets') or how many distinct individuals exist at any particular site.

POPULATION BIOLOGY AND VIABILITY

A single population of *Waldsteinia fragarioides* was found in Illinois (Schwegman and Mohlenbrock 1968), fewer than 20 have been found in Indiana, and in Arkansas, Connecticut, and New Hampshire the plants are known to exist in a single county (perhaps even in a single population). Little is known about the population biology in the species even where it is common, and viability in those states with few populations is doubtful in the long-term.

It is generally understood that fertility is reduced in inbred populations through the process of autogamy (self-fertilization). Autogamy is useful to the plant when there are small numbers of individuals per area, since the safeguarding of the success of propagation is more important than the production of new genotypes. In primary habitats, *i.e.*, those that are generally poorly vegetated, initial success is very important. However, in subsequent periods of vegetation increase pioneers are often substituted by other, more competitive, species (W-9). In plants such as Barren strawberry, all stems at a site may be genetically identical but there is no data supporting this yet. Therefore, if pollination should occur, and if the flowers are self-incompatible, there is almost no chance of fertilization by other genotypes unless they are within dispersal range, and, thus, no chance for fruit and seed production. Existing populations of the Barren strawberry are isolated from one another. Continued self-fertilization may have resulted in severe reproductive problems. With lack of data, one could even suspect that sexual

reproduction has never been as important as vegetative reproduction in this species. Nevertheless, the fact remains that flowers are produced on a regular cycle, the flowers are unspecialized and they are probably visited by several kinds of small insect pollinators as in other similar genera of the Rosaceae. Little more can be said without further field and laboratory research and observation.

The Barren strawberry may fit a pattern that is just starting to emerge. Studies that suggest similar problems in sexual reproduction have recently been conducted on some other local and rare perennial plants known from similar habitats, such as in *Calamagrostis porteri* A.Gray ssp. *insperata* (Swallen) C.W.Greene studied by Havens and Holland (1998), and in *Silene ovata* Pursh studied by Basinger (1998, 2002). Viable seed production in these species appears to be either rarely observed or virtually non-existent, and reproduction is primarily by vegetative rhizomes. Their studies may serve as examples that may fit the data (or lack of it) for *Waldsteinia fragarioides* as well, or that may be used as models for future work on *Waldsteinia*. Until the studies of Havens and Holland (1998), for example, the production of viable seed had never been observed in their grass. In the course of their investigation of more than 2,000 flowers, only one viable seed was found. They also noted that nearly all self-pollinated ovules failed to develop after pollination during their experiments, and that nearly every seed initiated overall in all crosses (including outcrossing) aborted. They suggested that this reproductive failure might be a reflection of a high genetic load that has occurred as a result of a long history of polyploidization. Other generally recognized implications of this low fertility may be that the number of genetically distinct individuals may be very low and the plant survives as a rare relict in the vegetative state only. For additional information on this study and the grass in question, see Hill (2003a). As information accumulates, a pattern of possibly ancient post-glacial relict species that are in danger of extinction at their southern limits of range (because of isolation-related reproductive problems) begins to emerge, but the evidence is still very meager.

Barren strawberry habitat has been observed to be decreasing (see Potential Threats below). The species may or may not occur at other suitable sites in Illinois and Indiana, but only a few searches have been made specifically for the Barren strawberry in recent years. Suitable habitat for the species appears to exist, but it appears that it may have never been common here in historical times. Additional searches are suggested. If individuals are relocated, or if new sites are found, they may persist with proper habitat management.

Maintaining the habitat in which it grows appears to be one of the most important means to insure the survival (or viability) of this species throughout its range. Its apparent lack of success in establishing many new colonies from seed suggests a very limited possibility for spread in *Waldsteinia fragarioides*. There appears to be little chance of natural colonization of new habitat by this plant (especially in its isolated southern populations) and so the long-term viability of this rare plant appears to depend entirely on the protection and management of existing populations through human intervention.

POTENTIAL THREATS

Globally, the Barren strawberry has been judged to be secure. However, the species is known from so few sites in Illinois and Indiana (as well as in only a few sites in several other states) that it does risk extirpation in this region. Some potential threats include natural catastrophe, habitat

loss, competition from non-native species, and long-term climate change. It is possible, but less likely, that over-collection is a current threat to the species because most colonies have many plants. The plant is also readily available and inexpensive at many local and mail-order nurseries.

As is the case with any endangered species with only one or very few extant populations in a given area, the Barren strawberry is vulnerable to natural catastrophes, which, by their nature, are both unpredictable and rare, but significant over time. Damage from severe floods, storms, or collapse of the rock and/or soil structure where colonies occur could result in extirpation of the plant because of the few remaining populations in some areas. While it is not known for certain, this may have contributed to the loss of the single Illinois population.

Waldsteinia fragarioides is threatened by forest management practices (particularly by heavy logging and clearcutting as well as from road and trail construction; W-10), and to a lesser extent by land-use conversion and habitat fragmentation. Additional threats to the plant and its habitat include flooding by impoundment, construction, and quarrying. Complete clearing or cutting of a forest stand could not be enacted where a colony occurs without adverse effects, at least in the southern portions of its range. It is thought that there has been a loss of populations on private land within its range. In some states where it has been monitored, the number of populations has been documented to be in decline. In New Hampshire and Maine, half of the historic sites have not been relocated (Jenkins 1981). The single Illinois population was located only a short distance from private land that was cleared for livestock use.

The Barren strawberry is not an aggressive species, and it is known to grow slowly and reproduce infrequently (if at all) from seed. It is endangered by the growth of aggressive non-native species, particularly Japanese honeysuckle, which can engulf the plants and prevent them from receiving sufficient sunlight to survive. While the Barren strawberry is not a species that requires full sunlight, excessive growth of introduced shrubs such as the exotic honeysuckles as well as saplings of native trees could result in too much shade for its growth.

The Barren strawberry is primarily a northern temperate climate species that has disjunct occurrences in cooler portions of several southeastern states. It is known that the plants are generally intolerant of long periods of heat and humidity, and that they grow best in northern climates with cool summers. If, as some predictions suggest, the climate becomes warmer and drier, the plants may lose what vigor remains and have lower reproductive rates. This may already have taken place regarding the single Illinois population whose extirpation has not been explained.

In areas where only a few populations of the Barren strawberry exist, the increased recreational use of the national forest in the vicinity of populations of this plant could pose a great threat to the species. User-made equestrian trails can endanger the plants, which are vulnerable to trampling. The development of user-created trails could pose a threat to the few populations of this species in some areas. The threat comes from the resulting loss of the thin soils present, as well as from the destruction of the delicate rootstock and rhizome systems by compaction of the soil (by human, equestrian, or vehicular traffic). In areas where this herb occurs, recreational activities could quickly exterminate a small local population. As noted previously, many of the populations are small and compact. Therefore, to protect this species, areas where these plants

grow should be closed to most recreational use because of the increased erosion and physical damage possible to the shallow roots and rhizomes of this herb, and increased enforcement of these restrictions or the relocation of trails may be needed.

Because viable seed production and the establishment of seedlings may be rare in this species, and because the plants may persist primarily through vegetative propagation, all vegetative colonies need strong protection, and threats to vegetative growth need to be reduced.

Waldsteinia fragarioides can persist in significant populations today only at rather inaccessible sites or in areas that are kept free of recreational activities and major disturbance. Since European settlement, much of the previously available habitat has been destroyed, converted to pastures, quarried, logged, or lost to development and the construction of buildings and roads. Many of the extant populations are in national forests or protected areas, and most have been found as a result of careful searches at these sites in recent decades; it cannot be determined how many populations were lost at other sites before these searches were initiated.

Deer predation on *Waldsteinia fragarioides* does not appear to be a threat; in fact, deer actively avoid browsing on this plant. Because of this, the Barren strawberry has been recommended for planting in areas frequented by deer (Bachtell 1997; Jull 2001; McGourty 2000). The possible threat of grazing by livestock is not known. Damage in pastured areas or in populations along trails would probably be greater from trampling than from foraging.

There is no evidence at this time that canopy closure, as a result of natural forest succession or succession due to fire suppression, is a threat to this species. The species appears to prefer more mesic sites within the sandstone hills, and significant exposure (opening, clearing) and drying of its habitat may be detrimental to this plant at its southern limits of range. In northern latitudes the species does appear to thrive best at the margins of forests rather than in the more shaded interiors.

The Barren strawberry is not an aggressive or competitive herb. Competition from exotic plant species (such as *Lonicera japonica* Thunb. and *Lonicera maackii* (Rupr.) Maxim.) can be a threat to the remaining populations. These species, as well as the uncontrolled growth of native woody plants and saplings, can form dense stands and eliminate ground layer herbaceous species (including this herb) due to excessive shade. While the Barren strawberry does grow in areas more than half-shaded by the canopy, excessive shade (typically produced by the exotic honeysuckles and some other species) will hinder its general growth, flowering, and fruiting. While *Waldsteinia fragarioides* is not normally described as a 'gap' species, it may require occasional gaps in the canopy (such as caused by tree fall) for its best growth.

Habitat fragmentation can have profound effects on the success and persistence of local populations (McCauley *et al.* 1995). 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 and Kohn 1991). When one is considering populations that are already isolated, as in the case of the midwestern populations, random genetic drift may have already occurred and may have caused negative effects to the species. It would appear, therefore, because of the fragmentation of habitat resulting from a mix of public and private ownership, that a strong effort should be made to add to the buffer around existing colonies and their habitats by purchasing nearby public and private lands as a means of

protection for the habitat and the species (Basinger 1998).

At the current time, it appears that the population of *Waldsteinia fragarioides* in the Shawnee National Forest has been extirpated, and those in the Hoosier National Forest are threatened with elimination from habitat change and disturbance unless selective management and/or increased enforcement of habitat protection is instituted or continued.

RESEARCH AND MONITORING

Few references concerning research on *Waldsteinia fragarioides* could be found in the literature. Monitoring of populations where it is being tracked as sensitive is on-going depending on the availability of personnel and resources.

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. The populations of rare plants are to be documented, former sites revisited, and plot information collected, and each exact location is to be noted with Global Positioning System technology. As of 2000, the single known site for *Waldsteinia fragarioides* within the Hoosier National Forest had been confirmed and documented (Day 2000).

There still appear to be a few problems concerning the taxonomy of this species, at least regarding the status and exact distribution of the two subspecies. Additional research may be needed before a consensus can be reached. This should start with herbarium surveys to act as a basis for the subspecies distributions, and the research may require subsequent DNA studies. Work on the distribution of the subspecies was conducted by Caroline Douglass at Clemson University as part of her work on *Waldsteinia lobata* (Douglass 1980) but it was never completed

An experimental study in Canada found that Barren strawberry increases in cover in response to prescribed burning, so fire could benefit this plant (Lynham *et al.* 1998). However, in southern populations this may or may not be true, particularly in areas with thin organic soils on outcrops, where fires could present more of a threat, but conclusions cannot yet be drawn and studies are needed.

One study has provided evidence that antiviral compounds are present in *Waldsteinia fragarioides* (Abou-Karam 1991, Abou-Karam and Shier 1992). The compound was shown to be a known flavonoid glycoside (isoquercitrin). There are probably also tannins in the plant, and most tannins have antiviral activities (Jim Duke, pers. comm.).

Field research on this species appears to be in its infancy. There still appear to be many questions concerning *Waldsteinia fragarioides*, many of them of a very basic nature. For example, are the plants in a colony or patch all genetically identical or not? This question is difficult to answer even by careful excavation of the plants. Less invasive, but more expensive, molecular studies using DNA methodology would be needed to determine the genetic identity of individuals both within and between colonies or populations of this plant. It would be especially important to discover if the colonies are entirely clonal or if they contain some genetically different individuals. This could be expanded to compare the local populations with the nearest

populations in adjoining states to assess their possible origin or degree of genetic distance between them.

Pollination and fertility studies are needed to help in understanding the reproductive potential for this plant. In the literature, only assumptions have been made that it is fertile and that it reproduces from seed. Its pollinators are unknown, although generalist insects are assumed. It is not known if the plants are self-compatible or if they have decreased fertility. Studies on these aspects of life history and population biology should be pursued, and plants should be studied both in the field and propagated for study at appropriate botanical institutions for these investigations.

Waldsteinia fragarioides is so rare in Illinois and Indiana that a primary emphasis should be to locate and vigorously protect all remaining populations. Similar habitat should be explored for more occurrences of the plant. There is a small to moderate area of additional suitable habitat in extreme southern Illinois where *Waldsteinia fragarioides* could still exist, and more searches for the species should be conducted. While its associated plants are generally common and widespread, its habitat is more specific and could be searched. Additional populations are to be expected at suitable forested sandstone ledge and canyon sites in southern Illinois, especially in the same drainage at which it once occurred.

Botanical surveys conducted by scientists from the Illinois Natural History Survey have shown repeatedly that with sufficient time and funding, and an experienced eye, many plants thought to be extirpated or else threatened or endangered can be found at additional locations (Hill 2002). These sorts of investigations have been important in that they have led not only to the de-listing of species once thought to be rare, but they have also resulted in the discovery of species previously unknown in the state. The U.S.D.A. Forest Service and related agencies have done a fine job in the effort to preserve rare species with the resources that they have available. Much of the locating and monitoring of known populations of rare species in southern Illinois has been done by Forest Service biologists in cooperation with Illinois Department of Natural Resources personnel. In addition, students seeking an advanced degree at institutions such as Southern Illinois University have conducted a significant amount of the research on these forest-sensitive species. 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. It appears that a high priority should be given to the training and hiring of more qualified field botanists to achieve these goals.

Basic research and on-site investigations are especially needed to determine the best management techniques to be used for this rare herb. Because some states have very few populations, caution is needed in field research to avoid harming the colonies. Some limited research on selective thinning of the forest canopy could be conducted in order to determine the effects of increased light levels to the habitat and populations for the purpose of better management. There is a need to locate the best habitat for the species and how to best protect the character of these areas; perhaps exclusion fencing of significant areas of habitat to protect the plants from trampling and vehicle activity should be conducted to determine its affects in some areas. It is generally recommended that the habitat quality where this plant grows should be monitored on a regular basis and that an assessment of the specific threats to all populations should be made.

Long-term monitoring of known populations should be conducted every 1-2 years to track their status with respect to current management and protection activities. As part of the basic research on current populations of this species, data such as counts of numbers of individuals present or the colony dimensions, the determination of the amount of yearly flowering and seed production that might occur, and an assessment of recruitment rates, if any, are greatly needed in order to monitor population dynamics and to assess the viability of the individual populations found. Studies of this kind on *Waldsteinia fragarioides* in southern Illinois were not conducted during the brief time in which it was known to occur in the state. In Indiana, individual plants should be monitored over time at each site. Such basic facts as fungal associations (if any), longevity, and yearly variations in colony size over a long period are not known. Surveys should be conducted during the flowering and fruiting periods. The techniques for several aspects of monitoring rare plant species are presented in Collins *et al.* (2001), Philippi *et al.* (2001), and Imm *et al.* (2001).

RESTORATION

There are no known restoration efforts being conducted on *Waldsteinia fragarioides* anywhere in its range and the restoration potential of this species is largely unknown. It seems possible that mature fruit production in this species may be infrequent and that reproduction (or, rather, the continuation of existing populations) may be taking place primarily by means of vegetative rhizome growth in much of its current range.

The generally recommended method to restore populations of rare plants is to protect and manage their habitat. Protection of the hydrology and thin soil layer of the sites may be crucial. Exotic and aggressive species should be completely eliminated from each site. This would entail physically pulling them out because it is very likely that herbicide application would eliminate the *Waldsteinia* at a site as well. The fencing of vulnerable populations may be beneficial, but this may also promote competition from other plant species within the fence. This and other management and restoration techniques need further investigation.

As previously mentioned, a study in Canada found that Barren strawberry increased in cover in response to prescribed burning, so fire could benefit this plant (Lynham *et al.* 1998). In that study, it was determined that shallow burns were more effective than deep soil burns in increasing the plant growth, and it was also noted that the fire caused an increase in the pH and also increased the amount of calcium and potassium in the soil, both of which may have been a primary cause of growth increase. The effects disappeared in ten years.

There are ethical questions concerning the restoration of species to areas, such as Illinois, where native populations are thought to no longer exist. *Waldsteinia fragarioides* may actually be extirpated in Illinois, and so genetically identical or even similar plants may be impossible to obtain. In this case, the question of restoration takes on a very different perspective. Any population introduced to Illinois would then be the introduction of a species no longer extant in the state. Restorations of any native plant species are recommended using only propagated material grown from native, local populations to avoid mixing 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). In Indiana, where the plant still occurs, asexual propagation of native material to similar suitable sites in the vicinity of the primary population would appear to be acceptable from an ethical perspective, and may insure against loss of the species there by means of catastrophic means.

It is well-known that the Barren strawberry is easily grown in cultivation (Steyermark 1963; W-4) and that it has been used in landscaping for years. Restoration in the wild would seem possible. The question remaining is the justification and goal of such an activity. Another question that has presented itself is that of the identification of the cultivated material obtained through commercial means. *Waldsteinia ternata* is increasingly being offered for sale as a ground cover, and it has been sold as the native species, generally because of the great similarity of the two plants. Verification of identification should be made before planting the commercial plants into a natural habitat if this is to be done at all. The Barren strawberry may be easily propagated by means of rhizome cuttings under controlled conditions. On the other hand, investigations on the reproduction of this plant may indicate that outcrossing may be necessary to restore a viable population. Experimentation may produce strains with confirmed viable seed production, and this might be considered desirable. These are issues that remain unsettled.

The populations and their surrounding habitats need special protection from destructive recreational activities, land development, indiscriminate herbicide application, trampling by native and non-native mammals, and from the establishment of exotic species. The management for extant colonies of *Waldsteinia fragarioides* should include the possible relocation or elimination of trails that are causing damage to the colonies, there should be experimental investigation of management techniques such as the use of enclosures to inhibit the trampling of the plants, or the use of selective thinning of the canopy in order to maintain suitable light levels for growth and flowering. The non-herbicidal elimination of woody plant encroachment in the understory, particularly for exotic species such as Japanese honeysuckle, should be incorporated into a management plan. At this time, with proper management, current populations should persist and they could even increase in size, but the establishment of additional populations will probably occur only through active human efforts.

SUMMARY

The Barren strawberry, *Waldsteinia fragarioides* Pursh ssp. *fragarioides*, is a perennial evergreen rhizomatous herb with basal leaves that closely resemble those of the edible strawberry and with stalked clusters of small yellow flowers. Populations normally are local and clonal. The species is found in much of the eastern United States and Canada, in twenty-five states and three provinces, respectively, and it occurs in several different habitats. At its southern margin of range, it grows primarily in organically-rich soil on talus slopes in rocky, dry to mesic upland forests where its survival appears to depend on habitat protection. There is some disagreement by experts concerning the recognition of its two subspecies. Globally, its ranking is G5T5 (the subspecies is considered to be secure world-wide), and it is most frequent in northern latitudes, becoming scarce at the margins of its range. Barren strawberry is listed as Endangered in Illinois and Maine (Critically Imperiled in both), as Threatened in New Hampshire (Critically Imperiled), as Rare in Indiana (Imperiled), and of Special Concern in Connecticut, Massachusetts, and Minnesota. Barren strawberry is included on the Regional Forester Sensitive Species list (RFSS) for both the Shawnee National Forest and the Hoosier

National Forest within Forest Service Region 9. The Barren strawberry is now thought to be extirpated in Illinois.

Suggested research priorities for this rare forest herb include attempts to locate additional populations, and to determine, through controlled and cautious experimentation, the best management techniques to insure its survival and increase (such as protection of colonies through fencing and the selective propagation of existing clones), to determine the genetic diversity of populations, and to determine a means to increase effective reproduction in the species. A pertinent question in Illinois remains regarding the ethics of reintroducing this species to the wild now that it is thought to be extirpated in the state. Management through enforced protection of its habitat, either through enforcement of existing regulations or through the creation of new rules for restricted access to the sites (particularly recreational and equestrian access), appears to be necessary to allow it to persist where it now occurs.

REFERENCES

- Abou-Karam, M. 1991. Antiviral activity in higher plants and characterization of antiviral activity in *Waldsteinia fragarioides* (pp. 135-139). Doctoral thesis, University of Minnesota.
- Abou-Karam, M. and W.T. Shier. 1992. Isolation and characterization of an antiviral flavonoid from *Waldsteinia fragarioides*. *Journal of Natural Products* 55 (10): 1525-1527.
- Bachtell, K.R. 1997. Plants not favored for browsing by deer. *Home, Yard & Garden Pest Newsletter* 22:2-4. Published by University of Illinois Cooperative Extension Service, Champaign.
- Barnes, P.W., L.L. Tieszen and D.J. Ode. 1983. Distribution, production and diversity of C₃-and C₄-dominated communities in a mixed prairie. *Canad. J. Bot.* 61: 741-751.
- Barrett, B.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: implications for conservation. [pp. 3-30 *In* Genetics and conservation of rare plants, D.A. Falk and K.E. Holtzinger, eds. Oxford University Press, New York, NY
- Basinger, M.A. 1998. Distribution, habitat, and demographic characteristics of *Silene ovata* Pursh (Caryophyllaceae) populations in Illinois. Report prepared for Illinois Department of Natural Resources, Division of Natural Heritage, Springfield. 34 pp.
- Basinger, M.A. 2002. Distribution and habitat characteristics of *Silene ovata* Pursh (Caryophyllaceae) populations in Illinois. *Trans. Illinois State Acad. of Science.* 95(1): 11-19.
- Brown, M.L., and R.G. Brown. 1984. *Herbaceous Plants of Maryland*. Port City Press, Baltimore, MD.
- Chester, E.W., B.E. Wofford, and R. Kral. 1997. *Atlas of Tennessee Vascular Plants. Volume 2. Angiosperms: Dicots*. Misc. Publication No. 13. The Center for Field Biology, Austin

- Peay State University, Clarksville, TN.
- Collins, B., P.S. White, and D.W. Imm. 2001. Introduction to Ecology and Management of Rare Plants of the Southeast. *Natural Areas Journal* 21:4-11.
- Day, K.G. 2000. Land and Resource Management Plan: Monitoring and Evaluation Report Fiscal Year 2000 - Hoosier National Forest. 55 pp.
- Deam, C.C. 1940. Flora of Indiana. Indiana Dept. of Conservation. Indianapolis. 1236 pp.
- Douglass, C.C. 1980. *Waldsteinia lobata* (Baldw.) T. & G. (Rosaceae) verified for South Carolina. *Castanea* 45(4): 228-232.
- Fernald, M.L. 1950. Gray's Manual of Botany, Eighth Edition. American Book Company, New York. 1632 pp.
- Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd edition. The New York Botanical Garden, Bronx. 910 pp.
- Harvill, A.M., Jr., T.R. Bradley, C.E. Stevens, T.F. Wieboldt, D.M.E. Ware, and D.W. Ogle. 1986. Atlas of the Virginia Flora. 2nd ed. Virginia Bot. Assoc., Farmville, VA. 135 pp.
- Herkert, J.R. and J.E. Ebinger (eds.). 2002. Endangered and Threatened Species of Illinois: Status and Distribution, Volume 1 - Plants. IL Endangered Species Protection Board, Springfield. 161 pp.
- Hill, S.R. 2002. Some recent changes in the Illinois flora. Illinois Natural History Survey Reports. Summer 2002. No. 3722.
- Hill, S.R. 2003. One botanist's view of the landscape. Illinois Natural History Survey Reports No. 374, Winter 2003. p. 2.
- Hill, S.R. 2003a. Conservation assessment for Ofer hollow reedgrass (*Calamagrostis porteri* A.Gray ssp. *insperata* (Swallen) C.W.Greene). Report submitted to the U.S.D.A. Forest Service, Eastern Region, Shawnee and Hoosier National Forests, 28 April 2003. 30 pp.
- Illinois Endangered Species Protection Board (IESPB). 1999. Checklist of endangered and threatened animals and plants of Illinois. Springfield. 20 pp.
- Imm, D.W., H.E. Shealy, Jr., K.W. McLeod, and B. Collins. 2001. Rare Plants of Southeastern Hardwood Forests and the Role of Predictive Modeling. *Natural Areas Journal* 21:36-49.
- Jenkins, J. 1981. The Rare Plants of the Green Mountain National Forest and their Potential Habitats. A research report prepared for the Supervisor's Office of the Green Mountain National Forest, Rutland, Vermont.
- Jones, S.B., and N.C. Coile. 1988. The Distribution of the Vascular Flora of Georgia.

University of Georgia, Athens, Georgia.

- Jull, L.G. 2001. Plants not favored by deer. Bulletin A3727, University of Wisconsin Cooperative Extension Service. University of Wisconsin, Madison. 4 pp.
- Kartesz, J.T. (data) and C.A. Meacham (software). 1999. Synthesis of the North American Flora. Version 1.0. CD-ROM. Biota of North America Program, North Carolina Botanical Garden, Chapel Hill.
- Lynham, T.J., G.M. Wickware, and J.A. Mason. 1998. Soil chemical changes and plant succession following experimental burning in immature jack pine. *Canadian Journal of Soil Science* 78(1): 93-104.
- Magee, D.W. and H.E. Ahles. 1999. *Flora of the Northeast*. University of Massachusetts Press: Amherst.
- McCauley, D.E., J. Raveill, and J. Antonovics. 1995. Local founding events as determinants of genetic structure in a plant metapopulation. *Heredity* 75: 630-636.
- McGourty, M.A. 2000. Dealing with deer. *City Trees* 36 (4):1-3. The Journal of the Society of Municipal Arborists, Watkinsville, Georgia.
- Mellinger, M.B. 1984. *Atlas of the vascular flora of Georgia*. Georgia Botanical Society. Studio Designs Printing, Milledgeville, Georgia. Unpaginated.
- Ode, D.J., L.L. Tieszen and J.C. Lerman. 1980. The seasonal contribution of C₃ and C₄ plant species to primary production in a mixed prairie. *Ecology* 61: 1304-1311.
- Olsen, S. and K. Reynolds. 2000. Draft Regional Forester's Sensitive Species in the Hoosier National Forest Plan. U.S.D.A. Forest Service. Hoosier National Forest. 38 pp.
- Ownbey, G.B. and T. Morley. 1991. *Vascular Plants of Minnesota - A Checklist and Atlas*. University of Minnesota, Minneapolis. 307 pp.
- Philippi, T., B. Collins, S. Guisti, and P.M. Dixon. 2001. A multistage approach to population monitoring for rare plant populations. *Natural Areas Journal* 21:111-116.
- Radford, A.E., H.E. Ahles, and C.R. Bell. 1968. *Manual of the vascular flora of the Carolinas*. University of North Carolina Press, Chapel Hill. 1183 pp.
- Rhoads, A.F. and T.A. Block. 2000. *The plants of Pennsylvania: an illustrated manual*. University of Pennsylvania press, Philadelphia. 1061 pp.
- Robertson, K.R. 1974. The genera of Rosaceae in the southeastern United States. *Journal of the Arnold Arboretum* 55: 303-401.
- Schwegman, J.E., G.B. Fell, M.D. Hutchinson, G. Paulson, W.M. Shephard, and J. White. 1973.

- Comprehensive plan for the Illinois Nature Preserve system. Part 2. The natural divisions of Illinois. Illinois Nature Preserves Commission, Rockford. 32 pp.
- Schwegman, J.E. and R.H. Mohlenbrock. 1968. Notes on the flora of extreme southern Illinois. Transactions of the Illinois State Academy of Science 61: 317-319.
- Smith, E.B. 1988. An Atlas and Annotated List of the Vascular Plants of Arkansas, 2nd ed. University of Arkansas, Fayetteville. 592 pp.
- Steyermark, J.A. 1963. Flora of Missouri. The Iowa State University Press: Ames. 1728 pp.
- Strausbaugh, P.D. and E.L. Core. 1971. Flora of West Virginia Part II. 2nd Ed. West Virginia University Bulletin ser. 71, No. 12-3. pp. 275-575.
- Voss, E.G. 1985. Michigan Flora Part II. Cranbrook Institute of Science Bulletin 59. University of Michigan, Ann Arbor. 724 pp.
- Webb, W.L., H.J. Schroeder, and L.A. Norris. 1975. Pesticide residue dynamics in a forest ecosystem: a compartmental model. Simulation 24: 161-169.
- Wherry, E.T., J.M. Fogg and H.A. Wahl. 1979. Atlas of the Flora of Pennsylvania. Morris Arboretum of the University of Pennsylvania, Philadelphia, PA.
- White, J. and M. H. Madany. 1978. Classification of natural communities in Illinois. Pages 310-405 (Appendix 30) in: White, J. Illinois Natural Areas Technical Report, Volume 1. Survey Methods and Results. Urbana. Illinois Natural Areas Inventory.

WEBSITES CONSULTED

- W-1. Preliminary Conservation Assessment - Hoard and Hill (2002)
http://www.life.uiuc.edu/hughes/undergrad_prog/abstracts/summer02/hoard.html
- W-2. USDA, NRCS. 2002. The PLANTS Database, Version 3.5. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.
http://plants.usda.gov/cgi_bin/topics.cgi
- W-3. NatureServe Explorer (The Nature Conservancy): An online encyclopedia of life. 2002. Version 1.6. Arlington, Virginia, USA.
<http://www.natureserve.org/explorer/>
- W-4. *Waldsteinia fragarioides* (Michx.) Tratt., from Kemper Center for Home Gardening, Missouri Botanical Garden, St. Louis. © Missouri Botanical Garden, February 2001
<http://www.mobot.org/gardeninghelp/plantfinder/codem/W950.shtml>
- W-5. *Waldsteinia fragarioides* (Michx.) Tratt. subsp. *fragarioides*. Wisconsin State Herbarium, Vascular Plant Species Database, University of Wisconsin, Madison.
<http://www.botany.wisc.edu/wisflora/>

- W-6. South Carolina Plant Atlas. University of South Carolina, Columbia.
http://cricket.biol.sc.edu/acmoore/atlas_version2/index.html
- W-7. Barren Strawberry. Connecticut Wildflowers, Connecticut Botanical Society.
 February 2003.
<http://www.ct-botanical-society.org/galleries/waldsteiniafrag.html>
- W-8. California Native Plant Society.
<http://www.cnpsci.org/html/PlantInfo/Definitions2.htm>
- W-9. Botany On-line - Reproductive Isolation. University of Hamburg, Germany.
<http://www.biologie.uni-hamburg.de/b-online/e38/38d.htm>
- W-10. *Waldsteinia fragarioides*. Rare plant fact sheet. Maine Department of Conservation,
 Augusta.
<http://www.state.me.us/doc/nrimc/mnap/factsheets/snameindex.htm>
- W-11. List of Endangered, Threatened, and Rare species by county; Department of Natural
 Resources, Indiana.
<http://www.in.gov/dnr/naturepr/species/>
- W-12. Biological Evaluation for Threatened, Endangered, and Sensitive (TES) Species For the
 Red Pine and White Spruce Thinning Environmental Assessment, Superior National
 Forest.
<http://www.superiornationalforest.org/resources/2002/biological%20evaluation.htm>
- W-13. Distribution of *Waldsteinia fragarioides*. Atlas of the New York Flora. Maintained by
 Steve Glenn, Brooklyn Botanic Garden, Brooklyn, NY.
http://www.nyflora.org/atlas/maps/_Rosidae/Rosaceae/Waldsteinia_fragarioides.htm

CONTACTS

Shawnee National Forest; 50 Highway 145 South, Harrisburg, IL 62946

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

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: 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

Indiana Department of Natural Resources, 402 W. Washington St., Indianapolis, IN 46204

Michael A. Homoya (317) 232-0208; e-mail: mhomoya@dnr.state.in.us

Biological Consultant

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

Department of Biological and Physical Sciences, Barton College, Wilson, NC 27893

Mark A. Basinger (800) 345-4973; e-mail: mbasinger@barton.edu

APPENDICES

APPENDIX 1

Representative specimens of *Waldsteinia fragarioides* ssp. *fragarioides* examined or cited in the literature

Herbaria:

GMUF = George Mason University, Fairfax, VA. ILLS = Illinois Natural History Survey, Champaign. MICH = University of Michigan, Ann Arbor. MO = Missouri Botanical Garden, St. Louis. NYS = New York State Museum, Albany. UMO = University of Missouri, Columbia. UNA = University of Alabama, Tuscaloosa. WIS = University of Wisconsin, Madison.

ALABAMA: BLOUNT CO., Rich woods in sandy alluvium, 1.5 air mi. W of Cleveland, Swan Covered Bridge along the Locust Fork, 29 Mar 1998, *Keener & Jones 544* (UNA);
LAUDERDALE CO., Cypress Creek bluff just E of Wildwood Park along Co. Rt. 14, Florence. Rich soil, bluff ledge and lower talus slope, 9 Apr 1988, *Haynes & Freeman 9358* (UNA);
LAWRENCE CO., Ravine, along stream banks in sandy soil, 25 air mi. S of Town Creek, Sipsey Fork River, William B. Bankhead National Forest, 7 Apr 1969, *Thomas, Simmers, & Patrick*

1909 (UNA).

ARKANSAS: STONE CO., Ozark National Forest, Cap Fork, upper bluff area before vertical drops, on talus, 13 May 1993, *Hyatt 5319* (MO).

GEORGIA: STEPHENS CO., Cleveland Pike Road 4.3 mi N of Yonah Dam Road, 20 Apr 1997, *Hill 29174* (ILLS).

ILLINOIS: POPE CO., 1.5 mi SW of Eddyville, on Hayes Creek, 16 Apr 1967, *Schwegman 1110* (ILLS).

INDIANA: JENNINGS CO., along Muscatatuck River northeast of Vernon, 18 April 1918, *Deam 24418* (MO); same area, 23 May 1942, *Yuncker & Welch 10868* (MO); WAYNE CO., 39.49.04N, 084.59.47W, 29 Apr 1973, *Markle s.n.* (UMO).

MICHIGAN: ALPENA CO., Beech-maple woods, Hamilton Road, Alpena Twp., 26 May 1972, *Garlitz 224* (MICH); CHIPPEWA CO.: Mixed woods, Maxton Plains, Drummond Island, 26 May 1985, *Freudenstein 1580* (MICH); EATON CO., Low deciduous woods, 2 mi NNW of Vermontville, 2 May 1958, *Voss 5441* (MICH); GOGEBIC CO., Tamarack swamp N of Ironwood, 12 Jun 1920, *Darlington 3146* (MICH).

MISSOURI: DALLAS CO., along Niangua River south of Windyville, 2 Jun 1951, *Steyermark 71475* (MO); DOUGLAS CO., east of Bryant Creek, Sweden, 36.57.00N, 092.29.00W, 06 Apr 1935, *Steyermark 18528* (UMO); HOWELL CO., ca. 5 mi northwest of Willow springs on Indian Creek, 2 Aug 1993, *Summers* (MO); OREGON CO., Wolfpen Hollow, 1 mi east of Paty Pond, 1993, *Summers* (MO); SHANNON CO., Medley Hollow, 8 May 1984, *Christ* (MO); TEXAS CO., Arroll, 37.19.00N, 091.58.00W, 16 Aug 1934, *Steyermark 14605* (UMO); Jack's Fork of Current River, 13 Apr 1935, *Steyermark 18597* (UMO).

NEW YORK: ALBANY CO., South Bethlehem: Hollyhock Preserve, on W side of Route 102, 1990, *Tucker 5351* (NYS); ESSEX CO., Woods near Newcomb, 1800 ft. altitude, 11 Jun 1921, *House s.n.* (UNA); ORANGE CO., Rackett Road and Bushville Road, 2001, *Glenn 5458* (BKL).

OHIO: HOLMES CO., slope above Doughty Creek, ca. 1 mi southwest of State Rt. 557 and TWP Rt. 154, NW of Charm, 2 May 1994, *Cusick 31568* (MO).

SOUTH CAROLINA: EDGEFIELD CO., along rapid creek with rock outcrops, NE of Rte. 230, level area near stream bank, ca. 0.3 mi NW of Aiken Co. line, 5 Apr 1990, *Hill & Soblo 21384* (CLEMS, NY).

TENNESSEE: MORGAN CO., south side of Lancing Road, ca. 2 mi W of US Route 62, NW of Wartburg, 22 Apr 1995, *Hill 26296* (ILLS).

VIRGINIA: ALBEMARLE CO., moist shelves of thinly-wooded greenstone cliff, along North Fork Moormans River, ca. 5 miles west-northwest of White Hall, Shenandoah National Park, 16 Aug 1991, *Fleming & Stevens 5856* (GMUF); AUGUSTA CO., open, rocky oak-heath woods on summit of Shenandoah Mountain above Left Prong of Ramseys Draft, ca. 4 miles southeast of

Palo Alto, 3 May 1994, *Fleming & Rawinski 8936* (GMUF); CHARLOTTE CO., hemlock slope near junction of Rte. 691 and Rte. 7011, 25 May 1968, *Harvill 19325* (GMUF).

WEST VIRGINIA: CABELL CO., Milton, 38.26.00N, 082.15.00W, 15 Apr 1938, *Gilbert et al. 678* (UMO).

WISCONSIN: BAYFIELD CO., 46.33.00N, 091.09.00W, 27 May 1976, *Bennett 326* (UMO); FLORENCE CO., Pine Ridge Trail near Lost Lake in Nicolet National Forest, 28 May 1996, *Radunzel 7* (WIS); ONEIDA CO., Cassian, 45.40.00N, 089.30.02W, 09 Jun 1925, *Palmer 27801* (UMO); VILAS CO., Crystal Bog, 46.00.422N, 089.36.361W, 17 Jun 1996, *Crane 96-122* (ILLS); Sparkling Lake, 46.00.871N, 089.41.829W, 30 May 1996, *Crane 96-96* (ILLS).

APPENDIX 2.

The Distribution of *Waldsteinia fragarioides* ssp. *fragarioides* in the United States. Information from herbarium specimens and the literature.

STATE	COUNTIES	NOTES
Alabama	Blount, Lauderdale, Lawrence; northern 1/3 of state	W-2; Ginzburg, pers. comm.; Appendix 1; includes William B. Bankhead N.F.; possible questions on ssp. distribution here
Arkansas	Stone	W-2; Smith (1978); includes Ozark N.F.
Connecticut	Litchfield	Magee and Ahles (1999); W-2
Georgia	52 counties, mostly northern 1/3 of state (Mellinger); only 10 counties documented by Jones and Coile, same region [Chattooga, Clarke, Floyd, Forsyth, Hall, Jackson, Lumpkin, Stephens, Towns, White]	W-2; Jones and Coile (1988); Mellinger (1984); neither source distinguishes subspecies, and both are said to occur in the state; possible questions on ssp. distribution here
Illinois	Pope	W-2; Appendix 1; includes Shawnee N.F.
Indiana	Clark [historic?], Crawford, Franklin, Greene, Harrison, Jefferson [historic?], Jennings, Wabash, Washington, Wayne	W-2; W-11; Deam (1940); Homoya, pers. comm.
Kentucky	17 counties, east-central portion of state [22 counties documented for species overall]	W-2; includes Daniel Boone N.F.; possible questions on ssp. distribution here
Maine	Kennebec, Penobscot [?]	Magee and Ahles (1999); W-2; Jenkins (1981); 2-3 extant sites (W-10)
Maryland	Allegany, Garrett, others ?	Brown and Brown (1984)
Massachusetts	Berkshire, Franklin, Plymouth	Magee and Ahles (1999); W-2
Michigan	27 counties, mostly western upper peninsula and eastern lower peninsula	Voss (1985); W-2

Minnesota	Itasca, Lake, Pine, St. Louis; northeastern portion of state	Ownbey and Morley (1991); W-12; Includes Superior N.F.; 30 populations, including 8 in northeastern Minnesota
Missouri	Dallas, Douglas, Howell, Oregon, Shannon, Texas	Appendix 1; Steyermark (1963) reported it from only Dallas, Douglas, and Texas Counties
New Hampshire	Coos, Grafton, Hillsborough [historic], Rockingham, Sullivan [historic]	Magee and Ahles (1999) show only Grafton; W-2; Jenkins (1981); 8 sites: 4 extant and 4 historic
New Jersey	Hunterdon, Sussex, Warren (and others ? - data not available)	Steve Glenn, pers. comm.
New York	34 counties throughout the state	W-13; Steve Glenn, pers. comm.
North Carolina	25 counties, mostly piedmont	W-2; W-3; Radford <i>et al.</i> (1968), ssp. not distinguished; includes Nantahala N.F., Pisgah N.F., and Great Smoky Mountains Natl. Park; possible questions on ssp. distribution here
Ohio	> 10 counties; especially eastern part of state	Allison Cusick, pers. comm.
Pennsylvania	62 counties, in all but about 5 counties	Wherry <i>et al.</i> (1979); possible questions on ssp. distribution here
South Carolina	Aiken, Cherokee, Edgefield, Kershaw, Lancaster, Oconee, Richland, Spartanburg	South Carolina Natural Heritage Records; see W-6 ; possible questions on ssp. distribution here
Tennessee	24 counties, mostly eastern third of state	W-2; Chester <i>et al.</i> (1997), ssp. not distinguished; in Great Smoky Mtns. Natl. Park; possible questions on ssp. distribution here
Vermont	Addison, Bennington, Caledonia, Chittenden, Orange, Rutland, Windham, Windsor	Magee and Ahles (1999); W-2; Jenkins (1981) 31 sites
Virginia	35 counties, central and western parts of state	W-2; Harvill <i>et al.</i> (1986), ssp. not distinguished; possible questions on ssp. distribution here
West Virginia	14 counties	W-2; Strausbaugh and Core (1971): "frequent throughout the State"
Wisconsin	19 counties, northern half of state	W-5

APPENDIX 3.

Natural Diversity Database Element Ranking System

modified from: <http://www.cnpsci.org/html/PlantInfo/Definitions2.htm> [W-8]

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.

Species Level Ranking (T)

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