Conservation Assessment

for the

Green Wood Orchid

(Platanthera clavellata (Michx.) Luer)

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ILLINOIS
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SURVEY

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Platanthera clavellata (Michx.) Luer, from University of Wisconsin – Stevens Point website, Robert J. Freckmann Herbarium, Plants of Wisconsin. Photographer: Robert W. Freckmann.

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EXECUTIVE SUMMARY

This Conservation Assessment is a review of the taxonomy, distribution, habitat, ecology, and status of the Green Wood Orchid, *Platanthera clavellata* (Michx.) Luer, 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 to, and conservation efforts regarding, the Green Wood Orchid to date. *Platanthera clavellata* is a rather small fleshy perennial terrestrial herb about 10-40 cm tall with white tuberous rhizomes and roots, and with 1-3 leaves attached below the center of the stem. There is a single terminal raceme with 5-15 congested flowers at its top. The flowers are inconspicuous, normally pale greenish or yellowish, and they normally self-pollinate. The orchid is widespread in eastern North America, and in the United States it is known historically from thirty-four states and six Canadian provinces, from Newfoundland to Ontario in Canada, and from North Dakota and Minnesota to Maine and south to Florida and Texas. It is a species that grows in acidic wet soils in mesic forests, seeps, and sphagnum bogs. It has been listed as Endangered in Florida and Illinois, as Exploitably Vulnerable in New York, and as Extirpated (Historic only) in North Dakota, and as at risk in both the Shawnee and Hoosier National Forests of Illinois and Indiana. While it is rather common locally, 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: *Platanthera clavellata* (Michx.) Luer [1972]
Common Names: Green Wood Orchid; Small Green Wood-orchid; Small Green Wood Orchid; Small Greenwood Orchid; Club-spur Orchid; Wood Orchid; Green Woodland Orchid; Green Woodland Orchis; Small Green Woodland Orchis; Frogspike; Green Reinorchid; Green Rein Orchid; Clove-like Platanthera.
Synonymy: *Orchis clavellata* Michaux [Michx.; 1803]
Orchis tridentata Muhl. ex Willd. [1805]
Orchis clavellata var. *tridentata* Muhl. [1813]
Habenaria tridentata (Muhl. ex Willd.) Hook. [1824]
Habenaria clavellata (Michx.) Sprengel [1826]
Habenaria maritima Raf. [1833]
Gymnadenia tridentata (Muhl. ex Willd.) Lindley [1835]
Gymnadenia tridentata var. *clavellata* (Michx.) A.W.Wood [1861]
Peristylus clavellatus (Michx.) Kraenzl. [1898]
Gymnadeniopsis clavellata (Michx.) Rydb. [1901]
Denslovia clavellata (Michx.) Rydb. [1931]
Habenaria clavellata var. *ophioglossoides* Fernald [1946]
Habenaria clavellata var. *wrightii* L.S.Olive [1951]
Gymnadeniopsis clavellata var. *ophioglossoides* W.J.Schrenk [1977]
Platanthera clavellata (Michx.) Luer forma *slaughteri* P.M.Brown [1995]

Class: Liliopsida (Flowering Plants - Monocotyledons)
Family: Orchidaceae (The Orchid Family)
Plants Code: PLCL (USDA NRCS plant database, W-1)
http://plants.usda.gov/

The orchid genus *Platanthera* Richard contains about 200 species worldwide, 32 of which are native in North America north of Mexico (Sheviak 2002). This generic name is a conserved name, a name that has been retained to best serve the stability of nomenclature. The genus is found mostly in the north temperate region of the world, though a few species are also in the tropics. The genus is closely related to several smaller genera placed with it in the orchid tribe Orchideae, subtribe Orchidinae, including *Amerorchis* Hultén, *Coeloglossum* Hartman, *Dactylorhiza* Necker ex Nevski, *Galearis* Raf., *Piperia* Rydb., and *Pseudorchis* Séguier (Romero-González *et al.* 2002). This group has been revised extensively in the past four decades, and many of the species within these genera, as well as all but three of the 32 North American species of *Platanthera*, have been previously treated within the large genus *Habenaria* Willd. (from the Latin word *habena*, a rein or strap, referring to the usual shape of the leaves). *Habenaria* has been redefined, and is now generally treated as a member of the tribe Orchideae

subtribe Habenariinae Bentham, and it is now recognized to be a primarily tropical genus with about 600 species, only four of which can be found in North America north of Mexico (Sheviak 2002). The redefined genera have not all been accepted by current North American botanists, but *Platanthera* does appear to be accepted by most as distinct from *Habenaria*. The name *Platanthera* was derived from the Greek *platys*, meaning broad, and *anthera*, anther, referring to the wide anthers (pollinia) at least in the first described species. *Platanthera* remains a rather large and diverse genus that may be subdivided again in the future as more data accumulates. Its primary features are its terrestrial habitats, the presence of non-articulate persistent (usually, but not always basal) leaves, terminal spicate or racemose inflorescences, a 3-lobed or 3-parted spurred lip, and a column that diverges from the lip (Sheviak 2002).

The Green Wood Orchid was first formally named by the Franco-American botanist Andre Michaux in 1803 within the genus *Orchis*, a genus that, at the time, included most small terrestrial orchids in the temperate zone. The specific epithet *clavellata* is a Latin word meaning little club, because the spur is clavate (club-like) and thickened towards its tip. Curt Sprengel (in 1826) of Germany redefined many orchid genera, and transferred many species previously described in *Orchis* into *Habenaria* Willd., where they remained for many years. In 1835, the English botanist John Lindley transferred many of the *Habenaria* species into the previously described genus *Platanthera* Richard, but it took many years for American botanists to accept these changes. At least one prominent flora, Gleason and Cronquist (1991) continues to accept the species within *Habenaria*. As can be seen in the list of synonyms presented above, the nomenclatural history of *Platanthera clavellata* has been complicated not only by the changes in the concepts of orchid genera, but also by perceived variation within the species.

Platanthera clavellata itself is most closely related to *Platanthera nivea* (Nuttall) Luer and *Platanthera integra* (Nuttall) A.Gray ex L.C.Beck in that it shares with them two pairs of appendages on the reproductive column within the flower. According to Sheviak (2002), these features suggest that these three species should not be included within the genus *Platanthera*, but an alternate placement has not yet been proposed.

No subspecies or varieties are presently generally accepted within the species, but some botanists have recognized *Platanthera clavellata* var. *ophioglossoides* Fernald on the basis of its wider leaves, said to be more prevalent in northern plants, but actually occurring throughout the range of the species (Sheviak 2002). In 1951, L. S. Olive described an unusual variant of *Platanthera clavellata* from the Blue Valley, about 10 miles southwest of Highlands in Macon County, North Carolina as *Habenaria clavellata* var. *wrightii* L.S.Olive (Radford *et al.* 1968). This variety, apparently a developmental mutation, had lost its spur and the lip lobes were modified into a rounded somewhat acute apex. This variety is also generally considered to be synonymous with the typical species (W-1). One hybrid is known and accepted, and that is a very infrequent hybrid with *Platanthera blephariglottis* (Willd.) Lindley, known as *Platanthera* x *vossii* Case (Case

1983, Sheviak 2002).

The common name used in this report, 'Green Wood Orchid', is one of many used for this plant. This common name is based upon its relatively inconspicuous greenish flowers and its usual preference for woodlands, though it is certainly not restricted to them. Other names are frequently used; this one has been chosen for this report because it appears to predominate in the current literature.

DESCRIPTION OF THE SPECIES

Platanthera clavellata, the Green Wood Orchid, is a relatively small, somewhat soft-fleshy, slender perennial terrestrial herb that is glabrous, somewhat colonial (clonal) and fleshy-rhizomatous. The fasciculate **roots** are both slender and tuberous and have mycorrhizae. The **rhizomes** are very root like, tuberous-swollen, white and fleshy, narrowed on one end, and have a stem bud or stem at each node; these frequently send up new plants forming small colonies. The **stems** are single, (8-) 10-40 (-47) cm tall, somewhat angled and narrowly winged. The **leaves** are 1 –2 (-3) in number and are located at the middle or on the basal half of the stem. They sheathe the stem, the lowermost is the largest, and they are ascending to spreading, (3-) 7-16 (-19) cm long x (0.8-) 1-3.5 cm wide, the blades are oblanceolate to oblong, narrowly oblanceolate, or elliptic, with an obtuse to acuminate apex; they are abruptly reduced to linear-lanceolate bracts at the inflorescence, and these bracts are as long as the ovaries. **Inflorescences** are terminal and are moderately dense racemes with generally (3-) 7-10 (-15) flowers concentrated towards the apex. The **flowers** (see cover illustration) are normally resupinate [upside-down] but often incompletely so and held at an angle of 45 ° so that the spur is lateral; they are rather inconspicuous, pale green to dull pale yellowish green and not showy, sessile to short pedicelled (the stout pedicels are about 1 cm long), and open at maturity (chasmogamous) and they usually have all parts except the lip directed forward, with 3 distinct sepals and 3 petals; the **sepals** are (3-) 4-5 (-6) mm long x 2-2.5 mm wide, ovate and obtuse; the lateral **petals** are also (3-) 4-5 (-6) mm long x 2-2.5 mm wide, and ovate to obovate and obtuse to acute; the **lip** is oblong and obscurely three-lobed (sinuately tridentate) at its tip and without a basal thickening and lacking a pair of teeth at its base, (3-) 4-6 (-7) mm long x 3-4 mm wide at apex, the margins are sometimes dentate-lacerate, the apex is truncate, the **spur** is slender, clavate (club-shaped at the tip), strongly curved upward, and (7-) 10 (-13) mm long, much longer than the lip; the rostellum lobes are directed downward, very short, and truncate; the 2 pollinaria of the single stamen are straight or slightly curved laterally; the pollen masses usually trail down onto the stigma; the column is 1 mm long and yellowish-green, the ovary is rather stout, 6-11 mm long. The **fruits** are capsules with numerous seeds. The **chromosome number** is 2*n* = 42. (Adapted from Sheviak 2002 and Yatskievych 1999).

The Green Wood Orchid is the one of the most widespread and common of the 32 species of

Platanthera in North America, and one of the least conspicuous. It is normally recognized and distinguished from the other species by its only obscurely apically lobed lip that lacks a basal pair of auricles or tubercle, and it is easily distinguished from the more showy-flowered species of the genus by its inconspicuous greenish yellowish flowers that are at an odd twisted 45 degree angle to horizontal. Its shortened, long-stalked and congested spike is also easily distinguished both in flower and fruit from most other species that tend to have more elongated spikes with a shorter unbracted portion. The infrequently used word 'levitative' has been used to describe this terminally concentrated flower cluster. It is quite different in its characters from other orchids in eastern North America and it is unlikely to be confused with other members of the genus when in flower.

Immature plants, however, can be confused with the similar immature individuals of other species of *Platanthera*, and they are also rather easily confused with infertile stems of the fern *Ophioglossum* (the Adder's-tongue Fern). Very young or newly emerged *Platanthera* stems can also strongly resemble seedlings or young plants of several lilies but the underground parts are quite different, and there is little chance for confusion as the plant matures.

HABITAT AND ECOLOGY

The Green Wood Orchid has been given the national wetland indicator status of FACW+ (Facultative Wetland) and OBL (Obligate Wetland) indicating that the species usually to almost always occurs in wetlands (67 % - 99 % probability). In Wetland Region 3, including both Illinois and Indiana, *Platanthera clavellata* has been specifically designated as an OBL species (occurs almost always in wetlands, probability 99%; Reed 1988; W-1; W-2). It generally prefers shaded swamps, seeps, and bogs with wet acidic sandy or peaty soils. Overall, this orchid can be found in sphagnum bogs, sphagnum seeps and meadows, wet sandy and peaty meadows, marshes, low woods, wet prairies and low roadsides, from 10 – 2000 meters elevation (Sheviak 2002). While this orchid most frequently occurs in shaded habitats, it can sometimes be locally common in open wetlands, especially in the northern parts of its range (pers. obs.). Within the United States, it appears to be most common in portions of Delaware, Georgia, and Virginia, and it is common in Canada in Newfoundland Island, Nova Scotia, Ontario, and Quebec. It is not a very cold sensitive species, and it occurs commonly both north and south of the Ice Age glacial boundary (W-3). It may, instead, be somewhat sensitive to non-seasonal warm areas.

A review of the literature demonstrates that this herb has a variety of different plant associates and habitats throughout its range. Various published floras have described the habitat of *Platanthera clavellata* as "Mossy or wet sandy woods, thickets, spring-heads, and shores" (Fernald 1950, as *Habenaria clavellata*), "Acid bogs and wet soils, especially in sphagnum" (Gleason and Cronquist 1991, as *Habenaria clavellata*), "bogs and low woods" in the Blue Ridge physiographic province (Georgia, North Carolina, South Carolina, Tennessee, and

Virginia; Wofford 1989), "Usually in bogs or swamps in dense woods" in North and South Carolina (Radford *et al.* 1968, as *Habenaria clavellata*), and "In water or at edge of water along streams in forests, swamps, on wooded seepage slopes and in ravines" in the southeastern states overall (Godfrey and Wooten 1979, Correll and Johnston 1970, as *Habenaria clavellata*). In Florida it is found in "Wet hammocks and stream banks" (Wunderlin 1998, W-4).

The soils where the Green Wood Orchid grows are formed over a variety of gneissic metamorphic schists, granites, and sandstones but the bedrock can be quite deep (as in bogs or on the coastal plain) or shallow (as in northern glaciated areas), and the soils are normally peaty and acidic (low pH). If the bedrock is calcareous, it is normally very deep and does act to raise the local soil pH.

In the northern portions of its range, as, for example, in Maine, Minnesota, and Wisconsin, *Platanthera clavellata* grows in boreal-type sphagnum bogs, wet peaty sands, marshes, and meadows, and wet low forests. In the more open wetlands, this orchid grows with the shrubs *Chamaedaphne calyculata*, *Vaccinium* spp. and *Spiraea tomentosa*, the forbs *Calopogon pulchellus, Iris versicolor, Polygala cruciata, Sarracenia purpurea, Triglochin maritima*, and *Xyris montana*, the graminoids *Calamagrostis canadensis, Carex canescens, Carex cephalantha, Carex limosa, Carex paupercula, Eriophorum virginicum, Juncus effusus, Juncus stygius*, and *Scirpus cyperinus* along with carpets of mosses. In less open bogs and wetlands the trees *Acer rubrum, Fraxinus nigra, Larix laricina, Picea mariana*, and *Thuja occidentalis* can be common (the above compiled from herbarium specimens and personal observations; also Smith 1993). In Canada the associates are somewhat similar and a review of its ecology in Canada has been provided by Brown and Scott (1997).

In the Midwest, in Indiana, the Green Wood Orchid grows primarily in the northern third of the state in the Northern Lakes and Northwestern Morainal natural regions (Homoya 1993). Several scattered populations also occur in the south-central portion of the state in several natural regions, including the Shawnee Hills, the Highland Rim, the Southwestern Lowlands, and, perhaps, the Southern Bottomlands natural regions. Within these regions, this orchid is normally found on hummocks of acid humus-rich wet soil at the bases of trees and fallen logs in shaded dense undergrowth and seeps. In this habitat it has little herbaceous competition because of the low light levels, and there is abundant moisture. Within these shaded environments it grows with associates such as the trees *Acer rubrum* and *Quercus rubra*, the shrubs (or small trees) *Alnus incana, Alnus serrulata, Aronia melanocarpa, Ilex verticillata, Lindera benzoin*, and *Toxicodendron vernix*, the herbs *Bartonia virginica, Carex atlantica, Carex bromoides, Cypripedium acaule, Oxypolis rigidior, Symplocarpus foetidus* and *Viola pallens*, and with a diversity of ferns including *Dryopteris carthusiana, Dryopteris cristata, Onoclea sensibilis, Osmunda cinnamomea*, and *Osmunda regalis*, and with an abundance of the moss *Sphagnum* spp. The Green Wood Orchid also grows in moist organic sands bordering wetlands and swamps

associated with the trees *Nyssa sylvatica* and *Sassafras albidum*, the shrub *Cephalanthus occidentalis*, and the herbs *Maianthemum canadense* and *Mitchella repens*. Infrequently, this orchid can be found in open fens with the shrub *Potentilla fruticosa* and the herbs *Cladium mariscoides, Drosera rotundifolia, Pedicularis lanceolata*, and *Solidago ohiensis* (Homoya 1993). In the southern part of the state, the orchid becomes restricted to acidic seep bogs and springs, and at one site on the Hoosier National Forest it occurs on the bank of an artificial pond with *Sphagnum* moss and the sedge *Rhynchospora*.

Also in the Midwest, in Illinois, the Green Wood Orchid grows in "Moist, shaded areas" (Mohlenbrock 2002). A description of the habitat and associated species for this orchid in Illinois has been given by Sheviak (1974). Herkert and Ebinger (2002) have stated that the Illinois populations occur in mesic sand prairies and thickets in northern Illinois and in acidic, forested seeps in southern Illinois. In northern Illinois this orchid is found in bogs with the shrub *Chamaedaphne calyculata* and the herb *Sarracenia purpurea* among others, and in peaty sand prairies with the herbs *Aletris farinosa, Bartonia virginica, Calopogon tuberosus* and *Xyris torta* (Swink and Wilhelm 1994). In wet prairie swale borders it associates with the perennial herbs *Comandra umbellata, Euthamia graminifolia, Pycnanthemum virginianum, Scleria triglomerata, Tradescantia ohiensis*, and *Zizia aurea* (Swink and Wilhelm 1994). In southern Illinois this orchid grows on organic deposits built up in seep springs, and it is associated primarily with *Sphagnum* spp. with an overstory of the trees *Acer rubrum* and *Liriodendron tulipifera*, and it can be associated with the additional rare herb *Bartonia paniculata* (see Hill 2003a) and the fern *Thelypteris noveboracensis*.

Slightly west, in Missouri, the Green Wood Orchid occurs in acid soils in acidic seeps and along margins of sinkhole ponds (Summers 1987, Yatskievych 1999) in the Ozark and Ozark Border Divisions in southeastern Missouri and in Crowley's Ridge, where the associates are generally the same as those in Illinois. Two notable associates in Missouri are the tree *Ilex opaca* and the gentian *Bartonia paniculata*, also quite scarce in the state (Summers 1987).

In Virginia and neighboring states, the Green Wood Orchid has been found in Magnolia Bogs (Simmons and Strong 2001) and Mountain / Piedmont Acidic Seepage Swamps (often called High-Elevation Seeps) (W-3; W-5) among others. The soils are saturated and strongly acidic. Typical associates in the bogs are the trees (or large shrubs) *Alnus serrulata, Amelanchier canadensis, Aronia arbutifolia, Chionanthus virginicus, Ilex laevigata, Ilex verticillata, Magnolia virginiana, Rhododendron viscosum, Toxicodendron vernix, Vaccinium atrococcum, Vaccinium corymbosum*, and *Viburnum nudum*, the smaller shrubs *Gaylussacia frondosa, Kalmia angustifolia, Leucothoe racemosa*, and *Lyonia ligustrina*, the forbs *Chelone glabra, Gratiola virginiana, Hypericum canadense, Lilium superbum, Maianthemum canadense, Oxypolis rigidior, Rhexia virginica*, and *Viola primulifolia*, the graminoids *Calamagrostis coarctata, Carex albolutescens, Carex crinita* (and many other *Carex* spp.), *Eleocharis tortilis, Juncus acuminatus, Juncus scirpoides, Leersia virginica, Rhynchospora capitellata*, and

Scirpus polyphyllus, the ferns *Osmunda cinnamomea, Osmunda regalis, Thelypteris palustris, Woodwardia areolata* and *Woodwardia virginica*, and the moss *Sphagnum* spp. (Simmons and Strong 2001). The higher elevation seeps from Virginia south into the southern Appalachians inland (W-3, W-5) tend to be dominated by the trees *Acer rubrum, Nyssa sylvatica,* and *Liriodendron tulipifera* with some *Pinus rigida* (often surrounded by *Abies fraseri, Betula alleghaniensis, Fagus grandifolia* and *Picea rubens*), the shrubs *Alnus serrulata, Diervilla sessilifolia, Ilex verticillata, Rhododendron viscosum, Vaccinium corymbosum*, and *Vaccinium fuscatum*, the forbs *Angelica triquinata, Aster acuminatus, Chelone lyonii, Drosera rotundifolia, Hypericum mutilum, Parnassia asarifolia, Solidago patula, Symplocarpus foetidus*, and *Veratrum viride*, the graminoids *Carex debilis, Carex folliculata, Carex gynandra, Carex ruthii, Cinna latifolia*, and *Glyceria melicaria*, and the ferns and fern allies *Lycopodium obscurum, Dennstaedtia punctilobula*, and *Osmunda cinnamomea*, with *Sphagnum* spp. continuing to be the dominant moss.

In the southern states at its southern and southeastern range limits, *Platanthera clavellata* continues to be associated with many of the species already listed above, and with a few that are more southern in range. Its favored community is often called the Swamp Blackgum Floodplain Seepage Forest (W-3). Associated trees in this habitat can include *Acer rubrum, Ilex opaca, Liquidambar styraciflua, Liriodendron tulipifera, Magnolia virginiana, Nyssa biflora, Persea palustris*, and *Quercus michauxii*; associated shrubs can include *Clethra alnifolia*, *Itea virginica*, *Leucothoe axillaris*, and the shrubby bamboo *Arundinaria gigantea*, as well as the vines *Decumaria barbara, Toxicodendron radicans,* and *Vitis rotundifolia*. Forbs may include *Boehmeria cylindrica, Ludwigia palustris, Hydrocotyle verticillata*, and *Mitchella repens*, and commonly associated graminoids include the sedges *Carex atlantica, Carex bromoides*, and *Carex leptalea*. Ferns are common, including *Osmunda cinnamomea, Osmunda regalis*, and *Woodwardia areolata*, and the moss *Sphagnum* is, again, abundant.

DISTRIBUTION AND ABUNDANCE

Platanthera clavellata, the Green Wood Orchid, is widespread in portions of the temperate eastern and southeastern United States, and it has been found historically in thirty-four states plus the District of Columbia, namely, Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia, West Virginia, and Wisconsin (W-1, W-3; Sheviak 2002). In Canada, this orchid has been found in six provinces, namely, New Brunswick, Newfoundland (including Labrador), Nova Scotia, Ontario, Prince Edward Island, and Quebec (Sheviak 2002). While Sheviak (2002) did not record its presence in Missouri in his Flora of North America treatment of the species, his map indicates its presence in the state; he did not,

however, include the species in North Dakota. Some sources indicate that this orchid is now extirpated in North Dakota (W-3) and Iowa (Niemann 1986). *Platanthera clavellata* is relatively rare in the extreme northwestern portions of its range.

According to state rankings compiled by the Nature Conservancy (W-3), this orchid appears to be most common in portions of Delaware, Georgia, and Virginia (as an S5 – secure species) followed by Kentucky, New Jersey, New York, North Carolina, Ohio, Tennessee, and West Virginia (as an S4 species). 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 wetland habitats nationally, resulting in local extinctions. This orchid remains unranked (SNR) in the sixteen additional states (including the District of Columbia) from which it has been reported.

A combination of records from several sources (see appendices) gives more detailed information on the frequency and distribution of *Platanthera clavellata*. Records from floras and herbarium labels show that this orchid has been found in more than 70 counties in Virginia, in more than 40 counties in Michigan, North Carolina, and Pennsylvania, and in 20 or more counties in Kentucky, Louisiana, New York, possibly Ohio, Tennessee, West Virginia, and Wisconsin. It also occurs in 10 or more counties in Arkansas, Georgia, Indiana, Maine, Massachusetts, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, South Carolina, Texas, and Vermont. In the remaining ten states *Platanthera clavellata* has been found in fewer than 10 counties. Of course, it should be kept in mind that several of these remaining states have fewer than 10 counties total. 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 Green Wood Orchid in the United States has been presented in Appendix 2.

Platanthera clavellata has been found in all of the east-central, midwestern states (W-3; Yatskievych 1999, Mohlenbrock and Ladd 1978, Deam 1940).

In Illinois where the species is listed as Endangered, *Platanthera clavellata* has been reported historically in Cass, Cook, Iroquois, Jo Daviess, Kankakee, Lake, Lee, Pope, and Will counties (W-1, W-3; Herkert and Ebinger 2002, Mohlenbrock 1986, 2002; Mohlenbrock and Ladd 1978; Shawnee National Forest 2005). Currently, the species may occur only in Cook, Iroquois, Lake, Lee and Pope counties. The various sites are located within three natural divisions of Illinois, the Northeastern Morainal Division (Morainal Section and Chicago Lake Plain Section), the Grand Prairie Division (Green River Lowland Section and Kankakee Sand Area Section), and the Shawnee Hills Division (Greater Shawnee Hills Section or Lesser Shawnee Hills Section) (Schwegman *et al.* 1973). Six populations of this species are presently known in the state, two in

state nature preserves, one in the Shawnee National Forest, and another in a state conservation area (Herkert and Ebinger 2002). Another report has stated that within the Shawnee National Forest, one population consists of 2 individuals last seen in 1988 and 14-16 individuals are in the second site last seen in 1970 (Dolan 2001). Within Shawnee National Forest this orchid is known from seep springs at Cretaceous Hills, Dean Cemetery East Barrens, Massac Tower Springs, and Kickasola Cemetery Ecological Areas (Shawnee National Forest 2005).

In Indiana where the species is included on the state's informal Watch List (Yatskievych 2000), *Platanthera clavellata* has been reported in twelve counties around the state primarily in the northern fourth of the state in the Northern Lakes and Northwestern Morainal natural regions (Homoya 1993). Several scattered populations also occur in the south-central portion of the state in several natural regions, including the Shawnee Hills, the Highland Rim, the Southwestern Lowlands, and, perhaps, the Southern Bottomlands natural regions. Two known sites are on the Hoosier National Forest, both in the Shawnee Hills, each with about 5 individuals (Olson 1999).

In Missouri, this orchid has been reported in the southeastern corner of the state in Bollinger, Butler, Carter, Dunklin, St. Francois, Stoddard, and Wayne counties (Yatskievych 1999), and more recently in Barry, Iron, Madison, and Ripley counties (W-3). This area is part of the Mississippi Lowlands Division (Summers 1987). According to Summers (1987) the Green Wood Orchid was first discovered in Missouri on 21 Jul 1900 near Kennett in Dunklin County. The other sites for the plant have been discovered since 1979.

Within the U.S. Forest Service Eastern Region (Region 9) *Platanthera clavellata* 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 Huron-Manistee National Forest in Michigan, the Hiawatha National Forest in Michigan, the Ottawa National Forest in Michigan, the Chequamegon – Nicolet National Forest in Wisconsin, the Superior National Forest in Minnesota, the Chippewa National Forest in Minnesota, and the Green Mountains National Forest in Vermont (W-6). It may also occur in several other national forests in the eastern region based on its known habitat preferences and range. It is apparently occasional 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 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. It is nevertheless likely that some forested and wetland sites where it may have occurred have been drained and 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, that the orchid can be 'abundant' in Wisconsin, 'frequent' in Connecticut, 'frequent' in Great Smoky Mountains National Park in Tennessee, 'uncommon' in Alabama, 'common' in Louisiana, and 'abundant' in Oklahoma [at one site]. Homoya (1993) reports that this orchid is abundant in places, apparently due to lack of herbaceous competition in its habitat. In the Hoosier National Forest in Indiana, there are only two known sites, and population sizes consist of about five individuals in each (Olson 1999, Olson and Reynolds 2000). In the Shawnee National Forest, in a previous report, 2 individuals were last seen in 1988 in one and 14-16 individuals were seen in the second site last seen in 1970 (Dolan 2001, Herkert 1991). Several additional sites are now known (Shawnee National Forest 2005). Summers (1987) reported that at least one colony in Missouri had about 200 fruiting plants.

PROTECTION STATUS

The Nature Conservancy currently ranks *Platanthera clavellata*, the Green Wood 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, *Platanthera clavellata* has been given the status of NNR (unranked 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. *Platanthera clavellata* is listed as Endangered in Florida (S1) and Illinois (S1; Illinois Endangered Species Protection Board 2005; W-1), as Exploitably Vulnerable in New York (S4) and as Extirpated (Historic only) in North Dakota (SH). It has been listed as Critically Imperiled (S1) in Florida, Illinois, and Iowa (where it is also included on the list of plants of Special Concern and has not been seen since 1894), as nearly Critically Imperiled (S1S2) in Oklahoma, and as Imperiled (S2) in Missouri and Rhode Island. It is considered Vulnerable (S3) in Indiana (where it has been included on the state's Watch List) and Minnesota (where it has been included on the Special Concern plant list). It is ranked as apparently secure to secure (S4, S5) in Delaware, Georgia, Kentucky, New Jersey, New York, North Carolina, Ohio, Tennessee (S4?), Virginia, and West Virginia (W-3). This orchid remains unranked in the sixteen additional states (including the District of Columbia) from which it has been reported.

In Forest Service Region 9, the Green Wood Orchid is included on the Regional Forester Sensitive Species list (RFSS) as 'At Risk' in the Shawnee National Forest (IL), the Hoosier National Forest (IN), the Mark Twain National Forest (MO), the Superior National Forest (MN), and the Chippewa National Forest (MN). It occurs in several other national forests (see distribution above) where it is not considered to be at risk (W-6; 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 S2 plant. It was formerly included in the checklist of rare and endangered species of Missouri as an Endangered plant ("…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 *Platanthera clavellata* 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-7).

A summary of the current official protection status for *Platanthera clavellata* follows:

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

Table 1: S-ranks for *Platanthera clavellata* [Heritage Element Code: PMORC1Y050]

State/Province	Heritage S-rank
UNITED STATES	
Alabama	SNR
Arkansas	SU

Connecticut	SNR		North Carolina	S4	
Delaware	S5		North Dakota	SH	[Apparently Extirpated]
District of Columbia	SNR				
Florida	S1	[Endangered]	Ohio	S4	
Georgia	S5		Oklahoma	S1S2	
Illinois	S1	[Endangered]	Pennsylvania	SNR	
Indiana	S3	[Watch List]	Rhode Island	S2	
Iowa	S1	[Special Concern]	South Carolina	SNR	
			Tennessee	S4?	
Kentucky	S4		Texas	SNR	
Louisiana	SNR		Vermont	SNR	
Maine	SNR		Virginia	S5	
Maryland	SNR		West Virginia	S4	
Massachusetts	SNR		Wisconsin	SNR	
Michigan	SNR				
Minnesota	S3	[Special Concern]	**CANADA**		
Mississippi	SNR		New Brunswick	S4	
Missouri	S2		Newfoundland Island	S5	
New Hampshire	SNR		Nova Scotia	S5	
New Jersey	S4		Ontario	S4S5	
New York	S4	[Exploitably Vulnerable]	Prince Edward Island	S2S3	
			Quebec	S4S5	

LIFE HISTORY

Platanthera clavellata is a perennial orchid that often forms small clonal colonies with several 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 described as *mycotrophic* (see below). Apparently, temperate zone orchids are not very species specific in their associated fungal partners, and several fungi may be involved. The literature suggests that the primary associated fungal symbiont with *Platanthera* is *Epulorhiza* (Currah *et al.* 1997). 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 some species of *Platanthera*.

Species such as the Green Wood Orchid, and members of most other orchid genera, while fully capable of photosynthesis and the production of most of their own food, rely partly upon fungal produced nutrition, and they especially depend on the fungi for the uptake of water to the plant throughout their life cycles. In most orchids, including *Platanthera clavellata*, 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. 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). Plants that are dependent on this form of nutrition can be described as mycotrophic (Taylor *et al.* 2003).

Small *Platanthera clavellata* plants emerge in the spring with the leaves protecting the flower buds until the inflorescence elongates. Most of the plants in a colony appear to flower every year, though there is little information available on this fact. The flowers are inconspicuous, small, and they do not appear to have an aroma. The flowers are unusual in that they are apparently not only self-compatible, but they are mostly self-pollinated throughout much of the species' range by a process in which the pollen masses crumble and fall onto the stigmatic surfaces (Yatskievych 1999). Catling (1983) describes the pollen as germinating in the pollinia and then growing down onto the stigma. This may help to explain the apparent lack of fragrance in this species (it does not need to attract insect pollinators), in contrast to some related insect pollinated species (Tollsten and Bergstrom 1993) but it does not explain the retention of the prominent spur, a structure within which nectar is produced to encourage visits from pollinator moths. However, as noted previously, a spurless mutation does occasional occur and persists. Despite the predominance of self-pollination, insects must at least occasionally visit the plants because a hybrid between *P. clavellata* and *P. blephariglottis*, *Platanthera* x *vossii* Case, has been described (Case 1983). If the ovules are fertilized, the flower parts normally wilt, dry, and persist on the end of the capsule and the ovary quickly develops into a horizontal seed capsule containing numerous dust-like seeds that are readily dispersed by wind. It is sometimes difficult to tell if the flowers are freshly open or not because the tepals remain the same color and fleshy for several days after the ovary has started to expand (Hill, pers. obs.).

Flowering appears to be rather consistent in this species, and flowering individuals are normally found in any given colony every year (Hill, pers. obs.). However, there is little data available on the percentage of stems that flower in a given year. Somewhat inexplicably, the natural fruit set, or the percent of fruits developed from flowers, in this orchid has been found to be only 50 % by one researcher (Gregg 1990) while the fruit set in a close relative with a similar pollination

mechanism, *Platanthera hyperborea* (L.) Lindl., is 99-100 % (Catling 1983). The percentage of seed success in the wild is not fully known but fruits are often seen because of the success of the self-pollination process. The process of establishment of new colonies has not been observed.

These orchids also propagate vegetatively and the connecting rhizomes between plants are well known (Holm 1925), and so a single colony can have many stems that are genetically identical, all from the establishment of a single plant from a seed. In the course of vegetative reproduction, new buds from the rhizomes or stolons develop into vegetative shoots before becoming flowering shoots (Holm 1925) and so small or young plants may be produced either from seeds or rhizomes.

The Green Wood Orchid flowers in the summer, from June to August (Gleason and Cronquist 1991; Sheviak 2002), in most portions of its range. In Wisconsin, approaching the northern limit of its range in the United States, flowering occurs from 10 July – 5 August. Midwestern localities record flowering as late as 21 August (in IN) and 25 August (in MO), but not earlier than 10 July. Specimens collected in late June in the north were in bud. In the southern and western portions of its range, flowering occurs at about the same time or slightly earlier, and herbarium specimen labels have indicated flowering from 6 June (in LA) and 26 June (in OK) to 8 August (in AL). Radford *et al.* (1968) and Wofford (1989) state that the flowering time for this orchid in the central and southern Appalachians and the Carolinas is June-September. Clewell (1985) reported its flowering time in Florida at its southeastern range limit to be July-September. In Indiana it is said to flower from early July to late August (Homoya 1993), and Summers (1987) states that its flowering time in Missouri is also July to August. In all parts of its range, *Platanthera clavellata* is found to be at peak flower from about 15 July to 31 July. The flowers appear to be long-lived and they persist on the fruits as they develop and mature (Hill, pers. obs.)

Young fruits are produced as early as 31 July (in NC) but they are not ripe until later. Mature fruits on herbarium specimens appeared to be present on plants from approximately 2 August (AR) to 2 November (in AL), though the dry, empty fruits can persist beyond that. The average time for fruit maturation appears to be approximately 1 September – 1 October through most of its range. 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. Orchid seeds are normally dispersed by wind, and the terminal capsules act as shakers when they open and are moved around by the wind.

This orchid 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 for this species. 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

Platanthera clavellata, as discussed in the previous section, appears to flower and fruit regularly and it has no known reproductive problems. Many of the flowers are self-pollinated leading to the dependable production of large numbers of seeds. However, the single study that reported that only about 50 % of the flowers actually produced capsules with seeds suggests that there may actually be some inbreeding problems in this species.

According to staff at the Shawnee National Forest (2005) *Platanthera clavellata* in southern Illinois grows in a habitat where several fire-adapted species also grow. It was therefore concluded that this species would benefit from fire management and tree and shrub removal. However, the Green Wood Orchid is not known to grow successfully in completely open sites in the southern portions of its range – instead, it is generally found in rather mature forests in acidic seeps under a canopy. It is not uncommonly found in more open areas at the northern limits of its range, but these, again, are usually wetlands that rarely burn. The common associates such as *Alnus, Acer rubrum*, and *Lindera benzoin* as well as *Quercus rubra, Ilex* spp., and *Liriodendron tulipifera* are, likewise, generally not considered to be fire resistant species. It is possible that a fire may contribute a sudden influx of nutrients and may help to eliminate some exotic species, but even exotics can usually survive a fire if it occurs in a wetland because the roots, protected by saturated substrate, do not burn. It has been shown that this species is known to grow well and persist in areas of relatively dense shrubs (Homoya 1993) and it is, as stated, typically found in shaded forests.

In most northern portions of its range, *Platanthera clavellata* is abundant and colonizes disturbed areas, even to the degree of appearing weedy (W-3). Towards the southern and western portions of its range, fewer suitable temperate acidic wetlands occur, and the orchid becomes far less common and certainly not weedy. The Green Wood Orchid grows in widely scattered and often isolated sites at the margins of its range because the suitable habitats also show this pattern. In these locations, there appears to be very little interaction (pollen dispersal) with populations of the same species in other areas. Certainly, the populations of this orchid in Illinois are isolated from one another and especially from those in other states. Populations of the Green Wood Orchid do appear to persist at a site and remain viable for many years as long as its wetland habitat is protected. As shown in the previous section on Life History, this orchid also propagates vegetatively, further increasing the chances of persistence and survivability provided the habitat remains stable. It seems clear that the southern habitats where this orchid has been found must be protected to allow its persistence.

It is generally understood by botanists that fertility is normally reduced in inbred populations through the process of autogamy (self-fertilization), a process that predominates in *Platanthera clavellata*. 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 immediately important than the production of new genotypes. *Platanthera clavellata* generally has increased the possibility of

inbreeding through its characteristic germinating pollen masses that regularly reach the receptive portion of the pistil column and fertilize the ovules. Because of this specialized pollination mechanism, most flowers are pollinated and produce mature fruits without the need for pollinators. Despite the rare event of pollen transfers, individuals in such a population are usually very closely related, and can even be progeny from a single introduction event, and so they can posses little genetic variability. Self-fertilization 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. 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-8). The appearance of mutations such as the spur-less form that has been found in several non-contiguous populations tend to provide evidence of the possible negative effects of inbreeding in this orchid (Brown and Olive 2006).

Another 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 *Platanthera clavellata* seeds produced in the Illinois and Indiana populations. While it is a vulnerable species in the Midwest, the Green Wood 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 Green Wood 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 overall. In North Dakota and Iowa, the species appears to have been extirpated and so is known from historic records only. This orchid is either critically imperiled or imperiled in 16 % (5 of the remaining 32 states) of the states where it occurs. In two of the remaining 27 states, it is vulnerable (S3), and it has been ranked as fully secure in only three states (Delaware, Georgia, and Virginia; W-3).

The primary threat to *Platanthera clavellata* is habitat loss (destruction) as a result of human activities (W-3). According to staff of the Shawnee National Forest (2005) the habitat destruction in southern Illinois is a result of several factors, including the woody species invasion of seep

springs, wetland drainage, channelization of streams and wetlands, logging, gravel mining, from predation by white-tailed deer and cattle grazing, from herbicide runoff from nearby fields or powerline corridors, and from the invasion of habitats by exotic and native woody vines (*e.g.*, *Lonicera japonica, Smilax* spp.). The population of *Platanthera clavellata* at Massac Tower Springs Ecological Area has not been seen for many years, and the hydrological disturbances to this seep along with the invasion of exotic species and woody vegetation may have led to the loss of this population (Shawnee National Forest 2005).

Throughout its range, populations of the Green Wood Orchid appear to have been eliminated by human activities (as best evidenced in Iowa and North Dakota 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-9). 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.

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 in the Midwest, 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.

Some forest management practices have been indicated as threats to this and similar orchids.

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 of suitable habitat to pine-plantation silvicultures, and by fire suppression (W-5; Michigan Natural Features Inventory 2000). Furthermore, because of its relationship with symbiotic fungi, *Platanthera clavellata* and other orchids are sensitive to the soil disturbance and compaction that often results from tree harvesting activities (W-10). Some human intervention may be beneficial in the form of occasional fire management when the substrate is thoroughly wet. It is not certain, however, that the actual opening of the canopy or forest in general might contribute to the success of this orchid because the addition of significant nutrients such as phosphorus and potassium 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 Green Wood Orchid is not known to grow successfully in completely open sites in the southern portions of its range – instead, it is generally found in seeps within successional to mature forests of *Acer rubrum* and *Liriodendron tulipifera*, not known to be especially fire-resistant (as previously mentioned). In southern Illinois this orchid grows on organic deposits built up in seep springs in association with the additional rare herbs *Bartonia paniculata* (Hill 2003a) and the fern *Thelypteris noveboracensis*. This species is known to grow well and persist in areas of relatively dense shrubs (Homoya 1993). 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.

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 invasive exotics may eventually eliminate several seep spring species sensitive to such intense competition for space, light, nutrients, and water (Hill 2003a). It is not known for certain 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. Exotic species are often controlled by herbicide application. One herbarium label (*Bryant 1138* at Miami University) demonstrates the threat of herbicide use by this statement on the label: “Previously several plants under electric line. Most killed by spray; these bent and deformed.” Herbicide use should, then, be avoided completely near these plants.

The destructive effects of herbivory (predation, grazing, browsing) 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-9). 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 (especially edible monocots) 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 *Platanthera clavellata* 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 Green Wood 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 a frequently studied relative, the orchid *Isotria medeoloides* (W-11). 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 *Platanthera clavellata* 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-11). However, 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-11). Additional threats from animal predators include wild pigs trampling or uprooting the orchid plants and herbivory by rabbits as well as the occasional trampling or herbivory by moose in the northern portion of its range.

Over-collection has not been indicated to be a threat to this orchid as it has been with many other orchids (Herkert and Ebinger 2002). It is well known that the Green Wood 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. However, this is also among the least conspicuous and least showy of the native orchids and so it is not sought out much by

gardeners. It does not seem to be available in the nursery trade.

At the current time *Platanthera clavellata* appears to be quite vulnerable within the Shawnee National Forest because of the extremely few colonies known there and dangers facing its habitat (Shawnee National Forest 2005).

RESEARCH AND MONITORING

The Green Wood Orchid has not been as intensely studied as many other orchids, such as the Federally Threatened *Isotria medeoloides*. Several types of basic research are still needed, including the continued basic examination of the widely scattered 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. Population sizes are not well known, nor are there any published studies of long-term variation on the numbers of flowering individuals in a given population. In addition, 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. 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.

Some information is known concerning the life history of the plant and its mycorrhizae but there is still a tremendous amount to learn about this orchid concerning its fertility, the actual population sizes, dormancy periods, early establishment requirements, precise 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). It is also somewhat surprising that its vegetative reproduction is generally not mentioned in the literature, perhaps because it is still a common orchid in many areas and less often studied.

Annual or periodic monitoring of existing populations of the Green Wood Orchid may be essential to the local survival of this species. In parts of its range, both in areas where it is obviously 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 why the successful fruit set is only about 50 % despite what appears to be a nearly 100 % successful self-pollination mechanism. It appears that more pollination and fertility studies are needed as well as long-term field observations in general. An explanation of current plant monitoring techniques can be found in Philippi *et al.* (2001). Certainly, 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 assumed by some to be beneficial (Shawnee National Forest 2005) would be useful towards the understanding and preservation of the Green Wood Orchid in our area. Carefully controlled experiments are needed to test these hypotheses. 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, and it is dependent on its highly organic substrate that may be vulnerable to fires.

Towards the southern portion of its range, the sensitive Forested Seep natural community is the normal habitat for *Platanthera clavellata*. According to the Natural Heritage Program in Louisiana, 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. Also in the south, in Alabama, the forested seeps where the Green Wood Orchid grows are often located within or adjacent to longleaf pine communities (U.S. Fish and Wildlife Service 2005). It is probable that all or most have historically experienced fire.

In contrast to the situation described in Louisiana above, some maintain that, across the South, seepage slope ecosystems embedded in the longleaf forest require periodic fire to maintain structure and health (Outcalt 2000). In Georgia, Wharton (1989) characterizes imbedded shrub and herb bogs to the south in the Coastal Plain as experiencing a three to eight year burn cycle. The frequency and history of fire within forested seeps, however, is difficult to characterize. The larger perennial seeps remain wet or moist most of the year and fail to burn during most fire events. During wildfires or prescribed burns, fires burned only to the seeps' edges leaving the seep interior unburned (U.S. Fish and Wildlife Service 2005). An exception to this occurred in 1987 within the Mountain Longleaf National Wildlife Refuge in Alabama within the Marcheta Mountain Seep (U.S. Fish and Wildlife Service 2005). During a drought period, a wildfire

burned across the seep. Observers noted that the seep glowed during the night indicating fire had burned into the seep's sphagnum layer. Observations following this fire indicated that the herbaceous layer, including the orchids, slowly decreased as time elapsed after the fire, while the shrub component slowly became denser. Historically, it is probable that these seeps or bogs periodically burned during extreme drought. Such a burn would be expected to reduce the shrub layer and open the herbaceous component to sunlight. The probable importance of fire in maintaining these communities is supported through observations by local researchers and managers (Garland 1996; Whetstone *et al.* 1998). Fire has been recommended as beneficial in maintaining forested seeps and their rare orchids in at least one other site, in Pulaski County, Arkansas (W-12). Prescribed burning should target the forests surrounding seepage areas and not the seep itself. Prescribed burns should not be scheduled under drought conditions in order to prevent fire from entering or burning within the seeps. It is critical, however, to seek academic guidance on the need to introduce fire within the seepage interior at some future time. Without fire, seeps may actually evolve through succession into shrub thickets, excluding many unique and rare herbaceous plants (U.S. Fish and Wildlife Service 2005).

Monitoring of the forests themselves where *Platanthera clavellata* 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. 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 to the few known Illinois populations.

When new populations are found, voucher specimens should be made according to techniques described in Hill (1995) or other similar references. The collecting of this locally 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 an incorrect identification). 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 July to mid August in the Midwest and eastern region when the flower stalks are most easily visible. There are rather large areas of additional suitable habitat with suitable

substrate and soils in southern Illinois, and, of course, elsewhere, where the Green Wood 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 occur with the species in Illinois. These indicator plants (especially Red Maple and Alder), 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 have been overlooked because of the possibility for 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. At this time, it is not known if this orchid can be introduced successfully 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. 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. An example of a working habitat restoration plan instituted within a National Forest is that of Dolloff *et al.* (2001). As mentioned in the previous section, it is currently thought that hydrological disturbances to the seeps in southern Illinois where the Green Wood Orchid has been known to grow must be corrected, and continued monitoring of the hydrology will be necessary for it to persist (Shawnee National Forest 2005). It also appears clear that exotic species such as *Lonicera japonica* and *Microstegium vimineum* pose a current and severe hazard to current populations, and these should be eliminated from these delicate habitats.

It has been suggested that prescribed burns should be conducted on *Platanthera clavellata* in Illinois (Shawnee National Forest 2005), but most other studies and recommendations have not

supported this (see Potential Threats above). Several states have issued management suggestions for the similar orchid *Isotria verticillata* that often associates with *Platanthera clavellata*. The Michigan Natural Features Inventory (2000) states the following regarding management suggestions for *Isotria* in that state: "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 of that state, 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.

There appears to be a significant amount of habitat available where restoration efforts can occur for *Platanthera clavellata* 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 usually rather high, but browsing by deer and other animals may pose a significant threat to the production and release of mature seeds. It would seem to be wise to determine if the 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-11). Considering the very low numbers of colonies of the Green Wood Orchid 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

Platanthera clavellata is a rather small fleshy perennial terrestrial herb about 10-40 cm tall with white tuberous rhizomes and roots, and with 1-3 leaves attached below the center of the stem. There is a single terminal raceme with 5-15 congested flowers at its top. The flowers are inconspicuous, normally pale greenish or yellowish, and they normally self-pollinate. The orchid is widespread in eastern North America, and in the United States it is known historically from thirty-four states and six Canadian provinces, from Newfoundland to Ontario in Canada, and from North Dakota and Minnesota to Maine and south to Florida and Texas. It is a species that grows in acidic wet soils in mesic forests, seeps, and sphagnum bogs. It has been listed as Endangered in Florida and Illinois, as Exploitably Vulnerable in New York, and as Extirpated (Historic only) in North Dakota, and as at risk in both the Shawnee and Hoosier National Forests of Illinois and Indiana. While it is rather common locally in several eastern states, 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 dynamics of its population sizes, an assessment of 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) of the hillside seeps where it grows, 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. 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.

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W-9. Uwharrie National Forest Ecological Sustainability Plan. National Forests in North Carolina, Asheville, North Carolina. http://www.cs.unca.edu/nfsnc/uwharrie_plan/eco_sustainability.pdf

W-10. Abstracts on Threatened and Endangered Species in Ohio: *Hexalectris spicata*. http://ohiodnr.com/dnap/Abstracts/H/hexaspic.htm

W-11. Endangered and Threatened Wildlife and Plants; Final Rule to Reclassify the Plant *Isotria medeoloides* (Small Whorled Pogonia) From Endangered to Threatened. [Federal Register: October 6, 1994] http://www.epa.gov/fedrgstr/EPA-SPECIES/1994/October/Day-06/pr-7.html

W-12. Pulaski County Arkansas Sensitive Natural Areas and their Recommended Management http://www.pulaskiswdistrict.org/documents/Layout.pdf

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APPENDIX 1

Representative specimens of *Platanthera clavellata* examined or cited in the literature

Herbaria:

CLEMS = Clemson University, Clemson, South Carolina. ILLS = Illinois Natural History Survey, Champaign. ISC = Iowa State University, Ames. MO = Missouri Botanical Garden, St. Louis. MU = Miami University, Oxford, OH. UNAF = University of North Alabama, Florence. VT = University of Vermont, Burlington. WIS = University of Wisconsin, Madison.

ALABAMA: BARBOUR CO., along Hwy 49 S of jct. w/ Hwy 82 in Comer, 7 Jul 1998, *MacDonald 11600* (MO); **HENRY CO**., road to Ft. Gaines, GA, NE of Abbeville, 2 Nov 1974, *Kral 54722* (MO); **LAUDERDALE CO.**, Zip City, 24 Sep 1985, *Rhodes s.n.* (UNAF); **LEE CO**., Auburn, 8 Aug 1897, *Earle & Baker s.n.* (MO); **MOBILE CO.**, Mobile, Jun 1919, *Graves 940* (MO).

ARKANSAS: GARLAND CO., Lonsdale, 10 Oct 1924, *Palmer 26470* (MO); **HOT SPRINGS CO.**, Hot Springs, Jul 1889, *Harvey 13034* (MO); near Hot Springs, 2 Aug 1879, *Letterman s.n.* (MO); **UNION CO.**, W of AR 7, 1 mi N of LA state line N of Lockhart, LA, 10 Sep 1993, *Thomas 136918* (MO).

CONNECTICUT: FAIRFIELD CO., Easton, 29 Jul 1889, *Wilkinson s.n.* (MU); **HARTFORD CO.**, Southington, 4 Aug 1897, *Bissell 2571* (MO); **NEW HAVEN CO**., Branford, 4 Aug 1877, *Trelease s.n.* (MO).

DISTRICT OF COLUMBIA: moist spot in hill, Washington, D.C., 11 Aug 1896, *Steele s.n.* (MO, MU).

GEORGIA: RABUN CO., at NC state line NE of summit of Rabun Bald, 3 Aug 1946, *Duncan 6864* (MO); vicinity of Tallulah Falls, Tallulah Lodge, 19 Jul 1901, *Seymour s.n.* (MO); **SUMTER CO.**, near Leslie, 23 Jul 1901, *Harper 1104* (MO); **UPSON CO.**, along small tributary to Flint River just above Pasley Shoals W of Thomaston, 16 Jul 1948, *Cronquist 5494*, (MO).

ILLINOIS: CASS CO., Beardstown, 18--, *Geyer s.n.* (MO); **COOK CO.**, *s. loc.*, Aug 1869, *Babcock s.n.* (MO); **POPE CO.,** Massac Tower, SW of Bay City, 20 Sep 1967, *Evers 93450* (ILLS).

INDIANA: **PORTER CO.**, Keiser, the Dunes of Lake Michigan, Chesterton, 21 Aug 1925, *Churchill 7* (MO); **STEUBEN CO.**, E side of Clear Lake, 21 Aug 1904, *Deam s.n.* (MO).

IOWA: FAYETTE CO., Wadena, 10 Jul 1894, *Fink s.n.* (ISC); **MUSCATINE CO.**, along Cedar River, Lake township, Jul 1894, *Reppert 737* (IA at ISC).

LOUISIANA: **BOSSIER PARISH**; 2.5 mi NW of Benton, 12 Aug 1938, *Correll & Correll 10250* (MO); **NATCHITOCHES PARISH**, Natchitoches, 9 Jun 1915, *Palmer 7927* (MO); **OUACHITA PARISH**, Jim Reeves Road off LA 846 S of Luna, 1 Jul 1971, *Thomas et al. 24050* (MU, UNAF); **RAPIDES PARISH**, vicinity of Alexandria, 6 Jun 1899, *Ball 564* (MO); **WASHINGTON PARISH**; 3 mi NE of Franklinton, 29 Jun 1938, *Correll & Correll 9195* (MO); **WINN PARISH**, Kisatchie Nat. Forest, Winn Distr. near Saline Bayou, 5 Aug 1997, *Thomas 154932* (MO).

MAINE: CUMBERLAND CO., Brunswick, Jul 1888, *Davis s.n.* (MO); **HANCOCK CO**., ME Rt. 195, between Prospect Harbor and Corea, 8 Aug 1989, *Hill 20948* (VT); **KENNEBEC CO.**, Augusta, 1 Jul 1865, *Smith s.n.* (MO); **KNOX CO**., E end of Crystal Lake, ca. 5 mi NE of Razorville, 17 Aug 1928, *Steyermark 947* (MO); Port Clyde, 7 Aug 1947, *Richardson s.n.* (MO); Matinicus, 17 Aug 1957, *Bicknell s.n.* (MO); **LINCOLN CO.,** Appalachia Lake, Boothbay Harbor, 10 Aug 1920, *Grover 215* (MU); **YORK CO**., Alfred, 12 Aug 1933, *Cleonique-Joseph 6116* (MO).

MASSACHUSETTS: BERKSHIRE CO., Berkshire, 7 Aug 1882, *Wells s.n.* (MU); **DUKES CO.**, Martha's Vineyard, 8 Aug 1877, *Morong s.n.* (MO); **FRANKLIN CO**., Northfield, 5 Jul 1888, *Metcalf s.n.* (MU); **HAMPDEN CO.**, Southwick, 11 Sep 1914, *Seymour 306* (MO); **HAMPSHIRE CO.**, Holland Glenn, Belchertown, 27 Jul 1929, *Thompson s.n.* (MO); **NORFOLK CO.**, Norwood, Purgatory Swamp, 3 Aug 1895, *Churchill s.n.* (MO).

MICHIGAN: CHEBOYGAN CO., Reese's Bog, Burt Lake, 17 Jul 1919, *Ehlers 833* (MO); **EMMET CO**., Bay View, 25 Jul 1892, *Swift 3330* (MO); **LEELANAU CO.**, W. Manitou Island, Lake Michigan, 30 Jul 1886, *Wislizenius 605* (MO); **LUCE CO**., along Rt. 123, ca. 5.0 mi W of Paradise, 30 Jul 1997, *McNeilus 97-601* (MO).

MINNESOTA: AITKIN CO., Nichos, Jun 1892, *Sheldon s.n.* (MO); **GOODHUE CO.**, Zumbrota, Aug 1892, *Ballard s.n.* (MO, MU).

MISSISSIPPI: **ALCORN CO.**, 1 mi N of Strickland, 5 Sep 1937, *Correll & Correll 8227* (MO).

MISSOURI: **BOLLINGER CO**., Wash Creek Fen, S side Co. Rd. 328 E of Marquand, 15 Jun 1994, *Brant 2959* (MO); Castor River Conservation Area, 9 Aug 1999, *Brant 4323* (MO); **BUTLER CO.**, Forest Service Rd 3109 NW 0.6 mi from Butler Co. Rd. 434 just S of Hurricane Creek ford, 15 Jul 1994, *Brant 3007* (MO); Mud Creek Natural Area, Hudson, 26 Jul 1995, *Richards & Weston 781* (MO); **CARTER CO.**, Mark Twain National Forest, Poplar Bluff Ranger District, S of Hwy. 60 on Ten Mile Creek, 5 Jul 1996, *Summers 7912* (MO); **SAINT**

FRANCOIS CO., into St. Genevieve Co. along Coldwater Creek, 14 Aug 1993, *Brant 2591* (MO); **STODDARD CO.**, near Dexter at base of Crowley Ridge, 25 Aug 1970, *Christ s.n.* (MO); **WAYNE CO.**, slopes of Wildcat Creek, State Hwy. M, N of Cascade, 3 Aug 1994, *Brant 3037* (MO).

NEW HAMPSHIRE: CHESHIRE CO., Hinsdale, Rt. 63 near Chesterfield line, 20 Jul 1972, *Boufford 7191* (MO); Richmond, 21 Aug 1922, *Batchelder s.n.* (MO); **COOS CO.**, Randolph, Jul 1889, *Cummings s.n.* (MO); **GRAFTON CO.**, Franconia Notch, Flume House, 7 Aug 1873, *Churchill s.n.* (MO); **ROCKINGHAM CO.**, Seabrook, Jul 1896, *Eaton s.n.* (MO).

NEW JERSEY: BURLINGTON CO., Wharton State Forest, Mullica River, 19 Aug 1987, *Hill 18676* (CLEMS); **CAMDEN CO.**, Winslow, 7 Sep 1873, *Martindale s.n.* (MO); **CAPE MAY CO.,** northeast branch of Pond Creek near Bay Road, 15 Jul 1918, *Stone s.n.* (MO); **MONMOUTH CO**, *s.d.*, *Perry s.n.* (MO); **OCEAN CO.**, Island Heights, Barnegat Bay, 13 Aug 1892, *Churchill s.n.* (MO).

NEW YORK: CAYUGA CO., north of Spring Lake, Conquest, 11 Aug 1916, *Griscom, Metcalf, & Wright 6236* (MO); **ESSEX CO.**, south shore of Lake Placid, 3 Sep 1929, *Muenscher, Manning & Maguire 334* (MO); **FULTON CO**., Caroga, Negro Lake, 19 Jul 1990, *MacDougal 4667* (MO); **ONONDAGA CO.**, Tully, 1869, *Cowles 7807* (MO).

NORTH CAROLINA: HAYWOOD CO., Great Smoky Mountains National Park, Big Creek floodplain, 27 Sep 2000, *Busemeyer et al. 353* (ILLS); **SWAIN CO.**, Andrews Bald, 5 Aug 1891, *Beardslee s.n.* (MU); **WATAUGA CO.**, vicinity of Blowing Rock, 31 Jul 1890, *Heller 162* (MO).

OHIO: CHAMPAIGN CO., Cedar Bog State Memorial, Urbana Twp., 31 Jul 1991, *McCormac 4041* (MU); **GALLIA CO.**, Rio Grande Reservoir, Raccoon Twp., 1 Aug 1976, *Bryant s.n.* (MU); **LORAIN CO.**, Camden Lake, Camden, 18 Jul 1893, *Cowles s.n.* (MU); **LUCAS CO**., Toledo Express Airport, Swanton Twp., 23 Jul 1989, *Denny 07-01* (MU); **PIKE CO.**, Jackson Twp., N of Jackson Lake, 22 Jul 1979, *Bryant 963* (MU); **PORTAGE CO.**, Mantua Bog State Nature Preserve, Mantua Twp., 18 Sep 1993, *Stine 1002* (MU); **GEAUGA CO.**, Munson, Jul 1877, *Ashcroft s.n.* (MO); **SCIOTO CO.**, Nile Twp., NE of Buena Vista, 8 Aug 1981, *Bryant 1138* (MU); **STARK CO**., N of Swamp Street, Marlboro Twp., 18 Aug 1995, *Gardner 525* (MU).

OKLAHOMA: CHOCTAW CO., 4.1 mi N of Swink, 26 Jun 1976, *Magrath, Lavallee, et al. 9361* (MO); 4.9 mi N of Fort Towson, 26 Jun 1976, *Magrath, Lavallee, et al. 9367* (MO).

PENNSYLVANIA: BUCKS CO., Buckwampum Mountain, 6 Aug 1885, *Ruth s.n.* (MU); **FRANKLIN CO.**, Mt. Alto, 1908, *Illick s.n.* (MO); **LANCASTER CO.**, Jul 1885, *Galen 2774*

(MO); **CARBON CO.**, Mt. Hope, 11 Aug 1895, *Eby s.n.* (MO); **LEBANON CO**., Mt. Gretna, Jul 1889, *Eby s.n.* (MO); **LEHIGH CO.**, Klines Crossing near Emaus, vicinity of Allentown, 24 Aug 1907, *Dowell 5104* (MO); **WESTMORELAND CO**., 10 Aug 1877**,** *Pierron s.n.* (MO).

RHODE ISLAND: PROVIDENCE CO., near Diamond Hill, 31 Jul 1943, *Palmer 46726* (MO).

SOUTH CAROLINA: AIKEN CO., Graniteville, 8 Aug 1898, *Eggert s.n.* (MO); **ANDERSON CO**., Whitner Park, Anderson, 2 Aug 1917, *Davis 7777* (MO); **OCONEE CO.**, Mountain Rest, West Village Creek, 21 Aug 1988, *Hill 19872* (VT).

TENNESSEE: COCKE CO., near Lemon's Gap, near summit of Max Patch Mountain, 8 Sep 1897, *Kearney Jr. 908* (MO); **SEVIER CO**., along trail from Hotel Place to Bogle Springs and Baker Place on Chilhowee Mountain, 6 Aug 1994, *Thomas et al. 141025* (MO); **WASHINGTON CO.**, Limestone Creek, 2 Aug 1967, *Small s.n.* (MU).

TEXAS: HOUSTON CO., Grapeland, 16 Sep 1918, *Palmer 14429* (MO); **SAN AUGUSTINE CO.**, San Augustine, 20 Sep 1918, *Palmer 14469* (MO).

VERMONT: ADDISON CO., Leicester, Scanlon Swamp, 3 Aug 1922, *Dutton s.n.* (MO); Middlebury, 10 Jul 1879, *Eggert 2756* (MO); **CALEDONIA CO.**, Gibson Quarry, Blue Mountain, Ryegate, 21 Jul 1960, *Seymour 18912* (MO); **CHITTENDEN CO**., Richmond, 19 Jul 1899, *Eggleston 1627* (MO); **ORLEANS CO.,** Brownington, 18 Jun 1932, *Potter s.n.* (MO); **RUTLAND CO.**, Pittsford, Sugar Hollow Pond, 18 Jun 1932, *Potter s.n.* (MO).

VIRGINIA: **CRAIG CO.**, Fort Sevenmile Mountain, 24 Aug 1903, *Steele 102* (MU); **PAGE CO**., Stony Man Mountain and vicinity in the Blue Ridge near Luray, 18 Aug 1901, *Steele 108* (MO); **SCOTT CO.,** Hilton, about Hampton, 25 Jul 1927, *Churchill 309*, (MO).

WEST VIRGINIA: GREENBRIER CO., Mayberry Hollow, 22 Jul 1930, *Berkley 1189* (MO); **MINERAL CO.**, in glade near Elk Garden, 20 Aug 1930, *Berkley 1626* (MO); **POCAHONTAS CO**., Drupe Mountain, 30 Jul 1930, *Berkley 1344* (MO); **RANDOLPH CO.**, Condon Run, Otter Creek, 18 Jul 1954, *Hutton Jr. 1211* (MO); **WEBSTER CO.**, Hacker Valley Twp., 7.7 mi S of Upshur County line, 17 Jul 1993, *Vincent 6283* (MU).

WISCONSIN: ASHLAND CO., Outer Island in Lake Superior, 23 Aug 1971, *Tans 29* (WIS); Devils Island, 1 Jul 1980, *Cochrane & Cochrane 9212* (WIS); **BAYFIELD CO.**, Bayview Township Park, 6 mi N of Washburn, shore of Chequamegon Bay, 24 Jul 1973, *Hansen 2020* (WIS); **BROWN CO**., near Green Bay shore, 22 Jul 1883, *Prucette s.n.* (WIS); **BURNETT CO.**, shore of Austin Lakes, Hertel, 20 Sep 1928, *Fassett 7721* (WIS); **COLUMBIA CO.**, Otsego, 26 Jul 1952, *Curtis s.n.* (WIS); **DANE CO.**, marshes of Mendota, Madison, 8 Jul 1890, *Cheney s.n.* (WIS); **DOUGLAS CO.**, Dergerman Rd. 3 mi N of Lake Nebagamon village, 24 Jul

1996, *Judziewicz 11977* (WIS); **FLORENCE CO**., NE side of Grandma Lake, 3.5 mi due SE of Long Lake, 7 Jul 1985,.*Cochrane 11190* (WIS); **IOWA CO**., Arena, 1 Aug 1929, *Davis s.n.* (WIS); ; **IRON CO.**, , 7 Sep 1959, *Iltis 15404* (WIS); **JACKSON CO.**, 2 mi E East Fork Campground, Black River State Forest, 13 Jul 1975, *Eickhoff 101* (WIS); **LINCOLN CO.**, near Wilderness Fire Tower, Corning, 13 Jul 1953, *Seymour 15375* (WIS); **MARQUETTE CO.**, 0.5 mile N of jct. 51 and Co. Rd. D, Packwaukee township, *s.d., Levy & Iltis s.n* (WIS); **MONROE CO.**, TA B30, 25 Jul 2001, *Williams 1098* (WIS) ; **OCONTO CO.**, Bagley, 5 Jul 1981, *Judziewicz 2210* (WIS); **ONEIDA CO.,** Hwy. D. Nokomis Lake, 5 Jul 1939, *Curtis 39-29* (WIS); **OZAUKEE CO**., Cedarburg bog, Jun 1953, *Jones s.n.* (WIS); **POLK CO.**, 1861, *Hale s.n.* (MO); **PORTAGE CO.**, Hwy. P, 16 Jul 1980, *Alverson 1622* (WIS); **PRICE CO.**, Ferrys Lake, Aug 1909, *Goessl s.n.* (WIS); **SAWYER CO.**, ca. 8 mi NE of Draper, 5 Jul 1973, *Hansen 1951* (WIS); **ST. CROIX CO**., St. Croix, 1861, *Hale s.n.* (MO, WIS); **TAYLOR CO.**, W side Mondeaux esker, Chequamegon National Forest, 18 Jul 1995, *Fields 2492* (WIS); **VILAS CO**., N shore of Camp Lake 7 mi N of Woodruff, 16 Jul 1983, *Kristen Meyer 33* (WIS); **WOOD CO**., June 1976, *Alverson & Mahack 1051* (WIS).

APPENDIX 2.

The Historic Distribution of *Platanthera clavellata* 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	Autauga, Clay, Elmore, Hale, Lee, Limestone, Madison, Tallapoosa, Tuscaloosa	W-1.
Arkansas	17 counties, mostly southwest and northeast	W-1; Smith (1978) [as *Habenaria clavellata*]
Connecticut	Every county [all 8]	W-1; Magee and Ahles (1999)
Delaware	Every county [all 3]	W-1.
District of Columbia	Present	W-1.
Florida	Calhoun, Gadsden, Liberty, Santa Rosa, Wakulla	W-1; W-3; W-4.
Georgia	15 counties, mostly northern 1/3 of state.	W-1.
Illinois	Cass, Cook, Iroquois, Jo Daviess, Kankakee, Lake, Lee, Pope, Will	W-1; W-3; Mohlenbrock and Ladd (1978) [as *Habenaria clavellata*]; Mohlenbrock (1986, 2002) [as *Platanthera clavellata*]; incl. Shawnee N.F.
Indiana	12 counties [De Kalb, Dubois, Elkhart, Jackson, Lagrange, Lake, La Porte, Martin, Monroe, Noble, Porter, Steuben]	W-1; W-3; Homoya (1993); includes Hoosier National Forest.
Iowa	Fayette, Muscatine [not collected since 1894]	W-1; D. Lewis (pers. comm.).
Kentucky	22 counties, scattered	W-1; includes Daniel Boone N.F.
Louisiana	20 parishes, northern half of the state.	W-1; MacRoberts (1989); Thomas and Allen (1993).
Maine	Every county	W-1; Magee and Ahles (1999).
Maryland	Allegany, Anne Arundel, Charles, Frederick, Harford, Montgomery, Prince Georges, Wicomico	Smith (unpublished atlas).
Massachusetts	Every county	W-1; Magee and Ahles (1999).
Michigan	At least 48 counties	W-1.

Minnesota	At least 12 counties, mostly eastern half of state	W-1; W-3; Ownbey and Morley (1991); includes the Chippewa N.F.
Mississippi	At least 12 counties; mostly absent along Mississippi River	W-1.
Missouri	Barry, Bollinger, Butler, Carter, Dunklin, Iron, Madison, Ripley, St. Francois, Stoddard, Wayne [southeastern corner of the state]	W-1; W-3; Yatskievych (1999); including Mark Twain N.F.
New Hampshire	Every county [10]	W-1; Magee and Ahles (1999).
New Jersey	At least 12 counties; absent in extreme southwestern part of state	W-1.
New York	At least 35 counties; least common in western limestone areas	W-1.
North Carolina	43 counties, scattered, most common in mountains	W-1; Radford *et al.* (1968); herbarium specimens.
North Dakota	Grand Forks	W-1.
Ohio	At least 19 counties; mostly northeastern and south-central areas of state	W-1.
Oklahoma	Bryan, Choctaw, Leflore, McCurtain, Pushmatahaw	W-1; W-3; Hoagland (2003).
Pennsylvania	At least 46 counties throughout, least frequent in west-central fourth of state	W-1; Wherry *et al.* (1979); Rhoads and Block (2000).
Rhode Island	Newport, Providence, Washington	W-1; Magee and Ahles (1999).
South Carolina	16 counties, widely scattered	W-1; Radford *et al.* (1968); herbarium specimens.
Tennessee	34 counties, Coastal plain, Cumberland Plateau, Mountains. Absent in limestone areas of middle of state.	W-1; Chester *et al.* (1993).
Texas	16 counties, eastern 1/3 of state.	W-1.
Vermont	Every county [13] except Washington	W-1; Magee and Ahles (1999).
Virginia	More than 70 counties; nearly every county.	W-1.
West Virginia	20 counties, mostly eastern and southern	W-1.
Wisconsin	At least 30 counties, least common in southeastern part of state.	W-1.

APPENDIX 3.

Natural Diversity Database Element Ranking System

Modified from: http://www.natureserve.org/explorer/ranking.htm [W-7]

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.