

*Conservation Assessment*

*for*

*Twining Screwstem (Bartonia paniculata) (Michx.) Muhl.*



*Photograph by Guy Anglin. Used with permission.*

***USDA Forest Service, Eastern Region***

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*This document is undergoing peer review, comments welcome*

*This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.*

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## EXECUTIVE SUMMARY

This Conservation Assessment is a review of the distribution, habitat, ecology, and population biology of the Twining screwstem, *Bartonia paniculata* (Michx.) Muhl. (ssp. *paniculata*), 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 the status, potential threats, and conservation efforts regarding Twining screwstem to date. Twining screwstem is an inconspicuous wiry annual or biennial herb with tiny white flowers, no obvious leaves, and greenish or purplish stems. It appears to be mycotrophic (a saprophyte), receiving some of its nutrients through association with fungi. The species (including both subspecies) is widespread, and it is found in 29 states and 5 Canadian provinces, mostly on the Atlantic coastal plain from Newfoundland, Canada, south to Florida, and west to Texas, then in a few populations inland north to Wisconsin and Ontario, Canada, around the Great Lakes. It grows mainly in acidic wetlands, generally in nutrient-poor peat soils in sphagnum bogs and reproduces only by seeds. Globally, its ranking is G5 (demonstrably secure globally, though it may be quite rare in parts of its range, especially at its periphery). This herb is listed as Endangered in Illinois and New York, and as Threatened in Maine and Michigan; it is ranked as critically imperiled in the District of Columbia, Missouri, Oklahoma, and Wisconsin (a Special Concern species). Twining screwstem is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest. Although it is considered to be

widespread and secure in most of its range, it faces several risks that could result in its extirpation at the extreme edges of its range (as in Illinois) if it is not properly managed.

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 species throughout its range within a given planning area.

The objectives of this document are to:

- Provide an overview of the current scientific knowledge on the species.
- Provide a summary of the distribution and status on the species range-wide and within the Eastern Region of the Forest Service, in particular.
- Provide the available background information needed to prepare a subsequent Conservation Approach.

## NOMENCLATURE AND TAXONOMY

**Scientific Name:** *Bartonia paniculata* (Michx.) Muhl. (1813)

**Common Names:** Twining screwstem; Twining bartonia; Screwstem; Panicked screw-stem; Branched bartonia; Slim bartonia

**Synonymy:** *Bartonia lanceolata* Small; *Bartonia tenella* Muhl. ex Willd. var. *brachiata* A.W. Wood; *Bartonia virginica* (L.) Britton *et al.* var. *paniculata* (Michx.) B. Boivin; *Centaurella moseri* Steud. & Hochstetter ex Griseb. Based on: *Centaurella paniculata* Michx. (1803)

**Class:** Magnoliopsida (Flowering Plants - Dicotyledons)

**Family:** Gentianaceae (the Gentian family)

**Plants Code:** BAPA / BAPA2 (USDA NRCS plant database, W-2)  
[http://plants.usda.gov/cgi\\_bin/topics.cgi](http://plants.usda.gov/cgi_bin/topics.cgi)

There are four species of screwstem (*Bartonia*) and one additional subspecies in North America north of Mexico. *Bartonia paniculata* is generally divided into two subspecies, the typical ssp. *paniculata* and the less common ssp. *iodandra* (B.L. Robins.) J. Gillett, which is found only from Connecticut to Nova Scotia along the Atlantic coast (Gillett 1959; Kartesz & Meacham 1999; W-2; W-3). James Pringle (Royal Botanical Gardens, Hamilton, Ontario; pers. comm.) has examined photographs of original specimens (isosyntypes) of *Centaurella moseri* at the New

York Botanical Garden herbarium (NY) and agrees with the conclusion that this name is a synonym of *Bartonia paniculata*.

Screwstems are thus named because the shoots are often twisted (even twining) and the leaves are arranged spirally (W-4). The species epithet refers to its inflorescence type, usually a panicle.

## DESCRIPTION OF SPECIES

*Bartonia paniculata* is a inconspicuous wiry or spindly annual or biennial herb with tiny white flowers, no obvious leaves, and very slender green or purplish angled stems. Its height is normally 10-40 cm, and the stem can be erect or sometimes scrambling or even twining. The leaves are reduced to just a few small green scales 1-3 mm long that are mostly alternate, though some can be opposite; the lowermost leaves near ground level are always alternate; the flower cluster is a raceme or panicle that is usually 5-10 (-25) cm long, and the flower stalks are 2-25 mm long, slender and ascending or arched and divergent. The flowers are 2.5-4 (-5) mm long, with 4 sepals and petals, the sepals are lance-subulate, 2-2.5 mm long, and the petals are white (to greenish-white or cream-white, sometimes pale pink), lanceolate, and long acuminate. The fruit is a capsule 4-5 mm long with numerous (100-1500) very tiny (0.2-0.3 mm) seeds; the chromosome number is  $2n = 52$  (adapted from W-4, W-5, Gleason & Cronquist 1991, and Radford *et al.* 1968). The species is readily distinguished from its close relative *Bartonia virginica* (L.) Britton *et al.* by its alternate, rather than opposite, leaves below the inflorescence and a calyx that is cleft from 2/3 or more to the base rather than the merely lobed calyx of *B. virginica* (W-5).

## HABITAT AND ECOLOGY

*Bartonia paniculata* is normally found in wet areas (bogs, marshes, wet meadows, shrub swamps) in wet sand or peaty soils and sphagnum moss. It does not grow in limestone areas or in basic soils. It is most common in level sandy or peaty acidic wetlands along the Atlantic coastal plain (W-4; Gleason & Cronquist 1991) as in acid bogs in the New Jersey pine barrens. This tiny gentian is considered to be a wetlands indicator species, and it has been classified as OBL in the national listing (W-2). The habitat is sometimes described as Coastal non-tidal wetland [non-forested, wetland] (W-5).

In Michigan, the Twining screwstem's habitat in Luce County has been described as a patterned fen or 'string bog' (strangmoor) with flarks (hollows) dominated by *Menyanthes trifoliata*, *Scirpus subterminalis*, and *Nymphaea* sp. The strangs (ridges) support *Carex exilis*, *C. oligosperma*, *Rhynchospora alba*, *Aronia prunifolia*, and *Larix laricina*. In Chippewa County it was found near the edges of several intermittent wetlands bordered by *Chamaedaphne calyculata*, and its associates included *Euthamia remota*, *Rhynchospora capitellata*, *Muhlenbergia uniflora*, and the coastal plain disjunct *Lycopodiella subappressa*. In one locality the coastal plain disjunct species *Rhexia virginica* was also present. It was thought to grow only when the wetlands were experiencing a drawdown, similar to that which occurs in typical coastal plain marsh habitat known primarily from the southeastern Lower Peninsula (W-4).

In Ontario, this gentian has been described to grow in peat soil in a "very wet Sphagnum bog on

the Canadian shield between low ridges of granitized rock...among scattered clumps of *Larix laricina*, *Aronia prunifolia*, and *Chamaedaphne calyculata* dominated by *Rhynchospora alba*, *Scheucheria palustris*, *Woodwardia virginica*, *Eriophorum virginicum*, and *Habenaria blephariglottis*" (Reznicek & Whiting 1976; White 1992).

Strong and Simmons (2000) conducted a study of several vulnerable seepage bogs in Prince Georges County, Maryland, and compiled a list of the herbaceous vascular plants that they found there that were associated with *Bartonia paniculata*. Some of the characteristic plants that they found bordering the stream and in the subtending sandy seepages were the ferns and fern-allies *Lycopodiella appressa*, *Selaginella apoda*, and *Thelypteris palustris* var. *pubescens*, the sedges *Cyperus flavescens*, *Eleocharis tenuis*, *Fimbristylis autumnalis*, *Fuirena squarrosa*, *Rhynchospora capitellata*, *Schoenoplectus purshianus* and, *Scleria pauciflora*, the grasses *Dichanthelium dichotomum* var. *dichotomum*, *D. scoparium*, *D. sphaerocarpon* var. *isophyllum*, and *Panicum verrucosum*, the rushes *Juncus acuminatus*, *J. canadensis*, *J. diffusissimus*, *J. effusus*, *J. longii*, *J. scirpoides*, the additional monocots *Lilium superbum*, *Sagittaria latifolia* var. *pubescens*, *Sparganium americanum*, *Spiranthes cernua*, *S. lacera* var. *gracilis*, and *Xyris torta*, and the herbaceous dicots *Asclepias incarnata*, *Bartonia paniculata* ssp. *paniculata* itself, *Drosera rotundifolia* var. *rotundifolia*, *Eupatorium pilosum*, *Helenium flexuosum*, *Liatrix pilosa* var. *pilosa*, *Linum medium* var. *texanum*, *Polygala mariana*, *Polygala sanguinea*, *Rhexia virginica*, *Sabatia angularis*, *Solidago rugosa* ssp. *aspera*, and *S. speciosa* var. *erecta*, *Aster patens* var. *patens*, and *Triadenum virginicum*.

In Wisconsin, where it occurs in two counties, this species grows in damp to wet sandy, mossy and boggy ditches in a powerline right-of-way that is kept clear of tall woody vegetation, and in small clumps of *Sphagnum* and damp, mucky sand around the edges of a desiccating pond. Its associates include the mosses *Polytrichum* and *Sphagnum*, and the vascular plants *Bartonia virginica*, *Carex oligosperma*, *Drosera rotundifolia*, *Eriophorum virginicum*, *Hypericum* sp., *Juncus canadensis*, *Juncus* sp., *Lycopodium inundatum*, *Muhlenbergia uniflora*, *Platanthera clavellata*, *Pogonia ophioglossoides*, *Polygala cruciata*, *Potentilla simplex*, *Rhynchospora alba*, *Rhynchospora capitellata*, *Rubus flagellaris*, *Solidago uliginosa*, *Vaccinium macrocarpon*, *Viola lanceolata*, *Xyris montana*, and *Xyris torta* (data from herbarium specimens at the University of Wisconsin herbarium, WIS).

In Missouri, where it is known from a single county, this species "occurs on wet mossy hummocks usually of sphagnum moss around springs and spring branches in acid soils in low woods of *Ilex opaca* at the base of Crowley Ridge bordering the lowlands"(Steyermark 1963). It is associated there with *Ilex opaca*, *Sphagnum*, *Habenaria clavellata*, *Oldenlandia uniflora*, and *Polygonum arifolium*. At one of its localities it grows with *Pyrus melanocarpa* and *Trisetum pensylvanicum*, which are also scarce in Missouri.

At its western limit of range in Oklahoma, a few specimens indicate habitats such as "swampy lake shore" and "open places in woods". Most populations grow in hillside bogs found in six southeastern Oklahoma counties on sandy formations of the old Gulf Coastal Plain (Taylor & Taylor 1978). At one site in McCurtain County, *Bartonia paniculata* occurred in one of these sandy bogs - seeps amid *Sphagnum*; understory shrubs included *Symplocos tinctoria* and *Itea virginica*, and the overstory was of *Quercus nigra* and *Q. phellos* (Hoagland, pers. comm.).

In Illinois, Twining screwstem has been found only south of the glacial boundary, and it has been included within the Seep and Spring wetland natural community, specifically in the Acid gravel seep and Sand seep communities (as defined by White & Madany 1978). The species has only been seen in examples of this community on the Sandstone Cliffs of extreme southern Illinois, and this habitat is similar to that described in Missouri. According to Eric Ulaszek (pers. comm.) this plant has been found primarily at the margins of acidic seeps, growing at one site with the ferns *Athyrium* sp. and *Osmunda regalis*, the sedges *Carex crinita*, *Carex incomperta*, *Cyperus strigosus*, and *Scirpus polyphyllus*, the grasses *Leersia virginica*, and *Panicum dichotomum*, and the dicot herbs *Chelone glabra*, *Impatiens capensis*, *Polygonum punctatum*, *Polygonum sagittifolium*, and *Solidago rugosa*. Trees shading the seep area included *Acer rubrum*, *Betula nigra*, *Liriodendron tulipifera*, and *Quercus pagoda*. At a second site he found the plant growing with the mosses *Sphagnum* cf. *intricatum* and *Thuidium recognitum*, the ferns *Onoclea sensibilis*, *Osmunda cinnamomea* and *Osmunda regalis*, and the trees *Acer rubrum* and *Betula nigra*. Botanists and ecologists have speculated on the original landscape in this part of Illinois based mostly upon land survey records and field observations (Ulaszek, pers. comm.). Evidence suggests that the original pre-settlement landscape was a 'barrens', a savanna or prairie-like community with scattered oak trees and oak brush, that was periodically burned by Native Americans. Within this woodland-savanna-prairie matrix the seeps may have existed as sedge meadows that, where shaded, may have been dominated by ferns. These sites lie within the Cretaceous Hills Section of the Coastal Plain Natural Division of Illinois (Schwegman *et al.* 1973, and pers. comm.).

## DISTRIBUTION AND ABUNDANCE

*Bartonia paniculata* is a widespread species, and it has been found in 29 states and 5 Canadian provinces, mostly on the Atlantic coastal plain from Newfoundland, Canada, south to Florida, and west to Texas, then inland north to Wisconsin and in the Muskoka District in south-central Ontario, Canada, around the Great Lakes. Individuals or colonies are very local, and they appear to be occasional and scattered in an area rather than common at any one site. Moreover, the populations are restricted to a specific habitat, and if this habitat is infrequent the Twining screwstem will also be infrequent. The distribution and frequency is very reminiscent of that of several infrequent or rare bog orchid species. Representative specimens of this unusual gentian have been listed in Appendix 1. A summary of the distribution of the subspecies *paniculata* in the United States has been presented in Appendix 2.

There may be some limited overlap in the range of the two subspecies, but not all sources are clear on this. According to Kartesz and Meacham (1999), the typical subspecies, *Bartonia paniculata* ssp. *paniculata* occurs in AL, AR, CT, DC, DE, FL, GA, IL, KY, LA, MA, MD, ME, MI, MO, MS, NC, NH, NJ, NY, OK, PA, RI, SC, TN, TX, and VA and Ontario, Canada. The less common subspecies *Bartonia paniculata* ssp. *iodandra* occurs in CT, MA, ME, and RI and according to their maps it also grows in New Brunswick, Newfoundland, and Nova Scotia in Canada. Kartesz and Meacham (1999) appear to have the ranges of the two subspecies correct, but Indiana and Wisconsin must be added because of relatively recent discoveries of ssp. *paniculata* in those states. The two subspecies appear to overlap only in CT, MA, ME, and RI, and only one of the subspecies occurs in each of the other states and provinces. Neither



subspecies has been found in Ohio or West Virginia, but the species should be sought there because several neighboring records are close by. According to Reznicek and Whiting (1976) “The species is strikingly disjunct in Michigan and Ontario” (see also Reznicek 1994). With the discovery of populations in Indiana and Wisconsin, this does not appear to be quite so unusual. The distribution does suggest that there were two different colonizations of the Midwest by this species, one from the Atlantic Coast west to the Great Lakes and one from the Gulf Coast north along the Mississippi River basin. It would be interesting to test this using DNA methodology. Additional details on the distribution of Twining screwstem can be found in the references cited within Appendix 2.

NatureServe (W-3) lists *Bartonia paniculata* (the species) from all of the states and provinces above, and adds Quebec, Canada, without indicating the subspecies in that province, and it adds Indiana to the distribution of ssp. *paniculata*. To the distribution of ssp. *iodandra*, that site adds NJ, NY, PA, and VA but does not include CT. It appears that there are still some details on the distribution of the two subspecies to clarify on the NatureServe maps. In the Midwestern states, only *Bartonia paniculata* ssp. *paniculata* is present, and, unless specifically stated otherwise, all subsequent remarks in this report pertain to that taxon.

At its western limit of range in Oklahoma, *Bartonia paniculata* was collected 1913-1914 by G. W. Stevens in LeFlore County, and it was only collected again by J. and C. Taylor in the 1970s (Goodman *et al.* 1978, Taylor & Taylor 1978) from two counties (Choctaw & Pushmataha Counties) where it still occurs; in 1999 it was found in McCurtain County as well. Correll and Johnston (1970) reported the species “in sandy bogs and meadows in e. Texas” but its precise range in that state has not been determined.

Based on herbarium records at the University of Alabama at Tuscaloosa (Ginzburg, pers. comm.) this species appears to be quite rare in Alabama and may be known from only two counties, Escambia and Mobile. It may also be scarce or rare in Mississippi, but the data is incomplete. *Bartonia paniculata* was reported for Louisiana by Thomas and Allen (1982), but no specimens were seen by MacRoberts (1989) and the species is undoubtedly scarce or very scarce in the state.

According to Kartesz and Meacham (1999) and the USDA database (W-2), *Bartonia paniculata* was not known in Indiana or Wisconsin. However, Michael Homoya first discovered *Bartonia paniculata* in Indiana in 1985, and soon after it was included on the state’s endangered species list; it was dropped from the list after the discovery of additional occurrences (M. Homoya, pers. comm.). Nine occurrences were mapped, until dozens of separate occurrences were found on the large Big Oak National Wildlife Refuge. It has been found in four counties in Indiana, namely Clark, Jefferson, Jennings, and Ripley. There are unconfirmed reports from elsewhere in the state. Deam (1940) reported the species (as *Bartonia iodandra* Rob.) from Steuben County, but later re-identified the specimen as *B. virginica* (1940, p. 1081).

In Illinois, the Natural Heritage Database contains three records for Illinois, all in Pope County (Illinois Department of Natural Resources 2002). The last observations of living plants were made in 1994 and 1995; at Snow Springs, about 20 plants were found in 1993 and these were in an area of about 0.254 acres in 1994; in Poco Cemetery, 20-30 plants were seen in 1994, but

none were observed in 1997; in the Cretaceous Hills Nature Preserve, 3 mature plants were observed in 1995. According to the Nature Conservancy, this plant has been designated as 'SH' or with historic records only in Illinois, but it remains on the Illinois Endangered plants list and it was observed less than 10 years ago (Herkert *et al.* 1991). The species was once reported from both Pope and Johnson Counties (W-6). However, the Johnson County report found in Mohlenbrock (1986) appears to have been in error, and the current edition (Mohlenbrock 2002) lists only Pope County. No information on any Johnson County site has been found, though suitable habitat occurs in the county (Ulaszek, pers. comm.).

*Bartonia paniculata* is present, but uncommon, in the Daniel Boone National Forest (DBNF) in Kentucky (David Taylor, pers. comm.). The species is not included on the Regional Forester Sensitive Species List for the DBNF or the Southeastern Region (Region 8).

Within the U.S. Forest Service Eastern Region (Region 9) *Bartonia paniculata* has been confirmed to be present in the Shawnee National Forest (IL), and all populations are either within or not far distant from the National Forest. No populations are known from within the Hoosier National Forest in Indiana; the known populations in Indiana are located more than 10 miles to its east.

Botanists generally believe that most native plants have reached the limits to which they can travel under present conditions of climate (that is, temperature and rainfall), substrate, dispersal mechanism, and other pertinent factors. In other words, species are in balance with their environment as long as the environment is stable. In many biological simulations, however, ecological extremes are more important than the means in controlling plant distribution (Webb *et al.* 1975). An obvious example is that of frost tolerance (temperature extremes). A plant species completely intolerant of freezing can persist in a site indefinitely until the first time extreme temperatures cause it to freeze. One such freeze in a century may be enough to eliminate a species entirely from a wide area of its range, and changes in climate historically have caused the greatest changes in plant distributions (see Hill 2003).

In the case of *Bartonia paniculata*, current distribution appears to be dependent primarily on hydrology, substrate type (including pH), and the openness of the habitat rather than from temperature extremes alone. With a limited number of individuals present and a very specific habitat requirement, it may be unable to increase its range very quickly where the habitat is scarce. The need for nearly continuous moisture appears to be crucial for this herb, as it is for wetland species world-wide, along with a stability of substrate and a lack of competition. Under natural conditions, these habitats are stable, but if the habitat becomes too dry, if nutrient and soil accumulation changes, or if human traffic increases, the fragile habitat balance can be destroyed and the populations can be lost.

## PROTECTION STATUS

The Nature Conservancy currently lists *Bartonia paniculata* as a G5 plant, indicating that the species is globally secure and common overall. In the United States the species is given the National Heritage rank of N? (for unknown reasons). In Canada, the species is ranked N1 and as of Special Concern Nationally (W-7, W-8) without legal protection, and it has been listed as

Threatened and Vulnerable at the provincial level in Ontario, Canada.

The state rankings vary considerably. Official protection for the species outside of Forest Service lands depends upon state and local laws because it is also not listed as Federally threatened or endangered. The limited number of herbarium specimens and reports concerning this species may indicate that its status may require further review in states where it grows. It appears to be less common than generally recognized, and may need additional protection.

This herb is listed as Endangered in Illinois (Illinois Endangered Species Protection Board 1999) and New York, and as Threatened in Maine (formerly endangered) and Michigan; it is ranked as critically imperiled in the District of Columbia, Missouri (formerly endangered), Oklahoma, and Wisconsin (of Special Concern). In North Carolina it is included on the Watch List. *Bartonia paniculata* is included on the Maryland rare, threatened and endangered plant species list without rank, but it is being tracked. In Missouri, *Bartonia paniculata* was previously listed as endangered, but current law in the state only allows the listing of federally listed taxa as state endangered (Yatskievych, pers. comm.). It occurs in only one county and is still being tracked due to its rarity. *Bartonia paniculata* is not included on Indiana's Threatened and Endangered Species list.

Twining screwstem 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 has been considered to be too common in the southeastern Forest Region (Region 8) to be included on the RFSS there. It is known to be uncommon but present within the Daniel Boone National Forest (D.Taylor, pers. comm.) in Region 8.

Table 1 lists the official state rank assigned by each state's Natural Heritage program according to the Nature Conservancy at their Internet site (W-3). Appendix 3 explains the meanings of the acronyms used (W-9).

A summary of the current official protection status for the Twining screwstem follows:

<b>U.S. Fish and Wildlife Service:</b>	Not listed (None)
<b>U.S. Forest Service:</b>	Region 9, Sensitive (Illinois only, Shawnee National Forest)
<b>Global Heritage Status Rank:</b>	G5T5 [= for subspecies; G5 for species]
<b>U.S. National Heritage Status Rank:</b>	N?
<b>Canada National Heritage Status Rank:</b>	N1

**Table 1:** S-ranks for *Bartonia paniculata* [Heritage identifier: PDGEN01010 / PDGEN01012]. To determining which subspecies is ranked, see Distribution and Abundance, above.

<b>State</b>	<b>Heritage S-rank</b>	<b>State</b>	<b>Heritage S-rank</b>
Alabama	SR	Mississippi	SR
Arkansas	S?	Missouri	S1
Connecticut	SR	New Hampshire	SR
Delaware	S2	New Jersey	SR
District of Columbia	S1	New York	S1
Florida	SR	North Carolina	S2
Georgia	S3S4	Oklahoma	S1
Illinois	SH	Pennsylvania	S3
Indiana	S3	Rhode Island	SR
Kentucky	S4	South Carolina	SR
Louisiana	SU	Tennessee	SR
Maine	S1	Texas	SR
Maryland	S3	Virginia	S3
Massachusetts	SR	Wisconsin	S1
Michigan	S2		

## **CANADA**

<b>Province</b>	<b>Heritage S-rank</b>	<b>Province</b>	<b>Heritage S-rank</b>
New Brunswick	S2	Ontario	S1
Newfoundland	SR	Quebec	SR
Nova Scotia	S3		

## **LIFE HISTORY**

*Bartonia paniculata* is an annual or biennial herb but its average life-span is not really known. It appears to reproduce only from seeds. The species is difficult or essentially impossible to locate unless fertile unless one knows precisely (within centimeters) where to look. Plants are sometimes or often clumped, and this could mean that several seeds from the same parent may have sprouted together, or it could mean that some stem proliferation can take place. Asexual or clonal reproduction has not been documented, but there has been little research in this area, and just as little research has been conducted on the growth of the species from seed to mature plant. Individuals or clumps are very local and only rarely common in an area.

It is sometimes written that the plants of this and the other species in the genus may be parasitic or hemiparasitic on the roots of other plants or trees (W-5). Another government Internet site has stated “Plants of this genus are annuals and are saprophytic, deriving their nourishment from decayed material.” (W-4). James Pringle (pers. comm.) has indicated “The trophic ecology of *Bartonia* remains a subject of speculation only. There have been no modern, thoroughgoing studies. What would seem by far the most likely is that it has a fungal-bridge ecology like that

which is best known in *Monotropa hypopithys* and *M. odorata*, except that the mycorrhizae are probably endomycorrhizal rather than ectomycorrhizal. I consider such a parasitic/symbiotic relationship probable because that is what has been found in the gentianaceous genus *Voyria*, reported upon in papers including: [Imhoff 1997; Imhoff 1999]. At least in *Voyria* the mycobionts are in the order Glomales, as are many endomycorrhizae". According to the current literature, then, it is likely that *Bartonia paniculata* is an endomycorrhizal species, defined as an organism with a symbiotic association between its roots and a fungus, wherein the fungal hyphae occur inside the root.

According to herbarium specimen data and the literature, *Bartonia paniculata* has been found in flower from August to October throughout its range. It appears capable of flowering until the first heavy frost or freeze. The fruiting time is likely similar throughout its range, from late summer to early fall, perhaps even as late as November, a month in which some fertile specimens have been collected in mild years. The fruit is a capsule that produces numerous (100-1500) very tiny (0.2-0.3 mm) seeds (W-7). The parallel with orchids is seen again in the size and number of these seeds and suggests that this gentian has a similar strategy, to produce many small seeds to reach the widest possible area of dispersal by air or water because suitable habitat and associates (fungal) are very scarce. Few are likely to reach a suitable site in which to germinate and mature.

## POPULATION BIOLOGY AND VIABILITY

As demonstrated by Pringle's comments above, and, perhaps, by the lack of literature on the subject, very little is known of the Twisted screwstem's population biology. It is possible that population numbers vary widely depending on weather and hydrology in a given year. Maintaining the natural hydrology of the wetlands in which it occurs is the most important means to insure the viability of this species throughout its range, and it is especially critical at the margins of its range where suitable habitat is so scarce.

In Illinois, the species viability is very uncertain. Part of this pessimism arises because its habitat has already been observed to be decreasing (see Potential Threats below). In addition, it may or may not occur at other suitable sites in the state, but few searches have been made. Only three populations are recorded in the Illinois Heritage Database, and no plants have been observed in the state since 1995, though few searches have been conducted since then.

Suitable habitat for the species occurs only in extreme southern Illinois in the area of the seeps and springs associated with the Cretaceous Hills. There may also be suitable habitat in the lesser Shawnee Hills where it may grow. The known populations are located in an area where the two natural divisions interweave in topographic complexity (Schwegman, pers. comm.). The range of the subspecies also suggests that it may yet be found in wet acidic sands in the Chicago region in habitats where *Bartonia virginica* has already been found. Additional searches are suggested. With proper habitat (canopy) management, the known populations could persist.

## POTENTIAL THREATS

The Michigan Natural Features Inventory (W-4) has stated that “Maintenance of natural hydrology is critical to protection of this species’ habitat. Alterations to wetlands in the watershed (especially upslope) should be avoided, and activities in adjacent uplands which drain into the wetlands should be undertaken with caution.”

According to Eric Ulaszek (pers. comm.), who has monitored several Illinois sites in and near the Shawnee National Forest along with other botanists, several serious threats similar to those known in Michigan exist for this species in Illinois. Number one is dehydration of the seep, possibly from heavy utilization of available water by red maples, tulip tree, and river birch, particularly in drought years. Another threat is from shading by these same trees. Ulaszek (pers. comm.) has observed suppressed sedge clumps and dead *Osmunda* rhizomes beyond the living seep margin at seep springs in Illinois, and has also observed the re-emergence of some small hillside seeps after the birches and other trees growing nearby were killed (by girdling, not cutting). The seeps have been used as sources of water for both humans and livestock, and some have been highly altered. In some cases, spring orifices and spring run channels have been constructed out of local sandstone, and some old hog wallows can still be seen. The nearby terraces are now dissected with entrenched streams that are working their way uphill to the seeps, and which will result in their further dehydration.

Other disturbances from human activity have also caused severe changes in the habitat. The adjacent terraces were farmed but are now dominated by successional growth of tulip tree and red maple. There are some ‘user-made’ recreation trails near these seeps, mostly from all-terrain vehicles but there are also a few equestrian trails. The network of trails has probably continued to grow because land ownership is especially fragmented in southern Pope County, making protection and enforcement difficult. The clearing and disturbance of the natural vegetation in the past allowed some exotic and aggressive plants to become common in or near the seeps and springs, including *Lonicera japonica*, *Microstegium vimineum*, and *Alliaria petiolata*. The exotics are utilizing the scarce water available and their aggressive growth shades and displaces native vegetation. *Bartonia paniculata* can not compete with such aggressive exotics for scarce resources in its habitat.

Globally, this species has been judged to be secure because it appears to have a wide distribution and many reported populations, based upon the literature and herbarium specimens. In the United States, however, the overall status of Twining screwstem has not even been determined. Its habitat is locally common on the Atlantic coastal plain but infrequent elsewhere. The species’ growth requirements and tolerances for habitat disturbance are not fully understood. It appears to grow rather well after the burning of wet pine savannas in New Jersey and the Carolinas (personal observations) because of the increased sunlight, but this may not be true of smaller acreages elsewhere. In Illinois it appears to respond favorably to the girdling of trees that are shading its habitat and utilizing the limited water available. Throughout its range, the species grows only in wet acidic soils and open habitats. Therefore, under natural conditions a threat to the species in an existing colony on suitable substrate would be from the closing of the canopy through increased vegetation growth. In order to manage for the species, then, selective thinning of the forest stand within which it grows by girdling would be indicated. Tree cutting might

damage the seep itself by disrupting the community and substrate too quickly. It is uncertain in Illinois how the populations would respond to fire. Caution is indicated because highly organic or peaty soil burns well when dry, and the species would certainly be eliminated if the seep's organic layer were to burn.

Complete clearing or cutting of a forest stand would appear to eliminate this species through the effects of drying and sudden erosion from increased water flow, just as a dense canopy would damage it from shading, and therefore such practices could not be enacted where a colony occurs without adverse effects. The difficulty in managing for this species in Illinois is that active management appears to be necessary and the ideal means and combination of maintaining sufficient water availability along with an open canopy has not been fully determined.

In addition, the areas where these plants grow should be closed to any recreational use, and increased enforcement of these restrictions may be needed. It would appear because of the fragmentation of habitat due to a mix of public and private ownership, that a strong effort should be made to add to the buffer around the habitats by purchasing nearby public lands as a means of protection of the habitat and the species.

Habitat fragmentation can have profound effects on the success and persistence of local populations. Any activities that result in barriers to dispersal, such as developments, clearcuts, road/utility line corridors, and mined areas limit the possibility of population expansion and genetic exchange in many species. Deleterious effects of fragmentation could possibly go unnoticed for a long period of time, making the short term effects on species viability less apparent, particularly in such an inconspicuous species as *Bartonia paniculata*. Over time, as populations become increasingly more isolated, the effects of fragmentation can potentially be observed at the molecular level by reduced genetic frequencies caused by random drift (Barrett & Kohn 1991). When one is considering populations that are already isolated, as in the case of the Illinois populations, random genetic drift may have already occurred and may have caused negative effects to the species.

At the current time, it appears that the populations of *Bartonia paniculata* in the Shawnee National Forest are threatened with elimination from habitat loss unless selective management is undertaken.

## **RESEARCH AND MONITORING**

Very little research has been conducted on this species in the United States. The taxonomy of the genus mostly has been worked out and there seems to be no great problem with the nomenclature or status of the species. Also, some distributional work has been undertaken on *Bartonia paniculata* in several states in order to collect more precise data on its current range, and to assess its status in each state, but more of this basic work is still needed.

As part of the basic search for current populations of this species, counts of numbers of individuals are greatly needed in order to monitor population dynamics and viability. It is recommended that surveys be conducted during the flowering and fruiting period because it is very difficult to find in its vegetative or immature state. Great care should be taken to avoid

trampling the sphagnum or peaty substrate upon which the plants grow. The small size of these plants makes them quite vulnerable to careless steps, as is also true of rare orchids in this habitat. The ideal survey period would be late August through September, though it can often be found in fruit for another month or so, and may start flowering in mid-August in some areas. Nothing appears to be known about its pollinators or flower behavior regarding pollination. Perhaps the flowers all self-pollinate, but this is not known. Counts should be made not only of individual stems, but whether or not these stems are in clumps, and an attempt should be made to find immature individuals at the same sites. Individual plants should either be monitored over time on site, or attempts should be made to determine more about its life history through observations in cultivation. Such basic facts as fungal associations, longevity, yearly variations in population size, pollination and pollinators, and seed establishment are not precisely known.

In addition to the basic effort of locating additional populations of the species and making population counts, it would be useful to initiate a genetic investigation of the diversity within and between the known populations. It would be very useful to know if clumped stems indicate clonal reproduction or related individuals. This could be expanded to compare the Illinois plants with the nearest populations in adjoining states to determine its origin or degree of genetic distance from them. As mentioned previously, the current distribution of the Twining screwstem suggests that there were two different colonizations of the Midwest by this species, one from the Atlantic Coast west to the Great Lakes and one from the Gulf Coast north along the Mississippi River basin. It would be interesting to test this using DNA methodology. The techniques for several aspects of monitoring and studying rare plant species are explained well in Collins *et al.* (2001), Philippi *et al.* (2001), and Imm *et al.* (2001).

*Bartonia paniculata* is being monitored by botanists working on behalf of the state Natural Heritage programs and other organizations in the areas where it is listed as endangered or threatened (W-2, W-3). However, 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. There is a small to moderate area of suitable habitat in extreme southern Illinois where *Bartonia paniculata* could also exist, and continued searches for the species could be conducted.

Botanical surveys conducted by scientists from the Illinois Natural History Survey have shown repeatedly that with sufficient time and funding, and an experienced eye, many plants thought to be extirpated or else threatened or endangered can be found at additional locations (Hill 2002). These sorts of investigations have been important in that they have led not only to the de-listing of species once thought to be rare, but they have also resulted in the discovery of species previously unknown in the state. The U.S. Forest Service and other related agencies have done a fine job in the effort to preserve rare species with the resources that they have available. In the case of *Bartonia paniculata*, much of the location and monitoring of known populations has been conducted by Forest Service biologists in cooperation with Illinois Department of Natural Resources personnel. However, in order to fully protect all of the endangered and threatened plants in this region more field botanists are needed and should be hired or funded so that the immense area of potential habitat can adequately be covered.



## RESTORATION

There are no known restoration efforts being conducted on *Bartonia paniculata* anywhere in its range. Also, the plant is unknown in cultivation and is, therefore, not commercially available. There is no information available on attempts to propagate the plant. All of this basic research is needed in order to secure the future existence of the species.

At this time, as previously stated, the only way known or suggested to restore populations of this plant is to protect and manage its habitat. Protection of the hydrology of the sites is the top priority, along with the maintenance of an open habitat. Preliminary indications are that girdling trees may be effective. Exotic and aggressive species must be completely eliminated from each site. This would entail physically pulling them out without trampling the sphagnum or peaty substrate upon which the plants grow. The small size of these plants makes them quite vulnerable to careless steps. It is very likely that herbicide or fungicide application would eliminate this species at a site. Also, fire may be damaging, particularly if the peaty substrate is dry. It is most likely that only exotics, tree seedlings, and *Impatiens* would dominate these sites after fires or other disasters. Elimination and reconstruction of the human constructs and channelization of the seeps and springs as well as the associated streams will likely be necessary either at present or after the purchase of any buffer lands.

Restorations of any native plant species are recommended using only nursery propagated material grown from native, local populations to avoid interbreeding with genotypes not adapted to the local conditions and to avoid compromising the local gene pool. If this rule is not followed, the result is generally the loss of plants because they are not competitive under local conditions or the result could be the success of a plant or plants that can not be considered truly native (considered by some to be a plant community reconstruction rather than a restoration). Local plants should be propagated for planting in such an effort if it can be done with this species.

## SUMMARY

*Bartonia paniculata* ssp. *paniculata*, Twining screwstem, is an inconspicuous wiry annual or biennial herb with tiny white flowers, no obvious leaves, and greenish or purplish stems. It appears to be mycotrophic (a saprophyte), receiving some or most of its nutrients through association with fungi. The species is widespread, and it is found in 29 states and 5 Canadian provinces, mostly on the Atlantic coastal plain from Newfoundland, Canada, south to Florida, and west to Texas, then in a few populations inland north to Wisconsin and Ontario, Canada, around the Great Lakes. It grows mainly in acidic wetlands, generally in nutrient-poor peat soils in sphagnum bogs. It reproduces only by seeds. Globally, its ranking is G5 (demonstrably secure globally, though it may be quite rare in parts of its range, especially at its periphery). This herb is listed as Endangered in Illinois and New York, and as Threatened in Maine and Michigan; it is ranked as critically imperiled in the District of Columbia, Missouri, Oklahoma, and Wisconsin (a Special Concern species). Twining screwstem 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. Although it is widespread and secure in most of its range, it faces several risks that could result in its extirpation at the extreme edges of its range (as in Illinois) if

it is not properly managed. Basic monitoring is needed in Illinois and elsewhere and searches should be conducted for additional populations in far southern and northeastern parts of the state in suitable habitat. Management through enforced protection of hydrology and the selective girdling of surrounding trees to open the habitat, and enforcement of rules of restricted access to the sites (particularly recreational access) appear to be necessary to allow it to persist at its current locations, which are fragile and vulnerable. Without this management the species may disappear from Illinois.

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## APPENDICES

### APPENDIX 1

#### Representative specimens of *Bartonia paniculata* examined or cited in the literature

##### Herbaria:

CLEMS = Clemson University, Clemson, SC. DUR = Southeastern Oklahoma State University, Durant. FTG = Fairchild Tropical Garden herbarium, Coconut Grove, FL. GMUF = George Mason University, Fairfax, VA. MARY = University of Maryland herbarium, College Park. NCU = University of North Carolina herbarium, Chapel Hill. OKL = Bebb Herbarium, University of Oklahoma, Norman. UNA = University of Alabama herbarium, Tuscaloosa. VT = University of Vermont herbarium, Burlington. WIS = University of Wisconsin, Madison.

**ALABAMA:** ESCAMBIA CO., forested wetland, ca. 7.5 mi due SSW of Brewton, 16 Aug 1994, *Haynes 9481* (UNA); MOBILE CO., Springhill, Oct 1878, *Mohr s.n.* (UNA); cedar swamp, 0.75 mi due W of Movico, 26 Sep 1992, *Haynes 9400* (NCU)

**GEORGIA:** TAYLOR CO., Little Whitewater Creek, Butler West quad., white cedar swamp, 9 Sep 1990, *Orzell & Bridges 15058* (FTG)

**ILLINOIS:** POPE CO., Kickasola Barrens, 27 Sep 1994, *Ulaszek, Shimp, & Stritch 2289* (Shawnee NF herbarium); Cretaceous Hills Ecological Area, Shawnee National Forest, 2 Nov 1995, *Ulaszek & Spivey 3060* (Shawnee NF herbarium )

**INDIANA:** RIPLEY CO., regrowth flatwoods, T. 6N., R. 10 E., sec. 21, 31 Aug 1995, *Homoya 95-08-31-59* (Homoya, at Indiana DNR)

**MARYLAND:** PRINCE GEORGES CO., powerline right-of-way just N of Beaverdam Road, 0.7 mi E of Soil Conservation Road, Beltsville, 21 Sep 1986, *Hill 17423A* (MARY)

**MISSISSIPPI:** MONROE CO., vicinity of old strip mine around Splunge, low wet boggy area, 28 Aug 1996, *MacDonald 9877* (UNA)

**NEW JERSEY:** ATLANTIC CO., NNW of Pleasant Mills, 25 Sep 1991, *Strong 869* (GMUF); CAMDEN CO., Rt. 536, 0.7 mi W of Rt. 206, 1.9 mi E of Atlantic County line, 9 Aug 1987, *Hill 18533* (CLEMS, VT)

**NORTH CAROLINA:** BRUNSWICK CO., near jct. U.S. Rt. 17 and NC Rt. 133, 6 Sep 1963, *Bradley 1561* (GMUF)

**OKLAHOMA:** CHOCTAW CO., 8.8 mi N of Swink, 18 Sep 1977, *Taylor & Wright 25546* (DUR; 5.5 mi N of Swink, 18 Sep 1977, *Taylor & Wright 25547* (DUR); E edge of Schooler Lake, fruit, 13 Mar 1996, *Folley & Carpenter 1723* (OKL); E edge of Schooler Lake, 31 Aug 1996, *Folley et al. 1941* (OKL); LE FLORE CO., near Page, 9 Sep 1913, *Stevens 2736* (OKL);



McCURTAIN CO., Grassy Slough Wildlife Management Area, 22 Sep 1999, *Hoagland & Benesh RSGS449* (OKL); PUSHMATAHA CO., bog 5.5 mi W of Antlers, 18 Oct 1976, *Taylor & Taylor 23819* (DUR).

**SOUTH CAROLINA:** CHARLESTON CO., savanna and wet ditches along Whilden Road, ca. 4 mi N of Awendaw, 18 Oct 1968, *Leonard 2164* (NCU, UNA)

**VIRGINIA:** AUGUSTA CO., W of Sherando, 23 Sep 1995, *Fleming 11374* (GMUF); CAROLINE CO., Collins RR crossing, Rt. 609, 18 Oct 1987, *Poole 301* (NBYC); CITY OF SUFFOLK CO., SE of Manning, 8 Sep 1995, *Fleming 11233* (GMUF); ESSEX CO., NE of Oakley, 13 Oct 1991, *Fleming 6178* (GMUF); FAIRFAX CO., Ft. Belvoir Military Res., 21 Sep 1994, *Fleming 9917* (GMUF); FAUQUIER CO., NW of Summerduck, 14 Aug 1992, *Fleming 7174* (GMUF); GREENSVILLE CO., SE of Brink, 1 Sep 1995, *Fleming 11183* (GMUF); NOTTOWAY CO., Ft. Picket Military Res., 9 Oct 1992, *Fleming 7690* (GMUF); PRINCE GEORGE CO., SW of Disputanta, 25 Aug 1995.

**WISCONSIN:** JACKSON CO., N of City Point, 5 Sep 1997, *Clark 1621* (WIS); roadside and powerline ROW, N of City Point, 24 Jul 1998, *Clark 1546* (WIS); MONROE CO., powerline ROW S of Norway Ridge, 25 Aug 1998, *Clark 1595* (WIS); S of Norway Ridge in powerline ROW, 20 Aug 1998, *Clark 1592* (WIS).

## APPENDIX 2

### The Distribution of *Bartonia paniculata* in the United States. Information from herbarium specimens and the literature. [Incomplete.]

STATE	COUNTIES	NOTES
Alabama	Escambia, Mobile	information contributed by S. Ginzburg, pers. comm.
Arkansas	11 counties, mostly west-central part of state.	see Smith 1988, W-2; includes Ouachita N.F.
Connecticut	Fairfield, Litchfield, New Haven, New London, Windham	Magee & Ahles 1999, subspecies not distinguished
Delaware	?	W-2
Florida	16 counties, northern and central part of state.	W-10; Wunderlin 1998
Georgia	Camden, Charlton, Fannin, McIntosh, Screven, Taylor, Toombs	see Jones & Coile 1988, Sheridan <i>et al.</i> 1999, W-2
Illinois	Pope	includes Shawnee N.F.
Indiana	Clark, Jefferson, Jennings, Ripley	Homoya, pers. comm.
Kentucky	? [apparently > 10 counties]	see W-2; includes Daniel Boone N.F.
Louisiana	?	see Thomas & Allen 1982

Maine	Cumberland, Hancock, Knox, York	Dates of documentation: 1893, 1917, 1990 (4), 1991 (8); W-5
Maryland	Prince Georges, Wicomico	Brown & Brown 1984; Strong & Simmons 2000
Massachusetts	Barnstable, Bristol, Dukes, Middlesex, Norfolk, Plymouth	Magee & Ahles 1999, subspecies not distinguished
Michigan	Allegan, Chippewa, Luce	see W-4. Documented in 1983, 1995. Henson 1985.
Mississippi	Monroe [probably more]	see W-2; information contributed by S. Ginzburg, pers. comm.
Missouri	Stoddard	see W-2; Steyermark 1963.
New Hampshire	Carroll	Magee & Ahles 1999, subspecies not distinguished
New Jersey	Atlantic, Burlington, Camden [probably several others]	see Appendix 1; W-2
New York	Kings, Nassau, Orange, Queens	W-11
North Carolina	Brunswick, Cumberland, Duplin, Gates, Hoke, Moore, Onslow, Scotland, Wake	see W-2, W-15; Radford <i>et al.</i> 1968
Oklahoma	Choctaw, LeFlore, McCurtain, Pushmataha	see W-12; Taylor & Taylor 1978; W. Elisens, pers. comm.
Pennsylvania	Berks, Bucks, Chester, Dauphin, Lancaster, Lebanon, Lehigh, Montgomery, Northampton, Schuylkill	see Wherry <i>et al.</i> 1979
Rhode Island	Kent, Washington	Magee & Ahles 1999, subspecies not distinguished; Seymour 1969
South Carolina	11 counties, southern half, disjunct in Greenville County in bog.	see W-2, W-13
Tennessee	10 counties, scattered in west-central and east-central areas, not in limestone areas or the central basin	see Chester <i>et al.</i> 1993; includes Cherokee N.F. [?]
Texas	“in sandy bogs and meadows in e. Texas.”	Correll & Johnston 1970
Virginia	14 counties, primarily coastal plain, but a few from the piedmont and one, Augusta Co., from the mountains	Ted Bradley, pers. comm.
Wisconsin	Jackson, Monroe	see W-14

## APPENDIX 3

### Natural Diversity Database Element Ranking System

modified from: <http://www.cnpsci.org/html/PlantInfo/Definitions2.htm> [W-9]

#### 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.

#### **SR**

Reported to occur in the state. Otherwise not ranked.

#### **SX**

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

**Notes:**

1. Other considerations used when ranking a species or natural community include the pattern of distribution of the element on the landscape, fragmentation of the population/stands, and historical extent as compared to its modern range. It is important to take a bird's eye or aerial view when ranking sensitive elements rather than simply counting element occurrences.
2. Uncertainty about the rank of an element is expressed in two major ways: by expressing the rank as a range of values (*e.g.*, **S2S3** means the rank is somewhere between S2 and S3), and by adding a '?' to the rank (*e.g.* S2?). This represents more certainty than S2S3, but less than S2.