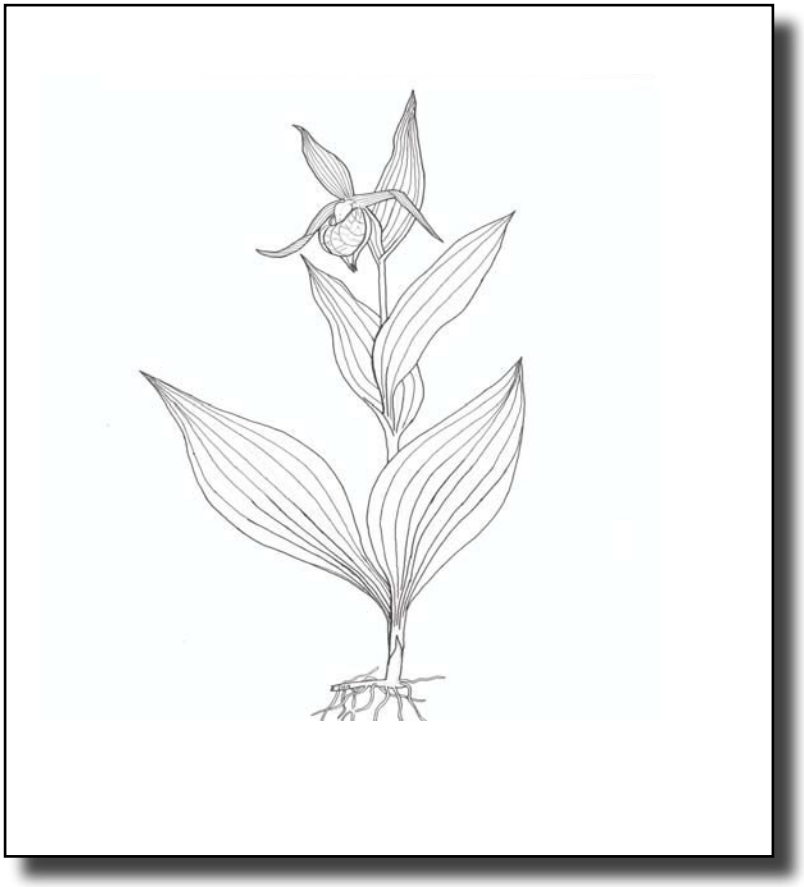
Cypripedium parviflorum Salisb. (lesser yellow lady's slipper): A Technical Conservation Assessment



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Acknowledgments

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Author's Biography

Daryl E. Mergen served in the U.S. Navy for a period of five years and was Honorably Discharged in 1982. After his military service Daryl attended Black Hills State College and graduated with his B.S. in science in 1985. Then he began studies at Fort Hays State University in Hays, KS and completed his Masters degree in the summer of 1991. Daryl was temporarily employed with the USDA Forest Service Ranger District in Spearfish, SD and at the Rocky Mountain Forest and Range Experiment Station in Rapid City, SD. In 1992, Daryl began studies at Colorado State University to pursue a Ph.D. in Rangeland Ecosystem Sciences in Fort Collins, CO. After three years of class work and fieldwork on his dissertation, he was hired as a plant ecologist for a private consulting firm in Boulder, CO. While employed with the consulting company, he completed his dissertation and graduated in 1998 from Colorado State University with a Ph.D. After graduating, Daryl resigned from his consulting position, married, moved to Colorado Springs, CO and started his own consulting company called Mergen Ecological Delineations, Inc. Much of his work has been plant surveys for the USDA Forest Service in Minnesota and the Black Hills, rangeland inventories, wetland delineations, vegetation mapping, developing habitat classification and monitoring systems for national grasslands and mining companies, and working with USDA Forest Service personnel on a riparian monitoring project for the Pike and San Isabel National Forest. He is also currently the Wildlife manager for The Corley Mountain Ranch.

Cover Photo Credit

Illustration of *Cypripedium parviflorum* drawn by author.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *CYPRIPEDIUM PARVIFLORUM*

Status

Cypripedium parviflorum Salisb. (lesser yellow lady's slipper) is an endemic of North America, with reported locations in all five states of the USDA Forest Service (USFS) Rocky Mountain Region. It is not listed as threatened or endangered, or as a species proposed for listing by the U.S. Fish and Wildlife Service, but it is listed by the USFS as a Region 2 sensitive plant species. NatureServe Global ranking is G5 indicating that it is demonstrably secure. State Natural Heritage Programs for Colorado, Kansas, Nebraska, South Dakota, and Wyoming rank *C. parviflorum* as imperiled (S2), vulnerable (S3), critically imperiled (S1), vulnerable but uncertain (S3?), and between imperiled and critically imperiled (S1S2), respectively. There are no data to quantify population trend in Region 2.

Primary Threats

Plant collecting, timber harvest, road construction, grazing, and all other activities that cause habitat loss are probably the greatest risks to *Cypripedium parviflorum*. Some management activities, such as plant collecting and livestock grazing, may cause direct damage to plants while other activities indirectly impact plants by altering their habitat. Most management activities, like recreation, weed control, fire suppression, mining, fuelwood harvest, and prescribed fires, may kill individual plants or change the habitat beyond a threshold that *C. parviflorum* can survive. Environmental risks to this species include drought, flooding, and wildfire.

Cypripedium parviflorum is suspected of requiring habitat other than climax for survival. Therefore, the same activities that may be viewed as a risk to *C. parviflorum* may also provide a change in its environment that may be beneficial up to some threshold, and then become detrimental. All risks may impact the different stages of the orchid life cycle at various intensities. Because *C. parviflorum* often occupies small areas, one small, spatially-isolated disturbance event could possibly destroy all reproducing plants. The amount of light and competition from other plants appear to have a negative influence on the number of *C. parviflorum* plants in an area. The optimum amount of light, level of competition, or any other specific requirements for *C. parviflorum* are unknown.

Primary Conservation Elements, Management Implications and Considerations

Cypripedium parviflorum is a long-living perennial that is restricted to calcareous derived soils. It is often associated with moist to saturated soils, but it may also be found in dry soils. This species is associated with many different plant communities, elevations, and aspects. The *C. parviflorum* life cycle is associated with mycorrhizal fungi, which are required for the survival of seedlings. Very little information is known about the ecology or biology of *C. parviflorum*, and less is known about the mycorrhizal fungi. The geographic distribution of sites makes extinction of this species unlikely from a single management activity or catastrophic event. More surveys of *C. parviflorum* habitat and monitoring will aid in determining its distribution, demography, and life history characteristics. Although no management or monitoring plans have been prepared for this species, its designation as a USFS Region 2 sensitive plant requires managers to consider how projects will impact local occurrences (populations).

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INTRODUCTION

This assessment is one of many being prepared to support the Species Conservation Project for the Rocky Mountain Region (Region 2), USDA Forest Service (USFS). *Cypripedium parviflorum* (lesser yellow lady's slipper) is the focus of an assessment because it is listed as a sensitive species in Region 2. Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as concern by a Regional Forester because of significant current or predicted downward trends in abundance or in habitat capability that would reduce its distribution (FSM 2672.11 2005). A sensitive species may require special management, so knowledge of its biology and ecology is required.

This assessment addresses the biology of *Cypripedium parviflorum* throughout its range in Region 2. The broad nature of the assessment leads to some constraints on the specificity of information for particular locales. This introduction outlines the goals and scope of the assessment and describes the process used in its production.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, and conservation status of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, and outlines information needs. While the assessment does not provide management recommendations, it does focus on the consequences of changes in the environment that may result from management or natural causes. Management recommendations proposed elsewhere are discussed in this assessment, and the successes of management practices that have been implemented are examined.

Scope

This assessment examines the biology, ecology, conservation status, and management of *Cypripedium parviflorum*, with specific reference to the geographic and ecological characteristics of Region 2. Most literature on the species originates from investigations outside the region. This document cites specifics of that literature so that the ecological content of the report can be viewed in context of Region 2. This assessment is also concerned with reproductive, population dynamics, and other characteristics of *C. parviflorum* in the context of the current environment rather than historical conditions.

In preparing this assessment, many peer-reviewed documents, non-refereed publications, research and management reports, and data accumulated by resource management agencies and myself were reviewed. Peer-reviewed literature was used whenever possible because it is an accepted standard in science. The non-refereed literature used in preparation was required because certain information is unavailable in peer-reviewed documents. For example, monitoring data collected by myself on the Black Hills National Forest and much of the demographic data are not published or are only published in USFS reports. This information is required to discuss certain subjects of concern in Region 2. Botanists are often able to give examples or references to specific occurrences; these unpublished references are also important to the discussion of this species in Region 2 and are included in this assessment. Information collected from Internet sources was generally regarded with greater skepticism because non-peer-reviewed Internet material could not be verified. However, it was necessary to collect some data from Internet sources, like the Natural Heritage Program databases for each state. This information generally included a disclaimer identifying the possibility of error.

Treatment of Uncertainty

Science represents a systematic approach to obtaining knowledge in ideal situations. Experimental results often give strong proof of the outcome and strengthen an inference. These results may provide insights and allow predictions that can be helpful in making management decisions. However, the limited abundance and distribution of rare plants often make experiments and systematic approaches inappropriate or unavailable. Experiments sometimes result in the loss or destruction of the plant or its habitat. Therefore, information about rare plants is generally gathered through observation instead of experimentation. Observations are less rigorous compared to experiments, and inferences may be less robust, but with rare plants observations often are the only information available. Inferences based on observations can be judged for reliability and assist in understanding of ecological relationships. In this assessment, the source of information and degree of uncertainty are described.

The most recent information about the biology, ecology, and conservation of *Cypripedium parviflorum*

was used when possible and applied to Region 2. Literature cited throughout this report is included in the **References** section. If the source of information was not published in peer-reviewed literature, the quality of the information is discussed so the reader can judge the reliability of the information and source. Much of the scientific information used in this report was the result of research conducted on *C. parviflorum* or other orchids in Europe, Canada, and throughout the United States. Little information about *C. parviflorum* in Region 2 was found during the literature search. Therefore, much of the literature cited throughout this document was presented as the best available information even though its application to Region 2 may be limited. Unpublished data (i.e., state Natural Heritage Program records and herbarium records) were important in estimating the geographic distribution and habitat information for this species. These data were examined with special attention because of the education and experience of persons and methods used in collection. Some unpublished data are included since they are the only data located for *C. parviflorum* characteristics within Region 2. In addition, some information is included for other orchid species to discuss possible implications of management. Information collected from the internet was generally omitted or viewed with great skepticism because it generally lacks any peer review process.

Publication of Assessment on the World Wide Web

Species assessments are being published on the Region 2 website to facilitate their use in the Species Conservation Project. Placing the documents on the Web makes them available to agency personnel and the public more rapidly than conventional publication. It also facilitates their revision, which will be conducted according to guidelines established by Region 2 personnel.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This assessment was reviewed through a process administered by the Society of Conservation Biology, employing two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of this assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Cypripedium parviflorum is endemic to North America and found in all five states of Region 2 (**Figure 1**). There are 224 reported occurrences within the region. This section discusses the management and conservation status, existing regulatory mechanisms, management plans, conservation strategies, and the biology and ecology of this species.

Management and Conservation Status

Various agencies assign a management status to a species for the purpose of identifying its need of protection based on a comparison of its current population, distribution, and available habitat with its historic population, distribution, and available habitat. Some of the agencies that assign management status are the USDI Fish and Wildlife Service (USFWS), the USFS, and the Bureau of Land Management (BLM) by each region, and the Natural Heritage Program of each state and NatureServe. The management status of *Cypripedium parviflora* in each state within Region 2 is listed in **Table 1**.

The USFWS is directed under the Endangered Species Act of 1973 to identify and protect Threatened and Endangered species. *Cypripedium parviflorum* is not listed as Threatened or Endangered species, nor is it a species proposed for listing by the USFWS. The BLM does not give this species any special status, but USFS Region 2 lists it as a sensitive species. In the National Forest System, a sensitive species is a species whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance or in habitat capability that would reduce its distribution (FSM 2672.11). Although data is lacking, anecdotal evidence in North America indicates *C. parviflorum* abundance and habitat may be declining due to plant collecting and habitat loss.

Natural Heritage Programs for each state originally listed state status for only species of conservation concern. They have now started to rank all species regardless of conservation status. Individual state Natural Heritage Programs have the most recent information for state status. In July 1999, The Nature Conservancy and Natural Heritage Network established an independent

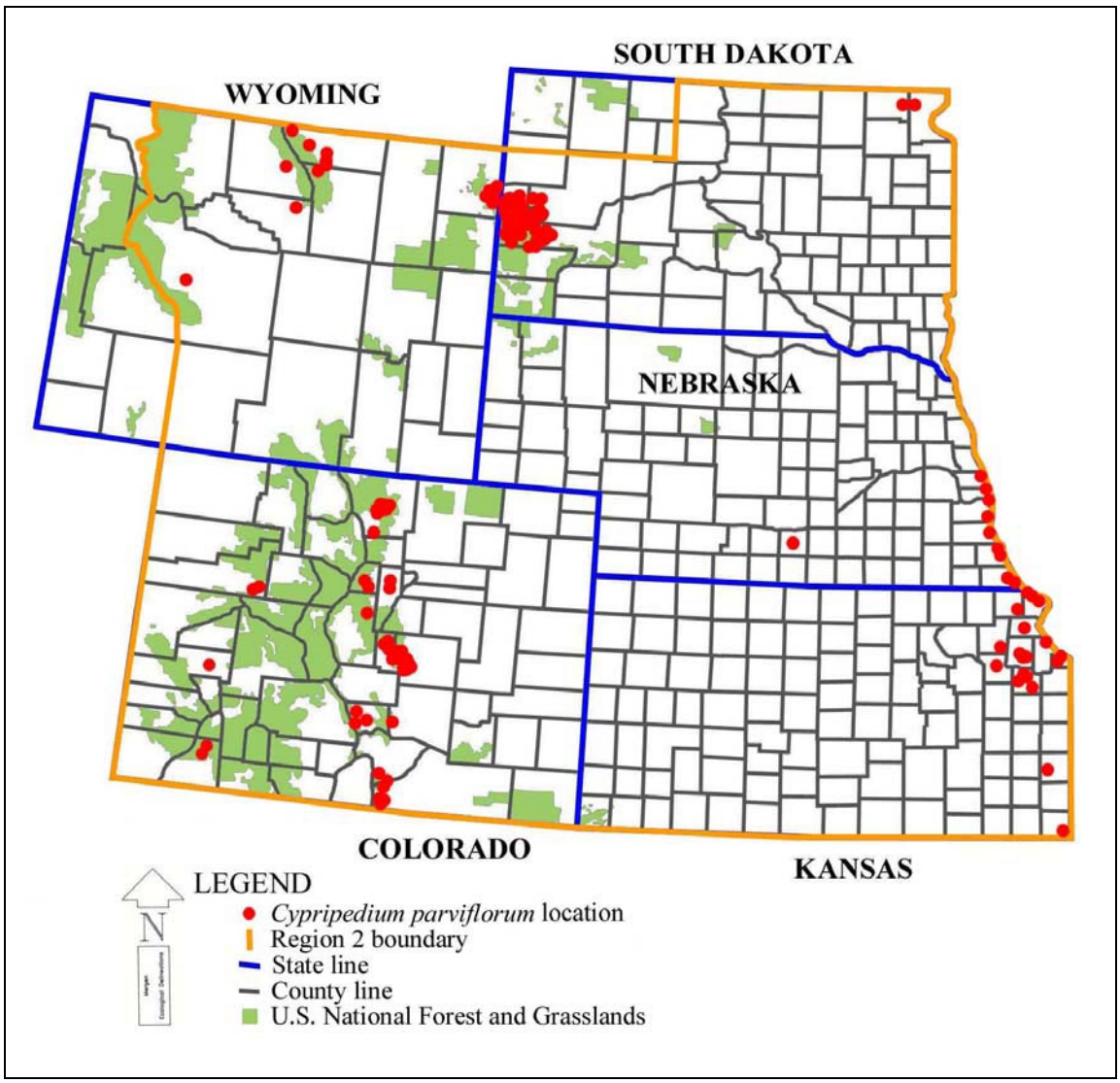

Figure 1. Distribution of *Cypripedium parviflorum* within USDA Forest Service Region 2.

organization under the name NatureServe. NatureServe works in partnership with independent Natural Heritage Programs and other organizations. NatureServe automatically assigns SR-state reported rank based on a checklist of plants (Kartesz 1999). NatureServe updates their website annually with information from the state Natural Heritage Programs. Numerous issues may cause differences in rankings between NatureServe and the individual state rankings. For instance, the recent changes in nomenclature for *Cypripedium parviflorum* and varieties is a current issue affect ranking status. Some states, such as Wyoming, only list a rank for a variety (Wyoming Natural Diversity Database 2006). Therefore, to correct information in the automatic updates for NatureServe, an individual must change the heritage information at the central location or state level. Each state Natural Heritage Program deals with this task at different levels of priority. In addition, much of electronic network is converting to a new software system, complicating automatic electronic updates issue further. It should not be of concern that state rankings and NatureServe have different rankings. NatureServe lists an Information Warranty Disclaimer for their data (NatureServe 2003, 2006). **Table 1** lists current status.

Until recently, *Cypripedium parviflorum* was identified as *C. calceolus* in North America. Data for *C. calceolus* in Europe and Asia show that this species has declined due to collection and habitat loss, and European nations have taken strict measures to conserve this species. The genus *Cypripedium* is included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In addition, the European Union has taken stricter measures than the Convention by increasing its protection status to a level as if *C. calceolus* were on

Table 1. Conservation and management status of *Cypripedium parviflorum* as ranked by the U.S. Fish and Wildlife Service, the Bureau of Land Management, USDA Forest Service Region 2, Natural Heritage Programs of states within USDA Forest Service, CITES, and the European Union.

Agency	Status
U.S. Fish and Wildlife Service	Not listed
Bureau of Land Management	Not listed
USDA Forest Service Region 2[1]	Sensitive
NatureServe Global Ranking[2]	Demonstrably secure (G5)
Colorado Natural Heritage Program	Imperiled (S2)
Kansas Natural Heritage Inventories	Vulnerable (S3)
Nebraska Natural Heritage Program	Critically imperiled (S1)
South Dakota Natural Heritage Program[3]	Vulnerable but uncertain (S3?)
Wyoming Natural Diversity Database[4]	Between critically imperiled and imperiled (S1S2)
CITES[5]	Appendix II
European Union[6]	Appendix I

[1]Designated by a USDA Forest Service Regional Forester; population viability is a concern due to downward trends in population numbers, density, or habitat capability.

[2]Key to Natural Heritage Program rankings:

G = Global rank based on range-wide status, S= State rank based on status of a species in each state.

G1S1 Critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2S2 Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3S3 Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 of 100 occurrences.

G4S4 Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. Cause for long-term concern.

G5S5 Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery.

G?S? Not yet ranked

[3]Ranked for *Cypripedium calceolus*.

[4]Ranked for *Cypripedium parviflorum* var. *pubescens*.

[5]CITES represents the Convention on International Trade in Endangered Species of Wild Fauna and Flora. This is in reference to the genus *Cypripedium*. Appendix II indicates species are not necessarily threatened with extinction but measures are to be controlled that threatens their survival.

6 European Union, Appendix I indicates species are threatened with extinction. This is in reference to the genus *Cypripedium*.

Appendix I of CITES (CITES Orchid Checklist 1995, Cribb and Sandison 1998). Appendix II species are not necessarily threatened with extinction but measures are to be controlled that threaten their survival, where as Appendix I species are threatened with extinction.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Having *Cypripedium parviflorum* listed as sensitive by the USFS allows greater consideration of this species when planning management practices on National Forest System lands within Region 2 since the USFS prohibits impacting sensitive-listed species (36 CFR 261.9(b) 2003). The USFS also requires a permit to collect plants from National Forest System lands, and this may be allowed only for beneficial purposes (36 CFR 261.9(b) 2003).

The genus *Cypripedium* is listed in Appendix II of CITES. Therefore, if individual *C. parviflorum* are to be exported to a foreign country, the exporter or importer would need to get a CITES permit from the CITES Management Authority from the country from where it is being exported. The USFWS Office of Law Enforcement has the authority to charge individuals who violate the CITES Treaty. This authority comes from the Endangered Species Act. Native plants to the United States are also protected

under the Lacey Act, which gives authority to USFWS Office of Law Enforcement to prosecute individuals who take native plants (USFWS/OLE 2003). Current regulatory mechanisms may be viewed as adequate to protect this species from collectors and transport from the United States.

No specific management plans for *Cypripedium parviflorum* were found in Region 2. General information only listed rare plants to be monitored with no specific indication of what characteristics are to be monitored. However, an action, conservation, and management plan for *C. calceolus* in Europe is cited often in this document and is discussed in other sections of this report that pertain to management of *C. calceolus* in Europe and may be applicable to plants in Region 2 (Terschuren 1999).

Methods for conservation of *Cypripedium parviflorum* can be directed at the land (limiting activities over a large contiguous area), orchid habitat (limiting activities within specific plant communities), or an individual plant. Conservation methods that can be employed at known orchid locations and on individual orchid plants include individual plant protection, salvage, off-site measures, propagation, population introduction or reintroduction, and population reinforcement. Off-site measures are associated with individual plant protection and salvage but may also include propagation of plants donated (plants that were salvaged) to universities, nurseries, or other locations where plant research or propagation can occur (Terschuren 1999).

Existing regulatory mechanisms can be used to enforce collecting and transport of plants, but the general public may be unaware of these restrictions on Federal lands. There are many possible management strategies for conservation, but efforts like propagation, introduction, and reintroduction are costly and may be unnecessary until more information on distribution and abundance is known. *Cypripedium parviflorum* is listed as a sensitive species for Region 2, but the full abundance and distribution is unknown. Plant surveys conducted within Region 2 for project planning increase the likelihood that more distribution and population information is reported.

Biology and Ecology

Classification and description

Systematics

The botanist Constantine Samuel Rafinesque (Rafinesque 1828 cited in Cribb 1997) made the point that many botanists had already encountered problems with identification and appropriate nomenclature for *Cypripedium parviflorum*, the currently accepted name for lesser yellow lady's slipper. Until recently, North American *C. parviflorum* has been identified as *C. calceolus* or as varieties or subspecies under this name. However, Atwood (1985), Sheviak (1993, 1994, 1995, 2002), Cribb (1997), among others, agree that *C. calceolus* should be restricted to plants of Europe and Asia, and that *C. parviflorum* should be a distinct species of North America.

Cypripedium parviflorum found in North America is divided into three currently recognized varieties: var. *parviflorum*, var. *makasin*, and var. *pubescens* (**Table 2**; Sheviak 1992, 1993, 1994, 1995, 2002, Kartesz 1999). All three varieties can be quite similar in morphological appearance depending on habitat conditions. Hybrids among the varieties also appear quite similar in morphology. Currently the identification and taxonomy of *C. parviflorum* has not been resolved for western plants, including plants in Region 2 (Sheviak personal communications 2003). *Cypripedium parviflorum* is treated at the species level for this assessment because of the recent changes and uncertainty of the sub-specific classification.

The common name for *Cypripedium parviflorum* on the PLANT Database website is lesser yellow lady's slipper (USDA Natural Resources Conservation Service 2005). It is referred to as the North American yellow

Table 2. Most recent taxonomic information on the currently accepted scientific names for *Cypripedium parviflorum* in North America.

Species name	Reference
Cypripedium parviflorum var. *parviflorum*	Atwood 1984, Sheviak 1992, 1993, 1994, 2002; Cribb 1997
Cypripedium parviflorum var. *makasin*	Sheviak 1993, 1994, 2002
Cypripedium parviflorum var. *pubescens*	Sheviak 1994, 1995, 2002

ladies slipper orchid in the Flora of North America and other publications (Sheviak 1993, 1994, 1995, 2002).

Species description

The following species description is compiled from Smith (1993), Rasmussen (1995a), Kull (1999), and Sheviak (2002). *Cypripedium parviflorum* is a perennial deciduous forb that grows as a single plant or in a colony. It is 10 to 80 cm (3.9 to 31.5 inches) tall, has three to six alternate green leaves, and is topped by one or rarely two flowers with an inferior ovary. A leaf-like bract that is much smaller than any leaves is located just below the ovary. Plants are generally less than 30 cm (11.8 inches) tall and have four or five leaves. The green stem is round and erect with tubular leaf sheaths. Stems and leaves are glandular-hairy (multicellular) throughout. The flower is made up of two petals and a lip, one dorsal sepal, and two laterally fused sepals (synsepalum) that are located below the yellow lip. Both the petals and sepals vary from yellowish-green to purplish-brown and are generally the same color on a plant (**Figure 2**, **Figure 3**, **Figure 4**, **Figure 5**; Sheviak 1993, Smith 1993, Sheviak 1994, 1995, Cribb 1997).

The yellow egg-shaped petal in the center, called the lip, pouch, labellum, or slipper has a small, round to oval hole on the top. The conspicuous yellow slipper-

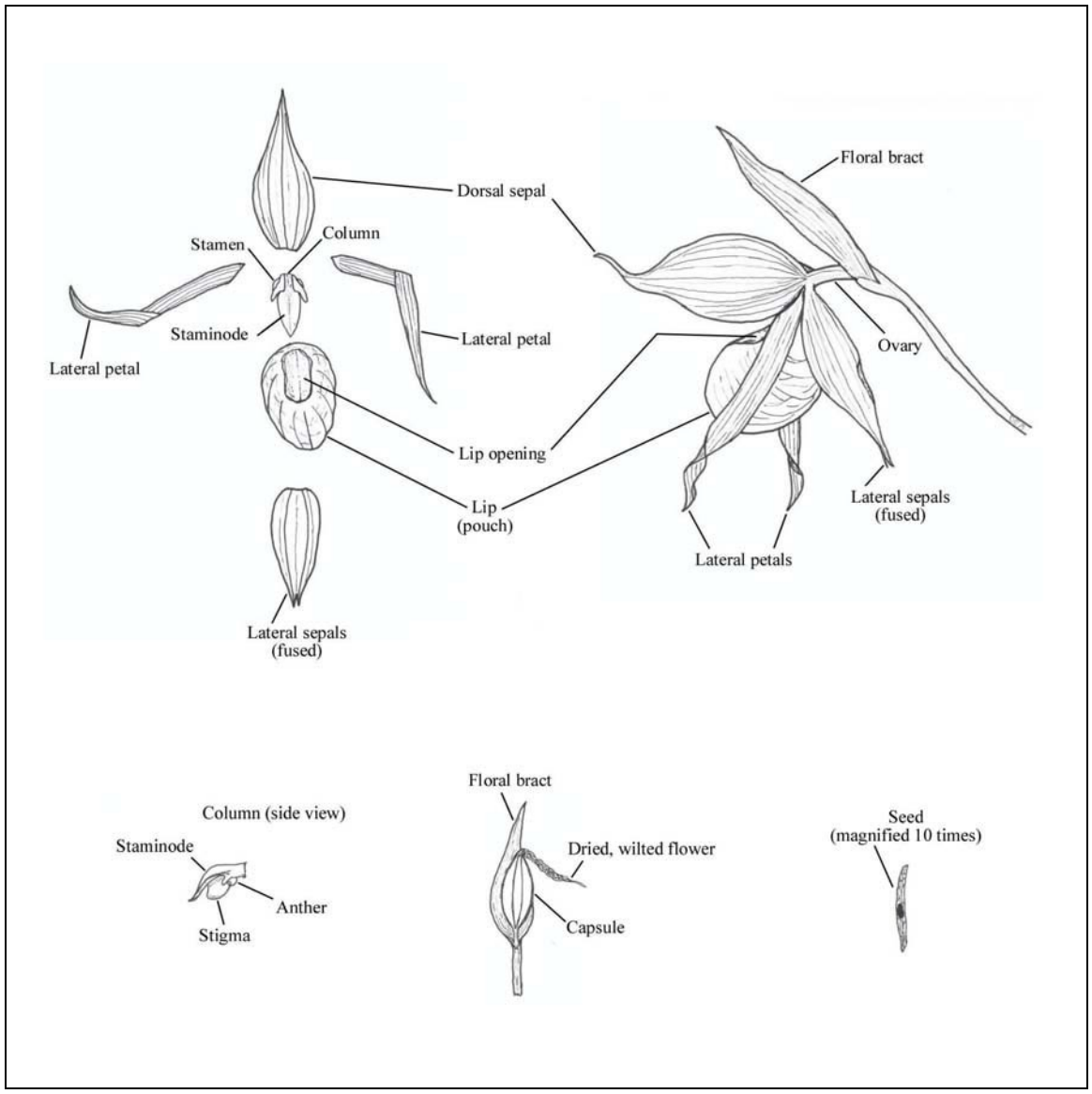

Figure 2. Drawing of a typical *Cypripedium* flower (top). Drawings below include column, capsule, and seed of *C. parviflorum*. Illustrations by author.

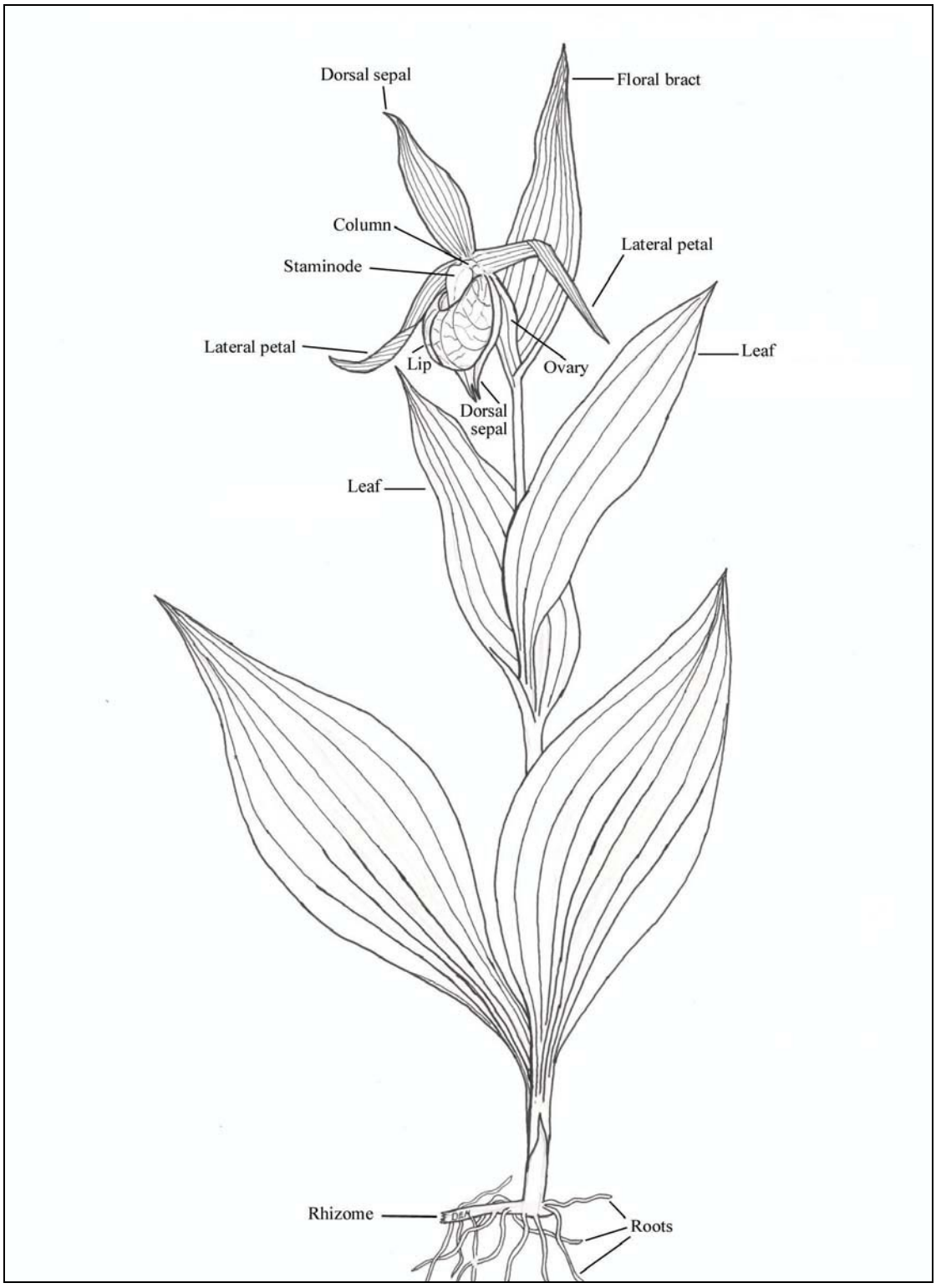

Figure 3. Drawing of a typical *Cypripedium parviflorum* plant. Plant illustrated has four leaves and one flower. Illustration by author.

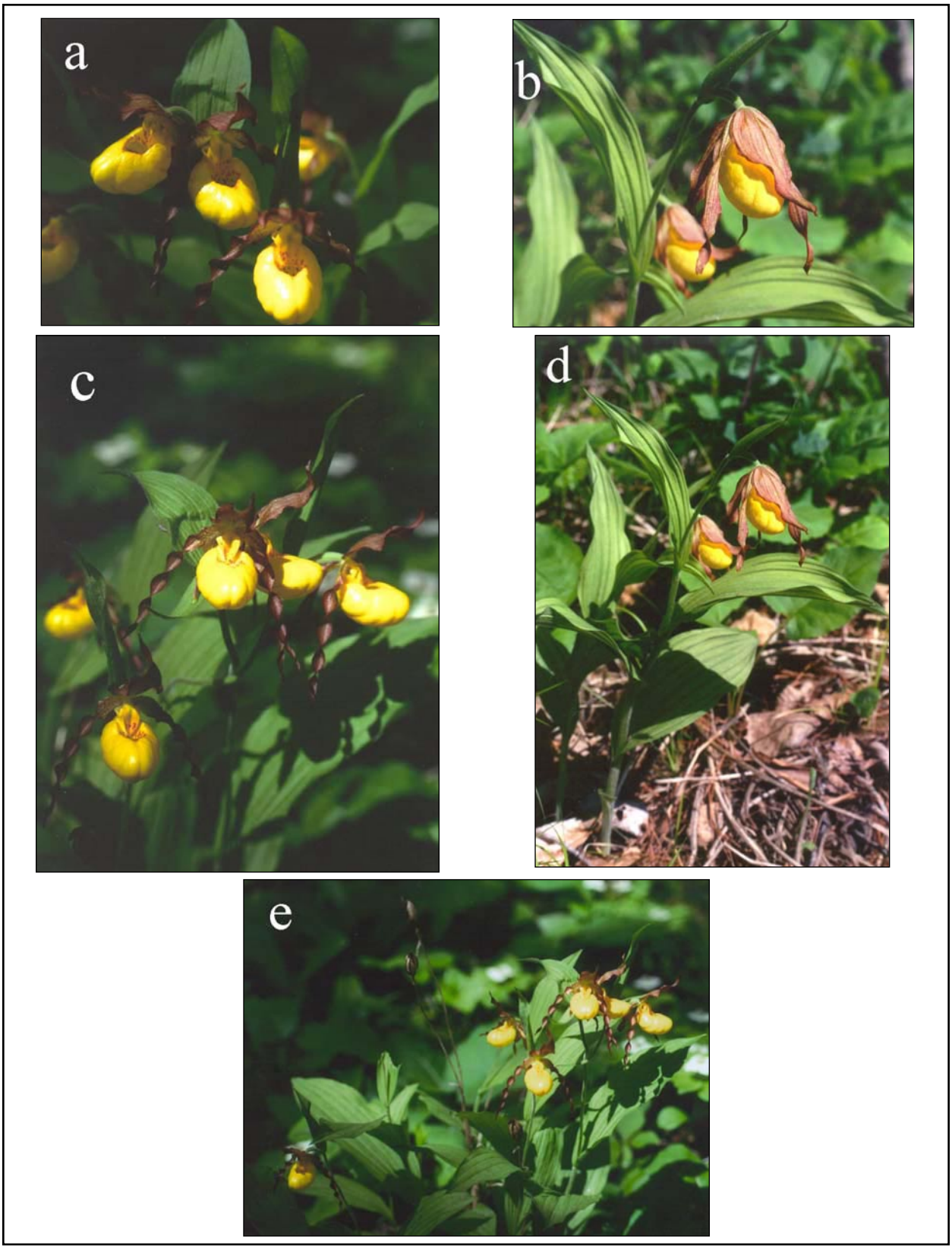

Figure 4. Photographs of *Cypripedium parviflorum* in Minnesota with flower. Photos “a” and “c” illustrate twisted lateral petals. Photos “b” and “d” illustrate less twisted lateral petals. Previous years capsules can be seen in photo “e”. Photographs by author.

Figure 5. *Cypripedium parviflorum* in the Black Hills, South Dakota with fruit (capsules). Dried flower parts can be seen on the top of many capsules. Top two photos were taken after flowering, but before frost. Bottom photo was taken in October after frost. Photographs by author.

shaped lip is strongly pouched with a near coriaceous (leather) texture and with magenta dots or streaks within. Lip length is 1.5 to 5.4 cm (0.6 to 2.1 inches) long and ellipsoidal, obovoid to sub-reniform (almost kidney-shaped). The lip represents one petal of three. The remaining two lateral petals are narrow and spread out and angle forward and downward from the pouch (**Figure 2**, **Figure 3**, **Figure 4**). These two petals are often twisted, wavy, or corkscrew and are 2.4 to 9.7 cm (0.9 to 3.8 inches) long and 0.3 to 1.2 cm (0.1 to 0.5 inches) wide (**Figure 2**). The sepals are found above and below the flower. Both the top (dorsal) sepal and bottom (synsepalum) sepals are much wider, but shorter than the two twisted petals. The bottom sepal is actually two sepals joined together as one, but both tips can be seen if examined closely (**Figure 2**, **Figure 3**).

Located within the mouth of the lip is a structure called the column or gynostemium (**Figure 2**, **Figure 3**). The style, stigma, and staminal filament are fused to form the gynostemium. Two fertile subglobose anthers are located laterally and dehisce by slits releasing individual pollen grains called monads. A third sterile anther is modified into a shield-like structure called the staminode. The staminode is apical to the gynostemium. The staminode is subsessile, triangular-ovate, and blunt. The stalked, trilobed stigma extends beyond the fertile anthers, and lies ventrally on the column behind the staminode.

The fruit is a capsule 2 to 3 cm (0.8 to 1.2 inches) long and about 1 cm (0.4 inches) wide with six prominent ridges. Capsules are near erect, and the sepals and petals may still be attached to the capsule (**Figure 2**, **Figure 5**). Capsule color is similar to the leaves (green or light brown) (**Figure 5**).

Roots are elongate, numerous, fibrous, slender, and seldom branching from the rhizomes. Rhizomes are short, stout, and very seldom branched and are often a group of annually produced growths that grow at the anterior end and die at the posterior end (**Figure 3**).

Technical descriptions of *Cypripedium parviflorum* can be viewed in the following citations (Great Plains Flora Association 1977, Sheviak 1992, Smith 1993, Sheviak 1993, 1994, 1995, Cribb 1997, Sheviak 2002). Photographs and line drawings of this species are in the Colorado Rare Plant Field Guide (Spackman et al. 1997) and Rare Plants of Colorado (Colorado Native Plant Society 1997).

Significance of species

Cypripedium parviflorum has received much attention throughout the world. Historically, many herbal and medicinal uses have been described for *Cypripedium* species in general and *C. parviflorum* specifically. Today it is probably more commonly sought for its aesthetic appeal and beauty as a horticultural plant, but holistic medicine may still pose risks to *C. parviflorum*.

Although scientific evidence for medicinal properties is lacking, the roots and rhizomes of *Cypripedium* species have been employed medicinally worldwide. Commonly known as American valerian or nerve-root, it was listed and widely prescribed as an antispasmodic and nerve medicine in the standard pharmaceutical reference *U.S. Pharmacopoeia* from 1863 to 1916 (Weiner 1972), and it has been described in several other medical references (Cook 1869, Scudder 1870, Felter and Lloyd 1898, Clarke 1900, and Beckstrom-Sternberg et al. 1994). *Cypripedium pubescens* and *C. parviflorum* were also listed and described as plants that can be collected and sold for medicinal use (Sievers 1930). However, Sievers (1930) indicated that the natural supply of some medicinal plants has been reduced by over-collection and habitat loss. Roots of *C. calceolus* are reported to be sold for $80.00 and $83.00 per pound from stores in New York and Maryland, respectively (Duke 2001).

Distribution and abundance

Cypripedium parviflorum and *C. calceolus* are distributed in boreal regions of the northern hemisphere. *Cypripedium calceolus* is found in northern and central Europe, Siberia, northern China, and Korea while *C. parviflorum* is confined to North America (**Figure 6**; Kull and Kull 1991). The present knowledge of the distribution, abundance, and potential habitat of *C. parviflorum* in Region 2 reflects the amount of botanical surveying and plant collecting that has been accomplished to date. Occurrences of *C. parviflorum* are reported from all five states of Region 2 (**Figure 1**). An occurrence represents an isolated group of *C. parviflorum* plants or possibly a single *C. parviflorum* plant, specific to one location, and is geographically isolated from another occurrence. Population may be used occasionally as a synonym of occurrence in this report. *Cypripedium parviflorum* on the Black Hills represents a minor disjunction from the Bighorn

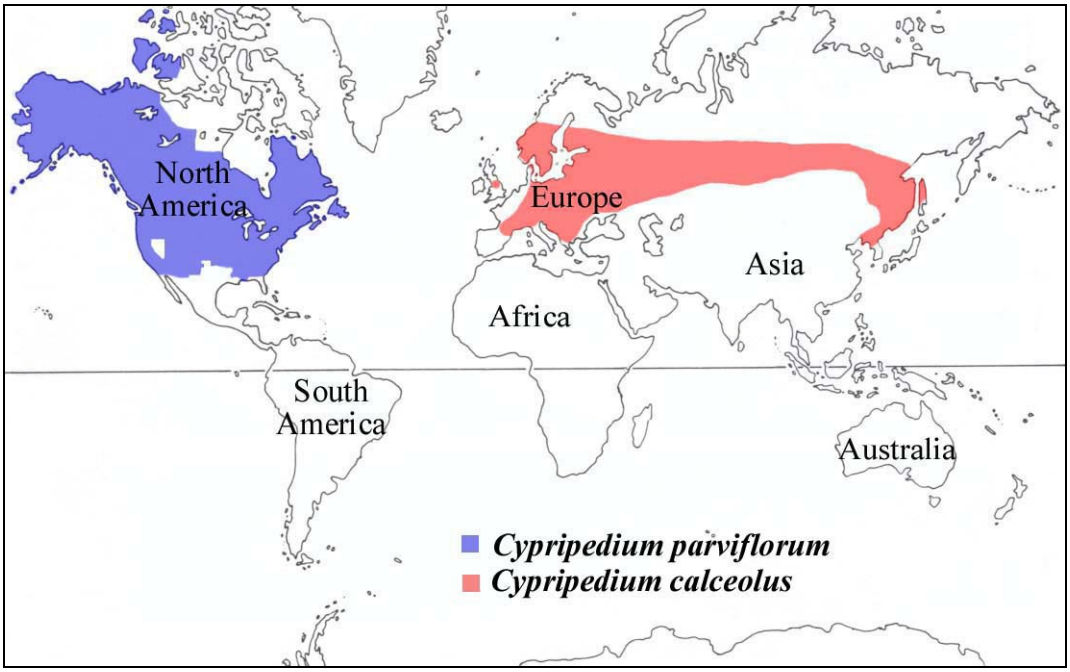

Figure 6. World distribution of *Cypripedium parviflorum* and *C. calceolus*. Distribution information compiled from Correll 1950, Summerhayes 1951, Case 1987, Cribb (1997), Ligglo and Ligglo (1999), and NatureServe (2001).

Mountains in Wyoming, western Montana, and northeastern North and South Dakota (Great Plains Flora Association 1977, Montana Natural Heritage Program 2002, Ode personal communication 2002, Rocky Mountain Herbarium 2006).

A brief summary of information for all known occurrences of *Cypripedium parviflorum* in USFS Region 2 is given in **Table 3**. More detailed information is presented in **Appendix A** (general), **Appendix B** (geographic), and **Appendix C** (habitat). Most Region 2 occurrence information was compiled from USFS personnel, the Colorado Natural Heritage Program, the Kansas Biological Survey and Natural Heritage Inventory, the Nebraska Natural Heritage Program, the South Dakota Natural Heritage Program, and the Wyoming Natural Diversity Database. Additional occurrence information was gathered from plant specimens at many herbaria (see **Herbarium Curators and Other Professionals** after the **References** section for herbaria locations).

Local abundance

There are currently 224 occurrences of *Cypripedium parviflorum* within Region 2. Each occurrence contains one suspected population of plants, but some occurrences may have been extirpated since being reported over a century ago and some could be reports of previous occurrences.

Of the 46 occurrences in Colorado, 32 records fail to list land ownership; two are listed as being on private land; one is on land owned by Jefferson County; and 11 are known from National Forest System lands. Of the occurrences documented on National Forest System lands, six are on the Pike-San Isabel National Forest, three are on the Arapaho-Roosevelt National Forest, and two are on the San Juan National Forest (Colorado Natural Heritage Program 2003).

There are 19 known occurrences in Kansas and 11 in Nebraska; most of these are from the eastern part of each state. Although land ownership is not listed for any of these occurrences, none appears to be on National Forest System lands (Kansas Natural Heritage Inventory 2001, Nebraska Natural Heritage Program 2001).

South Dakota Natural Heritage Program (2001), USFS records (Lynch personal communication 1999, Zacharkevics personal communication 2002, 2003, 2004, 2005), and records from the author (Mergen 1999, 2002, 2003a, 2003c, 2004a, 2004b, 2005) list 133 individual occurrences in South Dakota. The locations of two reports (64 and 65) are unknown, two reports (PMORC0Q0C0*001*SD and PMORC0Q0C0*002*SD) are from eastern South Dakota, and the rest are from within or near the Black Hills National Forest in the western part of the state. Ninety-four of the South Dakota records are on the Black Hills National Forest.

Table 3. Occurrence and habitat information for *Cypripedium parviflorum* within USDA Forest Service Region 2. A "-" within a cell indicates that no information is available. A complete summary table organized by state then occurrence number is given in Appendices of this document.

State	Number of counties	Number of occurrences	Number of plants	Estimated occurrence area (m^2 ($ft.^2$))	Land ownership	Elevation (m(ft.))	Slope (%)	Aspect (degrees)	Habitat description	Soil description by observer
CO	12 + [6]	46	few to 1130	2.70–40,000 (30-444,444)	Jefferson County; Arapaho, Pike, Roosevelt, and San Juan national forests; private	1,740-3,805 (5,800-12,683)	0-45	0-225	*Pinus ponderosa*, *Populus tremuloides*, *Pseudotsuga menziesii*,buffalo berry, conifer, fir, lodgepole pine, spruce	Dry to wet
KS	11	19	—	—	—	—	—	—	—	—
NE	7	11	—	—	—	—	—	—	*Carya ovata*, *Quercus alba*	Soils are moderately deep to silt loams formed in loess and are usually well drained
SD	5 + [5]	133	1 to 324	0.01—~1,254,528 (0.1-~13,939,200)	Black Hills National Forest; private	1,050-1934 (3,500-6,445)	0-160	0-360	*Acer negundo*, *Betula papyrifera*, *Corylus cornuta*, *Juniperus communis*, *Ostrya virginiana*, *Picea glauca*, *Pinus ponderosa*, *Populus angustifolia*, *Populus tremuloides*, *Salix bebbiana*, *Shepherdia canadensis*, *Ulum americana*, *Salix* sp., *Symphoricarpos* sp., birch, hazelnut, moss, oak, pine	Dry to saturated
WY	6	15	few to 60	392 (4,356)	Bighorn and Black Hills national forests; State of Wyoming; Wind River Indian Reservation; private	1,200-1,978 (4,000-6,594)	0-1	135	*Pinus ponderosa*, *Quercus macrocarpa*, *Picea* sp.	Mesic to saturated

"[ ]"signifies number of occurrences that did not list a county

In Wyoming, there are 15 records of *Cypripedium parviflorum*. Five are on the Black Hills National Forest, three are on the Bighorn National Forest, and three are listed as being on State of Wyoming lands. The location of one occurrence is uncertain, but it may be on the Black Hills National Forest. Two occurrences are on private land, and one is within the city limits of Sheridan (Wyoming Natural Diversity Database 2003).

The abundance of *Cypripedium parviflorum* plants and the number of occurrences within a forest of Region 2 only reflect the extent and intensities that National Forest System lands have been surveyed. Therefore, the number of occurrences reported within each state may not necessarily indicate complete or accurate distribution in Region 2. For example, about 60 percent of the reported occurrences indicate the species to occur along the northern and eastern portions of the Black Hills National Forest in South Dakota. This is an artifact of greater survey and record keeping efforts in the Black Hills compared to other areas in the region.

Occurrence sizes range from one plant to at least 1,130 plants. Nine occurrences exceed 100 *Cypripedium parviflorum* plants, and about half of the records that listed the number of plants present had fewer than ten plants. The largest reported occurrence found in Region 2 is on the Pike San Isabel National Forest in Colorado and extends onto adjacent private land. The Pike San Isabel National Forest site (PMORC0Q090*018*CO) reported between 937 and 1,130 plants within established monitoring plots (40,000m^2) for 3 years of data (2003-2005) (Cameron 2003, 2004, 2005). This population is reported to have more plants than were counted within the monitoring plots.

In summary, *Cypripedium parviflorum* is found within all five states that represent Region 2. The number of occurrences reflects survey intensity, frequency, and area of land surveyed. Some occurrences may have been reported previously but lacked detailed location information. The number of occurrences within Region 2 and the distribution may be incomplete, but the distribution is the best available estimate for Region 2. Occurrences generally have fewer than ten individual plants present, but the numbers of plants per occurrence range from one to at least 1,130 plants.

Population trend

Determining a population trend from historical accounts is difficult due to the lack of quantitative data. While a decline of *Cypripedium parviflorum* within Region 2 can be suspected, the actual population trend of *C. parviflorum* within Region 2 is unknown at this time because quantitative information on decline and recruitment are lacking. Mr. Steve Tapia reported that one occurrence near Woodland Park, Colorado had been lost in the mid 1990's because of an urban housing development (Tapia personal communications 2006). Significant declines are reported for *C. calceolus* in Europe (Summerhayes 1951, Wood et al. 1984, Wood 1989, Terschuren 1999). The decline in Europe is attributed to plant collecting, destruction of habitat, and use of fertilizers and herbicides.

Anecdotal information suggests that *Cypripedium parviflorum* was collected in the past and is currently collected for herbaria and voucher specimens. At least 65 plants have been collected for research or voucher specimens from the Black Hills population alone and now reside in herbaria. McIntosh (1930, 1931) commented on the decline of *C. parviflorum* on the Black Hills, South Dakota seventy years ago based on his observation that many plants were being collected. McIntosh (1930) also recounted an automobile he observed in a meadow somewhere in the Black Hills: "But in Castle Valley not many months ago I saw an automobile bedecked with hundreds of wilted flowers. Already the ladies' slipper orchid and the wild tiger lily are passing into oblivion." This one automobile may have had more *C. parviflorum* specimens collected for purposes other than research than have been collected over the past 100 years for herbarium specimens.

Habitat characteristics

Range-wide habitat characteristics

Global habitat conditions for *Cypripedium parviflorum* and *C. calceolus* fall within a range of light, heat, base content, and soil moisture (Terschuren 1999). These two species of orchids are generally found in shady deciduous and mixed woodlands; relatively open oak (*Quercus*), ash (*Fraxinus*), and hazelnut (*Corylus*) woodland; or shrublands, swamps, bogs, and spruce (*Picea*) and pine (*Pinus*) forests (Summerhayes 1951, Wood et al. 1984, Rasmussen 1995a, Kull 1998, 1999). Elevations from sea level to 2,900 m (9,700 ft.) have been reported (Wood et al. 1984, Kull 1999).

Cypripedium parviflorum is most often found on or confined to predominantly calcareous soils (Rasmussen 1995b, Kull 1999). In general, *C. parviflorum* and *C. calceolus* are often found on soils and stony soils that have developed over a calcareous substrate (Terschuren 1999), limestone scree and the base of limestone cliffs, or in peaty soils (Wood et al. 1984, Cribb 1997). Soil

pH is reported to be basic, neutral, to acidic, and soil nutrients are described as nitrogen poor to moderately nutrient rich with moderate amounts of humus present (Cribb 1997, Kull 1999, Terschuren 1999). Soil moisture is usually moderately moist to drying during summer months, and soils are well drained (Cribb 1997, Kull 1999) and have the ability to retain soil moisture while draining quickly (Terschuren 1999).

Region 2 habitat characteristics

Habitat characteristics of occurrences found in USFS Region 2 are summarized in **Table 3** and described in greater detail in **Appendix B** and **Appendix C**. In Colorado, *Cypripedium parviflorum* has been recorded at elevations between 1,746 and 3,805 m (5,800 and 12,683 ft.), slopes between 0 and 45 percent, and aspects between 0 and 225º in Colorado. Habitat was described as *Populus tremuloides* (aspen), *Pinus* (pine), conifer, *Populus/Shepherdia* (aspen/buffalo berry), *Pinus ponderosa* (ponderosa pine), *Pseudotsuga menziesii* (Douglas-fir), *Pinus contorta* (lodgepole pine), *Populus angustifolia* (narrowleaf cottonwood), and spruce-fir-aspen (**Table 3**).

No elevation, slope, or aspect data were included with the record information from Kansas (**Table 3**). For 10 of the 11 Nebraska occurrences, notes indicate that *Cypripedium parviflorum* is found on the upper and mid portions of gentle to moderately steep slopes with south and west exposures in a southern upland forest (*Quercus alba – Carya ovata*).

South Dakota records listed elevations between 1,050 and 1,934 m (3,500 and 6,445 ft.) and slopes between 0 and 150 percent. Many aspects were recorded, but northerly aspects were most common. A summary of information collected on the Black Hills through 2004 indicated that 53 percent of the habitats were a mix of conifer and deciduous trees, 26 percent were deciduous only, and 21 percent were conifer only (Mergen 2004a). The conifer–deciduous mix contained a mixture of *Pinus ponderosa*, *Picea glauca* (white spruce), *Populus tremuloides*, *Betula papyrifera* (birch), *Ostrya virginiana* (ironwood), *Corylus cornuta* and *C. americana* (hazelnut), *Shepherdia* sp., *Juniperus* sp. (juniper), and *Salix* sp. (willow). The deciduous-only habitats contained *Quercus macrocarpa* (oak), or a mix of the following species: *Quercus* sp., *O. virginiana*, *B. papyrifera*, *P. tremuloides*, *Cornus sericea* (dogwood), *Corylus* sp., and *Crataegus chrysocarpa* (hawthorn). Conifer-only habitats were characterized as pine, spruce, pine-spruce, and spruce-pine-juniper (Mergen 2003a, 2003b).

Wyoming records list elevations between 1,200 and 1,978 m (4,000 and 6,594 ft.). One slope of 0 to 1 percent and one southeast aspect were reported in the Wyoming data. Habitats for *Cypripedium parviflorum* in Wyoming were described as *Quercus macrocarpa* (bur oak), *Pinus ponderosa*, *Picea* sp., and shaded areas along river or creek bottoms or riparian. One record listed damp leaf mold as the habitat description.

Limiting factors of microhabitat

Much of the literature indicates that *Cypripedium parviflorum* occurs in small populations that are not frequently abundant. Statements in the literature and the general lack of information indicate that much is still unknown about the exact requirements of *C. parviflorum* and *C. calceolus*. The true factors that limit *C. parviflorum* in Region 2 are unknown. Interpretations of habitat conditions of known occurrences should not be confused as limiting factors. It is likely that more than one limiting factor exists. One limiting factor's influence on *C. parviflorum* under specific habitat conditions may alter that factor to a degree that another factor becomes limiting. Limiting factors are likely to change throughout the life history of an individual plant.

Moisture, temperature and light all influence orchids to a great extent (Correll 1950). Seedlings grown in laboratory media need constant moisture (Corkhill 1996 cited in Kull 1999), and water stress affects fruit production if it occurs during critical stages (Light and MacConaill 1998). Although fruits may still develop when stressed by water, few if any viable seeds are produced, and capsules were reported to be spongy (Light and MacConaill 1998).

Although Reed (1988) classified this species as a facultative wetland indicator, *Cypripedium parviflorum*, like most plants, is adapted to a range of moisture requirements. In Region 2, some occurrences are found in dry ponderosa pine habitat at elevations less than 1,200 m (4,000 ft.) where soil moisture can be very low late in the growing season. Other occurrences are confined to riparian areas, north slopes, and cool drainages that have moist to near saturated soil moisture throughout the growing season. Moss cover or leaf litter are included in the descriptions of several *C. parviflorum* locations within Region 2. In Europe, thick moss cover has been cited as being important to ensure stable and sufficient soil moisture for orchids, especially young orchids (Kull 1998). Soil moisture may be more important for populations on hillslopes away from riparian areas and for young plants, and it may be a

limiting factor for this species in Region 2. Drought conditions may limit or prevent growth and influence pollen viability, fruit and seed production, and seed germination success; drought may also kill seedlings that are still developing or were recently established.

Light appears to be one of the more frequently reported limiting factors for *Cypripedium* species (Curtis 1946, Stuckey 1967, Case 1987, Cribb 1997, Kull 1999). Kull (1999) among others reports that *C. calceolus* is severely out-competed for resources among tall forbs and graminoids that are favored by increased light conditions. Plant morphology and seed germination success are also related to the amount of light (Dementjeva 1985 cited in Kull 1999, Rasmussen 1995b, Sheviak personal communications 2003). Seeds of *C. parviflorum* exposed to light were less successful at germination, indicating that shaded environments and burying of seeds may increase germination success (Rasmussen 1995b). Light penetration at *C. parviflorum* locations in Region 2 has been reported as partial to rarely full sunlight. Kull (1999) reported light penetration of 26 percent, and Mergen (1999) reported overhead canopy covers between 14 and 94 percent, indicating that direct light impact could be as high as 86 percent to as low as 6 percent.

Soil chemistry and pH are two additional factors that may play some role in the presence or absence of *Cypripedium parviflorum*. Stuckey (1967) suspects that soil acidity may be the limiting factor in Rhode Island populations, where the soil is too acidic for the seedlings to survive. Kull (1999) reported that the percentage of orchid cells infected with mycorrhizal hyphae doubled when soil pH decreased from 6.0 to 5.0. Chemical characteristics within different soil horizons or the rate that organic matter decays on the soil surface will also alter pH conditions at various times (Case 1987). Very little information about soil chemistry or pH was included with location information for Region 2. All limiting factors discussed above may also impact the mycorrhizae associated with *C. parviflorum*.

Habitat summary

The 224 records of *Cypripedium parviflorum* in Region 2 show that the habitat of this species is quite variable and cannot be described precisely (**Table 3**). Also, the current reported habitat conditions for rare plants should not be viewed as habitat requirements since the requirements as well as the habitat will change over time. *Cypripedium parviflorum* is more common on shaded, cool, north-facing slopes. Soil moisture may be saturated at times to very dry later in the growing season. Occurrences with the greater number of individual plants are more commonly found in perennially moist to saturated soils. There is often some annual input of leaf litter to the soil surface, often a great amount of deciduous leaf fall, but lesser amounts from conifers. At some locations the soil surface is covered with leaf litter or moss while other occurrences are found in talus slopes and colluvium with little soil or soil surface cover. Associated plant habitats are described as a southern upland forest in eastern Nebraska to a *Pseudotsuga menziesii* forest in Colorado with many reported plant communities between (**Table 4**). The variability of *C. parviflorum* habitat reported indicates that this species can survive in multiple habitats, and it may survive at one location long enough for a plant community to change through succession. No long-term monitoring data or any quantitative data exist in Region 2 to make any generalization of habitat conditions.

Reproductive biology and autecology

Life history, strategy, and growth

Cypripedium parviflorum may be entirely or partially dependent on fungi throughout its life cycle. Plants may persist underground for several years before appearing above ground, where they may remain vegetative for several more years. Summerhayes (1951) reported *Cypripedium calceolus* to have grown in a vegetative state up to 16 years before flowering in England. However, in Wisconsin, plants of *Cypripedium* species averaged about 12 years from germination to flower (Curtis 1943). Insects are suspected vectors of pollination and must be lured into the slipper-shaped petal and then escape to accomplish pollination. A graphic of the life cycle of *C. parviflorum* is provided in **Figure 7**.

Most flowering plants have seeds with a seed coat, an embryo, and a food supply or endosperm. However, *Cypripedium parviflorum* seeds, which mature 3 to 4 months after being fertilized, lack a food source to sustain the embryo after germination. Instead, they depend on mycorrhizal fungi for development. The embryo itself is very small, consisting of only a few dozen cells surrounded by an impermeable coat of suberized cells (Cribb 1997). Orchid seeds may require up to 6 months in the soil after dispersal in order to interact with soil organisms and to allow time for the seed coat to deteriorate enough for germination to occur. Curtis (1943) reported that *C. parviflorum* seeds remain viable for at least 8 years.

Table 4. Plant communities within USDA Forest Service Region 2 that contain *Cypripedium parviflorum*. The number in parenthesis indicates the number of occurrences that listed that type as dominant plant community. Data were collected from herbaria, Natural Heritage Databases from Colorado, Kansas, Nebraska, South Dakota, and Wyoming and USDA Forest Service documents.

Conifer-deciduous mix (36)	Deciduous (32)	Conifer (17)	Other (7)
aspen-fir (1)	aspen (3)	conifer forest (1)	brushy creek bottom (1)
aspen-hazelnut-pine-buffalo berry (1)	aspen-birch (2)	pine (5)	marshland (1)
aspen-juniper (1)	aspen-buffalo berry (1)	pine-spruce (1)	meadow-streambank (1)
aspen-pine-fir (1)	aspen-hawthorn (1)	spruce (9)	riparian along creek (1)
birch-aspen-pine-hazelnut (1)	birch-dogwood (1)	spruce-pine-juniper (1)	shaded river bottom (1)
birch-ironwood- spruce (1)	birch-hazelnut (2)		wetland road ditch (1)
birch-pine (4)	birch-ironwood (4)		wooded hillside (1)
birch-spruce (3)	cottonwood-aspen (1)		
birch-spruce-ironwood (1)	ironwood-oak (2)		
fur-spruce-alder (1)	oak (1)		
ironwood-birch-pine (1)	oak-ironwood (2)		
ironwood-hazelnut-pine (3)	oak-snowberry (1)		
ironwood-pine (1)	white oak-hickory (10)		
pine-aspen (1)	willow-cottonwood (1)		
pine-aspen-birch-juniper (1)			
pine-birch (2)			
pine-birch-spruce (1)			
pine-hazelnut-birch (1)			
pine-oak (1)			
spruce-aspen (2)			
spruce-birch (3)			
spruce-birch-hazelnut (1)			
spruce-birch-ironwood-juniper (1)			
spruce-willow-juniper (1)			

Little is known about germination of this species in natural settings, but it is known that seeds germinate better in a dark location and 2 to 5 cm (0.75 to 2.0 inches) below the soil surface (Cribb 1997). Soil drainage and constant temperature also appear to be important for germination (Rasmussen 1995b), and it is thought that at 2 to 5 cm (0.75 to 2.0 inches) soil depth, soil temperature and humidity may be more constant than at lesser soil depths.

Mycorrhizal relationships

Cypripedium parviflorum plants depend upon mycorrhizal relationships for seed development, seedling establishment, and very possibly for adult phases such as dormancy (Rasmussen 2002, Bidartondo et al. 2004, Shefferson et al. 2005). In order to survive without a food source in the seed, the orchid depends on fungi early in its life (Case 1987, Dell 2002, Rasmussen 2002, Bidartondo et al. 2004, Shefferson et al. 2005). Seeds are assumed to germinate in the spring or summer; however protocorms of *C. calceolus* were reported in December in Europe (Irmisch 1853 cited in Cribb 1997). The protocorm is defined as the stage from germination until the seedling has developed a shoot tip with leaves, but no roots. The greenish-colored protocorm then forms rhizoids (like roots but simpler) that become infected with mycorrhizal hyphae (Cribb 1997); this is the beginning of the mycorrhizome stage, when the apical meristem elongates and first roots develop (Rasmussen 1995b).

Cypripedium parviflorum development is slow. First roots tend to form in the autumn of the first year. The young orchid continues to grow and produce additional roots throughout the second year. Root growth may continue up to the fifth year with the first root cortex initially being densely infected with fungi

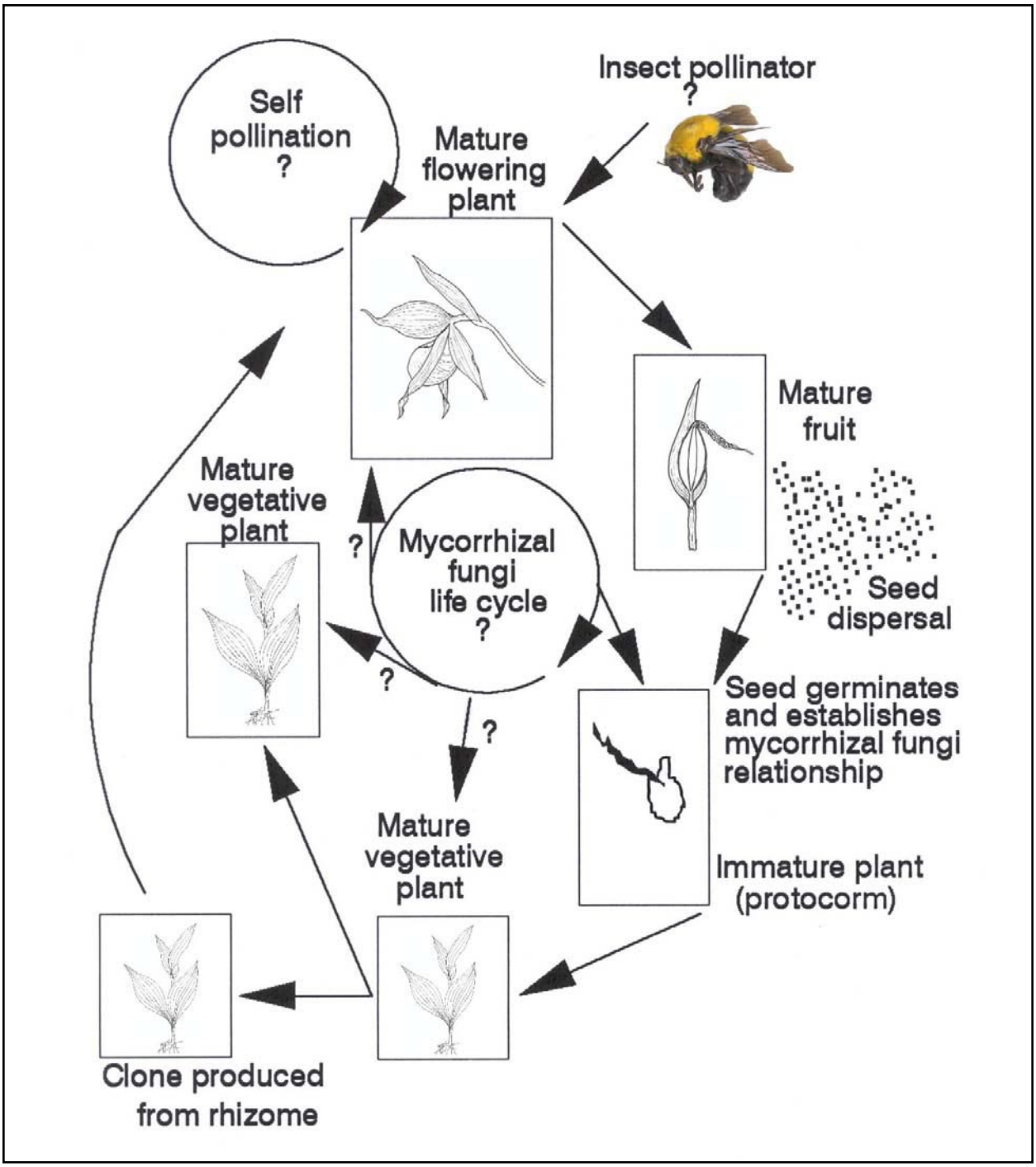

Figure 7. Life cycle of *Cypripedium parviflorum*.

and having mostly phloem tissue (Cribb 1997). The fungus-root relationship is what supports the juvenile orchid until it can photosynthesize its own food (Rasmussen 1995b). The fungus penetrates the orchid root and obtains food (energy) from decaying organic matter in the soil or from ectomycorrhizal associations with living trees (Bidartondo et al. 2004). The fungus transfers food to the mycorrhiza in the orchid root, which is then passed onto the orchid (Summerhayes 1951, Shefferson et al. 2005).

As roots develop in the following 2 to 5 years, there is generally less fungal infection and greater xylem development. The first leaf may appear anytime from the first to fourth year after germination (Irmisch 1853, Curtis 1943, Rasmussen 1995b). *Cypripedium*

parviflorum plants start to photosynthesize and produce their own food and may become independent organisms, losing their dependence on the mycorrhizae. However, they may remain dependent on mycorrhizae throughout life (Bidartondo et al. 2004, Shefferson et al. 2005). Mycorrhizae may decline from year to year as the aboveground plant increases in volume (Rasmussen 1995b), but the relationship of adult *Cypripedium* mycorrhizae is unclear (Shefferson et al. 2005).

Many soil fungi may be involved in the life cycle of *Cypripedium parviflorum* (Sheviak 1983, Bidartondo et al. 2004, Shefferson et al. 2005), and adult mycorrhizae may be different from juvenile mycorrhizae (Rasmussen 1995b, Shefferson et al. 2005). Recent research suggests that *Cypripedium* orchids exhibit high specificity to mycorrhizae (Shefferson et al. 2005). Other research indicates both saprotrophic (associated with dead organic matter) and ectotrophic (associated with live trees) mycorrhizae may be important to some orchid species (Bidartondo et al. 2004). To support this species, microsites must contain environmental conditions that are capable of supporting not only the orchid plant, but also the specific mycorrhizae on which *C. parviflorum* depends. Ideal microsite conditions for Region 2 are unknown but may be deduced by examining current habitat conditions and assuming that those conditions represent microsites optimal for seed germination and plant establishment.

Season for reproduction

Cypripedium parviflorum flowers develop in May and June and remain alive anywhere for up to 3 weeks or 11 to 17 days (Eberle 1973 cited in Kull 1999). In Region 2, flowering may range over a 10-week period; plants have been collected in flower from as early as late May to as late as early August (determined from herbarium specimens). However, flowering is probably more limited within local populations and depends on local environmental conditions, weather, and the number of individuals.

Pollinators and pollination

There is evidence to support insect pollination for *Cypripedium parviflorum* in North America. While *C. parviflorum* flowers do produce nectar (Sheviak personal communication 2004) that probably attracts some insects, other pollinators may be tricked into visiting the plant. Stoutamire (1967) reported trichomes (plant hair-like structures) that were chewed by insects, but the trichomes contain oil instead of nectar.

Most reports conclude that bees are the common pollinator, but other insect species are potential pollinators. Female *Andrena haemorrhoa* bees were the most frequent pollinators of *Cypripedium* orchids in North America, but *C. parviflorum* var. *pubescens* plants were pollinated by male lesser carpenter bees (*Ceratina calcarta*) (Nilsson 1979). The carpenter bees are a group of small (about 5 mm in length) solitary bees that are black or metallic blue or green and excavate nests in the central pith of plants like sumac and raspberries (Ourworld 2001).

The unique flower structure of *Cypripedium parviflorum* must lure the insect into the large lip opening on the upper surface (**Figure 2**, **Figure 4**). The margins inside the lip opening are incurved, which prevents the insect from exiting the way it entered (Darwin 1877). Not only do the incurved margins block the large opening on top, the staminode blocks the opening at the base of the lip (Cribb 1997). This leaves two small openings on either side of the column through which the insect may escape. Pollination occurs when the insect escapes the lip, but only if the insect is the correct size and has collected pollen previously.

Once pollination has occurred, there is a period of 26 to 35 days in *Cypripedium parviflorum* before actual fertilization occurs. Environmental factors are thought to affect the number of days to and success of fertilization (Rasmussen 1995b). Seed germination success varies year to year (Fast 1974, Riether 1990 cited in Rasmussen 1995b) and is thought to be the result of poor pollination efficiency, genetic, and climatic factors or a combination of these (Rasmussen 1995b). Embryos were formed in *C. parviflorum* var. *pubescens* seeds in Canada when they were self-pollinated or cross-pollinated with one or more paternal pollen source (Tremblay 1994).

Dispersal mechanisms

Orchid seeds are some of the smallest seeds (1.2 x 0.3 mm) of any vascular plant (Kull 1999). Light and MacConaill (1998) estimate that a full *Cypripedium parviflorum* capsule contains 7,000 seeds, and Kull (1999) reports between 5,940 and 16,700 seeds per pod for five fruits of *C. calceolus* examined. Characteristics like inflated, air-filled seed coats (testa), a rough outer texture, and long tapered ends make wind a likely method of orchid seed dispersal. Some reports show orchid seeds from an *Orchis* species have dispersed 100 to 1,500 km (60 to 900 mi.) from the nearest seed source (Rasmussen 1995b). *Cypripedium parviflorum* capsules

with quantities of seeds have been observed above the top surface of snow in the Great Lakes region as late as January (Stoutamire 1964), indicating that seeds could be wind transported throughout the winter if they remain viable under winter conditions. *Cypripedium parviflorum* seeds could be wind transported to many locations within Region 2 National Forest System lands and adjacent lands with the distances reported above.

Seed coats are also water repellent and could survive water dispersal (Arditti and Ghani 2000). Capsules from *Cypripedium calceolus* were observed to close when dry and open when wet, suggesting seed release with raindrops (observed by Böckel 1972 and cited in Rasmussen 1995b). Many *C. parviflorum* occurrences are found near stream and steep hillside drainages and may be the result of seeds that were transported downstream or downslope from a seed source by water.

Other vectors of dispersal that have been proposed include birds, mammals, insects, or humans (Arditti and Ghani 2000), but wind and water are probably the primary methods by which seeds are dispersed in Region 2. Curtis (1943) found that *Cypripedium* seeds remain viable for up to at least 8 years. Therefore, there is a great opportunity for viable seeds of *C. parviflorum* to be dispersed over time by wind, water currents, or other methods.

Cryptic phases

Dormancy behavior has been found with *Cypripedium calceolus* and *C. parviflorum* in Europe and Illinois respectively (Kull 1999, Shefferson et al. 2001). Some individual plants fail to produce aboveground tissue for periods up to 4 years. This is suspected to be caused by environmental conditions. Therefore, *C. parviflorum* may be present in an area but not visible because it has failed to produce aboveground plant parts. Dormancy for *C. parviflorum* is unknown for Region 2, but it is suspected.

Hybridization

Cypripedium parviflorum and *C. candidum* have been reported to hybridize in natural populations in the Midwest, and the hybrid is named *C.* x *andrewsii* (Sheviak 1992). *Cypripedium candidum* is a species of moist prairies, sedge meadows, and calcareous fens (Smith 1993). It is reported rare in wet meadows of eastern South Dakota (Van Bruggen 1985), but it may be more widespread in Nebraska (Sheviak 2002). Hybridization is possible between these two orchid species in the eastern portions of South Dakota, Nebraska, and possibly Kansas should they occur together.

Sheviak (1992) reports that *Cypripedium montanum* and *C. parviflorum* var. *pubescens* in northwestern North America have formed hybrids, which are assigned the binomial *C.* x *columbiana*. *Cypripedium montanum* and *C. parviflorum* are both found in Wyoming (Dorn 1992, Sheviak 2002), and hybridization of these two species is possible should these species occur together.

Cypripedium fasciculatum is another slipper orchid found in south-central Wyoming and north-central Colorado, but evidence of *C. parviflorum* and *C. fasciculatum* hybridization is lacking.

Most hybrid populations are generally located in very close proximity to each parental species and found in similar habitat. While it is possible that *Cypripedium parviflorum* can hybridize with *C. candidum*, *C. montanum*, or *C. fasciculatum*, no hybrids have been reported within Region 2.

Demography

Genetic characteristics

Genetic characteristics are unknown for *Cypripedium parviflorum* in Region 2, but genetic variability may be a concern in Region 2 since many occurrences are reported to have 10 or fewer plants. Evidence of cross pollination between adjacent plants or between adjacent occurrences is lacking. Also, *C. parviflorum* is known to produce clones (genetically identical individuals), so it is possible that little variability exists within a single group of plants. If there is little variability, then the species may be less viable and less likely to survive changes in the environment.

Survival and reproduction

Kull (1988 cited in Rasmussen 1995b) reported one *Cypripedium calceolus* plant in Europe living 192 years since it was first reported. Cribb (1997) reported that individuals of *Cypripedium* species live for several to many years. Life spans are unknown in Region 2 but are expected to be similar to those reported.

Little research has been done on the long-term survival of *Cypripedium parviflorum* or any *Cypripedium* species (Rasmussen 1995b). Kull and Kull (1991) demonstrated that population fluctuations

over time were small, indicating that *C. calceolus* populations in Estonia were influenced little by small changes in environmental conditions. They studied populations up to 13 years and accounted for small changes in plant numbers with variations in weather.

Kull and Kull (1991) showed that populations of *Cypripedium calceolus* flowered each year, but the number of plants that produced flowers varied among populations. Mean flowering percentages were between 35 and 70 percent. Flowers set fruit 11 to 33 percent of the time.

Data from four occurrences in Colorado, which contained between 5 and 137 plants, showed that 53 percent of the plants flowered, and 4 percent of the plants that had flowered from one population (42 plants) produced fruit. No data were available from Kansas and Nebraska to calculate flowering and fruiting estimates. Only one occurrence of six plants from Wyoming included flowering data; all six plants were reported to have flowered.

Where the number individual plants was recorded (2 to 324 plants) on the Black Hills National Forest, only 23 records included the number of plants that had flowered. Fifty-four percent of the plants that were counted at these 23 locations produced a flower. All but one record (1993) was recorded during a four-year period (1999-2002). Of all the plants that produced flowers at the 23 sites within this four-year period, 93 percent produced fruit. Data from sites visited in 1999 alone indicated that 40 percent of the plants within an occurrence eventually produced fruit.

Information gathered from two large occurrences in the Black Hills showed that about 53 percent of the plants produced one flower, 2 percent produced two flowers, and 35 to 43 percent of the plants were vegetative (Mergen 2002). The remaining 4 to 12 percent of the two large populations had been grazed, so flower and fruit success could not be determined. The summary of data from the Black Hills National Forest on flowering and fruit production are within the range described by Kull and Kull (1991).

Self- and sib-incompatibility mechanisms are likely present in *Cypripedium parviflorum* since they are found in other *Cypripedium* species (Weller 1994). The structure of the flower and behavior of pollinators probably decrease the likelihood of self- or sib-pollination (Proctor et al. 1996). If a population is too small and mechanisms are present to reduce self- and sib-pollination, then small populations may be unable to attract pollinators and will be unable to replace population members that are lost (Ramsay and Stewart 1998).

Vegetative reproduction occurs by rhizome ramification about 5 years after establishment in *Cypripedium calceolus*, and it is very important for many populations of this species (Kull 1999). While vegetative reproduction likely plays a role in many populations of *C. parviflorum* in Region 2, there is currently no information available on this topic.

Cypripedium calceolus and presumably *C. parviflorum* exhibit high adult survivorship, low recruitment, and delayed age for first reproduction. Most research has been conducted on *C. calceolus* in Europe and was assumed applicable to North American *C. parviflorum*. However, with the recent name change (separation of North American and Euro-Asian species), previously assumed similarities in biology and ecology may be questioned. High adult survival, low recruitment, and delayed age for first reproduction are characteristics that make extinction of a species more likely (Falk 1992, Fiedler and Ahouse 1992). Plants that are rare in number of individuals and number of locations throughout its range often have a greater probability for extinction than plants with many individuals and locations (Falk 1992, Fiedler and Ahouse 1992).

Population viability analysis

Terschuren (1999) offers a population viability analysis of *Cypripedium calceolus* projected over 100 years with many scenarios. He makes assumptions on the life history parameters, which may or may not be apply to *C. parviflorum* in Region 2. His data was collected from populations that include pollination, recruitment, and clone production. Populations studied contained between 5 and 200 plants (that assumed 5-2,000 flowering stems), a range that he determined included most European populations. Larger populations (50, 100, 200 plants) had a greater probability of survival compared to populations of 5, 10, and 20 individuals, regardless of disturbance.

Annual disturbance (i.e., digging up one or two plants) greatly reduced the probability of survival regardless of population size. Digging up either one or two plants on a 5-year disturbance scenario resulted in little or no survival for populations with less than 50 plants. Picking half the flowers at annual and 5-year disturbance times resulted in an increased probability of extirpation of a population based on initial size. The greater the initial population size, the less impact

of picking half the flowers. Again this analysis was conducted for *Cypripedium calceolus*, with assumptions of life history characteristics, and with several scenarios based on disturbance (Terschuren 1999). The results of Terschuren's (1999) analyses that may apply to Region 2 are that larger populations with less disturbance have a greater probability of long-term survival than smaller populations.

A second population viability analysis of *Cypripedium calceolus* from three Poland populations was reviewed (Nicolè et al. 2005). Results of their analysis indicate that when *Cypripedium* habitat is protected, the population dynamics are stable, and time until extirpation of a population was greater than 100 years. Long-lived plants, seed bank, and adult dormancy were all important characteristics for population stability. *Cypripedium calceolus* can persist where its habitat is protected and environmental change is slow (secondary forest succession).

Metapopulation structure

A metapopulation consists of loosely coupled, interacting populations, in which the probability of extirpation may be locally high, but unrelated to other populations (Bowles and Whelan 1994). Another definition of metapopulation structure is a collection of interacting populations dispersed through a spatially and temporally variable landscape. The fate of each population is influenced by its genetic, demographic, and environmental history (McEachern et al. 1994). *Cypripedium parviflorum* populations at any scale, regional, state, national forest, county, or even groups of plants located nearby each other (e.g., different drainages within one watershed) may have little or no interaction with other groups of plants. Groups of plants on the Black Hills National Forest are probably isolated from those on the Bighorn National Forest, and extirpation of one occurrence will not impact another occurrence. Nearby groups of plants may also be completely isolated, so the loss of any occurrence will have little or no influence on another occurrence. The independence of each occurrence and the scale where independence occurs are unknown for *C. parviflorum* in Region 2.

Each individual local occurrence in Region 2 is susceptible to extirpation since most of the recorded populations are less than 10 individual plants and their occupied area is small. Disturbances that affect small areas could easily damage small groups of plants. Even occurrences with over 100 plants are in danger of extirpation resulting from an isolated catastrophic event because they occupy such small areas.

Summary of demography

Genetic variability in *Cypripedium parviflorum* is unknown for Region 2. The metapopulation structure of Region 2 contains many occurrences with less than 10 plants and only nine locations with a large (>100) numbers of plants. Information is lacking about the life cycle and demography of this species. Population viability analyses conducted for *C. calceolus* in Europe may apply to *C. parviflorum* in Region 2. Results indicate that larger populations have a greater chance of survival from disturbances compared to smaller populations, and most populations remain relatively stable over time when habitat is protected. Long-lived plants, seed bank, and adult dormancy were vital characteristics for population stability and longevity and are probably apply to Region 2.

Community ecology

Some North American orchids, including *Cypripedium parviflorum*, may require some change in the local habitat to persist and increase population numbers (Stuckey 1967, Case 1987). These changes may be as simple as the annual addition of moss growth or the deposition of conifer leaf litter, or they may be more extreme, such as removal of trees, annual addition of leaf litter from deciduous trees, or changes in the water table. *Cypripedium parviflorum* of the Great Lakes region are plants of transient successional stages, not climax conditions (Case 1987), and Stuckey (1967) concludes that native orchids of Rhode Island appear to be part of the transitional vegetation rather than the climax plant community. Curtis (1932) referred to a transitional zone where *C. parviflorum*, *C. parviflorum* var. *pubescens*, and other slipper orchids were found growing in Wisconsin, and he described a transitional zone between a meadow and a gravel knoll. All of these authors found *C. parviflorum* to be more common in successional habitats than in a climax plant community. Slipper orchid ecology in the Great Lakes, Rhode Island, and Wisconsin may be similar to slipper orchid ecology in Region 2. Therefore, *C. parviflorum* may do better in transitional or successional plant communities than in climax communities. The different number of plant communities for Region 2 (**Table 3**, **Table 4**) does indicate that *C. parviflorum* is able to at least survive in microhabitats or conditions present in many plant communities.

Cypripedium parviflorum in habitats other than climax may take advantage of changing conditions and expand, increase vigor, or become established when more favorable environments develop. The time for these changes to occur may be rapid or over many years. In Upper Michigan, *C. calceolus* var. *pubescens* and *C. acaule* are found more commonly in roadside clearings, ditches, and zones occasionally disturbed by snowplows than they are a short distance back into undisturbed timber (Case 1987). Case also reports that it is common to find old clumps of these same species in heavy timber, but that seedlings are generally lacking in the heavy timber. Stuckey (1967) reports that in Rhode Island, *C. acaule* was then more common in light shade in second-growth oak or pinewoods than it was 50 years earlier. She also found *C. acaule* in older woods where a deep layer of organic matter had accumulated on the soil surface and where less light was available. However, she thought that these populations may be relics from larger populations, which have barely survived as light decreased, trees grew in size, and canopy cover increased. These relic populations are mature, rarely flower, and when they do flower, seldom set seed.

Within Region 2, *Cypripedium parviflorum* plants are found in a variety of plant communities (**Table 4**); it is a species capable of growing in many different plant communities or near the ecotone of different community types. Plants in the deciduous and conifer-deciduous mix habitats receive large annual inputs of leaf litter and seasonal fluctuations of light. Plants found in the coniferous communities also receive an input of leaf litter, but they may be receiving litter from moss cover; plants in conifer habitat may have less seasonal light fluctuations compared to the other communities. Plants growing in the eastern part of South Dakota, Nebraska, and Kansas are possibly better adapted to prairie or wet meadow habitats, but they are still generally found in woodlands.

Succession created by any means produces changes in light, humidity, humus accumulation, acidity, water holding capacity of the substrate, runoff, sediment movement, available nutrients, and/or microbial activity, thus creating a condition that did not exist previously (Case 1987). Orchids may have a narrow range of conditions required for seeds to germinate and become established. This narrow range of conditions may change continuously from year to year at a microsite, and these changes depend on the existing habitat, management activities, weather, or natural disturbances like fires or drought. Case (1987) explains that any change in succession, either fast or slow, may begin with a decrease in plant vigor, number, fruit set, seed production, or germination, and it eventually may prevent or eliminate recruitment and cause the population to become extirpated. Changes in succession may also reverse this trend, and the population may expand and vigor may improve. Kull (1998) states a lack of microsites limits recruitment of *Cypripedium calceolus*. Local *C. parviflorum* populations are always in a state of change, either decreasing as succession proceeds or capitalizing on changes that occur during succession to increase their abundance as suitable microsites become available (Case 1987). Some occurrences have small plants (possibly new recruits) while other occurrences consist of only a few similar sized plants (possibly one age class). Data to support or refute benefits of successional change on *C. parviflorum* in Region 2 are lacking.

The wide range of plant communities where *Cypripedium parviflorum* is found in Region 2 may suggest that the species is tolerant and may survive in many successional communities. A changing environment is reported to be beneficial to *C. parviflorum* in Wisconsin and Michigan and to other native orchid species in Rhode Island (Curtis 1943, Stuckey 1967, Case 1987). These studies would indicate that *C. parviflorum* may benefit from some form of disturbance. However, the specific stage of the life cycle that *C. parviflorum* may benefit, the extent of the disturbance, and type of disturbance are unknown for Region 2.

Browsers and grazers

All locations of *Cypripedium parviflorum* in Region 2 have probably experienced some grazing from livestock or wildlife. A large body of literature leaves little doubt that grazing animals influence the vegetation and soil and that some plants are preferentially selected by animals (Heady and Child 1994). Wildlife, like deer and elk, and domestic cattle are selective feeders and may choose forbs over trees, shrubs, or graminoids. Grazing can be viewed as having negative or positive impacts on *C. parviflorum*, depending on what is being grazed. If the leaf, flower, or fruit of a *C. parviflorum* plant is grazed, then its health and seed production may be decreased. However, if surrounding vegetation is grazed, then *C. parviflorum* may benefit because competition for resources is reduced. Grazing may be beneficial to some degree and then become detrimental after an optimal level is reached because any change to a microsite (similar to succession) will impact the ecology.

Grazing of woody vegetation by deer was seen as beneficial for *Cypripedium reginae* (showy lady's slipper) in a balsam fir-cedar bog in Michigan from 1946 to 1961. These plants grew well, had many flowers, and expanded numbers because deer had over-browsed the cedar and created conditions that were open or lightly shaded. In the early 1950's, the deer population decreased dramatically through starvation and hunting. By 1957, balsam fir and cedar seedlings increased in the bog, and the number and vigor of *C. reginae* decreased as the area became more shaded (Case 1987). In the same study, cattle grazing boggy turf with populations of *Spiranthes lucida* severely broke up the soil surface with their hooves. A combination of their hoof action and close cropping of competing vegetation created areas where the *Spiranthes* orchid could become established. A fence was installed on one pasture to exclude grazing. This allowed competing sedges and willows to grow tall, and *S. lucida* decreased while *Platanthera hyperborea* (green bog-orchid) increased. Data specific to the effects of grazing on *C. parviflorum* are lacking, but Case (1987) concluded that it is impossible to make broad generalizations about grazing effects on orchid populations.

Competitors

Cypripedium parviflorum and their close relatives appear to be very weak competitors among other vegetation, especially woody vegetation such as tree seedlings and shrubs (Curtis 1943, Stuckey 1967, Kull 1998). *Cypripedium calceolus* is reported to suffer severely from competition with taller forbs and grasses in Europe (Kull 1999). Young *C. parviflorum* plants are very small the first several years and are extremely weak competitors for aboveground space compared to many other perennial plants.

As with grazing, there is a trade-off with each community characteristic, and *Cypripedium parviflorum* will respond either positively or negatively depending upon its life cycle stage and the degree of the characteristic (e.g., shade, competition, moisture). *Cypripedium parviflorum* may benefit when there is an increase in light, but the degree to which it benefits depends on the degree to which other plants benefit more and may be better to out-compete *C. parviflorum*. The ideal amount of competition that *C. parviflorum* can tolerate is currently unknown for populations in Region 2.

Mutualistic interactions

The great number of seeds produced by orchids makes the chance of a viable seed reaching an acceptable environment likely, but dispersed seeds must land in habitat suitable for germination. Microsite conditions like temperature, pH, moisture, and soil chemistry must exist within the tolerance range for not only the orchid, but also the necessary fungi. If any of these variables changes enough to exceed the tolerance of the orchid or fungi, then the seedling will fail to germinate or simply die after germination. Rasmussen (1995b) reports considerable loss of seedlings, before or even after infection of fungi, once seeds have germinated. The probability is extremely low for a seed to reach maturity (Nicolè et al. 2005).

Animals may help or hinder seed displacement by trampling or burrowing; seeds may be affected directly or indirectly (i.e., change in microsite). Trampling may kill established plants, or it may create a microsite that is more conducive to seed germination and establishment. In their burrowing, earthworms and millipedes are thought to disperse small seeded plants like orchids, but they also digest some viable seeds (McRill and Sagar 1973). Veyret (1969) suggests that soil bacteria may increase germination as they digest the seed coat.

Cypripedium parviflorum pollen that became infected with fungus after rains, particularly in older flowers, did not contribute to germination, and capsules failed to form when hand pollinated with infected pollen in Quebec, Canada (Light and MacConaill 1998). Some pollen contaminated with bacteria also performed poorly (Light and MacConaill 1998).

Kull (1999) reported no information on parasites for *Cypripedium calceolus*. Case (1987) reports spider mite damage to *C. calceolus* var. *pubescens* (*C. parviflorum*) in the wild. Rasmussen (1995b) reports of parasitic fungi that attacked roots of recently transplanted *C. calceolus*. No information was found specific to Region 2.

Spiders have been reported to spin webs over the lip openings of *Cypripedium calceolus* in order to capture potential pollinators (Kull 1999). This could impact individual plants and perhaps a small local population. Large beetles or bumblebees may become trapped within flowers and destroy them in their efforts to escape, and caterpillars or other herbivorous insects may devour perianth parts (Kull 1999).

Summary of community ecology

A list of all reported plant communities where *Cypripedium parviflorum* is found to occur in Region 2 (about 39 percent of the records) indicates that communities are characterized as conifer-deciduous mix (47 percent), followed by deciduous only (35 percent), and then by conifer only (18 percent) (**Table 4**). How the survival and reproduction of *C. parviflorum* is affected by changes in its community depends on the degree of the change and what stage of the life cycle the plant is in when the change occurs. Relatively little is currently known about the community ecology of *C. parviflorum* within Region 2; most of the information accumulated is from studies conducted in other parts of North America and in Europe. The responses of *C. parviflorum* in Region 2 may be similar to those reported in Rhode Island, Michigan, and Wisconsin, but this is unknown.

Envirogram

An envirogram is a graphic representation of components in the environment that directly or indirectly affect an organism's chance to survive and reproduce. While envirograms have been used primarily to describe the condition of animals (Andrewartha and Birch 1984), they may also be used to describe the condition of a plant species. Andrewartha and Birch (1984) stated that the environment of an animal [plant] consists of everything that might influence its chance to survive and reproduce. The environment is composed of three major propositions. The first proposition is that the environment is made up of a "centrum" of directly acting components and a "web" of indirectly acting components. Secondly, the centrum is divided into four components, resources, predators, malentities, and mates; the web is made of a number of branching connections of a chain, and each chain link may represent living organisms, their artifact or residue, inorganic matter, or energy. These links are the third proposition and are organized in integer steps from the closest connection, and therefore, most influential (1) to infinity (n). The farther the web steps are removed from the centrum, the less influence their links have on the organism in question. An envirogram illustrates this by placing the organism on the far right, then the centrum to the organism's left, followed by the web to the centrum's left; the web steps are distributed from right to left.

Envirograms are an attempt to visually simplify the environmental complexity of an organism by highlighting the most important components that act upon the organism of concern. Problems, solutions, management activities, areas information is lacking, or possible research needs may be viewed more easily with an envirogram. All of the arrows and lines within the diagrams show where a component may influence another component closer to the centrum. The degree to which a component influences the next component can change from day to day. For example, precipitation is an important component of soil moisture. If it rains during the day, then the soil moisture component of the web would be satisfied for some time period and precipitation would be less important the following day. In addition, the degree to which each component may influence the component in the next step depends upon the organism's life cycle stage. Soil moisture is much more important to a juvenile *Cypripedium parviflorum* that is dependent upon mycorrhizae than it is to an independent adult *C. parviflorum*. Each section of the envirogram (**Figure 8a**, **Figure 8b**, **Figure 8c**, **Figure 8d**, **Figure 8e**) represents a portion of the environment that was determined to be most important to *C. parviflorum* in Region 2. The figures are an attempt to display complex environmental interactions in a simplified visual format; therefore, some components may have been excluded.

Figure 8a shows resources of adult *Cypripedium parviflorum*. Nutrients, water, and light were determined to be the most directly acting components. Management activities and natural events are illustrated to show that they influence other plants (vegetation) that compete for nutrients and water, and that overstory vegetation can block out light. These same management activities and natural events are illustrated in the fourth step of the web to show that they influence vegetation in previous years; this vegetation provides leaf litter and the soil organic needs in the current year.

Figure 8b is the predators division of the centrum. Wildlife and domestic livestock grazing are included since they could be important negative components. A grazing plan was included as a management activity to show that the number of animals, the time animals are allowed to graze an area, and the frequency or intensity of grazing may influence *Cypripedium parviflorum*. Road construction and recreation allow greater exposure of *C. parviflorum* to plant collectors and thus are included in this diagram.

Figure 8c represents only the malentities portion of the centrum. Malentities can be thought of as unfortunate negative consequences or damage, accidents, or impacts of some management activity that will negatively affect *Cypripedium parviflorum*.

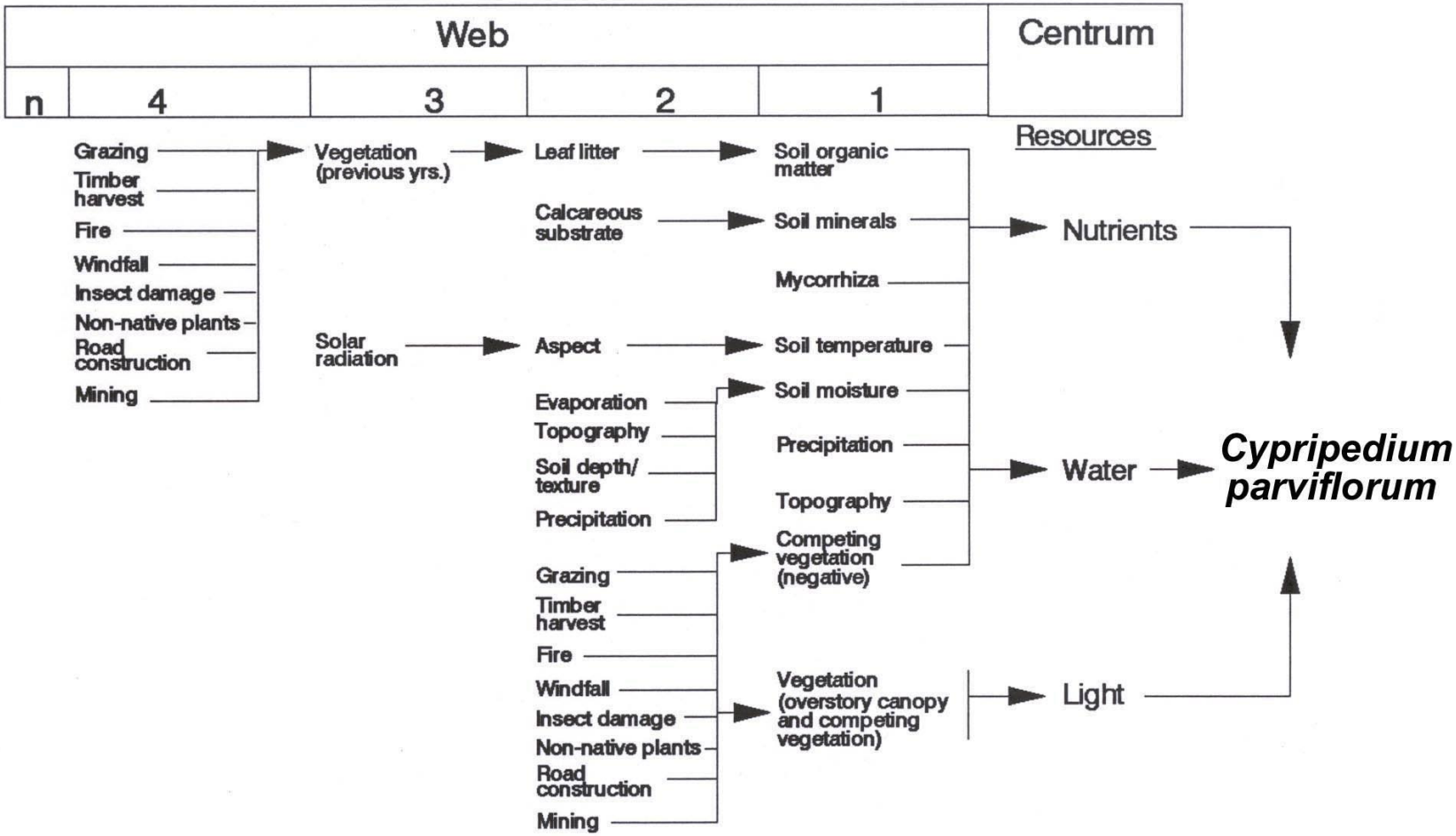

Figure 8a. Envirogram representing resources for *Cypripedium parviflorum*.

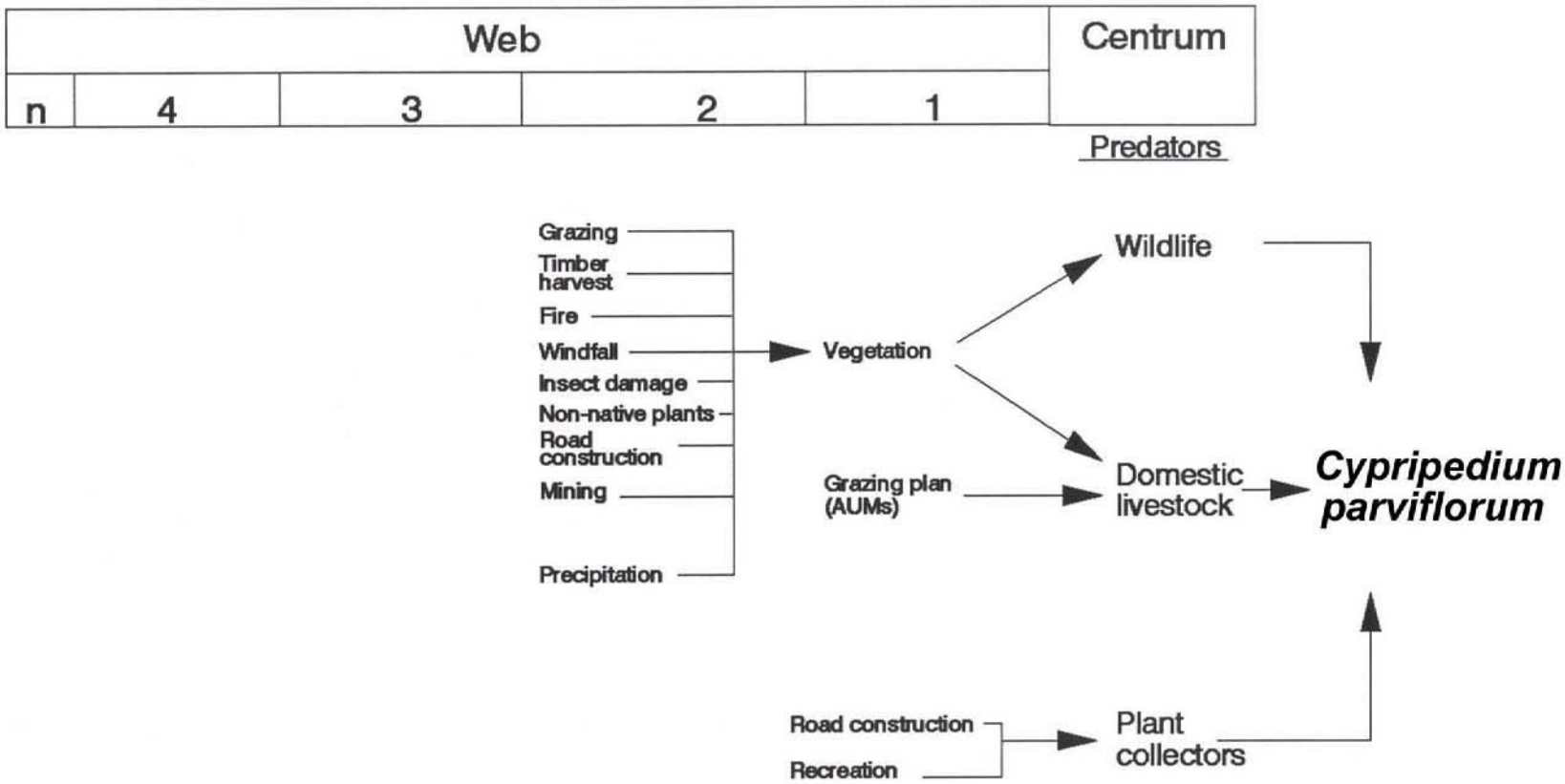

Figure 8b. Envirogram representing predators for *Cypripedium parviflorum*.

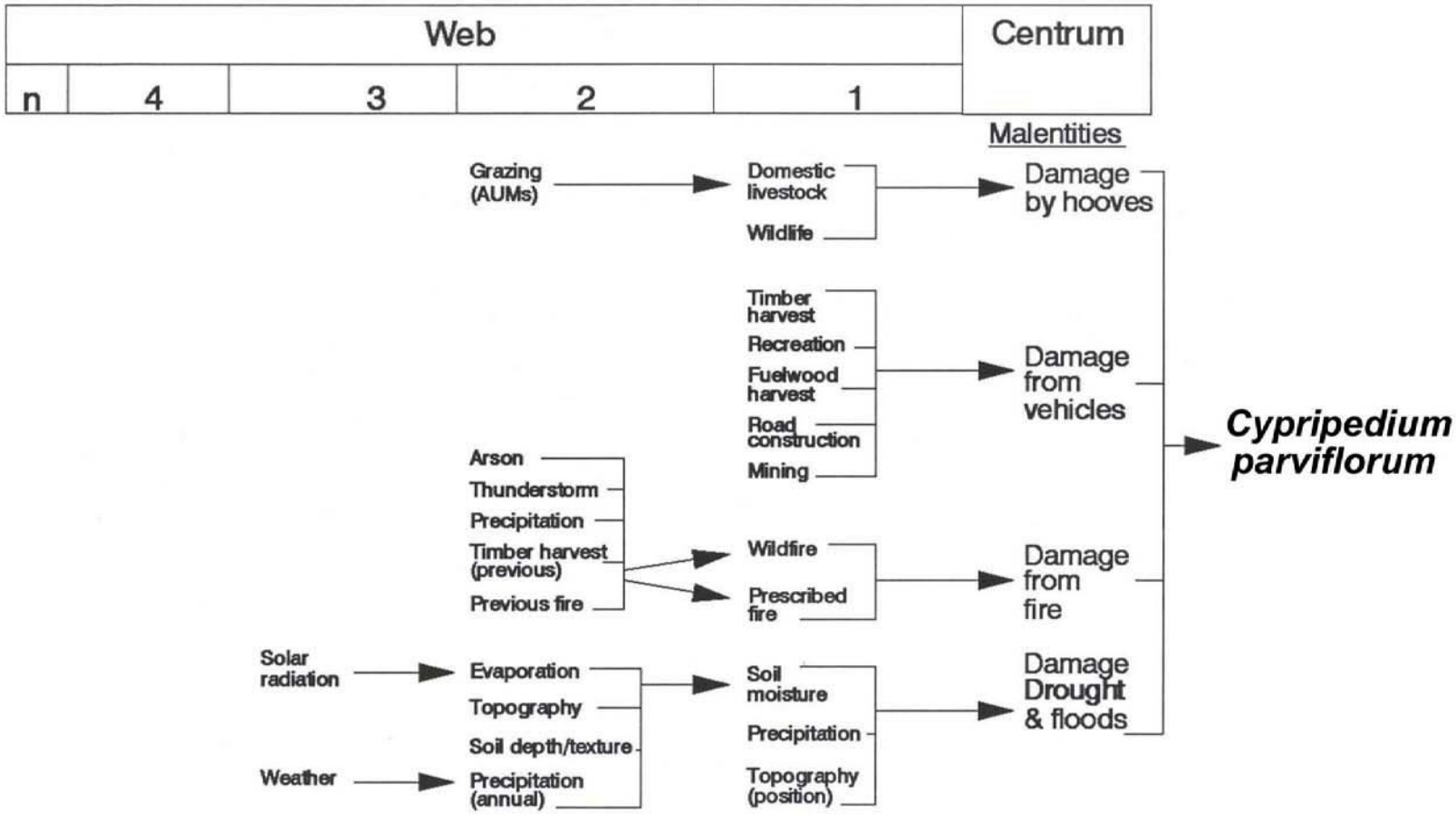

Figure 8c. Envirogram representing malentities for *Cypripedium parviflorum*.

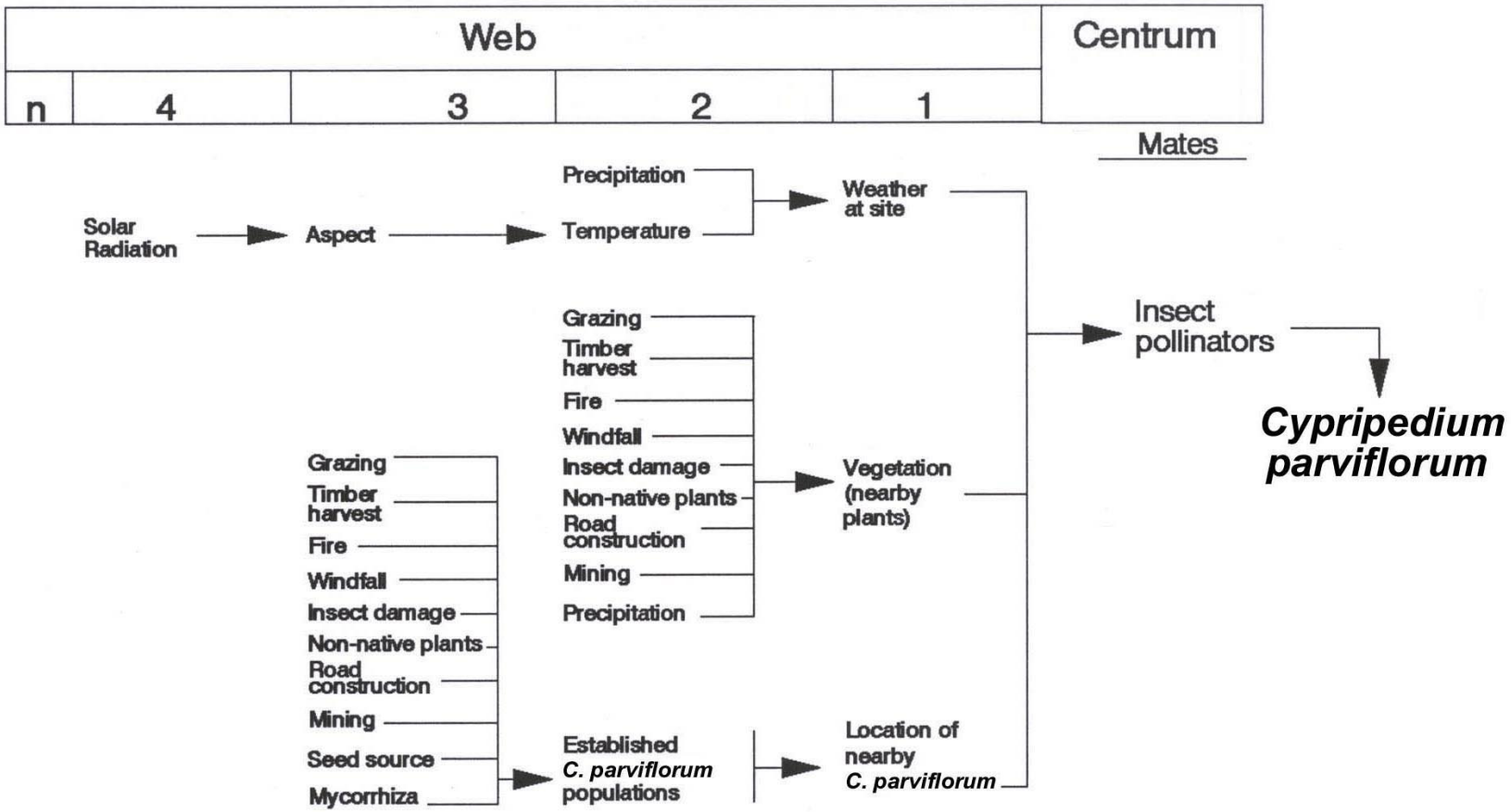

Figure 8d. Envirogram representing mates for *Cypripedium parviflorum*.

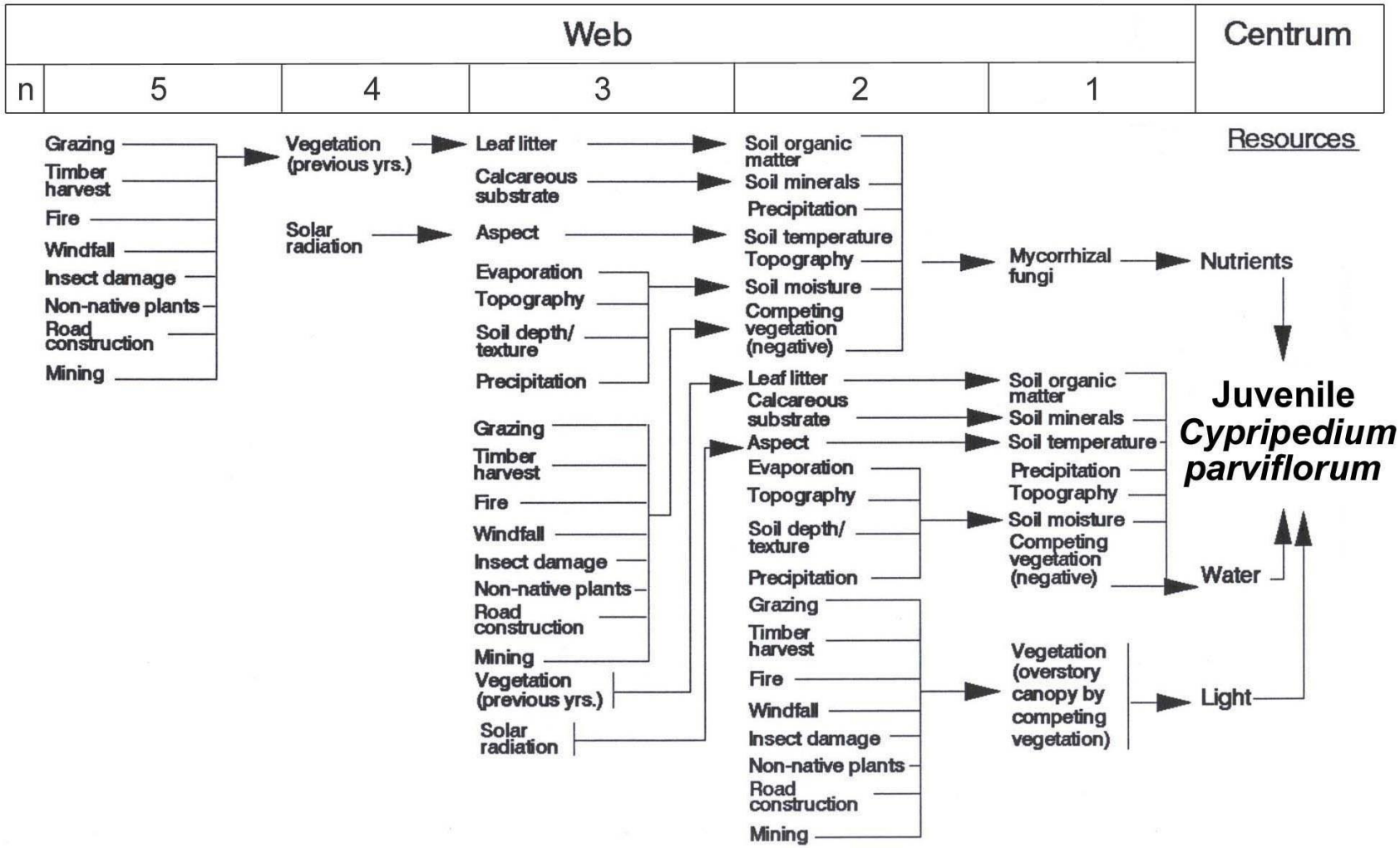

Figure 8e. Envirogram representing resources for juvenile *Cypripedium parviflorum*.

A malentity differs from a predator in that it will not be positively influenced by the consequence toward *C. parviflorum*. It is obvious that management activities can result in unintended consequences to this species. Drought and flood were included since these components may also damage *C. parviflorum*.

Figure 8d is the portion of the envirogram that illustrates the need for mates in the community. Mates are other *Cypripedium parviflorum* plants that are needed to cross-pollinate, preferably from a different clone or genetic line (occurrence in Region 2). This section shows that insect pollinators are the most important component that may directly affect an orchid's chance to reproduce sexually. Although no insects have been identified as actual pollinators within Region 2, they are suspected to be the vectors of pollination. The chance of pollination depends on the weather during the flowering period and the location of other *C. parviflorum* plants. Nearby vegetation may also influence the number of pollinators that frequent an area.

Figure 8e represents the resources section of the centrum again, but this time for juvenile plants only. A juvenile plant is defined as an individual from germination to the time it can photosynthesize a portion of its own energy requirements. Since mycorrhizal fungi have been identified as the suspected method by which young orchids receive their nutrients, mycorrhizal fungi are placed only one step removed from the centrum; this indicates that this component is very important during the juvenile stage of the life cycle. Light was included as a resource only because the juvenile orchid may begin synthesizing some of its own energy requirements while it is still dependent on mycorrhizal fungi. Including this additional information in **Figure 8a** would have complicated it beyond the goal of the simple graphic representation.

CONSERVATION

Risks and Response of Habitat and Plants to Management Activities and Risk Factors

It is difficult to evaluate risks to the long-term persistence of *Cypripedium parviflorum* in Region 2 because little is known about the species. The large number of occurrences (224) and their wide distribution decrease the risk to the current population within Region 2. While a risk or loss of any one occurrence may alter the viability of *C. parviflorum* locally, it may not reduce the species' viability overall in Region 2. Also, not all risks apply to all occurrences at the same level. Managers must consider each risk as it applies to individual plants or microhabitat, to local populations and habitat, and to the entire Region 2 population and range. The risk must also be considered from the following perspectives:

- Does the risk affect the habitat as a whole?
- Does it affect specific conditions within a specific plant community?
- How does the risk impact the flowering, reproduction, and recruitment success of individual plants and local populations?
- Does the risk affect different life cycle stages of *C. parviflorum*?

Cypripedium parviflorum is a long-lived perennial and may show population longevity, stability, and persistence (Silvertown and Franco 1993, Nicolè et al. 2005). National Forest System lands support most of the known locations of *C. parviflorum* in Region 2, but most National Forest System lands lack occurrence surveys and monitoring. The lack of surveys, monitoring, and knowledge of life history characteristics increases the difficulty to assess the population risk or cumulative risks to *C. parviflorum* in Region 2. A population decrease or reduction of available habitat may occur without recognition of the extent of these losses because of the lack of information.

Influence of Management Activities or Natural Disturbances on Habitat Quality and Individuals

The primary risks for *Cypripedium parviflorum* in Region 2 are plant collecting and habitat destruction. Habitat destruction may result from management activities (i.e., timber harvest, road construction, weed establishment, grazing) or natural disturbances. Other risks identified include fire (i.e., wildfire, fire suppression, and prescribed fires), recreation, mining, seeding, insect epidemics, wind events, drought, frost, and possibly acid rain or global warming.

Plant collection

Cribb and Sandison (1998) report that the 45 species of *Cypripedium* (*C. parviflorum* included) are the most sought after orchids by orchid enthusiasts. They also state that the major source of material for horticulture and medicine is from wild populations.

Many orchid suppliers offer orchids through mail order and supply seed-propagated plants or plants collected from the wild (Cribb 1997). Popular magazines like Martha Stewart Living (Galitzki 2002) report that native terrestrial orchids like *C. parviflorum* var. *pubescens* are increasingly scarce in the wild and that misguided gardeners and unethical commercial harvesters dig slipper orchids from the wild. Plant thieves may collect all individuals at a site if their intent is to make a profit. This has resulted in a decline in the more accessible populations (i.e., those nearest roads or high recreation use areas).

Cypripedium calceolus is the largest flowering, most exotic looking European orchid species, and is most often recognized to be an orchid (Wood et al. 1984). It has suffered a decline in numbers from collectors for more than two centuries in Europe. Collecting is partially responsible for the decimation of *C. calceolus* in England (Kull 1999). While there is no documented evidence that indicates the number of *C. calceolus* lost to collecting, the evidence presented is that only one population is currently found growing in the wild in England. *Cypripedium parviflorum* is described as once being abundant in rich Iowa forests, but it is now quite rare and localized. Because the habitat in Iowa remains suitable for *C. parviflorum*, the decline may be attributed to wildflower collectors (Niemann 1986). McIntosh (1931) reported *C. parviflorum* was being collected from the Black Hills and believed that this would be the demise of these plants. Although *C. parviflorum* still occurs in the Black Hills National Forest, no data are available to determine if McIntosh's prediction will come true.

Plant collecting is probably the greatest threat to *Cypripedium parviflorum* in Region 2, particularly to those occurrences that are easily accessible. The health of a population is obviously impacted when aboveground plant parts (i.e., flowers, stems, fruits) are collected. Collecting the rhizome and roots for research, personal garden use, illegal sale for horticultural or medicinal use, and botanical collections or voucher specimens also decreases a population size or at least negatively impacts the health of a population. Plant collecting indirectly affects a population by disturbing the rhizomes, fungi, immature plants, and microsite conditions required for *C. parviflorum* survival.

The only published or documented information available on the number of plants that have been collected in Region 2 are herbarium specimens. There are 65 known individual plant specimens that have been removed from the Black Hills alone since 1891; these are now deposited in herbaria. With some herbarium specimens, rhizomes and roots were lacking, but collecting flowering stems alone has been shown to be detrimental to *Cypripedium* orchid populations (Terschuren 1999). Most occurrences are reported to have fewer than 10 individuals; therefore each loss of a flower, fruit, single stem, or a complete individual (root included) makes an occurrence less healthy and increases the probability of extirpation.

The number of plants collected for garden, horticultural, and medicinal use may far exceed the number collected for herbaria specimens. However, there is no information about *Cypripedium parviflorum* being collected for commercial or medicinal purposes in Region 2. Legal plant collecting from National Forest System lands is only permitted for beneficial purposes and requires a permit (36 CFR 261.9(b) 2003). Most collecting activity (other than USFS-approved voucher or herbarium specimens) is illegal and done by a small number of individuals. Mr. Steve J. Popovich, Forest Service Botanist, stated that illegal theft (removal of entire plants) and trampling/crushing from high levels of unmanaged recreation were real threats to one *C. parviflorum* occurrence in Colorado. He believes that the site's long-term viability had been seriously impacted. Currently, the USFS is considering an emergency closure of this site to deter theft and use (Popovich personal communication 2006).

The impact of plant collecting on *Cypripedium parviflorum* in Region 2 is difficult to document when the current abundance and distribution are unknown and monitoring of known occurrences is lacking. Monitoring of easily accessible plant occurrences may give an indication of plant collecting risks in Region 2.

Timber harvest

Timber harvest includes all aspects required to remove trees from the forest. The Healthy Forest Initiative where fuelwood is cut and gathered to reduce the risk of catastrophic wildfire could also be included under timber harvest for this report, but it is less of a risk than commercial timber harvest because it is usually done by hand near current roads or at already severely disturbed landing areas.

Timber harvest, regardless of the tree species harvested, prescribed treatment and frequency of harvest, tending, or regeneration efforts, directly and indirectly impacts individual *Cypripedium parviflorum* plants, their habitat, or the entire occurrence negatively. The level of harvest will influence the level of impact

on succession and competition. The greatest concern during any timber harvest or thinning is the direct damage to plants from tree removal. Skidding a log to a landing during harvest could kill all plants within a small occurrence or by creating a gully, alter the microenvironment beyond a threshold that *C. parviflorum* could survive. Active management efforts to reduce the risk of skidding logs through an orchid site could be employed.

Alternatively, timber harvest could alter succession in such a way that proves beneficial to a local population. *Cypripedium parviflorum* is suspected to benefit from some canopy removal, and this management activity may improve habitat conditions at or near some current sites. Removing timber near orchid populations could result in increased soil water available to understory plants like orchids. However, greater soil moisture may also increase competition from other plants, thus reducing the benefit for *C. parviflorum*. Timber harvest combined with subsequent slash treatment may reduce the probability of large wildfires that may pose risk to more than one occurrence of *C. parviflorum*.

The lack of any individual plant monitoring within Region 2 prevents any determination of the positive or negative impacts of timber harvest on *Cypripedium parviflorum*. Monitoring individual plants at an occurrence before, during, and after timber harvest may give managers an indication of the positive or negative impacts of this activity. The improvement in habitat should be reflected in recruitment of new individual plants.

Road construction

Roads in general are a risk for *Cypripedium parviflorum* because their construction and maintenance may directly disturb individual plants and indirectly alter microsite conditions, primarily by changing the amounts of light and soil moisture. Creating roads through forests opens the overstory canopy and disturbs soils, thus making conditions conducive for early seral plants and increasing the likelihood of introducing noxious weeds. Dust from soil or gravel roads may impact habitat, pollinators, and individual plants nearby. A secondary negative impact of roads to *C. parviflorum* populations is increasing their accessibility to people (collectors, off-road vehicle drivers) and livestock. Case (1987) reports that off-road vehicles, like dirt bikes, three-wheelers, oversized four-wheel-drive vehicles, and dune buggies, do incalculable damage to orchid habitat in the western Great Lakes region and that large colonies of orchids, and other rare plants, are killed by these vehicles.

As with timber harvest, some activities associated with roads can benefit *Cypripedium parviflorum*. Highway 11 in northern Minnesota is referred to as the Orchid Highway because construction of the highway and the Canadian Pacific Railway, which runs parallel to the highway, created an area covered with large numbers of native orchids. It is believed that the crushed limestone used under railroad tracks, the altered hydrology, and the seasonal burning of brush by the railroad company has created optimum habitat for native orchids. The densities of *C. parviflorum* and *C. reginae* have increased greatly in this area since these transportation lanes were constructed (Hansen 2000). Case (1987) found dense populations of *C. parviflorum* in ditches where snow plowing and road grading often created a better microsite than what was available in adjacent wooded limestone areas near Lake Huron and Lake Michigan. Roads also change the natural hydrology of an area by concentrating surface or sub-surface runoff through a ditch or culvert. This may create greater soil moisture in some areas that previously lacked sufficient soil water and deprive other areas.

Information in Region 2 is lacking as to the positive and negative effects of roads on *Cypripedium parviflorum*. Highway 11 in Minnesota is an example of positive impacts of road construction, but the potential risk for damage to habitat and individual *C. parviflorum* plants may be much greater than any positive benefit in Region 2. Given the small areas where *C. parviflorum* occurrences are found, activities associated with a single road, whether it be a logging road, a recreation trail, or an expansion of an existing highway, could decimate an entire local population. Therefore, during planning for construction of new roads or maintenance of existing roads, efforts should be made to reduce any impact on known occurrences. These efforts could include moving the planned road a greater distance from known occurrences to insure that the current hydrology for an occurrence is not changed or installing a culvert to retain the current hydrology. Enforcement of off-road travel violations may also decrease the risks associated with roads.

Non-native species establishment and control

Non-native species establishment includes the intentional or unintentional introduction of any plant not native to Region 2. These include cultivars, invasive weeds, or escaped garden plants. Many *Cypripedium*

parviflorum occurrences within Region 2 were reported to contain non-native species, but no impacts have been noted. These species include: *Bromus inermis* (smooth brome), *Phleum pretense* (Timothy), *Poa pratensis* (Kentucky bluegrass), *Dactylis glomerata* (orchardgrass), *Cirsium arvense* (Canada thistle), *Tanacetum vulgare* (common tansy), *Taraxacum officinalis* (dandelion), *Cynoglossum officinale* (gypsyflower), *Trifolium* (clover) species, and other weeds. *Cypripedium parviflorum* is not reported to be specifically vulnerable or dependent on any non-native species in Region 2.

Since *Cypripedium parviflorum* is a poor competitor, any non-native plants that become established may out-compete it for resources. Non-native plants often form dense contiguous stands that could certainly occupy and consume much of the area and resources of *C. parviflorum*, particularly because of the relatively small areas inhabited at many orchid sites. Some introduced grasses have become established in near monoculture type stands within mesic meadows and riparian areas. When non-native plants become established, the light, nutrient, and water resources might change in the microsites of orchids to a point less than adequate for orchid survival. In addition, some species like *Bromus inermis* produce allelopathic compounds that, when excreted or secreted from their roots, injure or prevent other plants from becoming established nearby (Larcher 1991). There is no evidence that establishment of non-native plants, especially invasive or monocultures types of plants, has any positive benefit to *C. parviflorum* or any other native plant or plant community in Region 2.

Control of non-native plants with herbicide could be detrimental to *Cypripedium parviflorum* if individuals are sprayed directly or receive over-spray by personnel unable to identify them. Wood (1989) reports that the increased use of herbicides and artificial fertilizer in Europe has resulted in decreases in *C. calceolus* populations.

Efforts to prevent disturbance of soils nearby *Cypripedium parviflorum* sites would reduce the risk of non-native plant establishment. Non-native plants at orchid sites should be monitored to determine if they are becoming monocultures. Some invasive plants may need to be controlled with herbicide; this should be done under strict guidelines or supervision if conducted nearby rare plant occurrences.

Livestock grazing

All occurrences of *Cypripedium parviflorum* in Region 2 have probably experienced some grazing from livestock or wildlife, but no published data exists. Plants growing in more mesic locations, like riparian areas or on slopes of less than 40 percent, may experience greater grazing compared to plants found at drier locations or on greater slopes because they are more palatable and easier to obtain (Roth and Krueger 1982, Kauffman and Krueger 1984, Heady and Child 1994). Plants grazed by cattle and wildlife have been observed on the Black Hills National Forest (Mergen 2003a, 2004a, 2005). In two large occurrences discovered and observed in the Black Hills in 2002, 4 to 12 percent of the plants had been grazed by early August; elk were the most likely grazers. In 2003, only 3 percent of the plants in one of the same occurrences had been grazed by September while 100 percent of the plants in the second occurrence had been grazed when viewed in October; cattle were the likely grazers in this instance (Mergen 2003a).

Through their grazing, trampling, and elimination of waste, large herbivores concentrated in a small area, with or without moist soil, can disturb *Cypripedium parviflorum* occurrences to such an extent that neither the plants, their pollinators, nor their associated mycorrhizae may be able to survive. Indirect impacts could be positive or negative and include creating microsites for seed germination and establishment, removing competing vegetation, and altering nearby hydrology or nearby canopy cover to an extent that *C. parviflorum* could be harmed. Given the small area and low number of individual plants within a typical occurrence, excess livestock grazing could decimate a local population quickly.

Monitoring of sites in riparian areas and in areas grazed by livestock should be a priority in the conservation of *Cypripedium parviflorum*. Monitoring before and after livestock grazing could be used to determine the impact of this activity. Total exclusion of livestock at an occurrence may have some associated risks but could be an option for managers.

Fire

Fire has been an important component in the history of Region 2 as a major disturbance factor, and it has been listed as an important factor in the maintenance of a mosaic of habitats and biodiversity (USDA Forest

Service 1996). Since fire generally alters succession, this disturbance may be beneficial to *Cypripedium parviflorum*. Kull (1999) states that fire confined to low forest layers is known to benefit *C. calceolus* in Europe and Asia by decreasing competition. Fire may also recycle nutrients and alter soil chemistry, microbial activity, hydrology, and/or light penetration enough to benefit local populations. The frequency and intensity of fire most beneficial to *C. parviflorum* plants and habitat are unknown at this time. The degree at which fire becomes detrimental to orchids is also unknown. However, very intense and frequent fires can be expected to be more detrimental than less intense and frequent fires because very intense fires may kill all *C. parviflorum* individuals, damage the mycorrhizae found in the soil, or and/or alter the conditions to such an extent that *C. parviflorum*, its pollinators, or mycorrhizae are unable to survive long term. Fire can decrease viable fungi propagules (Rashid et al. 1997) and repeated fire may decrease soil biomass of fine roots, mycorrhizae, and reduce stored nitrogen and phosphorus levels (Hart et al. 2005).

Wildfires are usually started by people or lightning. They often burn at greater intensities and many more acres of land than prescribed fires. Depending on its size and location, a wildfire could burn one to many occurrences within Region 2. However, wildfires today are generally suppressed quickly after being reported, thus limiting acres burned. Active fire suppression at a *Cypripedium parviflorum* site could result in plants being damaged when fire-lines are constructed. Fire-line construction could also alter hydrology and other microsite conditions at or near an occurrence.

Fire suppression in the Black Hills has resulted in succession and production of more dense stands of vegetation (Hoffman and Alexander 1987). Greater shrub growth in the forest understory has been shown to negatively impact local populations of *Cypripedium calceolus*, *C. reginae*, and other *Cypripedium* species because of increased competition (Curtis 1943, Stuckey 1967, Case 1987, Wood 1989, Kull 1998, 1999). Fire suppression also results in increased overhead canopy cover of conifers, which affects the amount of light reaching the soil surface and negatively impacts *C. parviflorum*. The changes in succession and the decrease in light due to fire suppression may create habitat conditions that decrease or eliminate *C. parviflorum* recruitment. The long-term effects of fire suppression on *C. parviflorum* are unknown for Region 2, but they are suspected to be detrimental.

Depending on the time of year, prescribed fires can be a threat to *Cypripedium parviflorum* and its habitat. Conducting a prescribed fire in the late fall, after plants have been frozen and seeds have dispersed, may cause less damage than conducting one when plants are flowering in the spring or summer. Prescribed fires in the spring or summer may destroy plants and put them at greater risk since carbohydrate reserves are presumed to be lower. Earthmoving equipment is seldom used to create firebreaks in an effort to stop or slow the advance of a prescribed fire.

Recreation

All recreation could be viewed as a potential risk to *Cypripedium parviflorum* individuals and their habitat. The impacts of these activities could be direct (e.g., destruction of plants) and indirect (e.g., alteration of habitat). Any recreation activity that requires the construction of a road, trail, or picnic or parking area is likely to negatively impact orchids because individual plants or the entire population may be destroyed during construction or the habitat may be altered to an extent that plants fail to reproduce. Recreation may also place people near plants and increase the potential of plant collecting and the introduction of non-native plants (Mergen 2005).

The greatest impact of recreation impacts is direct trampling of *Cypripedium parviflorum* plants by humans, horses, bicycles, all-terrain and off-road vehicles, and snowmobiles. Trampling by bicycles and vehicles also indirectly impacts this species by compacting the soil and possibly altering the area's hydrology as wheels create ruts on damp off-road areas or steep hillsides. Soil compaction could also negatively impact mycorrhizae. Off-road vehicles did considerable damage to the habitat and crushed and killed large colonies of orchids (*C. parviflorum*, *C. reginae*, and other species) in Wisconsin and Michigan (Case 1987). Winter recreation, such as snowmobiling or cross country skiing, poses little direct risk since most occurrences would be covered by snow and dormant. Snow and soil compaction on occurrence sites could have some impact, but it is unknown. Efforts to reduce off-road travel could reduce the impact recreation activities; these efforts may include law enforcement or road and trail closure near know orchid locations.

A road that allows Colorado Springs Utilities access to a pipeline bisects the largest known *Cypripedium parviflorum* site in Region 2. The road

altered the hydrology and provided off-road vehicle access to the site. Recreational vehicles have driven both on and off the road, and camping has occurred within this large *C. parviflorum* site. Damage to specific plants and habitat is suspected, but there is no documentation of specific impacts. The access road has been gated and recently closed to recreational vehicles. While this has reduced recreational impacts greatly, it has not eliminated them because the locked gate has been breached on occasions (Olson personal communication 2006, Tapia personal communications 2006). Reducing recreation impacts (off-road travel and camping) on this road has greatly reduced the risk to one of the largest know populations in Region 2.

Mining

Literature concerning mining activities related to *Cypripedium parviflorum* occurrences or habitat was not found. Mining generally involves large-scale land disturbance to soil surface conditions and nearby plant communities. Therefore, mining likely decreases *C. parviflorum* numbers and habitat directly.

Mining could be a risk if mine activities were located directly on *Cypripedium parviflorum* locations or if impacts of mining activities altered current habitat conditions. Most impacts would be from road construction, waste rock dumps, open pits, ore storage areas, ore processing areas, and ancillary facilities. Land surfaces disturbed through mining processes might impact the hydrology, soil, and water chemistry of the area downslope. Large surface mines would be of greatest concern. However, most metamorphic rock material, which is more likely to contain valuable minerals, is generally less likely to have *C. parviflorum* nearby. Gravel mining may be the greatest risk to *C. parviflorum* in Region 2 since this mining is commonly done in limestone type geology (Mergen 2003b).

Areas near any proposed or existing gravel mine could be surveyed for *Cypripedium parviflorum* to determine if mining activities have had or might have any impacts. Current or proposed mines could be used to develop active management plans, such as relocation of an occurrence or individuals if it were determined that the mining operation would probably cause damage. Plants and soil could be transplanted to other known occurrences or introduced to areas suspected of being good habitat for *C. parviflorum*. Monitoring of individual plants would have to be done over several years to determine transplant success.

Seeding

Re-seeding an area following fire, flood, removal or construction of new roads, or reclamation of mine land or landing sites may be a risk to local *Cypripedium parviflorum* occurrences. Stand density of a seeded area is often considerably greater than that achieved through natural re-seeding, thus seeding may increase competition and reduce available orchid habitat. Non-native plants often are able to out-compete local vegetation for resources, and *C. parviflorum* appears to be a poor competitor. Seeding may also result in a monoculture stand of the most viable seed of an herbaceous species in the seed mixture. Monocultures of dense herbaceous vegetation generally decrease available resources and available sites for natural re-seeding of nearby native plants.

Atmospheric deposition

Components of atmospheric deposition include sulfur, nitrogen, calcium, magnesium, potassium, sodium, chloride, and ammonium concentrations (Mast et al. 2001, Turk et al. 2001, Fenn et al. 2003). While some natural deposition occurs, most atmospheric components are associated with anthropogenic actions such as urbanization, coal burning, automobile emissions, and industrialization (Mast et al. 2001, Turk et al. 2001, Fenn et al. 2003, Nanus et al. 2003). These air pollutants can significantly alter the acidity of the soil and water on which they fall, changing soil and water chemistry and altering nutrient availability and uptake (Paul and Clark 1989, Jury et al. 1991, Larcher 1991). Climate variables such as wind direction and precipitation patterns influence deposition rates, and the geology of an area also influences the impact of the pollution. These pollutants can accumulate in snowfall throughout the winter and then be released in snowmelt in the spring and summer. Rainfall can also transport these air pollutants throughout the environment.

The optimal range of soil chemistry required for *Cypripedium parviflorum* and its pollinators and mycorrhizae are currently unknown. The limestone geology with which *C. parviflorum* is associated may be able to buffer the effects of some soil chemistry changes. The amount of deposition, the buffering capacity of the geology, and the change in soil chemistry at a particular site in Region 2 are all variable. Managers should be aware of this risk and the possibility that this risk may interact and affect the severity of other risks.

Global warming

There is a general consensus of anthropogenic warming in the long-term climate record (Intergovernmental Panel on Climate Change 1995). An expected warming of global temperatures in the future has resulted in numerous predictions of environmental change (Manage and Wetherald 1986, Giorgi et al. 1998, Alward et al. 1999, Crowley 2000). Consequences of warming that could possibly have negative consequences for *Cypripedium parviflorum* may be an increase of available nitrogen, large-scale shifts in precipitation and vegetation plant community (Melillo 1999), and an increase of native and exotic forbs (Alward et al. 1999). The impact any of these changes or other predicted changes on *C. parviflorum* could only be speculative since the level of habitat and life-cycle requirements for this species are unknown. In addition, the level of monitoring required to detect any population change is currently lacking, and these changes would probably be gradual and difficult to detect. Therefore, to relate global climate change or predicted changes to habitat or population changes in Region 2 and for managers to manage for this risk now or in the foreseeable future is difficult if not impossible. Managers can be aware of climate change and understand these predicted changes such as increased in exotic forbs may increase in severity.

Wildlife grazing

The impacts of wildlife on *Cypripedium parviflorum* are likely to be similar to the impacts of livestock; see Livestock grazing section of this report for additional information. Wild herbivores are known to eat *C. parviflorum* plant parts (Cogshall 1928, Mergen 2003a), but little is known about the type of animals and the extent to which they graze this species. Grazing flowers reduces the opportunity for seed production. Grazing leaves and stems probably reduces the health of a plant, depending on the amount of material grazed and when it is grazed. Grazing capsules may reduce the number of available seeds, but it could also help in seed dispersal. As with livestock, total exclusion of wildlife from *C. parviflorum* occurrences could be an option for managers.

Habitat fragmentation

It is possible that some land use activities contribute to habitat fragmentation, but the impact that habitat fragmentation has on *Cypripedium parviflorum* is currently unknown. The many different plant communities where *C. parviflorum* is found may indicate that this species can survive some habitat fragmentation. Since habitat requirements are so little understood, fragmentation may be viewed as a compounded risk. Most occurrences are geographically isolated from other occurrences, and gene flow among occurrences may be limited (the extent of gene flow within and occurrence is currently unknown). However, any further fragmentation of habitat may increase the probability that the severity of current risks may be increased. Urban development within Spearfish Canyon watershed in the Black Hills will likely increase roads and single-family homes in some habitat, and this could fragment contiguous sections of *C. parviflorum* habitat. In addition, habitat fragmentation could also stress and increase habitat fragmentation risks to pollinators.

Flooding

Cypripedium parviflorum habitat near riparian areas can be altered by floods or by a raised water table caused by activities such as beaver dam, timber harvest upslope, or road construction. These types of disturbance generally result in new habitats becoming available around the periphery of the newly flooded area and may help in seed dispersal and recruitment near occurrence sites. However, *C. parviflorum* flooded plants can be killed if the water level is too high. The newly created habitat may also become invaded with non-native plants, especially invasive weeds, that can quickly become established and compete with *C. parviflorum*.

Flooding is a greater risk to plants near riparian areas where runoff from precipitation events could become concentrated enough to erode plants from the soil. Soil erosion and deposition of soil could also alter the hydrology or habitat and be considered a risk to individual plants or local populations. No information is available about the impacts of flooding to *Cypripedium parviflorum* in Region 2. Flooding is viewed as a risk to some individual occurrences found in the bottom of some drainage channels, but other than taking preemptive measures and moving these plants, there is little that can be done to prevent damage from natural flooding.

Insect epidemics

Like fire, insects have been an important component in the natural history of Region 2 forests. Insect epidemics of the mountain pine beetle were considered to have been a major historic factor within the Black Hills National Forest (USDA Forest Service 1996). Insects can gradually kill a tree. An infested

tree progresses through stages from a live tree to deadfall, and this progression offers a gradual increase in light penetration and a gradual decrease in rainfall interception when compared to timber harvest, wildfire, and wind events. These conditions of greater soil moisture and a gradual increase in light penetration are stated as beneficial to some orchid species, *Cypripedium parviflorum* and *C. calceolus* in particular (Stuckey 1967, Case 1987, Wood 1989).

Insect infestation can spread through a stand of trees, and the extent of these dying trees can expand over time. While an insect epidemic may appear to be detrimental, to some forest vegetation this gradual expansion of dying trees may offer species with very specific habitat conditions to take advantage of the new environmental conditions that may be present. For example, as a forested area is infected with an insect pest, trees begin to die and the leaves turn brown but may remain on the stems. The resources required by this tree are now available to surrounding plants and soil fauna, but the tree continues to offer the shade that it did while alive. This condition may only last a year to several years, but this may be long enough to allow *Cypripedium parviflorum* seeds to germinate and become established (recruitment).

Insect epidemics may initially increase the chance of wildfire as trees die (see Fire section earlier in this report). However, after a patch of infected trees have lost their leaves and over time have fallen or been replaced by smaller trees, there may be less risk of wildfire. In addition, an infected patch could break up the monotypic dense stands of conifer forest now dominating some forested areas in Region 2 (Mergen 2005). An insect epidemic may also decimate other plants that are important to pollinators of *Cypripedium parviflorum*. The insects themselves may out-compete the dominant pollinators of *C. parviflorum*. These two factors could decrease the opportunity for orchid pollination, thus decrease the health of local populations and the Region 2 population in general. No reports of insect epidemics directly or indirectly affecting *C. parviflorum* were located in the literature. Again, plants that are impacted by an insect epidemic could be monitored annually to determine what impacts are occurring.

Wind events

Unlike insect epidemics, wind events generally remove the overhead canopy and create new microsite conditions quickly. Small wind events that affect a few scattered trees within *Cypripedium parviflorum* habitat could be beneficial by allowing *C. parviflorum* to expand to newly created microsites. However, wind damage occurring at a localized level could also pose a risk to local occurrences. Large areas damaged by wind could negatively affect local *C. parviflorum* occurrences by directly covering plants with fallen trees, or decreasing the canopy cover enough that plants could not adapt to the rapid increase in sunlight exposure.

Drought

Soil moisture and precipitation requirements are currently unknown for *Cypripedium parviflorum*. Factors like shade, slope, soil characteristics, and elevation also affect the amount of moisture available from precipitation. Short-term drought may impact flower, fruit, seed, germination success, and possibly kill *C. parviflorum* plants living on the edge of the suitable moisture range. Fruit production of *C. parviflorum* was reported to be very susceptible if water stress occurred at a critical time (Light and MacConaill 1998). Kull (1999) reports that *C. calceolus* is very drought sensitive, especially the seedlings that need constant moisture.

A long-term drought could kill many local occurrences, depending on its severity and duration. Occurrences would be more at risk if they are located in drier areas or in areas on the extreme margin of their range of tolerable conditions. *Cypripedium parviflorum* plants have been reported to be able to remain dormant for up to four years in Illinois (Shefferson et al. 2001). Adult dormancy has been cited for population stability and longevity (Nicolè et al. 2005). Plants may remain underground until more favorable conditions (i.e., spring frost days, precipitation, mean spring temperature) are present.

Frost

Frost kill of *Cypripedium parviflorum* plants may occur sporadically and over a wide spatial area; timing of the frost (spring or fall) will also influence its impact. Frosts have been found to decrease *C. calceolus* shoot survival and flowering in clear-cut areas located at high altitudes in Europe and Asia (Kull 1999). Frost may have little effect on *C. parviflorum* habitat except that it could kill portions of competing vegetation, thus offer benefits to orchid populations. Frost could decrease populations or the activities of pollinators of *C. parviflorum*. Eberle (1973 cited in Kull 1999) reported that frosts can leave brown spots on the yellow lips of the flowers; this could damage the flower or at least decrease its attractiveness to pollinators.

Summary of risks

No single risk could completely extirpate *Cypripedium parviflorum* from its current distribution in Region 2. The severity of each risk at any particular occurrence is based on many items such as the number of plants per occurrence, current life cycle stage and season, current habitat, topographic position, distance from a trail or road, and current management activities for an area. Local managers need to assess the severity of each risk at an occurrence and then determine the management activities that can reduce the greatest risks.

Specific responses of individual *Cypripedium parviflorum* plants and their habitat to management activities and natural disturbances in Region 2 are unknown. Suspected responses cited were based on reports found in the literature; most reports were from places other than Region 2. Plant collecting, recreation, and invasion of non-native plant species can all be viewed as being detrimental to both *C. parviflorum* and its habitat. The more frequent or intense these activities are, the more detrimental. Any effort to prevent or reduce the impacts of these activities could benefit *C. parviflorum* and its habitat.

Management activities that may benefit habitat could be detrimental to individuals. For example, livestock grazing may reduce competition with herbaceous or woody plants near *Cypripedium parviflorum* and thus be viewed as positive, but individual plants may be killed or damaged by direct grazing or associated soil compaction. In general, management activities or natural disturbances that affect habitats (negatively or positively) will likely have similar effects on individuals, but this is unknown.

Conservation Status of Cypripedium parviflorum in Region 2

Population trend

The lack of monitoring of *Cypripedium parviflorum* since it was first documented in Region 2 (1872, Herbarium records) has prevented determination of any quantitative population trend. Evidence also is lacking to indicate whether this species' habitat is declining in Region 2. Since *C. parviflorum* is a long-lived perennial and capable of surviving in multiple habitats, the number of occurrences and distribution may mask a reduction in habitat and population. Although there is no documented population decline, reported anecdotal declines and the lack of *C. parviflorum* in high probability habitat (where it might be expected to be found or abundant) would suggest that there has been some population loss.

The geographic distribution of sites and the variety of habitats in which this species occurs (**Table 4**) make its complete extirpation from Region 2 due to a single management activity or catastrophic event unlikely. However, each known occurrence of *Cypripedium parviflorum* is at risk from natural and man-made disturbances because it often occupies very small areas and contains few plants. Therefore a small, spatially-isolated disturbance event could possibly destroy all plants in an occurrence.

The only known specific habitat characteristic of this species is that it is confined to calcareous geology. Ecological succession could lead to a decline in suitable habitat, and some level of disturbance is probably required for its survival. However, there is some threshold where disturbance will negatively impact an occurrence; this threshold is different in different habitats, locations, and life cycle stages and is unknown.

Most of the 224 known locations of *Cypripedium parviflorum* are found on National Forest System lands. There is private land ownership adjacent to some occurrences, and some occurrences are found on property other than of National Forest System lands. There is little managers can do to reduce risks to this species on adjacent private lands, but limiting risks at each occurrence on National Forest System lands will benefit the Region 2 population.

A program of population monitoring and plant surveys that could better identify its distribution, abundance, and viability does not exist in sufficient detail in Region 2. Nor has a specific region-wide conservation plan been developed for *Cypripedium parviflorum*. Plans are in progress to reduce the human impact to one occurrence in Colorado by closing access to the site (Popovich personal communications 2006). Popovich states this one occurrence has been impacted by collecting, off-road travel, altered hydrology, and sedimentation; the viability of this one occurrence is at risk because the number of plants and area occupied has decreased (Popovich personal communications 2006).

Many new occurrences of *Cypripedium parviflorum* have recently been discovered on the Black Hills National Forest recently (Mergen 1999, 2002, 2003a, 2005, Zacharkevics 2004, 2005), but this is only an indication that the species is being

found during USFS botanical surveys. Many of the most recent occurrences are on drier, steeper slopes in habitat considered less than optimal orchid habitat (low probability habitat for some surveys). More occurrences may be reported now that *C. parviflorum* is included as a Region 2 sensitive plant species.

Life history characteristics and risks

There is much unknown concerning the biology and ecology of *Cypripedium parviflorum* in Region 2. *Cypripedium calceolus*, and presumably *C. parviflorum*, exhibits high adult survivorship, low recruitment, and delayed age for first reproduction; all of these characteristics make extinction of a species more likely (Falk 1992, Fiedler and Ahouse 1992). The early life cycle stages, between seed germination and mature adult, are critical for *C. parviflorum*. It is suspected that the immature plant depends upon mycorrhizae and requires a greater or at least a more stable soil moisture condition. Any management activity or natural event that causes a decrease in soil moisture or impacts the immature plant or the associated mycorrhizae could reduce or eliminate all immature orchids that have germinated within the last few years. These losses could eliminate all recruitment at a single occurrence while the mature plants may persist. Recruitment of new individuals is important for the maintenance of plant numbers at each site; plants that die must be replaced. Mature *C. parviflorum* plants appear to be able to survive within Region 2, but there is little evidence of recruitment of new individuals in any known occurrences in Region 2.

As a long-lived perennial, *Cypripedium parviflorum* may be less vulnerable to population fluctuations. *Cypripedium calceolus* populations in Estonia were little influenced by small changes in environmental conditions and did not fluctuate very much over time (Kull and Kull 1991). Dormancy, when individual plants fail to produce aboveground tissue for periods up to four years, has been found with *C. parviflorum* and *C. calceolus* in Illinois and Europe respectively (Kull 1999, Shefferson et al. 2001). It is suspected that dormancy is caused by environmental conditions and may reduce risks at some occurrences. Because this species is a long-lived perennial that can remain dormant for long periods, small populations may persist for many (>100) years, and extirpation may take many years to occur.

The effects of specific management activities and the specific life cycle stage at which *Cypripedium parviflorum* is most vulnerable to these activities are unknown and may vary depending upon habitat. In certain conditions, specific management activities may benefit the mature, established plants and at the same time be detrimental to immature plants.

Management of Cypripedium parviflorum in Region 2

Potential management implications

Cypripedium parviflorum is widely distributed across many different habitats and management situations in Region 2 (**Figure 1**). Clusters of known occurrences on the eastern boundary of Region 2 are geographically isolated from others in the Black Hills of western South Dakota, the Bighorn Mountains of north-central Wyoming, and the Rocky Mountains of central Colorado. Even within these clusters, occurrences may be separated at such distances that they behave as isolated populations. This large scale fragmentation and distribution likely decreases the susceptibility of the entire Region 2 population to environmental fluctuations or management policies. However, the small number of plants growing and area occupied at each occurrence site make any single *C. parviflorum* occurrence more susceptible to environmental or management activities.

The first thing required when developing a conservation strategy for a rare plant is an understanding of the habitat in which the species occurs (Norton 1989, Wiser et al. 1998). It is obvious from this report that the habitat of *Cypripedium parviflorum* in Region 2 is quite variable, at least for adult plants. The majority of the occurrences are described as upland forested communities, but these have fewer individual plants than those characterized as riparian or wetland type environments. It is possible, but only speculative, that the riparian areas were once corridors that contained a core population and connected some of the current isolated upland populations. Any management activity (e.g., livestock grazing) that may impact occurrences found in the riparian or wetland communities should be considered carefully since these areas generally have the larger number of plants and may be most important for the viability of the species.

Another important part in conserving a rare plant is to understand the dynamics of small populations (Gilpin and Soulé 1986). Such information for *Cypripedium parviflorum* in Region 2 is sparse, and the little that is known is site-specific. Before management practices can be effectively implemented for Region 2, the following questions need to be addressed:

- What constitutes a population?
- Do adjacent plants within a small occurrence get cross-pollinated?
- At what scale do adjacent occurrences become geographically isolated?

Further research on the life cycle and ecology of *C. parviflorum* will increase our knowledge about this species and help managers to develop effective approaches to its conservation. Monitoring individual plants at an occurrence may give support that some management practice is benefiting *C. parviflorum* without knowing exactly what part of the life cycle or ecology is affected.

Management activities occurring on National Forest System lands include timber harvest, road construction, livestock grazing, prescribed fires, and recreation, to name a few. Some of these activities can benefit *Cypripedium parviflorum* to some threshold and then pose negative impacts. The point at which this threshold is reached or exceeded is unknown for Region 2 occurrences. Natural events can be viewed the same way, but there is little control over these events. Since *C. parviflorum* is found in many different plant communities throughout the Region, any conclusion as to the effect of a particular management activity will need to be habitat specific. For example, grazing management in a moist riparian area where *C. parviflorum* is located will require different intensity and timing to maintain an occurrence compared to that required for an occurrence found on steep slopes with dry soils.

Management activities that may protect the current habitat of *Cypripedium parviflorum* include those that may reduce damage to a current known location. These may be, but are not limited to, modifying timber sale boundaries to prevent damage by logging machines; planning, closing, or altering roads and trails near occurrences; preventing or reducing off-road travel; preventing non-native plant establishment; regulating livestock grazing to reduce herbivory and trampling, especially in moist soils; and eliminating or reducing soil disturbance of any kind. Managers should consider the effect that an activity will have on mature plants, immature plants, flowering, pollination, fruit set, seed dispersal, recruitment, as well as the species' habitat and associated mycorrhizae.

It is suspected (but unknown at this time) that management activities designed to reduce competition for resources (i.e., water, nutrients, light) may improve both the habitat and health of *Cypripedium parviflorum* occurrences. It is also suspected that distribution of *C. parviflorum*, which is capable of producing abundant seeds per plant, is limited by specific habitat conditions required for seed germination and plant establishment. Habitat requirements for seed germination and establishment are unknown and are probably the most important requirements for population viability. Until more information is known about the plant communities or habitat conditions within specific communities that best support *C. parviflorum*, it is impossible to predict how an occurrence will react to a change, unless the change is drastic.

Plant communities, habitat conditions (of known occurrences), and areas where large occurrences are currently found should not be viewed as the best or required habitat of *Cypripedium parviflorum*. Also, since little information exists on survival, recruitment, or any life history characteristic of this plant in Region 2, the consequences of any management activity should be viewed as site specific for each occurrence and habitat condition until more is known.

One conservation action that managers may implement into regional management policy is maintaining *Cypripedium parviflorum* on the USFS Region 2 sensitive species list. Being listed as a sensitive plant requires managers to consider how projects will impact local occurrences. Land and Resource Management Plans may also implement or improve standards and guidelines that would decrease impacts on National Forest System lands and reduce effects to individual occurrences, individual plants, habitat, or suspected pollinators. Managers may identify and propose land exchanges or conservation easements that would increase protection or reduce impacts to *C. parviflorum*. Land managers may also permit opportunity for seed collection, storage, and establishment of populations on lands other than National Forest System lands for conservation and research purposes.

There are 224 reported occurrences of *Cypripedium parviflorum* in Region 2. It is found in many different habitats, which are often managed differently. Therefore, there is an array of potential management implications possible for *C. parviflorum* in Region 2. Monitoring individual plants at as many occurrences as possible within Region 2 could provide information needed to determine the impacts of management activities on survival and recruitment, especially if a management activity is proposed at or

near an occurrence. It is known that *C. parviflorum* survives in many different habitats, probably requires some habitat disturbance for its viability, and has certain life history characteristics that both help and hinder its survivability. It occurs in small areas with few plants, making each occurrence susceptible to extirpation. With a basic understanding of *C. parviflorum*, managers may be able to identify potential management activities at the occurrence level that would pose minimal impact.

Conservation elements

Priority conservation activities for *Cypripedium parviflorum* include assessing known occurrence sites for possible damage to individual plants and habitat, especially the riparian type occurrences. In addition to planned use and habitat assessment, individual plants and occurrences require individual plant monitoring. Since this orchid species is capable of dormancy, any monitoring project must be established at the individual plant level. This monitoring must be established for long-term to capture variability in numbers, to detect recruitment, and to assess general life history characteristics. Monitoring individual plants in a variety of different habitats under different management activities may yield information such as the type of activity that may benefit recruitment. This species is known to respond favorably to unknown levels of disturbance, and monitoring plants before, during, and after management activities may help to determine proper disturbance levels. An effective conservation plan can be developed after quantitative data are accumulated for different management activities and in different habitats. However, any local management that can reduce any direct impact to plants and reduce soil disturbance at known occurrence sites could currently be viewed as the start of an effective management plan.

Tools and practices

Species and habitat survey approaches

Plant and habitat surveys are searches of areas at different intensities to locate specific plant species or to delineate and describe different habitats. They are good tools to identify specific plants within an area, and are often used to gather preliminary data about a species. Generally, surveys are conducted in areas where management, often timber harvest in Region 2, is proposed; more surveys are conducted on lands where more activities occur. These plant surveys are more effective for determining the local distribution and abundance of a species where management is planned than for attempting to develop wide range distribution, abundance, and baseline information about a species. Therefore, it is difficult to accurately determine the regional distribution and abundance of *Cypripedium parviflorum*. Systematic surveys throughout the region without regard to management could better help to define its regional abundance and distribution. At this time, information of the regional distribution and abundance is lacking and a regional conservation strategy is unlikely.

Specific objectives often dictate survey approaches, which can be quite different among forests and among ranger districts on the same forest. Such a variety of survey methods often limits direct comparison of data collected. The Black Hills National Forest has supervised detailed plant and habitat surveys. Surveys are conducted throughout all habitats before management activities are planned. All Region 2 sensitive plants, state listed, and other plant species of interest are specifically searched for. Multiple species surveys help managers to find out what resources are within the forest while reducing costs. Concurrent with the plant surveys, habitat is delineated and qualitatively described. Each occurrence record includes site-specific habitat information along with Global Positioning System coordinates so that it can be easily relocated. Thus, population and habitat data for one occurrence can be directly compared to data from another occurrence. Habitat data collected following the Black Hills methods are generally recorded at a half section scale while *Cypripedium parviflorum* occurrence data are recorded near the $10m^2$ plot scale. Due to these survey efforts, 59 percent of all reported Region 2 *C. parviflorum* occurrences are from the Black Hills. Managers from other national forests could adapt the Black Hills National Forest methods or portions of these methods easily, depending upon specific objectives.

This orchid is found in many habitats, and little is known about its specific requirements; therefore, most habitats should be sampled during plant surveys. In general, *Cypripedium parviflorum* is found in calcareous substrates. While stratifying survey intensity based on limestone geology may reduce survey costs for this one species, limiting surveys to habitat perceived to be most likely to contain *C. parviflorum* could result in biased estimates of abundance and distribution.

The bright yellow flower of *Cypripedium parviflorum* makes it very easy to locate and identify when it is flowering. Individual plants may flower for up to 3 weeks, giving surveyors considerable opportunity to locate populations. However, all plants may not flower each year. Experienced surveyors and botanists, though,

should be able to identify this species whenever any aboveground plant parts are exposed. Still, some plants and possibly some small populations could be missed entirely during surveys as this species can go dormant for up to 4 years (in Illinois; Shefferson et al. 2001). Surveys of an area may need to be conducted annually for a minimum of 5 years to insure that dormant plants or occurrences are not overlooked.

Monitoring approaches

Data from one visit to one location are the results of a survey while data from the same location on a second date can be considered the results of monitoring. Monitoring can be divided into two approaches (Elzinga et al. 1998), species (or resource) and habitat monitoring. Both types of monitoring can be used for *Cypripedium parviflorum* in Region 2. However, concise objectives should be known before any monitoring is initiated since each type of monitoring can be used to address specific questions or concerns about a population. Resource monitoring measures such things as population size, density, cover or frequency, and number of flowers and fruit at specific times (generally annually). Resource monitoring may reveal demographic and life history characteristics, but it must be plant specific (conducted on individual plants). Habitat surveys and monitoring measure things like overstory tree canopy (crown closure), basal area (area of stump surface of trees at breast height [1.4 m]), canopy cover of plants (plant cover above soil other than trees and shrubs not measured for crown closure), solar radiation, and soil characteristics (Bonham 1989). The data from habitat surveys and monitoring are easily evaluated but may not answer questions on population trend or life history characteristics. Habitat monitoring may be more cost-efficient than resource monitoring since key variables in the habitat may be related to more than one rare plant species, whereas monitoring just *C. parviflorum* would require separate measurements per rare plant species. Again, objectives of any planned monitoring must be clearly understood and described.

Information that can be collected through species and habitat surveys, quantitative population and habitat inventories and monitoring, and life history studies is necessary before most conservation plans can be fully developed or conservation elements can be effectively implemented. Long-term monitoring is required to adequately determine life history characteristics like dormancy, flowering success, pollination vectors, fruiting success, and environmental fluctuations in a populations to name a few. Short-term studies (genetic analyses) could be used to determine mycorrhizae, *Cypripedium parviflorum* varieties, and seed bank variability in Region 2.

Locations and number of locations to be sampled would need to be assessed and reviewed to determine which sites could give the greatest amount of information over time. Priority of quantitative population monitoring could be to sample or inventory the largest, most easily accessed, or most at peril populations first. Sampling from larger populations may decrease the chance that an entire local population may be extirpated during the sampling period. However, since only 9 occurrences in Region 2 are considered large (over 100 stems), monitoring smaller populations is also required so that data can be gathered from a wider geographic range. Monitoring easily accessed populations would help to reduce costs. Given that a small population may be extirpated during the first 5 years, these at risk occurrences should also be monitored. The scale selected for habitat monitoring must be determined based on specific objectives. When comparisons across Region 2 are to be made about specific habitat conditions, then the same scale (plot size) should be used throughout the Region so direct comparisons are possible.

Long-term assessment of management activities, like timber harvest, livestock grazing, recreation, and mining, will require both habitat and resource monitoring. Habitat monitoring can be used to determine changes in environmental characteristics under a specific management activity over time. Resource monitoring will supplement this information and give an indication of population trend for specific plants within an occurrence. Habitat and resource monitoring of the individual plants and occurrences will more than likely have to continue long after the management activity has ceased in order to detect change (allow immature plants to be detected).

A combination of resource and habitat monitoring may also be necessary until life history characteristics for *Cypripedium parviflorum* are better understood. While resource monitoring may indicate a change in population over time, habitat monitoring may indicate the possible causes of the change in population size. However, most monitoring data are generally of limited value to determine the cause of change (Elzinga et al. 1998).

Elzinga et al. (1998) believe that collecting data for purposes of basic ecology and biology is not to be considered monitoring. However, the item most required for *Cypripedium parviflorum* in Region 2

is basic population data. Individual plants could be measured (monitored) annually for a period of at least 5 years (Shefferson et al. 2001) to gather basic demographic information including survival, dormancy, flowering and fruiting frequency, plant recruitment, and establishment. This basic information could then be used to develop a population viability analysis model specific to Region 2. In addition, this basic information could be summarized to detect change in populations over time. Therefore, the top monitoring need would be to monitor the life history of individual plants in several populations across Region 2 or in populations determined to be at greatest risk. Greater amounts of information can be collected per location and per visit by monitoring sites that have the most plants. Small populations would need to be included to increase sample size and to widen the distribution over Region 2.

In addition, management activities planned for areas could be monitored to develop information on activity impacts. For example, if some local populations were within a forest stand where timber harvest was planned, then the monitoring could be started before and continued after the management activity (timber harvest) to determine if and how removing timber affected individual plants or the population (detect recruitment).

Population or resource monitoring

Population monitoring is the same as resource monitoring discussed above, and it is a prerequisite for demography, ecology, and life history studies. Again, before any population monitoring project is implemented, concise objectives must be outlined. Monitoring must be conducted at the individual plant level in order to follow and understand the plant's life history. Aboveground plants should be the focus of a monitoring program. Underground plants (immature) should be documented and would give an estimation of recruitment numbers. Long-term monitoring must be considered and continued even if all plants at a location are absent from annual counts because recruitments may take several years to appear above ground and because *Cypripedium parviflorum* can remain dormant for up to 4 years. Dormancy could give a false indication of a populations' reduction or extirpation. Therefore, it is very important when monitoring any population that each plant be physically marked or identified by survey, photograph, or map. Presence or absence monitoring of this species is less suitable for this species.

Elzinga et al. (1998) describe methods for photopoints and photoplots. Accurate land survey or high quality GPS survey is another method to identify individual plants without individually flagging plants. Population data (number of plants and phenology) is collected for all new occurrence records discovered on the Black Hills National Forest, and little additional time is required for data collection.

Monitoring of individual plants is done at the scale of the local population (occurrence). It is always best to start at this scale (smallest scale) because information can always be summarized from this scale to larger scales such as watershed, District, Forest, and Region. Depending upon specific objectives, additional information (variables) can easily be collected while monitoring individual plants. For example, the number of fruits present will help to indicate life history characteristics such as estimated annual seed bank and fruit success. The more variables collected, the greater our understanding of this species' life history and the more data that could be used for model development, application, and prediction.

Experimental approaches

Experimental research is generally unavailable for rare plants because of the risk that individual plants or their habitat may be damaged. However, this type of work can more definitively identify thresholds or give land managers better predictive capabilities than simple observation studies. Fifty-nine percent of the known Region 2 occurrences of *Cypripedium parviflorum* are within the Black Hills National Forest, where timber harvest is a primary management activity. Therefore, there may be enough occurrences of *C. parviflorum* in the Black Hills National Forest to allow for research to determine optimal canopy cover and the approximate thresholds at which tree removal becomes detrimental. This type of research could greatly expedite and be more informative than observational data. Many other suspected habitat characteristics (e.g., soil moisture, competing vegetation) or disturbance factors (e.g., grazing, prescribed fire, recreation) could also be addressed experimentally. The large occurrences in the Black Hills could be used to address livestock grazing while the large Colorado occurrence may be used to address plant collecting, recreation, and off-road vehicle use since these disturbance factors are most applicable to these locations respectively. Ecological relationships between *C. parviflorum* and its habitat must be determined before habitat monitoring can be effective (Elzinga et al. 1998). This may require some research of these conditions in Region 2 for *C. parviflorum*.

Another form of research that may benefit the knowledge and population in Region 2 and pose little risk would be seed introductions. Seeds could be collected from known occurrences throughout the region and planted in soils that are suspected to be capable of supporting *Cypripedium parviflorum*. Some soil may also have to be included in the seed plantings to include the correct mycorrhizae. This method could be used to help determine optimal habitat for recruitment, to increase the range of specific occurrences, and to increase the number of plants, to name a few benefits. Each plant is capable of producing many seeds; collection of seed would probably pose little risk to the populations. This is also discussed in the Introduction and reintroduction section below.

Models

Small numbers of individual plants generally make experimental trials unfeasible for many rare plants. Models can be very useful tools for managers because management scenarios may be tested without any on-the-ground risk to populations. Data required to develop or to be used in existing models would need to be collected from *Cypripedium parviflorum* populations and habitat within Region 2. The amount and quality of data collected, as well as the model design itself, all determine model reliability. However, even the most basic demographic and habitat data specific to Region 2 National Forest System lands are lacking. Therefore, most model application is unfeasible, and any model results may be unreliable at this time. However, comparing published results of models used by Terschuren (1999) and Nicolè et al. (2005) could give managers an indication of what could happen in Region 2 under different scenarios.

Assessments

The 224 known occurrences of *Cypripedium parviflorum* could be assessed qualitatively to determine which sites are at greatest risk of damage due to management activities or natural causes. Those occurrences identified at greater risk could be given a higher priority for monitoring compared to occurrences currently at little risk. Ideally, both occurrence types, at risk and at little risk, could provide beneficial knowledge and possibly allow comparisons of management activity impacts. In addition, active management could be initiated to reduce the risk at those sites identified as being at the greatest risk due to some management activity. This has already been implemented at two known sites to reduce human impacts (Olson personal communication 2006, Popovich personal communication 2006, Tapia personal communications 2006).

Propagation

In 1983 at the Royal Botanic Gardens in Great Britain, Kew Gardens began the Sainsbury Orchid Project with the intent to increase the number of locations where *Cypripedium calceolus* occurs in the wild (Ramsay and Stewart 1998, Kew 2006). Seeds are collected from a known location, germinated, and grown under greenhouse conditions until ready for transplant. This project has been successful and could be adapted to restoration of *C. parviflorum* in Region 2. *Cypripedium parviflorum* could be introduced (or reintroduced) into areas like the McIntosh Fen in the Black Hills National Forest once the site's hydrology and vegetation is restored.

Propagation and seed introduction could also be used to increase the number of individuals or occurrences within Region 2 that could be used for experimental purposes. Conducting experimental research on new *Cypripedium parviflorum* occurrences would eliminate any the impact of research on the current population.

Seed banks

Seeds could also be collected from within Region 2 to be stored in seed banks. This would make seeds available for establishing new occurrences and expanding the species' range or for re-establishing occurrences that have been extirpated. *Cypripedium parviflorum* seeds have been reported to remain viable for at least 8 years (Curtis 1943), and plants have been successfully grown from seeds at several greenhouses in North America. Seed banking may be unnecessary at this time since there is currently an abundance of seeds; however, the genetic makeup and viability of the current seed source are unknown. There may be a need for seed banks once the genetic variability of the seed source for Region 2 is better understood.

Manage protected areas

Management of protected areas is a step to conserve both habitat and individual plants (Terschuren 1999). This method could be used in Region 2 simply by managing habitat at and near local occurrences for the specific benefit of *Cypripedium parviflorum*. The area in which an occurrence is located and a surrounding buffer area could be conserved from management activities that are suspected to pose a risk. The size of the buffer

area would depend on habitat, management activity, and adjacent land ownership. At a minimum, managing areas that contain *C. parviflorum* would exclude known populations from management activities that could be detrimental. However, complete exclusion (e.g., building a fence to exclude livestock) could in itself be detrimental to a local occurrence. As a species that requires some disturbance, the impact of completely excluding timber harvest or grazing from an occurrence is unknown.

Current USFS policy requires that sensitive species be considered during planning purposes for projects. Management of protected areas would include any active management at the occurrence level and performed by local Region 2 land managers. This may include altering a timber sale boundary; relocating a road, trail, or culvert; enforcing off-road travel restrictions and prosecuting violators; or modifying a current grazing plan in order to reduced impacts from herbivory or trampling.

Land protection

Falk (1992) lists land protection as a management strategy for preserving rare plants, and this could be considered in Region 2. While this strategy is similar to managing protected areas, it would also include acquiring lands for conservation purposes. Land swaps for private lands, particularly lands with limestone geology that may have considerable *Cypripedium parviflorum* habitat, could be traded to the USFS and then managed for rare plants. This method could be used, for example, in future land exchanges with Homestake Mining Company in the Black Hills National Forest or with owners of Colorado mountain properties that are slated for residential development and near current occurrences.

Diffuse habitat management

Diffuse habitat management can be implemented to conserve habitat near or between occurrences on a specific national forest without specific conservation measures (Terschuren 1999).

Individual protection and public education

Terschuren (1999) believes that publicity about known sites of rare orchids should be extensive and that great efforts should be made in public education and awareness of areas where populations are still numerous. The greater the number of people that are aware of a site and the conservation needs of a plant, the more likely that the area will be watched by others and destruction of plants at the site will be deterred. Awareness programs may help people appreciate plants in the environment and make potential collectors feel conspicuous. Greater public awareness may even increase public help in locating additional populations and deterring some collectors. Wood (1989) describes *Cypripedium calceolus* as the panda of the plant world. He believes it is a valuable plant for publicity and can be used to demonstrate what could happen to other rare plants.

It may be best to promote public education and awareness of *Cypripedium parviflorum* within Region 2, but keep specific locations of known occurrences secret. Medicinal, horticultural, or garden plant collectors could use this information to easily locate large populations for their personal use. However, sites that are already well-known because they are near popular tourist or recreational destinations could be used to increase public awareness about *C. parviflorum* and other rare plants and concerns about the conservation of these plants.

Plant salvage

Plant salvage could be considered as an individual conservation measure for *Cypripedium parviflorum*. Plant salvage involves collecting orchids where habitat and plants are to be destroyed by road construction or other activity, with the intention of re-locating or propagating them. This strategy is used in Minnesota when orchids and their habitat are in areas that will be destroyed during road construction (Hansen 2000), and it could be used any place within Region 2 where some activity was determined to impact a known occurrence and transplanting was guaranteed a high level of success. Off-site conservation would involve donating salvaged plants to gardens, arboreta, universities, or private individuals (see discussion below). These various organizations may be able to propagate or sustain certain genetic lines or use the plants for educational purposes.

Population reinforcement

Population reinforcement is a management method to enhance small natural populations by increasing natural recruitment at a site. This method increases the population size and decreases the probability that it will become extirpated (Terschuren 1999). Population reinforcement activities at a *Cypripedium parviflorum* site could include altering the canopy cover, reducing the amount of herbaceous or shrubby plants, preparing a

seedbed near existing plants, prescribing fire, irrigation, or any other activity that would increase the recruitment of new seedlings to the existing populations. The necessary treatments for this method are yet unknown for Region 2.

Introduction and reintroduction

Introduction and reintroduction are two forms of biological management that involve releasing orchids into a site that currently lacks a population with the intent to establish a breeding population (Falk 1992). These techniques are similar to seeding sites mentioned above under experimental approaches, but use propagated plants or transplants instead of seeds. Introduction would be to establish a breeding population at a site that would fit within habitat requirements for *Cypripedium parviflorum*, but that never before contained the species. Reintroduction would be to transplant orchids to habitat where plants were once documented, but no longer live. There are problems with both methods. A site where introduction is to occur may be lacking some required factors that are not understood (e.g., specific fungi). For reintroduction, the problem that resulted in an initial loss of the plant (e.g., a pathogen) may still exist at the proposed site.

Population reinforcement, introduction, or reintroduction could easily be applied in Region 2. Most Region 2 occurrences generally have more than one flower, each flower has the capacity to produce a fruit (a capsule), and each capsule may contain thousands of individual seeds. Seeds from one to many capsules could be placed in habitats determined suitable for *Cypripedium parviflorum*. Some soil from the original site should also be added to the proposed site in an effort to include the required mycorrhizae.

Successional management

Successional management, also described by Falk (1992), includes considerations in management of habitat quality, competition, interactions with co-occurring species, pollinators, dispersal agents, and community ecology. This management involves the direct manipulation of seral stages within the existing community to produce the optimal habitat for a particular species. *Cypripedium parviflorum* probably benefits when succession occurs, and selective timber harvest, grazing, and periodic burns could be tools used to manipulate seral conditions. These management activities alter the competition with adjacent vegetation and possibly create conditions optimal for seed germination and plant recruitment. However, the optimal intensity, frequency, and timing of these treatments, the threshold at which any benefits cease and the activity becomes detrimental, and the optimal seral condition or plant communities for *C. parviflorum* are unknown for Region 2. Successional management is currently being applied without the known benefits or detriments.

Off-site conservation

Off-site conservation sites includes gardens, arboreta, and university or private greenhouses. These conservation facilities generally concentrate on management at genetic, individual, or population levels. Their methods can be divided into gene maintenance, propagation, research, and education (Falk 1992) and are generally used in conjunction with other methods like seed banks.

Wardening

Wardening is a practice used in Great Britain where a Conservation Officer is assigned a native orchid location with a primary duty to protect the site from human observers (Ramsay and Stewart 1998). The numbers of flowers and capsules at a native *Cypripedium calceolus* site in Great Britain have increased with protection by wardening. This method is generally employed when several rare plants occupy one location. Wardening could benefit very obvious populations, like ones located in picnic grounds or frequently visited recreation sites. This conservation method could probably be limited to the flowering period of *C. parviflorum*, when they are most conspicuous to people. Positive publicity has been received about orchid conservation from this management practice in addition to the education of the public about rare orchids in Europe (Farrell and Fitzgerald 1989). The locations for which wardening may be considered in Region 2 are high-use recreational sites and where collecting flowers or plants is determined to be a problem.

Conservation summary

Obtaining knowledge about the life history and habitat of *Cypripedium parviflorum* through surveys and monitoring is a prerequisite before effective conservation practices can be implemented. However, some conservation practices can be implemented in Region 2 and used to help understand the life history and habitat characteristics of this species. An assessment of known occurrence sites under different management activities and in different habitats for possible damage to individual plants and habitat

would contribute to the development of an effective conservation plan for this species.

Management activities and natural events that benefit *Cypripedium parviflorum* are currently unknown. Some may be beneficial up to some threshold, at which point they become detrimental. Others, like plant collecting and recreation, can be considered as solely detrimental. Best management and most effective conservation practices for *C. parviflorum* on a Region-wide bases would be to reduce the risk factors at each known occurrence. The lack of distributional and life history data at this time may limit the effectiveness of these practices. However, the resource (individual plant) and habitat can be assessed on the occurrence level within each national forest where data exist, and management and conservation practices can be used depending upon each individual situation. For example, in the Black Hills National Forest, the largest known populations are at greatest risk to late-season cattle grazing while the greatest risk to the large Colorado population appears to be off-road recreational use. Managers on the Black Hills National Forest may consider review and changes in livestock grazing while managers in Colorado have blocked and restricted off-road travel. Both examples could reduce the risk for a specific occurrence.

There are many individual and combinations of survey, inventory, monitoring, and conservation approaches that can be used for specific forests within Region 2. The impacts of management activities on *Cypripedium parviflorum* should be reviewed and monitored, and it may be beneficial to implement conservation methods that reduce or prevent severe impacts at known sites, or set those sites aside. However, more information needs to be collected in Region 2 to determine basic life history information to better inform managers about *C. parviflorum* requirements and thresholds.

Information Needs

There is much information lacking about *Cypripedium parviflorum* within Region 2. There are no experimental studies within Region 2 for this species. Few of the population monitoring projects conducted on *C. parviflorum* are conducted by non-funded volunteers or small-funded private organizations, but fail to monitor individual plants. Pollinators are unknown in Region 2. Therefore, any information specific to Region 2 would be beneficial to the knowledge of this species. Specific Forest Service objectives are the first requirement to determine research and monitoring direction on *C. parviflorum* within Region 2.

Long-term monitoring of individual plants and their habitat is greatly needed to achieve a better understanding of the life history characteristics and demography of *Cypripedium parviflorum* in Region 2. The life cycle stages that are at most risk within each habitat, the different varieties, and the mycorrhizae and insect species associated with *C. parviflorum* need to be identified in Region 2. In addition, more surveys are required if the true distribution and abundance of this species are to be understood.

Species distribution

Although *Cypripedium parviflorum* may be widely distributed throughout Region 2, accurate information on its distribution and abundance within each state or national forest is lacking. Its distribution on the Black Hills National Forest is better understood because of many recent botanical surveys. Plant surveys throughout Region 2 would increase our knowledge of *C. parviflorum* distribution and abundance.

Life cycle

Basic life history characteristics of *Cypripedium parviflorum* in Region 2 remain unknown. Since mycorrhizae are an important part of the life cycle of *C. parviflorum*, information concerning the mycorrhizae species and its life cycle are equally important. Other unknown characteristics include the immature life stages, recruitment, and pollinators.

Population trends and demography

No trend in any individual occurrence (population), let alone a trend over Region 2 can be determined because no accurate demographic data exist. So little is known, the word population could not be used in this assessment to describe a group of plants. Since *Cypripedium parviflorum* is a long-lived perennial plant, it could be slowly losing all plants within an occurrence thus losing viability and population without detection. Recruitment of new individuals must be determined to begin to assess the stability and viability of this species in Region 2. *Cypripedium parviflorum* is capable of being dormant (remaining underground) for periods of at least 4 years, and it may require over 10 years to flower. Methods like marking each individual plant location within an occurrence and recounting and recording the phenology of each plant annually

would be a reliable approach to determine population trend at each local occurrence. Only after a minimum of 5 years, and if enough of these populations are sampled throughout Region 2, can a population trend be determined. Marking individual plants and following known individuals will also help to determine dormancy and other demographic characteristics. Monitoring plants after seed set will increase demography data compared to spring time monitoring; a plant with fruit indicates that it flowered, was not grazed, and probably produced viable seeds. Identifying individual plants is very important since *C. parviflorum* may remain dormant for least 4 years in North America (Shefferson et al. 2001). It is very important to note recruitment because without recruitment, the occurrence will eventually be extirpated.

Habitat and response to change

Cypripedium parviflorum is known to occur in many different habitats, but specific habitat information for this species is sparse. Habitat information, such as soil type/structure, site moisture, and associated plant species is adequate for some locations, like the Black Hills National Forest, but lacking for other locations. More data could be collected at each known site, and this data should be gathered consistently among locations. Standardization of data (e.g., canopy cover estimate, plot size) would make comparisons among local occurrences possible and allow for a summary of data within Region 2, which in turn may help managers to identify optimal or at least current habitat characteristics.

Cypripedium parviflorum reacts positively to changes in habitat (succession), but the required changes are unknown for Region 2. From the literature, habitat variables that appear to cause great fluctuation in *C. parviflorum* populations are overstory canopy (amount of light), soil moisture, and the amount of competing herbaceous and shrubby plant cover. Management activities that can be used to manipulate these habitat variables (e.g., timber harvest, grazing, prescribed fire) have never been evaluated specifically to determine their impact to individuals or occurrences of *C. parviflorum*, but this could be a topic of research.

Region 2 may be home to two or more varieties of *Cypripedium parviflorum*, but this is not known with any certainty. A taxonomic study of *C. parviflorum* across the region is needed and could illustrate the variability of the species within Region 2 under different environmental conditions. This type of study may require measurements of morphological features of *C. parviflorum* in the wild and from herbarium specimens. DNA analyses would more likely be required since morphological features of this species are quite variable under different environmental conditions and morphological features overlap among varieties.

Restoration

Propagation and restoration of *Cypripedium calceolus* with the intent to re-establish plants in the wild have been implemented in Great Britain, and *C. parviflorum* plants have been grown from seed in North America. Kew Gardens began the Sainsbury Orchid Conservation Project in 1983 at the Royal Botanic Gardens with the intention of growing plants and re-establishing them at sites in the wild (Kew 2006). This successful project can be used as a model in Region 2 if restoration purposes are determined necessary. Restoration attempts within Region 2 are premature at this time since so little is known about the life cycle, demography, and habitat requirements of this species.

In particular, the underground ecology of *Cypripedium parviflorum* is poorly understood. Since mycorrhizae are necessary for the establishment of this species, some understanding of this aspect would benefit restoration, especially long-term restoration. However, transplanting plants or seeding an area could still be attempted, with introduction of soil from known occurrence sites in an attempt to introduce the required mycorrhizae.

Research priorities for Region 2

The first step in any information-gathering project is to determine the overall and specific objectives. The overall objective of Region 2 is to prevent *Cypripedium parviflorum* and its habitat from declining and to prevent its designation as a threatened or endangered plant species by the U.S. Fish and Wildlife Service. Specific objectives, priorities, or approaches may vary across forests. For example, the approach to management of *C. parviflorum* on a national forest or a ranger district that has considerable timber activity may be different from that on a forest with little timber activity. Similarly, forests that conduct many botanical surveys, like the Black Hills National Forest, may be less concerned with the defining the distribution of *C. parviflorum* compared to a national forest in Colorado where few plant surveys have been conducted. Information collected with monitoring methods for the resource and habitat must be long-term in order to detect both changes in plant numbers (e.g., death, dormancy, recruitment) and changes in habitat. Possible steps to collect information

in order of priority are listed below for Region 2. Several steps may overlap in collection of information and each individual forest may have its own objectives and priorities, so the order is not absolute.

1. Re-visit known occurrences and count and mark individual plants. This step would also include establishing a monitoring program at specific locations throughout the species' range in Region 2. Data collected from this project would help to determine demography and life history characteristics of *Cypripedium parviflorum* within Region 2 in addition to establish accurate population trend data.

2. Identify any imminent risks to a local occurrence and either implement strategies that will lessen or remove the risk or monitor the occurrence to determine what impact the risk has on the local occurrence. In Region 2, especially in the Black Hills, there may be enough occurrences that research could be conducted on several occurrences without significantly damaging the population as long as the research focuses on individual plants.

3. Collect current habitat (macro and micro) data using the same methods throughout Region 2 (habitat variables determined based on objectives). This could help managers to better identify habitat characteristics requirements in Region 2.

4. Survey areas that have never been surveyed throughout Region 2. Concentrate the surveys to areas with limestone geology, deciduous or deciduous-conifer canopy cover, and adequate soil moisture, at least in the early part of the growing season.

5. Identify the most vulnerable life cycle stages for *Cypripedium parviflorum* for each management activity, natural event, habitat, and occurrence. Mature plants may be at greater risk to livestock grazing while a decrease in soil moisture may be a greater risk to immature plants.

6. Identify *Cypripedium parviflorum* varieties throughout Region 2 with a detailed taxonomy study. This would probably require genetic analyses since the morphological variability of *C. parviflorum* is great and morphological features overlap among varieties depending on habitat. Management of all varieties will initially be the same until more is known about the life histories of each variety and its ecology.

7. Identify the required mycorrhizae that are associated with *Cypripedium parviflorum* and determine their distribution and habitat requirements within Region 2. This type of information will likely require genetic analyses.

8. Identify insect (or other) pollinators of *Cypripedium parviflorum* throughout Region 2. This may also help to determine the size of a *C. parviflorum* population.

9. Prove that an occurrence could actually be considered a population or part of a crossbreeding population. This may require genetic analyses or close study of the insect pollinator and life history characteristics like fruiting success and seed viability.

Long-term monitoring of individual plants and their habitat is greatly needed to achieve a better understanding of the life history characteristics and demography of *Cypripedium parviflorum* in Region 2. The life cycle stages that are at most risk within each habitat, the different varieties, and the mycorrhizae and insect species associated with *C. parviflorum* need to be identified in Region 2. In addition, more surveys are required if the true distribution and abundance of this species are to be understood.

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Definitions

Basal area: The cross-sectional area of a tree or stand of trees measured at breast height.

Column: The coalesced style and filaments in the Orchidaceae family.

Dehisce: Opening by pores or slits to discharge the contents, like seeds being discharged from the capsule of an orchid.

Ectomycorrhizal symbioses: a mutualistic relationship between a plant root and a fungus; the plant provides fixed carbon to the fungus, and in return, the fungus provides mineral nutrients, water, and protection from pathogens to the plant.

Gynosteinium: See column. The central structure in an orchid flower, made up of the style and filaments of one or more anthers.

Local population: All yellow lady's slipper orchids at one location or site within the Black Hills; each local population is represented by a population number in the summary tables of the Appendix of this document.

Mycorrhizal fungi (Mycorrhizae): The phenomenon of the probably symbiotic or least non-parasitic association between the root or rhizome of green plant and a fungus. Also, the structure so produced; for example, by the combination of the modified rootlet with fungal tissue.

Occurrence: A group of individuals with common ancestry that are much more likely to mate with one another than with individuals from another such group. Mating not verified.

Population: A group of individuals with common ancestry that are much more likely to mate with one another than with individuals from another such group. Mating verified.

Protocorm: The germinating orchid seed; the body from which a shoot and roots develop.

Ramification: To divide into branch-like parts; to branch out.

Risk: The possibility of suffering harm or loss; danger.

Suberized: Cells that contain suberin, which is a fatty substance deposited in the cell walls of certain types of cells and makes the cells waterproof.

Staminode: A sterile stamen.

Synsepalum: compound organ formed with the union of the two lateral sepals.

Threat: An expression of an intention to inflict pain, injury, evil, etc.

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Definitions were compiled from the following references:

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APPENDIX A

General Occurrence Information for Cypripedium parviflorum in Region 2

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
PMORC0Q090*001*CO	CO	El Paso	Pike National Forest	Jennings, W.F. 1998; Anderson 1977	1977-Jun 18	~50
PMORC0Q090*002*CO	CO	Larimer	Roosevelt National Forest	Jennings, W.F. 1991	1991	Jennings 1991: ~137, (~100), [a few seed heads]; Udall 1991: 147
PMORC0Q090*003*CO	CO	Larimer	Arapaho-Roosevelt National Forest; Private	Udall, R. and D. Udall 1991	1991	42, (21), [1]
PMORC0Q090*004*CO	CO	La Plata	San Juan National Forest	Edwards, M. 1978	1978-Jun 8	~12
PMORC0Q090*005*CO	CO	Park	Pike National Forest	Wood, A. 1988	1988-Jun 29	—
PMORC0Q090*006*CO	CO	Custer	—	Baltzell, L. 1969, personal collection 178; Gierisch, R.K. 1946-Jun 16	1969-Jun 27	Baltzell 1969: single colony; Gierisch 1946: sparse, in flower
PMORC0Q090*007*CO	CO	Clear Creek	—	Brown, G.A. 1972	1972-Jun 21	rare
PMORC0Q090*008*CO	CO	Las Animas	Private	Neely, B.E. 1987	1987	~40
PMORC0Q090*009*CO*a	CO	El Paso	Pike National Forest	Christ, J.H. 1935	1935-Jun 30	—
PMORC0Q090*009*CO*b	CO	—	Pike National Forest	—	—	—
PMORC0Q090*010*CO	CO	El Paso	—	Eastwood, Alice 1888	1888-Jun	—
PMORC0Q090*012*CO	CO	Teller	—	Walker, S.B. 1914	1914-Jun	—
PMORC0Q090*013*CO	CO	Jefferson	Jefferson County	Warren, M., D. Williams and B. Pritchett 1994	1994-Jun 6	3 small populations
PMORC0Q090*014*CO	CO	El Paso	—	Christ, J.H. 1935	1935-Jul 28	—
PMORC0Q090*015*CO	CO	La Plata	San Juan National Forest	Righter, Sandy 1993	1993	5, (2)
PMORC0Q090*017*CO	CO	El Paso	—	Carter, J. and Tassel 1978	1978	—
PMORC0Q090*018*CO	CO	El Paso	Pike National Forest; Private	Cameron, G. 2005-Jun 28; Cameron, G. 2004-Jun 24; Cameron, G. 2003-Jun 24; Coles, J. 1997-Jun 28	2005-Jun 28	Cameron 2005: 1130, (153); Cameron 2004: 997, (213); Cameron 2003: 937
PMORC0Q090*020*CO	CO	Pueblo	—	Osborn, N.L. 1972	1972	—
PMORC0Q090*022*CO	CO	Larimer	—	G.H.L. 1932	1932	In flower
PMORC0Q090*023*CO	CO	Las Animas	—	Osborn, N.L. 1985	1985	In flower
PMORC0Q090*024*CO	CO	Montrose	—	Payson, E. 1913, personal collection 91	1913-May 18	—
PMORC0Q090*025*CO	CO	Las Animas	San Isabel National Forest	Osborn, Neil 1971	1971	In flower

Appendix A (cont.).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
PMORC0Q090*026*CO	CO	Teller	—	LeCour, B. and K. LeCour 1994; Junker, J. and B. LeCour 1993	1994-Jun 25	16
PMORC0Q090*027*CO	CO	Teller	—	LeCoup, B., D. Hobbs and S. Book 1994	1994-Jun 20	19
PMORC0Q090*028*CO	CO	Garfield	Private	Spackman, S. and K. Fayette 1997	1997-Aug	—
PMORC0Q090*029*CO	CO	Garfield	—	Spackman, S. and K. Fayette 1998	1998-Jun 16	In flower
PMORC0Q090*030*CO	CO	Larimer	Arapaho-Roosevelt National Forest	Kratz, A., B.B. Johnson and S. Johnson 1997	1997	~100, (50)
PMORC0Q090*031*CO	CO	Larimer	—	Kiener, W. 1937	1937-Jul 4	—
PMORC0Q090*032*CO	CO	Clear Creek	—	Huestis, W.S.	—	—
PMORC0Q090*033*CO	CO	El Paso	—	Penfound, W. 1923	1923-Jul 16	—
PMORC0Q090*034*CO	CO	Jefferson	—	Bailar, E. 1905	1905	—
PMORC0Q090*035*CO	CO	Larimer	—	Osterhout, G.E. 1897, personal collection 1595	1897-Jun 23	—
PMORC0Q090*036*CO	CO	Larimer	—	Crandall, C.A. 1892	1892-Jul 10	—
PMORC0Q090*037*CO	CO	Las Animas	—	Jennings, S.N. 1985	1985-Jun 17	~40
PMORC0Q090*038*CO	CO	El Paso	—	Tassel and Miller 1978	1978-Aug 23	In fruit
PMORC0Q090*039*CO	CO	El Paso	—	Hartman and Stoller 1972	1972-Jun 20	—
PMORC0Q090*040*CO	CO	El Paso	—	Penland 1923	1923-May 16	—
PMORC0Q090*041*CO	CO	El Paso	—	Carter, C.B.	—	—
PMORC0Q090*042*CO	CO	Larimer	—	Crandall, C.S. 1896	1896-Jul 1	—
PMORC0Q090*043*CO	CO	(El Paso)	—	Schedin, L.M. and N.F. Schedin, personal collection 365	—	—
PMORC0Q090*044*CO	CO	(Huerfano)	—	Shear, C.L. and R.A. Rydberg 1896, personal collection 3555	1896-Jul 14	—
PMORC0Q090*045*CO	CO	Larimer	—	Cope, Mrs. Frank 1917, personal collection 562	1917-Jul 13	—
PMORC0Q090*046*CO	CO	(Huerfano or Las Animas)	—	(Church, Mrs.) 1902	1902-Jun 11	—
PMORC0Q090*047*CO	CO	(El Paso)	—	Brumback and Davies 1912	1902-Jun 11	—
PMORC0Q090*048*CO	CO	(El Paso)	—	Johnston, I.M. 1920	1920-Jul 4	—

Appendix A (cont.).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
PMORC0Q090*049*CO	CO	Custer	—	Brandegee, T.S. 1872	1872-Jun	—
PMORC0Q0C0*001*KS	KS	Atchison	—	—	—	—
PMORC0Q0C0*002*KS	KS	Bourbon	—	—	—	—
PMORC0Q0C0*003*KS	KS	Brown	—	—	—	—
PMORC0Q0C0*004*KS	KS	Cherokee	—	—	—	—
PMORC0Q0C0*005*KS	KS	Donipan	—	—	—	—
PMORC0Q0C0*006*KS	KS	Donipan	—	—	—	—
PMORC0Q0C0*007*KS	KS	Donipan	—	—	—	—
PMORC0Q0C0*008*KS	KS	Douglas	—	—	—	—
PMORC0Q0C0*009*KS	KS	Douglas	—	—	—	—
PMORC0Q0C0*010*KS	KS	Douglas	—	—	—	—
PMORC0Q0C0*011*KS	KS	Douglas	—	—	—	—
PMORC0Q0C0*012*KS	KS	Jackson	—	—	—	—
PMORC0Q0C0*013*KS	KS	Jefferson	—	—	—	—
PMORC0Q0C0*014*KS	KS	Jefferson	—	—	—	—
PMORC0Q0C0*015*KS	KS	Jefferson	—	—	—	—
PMORC0Q0C0*016*KS	KS	Leavenworth	—	—	—	—
PMORC0Q0C0*017*KS	KS	Shawnee	—	—	—	—
PMORC0Q0C0*018*KS	KS	Wyandotte	—	—	—	—
PMORC0Q0C0*019*KS	KS	Wyandotte	—	—	—	—
PMORC0Q0C0*001*NE	NE	Kearney	—	Hapeman, H. 1897	1897-May	—
PMORC0Q0C0*002*NE	NE	Douglas	—	—	1994-May 23	—
PMORC0Q0C0*003*NE	NE	Sarpy	—	—	1988-May 22	—
PMORC0Q0C0*004*NE	NE	Otoe	—	—	1915-May 12	—
PMORC0Q0C0*005*NE	NE	Cass	—	—	1934-May 14	—
PMORC0Q0C0*006*NE	NE	Cass	—	—	1921-Jun 15	—
PMORC0Q0C0*007*NE	NE	Nemaha	—	—	1897-May 4	—
PMORC0Q0C0*008*NE	NE	Douglas	—	—	1994-May 23	—
PMORC0Q0C0*009*NE	NE	Richardson	—	—	1931-Jul 18	—
PMORC0Q0C0*010*NE	NE	Richardson	—	—	1974-May 14	—
PMORC0Q0C0*011*NE	NE	Nemaha	—	—	1883-May	—
2	SD	Pennington	Black Hills National Forest	Mergen 1999, collection Shanks 8	1999-Aug 20	118, (30), [12]
3	SD	Pennington	Black Hills National Forest	Mergen 1999, collection Shanks 9	1999-Sep 16	13, (0), [0]

Appendix A (cont.).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
4	SD	Pennington	Black Hills National Forest	Mergen 1999, collection Shanks 10	1999-Jun 20	20, (15)
5	SD	Pennington	Black Hills National Forest	Mergen 1999, collection Shanks 11	1999-Sep 16	2, (1), [1]
6	SD	Pennington	Black Hills National Forest	Mergen 1999, collection Shanks 12	1999-Aug 20	39, (23)
7	SD	Pennington	Black Hills National Forest	Mergen 1999, collection Shanks 13	1999-Aug 20	4, (3), [2]
8	SD	Pennington	Black Hills National Forest	Mergen 1999, collection Shanks 14	1999-Aug 15	3, (2), [1]
9	SD	Lawrence	Uncertain	—	1892-Jun 28	—
10	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1989-Jun 27	4
11	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1999-Jul 14	13, (13), [13]
12a	SD	Meade	Uncertain	South Dakota Natural Heritage Program 2001	1975-Jun 26	—
12b	SD	Meade	Uncertain	—	1975-Jun 26	—
12c	SD	Meade	—	—	1975-Jun 26	—
13	SD	Lawrence	Uncertain	South Dakota Natural Heritage Program 2001	1939-Jun 18	—
14	SD	Meade	Uncertain	South Dakota Natural Heritage Program 2001	1924-Jun 19	Few
15	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1989-Jun 28	7
16	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1947-Jul 3	—
17	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1999-Aug 25	200, (200), [200]
18	SD	Pennington	Uncertain	South Dakota Natural Heritage Program 2001	1891-Aug	—
19	SD	Lawrence	Private	South Dakota Natural Heritage Program 2001	1928-Jun 28	—
20	SD	Lawrence	Uncertain	South Dakota Natural Heritage Program 2001	1932-Jul 1	—
21	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1973-Jun 23	—

Appendix A (cont.).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
22	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1981-Jun 16	—
23	SD	Pennington	Uncertain	South Dakota Natural Heritage Program 2001	1909-Jun 15	—
24	SD	Pennington	Uncertain	South Dakota Natural Heritage Program 2001	1996-May 29	—
25	SD	Lawrence	Uncertain	South Dakota Natural Heritage Program 2001	1921-May 30	—
26	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1990-Jul 6	20
27	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1990-Jun 29	9
28	SD	Meade	Uncertain	South Dakota Natural Heritage Program 2001	1996-May 29	Excellent number
29	SD	Meade	Black Hills National Forest	South Dakota Natural Heritage Program 2001	2000-Jun 21	8, (5)
30	SD	Pennington	Uncertain	South Dakota Natural Heritage Program 2001	1909-Jun	—
31	SD	Lawrence	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1986-Jul 17	Few
32	SD	Lawrence	Uncertain	South Dakota Natural Heritage Program 2001	1902-May	—
33	SD	Meade	Black Hills National Forest	South Dakota Natural Heritage Program 2001	1990-May	—
34	SD	Lawrence	Private	—	1990-Sep 22	—
35	SD	Lawrence	Uncertain	—	1896-Jul 26	—
36	SD	Lawrence	Uncertain	—	1984-Jul 1	—
37	SD	Lawrence	Uncertain	—	1938-Jun 19	—
38	SD	Lawrence	Uncertain	—	1990-Jun 9	—
39	SD	Lawrence	Uncertain	—	1990-Sep 16	—
40	SD	Meade/ Pennington	Black Hills National Forest	Lynch 1999	1996-May 22	—
41	SD	Meade	Black Hills National Forest	Lynch 1999	1996-Jun 6	—
42a	SD	Meade	Black Hills National Forest	Lynch 1999	1996-Jun 3	—
42b	SD	Meade	Black Hills National Forest	Lynch 1999	1996-Jun 3	—
43	SD	Pennington	Black Hills National Forest	Lynch 1999	1994-Aug 25	—
44	SD	Lawrence	Black Hills National Forest	Zacharkevics 2001	2000-Jul 13	Very few individuals

Appendix A (cont.).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
45	SD	Pennington	Private	Larson, G. 2001	2001-Nov	—
46	SD	Lawrence	Black Hills National Forest	Zacharkevics 2001	2001-Jul 24	12
47	SD	Meade	Black Hills National Forest	Zacharkevics 2001	1994-Jun 13	—
48	SD	Meade	Black Hills National Forest	Zacharkevics 2001	1994-Jun 15	—
49	SD	Lawrence	Black Hills National Forest	Zacharkevics 2001	1994-Jun 15	—
50	SD	Lawrence	Black Hills National Forest	Zacharkevics 2001	1994-Aug 1	—
56	SD	Lawrence	Black Hills National Forest	Zacharkevics 2001	1995-Jun 27	—
57	SD	Pennington	Black Hills National Forest	Zacharkevics 2001	1995-Jun 23	40
58	SD	Lawrence	Black Hills National Forest	Zacharkevics 2001	1995-Aug 2	—
59	SD	—	Black Hills National Forest	Zacharkevics 2001	1996	—
60	SD	—	Black Hills National Forest	Zacharkevics 2001	1996	—
61	SD	—	Black Hills National Forest	Zacharkevics 2001	1996	13
62	SD	Lawrence	Black Hills National Forest	Larson, G.E.	1980-Jun 18	—
63	SD	Lawrence	Black Hills National Forest	Johnson, K.L.	1970-Aug 3	—
64	SD	—	Uncertain	Moore, J.W. 1923	1923-Jun	—
65	SD	—	Uncertain	Pratt, A.D. 1895	1895-Jul	—
66	SD	Lawrence	—	Zacharkevics 2002	2002-Jul 24	2, (2), [2]
67	SD	Lawrence	—	Zacharkevics 2002	2002-Sep 14	>25, (22), [22]
68	SD	Meade	—	Zacharkevics 2002	2002-Sep 15	5, {5}
69	SD	Meade	—	Zacharkevics 2002	2002-Sep 17	4, {1}
70	SD	Meade	—	Zacharkevics 2002	2002-Sep 19	—
71	SD	Lawrence	—	Zacharkevics 2002	2002-Sep 24	—
72	SD	Meade	—	Zacharkevics 2002	2002-Sep 25	4, (4), [4]
73	SD	Meade	—	Zacharkevics 2002	2002-Sep 25	15, (15), [15]
74	SD	Lawrence	—	Zacharkevics 2002	2002-Sep 30	—
75	SD	Meade	—	Zacharkevics 2002	2002-May 29	1
76	SD	Lawrence	—	Zacharkevics 2002	2002-Jul 27	1
77	SD	Lawrence	—	Zacharkevics 2002	2002-Jul 27	12, (12)
78	SD	Lawrence	—	Zacharkevics 2002	2002-Jul 27	15, (11), [11]
79	SD	Lawrence	—	Zacharkevics 2002	2002-Jul 30	9, (9), [9]
80	SD	Lawrence	—	Zacharkevics 2002	2002-Sep 1	40
81	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Sep 17	2, (1)
82	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Jul 12	20, (10)
83	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Jul 16	109, (55), [2], 5 grazed, 2 plants with 2 fruits each

Appendix A (cont.).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
84	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Jul 16	6
85	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Jul 12	324, (166), [166], 38 possibly grazed; 6, (2), [4]
86	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Aug 1	4
87	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Aug 1	6, (4), [2]
88	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Aug 1	1
89	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Aug 1	5, (1)
90	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Aug 1	5, (1)
91	SD	Pennington	Black Hills National Forest	Mergen 2002	2002-Aug 1	5, (1)
03R03A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 26	1-10, [10% mature]
03R04B	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 27	1-10, [10% immature]
03R09A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 31	1-10, [20% mature]
03R10A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 31	1-10, [20% mature]
03R50A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 2	2
03R64B	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 27	4, (2)
03R67C	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 29	5
03R67D	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 29	1-10
03R88B	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 28	1, [1 immature]
03R90A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Jul 31	2
03R98B	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 9	37, (4 dried), [5 mature]
03U06A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 22	2, (1)
03U15D	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 24	1, [1 mature]
03U16A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 24	6, [20% mature]
03U31A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 25	23, (3), [1 mature]
03U34B	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 26	11-51, (5 dried), [2 immature]
03U35A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 26	3
03U60A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 31	1
03U61A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Aug 31	3, (1)
03U88B	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Sep 5	4, [1 immature]
03U91E	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Sep 5	1
03Y52A	SD	Lawrence	Black Hills National Forest	Mergen 2003	2003-Oct 6	1
04S001B	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Aug 19	1-10
04S005A	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Aug 24	18
04S005B	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Aug 24	1
04S006B	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Aug 25	1

Appendix A (cont.).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
04S006C	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Aug 25	3
04S015A	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Sep 14	77
04S018B	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Sep 23	11-51
04S018C	SD	Lawrence	Black Hills National Forest	Zacharkevics 2004	2004-Sep 23	11-51
05W029A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jun 25	11-51, (80%)
05W029D	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jun 25	1, (1)
05W032A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jun 27	11-51, (80%), [10% immature]
05W048A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jul 18	115, [35 immature]
05W048B	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jul 18	32, [6 immature]
05W051A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jul 20	22
05W052A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jul 22	28, [20 immature]
05W055A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Jul 22	146, (29)
05W068F	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Aug 10	59, [3]
05W070C	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Aug 11	13
05W072A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Aug 17	1, [1 immature]
05W077B	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Sep 9	1, [1]
05W078A	SD	Lawrence	Black Hills National Forest	Mergen 2005	2005-Sep 9	1, [1]
PMORC0Q0C0*001*SD	SD	Roberts	—	Stevens and Moir	1957-May 31	—
PMORC0Q0C0*002*SD	SD	Marshall	—	—	—	—
1	WY	Crook	Uncertain, near Black Hills National Forest lands if not on	WNDD 2001; Fertig, W. field notes; PMORC0Q0C0*008*WY	1993-Jun 19	3, (3)
51	WY	Crook	Black Hills National Forest	Zacharkevics 2001	1994-Aug 24	—
52	WY	Crook	Black Hills National Forest	Zacharkevics 2001	1994-Aug 28	60
53	WY	Crook	Black Hills National Forest	Zacharkevics 2001	1994-Sep 2	—
54	WY	Crook	Black Hills National Forest	Zacharkevics 2001	1994-Sep 7-8	—
55	WY	Crook	Black Hills National Forest	Zacharkevics 2001	1994-Sep 9	—
PMORC0Q0C0*001*WY*a	WY	Sheridan	State of Wyoming	Evert, E. 1985; Lichvar, R.W. 1979; Dumont A.G. 1960	1985	1985: 2 small colonies; 1979: frequent, in late flower
PMORC0Q0C0*001*WY*b	WY	Johnson	Bighorn National Forest	Galloway, T.	2003-Jun 19	6, (6)
PMORC0Q0C0*002*WY	WY	Sheridan	State of Wyoming	Willits, V. 1911	1911-Jun 14	In flower
PMORC0Q0C0*003*WY	WY	Big Horn	Private	Leon, C.	1995	10
PMORC0Q0C0*004*WY	WY	Sheridan	In city limits	Willits, V. 1906	1906-Jul	In fruit
PMORC0Q0C0*005*WY	WY	Sheridan	Bighorn National Forest	Hartman, R.L. 1979	1979-Jun 26	In flower and fruit

Appendix A (concluded).

Occurrence Number	State	County	Land ownership	Observer	Date last observed (year-month day)	Number of plants, (flowering), [fruit], {dormant}
PMORC0Q0C0*006*WY	WY	Washakie	State of Wyoming	Nelson, B.E. 1980	1980-Jun 6	In flower
PMORC0Q0C0*007*WY	WY	Sheridan	Bighorn National Forest	McWilliams, E. and M. Girard	1992-Jun	—
PMORC0Q0C0*009*WY	WY	Fremont	Private	Scott, R.	1989-Jun 14	In flower

Cells with a dash, "-", indicate no information available.

Parenthesis, "( )", in the column **'Number of plants'** refers to the number of *Cypripedium parviflorum* found flowering. Information in parenthesis "( )" in other columns indicates this data was estimated from other available information (such as county determined from legal description).

APPENDIX B

Geographic Attributes of Cypripedium parviflorum Occurrences in Region 2

Occurrence Number	Elevation (m (feet))	Estimated occurrence area (m^2 ($feet^2$))	Slope (%)	Aspect (degrees)
PMORC0Q090*001*CO	2,310 (7,700)	—	—	—
PMORC0Q090*002*CO	2,220 (7,400)	—	—	—
PMORC0Q090*003*CO	—	—	—	—
PMORC0Q090*004*CO	2,400 (8,000)	2.70 (30)	—	90
PMORC0Q090*005*CO	2,550 (8,500)	—	—	—
PMORC0Q090*006*CO	2,400 (8,000)	—	Level	—
PMORC0Q090*007*CO	2,490 (8,300)	—	—	225
PMORC0Q090*008*CO	2,400 (8,000)	—	—	—
PMORC0Q090*009*CO*a	—	—	—	—
PMORC0Q090*009*CO*b	—	—	—	—
PMORC0Q090*010*CO	2,160 (7,200)	—	—	—
PMORC0Q090*012*CO	2,550-2,592 (8,500-8,640)	—	—	—
PMORC0Q090*013*CO	2,274-2,280 (7,580-7,600)	—	3	225
PMORC0Q090*014*CO	2,100 (7,000)	—	—	—
PMORC0Q090*015*CO	2,400 (8,000)	—	45	180
PMORC0Q090*017*CO	2,790 (9,300)	—	—	—
PMORC0Q090*018*CO	2,400-2,436 (8,000-8,120)	40,000 (444,444)	<5	135
PMORC0Q090*020*CO	2,340-2,412 (7,800-8,040)	—	—	—
PMORC0Q090*022*CO	2,040 (6,800)	—	—	—
PMORC0Q090*023*CO	2,313 (7,711)	—	—	—
PMORC0Q090*024*CO	1,740 (5,800)	—	—	—
PMORC0Q090*025*CO	2,940-3,805 (9,800-12,683)	—	—	180
PMORC0Q090*026*CO	2,580-2,604 (8,600-8,680)	7,841-11,761 (87,120-130,680)	—	—
PMORC0Q090*027*CO	2,544-2,556 (8,480-8,520)	980 (10,890)	0-1	180
PMORC0Q090*028*CO	1,824 (6,080)	—	0	—
PMORC0Q090*029*CO	1,875 (6,250)	—	-	—
PMORC0Q090*030*CO	2,268 (7,560)	~11,761 (~130,680)	2-20	0
PMORC0Q090*031*CO	2,460 (8,200)	—	—	—
PMORC0Q090*032*CO	—	—	—	—
PMORC0Q090*033*CO	2,940 (9,800)	—	—	—
PMORC0Q090*034*CO	—	—	—	—
PMORC0Q090*035*CO	—	—	—	—
PMORC0Q090*036*CO	—	—	—	—
PMORC0Q090*037*CO	2,400 (8,000)	—	—	—
PMORC0Q090*038*CO	2,490 (8,300)	—	—	—
PMORC0Q090*039*CO	2,460 (8,200)	—	—	—
PMORC0Q090*040*CO	—	—	—	—
PMORC0Q090*041*CO	2,400 (8,000)	—	—	—
PMORC0Q090*042*CO	2,100 (7,000)	—	—	—

Appendix B (cont.).

Occurrence Number	Elevation (m (feet))	Estimated occurrence area (m^2 ($feet^2$))	Slope (%)	Aspect (degrees)
PMORC0Q090*043*CO	—	—	—	—
PMORC0Q090*044*CO	—	—	—	—
PMORC0Q090*045*CO	—	—	—	—
PMORC0Q090*046*CO	—	—	—	—
PMORC0Q090*047*CO	3,000 (10,000)	—	—	—
PMORC0Q090*048*CO	—	—	—	—
PMORC0Q090*049*CO	—	—	—	—
PMORC0Q0C0*001*KS	—	—	—	—
PMORC0Q0C0*002*KS	—	—	—	—
PMORC0Q0C0*003*KS	—	—	—	—
PMORC0Q0C0*004*KS	—	—	—	—
PMORC0Q0C0*005*KS	—	—	—	—
PMORC0Q0C0*006*KS	—	—	—	—
PMORC0Q0C0*007*KS	—	—	—	—
PMORC0Q0C0*008*KS	—	—	—	—
PMORC0Q0C0*009*KS	—	—	—	—
PMORC0Q0C0*010*KS	—	—	—	—
PMORC0Q0C0*011*KS	—	—	—	—
PMORC0Q0C0*012*KS	—	—	—	—
PMORC0Q0C0*013*KS	—	—	—	—
PMORC0Q0C0*014*KS	—	—	—	—
PMORC0Q0C0*015*KS	—	—	—	—
PMORC0Q0C0*016*KS	—	—	—	—
PMORC0Q0C0*017*KS	—	—	—	—
PMORC0Q0C0*018*KS	—	—	—	—
PMORC0Q0C0*019*KS	—	—	—	—
PMORC0Q0C0*001*NE	—	—	—	—
PMORC0Q0C0*002*NE	—	—	—	—
PMORC0Q0C0*003*NE	—	—	—	—
PMORC0Q0C0*004*NE	—	—	—	—
PMORC0Q0C0*005*NE	—	—	—	—
PMORC0Q0C0*006*NE	—	—	—	—
PMORC0Q0C0*007*NE	—	—	—	—
PMORC0Q0C0*008*NE	—	—	—	—
PMORC0Q0C0*009*NE	—	—	—	—
PMORC0Q0C0*010*NE	—	—	—	—
PMORC0Q0C0*011*NE	—	—	—	—
2	1,362 (4,540)	3,920 (43,560), most within 18.00 (200)	85	315
3	1,260 (4,200)	392 (4,356)	140	315
4	1,272-1,380 (4,240-4,600)	7,841 (87,120)	55-120	0
5	1,230 (4,100)	392 (4,356)	60	0
6	1,230 (4,100)	392 (4,356)	70-85	0-315
7	1,260 (4,200)	980 (10,890)	18	0-315
8	1,272 (4,240)	980 (10,890)	11	0-315
9	1,200 (4,000)	—	—	—
10	—	—	30	0
11	1,332 (4,440)	3.24 (36)	25	270-315

Appendix B (cont.).

Occurrence Number	Elevation (m (feet))	Estimated occurrence area (m^2 ($feet^2$))	Slope (%)	Aspect (degrees)
12a	—	—	—	0
12b	—	—	—	0
12c	—	—	—	—
13	—	—	—	0
14	—	—	—	—
15	—	392 (4,356)	Steep	0
16	—	—	—	—
17	1,428 (4,760)	6.75 (75)	20	—
18	—	—	—	—
19	—	—	—	—
20	—	—	—	—
21	1,620 (5,400)	—	—	—
22	1,320 (4,400)	—	—	—
23	—	—	—	—
24	—	—	—	—
25	—	—	—	—
26	1,350 (4,500)	—	—	—
27	1,440 (4,800)	—	—	—
28	—	—	—	—
29	—	—	—	—
30	—	—	—	—
31	1,560 (5,200)	—	—	45
32	—	—	—	—
33	1,215 (4,050)	—	—	315
34	—	—	—	—
35	—	—	—	—
36	—	—	—	—
37	1,350 (4,500)	—	—	—
38	—	—	—	—
39	—	—	—	—
40	1,290 (4,300)	—	—	—
41	1,290 (4,300)	—	—	—
42a	1,260 (4,200)	—	—	—
42b	1,260 (4,200)	—	—	—
43	1,620 (5,400)	—	—	—
44	—	—	—	—
45	1,050 (3,500)	—	—	315
46	1,314 (4,380)	—	70	45
47	1,425 (4,750)	—	20	—
48	1,470 (4,900)	—	10	—
49	1,440 (4,800)	—	15	45
50	1,224-1,404 (4,080-4,680)	—	55	—
56	1,440 (4,800)	—	22	—
57	—	—	—	—
58	1,230-1,320 (4,100-4,400)	—	50-70	—
59	—	—	—	—

Appendix B (cont.).

Occurrence Number	Elevation (m (feet))	Estimated occurrence area (m^2 ($feet^2$))	Slope (%)	Aspect (degrees)
60	—	—	—	—
61	—	—	—	—
62	—	—	—	—
63	—	—	—	—
64	—	—	—	—
65	—	—	—	—
66	1,662 (5,540)	0.09 (1)	60	45
67	1,423 (4,744)	10-50 (111-556)	0-10	315
68	1,380 (4,600)	1-5 (11-56)	50	0
69	1,320 (4,400)	1-5 (11-56)	11-20	45
70	1,164 (3,880)	—	10-25	Varies
71	1,302 (4,340)	—	Varies	Varies
72	1,260 (4,200)	50-100 (556-1,111)	10	315
73	1,185 (3,950)	7,841 (87,120)	0-10	315
74	1,296 (4,320)	—	Varies	Varies
75	—	—	—	—
76	1,515 (5,050)	0.01 (0.1)	34	315
77	1,654 (5,512)	1 (11)	45	45
78	1,515 (5,050)	400 (4,444)	4	315
79	1,732 (5,772)	0.09 (1)	60-80	45
80	1,590-1,680 (5,300-5,600)	—	Varies	Varies
81	1,830-1,920 (6,100-6,400)	1 (11)	11-20	225
82	1,905-1,908 (6,350-6,360)	10-50 (111-556)	0-10	0
83	1,824-1,827 (6,080-6,090)	3,920 (43,560)	0-10	0
84	1,867-1,934 (6,224-6,445)	10 (111)	0-10	0
85	1,800 (6,000)	19,602 (217,800)	0-10	0
86	1,149 (3,830)	10 (111)	90+	315
87	1,140 (3,800)	10 (111)	90+	315
88	1,140 (3,800)	10 (111)	90+	315
89	1,200 (4,000)	10 (111)	90+	0
90	1,230 (4,100)	10 (111)	90+	0
91	1,260 (4,200)	10 (111)	90+	0
03R03A	1,232 (4,108)	1-5 (11-56)	41-50	300
03R04B	1,470 (4,900)	1 (11)	31-40	90
03R09A	~1,500 (~5000)	1 (11)	11-20	320
03R10A	1,260 (4,200)	1 (11)	11-20	300
03R50A	1,664 (5,546)	1 (11)	11-20	350
03R64B	1,320 (4,400)	15 (167)	5	90
03R67C	1,230 (4,100)	1-5 (11-56)	5	325
03R67D	1,230 (4,100)	Entire drainage	45	320
03R88B	1,200 (4,000)	1 (11)	51+	120
03R90A	1,350 (4,500)	7,841 (87,120)	0-10	90
03R98B	1,290 (4,300)	~1,254,528 (~13,939,200)	0-10	90

Appendix B (cont.).

Occurrence Number	Elevation (m (feet))	Estimated occurrence area (m^2 ($feet^2$))	Slope (%)	Aspect (degrees)
03U06A	1,508-1,511 (5,025-5,035)	1 (11)	51+	0
03U15D	1,404 (4,680)	1 (11)	0-10	340
03U16A	1,514 (5,047)	1-5 (11-56)	0-10	320
03U31A	1,188 (3,960)	19,602 (217,800)	0-150	275
03U34B	1,200-1,350 (4,000-4,500)	7,841 (87,120)	21-30	0
03U35A	1,224 (4,080)	10-50 (111-556)	0-10	200
03U60A	1,319 (4,395)	1 (11)	70	84
03U61A	1,290 (4,300)	1-5 (11-56)	21-30	0
03U88B	1,440 (4,800)	10-50 (111-556)	41-50	45
03U91E	1,440 (4,801)	1 (11)	0-10	0
03Y52A	1,224 (4,080)	5-10 (56-111)	51+	0
04S001B	1,512 (5,040)	Unknown	—	45
04S005A	—	—	—	—
04S005B	—	—	—	—
04S006B	—	—	—	—
04S006C	—	—	—	—
04S015A	—	—	—	—
04S018B	1,590-1,665 (5,300-5,550)	—	—	0-90
04S018C	1,590-1,665 (5,300-5,550)	—	—	0-90
05W029A	1,482 (4,941)	7,841 (87,120)	51+	40
05W029D	1,555 (5,183)	1 (11)	21-30	360
05W032A	1,463 (4,875)	7,841+ (87,120+)	0-51+	360
05W048A	1,742 (5,807)	50-100 (556-1,111)	48	280
05W048B	1,753 (5,842)	5-10 (56-111)	45	260
05W051A	1,710 (5,700)	5-10 (56-111)	0-10	0
05W052A	1,457 (4,857)	10-50 (111-556)	31-40	0
05W055A	1,506 (5,020)	39,204 (435,600)	Varies	0-90
05W068F	1,605 (5,350)	50-100 (556-1,111)	11-20	50
05W070C	1,630 (5,434)	50-100 (556-1,111)	41-50	320
05W072A	1,380 (4,600)	10-50 (111-556)	31-40	0
05W077B	1,399 (4,663)	1 (11)	11-20	270
05W078A	1,479 (4,930)	5-10 (56-111)	160	45
PMORC0Q0C0*001*SD	—	—	—	—
PMORC0Q0C0*002*SD	—	—	—	—
1	1,200 (4,000)	392 (4,356)	—	—
51	1,334 (4,446)	—	—	—
52	1,202 (4,006)	—	—	—
53	1,342 (4,472)	—	—	—
54	1,296-1,440 (4,320-4,800)	—	—	—
55	1,392-1,560 (4,640-5,200)	—	—	—
PMORC0Q0C0*001*WY*a	1,670 (5,565)	—	—	—
PMORC0Q0C0*001*WY*b	1,717 (5,724)	—	0-1	135
PMORC0Q0C0*002*WY	1,560 (5,200)	—	—	—

Appendix B (concluded).

Occurrence Number	Elevation (m (feet))	Estimated occurrence area (m^2 ($feet^2$))	Slope (%)	Aspect (degrees)
PMORC0Q0C0*003*WY	1,292 (4,305)	—	—	—
PMORC0Q0C0*004*WY	1,230 (4,100)	—	—	—
PMORC0Q0C0*005*WY	1,630 (5,433)	—	—	—
PMORC0Q0C0*006*WY	1,462 (4,872)	—	—	—
PMORC0Q0C0*007*WY	1,494 (4,979)	—	—	—
PMORC0Q0C0*009*WY	1,978 (6,694)	—	—	—

Cells with a dash, "-", indicate no information available.

APPENDIX C

Habitat Attributes for Occurrences of Cypripedium parviflorum in Region 2

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q090*001*CO	—	—	—	—	Dry woods and along stream on east side of road
PMORC0Q090*002*CO	—	—	*Populus tremuloides*, *Juniperus communis*, *Arctostaphylos uva-ursi*, *Apocynum androsaemifolium*	—	Jennings 1991-found near *Cypripedium fasiculatum*; an isolated 160 acre patch, highly advertised so photographers have trampled the area
PMORC0Q090*003*CO	—	—	—	—	Wooded area
PMORC0Q090*004*CO	—	Pink granite	Cottonwood scrub and *Populus tremuloides*	—	—
PMORC0Q090*005*CO	—	—	—	—	—
PMORC0Q090*006*CO	—	Humus, deep loam	—	—	Baltzell 1969-marshland in shade; Gierisch 1946-meadow, stream bank, wet meadows, usual height of plant 6 to 12 inches
PMORC0Q090*007*CO	*Populus tremuloides*	Silty clay	*Populus tremuloides*	—	—
PMORC0Q090*008*CO	—	—	*Salix* sp., *Populus acuminata*, *Chrysanthemum* sp., and *Ephedra* sp.	—	Wet seep beneath willows; wet sites beneath *Populus acuminata* with *Chrysanthemum* sp. and *Ephedra* sp.
PMORC0Q090*009*CO*a	—	—	—	—	—
PMORC0Q090*009*CO*b	—	—	—	—	—
PMORC0Q090*010*CO	—	—	—	—	—
PMORC0Q090*012*CO	—	—	—	—	—
PMORC0Q090*013*CO	*Populus tremuloides*, buffalo berry	—	*Populus tremuloides*, buffalo berry	—	Concave mid slope, with open to partial shade; about 55% shrub cover, 5% forb cover, 5% graminoid cover, 20% bare ground
PMORC0Q090*014*CO	*Pinus ponderosa*	—	*Pinus ponderosa*	—	Gravelly hillside; also observed by Penland in 1923 at an elevation of 9,800 feet
PMORC0Q090*015*CO	—	—	*Pinus ponderosa*, scrub oak, snowberry, rose, geranium	—	Very close to heavily used trail; trail used by hikers, horses, bikes and motorbikes; dandelion and clover invading
PMORC0Q090*017*CO	—	—	—	—	Shaded montane

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q090*018*CO	—	Alluvial loam	*Aralia nudicaulis*, *Acteaea rubra*, and *Thalictrum* sp.	—	Fayette 1998-rank of 'B' given based on the number of individuals and the quality of habitat; Coles 1997-social trails pass by many plants – vulnerable to picking by visitors to the Ranch; some plants were in a meadow planted to pasture grasses; others were in a mixed riparian forest of Douglas fir, white fir and blue spruce with *Alder* sp. understory; estimated 20+ individuals, 100% in flower; Pals et al. 1994-less than 5 acres, 330 stems counted on 6-20-88 along the trail; 106 stems counted on 7-1-94 along the road; Tassel and Miller 1978-shady, dry montane
PMORC0Q090*020*CO	Spruce, fir, *Populus tremuloides*	—	Spruce, fir, *Populus tremuloides*	—	Osborn 1972-elevation 7,800 feet; Osborn 1970-habitat is spruce-fir-*Populus tremuloides*, elevation 8,000 feet
PMORC0Q090*022*CO	—	—	—	—	—
PMORC0Q090*023*CO	*Populus tremuloides*	—	*Populus tremuloides*	—	—
PMORC0Q090*024*CO	—	—	—	—	Dense shady thickets; plant raised in horticulture.
PMORC0Q090*025*CO	*Populus tremuloides* and *Pseudotsuga menziesii*	—	*Populus tremuloides* and *Pseudotsuga menziesii*	—	Rocky slope
PMORC0Q090*026*CO	—	—	Mostly mature *Populus tremuloides,* some fir, tall grasses, spreading juniper	—	Development to occur in near future – asked for site preservation and developer seems to be agreeable; about 16 individuals, within 5 sub-populations – 19 were counted in 1993; traditional orchid/fungus symbiotic relationship; 5% shrub cover, 70% forb cover, 1% graminoid cover, 3% moss/lichen cover, 2% bare ground
PMORC0Q090*027*CO	*Populus tremuloides*	Decomposed granite	Mature *Populus tremuloides*, fir, large (spreading) juniper, Indian paintbrush, golden banner	—	Upper, straight slope, in partial shade; close to new house being built; about 19 individuals, within 3 sub-populations; symbiotic fungus in soil; no evidence of disease, predation or injury; 10% shrub cover, 60% forb cover, 3% graminoid cover, 2% moss/lichen cover, 5% bare ground

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q090*028*CO	—	Organic	*Smilacina* sp. is a strong associate along with *Equisetum* sp., *Salix exigua*, *S. monticola*, *Juncus* sp., *Alder* sp., *Lonicera* sp., *Rosa* sp., *Poa pratensis*, spruce, *Pinus ponderosa*, some tansy, thistle, orchard grass, houndstongue is most prevalent exotic, *Limnorchis ensifolius*, *Maianthemum stellatum*, *Rhus trilobata*, *Amelanchier alnifolia*, *S. lasiandra* and *Shepherdia argentea*	—	Spackman and Fayette, August 1997-revisited the population to ensure that the black coating pathogen we found on a nearby population was not affecting this occurrence as well; it was not; the plants appeared in good health and were in full fruit; Spackman et al., June 1997-area has beaver activity in a floodplain; shaded; overall in good condition; high quality occurrence through habitat is somewhat degraded with some threat from invasive exotics; the population has increased and spread over the past 25 years according to owner of property; many flowering individuals, last years dried fruit observed; some tansy, *Poa pratensis*; little use; Jones 1993-adgacent communities include *Poa annua*, *Benitoa occidentalis*, *Salix exigua* and *Phragmites typha*; large and relatively little used area, easement would be very feasible; low elevation riparian forest, alternates with herbaceous wetlands; elevation 6,120 feet; drier banks; understory somewhat dominated by exotic grasses; grazed in past – has survived with horses within site; possible threat is currently abundant *Poa pratensis*, *Dactylis glomerata* and *Trifolium repens*, but habitat is recoverable; defensible as long as hydrologic flow maintained and area kept from heavy grazing; large number of individuals, thriving, vigorous and spread throughout area

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q090*029*CO	—	—	*Salix exigua*, mixed graminoids and forbs, narrowleaf cottonwood, *Maianthemum* sp., and *Equisetum* sp.	—	Spackman and Fayette, 26 June 1998-flowers were starting to fade to light yellow and brown; Spackman and Fayette, 15 August 1997-the plants are in fruit; Spackman and Fayette, 30 June 1997-the flowers are dried and the fruit is in early development; all individuals had a black coating – possible fungal pathogen – on the leaves and fruit; found in a riparian floodplain along the river; dominated by *Salix exigua* and mixed graminoids and forbs, including some exotic plant species; narrowleaf cottonwood dominates adjacent riparian areas, up, down and across the river; need to control spread of invasive exotic plants, especially tansy which appears to be taking over the habitat; weedy species increasing – very weedy; other non-native plants that are dominant within the site are *Poa pratensis*, *Dactylis glomerata*, oxeye daisy, cheatgrass, houndstongue, *Tragopogon* sp., thistle and *Bromus inermis*; barbed wire parallels river and may exclude cows; habitat is recoverable from invasive species; plants occur between a road, a ditch and a powerline near the city; no fruit observed, but plants are widely dispersed so probably reproducing by seed; plants also appear to be reproducing vegetatively and probably have been at the location for many years; 70 individual flowers counted, populations appears healthy; many individuals flowering; many large clumps with 1 to 25 flowers
PMORC0Q090*030*CO	*Populus tremuloides*, *Pinus ponderosa*, *Pseudotsuga menziesii*, and lodgepole pine	Granite, loam	*Populus tremuloides*, *Pinus ponderosa*, *Pseudotsuga menziesii*, lodgepole pine, *Shepherdia* sp., *Juniperus communis*, *Physocarpus* sp., *Acer glabrum*, *Ribes* sp., *Arctostaphylos uva-ursi*, *Poa* sp., *Arnica* sp., *Galium* sp., *Fragaria* sp., *Maianthemum stellatum*, *Apocynum androsaemifolium*, *Aquilegia coerulea*, *Rubus* sp., *Lilium philadelphicum*	—	Concave lower slope and bottom of drainage with partial shade; foothills; lightly used for camping, hiking and hunting; leafy spurge has heavily infested drainage just down stream of site; could spread; location is the type of isolated tract that the forest service prefers to trade in an effort to consolidate land holdings into contiguous blocks; this site could be converted to private property; some plants appear to be young – smaller and vegetative; no seedlings noted; 50% vegetative, 50-75% in flower or late bud; saw one bud nearly completely eaten by some insect; 25% shrub cover, 45% forb cover, 25% graminoid cover, 5% moss/ lichen cover, 2% bare ground
PMORC0Q090*031*CO	*Populus tremuloides*	Humus	*Populus tremuloides*	—	—
PMORC0Q090*032*CO	—	—	—	—	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q090*033*CO	—	—	—	—	—
PMORC0Q090*034*CO	—	—	—	—	—
PMORC0Q090*035*CO	—	—	—	—	—
PMORC0Q090*036*CO	—	—	—	—	—
PMORC0Q090*037*CO	—	—	—	—	Wet slope; lip yellow, sepals deep maroon/brown
PMORC0Q090*038*CO	—	—	—	—	Shady dry montane
PMORC0Q090*039*CO	Conifer	—	—	—	Wet shaded coniferous forest
PMORC0Q090*040*CO	—	—	—	—	—
PMORC0Q090*041*CO	—	—	—	—	—
PMORC0Q090*042*CO	—	—	—	—	—
PMORC0Q090*043*CO	—	—	—	—	—
PMORC0Q090*044*CO	—	—	—	—	—
PMORC0Q090*045*CO	—	—	—	—	—
PMORC0Q090*046*CO	—	—	—	—	Collector lived at Aguilar, Colorado
PMORC0Q090*047*CO	—	—	—	—	—
PMORC0Q090*048*CO	—	—	—	—	—
PMORC0Q090*049*CO	—	—	—	—	—
PMORC0Q0C0*001*KS	—	—	—	—	—
PMORC0Q0C0*002*KS	—	—	—	—	—
PMORC0Q0C0*003*KS	—	—	—	—	—
PMORC0Q0C0*004*KS	—	—	—	—	—
PMORC0Q0C0*005*KS	—	—	—	—	—
PMORC0Q0C0*006*KS	—	—	—	—	—
PMORC0Q0C0*007*KS	—	—	—	—	—
PMORC0Q0C0*008*KS	—	—	—	—	—
PMORC0Q0C0*009*KS	—	—	—	—	—
PMORC0Q0C0*010*KS	—	—	—	—	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q0C0*011*KS	—	—	—	—	—
PMORC0Q0C0*012*KS	—	—	—	—	—
PMORC0Q0C0*013*KS	—	—	—	—	—
PMORC0Q0C0*014*KS	—	—	—	—	—
PMORC0Q0C0*015*KS	—	—	—	—	—
PMORC0Q0C0*016*KS	—	—	—	—	—
PMORC0Q0C0*017*KS	—	—	—	—	—
PMORC0Q0C0*018*KS	—	—	—	—	—
PMORC0Q0C0*019*KS	—	—	—	—	—
PMORC0Q0C0*001*NE	—	—	—	—	—
PMORC0Q0C0*002*NE	—	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*003*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*004*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*005*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*006*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q0C0*007*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*008*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*009*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*010*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
PMORC0Q0C0*011*NE	Steinauer and Rolfsmeier, 2000: southern upland forest, *Quercus alba*, *Carya ovata*	—	*Quercus alba* and *Carya ovata*	—	Gentle to moderately steep upland slopes, usually on the upper slopes of bluffs, though it is often present on middle slopes of south and west exposures
2	*Betula papyrifera* and *Pinus ponderosa* forest, well shaded, lower slope, at birch/pine ecotone	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Betula papyrifera*, *Pinus ponderosa*, *Physocarpus opulifolius*, *Spiraea betulifolia*, *Shepherdia canadensis*, *Aralia nudicaulis*, *Symphoricarpos occidentalis*, *Cornus stolonifera*, *Oryzopsis asperifolia*, *Toxicodendron rydbergii*, *Sanicula marilandica*, and *Campanula rotundifolia*	*Pinus ponderosa* / sapling and pole timber	Many small plants and some may have been missed, some plants with one leaf to several leaved vegetative plants, if upslope is logged amount of light would increase, leaning tree may fall on site and damage population

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
3	*Betula papyrifera* and *Pinus ponderosa*, partial shade, 20 pine trees with birch as understory	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Betula papyrifera*, *Pinus ponderosa*, *Physocarpus opulifolius*, *Spiraea betulifolia*, *Rosa* sp., *Maianthemum stellatum*, *Bromus inermis*, *Elymus canadensis*, *Galium boreale*, and *Achillea millefolium*	*Pinus ponderosa* / mature timber	Evidence of past logging above the area, very steep hillside so grazing by cattle not a risk, no evidence of any small plants
4	*Picea glauca* and *Betula papyrifera*, shaded by vegetation, steep slope, and limestone outcrop	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Picea glauca*, *Betula papyrifera*, *Pinus ponderosa*, *Prunus virginiana*, *Maianthemum stellatum*, *Spiraea betulifolia*, *Galium boreale*, *Cornus canadensis*, *Rosa* sp., *Lonicera dioica*, *Goodyera repens*, and *Shepherdia canadensis*	*Pinus ponderosa* / mature timber	No risk of cattle grazing because slope is to steep, logging would decrease shade and destroy current soil surface which had moss cover, some smaller plants present
5	*Picea glauca*, partial to much shaded, very close to steep outcrop	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Picea glauca*, *Betula papyrifera*, *Prunus virginiana*, *Elymus canadensis*, *Maianthemum stellatum*, *Symphoricarpos occidentalis*, *Aralia nudicaulis*, *Oryzopsis asperifolia*, *Shepherdia canadensis*, *Rosa* sp., *Galium boreale*, *Arctostaphylos uva-ursi*, and *Solidago* sp.	—	Site very difficult to get to, no evidence of any reproductive success – no small plants
6	*Picea glauca* and *Betula papyrifera*, mostly shaded, steep hillside	Vanocker-Citadel complex, 10-40% slopes	*Picea glauca*, *Betula papyrifera*, *Aralia nudicaulis*, *Oryzopsis asperifolia*, *Maianthemum stellatum*, *Lonicera dioica*, *Juniperus communis*, *Arctostaphylos uva-ursi*, and *Arnica lonchophylla*	*Pinus ponderosa* / mature timber	Very steep hillside with no large timber or cattle grazing, some plants were much smaller than flowering plants which may indicate some reproductive success
7	Small *Betula papyrifera*, *Ostrya virginiana* community within *Pinus ponderosa* forest, at base of slope within a drainage channel	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Pinus ponderosa*, *Betula papyrifera*, *Ostrya virginiana*, *Physocarpus opulifolius*, *Salix scouleriana*, *Aralia nudicaulis*, *Cornus stolonifera*, *Picea glauca*, *Trifolium* sp., *Sanicula marilandica*, *Lonicera dioica*, *Toxicodendron rydbergii*, and *Maianthemum stellatum*	*Pinus ponderosa* / sapling and pole timber	No sign of any small plants in area

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
8	Small *Betula papyrifera*, *Ostrya virginiana* community within *Pinus ponderosa* forest, at base of slope within a drainage channel	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Pinus ponderosa*, *Betula papyrifera*, *Ostrya virginiana*, *Physocarpus opulifolius*, *Salix scouleriana*, *Fragaria virginiana*, *Bromus inermis*, *Cornus stolonifera*, *Galium boreale*, *Oryzopsis asperifolia*, *Trifolium* sp., *Ulmus* sp., *Anemone canadensis*, and *Aralia nudicaulis*	*Pinus ponderosa* / mature timber	Did not observe any small plants within area of population, plants within channel and large rainfall event could erode plants from shallow soils
9	Wooded canyon	Vanocker-Citadel association, steep	—	*Pinus ponderosa* / sapling and pole timber	—
10	Pine, birch, spruce	Rock outcrop-Vanocker association, very steep	*Aralia nudicaulis*, *Actaea rubra*, *Picea* sp. seedlings, *Rosa* sp., *Corylus* sp.	*Pseudotsuga menziesii* / mature timber	Observed on a convex slope
11	*Ostrya virginiana*, oak with pine and spruce seedlings, calcareous rock outcrop 10 feet from water	Vanocker-Citadel association, steep	*Ostrya* sp., *Quercus* sp., *Picea* sp. seedlings, *Pinus* sp. seedlings, *Osmorhiza* sp., and *Carex* sp.	*Pinus ponderosa* / mature timber	30 % Total CC
12a	Pine forest	Winetti gravelly loam	*Picea* sp.	—	—
12b	Pine forest	—	—	—	—
12c	Moist area at base of dry, rocky ledge	—	—	—	—
13	Canyon	—	—	—	—
14	Shaded humus ravine	Vanocker-Citadel association, steep	—	*Picea glauca* / mature timber	—
15	Spruce, *Populus tremuloides*, mossy litter and black humus, shaded	Stovho-Trebor association, steep – 25-60%	*Picea* sp., *Populus tremuloides*, *Clematis* sp., *Oryzopsis* sp., *Taraxacum* sp., *Picea glauca*, and *Viburnum nudum* var. *cassinoides*	*Picea glauca* / mature timber	Single genet found with 7 ramets on cutbank
16	Pine, spruce	Citadel association, hilly, slopes are 6-30%	—	*Picea glauca* / mature timber	Four plant specimens – 9 individual plants – at University of South Dakota Herbarium; all collected between June 21-July 3 near same area

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
17	Pine, *Betula papyrifera*	Grizzly-Virkula association, steep – 25-60%	*Picea* sp., *Betula papyrifera*, *Rosa* sp., *Pyrola* sp., *Cornus canadensis*, *Equisetum arvense*, *Picea glauca*, *Betula papyrifera*, *Salix* sp., *Linnaea borealis*, *Symphyotrichum ciliolatum*, *Taraxacum officinale*, *Galium triflorum*, *Trifolium* sp., *Fragaria virginiana*, *Geranium richardsonii*, *Galium boreale*, *Solidago* sp., and *Bromus* sp.	*Pinus ponderosa* / mature timber	30 % Total CC
18	—	Canyon-Rock outcrop complex	—	—	—
19	Canyon	Rock outcrop-Vanocker association, very steep	—	—	—
20	Canyon	Rock outcrop-Vanocker association, very steep	—	*Pinus ponderosa* / mature timber	—
21	Canyon or gulch	Rock outcrop-Vanocker association, very steep	—	*Pinus ponderosa* / mature timber	—
22	Moist woods, small, narrow, densely shaded canyon	Grizzly-Virkula association, steep – 25-60%	—	—	—
23	Gulch	Vanocker-Lakoa complex, 10-40% slopes	—	*Pinus ponderosa* / mature timber	—
24	*Betula papyrifera*, *Ostrya virginiana*, drainage bottom and lower slope with sedge understory	Vanocker-Lakoa complex, 10-40% slopes	*Betula papyrifera*, *Ostrya virginiana*, and *Carex* sp.	*Pinus ponderosa* / shrubs and seedlings	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
25	Rich soil in valley	Lakoa silt loam, 25-50% slopes	—	—	—
26	*Betula papyrifera*, hazelnut, shaded-semi-shaded bottom	Vanocker-Citadel association, steep	*Betula papyrifera* and *Corylus* sp.	*Pinus ponderosa* / mature timber	Population probably larger
27	Shaded-semi-shaded bottom of drainage	Vanocker-Citadel association, steep	—	*Pinus ponderosa* / mature timber	Population probably larger
28	*Betula papyrifera*, *Ostrya virginiana*, moist area at base of dry rock ledge, most near spring-fed creek at bottom of canyon	Vanocker-Citadel association, steep	*Betula papyrifera* and *Ostrya virginiana*	*Pinus ponderosa* / mature timber	—
29	—	Vanocker-Citadel association, steep	—	*Pinus ponderosa* / mature timber	Plants seen on both sides of creek drainage
30	—	Pactola-rock outcrop-Virkul associations	—	Mixed grasses/ Grass and forbs	** RIG was listed as soil type, but no RIG was listed within the soil survey. The soil description was taken from general soil map, USDA 1985
31	*Populus tremuloides*, *Betula papyrifera*, moist, shaded, steep slope above creek	Rock outcrop-Vanocker association, very steep	Moss, *Galium boreale*, *Clematis pseudoalpina*, *Arctostaphylos uva-ursi*, *Populus tremuloides*, *Betula papyrifera*, and *Arctium vulgare*	Shrubs/shrubs and seedlings	Unlogged, ungrazed, with heavy pedestrian traffic
32	Damp shady draw and talus	Vanocker-Citadel association, steep	—	—	—
33	Lower slope above creek bottom	Vanocker-Citadel association, steep	—	*Pinus ponderosa* / mature timber	—
34	Growing in moist areas in valleys	Paunsaugunt-rock outcrop complex, 6-50% slopes	—	—	—
35	Rocky hillside, northern Black Hills	—	—	—	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
36	Spruce, moist woodland, up bank from road along stream	Grizzly-Virkula association, steep – 25-60%	*Picea* sp.	*Pinus ponderosa* / mature timber	Cattle grazing in area
37	Spruce woods, almost closed canopy, in canyon	—	*Picea* sp.	—	—
38	Rich alluvial soil, partial shade, within 5 meter of creek	Vanocker-Citadel association, steep	—	*Pinus ponderosa* / mature timber	—
39	Moist soil in shady cool area	Rock outcrop-Vanocker association, very steep	—	*Populus tremuloides*, *Betula papyrifera* / Sapling andpole timber	—
40	Pine, birch, dry to moist soils	Vanocker-Citadel complex, 10-40% slopes	—	*Pinus ponderosa* / sapling and pole timber	0-30% total canopy cover, found in 4 sections
41	Oak, *Ostrya virginiana*, moist	Vanocker-Citadel association, steep	*Ostrya virginiana*	*Pinus ponderosa* / sapling and pole timber	5-50% total canopy cover, found in 3 sections
42a	Pine, *Populus tremuloides*	Winetti gravelly loam	*Populus tremuloides*	—	0-40% total canopy cover
42b	Pine, *Populus tremuloides*	Vanocker-Citadel association, steep	*Populus tremuloides*	*Pinus ponderosa* / mature timber	0-40% total canopy cover
43	Spruce, birch, moderate moist	Pactola-rock outcrop-Virkul associations	—	*Pinus ponderosa* / mature timber	0-90% total canopy cover. ** RIG was listed as soil type, but no RIG was listed within the soil survey. The soil description was taken from general soil map, USDA 1985
44	—	Vanocker-Citadel association, steep	—	*Pinus ponderosa* / mature timber	Cattle have access to site and have trampled; human trampling also a hazard
45	—	Tilford-silt loam, 6-15% slopes	—	—	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
46	*Betula papyrifera*, *Picea glauca*	Rock outcrop-Vanocker association, very steep – 6-75%	Weeds, *Poa pratensis*, *Betula papyrifera*, *Picea glauca*, *Pinus ponderosa*, *Ostrya virginiana*, *Shepherdia canadensis*, *Spiraea betulifolia*, *Lilium bolanderi*, *Cocculus carolinus*, *Rubus* sp., *Aralia nudicaulis*, and *Carex filifolia*	*Pinus ponderosa* / -	Roads, residential, several noxious weed on old road bed and along creek; no negative impact on slope behind cabin; weeds-*Tanacetum vulgare*, *Dalea candida*, *Hypericum perforatum*
47	*Populus tremuloides*	Paunsaugunt-Rock outcrop, 3-40% slopes	*Populus tremuloides*	*Pinus ponderosa* / mature timber	May want to consider *Populus tremuloides* treatment on east side of creek - regeneration has occurred, but not to a great extent
48	*Populus tremuloides*, *Corylus cornuta*, *Pinus ponderosa*, *Shepherdia canadensis*	Citadel association, hilly	*Populus tremuloides*, *Pinus ponderosa*, *Corallorrhiza striata*, *Amsonia hubrichtii*, *Shepherdia canadensis*, *Berberis repens*, *Corylus cornuta*, *Trifolium* sp., *Aralia nudicaulis*, *Zizia* sp., *Spiraea betulifolia*, *Achillea millefolium*, *Poa secunda*, *Fragaria virginiana*, *Cacalia suaveolens*, *Linnaea borealis*, *Viola* sp., and *Oryzopsis* sp.	*Pinus ponderosa* / Shrub and seedlings	Numerous mounds and small draws, old burn area: heavy slash and downed small timber, archaeological site 2/3 into draw, girdled pines in high ground near site, excellent wildlife usage-forage clippings evident, bedding and nest sites, *Populus tremuloides* regenerating, stand looks good, recommend no disturbance to draw and substantial buffer zone
49	*Pinus ponderosa*, *Corylus cornuta*, *Picea glauca*, *Symphoricarpos* sp.	Vanocker-Citadel association, steep	*Pinus ponderosa*, *Picea glauca*, *Betula papyrifera*, *Quercus macrocarpa*, *Populus tremuloides*, *Corylus cornuta*, *Symphoricarpos occidentalis*, *Salix* sp., *Amelanchier alnifolia*, *Crataegus succulenta*, *Rubus idaeus* ssp. *strigosus*, *Rosa* sp., *Viola* sp., *Maianthemum canadense*, *Sanicula marilandica*, *Galium* sp., *Trifolium* sp., *Aralia nudicaulis*, *Fragaria virginiana*, *Pycnanthemum virginianum*, *Medicago lupulina*, *Lathyrus ochroleucus*, *Halenia deflexa*, *Poa pratensis*, *Carex* sp., *Conimitella williamsii*, and *Collomia mazama*	*Pinus ponderosa* / mature timber	Intermittent water-at eastern end of draw there are two spring sources & water seems to be permanent. Draw is very diverse with spruce and oak intermixed at eastern end of draw. No disturbance recommended. If timber is to be removed from south facing slope-recommend large buffer zone

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
50	*Pinus ponderosa*, *Ostrya virginiana*	Vanocker-Citadel association, steep	*Pinus ponderosa*, *Ostrya virginiana*, *Spiraea betulifolia*, *Thalictrum dioicum*, and *Arnica cordifolia*	*Pinus ponderosa* / mature timber	The gulch is closest for cattle across the creek about 150 meters from the road so the cattle can still use the water but cannot get to the riparian area several creeks. A significant number of *Cypripedium candidum* over the riparian area. Although none of the sensitive species was found there is a high probability for *Adenocaulon bicolor* or *Equisetum* sp. there
56	*Pinus ponderosa*, *Corylus cornuta*, *Betula papyrifera*	Citadel association, hilly, slopes are 6-30%	*Pinus ponderosa*, *Betula papyrifera*, *Quercus macrocarpa*, *Populus tremuloides*, *Corylus cornuta*, *Rosa* sp., *Rubus idaeus* ssp. *strigosus*, *Apocynum* sp., *Galium* sp., *Berberis repens*, *Sanicula* sp., *Iris missouriensis*, *Actaea rubra*, *Medicago lupulina*, *Chimaphila umbellata*, *Arctium vulgare*, *Pyrola picta*, *Dactylis glomerata*, *Oryzopsis asperifolia*, *Poa palustris*, and *Phleum pratense*	*Pinus ponderosa* / mature timber	Excellent habitat for sensitive species in draw, slopes prove to be to dry, good usage of wildlife as seen by causeway and nests of wood peckers bored into trees, a lot of foliage clipped, two state listed sp. located, draw has moderate amounts of downfall present
57	—	Hopdraw-Sawdust-Rock outcrop complex, 40-80% slopes	—	*Pinus ponderosa* / sapling and pole timber	—
58	Pine, oak, *Ostrya virginiana*	Paunsaugunt-rock outcrop complex, 6-50% slopes	*Ostrya virginiana*, *Corylus cornuta*, *Bouteloua repens*, *Aralia nudicaulis*, and *Arnica cordifolia*	—	Steep slopes and dense cover of shrubs make across to the area impossible for cattle, no trace of their presence noticed, there is a creek running all the way through the area high possibility for *Adenocaulon bicolor* especially in the lower north-northeast-facing end of the area
59	—	—	—	—	—
60	—	—	—	—	—
61	—	—	—	—	—
62	—	Rock outcrop-Vanocker association, very steep	—	*Pinus ponderosa* / sapling and pole timber	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
63	—	Rock outcrop-Vanocker association, very steep	—	*Pinus ponderosa* / sapling and pole timber	—
64	—	—	—	—	—
65	—	—	—	—	—
66	*Betula papyrifera*	Rock outcrop-Vanocker association, very steep	*Betula papyrifera*, *Cornus sericea*, *Corylus cornuta*, *Rosa acicularis*, *Ribes* sp., *Spiraea betulifolia*, *Dasiphora floribunda*, *Poa* sp., *Arctostaphylos uva-ursi*, *Lonicera dioica*, *Fragaria virginiana*, *Rubus pubescens*, *Chamerion angustifolium*, and *Aralia nudicaulis*	—	Collected stem only with flower; other plant had green plump ovary; several clumps of *Carex eburnea* on limestone rock nearby
67	*Picea glauca*, *Betula papyrifera*	Grizzly-Virkula association, steep – 25-60%	*Picea glauca*, *Betula papyrifera*, *Viburnum opulus*, *Acer negundo*, *Corylus cornuta*, *Salix bebbiana*, *Solidago canadensis*, *Symphyotrichum ciliolatum*, *Linnaea borealis*, *Mentha arvensis*, *Ribes lacustre*, *Epilobium* sp., *Cicuta maculata* var. *angustifolia*, *Carex* sp., *Poa* sp., *Phleum pratense*, *Equisetum hyemale*, *Equisetum pratense*, and *Equisetum arvense*	—	*Picea glauca* community up to 53.5 centimeters DBH; 3 plants of *Botrychium virginianum* also present at this site; site is above stream/seep with abundant moss and liverwort mats
68	*Betula papyrifera*, *Populus tremuloides*, *Pinus ponderosa*	Vanocker-Citadel association, steep	*Betula papyrifera*, *Populus tremuloides*, *Pinus ponderosa*, *Proserpinaca pectinata*, *Corylus cornuta*, *Picea glauca*, *Amelanchier alnifolia*, *Arnica lonchophylla*, *Cornus sericea*, *Quercus macrocarpa*, and *Danthonia spicata*	—	Located at base of cliff, among loose, mossy rocks; on upper portion of slope, below cliff

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
69	*Pinus ponderosa*, *Betula papyrifera*	Vanocker-Citadel association, steep	*Pinus ponderosa*, *Betula papyrifera*, *Ulmus americana*, *Picea glauca*, *Arnica lonchophylla*, *Achillea millefolium*, *Galium boreale*, *Pyrola* sp., *Carex eburnea*, *Carex* sp., and *Cystopteris fragilis*	—	Growing on mossy bench about 5 feet above creek bed; near a current hiking trail
70	*Betula papyrifera*, *Pinus ponderosa*	Citadel association, hilly, slopes are 6-30%	*Betula papyrifera*, *Pinus ponderosa*, and *Ostrya virginiana*	—	No Target Species "pink" form filled out for this population
71	*Betula papyrifera*, *Picea glauca*	Grizzly-Virkula association, steep – 25-60%	*Betula papyrifera*, *Picea glauca*, and *Ostrya virginiana*	—	No Target Species "pink" form filled out for this population; occurred with *Carex eburnea*, *Arnica lonchophylla*, *C. pedunculata,* and *Viburnum lentago*
72	*Betula papyrifera*, *Populus tremuloides*, *Populus angustifolia*, *Pinus ponderosa*	Vanocker-Citadel association, steep	*Betula papyrifera*, *Pinus ponderosa*, *Populus tremuloides*, *Populus angustifolia*, *Ostrya virginiana*, *Picea glauca*, *Ulmus americana*, *Ribes* sp., *Tanacetum vulgare*, *Rudbeckia laciniata*, *Aralia nudicaulis*, *Fragaria virginiana*, *Rubus parviflorus*, *Glyceria grandis*, *Poa* sp., *Carex* sp., *Woodsia scopulina*, *Equisetum laevigatum*, and *Equisetum pratense*	—	—
73	*Betula papyrifera*, *Ulum americana*	Vanocker-Citadel association, steep	*Betula papyrifera*, *Ulmus americana*, *Picea glauca*, *Maianthemum stellatum*, *Galium* sp., *Ostrya virginiana*, *Amelanchier alnifolia*, *Cicuta maculata*, *Ribes* sp., *Rubus parviflorus*, *Carex* sp., and *Equisetum laevigatum*	—	—
74	*Picea glauca*, *Betula papyrifera*	Grizzly-Virkula association, steep – 25-60%	*Picea glauca*, *Betula papyrifera*, *Ostrya virginiana*, and *Juniperus communis*	—	No Target Species "pink" form filled out for this population
75	—	Citadel association, hilly, slopes are 6-30%	—	—	Logging/thinning on ridge above site – no impact to site

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
76	*Betula papyrifera*, *Pinus ponderosa*	Rock outcrop-Vanocker association, very steep	*Betula papyrifera*, *Pinus ponderosa*, *Picea glauca*, *Cornus sericea*, *Amelanchier alnifolia*, *Salix bebbiana*, *Shepherdia canadensis*, *Arctostaphylos uva-ursi*, *Cornus canadensis*, *Prunus pensylvanica*, *Antennaria parvifolia*, (*Vulpia octoflora*), and *Koeleria macrantha*	—	Growing among moss and litter on a rocky substrate
77	*Pinus ponderosa*, *Populus tremuloides*	Rock outcrop-Vanocker association, very steep	*Pinus ponderosa*, *Populus tremuloides*, *Picea glauca*, *Salix bebbiana*, *Shepherdia canadensis*, *Corylus cornuta*, *Juniperus communis*, *Rosa acicularis*, *Maianthemum canadense*, *Frasera speciosa*, *Symphyotrichum ciliolatum*, *Clematis columbiana*, and *Oryzopsis asperifolia*	—	Occurs in a small patch in an opening on a convex ridge slope
78	*Betula papyrifera*, *Pinus ponderosa*	Rock outcrop-Vanocker association, very steep	*Betula papyrifera*, *Pinus ponderosa*, *Picea glauca*, *Cornus sericea*, *Juniperus communis*, *Dasiphora floribunda*, *Arctostaphylos uva-ursi*, *Erigeron* sp., *Galium boreale*, *Shepherdia canadensis*, *Achnatherum occidentale*, *Poa pratensis*, and *Pellaea glabella*	—	Growing among leaf litter under *Betula papyrifera* canopy on rocky lower slopes
79	*Betula papyrifera*, *Picea glauca*	Rock outcrop-Vanocker association, very steep	*Pinus ponderosa*, *Picea glauca*, *Betula papyrifera*, *Juniperus communis*, *Thalictrum venulosum*, *Vaccinium scoparium*, *Linnaea borealis*, *Solidago canadensis*, *Agropyron trachycaulum*, and *Agropyron* sp.	—	Light gap created over plants by dead spruce; all have 2 capsules per stalk; about 12 inches or 30 centimeters tall, very broad leaves; plants and *Arnica lonchophylla* found together
80	*Betula papyrifera*	Rock outcrop-Vanocker association, very steep	*Betula papyrifera*, *Corylus cornuta*, *Cornus sericea*, *Linnaea borealis*, and *Actaea rubra*	—	No Target Species “pink” form filled out for this population; occurs below cliff and on mid to lower slopes; some found below limestone cliff on colluvial slope

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
81	*Picea glauca*, *Salix bebbiana*, *Juniperus communis*	Pactola-rock outcrop-Virkul associations	*Salix bebbiana*, *Juniperus communis*, *Picea glauca*, *Betula* sp., *Rosa* sp., *Pyrola* sp., *Carex disperma*, *Carex dunea*, *Symphoricarpos* sp., and *Taraxacum vulgare*	—	** RIG was listed as soil type, but no RIG was listed within the soil survey. The soil description was taken from general soil map, USDA 1985
82	*Picea glauca*	Stovho-Trebor association, steep – 25-60%	*Picea glauca*, *Maianthemum stellatum*, *Carex interior*, *Cornus sericea*, *Equisetum* sp., *Corallorrhiza maculata*, *Pyrola secunda*, *Goodyera repens*, and *Calypso bulbosa*	—	—
83	Picea glauca	Stovho-Trebor association, steep – 25-60%	*Picea glauca*, *Equisetum* sp., *Aralia nudicaulis*, *Lysimachia ciliata*, *Poa* sp., *Ribes* sp., *Cornus sericea*, and *Epilobium* sp.	—	—
84	*Picea glauca*, *Populus tremuloides*	Stovho-Trebor association, steep – 25-60%	*Picea glauca*, *Carex* sp., *Pyrola* sp., *Trifolium* sp., and *Equisetum* sp.	—	—
85	*Pinus ponderosa*	Stovho-Trebor association, steep – 25-60%	*Picea glauca*, *Maianthemum stellatum*, *Carex interior*, *Cornus sericea*, *Corallorrhiza maculata*, *Pyrola secunda*, *Goodyera repens*, and *Equisetum* sp.	—	—
86	*Ostrya virginiana* community within a *Pinus ponderosa* forest	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Pinus ponderosa*, *Ostrya virginiana*, *Prunus virginiana*, *Piptatherum micranthum*, *Aralia nudicaulis*, *Cheilanthes feei*, *Pellaea atropurpurea*, *Quercus macrocarpa*, *Maianthemum canadense*, *Smilacina racemosa*, *Maianthemum stellatum*, and *Clematis tenuiloba*	—	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
87	*Ostrya virginiana* community within a *Pinus ponderosa* forest	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Pinus ponderosa*, *Ostrya virginiana*, *Prunus virginiana*, *Piptatherum micranthum*, *Aralia nudicaulis*, *Cheilanthes feei*, *Pellaea atropurpurea*, *Quercus macrocarpa*, *Maianthemum canadense*, *Smilacina racemosa*, *Maianthemum stellatum*, and *Clematis tenuiloba*	—	—
88	*Ostrya virginiana*, oak, *Pinus ponderosa*	Vanocker-Lakoa complex, 10-40% slopes	*Pinus ponderosa*, *Ostrya virginiana*, *Prunus virginiana*, *Piptatherum micranthum*, *Aralia nudicaulis*, *Cheilanthes feei*, *Pellaea atropurpurea*, *Quercus macrocarpa*, *Maianthemum canadense*, *Smilacina racemosa*, *Maianthemum stellatum*, and *Clematis tenuiloba*	—	—
89	*Ostrya virginiana*, hazelnut, *Pinus ponderosa*	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Pinus ponderosa*, *Ostrya virginiana*, *Prunus virginiana*, *Piptatherum micranthum*, *Aralia nudicaulis*, *Cheilanthes feei*, *Pellaea atropurpurea*, *Quercus macrocarpa*, *Maianthemum canadense*, *Smilacina racemosa*, *Maianthemum stellatum*, and *Clematis tenuiloba*	—	—
90	*Ostrya virginiana*, hazelnut, *Pinus ponderosa*	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Pinus ponderosa*, *Ostrya virginiana*, *Prunus virginiana*, *Piptatherum micranthum*, *Aralia nudicaulis*, *Cheilanthes feei*, *Pellaea atropurpurea*, *Quercus macrocarpa*, *Maianthemum canadense*, *Smilacina racemosa*, *Maianthemum stellatum*, and *Clematis tenuiloba*	—	—

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
91	*Ostrya virginiana*, hazelnut, *Pinus ponderosa*	Vanocker-Sawdust-Rock outcrop complex, 40-80% slopes	*Pinus ponderosa*, *Ostrya virginiana*, *Prunus virginiana*, *Piptatherum micranthum*, *Aralia nudicaulis*, *Cheilanthes feei*, *Pellaea atropurpurea*, *Quercus macrocarpa*, *Maianthemum canadense*, *Smilacina racemosa*, *Maianthemum stellatum*, and *Clematis tenuiloba*	—	—
03R03A	*Betula papyrifera*, *Ostrya virginiana*, *Pinus ponderosa*	—	*Arctostaphylos uva-uris*, *Viola* sp., and *Goodyera oblongifolia*	Trees and shrubs / -	Mid slope drainage of *Betula papyrifera*, *Ostrya virginiana* and *Pinus ponderosa*; large outcropping of rock in immediate vicinity of species
03R04B	*Betula papyrifera*, *Ostrya virginiana*, *Pinus ponderosa*	—	*Arctostaphylos uva-uris*, *Pyrola* sp., *Chimaphila umbellata*, *Goodyera oblongifolia*, and *Viola* sp.	Trees and shrubs / -	Community Type #1 *Betula papyrifera*, *Ostrya virginiana*, *Pinus ponderosa*; habitat in mid slope rather steep drainage; plant was found in mesic to dry conditions without understory species in immediate area
03R09A	*Ostrya virginiana*, *Betula papyrifera*, *Pinus ponderosa*	—	*Pyrola* sp., *Goodyera oblongifolia*, *Juniperus communis*, and *Salix* sp.	Trees and shrubs / -	Perennial stream drainage of *Ostrya virginiana* and *Betula papyrifera*; the plant is located under/near a tree right near the stream flow; the drainage has flat areas dominated by sedges
03R10A	*Salix* sp., *Ostrya virginiana*, *Betula papyrifera*	—	*Pyrola* sp., *Arctostaphylos uva-uris*, *Juncus* sp., *Cyperaceae* sp., *Juniperus communis*, and *Poa annua*	Trees and shrubs / -	Sedge and willow dominated habitat; open and inundated swampy; this area leads to a small pond to the south
03R50A	*Betula papyrifera*, *Populus tremuloides*, *Corylus cornuta*	—	*Pteridium aquilinum*, *Rubus parviflorus*, *Vaccinium scoparium*, *Disporum trachycarpum*, *Astragalus* sp., *Shepherdia canadensis*, and *Toxicodendron rydbergii*	Trees and shrubs / -	North-facing slope with slightly moist soil; approximately 80% canopy cover; mostly *Betula papyrifera*, *Populus tremuloides* and *Corylus cornuta*; *C. cornuta* is more dense down slope
03R64B	*Picea glauca*, *Betula papyrifera*	—	*Rubus parviflorus*, *Viola* sp., *moss*, *Heracleum maximum*, and *Pyrola* sp.	Trees and shrubs / -	Narrow drainage bound by steep limestone cliffs; many moss covered rocks; moderately wet; water flowing in drainage below plant location
03R67C	*Ostrya virginiana*, *Betula papyrifera*, *Pinus ponderosa*	—	*Linnaea borealis*, *Rubus parviflorus*, *Pyrola* sp., *Cleome serrulata*, *Viola* sp., *Aralia nudicaulis*, and *Disporum trachycarpum*	Trees and shrubs / -	Edge of broad northwest sloping drainage; shady, dry-mesic; plants appear to be in poor condition – small, less than 4 inches tall, with brown splotchy leaves

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
03R67D	*Ostrya virginiana*, *Betula papyrifera*, *Pinus ponderosa*	—	*Linnaea borealis*, *Rubus parviflorus*, *Pyrola* sp., *Cleome serrulata*, *Viola* sp., *Aralia nudicaulis*, and *Disporum trachycarpum*	Trees and shrubs / -	Edge of steep, rocky drainage; water flowing under surface between rocks; plants covered by *Corylus cornuta* shrub; drainage bound by limestone cliffs; plants appear healthy, but are along hiking trail and could be trampled
03R88B	*Ostrya virginiana*, *Betula papyrifera*, *Pinus ponderosa*	—	*Rubus parviflorus*, *Clematis columbiana* var. *tenuiloba*, *Pyrola* sp., and *Disporum trachycarpum*	Trees / -	Steep east-facing slope of colluvium near path/trail under *Betula papyrifera* and *Ostrya virginiana* canopy; rock cliff, *Pinus ponderosa* and other trees upslope help shade this plant
03R90A	*Betula papyrifera*, *Picea glauca*, *Pinus ponderosa*	—	*Pyrola* sp., *Linnaea borealis*, moss, *Corylus cornuta*, and *Ribes* sp.	Trees / -	Well shaded cool canyon bottom; steep slopes, rim rocks and trees upslope shade area more than the canopy cover of 55% would indicate; area with moss cover and could be at risk from larger water flows down canyon
03R98B	*Picea glauca*, *Acer negundo*, *Betula papyrifera*, *Corylus cornuta*	—	*Carex eburnea*, *Elymus villosus*, *Pellaea atropurpurea*, *Carex pedunculata*, and *Fragaria virginiana*	Trees and shrubs / -	Deep canyon drainage; moist, cool, very well shaded with overstory and canyon walls; plants located within old channel bottom; plants found throughout survey area; more abundant near pipeline
03U06A	*Picea glauca*, *Betula papyrifera*	—	*Carex eburnea*	Trees and shrubs / -	Steep north-facing spruce-birch slope with little herbaceous canopy except thick moss cover; about 30 feet upslope of dry drainage channel; one plant flowered in 2003, but no fruit; second plant did not flower
03U15D	*Betula papyrifera*, *Corylus cornuta*	—	*Sorbus scopulina*, *Pteridium aquilinum*, *Viola* sp., *Disporum trachycarpum*, *Rubus parviflorus*, *Cornus canadensis*, *Linnaea borealis*, *Chimaphila umbellata*, *Goodyera* sp., *Pyrola* sp., *Maianthemum canadense*, *Aralia nudicaulis*, *Clematis columbiana* var. *tenuiloba*, *Fragaria virginiana*, and *Galium boreale*	Trees / -	Opening of small cave in bottom of side drainage 3/4 way down slope; mesic with dense covering of moss; rocky cave faces northeast; open canopy, but shady – *Betula papyrifera* and *Sorbus scopulina* in overstory
03U16A	*Betula papyrifera*, *Corylus cornuta*	—	*Carex eburnea*, *Rubus parviflorus*, *Linnaea borealis*, *Equisetum* sp., *Cornus sericea*, *Chimaphila umbellata*, *Goodyera* sp., *Pyrola* sp., and *Viola* sp.	Trees and shrubs / -	Rocky ledge 10 feet below rock outcropping, 30 feet above bottom of drainage; moist abundant mosses; tight canopy

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
03U31A	*Betula papyrifera*, *Picea glauca*, *Ostrya virginiana*	—	*Adenocaulon bicolor*, *Carex eburnea*, *Sorbus scopulina*, *Carex pedunculata*, and *Pellaea gastonyi*	Trees and shrubs / -	Steep, deep, drainage channel with very little herbaceous canopy cover; plants scattered throughout community type #1 and more common near drainage channel
03U34B	*Ostrya virginiana*, *Betula papyrifera*, *Picea glauca*, *Pinus ponderosa*	—	*Carex eburnea*, *Carex pedunculata*, *Pellaea glabella* ssp. *simplex*, *Pellaea gastonyi*, *Quercus macrocarpa*, and *Pteridium aquilinum*	Trees and shrubs / -	Deep canyon drainage; large boulders, moss, little to moderate herbaceous understory; *Ostrya virginiana*-birch-spruce forested drainage with some mature pine present; plant found in drainage bottom within northern half of *Ostrya virginiana*, *Betula papyrifera*, *Picea glauca*, and *Pinus ponderosa* habitat
03U35A	*Ostrya virginiana*, *Betula papyrifera*, *Pinus ponderosa*	—	*Echinacea angustifolia*, *Carex eburnea*, *Quercus macrocarpa*, and *Prunus virginiana*	Trees and shrubs / -	Dry drainage channel on southwest-facing slope; canopy of *Ostrya virginiana*, birch and large mature pine
03U60A	*Ostrya virginiana*, *Betula papyrifera*	—	*Sorbus scopulina*, *Carex pedunculata*, *Disporum trachycarpum*, *Rubus parviflorus*, *Goodyera oblongifolia*, *Pyrola* sp., *Oryzopsis asperifolia*, *Mahonia repens*, *Pteridium aquilinum*, *Amelanchier alnifolia*, *Cornus* sp., *Ribes* sp., *Rosa* sp., *Toxicodendron rydbergii*, *Crataegus chrysocarpa*, and *Aralia nudicaulis*	Trees and shrubs / -	Steep east-facing slope 20 feet from bottom; moist with fairly open overstory
03U61A	*Ostrya virginiana*, *Betula papyrifera*, *Corylus cornuta*, *Pinus ponderosa*	—	—	Trees and shrubs / -	North-facing, steep sloped drainage; wet, moist soil; downed pine and birch; mossy and rocky
03U88B	*Picea glauca*, *Betula papyrifera*	—	*Carex eburnea*, *Carex pedunculata*, *Arnica lonchophylla*, *Chimaphila umbellata*, *Cornus canadensis*, and moss	Trees / -	Spruce-birch community on steep slope; near base of steep hillslope; well shaded by canopy, steep slopes and trees upslope; plants growing in moss covered soils

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
03U91E	*Corylus cornuta*, *Betula papyrifera*, *Picea glauca*, *Pinus ponderosa*	—	*Carex eburnea*, *Pellaea glabella* ssp. *simplex*, *Sorbus scopulina*, *Viburnum opulus* var. *americanum*, *Equisetum scirpoides*, *Goodyera oblongifolia*, *Linnaea borealis*, *Pteridium aquilinum*, *Aralia nudicaulis*, *Symphoricarpos occidentalis*, *Disporum trachycarpum*, *Rubus parviflorus*, *Chimaphila umbellata*, *Rosa* sp., *Maianthemum racemosum* ssp. *racemosum*, *Trifolium pratense*, *Crataegus chrysocarpa*, *Maianthemum canadense*, *Toxicodendron rydbergii*, *Mahonia repens*, and *Cornus* sp.	Trees and shrubs / -	Juncture of large drainage with dry stream bed and small side drainage running east; very rocky, moist, abundant mosses; no water in bottom of drainage; *Betula papyrifera*, *Corylus cornuta*, and *Picea glauca* forest; flat bottom just below steep rock wall
03Y52A	*Betula papyrifera*, *Ostrya virginiana*, *Picea glauca*, *Pinus ponderosa*	—	*Chimaphila umbellata*, *Pyrola* sp., *Spiraea betulifolia*, *Prunus* sp., *Mahonia repens*, and *Juniperus communis*	Trees and shrubs / -	Steep north-facing community with little understory, but some dense hazelnut; limestone rim and boulders upslope; tree canopy mixed within community, but birch-hazelnut with some *Ostrya virginiana* best characterizes the site
04S001B	*Picea glauca*	—	*Corallorrhiza* sp., *Carex pedunculata*, *Pyrola chlorantha*, *Viburnum edule*, and *Aquilegia brevistyla*	—	Good *Picea glauca* habitat with *Aquilegia brevistyla* and seepy spring habitat with *Cypripedium parviflorum* present – Structure #1, 2, 3. Weeds in flat bottoms – all structures – a concern. North portion of creek not surveyed because close to creek and assume will not be treated. Structure #5: treated *Picea glauca*; snails, corner brushy with *Prunus virginiana*, *Corylus cornuta*, *Ribes* sp., and *Rubus* sp. – apparently from past treatment. *Tanacetum vulgare*, *Verbascum thapsus* along creek, also (*Linaria vulgaris*), *Cirsium vulgare*
04S005A	*Picea glauca*, *Pinus ponderosa*, *Betula papyrifera*	—	*Arnica lonchophylla* ssp. *arnoglossa*, *Carex pedunculata*, (*Platanthera huronensis*), *Carex disperma*, *Carex eburnea*, *Goodyera repens*, *Carex capillaris*, *Rubus* sp., *Carex leptalea*, *Aquilegia brevistyla*, *Carex granularis* var. *haleana*, and *Botrychium virginianum*	—	Seventeen were found in a springs; one in a dry *Picea glauca/Pinus Ponderosa* stand; slope with many springs. Springs excellent habitat, the drier portions not. Springs have *Picea glauca* overstory, understory many have *Salix* sp., *Carex* sp., moss, and (*Rudbeckia laciniata*). Snails present throughout most of entire survey area. Many small mossy inclusions. South side of gulch with *Picea glauca/ Betula papyrifera* and very good habitat that could use more extensive survey, including further upslope. *Botrychium virginianum* in open old road; check for other *Botrychium* species

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
04S005B	*Picea glauca*, *Pinus ponderosa*, *Betula papyrifera*	—	*Arnica lonchophylla* ssp. *arnoglossa*, *Carex pedunculata*, (*Platanthera huronensis*), *Carex disperma*, *Carex eburnea*, *Goodyera repens*, *Carex capillaris*, *Rubus* sp., *Carex leptalea*, *Aquilegia brevistyla*, *Carex granularis* var. *haleana*, and *Botrychium virginianum*	—	Drier conifer stand – I think spruce; slope with many springs. Springs excellent habitat, the drier portions not. Springs have *Picea glauca* overstory, understory many have *Salix* sp., *Carex* sp., moss, and (*Rudbeckia laciniata*). Snails present throughout most of entire survey area. Many small mossy inclusions. South side of gulch with *Picea glauca/ Betula papyrifera* and very good habitat that could use more extensive survey, including further upslope. *Botrychium virginianum* in open old road; check for other *Botrychium* species
04S006B	—	—	*Icmadophila ericetorum*, (*Platanthera huronensis*), *Goodyera repens*, *Geum rivale*, *Arnica lonchophylla* ssp. *arnoglossa*, *Aquilegia brevistyla*, *Viburnum edule*, and *Maianthemum racemosum*	—	Diverse – grass, forbs and shrubs – spot with mix of dry and moist indicators. Series of drier ridges – open *Pinus ponderosa/Juniperus communis* – and draws with springs and *Picea glauca*; not many weeds or other signs of disturbance – except past fire; overstory pine succeeding to spruce; low slope with moss/lichens and moisture-loving indicators – *Pyrola* sp., *Cornus canadensis*, *Chimaphila umbellata*, and *Betula papyrifera* occasional. Draws with species of interest; springs and gulch not thoroughly surveyed; gulch and low slope could contain additional species of interest; two *Maianthemum racemosum* noted on low slope. One *Geum rivale* noted, although was not targeted in search. Stream on east survey boundary contains *Picea glauca*/*Salix* sp./*Cornus sericea* and is excellent habitat
04S006C	—	—	*Icmadophila ericetorum*, (*Platanthera huronensis*), *Goodyera repens*, *Geum rivale*, *Arnica lonchophylla* ssp. *arnoglossa*, *Aquilegia brevistyla*, *Viburnum edule*, and *Maianthemum racemosum*	—	Diverse – grass, forbs and shrubs – spot with mix of dry and moist indicators. Series of drier ridges – open *Pinus ponderosa/Juniperus communis* – and draws with springs and *Picea glauca*; not many weeds or other signs of disturbance – except past fire; overstory pine succeeding to spruce; low slope with moss/lichens and moisture-loving indicators – *Pyrola* sp., *Cornus canadensis*, *Chimaphila umbellata*, and *Betula papyrifera* occasional. Draws with species of interest; springs and gulch not thoroughly surveyed; gulch and low slope could contain additional species of interest; two *Maianthemum racemosum* noted on low slope. One *Geum rivale* noted, although was not targeted in search. Stream on east survey boundary contains *Picea glauca*/*Salix* sp./*Cornus sericea* and is excellent habitat

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
04S015A	—	—	*Carex pedunculata*, *Carex aurea*, (*Platanthera huronensis*), *Carex interior*, *Carex capillaris*, *Salix* sp., *Cornus sericea*, *Prunus virginiana*, *Populus tremuloides*, *Epilobium* sp., *Rudbeckia laciniata*, *Carex granularis* var. *haleana*, *Geum rivale*, and *Carex leptalea*	—	Found late in year – turning brown. Did a quick pass through, most likely there are more in this area. This section is a series of springs and drier knobs. The springs are occupied by the lady's slipper and *Carex leptalea*. Potential for other species of interest if surveyed at a better time. Quite a bit of water seeping out of hillside as evidenced by willows near road, although seep narrows toward bottom of slope. Fire scars present, even close to seeps. Many (*Platanthera huronensis*) throughout, some very large
04S018B	*Picea glauca*, *Pinus ponderosa*, moss	—	*Carex leptalea*, *Viburnum edule*, and *Equisetum scirpoides*	—	Mix of already treated and open, and springs and seeps. Seeps and moist slopes are excellent habitat. Recommend buffer around creek. Northern portion has a spruce seep that is excellent habitat. This seep is moist to saturated soils and flat
04S018C	*Picea glauca*, *Pinus ponderosa*, moss	—	*Carex leptalea*, *Viburnum edule*, and *Equisetum scirpoides*	—	Mix of already treated and open, and springs and seeps. Seeps and moist slopes are excellent habitat. Recommend buffer around creek. Northern portion has a spruce seep that is excellent habitat. This seep is moist to saturated soils and flat
05W029A	*Betula papyrifera*, *Picea glauca*, *Pinus ponderosa*	—	*Betula papyrifera*, *Pinus ponderosa*, *Corylus cornuta*, *Picea glauca*, *Aralia nudicaulis*, *Rosa* sp., *Viola* sp., *Fragaria virginiana*, *Spiraea betulifolia*, *Maianthemum canadense*, *Rubus idaeus*, *Aquilegia brevistyla*, *Oryzopsis asperifolia*, *Carex* sp., and mixed grasses	Trees and shrubs / -	Occurrence is on old road bed just above creek and up drainage
05W029D	*Picea glauca*, *Betula papyrifera*	—	*Picea glauca*, *Betula papyrifera*, *Cornus sericea*, *Shepherdia canadensis*, *Linnaea borealis*, *Goodyera repens*, *Pyrola chlorantha*, *Viburnum edule*, *Cornus canadensis*, and *Cornus sericea*	Trees and shrubs / -	Plant growing on a moss-covered slope in a small gully

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
05W032A	*Betula papyrifera*, *Populus angustifolia*, *Salix* sp.	—	*Betula papyrifera*, *Picea glauca*, *Populus angustifolia*, *Shepherdia canadensis*, *Pinus ponderosa*, *Salix* sp., *Heracleum maximum*, *Cornus sericea*, *Tanacetum vulgare*, *Shepherdia canadensis*, *Maianthemum racemosum* ssp. *racemosum*, *Myosotis scorpioides*, and *Dactylis glomerata*	Trees and shrubs / -	Plants found on flat to steep north-facing slope within 30-40 feet of creek. *Maianthemum racemosum* within site
05W048A	*Picea glauca*, *Betula papyrifera*, *Pinus ponderosa*	—	*Picea glauca*, *Pinus ponderosa*, *Betula papyrifera*, *Juniperus communis*, *Rudbeckia hirta*, *Mahonia repens*, *Spiraea betulifolia*, *Frasera speciosa*, *Phleum pratense*, *Carex* sp., and *Bromus japonicus*	Trees / -	On top of rocky soil covering a 28 inch tile pipe along narrow road, ground at site is level. From 0.48 to 0.39 miles north of northwest flowing drainage. All plants appear healthy and vigorous
05W048B	*Picea glauca*, *Pinus ponderosa*	—	*Picea glauca*, *Pinus ponderosa*, *Populus tremuloides*, *Betula papyrifera*, *Arctostaphylos uva-uris*, *Shepherdia canadensis*, *Linnaea borealis*, *Mahonia repens*, *Frasera speciosa*, *Orthilia secunda*, *Agrostis stolonifera*, *Oryzopsis asperifolia*, and *Carex* sp.	Trees / -	In rocky soil on top 2 feet water pipe along trail above and parallel with creek. Plants are vigorous
05W051A	*Picea glauca*	—	*Picea glauca*, *Salix* sp., *Picea glauca*, *Arctostaphylos uva-uris*, *Linnaea borealis*, *Zigadenus venenosus*, *Viola renifolia*, *Frasera speciosa*, *Platanthera stricta*, and *Poa* sp.	Trees / -	In rocky soil over aqueduct; very mossy; all plants appear rigorous
05W052A	*Betula papyrifera*, *Picea glauca*	—	*Betula papyrifera*, *Picea glauca*, *Prunus virginiana*, *Betula papyrifera*, *Amelanchier alnifolia*, *Aralia nudicaulis*, *Linnaea borealis*, *Spiraea betulifolia*, *Rosa* sp., *Cornus canadensis*, *Viburnum edule*, *Pyrola* sp., *Disporum trachycarpum*, and *Ribes* sp.	Trees and shrubs / -	Occurrence on top of mossy boulder close to aqueduct. Creek in bottom with rim rock above slope

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
05W055A	*Betula papyrifera*, *Picea glauca*, *Pinus ponderosa*	—	*Betula papyrifera*, *Cornus sericea*, *Picea glauca*, *Pinus ponderosa*, *Prunus virginiana*, *Arctostaphylos uva-uris*, *Arnica lonchophylla*, and *Vaccinium scoparium*	Trees / -	Found on boulders and steep hillsides with much shade and little to moderate herbaceous cover. Little soil present at some locations
05W068F	*Picea glauca*, *Betula papyrifera*	—	*Picea glauca*, *Cornus sericea*, *Acer negundo*, *Sambucus racemosa* var. *racemosa*, *Heracleum maximum*, *Solidago canadensis*, *Achillea millefolium*, *Carex capillaris*, *Elymus virginicus*, and *Equisetum arvense*	Trees / -	Found at seep in saturated, wet, moss-covered soils. Very shaded with shrubs, but sparse forb cover except *Heracleum maximum*
05W070C	*Picea glauca*, *Betula papyrifera*	—	*Picea glauca*, *Betula papyrifera*, *Pinus ponderosa*, *Betula papyrifera*, *Salix* sp., *Cornus sericea*, *Taraxacum officinale*, *Fragaria virginiana*, *Trifolium pratense*, *Frasera speciosa*, *Zigadenus elegans*, *Lupinus argenteus*, and *Phleum pratense*	Shrubs / -	Along side of creek/road in seep area that has lots of moss present to make pretty thick layer. One plant was found in ditch beside road with no moss, but in limestone and metamorphic soils
05W072A	*Picea glauca*, *Betula papyrifera*, *Pinus ponderosa*	—	*Picea glauca*, *Aralia nudicaulis*, *Cornus canadensis*, *Rubus pubescens*, *Clematis columbiana* var. *tenuiloba*, and *Oryzopsis asperifolia*	Trees / -	Found on north-facing, moderately steep, well-shaded slope with little herbaceous or shrubby understory. Only 1 plant observed with immature fruit. Growing in 800 square meter moss mate. Little competing vegetation at site
05W077B	*Picea glauca*	—	*Picea glauca*, *Populus tremuloides*, *Betula papyrifera*, *Pinus ponderosa*, *Corylus cornuta*, *Toxicodendron rydbergii*, *Cornus sericea*, *Shepherdia canadensis*, *Mahonia repens*, *Corylus cornuta*, *Linnaea borealis*, *Thalictrum dasycarpum*, *Fragaria virginiana*, *Oryzopsis asperifolia*, and *Carex eburnea*	Trees and shrubs / -	Occurrence is on old road bed above creek. Site mostly dry at time of survey but dry moss present along road

Appendix C (cont.).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
05W078A	*Picea glauca*, *Betula papyrifera*, *Pinus ponderosa*	—	*Picea glauca*, *Betula papyrifera*, *Pinus ponderosa*, *Corylus cornuta*, *Mahonia repens*, *Cornus canadensis*, *Maianthemum canadense*, *Pyrola* sp., *Chimaphila umbellata*, *Viola* sp., *Oryzopsis asperifolia*, *Carex pedunculata*, and *C. eburnea*	Trees / -	Found on very steep slope in well shaded microclimate. Moss cover abundant, loose rock nearby as well as trail
PMORC0Q0C0*001*SD	—	—	—	—	—
PMORC0Q0C0*002*SD	—	—	—	—	Referenced in "Atlas of the Flora of the Great Plains", source unknown – no specimen found; could be located in Sica Hollow State Park
1	*Quercus macrocarpa* woods in moist environment along bank of well shaded stream. Population small. Habitat near dirt road	Rock outcrop-Vanocker complex, 50-75% slopes	*Quercus macrocarpa*	*Pinus ponderosa* / mature timber	Population small, near dirt road; first observed: 1993-Jun 19
51	—	Rock outcrop-Vanocker complex, 50-75% slopes	—	*Pinus ponderosa* / mature timber	—
52	—	—	—	—	—
53	—	—	—	—	—
54	—	—	—	—	—
55	—	Citadel-McCaffery complex, 3-10% slopes	—	*Pinus ponderosa* / mature timber	Some running water draws, few small ponds occur in bottom of creek bed, bottom side draws often saturated and disturbed by cows, big graminoids variety in area
PMORC0Q0C0*001*WY*a	Moist *Picea* sp. forest along stream; also reported from mesic *Pinus pondersosa* forest and in boggy areas	—	*Viola canadensis*, *Acer glabrum*, *Habenaria* sp., *Eupatorium* sp., and *Alnus* sp.	—	First observed/collected by A.G. Dumont in 1960. Surveyed/collected and reported as frequent 1979-Aug 2 by R.W. Lichvar. 1985: Surveyed by E. Evert – may be this species or *Cypripedium montanum* – flowers faded, color uncertain

Appendix C (concluded).

Occurrence Number	Habitat description	Soil name	Associated plant species	Cover type/ structural stage	Comments
PMORC0Q0C0*001*WY*b	*Pinus ponderosa* forest on granitic soil with thick forest litter and moderate moisture in low light	—	*Cypripedium montanum*, *Pinus ponderosa*, *Populus tremuloides*, *Lupinus* sp., *Geranium viscosissimum*, *Mertensia ciliata*, and *Maianthemum stellatum*	—	—
PMORC0Q0C0*002*WY	Damp leaf mold under trees	—	—	—	First observed: 1911-Jun 14
PMORC0Q0C0*003*WY	—	—	—	—	First observed: 1896-Jun 12. Specimens in flower and fruit. Claire Leon's report is presumed to be from the same general vicinity as Moore's 1896 specimens
PMORC0Q0C0*004*WY	—	—	—	—	First observed: 1906-Jul
PMORC0Q0C0*005*WY	Shaded river bottom with limestone boulders	—	—	—	First observed: 1979-Jun 26
PMORC0Q0C0*006*WY	Brushy creek bottom of canyon and along the creek	—	—	—	First observed: 1980-Jun 6
PMORC0Q0C0*007*WY	Riparian community in shade of shrubs along creek on limestone	—	—	—	First observed: 1986
PMORC0Q0C0*009*WY	—	—	—	—	First observed: 1989-Jun 14

Cells with a dash, "-", indicate no information available.

Information in parenthesis "( )" is in question, for instance some associated plant species that were included with data may be misidentifications.