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Conservation Assessment

for

Hay-scented Fern

(*Dennstaedtia punctilobula* (Michx.) T.Moore)

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Center for Biodiversity
Technical Report 2003 (3)

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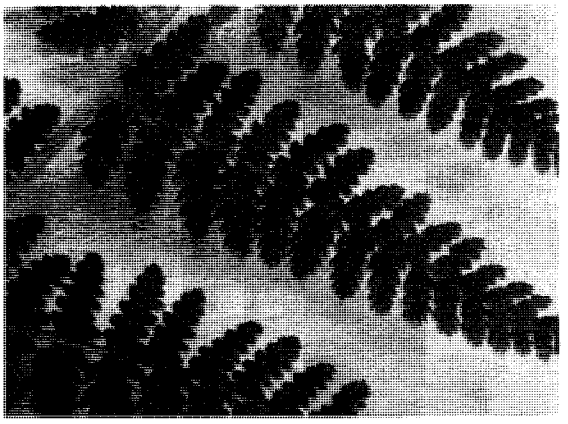

Photo:

Dennstaedtia punctilobula (Michx.) T.Moore, Hay-scented fern. Portion of frond with sori; Isle of Wight County, VA, 11 August 2001, Lytton Musselman, Old Dominion University, used with permission:

http://web.odu.edu/webroot/instr/sci/plant.nsf/

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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 these assessments (W-1), and to my assistant Sherry Weaver for her continuing assistance in processing the plant specimen vouchers.

EXECUTIVE SUMMARY

This Conservation Assessment is a review of the distribution, habitat, ecology, and population biology of the Hay-scented fern, *Dennstaedtia punctilobula* (Willd.) T.Moore, 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 the Hay-scented fern to date. Hay-scented fern is a generally large, deciduous fern, a perennial herb, that is found in the eastern United States and Canada, and it is known to occur historically in twenty-six states and the District of Columbia, namely, AL, AR, CT, DC, DE, GA, IL, IN, KY, MA, ME, MD, MI, MO, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT, WI, and WV, and in six Canadian provinces, namely, NB, NI, NS, ON, PE, and QC. This fern is common and considered to be rather aggressive in most of its range except at its periphery, and it is commonly grown in woodland gardens. It is found in acidic soils that are usually well-drained, in partial shade, but it also tolerates sun well and, in some areas, is common along roadsides. The colonies are generally large because it spreads by means of long, rather fast-growing rhizomes. Globally, its ranking is G5 (secure globally). Though common in much of its range, Hay-scented fern is rare (imperiled) in Illinois where it has been listed as Endangered, and it is has been found primarily within the Shawnee National Forest. It was formerly listed as Rare in Missouri. This fern is considered to have been extirpated in Michigan and Wisconsin. The species has not been included on the Regional Forester Sensitive Species list (RFSS) for the Eastern Region, but it is Forest Listed in the Shawnee National Forest. While secure in most of its range, it could be extirpated within Illinois without proper management.

In additional to species listed as endangered or threatened under the Endangered Species Act (ESA), or species of Concern by U.S. Fish and Wildlife Service, the Forest Service lists species that are Sensitive within each region (RFSS). The National Forest Management Act and U.S. Forest Service policy require that National Forest System land be managed to maintain viable populations of all native plant and animal species. A viable population is one that has the estimated numbers and distribution of reproductive individuals to ensure the continued existence of the species throughout its range within a given planning area.

The objectives of this document are to:

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

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

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

NOMENCLATURE AND TAXONOMY

Scientific Name:	*Dennstaedtia punctilobula* (Michx.) T.Moore
Common Names:	Hay-scented fern; Eastern hay-scented fern; Hayscented fern
Synonymy:	based on: *Nephrodium punctilobulum* Michx.
Class:	Filicopsida (Ferns)
Family:	Dennstaedtiaceae (the Bracken fern family)
Plants Code:	DEPU2 (USDA NRCS plant database, W-2) http://plants.usda.gov/cgi_bin/topics.cgi

There are three species of *Dennstaedtia* in North America north of Mexico. The other two (*Dennstaedtia bipinnata* (Cav.) Maxon and *D. globulifera* (Poiret) Hieron.) are tropical species that are rare in the United States and that have been found very locally in Florida and Texas, respectively (Nauman & Evans 1993, Tryon 1960). Most of the approximately 400 species in the family are tropical, and the Hay-scented fern is the northernmost species. It has no additional North American relatives (north of Mexico) other than the distantly related, but widespread bracken fern (*Pteridium*), and the likewise distantly related genera *Hypolepis* and *Odontosoria* that are rare north of the tropics. It is a true fern, a vascular plant that reproduces by spores.

The genus was named after the German botanist August Wilhelm Dennstedt (1776-1826). The species epithet means 'finely pointed lobes', referring to the delicately toothed margins of the leaf pinnules.

When fresh or freshly cut the fronds have a distinctive aroma of freshly mown hay, hence its common name.

DESCRIPTION OF SPECIES

Dennstaedtia punctilobula is a robust perennial fern with long-creeping straight underground stems (rhizomes) that are 2-3 mm in diameter. Its leaves (fronds) are clustered or more commonly scattered along the rhizome, erect, covered throughout with short soft sometimes gland-tipped hairs, 30-80 cm (to 1.3 m) long and 9-22 (-30) cm wide, with dull straw-colored to brown stalks about half the length of the blade. The leaves and their stalks are brittle and easily broken. The leaf blades (laminae) are lanceolate, widest near the bottom, about 3 times longer

than wide, yellow-green or pale green when fresh, finely divided and twice-pinnate-pinnatifid, slightly narrowed but truncate at the base, with an acuminate apex, with soft pale hairs on both surfaces, with numerous (often more than 30) pairs of mostly alternate pinnae (subopposite towards the base) that are ovate to lanceolate, equilateral, and truncate; the ultimate segment margins are deeply lobed to serrate-crenate; the pale sori are lateral in notches on the ultimate segments, globose to almost cylindric in shape and are formed by fused indusia to form this cup or tube bearing the sporangia; the chromosome number is $2n = 68$ (description primarily from Gleason & Cronquist 1991, Lellinger 1985, Nauman & Evans 1993). Hammen (1993) has shown that there can be significant morphological variation in this fern that is density-dependent.

The Hay-scented fern is easily recognized by its fresh-cut hay (or alfalfa) aroma, by the often scattered large fronds, by the highly divided appearance of the fronds, and by the very distinctive sori.

HABITAT AND ECOLOGY

Dennstaedtia punctilobula is normally found on deep, acid to strongly acidic soils or, less frequently, in thin acidic soils over rock in full sun or partial shade. Habitats have been described as rocky slopes, meadows, woods, stream banks, and roadsides (Conard 1908, Nauman & Evans 1993). It is tolerant of heat and cold, but it appears to be restricted to areas with a distinct winter season, during which it loses its leaves and becomes dormant. The soils where it grows are normally moist but well-drained, and they normally have a high sand or organic content. The soils can be seasonally wet. This fern does not appear to tolerate basic or calcareous soils.

Hay-scented fern is tolerant of drought and some habitat disturbance. In much of its range, it is a characteristic species along roadsides at the margins of dry or dry mesic upland forests (White & Madany 1978) composed mostly of oak and hickory and it tolerates occasional mowing. Its tolerance to mowing has contributed to the popularity of its common name. Hay-scented fern has also been characterized as growing on exposed ridges as well as shaded stream banks, but in areas of continually moist soil other ferns (*e.g.*, *Thelypteris noveboracensis* in the eastern states) appear to be better adapted and often replace it. It competes well with other plants, including aggressive flowering plants, much like its rather distant relative the Bracken fern. It spreads aggressively in open woods and clearings (Nauman & Evans 1993). Its roots and rhizomes can form a very dense turf-like layer where it has become well-established. It can be found on slopes with nearly any exposure, tending to be on south-facing slopes in colder parts of its range and on north-facing slopes in warmer climates.

The Hay-scented fern produces allelopathic chemicals, compounds that kill or inhibit the growth and/or germination of other plants (Horsley 1977, 1979, 1987; Lyon & Sharpe 1996) although one study suggested that there is no such inhibition (W-3). In most studies in areas where this

fern is common, however, the presence of this fern has been demonstrated to interfere not only with the growth of the roots of tree seedlings, but it also to reduce the ability of fungi to infect their roots (reduction of ectomycorrhizal infection frequency). These mycorrhizal infections are needed for the growth of many forest tree species, because the fungi assist in the gathering of water and nutrients to their roots. It has been shown that the ferns are primarily responsible for maintaining the open patches where they grow by obstructing the ability of other species (primarily tree seedlings) to germinate and grow in their immediate vicinity (Rooney & Dress1997 - "High species richness at the quadrat scale was negatively associated with high densities of hay-scented fern"). *Dennstaedtia punctilobula* is also known to be very resistant to grazing and browsing by livestock and deer, either because they do not like it or because it can grow new fronds quickly, and it is often one of the few herbs left in the understory of very overgrazed forests in parts of the eastern United States (Tilghman 1989).

Dennstaedtia punctilobula occurs in several plant community types from low to high elevation, and from Newfoundland to Arkansas. In Virginia, for example, within the George Washington National Forest (W-4) the Hay-scented fern grows in mesic cool forests with the trees *Tsuga canadensis*, *Tilia americana*, *Betula allegheniensis*, and *Robinia pseudoacacia*, the shrubs (or small trees) *Acer spicatum*, *Ilex montana*, and *Ribes rotundifolium*, and the herb *Aster acuminatus* along with the other ferns *Dryopteris intermedia*, *Dryopteris marginalis*, and *Polypodium virginianum*.

In Big Run Bog, Tucker County, West Virginia, within the Monongahela National Forest, the Hay-scented fern is considered to be a species of the Northern Hardwood Forest community on upland slopes and ridges. This forest has been characterized as a "Black Cherry – Maple type, with small inclusions of Sugar Maple – Beech – yellow Birch and Hemlock – Yellow Birch" (Braun, 1950; Core, 1966; Eyre, 1980). The tree dominants with this fern there include *Prunus serotina*, *Acer rubrum*, *Fagus grandifolia*, *Betula alleghaniensis*, *B. lenta*, *Tsuga canadensis*, and *Magnolia fraseri*, along with the less common associates *Quercus rubra*, *Acer saccharum*, *Magnolia acuminata* and *Amelanchier laevis*. Characteristic shrubs (and small trees) include *Acer pensylvanicum*, *Hamamelis virginiana*, *Ilex montana*, and *Rhododendron maximum*. Characteristic herbs include *Carex intumescens*, *C. debilis*, *C. laxiflora*, *C. pensylvanica*, *Lycopodium obscurum*, *L. digitatum*, *L. annotinum*, *L. clavatum*, *Oxalis montana*, *Smilax rotundifolia*, *Thelypteris noveboracensis*, *Dryopteris intermedia*, *Trillium undulatum*, *Gaultheria procumbens*, *Medeola virginiana*, *Erythronium americanum*, *Claytonia caroliniana*, *Epifagus virginiana*, *Mitchella repens*, *Maianthemum canadense*, *Trientalis borealis*, *Agrostis perennans*, *Anemone quinquefolia*, *Brachyelytrum erectum*, *Viola rotundifolia*, and *V. blanda* (W-5).

In Tennessee, Hay-scented fern is considered to be a typical member of the High Elevation Red Oak Forest (Deciduous shrub type) community (W-6). Dominants in this forest type are *Quercus rubra*, *Vaccinium simulatum*, *Rhododendron calendulaceum*, *Dennstaedtia punctilobula*, and *Thelypteris noveboracensis*. In the Carolinas, this fern grows primarily in the Montane oak forest

or Oak - hickory forest dominated by the trees *Quercus alba, Q. falcata, Q. coccinea, Q. velutina, Pinus echinata, Pinus strobus, Carya glabra, Carya tomentosa, Acer rubrum, Liriodendron tulipifera, Tsuga canadensis*, and *Cornus florida*, the shrubs *Calycanthus floridus, Ilex opaca*, and *Vaccinium pallidum*, the vines *Toxicodendron radicans* and *Smilax* spp., and the grass *Poa autumnalis* and the fern *Thelypteris noveboracensis* (Schafale & Weakley 1990).

In contrast to most populations in the eastern states, in the midwestern states Hay-scented fern is found almost exclusively on sandstone ledges, preferring moist acidic soils over sandstone and shales in deep, north-facing wooded ravines (Deam 1940, Herkert *et al.* 1991, Yatskievych 1999). Some of these sites have been called stone chimneys or rock houses (see Francis *et al.* 1993) and most of the rock outcrops are associated with deep canyons. The community where it grows in the Midwest is generally called the Sandstone Cliff Community (White & Madany 1978). The surrounding forests are normally dominated by tall mature trees, including *Quercus alba, Q. stellata, Q. velutina, Fagus grandifolia, Acer* spp., *Carya* spp., and *Ostrya virginiana*, and other associates can include the shrubs *Hydrangea arborescens, Kalmia latifolia, Vaccinium arboreum, V. pallidum*, and *Viburnum* sp., and the herbs *Anemonella thalictroides, Cimicifuga* sp., *Tiarella cordifolia, Solidago caesia*, and *Sedum ternatum.* Other associated ferns can include *Athyrium filix-femina, Osmunda cinnamomea*, and *Polypodium virginianum* and the club-moss *Lycopodium porophilum*, and, in locally wet places (especially in Illinois), peat moss, *Sphagnum* spp. is a common associate.

Dennstaedtia punctilobula is often a colonizer species in the northeastern United States, and it can be one of the early perennials to establish after forest clearing or other habitat degradation provided that established colonies are also in the vicinity (see Tilghman 1989). The fern is well adapted to this somewhat disturbed and common habitat, and, because many other plants are as well, its associates are numerous. It is easily cultivated in woodland gardens that have acidic soil and it is readily available commercially.

DISTRIBUTION AND ABUNDANCE

Dennstaedtia punctilobula is widespread and common in most of the temperate and cool-temperate eastern United States and Canada, and it is known to occur historically in twenty-six states and the District of Columbia, namely, AL, AR, CT, DC, DE, GA, IL, IN, KY, MA, ME, MD, MI, MO, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT, WI, and WV. It also occurs in six Canadian provinces, namely, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, and Quebec (W-2, W-7). In many of the Appalachian and eastern states, Hay-scented fern is one of the most common ferns encountered. Its range includes both formerly glaciated and unglaciated areas. A very few disjunctions have been reported at the western portions of its range. The Hay-scented fern appears to be an Appalachian species and it is rare in the Ozark regions of the Midwest. Additional details on the distribution of Hay-scented fern can be found in Chester *et al.* (1993), Harvill *et al.* (1977), Kartesz and Meacham (1999), Lellinger

(1985), Magee and Ahles (1999), Radford *et al.* (1964), Reed (1953), Smith (1988), and Yatskievych (1999) and several Internet sites (*e.g.*, W-2, W-7).

The Hay-scented fern has been reported from Iowa in the earlier literature, but that report has been shown to have been erroneous, and was based upon mislabeled specimens from New York (Cooperrider 1968).

Hay-scented fern is at its southern limit of distribution in the Cumberland Plateau, and just south, in northeastern Alabama and northern Georgia (Snyder & Bruce1986). Its western limit is in extreme northwestern Arkansas (Smith 1988). It reaches south-central eastern Missouri, and parts of Illinois and Indiana (Yatskievych 1999, Mohlenbrock & Ladd 1978, Deam 1940). It was found twice in Wisconsin and is probably extirpated there according to notes filed with the specimen at the University of Wisconsin herbarium (WIS). It is also considered to have been extirpated in Michigan (Michigan Natural Features Inventory 2000). In Canada, it is considered to be rare in Newfoundland (W-7). Representative specimens of this fern have been listed in Appendix 1. A summary of the distribution of the Hay-scented fern in the United States has been presented in Appendix 2.

Within the U.S. Forest Service Eastern Region (Region 9) *Dennstaedtia punctilobula* is present within both the Shawnee National Forest in Illinois and the Hoosier National Forest in Indiana, but is uncommon or rare. It is considered to be common, however, in the Allegheny National Forest in Pennsylvania, Monongahela National Forest in West Virginia, and the Wayne National Forest in Ohio. It is common in the National Forests of the Appalachian region generally to the southeast.

In Missouri, this fern is considered uncommon, and it is restricted to Madison, St. Francois, and Ste. Genevieve Counties (Yatskievych 1999) on ledges of La Motte sandstone bluffs. The Missouri Heritage Program lists 22 records for *Dennstaedtia punctilobula*, and, while not listed as threatened or endangered in the state, it is tracked as an S2 (imperiled) species. Of these 22 localities, 2 are in Madison County, 1 is in St. Francois County, and the other 19 are from Ste. Genevieve County; all but 1 of the Madison County sites are considered extant. None of the stations is within the present boundaries of the Mark Twain National Forest, but some of the sites come close (Yatskievych, pers. comm.).

In Indiana, *Dennstaedtia punctilobula* is particularly well-known in the protected areas of Saalman Hollow within the Hoosier National Forest in Perry County (W-8), and in Turkey Run State Park in Parke County. Overall, it has been found in Crawford, Lawrence, Martin, Parke, and Perry Counties (Deam 1940) and, perhaps, others.

In Illinois, where it is listed as Endangered, the species has been reported historically in Johnson and Pope Counties where five populations still occur in Shawnee National Forest and where two occur in state nature preserves (Mohlenbrock & Ladd 1978, Herkert *et al.* 1991, Illinois Endangered Species Protection Board 1999). The Illinois populations are primarily within the Hayes and Lusk Creek drainages, as well as the Double Branch Hole Ecological Area. The distribution map presented in Herkert *et al.* (1991) indicates an occurrence in Ogle County in northwestern Illinois without comment, and this was also mentioned by Mohlenbrock (1986) who stated that it had been reported from Wabash County as well. It may have been found in White Pines State Park in Ogle County where suitable habitat occurs, but I have not seen a specimen from there or from Wabash County. The southern Illinois sites fall within the Greater Shawnee Hills Section of the Shawnee Hill Natural Division of Illinois (Schwegman *et al.* 1973) just south of the glacial boundary, and the Ogle County site is within the Rock River Hill Country Natural Division.

The populations in Illinois and other parts of the Midwest are relatively small compared to populations in the eastern states. Furthermore, the populations are isolated from one another apparently because the fern in this region has a more narrow preference for moist to wet shaded acidic sandstone ledge habitat that is not common. There is little specific data in the Illinois Heritage database regarding population sizes. It is likely that the species was not common in the region at the time of European settlement because the amount of suitable habitat available then was also limited.

PROTECTION STATUS

The Nature Conservancy ranking for *Dennstaedtia punctilobula* is G5 (secure globally; W-7, Appendix 3). In the United States the species is given the National Heritage status rank of N5 with a similar meaning. The national ranking for Canada is N?. The state rankings vary, but it has been designated as Endangered in Illinois and it is generally considered to have been extirpated in Michigan and Wisconsin. It was formerly listed as Rare in Missouri (W-9) but current law in that state only allows the listing of federally listed taxa as state endangered (Yatskievych, pers. comm.). It is not tracked in most states where it occurs because of its greater frequency.

Dennstaedtia punctilobula has not been included on the Regional Forester Sensitive Species list (RFSS) for the Eastern Region, but it is Forest Listed in the Shawnee National Forest (Shawnee National Forest 2001).

Protection for this fern is currently dependent primarily on habitat protection, and so its survival will probably depend more on this than on species protection. *Dennstaedtia punctilobula* in Arkansas, Illinois, Indiana, and Missouri appears to be restricted to a relatively specialized and

scarce habitat, and high quality examples of this habitat (Sandstone cliff) have been given a priority for protection in some states.

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-7). Appendix 3 explains the meanings of the acronyms used (W-10). A summary of the current official protection status for Hay-scented fern follows:

U.S. Fish and Wildlife Service: Not listed (None)

U.S. Forest Service: Forest Listed in the Shawnee National Forest only

Global Heritage Status Rank: G5

U.S. National Heritage Status Rank: N5

Canada National Heritage Status Rank: N?

Table 1: S-ranks for *Dennstaedtia punctilobula* [Heritage identifier: PPDEN01050]

State/Province	Heritage S-rank
UNITED STATES	
Alabama	S3
Arkansas	S2
Connecticut	SR
Delaware	S5
District of Columbia	S?
Georgia	SR
Illinois	S2
Indiana	S3
Kentucky	S4?
Maine	SR
Maryland	SR
Massachusetts	SR
Michigan	S?
Missouri	S2
New Hampshire	SR
New Jersey	S5
New York	SR
North Carolina	S5
Ohio	SR
Pennsylvania	S?
Rhode Island	SR
South Carolina	SR
Tennessee	SR
Vermont	SR
Virginia	SR
West Virginia	S?
Wisconsin	SR

CANADA			
		Ontario	S5
		Prince Edward Island	S5
New Brunswick	S5	Quebec	SR
Newfoundland	S1		
Nova Scotia	SR		

Notes and maps found in the University of Wisconsin Herbarium at Madison (WIS) filed with the only specimen known from that state included a testimony from its discoverer. Based on those notes, this species was found only once or twice in the state, and repeated attempts to relocate it have been unsuccessful. Some of the data in Table 1 needs re-evaluation.

LIFE HISTORY

Dennstaedtia punctilobula is a robust deciduous-leaved perennial fern with long-creeping straight underground stems (rhizomes) that, in most of its range, form large colonies covering several square meters (Conard 1908). Its average life-span is not known, but it is assumed that a colony can be long-lived. Growth is fast relative to most ferns and it is often considered to be an aggressive native species that can invade pastures, roadsides, cleared land, and gardens. Furthermore, this fern has been shown to produce chemicals that inhibit the growth and establishment of competitor species (see above). The long rhizomes can also interweave and form a tough turf-like mat that helps to exclude competition from other species. If the mat or rhizome breaks or fragments, each portion can develop into another plant and colony under suitable conditions and vegetative reproduction is considered to be common in this fern. As with many herbs, plant growth and size is limited by features of its immediate habitat (microhabitat), including such factors as degree of exposure, thickness of soil, and nutrient availability and there may be longer periods of dormancy of individual plants in some populations in dry, hot, or cold periods.

Plants begin growth in early spring. My studies on phenology of plants in South Carolina in the Blue Ridge of Oconee County (unpublished data) indicate that *Dennstaedtia punctilobula* fronds begin to grow soon after the last frost (emergence is generally about 24 April) and the sporangia first become mature in mid-summer (about July 15). The fronds continue to release spores until they are exposed to the first frost and begin to turn yellow (the last spores fall about 31 October in South Carolina). In the Midwest the season may be shortened by a week or two on each end. The number of leaves on a given plant reflect its rate of growth, and a branched rhizome can have several tufts of leaves or many single ones. The number of individuals can only be determined by carefully excavating the plants or by DNA analysis. New fronds are produced each year. The ferns reproduce by means of spores that are produced in sporangia (spore cases) borne at the margins of the ultimate divisions of the leaves within a cup or tube shaped structure

(formed by the fused indusium) that is located in a notch. This cup can be seen to have brown sporangia within at maturity (green when immature). The dust like spores are dispersed into the air when mature, and the rather tall fronds may be able to disperse the spores greater distances than can smaller fern species. As is typical in the ferns, the spores grow into small heart-shaped flat green thalli (gametophytes) 0.5 cm long or less, and new spore-producing fern plants (sporophytes) are produced only if an egg on the gametophyte is fertilized by a free-swimming sperm whereupon the zygote can grow into a new rooted plant. The eggs are only fertilized when there is a film of water available on the gametophyte because the sperm must swim to the egg. Therefore, the spore must first disperse to a suitable moist or wet surface with sufficient soil for a vascular plant to grow, and it must not dry out before a sturdy young sporophyte has formed. The plant is not secure until it has developed a root mass that can withstand drought. Apparently, the young sporophytes are vigorous, and the Hay-scented fern propagates readily both sexually and asexually (clonally).

Because there are no closely related ferns within its range, natural hybrids are unknown in this species.

POPULATION BIOLOGY AND VIABILITY

As previously stated, within most of its range *Dennstaedtia punctilobula* is a common, fast-growing, aggressive fern that forms large colonies in often marginal habitats. At the western edge of its range in several midwestern states (particularly Arkansas, Illinois, Indiana, and Missouri) this fern is uncommon or rare, and forms very local colonies restricted to a more restricted habitat. Mature individuals appear to be sturdy and, perhaps, long-lived, and they can reproduce both vegetatively and by means of spores. It is not known how far the spores can travel, but the few colonies extant in this part of the country and their local nature may suggest that they cannot travel long distances or that there is little additional suitable habitat available for the species even if they can.

Dennstaedtia punctilobula is an diploid species with a chromosome number of $2n = 68$. There appear to be no reproductive problems of a genetic nature. In most of its range this fern is extremely successful and fully viable. It is only at the margins of its range where viability problems occur. Based on its distribution, one could speculate that this species is adapted to, and requires, seasonal dormancy that results from a cool or cold winter. This may be why it does not range much farther south. It also appears to require a rather long growing season, and this may explain why it does not range farther north and west where the continental climate is more harsh and climates are less moderate. Its distribution along the northeastern coast coincides with the milder influences between the Great Lakes and the Gulf Stream, both of which combine to produce a milder, less severe climate that lacks most of the extremes of the more interior continental region. Many North American plants follow this distribution pattern.

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. Plants are very sensitive to local conditions at the margins of their ranges.

In many biological simulations, the 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 Florida, for example, the royal palm (*Roystonea elata* (Bartr.) F. Harper) once grew as far north as Lake and Volusia Counties in the northern half of Florida, according to William Bartram who investigated the area in the 1760's (see Harper 1958, p. 90, 94, 115-116, 141) during which period citrus and indigo could be easily grown into the Carolinas. Certain severe freezes in subsequent years may have brought about a local extinction of the palm. In his 1958 edition of Bartram's book, Francis Harper wrote: "In 1835, for example, a severe northwest wind blew for 10 days, and the thermometer dropped to 7 degrees; the St. John's River was partly frozen, and 'all' fruit was killed to the ground". He reasoned that the trees "have not been reported so far north in Florida by subsequent observers, and it is presumed that they did not survive the 'freeze' of 1835". Other severe freezes were also documented in 1894-1895 and this palm and many of its associates may have been eliminated at either time from all but extreme south Florida, where it is rare today. Clearly, temperature extremes can be a primary factor determining the distributions of such plants.

In the case of *Dennstaedtia punctilobula*, current distribution appears to be dependent primarily on soil pH (hence substrate and bedrock type) and degree of canopy closure, but temperature extremes could easily play a role. In addition to substrate unsuitability, colder temperatures may have limited its occurrences in Wisconsin and Michigan where no individuals currently remain. Its failure to live outside of the mountains at its southern range limits suggests that extremes of heat or the lack of a cold season for dormancy may have prevented it from occurring farther south. While most populations are in dry or dry-mesic, well-drained sites, a few have been described as being in wetter sites, so soil moisture may not be as significant a limiting factor on its distribution. Throughout its range, however, the species grows only in acidic soils, and the populations are either in the open or in a forest with an open understory. Under natural conditions a threat to the species in an existing colony on suitable substrate at the southern part of its range might be either from the closing of the canopy through increased vegetation growth (so that insufficient light remained for growth) or from the opposite, a major clearing of the surrounding forest that might heat and dry the colony too much. In order to manage for the species, then, selective infrequent thinning of the forest stand within which it grows may be needed at some sites.

The long term viability of the Hay-scented fern at its range limits in the Midwest may depend entirely upon its persistence at the currently known sites and the maintenance or protection of its habitat at those sites.

In the Midwest or the other marginal areas of its range, it is unlikely that the species would be able to re-establish itself at a site from which it has been extirpated even though fern spores are light and can disperse on wind. The distances between populations are too great, and the numbers of reproductive individuals are too small in these borderline areas. The species has been given a very secure rank of G5 overall because in the greater part of its range numerous populations are known that appear to be extremely well adapted to their environment. However, in border states some of these populations are now gone, and the loss of a few populations at the periphery can eliminate the fern from an entire state (*e.g.*, Michigan and Wisconsin).

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

POTENTIAL THREATS

As a species, the future of Hay-scented fern is very secure. However, at the margin of its range in the Midwest, its habitat preferences have restricted the species to only a few sites that have the moderate temperatures, moisture, and acidic substrate that it needs. An obvious threat to the species in the Midwest is the quarrying or strip mining of its habitat. Other threats to the species include physical damage from trampling by rock climbers, hikers, or equestrians, and from other degradations of the environment. Because it is known to grow well in cultivation, an additional threat, locally, may be from collecting of live plants for gardens. Pollutants and herbicides applied around populations or at the top of cliffs could eliminate the species from toxic runoff. The elimination of vegetation cover on bluffs above some colonies may also reduce the soil and nutrients available to the plants below decreasing growth and reproductive potential. The spread of vines, such as Japanese honeysuckle and Virginia creeper among others, onto the sandstone ledge habitats may produce too much shade for the ferns to persist. Even in regions where this fern thrives, Japanese honeysuckle is one of the few plants that can engulf and eliminate it (personal observations). This and other vines may be rooted some distance away and so may not be affected by the allelopathic chemicals produced by the fern. The dense growth of trees may also shade some populations and cause them to decline.

The need for a winter dormancy and a need for spring moisture appears to be crucial for this fern as it is for many forest floor herbs throughout the northeastern states. Certainly they also need a

soil stability once established and a lack of aggressive competition. Under natural conditions, its habitat in the Midwest is stable, but if local conditions become either densely shaded or too exposed, if the soil becomes too dry for too long, if nutrient and soil accumulation changes, or if human or animal traffic increases, the fragile habitat balance can be destroyed and the populations could be lost. Burning of the surrounding forest might be detrimental by increasing drying and erosion, but hard data is lacking. It is just as likely that a partly burned forest could add nutrient to its microhabitat. In the eastern states this fern, like Bracken fern, is considered to increase after burns, but its habitat is different in the midwestern states and this may not apply.

It is also generally believed among biologists that habitat fragmentation can have profound effects on the success and persistence of local populations. Any activities that result in barriers to dispersal, such as developments, clearcuts, road/utility line corridors, and mined areas limit the possibility of population expansion and genetic exchange in many species. Deleterious effects of fragmentation could possibly go unnoticed for a long period of time, making the short term effects on species viability less apparent. Over time, as populations become increasingly more isolated, the effects of fragmentation can potentially be observed at the molecular level by reduced genetic frequencies caused by random drift (Barrett & Kohn 1991). When one is considering populations that are already naturally isolated, as in the case of Hay-scented fern in the midwestern states, random genetic drift may have already occurred.

For this fern and other plants in its habitat, management and protection of the outcrops and surrounding forest is necessary to buffer sites from the effects of erosion and drying and to preserve conditions which may influence its long-term viability in the marginal states.

In the Midwest, restricted access to the known sites, relocation of any hiking or equestrian trails in their vicinity, and the elimination of rock climbing where it grows would be indicated as a means to ensure the species' survival and viability, as in the case of other species with a similar habitat (Shawnee National Forest 2001, 2001a). Also, if the population sizes of this species are 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 to guard against this are presented in Hill (1995).

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

RESEARCH AND MONITORING

As previously stated, some research has been conducted on the competitive abilities of this fern in eastern forests. In at least one laboratory (Dr. David P. Richardson, Williams College, MA; see http://www.williams.edu/Chemistry/drichardson/] the nature of the allelopathic chemical components are being studied. There has not been a considerable amount of research on the genetics of this species, including the degree of variability between populations, as far as is known. There has not been very much research on its establishment, viability, and population dynamics in the Midwest, either. Both studies are recommended. 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).

Hay-scented fern 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-7). 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). Botanists unfamiliar with the fern may need a degree of training to distinguish it in the field as well. There is the potential of additional suitable habitat in extreme southern Illinois as well as in southern Indiana where *Dennstaedtia punctilobula* could exist, and continued searches for the species should be conducted. While photographs are a less damaging means to document plant species, it is recommended that a voucher be made of a fertile frond of this fern for a positive identification because the species must be positively identified for any data to be of use. In general, most photographs taken at a distance are not sufficient for the identification of this fern, and this species is unlikely to be harmed by the removal of a single complete frond, leaving the rhizome intact.

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

RESTORATION

The recovery potential for *Dennstaedtia punctilobula* is probably very good.

There are no known restoration efforts being conducted on *Dennstaedtia punctilobula* anywhere in its range because it has been considered to be too common overall. Most research on the species has been conducted to determine its allelopathic capabilities, its aggressive and weedy nature, and the means to control and restrict the plant. Some limited monitoring has been instituted only in relatively recent times as its vulnerability in the borderline states at its western range limits has become known. More data is needed on the species here and its future listing in the RFSS list as a forest sensitive species might help in this regard. The National Forests are among the greatest hopes for the protection of the westernmost isolated locations for this fern.

This species of fern is commonly sold in nurseries where outdoor native ferns are available, and it is often cultivated (Lellinger 1985; *e.g.* W-11) but it spreads too rapidly by the creeping rhizomes to be used in most gardens. Restorations of any native plant species are recommended using only nursery propagated material grown from native, local populations to avoid interbreeding with genotypes not adapted to the local conditions and to avoid compromising the local gene pool. If this rule is not followed, the result is generally the loss of plants because they are not competitive under local conditions or the result could be the success of a plant or plants that can not be considered truly native (considered by some to be elements of a plant community *reconstruction* rather than a restoration). The propagation of Hay-scented fern in Illinois from unknown spore or plant sources would not be encouraged in a restoration effort. Instead, local plants should be propagated for planting.

Ferns are considered to be rather easily grown from spores under controlled conditions, and *Dennstaedtia punctilobula* is even more easily grown from rhizome cuttings. The need for a species restoration of this fern in Illinois has not yet been specifically demonstrated, but a decline in the future may make it necessary. It would be advisable to propagate plants from each existing colony now to prevent loss of genetic diversity later if an individual colony is lost. Careful records of the sources should be made for any planting, and the clones should not be allowed to intermix, so that future genetic analysis can be conducted as needed.

SUMMARY

Hay-scented fern is a a generally robust, deciduous fern, a perennial herb, that is found in the eastern United States and Canada, and it is known to occur historically in twenty-six states and the District of Columbia as well as in six Canadian provinces. This fern is common and considered to be rather aggressive in most of its range except at its periphery, and it is commonly grown in woodland gardens. It is found in usually well-drained acidic soils in partial shade, but, in some areas, it also tolerates sun well and it is common along roadsides. The colonies are generally large because it spreads by means of long, fast-growing rhizomes and because it produces chemicals toxic to the establishment and growth of other vascular plants, particularly tree seedlings, and so helps to maintain its own habitat. Globally, its ranking is G5 (secure globally). Though common and secure in much of its range, Hay-scented fern is rare in Illinois

where it has been listed as Endangered, and where it is has been found primarily within the Shawnee National Forest. It was formerly listed as Rare in Missouri and it is considered to have been extirpated in Michigan and Wisconsin. The species has not been included on the Regional Forester Sensitive Species list (RFSS) for the Eastern Region, but it is Forest Listed in the Shawnee National Forest. It is imperiled in Arkansas, Illinois, and Missouri and vulnerable in Indiana because in these states it grows only on relatively undisturbed, moist, shaded, north-facing sandstone ledges, a habitat with limited acreage in these states, and it may not be tolerant of the climate farther south and west. Lack of site or habitat management and protection could result in its extirpation in these states. The risks include quarrying and mining, recreational rock climbing, collecting of live plants for gardens, and drying and erosion from modification of the surrounding habitat. Casual access to the vicinity of the populations should be limited. Continued population monitoring is needed and searches should be conducted for additional populations in Illinois and Indiana in suitable habitat. Management through protection of its habitat and through possible exclosures may be needed for it to persist at its present locations, which are currently thought to be secure.

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APPENDIX 1

Representative specimens of *Dennstaedtia punctilobula* examined or cited in the literature

Herbaria:

BOON = Appalachian State University, Boone, NC. CLEMS = Clemson University Herbarium, Clemson, South Carolina. ILLS = Illinois Natural History Survey Herbarium, Champaign. MICH = University of Michigan Herbarium, Ann Arbor. MO = Missouri Botanical Garden herbarium, St. Louis. NCU = University of North Carolina, Chapel Hill. NY = New York Botanical Garden Herbarium, Bronx. UMO = University of Missouri Herbarium, Columbia. VT = University of Vermont Herbarium, Burlington.

ARKANSAS: LOGAN CO., 35.13.00N 093.42.00W, 14 Oct 1923, *Palmer 24125* (UMO 54954)

CONNECTICUT: MIDDLESEX CO., 41.28.00N 072.32.00W, Jul 1973, *Cox & Buchanan 4709* (UMO 131989); 41.28.00N 072.32.00W, May 1973, Buchanan, *Warren 4462-X* (UMO 131993); NEW LONDON CO., 41.29.00N 072.04.00W, 1878, Call, *Ellsworth 35* (UMO 33008); TOLLAND CO., Union, Bigelow Hollow State Park, 24 Jul 1970, *Hill 404B* (VT)

ILLINOIS: POPE CO., Hayes Creek Canyon Ecological Area, Shawnee National Forest, 21 Jul 1995, *Ulaszek & Shimp 2692* (ILLS)

INDIANA: CRAWFORD CO., 38.20.04N 086.27.51W, 02 Sep 1940, *McCoy 5493* (UMO 44268)

MAINE: KNOX CO., 44.06.00N 069.07.00W, 11 Aug 1933, *Friesner 6215* (UMO 13596); SAGADAHOC CO., Richmond, 19 Sep1969, *Hill 404C* (VT); 43.56.00N 069.50.00W, *Swallow s.n.* (UMO 33002); WALDO CO., 44.28.00N 069.06.00W, 17 Aug 1935, *Friesner 9063* (UMO 150791); WASHINGTON CO., Steuben, Eagle Hill, 13 Jul 2001, *Hill 33950* (ILLS, NY, VT)

MARYLAND: BALTIMORE CO., Cromwell Bridge Rd at Glen Arm Rd north of Towson, wooded hillside and power line clearing, 13 Jul 1970, *Windler, Keenan & Lombardo 3144* (ILLS); PRINCE GEORGES CO., National Colonial Farm, Potomac River at Charles County line, 27 Jun 1984, *Hill 14308* (CLEMS)

MASSACHUSETTS: BARNSTABLE CO., 41.40.00N 070.15.00W, 28 Jul 1934, *Drouet 1654* (UMO 33007); 41.40.00N 070.15.00W, 01 Oct 1929, *Adams s.n.* (UMO 33005); DUKES CO., 41.20.00N 070.45.00W, 20 Jun 1934, *Drouet 1508* (UMO 33006); FRANKLIN CO., 42.35.00N 072.35.00W, 04 Aug 1972, *Markle s.n.* (UMO 152801); HAMPSHIRE CO., 42.20.00N 072.35.00W, 07 Aug 1972, *Ahles 75807-A* (UMO 109425); 42.20.00N 072.35.00W, 07 Aug 1972, *Ahles 75807-B* (UMO 110330); 42.20.00N 072.35.00W, 14 Jul 1980, *Ahles 89050* (UMO 162497); 42.20.00N 072.35.00W, 30 Aug 1979, *Ahles 87522A-X* (UMO 157737); SUFFOLK CO., 42.20.00N 071.05.00W, 08 Aug 1923, *Palmer 23431-B* (UMO 54714); 42.20.00N 071.05.00W, 27 Aug 1922, *Palmer s.n.* (UMO 54718); 42.20.00N 071.05.00W, 05 Aug 1923, *Palmer 23431-A* (UMO 54664); 42.20.00N 071.05.00W, 05 Sep 1930, *Palmer 38176* (UMO 184483)

MICHIGAN: KEWEENAW CO., Keweenaw Peninsula, *Farwell s.n.* (MICH)

MISSOURI: MADISON CO., 37.29.00N 090.21.00W, 22 May 1926, *Palmer 30291* (UMO 54708); 37.29.00N 090.21.00W, 23 May 1926, *Palmer 30299* (UMO 54707); 37.29.00N 090.21.00W, 06 Sep 1926, *Palmer 31573* (UMO 54706); SAINT GENEVIEVE CO., 900 ft., 37.48N 90.15W, moist, shaded crevice under overhanging ledge, 29 Sep 1993, *Brant 2677* (MO); 800 ft., 37.48N 90.14W, moist, shaded crevices on Chimney Rocks; with *Dryopteris marginalis*, *Mitchella repens*, 29 Sep 1993, *Brant 2679* (MO); 165 m, 37.50N 90.12W, moist to mesic ledges, 24 May 1993, *A. Brant 2286* (MO); 250-274 m, 37.47N 90.16W, closed canopy wet ledges, with *Michella repens*, *Huperzia lucidula,* 25 May 1993, *Brant 2291* (MO); 195-200 m, 37.48N 90.13W, ledges of sandstone bluffs, open canopy, with *Mitchella repens,* 1 Jun 1993, *Brant 2317* (MO); 260 m, 37.53N 90.20W, 260 m, open canopy moist ledges of sandstone bluffs, with *Mitchella repens*, *Athyrium filix-femina*, *Cystopteris protrusa*, *Dryopteris marginalis*, *Osmunda cinnamomea,* 10 Jun 1993, *Brant 2370* (MO); 171-213 m, 37.52N 90.13W, trailing on moist, open canopy ledges and cracks of low bluff, 29 Jul 1993, *Brant 2541* (MO); 37.53.00N 090.12.00W, 26 May 1974, *LeDoux 1420* (UMO 120710); 37.53.00N 090.12.00W, 04 Jun 1933, *Steyermark 8554* (UMO 23843).

NEW HAMPSHIRE: CHESHIRE CO., 42.56.00N 072.16.00W, 14 Aug 1972, *Boufford 7712* (UMO 114909)

NEW YORK: FRANKLIN CO., 500 m, 44.16.50N 74.16.20W, 2 Aug 1992, *Raven 28037* (MO); HAMILTON CO., 540 m, 43.45.21N 74.27.19W, herb 1.5 m fronds, drooping to erect, petiole dark red-brown, shiny, sori dark brown to black, common along road, rocky, moist soils, shaded areas, 29 Jul 1994, *Schmidt, Eddy & Rempala 1533* (MO)

NORTH CAROLINA: ALLEGHANY CO., near New River, 3 miles north of Amelia, edge of woods, 12 Jul 1966, *Radford 44933* (ILLS, NCU); 3,100 ft, 36.29.00N 081.07.00W, 03 Jul 1976, *Reeves R5117A* (UMO 150960); GRAHAM CO., 1,600 ft, 35.21.00N 083.48.00W, 19 Jul

1965, *Demaree 52636A-X* (UMO 95812); HAYWOOD CO., Great Smoky Mountains National Park, Big Creek watershed and trail, 21 Sep 2001, *Busemeyer et al. 798* (ILLS); POLK CO., 35.17.00N 082.10.00W], 18 Oct 1944, *Lord s.n.* (UMO 149749); WATAUGA CO., Will Glenn Road, 2830-3400 feet, 36.16.30N 81.50.15W, 9 Aug 2001, *Crosby 17833* (MO, BOON)

PENNSYLVANIA: JEFFERSON CO., Rt. I-80-E just west of Twp. Rd. 544, just west of Washington Township, 6 Jul 2000, *Hill 32577* (ILLS); NORTHUMBERLAND CO., 40.51.00N 076.40.00W, 14 Sep 1947, *Savage s.n.* (UMO 93346).

RHODE ISLAND: PROVIDENCE CO., 41.50.00N 071.36.00W], 13 Jun 1945, *Palmer 46045* (UMO 54719); 41.50.00N 071.36.00W, 23 Sep 1939, *Palmer 44955* (UMO 54715).

SOUTH CAROLINA: OCONEE CO., 1 mile southwest of Mountain Rest Lake, Mountain Rest, 24 July 1988, *Hill 19691* (CLEMS); PICKENS CO., Sassafras Mountain, 18 Apr 1997, *McCoy & Basinger 269* (ILLS);

TENNESSEE: BLOUNT CO., Great Smoky Mountains National Park [GSMNP], Panther Creek Watershed, Hannah, Mountain trail, 9 Jul 2001, *Busemeyer et al. 598* (ILLS); COCKE CO., GSMNP, Cosby Watershed, Bearneck Cove, Gabes Mountain trail, second growth hemlock forest, 25 Jul 1999, *Phillippe 31036* (ILLS); GSMNP, Indian Camp Creek watershed, along Old Settlers trail, 23 Jun 2000, *Feist, Phillippe & Busemeyer 506* (ILLS);

WISCONSIN: DANE CO., 300 feet from the Wisconsin River across from Sauk City, east-facing slope with oaks and white birch, 28 Jul 1965, Threlfall s.n. (WIS) "could not be found in summer of 1968"; DOOR CO., Ephraim, 1918, *Millspaugh s.n.* [Am. Fern J. 19: 1. 1929]

APPENDIX 2.

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

STATE	COUNTIES	NOTES
Alabama	Bibb, DeKalb, Jackson, Marshall, Winston	? may be in Talladega National Forest
Arkansas	Jefferson, Logan, Montgomery, Stone, White	see Smith 1988, W-2, Threlfall map at WIS; includes Ozark and Ouachita National Forests
Connecticut	every county	see Magee & Ahles 1999
Delaware	every county	see Reed 1953
District of Columbia		see Reed 1953
Georgia	19 counties, northern	see Snyder & Bruce 1986; includes Chattahoochee National Forest
Illinois	Johnson, Ogle, Pope [Wabash ?]	see Mohlenbrock 1986, Mohlenbrock & Ladd 1978; includes Shawnee National Forest
Indiana	Crawford, Lawrence, Martin, Parke, Perry	see Deam 1940
Kentucky	33 counties, mostly east half of state	see W-2; includes Daniel Boone National Forest
Maine	every county	see Magee & Ahles 1999
Maryland	every county	see Reed 1953
Massachusetts	every county	see Magee & Ahles 1999
Michigan	Emmet, Keweenaw	historic, extirpated
Missouri	Madison, St. Francois, Ste. Genevieve	22 sites; see W-2, Yatskievych 1999 & pers. comm.
New Hampshire	every county	see Magee & Ahles 1999
New Jersey	every county	see W-2
New York	every county	see W-2

North Carolina	36 counties, mostly western half of state	see W-2
Ohio	twelve counties, probably more, mostly southeastern two-thirds of state	see W-2
Pennsylvania	every county	see W-2
Rhode Island	every county	see Magee & Ahles 1999
South Carolina	Greenville, Oconee, Pickens, Spartanburg	see W-2
Tennessee	34 counties, eastern third of state	see Chester *et al.* 1993; includes Cherokee National Forest
Vermont	every county	see Magee & Ahles 1999
Virginia	almost every county, apparently not verified in about 10 counties	see W-2
West Virginia	every county	see W-2
Wisconsin	Dane, Door	historic, extirpated

APPENDIX 3.

Natural Diversity Database Element Ranking System

modified from: http://www.cnpsci.org/html/PlantInfo/Definitions2.htm [W-10]

Global Ranking (G)

G1

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

G2

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

G3

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

G4

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

G5

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

GH

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

GX

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

GXC

Extinct in the wild. Exists only in cultivation.

G1Q

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

National Heritage Ranking (N)

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

Subspecies Level Ranking (T)

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

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

State Ranking (S)

S1

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

S2

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

S3

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

S4

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

S5

Secure. Demonstrably secure to ineradicable in the state.

SH

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

SR

Reported to occur in the state. Otherwise not ranked.

SX

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

Notes:

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

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