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# Conservation Assessment for Bloodroot in the Black Hills National Forest, South Dakota and Wyoming

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**Species Assessment**
**of**
**Bloodroot**
**in the**
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**South Dakota and Wyoming**

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## EXECUTIVE SUMMARY

Bloodroot, *Sanguinaria canadensis* L. (Papaveraceae), is a common spring flowering herb in the deciduous forests of eastern North America. It is disjunctly distributed in the northeastern Black Hills of South Dakota. There are 22 known occurrences of bloodroot on Black Hills National Forest in hardwood forests, shrub thickets, and floodplain habitats of limited distribution. Bloodroot occurrences in the Black Hills are associated with beaver (*Castor canadensis*) dams, beaver-created floodplains, forested terraces, drainage bottoms, and north-facing footslopes. The species is considered secure on the forest at this time, but due to limited potential habitat, invasion by noxious and other invasive plants needs to be monitored. The species is not currently at risk from livestock grazing, as nine sites are currently not grazed and one site is not accessible to livestock. Timber harvest is not deemed a risk to bloodroot because known occurrences will either be avoided or timber management will be designed to benefit the species. Illegal bloodroot harvesting is not currently an issue in the Black Hills, but due to its value as a medicinal herb, harvesting could be detrimental. In the future, its persistence could be vulnerable to random natural catastrophes, long-term climate change, and drought. There is a monitoring plan to annually track four "key", widely distributed occurrences that encompass its range of habitats and topographic positions, and potential risks.



**Key words**: bloodroot, *Sanguinaria canadensis,* beaver ecology, Black Hills.



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# INTRODUCTION

Bloodroot, *Sanguinaria canadensis* L. (Papaveraceae), is a common understory herb in moist deciduous forests of eastern North America (Gleason and Cronquist 1991; NatureServe 2001). It is also widely cultivated as a medicinal herb both within and outside of its normal range. Bloodroot's distribution in the Black Hills of South Dakota is disjunct from the main portion of its range (Great Plains Flora Association 1986; Fertig 1993; Larson and Johnson 1999; NatureServe 2001) (fig. 1). There are 22 known bloodroot occurrences in the northern and northeastern Black Hills in Lawrence and Meade Counties (fig. 2, table 1). In this assessment, we use the term "occurrence" to describe bloodroot concentrations in general proximity to each other. The term "population", which refers to a group of breeding individuals, is not used since it is unknown to what degree these occurrences interbreed.

The objectives of this assessment are to review the status of bloodroot in the Black Hills and to synthesize information relevant to its management and long-term persistence. In general, the ecology of eastern deciduous herbaceous species is not well understood and there is little in the literature that addresses bloodroot management and conservation, or the effects of disturbance on the species. We relied on information from the main portion of the species' range to develop this assessment. Species nomenclature follows the USDA NRCS Plants Database (2001).

# CURRENT CONSERVATION SITUATION

The global conservation rank of bloodroot (*Sanguinaria canadensis* L.) is G5 (globally secure) (NatureServe 2001). It is ranked as secure (N5) in the United States and is unranked (N?) in Canada (NatureServe 2001). Bloodroot is a common and well-distributed species throughout eastern North America, but is less secure toward the periphery of its range in Texas, Louisiana, South Dakota and Manitoba, Canada (NatureServe 2001) (table 2). In South Dakota, bloodroot's state ranking of S4? (apparently secure?) (NatureServe 2001) applies to two separate distributions: populations at the eastern edge of the state in deciduous forest habitats; and in compositionally similar deciduous forests and thickets along drainages on the western side of the state in the Black Hills, where its potential habitats and dispersal ability are limited (Fertig 1993) (fig. 2). Because bloodroot has apparently been reproductively isolated in the Black Hills for some time, it is possible that these populations possess unique genetic or morphological characteristics not present elsewhere in the species range. Furthermore, its habitats in the Black Hills have likely been altered by impacts to riparian habitats from invasive plant species, road construction, timber production, fire suppression, livestock use, and the historic mining of stream courses (Hoffman and Alexander 1987; Froiland 1990; Parrish and others 1996). In 1993, bloodroot was listed as a Sensitive Species in Region 2 due to its limited distribution in the Black Hills, and assessment and ongoing monitoring of the species is warranted. The process and rationale for ranking bloodroot are described in Appendix A.

Since 1993, known bloodroot populations have been revisited, and areas proposed for Forest management activities have been surveyed for bloodroot. New populations have been located, including occurrences exceeding 1000 individuals, and the species' status on the R2 Sensitive Species list was re-evaluated in 2000 (Ode and others 2000). At the present time, the Black Hills bloodroot metapopulation is estimated to consist of at least 16,000 stems or ramets (table 1).

However, recent survey information further supports that this plant species has relatively narrow ecological amplitude in deciduous hardwood thickets along riparian corridors in the northeastern Black Hills (fig. 2).

In addition to the above considerations, bloodroot is a widely recognized medicinal plant species (Foster and Duke 1990). Trade in bloodroot has increased with the increasing popularity of herbal medicines (Robbins 1999), and increased demand is expected from German pharmaceutical companies (Greenfield, personal communication; Kauffman, personal communication). Data on bloodroot harvest from Forest Service lands in the southern and southeastern U.S. indicate that demand has increased in the past 10 years while both the species and local populations have declined (Robbins 1999). Although bloodroot is widely harvested, both legally and illegally, in the east, there is little documentation of either the degree of impact or the conservation status of existing populations on federal and state protected lands, or private lands (Rock, personal communication; Greenfield, personal communication; Kauffman, personal communication). Commercial cultivation is in the early stages of development, but it is not known if cultivated bloodroot will be able meet the needs of industry in its medicinal qualities or in the quantity that can be annually produced (Greenfield, personal communication).

Bloodroot is not currently under federal protection by the U.S. Fish and Wildlife Service, but the agency is planning to evaluate bloodroot for listing under the Convention on International Trade in Endangered Species (CITES) Appendix II, due to suspected over-harvest for export (US Fish and Wildlife Service 2001). In the Black Hills, bloodroot is not listed as a Regional Special Forest Products species (USDA Forest Service 1996), nor is it known to be a target for permitted or illegal harvest. However, because of its isolated and limited, but locally abundant distribution in the Black Hills, poaching should be considered a potentially serious risk to the species' persistence.

Because the existence and condition of bloodroot populations on private land in the Black Hills are unknown, they are not considered in this assessment.

# REVIEW OF TECHNICAL KNOWLEDGE

## Species Taxonomy

Bloodroot, *Sanguinaria canadensis* L. (Linnaeus. Species Plantarum, 1: 505. 1753; Gen. Pl. ed. 5, 223. 1754.), is classified as Class Magnoliopsida, Subclass Dicotyledonae, Order Papaverales, Family Papaveraceae A. L. Jussieu (Poppy Family), Subfamily Platostamenoideae. Bloodroot is the only member of the Genus *Sanguinaria* L. Alternative taxonomic treatments include: *Sanguinaria canadensis* L. var. *rotundifolia* (Greene) Fedde.; *Sanguinaria australis* Greene.; and *Sanguinaria dilleniana* Greene (Flora of North America Editorial Committee 1993).

## Species Description

Bloodroot is a perennial herb with stout rhizomes; it produces a single, distinct, glabrous, 3 to 9 lobed, kidney-shaped basal leaf 2.5 to 8 inches (6 to 20 cm) wide on a petiole 4 to 14 inches (10 to 35 cm) long; the stem and root exude clear, reddish-orange latex when broken; a short scape bears a single flower of 2 deciduous sepals, 8 to 10 (up to 16) white petals, numerous yellow stamens, and a single elongated ovary terminating in a two lobed stigma; the fruit is an elongate capsule 1 to 2 inches (3 to 5 cm) long with many seeds 1/16$^{th}$ to 1/8$^{th}$ inches (2 to 3 mm) long, each with fleshy attachments (arils or elaiosomes) to facilitate dispersal by ants (Gates 1942; Van Bruggen 1985; Great Plains Flora Association 1986; Gleason and Cronquist 1991; Larson and Johnson 1999) (fig. 3). Bloodroot flowers in early spring in April and May. This characteristic, in combination with its unique kidney-shaped leaves, distinguishes it from other species (Fertig 1993). See Appendix B for a technical description of the species.

## Species Significance

The Black Hills bloodroot population is significant in that it occurs far to the west of the main distribution of this eastern deciduous forest species (fig. 1). The species' disjunct occurrence in the Black Hills may be evolutionarily significant and may contribute to the overall genetic diversity of the species. Maintenance of populations in the wild, as well as collecting seed and plant materials for *ex situ* conservation efforts are warranted (Brown and Briggs 1991).

Native American peoples of eastern North America used bloodroot to treat a variety of ailments, but the species was consistently used as a cough medicine and to treat dermatological and gastrointestinal problems (Moerman 1998). Its colored latex also served as an orange-red dye (Moerman 1998). No traditional uses of bloodroot were found for the Lakota peoples of the Black Hills region (Moerman 1998).

The U.S. Food and Drug Administration has deemed bloodroot an unsafe herb due to the presence of the poisonous alkaloid sanguinarine that gives bloodroot latex its distinctive color (Duke 1985). Despite its toxicity, wild bloodroot is exported in large quantities each year for herbal medicines (Robbins 1999). It is used in the treatment of tumors, epidermal problems, in toothpaste (Duke 1985), and most recently as an anti-microbial in animal feed (Greenfield, personal communication). A pound of wild harvested, or "wild crafted", bloodroot is worth approximately $15 (Nickens 2001) and sells for around $55 retail (Frontier Natural Products Co-op 2002). A double-flowered variety is sold as an ornamental for around $3 (Nickens 2001).

## Life History

Bloodroot is a perennial herb with shallow, fleshy rhizomes (Schemske 1978). It reproduces vegetatively through branching or abscission of the rhizome to form clonal ramets (Schemske 1978). Leaf and flower buds are produced during the preceding summer and the leaves may persist into fall (Shaw 1904; Marino and others 1997). In the main portion of its range and in the Black Hills, bloodroot is one of the earliest spring flowers to appear. It emerges in April or early May when canopy leaves are just beginning to appear from buds. The flowers open before the leaves, apparently in response to the first several days of warm temperatures (Lindsey and Newman 1956; Schemske 1978). The flower remains open for only two days during which cross-pollination may occur; if the flower is not pollinated, self-fertilization occurs by the collapse of the anthers onto the stigma on the third day of flowering (Schemske 1978; Schemske and others 1978; Lyon 1992). This reproductive mechanism, called facultative xenogamy, is believed to be an adaptation to ensure fertilization when low temperatures may suppress pollinator activity (Schemske and others 1978; Lyon 1992). After fertilization, the ovary matures into an elongate pod containing 10 to 70 mature seeds (Schemske 1978), each with a fleshy, lipid-rich elaiosome or crest that facilitates dispersal by woodland ant species (Gates 1942; Marino and others 1997). The ants consume the lipid-rich crest, or eliasome, attached to the seed coat (Gates 1942). Ant seed dispersal, or myrmecochory, is a common adaptation in understory forbs found in North American deciduous forests and elsewhere. In Massachusetts, the seeds ripen in June and drop to the ground (Gates 1942). The timing of seed ripening and dehiscence is not known for the Black Hills, but presumably occurs in June or July.

Lyon (1992) noted few pollinators in an Iowa population of bloodroot, but found a species of solitary bee (*Andrena carlini* L.) to be the most effective pollinator, accounting for 58 to 64 percent of seed set. Other flower visitors included the bee fly (*Bombylius major*; Bombylidae), hover flies (Syrphidae), sweat bees (Halictidae) and the non-native honeybee (*Apis mellifera* L.; Apidae) (Lyon 1992; Lobstein and Rockwood 1993). Robertson (1892) noted syrphid flies, Andrenid bees, and sweat bees as bloodroot pollinators. Schemske (1978) found honeybees to be the most abundant pollinators of bloodroot in an Illinois population; and even though *Andrena carlini* was present and visited other flower species, no visits to bloodroot flowers were recorded. The importance of insect pollination is not clear, as the proportion of seed produced through self-fertilization is believed to be high (Schemske and others 1978). However, bloodroot produces large numbers of seeds, presumably to facilitate successful seed dispersal (Schemske and others 1978).

Hybridization has not been documented, nor is it likely to occur in *Sanguinaria*, since it is a monotypic genus and is not closely related to any other North American members of the Papaveraceae (Flora of North America Editorial Committee 1993). In addition, bloodroot is reproductively isolated by its early and very brief flowering period.

## Distribution And Local Abundance

Bloodroot is common in eastern North America from southern Quebec, New Brunswick and Nova Scotia west to southeast Manitoba and south to Texas, Louisiana and Florida (USDA NRCS 2001; NatureServe 2001) (fig. 1). Bloodroot's distribution in the Black Hills of South Dakota is disjunct from the species' main range (Ode in NatureServe 2001), which is mostly east of the Mississippi River, with the closest occurrences to the Black Hills at the eastern edge of the Dakotas, eastern Kansas, and northeast Nebraska (USDA NRCS 2001).

To date, 22 occurrences of bloodroot have been found in the northern and northeastern portions of the Black Hills. This includes one new occurrence found in May 2001, an occurrence that was not relocated due to limited information, and an occurrence that was not revisited due to limited accessibility. Eleven of these occurrences were surveyed in 2001 and nine had over 1,000 stems occurring in dense clonal groupings, scattered patches, and as scattered individuals (table 1). As a result, estimated numbers are higher than those reported in earlier surveys (Fertig 1993). Bloodroot was in flower or had immature fruit at the time of the 2001 survey in late April and early May.

Bloodroot is patchily distributed in its eastern deciduous forest habitats, presumably as a result of ant seed dispersal, vegetative reproduction, and spatial patterns produced by infrequent canopy gaps. Black Hills bloodroot occurrences are locally abundant, possibly in response to the open conditions within its habitats here. Dense concentrations of bloodroot likely contain a large proportion of clones, while occurrences with scattered patches or scattered individuals presumably were established by seed, and are therefore more genetically diverse. However, genetic relationships within and between the Black Hills bloodroot population, and its relatedness to bloodroot populations in the main portion of the species' range have not been examined.

## Habitat Relationship

In the main portion of its range, bloodroot is a common component of the eastern deciduous forest (Braun 1950). These habitats are characterized by a tall, multistoried canopy of deciduous tree species (Burns and Honkala 1990); a rich understory of mostly perennial herbs (Braun 1950); and a thick litter layer of decaying leaves above moist, well-drained, nutrient-rich soils (Lyon 1992; Faber-Landgendoen 2001). Understory herbs thrive within these closed, densely shaded conditions through adaptations that allow them to capture light that has filtered through the canopy, and many complete their life cycle in the spring before the canopy has closed (Hicks and Chabot 1985; Peet 1992). Intense competition for light has induced adaptations in understory herbaceous species that allow them to take advantage of small-scale disturbances created by infrequent, tree fall canopy gaps: the primary form of disturbance in the deciduous forest (Runkle 1985). These adaptations may include rhizomatous expansion, seed dispersal and colonization, or other mechanisms to facilitate rapid expansion into areas with increased light availability (Runkle 1985).

In eastern North America, bloodroot also occurs in northern hardwood forests and other deciduous forest types co-dominated by coniferous species (Braun 1950). At the western edge of its main range in Iowa, Nebraska, Kansas, and eastern South Dakota, bloodroot is associated with basswood (*Tilia americana*)-bur oak (*Quercus macrocarpa*)-eastern hophornbeam (*Ostrya virginiana*) forest types (Braun 1950). These habitats possess the rich herbaceous layer common to moist eastern deciduous forests (Braun 1950; Faber-Langendoen 2001), but may be structurally more open with less competition for light.

In the Black Hills, bloodroot occupies floodplains, forested terraces, drainage bottoms, and north-facing footslopes in open, rich hardwood plant communities, including: bur oak-eastern hophornbeam forest; (black) hawthorne (*Crataegus douglasii-Crataegus chrysocarpa*) shrubland; and paper birch-hazelnut (*Betula papyrifera-Corylus cornuta*) forest (Larson and Johnson 1999; Marriott and Faber-Langendoen 2000b) (figs. 4 and 5, table 3). These plant communities occur at low- to mid-elevations on moist soils, with high percentages of hophornbeam, hazelnut, and boreal species (table 4). Bloodroot appears to be most strongly associated with moist bur oak-hophornbeam forest. This habitat type occurs in moist (not saturated) drainage bottoms in South Dakota from 3,550 to 4,750 ft (1,080 to 1,450 m) elevation in the northern and eastern portions of the Black Hills, and is documented from a few locations in the Bear Lodge Mountains (Steinauer 1981; Hoffman and Alexander 1987; Girard ca. 1991; Marriott and Faber-Langendoen 2000b), although on a different soil type and bloodroot does not occur there. Bur oak-hophornbeam forests are replaced by paper birch/hazelnut forest at higher elevations and in transitional areas (Marriott and Faber-Langendoen 2000b). Bloodroot also occurs with quaking aspen (*Populus tremuloides*) at numerous sites, and over 40 plant species co-occur with bloodroot in the Black Hills (table 4).

The eleven bloodroot occurrences surveyed in 2001 occur from 3,900 to 5,000 ft (1,189 to 1,525 m) elevation in drainages with north and northwest facing aspects in association with beaver dams, flood plains and terraces on low-grade streams and adjacent east or northeast facing uplands. Information from currently known occurrences indicates that bloodroot is associated with cool, moist conditions where litter and debris have built up from high water: conditions found on streamside terraces adjacent to beaver ponds within remnant boreal or eastern deciduous forest habitats. The conditions that are commonly associated with accumulated debris and sediment in ponds behind beaver dams (Olson and Hubert 1994) are similar to the deep litter and moist, rich soils bloodroot prefers elsewhere. However, bloodroot also occupies rich soils on floodplains, upper terraces, and north-facing upland sites in the Black Hills and there is no indication that the species occurs in association with beaver elsewhere. In addition, there are a few occurrences in relatively dry habitat under a pine canopy and dense hawthorn thickets and a few sites where a portion of the occurrence occupies open, sunny habitats. In general, high soil moisture – often associated with beaver dams, and litter accumulation - is a common parameter at sites supporting expanding bloodroot occurrences. A summary of the general climate for known bloodroot occurrences is given in Appendix C.

The occurrences described here are comprised of scattered individual stems, scattered clumps, or high concentrations of plants over a large area. Seed germination is evidenced by the scattered individuals colonizing piles of woody debris associated with recent beaver activity and by individuals that occur 5 to 10 yards (4.5 to 9 m) from high-density sites of bloodroot.

Bloodroot's distribution in the Black Hills appears to follow drainages, possibly because they contain fast-growing hardwood habitats that are similar to eastern deciduous forests in their rich litter and high soil moisture. Also, it is possible that water flow plays a significant part in seed dispersal along drainage bottoms that occasionally flood and perhaps less so in floodplain terrace habitats that are subject to flooding rarely or momentarily. However, colonies in upland habitats are rarely flooded, and dispersal to these areas must take place by vegetative expansion or seed dispersal by ants. No other dispersal mechanisms have been documented for the species.

Seed dispersal by ants (myrmecochory) is believed to have evolved in response to seed predation by rodents (Culver and Beattie 1978; Pudlo and others 1980; Heithaus 1981). Myrmecochory reduces the loss of seeds to predation and is the only mode of seed dispersal currently documented in the literature for bloodroot (Pudlo and others 1980). Ants are attracted to the lipid rich crest (elaiosome) attached to the seed coat and carry seeds to their nest where the elaiosome is consumed (Lobstein and Rockwood 1993). The intact seeds are discarded in or near the nest (Lobstein and Rockwood 1993) in a microhabitat that is free of inter-specific competition and is nutrient-enriched by ant activity (Hanzawa and others 1988). Lobstein and Rockwood (1993) found bloodroot seed germination to be significantly enhanced by the removal of the elaiosome: an effect not observed in other species. The removal of the elaiosome may serve as an environmental cue that the seed is in suitable habitat, scarify the seed coat to allow moisture into the seed, or may cause a chemical change in the seed coat (Lobstein and Rockwood 1993). However, the presence of ant species of sufficient size is essential (Schemske 1978; Pudlo and others 1980).

Large ant species in the genera *Formica* and *Aphaenogaster* are capable of moving bloodroot seeds 2 to 39 ft (0.6 to 12 m) (Pudlo and others 1980). In Massachusetts, Gates (1942) identified the ant species *Formica neogagates*, *Myrmica emeryana* and *Lasius americanus* (no common names assigned) as likely dispersers of bloodroot seeds due to their large size and behavior. The silky ant (*Formica fusca)* has been noted as a particularly effective seed disperser (Robertson 1897). Oak forests reportedly have rich assemblages of ant species (Gregg 1944); however, any ant species associated with bloodroot in Black Hills' oak forests have not been identified. The plant rapidly expands in response to disturbance via rhizomatous expansion and/or increased seed production to facilitate successful ant-dispersal into available habitats (Marino and others 1997).

The relative distributions and topographic positions of Black Hills bloodroot occurrences suggest that the seeds are dispersed by water to sites that do not appear to be accessible to ants. However, ants may have taken seeds to these sites when water levels were low. At one site in particular, bloodroot has colonized "litter piles" of woody debris that were wrapped around old stumps and shrubs by flooding below beaver dams. Water surrounded these "litter piles" at the time of observation (2000), and very few other forbs had colonized them. Also, a limited number of other plants had colonized the litter piles, but mature bloodroot plants in bloom were growing on them. These observations, and the recently disturbed and very open conditions at these sites suggest that the species is capable of functioning as an early seral species. It is possible that occurrences further upland or in lower order streams in the uppermost parts of the watersheds serve as a source of seed for repopulation of areas scoured by infrequent (100-year) flood events.

Bloodroot is an obligate mycorrhizal species that supports vesicular arbuscular mycorrhizal (VAM) fungi in its fine, lateral roots in exchange for enhanced nutrient absorption (Brundrett and Kendrick 1988). Bloodroot may possibly share belowground VAM mycorrhizal hyphae networks with hardwood tree species (Newman and Reddell 1988). Eastern deciduous forest forbs have been found to take advantage of existing belowground VAM hyphal networks associated with canopy tree species, where certain tree species may exert a strong influence on the distribution of VA mycorrhizal obligate herbaceous species (Newman and Reddell 1988). Throughout its range, bloodroot occurs in association with deciduous hardwood canopy trees that support VAM fungal associations, including eastern hophornbeam, sugar maple (*Acer sachharum*), and oak species (Brundrett and Kendrick 1988), but does not appear to have an obligatory association with any particular tree species. The VAM fungi commonly associated with the roots of eastern deciduous trees may facilitate the establishment and persistence of bloodroot in the Black Hills and elsewhere. Overall, bloodroot appears to be facultatively tied to hardwood forest habitats in the Black Hills and, range wide, the species' distribution closely parallels hophornbeam's (NatureServe 2001).

## Disturbance Ecology

In the northern and northeastern Black Hills, the presence of hardwood forest habitats with sufficient soil moisture appears to be the primary factor in bloodroot's distribution. Secondary factors that could affect its persistence in these habitats are the positive influence of beavers on local hydrology and microenvironments, of upland tree densities on water inputs into streams and, although poorly understood in the Black Hills at this time, the role of forest ants to bloodroot dispersal. Because the species is self-compatible, the presence of suitable insect pollinators is not essential for seed production (see Life History section above).

Bloodroot evolved in deciduous forest ecosystems, where infrequent tree fall creates small openings with increased light availability and microsites for colonization. Disjunct bloodroot occurrences in the Black Hills could possess unique adaptations to the more frequent and large-scale disturbances that occur here, such as flooding and fire. But in the absence of any evidence, we must assume that the species reproduces and responds to disturbance here as it does elsewhere. In the Black Hills, bloodroot's ability to colonize forest openings is probably limited by soil moisture and the presence of suitable ant species for seed dispersal, although it appears that floodwaters serve as an alternative dispersal mechanism at some sites.

The type and frequency of disturbance can affect the availability of soil nutrients or light in bloodroot habitats, and induce changes in species' vegetative growth and allocation to sexual reproduction (Marino and others 1997). Bloodroot appears to be strongly influenced by light conditions, which produce the patchy distribution pattern observed in populations throughout its range (Marino and others 1997). Marino and others (1997) found total leaf area (leaf size and leaf number) to increase with increased light and soil nutrient availability, while sexual reproduction was reduced or non-existent in low light settings. The species appears to rapidly respond to increased light availability caused by canopy gaps or larger scale disturbances through increased vegetative and clonal growth that results in high-density occurrences (Marino and others 1997; Schemske 1978). Also, Schemske (1978) found significantly greater sexual reproduction in bloodroot plants growing in high light versus low light conditions, as areas warmed by sunlight in early spring would attract pollinators. Increased light availability created by disturbance promotes both vegetative and sexual reproduction (Pudlo and others 1980), but it is not known if this response takes place immediately or in subsequent growing seasons (Marino and others 1997). Bloodroot's locally abundant distribution in the Black Hills is supported by these studies (Schemske 1978; Marino and others 1997), which indicate that bloodroot forms dense patches in response to increased light availability.

Historic land management and fire suppression have altered landscape-scale ecological processes and, thereby, the distribution and composition of bloodroot's habitats in the Black Hills. Hardwood forest and riparian habitats in the northern hills have likely been altered by impacts to drainages from road construction, invasive plant species, timber production, fire suppression, livestock use, and the historic mining of stream courses (Hoffman and Alexander 1987; Froiland 1990; Parrish and others 1996; Sieg and Wright 1996). Also, the extirpation of beaver from large portions of the Black Hills around the turn of the century has altered the hydrology, species richness, and structure of riparian habitats (Parrish and others 1996). At the present time, approximately 50 percent of riparian areas associated with streams and wetlands in the Black Hills are privately owned and are subject to development and agricultural use (USDA Forest Service 1996).

Bloodroot is reportedly capable of surviving "considerable disturbance and clearing" (Voss 1985) and appears to respond positively to small-scale disturbances in the Black Hills, such as short-term seasonal inundation and edge effects from beaver activity and tree removal. Disturbances that favor hardwood regeneration would benefit bloodroot by maintaining its forest habitats. In a Massachusetts study, bloodroot was one of the few forest herbs that was more abundant in secondary forest than undisturbed forest (Bellemare and others 2002). In this study, bloodroot thrived in the high light environments on the margins of agricultural fields, and thereby provided a proximate seed source for recolonization of secondary forest (Bellemare and others 2002). The species' ability to quickly expand into microsites with high light availability enables it to colonize small-scale disturbances and also to colonize refugia following large-scale or severe disturbances.

Fire was a major disturbance in the semi-arid, ponderosa pine-dominated environment of the Black Hills (Brown and Sieg 1996, 1999). Infrequent large-scale fires, frequent small-scale fires, seasonal flooding, and the mosaic of disturbance and succession created by beavers (Parrish and others 1996) have likely all influenced bloodroot's habitats in the Black Hills. However, since European settlement of the area (ca. 1874), the density of pine has increased due to a reduction in both fire frequency and extent (Covington and others 1994; Parrish and others 1996), and has resulted in a reduction in water yields (Stewart and Thilenius 1964).

Historically, beaver served a vital role in the creation and maintenance of Black Hills riparian ecosystems, particularly in the low-gradient drainages that support deciduous woody species (Parrish and others 1996). Beaver dams moderate stream flows and retain sediment, both of which result in the expansion of riparian areas (Munther 1981; Olson and Hubert 1994; Parrish and others 1996), however, their numbers have been reduced since settlement (Turner 1974) with a resultant reduction in riparian habitats.

Beaver influence bloodroot habitats primarily by facilitating the build up of floodplains. Beaver also create openings in streamside deciduous tree canopies and increase the amount of light that reaches understory forbs (Munther 1981). Over the long-term, beaver raise the water table and shape the local topography of drainage areas, thereby creating moist upland habitats for bloodroot and other moisture-loving plant species.

There is little evidence of recent flooding in bloodroot habitats in the Black Hills. Plants on beaver dams and flood plains can be destroyed by flooding, but plants on nearby terraces and uplands could serve as refugia from which flood plains could be recolonized. In addition, floodplain occurrences would serve as a source of propagules from which upland habitats could be recolonized following fire. This hypothesis explains both the current distribution and long-term persistence of bloodroot in the Black Hills despite relatively frequent, large-scale historic disturbances.

Bloodroot's distribution on beaver-created structures could be facilitated by seed-dispersing ants, flooding, or both. Its scattered distribution suggests that a viable seed dispersal mechanism exists. If bloodroot requires ants for the dispersal of its seeds in the Black Hills, impacts to the ant fauna caused by disturbance to the litter layer, debris, or its food sources could reduce or eliminate bloodroot occurrences. In the absence of seed dispersal by ants, bloodroot may not be able to disperse into even nearby available habitats. Over the long term, negative effects on the ant-seed mutualism could reduce or eliminate the plant's ability to respond to, or escape from periodic disturbances and stochastic events. Also, limited dispersal could reduce population fitness due to the resulting high density of clonal ramets and inbreeding depression (Marino and others 1997).

Ant seed dispersal can exert a strong influence on the density, dispersal and reproductive success of bloodroot populations by serving as an intermediary in the plant's response to disturbance (Pudlo and others 1980). However, studies in West Virginia and Illinois suggest that beaver activity, fire disturbance, and land management activities can disrupt the ant-seed interaction and significantly alter the structure and distribution of bloodroot populations and bloodroot's ability to respond to disturbance through seed dispersal (Pudlo and others 1980). Different types and degrees of disturbance may affect the ant-seed dispersal relationship in different ways. In Illinois, bloodroot occurred in lower densities and seeds were removed more frequently at sites with low levels of disturbance; while it occurred in high densities and large clonal clumps where the ant-seed mutualism had been disrupted (Pudlo and others 1980). This study suggests that the long-term consequences of the loss of ant seed dispersers are reduced sexual reproductive success, increased clonal growth, and a shift towards asexual reproduction and inbreeding depression (Pudlo and others 1980). However, high local plant densities have higher sexual reproductive efforts, presumably as an adaptive response to the increased intraspecific competition caused by clonal expansion (Pudlo and others 1980), which may increase the chances of seed dispersal, and thereby, escape from competition.

Overall, bloodroot's distribution in historically disturbed deciduous forests in the Black Hills and elsewhere suggests that it is able to respond to severe and large-scale disturbances, provided that suitable refugia are available. In the Black Hills, upland slopes and streamside terraces likely provide refugia from flooding, while drainage bottoms and beaver-created structures provide refugia from upland fires. The close proximity of upland and bottomland concentrations at many sites supports this hypothesis, since each would serve as a source of seed for recolonization of the other following disturbance.

## Key Risk Factors

Bloodroot's habitats are vulnerable to invasion by noxious and invasive plants, and herbicide treatment of invasive species could be detrimental as well (Lorimer 2001). Eight of 11 bloodroot sites visited in 2001 have exotic invasive species. Canada thistle (*Cirsium arvense*) was present at one site, houndstongue (*Cynoglossum officinale*) at five sites, and tansy (*Tanacetum vulgare*) was noted at three bloodroot locations. In addition, spotted knapweed (*Centaurea maculosa*), Dalmatian toadflax (*Linaria dalmatica*), and lesser burdock (*Arctium minus*) occur on uplands above bloodroot at one location (South Dakota Natural Heritage Program Records). The close proximity of many of the bloodroot sites to roads makes them particularly vulnerable to invasion by designated noxious species and other exotic plants.

Bloodroot is not a fire-adapted species. Its origins are in eastern deciduous forests where the primary form of disturbance is infrequent canopy gaps created by tree fall (Runkle 1985). In the Black Hills, the long-term successional development of hardwood forest habitats is generally facilitated by infrequent fire that reduces conifer encroachment. However, the hophornbeam forest communities which bloodroot is associated with develop within bur oak communities in the absence of fire. Therefore, fire likely affect bloodroot and its habitats in the Black Hills in the short-term by killing hophornbeam and bloodroot plants. However, in the long-term, high-intensity fires function to regenerate fire-adapted species such as bur oak and aspen, and have the potential to enhance soil moisture by reducing tree densities on uplands (Wright and Bailey 1982).

Historic fire suppression and management for pine production in the Black Hills have significantly altered the distribution and character of riparian, hardwood and spruce boreal forests (Parrish and others 1996), and have increased the risk of catastrophic fire due to the increased density of conifers in uplands. Before European settlement, spruce was likely less abundant and hardwood forests and beaver-created riparian areas more widespread (Parrish and others 1996; USDA Forest Service 1996). Large-scale, stand-replacing fires are a risk to extant bloodroot occurrences and the hophornbeam hardwood forests they occur in. Sites adjacent to continuous, dense stands of highly flammable conifers are particularly vulnerable. Further, stand-replacing fires have the potential to deposit large amounts of sediment into riparian habitats, remove canopy cover, and kill individual bloodroot plants. Therefore, intense wildfire could extirpate existing sites and reduce the amount of hophornbeam habitats, but where fire enhances the development of suitable hardwood habitats and bloodroot seeds or rhizomes are present, the species can recolonize the area.

As an eastern deciduous species, it is doubtful that bloodroot evolved with grazing or fire (Lorimer 2001), but as described in the Habitat Relationship section above, it responds favorably to small-scale disturbance. The plant may persist with livestock and wildlife use, as it is poisonous and presumably unattractive as forage, although livestock and wildlife trampling could damage bloodroots' shallow, succulent rhizomes. In the Black Hills, the moist upper terraces and footslopes adjacent to riparian areas where bloodroot occurs are susceptible to concentrated livestock use. However, bloodroot is also concentrated in impenetrable wooded thickets, as evidenced by survey information. But it is not known whether or not bloodroot's concentration in thickets at some sites is due to livestock activity or habitat preference. At this time, nine bloodroot occurrences are within vacant grazing allotments in the Black Hills. Further, the 2001 survey noted little sign of grazing activity at bloodroot locations in active grazing allotments. Based upon the current levels of livestock use, the number of locations where the species occurs, and the large numbers of plants at individual sites (table 1), the persistence of bloodroot occurrences in the Black Hills is not at risk from livestock grazing at some locations. However, a general statement of risk from livestock use is difficult to make, because the amount of livestock use and the conditions at the sites are variable. Also, impacts later in the season could be greater, depending upon site accessibility, as upland vegetation dries out and grazing activity can become increasingly concentrated in riparian habitats.

To date, no evidence of disease or browsing by any species has been noted in the Black Hills bloodroot population. In bloodroot's eastern habitats, white-tailed deer *(Odocoileus virginianus)* selectively browse the plant and can be detrimental to sparsely distributed occurrences in fragmented deciduous forests (Augustine and Jordan 1998), but there is no indication that this is a risk to the species here. Also, reproduction may be suppressed by direct removal of the inflorescence or leaf and flower buds, or by reduction in belowground energy reserves (Rockwood and Lobstein 1994). In a study in the eastern United States, Rockwood and Lobstein (1994) noted extensive defoliation of bloodroot plants by deer and groundhogs (*Marmota monax*) that nearly eliminated reproduction in both current and subsequent seasons. Because of the species' limited distribution, low palatability, and unusual habitats in the Black Hills, it could be either isolated from, or more susceptible to wildlife use, insects and disease. However, there is no evidence of any impacts to bloodroot by wildlife, insects or disease in the Black Hills at this time.

Bloodroot occurrences in the Black Hills National Forest are unlikely to be impacted from timber harvesting activities. National Environmental Policy Act of 1969 [42 U.S.C. 4321 (note)] (NEPA) analyses for proposed timber harvesting include an assessment of known locations of designated sensitive species such as bloodroot. Known sites will be avoided to the extent possible unless the harvesting is designed to enhance bloodroot habitat (that is, removal of invading conifers). Indirect effects are possible where harvesting occurs in adjacent uplands, but these would be mostly limited to those from road building and decking activities and not directly due to tree removal, particularly when trees are harvested over snow. Even if timber is harvested on adjacent uplands on some sites, it is highly unlikely that all occurrences of bloodroot would be impacted. Furthermore, conifer removal from uplands adjacent to known bloodroot sites would likely benefit the species by opening the canopy and increasing water flow into drainages. These effects would likely enhance bloodroot's habitats in the long-term by improving local hydrology and hardwood regeneration, and could also provide open areas for colonization in the short-term.

While livestock grazing, road building and timber harvest may impact individuals, the extent of those impacts do not appear to be either acute or widespread and no notable impacts were documented at any of the 11 sites visited in 2001. Introduction of invasive and noxious plant species is a greater risk to the persistence of bloodroot in the Black Hills. Activities that facilitate the introduction and establishment of invasive plant species into bloodroot's limited habitats in the Black Hills, particularly road-building, are the primary risk to the species.

Throughout the eastern portions of its range, bloodroot is collected from the wild for sale as an herbal medicine. In some areas populations are in decline due to over-collection (see Current Conservation Situation section). Although there is no evidence of collection on Black Hills National Forest to date, the commercial value of the plant, and its local abundance in the Black Hills, makes it vulnerable to exploitation.

# CONSERVATION PRACTICES

## Management Practices

All currently known bloodroot occurrences on lands administered by the Black Hills National Forest are in the Northern Hills and Mystic Ranger Districts (USDA Forest Service 1996). Several of the designated "core" bloodroot locations occur in vacant grazing allotments where potential future impacts from livestock trampling are unlikely. The northern to northeastern portion of the Black Hills has a complex land ownership pattern, with many of the drainage areas in private ownership. Bloodroot occurrences are known to exist on private lands, and potential habitats are likely present on private lands as well. However, the distribution and abundance of bloodroot on private land is unknown.

Under current direction, management that would favor spruce or pine retention where bloodroot occurs in the northern Black Hills could have long-term effects on its habitats and long-term persistence. Management that protects and expands spruce or pine habitat could limit fire-induced regeneration of birch and hardwoods that are important components of bloodroot habitats and important food sources for beavers. Removal of conifers from the uplands surrounding known bloodroot locations would likely favor the species' existing habitats by increased water flow into drainages and would promote hardwood regeneration and thereby increase potential habitats.

Detection and control of invasive exotic plants have been identified as a conservation need for bloodroot occurrences in the Black Hills (USDA Forest Service 2000b). In order to minimize impacts from invasive and noxious plant treatments, attempts are being made to detect invasive species in and adjacent to bloodroot sites as early as possible and treat individual plants where feasible.

## Conservation Measures

Conserving currently known bloodroot occurrences will likely benefit the species' odds of persisting in the Black Hills. The fact that populations on National Forest land are dispersed across numerous separate watersheds greatly limits the likelihood of all populations being impacted by a single catastrophe, such as a large-scale wildfire or disease outbreak. The discovery of additional populations is likely, given that potential habitat remains to be surveyed. The Nature Conservancy (TNC) has identified several bloodroot occurrences as secondary targets for conservation in its ecoregional conservation plan for the Black Hills (Hall and others 2002). Seed collection, with seed stored in certified repositories, could preserve any unique genetic characteristics, but at this time artificial propagation is not warranted

## Survey, Inventory, And Monitoring Approach

The bloodroot metapopulation in the Black Hills consists of 22 occurrences. These occurrences range from five to over 1,000 individuals, and are scattered throughout the northeastern Black Hills in suitable habitat. Metapopulation analyses focus on identifying habitat patches that are thought to be critical to the maintenance of the metapopulation (Meffe and others 1997). "Core" occurrences are intended to provide a substantial, reliable seed source for establishment and reestablishment of the species in adjacent suitable habitats (= the "rescue effect" of the core occurrences). As such, the persistence of these core occurrences is central to maintaining the metapopulation. Smaller occurrences are less stable than the core occurrences, and those that are near core occurrences may be reestablished by seed dispersal from core occurrences. These smaller occurrences may also allow for expansion of the bloodroot metapopulation in favorable years, and provide experimental opportunities for habitat enhancement or recovery purposes.

The most recent data available were used in developing proposed monitoring guidelines for the Black Hills National Forest. "Core" bloodroot occurrences were proposed using four criteria: size (estimated number of individuals), geographic distribution of the occurrence, potential risk from livestock grazing, and community type. Thus, the largest estimated number of individuals observed at a given site was a primary factor used in delineating potential core occurrences. To incorporate geographic distribution, sites widely distributed from one another were selected over sites in close proximity to other occurrences. Sites in allotments currently not being grazed were selected over sites grazed by livestock. Finally, the selection of core sites included at least one in each community type (table 3). Based on these criteria, 11 core occurrences were proposed (table 1). Of these 11 occurrences, four were designated as "key," that is, occurrences of over 1,000 individuals deemed most critical to maintaining the bloodroot metapopulation on the Black Hills National Forest.

The proposed monitoring design involves assessing the status of the four "key" core occurrences on annual basis. The monitoring should address three questions: 1) is the species present, 2) is there evidence of plant collecting, and 3) have invasive plant species invaded the site? Although the proposed monitoring focuses on the presence or absence of a given occurrence, a categorical estimate of each occurrence will also be recorded. Bloodroot is most observable in April, when plants are likely to be blooming and other understory plants have yet to emerge. If bloodroot is absent at a "key" site, additional core sites will be surveyed for bloodroot until a site supporting bloodroot can be found. If necessary, all 11 designated "core" sites will be surveyed.

The second aspect of the proposed monitoring plan is designed to provide baseline data on the extent of bloodroot occurrences on all 11 designated "core" sites and a reassessment of the status of each occurrence during a drought year. Our assumption is that the high numbers of plants observed in 2001 were partially the result of several years of above-average precipitation. By documenting the size and extent of bloodroot occurrences during dry years, we hope to have a better understanding of the role that precipitation levels play in the distribution and abundance of bloodroot. Any changes in the occurrence boundaries, evidence of plant collection or the presence of invasive or noxious plant species will be documented at the time of follow-up surveys.

The third aspect of the proposed monitoring plan is to assess any additional changes in the extent of bloodroot occurrences following a second consecutive dry, or below-average precipitation year. Information on the extent and change of bloodroot occurrences following two drought years is critical to consider in reassessing the monitoring strategy. Information on the extent of occurrences in both wet and dry years will provide valuable data for re-examining, and potentially changing, the proposed monitoring plan.

## CONCLUSIONS AND INFORMATION NEEDS

Bloodroot is currently considered to be relatively secure in the Black Hills, based on the large number of occurrences (22) – several of which are estimated at over 1,000 individuals. However, the concern is that bloodroot's abundance and distribution may fluctuate in response to precipitation, and therefore the high numbers and multiple occurrences observed in 2000 and 2001 are the result of higher than average moisture in the Black Hills in recent years (NOAA 1996-2001). Therefore, baseline data on bloodroot numbers and distributions in dry years, as proposed in the monitoring strategy, could provide information needed to help understand the species' response to climatic changes. There is also a need to determine how to manage exotic invasive species in bloodroot habitats, if beaver can be introduced to enhance bloodroot habitat in the Black Hills, and if a combination of timber harvest and prescribed burning can be used to enhance soil moisture conditions necessary for bloodroot's persistence.

Finally, many aspects of the genetic makeup and life history attributes of bloodroot are unknown. Is the Black Hills' bloodroot population genetically similar to eastern bloodroot populations? How much genetic diversity exists within and between Black Hills occurrences? What species of ants are dispersing bloodroot seeds, and what are their habitat needs? Does flooding also play a role in dispersing seeds? How long do the seeds remain viable in the soil? What insect species function as pollinators? This basic information on life history attributes, in addition to an understanding of bloodroot's habitat needs, is critical to management for this species persistence in the Black Hills.

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# APPENDICES

**Appendix A.** Regional ranking process for bloodroot, *Sanguinaria canadensis* L.

The status of bloodroot, as a designated R2 Sensitive Plant Species, differs from other Sensitive plant species in the Black Hills: which merit status on the list due to their rarity or specific association with a limited habitat component. When species were evaluated in 1990 (Marriott and others1990), limited information was available for bloodroot, which is quite common in terms of global rarity (G5). The species' South Dakota state rank was S4, but only because it is known from both the eastern portion of the state and the Black Hills. Also, ranking information for this species from 1990 (Marriott and others 1990; South Dakota Natural Heritage Program Records) indicated that this species was rare and disjunct in Region 2, currently known occurrences were small, and habitat loss and downward trend were strongly suspected. This led to the species inclusion on the Rocky Mountain Region Regional Forester's Sensitive Species List in 1993 (Forest Service Manual Interim Directive 2600-93-1) (USDA Forest Service 1993).

Bloodroot's evaluation in 2000 used the same criteria that were used in 1990 and are the same criteria currently found in the Forest Service directive system for Region 2 (Forest Service Manual Title 2600) (USDA Forest Service 1994). The species' 2000 rank (Ode and others 2000) considered region-wide rarity (eastern Wyoming, western South Dakota and Nebraska, and Colorado), as well as increases in the number of known occurrences and average occurrence size, due to the discovery of numerous new locations, including several with 1000 or more individuals stems or clumps. However, the rankings for ecological amplitude, habitat loss and downward trend for these new sites resulted in little change in the overall ranks assigned in 1990 (Marriott 1990) and 2000 (Ode and others 2000).

Bloodroot's "downward trend" ranking reflects that changes from historic conditions in the Black Hills (Parrish and others 1996) have typically not been positive for the species (Ode and others 2000), and a downward trend over historic conditions is considered likely. Although some of the rankings changed between the 1990 and 2000 scorecards, the 2000 ranking still indicated that bloodroot, primarily due to its limited habitat, continued to merit status on the R2 Sensitive Species list based on the Region 2 Sensitive species identification process (Forest Service Manual Title 2600) (USDA Forest Service 1994).

**Appendix B.** Technical description of bloodroot, *Sanguinaria canadensis* L.

"Bloodroot. Sepals 2; petals 8, or up to 16; ovary narrowed above to a short style terminated by a capitate, 2-lobed stigma; placentas 2; capsule fusiform, crowned by the persistent style, dehiscent from the base upwards by elongate valves; seeds arillate; perennial herb with red juice, from a stout rhizome that sends up a single, lobed leaf and a large, white flower on a scape. Monotypic. *Sanguinaria canadensis* L. Leaf orbicular in outline, sometimes 8 inches (2 dm) wide at maturity, 3 to 9 lobed, the lobes undulate to coarsely toothed; scape 2 to 6 inches (5 to 15 cm) at anthesis; flowers without nectar, white (pink), ¾ to 2 inches (2 to 5 cm) wide; 4 petals usually longer than the others and the flowers quadrangular in outline; fruit 1¼ to 2 inches (3 to 5 cm)." (Gleason and Cronquist 1991).

**Appendix C.** Climate summaries for bloodroot occurrences, Black Hills National Forest (compiled from the High Plains Regional Climate Center 2001).

Average temperature extremes, annual precipitation and total snowfall at the climate stations in closest proximity to Black Hills bloodroot occurrences are given in the table below.

The closest climate stations to most of the known bloodroot occurrences in the Black Hills are the Deadwood and Lead Climate Stations west of the sites, and the Fort Meade Climate Station to the northeast of the sites, based upon the 11 sites visited in 2001. One occurrence occurs roughly 2 mi (3.2 km) immediately north of Deadwood and occurrences are scattered east and southeast of Lead to 5 mi (8 km) west of Fort Meade. There is also a occurrence between Lead and Spearfish, so the Spearfish Climate Station is included here as well. For the four climate stations, precipitation is concentrated in the months of April, May and June.

**Climate summary for bloodroot occurrences, 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 |
|---|---|---|---|---|---|
| **Lead** | 1948-2000 | 14º F (-10º C) | 79.5º F (26.4º C) | 29 inches (73.7 cm) | 169.3 inches (430 cm) |
| **Deadwood** | 1948-2000 | 10.8º F (-11.8º C) | 81.4º F (27.4º C) | 27.9 inches (70.9 cm) | 111.8 inches (284 cm) |
| **Fort Meade** | 1949-2000 | 12.4º F (-10.9º C) | 86.4º F (30.2º C) | 20.1 inches (51 cm) | 35.4 inches (89.9 cm) |
| **Spearfish** | 1948-2000 | 12.9º F (-10.6º C) | 85º F (29.4º C) | 21.2 inches (53.8 cm) | 59.8 inches (151.9 cm) |

# FIGURES

**Figure 1.** North American distribution of bloodroot, *Sanguinaria canadensis* L. (Flora of North America Editorial Committee 1993).

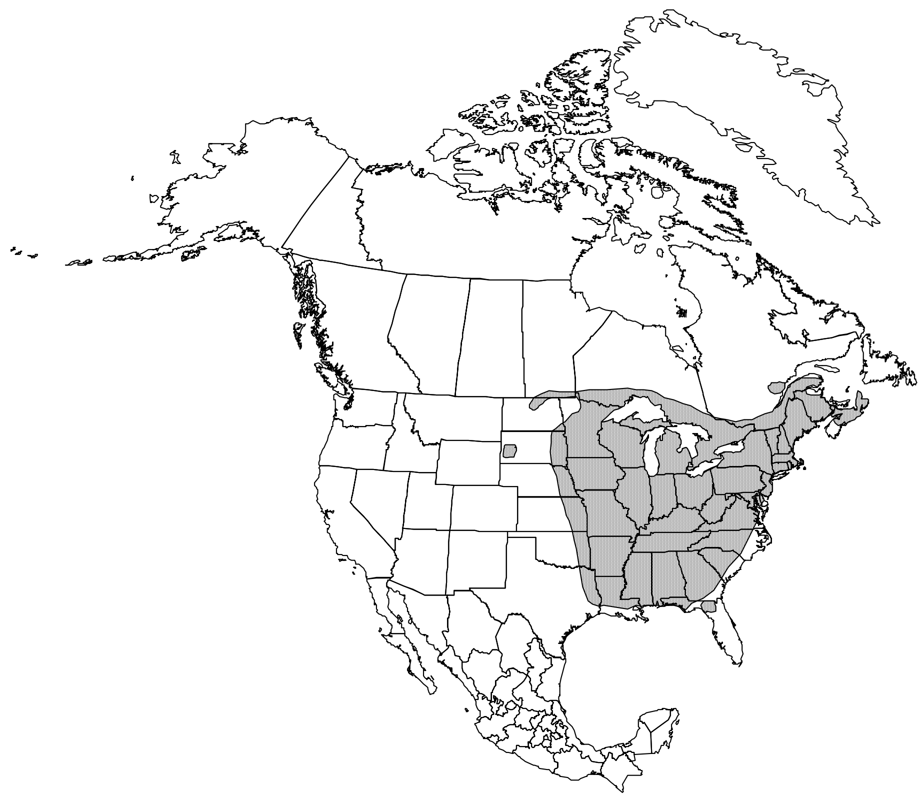

**Figure 2.** Black Hills National Forest distribution of bloodroot, *Sanguinaria canadensis*.

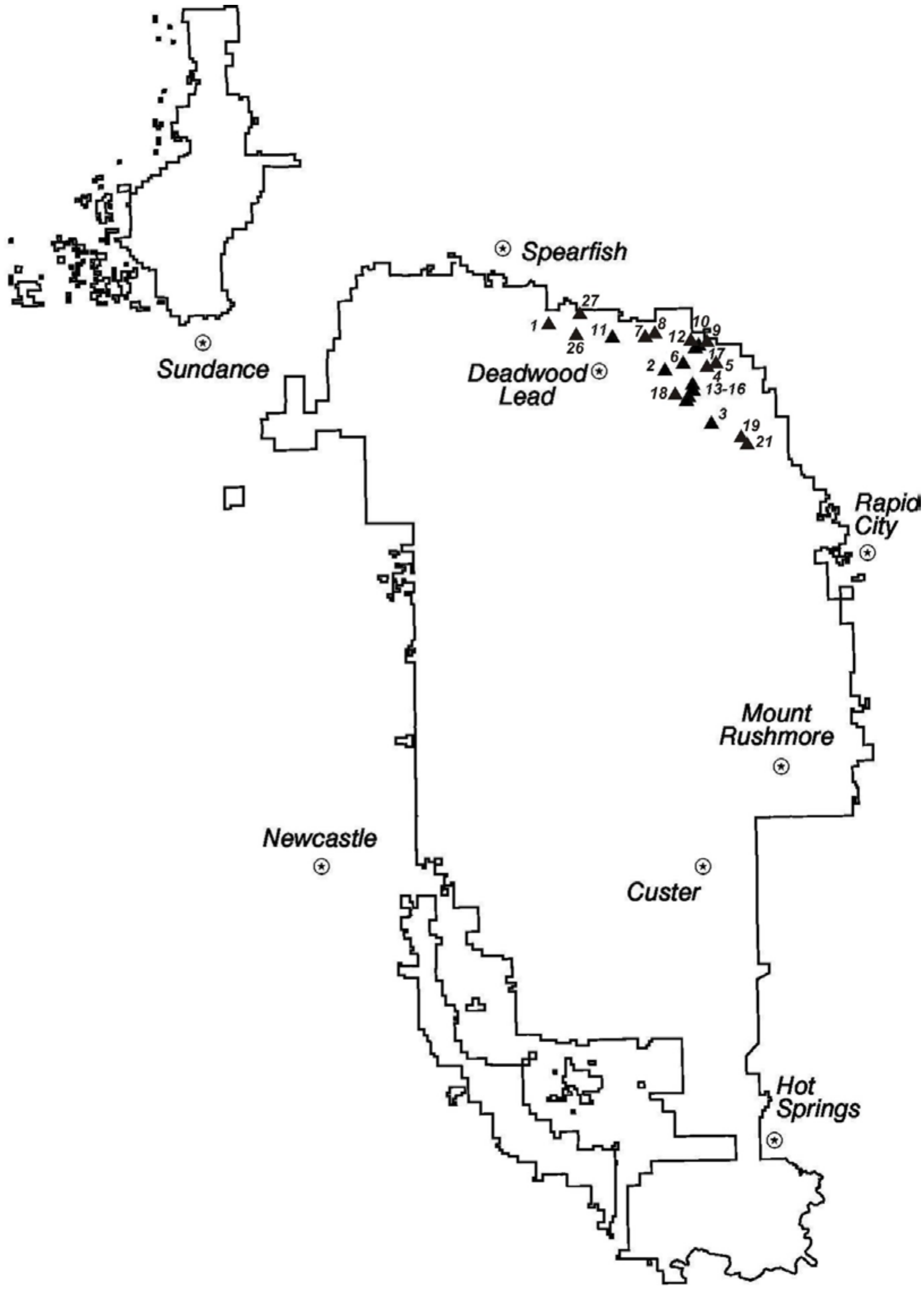

**Figure 3.** Illustration of bloodroot, *Sanguinaria canadensis* (Laura Vogel In Holmgren 1998)

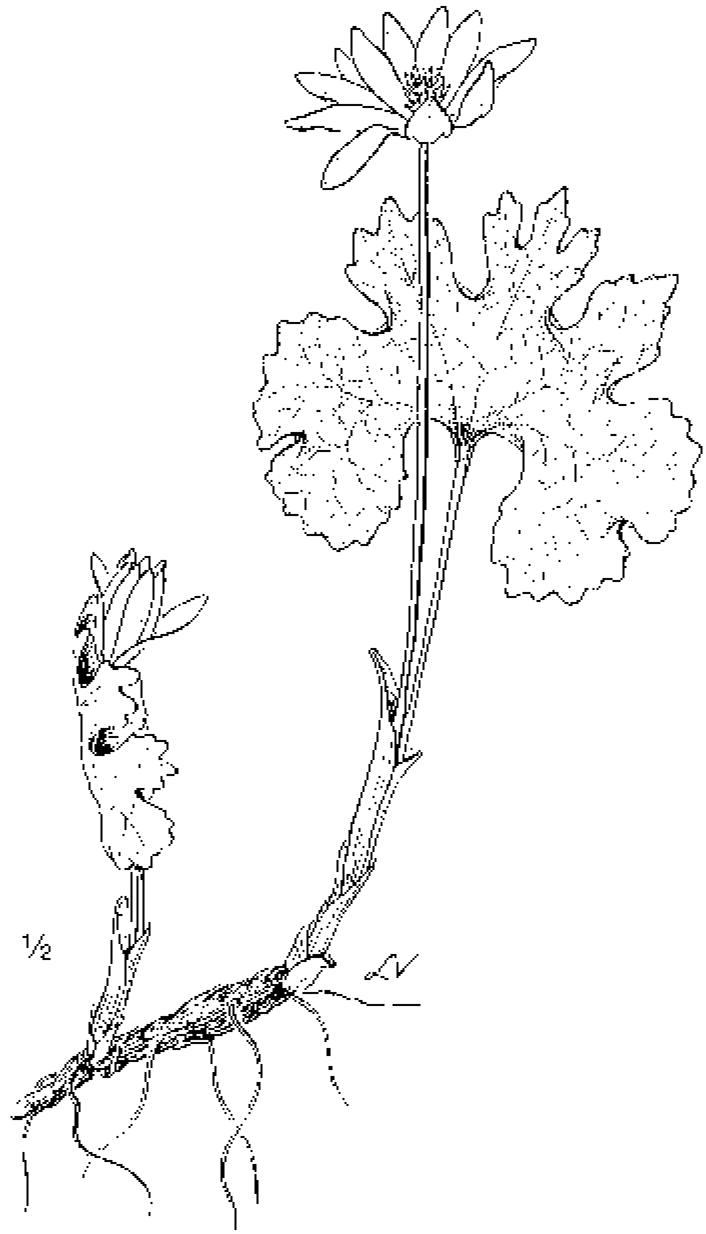

**Figure 4.** Bloodroot habitat in Black Hills National Forest (photograph, Bacon 2001).

**Figure 5.** Bloodroot concentration in Black Hills National Forest (photograph, Crook 2002).

**Table 1.** Known occurrences of *Sanguinaria canadensis* in the Black Hills National Forest, date last observed and estimated number of individuals present at last observation. Sites 1 through 10 and 14 are designated "core" occurrences; sites 1, 2, 3 and 14 are key occurrences for annual monitoring.

| Occurrence No. | Date last observed | Estimated number of individuals |
|---|---|---|
| 1*[k c] | 5/7/01 | 1001 - 10000 |
| 2*[k c] | 5/3/01 | 1001 – 10000 |
| 3[k c] | 5/2/01 | 1001 – 10000 |
| 4*[c] | 6/5/93 | ? |
| 5*[c] | 5/25/93 | >200 |
| 6*[c] | 5/9/01 | 1001-10000 |
| 7*[c] | 5/15/94 | 51-100 |
| 8*[c] | 5/18/94 | <10, not relocated to date. |
| 9*[c] | 5/12/93 | >200 |
| 10[c] | 6/14/94 | >501-1000 |
| 11* | 5/9/01 | 501-1000 |
| 12 | 5/14/01 | 1001 – 10000 |
| 13 | 5/15/01 | 1001 – 10000 |
| 14[k] | 4/30/01 | 1001 – 10000 |
| 15 | 5/8/01 | 101-1000 |
| 16 | 5/2/01 | 1001 – 10000 |
| 17 | 5/15/01 | >5000 |
| 18 | 6/6/94 | Not relocated in 2001 |
| 19 | 8/19/93 | 500-1000 |
| 21 | 8/4/95 | >100 |
| 26 | 8/24/90 | 11 |
| 27 | 6/12/90 | 25; not revisited to date due to extremely limited access. |

* Occurs in an allotment that is currently not being grazed

[k] Key site for annual monitoring

[c] Designated "core" site

**Table 2.** Conservation rankings of *Sanguinaria canadensis* in North America (NatureServe 2001).

| State/Province | Rank | Definition |
|---|---|---|
| Texas | S1S2 | Critically imperiled due to extreme rarity/Imperiled. |
| Louisiana | S2 | Imperiled. |
| Manitoba | S2 | Imperiled. |
| Rhode Island | S2 | Imperiled. |
| Nova Scotia | S3S4 | Apparently secure to vulnerable. |
| Iowa | S4 | Apparently secure. |
| South Dakota | S4? | Apparently secure? |
| New Jersey | S4S5 | Secure to apparently secure. |
| Nebraska | S5 | Secure. |
| North Carolina | S5 | Secure. |
| Ontario | S5 | Demonstrably widespread, abundant and secure. |
| Alabama | SR | Reported. |
| Arkansas | SR | Reported. |
| Connecticut | SR | Reported. |
| Florida | SR | Reported. |
| Georgia | SR | Reported. |
| Indiana | SR | Reported. |
| Kansas | SR | Reported |
| Maine | SR | Reported. |
| Maryland | SR | Reported. |
| Massachusetts | SR | Reported. |
| Minnesota | SR | Reported. |
| Mississippi | SR | Reported. |
| Missouri | SR | Reported. |
| New Brunswick | SR | Reported. |
| New Hampshire | SR | Reported. |

| State/Province | Rank | Definition |
|---|---|---|
| North Dakota | SR | Reported. |
| Ohio | SR | Reported. |
| Oklahoma | SR | Reported. |
| South Carolina | SR | Reported. |
| Tennessee | SR | Reported. |
| Vermont | SR | Reported. |
| Virginia | SR | Reported. |
| Wisconsin | SR | Reported. |
| Illinois | S? | Unranked. |
| Kentucky | S? | Unranked. |
| Michigan | S? | Unranked. |
| New York | S? | Unranked. |
| Pennsylvania | S? | Unranked. |
| West Virginia | S? | Unranked. |
| Delaware | S? | Unranked. |
| District of Columbia | S? | Unranked. |
| Quebec | S? | Unranked. |

**Table 3.** Community types (Marriott and Faber-Langendoen 2000a) of selected sites supporting bloodroot in the Black Hills.

| **Community Type** | **Site number** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **6** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| **Bur oak-ironwood forest** | X | X | | X | X | X | X | X | | | X |
| **Black hawthorne shrubland** | | | X | | | | | | | X | |
| **Paper birch/hazel forest** | | | | X | X | | X | X | X | | |

**Table 4.** Bloodroot, *Sanguinaria canadensis*, species associates, Black Hills National Forest from sites surveyed in May 2001.

| Scientific Name | Common Name | No. Sites |
|---|---|---|
| *Acer negundo* | Box elder | 2 |
| *Achillea millefolium* | Common yarrow | 2 |
| *Agrimonia sp.* | Agrimony | 2 |
| *Amelanchier sp.* | Serviceberry | 2 |
| *Amelanchier alnifolia* | Serviceberry | 1 |
| *Antennaria sp.* | Pussy toes | 1 |
| *Aralia nudicaulis*[a] | Sarsaparilla | 1 |
| *Arnica sp.* | Arnica | 4 |
| *Arnica cordifolia* | Heart-leaved arnica | 3 |
| *Betula occidentalis* | Water birch | 1 |
| *Betula papyrifera* | Paper birch | 2 |
| *Carex sp.* | Sedge | 5 |
| *Carex pedunculata* | Peduncled sedge | 1 |
| *Cirsium arvense* | Canada thistle | 1 |
| *Cornus canadensis* | Bunch berry | 1 |
| *Cornus sericea* | Red-osier dogwood | 1 |
| *Corylus cornuta* | Beaked hazelnut | 9 |
| *Crataegus chrysocarpa* | Hawthorn | 4 |
| *Cynoglossum officinale*[d] | Hounds tongue | 6 |
| *Disporum trachycarpum*[b] | Fairybells | 1 |
| *Dodecatheon pulchellum* | Shooting star | 1 |
| *Fragaria virginiana* | Wild strawberry | 7 |
| *Galium sp.* | Bedstraw | 4 |
| *Geranium sp.* | Wild geranium | 3 |
| *Goodyera oblongifolia*[b] | Western rattlesnake plantain | 1 |
| *Hieracium sp.* | Hawkweed | 2 |
| *Juniperus communis* | Common juniper | 2 |

| Scientific Name | Common Name | No. Sites |
|---|---|---|
| *Lathyrus sp.* | Pea | 2 |
| *Lathyrus ochroleucus*[a] | White pea | 1 |
| *Lithophragma parviflorum*[b] | Small-flowered star | 1 |
| *Lonicera dioica* | Honeysuckle | 1 |
| *Lupinus sp.* | Lupine | 1 |
| *Lycopodium dendroideum*[c] | Tree-like clubmoss | 1 |
| *Mahonia repens* | Oregon grape | 11 |
| *Maianthemum canadensis* | Canada mayflower | 2 |
| *Maianthemum stellatum* | Starry false lily of the valley | 5 |
| *Mertensia sp.* | Bluebells | 1 |
| *Monarda fistulosa* | Wild bergamot | 2 |
| *Oryzopsis asperifolia* | Wild licorice | 3 |
| *Osmorhiza sp.* | Sweet cicely | 2 |
| *Ostrya virginiana* | Hophornbeam | 7 |
| *Picea glauca var. densata* | Black Hills white spruce | 4 |
| *Pinus ponderosa* | Ponderosa pine | 10 |
| *Populus tremuloides* | Quaking aspen | 8 |
| *Prunus americana* | Wild plum | 2 |
| *Prunus virginiana* | Choke-cherry | 6 |
| *Pyrola sp.* | Wintergreen | 1 |
| *Quercus macrocarpa* | Bur oak | 7 |
| *Ribes sp.* | Gooseberry | 6 |
| *Rubus sp.* | Blackberry | 3 |
| *Sanicula sp.* | Snakeroot | 2 |
| *Spiraea sp.* | Spiraea | 1 |
| *Spiraea betulifolia* | Birch leaved spiraea | 1 |
| *Symphoricarpus sp.* | Snowberry | 4 |
| *Tanacetum vulgare*[d] | Tansy | 2 |

| Scientific Name | Common Name | No. Sites |
|---|---|---|
| *Taraxacum officinale* | Dandelion | 7 |
| *Thalictrum sp.* | Meadow rue | 9 |
| *Trifolium sp.* | Clovers | 2 |
| *Viola sp.* | Violets | 1 |

[a] S2 (Imperiled due to rarity) in Wyoming

[b] S3 (Vulnerable) in Wyoming

[c] S1 (Critically imperiled due to extreme rarity) in Wyoming

[d] Introduced plant species