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Conservation Assessment

for the

Large Whorled Pogonia Orchid

(Isotria verticillata (Muhl. ex Willd.) Raf.)

Steven R. Hill, Ph.D.

Division of Biodiversity and Ecological Entomology
Biotic Surveys and Monitoring Section
1816 South Oak Street
Champaign, Illinois 61820

ILLINOIS
NATURAL
HISTORY
SURVEY

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Isotria verticillata (Muhl. ex Willd.) Raf., from Tennessee Plants Atlas website, University of Tennessee. Photographer: Dennis D. Horn.

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EXECUTIVE SUMMARY

This Conservation Assessment is a review of the taxonomy, distribution, habitat, ecology, and status of the Large Whorled Pogonia Orchid, *Isotria verticillata* (Muhl. ex Willd.) Raf., 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 potential threats and conservation efforts regarding the Large Whorled Pogonia Orchid to date. *Isotria verticillata* is a fleshy perennial herb (4-) 15-25 (-40) cm tall that grows from a cluster of cord-like roots / rhizomes that often produce additional plants at their tips to form a clonal colony. One or rarely two moderately showy, fragrant, brown-purple and white flowers are produced in the spring at the top of the plant from its single whorl of, generally, five leaves. The orchid is widespread in the eastern United States, and it is known historically from thirty states and one Canadian province, from Maine to Michigan and adjacent Ontario, Canada, generally southward to southwestern Georgia, Arkansas, northeast Texas and northern Florida. It is a species that grows in acidic soils, in dry to mesic forests, seeps, and sphagnum bogs. It is listed as Endangered in Florida (S1), Illinois (S1), and New Hampshire (S1), as Threatened in Michigan (S2) and Vermont (S2), as Exploitably Vulnerable in New York (S3S4) and as Extirpated (Historic only) in Maine (SX). It has been listed as Critically Imperiled (S1) in Florida, Illinois, New Hampshire, Oklahoma, and Texas, as nearly Critically Imperiled (S1S2) in Missouri, and as Imperiled (S2) in Alabama, Delaware, Michigan, and Vermont. It is at risk at the margins of its range.

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: *Isotria verticillata* (Muhl. ex Willd) Raf. (1808)
Common Names: Large Whorled Pogonia Orchid; Whorled Pogonia; Large Whorled Pogonia; Purple Fiveleaf Orchid.
Synonymy: *Arethusa verticillata* Muhlenberg ex Willdenow (1805), the basionym *Pogonia verticillata* (Muhl. ex Willd.) Nuttall (1818)

Class: Liliopsida (Monocots)
Family: Orchidaceae (The Orchid Family)
Plants Code: ISVE (U.S.D.A. NRCS plant database, W-1) http://plants.usda.gov/

The genus *Isotria* Raf. contains 2 species worldwide, both of which are native only to eastern North America (Mehrhoff and Homoya 2002). The genus is found only in the eastern United States and a short distance into adjacent Canada. The two species generally occur in dry or mesic forests, and occasionally grow in seeps and bogs, from 10 – 2,000 meters in elevation. The genus is most closely related to the genera *Cleistes* Richard ex Lindley and *Pogonia* Jussieu, the former also restricted to eastern North America, and the latter to both eastern North America and temperate eastern Asia. The three genera are currently placed within the orchid tribe Vanilleae subtribe Pogoniinae (Romero-González *et al.* 2002). The genera and species of all three genera are normally considered to be quite distinct and have been well studied. The name *Isotria* was derived from the Greek *iso*, meaning equal, and *tri*, 3, probably referring to the three equal-sized and shaped sepals. *Isotria* is quite distinctive because of its single terminal whorl of smooth flat leaves.

The Large Whorled Pogonia Orchid was first formally named by G. H. E. Muhlenberg [in 1805] of Pennsylvania, who described the species within the genus *Arethusa*, the Dragon's-mouth Orchid, because of its superficial resemblance to that other genus known to him. The Latin epithet '*verticillata*', equivalent to the English 'verticillate' or 'whorled' was used to describe the fact that there were several leaves found in a single terminal whorl on the single stem, to distinguish it from the single-leaved, basal-leaved *Arethusa bulbosa* that had been previously described by Linnaeus in 1753. The second species, *Isotria medeoloides* (Pursh) Raf., was discovered and described subsequently by Fred Pursh in 1814, also within the genus *Arethusa*. In 1818, Tom Nuttall, also residing in Pennsylvania, transferred the species into the genus *Pogonia* because he thought it fit better there than in *Arethusa*. He may not have known of the genus *Isotria* that was actually published before this transfer. Constantine Rafinesque, a French expatriate, always eager to name new genera, recognized that this species was quite different from *Arethusa*, and transferred the species into his new genus, *Isotria*, in 1808, transferring the second species into his genus in 1838 when he became aware of it. No hybrids, subspecies, or

varieties are currently recognized for either species.

A few authors have chosen to retain *Isotria* (along with *Cleistes*) within the genus *Pogonia*, in which case the name *Pogonia verticillata* (Muhl. ex Willd.) Nuttall would be appropriate for this plant.

The common name Large Whorled Pogonia Orchid is generally used as the common name for this plant, though it is often shortened to Large Whorled Pogonia or just Whorled Pogonia. The common name is based upon its size (normally larger in all respects than *Isotria medeoloides*, the Small Whorled Pogonia Orchid) and the once accepted scientific name *Pogonia verticillata* has been literally translated into Whorled Pogonia. This common name can lead to some confusion with members of the genus *Pogonia* Jussieu, but the two genera are considered to be quite distinct by most botanists.

DESCRIPTION OF THE SPECIES

Isotria verticillata, the Large Whorled Pogonia Orchid, is a somewhat soft-fleshy perennial terrestrial herb that is glabrous, colonial (clonal), rhizomatous, and with a single stem to 0.4 m tall topped by a single whorl of usually 5 leaves. The fasciculate **roots** are long, slender, and hairy and have mycorrhizae. The **rhizomes** are very root like (perhaps are truly roots?), long and cordlike, and these frequently send up new plants forming colonies. The **stems** are hollow, pale, whitish-green, brownish-green, or purplish, glaucous, and fleshy, and grow (4-) 15-25 (-40) cm tall. There are normally 2-4 purplish scales typically below the soil line. The **leaves** are green and usually paler and glaucous beneath, all appearing to be in a single terminal whorl, nearly always 5 in number (rarely 2, 4, or 6, sometimes even to 10?), (2.5-) 4-5 (-10) cm long x (0.7-) 1.5-4 (-5.3) cm wide, oblong ovate to oblong lanceolate, to elliptic, with an obtuse to acuminate apex. **Inflorescences** are terminal and have no bracts, and generally are made up of a single flower, less frequently 2 are present in very robust plants. The **flowers** (see cover illustration) are normally somewhat ascending to erect, subsessile to short pedunculate (peduncle about 2.5 cm long), somewhat showy, and open at maturity (chasmogamous) and may have all parts directed forward or spreading, sweetly fragrant but without nectar; with 3 distinct sepals and 3 petals; the **sepals** are equal in size and shape, spreading slightly or widely, greenish-brown to purple brown, 34-67 mm long x 2-4 mm wide, narrowly lanceolate and acuminate; the **lateral petals** appear fused and form a hood over the column and lip, they are yellowish-green and 15-25 mm long x 3-7 mm wide, elliptic-obovate to elliptic-lanceolate; the **lip** is trough-shaped, (15-) 20-25 mm long x 8-9 mm wide, greenish-yellow to white towards the tip and streaked purple towards the base, shallowly 3-lobed, the triangular lateral lobes are streaked with purple with the margins involute, the middle lobe is rounded with margins revolute and undulate; the medial lip callus is green, longitudinal, and fleshy; the white reproductive column is 8-12 mm long with a denticulate apex, the green ovary is 20-30 mm long; the rostrellar flap is prominent but the

rostrellum is obscure; there are 2 soft hinged pollinia. The **fruits** are ellipsoid-cylindric capsules 20-35 (-42) mm x 5-10 mm with an acute tip; the pedicel of the mature capsule greatly elongates to 20-55 (-60) mm, and the capsule is held erect, and the dry fruit is usually persistent through the next growing season; the numerous seeds are 1.2 mm x 0.2 mm. The **chromosome number** is $2n = 18$. (Adapted from Mehrhoff and Homoya 2002).

The Large Whorled Pogonia Orchid is the more widespread and common of the two species in the genus. It is normally recognized and distinguished from the far less common *Isotria medeoloides* by its purplish-brown (not green or light green) sepals, its larger flowers (> 30 mm long), its purple-streaked (not green-streaked) lip, its larger capsule (20-55 mm long vs. 5-20 mm long in *Isotria medeoloides*) and its generally darker-tinted stems and darker green leaves (Mehrhoff and Homoya 2002). It is distinctly different in its characters from other orchids in eastern North America and it is unlikely to be confused with members of any other genus when fertile.

Wunderlin (pers. comm.) has pointed out that the 'whorl' of terminal leaves in this genus is actually a whorl of modified floral bracts, and that the only true leaves are the alternate scale-like leaves at the base of the stems.

Immature plants are often confused with the extremely similar immature individuals of Indian Cucumber Root (*Medeola virginiana*) but the leaf veins of the former are ultimately parallel with only a few cross veins (Yatskievych 2000); the latter has a white tuberous underground rhizome and *Isotria* has several radiating horizontal roots with no tuber, but most dependable is the fact that *Medeola* stems are downy pubescent at least at their base, solid, rather narrow and non-fleshy whereas *Isotria* stems are glabrous, smooth, hollow, glaucous, and fleshy (Hill, pers. obs.; Homoya 1993).

HABITAT AND ECOLOGY

The Large Whorled Pogonia Orchid has been given a national wetland indicator status of FACU (Facultative Upland), FAC (Facultative), indicating that the species infrequently to occasionally occurs in wetlands (FACU = estimated probability 1-33 %, FAC = 34-66 %). In Wetland Region 3, including both Illinois and Indiana, *Isotria verticillata* has been specifically designated as a FAC species (equally likely to occur in wetlands or non-wetlands, estimated probability 34% - 66%; Reed 1988; W-1; W-2). It generally prefers mesic forest communities in shade, with acidic soils. Overall, this orchid can be found in dry or mesic upland forests, acidic seeps, and sphagnum bogs, in acidic soils, from 10 – 2000 meters. It appears to be most common (at least historically) in portions of (listed in decreasing order) Virginia, Pennsylvania, Kentucky, North Carolina, Ohio, New York, Massachusetts, Mississippi, and New Jersey. It does not appear to be extremely cold sensitive, and it does occur north of the maximum southern Pleistocene glacial

boundary but only slightly into Canada (W-3).

A review of the literature demonstrates that this herb has a variety of different plant associates and habitats throughout its range. Floras have described the habitat of *Isotria verticillata* as "Acid or mediacid woodlands" (Fernald 1950), "Acid soil in woods" (Gleason and Cronquist 1991), "rich woods and stream banks" in the Blue Ridge physiographic province (Georgia, North Carolina, South Carolina, Tennessee, and Virginia; Wofford 1989), "Moist hardwood slopes, stream margins" in North and South Carolina (Radford *et al.* 1968), "Dry to moist sandy pine woods, low rich damp hardwoods along streams, floodplain forests, tamarack swamps, shady ravines, boggy places in upland woods, mixed hardwood slopes" in the southeastern states overall (Godfrey and Wooten 1979), and "Along streams and on slopes in hardwood forests" in Texas (Correll and Johnston 1970). In Florida it is found in "Bluff forests" (Wunderlin 1998, W-4).

The soils where the Large Whorled Pogonia Orchid grows are formed over a variety of gneissic metamorphic schists, granites, sandstones, siltstones, and shales and they are normally, but not always, rich in humus. The bedrock can be quite deep (as in bogs or on the coastal plain) or shallow (as on upland heath or pine ridges), but the soils are acidic (low pH) or infrequently nearly circumneutral, but not basic (high pH).

At its northeastern range limits in Ontario, Canada, and northern New England, *Isotria verticillata* normally grows (or grew, in some cases) in acid, sometimes sandy, well-drained, nutrient-poor soils in moist deciduous forests with oak and pine, or in sphagnum bogs. The habitat is often described as belonging to the Oak-Pine-Northern Hardwood Forest Formation (W-5). Associated trees can include *Betula allegheniensis, Carya ovata, Fagus grandifolia, Fraxinus americana*, *Liriodendron tulipifera, Pinus rigida, Pinus strobus, Quercus montana, Quercus rubra, Quercus velutina,* and *Thuja occidentalis*. Shrubs are usually scattered, and may include *Gaylussacia baccata*, *Vaccinium pallidum*, and *Viburnum acerifolium*. Other associates are often the vine *Smilax rotundifolia*, the forbs *Desmodium nudiflorum, Malaxis unifolia, Medeola virginiana*, and *Mitchella repens*, and several sedges and ferns. The habitat and associates are very similar to those described in Virginia to the south (see below).

In Michigan, also approaching its northern range limit, *Isotria verticillata* grows in three different natural communities (Michigan Natural Features Inventory 2000). The first is the dry-mesic northern forest community, characterized by the trees *Acer rubrum, Hamamelis virginiana*, and *Quercus alba*, the shrubs *Gaultheria procumbens, Vaccinium* spp., *Viburnum acerifolium, Amelanchier* spp., and the herbs *Carex pensylvanica*, *Maianthemum canadense*, *Monotropa uniflora*, and *Trientalis borealis*, along with the fern *Pteridium aquilinum*. The second natural community habitat for this orchid in Michigan is the southern swamp community. The usual associates in this habitat include the trees *Acer rubrum* and *Sassafras albidum*, the

shrubs *Gaultheria procumbens, Gaylussacia baccata,* and *Vaccinium corymbosum*, and the fern *Osmunda regalis*. The third natural community where *Isotria verticillata* grows in Michigan is the bog community, along with the trees *Acer rubrum*, *Larix laricina* and *Picea mariana*, the shrubs *Betula pumila, Chamaedaphne calyculata, Kalmia angustifolia, Vaccinium corymbosum*, and plenty of sphagnum moss (Michigan Natural Features Inventory 2000).

In the Midwest, in Indiana, the Large Whorled Pogonia Orchid grows in three distinct habitat types, namely, steep dry to dry-mesic forested slopes, sphagnum bogs, and mesic flatwoods (Homoya 1993). All three habitats have very acidic soils. The upland forests are generally on steep west-facing slopes of deep ravines at the sharp breaks where dry and dry-mesic forests grade into mesic forest on the lower slopes. The soils are characteristically shallow over siltstones, shales, and sandstones. Some of the typical canopy trees associated with the orchid in this habitat are *Acer rubrum, Fagus grandifolia, Nyssa sylvatica, Quercus alba, Quercus montana*, and *Quercus velutina*. Smaller trees and shrubs can include *Cornus florida*, *Gaylussacia baccata*, *Sassafras albidum*, *Vaccinium pallidum*, and *Viburnum acerifolium*. Other associates are often the vine *Smilax rotundifolia*, the forbs *Cunila origanoides, Desmodium nudiflorum, Malaxis unifolia, Medeola virginiana*, and *Mitchella repens*, and the sedge *Carex picta*, said to be an extremely good indicator species (Homoya 1993). The bog habitat is restricted to the northern natural regions, and in this habitat the orchid grows on moist hummocks of sphagnum moss, a habitat very different from those in the southern part of the state (Homoya 1993). Some of the associates with this orchid in this habitat are the trees *Acer rubrum* and *Larix laricina*, the shrubs *Aronia melanocarpa, Salix pedicellaris*, *Toxicodendron vernix*, and *Vaccinium corymbosum*, the dwarf creeping shrub *Vaccinium microcarpon*, the forbs *Menyanthes trifoliata* and *Sarracenia purpurea*, and the ferns *Osmunda cinnamomea, Osmunda regalis*, and *Thelypteris palustris*. The mesic flatwoods habitat is not as well known; at one flatwoods site Homoya (1993) observed this orchid with the associated trees *Acer rubrum, Nyssa sylvatica, Quercus alba, Quercus bicolor, Quercus falcata, Quercus palustris*, and *Sassafras albidum*, along with the vines *Toxicodendron radicans* and *Vitis labrusca*, and the sedges *Carex albolutescens, Carex annectens, Carex debilis*, and *Carex swanii*. Deam (1940) indicated that he had found it associated with *Larix laricina* in sphagnum bogs in the north, and with *Quercus alba* in southern forests. Yatskievych (2000) indicates the habitat in Indiana to be "Dry acidic wooded slopes, tamarack swamps, bogs".

Also in the Midwest, in Illinois, the Large Whorled Pogonia Orchid grows in "lowland woods" only (Mohlenbrock 2002). Associated trees include *Acer saccharum*, *Carya glabra*, *Carya ovalis*, and *Quercus alba*. Understory species can include *Smilax rotundifolia*, *Tipularia discolor*, *Triadenum tubulosum*, and *Uvularia sessilifolia*, among others. Herbarium labels on specimens in the Illinois Natural History Survey herbarium (ILLS) included the habitat 'southwest bank of a dry stream-bed'. Herkert and Ebinger (2002) and staff at the Shawnee National Forest (2005) have stated that the Illinois populations occur next to seep springs near

the bottom of forested ravine slopes and adjacent to fire-dependent natural communities. A description of the habitat and associated species for this orchid in Illinois has been given by Sheviak (1974).

Slightly west, in Missouri, the Large Whorled Pogonia Orchid occurs in acid soils in mesic upland forests on slopes and level terraces (bottoms) adjacent to streams and also in dry upland forests on chert and sandstone (Summers 1987, Yatskievych 1999) in the Ozark and Ozark Border Divisions and in Crowley's Ridge, where it is known from St. Francois, Ste. Genevieve, Butler, Oregon, and Stoddard counties. Among the species associates reported with this orchid in Missouri are the trees *Fagus grandifolia, Liquidambar styraciflua, Liriodendron tulipifera*, and *Quercus* spp., the shrubs *Alnus serrulata, Ilex verticillata*, and *Rhododendron roseum*, the orchid *Platanthera ciliata*, and the moss *Sphagnum lescurii* (data from herbarium specimens).

In Virginia and neighboring states, the Large Whorled Pogonia Orchid has been found in patches within a group of forests referred to as Oak / Heath forests (W-6). This group of oak-dominated forests is very common on xeric, upland sites throughout Virginia and the Appalachians, and these communities have replaced those previously dominated by American chestnut (*Castanea dentata*). The soils are strongly acidic and have high levels of iron, and the topmost soils usually have significant accumulations of organic matter from the abundant leaf fall. Dominants in these forests include the trees *Quercus alba, Quercus coccinea, Quercus montana, Quercus velutina* [and others], as well as *Populus grandidentata, Pinus echinata, Pinus rigida*, and *Pinus virginiana*. Additional common trees include *Acer rubrum, Ilex opaca, Nyssa sylvatica, Oxydendrum arboreum*, and *Sassafras albidum*. Common shrubs are *Kalmia latifolia, Gaylussacia baccata, Rhododendron periclymenoides*, and *Vaccinium* spp., along with the dwarf trailing shrubs *Epigaea repens* and *Gaultheria procumbens*. The vines *Parthenocissus quinquefolia, Smilax glauca*, and *Vitis rotundifolia* are rather common associates. True herbs are sparse because of typically dense leaf litter, but *Isotria verticillata* can be found in this habitat along with *Baptisia tinctoria*, *Cypripedium acaule*, *Desmodium nudiflorum, Michella repens, Polygala paucifolia*, *Smilacina racemosa*, *Tephrosia virginiana,* and the ferns *Polystichum acrostichoides* and *Pteridium aquilinum* (W-6). As one proceeds south, more cold-intolerant species occur. *Isotria verticillata* often grows in the midst of a relatively dense shrub cover (pers. obs.).

In Florida, at its southeastern range limit, *Isotria verticillata* has been collected in Bluff Forests (slope forests on the Appalachia River Bluffs; Clewell 1985) associated primarily with the tree *Fagus grandifolia*; other associates (many of which are also sensitive species) in this habitat may include the trees *Magnolia pyramidata* and (formerly) *Torreya taxifolia*, the shrubs *Calycanthus floridus, Cornus alternifolia, Kalmia latifolia, Stewartia malachodendron, Taxus floridana*, and *Zanthoxylum americanum*, and the herbs *Carex baltzellii, Croomia pauciflora, Epigaea repens* [actually a miniature creeping shrub], *Erythronium umbilicatum, Hybanthus concolor, Thalictrum thalictroides, Trillium lancifolium*, and *Veratrum woodii*.

In Oklahoma, near its western range limit, this orchid has been found in *Fagus grandifolia* forests, on a north slope on the south side of a mountain, as well as in pine woods with *Quercus* spp. and *Liquidambar styraciflua*, and, in addition, growing in dry humus just above a 'hanging' sphagnum bog. It has been recorded as being locally common (about 200 plants in a population) at one site (Magrath and Taylor 1978). In Texas, *Isotria verticillata* has been found in the Big Thicket region of east Texas with similar associates (Correll and Johnston 1970).

In Louisiana, *Isotria verticillata* has been described as a typical component of the Forested Seep Natural Community (Louisiana Natural Heritage Program 2004), a wetland community sometimes called a Baygall or Green-head, as well. These are typically on hillsides in mixed pine-hardwood forests, and are limited to a few acres. The soils are very sandy and acidic. Associated plants here include the trees *Acer rubrum*, *Magnolia virginiana*, and *Nyssa sylvatica*, the shrubs *Alnus serrulata, Aronia arbutifolia, Itea virginica, Lyonia ligustrina, Lyonia mariana, Myrica heterophylla, Toxicodendron vernix, Vaccinium fuscatum*, and *Viburnum nudum*; the vine *Smilax laurifolia* is common, and the understory is dominated by ferns, including *Athyrium filix-femina*, *Onoclea sensibilis, Osmunda cinnamomea, Osmunda regalis*, and *Woodwardia areolata*. Orchids such as *Platanthera clavellata, Platanthera ciliaris*, and *Platanthera cristata* may occur with the *Isotria*; sphagnum moss is abundant. This association is widespread along the eastern piedmont and coastal plain as well, as far north as Maryland and New Jersey, and most of these listed associates are the same throughout this wide area in this habitat (Simmons and Strong 2001).

DISTRIBUTION AND ABUNDANCE

Isotria verticillata, the Large Whorled Pogonia Orchid, is widespread in portions of the temperate eastern and southeastern United States, and it has been found historically there in thirty states plus the District of Columbia, namely, Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia, and West Virginia (W-1, W-3; Mehrhoff and Homoya 2002). It also occurs in adjacent Ontario, Canada. *Isotria verticillata* is relatively rare in the extreme northeastern portions of its range. According to the Nature Conservancy, it appears to be most common in portions of Kentucky, Massachusetts, Mississippi, New Jersey, Virginia, and West Virginia (W-3). Its range includes both formerly glaciated and unglaciated areas. As with most other species, it becomes scarce at the margins of its range. Its historic range assessed on a county basis was undoubtedly greater than its current range. One can generally expect that a decline has occurred in recent decades because of the general loss and degradation of its habitats nationally resulting in local extinctions.

The closely related *Isotria medeoloides*, a Federally Threatened species, is known to have a similar, but somewhat smaller, distribution, and its historic range includes twenty states, namely, Connecticut, Delaware, Georgia, Illinois, Maine, Maryland, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, and Virginia (W-1, W-3; Mehrhoff and Homoya 2002). It, also, has been found in Ontario, Canada. It appears to be absent in Alabama, Arkansas, Florida, Indiana, Kentucky, Louisiana, Mississippi, Oklahoma, Texas, and West Virginia, suggesting a generally greater sensitivity to hotter and drier climates than those for *Isotria verticillata*. Sterile plants of this species may have been reported as *Isotria verticillata* in some cases, and vice versa. *Isotria medeoloides* has sometimes been considered to be the rarest species of North American orchid, and it usually occurs as single individuals when found.

Based upon its state rankings (W-3) only, the Large Whorled Pogonia Orchid would appear to be most frequent in Virginia and West Virginia, and only somewhat less so in Kentucky, followed by Massachusetts, Mississippi, and New Jersey. The plant's abundance decreases in the other states, and this orchid is considered infrequent in Connecticut, Georgia, Indiana, Louisiana, North Carolina, and Rhode Island, and slightly less so in New York. *Isotria verticillata* is listed as Critically Imperiled in Florida, Illinois, New Hampshire, Oklahoma, and Texas, as Imperiled in Alabama, Delaware, Michigan and Vermont, and as very vulnerable in New York. It has become extinct in Maine. The species may be close to extinction in several other states where it has not been seen in recent decades (W-1, W-3). Its abundance is not ranked in seven of the thirty states from which it has been reported (W-3), so its frequency cannot be precisely determined in those states. The Large Whorled Pogonia Orchid is very local within most of its range because of its habitat preferences and specialized life history.

A combination of records from several sources (see appendices) gives more detailed information on the frequency and distribution of *Isotria verticillata*. Records from floras and herbarium labels show that this orchid has been found in more than 58 counties in Virginia, in more than 40 counties in Pennsylvania, and in more than 25 counties in Kentucky, North Carolina, and Ohio (and probably New York). It also occurs in more than 10 counties in Arkansas, Indiana, Louisiana [parishes], Massachusetts, Michigan, New Jersey, Tennessee, and West Virginia. In the remaining sixteen states *Isotria verticillata* has been found in 10 or fewer counties. Additional details on the distribution of this herb can be found in Kartesz and Meacham (1999) and several Internet sites (*e.g.*, W-1, W-3). Representative voucher specimens of this terrestrial orchid have been listed in Appendix 1. A summary of the distribution of the Large Whorled Pogonia Orchid in the United States has been presented in Appendix 2.

In the east-central states, the species has been found in Illinois and in Indiana, as well as in neighboring Kentucky and Missouri, but not in Iowa or Wisconsin (W-3; Yatskievych 1999,

Mohlenbrock and Ladd 1978, Deam 1940).

In Illinois where the species is listed as Endangered, *Isotria verticillata* has been reported historically only in Pope County (W-1, W-3; Herkert and Ebinger 2002, Mohlenbrock 1986, 2002; Mohlenbrock and Ladd 1978; Shawnee National Forest 2005). This orchid was first discovered in Illinois in Pope County in 1967 (Schwegman 1968). Its current distribution, as far as is known, includes only two colonies within the Shawnee National Forest, both within the protected Cretaceous Hills Ecological Area (Shawnee National Forest 2005). These sites are located within the Cretaceous Hills Section of the Coastal Plain Natural Division of Illinois (Schwegman *et al.* 1973).

In Indiana where the species is included on the state's informal Watch List (Yatskievych 2000), *Isotria verticillata* has been reported in twelve scattered counties around the state within five natural regions, namely, the Northern Lakes, Northwestern Morainal, Bluegrass, Shawnee Hills, and Highland Rim (Homoya 1993). It is most frequent in the Brown County Hills Section of the Highland Rim (Homoya 1993).

In Missouri, this orchid was first found in 1897 in Butler County (Summers 1987) at a site that no longer exists. Subsequently the species was found in Ste. Genevieve County in 1952 and in 1970 at another site in the county. A fourth location was found in Stoddard County in 1970 (Summers 1987). It has since been reported from two additional counties (Yatskievych 1999).

Within the U.S. Forest Service Eastern Region (Region 9) *Isotria verticillata* is known to be present within the Shawnee National Forest in Illinois, the Hoosier National Forest in Indiana, the Mark Twain National Forest in Missouri, the Allegheny National Forest in Pennsylvania, and the Green Mountains National Forest in Vermont (W-7). It may also occur in several other national forests in the eastern region based on its known habitat preferences and range. It is apparently more common in the Southern Region (Region 8) and its known range suggests that it occurs within the Talladega National Forest in Alabama, the Ozark and Ouachita National Forests in Arkansas, the Chattahoochee National Forest in Georgia, the Daniel Boone National Forest in Kentucky, the Kisatchie National Forest in Louisiana, Holly Springs and Homochitto National Forests in Mississippi, the Mark Twain National Forest in Missouri, the Nantahala, Pisgah, and Uwharrie National Forests in North Carolina, Sumter National Forest in South Carolina, the Cherokee National Forest in Tennessee, the Jefferson and George Washington National Forests in Virginia, and others, as well as in the Great Smoky Mountains and Shenandoah National Parks.

The populations of this orchid in Illinois and other areas of the Midwest are scattered widely and the populations are isolated from one another. It is possible that the species was somewhat more common in the region at the time of European settlement, but there is no direct evidence for this

because there are few early herbarium records from the region. For example, in Illinois, the species was discovered only in 1967 (Schwegman 1968). The forests in the region before European settlement are thought to have been kept more open by means of fires set by the earlier inhabitants in the area, and there is some evidence that *Isotria verticillata* prefers and reproduces better after a fire (Klinkenberg 1986; Shawnee National Forest 2005). The suppression of fires later may have led to a decline in the number of populations. It is also likely that some forested sites where it may have occurred have been developed or disturbed by agriculture and housing in the past 200 years, in which case there may have been a significant population decline as well for that reason.

There is some data available on population sizes for this herb, but herbarium label data only rarely include its local frequency or abundance. Herbarium labels have indicated, for example, 200 stems in a population in Missouri, about 15 in a population in Florida, and several hundred in the Illinois colonies. Herbarium records indicate that in Ohio some of the population sizes have been reported to contain more than 100 plants, and as few as 35 and 40 plants. Homoya (1977) reported increases in numbers of individuals at three colony sites in Illinois from more than 100 to "well over 1000 plants" during the period 1970 – 1977. A later visit by Schwegman in 2000 revealed 168 stems at one site (only one in flower), 164 at a second site, and none at the third site. Homoya (1993) reported populations with a density of as many as 60 stems per square meter in Indiana. Summers (1987) reported that the colonies in Missouri are "...similar to those of May apples but not as dense". It is important to note that while this orchid often occurs in rather large colonies, it appears sporadically and often does not flower for years (Homoya 1993, Summers 1987). This makes an estimate of actual population size quite difficult.

PROTECTION STATUS

The Nature Conservancy currently ranks *Isotria verticillata,* the Large Whorled Pogonia Orchid, as a G5 plant (W-3), indicating that the species is fully secure worldwide. In the United States, overall, the species is given the National Heritage rank of N5 for similar reasons. In Canada, *Isotria verticillata* has been ranked as N1 (Critically Imperiled nationally).

Official protection for this orchid outside of Forest Service lands depends upon state and local laws because it is not listed as Federally threatened or endangered. The state rankings vary considerably. *Isotria verticillata* is listed as Endangered in Florida (S1), Illinois (S1; Illinois Endangered Species Protection Board 2005), and New Hampshire (S1), as Threatened in Michigan (S2) and Vermont (S2), as Exploitably Vulnerable in New York (S3S4) and as Extirpated (Historic only) in Maine (SX). It has been listed as Critically Imperiled (S1) in Florida, Illinois, New Hampshire, Oklahoma, and Texas, as nearly Critically Imperiled (S1S2) in Missouri, and as Imperiled (S2) in Alabama, Delaware, Michigan, and Vermont. It is considered Vulnerable (S3) in Connecticut, Georgia, Indiana, Louisiana, North Carolina, and Rhode Island,

and slightly less so (S3S4) in New York. It is ranked as apparently secure to secure (S4, S5) in Kentucky (S4S5), Massachusetts (S4), Mississippi (S4?), New Jersey (S4), Virginia and West Virginia (W-3). This orchid remains unranked in the seven additional states from which it has been reported. It is at risk at the margins of its range.

In Forest Service Region 9, the Large Whorled Pogonia Orchid is included on the Regional Forester Sensitive Species list (RFSS) as 'At Risk' in the Shawnee National Forest (IL), the Mark Twain National Forest (MO), and the Green Mountain National Forest (VT). It occurs in the Hoosier National Forest (IN) but it is not considered to be at risk there, nor in the Allegheny National Forest (PA) where it also occurs (W-7; Shawnee National Forest 2005).

In Missouri, this orchid is not listed as threatened or endangered; current law in the state allows only the listing of federally listed taxa as state endangered (Yatskievych, pers. comm.); however, it is tracked in the state as a S1S2 plant and it is being tracked. It was formerly included in the checklist of rare and endangered species of Missouri as an Endangered plant (indicating survival in Missouri is in immediate jeopardy; Missouri Department of Conservation 1991).

Protection for this orchid is currently dependent primarily on habitat protection, and so its survival will probably depend more on this than on individual species protection.

Table 1 lists the official state rank for *Isotria verticillata* assigned by each state's Natural Heritage program according to the Nature Conservancy at their Internet site (W-3). Appendix 3 explains the meanings of the acronyms used (W-8).

A summary of the current official protection status for *Isotria verticillata* follows:

U.S. Fish and Wildlife Service:	Not listed (None)
U.S. Forest Service:	At Risk in the Shawnee National Forest, Mark Twain National Forest, and the Green Mountain National Forest, Region 9
Global Heritage Status Rank:	G5 - Secure
U.S. National Heritage Status Rank:	N5
Canada National Heritage Status Rank:	N1

Table 1: S-ranks for *Isotria verticillata* [Heritage Element Code: PMORC1F020]

State/Province	Heritage S-rank	
UNITED STATES		
Alabama	S2	
Arkansas	SNR	
Connecticut	S3	
Delaware	S2	
District of Columbia	SNR	
Florida	S1	[Endangered]
Georgia	S3	
Illinois	S1	[Endangered]
Indiana	S3	
Kentucky	S4S5	
Louisiana	S3	
Maine	SX	[Extirpated]
Maryland	SNR	
Massachusetts	S4	
Michigan	S2	[Threatened]
Mississippi	S4?	
Missouri	S1S2	
New Hampshire	S1	[Endangered]
New Jersey	S4	
New York	S3S4	[Exploitably Vulnerable]
North Carolina	S3	
Ohio	SNR	
Oklahoma	S1	
Pennsylvania	SNR	
Rhode Island	S3	
South Carolina	SNR	
Tennessee	SNR	
Texas	S1	
Vermont	S2	[Threatened]
Virginia	S5	
West Virginia	S5	
CANADA		
Ontario	S1	

LIFE HISTORY

Isotria verticillata is a perennial orchid that often forms extensive clonal colonies with hundreds of stems. As with other orchids, its life history is among the most complicated in all of the flowering plants, and much specific information is lacking for most individual species. What is known is that orchid seeds are very small and dust-like, and they lack the endosperm that feeds most flowering plants in their early development. Developing orchid embryos and seedlings must, instead, get their nutrition from other sources, and this source is usually decaying organic matter, or, in some species, another plant. However, orchids are actually not capable of true parasitism or saprophytism (though the latter term is often used to describe the orchid – fungus association) and their nutrition is provided through mycorrhizae, a symbiotic relationship between vascular plants and a saprophytic or parasitic fungus. More correctly, this relationship is termed *mycotrophic* (see below). Apparently, temperate zone orchids are not very species specific in their associated fungal partners, and several fungi may be involved. The developing embryo obtains nutrition from the fungal hyphae through the process of digestion (the orchid cells digest the fungal cells) and in return the orchid is thought to contribute substances to the fungus that it cannot produce itself (Withner 1974; Homoya 1993). Fungi may more frequently become predators on the orchid seeds, and it is thought that because of this, most orchid seeds never develop into mature plants. The genus *Cypripedium* requires 10–16 years for the plant to

grow to maturity (Shefferson *et al.* 2001); this amount of time may also be required for *Isotria*.

Species such as the Large Whorled Pogonia Orchid, and members of most other orchid genera, rely partly upon fungal produced nutrition, and uptake of water by the fungus to the orchid throughout their life cycles. In most orchids, including *Isotria*, this relationship is most obvious in the specialized, thickened, spongy roots that normally lack root hairs, and that have a distinctly earthy aroma related to the fungal component. Plants that are dependent on this form of nutrition can be described as mycotrophic (Taylor *et al.* 2003). The fungal hyphae are retained entirely within the underground plant tissues that have been variously interpreted as rhizomes and highly specialized roots (Taylor *et al.* 2003).

Small *Isotria verticillata* plants emerge in the spring with the whorl of leaves folded upright, enclosing the erect flower bud. As the flower opens, the plant becomes erect and the whorl of leaves spreads (Summers 1987). Non-flowering plants rarely have a white, undeveloped floral bud instead that measures 1-2 mm (Mehrhoff and Homoya 2002). In flowering individuals, the flowers are medium-sized and somewhat showy, and they have a light fragrance suggestive of vanilla. The flowers are pollinated by solitary bees of the families Andrenidae, Anthophoridae, and Halictidae, and plants are apparently self-compatible (Mehrhoff 1983). However, the flowers do not self-pollinate, as do those in the related *Isotria medeoloides*, and so the pollinators are required for fruits to form in *Isotria verticillata*. If the ovules are fertilized, the flower parts drop away immediately and the ovary quickly develops into an upright seed capsule. Most stems in a colony do not flower in a given year, and not all flowers are pollinated, making this an uncommon and seldom successful procedure.

As observed, many plants in a colony and, often, entire colonies do not flower in some years, but they remain vegetative instead (Summers 1987, Hill, pers. obs.). Homoya (1993) also notes that only a small percentage of the population flowers in a given year, and, in some years, a population that may have as many as 60 stems per square meter may produce no flowers at all. Furthermore, the root-like rhizomes apparently do not send up plants every year. Thus an entire colony may be dormant and absent one year, and have numerous individuals in the next year at the same site. This makes population counts very difficult.

As stated, flowering in *Isotria verticillata* is known to be very erratic, and the controls on this are unknown. The environmental factors controlling flowering in this orchid may be rainfall, temperature, nutrient availability, or a combination of these with some other factors. Observations suggest that fires tend to increase the number of flowering individuals in a colony during the next growing season (Shawnee National Forest 2005, W-9). The percentage of seed success in the wild also is not fully known but fruits are occasionally seen. However, the process of establishment of new colonies has not been observed. These orchids can probably be propagated vegetatively because connecting rhizomes between plants are well known, and this

also suggests that a single colony can have many stems that are genetically identical, all from the establishment of a single plant from a seed. According to Mehrhoff (1983), *Isotria verticillata* forms extensive clones with the numbers of shoots (ramets) reaching into the hundreds. As many as 300 closely spaced flowering shoots can be produced by a single clone (genet). The success of seed release from one fruit every few years is apparently enough to allow this species to survive.

The Large Whorled Pogonia Orchid flowers from April to June in most portions of its range. It is typical for it to flower in mid April and May in southern parts of its range and in May and June in more northern areas. Radford *et al.* (1968) state that the flowering time for this orchid in the Carolinas is April – July. Clewell (1985) reported its flowering time in Florida at its southeastern range limit as April only. One specimen collected in Texas appeared to have a flower as early as 23 March. In Indiana it is said to flower from early May to mid-June (Homoya 1993), and Summers (1987) states that its flowering time in Missouri is late April to May. The latest flower noted on a sampling of specimens was 16 June in upper New York State. In a given region, the flowering period is brief – the flowers last from 4-7 days, and at one observed site in North Carolina, the total observed length of the flowering period was 13 days, April 28 – May 10 (Mehrhoff 1983). This time period is also the approximate time of peak flower in much of the species' range.

Young fruits are produced as early as 7 June but they are not ripe until much later. Mature fruits on herbarium specimens appeared to be present on plants from approximately 17 July to 17 October, though the empty fruits can persist beyond that. The average time for fruit maturation appears to be approximately 15 September – 15 October through most of its range, but it is not uncommonly in fruit as early as 15 August (at least in Oklahoma). The wilted flowers do not persist on the capsules. As is typical in orchids generally, numerous seeds can be produced as a result of a single pollination event (in the 1,000s to millions in some species, per capsule) and plants usually propagate by seed. Mehrhoff (1983) considers the seed production in *Isotria* to be low to moderate compared to other orchids. He observed that two immature capsules of *Isotria verticillata* contained approximately 40,783 and 46,820 ovules each, but that the number of mature seeds produced by a capsule averaged (roughly) 16,000 (roughly 37 % o the ovules matured). His tests of seed fertility were inconclusive (Mehrhoff 1983). Orchid seeds are normally dispersed by wind, and the raised capsules act as shakers when they open and moved about by the wind. The dried fruits generally persist into the next season and they can be used to find populations when the green plants have died back and are dormant (Summers 1987). The species can be readily identified by these old fruits, that generally also have scars or fibers at the former point of attachment of the leaves, because the fruits of *Isotria verticillata* are relatively long-stalked compared to the nearly stalkless fruits of *Isotria medeoloides*.

The plant is probably edible to humans and most animals, as are most orchids, but studies or

observations on predation of either the above ground or subterranean parts are not known. The flowers and fruits may be vulnerable to foraging by deer, rabbits, and other animals (see threats below) as is known in similar orchids and lilies.

POPULATION BIOLOGY AND VIABILITY

Isotria verticillata, as discussed in the previous section, does not dependably flower in great numbers throughout its range, yet it has no known reproductive problems. Several pollinators visit the flowers, and fruit production is not rare in the species. As discussed in the previous section, however, not every population flowers every year, and it may be years before a given colony produces flowers and fruits. According to a few observations and reports (*e.g.*, Klinkenberg 1986; W-9), some fires may benefit this species. According to staff at the Shawnee National Forest (2005) open sunny seep slopes benefit *Isotria verticillata* and they are generally achieved by means of prescribed fire and selective tree and shrub removal. However, the Large Whorled Pogonia is not known to grow successfully in completely open sites, especially in the southern portions of its range – instead, it is generally found in rather mature forests of beech and oak, and it persists frequently with *Acer rubrum* (Red Maple), one of its most common associates, a species that is successional, but not fire resistant. It is possible that a fire may contribute a sudden influx of nutrients, such as phosphorus, a nutrient well known to stimulate flowering. This, in a moist year, may result in the sudden flowering within a colony of this orchid that was otherwise not known to be in the area. The elimination of the tree canopy or of encroaching shrubs and other vegetation may not be the cause for the apparent sudden appearance of a colony; instead it may be a collateral or incidental effect. It has been shown that this species is known to grow well and persist in areas of relatively dense shrubs (Ware 1987). This will be further discussed in the next section of this report.

As far as is known, this herb grows in widely scattered and often isolated sites not only at the margins of its range but throughout most of its range. There appears to be very little interaction (pollen dispersal or seed exchange) with other populations of the same species in other areas because of the erratic nature of its flowering. Populations of the Large Whorled Pogonia Orchid may persist at a site and remain viable for many years without emerging or flowering, surviving by means of its fungal symbionts; because of this, the number of individuals is very difficult to determine without return visits to a given site over many years. It then seems clear that the habitat where this orchid has been found must be protected to allow its persistence and eventual reproduction.

It is generally understood by botanists that fertility is normally reduced in inbred populations through the process of autogamy (self-fertilization). Autogamy is useful to the plant when there are small numbers of individuals per area, since the safeguarding of the success of propagation is more important than the production of new genotypes. *Isotria verticillata* generally avoids the

possibility of inbreeding, despite the fact that it is self-compatible, because the pollen masses are prevented from reaching the receptive portion of the pistil column by means of a structure called the rostrellum – a type of shield (Mehrhoff 1983). However, because of this specialized pollination mechanism, as in most orchids, few flowers are pollinated and even fewer produce mature fruits unless many pollinators are present. Despite successful pollen transfers, individuals in such a population can be very closely related, and can even be progeny from a single introduction event, and so they can posses little genetic variability. Fertilization by siblings is the most likely outcome in such cases because there is almost no chance of fertilization by other genotypes unless they are within dispersal range. The populations of this herb in Illinois are isolated from one another and especially from those in other states. In theory, continued fertilization within a group of closely related individuals can result in severe reproductive problems in these few isolated populations, and successful seed production as well as the genetic variation that allows competition with other species may be compromised (W-10). Its autogamous relative, the Federally Threatened *Isotria medeoloides*, appears to have suffered greatly from the accumulated genetic problems of self-pollination over time (Mehrhoff 1983).

An example of negative effects thought to have arisen through isolation of populations can be seen in the case of another monocot, Ofer Hollow Reedgrass (*Calamagrostis porteri* ssp. *insperata* (Swallen) C.W.Greene), which has become isolated on rather similar dry sandstone bluffs throughout its range. This grass almost never produces viable seed anywhere in its range and this reproductive failure may be a reflection of a high genetic load that has occurred as a result of its long isolation (see Hill 2003b). High genetic load can be seen in dominant mutations that result in factors lethal to embryos, and this situation appeared to be indicated in that grass. That plant survives as a rare relict in the vegetative state only.

There is no data at this time on the fertility of *Isotria verticillata* seeds produced in the Illinois and Indiana populations. While it is a vulnerable species in the Midwest, the Large Whorled Pogonia Orchid does appear to be secure in other areas with larger populations and suitable habitat remaining. Whether it persists or not in the future in areas where it is currently scarce appears to depend on the survival and maintenance of its habitat.

POTENTIAL THREATS

Globally, the Large Whorled Pogonia Orchid is considered to be secure (see Protection Status above) because it survives in many populations over a large area. However, the species is in decline. In Maine, the species has been extirpated and so is known from historic records only. This orchid is either critically imperiled or imperiled in 34 % (10 of the remaining 29 states) of the states where it occurs. In seven of the remaining 19 states, it is vulnerable, and it has been ranked as fully secure in only two states (Virginia and West Virginia; W-3).

Known threats to *Isotria verticillata* include habitat loss as a result of human activities, including several forest management practices, habitat fragmentation, hydrological changes to its habitat, competition from invasive species, land development, predation by animals, and from collectors (W-3; W-11; Herkert and Ebinger 2002; Shawnee National Forest 2005). There is some evidence that frequent fires may harm this orchid in some areas (Louisiana Natural Heritage Program 2004). According to the Southern Appalachian Species Viability Project (2002), this orchid is "Highly threatened by land-use conversion, habitat fragmentation, and forest management practices".

As stated, some forest management practices have been indicated as threats to this orchid. This has been indicated in the practices of clear-cutting, by the removal of the tree canopy by other types of logging activities, by conversion to pine-plantation silvicultures, and by fire suppression (W-6; Michigan Natural Features Inventory 2000). Furthermore, because of its relationship with symbiotic fungi, *Isotria verticillata* and other orchids are sensitive to the soil disturbance and compaction that often results from tree harvesting activities (W-12). Some human intervention may be beneficial in the form of occasional fire management. It is not certain, however, that the actual opening of the canopy or forest in general is the reason for the increased flowering, because the addition of significant nutrients to the soil after a fire may also be a major factor. There is no evidence that the natural closure of the forest canopy threatens this orchid, and so the removal of vegetation by means other than fire may not be necessary. The Large Whorled Pogonia is not known to grow successfully in completely open sites, especially in the southern portions of its range – instead, it is generally found in rather mature forests of beech and oak, and it persists frequently with *Acer rubrum*, one of its most common associates, although that species is not fire resistant. Furthermore, it has been mentioned that in Louisiana, regular fires have eliminated this orchid by changing its forested seep habitats into unsuitable hillside bog communities (Louisiana Natural Heritage Program 2004). It is possible that a fire may contribute a sudden influx of nutrients, such as phosphorus, a nutrient well known to stimulate flowering. This, in a moist year, may result in a sudden flowering within a colony of this orchid that was otherwise not known to be in the area. The elimination of the tree canopy or of encroaching shrubs and other vegetation may not be the cause for the apparent sudden appearance of a colony; instead it may be a collateral or incidental effect. This species is known to grow well and persist in areas of relatively dense shrubs (Ware 1987). A possible unwelcome side effect to some burns is the burning off of portions of the leaf litter and humus in which this orchid and its symbiotic fungi live. This management practice needs more study.

As stated in the previous section on Population Biology and Viability, it is generally believed among biologists that habitat fragmentation can also have profound effects on the success and persistence of small local populations through a process known as inbreeding depression. According to the study by Fletcher *et al.* (2001), current land-use changes in eastern deciduous forests, such as fragmentation, may affect population sizes of native wildlife that may exacerbate

declines in rare and endangered wildflower populations in the eastern deciduous forests. Over time, as populations become increasingly more isolated, the effects of fragmentation can potentially be observed at the molecular level by reduced genetic frequencies caused by random drift (Barrett and Kohn 1991). When one is considering populations that are already isolated, as in the case of most known populations of this plant, random genetic drift may have already occurred and this may have caused negative effects to the species. This genetic drift may cause the individuals to be less adaptive to competition and environmental change.

Hydrological changes in the habitat, resulting primarily from human activity, are also thought to be a threat to this orchid and other seep species (Shawnee National Forest 2005, Hill 2003a). The drying out of these springs resulting from a lowering of the water table can happen for various reasons, including the excessive use of underground water resources. Flooding by impoundment (where this would be possible) can also be responsible for the loss of seep-spring species.

Competition from invasive species has been suggested as a threat to this species (Shawnee National Forest 2005). *Lonicera japonica* and *Microstegium vimineum* have engulfed portions of the sensitive seep springs in Shawnee National Forest, and excessive competition by these species may eventually eliminate several seep spring species sensitive to such intense competition for space, light, nutrients, and water (Hill 2003a). It is not known if agricultural nutrient runoff from croplands presents a threat to the species, but such influx of nutrients can encourage the growth of weedy exotic species, dependent on these excessive nutrients, to gain a foothold causing a decline in native plants.

Throughout its range, populations of the Large Whorled Pogonia Orchid appear to have been eliminated by human activities (as best evidenced in Maine where the species has been extirpated). It is thought that there has been a considerable loss of populations on both public and private land within its range. It is well known that many acres of forest, savanna, and prairie have been lost through clearing and conversion to agricultural use as well as for construction of various kinds (including business, residential, and highway), and by quarrying. The habitat for this and other orchid species is sensitive to changes to its substrate and not likely to withstand much alteration (W-11). Grazing or browsing pressure (this being an edible plant to livestock and wildlife), certain types of vegetation removal (that may contribute to loss of humus and soil nutrients or composition), and substrate changes (*i.e.* stream alterations, road and building construction) would be detrimental to this orchid. Soil disturbance resulting from activities such as ATV trails (causing the destruction of plants and habitat), unmanaged timber removal, or any activity that results in increased erosion or chemical influx would also very likely be detrimental (Webb *et al.* 1975). Chemicals and agricultural runoff, spray drift, or the direct application of fungicides (or herbicides) would present a serious threat to this orchid because of its dependence on its symbiotic fungi. When these activities take place in wet weather, environmental

degradation generally increases exponentially. Certainly, road construction and mining or quarrying activities can eliminate entire populations of the species because of its complete dependence on its substrate.

The destructive effects of herbivory on orchids and other scarce plants by various animals, especially deer, have been suggested in the literature (USDA / APHIS / Wildlife Services 2001; Fletcher *et al.* 2001; Tilghman 1989; W-11). Fletcher *et al.* (2001) studied predation on the showy and fragile Turk's-cap Lily by rodents and deer in Virginia. The rodents (*Peromyscus leucopus*, *Sciurus* sp., and *Tamias striatus*) dug up and consumed 9% of all the bulbs and underground rhizomes planted in the study, and fatal rodent damage was 3 times greater in successional than in upland hardwood and creek bottom habitats. White-tailed deer (*Odocoileus virginianus*) consumed the apical meristem of 28% of the unprotected lilies that emerged, reducing mean plant height and stopping growth and reproduction for that season. Deer and insects, but not rodents, damaged a greater proportion of plants emerging in small patches (1-2 plants/0.04 ha) than on larger patches (3-20 plants/0.04 ha). The consumption of the buds and flowers is often the case for other species of lilies and orchids as well. Therefore, when protecting remaining populations or restoring new populations of rare perennial wildflowers in the eastern deciduous forest, methods for protecting plants from herbivory by rodents, white-tailed deer, and other herbivores should be considered. Deer often use existing footpaths for travel through forested terrain, and, in fact, many footpaths have begun as deer trails, so that the chances for deer to encounter *Isotria verticillata* plants that grow near trails may be great even if the deer population is not locally large. This may suggest that the creation of trails in the vicinity of a Large Whorled Pogonia Orchid population may increase damage to these plants by deer. Other herbivores, often not considered as threats, that may destroy local populations of this orchid are slugs, land snails, and box turtles. Rabbits, turtles, and slugs probably eat the plant as the tender new stems of these orchids emerge.

There are reliable reports of predation on its more frequently studied relative, *Isotria medeoloides* (W-13). Herbivory by white-tailed deer and invertebrates, including slugs and camel crickets is a known threat of currently unknown extent to *Isotria medeoloides*. Increasing development pressure near *Isotria medeoloides* populations results in the concentration of deer onto smaller parcels of woodland and may decrease local hunting pressure on suburban deer populations. As the local deer herd increases and is forced onto less land, there is a greater likelihood of herbivory on *Isotria medeoloides*, and, presumably, on *Isotria verticillata* as well. In Virginia, the magnitude of threat from deer browse of *Isotria medeoloides* populations may be second only to development of its habitat (W-13); at least one precipitous decline of a large Virginia *Isotria medeoloides* population located near a housing development, appears to be primarily due to grazing. However, symbolic fencing placed around four subpopulations appears to have prevented deer from grazing on the orchids. In that Virginia study, no plants were browsed after fencing, whereas prior to the fencing a majority of the plants were impacted by

deer browsing (W-13). Additional threats from animal predators include wild pigs trampling or uprooting the orchid plants and herbivory by rabbits in the southern portion of the Small Whorled Pogonia Orchid's range (W-13) as well as the occasional trampling or herbivory by moose in the northern portion of its range.

Over-collection has been indicated as a threat to this orchid as it has with many other orchids (Herkert and Ebinger 2002). It is well known that the Large Whorled Pogonia Orchid and similar species that are mycotrophic in nature cannot be very successfully transplanted, and this may actually help this orchid from being over collected in the wild. The species is difficult to propagate, and no nurseries are known to sell the plant. Yet, some gardeners and collectors continue to dig the plant.

At the current time, however, *Isotria verticillata* appears to be somewhat secure within the Shawnee National Forest, but this may change because of the extremely few colonies known there (Shawnee National Forest 2005).

RESEARCH AND MONITORING

The Large Whorled Pogonia Orchid has been the subject of study in several parts of its range, as pointed out in previous sections, though it has not been as intensely studied as its Federally Threatened sibling species, *Isotria medeoloides*. Several basic research needs are still called for, including the continued basic examination of the widely scattered and possibly misidentified herbarium specimens of this orchid to determine its current and historic range throughout the Midwest region. Fieldwork is an integral part of continued research and monitoring and can be concurrent, and additional populations may continue to be found as well. Because *Isotria verticillata* seldom flowers and because the sterile plants are sometimes confused with other species, additional populations may actually be present in Illinois and Indiana, and elsewhere (Shawnee National Forest 2005) and efforts are needed to find these additional sites.

Some information is known concerning the life history of the plant but there is still a tremendous amount to learn about this orchid concerning its fertility, actual population sizes, dormancy periods, early establishment requirements, moisture needs, growth rates, and genetic health (including variability). Much patient field observation over a period of years will be necessary to gather this data. At some point, this species will require experimental cultivation to fully understand the underground development of the young plants and to determine the controlling factors on the initial formation of the symbiotic relationship with fungal symbionts. Some research on the symbionts has already been done, but much of the relationship is still unknown (see Life History above).

Annual or periodic monitoring of existing populations of the Large Whorled Pogonia Orchid

may be essential to the local survival of this species. In parts of its range, both in areas where it is declining and in areas where it is still relatively common, periodic monitoring is needed not only to supply data on the life history of this herb, but also to evaluate the threats to its habitat caused by habitat degradation or destruction, and from threats by animal foragers. The potential threats from foraging native and domestic animals should not be underestimated because of the edibility of this orchid, and animals such as deer may specifically seek it out. Population stability, reproduction, and vigor should all be monitored. As stated, searches for additional populations are always needed to re-evaluate the plant's status, and this would involve the periodic search of suitable habitat during the proper season, though this may involve many acres of surveys. While hydrology and humidity fluctuations are assumed to occur in its habitat, it is not known precisely how much fluctuation can occur without adversely affecting the plants, and so additional research is needed in this area. It is also not known what triggers flowering, and this should be a more workable problem in wild populations, though it requires multiple observations in multiple seasons correlated with ecological and weather information. An explanation of current plant monitoring techniques can be found in Philippi *et al.* (2001).

At this time, it is not known if this orchid could be successfully introduced to suitable sites. It is also not known exactly how much disturbance can occur before an individual population is adversely affected, nor is it known precisely how large a habitat is needed to support a viable population. Nearby land use should be noted – as in the case of the conversion of areas to tree plantations and other crops – and the chemical and hydrologic effects on adjacent vegetation, as well as the appearance of new trails or road construction should also be noted and dealt with. While many fungicides and herbicides are thought to be detrimental, so may be fertilizers, which, at this time, have an unknown effect on this orchid. However, it may yet be found that some fertilizers, such as those rich in potassium and phosphorous, may benefit the species. There is as yet no known documentation either way on this regarding this orchid species.

Research on the use of fire management, already shown to have possibly mixed results, would be useful towards the understanding and preservation of the Large Whorled Pogonia Orchid in our area. The periodicity and optimum seasonality of such fires is incompletely known and the precise reason why fires benefit the species is also a mystery. The plant appears to grow well in shade. However, it does appear that a prescribed fire may stimulate flowering (Shawnee National Forest 2005). What the exact triggering may be is unknown, and one could speculate that it is a sudden influx of nutrients, or the physical effects of a fire, or some other cause rather than the clearing of other vegetation that may be the cause. It should also be considered that people are searching more intensely for this orchid in areas of prescribed fire, and that it is just as frequent in unburned areas that are not being searched. In Louisiana, the sensitive Forested Seep natural community, described above in the section on habitat, is the normal habitat for *Isotria verticillata.* According to the Natural Heritage Program in that state, regular fire causes a reversion of this community to a hillside bog community, in which this orchid does not appear to

persist (Louisiana Natural Heritage Program 2004). This suggests that fires can also play a role in eliminating this species. Carefully controlled experiments are needed to test these hypotheses.

Monitoring of the forests themselves where *Isotria verticillata* still occurs (or where it may yet be introduced) may assist in determining what the local environmental parameters should be for optimal health for this orchid. Where it still occurs, periodic surveys are needed to determine the basic health and productivity of the populations by periodically counting the numbers of flowering individuals. This is the only means to determine population trends accurately (W-3). Reproductive success can be estimated by counting the number of fruiting stems produced each season, but trends will be apparent only after many seasons because of the sporadic nature of the flowering typical to the species. As part of the basic research on current populations of this species, data such as counts and monitoring of the numbers of individuals present (or the area covered by the colony), the determination of the amount of yearly flowering and seed production that might occur, and an assessment of recruitment rates are needed in order to monitor the population dynamics and to assess the viability of the individual populations found. Individual plants should be monitored over several growing seasons at each site for basic phenology data. Such basic facts as the means of establishment of fungal associations, longevity, and yearly variations in colony size over a long period are not precisely known for populations of this species, and conclusions have so far been based upon infrequent visits and the infrequent flowering observed in known populations.

Once new populations are found, voucher specimens should be made according to techniques described in Hill (1995) or other similar references. The collecting of this rare orchid is usually discouraged unless a very large population is found, but photographs / images of flowers or fruits, along with a specimen of a sterile stem, should be adequate to document its presence, and these are preferred over a site report (that could conceivable be based upon a misidentification). Only one voucher should be made for a given colony site. Similar habitat should be explored for the plant at its flowering and fruiting seasons. Particular attention should be made to search for and / or monitor this herb at its peak period for flowering in one's local area, normally in mid April to late May in the Midwest and eastern region when the showy flowers are most visible, but also earlier in the spring in the southern parts of its range, such as in Florida and Texas. There are rather large areas of additional suitable habitat with suitable substrate and soils in southern Illinois, and, of course, elsewhere, where the Large Whorled Pogonia Orchid could also exist. A list of typical associates and indicator species has been compiled as a result of field studies in other states (see Habitat section above) and many of these should also occur with the species in Illinois. These indicator plants (especially Red Maple and American Beech), along with specific soils and substrates, can be very useful in facilitating the discovery of additional populations of this herb. It is quite possible that populations of this species either have been overlooked because of the unpredictable periodic emergence of these plants, or because of incorrect field identifications of sterile plants. There is also, certainly, a lack of adequate

voucher material that can be used to relocate historic populations.

Botanical surveys conducted by scientists from the Illinois Natural History Survey and elsewhere have shown repeatedly that with sufficient time and funding, and an experienced eye, many plants thought to be extirpated or else threatened or endangered occasionally can be found at additional locations (Hill 2002). These sorts of investigations have been important in that they have led not only to the de-listing of species once thought to be rare, but they have also resulted in the discovery of species previously unknown in the state. The U.S.D.A. Forest Service and 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, consultants, and students in cooperation with Illinois Department of Natural Resources personnel. 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.

RESTORATION

Restoration efforts have not yet been documented for this orchid species. Habitat restoration efforts are taking place throughout its range, and this orchid is a component of a significant number of these efforts, but not the only one. It has been suggested that prescribed burns should be conducted on *Isotria verticillata* in Illinois (Shawnee National Forest 2005), but other studies and recommendations have not supported this (see potential threats above). The Michigan Natural Features Inventory (2000) states the following regarding management suggestions for *Isotria verticillata* in that state: in the dry-mesic northern forest community "Very little is known of the population dynamics of this species, thus no specific management recommendations can be suggested. Monitoring and avoidance of cutting in the immediate area of colonies recommended at this time." Within the southern swamp community, the following management suggestion was issued "Maintain natural disturbance regime; plants may be susceptible to excessive timber cutting and associated activities that may directly impact small, localized colonies". In the bog community, management suggestions were as follows: "Primarily requires the protection of habitat and maintenance of hydrological and natural disturbance regime".

Habitat restoration and protection (W-3) is the generally recommended method to manage populations of this and other rare plants. Protection of the hydrology, topography, and exposure within and near the sites is crucial, and natural fire regimes are to be allowed. Added fire management may or may not be beneficial to this plant, and some additional research is needed (see previous sections). The specific effects of fungicides and herbicides on this mycotrophic herb are thought to be generally harmful, so these are not recommended in the management

program without additional study.

The species, while widely distributed, is generally not common in the midwestern states but there appears to be a significant amount of habitat available where restoration efforts can occur in southern Illinois. It may be necessary to purchase private land that has had historic populations of the species on it and to protect the habitat on this land for this plant. At this time, however, data suggests that the priority activity to encourage the persistence of reproductive colonies of this orchid should be careful study, the creation of fenced enclosures, and monitoring at known and suspected sites. Additional restoration and conservation efforts should involve the careful hand removal of invasive and exotic species in the vicinity of the existing colonies (Shawnee National Forest 2005).

Fruit production in this species is low, and it is possible that this may be partly due to browsing by deer, so it would be wise to determine if the strong mesh fencing of a population before flower stalks begin to emerge would help to eliminate this threat. Fencing has been recommended to protect populations of *Isotria medeoloides*, and this has been shown to be very effective protection (W-13). Considering the very low numbers of colonies known in Illinois, this may be a wise protective technique that would not cost a great deal of money.

Normally, true 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 (a plant community *reconstruction* rather than a restoration). However, the cultivation of this species from seed or vegetative structures is not being done commercially, as far as is known, and the propagation of this plant has not been widely attempted, though it appears that it could be quite successful. Until propagation of the species is widely done, only habitat protection and management can preserve this orchid.

SUMMARY

Isotria verticillata is a fleshy perennial herbaceous orchid (4-) 15-25 (-40) cm tall that grows from a cluster of cord-like roots / rhizomes that often produce additional plants at their tips to form a clonal colony. One or rarely two moderately showy, fragrant, brown-purple and white flowers are produced in the spring at the top of the plant from its single whorl of, generally, five leaves. The orchid is widespread in the eastern United States, and it is known historically from thirty states and one Canadian province, from Maine to Michigan and adjacent Ontario, Canada, generally southward to southwestern Georgia, Arkansas, northeast Texas and northern Florida. It is a species that grows in acidic soils, in dry to mesic forests, seeps, and sphagnum bogs. It is

listed as Endangered in Florida (S1), Illinois (S1), and New Hampshire (S1), as Threatened in Michigan (S2) and Vermont (S2), as Exploitably Vulnerable in New York (S3S4), and as Extirpated (Historic only) in Maine (SX). It has been listed as Critically Imperiled (S1) in Florida, Illinois, New Hampshire, Oklahoma, and Texas, as nearly Critically Imperiled (S1S2) in Missouri, and as Imperiled (S2) in Alabama, Delaware, Michigan, and Vermont. It is at risk at the margins of its range.

Suggested conservation research priorities for this local, rare orchid in the Midwest include attempts to locate additional populations, additional research on its life history and ecological parameters including the controls on flowering and the risks from predation and competition, studies to determine the best protection and management techniques to insure its survival and increase (such as the role, if any, of fire), studies to determine the genetic diversity of the populations, and studies to determine a means to propagate and increase the numbers of individuals within the local populations.

Habitat protection is crucial to the survival of this orchid. Habitats should be preserved and managed through the avoidance of cutting native woody plants in the immediate vicinity of colonies, through the protection of current hydrology (including erosion control), through protection from land development, through protection from indiscriminate or nearby fungicide, herbicide or fertilizer application, through protection from soil disturbance and physical damage to the plants and habitat by vehicles, and through fencing of colonies to exclude native and domestic animals (such as deer and livestock) and people. Fire management may or may not be beneficial to this species in the long run, and continued study of this technique is suggested before enacting a program of prescribed burns. Certainly, the picking of its flowers and digging of whole plants by people, and the foraging by deer and livestock, is to be discouraged in order to maintain reproductive populations, and so permanent exclosures may be necessary for this orchid's protection. At this time, with proper management, the current populations in southern Illinois and Indiana may persist, but its long-term chances of survival in these states may be good only within protected areas of the national forests. The establishment of additional populations is unlikely at this time.

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CONTACTS

Shawnee National Forest, Hidden Springs Ranger District, 602 N. 1st Street, Vienna, IL 62995

Elizabeth Longo Shimp (618) 658-2071; e-mail: eshimp@fs.fed.us

Shawnee National Forest, Mississippi Bluffs District, 521 N. Main Street, Jonesboro, IL 62952

Stephen P. Widowski (618) 833-8576; e-mail: swidowski@fs.fed.us

Hoosier National Forest; 811 Constitution Avenue, Bedford, IN 47421

Kirk Larson (812) 275-5987

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

Illinois Natural History Survey, 1816 S. Oak Street, Champaign, IL 61820-6970

Dr. Steven R. Hill (217) 244-8452; e-mail: srhill@mail.inhs.uiuc.edu

Illinois Endangered Species Board

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

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

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

Biological Consultant

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

Missouri Botanical Garden, P.O. Box 299, Saint Louis, MO 63166-0299

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

APPENDIX 1

Representative specimens of *Isotria verticillata* examined or cited in the literature

Herbaria:

DUR = Southeastern Oklahoma State University, Durant. GH = Gray Herbarium, Harvard University, Cambridge, Massachusetts. ILLS = Illinois Natural History Survey, Champaign. MARY = University of Maryland, College Park. MO = Missouri Botanical Garden, St. Louis. MU = Miami University, Oxford, Ohio. NY = New York Botanical Garden, Bronx. OCLA = University of Science and Arts of Oklahoma, Chickasha. UNAF = University of North Alabama, Florence. VT = University of Vermont, Burlington.

ALABAMA: TUSCALOOSA CO., E of North River ca. 10 mi N of Tuscaloosa, 20 Apr 1940, *Harper 3772* (MO).

ARKANSAS: GARLAND CO., NE of Crystal Springs, 12 Apr 1992, *Summers 4812* (MO); **HOWARD CO.**, Baker Springs, 12 April 1909, *Kellogg s.n.* (MO); **PULASKI CO.**, Little Rock, Jul 1835, *Engelmann 301* (MO).

CONNECTICUT: NEW LONDON CO., Norwich, 10 Jun 1884, *Lumsden s.n.* (MU); Pachaug State Forest, Voluntown, 06 Aug 1988, *Hill 19760* (VT); **TOLLAND CO.**, Storrs, Jun 1907, *s.col.* (MO).

DISTRICT OF COLUMBIA: Terra Cotta, 2 May 1913, *Holm s.n.* (MO).

GEORGIA: RANDOLPH CO.: SE of Cuthbert, 17 Oct 1902, *Harper 1762* (MO).

ILLINOIS: POPE CO., Shawnee National Forest nr. Azotus Ch., 3 May 1970, *Schwegman s.n.* (ILLS).

LOUISIANA: NATCHITOCHES PARISH, 29 Apr 1915, *Palmer 7439* (MO).

MARYLAND: ANN ARUNDEL CO., Severn Run at Dicus Mill Road near Aurora Hills, 28 Jun 1981, *Hill 10438* (MARY); **CHARLES CO.**, Nanjemoy Reserve along Friendship Landing Road, 9 Jun 1981, *Hill 10255* (MARY); **MONTGOMERY CO.**, Rockville, near jct. Montrose Road and Rt. 270, 11 May 1986, *Hill 16738* (GH, MO, NY, VT).

MASSACHUSETTS: BERKSHIRE CO., Stockbridge, 23 May 1891, *Beardslee s.n.* (MU); **MIDDLESEX CO.**, Sherborn, 1890, *Sturtevant s.n.* (MO); **NORFOLK CO.**, West Quincy, 17 Jul 1886, *Churchill s.n.* (MO); **WORCESTER CO.**, Sterling, 3 Jun 1947, *Seymour 2472* (MO).

MICHIGAN: KALAMAZOO CO., at Mud Lake, 4 mi N of Schoolcraft, 9 Jul 1937, *Hermann 9033* (MO).

MISSISSIPPI: SCOTT CO., 0.5 mi S of Homewood, 7 April 1963, *Hubricht B-2909* (MO).

MISSOURI: ST. FRANCOIS CO., ca. 2 mi SE of Doe Run, 5 Aug 2000, *Summers 9536* (MO); **STE. GENEVIEVE CO.,** along Pickle Creek near Pickle Spring, ca. 6 mi SE of Sprott, 7 Jun 1952, *Steyermark 73313* (MO); **STODDARD CO.**, 2 mi NE of Dexter, 13 Apr 1991, *Summers & Dodds 4177* (MO).

NEW JERSEY: BERGEN CO., Closter, 1858, *Austin s.n.* (MO); **MERCER CO.**, near Trenton, s.d., *Perry s.n.* (MO).

NEW YORK: CAYUGA CO., NE of Duck Lake, 16 Jun 1923, *Eames, et al. 15053* (MO); **OSWEGO CO.**, Oswego, 13 Jun 1882, *Sheldon s.n.* (MO, MU).

NORTH CAROLINA: BUNCOMBE CO., Biltmore estate, 7 May 1897, *Biltmore Herb. 1246* (MO); **HAYWOOD CO.**, Great Smoky Mountains National Park, Boogerman Trail, 4 Oct 2002, *Feisty et al. 2098* (ILLS); HENDERSON **CO.**, 5 mi E of Hendersonville on US 64, 11 May 1973, *Pittillo 4384* (UNAF).

OHIO: ADAMS CO., Abner's Hollow, 12 Jun 1975, *Howell s.n.* (MU); **HOCKING CO.**, ca. 0.2 mi N of Twp. Rt. 216, Ward Township, 2 Jun 1979, *Spooner 51* (MU); **JACKSON CO.**, Twp. Road 213, 2.8 mi due NW of Leo, 7 May 1978, *Bryant 759* (MU); **SCIOTO CO.**, Shawnee State Forest, Rocky Hollow, 18 May 1975, *Cusick 14132* (MU); **WASHINGTON CO.**, E side Co. Rd. 33, Grandview Township, 27 Jul 1979, *Ortt 851* (MU).

OKLAHOMA: LeFLORE CO., ca. 10.2 mi NE of Big Cedar, S slope Rich Mountain, 31 May 1977, *Taylor & Taylor 24466* (DUR, OCLA); **McCURTAIN CO.,** 3.5 mi N of Tom, 15 Aug 1976, *Magrath et al. 9525* (OCLA, DUR, MO).

PENNSYLVANIA: DELAWARE CO., near Cooperstown, May 1886, *Leeds s.n.* (MO); **LANCASTER CO.**, Chestnut Hill, Lancaster, May 1886, *Eby s.n.* (MO); **LEBANON CO.**, near Penryn, 27 May 1893, *Heller 866* (MO); **WESTMORELAND CO.**, 12 May 1878, *Pierron s.n.* (MO).

RHODE ISLAND: KENT CO., East Greenwich, Fruit Hill, 18 May 1888, *Congdon s.n.* (MO).

SOUTH CAROLINA: OCONEE CO., Sumter National Forest, Andrew Pickens District, Forest Rd 744 NW of Walhalla, 14 May 1993, *Hill 25017* (VT).

TENNESSEE: COFFEE CO., ca. 9 mi N of Manchester on road to Woodbury, 25 Aug 1972, *Kral 48165* (MO); **CUMBERLAND CO.**, NE of Herbert Domain on road to Crossville, 4 May 1941, *Sharp & Meyer 1346* (MO).

TEXAS: NACOGDOCHES CO., off Hwy. 59, ca. 5 mi S of Nacogdoches, 23 Mar 1952, *Lundell 15035* (MO).

VIRGINIA: WASHINGTON CO., slopes of White Top Mountains, 29 May 1892, *Britton s.n.* (MU).

APPENDIX 2.

The Historic Distribution of *Isotria verticillata* in the United States.
Information from herbarium specimens and the literature.
(If in > 10 counties, then only number of counties included.)

STATE	COUNTIES	NOTES
Alabama	Bibb, Chilton, Cleburne, DeKalb, Etowah, Jackson, Lee, Madison, Walker	(W-1; W-3)
Arkansas	19 counties, widespread	(W-1; W-3); Smith (1978)
Connecticut	Fairfield, Hartford, Litchfield, Middlesex, New Haven, Tolland, Windham	(W-1; W-3); Magee and Ahles (1999)
Delaware	All 3 counties – Kent, New Castle, Sussex	(W-1; W-3)
District of Columbia	Present	(W-1; W-3)
Florida	Gadsden, Washington [Apalachicola River bluffs]	(W-1; W-3); Clewell (1985); Wunderlin (1998)
Georgia	Bartow, Cobb, Early, Glascock, Habersham, Rabun	(W-1; W-3)
Illinois	Pope	(W-1; W-3); Mohlenbrock & Ladd 1978; Mohlenbrock 1986; includes Shawnee N.F.
Indiana	12 counties, north and southeast, not in the center of the state	(W-1; W-3); Homoya (1993)
Kentucky	At least 27 counties, nearly all southeastern	(W-1; W-3); includes Daniel Boone N.F.
Louisiana	13 parishes, most in NW third of state.	(W-1; W-3); MacRoberts (1989); Thomas and Allen (1993)
Maine	Androscoggin, Cumberland, Oxford [extirpated in all]	(W-1; W-3); Magee and Ahles (1999)
Maryland	Anne Arundel, Baltimore, Charles, Frederick, Howard, Montgomery, Prince Georges, St. Marys [probably elsewhere]	(W-1; W-3); Smith (unpublished atlas)
Massachusetts	Nearly every county (> 12), excluding the islands and Cape Cod.	(W-1; W-3); Magee and Ahles (1999)
Michigan	At least 11 counties, mostly southeastern lower peninsula.	(W-1; W-3)

Mississippi	Attala, Carroll, Franklin, Lafayette, Lauderdale, Tishomingo,	(W-1; W-3); includes Holly Springs N.F., Homochitto N.F.
Missouri	Butler, Oregon, St. Francis, Ste. Genevieve, Stoddard [Summers says only Ste. Genevieve, Butler, and Stoddard]	(W-1; W-3); Summers 1987; Yatskievych 1999; including Mark Twain N.F.
New Hampshire	Belknap, Carroll, Grafton, Hillsboro	(W-1; W-3); Magee and Ahles (1999)
New Jersey	At least 16 counties, least common in NW 1/3 of state	(W-1; W-3)
New York	At least 24 counties, avoiding far northeastern counties	(W-1; W-3)
North Carolina	26 counties, scattered	(W-1; W-3); Radford *et al.* (1968); includes Nantahala N.F., Pisgah N.F., Uwharrie N.F.
Ohio	At least 26 counties, mostly eastern and southeastern third of state	(W-1; W-3)
Oklahoma	LeFlore, McCurtain [only 2 counties]	(W-1; W-3); Magrath and Taylor (1978)
Pennsylvania	At least 40 counties, fewest in extreme north of state	(W-1; W-3); Wherry *et al.* (1979); Rhoads and Block (2000)
Rhode Island	Providence, Washington, including Block Island	(W-1; W-3)
South Carolina	Darlington, Greenville, Oconee	(W-1; W-3); Radford *et al.* (1968); Herbarium specimens; incl. Sumter N.F.
Tennessee	At least 22 counties, mostly Cumberland plateau [E-central] and NE mountains.	(W-1; W-3); Chester *et al.* (1993); includes Cherokee N.F.
Texas	Cass, Nacogdoches, Sabine, Tyler	(W-1; W-3)
Vermont	Addison, Bennington, Chittenden, Windham	(W-1; W-3); Magee and Ahles (1999)
Virginia	Nearly every county (> 58 counties), fewest in southeastern 1/3 of state	(W-1; W-3)
West Virginia	At least 17 counties, widely scattered	(W-1; W-3)

APPENDIX 3.

Natural Diversity Database Element Ranking System

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

Global Ranking (G)

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

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

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

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

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

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

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

GXC
Extinct in the wild. Exists only in cultivation.

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

with it.

National Heritage Ranking (N)

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

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.

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.