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Conservation Assessment

for the

Crested Coral-root Orchid

(Hexalectris spicata (Walter) Barnhart)

Steven R. Hill, Ph.D.

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

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SURVEY

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Hexalectris spicata (Walter) Barnhart, from Maryland Department of Natural Resources, Endangered Plants of Maryland website. Photographer: R. H. Wiegand.

http://www.dnr.state.md.us/wildlife/rteccroot.asp

Table of Contents

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EXECUTIVE SUMMARY

This Conservation Assessment is a review of the taxonomy, distribution, habitat, ecology, and status of the Crested Coral-root Orchid, *Hexalectris spicata* (Walt.) Barnh. var. *spicata*, throughout the United States, and in the U.S.D.A. Forest Service lands, Eastern Region (Region 9), in particular. This document also serves to update knowledge about potential threats and conservation efforts regarding the Crested Coral-root Orchid to date. *Hexalectris spicata* is a primarily subterranean mycotrophic perennial herb from a rhizome that occasionally produces a 25 cm to 1 meter tall raceme of rather attractive flowers above ground in order to reproduce. It is nearly always found in association with *Quercus* (Oak) trees. The typical variety is widespread in the southeastern United States southwest to northern Mexico, and it is known historically from twenty-two states, from Maryland west to Illinois, Missouri, Oklahoma, and Arizona south to northern Mexico and Florida. There is one additional variety recognized, var. *arizonica*, restricted to Arizona, New Mexico, and Texas. It is a species that grows in humus in normally rocky soils over calcareous substrates in open, usually well drained mesic to dry open woodlands. Globally, its ranking is G5 (secure world-wide); its National status in the United States is N4? (probably secure nationally). The Crested Coral-root Orchid is listed as Endangered in Florida (S3), Illinois (S1), and New Mexico (S2), as Threatened in Ohio (S3), as Rare in Indiana (S2), as Salvage Restricted in Arizona (S3S4) and as Extirpated (Historic only) in Maryland (SH). In Forest Service Region 9, the Crested Coral-root Orchid is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest where it has not yet been found. 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 and variety.

-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: *Hexalectris spicata* (Walt.) Barnh. (1904)
Common Names: Crested Coral-root Orchid, Crested Coral-root, Crested Coral Root, Spiked Crested Coralroot
Synonymy: *Arethusa spicata* Walt. (1788)
Bletia aphylla Nuttall (1818)
Hexalectris aphylla (Nuttall) Raf. (1825)
Hexalectris aphylla (Nuttall) Raf. ex S.Wats. & J.M.Coult. (1890)
Hexalectris squamosa Raf. (1838 '1836') *nom. illegit.*
Corallorhiza spicata (Walt.) Tidestrom (1941)
Hexalectris spicata fo. *albolabia* P.M. Br. (1995)

Class: Liliopsida (Flowering Plants - Monocotyledons)
Family: Orchidaceae (The Orchid Family)
Plants Code: HESPS3 (U.S.D.A. NRCS plant database, W-1)
http://plants.usda.gov/

The genus *Hexalectris* Raf. contains about 7 species worldwide, 5 of which are native to North America (Goldman *et al.* 2002). The genus is found only in the Western Hemisphere, and most species are tropical and in Mexico (south to Guatemala), but several species extend into the temperate zone north of Mexico. They generally occur in dry or mesic upland forests. In North America, the various species can be found on shaded slopes and dry rocky creek beds in canyons, in open oak-juniper-pine woodlands, and in limestone glades, often in rocky soils, from 0 – 2,500 meters in elevation. The genus is most closely related to the Neotropical genera *Basiphyllaea* Schlechter and *Bletia* Ruiz & Pavón (Goldman *et al.* 2002). The taxonomy within the genus is still being investigated, and a different number of accepted species and varieties may yet result (Goldman *et al.* 2002; Kennedy, pers. comm.). The name *Hexalectris* was derived from the Greek *hex*, meaning six, and *alectryon*, cock's-comb, referring to six longitudinal crests found on the floral lip. However, this name is not always appropriate because flowers of the various species may have five or seven crests on the lip (Goldman *et al.* 2002). The members of this genus are quite odd in that they possess neither roots nor leaves, being mycotrophic (~ saprophytic; but see life history below). The flowers are rather small, but generally showy, and they are easily recognized to be orchids.

The Crested Coral-root Orchid was first named by Tom Walter [in 1788] of South Carolina, who described the species within the genus *Arethusa*, the Dragon's-mouth Orchid, because of its superficial resemblance to that other genus known to him. The Latin epithet '*spicata*', equivalent to the English 'spicate' or 'in a spike' was used to describe the fact that there were several flowers on an axis, to distinguish it from the single terminal flowered *Arethusa bulbosa* that had been previously described by Linnaeus in 1753. The additional six species were

discovered and described subsequently (mostly in the 1940's), and placed along with this species into the genus *Hexalectris*, proposed by Rafinesque in 1825. Preliminary studies have suggested that *Hexalectris spicata* is within a closely related species complex along with *Hexalectris nitida* L.O.Williams, *Hexalectris parviflora* L.O.Williams, and *Hexalectris revoluta* Correll (Goldman *et al.* 2002). *Hexalectris spicata* itself has been recognized to contain two varieties, the typical variety, var. *spicata*, and the var. *arizonica* (S.Watson) Catling, restricted to Arizona, New Mexico, Texas and northern Mexico. This conservation assessment is intended to be restricted to the typical variety, though mention will also be made occasionally to var. *arizonica* when deemed appropriate. The var. *arizonica* may be of hybrid origin, but this remains to be determined and named hybrids have yet to be recognized and accepted (Goldman *et al.* 2002).

The common name Crested Coral-root is generally used as the common name for this plant, along with several others cited above. Because of the awareness and popularity of the orchids, however, this report refers to the species as the Crested Coral-root Orchid. The common name is based upon the crested lower petal already mentioned as well as to a fancied resemblance of the rather unusual articulate branching annular and stout compact rhizome of members of the genus to a mass of tropical coral. This common name can lead to some confusion with members of the genus *Corallorhiza* Gegnebin (literally 'coral-root'), the rhizomes of which also resemble coral and can even approach a coral-pink color, but the two genera are considered to be quite distinct.

DESCRIPTION OF THE SPECIES

Hexalectris spicata, the Crested Coral-root Orchid, is a somewhat soft-fleshy perennial terrestrial herb that is glabrous, leafless, rootless, and mycotrophic (~saprophytic), it lacks chlorophyll, and it usually grows in very local populations. The aerial **stems** are yellow-brown, pink-brown, or purple in color, and grow (15-) 25-80 (-90) cm tall (usually 25-35 cm tall in the Midwest). The **rhizomes** are thick, branching, articulate, annular (encircled at regular intervals by scars of successive sheathing bracts) and stout; there are generally 3-5 reduced sheathing bracts present. **Inflorescences** are racemes with (5-) 8-25 flowers towards their tips, and they actually make up the entire aboveground portion of the plant; floral bracts are lanceolate to triangular-ovate, 5-10 mm x 2-6 mm. The **flowers** (see cover illustration) are somewhat ascending at first and then more nodding with age, on pedicels 8-20 mm long, open at maturity (chasmogamous); the distinct sepals and petals are often apically recurved, yellow-tan to purple-brown with prominent purple or brown veins; the **dorsal sepal** is oblong-elliptic, obtuse, and 15-24 mm long x 4-8 mm wide; the **lateral sepals** are falcate, lanceolate or narrowly oblong and 14-20 mm x 5.5-9 mm, with an acute apex; **lateral petals** are narrowly obovate, oblanceolate, to narrowly elliptic, 14-23 mm x 5-9 mm; the **lip** is tan to purple-white, rarely entirely white, obovate to ovate, with undulate margins, shallowly 3-lobed with the middle lobe broadly fan-shaped, 13-20 mm x 8-16 mm; the prominent 5 (-7) lamellae (crests or longitudinal ridges) are central and basal, purple to white, and 0.7-1 mm tall; the white reproductive column is (11-) 13-18 mm long and apically winged, a rostrellum is present, and the anthers of the single stamen are whitish to yellow.

The **fruits** are pendent strongly ribbed ellipsoid capsules 16-30 mm x 8-20 mm with a somewhat flattened tip; the numerous seeds are 0.5-0.7 mm long. The **chromosome number** is apparently unknown. (Adapted from Yatskievych 1999 and Goldman *et al.* 2002).

The Crested Coral-root Orchid is the most widespread temperate species and variety of *Hexalectris*, and the only one that occurs east of Texas. It is normally recognized and distinguished from other species of the genus by its relatively long lateral sepals (more than 12 mm), its tan to purple-white or white lip (slightly recurved, not dark purple), and by its shallowly (not deeply) lobed lip with 5-7 typically purple to white lamellae (crests; not 3-7 obscure white to yellow lamellae). It can be distinguished from similar occasionally leafless orchids within its range (*i.e.*, *Aplectrum*, *Corallorhiza*, *Spiranthes*, and *Tipularia*) by the flower's lack of a conspicuous spur (unlike *Tipularia*), by its racemose, non-white flowers (unlike *Spiranthes*), and by its longer sepals and lip, the latter having 5-7 prominent ridges (eliminating *Aplectrum* and *Corallorhiza* with shorter 3-15 mm sepals and 2.5-12 mm lip having 1-3 low ridges). *Corallorhiza* is the only other genus among these five that totally lacks chlorophyll and that never develops leaves. *Hexalectris spicata* is sometimes confused with *Corallorhiza striata* Lindl., but, unlike the latter species, the lip has a three-lobed shape and distinctive ridges down the central lobe. *Hexalectris spicata* var. *arizonica* differs from the typical variety by the fact that the flowers remain closed (cleistogamous) and self-pollinate, the rostrellum is reduced or absent, the lamellae are reduced to 0.2-0.7 mm, and the petals are also smaller, measuring less than 16 mm x 5 mm (Goldman *et al.* 2002).

HABITAT AND ECOLOGY

The Crested Coral-root Orchid has been given a national wetland indicator status of UPL, FACU, indicating that the species almost always occurs (estimated probability 99%) in non-wetlands. Rarely, it can occur in wetlands (estimated probability 1% - 3%). In Wetland Region 3, including both Illinois and Indiana, *Hexalectris spicata* has been specifically designated as a UPL species (Reed 1988; W-1; W-2). It prefers upland forest communities, and especially Xeric oak forests, Dry oak-hickory forests, (mafic), and Dry-mesic oak-hickory forests (mafic), all plant communities / associations that are ranked as imperiled or vulnerable globally (W-3). It is nearly always found in association with *Quercus* (Oak) trees. Overall, these habitats can include dry (or mesic) upland forests, shaded slopes and dry rocky creek beds in canyons, open oak-juniper-pine woodlands, and in limestone glades, often in humus-rich rocky soils, from 0 – 600 meters east and north of Texas, and between 1,600 meters – 2,000 meters in elevation in the westernmost portion of its range. Most frequently, the habitat is characteristically seasonally very dry and open, and it grows in areas where competition from other plants is minimal (Shawnee National Forest 2005). It appears to be most common in portions of Alabama, Florida, Kentucky, North Carolina, Tennessee, and Virginia in calcareous areas, but it can be found at wide range of elevations and climates, and it can be found in both wet and dry habitats in

different portions of its range; it does appear to be cold sensitive, and it does not occur north of the maximum southern Pleistocene glacial boundary.

A review of the literature demonstrates that this herb has a somewhat limited variety of plant associates and habitats throughout its range. *Hexalectris spicata* grows mainly in humus-rich, mesic to dry soils over limestone or sandstone, especially in the vicinity of individuals of the genera *Juniperus*, *Pinus*, or, especially, *Quercus*. Floras have described the habitat of *Hexalectris spicata* as "Dry woods" (Fernald 1950), "Woods" (Gleason and Cronquist 1991), "dry woodlands, especially over calcareous rocks" in the Blue Ridge physiographic province (Georgia, North Carolina, South Carolina, Tennessee, and Virginia; Wofford 1989), "Circumneutral or calcareous soils of rocky woods and woodland stream margins" in North and South Carolina (Radford *et al.* 1968), and "In moist shady soil on stream banks, in creek basins, grassy woodlands, canyons, cedar thickets, usually associated with limestone" in Texas (Correll and Johnston 1970). In Florida it is found in calcareous hammocks and shell middens (Wunderlin 1998).

The soils where the Crested Coral-root Orchid grows are formed over limestone, dolomite, or sandstone, they are normally rich in humus, and they can be basic to acidic if there is a sufficient humus buildup (Goldman *et al.* 2002).

In Indiana the Crested Coral-root Orchid grows on forested hills and slopes in extreme southern Indiana (Deam 1940), and it is restricted to the dry, rocky slopes where limestone bedrock is evident (Homoya 1993). The plant is most common on slopes bordering limestone glades where heat and drought are at their extreme. These dry conditions are sparsely vegetated, and the associates in this habitat are usually dwarfed individuals of the trees *Cercis canadensis*, *Fraxinus quadrangulata*, *Juniperus virginiana, Quercus prinoides*, *Quercus stellata*, *Ulmus alata*, and *Viburnum rufidulum*. Associated vines commonly include *Dioscorea quaternata* and *Parthenocissus quinquefolia*. Associated herbs can include *Allium cernuum*, *Dodecatheon meadia*, *Euphorbia corollata*, *Frasera caroliniensis*, *Helianthus hirsutus*, *Lithospermum canescens*, *Thaspium barbinode*, *Thaspium trifoliatum*, and *Viola sororia* (Homoya 1993). Deam (1940) indicated that he had found it associated with *Quercus alba* and *Quercus velutina*. Homoya (1993) also indicated that he had seen this orchid growing in full sun in a grassy limestone glade, with *Allium cernuum*, *Blephilia ciliata*, *Liatris squarrosa*, *Lobelia spicata*, *Manfreda virginica*, *Schizachyrium scoparium*, *Scleria oligantha*, and *Silphium trifoliatum*. Most populations in Indiana occur close to the Ohio River in the Muscatatuck Flats and Canyons Section of the Bluegrass Natural Region, one population occurs within the Highland Rim Natural Region, and it may also occur in the Shawnee Hills Natural Region (Homoya 1993). A detailed description of the habitat and associated species for this orchid in Indiana has been presented by Homoya (1993).

In Illinois, the Crested Coral-root Orchid grows in "Dry woods, limestone ledges" also in

the extreme south of the state in habitats similar to those where it is found in Indiana (Mohlenbrock 1986, 2002). Herbarium labels on specimens in the Illinois Natural History Survey herbarium (ILLS) included the habitats 'wooded bluff', and 'wooded ravine-hill prairie border'. Its usual associates in Illinois are the same as listed for Indiana. Winterringer (1950) described its habitat as an open oak-hickory (*Quercus – Carya*) woods mixed with prairie openings on a rocky limestone slope, and its immediate associates were the small shrubs *Ceanothus americanus* and *Rhus aromatica*, the perennial forbs *Monarda bradburiana, Dalea candida, Ratibida pinnata, Rudbeckia hirta*, and *Vernonia baldwinii*, and the grass *Elymus hystrix*. A detailed description of the habitat and associated species for this orchid in Illinois has been given by Sheviak (1974).

In Missouri, where it reaches its northern range limit, the Crested Coral-root Orchid also occurs in calcareous soil over limestone and dolomite in dry upland forests and limestone glades on bluff tops, often in association with *Juniperus* in the glades (Summers 1987, Yatskievych 1999) in the Ozark and Ozark Border Divisions. Among the species associates reported as dominants with this orchid are the trees *Acer saccharum*, *Juniperus virginiana*, and *Quercus montana*.

In Virginia and Maryland, the Crested Coral-root Orchid has been found in patches of dry, open calcareous forests in the Inner Coastal Plain, as well as in the interior. The ecological association name of this threatened community is the *Quercus muehlenbergii – Erigeron pulchellus – Dichanthelium boscii – (Verbesina virginica)* Forest (W-3). Other associates in this Forest type are the trees *Acer barbatum*, *Carya cordiformis*, *Fagus grandifolia, Fraxinus americana, Quercus alba, Quercus rubra,* and *Quercus montana*, the shrub *Viburnum rufidulum*, the vine *Celastrus scandens*, the forbs *Agrimonia rostellata, Aristolochia serpentaria, Galium circaezans, Senecio aureus, Verbesina occidentalis,* and the grasses *Bromus pubescens*, *Dichanthelium commutatum*, and *Sorghastrum elliottii*.

In Florida, *Hexalectris spicata* has been collected on hardwood hammocks along rivers and near sinkholes over limestone bedrock, growing in humus with *Sabal palmetto* and *Quercus virginiana, Juniperus* sp., *Persea americana, Yucca sp.,* (data from herbarium specimens; W-4) and the orchid *Triphora trianthophora* and the fern *Botrychium* sp. In this part of the country, the plants are very robust and have been confused with individuals of *Eulophia alta*. Plants have been described as being in clumps or single.

In Oklahoma, this rare orchid has been found in several habitats, including an oak-hickory woods, near a sphagnum bog, in sandy loam soil; in a post oak (*Quercus stellata*) - blackjack oak (*Quercus marilandica*) woods over outcropping sandstone; in a pine-oak woods in loam soil; in a woodland in cherty soil; in a oak-hickory woods on an alluvial flood plain in loam; in leaf mold in an oak-hickory forest near an amphibious landing on a lake; and in a canyon at the base of a hickory tree (Magrath and Taylor in Taylor 1978). Populations sizes are generally very small, less than a dozen plants, but at one site (the post oak – blackjack oak woods) several hundred

stems were counted in one population.

In Texas, *Hexalectris spicata* has been found in humus litter on west facing slopes on the northeast side of a creek in Cass County (and elsewhere), growing in a mesic upland forest with the trees *Acer rubrum*, *Quercus alba*, and *Quercus shumardii*, the shrubs *Asimina triloba* and *Vaccinium elliottii*, the forbs *Heuchera americana*, *Mitchella repens*, *Pedicularis canadensis*, *Phryma leptostachya*, *Silene stellata*, *Silene virginica*, and *Thalictrum dasycarpum*, and with the fern *Polystichum acrostichoides* (Singhurst *et al.* 2002). This association normally indicates circumneutral to acidic soils.

DISTRIBUTION AND ABUNDANCE

Hexalectris spicata var. *spicata*, the Crested Coral-root Orchid, is widespread in portions of the temperate eastern and southeastern United States, with outliers to the south and west, and it has been found historically in twenty-two states, namely, Alabama, Arizona, Arkansas, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New Mexico, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia (W-1, W-3; Goldman *et al.* 2002). It also occurs in adjacent northern Mexico. *Hexalectris spicata* is relatively rare in the extreme northeastern portions of its range. It appears to be most common in portions of Alabama, Florida, Kentucky, North Carolina, Tennessee, and Virginia (W-3). Its range appears to include only formerly unglaciated areas. As with most other species, it becomes scarce at the margins of its range. Its historic range assessed on a county basis was undoubtedly greater than its current range. One can generally expect that a decline has occurred in recent decades because of the general loss and degradation of its habitats nationally resulting in local extinctions.

Hexalectris spicata var. *arizonica* is restricted to small areas of Arizona, New Mexico, and Texas. Records for this variety can be confused with those for the typical variety, the subject of this assessment. They may or may not occur together in a few counties in these states.

Based upon its state rankings (W-3) only, the Crested Coral-root Orchid would appear to be most frequent in Kentucky (as a S4 species) and in Alabama and Arizona (as an S3S4 species). However, in Arizona this orchid is protected as a 'Salvage restricted' species. It is not ranked in five of the twenty-two states from which it has been reported (W-3), so its frequency cannot be precisely determined in those states. The Crested Coral-root Orchid is very local within most of its range because of its habitat preferences and unusual or specialized life history (W-3). A combination of records from several sources (see appendices) gives somewhat different results on the frequency of *Hexalectris spicata*. Records from floras and herbarium labels show that this orchid has been found in more than 20 counties in Florida and Virginia, and in more than 10 counties in Kentucky, Mississippi, Missouri, North Carolina, and Tennessee. In the remaining

fifteen states *Hexalectris spicata* has been found in 10 or fewer counties. Additional details on the distribution of this herb can be found in Kartesz and Meacham (1999), Coleman (2002), 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 Crested Coral-root Orchid has been presented in Appendix 2.

In the east-central states, the species has been found in Illinois and in Indiana, as well as in neighboring Kentucky and Missouri, but not in Iowa or Wisconsin (W-3; Yatskievych 1999, Mohlenbrock and Ladd 1978, Deam 1940). The species has been listed as historic only (SH) in Maryland and it may also have been extirpated in several other states where it has not been seen in recent decades (W-1, W-3).

Within the U.S. Forest Service Eastern Region (Region 9) *Hexalectris spicata* is known to be present within the Shawnee National Forest in Illinois, the Monongahela National Forest in West Virginia, and in the Mark Twain National Forest in Missouri. It may also occur in the George Washington National Forest in West Virginia. It is apparently more common in the Southern Region (Region 8) and its known range suggests that it occurs within the Bankhead and Talladega National Forests in Alabama, the Ozark National Forest in Arkansas, the Apalachicola, Ocala, and Osceola National Forests in Florida, the Chattahoochee National Forest in Georgia, the Daniel Boone National Forest in Kentucky, the Kisatchie National Forest in Louisiana, the DeSoto, Tombigbee, and Holly Springs National Forests in Mississippi, the Mark Twain National Forest in Missouri, the Pisgah National Forest in North 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.

In Illinois where the species is listed as Endangered, *Hexalectris spicata* has been reported historically in Hardin, Jackson, Monroe, Pope, and Randolph counties (W-1; Herkert and Ebinger 2002, Mohlenbrock 1986, 2002; Mohlenbrock and Ladd 1978; Shawnee National Forest 2005). This orchid was first discovered in Illinois in Randolph County in 1949 (Winterringer 1950). Its current distribution, as far as is known, includes only Hardin and Monroe counties. It is found in dry calcareous woods and dry prairie openings primarily along the Mississippi River bluffs and on limestone glades within the Shawnee National Forest. The Monroe County population is within a state nature preserve (Herkert and Ebinger 2002). Within the Shawnee National Forest it has been found recently within the Whoopie Cat Mountain Research Natural Area (RNA) and in the Barker Bluff RNA, and it is suspected to occur at the Leisure City Barrens Ecological Area (Shawnee National Forest 2005). Few flowering individuals are ever seen in Illinois, and, because the plants remain underground unless flowering, they may remain at a site for many years unnoticed. These sites are located within the Northern and Central Sections of the Ozark Natural Division and the Lesser and Greater Shawnee Hills Sections of the Shawnee Hills Natural Division of Illinois (Schwegman *et al.* 1973).

In Indiana where the species is listed as Rare, *Hexalectris spicata* has been reported in Clark, Floyd, Harrison, and Washington counties and, probably, Crawford County (W-1; Deam 1940; Homoya 1993, Yatskievych 2000). Most populations in Indiana occur close to the Ohio River in the Muscatatuck Flats and Canyons Section of the Bluegrass Natural Region, one population occurs within the Highland Rim Natural Region, and it may also occur in the Shawnee Hills Natural Region (Homoya 1993).

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. In Illinois, the species was discovered only in 1949, and most of our current records have been found within the last two decades. The forests in the region before European settlement are thought to have been kept more open by means of fires set by the earlier inhabitants in the area, and there is some evidence that *Hexalectris spicata* prefers and reproduces better in open forest areas (Homoya 1993; Shawnee National Forest 2005). The suppression of fires later may have led to a decline in the number of populations. It is also likely that some open dry woodlands where it may have occurred have been developed or disturbed by agriculture and housing in the past 200 years, in which case there may have been a significant population decline as well for that reason.

There is some data available on population sizes for this herb, but herbarium label data rarely include its local frequency or abundance. According to personnel at the Shawnee National Forest (2005), the Whoopie Cat Mountain RNA population was discovered in 1976 when 29 plants were found, and in 1989 13 plants appeared following a prescribed burn in the dry woodland; in 1994, only 3 flowering plants were found. The Barker Bluff RNA population was discovered in 1993 with 17 plants and it was last seen in 1994 with 8 flowering plants. In other portions of its range, populations of several hundred flowering individuals have been reported at a single site. Specimens from Florida have indicated population sizes of 10-15 plants, and about a dozen flowering individuals appears to be typical in many populations overall. In Oklahoma, this orchid has been found generally in small populations of less than a dozen flowering plants in at least 5 sites. At one of those sites, however, this orchid was locally abundant and several hundred flowering stems were found (Magrath and Taylor in Taylor 1978). There is no data on actual population sizes where this species grows, because the plants not only are hidden underground, but they do not flower every year. It would seem that only very long-term observations at a given site or a very careful excavation at a site would produce reliable data on the actual population sizes of this orchid.

PROTECTION STATUS

The Nature Conservancy currently ranks *Hexalectris spicata,* the Crested Coral-root 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 N4? (tentatively secure nationally). The typical variety, *Hexalectris spicata* var. *spicata*, is listed as a G5T4T5 plant with a rounded global status of T4 (apparently secure). The much less common var. *arizonica* has been ranked as a G5T2T4 plant rounded to T3 (Vulnerable). The varieties have not been ranked nationally (NNR).

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 somewhat. *Hexalectris spicata* is listed as Endangered in Florida (S3), Illinois (S1; Illinois Endangered Species Protection Board 2005), and New Mexico (S2), as Threatened in Ohio (S3), as Rare in Indiana (S2), as Salvage Restricted in Arizona (S3S4) and as Extirpated (Historic only) in Maryland (SH). It has been listed as Critically Imperiled (S1) in Illinois and West Virginia, as nearly Critically Imperiled (S1S2) in Oklahoma, and as Imperiled (S2) in Arkansas, Indiana, Louisiana, Mississippi, New Mexico, and North Carolina. It is considered Vulnerable (S3) in Florida, Georgia (as S3?), Ohio, and Virginia, and slightly less so (S3S4) in Alabama and Arizona. This orchid remains unranked in the remaining five states from which it has been reported. It is at risk at the margins of its range. The var. *arizonica* has not been ranked (SNR) within any state where it occurs.

In Forest Service Region 9, the Crested Coral-root Orchid is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest and the Monongahela National Forest in West Virginia but not the Hoosier National Forest, where it has not yet been found (W-5; Shawnee National Forest 2005). It is known to be present within the Mark Twain National Forest in Missouri but it has not been designated to be at risk there.

Table 1 lists the official state rank for *Hexalectris spicata* assigned by each state's Natural Heritage program according to the Nature Conservancy at their Internet site (W-3). In this table, it is assumed that if only a single variety occurs within a given state that the rank of the typical variety is the same as that for the species overall. Appendix 3 explains the meanings of the acronyms used (W-6).

A summary of the current official protection status for *Hexalectris spicata* follows:

U.S. Fish and Wildlife Service:	Not listed (None)
U.S. Forest Service:	At risk in the Shawnee National Forest and the Monongahela National Forest, Region 9
Global Heritage Status Rank:	G5 (species); G5T4T5 rounded to T4 (var. *spicata*)
U.S. National Heritage Status Rank:	N4? (species); NNR (var. *spicata*)

Table 1: S-ranks for *Hexalectris spicata* in the United States [Heritage Element Codes: PMORC1C040 (species); PMORC1C042, var. *spicata*)]

State/Province	Heritage S-rank		State/Province	Heritage S-rank	
Alabama	S3S4		Maryland	SH	[Extirpated]
Arizona	S3S4	[Salvage Restricted]	Mississippi	S2	
Arkansas	S2		Missouri	SNR	
Florida	S3	[Endangered]	New Mexico	S2	[Endangered]
Georgia	S3?		North Carolina	S2	
Illinois	S1	[Endangered]	Ohio	S3	[Threatened]
Indiana	S2	[Rare]	Oklahoma	S1S2	
Kansas	S1		South Carolina	SNR	
Kentucky	S4		Tennessee	SNR	
Louisiana	S2		Texas	SNR	
			Virginia	S3	
			West Virginia	S1	

LIFE HISTORY

Hexalectris spicata is a somewhat fleshy, erect perennial herb; however, except for the flowering stem, the plant is subterranean (it lives entirely underground) and has no chlorophyll, leaves, or roots. Because it has no chlorophyll, it has no need to appear above ground except for reproduction, and it does not use sunlight to make its food like most other plants. Instead, the body of the plant, a rhizome, lives in association with fungi, and the fungal hyphae function as root hairs to absorb water and nutrients, plus the fungus breaks down plant debris into chemical nutrients that the orchid can use for its own growth. Its flowers are medium-sized and showy, suggesting a need for insect pollination, though *Hexalectris spicata* var. *arizonica*, in contrast, often has cleistogamous flowers that pollinate themselves (autogamous) and never open (Goldman *et al.* 2002). Nothing is known about the pollinators of *Hexalectris spicata* (Kennedy, pers. comm.). In one case in Indiana a bumblebee (*Bombus impatiens*) was observed visiting the flowers, but no pollinia were found on its body (W-7); in that same study, tests determined that *Hexalectris spicata* has no detectable scent, and so scent appears to be a minimal factor in attracting pollinators.

The life history of orchids is among the most complicated in all of the flowering plants, and much specific information is lacking for most individual species. What is known is that orchid seeds are very small and dust-like, and they lack the endosperm that feeds most flowering plants in their early development. Developing orchid embryos and seedlings must, instead, get their nutrition from other sources, and this source is usually decaying organic matter, or, in some species, another plant. However, orchids are actually not capable of true parasitism or

saprophytism (though the latter term is often used to describe the orchid – fungus association) and their nutrition is provided through mycorrhizae, a symbiotic relationship between vascular plants and a saprophytic or parasitic fungus. More correctly, this relationship is termed *mycotrophic* (see below). Apparently, temperate zone orchids are not very species specific in their associated fungal partners, and several fungi may be involved. Members of the fungal family Sebacinaceae (within the jelly fungi, Basidiomycota) have been found to be the primary mycorrhizal fungi in every *Hexalectris* so far studied (Taylor *et al.* 2003). 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.

Species such as the Crested Coral-root Orchid, and members of several other genera, have given up photosynthesis entirely and rely upon fungal produced nutrition throughout their life cycles. Plants that are completely dependent on this form of nutrition and that have lost photosynthetic capabilities are described as fully myco-heterotrophic (Taylor *et al.* 2003) or mycotrophic in general. 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). Beyond this, little is known about the life history of these orchids. 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 *Hexalectris*. The fact that the plant develops under ground makes this especially difficult to observe.

Flowering in *Hexalectris* is known to be very erratic, and the controls on this are unknown. It is commonly known that flowers may or may not appear at a given site in successive years, only to emerge again at some later date. The environmental factors controlling flowering in this orchid may be rainfall, temperature, nutrient availability, or a combination of these with some other factors. The complex life history makes studies of flower triggering extremely difficult to undertake in this and other similar genera. The percentage of seed success in the wild also is not known and there is little data on fruit production for this species. The seedlings are subterranean, and both they and adult plants are simply not seen until they flower. It is also not known if these orchids can propagate vegetatively because connecting rhizomes between plants have not been demonstrated.

The plant is probably edible to humans and most animals, as are most orchids, but studies or observations on predation of either the above ground or subterranean parts are not known. One can speculate that animals such as feral pigs may be able to find the underground tubers by their aroma and consume them. The fact that most of the plants live in very rocky ground suggests that they are susceptible to rodents and other burrowing animals, and that the rocky ground helps to protect them from predation. The flower stalks may be vulnerable to foraging by deer, rabbits, and other animals (see threats below).

Crested Coral-root Orchid flowers, on average, from early July to late August in most portions of its range. According to Goldman *et al.* (2002), *Hexalectris spicata* var. *spicata* can flower as early as April in the southern portions of its range. In Texas, this orchid has been found in flower as early as 8 April (Singhurst *et al.* 2002). In Florida this orchid is known to flower at least from 18 May to 20 June, and it appears capable of flowering also much later in the year, at least until the end of October (based on herbarium specimens; W-4). Summers (1987) states that its flowering time in Missouri, at its northern range limit, is mid-July to September. According to Coleman (2002), *Hexalectris spicata* var. *spicata* flowers from mid-June to early July, while var. *arizonica* flowers from late July to Late August in Arizona (May to July in New Mexico). The plants of both varieties rarely flower 2 years in a row and more often skip several years before reappearing. In both varieties, a significant percentage (10-80%) of spikes and buds abort without fully developing, and others are browsed upon by animals (Coleman 2002; Kennedy, pers. comm.). In Texas, Aaron Kennedy (pers. comm.) noted the following: "…I have seen *H. spicata* var. *spicata* in flower in Dallas, TX in early August, and from the same population where all other plants flowered in mid-May and were currently in mature fruit."

Fruits are produced as early as 16 June in Florida (and Texas?) and as late as November in the same areas, but in most portions of its range, fruit production occurs in early August - September (based upon herbarium specimens). The wilted flowers persist on the capsules. This orchid is rarely collected in fruit, however, so data is spotty. According to Summers (1987), in fall and winter the dried stalks and capsules of this species somewhat resemble those of *Aplectrum hyemale*, but they differ in being obovoid with a broad, rounded end and are on short stalks, whereas those of the *Aplectrum* are sessile and elliptical. 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.

POPULATION BIOLOGY AND VIABILITY

Hexalectris spicata var. *spicata*, as discussed in the previous section, rarely flowers predictably throughout its range, yet it has no known reproductive problems. According to observations in Illinois (Shawnee National Forest 2005), open sunny areas and fires appear to benefit this species. At least in Illinois, this orchid prefers open dry open calcareous forests as well as dry prairie openings. At least here, it is considered by some to be a fire-dependent species. It is not so certain that this holds true everywhere in its range, because many populations are located in more mesic forests that seem not to have burned recently. Overall, the species does appear to prefer open, rather well drained areas, but this may be correlated just as well with the shallow rocky habitats (unsuitable for many deep-rooted plants) it prefers as with fire history. Mycorrhizal plants can live for many years underground as they obtain nutrition from their fungal symbionts, and flowering need not depend upon the amount of sunlight that illuminates the ground above them. It is possible that a fire may contribute a sudden influx of nutrients, such

as phosphorus, a nutrient well known to stimulate flowering. This, in a moist year, may result in the sudden flowering within a colony of this orchid that was otherwise not known to be in the area. The elimination of the tree canopy, or encroaching shrubs and other vegetation may not be the cause for the apparent sudden appearance of a colony; instead it may be a collateral or incidental effect.

As far as is known, this herb grows in widely scattered and often isolated sites not only at the margins of its range but throughout most of its range. There appears to be very little interaction (pollen dispersal or seed exchange) with other populations of the same species in other areas because of the erratic nature of its flowering. Populations of the Crested Coral-root Orchid may persist at a site and remain viable for many years in the subterranean form, and, because of this, the number of individuals is essentially impossible to determine. Most of our population data is based upon counts of the occasional flower stalks that appear in a known population – and the actual careful excavation of an entire population to determine the true number of individuals per square meter has not been done, as far as is known. There would be considerable resistance by many organizations to that kind of study on this orchid because of a fear of damage to the plants and because it is rare in so much of its range.

It is generally understood by botanists that fertility is normally reduced in inbred populations through the process of autogamy (self-fertilization). Autogamy is useful to the plant when there are small numbers of individuals per area, since the safeguarding of the success of propagation is more important than the production of new genotypes. *Hexalectris spicata* var. *spicata* generally avoids the possibility of inbreeding because the pollen masses are prevented from reaching the receptive portion of the pistil column by means of a structure called the rostrellum – a type of shield. However, because of this specialized pollination mechanism, as in most orchids, few flowers are pollinated and even fewer produce mature fruits. Individuals in such a population can, however, be very closely related, and can even be progeny from a single introduction event, and so they can posses little genetic variability. Fertilization by siblings is the most likely outcome in such cases because there is almost no chance of fertilization by other genotypes unless they are within dispersal range. The populations of this herb in Illinois are isolated from one another and from those in other states. In theory, continued fertilization within a group of closely related individuals can result in severe reproductive problems in these few isolated populations, and successful seed production as well as the genetic variation that allows competition with other species may be compromised (W-8).

An example of negative effects thought to have arisen through isolation of populations can be seen in the case of another monocot, Ofer Hollow Reedgrass (*Calamagrostis porteri* ssp. *insperata* (Swallen) C.W.Greene), which has become isolated on rather similar dry sandstone bluffs throughout its range. This grass almost never produces viable seed anywhere in its range and this reproductive failure may be a reflection of a high genetic load that has occurred as a result of its long isolation (see Hill 2003). 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 *Hexalectris spicata* seeds produced in the Illinois and Indiana populations. While it is a vulnerable species in the Midwest, the Crested Coral-root Orchid does appear to be secure in other areas with 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 Crested Coral-root Orchid is considered to be secure (see Protection Status above), though this seems somewhat surprising considering the fact that the species is sensitive in so many states. In Maryland, the species has been extirpated and so is known from historic records only. This orchid is either critically imperiled or imperiled in 48 % (10 of the remaining 21 states) of the states where it occurs. In four of the remaining 11 states, it is vulnerable, and it has been ranked as secure in only one state (Kentucky; W-3).

Known threats to *Hexalectris spicata* var. *spicata* include habitat loss as a result of human activities, forest management practices, habitat fragmentation, deer herbivory, and, according to some, soil disturbance and compaction (W-3; W-9; Shawnee National Forest 2005). According to the Southern Appalachian Species Viability Project (2002), "*Hexalectris spicata* is a wide ranging but infrequently occurring species that is somewhat threatened by land-use conversion [loss], habitat fragmentation, and forest management practices." It is well known to be limited by its naturally limited habitat that is dependent on the geologic substrate and also the canopy structure (closed or with gaps). However, it should also be pointed out that there is limited direct information concerning these threats.

Because of its relationship with symbiotic fungi, *Hexalectris spicata* is sensitive to soil disturbance and compaction (W-10, W-11) which often results from tree harvesting activities. In the southwest the habitat of the species is threatened by mining activities (W-11). This orchid is thought by some to be highly threatened by forest management practices (particularly by heavy logging and clearcutting), and to a lesser extent by land-use conversion and habitat fragmentation. It is thought that there has been a loss of populations on private land within its range. Additional threats include grazing, flooding by impoundment (where this would be possible), construction, and quarrying.

Throughout its range, populations appear to have been eliminated by human activities (as best evidenced in Maryland where the species has been extirpated). It is well known that many acres of forest, savanna, and prairie have been lost through clearing for agricultural use as well as for construction of various kinds. The habitat for this 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 humus and soil nutrients or composition), and substrate changes (*i.e.* stream alterations, road and building construction) would be detrimental. 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 likely be detrimental. 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.

Observations suggest that *Hexalectris spicata* requires fairly open surroundings in order to flower, and so the increase in vegetation density that often follows human disturbance (such as the intensive logging of mature forests) may also threaten populations. The use of fire management has been thought to have positive effects on this species, as at the Whoopie Cat Mountain Research Natural Area within Shawnee National Forest (2005). Therefore, some human intervention may be beneficial in the form of fire management. It is not certain, however, that the actual opening of the canopy or forest in general is the reason for the increased flowering, because the addition of significant nutrients to the soil after a fire may also be a major factor. There is no evidence that the natural closure of the forest canopy threatens this orchid, which does not require sunlight for photosynthesis, and so the removal of vegetation by means other than fire may not be necessary.

Competition from invasive species has not yet been demonstrated to be a threat to this species, though it is a known threat to many scarce photosynthetic species. It is also not known if agricultural nutrient runoff from croplands presents a threat to the species, but it is likely that runoff, drift, or the direct application of fungicides (or herbicides) would present a serious threat to this orchid because of its absolute dependence on its symbiotic fungi.

The destructive effects of herbivory on *Hexalectris spicata* and other scarce plants by various animals, especially deer, have been suggested in the literature (USDA / APHIS / Wildlife Services 2001; Fletcher *et al.* 2001; W-9). Fletcher *et al.* (2001) studied predation on the Turk's-cap Lily by rodents and deer in Virginia. The rodents (*Peromyscus leucopus*, *Sciurus* sp., and *Tamias striatus*) dug up and consumed 9% of all the bulbs and underground rhizomes planted in the study, and fatal rodent damage was 3 times greater in successional than in upland hardwood and creek bottom habitats. White-tailed deer (*Odocoileus virginianus*) consumed the apical meristem of 28% of the unprotected lilies that emerged, reducing mean plant height and stopping growth and reproduction for that season. Deer and insects, but not rodents, damaged a greater proportion of plants emerging in small patches (1-2 plants/0.04 ha) than on larger patches (3-20 plants/0.04 ha). The consumption of the buds and flowers is often the case for other species of lilies and orchids as well. Therefore, when protecting remaining populations or restoring new populations of rare perennial wildflowers in the eastern deciduous forest, methods for protecting plants from herbivory by rodents and white-tailed deer should be considered. Deer often use existing footpaths for travel through forested terrain, and, conversely, many footpaths have begun as deer trails, so that the chances for deer to encounter *Hexalectris spicata* 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 Crested Coral-root 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 and slugs probably eat the plant as the tender new flower stalks of these orchids emerge.

Over-collection has not yet been indicated as a threat to this orchid as it has with many other orchids. It is well known that the Crested Coral-root 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. Also, mycotrophic plants in general are not desired in gardens because leaves never develop. The species is extremely difficult to propagate, and no nurseries are known to sell the plant.

As stated in the previous section on Population Biology and Viability, it is generally believed among biologists that habitat fragmentation can also have profound effects on the success and persistence of small local populations through a process known as inbreeding depression. According to the study by Fletcher *et al.* (2001), current land-use changes in eastern deciduous forests, such as fragmentation, may affect population sizes of native wildlife that may exacerbate declines in rare and endangered wildflower populations in the eastern deciduous forests. Over time, as populations become increasingly more isolated, the effects of fragmentation can potentially be observed at the molecular level by reduced genetic frequencies caused by random drift (Barrett and Kohn 1991). When one is considering populations that are already isolated, as in the case of most known populations of this plant, random genetic drift may have already occurred and this may have caused negative effects to the species. This genetic drift may cause the individuals to be less adaptive to competition and environmental change.

At the current time, however, *Hexalectris spicata* appears to be secure within the Shawnee National Forest provided there is some active management and land protection (Shawnee National Forest 2005).

RESEARCH AND MONITORING

The Crested Coral-root Orchid has been the subject of study in several parts of its range, and at least one study (by A. Kennedy at Miami University) is continuing. In Illinois, recent observations by Shimp and others (Shawnee National Forest 2005) have helped to increase the understanding of the species as it occurs in this region. Several basic research needs are still called for, including the continued examination of the widely scattered and possibly misidentified herbarium specimens of this orchid to determine its current and historic range throughout the Midwest region. Fieldwork is an integral part of continued research and monitoring and can be concurrent, and new populations may continue to be found as well. Because *Hexalectris spicata* seldom flowers and because the sterile plants are essentially impossible to notice in the wild, additional populations may actually be present in Illinois and Indiana, and elsewhere, as Shimp and others already have clearly demonstrated (Shawnee National Forest 2005).

Only a little information is known concerning the life history of the plant and there is still a tremendous amount to learn about this orchid concerning its fertility, pollinators, population sizes, early establishment requirements, 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, to determine if vegetative reproduction is possible, and to determine the controlling factors on the initial formation of the symbiotic relationship with fungal symbionts. Some research on the symbionts has already been done, but much of the relationship is still unknown (see Life History above).

Annual or periodic monitoring of existing populations of the Crested Coral-root Orchid may be essential to the local survival of this species. In parts of its range, both in areas where it is declining and in areas where it is still relatively common, periodic monitoring is needed not only to supply data on the life history of this herb, but also to evaluate the threats to its habitat caused by habitat degradation or destruction, and from threats by animal foragers. The potential threats from foraging native and domestic animals should not be underestimated because of the edibility of this orchid, and animals such as deer may specifically seek it out. Population stability, reproduction, and vigor should all be monitored, and new methods for monitoring the subterranean rhizomes may need to be developed. Searches for additional populations are always needed to re-evaluate the plant's status, and this would simply involve the periodic search of suitable habitat during the proper season, though this may involve many acres of surveys. While hydrology and humidity fluctuations are assumed to occur in its habitat, it is not known precisely how much fluctuation can occur without adversely affecting the plants, and so additional research is needed in this area. It is also not known what triggers flowering, and this should be a more workable problem in wild populations, though it requires multiple observations in multiple seasons correlated with ecological / weather information. At this time, it is not known if this orchid could be successfully introduced to suitable sites. It is also not known exactly how much disturbance can occur before an individual population is adversely affected, nor is it known precisely how large a habitat is needed to support a viable population.

Research on the use of fire management, already shown to have promising results, would be useful towards the understanding and preservation of the Crested Coral-root Orchid in our area. The periodicity and optimum seasonality of such fires is incompletely known and the precise reason why fires benefit the species is also a mystery. Because the plant does not require sunlight for photosynthesis, it would seem that it should grow equally well in sun or shade. However, it does appear that a prescribed fire can stimulate flowering (Shawnee National Forest 2005). What the exact triggering may be is unknown, and one could speculate that it is a sudden influx of nutrients, or the physical effects of a fire, or some other cause rather than the clearing of other vegetation that may be the cause. It should also be considered that people are searching more intensely for this orchid in areas of prescribed fire, and that it is just as frequent in unburned areas that are not being searched. Controlled experiments are needed to test these

hypotheses.

Monitoring of the forests where it still occurs or where it has been 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 population 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 because seedlings and young plants cannot yet be found in the field, and most flowers do not produce fruits. As part of the basic research on current populations of this species, data such as counts of 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 population dynamics and to assess the viability of the individual populations found. Individual plants should be monitored over several growing seasons at each site for basic phenology data. Such basic facts as the means of establishment of fungal associations, longevity, and yearly variations in colony size over a long period are not precisely known for populations of this species, and conclusions have so far been based upon infrequent visits and the infrequent flowering observed in known populations.

Once new populations are found, voucher specimens should be made according to techniques described in Hill (1995) or other similar references. Collecting of this rare orchid is usually discouraged unless a very large population is found, but a portion of an inflorescence, or a flower, along with photographs, should be adequate to document its presence, and these are preferred over a site report (that could conceivable be based upon a misidentification). Only one voucher should be made for a given population 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 August in the southeast when the showy flowers are most visible, but also in the spring (April-June) in the southern parts of its range, such as Florida and Texas. There are rather large areas of additional suitable habitat with suitable substrate and soils in southern Illinois, and, of course, elsewhere, where the Crested Coral-root Orchid could also exist. A list of typical associates and indicator species has been compiled as a result of field studies in other states (see Habitat section above) and many of these should also occur with the species in Illinois. These indicator plants (especially Oaks), along with the specific soils and substrates, can be very useful in facilitating the discovery of additional populations of this herb. It would be unlikely, for example, to find this species in hard clay soils or in sands without an abundance of humus, but both shaded and sunny sites with suitable substrate may harbor this orchid (Homoya 1993). It is quite possible that populations of this species either have been overlooked because of the near impossibility of finding sterile plants, or because of incorrect field identifications of fertile plants. The plants can be difficult to see because of their brown-earthy color and lack of green tissue. 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 by means of prescribed burns are being conducted on *Hexalectris spicata* var. *spicata* in Illinois (Shawnee National Forest 2005), and the restoration potential of this and similar species may be good. Fruit production in this species appears to be relatively rare, partly due to browsing by deer, and it would be wise to determine if the strong mesh fencing of a population before flower stalks begin to emerge would help to eliminate this threat. The species, while widely distributed, is generally not common in the midwestern states and there appears to be a significant amount of habitat available where restoration efforts can also occur in southern Illinois. It may be necessary to purchase private land that has had historic populations of the species on it and to protect the habitat on this land for this plant. At this time, however, data suggests that the priority activity to encourage the persistence of reproductive colonies of this orchid should be carefully scheduled and monitored prescribed burns at known and suspected sites (Shawnee National Forest 2005).

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 appears to be beneficial to this plant, though some additional research is needed (see previous section). The specific effects of fungicides and herbicides on this mycotrophic herb are thought to be generally harmful, so these are not recommended in the management program without additional study. The threat to this orchid from exotic species has not yet been demonstrated.

As also described in the previous section of this report, it is generally recommended that the habitat quality where this and other rare plants grow should be monitored on a regular basis and an assessment of the specific threats to all populations should be made (W-3). Successful

management or restoration of the Crested Coral-root Orchid depends on periodic surveys of both the environment in which it grows as well as the monitoring of population sizes and individual plants. 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. 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 documentation either way on this.

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 is not yet possible. Until this happens, only habitat protection and management can preserve this orchid species.

SUMMARY

The Crested Coral-root Orchid, *Hexalectris spicata* (Walt.) Barnh. var. *spicata* is a primarily subterranean mycotrophic perennial herb from a rhizome that occasionally produces a 25 cm to 1 meter tall raceme of rather attractive flowers above ground in order to reproduce. The typical variety is widespread in the southeastern United States southwest to northern Mexico, and it is known historically from twenty-two states, from Maryland west to Illinois, Missouri, Oklahoma, and Arizona south to northern Mexico and Florida. There is one additional variety recognized, var. *arizonica*, restricted to Arizona, New Mexico, and Texas. It is a species that grows in humus in normally rocky soils over calcareous substrates in open, usually well drained mesic to dry open woodlands. It is nearly always found in association with *Quercus* (Oak) trees. Globally, its ranking is G5 (secure world-wide); its National status in the United States is N4? (probably secure nationally). The Crested Coral-root Orchid is listed as Endangered in Florida (S3), Illinois (S1), and New Mexico (S2), as Threatened in Ohio (S3), as Rare in Indiana (S2), as Salvage Restricted in Arizona (S3S4) and as Extirpated (Historic only) in Maryland (SH). In Forest Service Region 9, the Crested Coral-root Orchid is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest where it has not yet been found. It is at risk at the margins of its range

Suggested conservation research priorities for this local, rare herb in the Midwest include attempts to locate additional populations, additional research on its life history and ecological parameters including the controls on flowering and the risks from predation and competition,

studies to determine more precisely the best management techniques to insure its survival and increase (such as the periodic controlled use 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 appears to be crucial to the survival of this orchid. Habitats should be preserved and managed by means of the protection of current hydrology (including erosion control), through protection from land development, by protection from indiscriminate or nearby fungicide, herbicide or fertilizer application, by protection from soil disturbance and physical damage to the plants and habitat by vehicles, animals (such as grazing or trampling by livestock), and people, and by protection of the habitat from predatory (foraging) species such as deer. Fire management appears to be beneficial though continued study of this technique is suggested. Certainly, the picking of its flowers by people and the foraging by deer and livestock is to be discouraged in order to maintain reproductive populations, and permanent exclosures may be necessary for this orchid's protection. At this time, with proper management, the current populations in southern Illinois and Indiana should persist and its long-term chances of survival in these states now appears to be good within the national forests. The establishment of additional populations is unlikely at this time.

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CONTACTS

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

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

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

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

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

Kirk Larson (812) 275-5987

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

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

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

Illinois Endangered Species Board

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

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

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

Biological Consultant

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

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

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

APPENDIX 1

Representative specimens of *Hexalectris spicata* var. *spicata* from the United States examined or cited in the literature

Herbaria:

BAYLU = Baylor University, Waco, Texas. BUT = Butler University, Indianapolis, Indiana. F = Field Museum, Chicago, Illinois. ILLS = Illinois Natural History Survey, Champaign. IND = Indiana University, Bloomington. KANU = University of Kansas, Lawrence. KY = University of Kentucky, Lexington. LSU = Louisiana State University, Baton Rouge. MISS = University of Mississippi, University. MO = Missouri Botanical Garden, St. Louis. MU = Miami University, Oxford, OH. OCLA = University of Science and Arts of Oklahoma, Chickasha. OKL = Oklahoma State University, Stillwater. SIU = Southern Illinois University, Carbondale, Illinois. TULS = University of Tulsa, Tulsa, Oklahoma.

ARKANSAS: CRAIGHEAD CO., Jonesboro, 4 Jul 1927, *Demaree 3549* (LSU).

FLORIDA: CITRUS CO., 12 Jun 1983, *Schmid A-258* (USF); US Rt. 19, north of Crystal River, 20 May 2004, *Kennedy 54* (MU); HERNANDO **CO.**, hardwood hammock, 3 Nov 1964, *Lassiter & Lassiter 28* (USF); **LEE CO.**, Sanibel Island, 16 Jun 1979, *Hansen & Hansen 5692* (USF); **LEVY CO.**, Blue Run below Rainbow Springs, 14 Jun 1962, *Beckner s.n.* (USF); near end of loop trail around lake, 18 May 1989, *Petty s.n.* (USF); **SUMTER CO.**, 12 Jun 1992, *van Hoek 278* w/ *Petty* (USF).

ILLINOIS: MONROE CO., Fults Hill Prairie, 22 Jul 1969, *White 1910* (SIU); **POPE CO.**, Jackson Hollow, Shawnee N.F., 17 Sep 1950, *Hatcher 1168* (SIU); **RANDOLPH CO.**, Above Stotz Quarry, north of Prairie du Rocher, 30 Jul 1950, *Evers 25739* (ILLS); same location, 4 Aug 1971, *Evers 143101* (ILLS).

INDIANA: CLARK CO., army ammunition plant N of Charleston, 6 Aug 1980, *Maxwell 1838* (IND); **FLOYD CO.**, Bald Knob, 2 Aug 1889, *Thaerus* [?] *s.n.* (F); Evansville, 20 Aug 1923, *Friesner s.n.* (BUT); HARRISON **CO.**, ca. 1.5 mi NE of Davidson, 3 Aug 1922, *Deam 37231* (IND); **WASHINGTON CO.**, SE ¼ Sec. 32, T3W, R3E, 13 Aug 1985, *Homoya, Brothers, & Hutchison s.n.* (IND).

KENTUCKY: BELL CO., Pine Mountain State Park, 1 Aug 1975, *Ettman s.n.* (KY); **CLARK CO.**, Pine Ridge Road, 5 Aug 1955, *Beckett 848* (KY); **LOGAN CO.**, 0.5 mi NE of Lake Hancock, Russellville Waterworks, 8 Jul 1963, *Browne & Browne 7582* (KY); **MADISON CO.**, 5 mi NE of Big Hill, 6 Aug 1940, *Wharton 5693* (KY); **McLEAN CO.**, 2 mi W of Beech Grove, 4 Aug 1973, *Conrad 1857* (KY).

LOUISIANA: NATCHITOCHES PARISH, cliffs at Pierre Bayou at Red River near Grand Ecore, 21 Jun 1939, *Brown 7962* (LSU); **RAPIDES PARISH,** Bailey Branch Hills, Tioga, 15 Jun 1935, *Smith s.n.* (LSU); **WEBSTER PARISH**, Minden, 2 Jul 1934, *Brown 5327* (LSU).

MISSISSIPPI: LAMAR CO., Hattiesburg, 10 Aug 1970, *Brown & Arnold 21574* (LSU); **UNION CO.**, Pontotoc Ridge natural area, 22 Jul 1994, *Huneycutt, Floyd & Floyd s.n.* (MISS); **WILKINSON CO.,** near the Tunica Waterfalls, ca. 1 mi SW of Pond, 24 Aug 1982, *Pruski 29117* (LSU).

MISSOURI: BARRY CO., Eagle Rock, 6 Aug 1905, *Bush 3119* (MO); **COOPER CO.**, Prairie Home Conservation Area, 29 Jul 1998, *Leahy s.n.* (MO); **DUNKLIN CO.**, Kennett, 27 Jul 1895, *Bush 620* (MO); **FRANKLIN CO.,** 2.5 mi S of Robertsville, 20 Jul 1941, *Meyer 2086* (F); **GENEVIEVE CO.**, Hickory Creek, ca. 4 mi NW of Weingarten, 5 Jul 1946, *Steyermark 63844* (F); **JEFFERSON CO.**, farm north of Eureka, 26 Aug 1891, *Eggert s.n.* (MO); **McDONALD CO.**, 2.5 mi E of Jane, 31 Jul 1956, *Palmer 63434* (SIU); **MONTGOMERY CO.**, Grand Bluffs Conservation area, ca. 1 mi E of Bluffton, 23 Jul 1999, *Leahy 11* (MO); **OREGON CO.**, Reader Hollow, tributary of McCormack Hollow, 13 Jul 1992, *Summers 5202* (MO); **PULASKI CO.**, 2 mi E of Waynesville, N side Gasconade River, 28 Jul 1935, *Steyermark 19327* (MO); **ST. LOUIS CO.**, Meramec schoolhouse SE of Pacific, 7 Aug 1910, *Craig s.n.* (MO); Allentown [Allenton], Aug 1879, *Letterman s.n.* (MO); **STONE CO.**, 27 Jul 1991, *Brews s.n.* (MO); **WASHINGTON CO.**, Mark Twain N.F. ca. 3 mi SE of Berryman on Courtois Creek, 3 Aug 1994, *Summers 6841* (MO).

NORTH CAROLINA: ALLEGHANY CO., Stone Mountain State Park, 20 Jul 2004, *Kennedy15* (MU).

OHIO: ADAMS CO., Appalachia Preserve, 25 Jul 2004, *Kennedy 20* (MU).

OKLAHOMA: BRYAN CO., 5 mi E of Bennington, 20 Jul 1974, *Magrath et al. 8532* (OCLA); **CADDO CO.**, 2 mi E of Cement, 15 Jul 1974, *Magrath et al. 8413* (OCLA); **CHOCTAW CO.**, 3.5 mi N of Swink, 20 Jul 1974, *Magrath et al. 8563* (OCLA); **GRADY CO.**, 5 mi E of Alex, 24 Jun 1964, *Pearce 1340* (OKL); **MAYES CO.**, Camp Scott, 25 Jul 1945, *Hughes s.n.* (TULS); **MCCURTAIN CO.**, 4.1 mi S of Broken Bow, 20 Jul 1974, *Magrath et al. 8517* (OCLA); **MUSKOGEE CO.**, 3 mi E of Braggs, 18 Jul 1950, *Inkenberry et al. 9623* (OKLA, KANU); **ROGERS CO.**, 6 mi W of Claremore, 19 Jul 1967, *Blair s.n.* (TULS).

TEXAS: BREWSTER CO., Big Bend National Park, 29 Jul 2004, *Kennedy & Freeman 33* (MU); **CASS CO.,** Atlanta State Park, trail head, ca. 1.0 km east-northeast to large bluff on northeast side of creek, 8 Apr 2001, *Singhurst 10294* (BAYLU).

APPENDIX 2.

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

STATE	COUNTIES	NOTES
Alabama	Bibb, Cullman, Hale, Lawrence, Lee, Lowndes, Macon, Tuscaloosa	(W-1; W-3); apparently incl. William B. Bankhead N.F. and Talladega N.F.
Arizona	Cochise, Yavapai [var. *arizonica* is in Cochise, Pima and Santa Cruz cos., var. *spicata* may be restricted to Yavapai]	(W-1; W-3; W-11).
Arkansas	Baxter, Craighead, Washington; reported Hempstead, Pulaski	(W-1; W-3); Smith (1978); incl. Ozark N.F.
Florida	22 counties	(W-1; W-3; W-4); apparently incl. Apalachicola N.F., Ocala N.F., and Osceola N.F.
Georgia	Clarke, Hancock, McIntosh, Madison, Morgan, Newton, Stephens, Twiggs, Upson	(W-1; W-3); apparently incl. Chattahoochee N.F.
Illinois	Hardin, Jackson, Monroe, Pope, Randolph	(W-1; W-3); Mohlenbrock & Ladd (1978); Mohlenbrock (1986); Shawnee National Forest (2005); incl. Shawnee N.F.
Indiana	Clark, Floyd, Harrison, Washington; possibly Crawford	(W-1; W-3); Deam (1940); Yatskievych (2000)
Kansas	Montgomery	(W-1; W-3).
Kentucky	17 counties	(W-1; W-3); apparently incl. Daniel Boone N.F.
Louisiana	Caldwell, Claiborne, Evangeline, Lincoln, Natchitoches, Ouachita, Rapides, Webster, West Feliciana, Winn parishes	(W-1; W-3); MacRoberts (1989); Thomas & Allen (1993); apparently incl. Kisatchie N.F.
Maryland	Anne Arundel [Historic only]	Smith (unpublished Atlas).
Mississippi	13 counties, widely scattered	(W-1; W-3); apparently incl. DeSoto N.F., Tombigbee N.F., Holly Springs N.F.

Missouri	19 counties, mostly central and southern, Ozark and Ozark Border Divisions	(W-1; W-3); Yatskievych (1999); Summers (1987); incl. Mark Twain N.F.
New Mexico	Var. *spicata* distribution uncertain. [var. *arizonica* is in Hildago, Dona Ana, Sierra, Otero]	(W-1; W-3); apparently incl. Coronado N.F., Lincoln N.F.
North Carolina	18 counties, mostly piedmont	(W-1; W-3); Radford *et al.* (1968); herbarium specimens; apparently incl. Pisgah N.F.
Ohio	Adams, Scioto. [Probably extant only in Adams County]	(W-1; W-3; W-10).
Oklahoma	Bryan, Caddo, Choctaw, Grady, Mayes, McCurtain, Muskogee, Rogers, Sequoyah, Stephens	(W-1; W-3); Magrath and Taylor in Taylor (1978).
South Carolina	Aiken, Greenville, Bamberg, Beaufort, Calhoun, Dorchester, Darlington, Kershaw, Lancaster, Spartanburg	(W-1; W-3); Radford *et al.* (1968); herbarium specimens.
Tennessee	15 counties, eastern half of state.	(W-1; W-3); Chester *et al.* (1993); apparently incl. Cherokee N.F., Great Smoky Mountains N.P.
Texas	Brazos, Cherokee, Dallas, Travis, Tyler; possibly Brewster and Presidio [var. *arizonica* is in either or both Brewster, Presidio]	(W-1; W-3); apparently incl. Big Bend N.P.
Virginia	> 20 counties, widely scattered	(W-1; W-3); Harvill *et al.* (1977); apparently incl. George Washington N.F., Jefferson N.F., Shenandoah N.P.
West Virginia	Grant, Pendleton, Wayne	(W-1; W-3); apparently incl. Monongahela N.F. and George Washington N.F.

APPENDIX 3.

Natural Diversity Database Element Ranking System

Modified from: http://www.cnpsci.org/html/PlantInfo/Definitions2.htm [W-6]

Global Ranking (G)

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

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

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

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

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

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

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

GXC
Extinct in the wild. Exists only in cultivation.

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

National Heritage Ranking (N)

The rank of an element (species) can be assigned at the national level. The **N-rank** uses the same suffixes (clarifiers) as the global ranking system above. **NNR** = not nationally ranked.

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

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

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

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.