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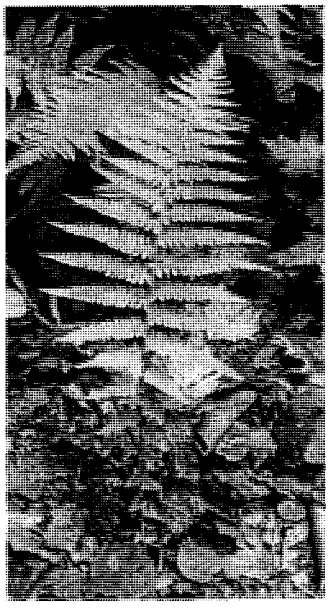
Conservation Assessment

for the

New York Fern

(Thelypteris noveboracensis (L.) Nieuwl.)



28 April 2006

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ILLINOIS
NATURAL
HISTORY
SURVEY

Illinois Natural History Survey
Center for Wildlife and Plant Ecology Technical Report 2006 (4)

Cover photo:

Thelypteris noveboracensis (L.) Nieuwl., from The Field Biology pages, constructed by Catherine Taggart, SUNY Cortland Outdoor Education Center in the Adirondack State Park of upstate New York. Contact for Field Biology at SUNY Cortland : Dr. Steven B. Broyles (broyles@cortland.edu).

http://web.cortland.edu/broyles/newyorkfern.html

Table of Contents

Acknowledgments....4
Executive Summary....5
Nomenclature and Taxonomy....6
Description of Species....7
Habitat and Ecology....8
Distribution and Abundance....10
Protection Status....12
Life History....13
Population Biology and Viability....15
Potential Threats....15
Research and Monitoring....17
Restoration....19
Summary....20
References....21
Websites Consulted....25
Contacts....26
Appendix 1. Representative specimens of *Thelypteris noveboracensis* examined or cited in the literature....27
Appendix 2. The distribution of *Thelypteris noveboracensis* in the United States. Information from herbarium specimens and the literature....30
Appendix 3. Natural Diversity Database Element Ranking System....32

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EXECUTIVE SUMMARY

This Conservation Assessment is a review of the taxonomy, distribution, habitat, ecology, and status of the New York fern, *Thelypteris noveboracensis* (L.) Nieuwl., 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 any potential threats and conservation efforts regarding the New York fern to date in the region. The New York fern is a clonal, spreading (rhizomatous) fern normally with clumped fronds (cespitose) about 0.5 m tall, and to nearly 1 m tall in some areas. The species is found in eastern North America in the United States and Canada, and it is generally widespread and common there. It grows mainly in moist level or gently sloping open forests near drainages in somewhat acidic soils. It is capable of developing large colonies locally by means of rhizomes that can establish new individuals if isolated from the main colony. Globally, its ranking is G5 (**Secure globally.** Numerous populations exist and there is no danger overall to the security of the species). New York fern is scarce only at the margins of its range, and it is listed as Endangered in Illinois, where only one population is currently known. It is also critically imperiled in Louisiana. New York fern is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest, where it is more common. Globally, this species is neither vulnerable nor threatened. In Illinois, it warrants protection because of the very few plants present, and it faces extirpation in the state because of its local scarcity. Basic research data is especially needed on the Illinois plants.

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: *Thelypteris noveboracensis* (L.) Nieuwland [1910]
Common Names: New York Fern; Tapering Fern [rarely used]
Synonymy: *Polypodium noveboracense* L. [1753], the basionym
Aspidium noveboracense (L.) Sw. [1800]
Dryopteris noveboracensis (L.) A.Gray [1848]
Parathelypteris noveboracensis (L.) Ching [1963]
Thelypteris thelypterioides (Michx.) Holub [1972]

Class: Polypodiopsida (True Ferns)
Family: Thelypteridaceae (The Marsh Fern Family)
Plants Code: THNO (USDA NRCS plant database, W-1)
http://plants.usda.gov/java/profile?symbol=THNO

The fern genus *Thelypteris* contains 21 species and one additional variety in North America north of Mexico, according to A.R.Smith (1993). The genus is large, widespread, worldwide, and it has a total of about 875 species found from tropical to temperate zones. Some botanists (*e.g.* Holttum 1971) have considered the genus to actually consist of about 30 genera, whereas others treat these units as subgenera and / or sections (A.R.Smith 1993).

The New York fern was first named *Polypodium noveboracensis* by Linnaeus (in his *Species Plantarum* in 1753), who understood it to be from the British colony of New York. In the subsequent years the broad genus *Polypodium* was redefined and divided into many other genera. Among the divisions, the large genera *Aspidium* and *Dryopteris* were redefined several times as well, and, currently, the species is generally placed and accepted within the genus *Thelypteris*. The genus name *Thelypteris* originates from the Greek *thelys*, female, and *pteris*, fern, and the specific epithet is a latinization of the name New York [new, *nov-*, and the Roman name for York, England, *Eboracensis,* combined into an adjective]. Tryon and Tryon (1982) defined the classification within *Thelypteris*, placing this species within the subgenus *Parathelypteris* (H.Ito) R.R.Tryon & A.F.Tryon. This species is thought to be most closely related to the Massachusetts fern, *Thelypteris simulata* (Davenport) Nieuwland, but its distinctness from that species has not been questioned. Taxonomic confusion has occurred only at the generic level. No significant variation has been recognized within this species at any subspecific taxonomic rank.

The common name New York fern is generally used throughout its range.

DESCRIPTION OF SPECIES

Thelypteris noveboracensis, the New York fern, is a moderately delicate perennial fern with long-creeping essentially glabrous **rhizomes** 1.5 – 2.5 mm in diameter, and **leaves [fronds]** that often appear clustered, but they are generally evenly spaced on the rhizome 1 cm or more from each other (A.R.Smith 1993). The leaves are deciduous, generally changing from green to yellow then brown in Autumn, and the **petioles** are straw-colored, (4-) 12-20 (-25) cm x 1-3 mm, much shorter than the blade, and have tan to reddish-brown ovate glabrous scales only toward the base. The leaf **blade** is elliptic (or appearing narrowly lanceolate), 15-60 cm long (the entire leaf, then, can be as long as 85 cm in robust individuals, but normally less than 50 cm in Illinois plants), pinnate [feather-like], and, perhaps most importantly for identification, the blade distinctly tapers at both ends (apex and base) and the smallest pinnae (primary divisions) at the base are rudimentary, often less than 5 mm long. Each **pinna** of the frond is deeply pinnatifid to within 1 mm of the pinna axis, and the size varies from 3-9 (-13) cm long x 1-2 (-2.5) cm wide, the longest being in the middle region of the blade; the ultimate segments are rather obtuse and essentially entire- to crenulate-margined, and their veins are normally simple (not forked); the proximal pair of veins from adjacent segments extend to the margin above the sinus. A fine covering of moderately to densely arranged hairs up to 1 mm long can be found on the rachis, costae, and veins of the frond, and there may or may not be pale yellowish sessile glands on the blade tissue; no scales are present on the pinnae. The fertile and sterile fronds closely resemble each other in size and shape. The **sori** are round and supramedial, and they have small, pale tan, often ciliate indusia; the sporangia are glabrous. The rhizomes may allow an individual plant to cover a relatively large area (several square meters) with multiple fronds each of which is genetically identical to its neighbors, but plants are generally seen or described as loose colonies of scattered tufts. Discerning the stem connections can be difficult if not impossible because the oldest portions of the stems may have already died and decayed leaving no evidence of an original connection. The chromosome number is $2n = 54$, one of the lowest for the American species (adapted from A.R.Smith 1993 and Gleason and Cronquist 1991).

This fern species is relatively distinctive and easily identified simply by the size and shape of its frond (leaf) – which strongly tapers at both the apex and base (see cover illustration). This is unlike the other ferns of eastern North America with the exception of the Ostrich fern (*Matteuccia struthiopteris* (L.) Todaro) a much more robust fern that lacks the narrow long-creeping rhizomes and that has a remarkably specialized fertile frond. That fern has a generally more northerly distribution and tends to inhabit more basic soils than the New York fern.

The New York fern has very limited regional variation, such as robustness, most of which is habitat and competition dependant (see Hammen 1993). In Illinois the leaves rarely exceed 50 cm long (Herkert and Ebinger 2002).

HABITAT AND ECOLOGY

A review of the literature and herbarium specimens demonstrates that this fern has a variety of plant associates and habitats throughout its wide range. *Thelypteris noveboracensis* grows mainly in moist woods, especially near swamps, streams, and in vernal seeps of ravines, and it frequently forms large colonies, often in disturbed secondary forests, within most of its range (A.R.Smith 1993, W-2). Normally it does not grow in areas of standing water or continually saturated soils as does its close relative the Massachusetts fern (*Thelypteris simulata*) and its more distant relative the Marsh fern (*Thelypteris palustris* Schott), but it has been recorded from areas with sphagnum moss as well as seeps, particularly at the southwestern limits of its range. It has been given the national wetland category rating FAC+, indicating that it is only slightly more likely to occur in wetlands than in non-wetlands (P.B.Reed 1988). One edaphic feature that all populations of the New York fern appear to have in common is a well-developed surface layer of moist leaf mold or humus at least 3 cm thick through which the fern's rhizomes grow. In wetlands, for example, the fern is to be found in elevated areas of this humus, such as at wetland margins or on hummocks, rather than in lower-lying saturated areas of this peaty substrate

At its northern range limits, the species becomes less frequent as the mixed deciduous forests, its primary habitat, are replaced by evergreen (conifer) forests. Its most common tree associates in this area are *Acer rubrum*, *Fagus grandifolia*, *Pinus strobus*, and *Quercus alba*. Towards the southeast and midwest at lower elevations it can be associated with the trees *Liquidambar styraciflua, Liriodendron tulipifera, Nyssa sylvatica,* and *Quercus palustris*. In the southern Appalachians (pers. obs.) it commonly occurs with *Acer rubrum*, *Fagus grandifolia*, *Halesia tetraptera*, *Liriodendron tulipifera*, *Pinus strobus*, *Quercus alba*, and *Tsuga canadensis*, and also in thickets of *Rhododendron maximum*. Typical understory associates include *Athyrium filix-femina*, *Gaylussacia* spp., *Maianthemum canadense*, *Osmunda cinnamomea*, *Parthenocissus quinquefolia*, *Polystichum acrostichoides*, and *Vaccinium* spp. Mosses are also common associates, as are the vines *Smilax* spp. and *Vitis* spp. The New York fern typically can be found at a lower and moister ecotone than the Hay-scented fern (*Dennstaedtia punctilobula*; see Hill 2003; Hill and Silander 2001) with which it often grows, the two forming extensive colonies side-by-side that only occasionally mix with one another. The *Thelypteris* inhabits the moister sites, and the *Dennstaedtia* grows in the more disturbed or open drier sites.

Among the habitats recorded for this fern on herbarium specimen labels are the following. In the northeastern and Appalachian states, grading approximately from wet to dry habitats: swampy woods, boggy thicket, low moist woods, moist slope in low woods, damp shady woods, wet rocky woods, rich beech woods, deciduous woods, semi-open mossy bank, wood margin in dry ground, opening in forest along ski trail, old pastures, and dry woods. In the western and southwestern (midwestern) parts of its range, the following habitats are listed: shaded sandy seep in oak-pine hills, seep area in rich oak woods, seeps along creek below oak-pine barrens, sandy swampy ground, moist place in sand rock bluffs, sandy shaded bluffs, shady sandstone, and

damp sandy humus. It appears, then, that at the western and southwestern margins of its range that the New York fern is found in humus layers over somewhat acidic sandy soils associated with sandstones, and that it is further restricted to seepage slopes and seeps within that habitat. It appears to be lacking in calcareous areas.

In Indiana, the New York fern is found only in slightly acid soils, and its distribution in the southern and northern counties reflects that preference (Deam 1940). In the northern part of the state it usually occurs in mesic forests associated with the trees *Acer saccharum, Cornus florida, Fagus grandifolia, Hamamelis virginiana, Liriodendron tulipifera, Quercus rubra, Sassafras albidum*, and *Ulmus americana*, the shrub *Lindera benzoin*, and the understory herbs *Claytonia virginica, Erythronium americanum, Osmunda cinnamomea*, and *Polystichum acrostichoides*. This fern is characteristic of moist hummocks in the wet-mesic swamps of the Indiana dune region (Swink and Wilhelm 1994) where it is associated with the trees *Acer rubrum, Betula papyrifera, Hamamelis virginiana, Nyssa sylvatica*, and *Quercus rubra*, the shrubs *Ilex verticillata* and *Lindera benzoin*, the vine *Parthenocissus quinquefolia*, and the understory species *Carex* spp., *Maianthemum canadense, Mitchella repens, Osmunda cinnamomea, Osmunda regalis, Platanthera clavellata, Rubus hispidus*, and *Saururus cernuus*. While known from several different Natural Regions in Indiana (Homoya *et al.* 1985, Homoya 1997) it is most frequent in the Northwestern Morainal Natural Region and the Northern Lakes Natural Region. In the southern part of the state it is usually closely associated with *Fagus grandifolia* as well as *Liquidambar styraciflua*. Here it is most frequently found in the Shawnee Hills Natural Region and the Highland Rim Natural Region, sometimes on or near sandstone cliff ledges (Homoya, pers. comm.). The species is essentially absent from the less acidic till plain in the center of the state (the Central Till Plain Natural Region), but, because that area is primarily agricultural, any former distribution in that region is unknown.

In Illinois, the New York fern formerly grew in habitats similar to those in Indiana in the northeastern part of the state, but appears to have been extirpated there. Mohlenbrock (1986, 2002) states that its habitat in Illinois is moist or rarely dry woods. It appears to survive at a single known site next to a forested seep / spring over sandstone in the southeastern part of the state. The site is in a Forest Service botanical area, the Cretaceous Hills Ecological Area. Here it can be considered to be a member of the Mesic Upland Forest Community (White and Madany 1978). According to John Schwegman (pers. comm.), who conducted a search for this fern in 2004 and again recently in April 2006, associates included the canopy trees White Oak (*Quercus alba*) and Tulip Tree (*Liriodendron tulipifera*) with a mid-canopy of Flowering Dogwood (*Cornus florida*), Sassafras (*Sassafras albidum*), and Black Gum (*Nyssa sylvatica*). Other woody plants with it included Hazel (*Corylus americana*) and Virginia Creeper (*Parthenocissus quinquefolia*). Herbs included Christmas Fern (*Polystichum acrostichoides*), Broad Beech Fern (*Phegopteris hexagonoptera*), Solomon's Seal (*Polygonatum commutatum*), Wild yam (*Dioscorea villosa*) and Shining bedstraw (*Galium concinnum*). Similar sites exist in southern Illinois, but the fern has been noted only here.

DISTRIBUTION AND ABUNDANCE

Thelypteris noveboracensis, the New York fern, is widespread and common in much of the temperate and cool-temperate eastern United States and Canada, and it is known to occur historically in twenty-seven states plus the District of Columbia, namely, Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, and West Virginia. In Canada, this fern has been found in the provinces of New Brunswick, Newfoundland (including St. Pierre and Miquelon), Nova Scotia, Ontario (southern), Prince Edward Island, and Quebec (southern) (A.R.Smith 1993, W-2). In most of the Appalachian and eastern states, the New York fern is one of the most common ferns encountered. Its range includes both formerly glaciated and unglaciated areas. The New York fern appears to be an essentially Appalachian species and it is rare or absent in the Ozark regions of the Midwest. A very few disjunctions have been reported at the western portions of its range, most notably along the border of Arkansas and Oklahoma. Additional details on the distribution of the New York 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), C.F.Reed (1953), and E.B.Smith (1988) among others, as well as on several Internet sites (*e.g.*, W-2). Representative herbarium specimens of this fern have been listed in Appendix 1. A more detailed summary of the distribution of the New York fern in the United States has been presented in Appendix 2.

The New York fern is at its southern limit of distribution near the Gulf Coast in southern Mississippi and Alabama (it has not been found in Florida). Its western limit is in extreme northwestern Arkansas (E.B.Smith 1988) and extreme northeastern Oklahoma (A.R.Smith 1993). It reaches southern Illinois and northern and southern Indiana but it has not been found in neighboring Iowa, Missouri, or Wisconsin (Cooperrider 1968, Deam 1940, Mohlenbrock and Ladd 1978, Swink and Wilhelm 1999, Yatskievych 1999).

Within the U.S. Forest Service Eastern Region (Region 9) *Thelypteris noveboracensis* is present within both the Shawnee National Forest in Illinois and the Hoosier National Forest in Indiana, but it is far less common in Illinois. It is known to be present and more common in the Allegheny National Forest in Pennsylvania, the Green Mountain National Forest in Vermont, the Hiawatha National Forest in Michigan, and the Ottawa National Forest in Michigan (Regional Forester Sensitive Plant List 2000), and most probably in others as well. It is common in the National Forests of the Appalachian region generally to the southeast.

In Illinois, where it is listed as Endangered, the species has been reported historically in Kane, Kankakee, Monroe, Pope, and Wabash Counties, but it is currently known to survive only in Pope County in Shawnee National Forest where a single population still occurs (Herkert *et al.* 1991, Herkert and Ebinger 2002, Mohlenbrock 1986, 2002, Mohlenbrock and Ladd 1978).

Historically, in Illinois this fern occurred in several Natural Divisions of the state, namely, the Northeastern Morainal Division, Morainal Section; the Grand Prairie Division, Kankakee Sand Area Section; the Ozark Division, Northern Section; the Lower Mississippi River Bottomlands Division, Northern Section; the Wabash Border Division, Bottomlands Section and Southern Uplands Section; and the Shawnee Hills Division, Greater Shawnee Hills Section. The currently known southern Illinois site falls within the Cretaceous Hills Section of the Coastal Plain Natural Division of Illinois (Schwegman *et al.* 1973) just south of the glacial boundary. This single remaining site is in a Forest Service protected area (Olson *et al.* 2004), the Cretaceous Hills Ecological Area (Natural Area). The fern colony was seen to be healthy during the April 2006 inspection of the site (Schwegman, pers. comm.) though it had not been located in a 2004 survey. The area covered by the Illinois population currently measures about 6 m in diameter.

The population in Illinois (certainly) and those in other parts of the Midwest are relatively small and local compared to populations in the more eastern states. Furthermore, the populations are isolated from one another apparently because the preferred acidic habitats are also uncommon here. It is likely that the species was not common in the southern region of Illinois at the time of European settlement because the amount of suitable habitat available then was also limited. However, based on historical records, we do know that the New York fern was previously more common in Illinois overall than it is today, and nearly all of the populations are now gone. It is assumed that the former populations in northeastern Illinois succumbed to the clearing of land for agriculture, or the draining of wetlands, or because of development (or from all three causes).

Based on its overall distribution and deciduous habit, one could speculate that this fern species is adapted to, and requires, seasonal dormancy that results from a cool or cold winter. This may be one reason why it does not range much farther south. Its northern range may be restricted by the shorter growing season that may not allow full annual growth and reproduction before frost. As with other eastern deciduous forest herbs with tiny propagules, drought and exposure, as well as the prevailing winds from west to east, probably limit its spread to the western half of the continent. Its distribution farther to the north along the northeastern coast coincides with the milder influences of the Great Lakes and the Gulf Stream, both of which combine to produce a milder, less severe climate there 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), and another is that of drought tolerance. A plant species completely intolerant of freezing can persist in a site indefinitely until the first time extreme temperatures cause it to freeze. Likewise, a severe drought can eliminate

species intolerant of complete drying. One such freeze or drought in a century may be enough to eliminate a species entirely from a wide area of its range, and, with the exception of human activities, changes in climate historically have caused the greatest changes in plant distributions.

In the case of the New York fern, current distribution appears to be equally dependent on soil pH (hence substrate and bedrock type) and the degree of canopy closure (that affects both light and moisture availability), in addition to the temperature extremes. Both substrate unsuitability and colder temperatures may have prevented the establishment of colonies of this fern in Minnesota, Wisconsin, and Iowa. Its failure to occur beyond 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, though pH may also be involved. While most populations are in moist sites, a few (in areas where the species is generally common) have been described as being in drier sites, so constant soil moisture may not always 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 marginally open situations or in forests with an open understory.

PROTECTION STATUS

The Nature Conservancy ranking for *Thelypteris noveboracensis* is G5 (secure globally; W-2; Appendix 3). In the United States the species is given the National Heritage status rank of N5 with a similar meaning. In Canada the species is not ranked (NNR), but the rankings within the provinces vary from S3 to S5, and the fern's status is considered to be secure in Canada. The state rankings within the United States vary from not ranked (SNR) to S1, S3, S4, and S5. The New York fern has been designated as Endangered in Illinois (Herkert and Ebinger 2002, Illinois Endangered Species Protection Board [IESPB] 2005), and, while not legally protected in Louisiana, it has also been designated as a S1 species there. It is not tracked in most states where it occurs because of its greater frequency overall.

Thelypteris noveboracensis has not been included on the Regional Forester Sensitive Species list (RFSS) for the entire Eastern Region, but it is listed as Regional Forest Sensitive in the Shawnee National Forest (Shawnee National Forest 2001).

Protection for this fern at the margins of its range is currently dependent primarily on habitat protection, and so its survival will probably depend more on this than on species protection. *Thelypteris noveboracensis* is protected in Illinois where the IESPB listing can be enforced, and it is also fully protected within the Shawnee National Forest, where it occurs within a designated Ecological Area (Olson *et al.* 2004).

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-2). Appendix 3 explains the meanings of the acronyms used (W-3). A summary of the current official protection status for the New York fern follows:

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

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

Global Heritage Status Rank: G5

U.S. National Heritage Status Rank: N5

Canada National Heritage Status Rank: NNR

Table 1: S-ranks for *Thelypteris noveboracensis* [Heritage identifier: PPTHE050X0; W-2]

State/Province	Heritage S-rank
UNITED STATES	
Alabama	SNR
Arkansas	S3
Connecticut	SNR
Delaware	S5
District of Columbia	S5
Georgia	SNR
Illinois	S1 [Endangered]
Indiana	SNR
Kentucky	S5
Louisiana	S1
Maine	SNR
Maryland	SNR
Massachusetts	SNR
Michigan	SNR
Mississippi	SNR
New Hampshire	SNR
New Jersey	S5
New York	SNR
North Carolina	S5
Ohio	SNR
Oklahoma	SNR
Pennsylvania	SNR
Rhode Island	SNR
South Carolina	SNR
Tennessee	SNR
Vermont	SNR
Virginia	SNR
West Virginia	S5
CANADA	
New Brunswick	S5
Newfoundland	S3S4
Nova Scotia	S5
Ontario	S4S5
Prince Edward Island	S5
Quebec	S4S5

LIFE HISTORY

Thelypteris noveboracensis is a moderately delicate, but usually strongly growing, deciduous-leaved perennial fern with long-creeping straight underground stems (rhizomes) that, in most of its range, form large colonies covering several square meters. Its average lifespan is not known,

but it is assumed that a colony can be long-lived. Growth is rather fast relative to most ferns and it is rather easily grown in woodland or partly shaded gardens (Lellinger 1985). As in the case of the Hay-scented fern (Hill 2003) the long rhizomes can 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 or 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. As in most wild ferns of eastern North America, the New York fern needs an organically-rich surface layer of humus in which to grow. The rhizomes creep horizontally through this layer, and rarely penetrate to the mineral soils beneath. This humus-rich surface layer can vary from about 3 cm to several meters in depth depending on the hydrology and history of the site.

Plants begin new growth in early spring after the danger of frost is past. Studies on phenology of plants in South Carolina in the Blue Ridge of Oconee County (Hill, unpublished data) indicate that *Thelypteris noveboracensis* fronds begin to grow soon after the last frost (emergence is generally about 14-24 April) and the sporangia first become mature in mid-summer (between 29 June to July 7). 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, at which time the leaves have also fallen). In the Midwest and North the season is usually shorter by a week or two on each end, and the primary release of spores occurs from mid-August to early September. The number of leaves on a given plant as well as its actual extent may be difficult to determine because the stems are underground and they may branch many times within a colony. The number of individuals in an area 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 slightly more than halfway from the pinnule's midrib and the leaf margins. The sporangia are covered with a somewhat kidney-shaped protective indusium that shrinks and dries at spore maturity at which time the sporangia split. The dust like spores are dispersed into the air when mature, and the relatively tall erect fronds may be able to disperse the spores to 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 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 young sporophyte has formed. As in many other ferns, this species requires a moist habitat and high humidity to grow best. The gametophytes are most commonly found on shaded raised moist hummocks of peat, on wet decomposing logs, and on damp, open banks where they will not be covered by falling

leaves and debris. The New York fern propagates readily both sexually and asexually (clonally) from rhizome cuttings.

Natural hybrids are unknown in this species.

POPULATION BIOLOGY AND VIABILITY

As previously stated, within most of its range in the eastern United States and adjacent Canada *Thelypteris noveboracensis* is a common, vigorously-growing fern that can form large colonies in moist open forests and forest clearings. At the western and southern margins of its range this fern is less common, and it tends to occur in very local colonies in 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.

While older (especially senescent) fronds may be susceptible to some mildew fungi, the New York fern plants normally appear to be disease free, and the fronds and rhizomes generally do not appear to be significantly damaged by herbivory (Hill, pers. obs.). Ferns in general are known to be pest and disease free. In sites that are too wet or too dry for this fern, individuals may be more susceptible to disease and predation as a result of weakening from stress.

The New York fern is a diploid species with a chromosome number of $2n$ =54. There appear to be no reproductive problems of a genetic nature. In most of its range this fern is very successful and fully viable.

The long-term viability of the New York fern at its range limits in the Midwest and South may depend entirely upon its persistence at the currently known sites and the maintenance or protection of its habitat at those sites. It is quite normal for species of plants to be more sensitive and vulnerable to environmental changes at the margins of their ranges.

POTENTIAL THREATS

As a species, the foreseeable future of the New York fern is very secure. However, at the margin of its range in the Midwest and South, its habitat preferences have restricted the species to only a few sites that have the moderate temperatures, moisture, and acidic substrate that it needs. Some threats to the species in this area may include physical damage to the delicate fronds and rhizomes from trampling by hikers or equestrians and from other degradations of the environment simply because of the limited number of individual plants present. Compaction of the surface humus layers can crush and destroy the stems of this fern. Toxic runoff from

pollutants and herbicides applied around populations could eliminate many individuals. In small isolated populations, local catastrophic events of several kinds can exterminate a significant population of a species.

The elimination of vegetation cover (especially from clear cutting its habitat) over or in close proximity to known colonies may result in conditions that are too dry and hot for reproduction of this moisture-dependent fern, which is also known to grow best in areas of relatively cool and still air. On the other hand, the spread of aggressive vines and some shrubs, such as Japanese honeysuckle and bush honeysuckles among others, may produce too much shade too close to the plants 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 both native and exotic shrubs, can greatly increase after forest thinning or harvesting as a result of disturbance, and such a dense growth would, most likely, be very detrimental for this moderately light-loving fern.

In a similar fashion, a dense, often mature, tree canopy that cuts out much of the light from the forest floor may be as harmful to this fern as too much light from excessive clearing of the forest (Rooney and Dress 1997). This is not a fern of dense dark forests. It is the contrast and balance between the various environmental variables that makes it difficult to manage for this and similar species at the margins of their ranges.

The need for a winter dormancy and a need for spring moisture appear to be crucial for this fern, as it is for many forest understory herbs throughout the northeastern states. Certainly they also need soil stability and a lack of aggressive competition once established. 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.

Selective burning of the surrounding forest using fire management techniques 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 and provide the more open habitat that it prefers. A winter burn when the plants are dormant, or whenever the soils are saturated, may have little harmful effect on the plants and may actually open the forest up in a positive way for this fern. Similarly, selective but infrequent thinning of the forest stand within which it grows may be needed at some sites for this fern (but see Research and Monitoring, below).

It is generally believed among biologists that habitat fragmentation can have profound long-term detrimental effects on the success and persistence of local populations. Any activities that result in barriers to dispersal, such as land development, clearcuts, road / railroad / 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 and Kohn 1991). When one is considering populations that are already naturally isolated, as in the case of the New York fern in Illinois, random genetic drift may have already occurred and weakened the population. This cannot be easily determined. In the case of garden-grown plants, including ferns, cause for alarm is generally indicated by a gradual loss of vigor and partial die-off of the plants (especially the fronds) as well as a progressive reduction in the size of the fronds.

In Illinois, restricted access to the known site, elimination of any hiking or equestrian trails in its vicinity, and a ban on extensive tree cutting in its vicinity 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 reproductive individuals by collecting could endanger the continued existence of this small local population. Some of the generally used guidelines for plant collecting to guard against this at a given site are presented in Hill (1995).

At the current time, it does not appear that the population of the New York fern in the Shawnee National Forest is immediately threatened with elimination because of active or inactive management programs, direct habitat loss, or other human activity. However, in the absence of future monitoring and limited canopy management of the forest and a shift in the hydrology in the vicinity of this species, it could decrease or disappear altogether. It is also conceivable that the (apparent) currently increasing changes in climate (*i.e.* global warming) may change the fern's peripheral habitats sufficiently to make them unsuitable for the species.

RESEARCH AND MONITORING

Thelypteris noveboracensis is so rare in Illinois that a primary emphasis should be to locate and monitor all remaining populations. At this time, because the plant is known at a single site in Illinois (Schwegman, pers. comm.) the primary concern is to monitor it. Historic sites in other parts of the state should also be searched again, if possible, and new sites should be sought. Similar suitable habitat should be explored for the plant. There is a moderate area of additional suitable habitat in extreme southern Illinois where *Thelypteris noveboracensis* could also exist, and continued searches should be conducted. In southern Illinois and Indiana, additional suitable habitat for the species occurs in the area of the Shawnee Hills. While it is thought that most significant sized populations have been found because the habitat is a popular one among hikers (and botanists to some extent), additional searches may reveal additional populations.

In addition, more information is needed on the habitat characteristics where the fern persists in Illinois. While John Schwegman (pers. comm.) has determined some of the local associates of this plant, there is little data on the fundamental soil characteristics of its local environment,

including the depth of the crucial surface humus layer, the soil moisture regime, and the soil pH, at its current population site. If additional populations are discovered in Illinois, similar data would be needed from those.

Experimental management may not be possible for this plant in Illinois because of the few individuals present. However, fire management testing as well as other management techniques are probably feasible in other states to the east of Illinois in cooperation with other management groups, and these results may shed light on what may be best for the plants remaining in Illinois.

In the case of garden-grown plants, including ferns, cause for alarm is generally indicated by a gradual loss of vigor and partial die-off of the plants (especially the fronds) as well as a progressive reduction in the size of the fronds over a period of several years. This should also be apparent in wild plants, and this change can be easily measured over time as part of on-going research and monitoring program. The causes for this decline in cultivation generally turn out to be too much or too little water, the failure to maintain an adequate humus layer for growth, too much or too little light, and locally heavy predation by garden invertebrates including arthropods and slugs. It is also common to discover that too much or too little fertilizer has been applied without the benefit of the buffering humus layer. These are areas to be investigated in the wild populations as well.

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. Forest Service and other 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 conducted by Forest Service biologists in cooperation with Illinois Department of Natural Resources personnel and other professional botanists. 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.

In summary, then, it is generally recommended that the habitat quality where this plant grows should be monitored on a regular basis and an assessment of the specific threats to the population should be made (W-2). It has been suggested that prescribed burning and selective harvesting of timber could be conducted cautiously (on an experimental basis) to determine how populations respond to the opening of the canopy; this will yield information on whether such activities can result in increased vigor, population size, and production of fertile fronds and spores (W-2; Summers 1993). It is important to note that fire also may burn the surface humus layer so

important to this and other ferns in a forest. Long-term monitoring of known populations should be conducted every 1-2 years to track their status with respect to these current management activities (see Hill and Silander 2001 and Philippi *et al.* 2001 for suggested methodology). As part of the basic research on current populations of this species, data such as the counts of numbers of individuals (or frond clusters) present, the estimation of the amount of yearly fertile frond and spore production, if any, 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. 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 precisely known. Surveys and monitoring should be conducted during the spore-release period from mid-August to early September. With proper monitoring and habitat management, the current local population should persist.

RESTORATION

There are no known restoration efforts being conducted on *Thelypteris noveboracensis* anywhere in its range because it is generally so common. Because of its normally aggressive growth under suitable conditions, the restoration potential of this fern would seem to be very good. At marginal sites, however, as in Illinois, climate and habitat changes beyond human control may make it difficult to restore or expand the range of the New York fern.

In Illinois or in the other marginal areas of its range, it is unlikely that the species would be able to re-establish itself by chance 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. In addition, the marginal areas may no longer be suitable habitats for the species because of weather and climate changes that appear to be accelerating at this time. 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 the states at the edges of its range the loss of a few populations at the periphery can eliminate a plant from an entire state, and it is even possible that this may yet occur with the New York fern in Illinois.

The generally recommended method to secure populations of this and other rare plants is to protect and manage their habitat. Protection of the hydrology and organic - humus soil layer of the sites may be crucial, along with the maintenance of a somewhat open habitat. Girdling trees may be effective and less damaging to the fern and its habitat than cutting. Ideally, 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, especially that of a systemic herbicide, could eliminate this species at a site as well. The use of controlled burns, the thinning of the overstory, and the thinning of competing understory species may be very beneficial to this

plant provided that care is taken not to eliminate the important surface humus layer and not to trample the plants and rhizomes, but, as discussed in the previous section, a specific management technique has not yet been determined for the conservation or restoration of this fern.

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 cannot be considered truly native (considered by some to be a plant community reconstruction rather than a restoration). Local plants should be propagated for planting in such an effort. The New York fern can be propagated by means of spores or by means of rhizome cuttings under controlled conditions. In the Shawnee National Forest, careful propagation of that population would be recommended, keeping some in cultivation to ensure the survival of the genotype. Introducing plants to additional sites then becomes a delicate, even ethical, question beyond the scope of this discussion.

This fern is common in cultivation in woodland gardens and it is commercially available from many local and national plant nurseries. Normally, however, the original sources of the plants are unknown, and it would not be advisable to introduce these unknown genotypes into a natural habitat, as discussed above. The New York fern is easily propagated by means of rhizome cuttings, and, in fact, it can overwhelm a garden that it finds particularly suitable.

Species restorations must be governed by the data known to describe suitable conditions for native colonies of the same plant. For this fern, threats may continue to interfere with establishment success; the threats 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 preventing vigorous growth as well as reproduction from spores. In order to manage or restore the species, then, selective but infrequent thinning of the forest stand within which it grows may be needed at some peripheral sites.

SUMMARY

The New York fern, *Thelypteris noveboracensis* (L.) Nieuwl., is a clonal, spreading (rhizomatous) fern normally with clumped fronds (cespitose) and the leaves grow to nearly 1 m tall (but usually less) in some areas. The species is found in eastern North America in the United States and adjacent Canada, and it is generally widespread and common there. It grows mainly in moist level or gently sloping open forests near drainages in a significant surface humus layer of somewhat acidic soils. It is capable of developing large colonies locally by means of rhizomes that can establish new individuals if isolated from the main colony. Globally, its ranking is G5 (**Secure globally.** Numerous populations exist and there is no danger overall to the security of the species). New York fern is scarce only at the margins of its range, and it is listed as

Endangered in Illinois, where only one population is known. It is also critically imperiled in Louisiana. New York fern is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest, where it is more common. Globally, this species is neither vulnerable nor threatened. In Illinois, it warrants protection because of the very few plants present, and it faces extirpation in the state because of its local scarcity.

Complete clearing or cutting of a forest stand could not be enacted where a colony occurs without adverse effects. In addition, the areas where these plants grow and are rare should be closed to most recreational use because of the increased erosion and physical damage possible to the shallow roots and rhizomes of this fern, and increased enforcement of these restrictions or the relocation of trails may be needed. Large groups of people and / or animals could severely damage this fern in Illinois.

Suggested research priorities for this locally rare fern include attempts to monitor the health of the single known colony in Illinois, to attempt to locate additional populations, and to determine, through controlled and cautious experimentation, the best management techniques to insure its survival and increase (such as controlled use of fire and the selective thinning of canopy trees to open the habitat). Basic environmental data is needed for the Illinois population. Monitoring over time is needed to determine if the fern is decreasing or increasing in vigor. 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 occurs in Illinois.

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APPENDIX 1

Representative specimens of *Thelypteris noveboracensis* examined or cited in the literature

Herbaria:

CLEMS = Clemson University, Clemson, SC. GH = Gray Herbarium, Harvard University, Cambridge, MA. ILLS = Illinois Natural History Survey, Champaign. MO = Missouri Botanical Garden, St. Louis. NCU = University of North Carolina, Chapel Hill. NY = New York Botanical Garden, Bronx. UNAF = University of North Alabama, Florence. VT = University of Vermont, Burlington.

ALABAMA: CLARKE CO., seep by US 43 at Greenwood, 19 Jul 1970, *Kral 40191* (MO); FAYETTE CO., shaded sandy seep in oak-pine hills by AL 129, ca. 5 mi N of Fayette, 19 May 1975, *Kral 55543* (MO); JACKSON CO., Cargile Swamp, Bryant, Sand Mountain, 23 Jun 1937, *Porter s.n.* (MO); LAUDERDALE CO., ca. 0.25 mile east on Hurricane Church Rd, just off Hwy. 207, on bank of spring, 24 Sep 1989, *Patterson s.n.* (UNAF); MARION CO., river bank, 9 Sept 1984, *Hardy s.n.* (UNAF); south side of US 278 near a stream, 22 Sep 1989, *Spiller s.n.* (UNAF); MARSHALL CO., Bucks Pocket State Park, 10 Aug 1973, *Kral 51124* (MO); WINSTON CO., sandy shaded bluffs above Sipsey River by where crossed by Co. Rt. 60, Bankhead National Forest, 28 May 1970, *Kral 39286* (MO).

CONNECTICUT: HARTFORD CO., Collier Swamp, Prospect Street, Wethersfield, 23 Jul 1970, *Hill 429* (NCU, VT); MIDDLESEX CO., moist woods near stream, Middlefield, 7 Aug 1970, *Hill 456* (VT); NEW LONDON CO., valley of Stony Brook, 1 mile N of Oswegatchie, Waterford, 28 Jun 1941, *Clausen 5449* (MO).

DELAWARE: NEW CASTLE CO., Centreville, Aug 1865, *Commons s.n.* (MO).

GEORGIA: DEKALB CO., wet woods, Archean geologic formation, 10 Jul 1900, *Wilson 24* (MO); Stone Mountain, 22 Jul 1898, *Eggert s.n.* (MO); GILMER CO., rich moist shaded places by Flat Creek, Carters Reservoir area, 15 Jul 1973, *Kral 50598* (MO); RABUN CO., roadside near Turkey Cave, Mountain City, 7 Sep 1911, *Reade s.n.* (MO); STEPHENS CO. 1.3 mi SW of confluence of Panther Creek and Tugaloo River along Panther Creek, 12 May 1976, *Solomon 1777* (MO); UNION CO., Cooper Creek, N of Cooper Creek Recreation Area, 15 Jul 1975, *Boufford & Wood 17315* (MO).

ILLINOIS: specimens not seen [note: *Palmer 14873* from Mounds, Pulaski Co., was det as *Aspidium noveboracensis* but is *Deparia acrostichoides* (MO); *Palmer 15211* from Tunnel Hill, low rich woods along Cache River, Johnson Co., is also *Deparia acrostichoides* (MO)].

INDIANA: CRAWFORD CO., 4.5 mi SE of Taswell, rich damp shady woods, 1 Sep 1938,

Tryon 4193 (MO); JACKSON CO., low pin oak-sweet gum woods E of RR 0.5 mi S of Chestnut Ridge, 31 Aug 1937, *Friesner 11281* (MO); JENNINGS CO., woods about 4 mi SE of Vernon, 16 Aug 1910, *Deam 7135* (MO); MARTIN CO., artificial cliff of a road cut 1.5 mi S of Willow Valley, damp, shady sandstone, 24 Aug 1936, *Tryon 2726* (MO); PORTER CO., Dunes State Park, 3 mi N of Chesterton, 1932, *Tryon 499* (MO); Indiana Dunes State Park, 3 mi N of Chesterton, on sandy hillocks in a low woods, damp, sandy humus, 24 Aug 1940, *Tryon 4419* (MO); PUTNAM CO., rich bank of Walnut Creek, 1.5 mi E of Bainbridge, 3 Sep 1941, *Tryon 4549* (MO); STEUBEN CO., Pokagon State Park, 5 mi N of Angola, 1932, *Tryon 501* (MO).

KENTUCKY: BATH CO., rich oak woods, NE slope, Olympian Springs, 10 Jun 1938, *Wharton 2542* (MO); CALLOWAY CO., junction Hwy. 121 and 280, 3 mi N on 280, seep area, 6 Aug 1973, *Funk 236* (MO); MUHLENBERG CO., sandy swampy ground, partial shade, Central City, 7 Jun 1920, *Palmer 17789* (MO); WARREN CO., near Indian Creek, 21 Sep 1900, *Price s.n.* (MO).

MAINE: AROOSTOOK CO., maple-beach remnant, NE of Presque Isle, 6 Sept 1937, *Chrysler s.n.* (MO); CUMBERLAND CO., South Freeport, coastal woodland, 4 Aug 1972, *Hill 900* (NCU, NY, VT); KNOX CO., opening in forest along ski trail on Megunticook Mt., 15 Aug 1940, *Friesner 14756* (MO); LINCOLN CO., Monhegan Island, 1 Jul 1919, *Jenney et al. s.n.* (MO); PISCATAQUIS CO., deciduous woods, Dover, 22 Jul 1895, *Fernald 316* (MO); WASHINGTON CO., Eagle Hill, Steuben, 14 Jul 2001, *Hill 33961* (ILLS).

MARYLAND: MONTGOMERY CO., Silver Spring, along the NW branch of the Anacostia River at MD Rt. 29, between White Oak and Four Corners, 12 Jun 1990, *Miller & Myers 5238* (MO); PRINCE GEORGES CO., vicinity of Lanham, low woods, 22 Sep 1912, *Maxon 5874* (MO).

MASSACHUSETTS: BERKSHIRE CO., abundant in old pastures, Becket, 30 Jul 1943, *Jones & Jones 16221* (MO); DORCHESTER CO., Mattapan, 2 Aug 1884, *Churchill s.n.* (MO); DUKES CO., Elizabeth Islands, boggy thicket W end of island, Nonamessett, 30 Aug 1927, *Fogg Jr. 2907* (MO); ESSEX CO., Lake Attatash, Amesbury, 10 Aug 1936, *Conklin s.n.* (MO); FRANKLIN CO., Deerfield, 24 Aug 1953, *Poland s.n.* (MO); HAMPDEN CO., West Granville, 14 Sep 1915, *Seymour 318* (MO); MIDDLESEX CO., woods along Rt. 2, N of Lincoln, ca. 15 mi W of Boston, 5 Oct 1983, *Moran s.n.* (MO); NORFOLK CO., low moist woods near Medfield, 16 Jul 1939, *Correll & Correll 11185* (MO).

MICHIGAN: BERRIEN CO., Warren Woods 3 mi N of Three Oaks, 1932, *Tryon 512* (MO); GRATIOT CO., collected about Alma, dry woods, 10 Aug 1891, *Davis s.n.* (MO); ST. CLAIR CO., near Port Huron, 5 Sep 1906, *Dodge s.n.* (MO); WASHTENAW CO., moist slope in low woods, 3/4 mi E of Dixboro, 14 Jul 1935, *Hermann 6903* (MO).

MISSISSIPPI: TISHOMINGO CO., base of deciduous forest slope, SW of park in

Tishomingo State Park, 26 Jun 1974, *Roush s.n.* (UNAF).

NEW HAMPSHIRE: CARROLL CO., near Wakefield, in a rocky red maple woods, 5 Oct 1940, *Tryon 4489* (MO); CHESHIRE CO., Westmoreland, NW side of Highland Hill, 8 Aug 1972, *Boufford 7529* (MO); HILLSBOROUGH CO., Temple, 6 Oct 1900, *Seymour s.n.* (MO); MERRIMACK CO., Danbury, hill between Forbes Mountain and The Pinnacle, 17 Aug 1974, *Rousseau 1869* (MO).

NEW JERSEY: CAPE MAY CO., woods and thickets SE border of Pond Creek marshes, 28 Jul 1918, *Stone s.n.* (MO); MIDDLESEX CO., swampy woods, Stelton, 25 Aug 1907, *Mackenzie 2856* (MO).

NEW YORK: ESSEX CO., woods along Catlin Lake, Necomb 23 Aug 1939, *House 26946* (MO); HAMILTON CO., Indian Lake, low, wet woods, 7 Aug 1940, *Correll & Correll 11396* (MO); NASSAU CO., Cold Spring Harbor, Long Island, 11 Jul 1935, *Cain 236* (MO); RENSSELAER CO., semi-open mossy bank mixed with *Dennstaedtia punctilobula*, Poestenkill twp., ca. 1 mi E of East Poestenkill, 5 Sep 1979, *Ogden 7908* (MO); STATEN ISLAND: woodland swamp E of South Avenue W of fireworks factories at Bulls Head, 28 Jul 1905, *Dowell 3957* (MO); TOMPKINS CO., rich beech woods at edge of swamp, Ringwood, 17 Jul 1938, *Clausen 3503* (MO).

NORTH CAROLINA: BUNCOMBE CO., Warren Wilson College Forest Area Number 4, near Bull Creek, 12 Jun 1967, *Dunton s.n.* (UNAF); HAYWOOD CO., Great Smoky Mountains National Park, 21 Sep 2001, *Busemeyer 800* (ILLS); SWAIN CO., Great Smoky Mountains National Park, 7 Oct 2003, *Marcum 2174* (ILLS); TRANSYLVANIA CO., Toxaway Gorge, 12 Jul 1936, *Oosting 36125* (MO); WATAUGA CO., 3 mi E of Boone, jct. US 421 and Co. Rt. 1512, 10 May 1976, *Solomon 1652* (MO).

OHIO: WAYNE CO., 3 Aug 1909, *Hopkins s.n.* (MO).

PENNSYLVANIA: ADAMS CO., 5.5 mi WNW of Ashtown, moist woods along Conocheague Creek, 28 Aug 1941, *Tanger 4677* (MO); ELK CO., wet rocky woods near Elbon, 14 Jun 1933, *Palmer 40326* (MO); JEFFERSON CO., US Rt. I-80-W, 1.3 mi E of Reynoldsville, 2 Jul 2002, *Hill 34801* (ILLS, NY, VT); POTTER CO., Abbott township, 10.2 km NW of jct. Rts. 44 and 144 at Carter Camp, then SSE 10.2 km, low woods along tributary of Cross Fork River, 4 Jul 1979, *Boufford & Wood 21162* (MO).

RHODE ISLAND: BRISTOL CO., moist woods with *Lindera benzoin*, Bristol, 11 Aug 1961, *Seymour 19458* (MO); PROVIDENCE CO: moist rocky woods about lake near North Scituate, 8 Aug 1937, *Palmer 4378* (MO).

SOUTH CAROLINA: ANDERSON CO., Anderson, 16 Jul 1919, *Davis 8389* (MO);

OCONEE CO., West Village Creek, Mountain Rest, 24 Jul 1988, *Hill 19693* (CLEMS, GH, VT).

TENNESSEE: CUMBERLAND CO., oak-pine barrens, seep area, by I-40, 13.6 mi W of Crossville, 9 Jul 1972, *Kral 47417* (MO); FRANKLIN CO., shaded stream bank, Suwannee, 11 Jul 1972, *Kral 47610* (MO); HICKMAN CO., Pickett Hollow, just N of Bond Switch, 6 mi E of Centerville, and just S of hwy. 50, rich woods, in seepy sites along creek, 22 Jun 1982, *Carter 3090* (MO); LAWRENCE CO., Caney Branch, Loretto, creek bank, 31 Aug 1986, *Simbeck s.n.* (UNAF); WAYNE CO., near the creek on the Holt Property Pumping Station Rd., 10 Jul 1992, *Wear s.n* (UNAF).

VERMONT: ORLEANS CO., deciduous woods along northern end of Seymour Lake, Rt. 111, Morgan, 2 Sep 1966, *Seymour 25149* (MO); WINDSOR CO., damp shady woods 3 mi N of Norwich, 15 Sep 1942, *Tryon 4790* (MO).

VIRGINIA: FAUQUIER CO., W slope of Bull Run Mountains, near swamp east of White Rocks, 1 mi W of Hopewell Gap, 30 Jun 1935, *Allard 685* (MO); GILES CO., 0.5 mi past Mountain Lake Station turnoff on VA Rt. 700, ca. 2 mi past Mountain Lake, *Quercus-Kalmia-Vaccinium* association, 12 Jul 1979, *Rechel 197* (MO); NORFOLK CO: low woods, 1.5 mi W of Ocean Park, 9 Jul 1944, *Hubricht B2528* (MO).

WEST VIRGINIA: UPSHUR CO., Sago, Jul 1945, *Grose 502* (MO); WAYNE CO., shaded ravine, Cabwaylingo State Park, 26 Jun 1937, *Gilbert 600* (MO).

APPENDIX 2.

The Historic Distribution of *Thelypteris noveboracensis* in the United States. Information from herbarium specimens and the literature.

(If in > 10 counties, then only number of counties included.)

[Thought to be incomplete]

STATE	COUNTIES	NOTES
Alabama	Clarke, Clay, Cullman, Fayette, Jackson, Lamar, Lauderdale, Marion, Marshall, Winston	See W-1; W-2.
Arkansas	Cleburne, Garland, Montgomery, Newton, Pike, Polk, Pulaski, Saline	See W-1; W-2; E.B.Smith 1978
Connecticut	Every county	See W-1; W-2; Magee and Ahles 1999
Delaware	Every county	See W-1; W-2; C.F.Reed 1953
District of Columbia	Present	See W-1; W-2; C.F.Reed 1953
Georgia	48 counties, scattered, but concentrated in the northwestern third of the state; absent in the southeastern 2/3 of the state.	See W-1; W-2; Snyder and Bruce1986
Illinois	Kane, Kankakee, Monroe, Pope*, Wabash * Currently known only in Pope County	See W-1; W-2; Mohlenbrock and Ladd 1978; Mohlenbrock 1986; Herkert and Ebinger 2002; includes Shawnee N.F.
Indiana	35 counties, in a northern zone and a southern zone.	See W-1; W-2; includes Hoosier N.F. Deam 1940
Kentucky	36 counties, scattered, but primarily in the eastern third of the state.	See W-1; W-2; includes Daniel Boone N.F., Stanton and Morehead Ranger Districts
Louisiana	Rapides and Washington Parishes	See W-1; W-2; MacRoberts 1989 [in Aspleniaceae]; Thomas and Allen 1993 [in Thelypteridaceae]
Maine	Every county	See W-1; W-2; Magee and Ahles 1999
Maryland	Every county	See W-1; W-2; C.F.Reed 1953
Massachusetts	Every county	See W-1; W-2; Magee and Ahles 1999

Michigan	Berrien, Gratiot; St. Clair, Washtenaw [probably more than 10, possibly every county]	See W-1; W-2.
Mississippi	Tishomingo	See W-1; W-2.
New Hampshire	Every county	See W-1; W-2; Magee and Ahles 1999
New Jersey	Cape May, Middlesex [probably every county]	See W-1; W-2.
New York	Essex, Hamilton, Nassau, Rensselaer, Staten Island, Tompkins [probably every county]	See W-1; W-2.
North Carolina	41 counties, concentrated in the western third of the state [mountains especially]	See W-1; W-2; Radford *et al.* 1968; includes Smoky Mountains National Park, Pisgah and Nantahala N.F.s
Ohio	Wayne [probably every county]	See W-1; W-2.
Oklahoma	[extreme eastern]	See W-1; W-2.
Pennsylvania	Every county	See W-1; W-2; Wherry *et al.* 1979; Rhoads and Block 2000
Rhode Island	Every county	See W-1; W-2; Magee and Ahles 1999
South Carolina	Anderson, Cherokee, Greenville, Kershaw, Lancaster, Oconee, Pickens, Spartanburg, [undoubtedly more]	Radford *et al.* 1968; See W-1; W-2; includes Sumter N.F.
Tennessee	60 counties, excluding most along the Mississippi River	See W-1; W-2; Chester *et al.* 1993; includes Cherokee N.F., Smoky Mountain National Park
Vermont	Every county	See W-1; W-2; Magee and Ahles 1999
Virginia	Every county [probably]	See W-1; W-2; includes Jefferson N.F., George Washington N.F.; Shenandoah National Park; Harvill *et al.* 1977
West Virginia	At least 29 counties, scattered.	See W-1; W-2; includes Monongahela N.F.

APPENDIX 3.

Natural Diversity Database Element Ranking System

modified from: NatureServe Conservation Status [W-3].

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. **NNR** is used when there is no national rank yet assigned.

Subspecies Level Ranking (T)

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

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

State Ranking (S)

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

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

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

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

S5
Secure. Demonstrably secure to ineradicable in the state.

SH
All state sites are historic; the element has not been seen for at least 20 years, but suitable

habitat still exists. Possibly extirpated.

SNR, SU
Reported to occur in the state. Otherwise not ranked.

SR

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

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.