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Conservation Assessment of the Beaked Spikerush in the Black Hills National Forest, South Dakota and Wyoming

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EXECUTIVE SUMMARY

Beaked spikerush, *Eleocharis rostellata* (Torr.) Torr., is an obligate wetland graminoid species (Reed 1988). Beaked spikerush is widespread in the Americas from across southern Canada to northern Mexico, to the West Indies, the Caribbean, and the Andes of South America (Cronquist *et al.* 1994; Hitchcock *et al.* 1994). The species is secure throughout its range with a G5 ranking, but infrequent across most of the U.S., with Region 2 state rankings ranging from S1, critically imperiled; to S2, imperiled; to SR, reported (NatureServe 2001). Beaked spikerush is a "species of special concern" with the South Dakota Natural Heritage Program (Ode pers. comm. 2001).

The only currently known population of beaked spikerush in South Dakota is in Fall River County, along Cascade Creek, an area where several other rare plant species occur. The beaked spikerush population is present on lands administered by Black Hills National Forest (BHNF), and on surrounding private lands, including the Whitney Preserve owned and managed by The Nature Conservancy (TNC). BHNF has been coordinating management activities with TNC for beaked spikerush and other rare plant species in the area. The Fall River Ranger District of the Nebraska National Forest is currently responsible for the direct maintenance of the grounds (i.e., cleaning, mowing, etc.,) at J. H. Keith Cascade Springs and Cascade Falls Picnic Grounds through an agreement with the Hell Canyon Ranger District, Black Hills National Forest (Reyher, pers. comm. 2001). The Hell Canyon Ranger District retains responsibility for larger "improvements" (i.e., gates, signs, etc.,) (Reyher, pers. comm. 2001). Under the terms of the original property warranty deed to the Forest Service, J. H. Keith Cascade Springs must be managed and maintained for public recreational purposes. Species specific surveys for beaked spikerush have not been performed on Black Hills National Forest, and it may have a broader distribution than is presently recognized. It is currently unknown how restricted beaked spikerush is in the Black Hills (Marriott 2002). It is possible that unsurveyed potential habitat for beaked spikerush exists in the Black Hills, although no other specific potential habitat areas on BHNF have been identified (Ode pers. comm. 2001).

The species is not known to have suffered significant impacts as a result of historic development activities or other human induced impacts in the area (Ode pers. comm. 2001). The main risks to beaked spikerush on BHNF are impacts to hydrology, including direct changes to the springs and modifications to runoff patterns from adjacent uplands and paved areas, development on adjacent private land, human trampling from recreational activities, and invasion of noxious weeds.

The basic management objective for the Cascade Complex has been to provide continued access for traditional recreational activities such as picnicking, while minimizing potential effects of erosion and trampling. Recent management activities include paving and fencing trails and high use areas to limit access to sensitive riparian areas which support rare plant species. Conservation and enhancement of hydrologic resources throughout the watershed is essential, not only along Cascade Creek, but also on upstream areas, including private lands. The Forest Service is already working closely with TNC to control and eliminate noxious weeds such as Canada thistle (*Cirsium arvense*) and invasive plant species such as Russian olive (*Elaegnus angustifolia*) in the area that could jeopardize resources within the Cascade Spring Complex.

Key words: *Eleocharis rostellata*, beaked spikerush, Black Hills, Cascade Springs, warm spring.

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INTRODUCTION

The objective of this assessment is to review the status of beaked spikerush in the Black Hills and to synthesize information relevant to its management and long-term persistence. There is little information about the habitat needs of beaked spikerush and its responses to management activities in the Black Hills. The result is a fairly low state of knowledge about the local requirements of this species. In addition to published literature on beaked spikerush and its habitats, other sources of information were important in developing this assessment. The USDA, NRCS PLANTS Database is referenced frequently in this document, although the geographical basis and source of specific habitat data is often unknown and may not be directly applicable to the Black Hills in all instances. This document was developed in accordance with content and format requirements defined by Black Hills National Forest.

CURRENT MANAGEMENT SITUATION

Management Status

International

Global Heritage Status Rank: G5; secure worldwide, but possibly quite rare in parts of its range, especially at the periphery (NatureServe 2001).

Federal

Beaked spikerush has no special federal status and is not a designated "Sensitive" species in USFS Region 2 (USDA 1994) or "Special Status" plant species by the BLM (USDI BLM 1997).

Beaked spikerush, *Eleocharis rostellata* (Torr.) Torr., is an obligate wetland graminoid species. Beaked spikerush is widespread in the Americas from across southern Canada to northern Mexico, to the West Indies, the Caribbean, and the Andes of South America (Cronquist *et al.* 1994; Hitchcock *et al.* 1994). Although widespread across the contiguous United States, beaked spikerush typically occurs in scattered disjunct populations in saline, alkaline, or calcareous wetlands, often in association with hot springs (Mason 1957 in Carey 1994; Godfrey and Wooten 1979 in Carey 1994; Gleason and Cronquist 1991; Larson 1993 in Carey 1994; and Welsh *et al.* 1993; Cronquist *et al.* 1994). The species is secure throughout its range with a G5 ranking, but infrequent across most of the U.S. with Region 2 state rankings ranging from S1, critically imperiled, in South Dakota and six other states; to S2, imperiled, in Wyoming, Montana, Nebraska, and Minnesota, and five other states,; to SR, reported, in Colorado and 15 other states (NatureServe 2001). Beaked spikerush is a "species of special concern" with the South Dakota Natural Heritage Program (Ode pers. comm. 2001). Virginia is the only state where beaked spikerush is listed as vulnerable (S3) (NatureServe 2001). Across its range, beaked spikerush is rare where suitable wetlands are less abundant or human impacts are more widespread. In addition, human activities may have directly and indirectly impacted the quality, quantity, and distribution of beaked spikerush's naturally uncommon wetland habitats.

The only currently known population of beaked spikerush in South Dakota is in Fall River

County, along Cascade Creek, where it occurs with several other rare plant species. This relatively large, scattered population includes sub-populations on Black Hills National Forest (BHNF) J. H. Keith Cascade Springs and Cascade Falls Picnic Grounds and on private land along Cascade Creek, including The Nature Conservancy's recently established Nathanial and Mary Whitney Preserve (SDNHP 2000; Ebbert pers. comm. 2001). The population of beaked spikerush extends along Cascade Creek from the headwaters at Cascade springs in the J. H. Keith Cascade Springs Picnic Ground to within one-half mile of the confluence with the Cheyenne River, and the species is especially abundant along the reach between Cascade Springs to just below Cascade Falls (Burkhart and Ebbert 2001). Approximately 10 percent of the total population occurs on lands administered by BHNF (Ebbert 2001).

The population of beaked spikerush exists in an area that has been subject to Anglo-American use and development for over a century. BHNF has been coordinating management activities with TNC for beaked spikerush and other rare plant species.

The main risks to beaked spikerush on BHNF include impacts to hydrology, such as direct impacts to the springs and changes to runoff patterns from adjacent uplands and paved areas, development on adjacent private land, human trampling from recreational activities, and invasion of noxious weeds.

The remains of the town of "Cascade Springs" are still visible just to the southwest of the springs. The town was founded in 1888 as a resort based upon the "medicinal waters" of Cascade Springs and the spring site was presumably heavily used at that time (Parker and Lambert 1974). However, despite development efforts by the Carlsbad Springs Company of Chicago, Illinois in 1893, the town's 30 planned city blocks had only a few residents by the turn of the century (Parker and Lambert 1974). The town's original limestone bank building still stands and is now a private residence. Because of the topography and consistent water source, Cascade Valley was historically proposed as a dam site (Ode, pers. comm., Jan 18, 2001).

J. H. Keith Cascade Springs Picnic Ground and Cascade Falls are relatively small, outlying areas of BHNF (10 and 15 acres, respectively), surrounded by private land and managed as Developed Recreation Complexes (USDA BHNF 1996). The Land and Resource Management Plan for the Black Hills National Forest states, *"Activities associated with management of Cascade Complex would be directed at the maintenance and improvement of* the *areas natural setting, providing a healthy and safe recreational environment, conserving and enhancing areas of botanical interest and protecting sensitive natural resources, such as the warm springs."* (USDA BHNF 1996). Several other rare plant species are also found in the BHNF Cascade Complex and on private land along Cascade Creek, including stream orchid (*Epipactis gigantea* Dougl. Ex Hook.), southern maidenhair fern (*Adianthum capillus-veneris* L.), and tulip gentian (*Eustoma exaltatum* (L.) Salisb. Ex G. Don. *ssp. russellianum* (Hook) Kartesz).

The 10-acre Cascade Springs site at J. H. Keith Cascade Springs Picnic Ground and 15-acre Cascade Falls Picnic Ground are currently under the administration of the USDA Forest Service. An out-of-state party owns the land immediately to the north of J. H. Keith Cascade Springs Picnic Ground. The 4-acre parcel of land between the old "Bank Building" along South Dakota Highway 71 and the next bridge to the south at Cool Creek is also privately owned and includes about 100 yards of the Creek bed (Paulson pers. comm. 2001). The 1,195-acre parcel of land between Cascade Springs and Falls, from just south of the Cool Creek culvert to Cascade Falls, was recently purchased by the Black Hills chapter of The Nature Conservancy and has been

established as The Nathanial and Mary Whitney Preserve at Cascade Creek (Paulson 2000).

The Cascade Springs and Falls Complex is within Black Hills National Forest. The Fall River Ranger District of the Nebraska National Forest is currently responsible for the direct maintenance of the grounds (i.e., cleaning, mowing, etc.,) at J. H. Keith Cascade Springs and Cascade Falls Picnic Grounds through an agreement with the Hell Canyon Ranger District, Black Hills National Forest (Reyher, pers. comm. 2001). However, the Hell Canyon Ranger District retains responsibility for larger "improvements" (i.e., gates, signs, etc.,) (Reyher, pers. comm. 2001).

The Warrantee Deed granted to the USFS in 1962 specifically requires that the USFS (Grantee) must conserve Cascade Springs as "J. H. Keith Picnic Ground", and must develop, care for and maintain the site as a park for the use of the public and for no other purpose.

Conservation Status

State	Rank	Comments	Source
South Dakota	S1	Critically imperiled due to extreme rarity.	NatureServe 2001

Conservation Status - Elsewhere

State/Province	Rank	Comments	Source
Region 2			
Wyoming	S2	Imperiled	NatureServe 2001
Colorado	SR	Reported	NatureServe 2001
U.S. – other states			
Maine	SH	Possibly Extirpated	NatureServe 2001
Alabama, Delaware, Florida, Pennsylvania, Rhode Island, South Dakota, Washington, West Virginia	S1	Critically Imperiled	NatureServe 2001
Illinois, Kansas, Maryland, Montana, Nebraska, North Carolina, Wisconsin	S2	Imperiled	NatureServe 2001
Virginia	S3	Vulnerable	NatureServe 2001
Connecticut	SU	Unrankable	NatureServe 2001
Arizona, California, Georgia, Idaho, Indiana, Nevada, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Texas, Utah	SR	Reported	NatureServe 2001
Massachusetts, Michigan, South Carolina	S?	Unranked	NatureServe 2001
Canada			
Nova Scotia	S1S2	Imperiled	NatureServe 2001
Ontario	S3	Vulnerable	NatureServe 2001
British Columbia	S2S3	Secure	NatureServe 2001

Existing Management Plans, Assessments Or Conservation Strategies

No other management documents were identified for beaked spikerush.

REVIEW OF TECHNICAL KNOWLEDGE

Systematics

Citation: Torr. Fl. State New York 2: 347, 1843.

Beaked spikerush, *Eleocharis rostellata* (Torr.) Torr., is classified as Division Magnoliophyta, Class Lilliopsida, Order Cyperales, Family Cyperaceae (Sedge Family), Genus *Eleocharis*, (ITIS 2001). Alternative taxonomic treatments include *Scirpus rostellata* Torr. Two varieties have been recognized, *E. rostellata* var. *congdonii* Jepson, and *E. rostellata* var. *occidentalis* S. Wats. (ITIS 2001). Ode (pers. comm. 2001) is not aware of anyone who makes these varietal distinctions and has not seen any Black Hills material annotated to varietal level. The Heritage Identifier for beaked spikerush (*Eleocharis rostellata* (Torr.) Torr.) is PMCYP091P0.

Species Description

Non-Technical

Beaked spikerush is a native, tufted perennial spikerush with short, stout, often ascending or nearly vertical rhizomes (Hitchcock *et al*. 1994; Godfrey and Wooten 1979 in Carey 1994; Larson 1993 in Carey 1994; Radford *et al.* 1968 in Carey 1994). Roots are shallow; in a New York fen, 65 percent or more of beaked spikerush roots were in the top 4 inches (10 cm) of soil (Seischab *et al.* 1985 in Carey 1994). The flattened, wiry culms are mostly 1.3 to 3.3 feet (0.4-1.0 m) long. There are three types of culms: layering, which root at the tips upon contact with moist soil, fertile, and sterile. Spikes are 0.3 to 0.8 inches (0.8-2.0 cm) long and have many flowers (Hitchcock *et al*. 1994; Godfrey and Wooten 1979 in Carey 1994; Larson 1993 in Carey 1994; Radford *et al.* 1968 in Carey 1994). *Eleocharis rostellata* is most readily distinguished from other spikerushes by the elongated, apically rooting stems.

Technical

"Perennial with clustered stems on short, stout, often ascending or nearly vertical rhizomes; culms (2) 4-10 dm tall or sometimes more, more or less flattened at least distally and commonly 1-2 mm wide, some of them commonly proliferous (rooting from an apical bulbil); spikelets (5) 8-13 mm long, (5) 10- to 20- (25)-flowered; scales equaling or surpassing the achene; stigmas 3; achene light greenish to medium brown, rounded-trigonous to planoconvex, smooth and shining or slightly cellular-roughened, 1.9-2.8 mm long, including the prominent pale tubercle which is up to 0.75 mm long and is confluent with the body of the achene." (Cronquist *et al.* 1994).

Species Significance

Although it ranges across much of the continent, beaked spikerush is present in Region 2 mostly as widely scattered occurrences, typically in association with saline, alkaline or calcareous wet meadows and thermal features (warm/hot springs). In South Dakota, it is apparently restricted to Cascade Creek, occurring on BHNF and adjacent private lands (Ode pers. comm. 2001). As the only occurrence of beaked spikerush in the state, the Cascade Springs population may be an important source of genetic diversity. Due to their unique characteristics, the warm, calcareous outflows from Cascade Springs support other rare plant species along Cascade Creek, and may

influence other rare or relict species (USDA Forest Service 1997). It is possible there are species, such as butterflies or other invertebrates, mosses or other non-vascular species, that are also restricted to Cascade Creek and directly or indirectly dependent upon the plant community found there, including beaked spikerush. Insect pollinators and animal herbivores may utilize beaked spikerush as well.

Waterfowl eat the stems, roots, and achenes of spikerush (*Eleocharis* spp.) (Godfrey and Wooten 1979 in Carey 1994). Spikerush palatability is low for livestock and wildlife (Kovalchik 1987 in Carey 1994). The stems of various Cyperaceae have been used to make baskets, hats, mats, for thatch, and other similar purposes (Walters and Keil 1996). There is no record for the use of beaked spikerush as an ornamental species or for other commercial purposes.

Distribution And Abundance

Distribution Recognized In Primary Literature

Beaked spikerush is widespread in the Americas from across southern Canada to northern Mexico, to the West Indies, the Caribbean, and the Andes of South America (Cronquist *et al.* 1994; Hitchcock *et al.* 1994). The species is secure throughout its range with a G5 ranking, but infrequent across most of the U.S. with Region 2 state rankings ranging from S1, critically imperiled; to S2, imperiled; to SR, reported (NatureServe 2001).

The Black Hills were not glaciated during the Pleistocene era and are known to have supported vegetation during that cooler and wetter period when coniferous forests may have linked the Hills with surrounding areas, including the Rocky Mountains to the west (Froiland 1999). The preference of beaked spikerush for alkaline, calcareous, and saline wetlands and thermal features, and its scattered distribution across the continent (Cronquist *et al.* 1994; Hitchcock *et al.* 1994), suggest the species would have been more abundant during the Pleistocene. As the climate became drier, available habitat for such species would have decreased and populations would have become increasingly restricted and isolated in their range. The disjunct occurrences in the Great Plains, Black Hills, and Rocky Mountains may be relicts from the last Pleistocene glaciation 11,000 years ago (Froiland 1999).

Beaked spikerush's scattered distribution across most of its range, including the Rocky Mountains, Black Hills, and Great Plains, is presumably due to its association with saline, alkaline, and calcareous wetlands and thermal features, and likely the result of greater geographic isolation of these habitats during the current inter-glacial drying trend (Froiland 1999; Price *et al*. 1996). The species was presumably more widespread historically. The species' reported habitat requirements in other portions of its range are similar to those found along Cascade Creek, i.e., warm springs and calcareous wetlands (Cronquist *et al.* 1994; Hitchcock *et al.* 1994).

Additional Information From Federal, State, And Other Records

In the Black Hills, beaked spikerush occurs as a disjunct population restricted to the Cascade Creek/Springs riparian zone (Ode pers. comm. 2001). The first report of beaked spikerush in South Dakota by McIntosh in 1931, from high mountain streams near Deadwood, is believed to be based on a mis-identification as no supporting herbarium specimens are available (Ode pers. comm. 2001). The only documented occurrence of beaked spikerush was in 1966 from along

Cascade Creek (SDNHP 2000). The known range of this population has since been expanded as additional surveys along the length of Cascade Creek have been completed, but the population along Cascade Creek remains the only currently known occurrence in South Dakota (Ebbert pers. comm. 2001; Ode pers. comm. 2001). The species is not known to have suffered significant impacts as a result of historic development activities and other human induced impacts in the area (Ode pers. comm. 2001). Other thermal spring-fed systems in the area, such as Fall River and Hot Brook, have not been thoroughly surveyed. Ode has spot checked areas along Hot Brook, but did not observe any beaked spikerush. Beaked spikerush is currently unknown from these or other potential habitat areas in the Black Hills (Ode 2001).

In Montana, beaked spikerush is listed as Imperiled (S2) and restricted to the valleys and foothills of the western, mountainous portion of the state (Montana Natural Heritage Program 2001).

In Wyoming, the species is listed as Imperiled (S2), but not tracked by the state Heritage Program, although it may warrant attention as a rare community (Fertig pers. comm. 2001). Wyoming beaked spikerush occurrences are restricted to the Absaroka, Teton, and Wind River ranges (University of Wyoming 2001). The species is typically found in very wet marshy areas, often on floating mats, and can be quite abundant locally (Fertig pers. comm. 2001).

In Colorado, beaked spikerush is reported from Larimer and Delta counties, in association with peat, meadow, and spring runoff (Ackerfield 2001).

In Nebraska, beaked spikerush is known only from stream margins in the Republican River and Platte River drainages in Lincoln County. Soils in these drainages typically range from slightly calcareous to alkaline (Rolfsmeier pers. comm. 2001)

In Utah, beaked spikerush occurrences are scattered across the state, present in at least 16 counties in association with wet meadows, seeps and springs (often alkaline), ditches and streams, and marshes, and ranging from 775 to 2700 meters in elevation (Welsh *et al*. 1993)

There is only one reported Element Occurrence (EO) record for beaked spikerush in South Dakota, in the southern portion of the Black Hills, along Cascade Creek. The restricted occurrence of beaked spikerush in the Black Hills and South Dakota may be due to naturally limited habitat availability (Ode pers. comm. 2001).

The population of beaked spikerush in the Black Hills is comprised of numerous localized, sometimes extensive, sub-populations, extending along Cascade Creek from the headwaters at J. H. Keith Picnic Ground to approximately one-half mile above the confluence with the Cheyenne River (Burkhart and Ebbert 2001). It is not known if there is any genetic exchange between the other locations in the region or surrounding states, but the nearest populations to the Black Hills are at least 100 miles distant.

The long-term persistence of beaked spikerush in the Black Hills is dependent upon the continued maintenance and enhancement of the population along Cascade Creek. However, the species' ability to disperse elsewhere in the Black Hills may be limited by the quality and extent of calcareous wetlands and perennial warm spring fed habitats or other suitable water sources in the area.

Local Abundance

According to Burkhart and Ebbert (2001), beaked spikerush is very extensive along the majority of the length of Cascade Creek. It is less abundant at Cascade Springs on USFS property and along the headwaters of Cascade Creek. It is especially abundant along the midsection of the creek, and forms large "mats" in places, especially in the vicinity of Cascade Falls. Beaked spikerush was found in the lower section of the creek, but was not seen for the last ½ mile upstream from the confluence of Cascade Creek and the Cheyenne River.

Population Trend

No specific population trend monitoring data is available for beaked spikerush in Black Hills National Forest. However, The Nature Conservancy collected some baseline data during 2001as part of a monitoring plan for other rare plant species in the area (Ebbert pers. comm. 2001). The species is not known to have suffered significant impacts as a result of historic development activities and other human induced impacts in the area (Ode pers. comm. 2001).

Broad Scale Movement Patterns

The Black Hills population of beaked spikerush is over a hundred miles away from the nearest populations, which are in western Wyoming and southwest Nebraska. Beaked spikerush pollen may be transported considerable distances by wind or insects, but natural transfer of seed material from other beaked spikerush populations or export to other suitable habitat is probably limited. Water transport is conceivable on a localized basis, but not likely as a means of long range transport, especially in the absence of direct transfer routes. Migratory waterfowl or insects may represent the most likely mode of transfer under present climatic conditions. The disjunct Black Hills population of beaked spikerush may be an important source of genetic diversity. If the Black Hills population was extirpated, it is unlikely that natural recolonization would occur.

Habitat Characteristics

Beaked spikerush is an obligate wetland species (Reed 1988) that appears to have a broad ecological amplitude. It occurs in many types of alkaline wetlands including salt and brackish marshes, tidal flats, alkaline seeps, bogs, stream margins, hot spring edges, and swamps (Gleason and Cronquist 1991; Godfrey and Wooten 1979 in Carey 1994; Larson 1993 in Carey 1994; Mason 1957 in Carey 1994). Beaked spikerush occurs near springs and seeps in desert areas of the Southwest (Pinkava *et al.* 1992 in Carey 1994; Welsh *et al.* 1987). The depth to the water table averages 2.2 inches (5.5 cm) for beaked spikerush sites in New York (Seischab 1984 in Carey 1994). In Ohio, beaked spikerush forms solid mats in meadows where the water table is at or above the soil surface (Frederick 1974 in Carey 1994). In northern Minnesota, beaked spikerush occurs 4 inches (10 cm) above the water table in spring-fen channels with peaty soil (Glaser 1983 in Carey 1994; Glaser *et al.* 1990 in Carey 1994).

In a fen in New York, beaked spikerush occurs on wet minerotrophic sites, nutrient-poor marl beds, and organic soils (marl beds are soils formed from calcium carbonate precipitates). Average soil pH for all sites in New York was greater than 7.0 (Seischab *et al.* 1985 in Carey 1994). In the Minnesota spring-fen, groundwater discharge from calcareous till maintains a pH greater than 7.0 and calcium concentrations between 20 and 45 parts per million (ppm) (Glaser 1983 in Carey 1994; Glaser *et al.* 1990 in Carey 1994). Brotherson (1987 in Carey 1994) studied

soil characteristics of a common spikerush community in Utah in which beaked spikerush averaged 0.6 percent cover. Soil pH averaged 7.7, soluble salts averaged 4,003 ppm, and organic matter averaged 32.7 percent. The mineral fraction averaged 13 percent sand, 48 percent silt, and 39 percent clay (Brotherson 1987 in Carey 1994).

Beaked spikerush occurs from sea level in Atlantic, Gulf, and Pacific coast salt marshes and tidal flats (Godfrey and Wooten 1979 in Carey 1994; Hitchcock and Cronquist 1973; Mason 1957 in Carey 1994) to nearly 9,000 feet (2,700 m) elevation in Colorado (Dittberner and Olson 1983 in Carey 1994). In Montana, it primarily occurs in valley and foothill zones from 3,200 to 5,500 feet (915-1,675 m) elevation (Lesica and Shelly 1991). Beaked spikerush occurs in saline or alkaline wetlands (Godfrey and Wooten 1979 in Carey 1994; Larson 1993 in Carey 1994; Mason 1957 in Carey 1994). In Montana thermal areas and alkaline seeps, beaked spikerush occurs with common arrowgrass (*Triglochin maritimum*), hardstem bulrush (*Scirpus acutus*), Torrey's rush (*Juncus torreyi)*, and alkali muhly (*Muhlenbergia asperifolia*). Adjacent wetlands may be dominated by hardstem bulrush or common arrowgrass (Hansen *et al.* 1995).

In a saline meadow near Utah Lake, Utah, beaked spikerush occurs at low densities in a common spikerush (*Eleocharis palustris*) community with sea milkwort (*Glaux maritima*), saltgrass (*Distichlis spicata*), and Baltic rush (*Juncus balticus*) (Brotherson 1987 in Carey 1994). In a spring-fed meadow near Coalville, Utah, beaked spikerush occurs at moderate densities in a diverse, open canopied community of graminoids and forbs (Glisson, pers. obs. 2001a). Associated species include Nebraska sedge (*Carex nebrascensis*), common arrowgrass (*Triglochin maritimum*), hardstem bulrush (*Scirpus acutus*), redtop (*Agrostis stolonifera*), Baltic rush (*Juncus balticus)*, sea milkwort (*Glaux maritima*), silverweed (*Potentilla anserina*), and alkali muhly (*Muhlenbergia asperifolia*).

In northern Minnesota, beaked spikerush occurs near spring-fen channel margins with mud sedge (*Carex* limosa), lesser panicle sedge (*C. diandra*), tufted bulrush (*Scirpus cespitosus*), whitebeaked rush (*Rhynchospora alba*), and common reed (*Phragmites australis*). These channels have standing water and lack forest cover (Glaser 1983 in Carey 1994; Glaser *et al.* 1990 in Carey 1994).

In a Delaware salt marsh, beaked spikerush is associated with saltgrass, Olney threesquare (*S. americanus*), and saltmeadow cordgrass (*Spartina patens*) (Stearns and MacCreary 1957 in Carey 1994).

Beaked spikerush is codominant in meadows in western New York with needle beaksedge (*Rhynochospora capillacea*). It forms small mounds or tussocks within moss (*Campylium stellatum*) mats. It also occurs with low nutrush (*Scleria verticillata*) and Indian grass (*Sorghastrum nutans*) (Seischab 1984 in Carey 1994).

At a calcareous seep in Illinois with sparse to patchy ground cover, beaked spikerush and shrubby cinquefoil (*Potentilla* fruticosa) are dominant. Needle beaksedge and tufted hairgrass (*Deschampsia cespitosa*) also occur (Stoynoff 1993 in Carey 1994).

Overall, the habitat characteristics of the Black Hills occurrence appear to be consistent with many other range-wide occurrences that also tend to form floating mats. Specific shared habitat characteristics include an apparent association with a warm, calcareous, perennial water source, and predominantly herbaceous communities, typically with open canopies. In addition, as an early seral species with an apparent preference for tidal flats, salt marshes, and flood plains, it is

likely adapted to, or possibly dependent upon, physical disturbance for successful recruitment or elimination of competitors. The South Dakota population of beaked spikerush extends along Cascade Creek from the headwaters at Cascade Springs to within one-half mile of the confluence with the Cheyenne River, and the species is especially abundant along the reach between Cascade Springs to just below Cascade Falls (Ebbert pers. comm. 2001). At J. H. Keith Picnic Ground, concentrations of beaked spikerush occur at approximately 3400 feet elevation in close association with the site's six natural artesian warm springs. The species is reportedly intolerant of shade (USDA NRCS 2001), although portions of the J. H. Keith Picnic Ground population were at least partially shaded (Glisson pers. obs. 2001b). The plant occurs on floodplains and along channel margins, in partial shade to full sun, in moist to inundated soils. Along Cascade Creek, beaked spikerush is most abundant where stream banks are gentle, with larger, flat, often wet floodplains, presumably in lower gradient, wider valley bottom stream reaches. Associated species in these areas include hardstem bulrush, common reed, and prairie cordgrass (*Spartina pectinata*). Beaked spikerush appears to be more tolerant of saturated water conditions than stream orchid and southern maidenhair fern, two of the other rare plant species in the area. However, both stream orchid and southern maidenhair fern were found growing with beaked spikerush in some slightly drier sites (Burkhart and Ebbert 2001). Suitable hydrology is undoubtedly a key requirement for recruitment and on-going maintenance of the beaked spikerush population along Cascade Creek.

Calcareous soil map units along Cascade Creek's bottomlands range from the Rock outcrop-Gystrum complex, 9 to 50 percent slopes type, in the vicinity of the Springs, to the Haverson loam and Haverson variant loam, 3 to 9 percent slopes types that predominate along most of the remaining stream reach downstream to the Cheyenne River (USDA SCS 1982). Inclusions along floodplains in the valley bottom may include Barnum, Nevee, Kyle, and Lohmiller soils.

The dry upland soil types on the surrounding hillslopes which are naturally moderately erosive combined with a low precipitation site, may result in naturally moderate-to-high bare soil conditions. Additionally, since this area of the Hills often receives intense short duration thunderstorms, there is probably a naturally high sediment load to this hydrologic system, and dynamic lateral stream channel migration in the lower reaches of Cascade Creek, as evidenced by multiple channel and floodplain remnants (Reyher 2001). This suggests that frequent disturbance and early seral conditions are inherent to the Cascade Creek system.

According to Burkhart and Ebbert (2001), "The plant communities found along Cascade Creek are a mosaic of Cottonwood – Peach-leaf Willow Floodplain Woodland (*Populus deltoides* – (*Salix amygdaloides*/*Salix exigua*)) and Great Plains Cattail – Bulrush Marsh (*Typha* spp. – *Scirpus* spp. – Mixed Herbs Great Plains Herbaceous Vegetation). These community types are described in detail in Riparian and Wetland Plant Communities of the Black Hills (Marriott and Faber-Langendoen, 2000). The cattail – bulrush type is coarsely patchy in itself, with patches along Cascade Creek of hard bulrush *(Scirpus acutus)*, American three-square *(Schoenoplectus pungens)*, beaked spikerush *(Eleocharis rostellata)*, and broad-leaved cattail *(Typha latifolia)*. Prairie cordgrass *(Spartina pectinata)* is also present in relatively small stands along the length of the creek. It's uncertain without more investigation if it is most accurate to describe the situation as a riparian mosaic including the cordgrass community (Prairie Cordgrass – Sedge Wet Meadow *(Spartina pectinata – Carex* spp. Herbaceous Vegetation) or as a mosaic of the Cottonwood – Peach-leaf Willow Floodplain Woodland and Great Plains Cattail – Bulrush Marsh containing remnant stands of prairie cordgrass from an earlier seral stage.

The most common non-native species in the Cascade Creek floodplain is *Eleagnus angustifolia* (Russian olive). In slightly drier habitat further back from the stream, *Cirsium arvense* (Canada thistle) can be found in large patches". *Polypogon monspeliensis* (rabbitfoot grass) is also common.

According to Burkhart and Ebbert (2001), "Common native herbaceous species include *Nasturtium officinale* (watercress), *Asclepias incarnate* (swamp milkweed), *Asclepias speciosa* (showy milkweed), *Helianthus maximilianii*, (Maximiliian's sunflower), *Lobelia siphilitica* (blue cardinal flower), *Mentha arvensis* (rield mint), *Parthenocissus vitacea* (woodbine), Solidago *canadensis* (Canada goldenrod), and *Verbena stricta* (hoary vervain). Common native shrub species include *Ribes* spp. (currants) and *Shepherdia argentea* (silver buffaloberry)."

Phragmites australis (common reed or elephant grass) is present in large patches along Cascade Creek. This is a cosmopolitan species apparently native to North America, although there may be races of introduced plants that are invasive and threaten native species and their habitats (TNC 1993). McIntosh (1931) observed *Phragmites* in the 1920's and noted that it was "locally common along Cascade Creek". Whether it is native or was introduced via tourist traffic in the 1890's is unknown for certain, but it obviously hasn't overrun the wet meadows of the valley in the last seventy years (Ode pers. comm. 2001).

The continuous flow of spring water at a constant, year-round temperature moderates the climate in and around Cascade Springs. This effect may be important to the survival of beaked spikerush in this part of its range. Total annual precipitation at Hot Springs, South Dakota is 15.83 inches, with average temperatures ranging from 11.4 degrees (January) to 90.2 degrees Fahrenheit (July); precipitation is concentrated in the early summer months from May (2.82 inches) through July (2.62 inches); first frost is in early October and last frost in early June; and extreme temperatures for 1998 and 1999 ranged from minus 25 to over 100 degrees Fahrenheit (NOAA 1998, 1999). The past several years have had relatively mild winters with little snowfall and cool, rainy summers.

Cascade Springs is the largest single springs in the Black Hills with water emerging at 22.5 cubic feet/second (CFS) at a constant 67 degrees Fahrenheit from six known discharge points (Rahn and Gries 1973; Hayes reported a collective flow of 19.6 cfs at 68 degrees F in 1999). Cascade Springs occurs along a band of quaternary alluvium between the Triassic and Permian Spearfish formation and "Permian Minnekahta limestone selected outcrop" (Hayes 1999). Cascade Springs' water is believed to originate from the Madison and/or Minnelusa aquifers (Rahn and Gries 1973). The water contains 2530 ppm (parts per million) total dissolved solids comprised of the following: 1540 ppm sulfate; 568 ppm calcium; 235 ppm bicarbonate; 92 ppm magnesium; 62 ppm chloride; 60 ppm sodium; 22 ppm silica; 1 ppm fluoride; and < 1 ppm iron, with a neutral pH of 7.0 (Rahn and Gries 1973). Busby *et al*. (1991) reported roughly the same mineral constituents for Cascade Springs: 1500 ppm sulfate (SO4); 540 ppm calcium (Ca); 240 ppm bicarbonate (HCO3); 83 ppm magnesium (Mg); 31 ppm chloride (C1); 27 ppm sodium (Na); 15 ppm silica (SiO2); 5.2 ppm potassium (K); and a pH of 6.89. The calcium level in Cascade Springs' water is considerably higher than the 20 to 45 ppm mentioned earlier for the Minnesota spring-fen. Cascade Springs, and other artesian springs in the Hills, have moved steadily outwards from the center of the Black Hills uplift since their formation as a result of the ongoing development, erosion and collapse of underground geologic formations (Hayes 1999).

Cascade Valley is lined with limestone outcroppings comprised almost entirely of petrified

Chara, or stonewort (Charophyceae), a calcium deposit-forming alga that still occurs along the banks of Cascade Creek (McIntosh 1928). The limestone walls and pools that were built around the springs' at the turn of the century may provide a calcareous substrate, in addition to the water's mineral content, for beaked spikerush and other plant species.

The Cascade Springs area is a Native American religious site and the Cascade Valley likely supported a full range of native cultural activities historically, as evidenced by campsites in the general area (McKee 2002). Ongoing human habitation of the area could have provided regular sources of disturbance to the vegetation communities, via activities such as cutting of vegetation for firewood, ceremonial use, and sweatlodges. As a perennial, warm water source, Cascade Creek may also have served as a stable, high-quality drinking water source, especially compared to other, more alkaline tributaries of the Cheyenne River, further encouraging Native American encampments in the area (Reyher 2001). Bison herds may also have served as a major source of physical disturbance to the Cascade Valley. Although usage patterns by bison are not clearly understood for the immediate area, it is likely that large herds passed through the area at least occasionally (McKee 2002). In addition, it is likely that the perennial, open water of Cascade Creek may have encouraged more permanent visitation by bison during the winter months (McKee 2002). The resulting disturbance patterns may have been important to the ongoing recruitment and long-term persistence of beaked spikerush in the area, although this has not been documented.

Beaked spikerush's habitat requirements in this portion of its range may be influenced by arid conditions or other factors and may be different from its habitat needs in other portions of its range. Unoccupied potential habitats for beaked spikerush may occur in other portions of the Black Hills as noted earlier, specifically, along Fall River and Hot Brook, although these drainages are not on lands administered by the National Forest (Ode 2001). Unoccupied potential habitats for beaked spikerush may also occur in the intermediate areas between populations along the Rocky Mountains from Montana to Colorado. The reasons for the species absence from these habitats may be due to specific micro-site requirements (e.g., water chemistry and temperature, canopy cover, stream type, etc.,), dispersal limitations, the absence of various disturbance factors that may facilitate plant establishment (e.g., human activities, bison, beaver, flooding, etc.,), or habitat needs that have yet to be discovered.

Demography

Life History Characteristics

Beaked spikerush is an early colonizer of marl beds by seeding into wet depressions (Seischab 1984 in Carey 1994; Seischab *et al*. 1985 in Carey 1994). After colonization, the marl sites in the Byron-Bergen Swamp in western New York accumulate peat and gradually become small hummocks dominated by beaked spikerush, needle beaksedge, and moss. These small hummocks succeed to either moss mats with tufted bulrush or large hummocks with shrubs and northern white-cedar (*Thuja occidentalis*), tamarack (*Larix laricina*), and eastern white pine (*Pinus strobus*) (Seischab 1984 in Carey 1994). Succession towards northern white-cedar communities is accelerated by a decrease in the water table level (Frederick 1974 in Carey 1994).

Beaked spikerush remained in a Delaware marsh dominated by Olney threesquare, saltmeadow cordgrass, and saltgrass for 20 years. During this time the marsh accumulated 4 inches (10 cm)

of mud and debris (Stearns and MacCreary 1957 in Carey 1994). Beaked spikerush probably survives and likely benefits from low-severity fire by sprouting from rhizomes and through reduced competition from less fire tolerant species. In salt marshes of the Gulf Coast, prescribed low-severity winter fires maintain early successional genera such as *Scirpus* and *Eleocharis* (Faulkner and Armando 1982 in Carey 1994). Spikerushes occur on sites that experience high-severity fire during extreme drought when water table levels drop (Abramson 1977 in Carey 1994; Keeley 1981 in Carey 1994). High-severity fires in coastal marshes result in either root burns or peat burns. Root burns kill dense climax vegetation in marshes and allow earlier successional plants such as spikerush to colonize the site. Peat fires burn holes in the marsh floor and create areas of open water (Lynch 1941 in Carey 1994).

The chance of fire in any given year in most marshes is low due to moisture conditions. Marshes in the southeastern United States are subject to severe drought coinciding with lightning ignition approximately once every 30 to 100 years (Keeley 1981 in Carey 1994). Salt marshes of the Gulf Coast burn readily and are often ignited by lightning (Lynch 1941 in Carey 1994). According to Dr. Carolyn Sieg (Sieg pers. comm. 2002), fire frequency in the Cascade area remains uncertain. Dendrochronological studies on the forest-prairie ecotone of the Black Hills documented that fires burned, on average, every 10 to 12 years (Brown and Sieg 1999). However, riparian settings most likely burned less frequently as these communities tend to be green throughout most of the growing season, have higher relative humidities than uplands, and often have running water or moist soils that may slow the spread of fire. Therefore, in most years, wildfires would tend to skip over or only burn lightly through these areas (Severson and Boldt 1978). However, the relatively high frequency of fires in adjacent pine and grassland communities would suggest that riparian and riparian-like areas did occasionally burn, especially on hot and windy days during droughty spells (Sieg and Severson 1996). High-severity fires probably occurred infrequently in wetlands and riparian areas of the Great Plains, but may have functioned to maintain these communities (Sieg and Wright 1996; Sieg 1998).

Beaked spikerush is a native perennial obligate wetland graminoid species associated with a range of soil textures (fine to coarse) across its range (USDA NRCS 2001). It exhibits a medium tolerance to anaerobic and calcareous conditions, (although some occurrences suggest it is a calciphile), has high tolerance to fire, and is reportedly moderately tolerant of salinity (USDA NRCS 2001). Its active growth period extends from spring to fall, and it reportedly has a moderate growth rate and moderate lifespan (USDA NRCS 2001). Beaked spikerush generally flowers from late spring to September across its range (Larson 1993 in Carey 1994; Radford *et al*. 1968 in Carey 1994). In the Rocky Mountain region it flowers in July and August (Cronquist *et al*. 1994; Lesica and Shelly 1991). Cold stratification is not required for seed germination, and the minimum root depth requirement is reportedly 10 inches (USDA NRCS 2001), a condition that appears to be met by soil map units and inclusions along Cascade Creek (USDA SCS 1982)

Survival And Reproduction

Beaked spikerush flowers during late spring, and produces seed from summer until fall (USDA NRCS 2001). Seed germination is a viable form of reproduction (USDA NRCS 2001). Beaked spikerush regenerates vegetatively by sprouting and layering. It sprouts from short shallow rhizomes, and has elongated layering culms which arch to the ground and root in moist soil from the apical bulbil (Hitchcock *et al*. 1994; Mason 1957 in Carey 1994; Seischab *et al*. 1985 in Carey 1994; Welsh *et al*. 1987). Beaked spikerush does not have long creeping rhizomes so is

not as colonial as common spikerush (Godfrey and Wooten 1979 in Carey 1994; Larson 1993 in Carey 1994). More biomass is allocated to reproduction on nutrient-poor sites than on more fertile sites (Seischab 1984 in Carey 1994). Members of the family Cyperaceae are typically wind pollinated, but even the few insect pollinated species do not produce nectar (Walters and Keil, 1996). Beaked spikerush reportedly has low seed abundance, a slow seed spread rate, low seedling vigor, and a moderate vegetative spread rate (USDA NRCS 2001).

As an obligate wetland species, beaked spikerush requires continued access to the water table, and it is often found growing in saturated or inundated soil conditions, including floodplain areas. The present geographic isolation of Black Hills' beaked spikerush populations from the nearest locations in Nebraska, Wyoming, Colorado, and Montana would appear to prohibit any interbreeding between them, although there is the limited possibility of seed or pollen transfer via birds or air masses.

Local Density Estimates

According to Burkhart and Ebbert (2001), beaked spikerush is very extensive along the majority of the length of Cascade Creek. It is less abundant at Cascade Springs on USFS property and along the headwaters of Cascade Creek. It is especially abundant along the midsection of the creek (present in 43 of 54 sample plots) and forms large "mats" in places, especially in the vicinity of Cascade Falls. Beaked spikerush was found in the lower section of the creek but was not seen for the last one-half mile upstream from the confluence of Cascade Creek and the Cheyenne River. Differences in abundance may be due in part to variation in stream type (e.g., gradient, floodplain development, etc.,) or canopy closure, although this has not been documented.

Limiting Factors

Beaked spikerush has an apparent affinity for alkaline or calcareous wetlands and thermal features in the Black Hills and elsewhere. The species is reportedly intolerant of shade (USDA NRCS 2001), although portions of the J. H. Keith Picnic Ground population were at least partially shaded (Glisson pers. obs. 2001b). The presence of a consistent, warm, calcareous water source is undoubtedly a major limiting factor since these features are relatively rare in the Black Hills. In addition, in this portion of beaked spikerush's range, the distribution and character of riparian and wetland habitats are strongly influenced by fire, flooding, and beaver-created disturbances (Parrish *et al*. 1996). Wetland habitats are often enhanced by the removal of trees, increased groundwater flow from scorched uplands, and by the flooding, sediment deposit, and other disturbances created by beaver during dam building. These disturbances may be important to beaked spikerush's long-term persistence in the Black Hills, and to its ability to occupy potential habitats, but no specific information is available in the literature. Although beaver are known from along Cascade Creek, they do not appear to exert a major process-level geomorphic effect in the area (Reed pers. comm. 2001).

Long-term climate and hydrological changes since the last Pleistocene glaciation, and the more recent decline in beaver has resulted in a reduction in the amount of habitat available to wetland species throughout North America (Cates *et al*. 1999). It is possible that beaked spikerush was more widely distributed prior to European settlement, and the disjunct and isolated distribution that exists today is in part due to human impacts on the abundance and distribution of wetland

habitats in North America. In the Black Hills, Great Plains, and Rocky Mountains, the natural disturbances that benefit many wetland species, such as fire and beaver activity, have been reduced or eliminated (Parrish *et al*. 1996; Price *et al*. 1996). At the same time, timber production, mining, livestock and other agricultural use, flow regulation and flood control, and extirpation of beaver since the late 1800s have resulted in a sharp downward trend in the quantity and distribution of many riparian/wetland species (Parrish *et al*. 1996).

The literature contains no specific references to competitive interactions that would limit the distribution of beaked spikerush in any portion of its range. Because beaked spikerush prefers saturated, nutrient rich habitats, both belowground and aboveground competition may be nominal, although some interspecific competition with other wetland species is likely. Beaked spikerush is presumably subject to the same risks as other native wetland plants from competitive exclusion by invasive wetland weed species. Livestock and human traffic may directly impact a variety of wetland species by trampling plants, and indirectly by altering the microtopography, hydrology, and nutrient dynamics of the species' habitats (USDA Forest Service 2000). However, bison and livestock use have occurred in the area historically, and do not appear to have adversely affected beaked spikerush. In fact as an early seral species, beaked spikerush is probably adapted to disturbance. The primary ecological stressors to beaked spikerush on BHNF appear to be impacts to local hydrology and competition from weedy species. Trampling via recreational traffic may serve as a minor stressor, although the species is presumably adapted to physical disturbance as noted above. Overall, it appears that the species' distribution is dependent on a combination of geologic and hydrologic conditions, primarily warm spring flows and/or calcareous substrates. The effect of fire as a disturbance factor on beaked spikerush along Cascade Creek is unclear, although maintenance of early seral conditions and reduced encroachment of woody species would probably benefit existing occurrences of beaked spikerush by reducing competition for light and other resources and by providing ongoing recruitment opportunities.

Metapopulation Structure

The fairly extensive population of beaked spikerush extends along Cascade Creek from the headwaters at Cascade Springs to within one-half mile of the confluence with the Cheyenne River, and the species is especially abundant along the reach between Cascade Springs to just below Cascade Falls (Ebbert pers. comm. 2001). Approximately 10 percent of the total population occurs on lands administered by BHNF (Ebbert 2001). Along Cascade Creek, beaked spikerush is most abundant where stream banks are gentle, with larger, flat, often wet floodplains, along lower gradient reaches. Associated species in these areas include hardstem bulrush, common reed, and prairie cordgrass (*Spartina pectinata*). Suitable hydrology is undoubtedly a key requirement for recruitment and on-going maintenance of the beaked spikerush population along Cascade Creek.

As regional disjuncts, the Black Hills populations are inherently less secure than populations in the core range of the species, although they have likely persisted since the last glacial period. If populations in the Black Hills area were extirpated, it is unlikely that natural recruitment from other extant stands would occur.

Propagation Or Cultivation

Beaked spikerush may be propagated by seed germination and bare root or sprig transplants, but reportedly has low seed abundance, a slow seed spread rate, low seedling vigor, and a moderate vegetative spread rate (USDA NRCS 2001).

Community Ecology

Browsers Or Grazers

Beyond selective pressures from grazing, which are expected to be minimal, trampling and soil compaction might reduce soil moisture-holding capacity. This could adversely impact beaked spikerush due to its apparent ecological preference for wet sites. Although it is likely that minor unmapped soil microsites adjacent to Cascade Creek support riparian inclusions (i.e. Aquic, Aquolls, Histic) that may be high in organic content, with the exception of Histisols, these soil types may still be prone to compaction if subjected to heavy livestock use (Cooley pers. comm. 2002). However, these soils would also be expected to recover fairly rapidly after the disturbance was removed (Cooley pers. comm. 2002). Direct physical disturbance and transport of noxious weed propagules by livestock may pose an additional risk to beaked spikerush habitat. It has also been suggested that disturbance by livestock may mimic historic and ongoing natural disturbances for this plant, suppressing competitors and providing recruitment niches (Reyher pers. comm. 2001). In any event, livestock use is not permitted in BHNF areas on Cascade Creek. The Nature Conservancy have already developed and implemented livestock management practices for the Whitney Preserve (Paulson pers. comm. 2001).

Competitors

Invasive wetland weeds such as purple loosestrife and Canada thistle may disrupt wetland ecosystems by rapidly overtaking native species and may out-compete woody plants as well. Unfortunately, weed treatments can be equally detrimental to native vegetation and insect pollinators, and may indirectly impact native species by reducing the quantity and/or diversity of pollinating insects. Noxious weeds further alter wetland ecosystems by reducing or eliminating the structural diversity and microhabitats that comprise native plant communities. Noxious weeds and invasive species such as salt cedar (*Tamarix ramosissima*) and Russian olive (*Eleagnus angustifolia*) may adversely impact beaked spikerush and its habitats. See REVIEW OF TECHNICAL KNOWLEDGE, Risk Factors for further discussion of weeds.

Encroachment by later successional or less fire-tolerant species may also displace beaked spikerush plants that might otherwise persist indefinitely under stable site conditions.

Parasites, Disease, And Mutualistic Interactions

No information is available.

Other Complex Interactions

Beaver may facilitate the establishment and persistence of various wetland species by creating flood disturbance and saturated wetland conditions (Olson and Hubert 1994), particularly in the arid western portions of the species' range. Even in more mesic, boreal regions of North America, beaver exert a strong influence on the quantity and quality of wetland habitats (Naiman *et al*. 1988). For this reason, it is possible that the metapopulation dynamics of beaked spikerush

in the Black Hills are at least partially tied to the recent and historic distribution and abundance of beaver. Although beaver are known from along Cascade Creek, they do not appear to exert a major process-level geomorphic effect in the area (Reed pers. comm. 2001).

Both biotic and abiotic disturbances may play a significant role in the distribution and abundance of beaked spikerush. Natural disturbances such as periodic insect outbreaks and fire may benefit a variety of species by the increased groundwater flow that results from the death of upland trees. However, the limited forest stands in this area suggest that increased groundwater flow from the death of upland trees is not an important factor for this drainage or this population of beaked spikerush. The source aquifer for Cascade Springs is not likely to be impacted by small scale fire events, however, fire may affect surface runoff rates, patterns, and sediment yield from storm events in the watershed. Fire also serves to maintain the open character of wetland habitats and facilitates the regeneration of hardwoods favored by beaver. By damming and flooding lowlands, beaver effectively exclude invading tree species, raise local water tables, expand wetlands and create both large and small-scale soil disturbance (Olson and Hubert 1994). These actions may directly create and/or enhance habitats for beaked spikerush and other species. Where suitable habitat conditions exist, beaked spikerush would be expected to quickly recover from beaver or flood disturbance by rhizome expansion or colonization of disturbed soils. The successional relationships and disturbance ecology of beaked spikerush are not well understood at this time, and beaver may not be an important disturbance factor for this species in general, or in this part of its range.

Direct disturbances from trail, road, or highway construction, mining, or off-road vehicle use are all potentially detrimental to beaked spikerush and the structure and integrity of its wetland habitats. Road construction can impact wetlands directly and/or by altering local runoff patterns and hydrological features, such as springs and seeps. In addition, roads, trails, and highways facilitate the introduction of noxious weeds into wetland habitats. Highway construction activities occurred in the vicinity of Cascade Springs within the last 10 years (Reyher pers. comm. 2001), so additional activity in the near future may be unlikely. No off-road vehicle use is permitted on these Forest Service Developed Recreation sites.

Risk Factors

Beaked spikerush is an obligate wetland species that may require soil disturbance for seed germination and establishment. Across its range, beaked spikerush habitat is threatened by development of coastal plains and thermal areas (Lesica and Shelly 1991; Porter 1979). Livestock may damage the narrow spikerush zone at stream margins while drinking and feeding (Kovalchik 1987 in Carey 1994). It may be assumed that beaked spikerush's wetland habitats on private lands are at risk from agricultural land use and development. Factors that impact wetland hydrology, or that affect flood intervals and intensities, and fire, may have negative effects on its long-term persistence in the Black Hills. Potential exists for water diverting development on private land downstream from the springs, such as wells, pavement, irrigation draws, and culverts, and could negatively affect stream flows in the drainage. Improper livestock management of upland areas in the watershed may affect vegetation cover, surface flows, and sediment yield, especially in response to heavy seasonal thunderstorm activity, and may alter hydro-geomorphic processes along the length of Cascade Creek. Low vegetation cover may cause increased surface flows, potentially resulting in channel downcutting and loss of saturated floodplain areas. However, low vegetation cover in this arid area may naturally contribute to

high surface runoff from storm events. In addition, short and long-term droughts may reduce water availability to the site, although the springs themselves are believed to be fed by a fairly deep aquifer and have remained stable for nearly 30 years (Rahn and Gries 1973; Hayes 1999).

Noxious weeds and other invasive species pose a serious risk to beaked spikerush at Cascade Springs. Canada thistle (*Cirsium arvense*), a noxious weed, is present, but high soil moisture levels preferred by beaked spikerush may discourage their advancement into beaked spikerush habitat. Although purple loosestrife does not occur at Cascade Springs, it has been documented along Rapid Creek near Rapid City, South Dakota and poses a potentially serious risk to the rare wetland species along Cascade Creek if it were somehow introduced to the area (Ode pers. comm. 2001). If purple loosestrife were to invade Cascade Creek, it has the potential to out-compete riparian natives, and would represent a significant competitive risk to the beaked spikerush population. The occurrence of noxious weeds may also restrict the ability of beaked spikerush to disperse into other wetland habitats. Herbicides are potentially detrimental to beaked spikerush and other rare plant species in the Cascade Complex, water quality, and herbaceous species, so broadcast spraying is not used at Cascade Springs. Recent weed treatments at Cascade Springs involved hand-pulling of individual plants and direct application of herbicide to individuals or clusters of Canada thistle (Paulson pers. comm. 2001). Common reed (*Phragmites australis*) may also be an aggressive species and may potentially out-compete beaked spikerush, although the species reportedly have co-occurred in the Cascade Valley since the late 1920's (McIntosh 1931). See earlier comments regarding common reed in REVIEW OF TECHNICAL KNOWLEDGE, Habitat Characteristics.

See REVIEW OF TECHNICAL KNOWLEDGE, Response To Habitat Changes, *Managemnet Activities* - Recreation for recreation related risks, and Road Construction for discussion of road construction related risks. Prolonged regional warming and or drying trends may pose risks to beaked spikerush populations if site hydrology is sufficiently altered.

Response To Habitat Changes

Management Activities

Timber Harvest

No commercial timber grows in, and no timber harvest is planned for, the Cascade Springs Complex.

Recreation

Hot and warm spring sites are popular outdoor destinations that are frequently advertised in trail guides, tourism guides and other recreation manuals (e.g., Litton 1990 and Loam 1980 in Mancuso 1991). Throughout its range, beaked spikerush is potentially subject to risks posed by heavy use or alteration of its habitats as an outdoor destination or development of thermal springs. The J. H. Keith Cascade Springs Picnic Ground has been used as a therapeutic and recreational destination since the turn of the century, and is still used as a Developed Recreation area. The Cascade Springs Complex is subject to seasonal impacts from tourism and recreation use, including trampling of vegetation and stream bank habitats during fishing, picnicking, swimming, and inner-tubing. Trampling of stream banks and streamside riparian areas could adversely affect beaked spikerush in the area. Recent measures such as fencing and paving of

trails have been implemented to deter recreational foot-traffic from sensitive rare plant habitat areas at Cascade Springs. Approximately 10 percent of the total population occurs on lands administered by BHNF (Ebbert 2001).

Livestock Grazing

Livestock may impact streamside communities through the effects of their grazing, trampling, resting, and trailing (Hoffman and Alexander 1987) and may also introduce noxious weeds. Spikerush palatability is low for livestock and wildlife (Kovalchik 1987 in Carey 1994). Grazing is not permitted on the Cascade Springs Complex. The Nature Conservancy has reduced grazing to one to two weeks per year on the Whitney Preserve lands where the species occurs (Paulson pers. comm. 2001).

Mining

Mining is not allowed in Cascade Springs Complex.

Prescribed Fire

Beaked spikerush is probably top-killed by fire and the shallow rhizomes may be damaged or killed by high-severity fire (Keeley 1981 in Carey 1994). Beaked spikerush probably sprouts from rhizomes after low-severity fire. It may disappear from a site after high-severity fire (USDA FS RMRS 2001). High-severity fires are not-likely in the Cascade Springs Complex because of extensive adjacent grasslands, open canopy conditions along the riparian zone, and generally low cover of trees in the area. Prescribed fire is not practical in spikerush communities except during drought years. Fire will reduce litter accumulation but will not change species composition unless the fire burns the organic soil and rhizomes are killed (Kovalchik 1987 in Carey 1994).

Fire Suppression

Although beaked spikerush is reported to have a high fire tolerance, its successional status and disturbance ecology is not well understood. Since some references indicate beaked spikerush is reportedly intolerant of shade, any seral progression toward a forest dominated riparian ecosystem or other encroachment of trees (e.g., Russian olive) would be expected to adversely affect the species (see REVIEW OF TECHNICAL KNOWLEDGE, Demography - *Limiting Factors*).

Non-Native Plant Establishment And Control

Several invasive exotic species have been documented at the Springs and along Cascade Creek. Salt cedar (*Tamarix ramosissima*) occurs in the uplands surrounding Cascade Creek (Paulson pers. comm. 2001). Canada thistle has been documented all along the creek bed and adjacent to the springs and uplands, and Russian olive occurs in scattered thickets along the creek and at the springs. Purple loosestrife has not been documented in Cascade Valley; however, this species has invaded Rapid Creek in the Black Hills and should be considered a serious risk to the integrity of riparian and wetland habitat at Cascade Springs and elsewhere along Cascade Creek (Ode, pers. comm. 2001).

There is no specific information available for beaked spikerush, although it may not compete

well with aggressive species capable of exploiting its habitat such as Canada thistle and purple loosestrife. Also, see earlier comments regarding common reed in REVIEW OF TECHNICAL KNOWLEDGE, Habitat Characteristics.

Fuelwood Harvest

Fuelwood harvest is not allowed in Cascade Springs Complex.

Road Construction

The lands immediately to the north of Cascade Springs and bordering Cascade Creek to the south are privately owned. Lots have been sold and developed on land surrounding Cascade Springs (Ode, pers. comm. 2001). Development of subdivisions, housing, or roads, and any pollution and/or erosion that results could adversely affect beaked spikerush habitat. While the hydrology of the springs is apparently not vulnerable to alteration of the surface of the surrounding lands (Hayes 1999), direct impacts to the springs and its associated riparian and downstream habitats are potential risks. In the late 1990's, South Dakota Highway 71 was re-positioned toward the east, away from Cascade Creek, and the old roadbed was retained as a parking area for Cascade Springs. It does not appear that these activities directly impacted the springs or rare plant occurrences, but the existence of the road is an ongoing risk to the springs and Cascade Creek (Ode, pers. comm. 2001). In June 2000, several sections of the creek bank had eroded and collapsed within the boundaries of J. H. Keith Cascade Springs Picnic Ground, which may suggest that the creek's hydrology has been affected by nearby development or runoff from the road or roadside ditches (Paulson pers. comm. 2001).

Other

Collection of plant specimens is not likely to pose a risk. Although the species may appeal to some amateur botanists, it is not likely to be sought after by the general public.

Natural Disturbance

Insect Epidemics

No information is available.

Wildfire

Beaked spikerush is highly tolerant of fire (USDA NRCS 2001). Beaked spikerush is probably top-killed by fire and the shallow rhizomes may be damaged or killed by high-severity fire (Keeley 1981 in Carey 1994). Beaked spikerush probably sprouts from rhizomes after low-severity fire. It may disappear from a site after high-severity fire (USDA FS RMRS 2001). Fire will reduce litter accumulation but will not change species composition unless the fire burns the organic soil and rhizomes are killed (Kovalchik 1987 in Carey 1994).

Wind Events

Wind events are not expected to pose a significant risk to beaked spikerush and may actually benefit the species by toppling woody species that may shade or otherwise encroach into potential habitat.

Flooding

Beaked spikerush is apparently adapted to and dependent on inundation and/or saturated soils. As an early seral species, it may also require or benefit from physical disturbance from stream scouring and deposition processes for recruitment of new colonies. Adverse impacts due to destructive floods are unlikely due to the high watershed position of portions of the occupied habitat (e.g., J. H. Keith Picnic Ground), although the likelihood of adverse flood effects may be expected to increase progressively lower in the watershed as drainage area increases. Changes in surface flow patterns resulting from on- and off-site road pavement, other development, or excessive livestock grazing on upland areas may accentuate high runoff events and erosion. This may already have occurred in the vicinity of J. H. Keith Picnic Ground as noted in REVIEW OF TECHNICAL KNOWLEDGE, Response To Habitat Changes, *Managemnet Activities* - Road Construction.

Other Events

Prolonged drought may adversely impact beaked spikerush, by reducing aquifer recharge and spring outflows.

REVIEW OF CONSERVATION PRACTICES

Management Practices

No specific management practices have been applied in the Black Hills or elsewhere for beaked spikerush although recent management efforts at Cascade Springs have attempted to minimize adverse recreational impacts to all rare plants at the site. The J. H. Keith Cascade Springs site is managed and maintained as a public picnic ground by Black Hills National Forest. Forest management activities in Developed Recreation areas may include prescribed burning, and "are directed at the maintenance and improvement of the area's natural setting" (USDA BHNF 1996). No forest vegetation management or livestock use are planned for USFS land in the Cascade Creek area. However, development or alteration of adjacent private land may occur (Reyher pers. comm. 2001). J. H. Keith Cascade Springs Picnic Ground is subject to seasonal impacts from tourism and recreation use including trampling of vegetation and stream bank habitats during fishing, picnicking, swimming, inner-tubing and maintenance activities. A "no-mow" zone has been established around known Sensitive plant populations in order to deter foot traffic in these areas and appears to be somewhat effective (Reyher pers. comm. 2001).

Although public access remains a management priority at the site, recent management initiatives have redesigned facilities to direct human activities away from Sensitive species and riparian areas and concentrate human use in the uplands (Reyher, pers. comm. 2001). However, recreational use of the Picnic Ground and surrounding area remains a risk to beaked spikerush at Cascade Springs and downstream habitats. Any additional developments may pose similar risks, although none are currently planned (Reyher pers. comm. 2001). Swimming and inner-tubing have the potential to negatively impact beaked spikerush and other rare plant species by damaging stream bank soils and Sensitive species populations along the creek, although no actual adverse impacts have been documented to date. The Picnic Ground's trail network was paved in August 2000 to prevent runoff of aggregate from trails into the Creek (Reyher pers. comm. 2001). Fences were recently installed around the developed picnic area at Cascade

Springs to reduce access and trampling near the springs and creek where rare plant occurrences, including beaked spikerush, are located (Reyher pers. comm. 2001). However, alteration of streamside habitats and disturbance to Sensitive plants by park users still occurred in 2001 (Reyher pers. comm. 2001). There is a USFS easement on the private land immediately north and west of J. H. Keith Cascade Springs Picnic Ground that allows use of an old roadbed, typically once a year or less, to maintain outhouses and other facilities in the park (Reyher, pers. comm. 2001). A gate was put in place where the private road adjoined the highway to prevent off-road recreation vehicles from entering the developed recreation site and the area near the spring, and to maintain the vegetative cover on the native surface two-track road. A small area on the slope, adjacent to the highway where the gate was placed, was covered with aggregate in August 2000, but no aggregate was placed on the lower portion of the road or where the road occurs near the spring (Reyher pers. comm. 2001).

At the Cascade Springs location, noxious weeds pose a significant risk, as Canada thistle and Russian olive are already established, and may overtake streamside habitats if they are not controlled (Paulson pers. comm. 2001). At the Cascade Falls location, salt cedar reportedly occurs above the falls, on the west side of the 15-acre Forest Service parcel (Paulson pers. comm. 2001). Although not yet documented along Cascade Creek, the aquatic invader purple loosestrife occurs in the Black Hills and should be considered a serious risk to the long-term persistence of beaked spikerush and the integrity of the Cascade Creek riparian ecosystem.

Erosion and noxious weed invasion at Cascade Springs and along Cascade Creek are of immediate concern. An integrated weed management plan for the springs and surrounding lands in the Cascade Valley was implemented in summer 2000, by the Fall River Ranger District, TNC, and private landowners (Paulson pers. comm. 2001). Hand pulling and herbicide treatment of Canada thistle began in June 2000 at Cascade Springs, Cascade Falls and on the TNC Whitney Preserve. The TNC has an 8-10 year plan for the removal of Russian olive along Cascade Creek within the Whitney Preserve, wherein the tree will be systematically replaced with native species (Paulson pers. comm. 2001). Removal of salt cedar is also planned for TNC lands in the area. Salt cedar on USFS lands in the area were cut down and treated during early spring 2002 (Reyher pers. comm. 2002). In addition, TNC has limited livestock access to Preserve riparian areas to one to two weeks per year (Paulson pers. comm. 2001).

Successional overgrowth of the riparian habitat by native and exotic invasive woody species (*Eleagnus* spp., *Ulmus* spp., *Acer negundo, Tamarix ramosissima,* etc.) may need to be monitored. Beaked spikerush may require periodic disturbance of the canopy in order to maintain the early successional quality of the Cascade Springs habitat. If so, periodic removal of riparian canopy species may serve to maintain high-quality beaked spikerush habitat at Cascade Springs by mimicking disturbance and providing new sites for colonization.

Although the BHNF sites are protected from livestock use and there is no commercial timber present, facilities management and human activities at J. H. Keith Cascade Springs Picnic Ground such as picnicking, swimming, fishing, and botanizing in and around the Picnic Ground's riparian areas should be considered potential risks to both beaked spikerush. Some of the trails footpaths and "nick" trails were eliminated or fenced and mowed areas have been reduced in order to limit human activities at sites of Sensitive species occurrences. Mitigation efforts to control runoff from both South Dakota Highway 71 and the easement road immediately north of the springs include placement of a water bar to redirect flows from the maintenance

access road and installation of a gate to minimize access on the easement road (Reyher pers. comm. 2001). In order to maintain and enhance filtering by vegetation, the area has been seeded with native species, and silt fences, and mulching blankets have been applied (Reyher pers. comm. 2001).

Interpretive trails and signage may be appropriate for Cascade Springs Complex to create an awareness and appreciation for the unique qualities of the warm springs and other historic features of the area.

Models

GIS linked habitat modeling may be used to identify potential survey sites by mapping areas with alkaline or calcareous flows or thermal features.

Survey And Inventory Approaches

Species specific surveys for beaked spikerush have not been performed on Black Hills National Forest, and it may have a broader distribution than is presently recognized. The species and its potential habitat may be under-surveyed in the Black Hills and it is currently unknown how restricted beaked spikerush is in the Black Hills (Marriott 2002). It is possible that unsurveyed potential habitat for beaked spikerush exists on public and private land in the Black Hills, although the only specific potential sites suggested by Ode (e.g., Fall River and Hot Brook) do not occur on lands administered by the BHNF (Ode pers. comm. 2001).

Beaked spikerush and other rare plant sub-populations along the length of Cascade Creek were mapped during 2001 as part of a rare plant monitoring pilot project on TNC land (Ode pers. comm. 2001). Mapping of existing occurrences and potential habitat may be used as baseline data for evaluating distribution and population trends in the future. If new populations are identified in other areas, occurrences could be documented via GPS and the associated environmental conditions could be characterized. Existing sub-populations and potential habitat along Cascade Creek could be resurveyed periodically (e.g., every 5 years) to assess population trends and determine if new recruitment has occurred.

Monitoring Approaches

The 2001 monitoring pilot project was conducted on the middle Cascade Creek area, from private property below J. H. Keith Cascade Springs Picnic Ground downstream through the Whitney Preserve to the upstream end of BHNF land at Cascade Creek, but was not focused on beaked spikerush (Burkhart and Ebbert 2001). Permanent sample points were randomly located and quantitative baseline monitoring data was collected for stream orchid and southern maidenhair fern using one meter square sampling frames (Burkhart and Ebbert 2001). The number of sample points may be increased in the future to ensure statistical strength and the approach may be expanded upstream and downstream to include BHNF lands, if funding is available. Data collection for beaked spikerush was limited to presence absence data during the pilot study, but quantitative cover class data could be readily collected without much additional effort, although it is presently unknown if cover class data is needed to answer monitoring questions.

Another possible monitoring approach involves application of USFS protocols defined in the

Integrated Riparian Evaluation Guide (IREG) (USDA FS IR 1992). IREG Level II vegetation data may be collected via trans-riparian (valley bottom cross-sectional line intercept) transects and intra-riparian transects (e.g., greenline data) by community type or understory type. The typical Level II approach relies on step transects to estimate dominance by community type or understory type, but using a tape measure will yield more precise data and may be appropriate considering the relatively narrow riparian zone on much of the BHNF land. In addition to providing data for beaked spikerush, greenline data may provide insights regarding overall riparian health and seral status of bank margin vegetation. Both methods can also be used to quantify the extent of noxious weed infestations or investigate changes in woody species canopy cover. Monitoring of common reed stands could be performed via permanent photopoints and/or line intercept transects to determine if the species is expanding its coverage in the area.

ADDITIONAL INFORMATION NEEDS

Beyond the guidance for additional survey and monitoring outlined above, there are no additional information needs for this species at this time.

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DEFINITIONS

THE NATURE CONSERVANCY NATURAL HERITAGE RANKS:

GLOBAL RANK (G): based on range-wide status of a species

-G1 Critically imperiled globally because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction. (Critically endangered throughout its range).

-G2 Imperiled globally because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. (Endangered throughout its range).

-G3 Vulnerable throughout its range or found locally in a restricted range (21 to 100 occurrences). (Threatened throughout its range).

-G4 Apparently secure globally, though it might be quite rare in parts of its range, especially at the periphery.

-G5 Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

-GX Presumed extinct

-GQ Indicates uncertainty about taxonomic status.

-GU Unable to assign rank due to lack of available information.

-G? Indicates uncertainty about an assigned global rank.

TRINOMIAL RANK (T): used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.

STATE RANK (S): based on the status of a species in an individual state. S ranks may differ between states based on the relative abundance of a species in each state.

-S1 Critically imperiled in state because of extreme rarity (5 or fewer occurrences, or very few remaining individuals, or because of some factor of its biology making it especially vulnerable to extirpation from the state. (Critically endangered in state).

-S2 Imperiled in state because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extirpation from the state. (Endangered or threatened in state).

-S3 Vulnerable in state (21 to 100 occurrences).

-S? Indicates uncertainty about an assigned state rank.

-SR Reported in state.

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FIGURES

Figure 1. U.S. distribution for beaked spikerush (USDA, NRCS 2001). Grey areas indicate confirmed presence.

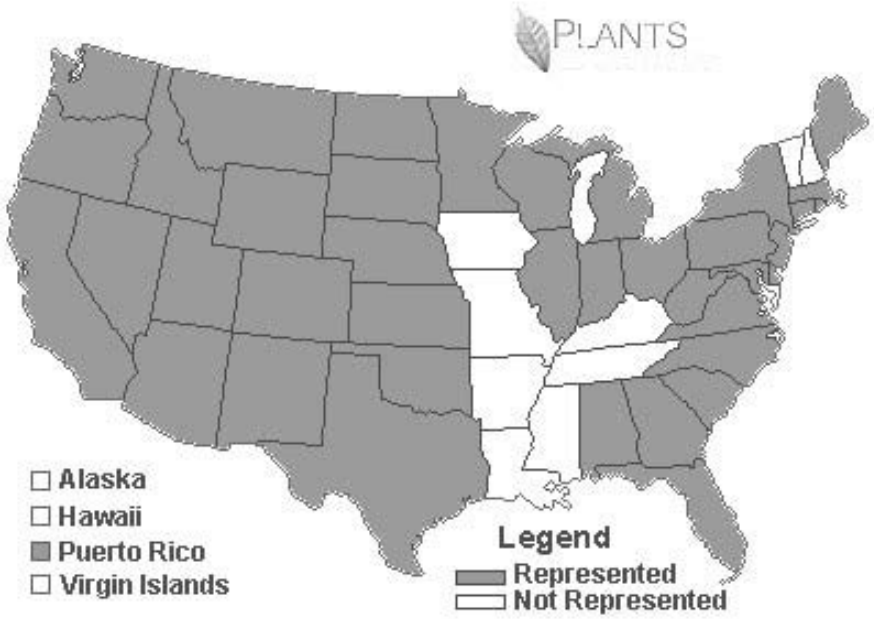

Figure 2. South Dakota distribution for beaked spikerush (USDA NRCS, 2001).

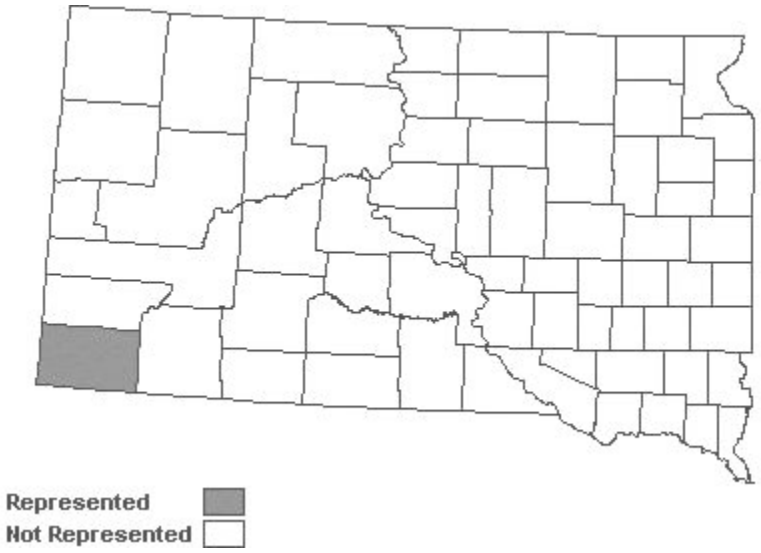

Figure 3. Montana distribution for beaked spikerush (Montana Natural Heritage Program 2001).

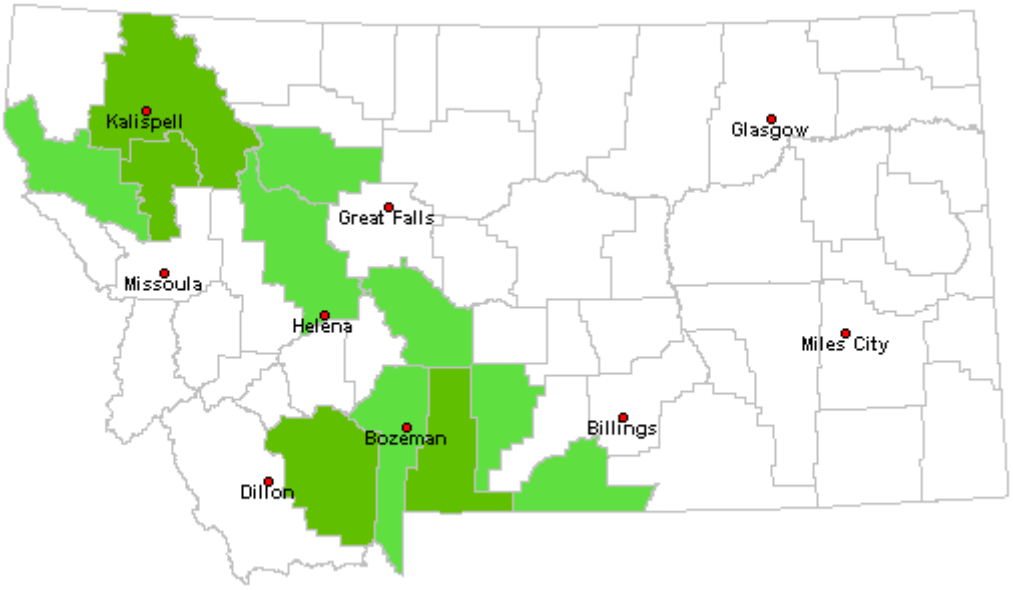

Figure 4. Wyoming distribution for beaked spikerush (University of Wyoming, 1998).

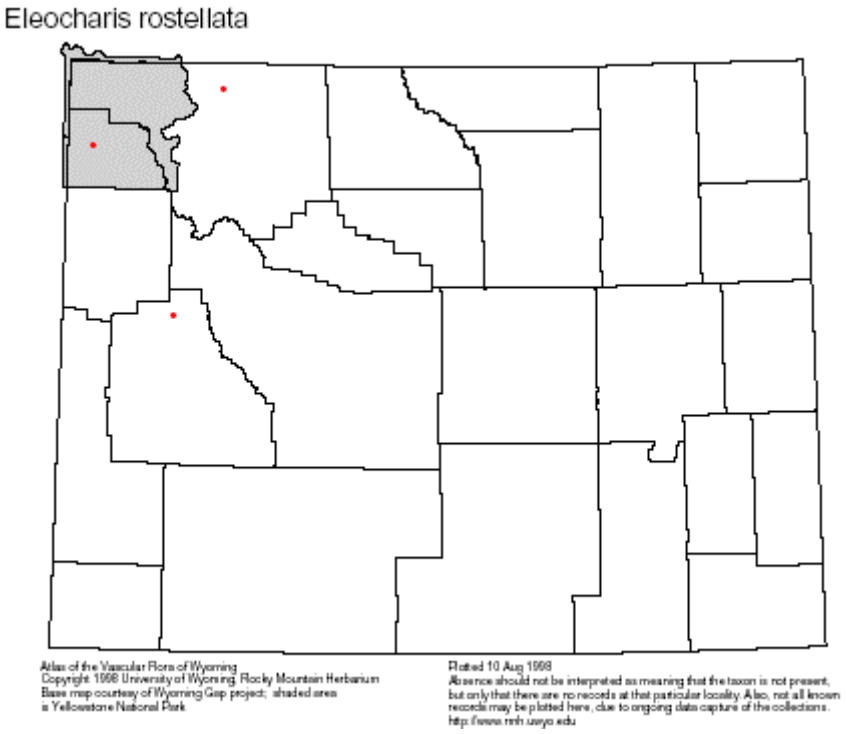

Figure 5. Line drawing of beaked spikerush from Vascular Plants of the Pacific Northwest (1989).

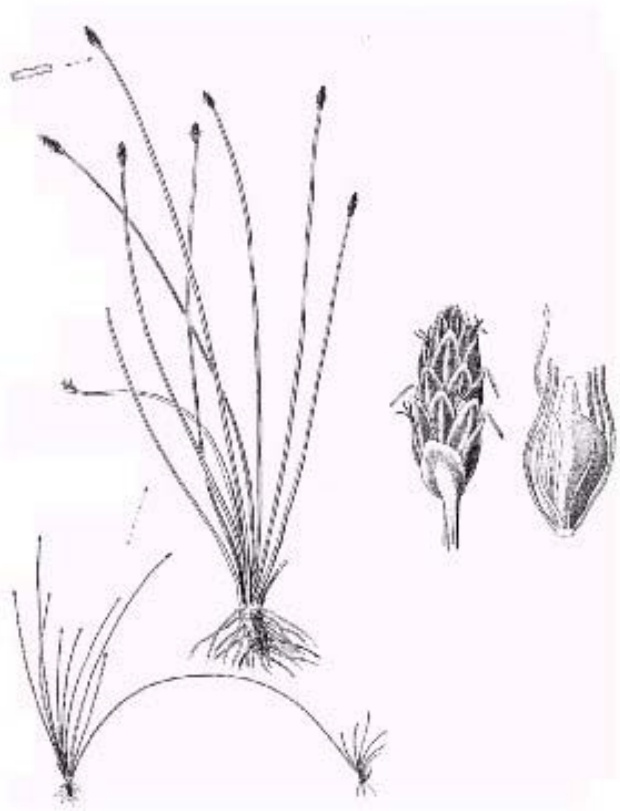

Illustration by Jeanne R. Janish.
From 'Vascular Plants of the Pacific Northwest'

ELEOCHARIS ROSTELLATA
BEAKED SPIKERUSH

Beaked Spikerush is a grass-like perennial with stems that are 40-100 cm long, 1-2 mm wide, and clustered on a rootstock. All leaves occur on the lower stems and are reduced to sheathing scales, making the plants appear leafless. Longer stems arch over and root at the tips, forming new plants. The flowers are composed of ca. 6 bristles subtended by a blunt, lance-shaped, brownish scale that is 3-5 mm long and has a pale midrib. There are 3 stamens. 10-20 flowers are spirally arranged in a solitary, cone-like spike, 8-13 mm long, at the tip of the stem. The achene is green to brown, egg-shaped, 3-sided seed, 2-3 mm long and tapers to a prominent beak. Flowering in July, mature fruit in July-August.

The long-pointed, round beak tip of the achene is continuous with the body, unlike the notched base of the more common ELEOCHARIS PALUSTRIS and the short beak tip of E. TENUIS set in a dish like depression at the top of the achene. The stems of E. ROSTELLATA usually root at the tips, a feature that is apparent in walking through it.

Figure 6. Photograph of beaked spikerush (Montana Natural Heritage Program 2001).

Figure 7. Photograph of beaked spikerush habitat, at Cascade Springs (Glisson, 2001).

Figure 8. Photograph of beaked spikerush habitat, below Cascade Falls (Glisson, 2001).