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Conservation Assessment for Southern Maidenhair Fern and Stream Orchid in the Black Hills National Forest South Dakota and Wyoming

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Species Assessment

of

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Black Hills National Forest,

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EXECUTIVE SUMMARY

Southern maidenhair fern (*Adiantum capillus-veneris* L.; Pteridaceae) is a cosmopolitan species that is widely distributed in southern North America. Stream orchid (*Epipactis gigantea* Dougl. ex Hook.; Orchidaceae) occurs in western North America from British Columbia, Canada; south to California, Arizona and New Mexico; and east to Texas. The species co-occur in disjunct populations in mineral warm springs habitats in South Dakota and British Columbia. Both species prefer warm, moist habitats and expand via rhizomatous growth and by wind- or water-dispersed propagules. In the Black Hills, southern maidenhair fern and stream orchid occur in scattered colonies at Cascade Springs, a series of six artesian warm springs, and downstream along Cascade Creek in Fall River County, South Dakota. Large populations of these species occur in recreational sites along Cascade Creek that are managed by the Black Hills National Forest. The species have persisted through decades of intense human disturbance during the springs use as a commercial mineral spa at the turn of the century and ongoing public use. The confinement of these two species to just one watershed in the Black Hills makes them potentially vulnerable to random events such as extreme drought. However, their potential for persisting along Cascade Creek is increased by the relatively constant water source originating from a deep source and the fact that, with the exception of invasion by noxious weeds, not all the populations are exposed to other impacts such as recreation. Further, regular monitoring and vigilance in controlling invasive species, as proposed, will increase the odds of detecting and responding to factors that could lead to the demise of these species.

Key words: *Adiantum*, *Epipactis*, warm springs, Cascade Valley, Black Hills.

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INTRODUCTION

The genus *Adiantum* (L.) consists of 150 to 200 species worldwide distributed between 60° North and 60° South latitude, with nine species in North America (Paris 1993). In North America, southern maidenhair fern (*Adiantum capillus-veneris* L., Pteridaceae) is distributed across the southern third of the United States, with disjunct populations in South Dakota and British Columbia, Canada (Lellinger 1985; Gleason and Cronquist 1991) (fig. 1). It is introduced in California and has spread elsewhere beyond its original range (Lellinger 1985; Hickman 1993).

Stream orchid (*Epipactis gigantea* Dougl. ex Hook., Orchidaceae) is the only member of the genus *Epipactis* native to North America (Brunton 1986a). It is sparsely distributed across the cordilleran areas of the western United States, Mexico, and southern British Columbia in geographically isolated occurrences along the margins of rivers, streams, springs and seeps (Hitchcock and others 1969; Hitchcock and Cronquist 1973; Luer 1975; Brunton 1986a; Fertig 1994). The orchid is strongly associated with thermal springs in the mountainous and northern parts of its range (Mancuso 1991; Mantas 1993), although it does occur in seeps and bogs that are subject to freezing on the Colorado Plateau (Fowler 1995). The closest occurrences of stream orchid to the Black Hills are 200 mi (320 km) to the west in Bighorn County, Wyoming, ca. 350 mi (560 km) to the west-northwest in Carbon County, Montana, and over 400 miles (674 km) to the southwest in Colorado (Colorado Natural Heritage Program 2001) (fig. 2).

In the Black Hills, disjunct populations of these species co-occur at 3,400 ft (1,036 m) elevation in Fall River County, South Dakota in association with Cascade Springs, a series of six artesian warm springs, and downstream along Cascade Creek (fig. 3). Large subpopulations of both species occur on Cascade Creek within The Nature Conservancy's Whitney Preserve (Ebbert, personal communication 2000; Burkhart and Ebbert 2001), and small concentrations occur on private land just south of the springs (Hall and others 2002). All occurrences of both species in the Black Hills are contained within the Cascade Valley. Within this area, distinct locations (occurrences) of the fern and orchid are considered sub-populations of single populations of the species. The distribution and abundance of both species on Black Hills National Forest administered lands at Cascade Springs, and of the fern at Cascade Falls, were surveyed and mapped in detail in June 2000 and revisited in June 2001.

The objectives of this assessment are to review information on the occurrence and distribution of southern maidenhair fern and stream orchid in the Black Hills National Forest and to synthesize information relevant to the management, monitoring and long-term persistence of these species. To develop this assessment, we relied upon general information on maidenhair ferns and limited species-specific literature from elsewhere in the fern's range. Stream orchid is charismatic, well known and of interest throughout its range and we were able to find species-specific literature and management documents from California, Montana and Idaho. Species nomenclature follows the USDA NRCS Plants Database (2001).

CURRENT CONSERVATION SITUATION

Southern maidenhair fern's global conservation status is secure (G5) (NatureServe 2001). It is

nationally ranked as secure (N5) in the United States, but in Canada it is ranked as critically imperiled (N1) and is listed as an endangered species (E) by the Committee on the Status of Endangered Wildlife (NatureServe 2001). Southern maidenhair fern is on the USDA Forest Service Region 2 Sensitive Species List. It is currently ranked as critically imperiled due to extreme rarity (S1) in South Dakota, North Carolina, and British Columbia and imperiled due to rarity (S2) in Colorado, Kentucky, and Mississippi (NatureServe 2001) (table 1). The fern's conservation status in Mexico, South America, Africa, and Southern Asia has not been ranked, but the species is considered widespread in the tropical and temperate regions of the World (Larson 1993).

Stream orchid's global conservation status was re-ranked from secure (G4) to "apparently secure, but may be quite rare in parts of its range" (G3G4) in December 2000 (NatureServe 2001). In July 2001, stream orchid's national conservation status was re-ranked from unranked (N?) to "vulnerable to apparently secure" (N3N4) in the United States; and from "imperiled" (N2) to "imperiled to vulnerable" (N2N3) in Canada (NatureServe 2001). Stream orchid is on the USDA Forest Service Region 2 Sensitive Species List. It is currently ranked as critically imperiled due to extreme rarity (S1) in South Dakota and Wyoming; critically imperiled to imperiled (S1S2) in Oklahoma; imperiled due to rarity (S2) in Colorado, Montana, and Mexico (S2?); and imperiled to vulnerable (S2S3) in Utah and British Columbia (NatureServe 2001) (table 2). Stream orchid is most abundant in California, where it occurs in all forty-seven counties (NatureServe 2001).

In the Black Hills National Forest, these species occur together in isolated populations at ca. 3,400 ft (1,036 m) elevation at J. H. Keith Cascade Springs Picnic Ground and downstream along Cascade Creek's steep, shady banks in Fall River County, South Dakota. The fern also occurs a few miles downstream at the Cascade Falls Picnic Ground. Southern maidenhair fern occurs in large concentrations, but is discontinuously distributed, from the uppermost spring at Cascade Springs to approximately 1/3 mi (536 m) above the creek's confluence with the Cheyenne River (Burkhart and Ebbert 2001). In 1983, 150 to 200 stream orchids were noted at the picnic area at Cascade Springs (South Dakota Natural Heritage Program). In 1994, 30 fern plants and 5 orchid plants were reported at Cascade Springs (Hildebrand 1994), but it is unknown what survey intensity was used, what was defined as an individual, or if the entire site was surveyed in either of these reports. In 2000 and 2001, southern maidenhair fern covered approximately 1,200 ft^2 (365 m^2) and had an estimated 3,200 to 4,000 orchid ramets (stems), including several dense concentrations of approximately 1,000 orchid stems from the uppermost springs to the picnic ground's southern boundary. Twenty-five to thirty percent of the orchid plants were in flower or bud at the time of the 2000 survey and several additional patches of stream orchid were noted in June 2001. Reproductive success is unknown because seed set and germination are unlikely to occur at time of survey and have not been documented to date.

REVIEW OF TECHNICAL KNOWLEDGE

Species Taxonomy

Southern maidenhair fern, *Adiantum capillus-veneris* L. (Linnaeus. 1753. Species Plantarum 2. 1096.), is classified as a true fern in the Phylum Pteridophyta, Family Pteridaceae (Adiantaceae) (Flora of North America Editorial Committee 1993). The species' form varies from region to

region. North American and European *Adiantum capillus-veneris* were originally thought to be distinct varieties (Fernald 1950), but none are currently accepted (Paris 1993). Although the genus *Adiantum* is well defined, relationships between species of *Adiantum* are not well understood (Paris 1993). See Appendix A for alternative taxonomic treatments.

Stream orchid, *Epipactis* gigantea Dougl. ex Hook. (David Douglas 1798-1834, Royal Horticultural Society; Sir William Jackson Hooker, 1785-1865, Flora Boreali-Americana, 2: 202. 1839) (Kaul 1986), is classified in Class Monocotyledoneae, Order Orchidales, Family Orchidaceae (Orchid Family) (NatureServe 2001), SubFamily Orchidoideae, Tribe Neottieae, Subtribe Limodorinae (Dressler 1981). There are 20 species of *Epipactis* across the temperate regions of Europe and North America (Luer 1975). Three European *Epipactis* species have become established in the United States: red helleborine (*E. atrorubens*), which is currently limited to Vermont (Biota of North America Project 2001); marsh helleborine (*E. palustris*), which occurs only in New York state (Biota of North America Project 2001); and eastern helleborine (*E. helleborine*) is a weedy species that has become naturalized in parts of eastern and western North America (NatureServe 2001). See Appendix B for alternative taxonomic treatments.

Species Descriptions

Southern maidenhair fern is a perennial herb with creeping rhizomes; oval, compoundly divided, drooping leaf blades 4 to 16 inches (10 to 40 cm) tall, borne on unbranched, shiny black stems; the leaflets are wedge-shaped and lobed at the tips; the spore-producing sori are scattered along the edge of the leaflets and covered by the backrolled margin of the leaf, or false indusium, and the spores mature from July to September (Lellinger 1985; Van Bruggen 1985; Great Plains Flora Association 1986; Fertig 1993) (fig. 4). See Appendix A for further technical description.

A closely related species, maidenhair fern (*Adiantum pedatum* L.), occurs in eastern South Dakota in eastern deciduous forest habitats. The species are distinguished by the leaf stalk, which is divided into two main branches in *A. pedatum* (Fertig 1993), and the ultimate leaf segments, which are nearly as long as wide in *A. capillus-veneris*, but at least two times as long as wide in *A. pedatum* (Paris 1993). Confusion is unlikely, as the species do not co-occur in the Black Hills (Van Bruggen 1985).

Stream orchid is a large perennial herb with one to many leafy stems 1 to 3½ ft (3 to 12 dm) tall from short rhizomes; the smooth to rough sheathing leaves are up to 8 inches (7 to 14 cm) long and ½ to 2 inches (1.5 to 5 cm) wide and lack petioles; numerous brown to reddish flowers are borne in a long, mostly one-sided, leafy-bracted inflorescence at the top of the stem; the flowers have two short, broad upper petals, 3 long greenish sepals, and a sac-like lower petal; and each flower is subtended by a leaf-like bract (Moseley 1989) (fig. 5). See Appendix B for further technical description.

Stream orchid is distinguished by its large stature, large leaves, and by an impressive inflorescence of red-brown flowers. Vegetative plants can be confused with *Habenaria* and *Platanthera* (Orchidaceae), but can be distinguished by their larger size and numerous, large leaves. Non-flowering stems may also be confused with starry false lily of the valley (*Maianthemum stellatum;* syn. *Smilacina stellata*) (Mancuso 1991), a much smaller species that occurs with the orchid at Cascade Springs.

Species Significance

Southern maidenhair fern's distribution in South Dakota is unique both as a disjunct occurrence from the species' main distribution in North America and as the second most northerly occurrence. Only the occurrences in the Cascade Valley, South Dakota and British Columbia, Canada are restricted to warm springs habitats.

Southern maidenhair fern was reportedly used by the Mahuna people of southwestern California as an anti-rheumatic, and by the Kayenta Navajo people of northeastern Arizona as a treatment for insect stings and a psychological treatment for insanity (Moerman 1998). The Hahwunkwut people of northern California used fiber from Maidenhair ferns (*Adiantum* sp.) for baskets, and the Apalachee people of Florida and Georgia used *Adiantum* for unspecified medicinal use (Moerman 1998). No historic or contemporary uses of the fern by the Lakota peoples of the Black Hills have been identified.

The fern is commonly cultivated and can become weedy in greenhouses (Hoshisaki 1970).

Stream orchid appears to possess an unusually large amount of genetic variation and occurs in geographically distinct locations (such as its disjunct occurrence in the Black Hills) the combination of which may produce unique characteristics or taxonomically distinct populations (Thornhill 1996). Because of stream orchid's high degree of genetic variability between populations (Thornhill 1996), it is possible (but unknown at this time) that the population in the Cascade Valley is a distinct subspecies or variety. Isolated, disjunct populations of the species may be evolutionarily important and genetically valuable in that they may possess unique genetic material or characteristics. The populations at Cascade Creek could play a role in a speciation event or the species' future biogeography.

Mutualistic relationships between the orchid and insect pollinators and mycorrhizal fungi likely occur at Cascade Springs.

Stream orchid was reportedly used by the Kayenta Navajo people of northeastern Arizona as a general treatment of disease, to purify newborn infants, and as a ceremonial medicine; and by the Karok people from the Klamath River area of California as a decoration (Moerman 1998). It was allegedly used medicinally by native peoples of northern California (Dale 1986), and is also included in "The Ethno-Botany of the Gosiute Indians of Utah" although no uses are described (Chamberlin 1912). It is listed in the Herbal Materia Medica as a medicinal species (Moore 1995). No historic or contemporary uses of the orchid by the Lakota peoples of the Black Hills have been identified.

Stream orchid is listed in garden literature and on the Internet as an easily cultivated terrestrial orchid (Rach 1998). The Houston Orchid Society recommends a mixture of peat, sand, perlite, humus or a leaf-mold compost, and charcoal with powdered lime and bone meal in partial shade to full sun with a constant source of water (Rach 1998); however, local climate should be considered.

Life Histories

Southern maidenhair fern is a spore-producing, herbaceous plant with short, creeping rhizomes (Gleason and Cronquist 1991; Walters and Keil 1996). It produces spores in sporangia, or sori, that form under the backrolled margins of the leaves, or false indusia, generally in spring and

summer (Paris 1993; Raven and others 1999) and from July to August in the Black Hills (Fertig 1993). The spores are minute, numerous, and wind-dispersed for both local and long distance colonization (Wherry 1978; Ito and others 1992; Barrington 1993). The species' disjunct occurrences indicate that long-distance dispersal has occurred in the past (Bessey 1898; Brunton 1986b), and is presumably how the fern originally colonized the Black Hills (Griggs 1940). Like all vascular plants, ferns go through alternating haploid and diploid life stages: the diploid fronds of the sporophyte produce haploid spores that germinate to form small, photosynthetic heart-shaped plants (haploid gametophytes), which then produce both male and female gametes for sexual reproduction (Raven and others 1999) (fig. 4). The sporophyte arises from a diploid zygote on the surface of the haploid gametophyte (Raven and others 1999).

Ferns require moist to wet conditions for spore germination, gametophyte development, and to allow the movement of the motile sperm to female gametes (eggs) (Raven and others 1999). The bisexual gametophyte promotes self-fertilization, particularly where conditions limit the range of sperm movement (Barrington 1993). As a result, fern populations may have low genetic diversity with high levels of local differentiation between populations (Barrington 1993; Schneller and Holderegger 1996; Rumsey and others 1999). It is not known if southern maidenhair fern is a predominantly out-crossing or self-fertilizing species, but the closely related maidenhair (*A. pedatum*) is believed to be an out-crossing species (Peck and others 1990).

The Black Hills southern maidenhair fern population may lack genetic diversity and could be genetically distinct from populations elsewhere in the species' range. Long distance spore dispersal is believed to compensate for low local diversity to some degree (Barrington 1993), but the probability of spore dispersal depends upon the distance from an available source of propagules (Schneller and Holderegger 1996). For this reason, there would appear to be limited likelihood of southern maidenhair fern spores reaching the Cascade Valley from the closest populations in southeast British Columbia and northwest Colorado. Some species of fern (*Asplenium*, *Polypodium*) are able to maintain small populations that lack genetic diversity without negative effects (Schneller and Holderegger 1996), even though every individual in the population is genetically identical (Schneller and Holderegger 1996; Rumsey and others 1999).

Southern maidenhair fern reproduces vegetatively through rhizomatous growth and can expand rapidly to form large colonies (Brunton 1986b). It also appears to expand vegetatively through the transport of clumps or pieces of the plant that are dislodged, float downstream, and become lodged elsewhere on stream banks, sand bars, or protruding objects midstream (Fowler 1995).

An infertile hybrid, X *Adiantum tracyi* C. C. Hall, is known to occur naturally between *Adiantum jordanii* K. Müll. and *A.* pedatum L. in California (Wagner 1956). This hybrid occurs in close proximity to both the parent species. Hybridization may be possible in *A. capillus-veneris* where it occurs with other *Adiantum* species.

Ferns have few predators due to limited palatability and, because they do not require pollinators or seed dispersal vectors, they have few co-evolved facultative relationships (Barrington 1993).

Stream orchid flowers for approximately two months from April at the southern extreme of its range in Baja California and mid-June in its northern range until May to the south and mid-August in Canada (Brunton 1986a). Stream orchid has several flower characters that are relatively primitive for orchids: erect anthers, soft pollinia, open nectaries, and self-compatible fertilization (Dressler 1981; Thornhill 1996). Stream orchid reproduces via microscopic seeds or

vegetatively via rhizomatous shoots that form large clusters of clonal ramets (Luer 1975; Brunton 1986a). The tiny seeds, typical for orchids, are probably dispersed by wind or water (Dressler 1981). Germination rates for stream orchid average twenty percent; however, the seeds become less viable with age (Arditti and others 1981).

Stream orchid requires an endomycorrhizal fungal symbiont for seed germination to occur (Prendergast 1994; Smith and Read 1997). This is true for most orchids, because their miniscule seeds lack an endosperm, a protective seedcoat, or root or leaf rudiments from which initial growth may occur (Arditti and others 1981; Dressler 1981). The species or group of endomycorrhizae associated with stream orchid has not been identified. However, the form-genus *Rhizoctonia* in the Basidiomycota has been determined to be the predominant form of endomycorrhizae associated with orchids (Smith and Read 1997). Orchidaceous endomycorrhizal fungi generally serve only to promote seed germination and initial plant growth and may become inactive or be destroyed by the plant once it becomes established, at which time photosynthetic orchids may host vesicular-arbuscular (VA) mycorrhizal symbionts to aid in nutrient acquisition (Smith and Read 1997). Stream orchid is likely associated with at least one species of endomycorrhizae and possibly VA mycorrhizae as well.

Stream orchid flowers contain nectar to attract generalist pollinators (Nilsson 1981; Burns-Balogh and others 1987). Common yellow jackets (*Vespula vulgaris* L.) have been observed with stream orchid pollinia attached to their backs (Mantas 1993), and wasps (Vespids) have been identified as the primary pollinators for the genus *Epipactis* (van der Pijl and Dodson 1966). Syrphid (hover) flies (Syrphidae) have been repeatedly noted as *Epipactis* pollinators (Ivri and Dafni 1977; Correll 1978; Dressler 1981; Coleman 1995) and have been documented with stream orchid pollinia (Coleman 1995). Generalist pollinators at Cascade Springs/Creek presumably pollinate the species, however, no pollinator activity was observed on plants at Cascade Springs in 2000 or 2001.

Stream orchid possesses high genetic variability between populations compared to species with similar life history traits and other orchids (Thornhill 1996). Within-population genetic diversity is also high relative to plant species with similar life histories and reproductive strategies, and with wide distributions (Thornhill 1996). California stream orchid populations show high levels of differentiation between them, which suggests that very little genetic material, in the form of pollen or seeds, is being exchanged between populations (Thornhill 1996). This pattern of high within- and between-population variability could be due to the founder effect, where an individual plant founds a new population (Raven and others 1999). The resulting genetic variation between populations is consistent with the orchid's life history, widespread range, and the differing selection pressures between populations (Thornhill 1996), which appear to be directly related but have rapidly evolved (differentiated) to meet local conditions (Dressler 1981). The species' genetic variability and self-compatibility make it ideally suited to establish populations in geographically isolated and variable habitats, as once it is established the probability of influx of new genetic material is low (Thornhill 1996). For this reason, populations are believed to differentiate quickly and the development of unique new traits within populations or regional variants is probable (Thornhill 1996).

It is not known if stream orchid can hybridize with other *Epipactis* species. Hybridization is unlikely at Cascade Springs, due to the population's geographic isolation from occurrences of red helleborine in Vermont and marsh helleborine in New York. The orchid is probably

reproductively isolated from eastern helleborine, whose closest occurrences are in Montana to the west, and Minnesota and Missouri to the east (Biota of North America Project 2001).

Distributions And Local Abundance

Southern maidenhair fern occurs primarily in tropical and warm temperate regions of the world, and the Black Hills population represents one of the northernmost occurrences of the plant anywhere in its range (Paris 1993) (fig. 1). Disjunct northern populations of the species appear to be restricted to moist, calcareous substrates that are closely associated with warm or hot springs (Wherry 1978; Brunton 1986b). A single population (currently in decline) occurs in the Columbia Valley in southeastern British Columbia at Fairmont Hot Springs (Brunton 1986b). There are 12 populations in southern and western Colorado from 4,800 to 7,800 ft (1,460 to 2,380 m) elevation on dripping limestone cliffs and seeps (Colorado Natural Heritage Program 2001).

Stream orchid's range is almost entirely within the cordilleran areas of western North America (Brunton 1986a) and it is widely but sparsely distributed west of the continental divide from southern British Columbia south to central Mexico and east to western Montana, South Dakota and western Texas (Hitchcock and others 1969; Luer 1975; Brunton 1986a; Fertig 1994) (fig. 2). In the Rocky Mountains, the orchid occurs from 2,630 to 8,000 ft (800 to 2,440 m) elevation in association with thermal springs and seeps, non-thermal springs, seeps, and fens, on sandstone cliffs and hillsides (Spackman and others 1997; Colorado Natural Heritage Program 2001), and on both limestone and granitic substrates (Lesica 1990; Mancuso 1991; Mantas 1993; Montana Natural Heritage Program 2001).

The closest occurrences of stream orchid to Cascade Springs include a population in Bighorn County, Wyoming (Marriott 1991; Fertig 1994) and 27 occurrences in Colorado, only one of which occurs on Forest Service lands (Colorado Natural Heritage Program 2001).

In the Black Hills, stream orchid and southern maidenhair fern occur at ca. 3,400 ft (1,036 m) at Cascade Springs and downstream along the 3.5 mi (5.6 km) extent of Cascade Creek in Fall River County, South Dakota (fig. 3). The fern and orchid occur on Black Hills National Forest lands at J. H. Keith Cascade Springs Picnic Ground (location of Cascade Springs) and the fern also occurs at the Cascade Falls Picnic Ground. The fern is not believed to have ever occurred at other warm springs habitats in the Black Hills, with the possible exception of uppermost Hot Springs, South Dakota (Bessey 1898).

The fern is abundant on The Nature Conservancy's Whitney Preserve at Cascade Creek and occurs in scattered colonies on a 4 A (1.6 ha) private parcel just south of Cascade Springs at Cool Creek and on private land south of Cascade Falls (Burkhart and Ebbert 2001). A sub-population of more than 1,000 stream orchid ramets was located on The Nature Conservancy Whitney Preserve at approximately 3,400 ft (1,036 m) in July 2000 (Ebbert personal communication). A second sub-population of <50 orchid plants on private land immediately south of Cascade Springs was originally observed on August 10, 1983 (South Dakota Natural Heritage Program Records) and was estimated as the same size in 2001 (Hall and others 2002).

The distribution of southern maidenhair fern and stream orchid in the Black Hills is likely due to both species' tiny, wind-dispersed propagules and ability to establish populations with a single individual and to persist with little or no genetic diversity (described in Life History section

above). It is not possible to determine the number of individuals due to both species' dense clonal growth habit, but data collected in 2000 and 2001 indicate that populations of both maidenhair fern and stream orchid are larger and more widely distributed than previously reported (see Current Conservation Situation section above). Both species appear to be vigorous and occupy nearly all suitable streamside habitats along Cascade Creek from just below the uppermost spring downstream to just upstream of the northern boundary of Cascade Falls (Burkhart and Ebbert 2001).

Habitat Relationship

The occurrence of both species in the Black Hills appears to be dependent upon the constant moisture and warmth provided by the springs. Cascade Springs is the largest single springs in the Black Hills with water emerging at 22.5 cubic ft (0.6 cubic m) per second at a constant 67º F (19.4º C) from six known discharge points (Rahn and Gries 1973; Hayes 1999) (fig. 6). For this reason, neither species is likely to survive anywhere else in the Black Hills, except possibly along warm-water habitat on private land near Hot Springs, though potential habitats may occur in warm springs habitats elsewhere in the region. Summaries of the climatic conditions at Cascade Springs and the geology and hydrology of Cascade Springs are given in Appendices C and D, respectively.

The water emerging from Cascade Springs is enriched in calcium salts that have been deposited along the bottom of the valley over time (McIntosh 1928). Cascade Creek is lined by limestone precipitate, or calc-tufa, that is formed by lime-precipitating algae: *Chara* or stonewort (Order Charales, Charophyceae) (McIntosh 1928; Rahn and Gries 1973; Appendix D). Cascade Valley is lined with limestone outcroppings comprised almost entirely of petrified *Chara*, a calcium deposit-forming alga that occurs along the banks of Cascade Creek (McIntosh 1928; Raventon 1994). These formations are evident immediately above Cascade Falls (McIntosh 1928) (fig. 8). The limestone walls and pools that were built at the springs around the turn of the century also provide a calcareous substrate in addition to the existing limestone and calcium deposits (fig. 9).

The perennial portion of Cascade Creek originates at the site of Cascade Springs where the drainage is narrow and more heavily shaded than at the Cascade Falls. The springs area is surrounded by moderate to steep slopes dissected by steep ephemeral drainages that connect to Cascade Springs and Cascade Creek. Bare mineral soils commonly and naturally occur in the area; these soils are highly erosive, and especially during high intensity rainfall events, contribute to sporadic high sediment loads in the creek (Hayes 1999). The Cascade Creek drainage continues to be relatively narrow as it passes through private land below Cascade Springs, but widens out into a broad valley after crossing a short stretch on The Nature Conservancy Whitney Preserve. Currently, this upper portion of Cascade Creek is relatively shaded with only a few canopy openings. As Cascade Creek opens into a broad alluvial valley bottom with marshy areas, it drops in elevation towards Cascade Falls and the confluence with the Cheyenne River. Overstory trees and shaded conditions are currently less abundant in this reach of the stream. Evidence of historic stream meandering, flood scoured features (that is, oxbows, remnant dry channels) and smaller waterfalls occur along this stretch. The valley bottom narrows just above Cascade Falls, which may have contributed to the size of the falls and the development of a pocket of overstory vegetation and large pool below.

There is a strong association between southern maidenhair fern and stream orchid at Cascade

Springs and downstream along Cascade Creek (McIntosh 1928; Ebbert, personal communication; Burkhart and Ebbert 2001) (fig. 7). The species also occur together in British Columbia (Brunton 1986b) and in some hanging garden habitats in Utah (Fowler 1995). Evidence of a facultative relationship between these two species has not been documented. It is most likely that the species simply share similar habitat requirements in the northern portion of their ranges. Southern maidenhair fern and stream orchid do not co-occur everywhere, and stream orchid is more widely distributed in cordilleran North America.

In the main portions of its range, **southern maidenhair fern** occupies shaded, calcareous, moist banks, canyon walls or porous rocky sites, often within the spray of waterfalls, and grows on masonry, storm drains, and limestone from sea level to 8,200 ft (2,500 m) elevation (Brunton 1986b; Gleason and Cronquist 1991; Paris 1993). Southern maidenhair fern commonly occurs on rock walls and mineral deposits in the American Southwest (Wherry 1978; Welsh 1989; Paris 1993; Fowler 1995). It also occurs on tufa, a calcium carbonate rock that is formed by the precipitation of hot, minerotrophic spring water in British Columbia (Wherry 1978; Brunton 1986b), and on similar substrates along Cascade Creek (Rahn and Gries 1973) (figs. 8 and 9). At the northern limits of its range, the fern requires a very humid, continuously warm microclimate and calcareous conditions to survive (Brunton 1986b). The species apparently tolerates a wide range of light conditions (Augustynowicz and Gabrys 1999), which may contribute to its wide geographical distribution, but it appears to be intolerant of inter-specific competition (Wherry 1978; Hoshizaki 1970; Brunton 1986b).

Southern maidenhair fern's potential habitats are limited in the northern portion of its range, where it requires the climate moderating effect of a constant flow of warm water to prevent freezing in winter (Brunton 1986b). Temperatures below 0.4º F (18º C) have been reported to be lethal to the fern (Hoshizaki 1970); however, where the species occurs on the Colorado Plateau in Canyonlands National Park, Utah and Dinosaur National Monument, Colorado (Fowler 1995), it may be exposed to low temperatures of -13º to -29º F (-25º to –34º C) (Western Regional Climate Center 2002). The fern is apparently able to tolerate freezing temperatures at some locations that lack the warming effect of hot springs (Fowler 1995). In British Columbia, the fern is never found more than a few decimeters from warm water (Brunton 1986b), and in the Black Hills, maidenhair fern occurs immediately adjacent to the springs' 67º F (19.4º C) water (Rahn and Gries 1973) and water warmed by the springs along Cascade Creek. Although Cascade Falls is ca. 2 mi (3.2 km) south of the lowermost warm spring discharge point, the water apparently retains enough warmth, possibly aided by Cascade Falls' southwest exposure, to sustain the fern through the winter. There are several locations where the fern occurs more than 3 ft (1 m) from the water on stream banks.

In mountainous areas, **stream orchid** is commonly associated with calcareous habitats such as minerotrophic fens, thermal seeps and springs, often with a diverse riparian plant community (Schassberger 1988; Marriott 1991; Mantas 1993). Across the central and northern Rocky Mountains, stream orchid occupies a wide range of habitats from sedge marshes (Mantas 1993) to wet, sandy habitats in pinyon/juniper woodland and at the base of cliffs with poison ivy *(Toxicodendron radicans),* skunk brush *(Rhus aromatica)* and willow *(*Salix *species)* (Colorado Natural Heritage Program 2001). Stream orchid's distribution follows other rare taxa including Geysers panicgrass *(Dicanthelium acuminatum* var. *thermale;* synonym = *Panicum thermale)* to the west (USDA NRCS 2002; Mancuso 1991); and southern maidenhair fern (*Adiantum capillus-veneris*) to the south (Brunton 1986b).

Stream orchid may also require a geothermally modified environment in the northern parts of its range (Mantas 1993). However, stream orchid also occurs on the Colorado Plateau (and possibly elsewhere) where it is exposed to freezing temperatures (Fowler 1995). It may be that the species is able to tolerate freezing conditions or is adapted to tolerate extreme climatic or habitat conditions, in some parts of its range. Average winter low temperatures at Hot Springs, South Dakota are below 23° F (-5° C), and both the orchid and fern are occasionally exposed to extreme low temperatures below 0° F (-18° C) (NOAA 1996-2001; Appendix C).

Throughout its range, stream orchid occurs in moist areas along streams and rivers, lake margins, wet meadows, at the base of cliffs, and commonly in seeps and springs, especially near calcareous or minerotrophic thermal waters (Hitchcock and others 1969; Mancuso 1991; Marriott 1991). In general, stream orchid is found growing in thin, partially decomposed, wet soils (Brunton 1986a) from sea level to 9,000 ft (2,740 m) elevation (Washington Natural Heritage Program 1999). A shaded environment is required for seed germination, but the species reportedly does not compete well in shady conditions later in its development (Arditti and others 1981). However, this has not been demonstrated where the orchid occurs in both open and constantly shaded habitats on the Colorado Plateau (Fowler 1995).

Southern maidenhair fern and stream orchid occur in both full shade and full sun habitats on the Colorado Plateau (Fowler 1995). At Cascade Springs and Cascade Falls, southern maidenhair fern does not appear to be as robust in full sun (which may simply be a leaf density factor to absorb more sunlight in shadier conditions), but also does not occur along densely shaded portions of the creek. The largest concentrations of southern maidenhair fern occur beneath a stand of sandbar willow (*Salix exigua*), but it is unclear if this indicates a preference for shade, if the willows restrict trampling, or if some other feature of the site is more favorable for the species. The occurrence of sandbar willow may indicate past scouring or erosion of streamside habitats, which may have facilitated the fern's occurrence away from the streambank as well.

At Cascade Springs, southern maidenhair fern and stream orchid occur immediately adjacent to the active springs, on streamside benches, and on rocks and emergent areas within the stream course, in partial shade to full sun on mostly saturated soils (fig. 7). At Cascade Springs, the rhizomatous growth of the fern forms dense mats over exposed rock and along the stream banks, which may stabilize these substrates for other species. At Cascade Falls, the fern is sparsely distributed on tufa limestone and streamside soils in and along the creek in full sun, and in shaded sloughs or abandoned channels some distance from the main stream channel (fig. 8). This site is more open and there is less exposed rock with little topographic variation (Burkhart and Ebbert 2001). The species' habitats at both sites are consistent with their habitats on the Colorado Plateau, where they occupy permanently wet rocks and colluvial soils (Fowler 1995). At Cascade Springs and Falls, both species occur primarily on alluvial soils. Both the fern and the orchid are closely associated with the limestone walls at Cascade Springs and the Chara calc-tufa terraces downstream (McIntosh 1928).

In western Montana, populations of stream orchid at sites fed by minerotrophic waters with high concentrations of extractable potassium (K+) and calcium (Ca+), have been shown to produce significantly taller ramets that bear more flowers (Mantas 1993). However, ramet and flower production could be influenced by another variable such as another environmental factor or a non-ecological variable, such as genetics (Mantas 1993). Mantas (1993) found stream orchid ramet height to be significantly correlated with flower number and high ramet density to be

correlated with lower flower numbers. This suggests that periods of clonal spread into available habitat are inversely related to sexual reproduction (Mantas 1993). The density and apparent expansion of stream orchid at Cascade Springs and downstream suggests that the species has recently expanded into new areas. The intensity of surveys prior to 2000 is not known, but it seems reasonable that the populations have expanded in response to mild winters and above-average summer rainfall in recent years (NOAA 1996-2001), which may have increased the amount of riparian habitat along the creek.

The orchid almost never occurs where the fern is not present along Cascade Creek (Burkhart and Ebbert 2001). The fern is low growing and apparently does not exclude stream orchid, although the species may compete. The orchid does occur at the springs in deep shade, but southern maidenhair fern may be excluded where the creek bed is densely shaded by riparian tree species. However, both species appear to be excluded in more open habitats and where the exposure shifts from north-south to east-west (Burkhart and Ebbert 2001). Several large sedge marshes border Cascade Creek, but southern maidenhair fern and stream orchid occur only on the margins of these standing water habitats. The plant species associated with stream orchid and southern maidenhair fern at Cascade Springs and Cascade Falls are given in Table 3.

Disturbance Ecology

Human disturbance has played a prominent role in the recent history of Cascade Springs; however, fire, flooding, and wildlife use have also been important historic disturbances to the Cascade Creek system. The area's native riparian plant species likely require, or are tolerant of, the episodic soil disturbances associated with historic disruptions of their habitat. The arid uplands in and around the Cascade Valley have been subject to historic and recent fire (see Key Risk Factors), which can indirectly contribute to flooding, erosion, and siltation of streams. Seasonal and episodic flooding of the springs and downstream habitats along Cascade Creek can dislodge streamside vegetation, scour streamside terraces, collapse stream banks, and reroute portions of the creek. Unlike many other riparian areas in the Black Hills, there is no historic or recent evidence of beaver *(Castor canadensis)*. Beaver dams would moderate the impacts of floods (Olson and Hubert 1994).

A paleoenvironmental excavation in 1993 of the Kenzy site along Castle Creek in the central Black Hills, documented floodplain deposits that have accumulated over the last 340 years, as well as bison (*Bos bison*) remains, several of which were butchered, elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*) and deer (*Odocoileus hemionus and/or O. virginianus*) remains, and charcoal remains of previous fires (Saunders 1996). It is likely that these wildlife species also occurred in the vicinity of Cascade Creek. It seems reasonable to assume that the constant flow of warm water from Cascade Springs would have attracted both native peoples and wildlife. The Cascade Valley's position at the convergence of the Black Hills and the Great Plains also would have provided warmth in winter due to its southwest aspect and shelter from prevailing winds; further, the area receives less snowfall than other parts of the Black Hills (High Plains Regional Climate Center 2001, Appendix C).

In the limited northern portions of their ranges, both stream orchid and southern maidenhair fern are at risk from heavy use of their habitats by recreationists and commercial development of thermal springs (Mancuso 1991). Hot and warm springs are popular outdoor destinations that are frequently advertised in trail and tourism guides, and other recreation manuals (Mancuso

1991). The fern population at Fairmont Hot Springs in British Columbia was first noted in 1888 and was believed to have been extirpated when the springs were developed in the 1960s, but the fern was rediscovered in a much smaller concentration in 1974 (Brunton 1986a). Stream orchid populations in Idaho and Canada have been extirpated or are at critically low numbers due to habitat alteration for recreational use (Brunton 1986a; Mancuso 1991). Although widespread and locally abundant in Colorado, stream orchid is reportedly in general decline due to habitat loss from alteration of riparian areas, seeps and springs (Colorado Natural Heritage Program 2001).

The resort town of Cascade Springs was founded in 1888 just south of the springs, which were used as commercial mineral spas until shortly after the turn of the century (Parker and Lambert 1974). Several of the springs are still bordered by limestone bricks from their historic development (McIntosh 1928; Parker and Lambert 1974) (fig. 9) and both Cascade Springs and Cascade Falls have continued to be used recreationally by the public since that time. In 1962, the lands containing Cascade Springs and Cascade Falls were donated to the USFS to be maintained and used solely as public parks.

Southern maidenhair fern was first documented at Cascade Springs in 1898 (Bessey 1898), but the earliest record of stream orchid at the site is from a specimen collected by W. H. Over in 1929 (Van Bruggen 1985; South Dakota Natural Heritage Program). It is not known if stream orchid occurred at the springs prior to the site's development or at other commercially developed springs in the area, but it has persisted through periods of heavy human disturbance since 1929 and possibly before that time. This may indicate that intense, episodic disturbance is not detrimental, and could actually facilitate the species' establishment, as both species will readily establish themselves on disturbed soil. However, the effects of differing degrees of disturbance or specific soil conditions are unknown. It is not clear how individuals or populations of either species are impacted by disturbance or if disturbance is an effective mechanism for the creation of new habitats, seed dispersal or colonization.

In Canada, stream orchid is reported to prefer open, early successional habitats, which it colonizes quickly but is out-competed in later succession (Brunton 1986a). This also appears to be the case in the Black Hills, where the orchid occupies flood bench habitats, and moist areas associated with the springs and the creek's steep, shady banks and open sedge meadows. However, the orchid occupies somewhat different habitats in association with cliffs and seeps on the Colorado Plateau (Fowler 1995) and open wetlands in Montana (Mantas 1993).

It is not known to what degree either the orchid or fern are negatively or positively affected by disturbance in the Black Hills. There is no evidence to suggest that disturbance is necessary for the species' establishment or persistence, but it is possible that disturbance or displacement of streamside soils may create establishment sites for wind- or animal-borne propagules, or for rhizomatous expansion. Both species may be well adapted to periodic scouring of stream banks and benches and quickly occupy newly disturbed soils. Although moderate flood disturbance has occurred during the past two seasons of monitoring along the creek, there has not been an associated decrease in the number of orchid ramets or in the extent of the fern. The long history of natural and human disturbance at Cascade Creek suggests that southern maidenhair fern and stream orchid are tolerant of, or perhaps able to exploit disturbances. In contrast, both species also thrive in habitats that receive little or no disturbance, such as hanging garden communities in the Southwest (Fowler 1995). In addition, the distribution of the fern at Cascade Springs and

Cascade Falls suggests that it may colonize new habitats when clumps are dislodged and become established downstream. Dislodged fern and orchid clumps have been observed floating downstream in the Colorado Plateau as well (Fowler 1995).

Slugs (*Zacoleus* and *Arion* spp.) were noted in Montana stream orchid populations by Mantas (1993), but caused minimal damage. Fungal anthracnose (*Glomerella* sp.) has been known to kill stream orchid, kill or damage flower buds and damage leaves, but the degree of seasonal variability or long term effects of anthracnose are not known (Mantas 1993). No evidence of disease or predation was observed on either species at Cascade Springs or Falls in 2000 or 2001.

Cascade Springs has been reported to "run red" several times in the past century with the most recent documentation from 1992 (Hayes 1999). Local residents report that Cascade Creek has "run red" numerous times within the past decade, and The Nature Conservancy is now tracking discharge events. The red flow is the result of the collapse of breccia pipes due to dissolution of mineral quartz and red hematite in the upper Minnelusa Formation by fresh water from the Madison Aquifer (Hayes 1999) (see summary of Cascade Springs Geology in Appendix D). While the process is caused by erosion, it is thought to be a normal periodic event that has occurred since the Black Hills Uplift and subsequent movement of upper strata outward (Hayes 1999). At the present time, there is no evidence that the release of mineral silt and clay sediments into the springs is harmful to the stream or its associated biota. Hayes (1999) indicates that the quantity of discharge points and erosion influences the process, but does not state that wells or erosion from development cause or expedite the collapse and release of these sediments into Cascade Creek.

Key Risk Factors

Ongoing recreational use and invasion by exotic plant species are currently considered to be the most significant risks to both species and their habitats at Cascade Springs and Cascade Falls (USDA Forest Service 2001). Impacts associated with recreation include new road or trail construction, trampling, bank destabilization, and non-target weed control and mowing in the riparian zone (USDA Forest Service 2000). Although both species have persisted during periods of heavy human use in the past and may even benefit from intense episodic disturbance (USDA Forest Service 2000), there is a concern that recreational effects might be insidious until a threshold is reached that could result in one or more local populations being decimated. Fortunately, some of the populations of both species occur in areas that are naturally protected by dense vegetation or inaccessible slopes, and therefore are unlikely to be impacted by recreationists.

Invasion by noxious weeds and other exotic plants could be detrimental, as neither the fern (Brunton 1986b) nor the orchid (Arditti and others 1981) tolerates intense interspecific competition. Several invasive plants have been documented at Cascade Springs and Cascade Creek: Canada thistle (*Cirsium arvense*) occurs in scattered concentrations adjacent to the springs and at Cascade Falls, but has so far not expanded into saturated riparian habitats; Russian olive (*Elaeagnus angustifolia*) occurs in scattered thickets along the creek and at the springs; perennial sowthistle (*Sonchus arvensis*) occurs at Cascade Falls; and salt cedar (*Tamarix ramosissima*) occurs in the uplands northwest of Cascade Falls (Burkhart, personal communication). Salt cedar is of particular concern because it has the potential to expand explosively along riparian corridors (Whitson 1991). Recently, a single salt cedar plant occurred

approximately 30 yards (27.4 m) from concentrations of maidenhair fern at Cascade Falls (Burkhart, personal communication), but the individual has been removed. There is a plan to monitor the site and continue treatment if needed.

Several State noxious weed species occur at one or both sites: perennial sowthistle, Canada thistle, and curly dock (*Rumex crispus*). The noxious weed purple loosestrife (*Lythrum salicaria* L.) has not been documented in the Cascade Valley, but has been noted along Rapid Creek in the Black Hills (South Dakota Natural Heritage Program), and should be considered a serious risk to the integrity of riparian and wetland habitats at Cascade Springs and Cascade Creek (Whitson 1991). In addition, uplands are potentially at risk from other noxious weeds such as leafy spurge (*Euphorbia esula*), which could greatly alter the species composition of surrounding uplands (USDA Forest Service 2000). However, broadcast spraying for any invasive species has the potential to affect non-target plant species and could thereby greatly alter species richness in the area (USDA Forest Service 2000). Localized spraying or mechanical treatment (hand-pulling) of individuals or patches would be expected to benefit both species.

The constant flow of warm water from Cascade Springs is essential to the persistence of southern maidenhair fern and stream orchid in the Black Hills (USDA Forest Service 2000). Due to the springs' deep source in Hell Canyon to the northwest, the quality and quantity of its water are not greatly affected by alteration of surrounding lands (Hayes 1999). However, local disturbances may affect sediment levels and have the potential to increase non-point source pollutants.

Southern maidenhair fern and stream orchid's single populations along Cascade Creek and highly specialized habitats make them vulnerable to habitat alteration and hydrologic modifications (Marriott and others 1990), and any direct impacts to the springs and riparian areas are a potential risk. In the late 1990's, South Dakota Highway 71 was moved away from Cascade Creek and the original roadbed was retained as a parking area for Cascade Springs. Direct impacts of these activities to the springs or to southern maidenhair fern and stream orchid habitats have not been documented, but the close proximity of the road is a concern due to the potential for contamination of the springs and Cascade Creek with toxic substances or introduction of noxious weeds or other invasive species by vehicles.

Development of subdivisions, housing, or roads, and any resulting pollution and/or erosion could adversely affect the species' habitats (Marriott 1993). The lands immediately to the north of Cascade Springs and bordering Cascade Creek to the south are privately owned, and lots have been sold and developed on land surrounding Cascade Springs. Development could cause increased runoff, erosion, increase the nutrient load in the creek and riparian habitats, and introduce pollutants or invasive plants to the Cascade Springs system. Off-site mitigation may be necessary to prevent alteration of the ecology of the riparian and aquatic ecosystems of Cascade Springs and Cascade Creek.

Cascade Springs and Cascade Falls have been used intensively by people in the past and will likely continue to be heavily used. Erosion at Cascade Springs and downstream along Cascade Creek is an immediate concern. Several areas of active erosion were noted in both 2000 and 2001, and may include areas where southern maidenhair fern occurred. However, erosion is an ongoing, natural process along Cascade Creek due to the high volume of water from the springs, episodic flood events, local topography and soil characteristics (Hayes 1999). Spring flooding or flooding associated with intense thunderstorms at other times may contribute to elevated erosion and sediment loading from adjacent steep slopes and areas of erosive soils in the narrow drainage

area where the springs are located. Erosion levels along Cascade Creek are also likely being influenced by several additional factors: slopes exposed by highway reconstruction in the mid-1990's are not fully revegetated; there are ongoing land use activities on adjacent private lands; and soil disturbance from recreation at Cascade Springs is likely adding to erosion along adjacent portions of Cascade Creek.

In addition, two recent fires, the West Hell Canyon Fire and Flagpole Fire, occurred in some of the watersheds above Cascade Creek. In August 2000, the Flagpole Fire burned 7,386 A (2,989 ha) ca. 3 mi (4.8 km) southeast of Cascade Creek and in September 2001, the West Hell Canyon Fire burned 10,547 A (4,268 ha) from 3 to 9 mi (4.8 to 14.5 km) northwest of Cascade Springs. A large portion of these fires were in drainages upslope of Cascade Creek and could result in increased erosion of the area's highly erosive soils and increased siltation into the creek during subsequent flood events.

Trampling of stream banks associated with swimming, inner tubing, and fishing are also a risk to both species (USDA Forest Service 2000). On the 4th of July, 2000, an estimated 200 people were in the water at Cascade Falls and additional people were in the picnic areas and on the stream banks. The relatively small size of the maidenhair fern population at Cascade Falls may be due to such intense use of the site, or may simply be due to it being less suitable habitat. A relatively large section of the creek above Cascade Falls washed out in the spring of 2001 and cut a new course that separated a small section of the creek from its main course. The fern could potentially be eradicated from Cascade Falls by intense human activity or other disturbances, but is suspected to periodically re-colonize the area via dislodged clumps from upstream.

Footpaths and visitor-created "nick" trails at Cascade Springs are being monitored and some were fenced in 2001 to limit recreational access to sites where sensitive species occur. Although there has been no evidence of plant collection to date, the populations of southern maidenhair fern and stream orchid at Cascade Creek are specifically identified as botanical attractions in local tourist information and in the plant field guide "Plants of the Black Hills and Bear Lodge Mountains" (Larson and Johnson 1999). Therefore, plant collection should be considered a potential risk to both species.

CONSERVATION PRACTICES

Management Practices

The only known occurrence of stream orchid on Black Hills National Forest lands is at J. H. Keith Cascade Springs Picnic Ground. Southern maidenhair fern occurs on Black Hills National Forest at Cascade Springs and at the Cascade Falls Picnic Area 1.5 miles (2.4 km) downstream from the springs. In 1962, Edna Keith Florence, one of the original landowners in Cascade Valley, deeded the 10 A (4 ha) Cascade Springs site and 15 A (6 ha) Cascade Falls portions of the Cascade Creek drainage to the USFS for one dollar. J. H. Keith Cascade Springs Picnic Ground and the Cascade Falls Picnic Area are administered by the Hell Canyon Ranger District, Black Hills National Forest, but are managed and maintained by the Fall River Ranger District, Nebraska National Forest due to its close proximity to the sites (Poppert, personal communication). The land deed granted to the USFS specifically requires that the grantee (USFS) must preserve, develop, care for and maintain Cascade Springs and Cascade Falls as

parks for the use of the public and for no other purpose (USDA Forest Service 1962).

The 1,195 A (483 ha) parcel of land between Cascade Springs and Falls, from just south of the Cool Creek culvert to Cascade Falls, was purchased by the Black Hills Chapter of The Nature Conservancy in 2000 and has been established as The Nathaniel and Mary Whitney Preserve at Cascade Creek (The Nature Conservancy 2000). Large concentrations of both the fern and orchid occur on the Whitney Preserve, and there are scattered occurrences on private land under conservation agreement with The Nature Conservancy as well. These private lands include a 4 A (1.6 ha) parcel of land between the old Keith family residence (the original bank building for the town of Cascade Springs) and the bridge at Cool Creek that includes about 100 yards (91 m) of the creek (Paulson, personal communication 2000; Burkhart and Ebbert 2001). There are also scattered occurrences of the fern on private land south of Cascade Falls (Burkhart and Ebbert 2001). In 2001, The Nature Conservancy established 54 permanent 1-m^2 plots to monitor populations of southern maidenhair fern, stream orchid, tulip gentian, and beaked spikerush along Cascade Creek on the Whitney Preserve and nearby easement lands (Burkhart and Ebbert 2001).

Both Cascade Springs and Cascade Falls are surrounded by private land. Both sites are picnic areas, but recreational use is lower at Cascade Springs than at Cascade Falls. Cascade Falls is a popular swimming hole and human disturbance near the falls is notable. Disturbances from recreation include trampling of vegetation and stream bank habitats during fishing, picnicking, swimming and inner tubing. In addition, maintenance activities occasionally contribute to these disturbances. A "no-mow" zone has been established around known populations of sensitive plants at Cascade Springs to deter foot traffic and appears to have decreased use in these areas. However, alteration of streamside habitats and impacts to sensitive plants by picnic area users still occurred in 2000 from trampling and use of streamside habitats. Public access remains a management priority at the developed recreation areas, but the facilities were recently redesigned to direct human activities away from sensitive species and their riparian habitats (Poppert, personal communication).

There is a USFS easement on the 4-A (1.6-ha) parcel of private land immediately north and west of J. H. Keith Cascade Springs Picnic Ground that allows use of an old roadbed to maintain facilities in the recreation area (Poppert, personal communication). A portion of the roadbed adjacent to the highway and on the uppermost slope was resurfaced with aggregate to prevent erosion in August 2000. In 2001, the steeply sloped portion of the road was covered with erosion mat and seeded with native species in an attempt to reduce sediment runoff into the adjacent springs. The portion of the roadbed on the bottomlands near the uppermost spring was not resurfaced so that the existing vegetation could act as a filter to catch sediment before it reaches the springs. In August 2000, the Cascade Springs trail network was paved to reduce sediment and aggregate runoff into the springs and Cascade Creek. In 2001, fencing was installed along portions of the trail system to restrict access to the streamside by blocking "nick points" (trails created by recreational users between the picnic area and the creek).

In 2000, an integrated weed management plan for Cascade Springs, Cascade Falls, the Whitney Preserve, and adjacent private lands was implemented by the Fall River Ranger District, The Nature Conservancy, and private landowners (Paulson, personal communication). This includes an 8 to 10-year plan to replace Russian olive along Cascade Creek on the Whitney Preserve with native tree species and to remove salt cedar on both TNC and USFS administered lands (Paulson,

personal communication). The Buffalo Gap National Grassland - Nebraska National Forest and Black Hills National Forest removed the single salt cedar at Cascade Falls in 2001. The Canada thistle stem weevil (*Haploplontus litura)*, a biological control agent, was released in two separate locations at Cascade Springs on May 17, 2001 (Allen, personal communication). However, due to the substantial seed source in the area, mechanical weed pulling or hand application of herbicides in the vicinity of populations of rare species will likely be needed to suppress Canada thistle and other invasive or noxious weeds.

Livestock grazing is not permitted at Cascade Springs or Cascade Falls and does not occur on private land south of the springs, but grazing does occur on portions of The Nature Conservancy's Whitney Preserve. There was no evidence of browsing, disease or predation on plants at Cascade Springs or Cascade Falls in June 2000 or 2001.

No timber harvest or other management activities are planned for USFS land in the immediate area, other than to suppress noxious weeds or other exotic plants; however, development or alteration of adjacent private land could occur.

Conservation Measures

The persistence of southern maidenhair fern and stream orchid in the Black Hills has likely benefited from the recent acquisition and conservation of additional habitats and subpopulations on The Nature Conservancy's Whitney Preserve. The Nature Conservancy (TNC) has identified the Cascade Creek drainage, part of the Cheyenne River Canyons area and all occurrences of the fern and orchid as priorities for conservation in its ecoregional conservation plan for the Black Hills (Hall and others 2002). Additional conservation of private land occurrences may potentially be achieved through TNC easements or long-term Forest Service/TNC acquisition, but this is dependent upon funding, land availability, and landowner willingness to participate. The possibility of collecting and storing fern spores and orchid seed in certified repositories, both for genetic analyses and *ex situ* propagation, could be explored.

Survey, Inventory And Monitoring Approach

Quantitative monitoring is problematic as some areas at Cascade Springs are inaccessible or involve high risk of damage to the plants from trampling or dislodging them on steep slopes. Also, because both species expand clonally, it is not possible to determine the number of individual plants. Baseline monitoring began in June 2000 and ongoing annual monitoring is planned. Monitoring of southern maidenhair fern can occur any time during the growing season, but stream orchid is most efficiently conducted during its flowering period in June. Monitoring of both species includes verification of presence/absence of mapped patches along stream transects and recording any new occurrences. Any changes to the populations are to be indicated on baseline map diagrams for both sites. Also, plans are to document any recreation nick points, trails, stream bank erosion, weeds or other disturbances in or near the populations. If the extent of the mapped patches declines by 10 percent or more, plans are to consult ecologists, botanists and biometricians knowledgeable about the species to develop a more rigorous monitoring strategy.

As of 2001, the USGS gauging station at the southern end of J. H. Keith Cascade Springs Picnic Ground is no longer being monitored by the USGS. A water level monitor may be installed to measure water table levels. A flow gauge may also be used to measure any change in stream

flow volume or velocity. Areas that are vulnerable to erosion and other impacts may be selected as key sites for more intensive monitoring.

CONCLUSIONS AND INFORMATION NEEDS

In the Black Hills, maidenhair fern and stream orchid are limited to occurrences at Cascade Springs and downstream along Cascade Creek in the Black Hills National Forest and The Nature Conservancy Whitney Preserve. Their limited distribution makes both species vulnerable to random events such as disease outbreak. However, the increased extent of both the fern and orchid in recent surveys in comparison to earlier reports (see Distribution and Local Abundance section above) is encouraging. In addition, the existence of multiple subpopulations of both species in the watershed will potentially help buffer against any potential catastrophes in the area.

Both species' dependence upon saturated conditions could make them vulnerable to geologic or long-term climatic changes that affect the flow of water from the springs. The current size of the fern and orchid populations could be in response to several recent years of higher than average moisture in the Black Hills (NOAA 1996-2001), as well as recent conservation activities taking place in the Cascade Creek valley. Populations of both species appear to be stable or increasing, but there is insufficient data to demonstrate a trend at the present time. Negative climatic influences, such as drought or long-term climate change, could be tempered or overridden by the springs' constant flow from its deep source in the Madison and/or Minnelusa aquifers. A rigorous monitoring program has been instituted to detect and quickly respond to alterations in the distribution and extent of either species or impacts upon them from recreation.

There are many aspects of the genetic makeup and life history attributes of both species that are unknown. Because of the high degree of local adaptation in the orchid, and both species' ability to found populations with a single individual, it is not known to what degree Black Hills populations are related to populations elsewhere in the species' ranges. Also, the orchid's local pollinators are unknown, and seed viability and germination requirements should also be examined. In addition, collection and storage of spores and seeds in certified repositories are being considered, which would allow researchers to assess how the genetic composition of these species differs from disjunct populations elsewhere in their ranges. Finally, although it is unlikely that other warm springs habitats that could support these species exist in the Black Hills, reintroduction is possible should the species be extirpated from the Cascade watershed. Both species are reported to be relatively easy to propagate and could be grown off-site to provide material for reintroduction if needed.

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APPENDICES

Appendix A. Technical description of southern maidenhair fern, *Adiantum capillus-veneris*.

"Stems short-creeping; scales golden brown to medium brown, concolored, iridescent, margins entire or occasionally with single broad tooth near base. Leaves lax-arching or pendent, closely spaced, 15-75 cm [5.9 – 29.5 inches]. Petiole 0.5 – 1.4 mm [0.02-0.1 inches] diam., glabrous, occasionally glaucous. Blade lanceolate, pinnate, 10-45 x 4-15 cm [3.9-17.7 X 1.6-5.9 inches], glabrous, gradually reduced distally; proximal pinnae 3(-4)-pinnate; rachis straight to flexuous, glabrous, not glaucous. Segment stalks 0.5-3.5 mm [0.02-0.1 inches], dark color extending into segment base. Ultimate segments various, generally cuneate or fan-shaped to irregularly rhombic (plants in American Southwest occasionally with segments nearly round), about as long as broad; base broadly to narrowly cuneate; margins shallowly to deeply lobed, incisions 0.5-7 mm [0.02-0.28 inches], occasionally ± laciniate, sharply denticulate in sterile segments; apex rounded to acute. Indusia transversely oblong or crescent-shaped, 1-3(-7) mm [0.04-0.12(0.28) inches], glabrous. Spores mostly 40-50 μm [0.0016 – 0.0020] diameter" (Flora of North America Editorial Committee 1993) (fig. 4).

North American and South American forms were divided into separate varieties: *Adiantum capillus-veneris* L. var. *protrusum* Fernald represents plants in the southern United States, Cuba, portions of Mexico, and the Black Hills (Lellinger 1985); *A. capillus-veneris* L. var. *modestum* (Underw.) Fernald represents material found in the southwestern United States and portions of Mexico; and *A. capillus*-veneris L. var. *modestum* (Underw.) Fernald forma *rimicola* (Slosson) Fernald was assigned to the exceptionally large fertile fronds found in the Rocky Mountain region (Paris 1993). The Flora of North America (1993) does not accept any of these varieties as distinct and considers all forms a single species. Alternative taxonomic treatments include: *Adiantum capillus-veneris* (L.) Hook. 1851; *A. capillus-veneris* form *capillus-veneris*; *A. capillus-veneris* form *dissectum* (M. Martens and Galeotti) Ching 1957; *A. capillus-veneris* form *fissum* (H. Christ) Ching 1957; *A. capillus-veneris* var. *laciniatum* H. Christ ex Tardieu and C. Chr.; *A. capillus-veneris* var. *modestum* (Underw.) Fernald (Tardieu-Blot, M. L. 1958); *A. capillus-veneris* form *rimicola* (Sloss.) Fernald 1950; and *A. capillus-veneris* form *lanyuanum* W.C. Shieh 1968 (Missouri Botanical Garden Tropicos Database 2001).

Appendix B. Technical description of stream orchid, *Epipactis gigantea*.

"Stems 1 to many from short rhizomes, mostly 3-7 (up to 12) dm tall; leaves numerous, sheathing, the lowest blades almost lacking, but gradually enlarged upward, almost glabrous to scabridulous-puberulent, broadly elliptic-lanceolate, mostly 7-14 (19) cm long and 1.5-5 cm broad; flowers 3-15, rather showy, the racemes usually secund, the bracts gradually reduced upward, but even the uppermost one usually exceeding the ovary; sepals coppery-green, lightly brownish-veined, 12-16 mm long; petals similar to the sepals, but thinner and (at least the venation) more brownish-purple; lip 15-20 mm long, the sac with prominent, raised purplish lines leading to the base, 3-lobed, the outer (basal) lobe prominent, the blade (central lobe) about as long as the basal lobes, somewhat curved downward, triangular-ovate, the tip flattened but with uprolled margins, greenish-yellow, the basal portion much thickened, yellow, the margins thickened and erect, with numerous linear callosities leading to the sac; column 6-9 mm long; anther 4-5 mm long; capsule reflexed, 2-3.5 cm long" (Hitchcock and others 1969) (fig. 5).

Alternative taxonomic treatments include: *Limodorum giganteum* Kuntze, Revisio Gen. Pl. 2: 672. 1891; *Peramium giganteum* J. M. Coulter, Contr. U.S. Nat. Herb. 2: 424. 1894; *Serapias gigantea* A. A. Eat., Proc. Biol. Soc. Wash. 21: 67. 1908; *Helleborine gigantea* Druce, Bull. Torrey Bot. Club 36: 547. 1909; *Amesia gigantea* Nels. and Macbr., Bot. Gaz. 56: 472. 1913 (Cronquist and others 1977).

Appendix C. Climate summary for Cascade Valley, Fall River County, South Dakota.

The closest weather station to southern maidenhair fern and stream orchid populations along Cascade Creek is the Hot Springs, South Dakota Climate Station, approximately 8 mi (12.9 km) to the north. The climate at Hot Springs is somewhat warmer and considerably drier than the northern or central Black Hills. The past several years have had relatively mild winters with little snowfall and cool, rainy summers (NOAA 1996-2001). Precipitation is concentrated in May, June and July (High Plains Regional Climate Center 2001). Average temperature extremes, annual precipitation and total snowfall at Hot Springs, South Dakota are given in the table below. The Hill City and Lead, South Dakota Climate Stations, approximately 35 mi (56.3 km) and 60 mi (96 km) north of Hot Springs, respectively, are included for comparison.

Climate summary for southern maidenhair fern and stream orchid occurrences in the Black Hills National Forest (High Plains Regional Climate Center 2001).

Climate Station	Period of record	Average min. temp. (January)	Average max. temp. (July)	Total annual precip.	Average total snowfall
Hot Springs	1908-2000	10.9º F (-11.7º C)	89.1º F (31.7 C)	17.3 inches (44.0 cm)	35.4 inches (90.0 cm)
Hill City	1955-2000	7.9º F (13.4º C)	79.1º F (26.2º C)[a]	20.4 inches (51.8 cm)	60.0 inches (152.4 cm)
Lead	1948-2000	14.0º F (-10.0º C)	79.5º F (26.4º C)	29.0 inches (73.7 cm)	169.3 inches (430 cm)

[a] Average Maximum Temperatures are in August at this station.

Appendix D. Geology of Cascade Springs, Fall River County, South Dakota.

Cascade Springs occurs along a band of quaternary alluvium between the Triassic and Permian Spearfish formation and "Permian Minnekahta limestone selected outcrop" (fig. 6) (Hayes 1999). It is the largest single spring in the Black Hills with high discharge (average flow 23.65 cfs) at the point of contact between the Minnekahta and Spearfish Formations (Rahn and Gries 1973). 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 and others (1991) reported roughly the same mineral constituents for Cascade Springs: 1500 mg/L sulfate (SO_4); 540 mg/L calcium (Ca); 240 mg/L bicarbonate (HCO_3); 83 mg/L magnesium (Mg); 31 mg/L chloride (Cl); 27 mg/L sodium (Na); 15 mg/L silica (SiO_2); 5.2 mg/L potassium (K); and a pH of 6.89. 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).

FIGURES

Figure 1. North American distribution of southern maidenhair fern, *Adiantum capillus-veneris* (Flora of North America Editorial Committee 1993, 2002 online).

Figure 2. North American distribution of stream orchid, *Epipactis gigantea* Dougl. ex Hook (Luer 1975).

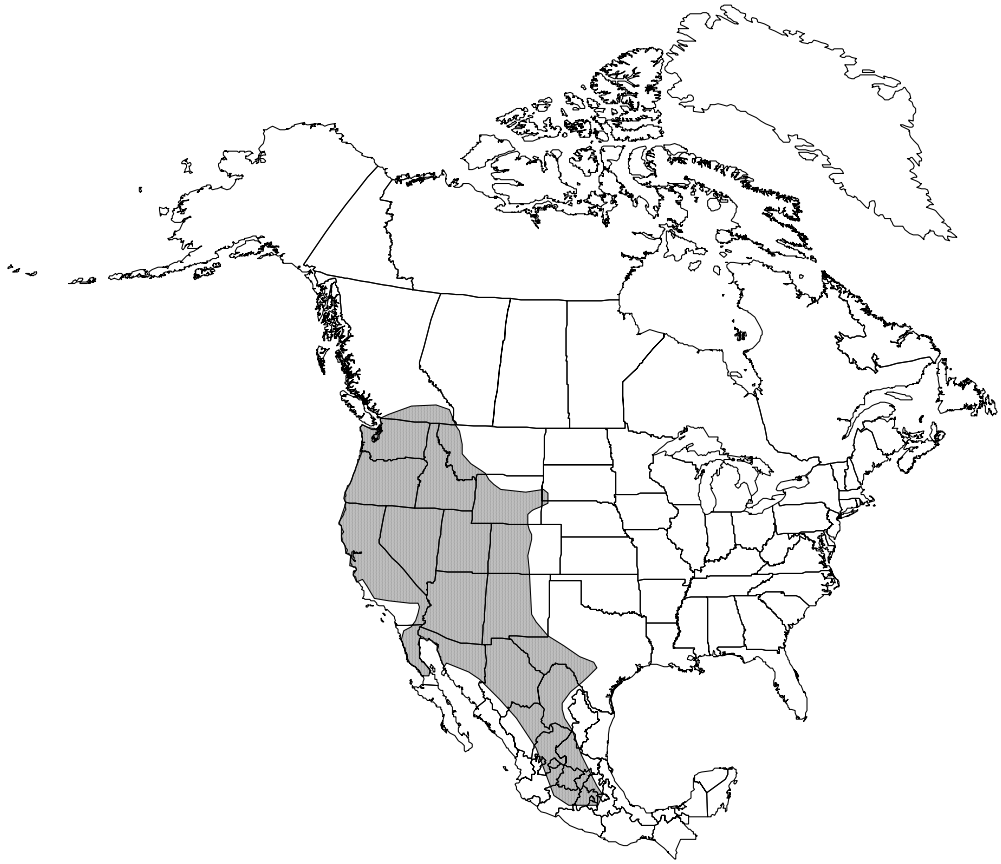

Figure 3. Black Hills distribution of southern maidenhair fern (ADCA), *Adiantum capillus-veneris*, and stream orchid (EPGI), *Epipactis gigantea*.

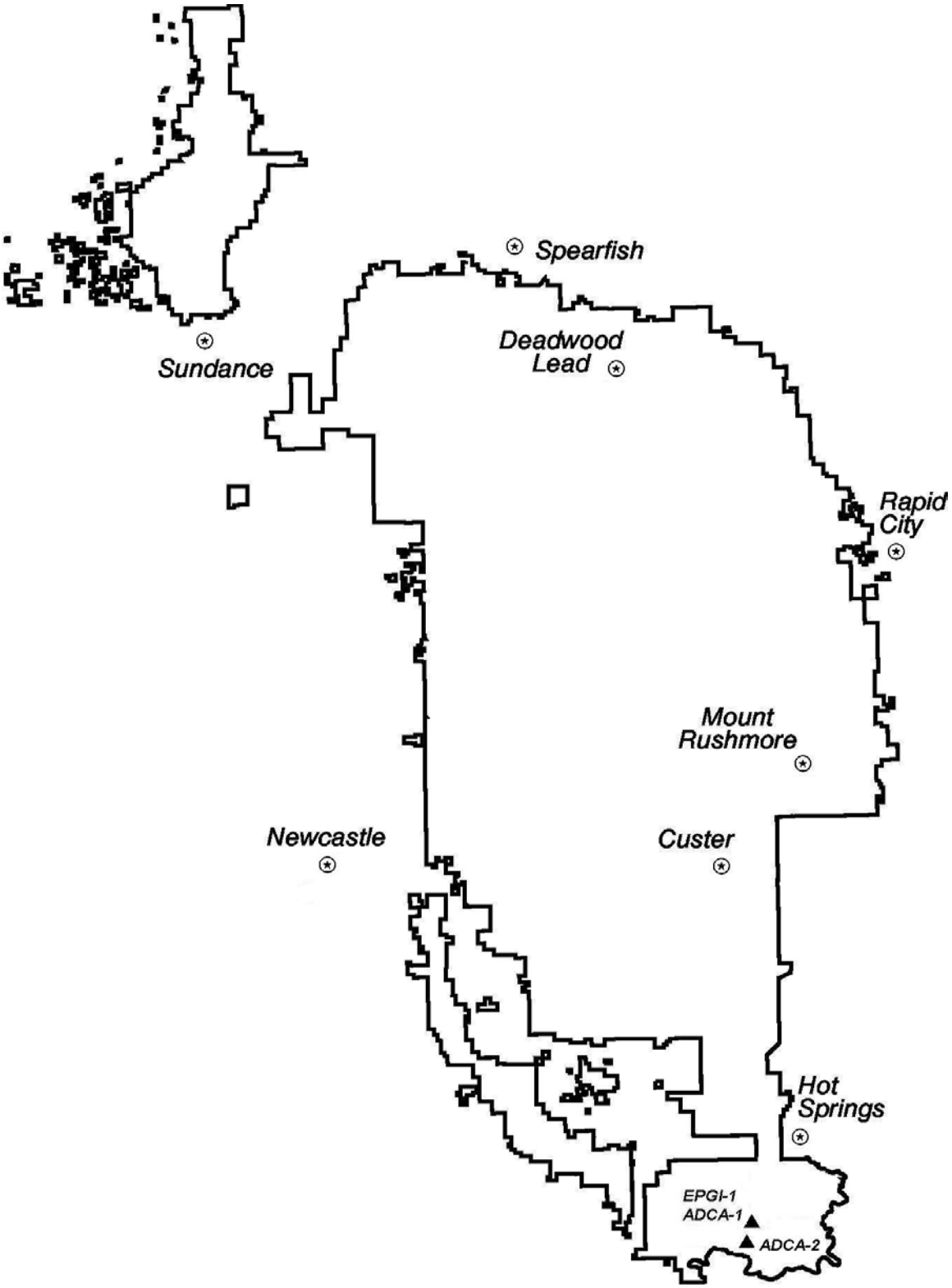

Figure 4. Illustration of southern maidenhair fern, *Adiantum capillus-veneris*.

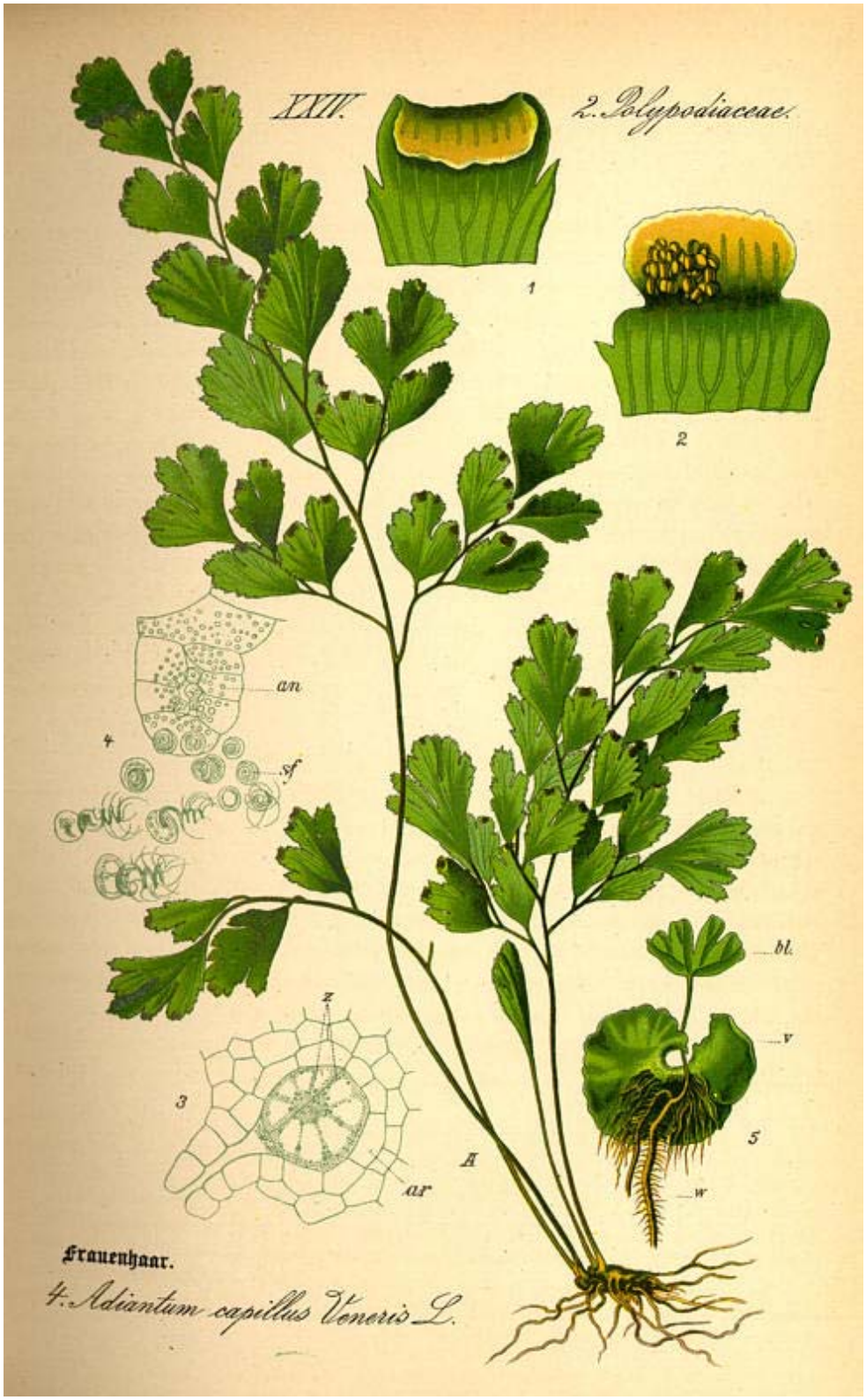

Figure 5. Illustration of stream orchid, *Epipactis gigantea* (Jeanne R. Janish In Hitchcock and others 1969).

Figure 6. Geology of Cascade Springs (Hayes 1999).

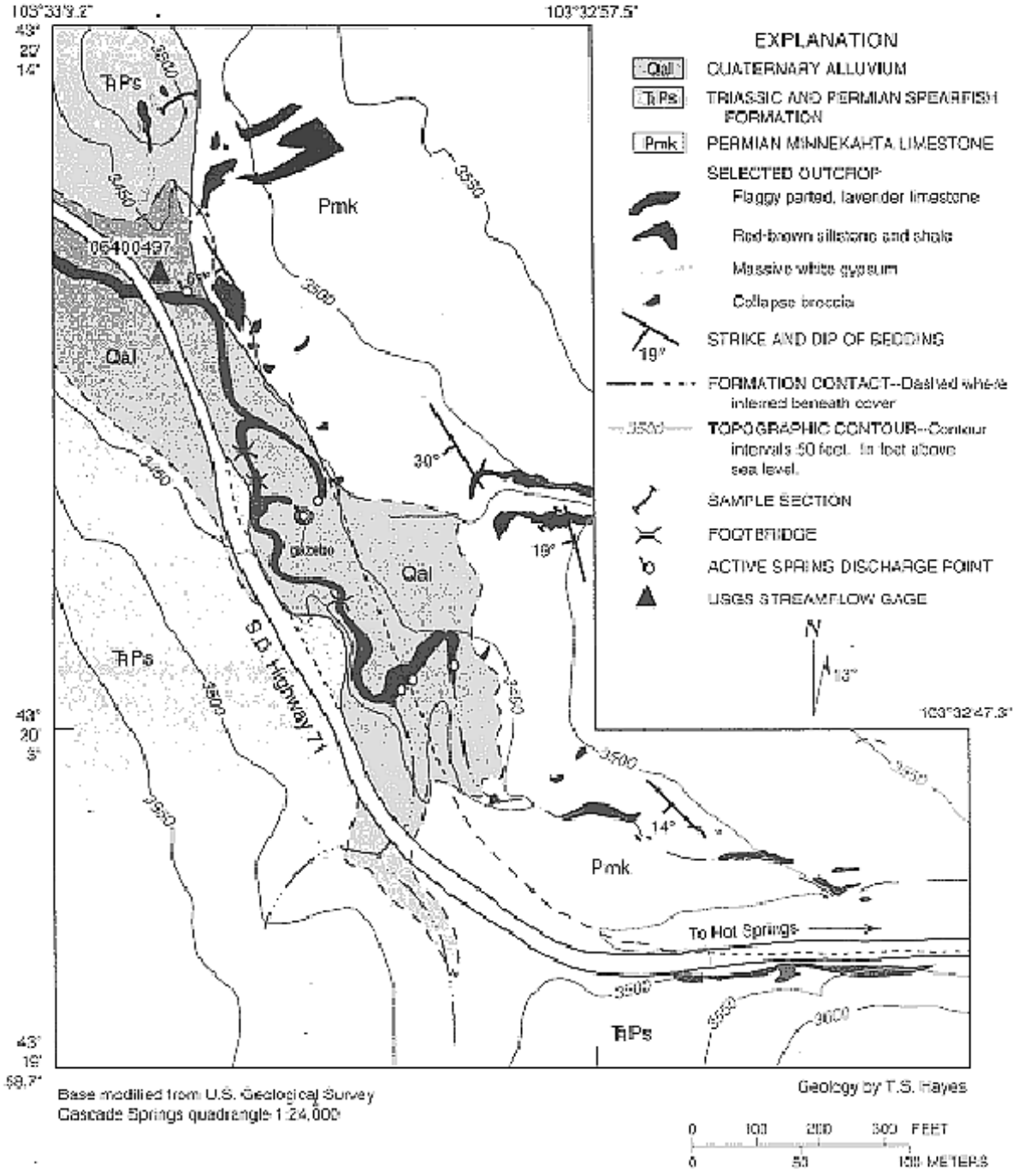

Figure 7. Southern maidenhair fern and stream orchid habitat at Cascade Springs.

Figure 8. Southern maidenhair fern habitat at Cascade Falls.

Figure 9. Southern maidenhair fern in limestone brick pool at Cascade Springs.

TABLES

Table 1. North American conservation status of *Adiantum capillus-veneris* (NatureServe 2001).

State/Province	Rank	Definition
North Carolina	S1	Critically imperiled due to extreme rarity.
South Dakota	S1	Critically imperiled due to extreme rarity.
British Columbia, Canada	S1	Critically imperiled due to extreme rarity.
Colorado	S2	Imperiled due to rarity.
Kentucky	S2	Imperiled due to rarity.
Mississippi	S2	Imperiled due to rarity.
Florida	S3S4	Vulnerable to apparently secure.
Georgia	S3S4	Vulnerable to apparently secure.
Alabama	SR	Reported.
Arizona	SR	Reported.
Arkansas	SR	Reported.
California	SR	Reported.
Hawaii	SR	Reported.
Oklahoma	SR	Reported.
Louisiana	SR	Reported.
Maryland	SR	Reported.
Missouri	SR	Reported.
Nevada	SR	Reported.
New Mexico	SR	Reported.
South Carolina	SR	Reported.
Tennessee	SR	Reported.
Texas	SR	Reported.
Utah	SR	Reported.
Virginia	SH	Historical report.

Table 2. North American conservation status of stream orchid *Epipactis gigantea* (NatureServe 2001).

State/Province	Rank	Comments
South Dakota	S1	Critically imperiled due to extreme rarity.
Wyoming	S1	Critically imperiled due to extreme rarity.
Oklahoma	S1S2	Imperiled to critically imperiled due to rarity.
Colorado	S2	Imperiled due to rarity.
Montana	S2	Imperiled due to rarity.
New Mexico	S2?	Imperiled due to rarity (rank uncertain).
British Columbia	S2S3	Imperiled due to rarity to vulnerable.
Utah	S2S3	Imperiled due to rarity to vulnerable.
Idaho	S3	Vulnerable.
Texas	S3	Vulnerable.
Washington	S3	Vulnerable.
Arizona	SR	Reported.
California	SR	Reported.
Nevada	SR	Reported.
Oregon	SR	Reported.
Nebraska	SU	Unrankable, no occurrences.
Mexico	?	Status not available.

Table 3. Southern maidenhair fern (*Adiantum capillus-veneris*) and stream orchid (*Epipactis gigantea*) species associates at Cascade Springs and Cascade Falls.

Scientific Name	**Common Name**	**Family**
Acer negundo	Boxelder	Aceraceae
Agropyron cristatum[d]	Crested wheatgrass	Poaceae
Asclepias incarnata	Swamp milkweed	Asclepiadaceae
Asclepias speciosa[c]	Showy milkweed	Asclepiadaceae
Asparagus officinalis[d]	Garden asparagus	Liliaceae
Carex spp.	Sedge species	Cyperaceae
Cirsium arvense[e]	Canada thistle	Asteraceae
Clematis ligusticifolia	Western white clematis	Ranunculaceae
Cornus sericea L. ssp. *sericea*	Redosier dogwood	Cornaceae
Dactylis glomerata[d]	Orchardgrass	Poaceae
Echinacea angustifolia	Purple coneflower	Asteraceae
Elaeagnus angustifolia[d]	Russian olive	Oleaceae
Eleocharis compressa	Flatstem spikerush	Cyperaceae
Eleocharis rostellata[a]	Beaked spikerush	Cyperaceae
Epilobium spp.	Willowherb species	Onagraceae
Fraxinus pennsylvanica	Green ash	Oleaceae
Hordeum jubatum[c]	Foxtail barley	Poaceae
Juncus spp.	Rush species	Juncaceae
Lycopus spp.	Waterhorehound species	Lamiaceae
Maianthemum stellatum	Starry false lily of the valley	Liliaceae
Mentha arvensis[c]	Wild mint	Lamiaceae
Monarda fistulosa[c]	Wild bergamot	Lamiaceae
Parthenocissus vitacea	Woodbine	Vitaceae
Phragmites australis	Common reed	Poaceae
Plantago major[c]	Common plantain	Plantaginaceae
Populus deltoides ssp. monilifera	Plains cottonwood	Salicaceae

Scientific Name	**Common Name**	**Family**
Potamogeton spp.	Pondweed species	Potamogetonaceae
Prunus virginiana	Chokecherry	Rosaceae
Ratibida columifera	Prairie coneflower	Asteraceae
Rhus aromatica	Skunkbrush	Anacardiaceae
Ribes sp.	Currant species	Grossulariaceae
Rorippa nasturtium-aquaticum	Watercress	Brassicaceae
Rosa woodsii	Wood's rose	Rosaceae
Rumex crispus[e]	Curly dock	Polygonaceae
Salix amygdaloides	Peachleaf willow	Salicaceae
Salix exigua	Sandbar willow	Salicaceae
Schoenoplectus pungens	Three-square bulrush	Cyperaceae
Schoenoplectus tabernaemontani	Softstem bullrush	Cyperaceae
Sisyrinchium montanum	Blue-eyed grass	Iridaceae
Solidago spp.[c?]	Goldenrod	Asteraceae
Sonchus arvensis[e]	Perennial sowthistle	Asteraceae
Sonchus asper[d]	Spiny sowthistle	Asteraceae
Spartina pectinata	Prairie cordgrass	Poaceae
Toxicodendron rydbergii	Western poison ivy	Anacardiaceae
Typha latifolia	Cattail	Typhaceae
Ulmus americana	American elm	Ulmaceae
Vitis riparia	River grape	Vitaceae

[a] S1 (Critically imperiled due to extreme rarity) in South Dakota
[b] S2 (Imperiled due to rarity) in South Dakota
[c] Native, invasive weed species
[d] Introduced weed species
[e] South Dakota noxious weed species