United States
Department of
Agriculture

Forest Service

Rocky
Mountain
Region

Black Hills
National
Forest

Custer,
South Dakota

April 2003

Conservation Assessment for Great-spurred Violet in the Black Hills National Forest, South Dakota and Wyoming

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Species Assessment
of
Great-spurred Violet
in the
Black Hills of South Dakota

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EXECUTIVE SUMMARY

Great-spurred violet (*Viola selkirkii* Pursh ex Goldie; Violaceae) is an early spring flowering herb that occurs in the boreal and Rocky Mountain regions of North America, and cool temperate regions of Eurasia, eastern China and Japan. In the Black Hills, the species is restricted to spruce-dominated forests in cold, shady ravines from 5,400 to 7,000 ft (1,645 to 2,135 m) elevation on soils derived from granitic parent material. There are currently 17 known occurrences of great-spurred violet in the Black Hills: ten on Black Hills National Forest land, including eight sites in the Black Elk Wilderness and two in the Norbeck Wildlife Management Area, and seven in Custer State Park administered by the State of South Dakota. Occurrences on Black Hills National Forest lands are not currently at risk from management activities; in the future, recreationists, wildlife use and weed invasion and treatment could potentially impact localized patches. Periodic flooding may reduce the size and extent of some patches, but create habitat for others. The occurrence of the species in the upper portions of several disjunct watersheds, as well as in a variety of topographic positions within each watershed offer opportunities for reestablishing patches impacted on lower landscape positions. Unfortunately, conservation management cannot prevent the impacts of persistent dry and warm periods that have the potential of drastically reducing both the distribution and occurrence levels of this boreal species.

Key words: great-spurred violet, *Viola selkirkii*, Black Hills, boreal forest, myrmecochory.

ACKNOWLEDGMENTS

Many individuals have contributed to our understanding of great-spurred violet's distribution in the Black Hills. Hollis Marriott, an independent Ecological Consultant, and Sylvia "Tass" Kelso, Colorado College, provided invaluable insights and expertise in their reviews of the manuscript. Hollis Marriott also collected a large part of the data used in this assessment. Cheryl Mayer, Reed Crook, Darcie Bacon and Terri Hildebrand, Black Hills National Forest, performed field surveys and collected data used in this assessment. Rudy King, Rocky Mountain Research Station, provided insights and suggestions on the design of the monitoring plan. Ken Marchand and Lorrie Martinez, Black Hills National Forest, produced the Black Hills distribution map, and Noah Barstatis, Rocky Mountain Research Station, produced the North American distribution map. In addition, numerous field technicians and biologists from The Nature Conservancy and South Dakota Natural Heritage Program, and Black Hills National Forest district biologists, ecologists and range conservationists performed data collection and field surveys that have been invaluable to this project.

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INTRODUCTION

Great-spurred violet, or Selkirk's violet (*Viola selkirkii* Pursh ex Goldie; Violaceae), is a circumboreal herbaceous species that is distributed across the boreal and Rocky Mountain regions of North America, and cold temperate regions of northern Europe, Eurasia, eastern China and Japan (Gleason and Cronquist 1991; Missouri Botanical Garden 2001; NatureServe 2001) (fig. 1). Throughout the species' range, it is locally abundant in specialized mircosites in coniferous and deciduous forests (Larson and Johnson 1999). In the Black Hills, great-spurred violet occurs from 5,400 to 7,000 ft (1,645 to 2,135 m) elevation on moist, mossy mats and benches, rocky slopes in cool, shaded ravines, plus cold air drainages and cliff bases (USDA Forest Service 2000; Marriott 2001a). There are currently 10 known occurrences of great-spurred violet in Black Hills National Forest administered lands (Larson 1993; Hildebrand 1996; Marriott 2000; Marriott 2001c) (fig. 2).

The objective of this assessment is to review information on the occurrence and distribution of great-spurred violet in the Black Hills National Forest and to synthesize information relevant to the management, monitoring and long-term persistence of the species. In general, the ecology of boreal understory herbaceous species is not well understood; and, because great-spurred violet is widely distributed, literature that specifically addresses its ecology and conservation is limited. Also, the species' disturbance ecology is confounded by its broad distribution across circumboreal forest types. We relied on information from throughout the species' range to develop this assessment. Species nomenclature follows the USDA NRCS Plants Database (2001).

CURRENT CONSERVATION SITUATION

The global conservation rank for great-spurred violet is demonstrably secure (G5), but it can be quite rare in parts of its range, especially at the periphery (NatureServe 2001). It has not been ranked (N?) in the United States and Canada and is not under federal protection by the U.S. Fish and Wildlife Service (NatureServe 2001). Great-spurred violet is currently on the USDA Forest Service Region 2 Sensitive Species List. The species is currently ranked as critically imperiled due to extreme rarity (S1) in Colorado, Connecticut, Montana, Pennsylvania, and South Dakota; imperiled due to rarity (S2) in Manitoba, Canada; imperiled to vulnerable (S2S3) in Saskatchewan; and vulnerable (S3) in Alaska and Alberta (NatureServe 2001) (table 1). The violet is widely distributed in boreal regions of North America, but information on the status of individual occurrences and habitats is extremely limited. The closest occurrences to known Black Hills locations are in the Colorado Rocky Mountains.

There are 17 currently known occurrences of great-spurred violet in the Black Hills: ten administered by Black Hills National Forest, including eight sites in the Black Elk Wilderness and two in the Norbeck Wildlife Preserve (Larson 1993; Hildebrand 1996; Marriott 2000); and seven in Custer State Park administered by the State of South Dakota (Marriott 2001c) (fig. 2). Until Marriott's 2000 survey, the two locations in the Norbeck Wildlife Preserve were the only known occurrences on Black Hills National Forest lands. Six additional locations were documented in the Black Elk Wilderness during Marriott's 2000 survey, and two more sites were discovered in 2001 (Marriott 2001b). In addition, there is an unconfirmed occurrence from the

Limestone Plateau at Deer Mountain, Lawrence County, South Dakota that was reported in 1975 by Judy Blank (South Dakota Natural Heritage Program). Additional sites may exist; however, a flower is required to correctly identify the species and its flowering period is limited to May and early June, depending upon elevation (Marriott 2001a). There are no known occurrences of the species on private lands in the Black Hills.

REVIEW OF TECHNICAL KNOWLEDGE

Species Taxonomy

The Violet Family (Violaceae) is nearly cosmopolitan in temperate and boreal regions of the world (Walters and Keil 1996), and at least 80 species of *Viola* occur in North America (Zomlefer 1994). Great-spurred violet, *Viola selkirkii* Pursh ex Goldie (Edinburgh Philosophical Journal 6: 324. 1822), is classified as Phylum Anthophyta, Class Dicotyledoneae, Order Violales, Family Violaceae (Violet Family) (Kartesz 1994; Missouri Botanical Garden 2001; NatureServe 2001). Great-spurred violet is a blue-flowered violet that is often taxonomically confused with the *Viola sororia* complex of non leafy-stemmed, or “stemless” blue violets (Great Plains Flora Association 1986; Ode personal communication), which bear their flowers on a leafless stem and are distinct from violets that produce both flowers and leaves on the same stem. Although common blue violet (*Viola sororia* Willd.) is known to freely hybridize with other stemless blue violets, great-spurred violet is not known to form any natural hybrids (Russell 1965).

Alternative taxonomic treatments of *Viola selkirkii* include: *Viola borealis* Weinm. Linnaea 10: 66. 1836; *Viola carnosula* W. Becker Beihefte zum Botanischen Centralblatt 36(2): 57-58. 1918; *Viola crassicornis* W. Becker & Hult.; *Viola imberbis* Ledeb. Flora Altaica 1: 257-258. 1829; *Viola* kamtschatica Ging. Linnaea 1: 406-407. 1826; *Viola umbrosa* Fries Novitiae Florae Suecicae (ed. 2) 271. 1828; *Viola selkirkii* var. *angustistipulata* W. Becker Beihefte zum Botanischen Centralblatt 34(2): 245. 1916; *Viola selkirkii* var. *brevicalcarata* W. Becker Beihefte zum Botanischen Centralblatt 34(2): 414. 1917; and *Viola selkirkii* var. *variegata* Nakai (Missouri Botanical Garden 2001).

Species Description

Great-spurred violet is a small, spring flowering, perennial herb with long slender rhizomes without stolons (Great Plains Flora Association 1986). Key identifying characteristics include: short flower petals ¼ to ½ inch (5 to 10 mm) long; small, scalloped, overlapping lobes on its heart-shaped leaves, leaf surfaces that are smooth below and have minute, spreading, glassy hairs above; and a floral spur that is relatively long, thick and bluntly rounded (Voss 1985; Great Plains Flora Association 1986; Gleason and Cronquist 1991; Fertig 1993; Spackman and others 1997; Colorado Natural Heritage Program 2001) (fig. 3). A detailed technical description of great-spurred violet is given in Appendix A.

Great-spurred violet is often confused with common blue violet (*V. sororia*), which is adapted to a wide variety of habitats from the eastern U.S. to eastern South Dakota and the Colorado Rockies (*Great* Plains Flora Association 1986; Kelso, personal communication 2001; Ode, personal communication). A flower is required to correctly identify the species, and collection and careful identification are required to verify occurrences. Distinguishing characteristics for great-spurred violet and two very similar species, common blue violet (*Viola sororia*) and hookedspur violet (*V. adunca*), are given in Appendix A.

Species Significance

Great-spurred violet occupies rare boreal habitats at higher elevations in the Black Hills and in central and southern portions of the Rocky Mountains. The species' disjunct occurrence in the Black Hills may be evolutionarily significant and may contribute to the overall genetic diversity of the species (Brown and Briggs 1991). Because Black Hills occurrences of the violet are geographically isolated, they may possess unique genetic material, be taxonomically distinct from occurrences elsewhere, or play a role in determining the future biogeography of the species. Boreal disjuncts are also often important in the study of phytogeography and paleoecology. The species is likely a food source for insect pollinators and seed-dispersing ant species in habitats where few flowering plant species occur. In addition, violets may be butterfly-pollinated and great-spurred violet could be an important food source for rare butterflies in its subalpine habitats (Kelso, personal communication 2002).

No commercial uses of the violet were identified in the literature; however, perfume is produced from hybrids of sweet violet (*V. odorata*), and the garden pansy (*Viola x wittrockiana*) is a common ornamental (Zomlefer 1994; Walters and Keil 1996). No specific uses of great-spurred violet were found for any Native American peoples, nor were traditional uses of any *Viola* species identified for the Lakota peoples of the Black Hills region (Moerman 1998).

Life History

Members of the genus *Viola* possess highly specialized flowers for insect pollination (Zomlefer 1994) and their seeds are ant-dispersed (Gates 1943; Handel 1976). *Viola* flowers have a large, spur-like petal that contains nectar and lateral petals with nectar guides (coloration that directs insect pollinators toward the entrance to the spur) (Zomlefer 1994; Walters and Keil 1996). The anthers and stigma are positioned to release and receive pollen, respectively, when an insect enters the flower (Zomlefer 1994). The specific pollinators of great-spurred violet, here or elsewhere, have not been identified. Violet flowers are formed to conceal the reproductive structures and require specialized pollinators for out-crossing to occur (Beattie 1971). Pollinator data from several species of *Viola* in England demonstrated that a relatively wide variety of pollinators, including bumble bees (*Bombus* spp.), honey bees (*Apis mellifera*), solitary bees (*Andrena* spp.), and several types of flies may transfer pollen between violet flowers (Beattie 1971). Butterflies are also suspected to be specialist pollinators of *Viola* species (Kelso, personal communication 2002).

Great-spurred violet flowers from April or May to June or July across its range (Britton and Brown 1970; Gleason and Cronquist 1991; Spackman and others 1997), and from mid-May to early June in the Black Hills (Marriott 2001a). *Viola* species also produce small, self-pollinated flowers that lack petals and do not open (Madge 1929; Zomlefer 1994; Walters and Keil 1996), but that may produce a large quantity of seed (Great Plains Flora Association 1986). Self-pollinating flowers are produced at the same time as, or later in the growing season than, the fully developed, cross-pollinated flowers (Walters and Keil 1996) (fig. 3). The production of seeds via self-fertilized flowers is suspected to be a mechanism for population maintenance and for expansion into favorable habitats (Williams 1975; Culver and Beattie 1980). Great-spurred violet may also reproduce vegetatively via long, slender rhizomes. The violet is not known to hybridize with other *Viola* species (Voss 1985).

Violet seeds are dispersed by three potential mechanisms: by the explosive ejection of the seeds from the mature capsule; by the removal of the seeds from the mature capsule by ants (myrmecochory); or by the explosive ejection of seeds away from the parent plant followed by ant dispersal to another location (diplochory) (Gates 1942; Beattie and Lyons 1975; Handel 1976; Culver and Beattie 1980). In addition, it is possible that seeds are dispersed via other mechanisms, such as in water, but this has not been verified.

Great-spurred violet's floral characteristics suggest that it ejects its seeds away from the plant where they are removed by ants (Ohkawara and Higashi 1994). Although violet seeds are generally dispersed greater distances by explosive ejection than by ant movements, the ant-seed interaction may benefit Viola species by: reducing seed predation (Culver and Beattie 1978; Heithaus 1981); reducing interspecific competition (Handel 1976); scarifying seeds through ant removal of the lipid-rich crest (elaiosome) (Culver and Beattie 1978; Heithaus 1981); and/or relocating seeds to microsites favorable for germination and plant establishment (Beattie and Lyons 1975; Culver and Beattie 1978, 1980, 1983). Another potential benefit is that seeds carried into ant nests may be protected from fire (Berg 1975; Hanzawa and others 1988). A study of *Viola* in England and research on great-spurred violet in northern Japan found high predation on seeds that were not transported away from the parent plant (Culver and Beattie 1978, 1980; Ohkawara and Higashi 1994). Ground beetles (Family Carabidae), in particular, were significant predators of great-spurred violet seeds in Japan (Ohkawara and Higashi 1994), although there is some disagreement whether the seeds are actually consumed or are relocated unharmed (Beattie and Culver 1982). In North America, violet seed predators include beetles, butterfly larvae, small mammals, and birds (Olmsted and Curtis 1947; Martin and others 1951).

The reproductive value of the violet seed's lipid crest in attracting ants for seed dispersal is demonstrated by the limits its weight places on the distance a seed can be dispersed by ejective force (Culver and Beattie 1978). For this reason, crest size may be an indicator of the primary dispersal mechanism, where species that are dependent upon seed ejection followed by ant dispersal possess reduced elaiosomes compared to seeds dispersed by ants alone (Culver and Beattie 1978). In Japan, great-spurred violet is recognized as a diplochorous species with exploding capsules and a relatively large elaiosome (0.02 ± 0.12 mg or 3.3 percent of seed weight); ant dispersal is believed to be an important component of the species' life history (Ohkawara and Higashi 1994). Ant nests apparently provide highly favorable microhabitat conditions for seed germination and seedling emergence: low density soil, greater moisture and nutrient availability, and escape from predation and interspecific competition (Lyford 1963; Beattie and Lyons 1975; Culver and Beattie 1980). Although ants may negatively affect seedling emergence by concentrating seeds in their nests, this effect occurs in most natural populations of seed dispersed plants, and does not appear to significantly impact violet populations (Culver and Beattie 1980). The ant species that disperse great-spurred violet's seeds are not known, but most North American *Viola* species depend upon medium-sized ground foraging ant species that vary across the violet's range (Culver 1974; Culver and Beattie 1980). The self-pollinating flowers generally produce seeds later in the season with smaller elaiosomes and are rarely taken by ants, which prefer other food sources as the growing season progresses (Culver and Beattie 1980).

Great-spurred violet is also capable of expanding vegetatively through rhizomatous growth to form clonal ramets. It is possible that ramets or rhizome fragments break off from the parent plant due to natural disturbances, such as herbivory or flooding, and become established as separate, but genetically identical individuals. This may be an effective means of dispersal and could indicate that the species is easy to cultivate or introduce to potential habitats.

No references to associations between great-spurred violet and mycorrhizal fungi were found in the literature. Although the species could be mycorrhizal, the violet family (Violaceae) is not generally considered a mycorrhizal plant family (Newman and Reddell 1987). It may be that the ant mutualism reduces the need for fungus-assisted nutrient acquisition by providing increased nutrients early in the plant's development.

Distribution And Local Abundance

Great-spurred violet is a circumboreal species that occupies the boreal regions of North America south to Pennsylvania, Minnesota, and British Columbia, with disjunct occurrences in the Black Hills of South Dakota and the Rocky Mountains of Colorado and New Mexico (Gleason and Cronquist 1991; NatureServe 2001) (fig. 1). The closest *confirmed* occurrences (see Species Description, above) of great-spurred violet to the Black Hills are an historical record (presumed extirpated) of an occurrence approximately 300 mi (480 km) south in Colorado at 9,100 ft (2,775 m) in cold, moist woods in Larimer County (Spackman and others 1997; Colorado Natural Heritage Program 2001), and one occurrence approximately 650 mi (1,050 km) to the northwest at 3,300 ft (1,006 m) elevation on the Kootenai National Forest in Lincoln County, Montana (Montana Natural Heritage Program 2001). The closest occurrence in Colorado may have been eradicated (Weber and Wittman 2001) since it has not been relocated, and two occurrences in Douglas and El Paso Counties, Colorado are suspected to be misidentifications that are species in the *Viola sororia* complex (Kelso, personal communication 2001). There are confirmed locations within Rocky Mountains National Park and south of Denver in the Rampart Range (Kelso, personal communication 2002). Additional occurrences may occur in the Rocky Mountains of northern Colorado that have not been verified (Kelso, personal communication 2001). One or more occurrences are reported in Minnesota, but location and habitat information are not currently available.

In the Black Hills, great-spurred violet is limited to high elevation areas of the granitic Central Core from 5,400 to 7,000 ft (1,645 to 2,135 m) elevation (USDA Forest Service 2000; Marriott 2001a) (fig. 2). There are 10 known occurrences of great-spurred violet in Black Hills National Forest: eight in the Black Elk Wilderness, and two in the Norbeck Wildlife Preserve (Larson 1993; Hildebrand 1996; Marriott 2000). There is also an unverified report from the Deer Mountain area, Lawrence County, South Dakota in 1975 (South Dakota Natural Heritage Program). During the 2000 survey effort, five new occurrences were located in addition to the two known occurrences: four in the Black Elk Wilderness and an additional patch adjacent to a known occurrence in the Norbeck Wildlife Preserve (Hildebrand 1996). In 2001, three more occurrences were found in the Black Elk Wilderness (Marriott 2001b). In addition, there are seven great-spurred violet occurrences in Custer State Park administered by the State of South Dakota: occurrences located during the 2000 survey effort (Marriott 2000), and five additional sites located in 2001 (Marriott 2001c). Most of these occurrences consist of two to several patches scattered in sheltered microsites (Hildebrand 1996; Marriott 2001a).

All known occurrences are locally dense: the eight occurrences in the Black Elk Wilderness range from 11 to >1000 ramets; the two occurrences in the Norbeck Wildlife Preserve are estimated at 250 and 500 ramets each (table 2). From 20 to 90 percent of plants were in flower or setting fruit at the time of survey in June of 2000 and 2001 (Marriott 2001a; Marriott 2001b).

The seven occurrences in Custer State Park range from 11 to >500 plants; two of these are estimated at >1,000 ramets each (Larson 1993; Hildebrand 1996; Marriott 2001c). Rhizomatous clonal ramets were counted as individuals because distinguishing individuals is destructive to both the habitat and the plants. However, the number of clonal ramets does not provide an accurate estimate of the size of the occurrence or amount of genetic diversity within a given occurrence.

Habitat Relationship

Great-spurred violet occupies moist, shaded ravines and cold boreal and hardwood forest habitats throughout its North American distribution (Britton and Brown 1970; Gleason and Cronquist 1991). Violets in general, including great-spurred violet, are frequently found growing on rotting logs and stumps (Russell 1965; Handel 1976). In the Black Hills, great-spurred violet is restricted to remnant boreal habitats at higher elevations and on north-facing slopes where temperature and precipitation are similar to boreal habitat conditions to the north (Peet 1988) (fig. 2). Great-spurred violet's known distribution in the Black Hills is restricted to high elevation, cold, shaded, spruce-dominated forest habitats in moist, mossy or grassy, sheltered microsites and similar microhabitats on streamside benches, ledges in rock walls, and places where grass or litter has accumulated next to cliffs or canyon walls created by the exposed granitic spires (Larson 1993; Hildebrand 1996; Marriott 2001a). Great-spurred violet occurs in the Black Hills' high elevation Central Core in white spruce forest and in open vegetated pockets, both of which are shaded by huge granite outcrops (Marriott 2000, 2001a,b,c). Several sites are in drainage bottoms with dense spruce cover, but granite outcrops are more common habitat and often there are no spruce trees present (Marriott 2000, 2001a,b,c). The violet grows within rock outcrop areas where soil and other vegetation are developed rather than in true rock fractures (Marriott 2000, 2001a,b,c) (note moss mat in cover photograph). The species is often associated with runoff from rock formations (Marriott 2001a).

Its boreal white spruce forest habitats in the Black Hills are disjunct from spruce forests along the Canadian border and elsewhere in the Rocky Mountains (Hoffman and Alexander 1987). At high elevations in the Central Core, the species is locally abundant in patchily distributed open and spruce-dominated microhabitats with granitic soils in association with moist mossy benches or rocky slopes in cool, shady ravines from 5,400 to 7,000 ft (1,645 to 2,135 m) elevation (Larson 1993; Hildebrand 1996; Marriott 2000) (fig. 4). The violet most commonly occurs in microsites in the bottoms of narrow north-trending gullies and bases of high northerly-facing rock walls, but occurs on a wider range of aspects at higher elevations (Marriott 2000, 2001a,b,c). Although there are spruce-dominated habitats on the limestone plateau within the elevation range of the species, the violet does not occur there and may be excluded due to the lack of steep, rocky, narrow, cold air drainages in that portion of the Black Hills.

Throughout its range, great-spurred violet occurs in a wide variety of habitats. In Colorado and Minnesota, the species is found in moist, coniferous woods (Morley 1969; Spackman and others 1997). In Michigan, great-spurred violet occurs on rotting logs and mossy crevices associated with limestone-derived soils in deciduous forest and is less frequent in coniferous forest (so much so that the species is reported as calcium-loving) (Voss 1985). In Wisconsin, the species is associated with beech (*Fagus grandifolia*) forest habitats that vary from a rich understory flora in the east to a species poor understory in the north (Wisconsin State Herbarium 2001). In northwestern Montana, great-spurred violet occurs in association with western red-cedar/wild sarsaparilla (*Thuja plicata/Aralia nudicaulis*) forest co-dominated by paper birch (*Betula papyrifera*) (Montana Natural Heritage Program 2001; NatureServe 2001). And in Alberta, Canada, great-spurred violet occupies seepages, streamside habitats, marshy areas, white spruce-birch forest, black spruce *(Picea mariana)* forest, aspen *(Populus tremuloides)* forest and other deciduous and mixed wood forest habitats (Gould, personal communication). This variety of habitats suggests that the species' limited distribution in the Black Hills is probably a function of moisture availability or climate, and not granitic soils or specific species associations at higher elevations.

The relationship between great-spurred violet and soil has not been studied directly, and it could be a key factor in its distribution both here and elsewhere. It is also possible that the presence or absence of key species interactions, such as ant seed dispersers, predators or pathogens, or mycorrhizal associates, could also play a role in the species' apparent habitat preferences. The violet does appear to be closely associated with exposed rock, cliffs, canyons and other granitic rock formations where it occurs in the Central Core of the Black Hills. Data collected at these sites suggest that canyon walls and cliffs may shelter the sites from drying winds and other microclimatic influences (Hildebrand 1996; Marriott 2001a) (fig. 4). A summary of climatic conditions at the closest reporting stations to great-spurred violet habitats in the Black Hills is given in Appendix B.

The violet's patchy distribution at high elevations in the Black Hills may be, in part, due to shade conditions created by rock formations and north-facing aspects that result in retention of snow late in the spring and significantly greater soil moisture throughout the year. Sites that are topographically shaded or sheltered retain snow pack much later in the spring and after early snows in late autumn. This effect may be compounded at higher elevations, where conditions are cooler, but solar radiation is more intense (Barbour and Billings 1988). Topographic sheltering may create unusual, high moisture microhabitats that do not extend more that a few feet away from the snow-covered site, and is thought to be a significant factor in the distribution of rare habitats in the Northern Black Hills (Zacharkevics and Silvey, unpublished data). This effect appears to occur in areas of the semi-arid Black Hills that receive greater precipitation, particularly snowfall, and that possess fairly complex topography; which includes the Northern Black Hills and great-spurred violet's habitats in the Central Core.

Based upon current species associate lists (Table 3) and ecological information, great-spurred violet's habitats in the Black Hills may be best described as shaded microhabitats associated with vegetated granitic rock outcrops or white spruce (*Picea glauca*) forest with a highly variable understory. In the Norbeck Wildlife Preserve, great-spurred violet occurs with muskroot (*Adoxa moschatellina*), peduncled sedge (*Carex pedunculata*), and spinulose woodfern (*Dryopteris carthusiana*) in spruce forest at the base of a granite wall (Larson 1993). The species also occurs with muskroot in Alberta, Canada (Gould, personal communication). Great-spurred violet occurs with numerous other violet species in the Black Hills, particularly hookedspur violet (*Viola adunca*) (Marriott 2000, 2001a,b,c), small white violet (*V. mackloseyi)* and white violet (*V. renifolia)*. A total of seven violet species occur at "Violet Valley" in the Norbeck Wildlife Preserve (Hildebrand 1996; Marriott 2001a). In Custer State Park, the violet occurs in forested habitats dominated by white spruce, paper birch and ponderosa pine with dense moss cover, muskroot, and Sprengell's sedge (*Carex sprengellii*) (Marriott 2001c).

Disturbance Ecology

Great-spurred violet occupies sheltered microhabitats within remnant boreal forests at high elevations in the Black Hills where historic disturbances have most likely been from infrequent, high intensity fire, localized, infrequent flooding, and wildlife use. Landscape-scale disturbances, particularly fire, have strongly influenced the distribution of spruce habitats in the Black Hills, but it is unknown to what degree this would effect the distribution of great-spurred violet's isolated and patchy microhabitats. Although the species occupies cool, rocky drainages that are less susceptible to fire than surrounding habitats, large rock outcrops and some spruce tree cover provide shade and maintain the cool, moist microclimate. In the higher elevations of the Black Hills, historic vegetation management and fire suppression activities have likely contributed to the expansion of spruce habitats in the last century (Hoffman and Alexander 1987; Parrish and others 1996). Today, white spruce stands are denser and more widespread than what historically occurred in the Black Hills, and are highly susceptible to fire (Parrish and others 1996), but this effect may be limited in high elevation areas.

At the local scale, topographic variability, climate and moisture are important factors in the species' patchy distribution in specific microsites. At known sites on Black Hill National Forest land, some patches of great-spurred violet occur along stream channels that may occasionally be flooded. Most of the known great-spurred violet occurrences are in first or second order watersheds, and are therefore unlikely to be subjected to long-term severe flooding because they are above flood zones or are well above the riparian corridor in developed soils and vegetation associated with rock outcrops. These protected patches above the riparian corridor may be important sources for seeds to replenish sites on lower landscape positions in the event of a flood or other disturbance. There is also the potential that periodic floods serve to disperse seeds downstream; however, whether seeds transported in this manner would remain viable is unknown. Ant seed dispersal influences the species' local distributions, density and reproductive success. As an indirect result, ants may serve as an intermediary in the plant's response to both large- and small-scale disturbances such as fire, canopy gaps, erosion, or soil compaction (Pudlo and others 1980).

Key Risk Factors

Based on surveys in 2000 and 2001, few risk factors have been documented at known occurrences of great-spurred violet on the Black Hills National Forest. There is some evidence of wildlife use at two sites, nearby recreation trails at two others, evidence of past flooding near some patches in riparian corridors, and there is concern that noxious weeds or other exotic plants might invade some sites in the future. The fact that known occurrences are geographically separated and some occupy sheltered rock outcrops increases the odds of maintaining the species on Forest Service land. Perhaps the greatest risk to great-spurred violet occurrences in the Black Hills is the potential for long periods of drought and climatic warming that could have a devastating impact on the species by eliminating its habitat. Trampling by wildlife or recreationists, plus invasion of habitat by noxious weeds or other invasive plants are also risks.

High concentrations of wildlife species, particularly elk (*Cervus elaphus*) and mountain goats (*Oreamnos americanus*), have the potential to damage violets directly by trampling, and indirectly through effects on its habitat. Evidence of past wildlife or livestock use has been noted at two of the 10 occurrences in the Black Hills National Forest. Although there is the potential for wildlife trampling or browsing at all sites, the odds of an occurrence being eliminated is judged to be low.

Evidence of dispersed recreation has been documented at two sites near Harney Peak (Marriott 2001a), and there is the potential for recreational use at the six other great-spurred violet occurrences in the Black Elk Wilderness. Although most of the known sites are sufficiently isolated to limit recreational activities and few sites have any reported on-site disturbance to date, activities associated with rock climbing and hiking are an on-going risk that is expected to increase due to increasing use of the Black Hills' Central Core by recreationists (USDA Forest Service 2000; Marriott 2001a).

Trails or roads management, recreation and other management activities, including timber harvesting, mining, fuels reduction or prescribed fire are unlikely to impact currently known occurrences of great-spurred violet in the Black Hills National Forest. In the event that management is proposed, National Environmental Policy Act of 1969 [42 U.S.C. 4321 (note)] (NEPA) analyses include assessments of known locations of designated sensitive species such as great-spurred violet. Known sites are avoided to the extent possible.

The historic and future effects of wildfire, or fire and fuels reduction on the violet are not known, but the species appears to benefit from the build up of woody debris (USDA Forest Service 2000). The increased density of trees that results from fire suppression could affect the species by reducing groundwater flow into its habitats, which could result in fewer flood events and/or reduce the quantity and quality of its habitats. The risk of fire or flooding at known occurrences is variable, depending upon the characteristics of the site and the surrounding landscape. Fire is a greater risk to those sites with dense conifer stands nearby, but nearly all occurrences are in treeless habitats that are sheltered by large rock formations that may exclude fire (Marriott 2000, 2001a,b,c).

Flooding appears to be a risk in at least a portion of the known sites, but is likely a greater risk to occurrences that occupy narrow rock drainages. Most of the known occurrences of great-spurred violet occupy first or second order watersheds, and are therefore unlikely to be subjected to long-term severe flooding because they are above flood zones. Also, most of the known occurrences of great-spurred violet are characterized by having some patches well above the riparian corridor in developed soils and vegetation associated with rock outcrops that may offer some protection. Where flooding does occur, the species may be able to re-colonize low areas from patches on higher ground. Although invasion by exotic species is not an immediate risk to any of the known locations, competition from invasive exotic plants and impacts from weed treatments are a potential risk to the species.

There is no expectation that all occurrence sites would be lost at any one time for the following reasons: intense trampling by humans, wildlife, or livestock would be limited to one or a few sites; fire wouldn't carry in the species' habitats due to rock formations; mountain goats or elk use does not occur at every site; rock climbing access routes and staging areas do not occur at every site; and potential weed invasion is not likely at many of the sites (USDA Forest Service 2001). The great-spurred violet occurrence at "Violet Valley" in the Norbeck Wildlife Preserve is considered to have the greatest combined potential risk from elk use, fire, flooding and weed invasion; plans are to monitor the site annually (see below). Climatic warming and drought may pose the greatest potential risk to all known occurrences in Black Hills National Forest.

Great-spurred violet occurrences in Custer State Park (Marriott 2001c) face potential risks from dispersed recreation, invasive weeds, fire and flooding, and are equally vulnerable to drought and climatic warming. Timber is harvested in the park, but it is not known if cutting or associated activities will occur in close proximity to great-spurred violet habitat, and if so, whether these activities will affect the species. Trampling appears to be a greater risk in Custer State Park than in National Forest lands, especially since rock climbing access routes or staging areas are in or adjacent to three of seven occurrences with at least a portion of each of these occurrences potentially at risk to heavy use (Marriott 2001c). Trampling from dispersed recreation at pullouts along the Needles Highway is also a significant risk (Marriott 2001c). Mountain goat browsing occurs at one, possibly two, of the other four occurrences in Custer State Park (Marriott 2001c). Given that great-spurred violet is most often found in rocky, protected sites, it is unlikely that wildfire poses a serious risk to the persistence of this species in the Black Hills. Moreover, it is unlikely that all known sites would be affected by a catastrophic event, such as a wildfire, since the occurrences are dispersed among several watersheds.

CONSERVATION PRACTICES

Management Practices

The 10 known occurrences of great-spurred violet in the Black Hills National Forest all occur within the Black Elk Wilderness or the Norbeck Wildlife Preserve. There are no known occurrences of the species on private lands in the Black Hills. Trails management, prescribed burning, and/or recreation management activities will likely be conducted in the Black Elk Wilderness and Norbeck Wildlife Preserve in the future (USDA Forest Service 2000, 2001). Road management is also likely to occur along Scenic Byways and for vegetation treatment in the Black Hills National Forest, but the highways are not near any currently known locations of the violet. The potential impact of these activities on great-spurred violet habitat is unknown; however, Forest projects are typically designed and implemented to avoid locations where sensitive plant species occur.

The long-term effects of disturbance from dispersed recreation are potentially negative if the use intensifies at locations where the plants are found, and current efforts are being made to document and quantify them. If impacts are noted, recommendations may be made to restrict access or identify ways to reduce impacts to great-spurred violet, and other sensitive species occurrences and habitats (Marriott 2001a). The area is open to hiking; however no signs of recreational use have been observed during monitoring in the Black Hills National Forest.

Eight of the 10 known occurrences on Black Hills National Forest are in the Black Elk Wilderness where timber harvest does not occur (USDA Forest Service 2000). In the Norbeck Wildlife Preserve, the violet occurrence that is currently being monitored is in the vicinity of vegetation treatment sites, but not included in them. Current vegetation management includes timber removal to stimulate growth of forage and browse for wildlife, and could result in increased moisture to violet sites, but these activities are currently restricted from known violet locations.

Livestock use does not occur at the Black Elk Wilderness violet sites (USDA Forest Service 2000, 2001). Ninety percent of the “Violet Valley” occurrence in the Norbeck Wildlife Preserve had been fenced to exclude livestock (the existing fence was reconstructed on May 22, 2000). Due to recent events involving changes to the grazing permit for the allotment where “Violet Valley” is located, there are no plans to reissue the permit.

Conservation Measures

Conserving currently known occurrences will likely enhance the odds of great-spurred violet persisting in the Black Hills. The fact that occurrences on National Forest land are dispersed among four separate watersheds and that an additional seven occurrences have been documented in Custer State Park lessens the likelihood of all occurrences being impacted by a single catastrophe, such as a large-scale wildfire or disease outbreak. In addition, the remoteness of most of the occurrences in the Black Hills National Forest and the current low level of identified risks at these sites is encouraging. If recreation increases, it would likely be the biggest risk at most sites. However, to date, recreational impacts at Black Hills National Forest sites do not exist, or are quite limited. The discovery of additional occurrences is also possible, given that potential habitat apparently exists, and surveys by known experts have proven successful in recent years. In addition, The Nature Conservancy (TNC) has identified the High Granite Region of the Black Hills Central Core and all currently verified occurrences of great-spurred violet as targets for conservation in its ecoregional conservation plan for the Black Hills (Hall and others 2002. Finally, all occurrences on National Forest lands are under the Management Area direction in the Black Elk Wilderness and Norbeck Wildlife Preserve.

Great-spurred violet's dependence on cool, moist boreal habitats makes it potentially vulnerable to large-scale climate changes and it is not known if the species can be sustained through catastrophic drought or prolonged climatic change. As a conservative measure, collection and storage of great-spurred violet seed in a certified repository could be considered.

Survey, Inventory And Monitoring Approach

The proposed monitoring strategy for this species on Forest Service land currently includes: 1) surveys for additional occurrences, 2) inventory of new and currently known occurrences on a periodic basis, and 3) annual monitoring of one of the three largest occurrences on Forest Service land. Potential survey sites include watersheds where the species is known to occur, as well as other high elevation watersheds with deep canyons and boreal vegetation. Surveys should be conducted during the violet's flowering period approximately from May 10 to May 30, when the species can be identified. Plans are to use the current inventory protocol when new occurrences are located.

The current plan is to re-inventory known Forest occurrences at least every five years, after which time an effort will be made to sample all known sites in the same year. In addition to periodic inventories, plans are to obtain baseline data on known Black Hills National Forest occurrences during and following a drought cycle (or at least two consecutive years of below average precipitation). Occurrence numbers collected in 2000 and 2001 may be a reflection of a series of relatively wet years since 1996 (NOAA 1996-2001). Documenting relative occurrence levels and extent of great-spurred violet during dry years will hopefully provide insights into the role that precipitation plays in the distribution and abundance of this species. Finally, the current plan includes monitoring great-spurred violet sites that are affected by a fire or significant flood event.

The current protocol also includes annual monitoring of "Violet Valley" in Norbeck Wildlife Preserve when the violet is in flower from mid- to late-May. The Violet Valley site was selected because it is one of the three largest occurrences of great-spurred violet on Black Hills National Forest lands, it is relatively accessible, and it has the largest combination of potential risks from hikers, elk, fire, and exotic plant invasion. Further, because it is one of the lower elevation sites, it is likely that declines associated with drought conditions would occur here before they occur at higher elevations. The current protocol is to use the Violet Valley location as an indicator of whether other sites need to be monitored. The current trigger for additional monitoring would be the absence of one or more of the four largest patches (there are eight distinct patches at the Violet Valley site). If this occurs, an effort will be made to document the reason (that is, drought, elk, weeds) and select two additional occurrences to monitor based on the cause of the disruption and current information on known risks to other sites. Additional occurrence and site information will be used to reassess the adequacy of the monitoring protocol.

CONCLUSIONS AND INFORMATION NEEDS

Great-spurred violet occurrences in the Black Hills are relatively secure from most potential risks, with the potential exception of an extreme climatic change. There are 10 currently known occurrences on National Forest lands, one occurrence with over 3,000 ramets, one with over 1,000 ramets, one with over 500 ramets, and four with over 100 ramets each. Seven additional occurrences occur on lands managed by Custer State Park, six estimated at over 100 ramets including one occurrence over 500 and two occurrences over 1000 violet ramets. The species is considered secure at this time, however there are potential risks due to the low number of currently known occurrences. Given that the occurrences in Black Hills National Forest are scattered in four distinct watersheds and the Custer State Park occurrences are located in two additional watersheds, it is unlikely that a random stochastic event (such as flooding or disease) would affect them all. Further, many occurrences include patches on relatively protected locations that could serve as potential seed source for re-colonization should other portions of the occurrence perish as the result of a disturbance event. Because potential habitats are believed to occur and are relatively remote, there may be additional occurrences that have not yet been documented.

The 10 known occurrences on Black Hills National Forest administered lands are not presently at risk from management activities, but may be vulnerable to impacts from hikers and rock climbers in the future. In addition, invasion by noxious weeds or other exotic plant species and efforts to control them, and trampling or browsing by elk or mountain goats are potential risks at some sites. The proposed monitoring plan focuses on a large occurrence that is considered to have the greatest potential of combined risk from recreation, fire and invasive plants. Additional monitoring may need to be implemented on other sites if recreational use increases.

The long-term persistence of great-spurred violets in the Black Hills is dependent on maintaining cool, moist habitats. Violet occurrences likely fluctuate in response to precipitation levels, and therefore the high numbers and multiple occurrences observed in 2000 and 2001 may reflect higher than average precipitation levels in the Black Hills in recent years (NOAA 1996-2001). Therefore, baseline data on violet numbers and distributions in dry years, as proposed in the monitoring strategy, will provide information potentially helpful in understanding the species' response to climatic changes. Establishing the violet in suitable habitats at higher elevations could be considered as a conservative measure to buffer the species against long-term climate warming. In addition, *ex situ* conservation measures such as depositing seeds at certified seed repositories or propagating plants at botanical gardens are options that could be considered to help buffer the species against extirpation in the Black Hills.

As is the case with many rare species, there are many unknowns about great-spurred violet. Do occurrences of great-spurred violets in the Black Hills' differ genetically from occurrences in the main portion of its range? What species of insects pollinate the violet and which ant species play a role in dispersing its seeds? Information on long-term seed viability in ant mounds and soils, as well as the role of other potential dispersal mechanisms, such as flooding, is also of interest. This basic information on life history attributes, in addition to an understanding of great-spurred violet habitat needs, could potentially enhance the odds of this species persistence in the Black Hills.

REFERENCES

Barbour, Michael G.; Billings, William D. 1988. North American Terrestrial Vegetation, First Ed. New York: Cambridge University Press: 392-394.

Beattie, Andrew J. 1971. Pollination mechanisms in *Viola*. New Phytologist. 70: 343-360, 415.

Beattie, Andrew J.; Culver, David C. 1982. Inhumation: how ants and other invertebrates help seeds. Nature. 297: 627.

Beattie, Andrew J.; Lyons, N. 1975. Seed dispersal in *Viola* (Violaceae): adaptations and strategies. American Journal of Botany. 62(7): 714-722.

Berg, R. Y. 1975. Myrmecochorous plants in Australia and their dispersal by ants. Australian Journal of Botany. 23: 475-508.

Biota of North America Program. 2001. U.S. Distribution of *Viola selkirkii*. Available: http://www.csdl.tamu.edu/FLORA. [2001, October 21].

Britton, Nathaniel L; Brown, Hon. Addison. 1970. An illustrated flora of the northern United States and Canada. Volume II. Amaranthaceae to Loganiaceae. New York: Dover Publications, Inc. 735 p.

Brown, A.H.D.; Briggs, J.D. 1991. Sampling strategies for genetic variation in *ex situ* collections of endangered plant species. *In* Falk, Donald A.: Holsinger, Kent E., eds. Genetics and conservation of rare plants. New York, New York: Oxford Press: 99-119.

Colorado Natural Heritage Program. 2001. *Viola selkirkii* Element Occurrence and Plant Characterization Abstracts as of 13 June 2001. Handwerk, J. (ed.). Unpublished data on file at: The Colorado Natural Heritage Program, Ft. Collins, Colorado.

Culver, David C. 1974. Species packing in Caribbean and north temperate ant communities. Ecology. 55: 974-988.

Culver, David C.; Beattie, Andrew J. 1978. Myrmecochory in *Viola*: dynamics of seed-ant interactions in some West Virginia species. Journal of Ecology. 66: 53-72.

Culver, David C.; Beattie, Andrew J. 1980. The fate of *Viola* seeds dispersed by ants. American Journal of Botany. 67(5): 710-714.

Culver, David C.; Beattie, Andrew J. 1983. Effects of ant mounds on soil chemistry and vegetation patterns in a Colorado montane meadow. Ecology. 64: 485-492.

Fertig, Walter. 1993. Black Hills National Forest Sensitive Plant Field Guide. Unpublished report prepared for Black Hills National Forest by the Wyoming Natural Diversity Database, Laramie, Wyoming. 75 p.

Gates, Burton N. 1942. The dissemination by ants of the seeds of bloodroot, *Sanguinaria canadensis*. Rhodora. 44: 13-15.

Gates, Burton N. 1943. Caruncculate seed dissemination by ants. Rhodora. 45: 438-445.

Gleason, Henry A.; Arthur Cronquist. 1991. Manual of the vascular plants of northeastern United States and adjacent Canada, Second Edition. New York, New York: New York

Botanical Garden. 910 p.

Gould, Joyce (Alberta Natural Heritage Information Centre, Parks and Protected Areas Division, Natural Resources Service, Alberta Environment). 2000. Personal communication with Deanna J. Reyher. December 11. 3 leaves. On file at: U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, SD.

Great Plains Flora Association. 1986. Flora of the Great Plains. Lawrence, Kansas: University Press of Kansas. 1402 p.

Hall, Jennifer S.; Marriott, Hollis J.; Perot, Jennifer K. 2002. Ecoregional conservation in the Black Hills. Minneapolis, MN: The Nature Conservancy, Midwest Conservation Science Center. 176 p.

Handel, Steven N. 1976. Dispersal ecology of *Carex pedunculata* (Cyperaceae), a new North American myrmecochore. American Journal of Botany. 63(8): 1071-1079.

Hanzawa, Frances M.; Beattie, Andrew J.; Culver, David C. 1988. Directed dispersal: demographic analysis of an ant-seed mutualism. The American Naturalist. 131(1): 1-13.

Heithaus, E. Raymond. 1981. Seed predation by rodents on three ant-dispersed plants. Ecology. 62(1): 136-145.

High Plains Regional Climate Center. (2001, January 5 - last update). Historical Data Summaries: Period of Record Monthly Climate Summary, [Online] for the Wyoming Alva 5 SE (480200), and South Dakota Hill City (393868), Lead (394834), Mt. Rushmore (395870) and Spearfish (397882) Climate Stations. Available: http://www.hprcc.unl.edu. [2001, November 13].

Hildebrand, Terri. 1996. North Custer AMP Sensitive plant species survey. Unpublished report prepared for the Black Hills National Forest, Custer, South Dakota. Unpaginated.

Hoffman, George R.; Alexander, Robert R. 1987. Forest vegetation of the Black Hills National Forest of South Dakota and Wyoming: a habitat type classification. Res. Pap. RM-276. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 48 p.

Holmgren, Noel H. 1998. Illustrated companion to Gleason and Cronquist's Manual: Illustrations of the Vascular Plants of Northeastern United States and Adjacent Canada. Bronx, New York: The New York Botanical Garden. 937 p.

Kartesz, John T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Vol. 1: Checklist. Vol. 2: Thesaurus. 2nd edition. Timber Press, Inc., Portland, OR. Vol. 1: xi, 622 p.; Vol. 2: vii, 816 p.

Kelso, Sylvia (Department of Biology, Colorado College, Colorado Springs). 2001. E-mail communication with Deanna J. Reyher. February 25. 4 leaves. On file at: U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, SD.

Kelso, Sylvia (Department of Biology, Colorado College, Colorado Springs). 2002. Personal communication with J. Hope Hornbeck. Date. X leaves. On file at: U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, SD.

Larson, Gary E. 1993. Sensitive Plant Survey of Needles Project Area. Unpublished report prepared for the Black Hills National Forest, Custer, South Dakota. 9 pages plus maps and appendices.

Larson, Gary E.; Johnson, James R. 1999. Plants of the Black Hills and Bear Lodge Mountains: a field guide with color photographs. A South Dakota State University, College of Agricultural Sciences Book: 368-369.

Lyford, W. H. 1963. Importance of ants to brown podzolic soil genesis in New England. Harvard Forest Paper No. 7. Massachusetts: Harvard University Press. 18 p.

Madge, M. 1929. Spermatogenesis and fertilization in the cleistogamous flowers of *Viola odorata* var. *praecox* Gregory. Ann. Bot. (Oxford). 43: 545-577.

Marriott, Hollis J. 2000. Unpublished survey sheets from Marriott's Floristic Inventory of the Black Elk Wilderness. Challenge Cost Share Agreement with South Dakota Game, Fish and Parks. 17 leaves. On file at: U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, SD.

Marriott, Hollis J. 2001a. Floristic Inventory of the Black Elk Wilderness, Black Hills National Forest, South Dakota. Challenge Cost Share Agreement between Black Hills National Forest, Custer, South Dakota and South Dakota Game, Fish and Parks, Wildlife Division. February 22, 2001. ii, 11 pages plus appendices.

Marriott, Hollis J. 2001b. Rare plant surveys of selected sites in the Black Elk Wilderness and Norbeck Wildlife Preserve, Black Hills National Forest, South Dakota. October 31, 2001. 8 pages plus appendices.

Marriott, Hollis J. 2001c. Identification and mitigation of climber impact on rare plants, Custer State Park, South Dakota (Black Hills Needles climbing area). Prepared for the Access Fund, and the South Dakota Department of Game, Fish & Parks, Wildlife Division, Pierre, SD. Available from: South Dakota Natural Heritage Program.

Martin, A. C.; Zim, H. S.; Nelson, A. L. 1951. American wildlife and plants: a guide to wildlife food habits. New York: Dover. p. 412. 500 p.

Missouri Botanical Garden. 2001. *Viola selkirkii*. *In* W^3 Specimen Data Base. Available: http://mobot.mobot.org. [Accessed June 17, 2001].

Moerman, Daniel E. 1998. Native American Ethnobotany. Portland, Oregon: Timber Press. 927 p.

Montana Natural Heritage Program. 2001. Species of special concern. (1 October 2001–last update). Available: http://nhp.nris.state.mt.us/plants. [12 October, 5 November 2001].

Morley, Thomas. 1969. Spring flora of Minnesota, including common cultivated plants. Minneapolis: The University of Minnesota Press. 283 p.

National Oceanic & Atmospheric Administration. 1996. Annual Climatological Summary, 1996. Available: http://lwf.ncdc.noaa.gov/servlets/ACS [2002, April 21].

National Oceanic & Atmospheric Administration. 1997. Annual Climatological Summary, 1997. Available: http://lwf.ncdc.noaa.gov/servlets/ACS [2002, April 21].

National Oceanic & Atmospheric Administration. 1998. Annual Climatological Summary, 1998. Available: http://lwf.ncdc.noaa.gov/servlets/ACS [2002, April 21].

National Oceanic & Atmospheric Administration. 1999. Annual Climatological Summary, 1999. Available: http://lwf.ncdc.noaa.gov/servlets/ACS [2002, April 21].

National Oceanic & Atmospheric Administration. 2000. Annual Climatological Summary, 2000. Available: http://lwf.ncdc.noaa.gov/servlets/ACS [2002, April 21].

National Oceanic & Atmospheric Administration. 2001. Annual Climatological Summary, 2001. Available: http://lwf.ncdc.noaa.gov/servlets/ACS [2002, April 21].

NatureServe Explorer: An online encyclopedia of life [web application]. 2001. Version 1.6. Arlington, Virginia, USA: NatureServe [online]. (1 November 2001-last update). Available: http://www.natureserve.org/explorer. [7 August 2002].

Newman, E. I.; Reddell, P. 1987. The distribution of mycorrhizas among families of vascular plants. New Phytologist. 106: 745-751.

Ode, David (Botanist/Data Manager, South Dakota Natural Heritage Program). 2001. E-mail communication with Deanna J. Reyher. March 6. 4 leaves. On file at: U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, SD.

Ohkawara, Kyohsuke; Higashi, Seigo. 1994. Relative importance of ballistic and ant dispersal in two diplochorous *Viola* species (Violaceae). Oecologia. 100: 135-140.

Olmsted, N.W.; Curtis, J. D. 1947. Seeds of the forest floor. Ecology. 28: 49-52.

Parrish, J. Barry; Herman, Daryl J.; Reyher, Deanna J. 1996. A century of change in Black Hills forest and riparian ecosystems. U.S. Forest Service Agricultural Experiment Station Publication No. B 722. USDA, South Dakota State University. 20 p.

Peet, Robert K. 1988. Forests of the Rocky Mountains. *In* Barbour, Michael G.; Billings, William D., eds. North American terrestrial vegetation. New York, NY: Cambridge University Press: 63-101.

Pudlo, Ronald J.; Beattie, Andrew J.; Culver, David C. 1980. Occurrences consequences of changes to an ant-seed mutualism in *Sanguinaria canadensis*. Oecologia. 146: 32-37.

Russell, N. H. 1965. Violets (*Viola*) of central and eastern United States: An introductory survey. Sida. 2(1): 106-107.

South Dakota Natural Heritage Program. Element occurrence records for *Viola selkirkii*. Pierre, SD: South Dakota Department of Game, Fish and Parks.

Spackman, S.; Jennings, B.; Coles, J.; [and others]. 1997. Colorado Rare Plant Field Guide. Prepared for the Bureau of Land Management, the U.S. Forest Service, and the U.S. Fish and Wildlife Service by the Colorado Natural Heritage Program. Unpaginated.

USDA Forest Service. October 2000. Expert Interview Summary for the Black Hills National Forest Land and Resource Management Plan Amendment. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, South Dakota. 143 p.

USDA Forest Service. 2001. 1997 Land and Resource Management Plan Amendment 1 Biological Assessment and Biological Evaluation. Forest Service. Custer, SD: Black Hills National Forest. 85 p.

USDA NRCS. 2001. The PLANTS Database, Version 3.1 (http://plants.usda.gov). National

Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Voss, Edward G. 1985. Michigan Flora. Part II: Dicots. Ann Arbor, Michigan: Cranbrook Institute of Science Bulletin 59 and University of Michigan Herbarium. 727 p.

Walters, Dirk R.; Keil, David J. 1996. Vascular Plant Taxonomy, Fourth Edition. Dubuque, Iowa: Kendall/Hunt Publishing Company. 621 p.

Weber, William A.; Wittmann, Ronald C. 1996. Colorado flora: eastern slope. Boulder, CO: University Press of Colorado. X p.

Williams, George C. 1975. Sex and evolution. Princeton, New Jersey: Princeton University Press: 26-35.

Wisconsin State Herbarium. 2001. *Viola selkirkii*. In: Wisconsin Vascular Plants. Website. Madison, Wisconsin: University of Wisconsin. Available: http://wiscinfo.doit.wisc.edu/herbarium. [25 October 2001].

Zacharkevics, Katherine; Silvey, Tom. 2002. Unpublished data. Northern Hills Ranger District, Black Hills National Forest, Spearfish, SD.

Zomlefer, Wendy B. 1994. Guide to flowering plant families. Chapel Hill, North Carolina: The University of North Carolina Press: 112-114.

APPENDICES

Appendix A. Technical description of great-spurred violet, *Viola selkirkii* Pursh ex Goldie.

"Rather delicate plants from long, slender rhizome, without stolons; leaves glabrous beneath, minutely spreading-hairy above, ½ to 1 inch (1.5 to 3 cm) at anthesis, later larger, crenate, broadly ovate-cordate, with a narrow basal sinus and converging or overlapping lobes; flowers numerous, ½ inch (1.5 cm) wide; sepals eciliate; petals pale violet, beardless, the spur large and blunt, 1/8th to ¼ inch (4 to 7 mm); fruits small, stoutly ellipsoid or globose, 1/8th to 1.4 inch (4 to 6 mm); seeds buff" (Gleason and Cronquist 1991) or grayish brown, 1/16th inch (1.5 to 1.7 mm) long, borne in a pale or yellowish-green, round to ellipsoid capsule, ¼ in to 3/8 inch (4 to 6 mm) long (Great Plains Flora Association 1986).

Distinguishing characteristics for Selkirk's violet (*Viola selkirkii*) and its similar species associates, hookedspur violet (*V. adunca*) and common blue violet (*V. sororia*) (Kelso, unpublished data):

Viola selkirkii is not leafy stemmed, but its flowering stems are relatively short. It is not stoloniferous but rhizomatous, with very thin, elongated rhizomes. The plants appear quite delicate in comparison to late season *V. sororia* individuals. There are hairs on the upper leaf surface only, and these generally appear longer and may be described as strigose, hirtellous, or glassy and are visible with a hand lens. The hairs appear, at least when leaves are young, to be denser or clustered at the leaf apex. The large, broad spur on *V. selkirkii* is its most reliable character; it is blunt and fat, and very noticeable – usually 1/8th to ¼ inch (5 to 8 mm) in length, about equal to the petals.

Viola adunca is leafy stemmed, growing early as short tufts, but plants often stretching out laterally later in the season. It is similar to *V. selkirkii* in its slender rhizomes and hairy leaves. However, *V. adunca*'s hairs are really minute and are best described as puberulent in comparison to the longer hairs on *V. selkirkii* (you need strong magnification to see them). *Viola adunca* also has a relatively long spur, but it can be distinguished by its leafy stems, the stems can be short, so it may be hard to tell at first. The species' habitats and ecology are quite similar. However, *V. adunca* has a much wider ecological amplitude than *V. selkirkii* (Marriott 2000, 2001a,b,c).

Viola sororia is not leafy stemmed, that is the flowers are on stems without leaves. The leaves are variously hairy to occasionally glabrous. Young leaves are relatively small and hairs appear closer together somewhat like they do in *V. selkirkii*, and the later leaves are larger and look less like *V. selkirkii*. The spur is very short and thinner than in *V. selkirkii*. *Viola sororia* typically occurs at lower elevations at least in the west. The *Viola sororia* complex of blue violets is somewhat troubling and variable, and its total range of variation is still unclear. *Viola sororia*'s short spur is generally the most helpful character to distinguish it from *V. selkirkii* when in flower.

Appendix B. Climate summary for great-spurred violet, *Viola selkirkii*, on Black Hills National Forest (compiled from High Plains Regional Climate Center 2001).

The closest climate stations to great-spurred violet occurrences in the Black Elk Wilderness, Norbeck Wildlife Management Area, and Custer State Park are Hill City, Mount Rushmore, and Custer, South Dakota. The climate in the violet's high elevation habitats is likely cooler than conditions reported by the three climate stations, and is likely further moderated by the limited exposure of the sites due to shelter provided by rock outcrops or tree cover. The Hill City Climate Station is ca. 6 miles (9.6 km) northwest of the occurrences. The Mount Rushmore Climate Station is ca. 3 miles (4.8 km) east-northeast of the occurrences. The Custer Climate Station is ca. 5 to 10 miles (8 to 16 km) to the west or southwest of known occurrences. Precipitation is concentrated in May, June and July at all three climate stations (High Plains Regional Climate Center 2001).

Climate summary for great-spurred violet 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
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)
Mt. Rushmore	1962-2000	15.8º F (-9º C)	80.6º F (27º C)	22.0 inches (55.9 cm)	57.9 inches (147.1 cm)
Custer	1926-2000	8.3º F (-13.2º C)	79.9º F (26.6º C)[a]	18.7 inches (47.5 cm)	47.9 inches (121.7 cm)

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

FIGURES

Figure 1. General North American distribution of great-spurred violet, *Viola selkirkii* Pursh ex Goldie showing disjunct Rocky Mountain and Black Hills locations (compiled from NatureServe 2001; USDA NRCS Plants Database 2001).

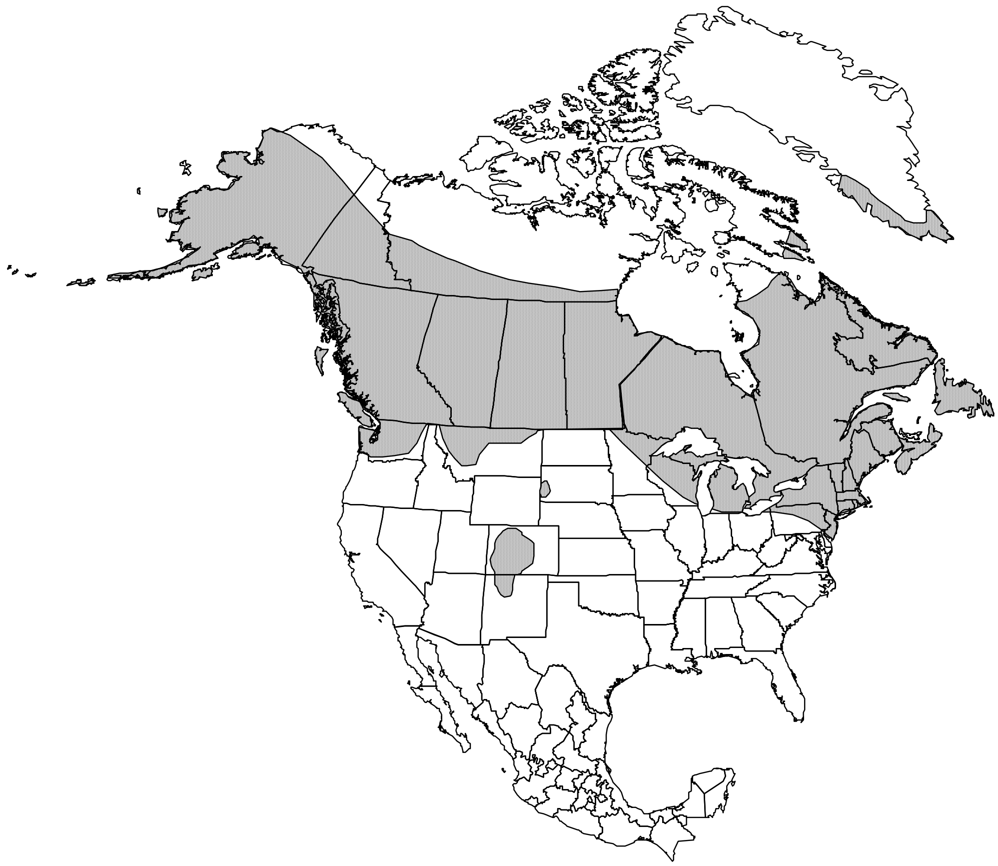

Figure 2. Black Hills distribution of great-spurred violet (*Viola selkirkii* Pursh ex Goldie).

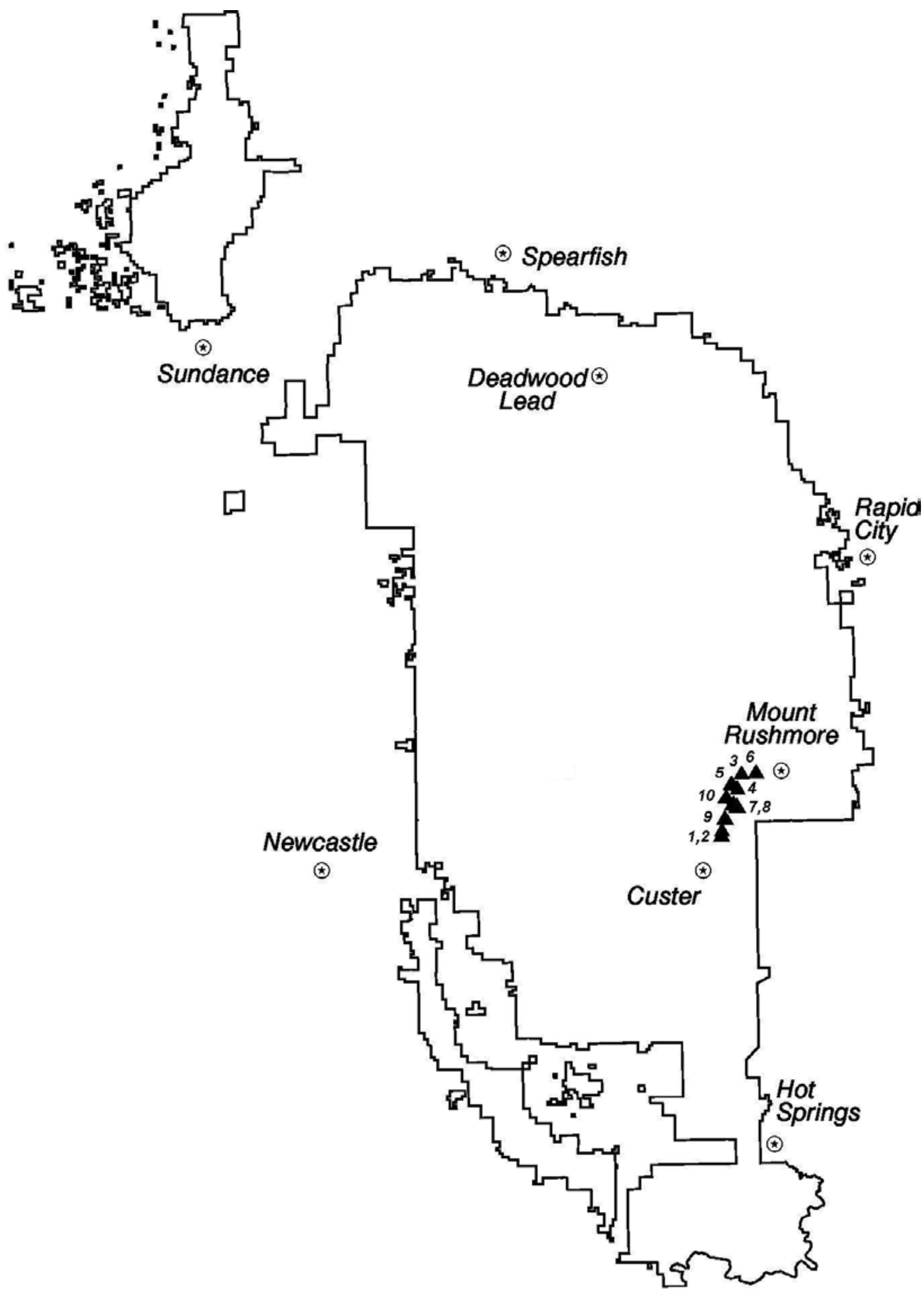

Figure 3. Line drawing of great-spurred violet, *Viola selkirkii* Pursh ex Goldie (Eduardo Salgado In Holmgren 1998).

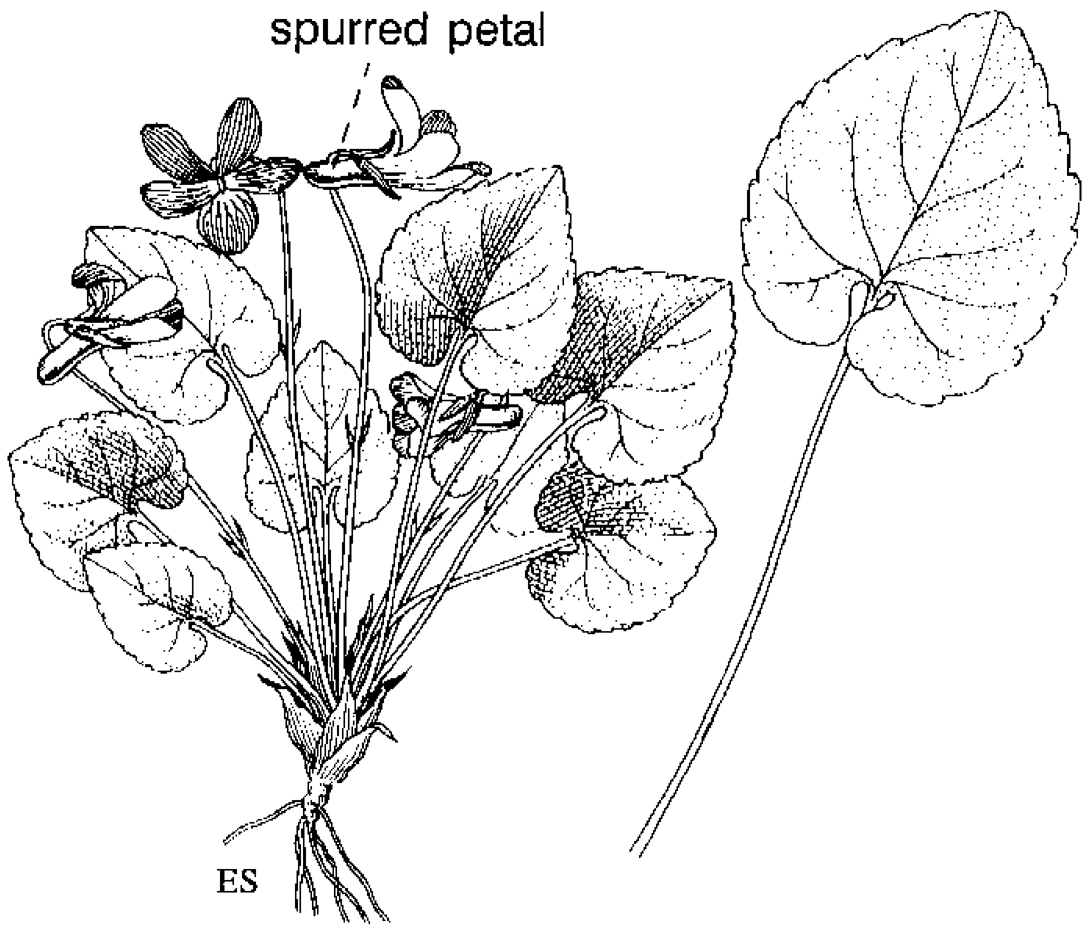

Figure 4. Great-spurred violet habitat in the Black Hills.

Table 1. Conservation status of great-spurred violet in North America (NatureServe 2001).

State/Province	**Rank**	**Definition**
Colorado	S1	Critically imperiled due to extreme rarity.
Connecticut	S1	Critically imperiled due to extreme rarity.
Montana	S1	Critically imperiled due to extreme rarity.
Pennsylvania	S1	Critically imperiled due to extreme rarity.
South Dakota	S1	Critically imperiled due to extreme rarity.
Manitoba	S2	Imperiled due to rarity.
Newfoundland Is. (Newfoundland)	S2	Imperiled due to rarity.
Saskatchewan	S2S3	Imperiled to vulnerable.
Labrador (Newfoundland)	S2S4	Imperiled to apparently secure.
Alaska	S3	Vulnerable.
Alberta	S3	Vulnerable.
New Brunswick	S3	Vulnerable.
Nova Scotia	S4	Apparently secure.
Ontario	S5	Demonstrably secure.
Maine	SR	Reported.
Minnesota	SR	Reported.
New Hampshire	SR	Reported.
New Mexico	SR	Reported.
New York	SR	Reported.
Northwest Territories	SR	Reported.

State/Province	Rank	Definition
Nunavut	SR	Reported.
Quebec	SR	Reported.
Vermont	SR	Reported.
Washington	SR	Reported.
Wisconsin	SR	Reported.
Yukon Territory	SR	Reported.
British Columbia	S?	Unranked.
Massachusetts	S?	Unranked.
Michigan	S?	Unranked. Rank not yet assessed.
New Jersey	S?	Unranked. False report (Aug 1999, BONAP 2001).
Prince Edward Island	SU	Unrankable due to insufficient information.

Table 2. Estimated numbers of violet ramets at 10 known sites supporting *Viola selkirkii* on the Black Hills National Forest.

Occurrence No.	Site	Watershed	Date last observed	Estimated number of ramets
VISE2-1	Norbeck W.P.	Bismarck Lake	5/22/01	300-500
VISE2-2*	Norbeck W.P	Bismarck Lake	5/31/01	501-1000 in 2000
VISE2-3	Black Elk	Willow Creek	5/23/01	101-500 in 2000
VISE2-4	Black Elk	Willow Creek	6/02/00	11-50
VISE2-5	Black Elk	Nelson Creek	6/01/00	11-50
VISE2-6	Black Elk	Pine Creek	6/07/00	>4000
VISE2-7	Black Elk	Lost Cabin Creek	5/24/01	101-500
VISE2-8	Black Elk	Nelson Creek	5/31/01	1001-10000
VISE2-9	Black Elk	Lost Cabin Creek	5/31/01	101-500
VISE2-10	Black Elk	Nelson Creek	6/6/01	51-100

* "Violet Valley" will be monitored annually

Table 3. Great-spurred violet, *Viola selkirkii*, species associates in Black Hills National Forest.

Scientific name	Common name	No. Sites
Achillea millefolium	Yarrow	4
Adoxa moschatellina[a]	Muskroot	9
Betula papyrifera	Paper birch	3
Carex pedunculata	Peduncled sedge	1
Carex sp.	Sedge	4
Cornus canadensis	Bunchberry	2
Cystopteris fragilis	Bladderfern	4
Disporum trachycarpum	Fairybells	1
Dodecatheon pulchellum	Shooting star	2
Dryopteris carthusiana[b]	Woodfern	1
Dryopteris filix-mas	Male fern	1
Fragaria virginiana	Strawberry	5
Galium sp.	Bedstraw	4
Heracleum maximum	Cowparsnip	2
Juniperus communis	Juniper	1
Linnaea borealis	Twinflower	1
Maianthemum stellatum	Starflower	2
Oryzopsis asperifolia	Rice grass	3
Picea glauca	White spruce	9
Pinus ponderosa	Ponderosa p.	3
Polygonum viviparum	Alpine bistort	1
Populus tremuloides	Quaking aspen	2
Potentilla sp.	Potentilla	1
Pyrola sp.	Wintergreen	1
Ribes sp.	Gooseberry	4
Rubus sp.	Blackberry	3
Sambucus racemosa	Stinking elder	2

Scientific name	Common name	No. Sites
Spiraea betulifolia	Spiraea	1
Symphoricarpus sp.	Snowberry	2
Viola adunca	Hookedspur violet	5
Viola canadensis	Canada violet	1
Viola macloskeyi	Small white violet	6
Viola nephrophylla	Northern bog violet	1
Viola pedatifida	Prairie violet	1
Viola pubescens	Downy yellow	1
Viola renifolia	White violet	5
Moss sp.	Moss cover	8
Graminoid sp.	Grass cover	5

[a] S2 (Imperiled due to rarity) in South Dakota

[b] SU (Unrankable) in South Dakota