Epipactis gigantea Dougl. ex Hook. (stream orchid): A Technical Conservation Assessment

Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project

March 20, 2006

Joe Rocchio, Maggie March, and David G. Anderson
Colorado Natural Heritage Program
Colorado State University
Fort Collins, CO

Peer Review Administered by
Center for Plant Conservation

Rocchio, J., M. March, and D.G. Anderson. (2006, March 20). *Epipactis gigantea* Dougl. ex Hook. (stream orchid): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/epipactisgigantea.pdf [date of access].

ACKNOWLEDGMENTS

This research was greatly facilitated by the helpfulness and generosity of many experts, particularly Bonnie Heidel, Beth Burkhart, Leslie Stewart, Jim Ferguson, Peggy Lyon, Sarah Brinton, Jennifer Whipple, and Janet Coles. Their interest in the project, valuable insight, depth of experience, and time spent answering questions were extremely valuable and crucial to the project. Nan Lederer (COLO), Ron Hartman, Ernie Nelson, Joy Handley (RM), and Michelle Szumlinski (SJNM) all provided assistance and specimen labels from their institutions. Annette Miller provided information for the report on seed storage status. Jane Nusbaum, Mary Olivas, and Barbara Brayfield provided crucial financial oversight. Shannon Gilpin assisted with literature acquisition. Many thanks to Beth Burkhart, Janet Coles, and two anonymous reviewers whose invaluable suggestions and insight greatly improved the quality of this manuscript.

AUTHORS' BIOGRAPHIES

Joe Rocchio is a wetland ecologist with the Colorado Natural Heritage Program where his work has included survey and assessment of biologically significant wetlands throughout Colorado since 1999. Currently, he is developing bioassessment tools to assess the floristic integrity of Colorado wetlands. Mr. Rocchio's prior experience comes from environmental consulting where he worked on wetland regulatory issues such as delineation, permitting, mitigation, restoration, and monitoring. Mr. Rocchio received a B.S. in Public and Environmental Affairs from Indiana University (1993) and a M.S. in Ecosystem Analysis (1998) from the University of Washington. His thesis research focused on the success of using donor soils for establishing vegetation in wetland restoration projects.

Maggie March is a field ecologist for the Colorado Natural Heritage Program where her work has included riparian and wetland inventory in southwestern Colorado since 2001, and riparian/upland inventory of grazing districts on the Comanche National Grassland in 1995. Ms. March has benefited from prior naturalist positions held with the Denver Botanic Gardens and the San Juan Mountains Association. She also benefits from experience as an organic farmer, gardener and nurseryman for seven years. She received a B.S. in Environmental Biology with a minor in Chemistry from Fort Lewis College in 1994.

David G. Anderson is a botanist with the Colorado Natural Heritage Program where his work includes inventory and mapping of rare plants throughout Colorado, mapping weeds, maintaining and updating Colorado Natural Heritage Program's database, and writing reports on the rare plants of Colorado. He has worked with Colorado Natural Heritage Program since 1999. Much of Mr. Anderson's prior experience comes from five years of fieldwork studying the flora and ecosystem processes of the Alaskan and Canadian Arctic. Mr. Anderson also served in the Peace Corps as a science teacher in the Solomon Islands from 1996 to 1998. He received his B.A. in Environmental, Population, and Organismic Biology from the University of Colorado, Boulder (1991) and his M.S. in Botany from the University of Washington, Seattle (1996).

COVER PHOTO CREDIT

A close up photo of *Epipactis gigantea* (stream orchid). Photograph by Karin Freeman. Used with permission.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *EPIPACTIS GIGANTEA*

Status

Epipactis gigantea (stream orchid) is a sensitive species in the Rocky Mountain Region (Region 2) of the USDA Forest Service; it is not designated sensitive by the Bureau of Land Management (BLM) in Colorado or Wyoming. NatureServe ranks this species as globally vulnerable to apparently globally secure (G3G4). The state heritage ranks in Region 2 range from critically imperiled (S1) in Wyoming and South Dakota to imperiled (S2) in Colorado.

The global distribution of *Epipactis gigantea* extends from southern British Columbia through the western United States, reaching inland as far as Texas, with one collection from central Mexico. Throughout its wide range, it occurs infrequently but can be locally abundant. *Epipactis gigantea* occupies a variety of habitats; because it requires a constant supply of water, suitable habitats include seeps, springs, and perennial streams.

Forty-one occurrences of *Epipactis gigantea* are known from Region 2; the majority of these occurrences (32) and much of the species' habitat are on public lands. Fifteen occurrences are on land managed by the BLM, and 13 occurrences are on National Park Service land. Only two occurrences are on NFS lands: one on the Black Hills National Forest and one on the San Juan National Forest. Six occurrences are under unknown management, three are on private land, one occurrence is on land managed by the U.S. Fish and Wildlife Service, and one occurs on the Ute Mountain Ute Reservation.

Estimates of abundance of these occurrences vary from a few to thousands of plants. These estimates represent the number of aboveground stems (ramets) as opposed to number of individual plants. NatureServe estimates that the actual number of genets (genetic individuals) is low, but there are many thousands of ramets of *Epipactis gigantea* across its range.

Primary Threats

Observations of known occurrences suggest several potential threats to *Epipactis gigantea*. In order of greatest to least concern, these threats include recreation, exotic species invasion, water development, domestic livestock grazing, urban development, timber harvest, and utility line construction/maintenance. Not all threats are equally valid for every occurrence, and some threats may interact and influence each other. For example, recreation can affect hydrology, introduce non-native species, or result in habitat loss (e.g., hot spring development). In many localities, it is difficult to consider these threats in isolation from one another, both temporally and spatially. Specific impacts to *E. gigantea* and its habitat should not be considered in isolation from the cumulative impacts to an area.

Primary Conservation Elements, Management Implications and Considerations

Maintaining an intact hydrological regime is the most significant conservation element for *Epipactis gigantea*. Other conservation elements include exotic species invasion, habitat loss, disturbance intensity, and altered nutrient cycles.

Site-scale conservation efforts to protect known occurrences are likely to be effective. However, landscape-scale threats, such as groundwater withdrawal and stream flow alteration, can complicate these efforts since they may occur off-site. Further inventory work is a priority for *Epipactis gigantea* and is likely to identify other occurrences, especially on public lands managed by the BLM in Colorado. Research is needed to investigate the population biology and autecology of *E. gigantea* so that conservation efforts on its behalf can be most effective.

TABLE OF CONTENTS

EDITORS: Beth Burkhart and Janet Coles, USDA Forest Service, Rocky Mountain Region

List of Tables and Figures

Tables:

Figures:

INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2), USDA Forest Service (USFS). *Epipactis gigantea* (stream orchid) is the focus of an assessment because it is designated a sensitive species in Region 2 (USDA Forest Service 2003). Within the National Forest System (NFS), a sensitive species is a plant or animal whose occurrence viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance or significant current or predicted downward trends in habitat capability that would reduce its distribution (FSM 2670.5(19)). A sensitive species requires special management, so knowledge of its biology and ecology is critical.

This assessment addresses the biology and ecology of *Epipactis gigantea* 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 defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal of Assessment

Species 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, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, this assessment cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope of Assessment

This assessment examines the biology, ecology, conservation status, and management of *Epipactis gigantea* with specific reference to the geographic and ecological characteristics of Region 2. Although some of the literature on the species may originate from field investigations outside the region, this document places that literature in the ecological and social context of the central Rocky Mountains. Similarly, this assessment is concerned with reproductive behavior, occurrence dynamics, and other characteristics of *E. gigantea* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting the synthesis, but placed in a current context.

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies were reviewed. All known publications, reports, and element occurrence records on *Epipactis gigantea* are referenced in this assessment, and most of the regional experts on this species were consulted during its synthesis. *Epipactis gigantea* specimens were searched for at COLO (University of Colorado Herbarium), CS (Colorado State University Herbarium), RM (Rocky Mountain Herbarium), and SJNM (San Juan College Herbarium). The assessment emphasizes refereed literature because this is the accepted standard in science. Some non-refereed literature was used in this assessment when information was unavailable elsewhere; these publications and reports were regarded with greater skepticism than the refereed literature. The vast majority of the useful information known on *E. gigantea* is found in unpublished data (e.g., state natural heritage program records). These data were especially important in estimating the geographic distribution of *E. gigantea*. However, these data required special attention because of the diversity of persons and methods used in their collection.

Treatment of Uncertainty in Assessment

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in physics. The geologist T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). Ecological science is, in some ways, more similar to geology than physics because of the difficulty in conducting critical experiments, and the reliance on observation, inference, good thinking, and models to guide understanding of the world (Hillborn and Mangel 1997).

Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations and inference are accepted as sound approaches to understanding.

Overall, our knowledge of *Epipactis gigantea* is sparse and incomplete. There have been few quantitative or qualitative studies yielding valuable insights into facets of the autecology of *E. gigantea*. The existing information is mostly from herbarium labels, field surveys, and anecdotal observations. The paucity of information on *E. gigantea* has forced the authors of this assessment to rely heavily on natural heritage program data and personal communications with botanists that have had experience with the species.

Treatment of This Document as a Web Publication

To facilitate use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, Web publication will facilitate the revision of the assessments, which will be accomplished based on guidelines established by Region 2.

Peer Review of This Document

Assessments developed for the Species Conservation Project were peer reviewed prior to their release on the Web. This assessment was reviewed through a process administered by the Center for Plant Conservation, 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 the assessment.

Management Status and Natural History

Management Status

Thirty-two of the 41 occurrences of *Epipactis gigantea* within Region 2 are known to occur on public lands, and 28 of those are on lands managed by the BLM and the National Park Service (NPS). Two Region 2 occurrences are on NFS lands, on the Black Hills and San Juan national forests. The USFWS and the Ute Mountain Ute Tribe each manage one occurrence.

The USFS lists *Epipactis gigantea* as a sensitive species in Region 2. It is not designated sensitive by the BLM in Colorado (Bureau of Land Management 2004a) or Wyoming (Bureau of Land Management 2004b) although it was a Colorado BLM sensitive species in the past (Spackman et al. 1997). *Epipactis gigantea* is not listed as threatened or endangered under the Endangered Species Act of 1973 (U.S.C. 1531-1536, 1538-1540).

NatureServe (2005) ranks this species as globally vulnerable to apparently globally secure (G3G4). The provincial and state heritage program imperilment ranks given to *Epipactis gigantea* are summarized in **Table 1**. The state heritage programs in Wyoming and South Dakota rank this species as critically imperiled (S1), and the Colorado Natural Heritage Program ranks this species as imperiled (S2). It is considered unrankable (SU) in Nebraska, and since the species is not known to occur in Kansas, there is no rank given the species in that state. Outside of Region 2, state ranks range from critically imperiled to imperiled (S1S2) in Oklahoma, imperiled (S2) in Montana and New Mexico, imperiled to vulnerable (S2S3) in Utah and British Columbia, and vulnerable (S3) in Texas, Idaho, and Washington. Other western states (i.e., Arizona, California, Nevada, and Oregon, have reported the species but do not track it. While NatureServe and state heritage program ranks do not carry any legal or regulatory authority, they do highlight the conservation needs of *E. gigantea* and may influence management.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Adequacy of current laws and regulations

Regulatory mechanisms offering potential protection for *Epipactis gigantea* include: (1) Section

Table 1. Known distribution of *Epipactis gigantea* in the western hemisphere (from NatureServe 2005 and USDA Natural Resources Conservation Service 2003). Region 2 states are in bold. See **Definitions** section for an explanation of S ranks.

Nation	State/Province/District	S Rank
Canada	British Columbia	S2S3
USA	Arizona	SR
USA	California	SR
USA	**Colorado**	**S2**
USA	Idaho	S3
USA	**Kansas**	**No Rank**
USA	Montana	S2
USA	Nevada	SR
USA	**Nebraska**	**SU**
USA	New Mexico	S2?
USA	Oklahoma	S1S2
USA	Oregon	SR
USA	**South Dakota**	**S1**
USA	Texas	S3
USA	Utah	S2S3
USA	Washington	S3
USA	**Wyoming**	**S1**
Mexico		?

404 of the Clean Water Act, which regulates the filling of wetlands, (2) the National Environmental Policy Act (NEPA; U.S. Congress 1982), which requires an assessment of environmental impacts associated with federal projects, and (3) biological evaluations, which are required by USFS to assess project impacts on sensitive species (USDA Forest Service 1995). In addition to these mandates, collecting native plants without a permit is not allowed within national parks (National Park Service 2004), nor may sensitive species be collected on NFS lands without a permit (USDA Forest Service 1995).

Although these regulatory mechanisms are in place, it is uncertain how effective they are at protecting *Epipactis gigantea*. For example, the National Research Council (2001) wrote that under the "no net loss policy" of wetlands initiated in 1989 by the Bush Administration, the permitting process of Section 404 of the Clean Water Act still allows a net loss of wetland functions. The NRC also noted a disparity in the hydrological equivalence of destroyed versus created wetland types (i.e., wetland types are not being mitigated in-kind). Wetland alteration and mitigation activities regulated under Section 404 are not known to have affected any occurrences of *E. gigantea*; however, a net loss of wetlands does decrease potential *E. gigantea* habitat in Region 2, especially in Colorado where the species is known from several different types of wetlands.

Likewise, it is unclear how effectively NEPA regulations protect *Epipactis gigantea* occurrences. Of the 41 documented occurrences in Region 2, most (32) occur on federal lands (**Table 2**). However, *E. gigantea* only has special status on NFS lands, which contain only two occurrences in Region 2 (Hornbeck et al. 2003, Colorado Natural Heritage Program 2005). No other federal agency lists *E. gigantea* as a sensitive species; therefore, BLM, USFWS, and NPS will not include *E. gigantea* in their NEPA analyses.

No biological evaluations are known to have been written for *Epipactis gigantea*. However, a mechanism is in place should projects be proposed that might impact occurrences of this species on NFS lands. A Threatened, Endangered, and Sensitive (TES) Plant Management Strategy (1999) was developed for portions of Region 2 (Grand Mesa-Uncompahgre-Gunnison, San Juan, Rio Grande, and Pike-San Isabel national forests). This document provides guidance for conducting biological evaluations of TES plant species and outlines long-term strategies to achieve "healthy, diverse ecosystems on selected National Forests and Grasslands."

Table 2. Land ownership status of the 41 known occurrences of *Epipactis gigantea* in Region 2.

Land Ownership Status	Number of Occurrences	Subtotals
Bureau of Land Management	**15**	
National Park Service	**13**	
Colorado National Monument		2
Dinosaur National Monument		8
Grand Teton National Park		1
Mesa Verde National Park		1
Yellowstone National Park		1
Unknown	**6**	
USDA Forest Service	**2**	
San Juan National Forest		1
Black Hills National Forest		1
Private	**3**	
U.S. Fish and Wildlife Service	**1**	
Hotchkiss National Fish Hatchery		1
Ute Mountain Ute Tribe	**1**	
Ute Mountain Tribal Park		1

Nine occurrences of *Epipactis gigantea* are protected to some degree by their location within special management areas. Two large occurrences are located within the Escalante and Unaweep Seep Areas of Critical Environmental Concern in Colorado (Colorado Natural Heritage Program 2005), and seven occurrences are within Mesa Verde, Yellowstone and Grand Teton national parks, and Dinosaur and Colorado national monuments (Colorado Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005). However, some of the occurrences in Dinosaur National Monument may be subjected to domestic livestock grazing (Janet Coles personal communication 2005).

There are no state laws within Region 2 that specifically protect *Epipactis gigantea*. Arizona has a salvage restriction for *E. gigantea* meaning the plant is "subject to a high potential for damage by theft or vandalism" (Arizona Department of Agriculture 1999). The species is "afforded the exclusive protections involving the use of salvage permits, tags and seals" (Arizona Department of Agriculture 1999).

The National Wetland Inventory of the USFWS devised a system to categorize the probability that a plant occurs in a wetland. The categories are Obligate (>99 percent of time species occurs in wetlands), Facultative Wet (67 to 99 percent of time species occurs in wetlands), Facultative (34 to 66 percent of time species occurs in wetlands), Facultative Upland (1 to 33 percent of time species occurs in wetlands), and Upland (<1 percent of time species occurs in wetlands). Plus (+) or minus (–) signs are used to indicate species near the wetter (+) or drier (–) end of the category. Wetland indicator status reflects the best judgment of a panel of experts (U.S. Fish and Wildlife Service 1988). USFS Region 2 includes parts of three USFWS Regions. *Epipactis gigantea* is categorized (**Table 3**) as an Obligate Wetland species in USFWS Region 4 (North Plains) and Region 8 (Intermountain), and is considered Facultative Wet+ in Region 9 (Northwest).

Because *Epipactis gigantea* is a wetland indicator species in USFS Region 2, if it is found in an area that meets the U.S. Army Corps of Engineers definition of a jurisdictional wetland (U.S. Army Corps of Engineers 1987), then its habitat could be regulated via Section 404 of the 1977 Clean Water Act (33 CFR328.3 (b)). These regulations do not automatically protect occupied habitat; rather they require a permit application to be filed with the Corps and environmental concerns to be considered during the permitting process. As mentioned above, Section 404 of the Clean Water Act is still resulting in a "net loss" of wetlands. In addition, Section 404 regulates only those activities that place fill in a wetland, not those that drain them.

Adequacy of current enforcement of laws and regulations

There are no known cases in Region 2 in which an occurrence of *Epipactis gigantea* was extirpated due to the failure to enforce regulations. However, this

Table 3. Wetland Indicator Status for *Epipactis gigantea* after U.S. Fish and Wildlife Service 1988.

USFWS Region	Geographic Areas in Region	Wetland Indicator Status[1]
4 (North Plains)	MT (Eastern), ND, SD, WY (Eastern)	OBL
6 (South Plains)	OK, TX	OBL
7 (Southwest)	AZ, NM	OBL
8 (Intermountain)	CO (Western), NV, UT	OBL
9 (Northwest)	ID, OR, MT (Western), WA, WY (Western)	FACW+
0 (California)	CA	OBL

[1]Wetland Indicator Status Explanations:

OBL	Obligate	Occurs almost always (estimated probability 99 percent) under natural conditions in wetlands.
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67 percent to 99 percent), but occasionally found in non-wetlands.

Often + or – are used to represent species near the wetter (+) or drier (-) end of the spectrum.

does not necessarily indicate that current regulations or their enforcement are adequate for its protection. The National Resource Council (2001) study on compensatory mitigation found that mitigation projects required under Section 404 of the Clean Water Act (e.g., wetland creation, enhancement, and restoration activities) are often not completed or fail to meet permit conditions. Enforcement of permit violations is the responsibility of the U.S. Army Corps of Engineers; however, enforcement is not a high priority for the Corps due to restricted budget and staff (National Research Council 2001). A lack of enforcement could affect *E. gigantea* by allowing destruction of habitat without scrutiny or compensatory mitigation.

Biology and Ecology

Classification and description

Taxonomic description

Epipactis gigantea is a perennial monocot and a member of the orchid family (Orchidaceae; **Table 4**). There are approximately 25 *Epipactis* species worldwide (Coleman 2002), 20 of which occur in the temperate regions of North America and Europe (Luer 1975). The PLANTS Database documents four species of *Epipactis* in North America (USDA Natural Resources Conservation Service 2003), and the Flora of North America reports three (Brown and Argus 2002). Of these, *E. gigantea* is the only species native to North America. The other three (*E. atrorubens*, *E. helleborine*, and *E. palustris*) are introduced (Brown and Argus 2002, NatureServe Explorer 2003, USDA Natural Resources Conservation Service 2003). *Epipactis atrorubens* (red helleborine) and *E. palustris* (marsh helleborine) have thus far only been reported from the northeastern United States while *E. helleborine* (broad-leaved helleborine) has become naturalized in many portions of the eastern and western United States (NatureServe 2005).

There is no known confusion in *Epipactis gigantea*'s current taxonomy (Kartesz 1999) although common names may vary. The plant's labellum has contributed to many of its common names throughout the region. The apical portion of the labellum, the epichile, vibrates easily when moved, resulting in the common name "chatterbox" (Coleman 2002). The basal portion of the labellum, or the hypochile, has a pouch-like appearance, which is why *E. gigantea* is sometimes referred to as "false ladies slipper" (Coleman 2002). This species' large size has given the name "giant helleborine." The most commonly accepted name, "stream orchid," reflects its preferred habitat (Coleman 1986).

Physical description

Members of the orchid family share a unique combination of floral characters. Like most monocots, orchid flowers have sepals and petals in multiples of three (i.e., three or six). However, in orchids the sepals and petals can be colorful and are dissimilar to each other whereas in most monocots they are alike.

Reproductive parts (i.e., pistils and stamens) in the Orchidaceae are united into a single structure called the column (Coleman 2002). The anther is usually reduced to one cap-like structure at the apex of the column. It contains pollen grains fixed together by a sticky substance (viscin) into a coherent mass called a pollinium. When pollinators encounter a pollinium, the pollen sticks to them when they leave. The stigma is also specialized and variable in the family and tends

Table 4. Classification of *Epipactis gigantea* after USDA Natural Resources Conservation Service 2004.

Kingdom	Plantae (Plants)
Subkingdom	Tracheobionta (Vascular Plants)
Division	Magnoliophyta (Flowering Plants)
Class	Liliopsida (Monocotyledons)
Order	Orchidales
Family	Orchidaceae (Orchid Family)
Genus	*Epipactis* Zinn (helleborine)
Species	*Epipactis gigantea* Dougl. Ex Hook – stream orchid

to secrete a sticky substance that adheres to the pollinia for fertilization. Orchids are distinct among flowering plants in having a petal opposite the column called the labellum. The labellum is a modified petal, positioned on the lower side of the flower – a result of the flower turning downward during development. The labellum is highly variable among the orchids and offers pollinators a landing platform.

Epipactis gigantea is a showy perennial with a large flower that is not easily confused with other species in Region 2 (Coleman 2002). Blooming plants can exceed 3 ft. in height, with between two and 32 flowers per stem (Brown and Argus 2002). Flowers are showy, in lax racemes spread out along the stem. Sepals are green or greenish, with petals ranging from greenish to pink to rose, often with purple-brown or red markings or veins (Cronquist et al. 1977, Spackman et al. 1997, Brown and Argus 2002). There is one account of a white *E. gigantea* from the Santa Monica Mountains in California (Coleman 1986), and a dark red variation also in California (NatureServe Explorer 2003). *Epipactis gigantea* has one to several leafy stems. The leaves are sheathing, smooth to rough; lower leaves are sessile, ovate, and upper leaves are linear to linear-lanceolate.

Cronquist et al. (1977) provide a technical description of *Epipactis gigantea*: "stems 1 to several, from creeping rhizomes, 3 to 7 (10) dm high, glabrous or nearly so and becoming pubescent in the inflorescence; lower leaves ovate, sessile, the upper becoming narrower, lanceolate to linear-lanceolate; flowers 3 to 9 (12), rather showy, the raceme usually secund, the long bracts becoming reduced above, the terminal one often exceeding the ovary; sepals with a greenish sheen, with brownish veins, 12 to 15 mm long; petals similar to the sepals but somewhat thinner, more brownish-purple; labellum 15 to 18 mm long, the sac with raised purplish lines leading to the base, three-lobed, with prominent outer lobes, the blade or central lobe about the same length as the basal lobes, slightly curved downward, the flattened labellum with uprolled margins, greenish-yellow, the basal portion much thickened, yellow, with several crests leading into the sac; column 6 to 8 mm long, broadened above; capsule 2 to 2.5 cm long, reflexed, ovoid to ellipsoid, dark brown on the ridges and otherwise yellowish."

There is a line drawing of *Epipactis gigantea*'s flower in *The Orchids: Natural History and Classification* (Dressler 1981). A line drawing of the entire plant appears in *Intermountain Flora, Volume 6* (Cronquist et al. 1977). Photographs of *E. gigantea* in a streamside occurrence in Colorado appear in **Figure 1** and **Figure 2**. **Figure 3** is a line drawing from the Colorado Rare Plant Field Guide (Spackman et al. 1997). Additional photographs and drawings appear in the Colorado Rare Plant Field Guide (Spackman et al. 1997), Wyoming Rare Plant Field Guide (Fertig et al. 1994), Rare Plant Guide to the Pocatello and Idaho Falls Field Offices of the BLM (Idaho Department of Fish and Game 2004), Montana Rare Plant Field Guide (Montana Natural Heritage Program 2004), Field Guide to Selected Rare Plants in Washington (Washington Natural Heritage Program 2000), and on the PLANTS website (Natural Resources Conservation Service 2004).

Comparison to other species

Epipactis is distinguished from other genera in the Orchidaceae by having a sessile, three-lobed labellum at the base of the column, divided into two parts by a central constriction (Brown and Argus 2002). The labellum of *E. gigantea* is three-lobed, distinguishing it from other species within the genus. *Epipactis gigantea*'s large size and leafy stems help to distinguish vegetative plants from similar genera such as *Habenaria* and *Platanthera* (Hornbeck et al. 2003). Mancuso (1991) notes that non-flowering stems of *E. gigantea* can be confused with *Maianthemum stellatum*.

Figure 1. *Epipactis gigantea* individual. Photograph by Karin Freeman, used with permission.

Figure 2. Stand of *Epipactis gigantea*. Photograph by Sarah Brinton, used with permission.

Distribution and abundance

The global distribution of *Epipactis gigantea* (**Figure 4**) extends from southern British Columbia through the western United States as far inland as Texas. There is one documented collection from central Mexico (Coleman 2002, NatureServe Explorer 2003, USDA Natural Resources Conservation Service 2003). *Epipactis gigantea* is most abundant in California, where it is the most widely distributed orchid in the state (NatureServe Explorer 2003). Although this species occupies a variety of habitats, occurrences are limited to locations with a constant supply of water (Colorado Natural Heritage Program 2005). Despite an abundance of apparently suitable habitat within a broad geographic range, *E. gigantea* is only found

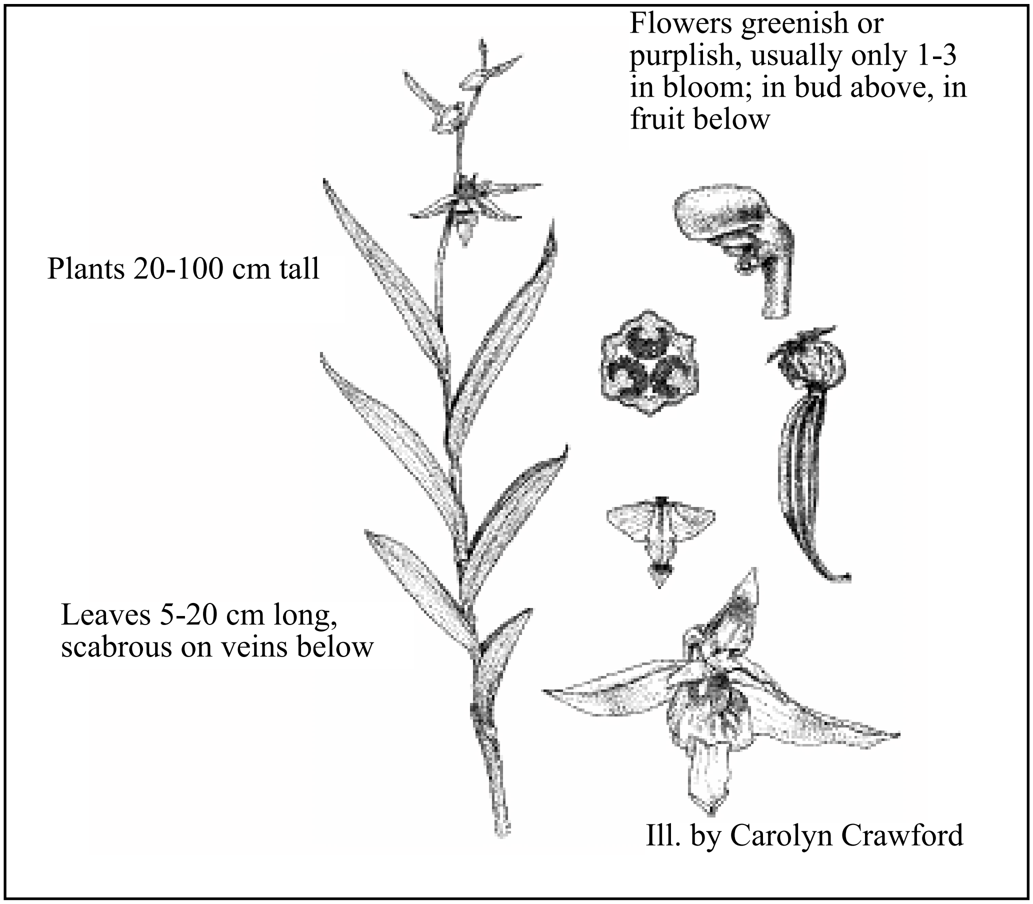

Figure 3. Illustration of *Epipactis gigantea* (by Carolyn Crawford from the Colorado Rare Plant Field Guide).

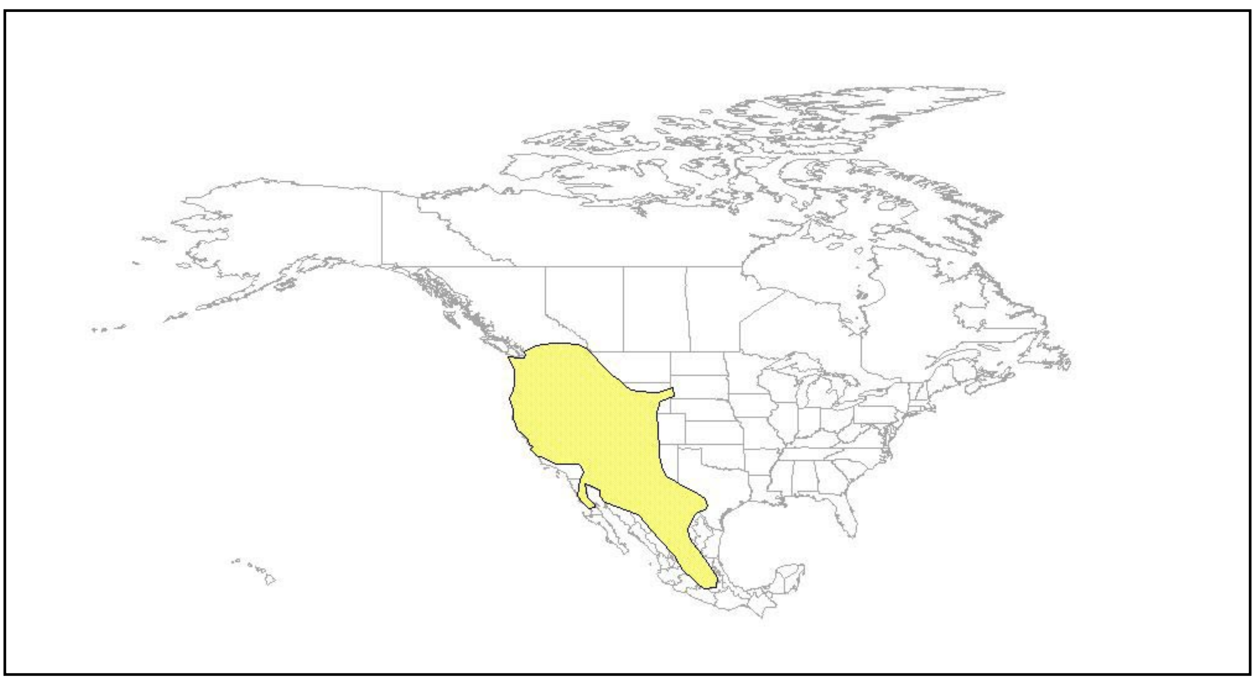

Figure 4. North American distribution of *Epipactis gigantea* Dougl. ex Hook (from Luer 1975).

infrequently in isolated occurrences, where it may be locally abundant (NatureServe Explorer 2003).

There are 41 occurrences in Region 2, only two of which are located on NFS lands. Thirty-six occurrences are in Colorado, four are in Wyoming, and one is in South Dakota (**Table 5**, **Figure 5**; Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005). No occurrences have been documented in Nebraska or Kansas. Occurrences in Region 2 are documented from natural heritage data (Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005), and herbarium labels from collections at the University of Wyoming, University of Colorado, Colorado State University, and San Juan College. Many more occurrences of *Epipactis gigantea* may be present in seeps and springs (also known as "hanging gardens") throughout the Colorado Plateau, including areas within Region 2 such as western Colorado (Janet Coles personal communication 2005).

Given the clonal nature of *Epipactis gigantea*, it is difficult to estimate the actual number of genetic individuals at a particular site. Occurrence estimates are typically given as the number of aboveground stems (ramets), not the number of individual plants. NatureServe (2003) estimates that the actual number of genets (genetic individuals) is small, but there are many thousands of ramets of *E. gigantea* across its range. The total number of plants estimated from the 41 occurrences in Region 2 is between 8,000 and 17,000 (Hornbeck et al. 2003, Colorado Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005).

In South Dakota, *Epipactis gigantea* occurs along Cascade Creek on the Black Hills National Forest and The Nature Conservancy's Whitney Preserve (Record 31 in **Table 5**, **Figure 5**). This occurrence contains 500 to 1,000 ramets (South Dakota Natural Heritage Program 2005) in several sub-occurrences scattered along the creek (Hornbeck et al. 2003). It is disjunct from the main part of *E. gigantea*'s range and is supported by warm springs, suggesting that relatively warm water temperatures and consistency of water flow are required for the species' persistence in the Black Hills.

In Wyoming, there are four documented occurrences of *Epipactis gigantea* (Records 32, 33, 34, and 35 in **Table 5**, **Figure 5**). The occurrence along Shell Creek near the town of Shell has not been seen since its discovery in 1896 (Wyoming Natural Diversity Database 2005). One occurrence is near a warm calcareous pond on private land; in 1991 it was estimated to contain between 1,000 and 3,000 ramets. *Epipactis gigantea* also occurs as several small sub-occurrences within the Silver Scarf Thermal Area of Yellowstone National Park, and in Grand Teton National Park, it occurs near a calcareous warm spring, where between 50 and 100 ramets were documented (Wyoming Natural Diversity Database 2005).

In Colorado, *Epipactis gigantea* is known from 30 locations in eight western counties (Records 1 through 30 in **Table 5**, **Figure 5**). The two highest elevation occurrences in Colorado are located on private land at Valley View Hot Springs in Saguache County and Poncha Hot Springs in Chaffee County. There are occurrences in the Dolores River and Coyote Wash drainages in Montrose and Delta counties and in the Escalante River drainage in Montrose, Delta, and Mesa counties; many of these are on BLM or NPS lands. Delta County has an occurrence on USFWS land at the Hotchkiss National Fish Hatchery. In Mesa County, there is a large occurrence at Unaweep Seep and a smaller one in Mee Canyon, both of which are on BLM land. An occurrence in Archuleta County is on the San Juan National Forest in the Piedra River drainage. Moffat County supports eight documented occurrences in the Yampa River drainage in Dinosaur National Monument. However, many more occurrences may be located in the canyons of the Monument (Janet Coles personal communication 2005) in both Colorado and Utah. There are three occurrences in Montezuma County; one is on the Dolores River on Colorado Division of Wildlife property, one is at Mesa Verde National Park, and one is in a tributary of Mancos Canyon on the Ute Mountain Ute Tribal Park. Four occurrences of *E. gigantea* in Colorado that have not been visited in more than 60 years (Colorado Natural Heritage Program 2005). Of those, two are on private lands, one is on BLM land, and one is under unknown ownership due to poor location information.

Population trend

There are no rigorous data from which to determine population trends for *Epipactis gigantea*. Of the 41 known occurrences, only 12 (Records 1 [San Juan National Forest], 2, 5, 6, 12, 13, 17, 18, 30, 31 [Black Hills National Forest], 32, and 33 in **Table 5**) are known to have been visited more than once, and only three are known to have been visited more than twice (Records 6, 12, and 31 [Black Hills National Forest]). Other than the Cascade Creek occurrence on the Black Hills National Forest in South Dakota (Record 31), which is thought to have increased in abundance (Hornbeck et al. 2003),

Table 5. Summary of occurrences of *Epipactis gigantea* in Region 2 (from Natural Heritage element occurrence records).

Arbitrary Record #	State	County	Location	Land Ownership	Elevation (ft.)	Date First / Last Observed	Estimated Size	Collector/ Observer	Herbarium	Habitat	Threats	Notes
1	CO	Archuleta	Piedra River	USDA Forest Service (USFS) San Juan National Forest	6,720 to 6,880	1990 / 2001	2001: 500+ individuals	2001: Lyon, P. 1997: Koper, T.	Not Available (NA)	Hillside seep in ponderosa pine/Douglas-fir forest.	Utility line maintenance, grazing nearby, recreation	Multiple observations. Varying flowering success
2	CO	Chaffee	Poncha Hot Springs	Private	7,940	1894 / 2001	2001: 500 individuals	2001: Madsen, B.	NA	Warm spring emergent wetland in pinyon - juniper zone.	Urban development, hot spring development	Multiple observations
3	CO	Delta	Hotchkiss National Fish Hatchery	U.S. Fish and Wildlife Service (USFWS)	5,200 to 5,380	1997	>1000 plants	Lyon, P..	NA	Steep hillside with springs and seeps, apparently perennially wet.	Some non-native species nearby	Water development may threaten seep
4	CO	Delta	Little Dominguez Creek	Bureau of Land Management (BLM)	5,000	1997	Approximately 100 individuals	Lyon, P.	NA	On streambank of small year-round stream with bulrush, scouring rush, sandbar willow.	Natural flood scouring	Not Available (NA)
5	CO	Delta	Escalante Canyon	BLM Escalante Area of Critical Environmental Concern (ACEC)/ Colorado Division of Wildlife(DOW) - Escalante State Wildlife Area (SWA)	5,500	1971 / 1981	Not stated	1981: Siplivinsky, V.	NA	Seep in sandstone alcove.	Unknown	NA
6	CO	Delta/ Montrose	Escalante Canyon	BLM Escalante (ACEC)/ Colorado DOW - Escalante (SWA)	5,840 to 6,200	1980 / 1997	Four sub occurrences, described as “medium” and “large” one listed as “hundreds of plants” (summary from 1980 & 1997 data)	1997: Lyon, P.	NA	Sandstone seeps below hanging gardens with surrounding riparian area rich in species diversity and vegetation structure.	A few non-native species, signs of past water development, recreation nearby	Several sub occurrences of one occurrence, crossing into Delta County (EO#14)

Table 5 (cont.)

Arbitrary Record #	State	County	Location	Land Ownership	Elevation (ft.)	Date First / Last Observed	Estimated Size	Collector/ Observer	Herbarium	Habitat	Threats	Notes
7	CO	Mesa	Colorado National Monument	National Park Service (NPS) – Colorado National Monument	5,160 to 5,200	1996	100 to 300 plants	Lyon, P.	NA	Small stream in granite canyon.	Non-native species, potential for increased recreation	Flowering
8	CO	Mesa	Colorado National Monument	NPS – Colorado National Monument	4,920 to 5,100	1996	200+	Lyon, P.	NA	Creek bank with horsetail.	Somewhat disturbed – no indication as to why	NA
9	CO	Mesa	Mee Canyon	BLM	5,420 to 5,500	1996	400+	Lyon, P.	NA	Small stream in steep narrow canyon, associated With scouring rush.	None	Beginning to flower
10	CO	Mesa	Escalante Creek	BLM	6,200 to 7,000	1996	50 to 60 individuals	Richard, C.	NA	Cliff seeps in Wingate sandstone with Douglas fir - cottonwood riparian area.	Upstream stock ponds, downstream grazing, non-native species	Few flowering
11	CO	Mesa	Unaweep Canyon	BLM – Unaweep Seep ACEC	5,650 to 5,750	1996	100+ plants	Lyon, P.	NA	Hillside seep with riparian shrubs and spikerush.	Some non-native species nearby	NA
12	CO	Mesa	Unaweep Seep	BLM – Unaweep Seep ACEC	5,800	1980 / 2000	In 2000, “thousands” of individuals were reported	2001: Rocchio, J.	NA	Diverse seep wetland complex, plants associated with spikerush and river birch.	Some non-native species nearby	Abundant fruiting success
13	CO	Mesa	Grand Junction	Private	5,300 to 5,500	1893 / 1915	Insufficient information	1915: Macbride, J.F. and Payson	Rocky Mountain Herbarium	Moist bank in canyon.	Unknown	Occurrence is historical
14	CO	Mesa and Montrose	Dolores River	Unknown	4,800	1935	Insufficient information	Maguire, B. and G. Piranian	Utah State University Intermountain Herbarium	Shade of dripping sandstone cliffs in rich soil.	Unknown	Occurrence is historical
15	CO	Montezuma	Wing Spring - Mancos Canyon	Ute Mountain Ute Tribe	5,800	1991	Insufficient information	Jamieson, D.W. and W.A. Weber	Fort Lewis and University of Colorado Herbaria	In hanging garden at spring.	Unknown	Flowering

Table 5 (cont.)

Arbitrary Record #	State	County	Location	Land Ownership	Elevation (ft.)	Date First / Last Observed	Estimated Size	Collector/ Observer	Herbarium	Habitat	Threats	Notes
16	CO	Montezuma	Lower Dolores River	Colorado DOW - Lone Dome State Recreation and Wildlife Area	6,500	1999	Two sub occurrences, 200 individuals	Stewart, L.	NA	Sandstone seep in riparian area rich in shrub diversity.	Some non-native species nearby	10 percent flowering
17	CO	Montezuma	Mesa Verde	NPS - Mesa Verde National Park	6,800 to 6,900	1959 / 1984	Two occurrences with 50 individuals each (1984)	1984: Colyer, M.	Mesa Verde National Park Herbarium	Cliff seep in pinyon - juniper zone with associated willow and poison ivy.	None	90 percent fruiting
18	CO	Montrose	Coyote Wash	BLM	5,150 to 5,420	1992 / 1999	75+ individuals (1999)	1999: Lyon, P.	NA	Wet area in sandstone alcove.	Recreation nearby	Two sub occurrences of one occurrence
19	CO	Montrose	Dolores Canyon Spring	BLM	4,900	1999	50 plants	Lyon, P.	NA	Spring fed wet area in large alcove on south facing sandstone cliffs in desert environment.	None	NA
20	CO	Montrose	Above Dolores Canyon	BLM	5,300	1999	Six individuals	Lyon, P.	NA	Wet grassy hillside below hanging gardens.	None	NA
21	CO	Montrose	Dolores Canyon	BLM	4,800 to 5,240	1991	Insufficient information	Jennings, W.F.	University of Colorado	Cliffside seep and spring.	Near road, non-native species	NA
22	CO	Montrose	Dolores River at Sewemup	BLM	4,920	1991	Insufficient information	Jennings, W.F.	NA	In hanging garden.	None	NA
23	CO	Montrose	West drainage of Escalante Creek	BLM	5,920 to 6,200	1998	500+ plants	Lyon, P.	NA	Below hanging garden in rich riparian area.	Grazing	NA
24	CO	Montrose	Escalante Creek	BLM	6,000	1979	Insufficient information	Long, L.	NA	Marshy slope in dark brown mud.	Unknown	NA
25	CO	Montrose	Dolores Canyon	BLM	5,200	1999	100+ (“several hundred individuals”)	Lyon, P.	NA	Damp area behind grasses at base of cliff.	Some human use of area for inspecting rapids (rafting)	20 percent flowering
26	CO	Montrose	Dolores Canyon	BLM	4,800	1999	25 plants	Lyon, P.	NA	Box canyon with hanging gardens with *Aquilegia micrantha*.	None	In fruit

Table 5 (cont.)

Arbitrary Record #	State	County	Location	Land Ownership	Elevation (ft.)	Date First / Last Observed	Estimated Size	Collector/ Observer	Herbarium	Habitat	Threats	Notes
27	CO	Montrose	Paradox Valley	Private (?)	5,500	1912	Insufficient information	Walker, E.P.	Specimen from unknown herbarium	Wet ditch banks.	Unknown	Occurrence is historical
28	CO	Moffat	Signature Cave	NPS - Dinosaur National Monument	5,400	1988	Insufficient information	Naumann, T. and L. Riedel	NA	On crevices and slope below cave with *Zigadenus vaginatus*.	None	100 percent fruit
29	CO	Moffat	Bull Canyon	NPS - Dinosaur National Monument	5,320	1988	Insufficient information	Naumann, T. and L. Riedel	NA	Stream bank and ledge above stream bottom, on tributary to Yampa River.	Grazing	100 percent fruit
30	CO	Saguache	Valley View Hot Springs	Private	8,480 to 8,800	1989 / 1997	20 plants (1997)	1997: Rondeau, R.	NA	Plants under a dense canopy of oaks and cottonwoods at hot springs.	Developed hot spring	20 plants, 5 in bloom
31	SD	Fall River	Cascade Creek	USFS - Black Hills National Forest	3,400	1983 / 2000	500+ plants (2000)	South Dakota Natural Heritage Program Staff	South Dakota State University and several other herbaria	Steep, mostly shaded stream banks of Cascade Creek. Warm springs and stream in rocky canyon.	Non-native species, recreation, grazing	NA
32	WY	Teton	Jackson Hole	Private	6,650	1979 / 1991	1000 to 3000 above ground stems (1991)	1991: Marriott, H.J.	Rocky Mountain Herbarium	Margins of warm calcareous pond in both open and forested areas.	Recreation – summer camp nearby	NA
33	WY	Teton	Jackson Hole	NPS - Grand Teton National Park	6,700	1991 / 1992	20 stems (1992)	1991: Marriott, H.J.	Rocky Mountain Herbarium	Moist meadow with scattered willows near calcareous warm springs.	Grazing	Count may be inaccurate due to closely cropped stems from grazing

Table 5 (concluded).

Arbitrary Record #	State	County	Location	Land Ownership	Elevation (ft.)	Date First / Last Observed	Estimated Size	Collector/ Observer	Herbarium	Habitat	Threats	Notes
34	WY	Teton	Yellowstone Plateau	NPS - Yellowstone National Park	6,600 to 7,300	1991	50 to 200 flowering stems	Whipple, J.	Yellowstone National Park Herbarium	Edge of warm springs. Associated species include *Castilleja exilis*, *Eleocharis rostellata*, *Scirpus acutus*, *S. americanus*, and *Juncus ensifolius*.	None	3 sub occurrences of one occurrence
35	WY	Big Horn	Big Horn Basin	Shell city limits?	4,200	1896	Insufficient information	Moore, FlL. and E.E. Moor	Rocky Mountain Herbarium	Spring soil.	Urban development?	Occurrence is historical
36	UT	Uintah	Ely Creek	NPS	5,278	2002	2.5 percent cover of 400 m^2 plot	Coles, J.	NA	Narrow canyon drainage.	??	NA
37	UT	Uintah	Ely Creek	NPS	5,400	2002	2.5 percent cover of 400 m^2 plot	Coles, J.	NA	Hanging Garden.	??	NA
38	CO	Moffat	Bull Canyon	NPS	5,820	2002	Trace cover of 400 m^2 plot	Thompson, W.	NA	Hanging Garden.	??	In alcove
39	CO	Moffat	Starvation Valley	NPS	5,482	2002	Trace cover of 400 m^2 plot	Condie, T.	NA	Riparian.	??	Riparian area with high diversity
40	CO	Moffat	Bull Canyon	NPS	5,643	2002	20 percent cover of 400 m^2 plot	Williams, H.	NA	Hanging Garden.	??	NA
41	CO	Moffat	Harding Hole	NPS	5,462	2002	20 percent cover of 400 m^2 plot	Hahn, W.	NA	Hanging Garden.	??	NA

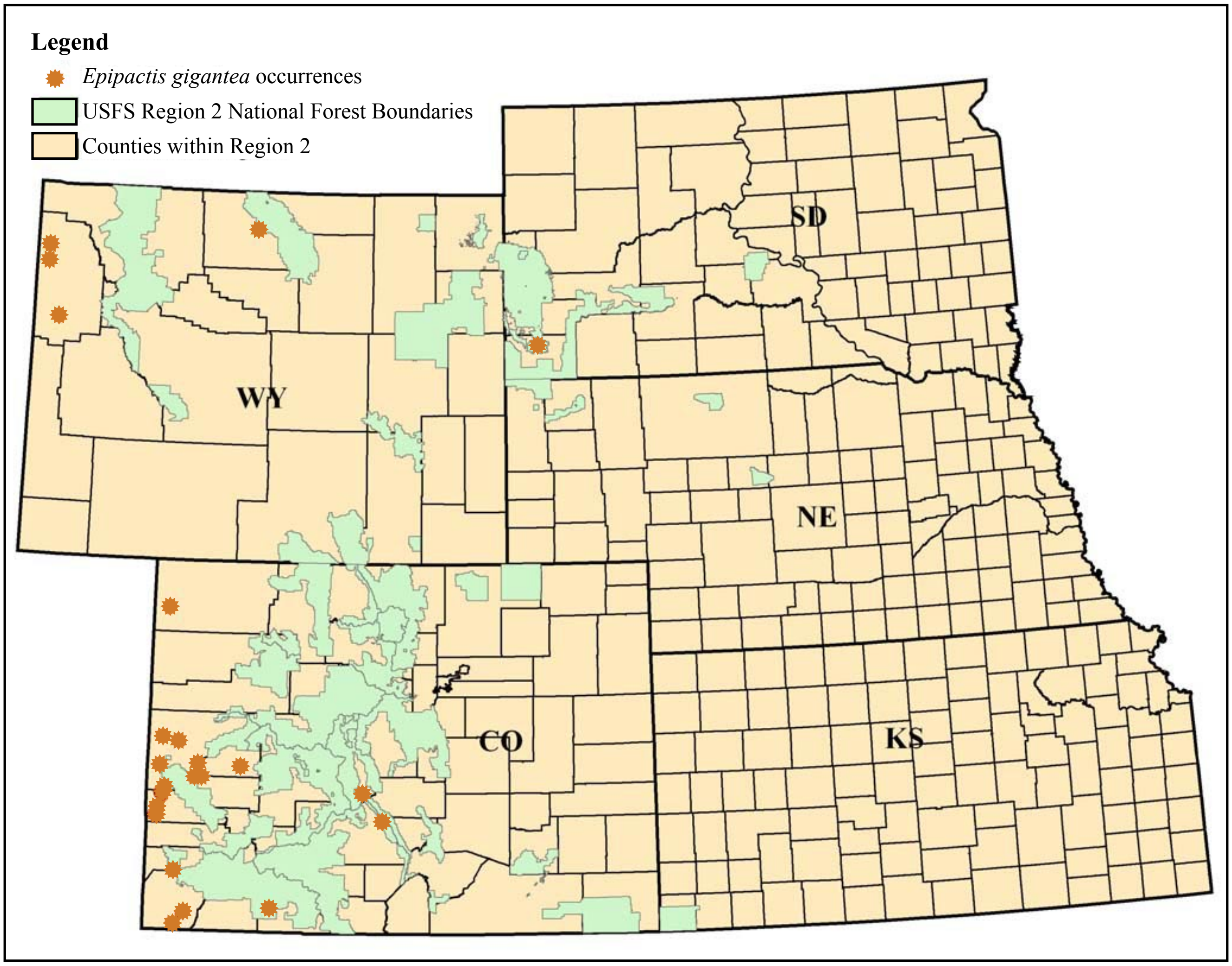

Figure 5. Distribution of *Epipactis gigantea* in Region 2.

none of the other 11 occurrences showed any trend (either positive or negative).

State natural heritage programs in Region 2 have estimated trends based on the number of occurrences in their databases and known threats. The Wyoming Natural Diversity Database flags *Epipactis gigantea* as being "in moderate decline?" (http://uwadmnweb.uwyo.edu/Wyoming Natural Diversity Database/). The Colorado Natural Heritage Program states that the general trend of *E. gigantea* is "one of decline due principally to habitat loss" (Colorado Natural Heritage Program 2005). The loss and modification of riparian areas, seeps, and springs on private and public lands may have led to local declines or extirpation of *E. gigantea*. Globally, NatureServe (2003) states that *E. gigantea* shows a declining trend.

As a long-lived perennial, *Epipactis gigantea* occurrences are likely to be stable as long as there are no alterations to hydrology or habitat. Based on repeated observations, seven occurrences of *E. gigantea* within Region 2 appear to be stable. These occurrences include Unaweep Seep (Record 12 in **Table 5**), Piedra River drainage (Record 1, San Juan National Forest), Valley View Hot Springs (Record 30), Poncha Hot Springs (Record 2), Mesa Verde National Park (Record 17), and Escalante Canyon (Records 5, 6) in Colorado (Colorado Natural Heritage Program 2005). *Epipactis gigantea* has persisted since at least 1929 at the Cascade Creek occurrence in South Dakota (Record 31, Black Hills National Forest), despite new road and trail construction, trampling, bank destabilization, invasion by exotic species, mowing, and non-target weed control (South Dakota Natural Heritage Program 2005). The fact that *E. gigantea* occupies most of the suitable habitat within the wetlands in which it occurs suggests that the species is stable in western Colorado (Jim Ferguson personal communication 2004).

The severe drought of 2001 to 2003 in Region 2 may have reduced some occurrences of *Epipactis gigantea* by reducing groundwater discharge in seeps and springs associated with local, shallow aquifers and by decreasing flow in some streams. However, this conclusion is speculative. No quantitative data exist confirming that *E. gigantea* has been adversely affected by drought. However, drought effects may not be discernable until many years after the drought ends due to the long residence time of some aquifers. According to a Californian nursery, *E. gigantea* will go dormant at the first signs of drought (Las Pilitas Nursery 2004), suggesting that the species may be able to survive short-term fluctuations in water availability. Most reports of *E. gigantea* document it as occurring along perennial seeps/springs and riparian areas, indicating that the species requires constant water flow in order to survive (Hornbeck et al. 2003, Wyoming Natural Diversity Database 2004, Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005). However, if *E. gigantea* were able to go dormant during extended droughts, the species would likely also occur in habitats where water flow was intermittent; this is not the case.

Habitat

Epipactis gigantea is one of the few orchids that grow in the desert, albeit in wet habitats. Its global range includes life zones ranging from desert to montane. In California, *E. gigantea* is widespread throughout desert environments, including Death Valley and mountains below 7,500 ft. (Coleman 1988). In the southern part of British Columbia, *E. gigantea* occurs on calcareous deposits associated with mineral hot springs (Brunton 1986). In Wyoming, all four occurrences are associated with calcareous warm springs (Wyoming Natural Diversity Database 2005), and the South Dakota occurrence is located in calcareous warm spring habitats along Cascade Creek in the Black Hills National Forest (Hornbeck et al. 2003). Most Colorado occurrences occupy seeps, streambanks, and hanging gardens between 4,800 and 6,500 ft. The two highest occurrences in Colorado (7,900 and 8,800 ft. [Records 2 and 30, respectively]) are associated with geothermal springs. The fact that *E. gigantea* appears to prefer geothermally supported wetlands at higher elevations indicates that temperature may be a limiting factor.

Although *Epipactis gigantea* occurs from desert, montane, and boreal climates, it is always restricted to minerotrophic (nutrient-rich) habitats and requires a constant supply of moisture (Cronquist et al. 1977, Brunton 1986, Mantas 1993). Water sources include thermal and non-thermal springs, seeps, and streams (Schassberger 1988, Mancuso 1991, Mantas 1993, Spackman et al. 1997, Hornbeck et al. 2003). Most occurrences of *E. gigantea* in Region 2, including many of those along streams, are associated with groundwater discharge, either directly or indirectly. Many of the riparian occurrences of *E. gigantea* in western Colorado occur along streams where base flows are held constant by groundwater discharge within the drainage. In California, on the other hand, riparian occurrences are commonly associated with surface water (Coleman 1986). Occurrences on NFS lands in Region 2 are associated both with riparian areas (Piedra River on the San Juan National Forest, Colorado, and parts of Cascade Creek on the Black Hills National Forest, South Dakota) and springs (parts of Cascade Creek).

Little is known about the soil requirements for *Epipactis gigantea*. This species appears to have a wide tolerance for soil pH in California (Coleman 1988). Mantas (1993) found a positive correlation between extractable soil potassium (K^+) concentration and ramet height for *E. gigantea* occurrences in Montana fens. In Region 2, many occurrences grow in alkaline or calcareous mineral soils (Wyoming Natural Diversity Database 2004, Colorado Natural Heritage Program 2005).

Disturbance may be necessary for successful establishment of *Epipactis gigantea* (Brunton 1996, Hornbeck et al. 2003). Brunton (1986) indicates that in Canada, *E. gigantea* prefers early successional habitats such as streambanks. Rhizomatous species are often able to tolerate scouring and emerge from buried sediments, suggesting that *E. gigantea* may have a competitive advantage in environments where such disturbances are prevalent (Keddy 2000). Flooding may create sites for propagules or rhizomatous expansion of *E. gigantea* in riparian areas (Levine 2000, Hornbeck et al. 2003). Data from other occurrences suggest that disturbance is not required for species persistence (Mantas 1993, Wyoming Natural Diversity Database 2004, Colorado Natural Heritage Program 2005). Seep and spring occurrences of *E. gigantea* in Region 2 do not generally experience flooding. Some occurrences in Montana are in fens, which are essentially "old growth" wetlands with minimal physical disturbance (Mantas 1993). Occurrences associated with hanging gardens may be subject to disturbance resulting from erosion of sandstone from the back and roof of alcoves (Janet Coles personal communication 2005).

Arditti et al. (1982) note that under laboratory conditions, a shaded environment is needed for germination, but the species does not compete well in shady conditions later in its development. Occurrences in Colorado occupy both shady and sunny locations (Colorado Natural Heritage Program 2005). One of Colorado's largest occurrences is at Unaweep Seep, where *Epipactis gigantea* grows taller under the shade of willow and alder trees than in open areas (Colorado Natural Heritage Program 2005).

Reproduction biology and autecology

Reproduction

The orchid family is known for its specialized relationships with insects. Many orchid genera have developed unique structures to attract pollinators, including morphological changes to imitate a pollinator larval food source. *Epipactis gigantea* may attract generalist pollinators (Dressler 1981), but there is evidence of a specialized relationship with syrphid flies. Luer (1975) states that syrphid flies are specialist pollinators of *E. gigantea*. Ross (1988) observed syrphid flies hovering about *E. gigantea* with pollinia attached to their backs. Syrphid flies were studied in Japan in relation to *E. thunbergii*, where it was hypothesized that the "hinging" labellum aided in forcing the fly into contact with the pollinia (Sugiura 1996). Flies have been observed flying near *E. gigantea* in California with pollinia attached (Coleman 1986), but it was unknown if they were syrphid flies.

Syrphid flies normally lay their eggs in masses of aphids, which serve as the food supply for syrphid larvae (Coleman 2002). Based on observations of syrphid flies laying eggs on the labellum of *Epipactis gigantea*, Ross (1988) hypothesized that the nectar on the labellum mimics the honeydew scent of aphids. The aphid-scented nectar attracts the flies into laying eggs within the orchid flower, resulting in the fly picking up pollinia and depositing them on the next flower they visit (Coleman 2002). This suggests that *E. gigantea*'s pollination strategies do not necessarily attract pollen-eating insects, but rather use deception to create insect contact with the pollinium (van der Pijl and Dodson 1966).

Burns-Balogh et al. (1987) suggested that wasps pollinate the genus *Epipactis*. This is supported by observations in Montana where common yellowjackets were reported as pollinators of *E. gigantea* (Mantas 1993). Vespid wasps have also been suggested as pollinators of *Epipactis* (van der Pijl and Dodson 1966). Self-pollination may occur in *Epipactis*, but it is not known how common this may be (Dressler 1981, Thornhill 1996, Squirrell et al. 2002).

The Flora of North America records the range-wide flowering period of *Epipactis gigantea* as lasting from April to August (Brown and Argus 2002). In milder climates, *E. gigantea* starts flowering as early as April and in cooler regions, such as Region 2, as late as mid-June (Coleman 1986, Brunton 1986, USDA Forest Service 1999). In Arizona and New Mexico, most of the flowering occurs in May and early June, but the amount and duration of flowering depend on annual rainfall (Coleman 2002). When rainfall is below average, some seeps and streambanks dry up, and flowers either do not develop or abort without opening (Coleman 2002).

Flowers along the stem bloom at different times, with the lowermost flowers maturing first. Mantas (1993) found that taller ramets of *Epipactis gigantea* produced more flowers than smaller ones and that denser stands produced smaller ramets with fewer flowers than more open stands. This study also suggests that open stands are more likely to produce seeds than dense stands, which may use vegetative reproduction. Sexual reproduction results in a large number of miniscule seeds in mid to late summer that are dispersed by wind and water (Dressler 1981). Orchid seeds can remain viable for long periods if they are desiccated and remain cool (Dressler 1981); however, there is little information available about *E. gigantea*'s seed bank dynamics, seed longevity, or dormant stages. Arditti et al. (1981) noted that germination rates for *E. gigantea* average 20 percent under laboratory conditions. However, seed viability decreases with age, and a shaded environment is required for germination.

Vegetative reproduction in *Epipactis gigantea* occurs by means of short, fibrous rhizomes (Brown and Argus 2002) that grow laterally across the substrate to form either a dense monoculture or a looser colony within dense stands of other vegetation such as spikerush (*Eleocharis* spp.) or sedge (*Carex* spp.) (Brunton 1986, Levine 2000, Peggy Lyon personal communication 2004). Thornhill (1996) notes that the connections between *E. gigantea* parent and daughter ramets are often severed within one season.

Life history and strategy

In the Competitive/Stress-Tolerant/Ruderal (CSR) model of Grime (2001), characteristics of *Epipactis gigantea* most closely approximate those of competitive plant species. Competitive plants are characterized by rapid growth and often reproduce by rhizomes. Their primary response to overgrowth by other plants or stressful phenomena (e.g., drought) is to preemptively capture resources and maximize vegetative growth. Hornbeck et al. (2003) note that *E. gigantea* has persisted despite periods of disturbance associated with recreation, invasion by exotic plants, mowing, and non-target weed control in the past 75 years along Cascade Creek, suggesting the species is able to compete with other species following disturbance. Competitive plants are strongly seasonal. Their overall strategy is to maximize resource acquisition and biomass production (Grime 2001). Due to the abundance of resources in their habitats, wetland plant species are often competitive.

Epipactis gigantea has characteristics that demonstrate competitive strategies. It is a rhizomatous perennial that can colonize an area via lateral growth. It has very leafy stems and can grow up to 3 ft. tall; some individuals have been observed as tall as 5 ft. (Coleman 1988). Aboveground parts die off completely every season, and rhizomes lie dormant through the winter. Seedlings have been observed in the field (Coleman 1986, Peggy Lyon personal communication 2004), but the most evident reproductive strategy appears to be vegetative. Large stands can colonize bare ground or organic substrate, and one occurrence was observed growing over "recent human artifacts i.e., glass bottles" (Brunton 1986). However, rapid growth and the production of many seeds, which *E. gigantea* exhibits, are also characteristics indicative of ruderal species. The production of numerous small seeds is advantageous, as they lend themselves to long-distance dispersal via wind and water (Walker and del Moral 2003) and allow *E. gigantea* to colonize suitable habitat downwind or downstream of the source population. This suggests that *E. gigantea* may fit Grime's (2001) competitive-ruderal type of secondary strategy. Competitive-ruderal plant species occur in highly productive habitats where competition is prevented by disturbance. *Epipactis gigantea* may depend on its ruderal characteristics (i.e., rapid growth, production of many seeds) when growing in areas with periodic disturbance (e.g., riparian areas) and rely on competitive strategies in habitats or successional stages where disturbance is less frequent.

MacArthur and Wilson (1967) suggest a functional classification of species consisting of *r*- and *K*-selected species. *R*-selected species are adapted to disturbance, have good dispersal capabilities, and produce large numbers of propagules. *K*-selected species tend to be later successional species that exhibit good competitive capabilities, produce a smaller numbers of offspring, and often are habitat specialists. Although *Epipactis gigantea* produces an enormous amount of tiny seeds, which is typical of *r*-selected species, the species appears to be most similar to other *K*-selected species, (MacArthur and Wilson 1967, Begon et al. 1990) due to its reliance on a vegetative growth strategy and its ability to claim available space within a specialized habitat.

Demography

Epipactis gigantea occurs in isolated populations scattered over a broad geographic range. Occurrences of *E. gigantea* in California are very different from each other, suggesting that minimal genetic information is transferred among occurrences (Thornhill 1996), and that occurrences may represent genetically distinct populations. Thornhill (1996) notes that because of this genetic variability and self-compatibility, *E. gigantea* is capable colonizing a variety of geographically isolated habitats. Genetic variability allows a species to adapt to variable habitat conditions while self-compatibility increases the potential for successful sexual reproduction even when few individuals are present. This is consistent with some of *E. gigantea*'s life history characteristics, such as long-range dispersal (via wind and water) and its habitat requirements. Mantas (1993) suggests that genetic variation exists in *E. gigantea* due to its presence in a wide range of habitat conditions within the fens of Swan Valley in Idaho. There are no data available on genetic variability or characteristics of *E. gigantea* in Region 2. Given that most occurrences in Region 2 are isolated from each other, it is likely that genetic variability of these occurrences is considerable (Thornhill 1996). Hornbeck et al. (2003) speculate that the Cascade Creek occurrence in the Black Hills of South Dakota may be its own variety or subspecies due to its isolation.

Demographic studies of *Epipactis gigantea* are lacking, thus limiting our ability to describe its life history characteristics. **Figure 6** shows a hypothetical lifecycle diagram based on the model by Caswell (2001). Since there are no monitoring or multi-year data available for most occurrences, most transition probability values are left unquantified. In the scenario shown in **Figure 6**, a flowering adult is insect-pollinated and produces seeds later that same season. Seeds are dispersed by wind and water (Dressler 1981).

Seeds require mycorrhizae for germination (Arditti et al. 1981, Dressler 1981), and mycorrhizal symbionts are common and available in most soils (Dressler 1981). No data exist to document germination success in the field. However, Arditti et al. (1981)

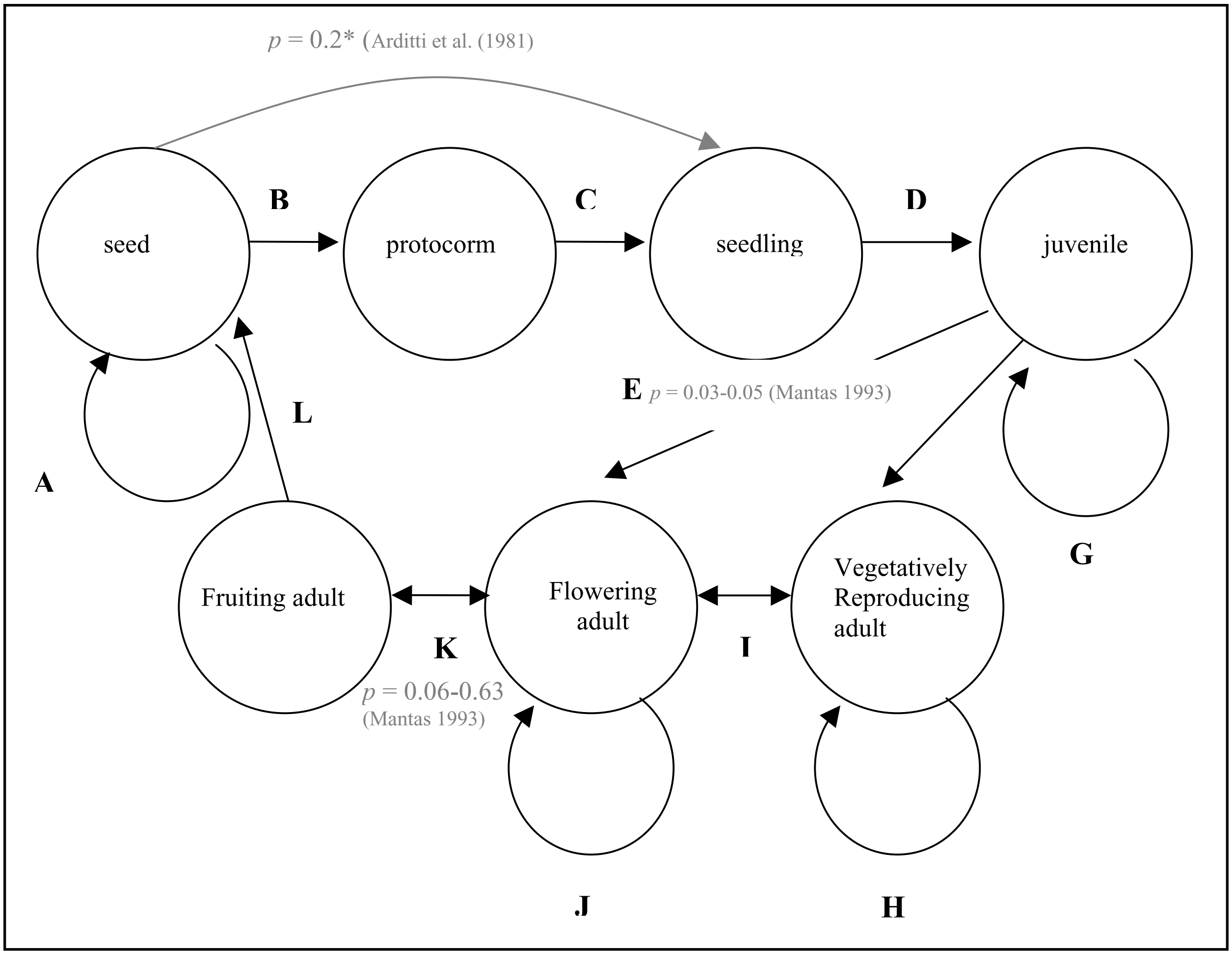

Figure 6. Hypothetical lifecycle graph for *Epipactis gigantea* (after Caswell 2001). There has been minimal investigation of the life history stages of this species. Other than germination rates, no transition probabilities are known for *E. gigantea*, and there has been no demographic monitoring of other species of *Epipactis* from which valuable inferences can be drawn. The value of **A** probably varies from year to year depending on climatic variables. The probability of germination (**B** and **C**) is 20 percent. Probability transitions for **B** and **C** individually are not known. No seedlings have ever been observed at length, so there are no data from which to infer rates for **D**. The probability of a juvenile maturing to a flowering adult (**E**) is 3 to 5 percent in Montana fens. The probability of the juvenile maturing to a vegetatively reproducing (**F**) adult is not known. The duration of the juvenile stage is also not known (**G**). Adults (**H** and **J**) are thought to be long-lived, but the probability of survival is unknown. The probability of the mature adult switching from sexual to vegetative reproduction or vice versa (t**I**) is also unknown. The probability that a flowering adult will produce viable seed (**K**) (each fruit contains thousands of tiny seeds) was estimated to be between 6 and 63 percent, with the variability attributed to climatic conditions that minimize pollinator visitation. **L** represents the probability that a seed will arrive at a safe site.

note that germination rates for *Epipactis gigantea* in the laboratory average 20 percent. Field observations (Brunton 1986, Coleman 1986, Colorado Natural Heritage Program 2005) suggest that seedlings are much less common than clonal ramets, but seedlings have been observed in the wild (Brunton 1986, Coleman 1986). It is unknown how long seeds remain viable, or whether seeds germinate the same year or in subsequent years.

Once germination begins, orchid seeds develop a protocorm before developing a visible shoot or seedling (Arditti et al. 1981, Dressler 1981). The mycorrhizal symbiont infects a seed, causing the seed coat to open and form a protocorm, which is an embryo that has swelled and developed root hairs. This stage is saprophytic because the protocorm depends on nutrients made available by the mycorrhizal symbiont. The protocorm then develops a leafy shoot and, depending on the environment, will eventually or immediately develop chlorophyll. While some orchids may not develop chlorophyll for several months, orchids in sunny and moist environments will become photosynthetic more quickly (Dressler 1981). In culture, using a variety of media, *Epipactis gigantea* seeds took anywhere from 2.25 to 12 months to germinate and form a protocorm and from 3.3 to about 18 months to form aboveground shoots (Arditti et al. 1981). It is unknown how long *E. gigantea* seeds take to germinate and develop visible shoots in the field. Further, it is unknown at what stage plants begin to spread vegetatively or how long before the plants reach reproductive age or size.

Adults flower during the growing season as conditions permit. Based on field observations, flowering success is highly variable (Colorado Natural Heritage Program 2005). Kindlmann and Balounova (2001) could not explain the irregular flowering patterns of the terrestrial orchids *Epipactis albensis* and *Dactylorhiza fuchsiai*, but they did note that flowering depends on a complex set of biotic and abiotic factors. Mantas (1993) described variable flowering and fruiting success in a two-year study of *E. gigantea* in Montana fens. That study showed that the probability of a juvenile *E. gigantea* individual maturing to a flowering adult in any given year was 0.03 to 0.05, while the probability of a flowering adult producing seed was 0.06 to 0.63 (**Figure 6**). Climatic conditions may affect fruiting success; for example, high rainfall resulted in fewer visits by pollinators (Mantas 1993).

Asexual reproduction by rhizome spread is an important part of the life history of *Epipactis gigantea*. Daughter ramets can become independent within one growing season (Thornhill 1996). Under greenhouse conditions, *E. gigantea* can produce up to three new ramets per growing season (Thornhill 1996). An adult plant can alternate between sexual and asexual reproduction from year to year, depending on conditions. It is unknown how old plants must be before they are able to reproduce by rhizomes.

Epipactis gigantea exhibits many competitive plant strategies (see Reproduction biology and autecology section of this document), including responding to stress by capturing resources and maximizing vegetative growth (Grime 2001). It is reasonable to assume that under stressful or abnormal conditions, *E. gigantea* directs its stored energy toward vegetative growth rather than sexual reproduction. This partition is typical of competitive species whose strategy is to obtain abiotic resources preemptively.

There are no data sets available that could be used for a population viability analysis (PVA) of *Epipactis gigantea*. Although many occurrences appear to be stable, the identification of a minimum viable population size could assist in determining management objectives (Brackley 1989). Due to the rarity and isolation of *E. gigantean* occurrences, there are few quantitative data describing the effects of herbivores, disease, competition, hybridization, or allelopathy on occurrence viability. However, exotic species are a concern, especially in western Colorado where several occurrences describe them as a threat (Colorado Natural Heritage Program 2005). Population growth in the Cascade Creek occurrence in South Dakota is thought to be limited by the extent of habitat fed by warm calcareous springs (Hornbeck et al. 2003). Population growth region-wide is limited by the species' very narrow ecological requirements. There is a great deal of unoccupied potential habitat; it is unclear why occurrences are so infrequent.

Community ecology

The community ecology of *Epipactis gigantea* has been little studied, and there are few sources addressing the topic. The inferences below are based on observations of *E. gigantea* in Region 2.

Associated plant communities and plant species

Although available data are not sufficient to classify all plant communities containing *Epipactis gigantea* to the association level of the U.S. National Vegetation Classification (Anderson et al. 1998, Carsey et al. 2003), broad plant community types are discernable. In Colorado, *E. gigantea* occurs within riparian plant communities dominated by *Populus* spp. (cottonwood), *Salix* spp. (willow), or *Betula occidentalis* (river birch) (Carsey et al. 2003, Colorado Natural Heritage Program 2005). *Eleocharis rostellata* (creeping spikerush), river birch, and hanging garden (*Aquilegia micrantha – Mimulus eastwoodiae*) plant communities dominate the seep and spring habitats of *E. gigantea* (Carsey et al. 2003, Colorado Natural Heritage Program 2005). Hanging gardens are considered a rare plant community type (G2G3) by NatureServe (2003). In South Dakota, *E. gigantea* occurs around the periphery of *Carex* spp. (sedge) marshes and under the canopy of *Populus deltoides* ssp. *monilifera* (plains cottonwood) woodlands in riparian areas (Hornbeck et al. 2003). Data from Wyoming do not indicate associated plant communities (Wyoming Natural Diversity Database 2005).

A diversity of plant species is associated with *Epipactis gigantea* in Region 2 (**Table 6**) because of the wide range of elevational zones and wetland types in which the orchid occurs. Common associates in Colorado (Colorado Natural Heritage Program 2005) include *Hippochaete laevigata* (scouring rush), *Equisetum arvense* (horsetails), *Eleocharis palustris* (common spikerush), *Maianthemum stellatum* (starry false Solomon's seal), *Toxicodendron rydbergii* (poison ivy), *Salix exigua* (coyote willow), and *Rhus trilobata* (skunkbush). Associated plants in Wyoming include *Castilleja exilis* (Indian paintbrush), *E. rostellata* (creeping spikerush), *Scirpus acutus* (Hardstem bulrush), *S. americanus* (bulrush), *Juncus ensifolius* (rush), *Gentianella detonsa* (fringed gentian), *Solidago canadensis* (goldenrod), and *M. stellatum* (starry false Solomon's seal) (Wyoming Natural Diversity Database 2005). One of the most common species at the occurrence in South Dakota is *Adiantum capillus-veneris* (southern maidenhair fern) (Hornbeck et al. 2003, South Dakota Natural Heritage Program 2005).

Herbivory

A BLM botanist in Idaho noted that native wildlife eat *Epipactis gigantea* early in the growing season (Mancuso 1991). In Dinosaur National Monument, native herbivores (likely bighorn sheep or mule deer) selectively browsed *E. gigantea* occurrences in hanging gardens (Janet Coles personal communication 2005). However, no additional information was located regarding the palatability of this species to native herbivores; the extent and effect of ungulate herbivory on *E. gigantea* are not known. If native herbivores find *E. gigantea* palatable, its ability to reproduce vegetatively would tend to buffer it from negative effects of this activity (Janet Coles personal communication 2005).

Competition

Although Brunton (1986) suggests that *Epipactis gigantea* is not a good competitor, other researchers believe otherwise. Levine (2000) studied the competitive interactions of four plant species, including *E. gigantea*, in a streamside community on the South Fork Eel River in Northern California. *Carex nudata* (sedge) tussocks were shown to provide a critical stable substrate for several species, including *E. gigantea*, and to provide protection to *E. gigantea* from herbivores, thus facilitating the survival of *E. gigantea* within this community. This study also showed that *E. gigantea* biomass was reduced by *Carex* competition, but the protection from herbivory appeared to counterbalance the negative effects of competition (Levine 2000). Mantas (1993) found no indication that *E. gigantea* was a poor competitor in the fens of northwestern Montana. Schassberger (1988) suggests that *E. gigantea* is tolerant of interspecific competition. Its adaptability to increased solar radiation may allow *E. gigantea* to be more competitive in sunny locations, as suggested by its prevalence in open, sunny areas. In addition, *E. gigantea* shows many characteristics of competitive plants, as defined by the CSR model of Grime (2001).

Parasites and disease

There is little known about parasites or disease in *Epipactis gigantea*. Field observations in Region 2 reported no parasites or visibly diseased plants (Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005). However, outside of Region 2, a fungal pathogen (an anthracnose from the genus *Glomerella*) was collected in Montana from the leaves and the flowering buds of *E. gigantea* (Mantas 1993). The fungus was widespread throughout the sampled sites, inflicting damage to the leaves, and in some cases affecting flower production; however, the fungus did not appear to completely kill the plant.

Symbiotic relationships

Symbiotic relationships with insect pollinators are crucial for sexual reproduction. *Epipactis gigantea* offers nectar for insects; the insects distribute pollen among plants in the occurrence.

In addition to insects, mycorrhizal symbionts are important to *Epipactis gigantea* in germination and probably in nutrient and water uptake. Prendergast (1994) suggests that an endomycorrhizal fungal symbiont is required for seed germination in *E. gigantea*. This is due to the extremely small seed lacking any endosperm, radicle, or leaf rudiments (Arditti et al. 1981, Dressler 1981). Vesicular-arbuscular mycorrhizae have also been cited as possibly associated with *E. gigantea* (Hornbeck et al. 2003).

In a study of the mycorrhizal relationship of *Epipactis atrorubens* on mine tailings in Poland, heavy metals such as lead and cadmium were found in concentration on mycorrhizal coils in the orchid's roots, indicating a biofiltering service provided by the fungus (Jurkiewicz et al. 2001). It is unknown if a similar relationship might exist between *E. gigantean* and its mycorrhizal symbionts.

Table 6. Vascular plant species associated with *Epipactis gigantea* in Region 2. Data are from records on file with Colorado Natural Heritage Program, South Dakota Natural Heritage Program, and Wyoming Natural Diversity Database. Species in bold are ranked G1, G2, or G3 species by NatureServe (http://www.natureserve.org/explorer/index.htm).

Associated Species	Reported State	Exotic?	Associated Species	Reported State	Exotic?
Acer negundo	CO, SD		*Juncus ensifolius*	WY	
Achillea lanulosa	CO		*Juncus saximontanus*	CO	
Acosta maculosa	CO	X	*Juncus* spp.	SD	
Agropyron cristatum	SD	X	*Juncus torreyi*	CO	
Agrostis gigantea	CO	X	*Juniperus scopulorum*	CO	
Agrostis stolonifera	CO	X	*Limnorchis* sp.	CO	
Ailanthus altissima	CO		*Lycopus* spp.	SD	
Alnus incana	CO		*Maianthemum stellatum*	CO, SD, WY	
Apocynum spp.	CO		***Mimulus eastwoodiae* (G3)**	**CO**	
Aquilegia micrantha	CO		*Monarda fistulosa*	SD	
Asclepias incarnata	SD		*Muhlenbergia andina*	CO	
Asclepias speciosa	SD		*Opuntia phaeacantha*	CO	
Asparagus officinalis	SD	X	*Panicum capillare*	CO	
Aster spp.	CO		*Panicum virgatum*	CO	
Baccharis salicina	CO		*Parthenocissus vitacea*	SD	
Barbarea orthoceras	CO		*Phalaris arundinacea*	CO	X
Berberis fendleri	CO		*Phragmites australis*	CO, SD	
Betula occidentalis	CO		*Pinus ponderosa*	CO	
Brickellia californica	CO		*Plantago major*	SD	X
Calamagrostis scopulorum	CO		*Platanthera sparsiflora*	CO	
Cardamine cordifolia	CO		*Poa pratensis*	CO	
Carex aurea	CO		*Populus angustifolia*	CO	
Carex hystericina	CO		*Populus deltoides* ssp. *monilifera*	SD	
Carex pellita	CO		*Populus deltoides* var. *wislizeni*	CO	
Carex spp.	SD		*Potamogeton* spp.	SD	
Castilleja exilis	CO, WY		*Prunus virginiana*	SD	
Celtis reticulata	CO		*Pseudotsuga menziesii*	CO	
Centaurea maculosa	CO		*Quercus gambelii*	CO	
Cirsium arvense	SD	X	*Ratibida columnifera*	SD	
Cirsium calcareum	CO		*Rhus trilobata*	CO, SD	
Clematis ligusticifolia	CO, SD		*Ribes aurea*	CO	
Comandra umbellata	CO		*Ribes* spp.	SD	
Conium maculatum	CO		*Rorippa-nasturtium-aquaticum*	SD	X
Cornus sericea	CO, SD		*Rosa woodsii*	SD	
Cyperus erythrorhizos	CO		*Rubus discolor*	CO	
Dactylis glomerata	SD	X	*Rumex crispus*	SD	X
Distichlis spicata	CO		*Salix amygdaloides*	SD	
Echinacea angustifolia	SD		*Salix bebbiana*	CO	
Elaeagnus angustifolia	SD	X	*Salix exigua*	CO, SD	
Eleocharis compressa	SD		*Salix ligulifolia*	CO	

Table 6 (concluded).

Associated Species	Reported State	Exotic?	Associated Species	Reported State	Exotic?
Eleocharis palustris	CO		*Salix lutea*	CO	
Eleocharis rostellata	CO, SD, WY		*Salix monticola*	CO	
Elymus cinereus	CO		*Scirpus acutus*	CO, WY	
Ephedra viridis	CO		*Scirpus americanus*	WY	
Epilobium ciliatum	CO	X	*Scirpus pungens*	SD	
Epilobium spp.	SD		*Scirpus tabernaemontani*	CO, SD	
Equisetum arvense	CO		*Shepherdia canadensis*	CO	
Equisetum hyemale	CO		*Sisyrinchium montanum*	SD	
Equisetum laevigatum	CO		*Solidago canadensis*	WY	
***Erigeron kachinensis* (G2)**	**CO**		*Solidago gigantea*	CO, WY	X
Eupatorium maculatum	CO		*Solidago* spp.	SD	
Fendlera falcata	CO		*Sonchus arvensis*	SD	X
Forestiera pubescens	CO		*Sonchus asper*	SD	
Fraxinus pennsylvanica	SD	X	*Spartina pectinata*	SD	
Galium spp.	CO		*Stephanomeria* spp.	CO	
Gentianella detonsa	WY		*Tamarix ramosissima*	CO	
Glyceria striata	CO		*Toxicodendron rydbergii*	CO, SD	
Heterotheca villosa	CO		*Typha latifolia*	CO, SDSD	
Hordeum jubatum	SD		*Ulmus americana*	SD	X
Humulus lupulus	CO		*Vitis riparia*	SD	
Hypericum formosum	CO		*Yucca baccata*	CO	
Juncus balticus	CO		***Zigadenus vaginatus* (G2)**	**CO**	

No information was found to indicate what ecological requirements are necessary for the persistence of mycorrhizae in *Epipactis gigantea* habitat, but soil compaction is generally thought to negatively affect mycorrhizae.

CONSERVATION

Threats

Threats to *Epipactis gigantea* include natural variability and human-related activities that adversely affect the ecological processes with which the species has evolved and upon which it depends for survival. The hierarchy of threats and impacts discussed below is speculative and based on observations (Beth Burkhart personal communication 2004, Sarah Brinton personal communication 2004, Jim Ferguson personal communication 2004, Leslie Stewart personal communication 2004, Jennifer Whipple personal communication 2004) and information derived from state natural heritage programs (Wyoming Natural Diversity Database 2004, Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005). Additional research on the ecology of *E. gigantea* may reveal other threats currently unknown or underestimated.

Human-related activities

Of the 41 occurrences known in Region 2, seven do not appear to be immediately threatened by human-related activities. Of those seven, three are on NPS lands (Records 17, 28, and 34 in **Table 5**), and four are on BLM-managed lands (Records 9, 19, 20, and 22). Twelve occurrences, none of which are on NFS lands, did not have enough information to discern potential threats (Records 5, 13, 14, 15, 24, 27, 36, 37, 38, 39, 40, and 41). Field observations and analysis indicate that human activities may threaten the remaining 22 *Epipactis gigantea* occurrences in Region 2. However, observations provide only anecdotal evidence of impacts. Research is needed to monitor the specific changes in habitat quality that are evoked by management actions.

In estimated order of greatest to least concern, human-related threats to *Epipactis gigantea* include recreation (road/trail construction, rafting, hiking, fishing, camping, hot spring development), water development (stock ponds, spring development), domestic livestock grazing, urban development, and utility line construction/maintenance. In estimated order of greatest to least concern, the impacts resulting from these threats include hydrological alteration, exotic species invasion, habitat loss, and altered nutrient cycles. These impacts may degrade *E. gigantea* habitat to the extent that it can no longer support the species. For example, reductions in groundwater discharge may reduce the extent of habitat available for *E. gigantea*. Exotic species have the potential to displace *E. gigantea* from its habitat and to alter nutrient and hydrological patterns. Any activity that destroys existing or potential *E. gigantea* habitat can significantly impact the species. Changes in nutrient cycles might put *E. gigantean* at a competitive disadvantage with other species or limit its ability to survive.

Much of the information in this section is based on speculation as there are very few long-term data describing how *Epipactis gigantea* responds to individual threats and/or impacts. Hornbeck et al. (2003) note that despite disturbance associated with recreation, exotic plant invasion, mowing, and weed control, *E. gigantea* has persisted for 75 years on Cascade Creek in South Dakota. They suggest that intense, episodic disturbance is not always detrimental to *E. gigantea* and that such disturbance may actually facilitate establishment at new sites through the creation of additional habitat (Levine 2000, Hornbeck et al. 2003). However, they conclude that it is unclear how individuals or occurrences are affected by disturbance (Hornbeck et al. 2003). Data for other *E. gigantea* occurrences in Region 2 are too incomplete to allow such an analysis.

There are clearly geographic differences in the types and magnitude of threats to *Epipactis gigantea* in Region 2. Recreation, particularly hot spring development, threatens occurrences at geothermal sites in Wyoming (Records 32, 33, 34, and 35 in **Table 5**) and South Dakota (Record 31 [Black Hills National Forest]). Conversely, many Colorado occurrences in remote or inaccessible habitats such as hanging gardens are not as obviously threatened (Colorado Natural Heritage Program 2005, Jim Ferguson personal communication 2004); however, some of these occurrences are still vulnerable to activities that may impact local stream or groundwater hydrology.

Recreation

Threats from recreation activities have been noted at eight *Epipactis gigantea* occurrences (Records 2, 6, 7, 18, 25, 30, 31 [Black Hills National Forest], 32 in **Table 5**). Rafting, hiking, camping, and hot spring development can directly impact *E. gigantea* habitat via trampling and soil compaction and serve as vectors for non-native species; hot spring development can also result in water diversions and habitat loss (Schassberger 1998, Hornbeck et al. 2003, Colorado Natural Heritage Program 2005).

Ongoing recreational use associated with swimming, tubing, fishing, picnicking, and hiking are of concern for the Cascade Creek occurrence (Record 31 in **Table 5**) on the Black Hills National Forest in South Dakota (Hornbeck et al. 2003). The USFS has fenced some unofficial footpaths to discourage recreational access to areas where *Epipactis gigantea* occurs along the creek (Hornbeck et al. 2003).

Rafting activities have been noted as a concern for an occurrence in southwestern Colorado (Record 25), but no specific information regarding the timing, duration, and specific impacts from rafting was noted. Leslie Stewart (personal communication 2004) believes that recreation impacts (mostly from curious botanists) threaten another occurrence in southwestern Colorado (Record 1, on the San Juan National Forest) due to trampling, potential changes in hydrology, and potential collecting.

Occurrences of *Epipactis gigantea* near hot springs are most vulnerable to recreation impacts due to the amount of trampling and physical manipulation of habitat that could occur (Schassberger 1988, Mancuso 1991, Hornbeck et al. 2003, Colorado Natural Heritage Program 2005). Development of hot springs could result in removal of plants or habitat (Brunton 1986, Schassberger 1988, Mancuso 1991, Hornbeck et al. 2003). Impacts from development of geothermal springs have been noted at two occurrences in Region 2 (Records 2 and 30).

Each type of recreational activity has its range of impacts. For example, impacts from hiking depend on the intensity of trail use and the proximity of the trail to an *Epipactis gigantea* occurrence. In addition, site characteristics will influence the extent of impact emanating from trail use. A trail traversing a very dense, brushy riparian area may discourage hikers from wandering too far off-trail. On the other hand, if the trail winds through a meadow, hikers may be more likely to leave the trail and explore. The popularity of a trail as well as the type of use (i.e., horse, domestic livestock, human) will influence the probability that exotic species will invade an occurrence.

Fencing sensitive areas may be an effective means of managing recreation threats. Signage may also provide an opportunity to educate the public as to the importance and unique value of a particular area due to the presence of *Epipactis gigantea*. For example, the BLM in Colorado provides a roadside interpretative sign highlighting the unique characteristics of Unaweep Seep (Record 12) yet does not allow public access to the site.

The construction of roads and trails for recreation can impact *Epipactis gigantea* habitat by altering hydrological regimes and nutrient cycles, and by serving as corridors for non-native species (Reid 1993). For example, the compacted surface of dirt roads restricts infiltration of precipitation into the soil and directs runoff and toxic materials into local streams (MacDonald and Stednick 2003). Roads cut into hill slopes can intercept groundwater flows (MacDonald and Stednick 2003), which may affect downslope seeps or springs. Roads may also increase the amount of water rerouted into local streams. Unvegetated slopes exposed by highway construction are cited as a potential threat to the Cascade Creek occurrence on the Black Hills National Forest in South Dakota (Record 31). Revegetating these areas and building roads away from riparian corridors are two ways to lessen threats from road construction. Threats from existing roads and new road and trail construction exist at the Poncha Hot Springs and Dolores Canyon occurrences (Records 2 and 21; Colorado Natural Heritage Program 2005).

Water development

Water diversions and impoundments associated with domestic livestock grazing (i.e., irrigation, stock ponds, and spring development), recreation (i.e., hot spring development), or other uses (i.e., municipal water supply) can affect the hydrological regime of streams and local aquifers by altering natural flows (e.g., base flow, low and high flows, peak floods, groundwater discharge) that support *Epipactis gigantea* occurrences. However, one occurrence in Colorado (Record 3 in **Table 5**) is supported by seepage from irrigation practices associated with the Hotchkiss Fish Hatchery (Peggy Lyon personal communication 2004).

Seeps and springs have been developed for livestock use throughout western Colorado, altering the hydrological regime and species composition of many of these areas (Bureau of Land Management 2001b, Rocchio et al. 2001, Doyle et al. 2002). Development of seeps and springs currently supporting *Epipactis gigantea* would likely degrade the habitat, and development of unoccupied habitat can result in degradation or loss of potential habitat. It is unknown if any past spring development projects destroyed *E. gigantea* occurrences. Impacts from water development associated with domestic livestock grazing have been noted at two occurrences in Region 2 (Records 6 and 10).

Mancuso (1991) notes that occurrences on the Payette National Forest in Idaho, all of which occur near hot springs, are subject to numerous threats associated with recreational use of the hot springs, including hot spring development, water diversions, trampling, and non-native species. Mantas (1993) notes that activities that might alter groundwater hydrology are of concern to *Epipactis gigantea* plants growing in fens in northwestern Montana. In Region 2, no occurrences are in fens. However, alteration of stream hydrology is of concern for the 11 Region 2 occurrences in riparian areas (Records 4, 7, 8, 9, 13, 23, 27, 29, 31, 36, and 39).

Domestic livestock grazing

Impacts from livestock grazing were noted in three occurrences in Region 2 (Records 23, 29, and 33), but these records did not provide specific information regarding the type, intensity, or severity of the impacts. Grazing was noted as a potential threat for three additional occurrences (Records 1, 10, and 3), but again specific information regarding impacts was not provided. The following discussion is based on best professional judgment regarding how domestic livestock may impact *Epipactis gigantea* occurrences and/or habitat.

Cattle tend to congregate in riparian and wetland areas, especially in arid regions, to take advantage of the water, shade, and food resources those areas offer. Grazing can directly impact *Epipactis gigantea* individuals through trampling or consumption. In Region 2, only two occurrences mentioned observation of grazing of *E. gigantea* individuals by domestic livestock (Records 23 and 33). These observations suggest that *E. gigantea* is occasionally eaten by domestic livestock, but it is not known whether it is a preferred forage species.

While little is known about the direct effects of livestock herbivory on *Epipactis gigantea*, riparian and wetland habitats can degrade because of improper domestic livestock grazing. The intensity, location, duration, and frequency of grazing determine the degree of impact. Poorly managed livestock use of wetland and riparian areas may erode stream banks, cause streams to incise, lower the water table, alter channel morphology, impair plant regeneration, introduce non-native species, shift community structure and composition, degrade water quality, and diminish general riparian and wetland functions (Windell et al. 1986, Reid 1993). Properly managed grazing, on the other hand, may not pose any threats to *E. gigantea* occurrences.

Depending on grazing practices and local environmental conditions, impacts can range from reversible (slight shifts in species composition) to severe and irreversible (extensive gullying, introduction of non-native plant species). Management practices such as fencing off riparian areas, rest-rotation, or winter grazing may improve the health of the riparian ecosystem by allowing the vegetation to re-grow (Leonard et al. 1997).

Urban development

Marriott (1993, as cited in Hornbeck 2003) notes that subdivision and housing development can increase runoff, erosion, nutrient loads, and pollutants into *Epipactis gigantea* habitats. Two occurrences of *E. gigantea* in Region 2 (Records 2 and 35 in **Table 5**) may be subject to impacts associated with urban development. The Poncha Springs occurrence (Record 2) is noted as being threatened by development associated with the nearby town of Salida, Colorado. Since the other occurrence (Record 35) has not been seen in more than 100 years, it is difficult to place much value on the information associated with it. However, the presumed location of the occurrence near the city of Shell, Wyoming suggests that urban development may be (or may have been) a threat.

Utility line construction and maintenance

One occurrence on the San Juan National Forest in Colorado (Record 1 in **Table 5**) has been affected by maintenance activity associated with a utility line. In 2001, a biologist from the Colorado Natural Heritage Program observed that numerous large branches had been cleared from underneath the utility line and then piled in the wetland where *Epipactis gigantea* was growing. The San Juan National Forest was notified, and the utility company personnel were directed to remove the branches. This event highlights one of the benefits of monitoring; regular visits to *E. gigantea* occurrences may reveal threats that can be mitigated before irreversible damage occurs.

Other potential threats

Timber harvest has impacted *Epipactis gigantea* in Idaho and Montana, but most occurrences in Region 2, especially those in Colorado, are not threatened by this activity due their location in semi-arid canyons where commercially valuable timber is sparse. Where timber management activities do occur within occupied habitat, they could alter the site's hydrology through soil compaction or physical disturbance to the soils and associated surface drainage patterns (Reid 1993). Timber harvest can also impact *E. gigantea* habitat via removal of overstory, alteration of nutrient cycles, and invasion by exotic species (Schassberger 1988, Mantas 1993).

Timber activities might also alter the hydrological regimes of streams down slope in the watershed (Reid 1993, MacDonald and Stednick 2003), resulting in degraded habitats. Timber management, especially clearcutting, can increase runoff, decrease infiltration, and thus deplete local aquifers, thereby decreasing or possibly eliminating groundwater discharge to local seeps and springs that support *Epipactis gigantea*. (Reid 1993, MacDonald and Stednick 2003).

Timber management is not part of the management prescription for the occurrence on the Black Hills National Forest in South Dakota (Record 32 in **Table 5**). The occurrence on the San Juan National Forest would likely not be affected by timber harvest activities should they occur (Sarah Brinton personal communication 2004). Should timber harvest occur near *Epipactis gigantea* occurrences, providing an undisturbed buffer around the occurrence and its habitat would be beneficial.

Epipactis gigantea has been reported as a ceremonial herb by some Native American tribes, and it is used as an ornamental but not medicinally (NatureServe 2005). *Epipactis gigantea* plants are available for purchase on the Internet (NatureServe 2005), but it is unclear if these specimens are cultivated or collected from wild occurrences. This species is reported as an easily cultivated terrestrial orchid (Arditti et al. 1982, Northen 1986, Rach 2003). Brunton (1986) notes that *E. gigantea* has been successfully transplanted from the wild into gardens in Canada but provides no indication as to how often this occurs. Overcollecting may not be a significant threat, and it has not been documented in any occurrences in Region 2. Collecting specimens to document new occurrences of *E. gigantea* or for scientific purposes should only occur in large occurrences with more than 20 stems per stem collected. Care should be taken by collectors not to remove plants from small occurrences (Wagner 1991, Pavlovic et al. 1992), nor should large quantities of rhizomes be collected.

Interaction and cumulative effects of threats

While these human-related activities pose their own unique threats to *Epipactis gigantea*, they also can interact and influence each other. Specific impacts to *E. gigantea* and its habitat should not be considered in isolation from the cumulative impacts to the site. Spatial and temporal cumulative effects of all land use activities have the potential to affect *E. gigantea* habitat, especially those occurrences along stream courses where cumulative watershed effects are most apparent (Reid 1993). However, other than observations from natural heritage databases (Wyoming Natural Diversity Database 2004, Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005), no data exist to suggest how often or to what extent impacts directly affect *E. gigantea* or occupied habitat.

Threats can interact and compound their effects on *Epipactis gigantea* in a number of ways. Exotic species can potentially displace *E. gigantea* and alter nutrient cycles as well as hydrological regimes. Water development directly impacts the hydrological regime upon which *E. gigantea* depends. Domestic livestock grazing can directly affect *E. gigantea* individuals, or it can alter hydrological patterns through soil compaction, stream destabilization, and creation of new surface drainage patterns. Grazing can also serve as a vector for the spread of exotic species. Urban development can result in direct loss of habitat, or it can alter hydrological regimes and nutrient cycles. Timber harvesting in and near riparian areas and wetlands may influence hydrological patterns, nutrient cycles, and habitat integrity (e.g., integrity of biotic and abiotic processes). Utility line construction and maintenance was found to affect one occurrence due to brush removal along the utility line corridor.

Human-related activities can have a significant impact on cumulative habitat. Since 1986, wetlands have been lost at a rate of 58,500 acres per year in the continental United States (Dahl 2000). In Colorado alone, an estimated one million acres of wetlands (50 percent of the total in the state) were lost prior to 1980 (Dahl 1990). In total, estimated losses from all Region 2 states is approximately 39 percent of the original wetland acreage (Dahl 1990). Not included in these numbers is the loss and degradation of those wetlands not regulated by Section 404 of the Clean Water Act, such as riparian areas. It is unknown what percentage of the wetlands lost in Region 2 would be considered *Epipactis gigantea* habitat. The loss of occupied wetlands is an obvious detriment to *E. gigantea*, but no data exist to determine whether or to what extent this has occurred in Region 2. However, the loss of wetlands in general is a threat to *E. gigantea*, as the spatial extent of unoccupied habitat is decreasing.

Interaction with exotic species

Studies showing direct impacts to *Epipactis gigantea* from exotic species invasion are needed. Non-native species are often cited as a potential threat to *E. gigantea* (Records 3, 7, 10, 11, 12, 16, 21, and 31 [Black Hills National Forest] in **Table 5**; Schassberger 1988, Mancuso 1991, Hornbeck et al. 2003, Jim Ferguson personal communication 2004, Colorado Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005). Canada thistle (*Cirsium arvense*), curly dock (*Rumex crispus*), Russian olive (*Elaeagnus angustifolia*), perennial sowthistle (*Sonchus arvensis*), spotted knapweed (*Centaurea maculosa*), Kentucky bluegrass (*Poa pratensis*), reed canarygrass (*Phalaris arundinacea*), and salt cedar (*Tamarix ramosissima*) are exotic species known from *E. gigantea* occurrences in Region 2. Purple loosestrife (*Lythrum salicaria*) is a concern in the South Dakota occurrence (Hornbeck et al. 2003), but it does not appear to be an issue in other Region 2 occurrences. Tree of heaven (*Ailanthus altissima*) and Himalayan blackberry (*Rubus discolor*) are both found at the Unaweep Seep occurrence in Colorado (Anderson et al. 2001). Aggressive native species such as *Typha* spp. (cattail) and *Phragmites australis* (giant reed) have also been reported in many *E. gigantea* occurrences. These species have the potential to displace other native species, including *E. gigantea*. Although not reported at any occurrences in Region 2, the exotic shrub, tamarisk (*T. ramosissima*), is especially threatening to riparian areas in western Colorado. This species tends to form monocultures by outcompeting native vegetation, lowering water tables, and concentrating salts in the soil (Sala et al. 1996).

Epipactis gigantea possesses some life history strategies (e.g., early spring emergence, rhizomatous growth) that suggest it can compete with exotic species. Although no known occurrences in Region 2 have been documented as being drastically affected by exotic species invasion, exotic species should remain a concern given the potential of some species, such as tamarisk, to alter the chemical, physical, and hydrological conditions of a site as well as crowd out other species (Sala 1996). Neglecting the spread of such species may negatively impact *E. gigantea* occurrences.

Broadcast spraying for exotic species could harm *Epipactis gigantea* individuals. Implementing integrated weed management strategies that employ localized spraying or mechanical treatment of individuals or patches of exotic species is less likely to negatively affect *E. gigantea* (Schassberger 1988, Hornbeck et al. 2003). Given that *E. gigantea* is a monocot, ensuring that applied herbicides are specific to dicots will alleviate any potential negative impacts.

Natural variability of ecological processes

Natural variability of the ecological processes supporting *Epipactis gigantea* may be a threat to the species. However, no specific research has sought to quantify what amount, intensity, and type of variability are most threatening. The discussion that follows is therefore speculative and based on the best professional judgment of the authors.

Global climate change is likely to have wide-ranging effects in the near future. Projections based on current atmospheric CO_2 trends suggest that average temperatures will increase and precipitation will decrease in Colorado (Manabe and Wetherald 1986). This will significantly affect hydrology, nutrient cycling, vapor pressure gradients, and a suite of other environmental variables. Occurrences of *Epipactis gigantea* in Wyoming and South Dakota are associated with geothermal springs at a variety of elevations while occurrences associated with geothermal springs in Colorado occur at high elevations. With increasing elevation and latitude, *E. gigantea* prefers geothermal-supported habitat, indicating that the species' range is possibly limited by decreasing temperatures. With increased global warming, these occurrences would likely persist, assuming their geothermal sources remained intact. Increased temperature might also allow *E. gigantea* to migrate upward along elevational and latitudinal gradients; however, occurrences at lower elevations or in the southern portion of its range may be extirpated if precipitation decreases.

Changes in climate may alter stream levels and groundwater discharge. A decrease in either hydrologic factor due to drought could negatively affect *Epipactis gigantea* occurrences, given that the species is limited to habitats with a constant supply of water. However, it is not known precisely how *E. gigantea* would respond to drought. Mantas (1993) found that this species was not sensitive to minor fluctuations in the water table, but a persistently wet environment was essential to healthy growth. A California nursery suggests that *E. gigantea* will go dormant at the first signs of drought (Las Pilitas 2004), indicating that the species may be able to survive short-term reductions in water flow. If *E. gigantea* was able to go dormant during extended drought conditions, then the species would likely also occur in intermittently wet habitats, but this is not the case.

An increase in the flashiness of seasonal flooding may cause an increase in erosion of streambanks, with the potential threat of dislodging *Epipactis gigantea* individuals growing there. This may be most pronounced in watersheds with highly erosive soils. The occurrence along Cascade Creek on the Black Hills National Forest in South Dakota (Record 31) is subjected to occasional erosive floodwaters; however, these are thought to aid the species in persisting along the creek by opening sites for colonization and spread (Hornbeck et al. 2003). The potential for erosive flooding appears to be highest on the BLM occurrences in western Colorado due to the erosive soils and sparsely vegetated uplands (Jim Ferguson personal communication 2004).

Environmental fluctuations may also affect the success of pollinators. For example, Mantas (1993) cited climatic conditions as possibly affecting fruiting success of *Epipactis gigantea* in Montana fens, due to decreased pollination, as high rainfall resulted in fewer pollinator visits. No such studies have occurred in Region 2.

Wildfire has been reported as a potential threat to the Cascade Creek occurrence in South Dakota (Record 31 in **Table 5**) due to the possibility of increased erosion of the watershed's erosive soils and subsequent increased siltation into Cascade Creek (Hornbeck et al. 2003). Wildfire threat was not noted for any other occurrences in Region 2 and is not a significant threat to *Epipactis gigantea* overall.

Conservation Status of Epipactis gigantea in Region 2

Population trends

There are no data available that would allow a quantitative assessment of population trends and changes in distribution of *Epipactis gigantea* in Region 2. Since this species often reproduces vegetatively, it is difficult to separate individual plants. Therefore, population estimates are based on the number of stems (ramets) observed at an occurrence. In Region

2, known occurrences range from a few to a thousand ramets (Hornbeck et al. 2003, Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005). Colorado has the most occurrences in Region 2 (30) while Wyoming has four and South Dakota has one. Of the 41 occurrences within Region 2, only 12 (Records 1 [San Juan National Forest], 2, 5, 6, 12, 13, 17, 18, 30, 31 [Black Hills National Forest], 32, 33 in **Table 5**) are known to have been visited more than once, and only three of these (Records 6, 12, and 31 [Black Hills National Forest]) are known to have been visited more than twice. Other than the Cascade Creek occurrence (Record 31), which is thought to have increased in abundance in the past 15 years (Hornbeck et al. 2003), none of the other 11 occurrences are known to have increased or decreased in numbers of ramets. However, these occurrences were not systematically revisited, most re-visits occurred within 10 years of the previous visit (i.e., there is no long-term record), and quantitative methods were not used to monitor changes in the numbers of ramets. Given the paucity of repeat visits to occurrences, it is difficult to discern whether any reported changes in populations are real or what the overall population trend is in Region 2.

Both occurrences on National Forest Service lands, the Piedra River occurrence in the San Juan National Forest in Colorado (Record 1 in **Table 5**) and the Cascade Creek occurrence in the Black Hills National Forest in South Dakota (Record 31), have been visited more than once. As mentioned above, the Cascade Creek occurrence is thought to have increased in abundance of ramets (Hornbeck et al. 2003), but there is no indication that the Piedra River occurrence has changed (Colorado Natural Heritage Program 2005).

The Wyoming Natural Diversity Database (Wyoming Natural Diversity Database 2005) designates *Epipactis gigantea* as in "moderate decline?" while the Colorado Natural Heritage Program (2005) and NatureServe (2005) indicate that *E. gigantea* is in "general decline" due to loss of wetland and riparian habitat in the past few hundred years. Given that approximately 39 percent of historical wetland acreage was lost in Region 2 prior to 1980 (see Threats discussion in this document), there is a chance that occurrences of *E. gigantea* have been lost. However, no data exist to show that loss of wetlands (i.e., habitat loss) has resulted in loss of *E. gigantea* occurrences, so this conclusion is speculative. Known occurrences in Region 2 appear to be stable (Leslie Stewart personal communication 2004, Jennifer Whipple personal communication 2004, Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005).

Potential *Epipactis gigantea* habitat has been highly modified in Colorado as many natural hot springs have been developed for commercial use. It is unknown if these areas ever supported *E. gigantea*. Occurrences of *E. gigantea* in Idaho and Canada are thought to have declined due to development of hot springs for recreational use (Brunton 1986, Mancuso 1991). *Epipactis gigantea* is thought to be in decline in Colorado due the alteration of riparian areas, seeps, and springs resulting from water diversions, dams, and stock ponds, especially in western Colorado (Colorado Natural Heritage Program 2005). Heavy domestic livestock grazing at the turn of the 20^{th} century may have damaged or destroyed occurrences of *E. gigantea* in western Colorado; these impacts were widespread, and many streams in the area are still recovering (Jim Ferguson personal communication 2004). It is unknown to what extent habitat loss has occurred on NFS lands in Colorado. It is likely that with increasing human presence in Region 2, potential threats to *E. gigantea* will increase, due to increasing demands for water for residential, recreational, and industrial uses.

Variation in habitat suitability

Although *Epipactis gigantea* occurs from desert to boreal climates, it appears to be limited to moist or wet minerotrophic habitats and to require a constant supply of water (Cronquist et al. 1977, Brunton 1986, Mantas 1993). Within Region 2, habitats that provide constant water (e.g., some streams, seeps, and springs) appear to be capable of supporting *E. gigantea*.

Epipactis gigantea appears to prefer early successional habitats in some portions of its range (Brunton 1986, Coleman 2002). However, many occupied habitats in Region 2 and elsewhere, such as inaccessible sandstone seeps, do not experience periodic disturbance. Thus, it appears that disturbance is not a limiting factor for successful establishment of *E. gigantea*.

Arditti et al. (1982) note that a shaded environment is needed for germination, but that *Epipactis gigantea* does not compete well in shade later in its development. Coleman (2002) notes that *E. gigantea* grows under the canopy of trees, but many northern occurrences are found in full sun. An occurrence in Colorado was found to grow taller under the shade of willow and alder shrubs than nearby individuals growing in open areas (Colorado Natural Heritage Program 2005), suggesting

E. gigantea may exhibit a morphogenetic response to low light. Within Region 2, occurrences are located in both shady and sunny locations (Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005). Canopy closure also does not appear to affect a habitat's ability to support *E. gigantea*.

In general, it appears that a permanent source of water determines the capability of a particular habitat to support *Epipactis gigantea*. A riparian area with a consistently wet floodplain (e.g., Cascade Creek in South Dakota) may support as many plants as a large seep (e.g., Unaweep Seep in Colorado). Most occurrences of *E. gigantea* in Region 2 appear to be associated with groundwater discharge sites (Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005). In Wyoming, South Dakota, and high elevations in Colorado, *E. gigantea* appears to be limited to geothermally-supported habitats (Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005, Wyoming Natural Diversity Database 2005).

Vulnerability due to life history and ecology

Epipactis gigantea is distributed from Mexico to southern British Columbia, but occurrences are small and isolated, which makes them vulnerable to random events and disease (Hornbeck et al. 2003). Thornhill (1996) found genetic differences among occurrences in California, suggesting that the species retains the potential to adapt to changing environments and to establish or re-establish new occurrences in geographically isolated habitats. The probability of a colonization event would be low because of the distance between most occurrences. NatureServe (2003) suggests that maintaining many small occurrences rather than one large occurrence is better for conserving the genetic diversity of the species. More research is needed to identify what prevents *E. gigantea* from occupying more suitable habitat across its range.

The mode of reproduction appears to be correlated with the density of ramets. Mantas (1993) found that dense stands of *Epipactis gigantea* in Montana fens produced smaller ramets and fewer flowers than less dense stands. In the same paper, Mantas noted that once established, *E. gigantea* is likely to persist due to its clonal habit. It is unclear what, if any, environmental factors may cause *E. gigantea* to favor one reproductive strategy over the other.

Reliance on a constant source of water is a liability to this species since springs, seeps, and riparian areas are often subject to hydrologic alterations that could render them unsuitable. In the Intermountain West, demand for water is so high that any plant species dependent on wetland habitats may be threatened to some extent.

Evidence of occurrences in Region 2 at risk

The rarity and small size of most *Epipactis gigantea* occurrences in Region 2 suggest that it is highly vulnerable to local extirpation. Only 12 of the 41 occurrences within Region 2 have been visited more than once, so it is difficult to know how many occurrences within Region 2 are increasing, declining, or are at risk of extirpation. Because *E. gigantea* is a rhizomatous species, assessing changes in the numbers of genetic individuals in an occurrence would require intensive genetic sampling of stems.

Current data suggest that most known occurrences of *Epipactis gigantea* in Region 2 are not at risk from immediate, site-specific threats (Wyoming Natural Diversity Database 2004, Colorado Natural Heritage Program 2005, South Dakota Natural Heritage Program 2005). However, stochastic processes and normal environmental variation could result in extirpation of the smaller occurrences from Region 2. In addition, the quality and availability of habitat in Region 2 have declined due to hydrologic alteration, exotic species invasion, and loss of habitat integrity (e.g., integrity of biotic and abiotic processes). Such degradation poses a long-term threat to the viability of *E. gigantea* in Region 2. Additional research on local and watershed threats may identify more occurrences at risk.

Management of Epipactis gigantea in Region 2

Implications and potential conservation elements

The most current data available suggest that *Epipactis gigantea* is imperiled in Region 2 due to the small number of occurrences and threats to the species' wetland and riparian habitats. Desired environmental conditions for *E. gigantea* occurrences center on maintaining an intact hydrological regime. This species appears to be resilient to light to moderate disturbance.

Given the paucity of detailed information from NFS occurrences in Region 2, it is unknown how far these conditions are from being achieved. It is possible that most or all of the ecosystem processes on which *Epipactis gigantea* depends are functioning at many or most of the occurrences of this species. However, as human activities continue to alter hydrological regimes and lower groundwater levels, the potential to disrupt hydrology increases. Until a more complete picture of the distribution and ecology of this species exists, priorities lie with conserving known occurrences.

Currently, only two occurrences in Region 2, Unaweep Seep on the San Juan National Forest in Colorado (Record 12) and Cascade Creek on the Black Hills National Forest in South Dakota (Record 31), have a conservation and/or monitoring plan (Bureau of Land Management 1999, Burkhart and Ebbert 2001, USDA Forest Service 2001). Further research is needed before meaningful inference can be offered regarding restoration policy. Please see the Tools and practices and Threats sections of this document for information on mitigating threats resulting from management.

Tools and practices

Species and habitat inventory

Inventories for *Epipactis gigantea* in Region 2 are likely to find additional occurrences. This species is easy to identify, especially when in flower. If no flowers are present, *E. gigantea* can be confused with other orchids such as those in the genera *Habenaria* and *Platanthera*, but *E. gigantea* is larger and has more leaves than these species (Hornbeck et al. 2003). Surveys conducted during peak reproductive period (June through September in Region 2; Spackman et al. 1997) are recommended.

The Colorado Natural Heritage Program uses aerial photography, topographic maps, soil maps, National Wetland Inventory maps, and geology maps to refine search areas when conducting inventories. This is most effective for species like *Epipactis gigantea*, whose general habitat requirements are understood. For *E. gigantea*, successful inventories will target cold seeps and springs at elevations below 8,000 ft. and geothermal springs and fens at higher elevations. Riparian areas between 3,000 and 8,000 ft. also appear to be potential habitat; however, these areas are much more difficult to search. To date, no predictive environmental characteristics of *E. gigantea* habitat on streams have been identified. Specific areas to search on NFS lands include the canyons of the Uncompahgre Plateau, the Dolores River, and the Piedra River.

Occurrence monitoring

Occurrence monitoring is among the highest priorities for *Epipactis gigantea* research. Due to *E. gigantea*'s clonal habit, it can be difficult to count genetic individuals. Counting or sampling ramets (stems) may provide an indication of occurrence vigor under normal climatic conditions (Mantas 1993). As part of the Monitoring and Evaluation component of the Black Hills National Forest Plan, three aspects of *E. gigantea* occurrences are tracked: (1) presence/absence of patches of *E. gigantea* along stream transects, (2) water levels along the stream supporting *E. gigantea*, and (3) presence/absence of noxious weeds (USDA Forest Service 2001). If a 10 percent or greater change is observed, a more rigorous monitoring strategy will be implemented (Hornbeck et al. 2003). Further detail can be incorporated into this protocol by calculating the area of each patch and monitoring change within patches.

Few other *Epipactis gigantea* occurrences in Region 2 are as large or complex as the Cascade Creek occurrence being monitored by the Black Hills National Forest. Elzinga et al. (1998) offer suggestions for abundance estimates and photo plot methods for qualitative comparisons in small occurrences. A handbook on photo point monitoring is available that offers guidance on establishing photo-point monitoring plots (Hall 2002). This technique can be done quickly in the field, and although it does not provide cover or abundance data, it can help to explain patterns observed in quantitative data. Photo monitoring can be difficult in densely vegetated areas.

Habitat monitoring

Monitoring the habitat of known occurrences will alert managers to new threats such as weed infestations and damage from domestic livestock grazing. Water table levels, groundwater discharge rates, and water chemistry are the most important habitat variables to monitor (Mantas 1993). Piezometers and/or shallow groundwater wells could be installed in occupied habitat and monitored at least monthly to determine trends in groundwater levels. Documenting vegetation attributes (e.g., cover of native and non-native species, vegetation structure) and disturbance regime (e.g., changes in flooding patterns, soil disturbance) during occurrence monitoring would augment our understanding of *Epipactis gigantea* habitat requirements and management needs.

Observer bias can be a problem with some methods of habitat monitoring (Elzinga et al. 1998).

Habitat monitoring is therefore usually better at identifying new impacts rather than tracking change in existing conditions. Using broad abundance classes to estimate species cover helps to reduce the effects of observer bias. Using photos to assess trampling impacts may help field crews to consistently rate the severity of the impacts. The use of photo points for habitat monitoring is described in Elzinga et al. (1998). Practical details of photographic monitoring are covered in Hall (2002).

The Colorado Natural Heritage Program is developing a vegetation-based Index of Biotic Integrity for montane riparian shrublands, wet meadows, and fens in Colorado. An index is a cost-effective way to evaluate the biotic integrity of a wetland by measuring attributes of the biological community known to respond to human-induced disturbance (U.S. Environmental Protection Agency 2002a). These measurements provide a semi-quantitative method for assessing the health and biotic integrity of a wetland and may be used to compare similar wetlands in different areas. This tool could be useful in monitoring trends in the integrity of *Epipactis gigantea* habitat (e.g., changes in species composition, increases in exotic species).

The Colorado Natural Heritage Program is also developing a Floristic Quality Assessment (FQA) tool for Colorado. Originally developed for the Chicago region in the late 1980s (Swink and Wilhelm 1994), the FQA is an index designed to assess the degree of "naturalness" of an area based on the presence of species whose ecological tolerances are conservative (U.S. Environmental Protection Agency 2002b). The FQA has been a very successful metric for detecting disturbance in wetlands (Andreas and Lichvar 1995) and will provide another tool to monitor *E. gigantea* habitat in Colorado and potentially Wyoming.

Beneficial management actions

The status of *Epipactis gigantea* as a Region 2 sensitive species encourages many beneficial actions on NFS land. Any potential impacts to sensitive species such as *E. gigantea* from USFS management activities must be considered prior to commencing the activities. This is to ensure that USFS actions (1) do not decrease the viability of rare plant and animal species, (2) do not contribute to a trend towards Federal listing under the Endangered Species Act of any species, and (3) incorporate concerns for sensitive species throughout the planning process, identifying opportunities for enhancement and reducing any potential negative impacts (USDA Forest Service 1995). Before starting management activities within known or potential *E. gigantea* habitat, USFS personnel are required to conduct surveys to delineate occurrence boundaries and to ensure that proposed actions avoid or minimize impacts to the species. Following an incident in which an occurrence on the San Juan National Forest in Colorado (Record 1 in **Table 5**) was impacted by utility personnel dumping slash from vegetation maintenance along a nearby utility line corridor, USFS directed utility operators to consider the *E. gigantea* occurrence when conducting maintenance (Sarah Brinton personal communication 2004). However, only two occurrences of *E. gigantea* in Region 2 occur on NFS lands and are given the consideration afforded designated sensitive species.

Although *Epipactis gigantea* was removed from the Colorado BLM sensitive species list (Spackman et al. 1997), current information suggests that be reconsidered for status as a Colorado BLM sensitive species. *Epipactis gigantea* meets two of the four criteria for consideration for BLM sensitive species status, by having "typically small or widely dispersed occurrences" and by "inhabiting ecological refugia or other specialized or unique habitats" (Bureau of Land Management 2001a). Sensitive species status would benefit *E. gigantea* by ensuring that consideration is given to occurrences in land management decisions, and by prioritizing habitat conservation work (Bureau of Land Management 2001a).

Educating recreation users about the rarity and conservation significance of *Epipactis gigantea* might benefit those occurrences in areas of high recreation use, such as hot springs or streams with rafting or angling use, especially the Cascade Creek occurrence on the Black Hills National Forest in South Dakota. Controlling motorized access to habitat and providing informational signs at access points may help to decrease impacts to *E. gigantea*. Avoiding any management actions that may alter the hydrology of *E. gigantea* habitat would greatly benefit the species. Considering the needs of *E. gigantea* when developing management plans and local land use decisions will benefit the species.

Establishing protected areas for *Epipactis gigantea* is an important conservation strategy for this species. This includes sites that support *E. gigantea* occurrences as well as areas that are important for maintaining the hydrological integrity of those occurrences. Currently, 16 of the 41 occurrences are in protected areas: 13 within national parks (Records 7, 8, 17, 28, 29, 33, and 34 in **Table 5**), one within the BLM's Escalante Canyon Area of Critical Environmental Concern (Record 5) and two within the BLM's Unaweep Seep Area of Critical Environmental Concern (Records 11 and 12). Bringing sites on private land into public ownership through land exchange or purchase could protect the three occurrences known from private lands. Similarly, preventing federal exchanges involving occurrences that are currently on public land would be beneficial to *E. gigantea*. Conservation easements and other land trust activities would be useful conservation tools to protect occurrences on private land. The Nature Conservancy maintains a preserve along Cascade Creek in South Dakota, protecting some of the sub-occurrences outside of National Forest Service lands (Hornbeck et al. 2003).

Because of threats to *Epipactis gigantea* and its habitat from exotic species, aggressive weed management in and near occurrences is a high priority. Any management strategies that prevent the infestation of *E. gigantea* occurrences will confer benefits. Hand pulling weeds where possible has the least impact on occurrences of *E. gigantea*. Direct application of herbicides to the target exotic species will mitigate the loss of orchids due to overspray and indiscriminate application. Biological control agents may help to control some exotic species. Weed management is an important activity at the Cascade Creek occurrence on the Black Hills National Forest in South Dakota. An integrated weed management plan for the Cascade Creek area was developed and implemented by the Hell Canyon Ranger District of the Black Hills National Forest (Hornbeck et al. 2003). The Canada thistle stem weevil (*Haploplontus litura*) is being used as a biological control agent for Canada thistle at this occurrence (Hornbeck et al. 2003). It is unknown how successful this agent will be or if there is any potential that it could impact *E. gigantea* individuals.

Avoiding right-of-way mowing in *Epipactis gigantea* occurrences between June and September (after fruit has dried and seeds are released) will be beneficial. Along Cascade Creek in South Dakota, a "no-mow" zone has been established around known occurrences of *E. gigantea* and appears to have deterred human trampling in the area (Hornbeck et al. 2003).

How to manage domestic livestock grazing to benefit *Epipactis gigantea* is unclear, as no data exist to suggest any benefits to the species. Of the two USFS occurrences, only the occurrence on the San Juan National Forest in Colorado is within an active grazing allotment. However, cattle rarely wander into the area in which *E. gigantea* is located (Sarah Brinton personal communication 2004). Of the remaining 33 occurrences in Region 2, 15 are in active grazing allotments on BLM lands (Records 4, 5, 6, 9, 11, 12, 18, 19, 20, 21, 22, 23, 24 25, and 26). Only one of these occurrences (Record 23) had any indication that grazing was a threat. Managing grazing so that streambanks are protected, and soil compaction and direct effects to *E. gigantea* individuals are minimized will help to conserve this species and maintain the integrity of its habitat. Allotment management plans that consider the viability of *E. gigantea* occurrences are likely to have positive impacts. These plans may include recommendations such as the construction of exclosures and adjustments of stocking rates to reduce impacts to *E. gigantea* occurrences and associated habitat if needed.

Fire is not likely to be useful as a habitat management tool for *Epipactis gigantea*. Its habitat is moist to saturated, and plants thrive in both wooded and open areas. However, fire management in a watershed may affect water and hydrological regimes and nutrient cycles and thus might have some impact on *E. gigantea* occurrences, especially those along riparian corridors.

The establishment of a coordinated monitoring program by the BLM, USFS, and NPS would benefit occurrences of *Epipactis gigantea* on federal lands by providing information on its population trends, ecology, and threats. This information would help to develop better management protocols and conservation priorities.

Seed banking

No *Epipactis gigantea* seeds or genetic material are currently in storage at the National Center for Genetic Resource Preservation (Annette Miller personal communication 2004). *Epipactis gigantea* is not among the National Collection of Endangered Plants maintained by the Center for Plant Conservation (Center for Plant Conservation 2002). The Orchid Seedbank Project (http://www.orchidseed.com/) serves as a clearinghouse for orchid seeds. This effort strives to provide conservationists, researchers, and commercial and hobbyist growers a source for orchid seed. As of March 2004, *E. gigantea* seed was not stocked; however, it may be in the future.

Information Needs

More information is needed regarding the distribution, abundance, population trend, habitat, life history, demography, metapopulation dynamics, and community ecology of *Epipactis gigantea*. This information would help to develop an understanding of the species' rarity and to appropriately prioritize its conservation needs.

Distribution and abundance

Surveys are needed for *Epipactis gigantea* in Region 2, especially in Colorado. Because *E. gigantea* is limited to geothermal sites in Wyoming and South Dakota, it is unlikely that additional occurrences will be found in those states. In Colorado, on the other hand, this species may be found along low-elevation seeps, springs, and riparian areas. Many of these locations remain to be searched, and surveys of these areas could lead to more discoveries of *E. gigantea*. More complete knowledge of the distribution of *E. gigantea* in Colorado will help to identify areas suitable for conservation management. Similarly, assessing stem abundance and extent of each *E. gigantea* occurrence is important for determining conservation needs and priorities for this species. Although *E. gigantea*'s distribution and abundance are not yet thoroughly understood, there is sufficient information available to begin to formulate conservation strategies for this species in Region 2.

Population trend, habitat, life history

Although the numbers of stems of *Epipactis gigantea* have been estimated in some occurrences, there are no data in Region 2 from which population trends can be determined. Periodic monitoring is needed to assess trends at significant occurrences.

Information that is more detailed is also needed regarding *Epipactis gigantea*'s habitat. Hydrology is clearly a controlling process; however, information on the ecological amplitude of *E. gigantea* with respect to soil texture, soil moisture, and nutrient concentrations is needed to understand its species-environment relationships. Investigating spatial autocorrelation with other species may help determine underlying ecosystem processes. Autecological research is needed to help refine the definition of appropriate habitat and to facilitate effective habitat monitoring and conservation stewardship of this species.

While Mantas (1993) has examined the ecology and reproductive biology of *Epipactis gigantea* and Thornhill (1996) has studied genetic variability among populations in California, additional research is needed to better understand *E. gigantea*'s life history and ecology. Information on recruitment, pollination, safe sites, longevity, seed viability, reproductive effort, and seed germinability on different substrates would help to establish basic life history parameters that would be useful in population models and restoration efforts.

Demography

Currently, only the broadest generalizations can be made regarding the demography of *Epipactis gigantea*. Abundance has not been rigorously determined at any occurrence. Reproductive output, recruitment, longevity, and other demographic parameters are not known. Much additional field work is needed before local and range-wide persistence can be assessed with demographic modeling techniques. Short-term demographic studies often provide misleading guidance for conservation purposes, so complementary information, such as historical data and experimental manipulations, should be included whenever possible (Lindborg and Ehrlén 2002).

Metapopulation dynamics

Research on the population ecology of *Epipactis gigantea* has not been done to determine the importance of metapopulation structure and dynamics to its long-term persistence at local or regional scales. Emigration, immigration, and extinction rates are unknown for *E. gigantea*. More information is needed to understand why, despite widespread suitable habitat, much of it remains unoccupied in Region 2.

Response to change

The amount of disturbance that *Epipactis gigantea* can tolerate is of considerable importance to managers. *Epipactis gigantea* is thought to have persisted through disturbance associated with recreation, invasion by exotic species, non-target weed control, and mowing for the past 75 years in South Dakota (Hornbeck et al. 2003). How this species responds to disturbance, competition, and succession is not clear and needs investigation. *Epipactis gigantea*'s response to water table fluctuation, periodic inundation, and drought are particularly relevant throughout Region 2. Cronquist et al. (1977) indicate that *E. gigantea* requires a permanent and constant source of water at its roots. However, Mantas (1993) found that *E. gigantea* was not sensitive to minor fluctuations in the water table, but a wet environment was essential to healthy growth. Other than the Mantas (1993) study, the nature of observations of *E. gigantea*'s response to both natural and anthropogenic disturbance in Region 2 is informal, and better data are needed to understand the role of disturbance in the species' life history and persistence.

An understanding of the range of reproductive rates in *Epipactis gigantea* and its ability to colonize new sites is important since these factors affect the species' ability to adapt to changing environments. Some researchers suggest that *E. gigantea* is negatively affected by competition (Brunton 1986, Levine 2000). However, Levine (2000) also showed that high biomass of associated species provided *E. gigantea* protection against browsing by deer. Mantas (1993) showed no negative effects from competition. More research on the effects of herbivores and exotic species on the viability of *E. gigantea* occurrences is needed.

Population trend monitoring methods

Population monitoring is among the highest priorities for research on *Epipactis gigantea*. The only known specific monitoring currently being conducted for *E. gigantea* is that by the Black Hills National Forest (USDA Forest Service 2001). This effort is monitoring changes in the number of patches of *E. gigantea* along Cascade Creek in South Dakota. Any change in individual numbers within patches is not addressed. No other trend monitoring protocols are known to have been developed for *E. gigantea*.

Selection of monitoring sites from a variety of physiognomic, hydrologic, and geological settings and land use scenarios will be necessary to monitor trends at the occurrence level. Monitoring occurrences associated with specific threats may provide additional information regarding *Epipactis gigantea*'s response to those threats. Please also see the Occurrence monitoring section of this document.

Restoration methods

There have been no known attempts to restore occurrences of *Epipactis gigantea*, but restoration warrants further research. Brunton (1986) notes that *E. gigantea* has been successfully transplanted from wild occurrences into gardens in Canada, and the horticultural literature suggests that the species is easily cultivated (Prendergast 1994, Rach 2003). It is unclear if cultivated *E. gigantea* individuals can be successfully transplanted into natural habitat.

An endomycorrhizal fungal symbiont is required for seed germination in *Epipactis gigantea* (Prendergast 1994). Vesicular-arbuscular mycorrhizae have also been cited as possible associates with *E. gigantea* (Hornbeck et al. 2003). Thus, restoration efforts should consider inoculating sites prior to planting or seeding. Utilizing donor soils from sites supporting *E. gigantea* may provide the necessary mycorrhizal associations for successful establishment.

Restoration or maintenance of native habitat and hydrology will be a crucial part of any restoration of *Epipactis gigantea*. Section 404 of the Clean Water Act requires mitigation of impacts to wetlands that are considered "waters of the United States" Mitigation typically involves creation, enhancement, and restoration of wetlands. As a result, much research has been conducted in the realm of wetland restoration ecology. While much progress has been made in our ability to restore native vegetation, many difficulties remain. For example, proper hydrological conditions are often not achieved; groundwater flows are especially difficult to restore. Non-native species are often a problem in restored sites. More research is needed to ensure that restoration activities are an adequate means of mitigating additional impacts to wetlands, specifically those supporting *E. gigantea*.

Restoration of occurrences impacted by grazing can be achieved through practices such as fencing off riparian areas, especially those closest to the river and along backchannels. Allowing riparian vegetation to re-grow will improve the stability and ecological integrity of the riparian area.

Research and monitoring priorities for Region 2

Inventory is the greatest priority for *Epipactis gigantea* in Region 2, followed by research and monitoring of this species' ecological requirements and dynamics, demography, and the impact of non-native species. These factors are fundamental to understanding the species' rarity and prioritizing its conservation.

A better understanding of the distribution of *Epipactis gigantea* is needed; it is likely that occurrences remain to be discovered, especially within Colorado where many miles of suitable riparian habitat exist. This underscores the need to conduct new surveys for this species. Conservation actions cannot be effective for undocumented occurrences. If *E. gigantea* is found to be more common than currently believed, then other species may warrant greater or more immediate conservation attention.

Research is needed to clarify the autecology of *Epipactis gigantea*, particularly with regard to its response to domestic livestock grazing, anthropogenic disturbance, changes in hydrology, and succession. The changes in *E. gigantea* occurrences that result from hydrological alterations both locally and within watersheds should also be investigated. Although suitable habitat is available throughout Region 2, this species is documented infrequently. More research is needed to determine the types, intensity, and periodicity of disturbance that create and maintain suitable habitat for *E. gigantea* and to understand specific habitat requirements and stressors that may limit its distribution.

More demographic information is needed to better understand *Epipactis gigantea*'s life history characteristics including age, dormancy, growth rates, reproductive rates, and trends in Region 2. Investigating the migration, extinction, and colonization rates of *E. gigantea* could yield metapopulation data valuable for its conservation. Determining the critical life history stages of *E. gigantea* will allow managers to focus their efforts on implementing management protocols that benefit those stages. A monitoring program that determines effective occurrence sizes and investigates the growth, survival, and reproduction of individuals within occurrences will have considerable practical value and will help to determine the conservation status of *E. gigantea*. Understanding the ecological dynamics for *E. gigantea* will provide insight regarding the coping strategies employed by this species and the causes of its rarity, as well as help to model its potential distribution. Examination of hypotheses regarding the causes of endemism and rarity in *E. gigantea* will help to gain an understanding of management practices, locations for further searching, and potential reintroduction sites.

Estimating the cover and/or abundance of associated species, including noxious weed species, could permit the investigation of interspecific relationships through ordination or other statistical techniques. Understanding environmental constraints on *Epipactis gigantea* could facilitate the conservation of this species. Gathering data on edaphic characteristics (e.g., moisture, texture, soil chemistry, pH) would permit the canonical analysis of species-environment relationships. These data would facilitate hypothesis generation for further studies of the ecology of this species, would be valuable in the event that a occurrence needs to be restored, and would help to determine biotic and abiotic factors that contribute to its survival.

A clearer understanding of the relationship between *Epipactis gigantea* and its mycorrhizal symbionts will also have practical value. A study of the effects of different timing and intensity of fire and domestic livestock grazing regimes on its mycorrhizae will assist managers in ascribing appropriate management protocols.

DEFINITIONS

Calcareous – rich in calcium salts; pertaining to limestone or chalk; growing on or having an affinity for chalky soil (Lincoln et al. 1998).

Competitive/Stress-tolerant/Ruderal (CSR) model – a model developed by J.P. Grime in 1977 in which plants are characterized as Competitive, Stress-tolerant, or Ruderal, based on their allocation of resources. Competitive species allocate resources primarily to growth; stress-tolerant species allocate resources primarily to maintenance; and ruderal species allocate resources primarily to reproduction. A suite of other adaptive patterns also characterizes species under this model (Barbour et al. 1987).

Endomycorrhizae – a type of mycorrhizae where the fungal hyphae penetrate the cells of the root. Arbuscular mycorrhizae are a type of endomycorrhizae (Allaby 1998).

Fen – a peat-accumulating wetland that receives some drainage from surrounding mineral soil and usually supports marsh-like vegetation (Mitsch and Gosselink 1993). A peatland supported by groundwater discharge.

Labellum – lip; the exceptional petal of an orchid blossom (Harris and Harris 1994).

Hanging Garden – a semi-arid wetland plant community associated with desert seeps, typically in sandstone alcoves, terraces, and canyon walls in southern Utah and southwestern Colorado.

Imperilment Ranks – used by natural heritage programs, natural heritage inventories, Natural Diversity Databases, and NatureServe.

Global imperilment (G) ranks are based on the range-wide status of a species. State-province imperilment (S) ranks are based on the status of a species in an individual state or province. State-province and Global ranks are denoted, respectively, with an "S" or a "G" followed by a character. **These ranks should not be interpreted as legal designations.**

G/S1	Critically imperiled globally/state-province because of rarity (5 or fewer occurrences in the world/state; or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction.
G/S2	Imperiled globally/state-province because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range.
G/S3	Vulnerable through its range or found locally in a restricted range (21 to 100 occurrences).
G/S4	Apparently secure globally/state-province, though it might be quite rare in parts of its range, especially at the periphery.
G/S5	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GX	Presumed extinct.
G#?	Indicates uncertainty about an assigned global rank.
G/SU	Unable to assign rank due to lack of available information.
GQ	Indicates uncertainty about taxonomic status.
G/SH	Historically known, but not verified for an extended period, usually.
G#T#	Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.
S#B	Refers to the breeding season imperilment of elements that are not permanent residents.
S#N	Refers to the non-breeding season imperilment of elements that are not permanent residents. Where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used.
SZ	Migrant whose occurrences are too irregular, transitory, and/or dispersed to be reliable identified, mapped, and protected.
SA	Accidental in the state or province.
SR	Reported to occur in the state or province, but unverified.
S?	Unranked. Some evidence that the species may be imperiled, but awaiting formal rarity ranking.

Notes: Where two numbers appear in a G or S rank (e.g., S2S3), the actual rank of the element falls between the two numbers.

Mineral Soil – a soil consisting predominantly of, and having its properties determined predominantly by, mineral matter, but it may contain an organic surface layer up to 30 cm thick (Soil Science Society of America, Soil Science Glossary, 2004: http://www.soils.org/sssagloss/).

Minerotrophic – habitat in which mineral-rich water (typically groundwater) is the main hydrological source.

Nectary – a tissue or organ that produces nectar (Harris and Harris 1994).

Pollinium (plural: pollinia) – a mass of waxy pollen grains transported as a unit in many members of the Orchidaceae and Asclepiadaceae (Harris and Harris 1994).

Protocorm – an embryo that has swelled and developed root hairs. A tuber structure that develops from the embryos of the lycopods (Lycopodiaceae) and orchids (Orchidaceae) (Allaby 1998).

Ramet – an individual member of a clone. (Allaby 1998).

Saprophytic – a plant obtaining nutriment from dead or decaying organic matter (Lincoln et al. 1998).

Self-compatible – a plant that can be self-fertilized (Lincoln et al. 1998).

Symbiont – a participant in symbiosis (Lincoln et al. 1998).

References

Allaby, M. 1998. A Dictionary of Plant Sciences. Oxford University Press, New York, NY.

Anderson, D., P. Lyon, S. Spackman, and J. Handwerk. 2001. Weed and rare plant assessments on selected BLM ACECs. Unpublished report prepared for the Bureau of Land Management, Colorado. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Anderson, M., P. Bourgeron, M.T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D.H. Grossman, S. Landaal, K.D. Patterson, M. Pyne, M. Reid, L. Sneddon, and A.S. Weakley. 1998. International classification of ecological associations: terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: list of types. The Nature Conservancy, Arlington, VA.

Andreas, B.K. and R.W. Lichvar. 1995. Floristic index for establishing assessment standards: A case study for northern Ohio. Technical Report WRP-DE-8, U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MS.

Arditti, J., J.D. Michaud, A.P. Olivia, and P. Allison. 1981. Seed germination of North American orchids, I. Native California and related species of *Calypso, Epipactis, Goodyera, Piperia,* and *Platanthera*. Botanical Gazette 142(4):442-453.

Arditti, J., J.D. Michaud, and A.P. Olivia. 1982. Practical germination of North American and related orchids – *Epipactis atrorubens, Epipactis gigantea,* and *Epipactis helleborine*. American Orchid Society Bulletin 51(2): 162-172.

Arizona Department of Agriculture. 1999. Appendix A: Protected Native Plants by Categories (http://agriculture.state.az.us/PSD/protplantlst.htm). State of Arizona.

Barbour, M.G., J.H. Burk, and W.D. Pitts. 1987. Terrestrial Plant Ecology. Benjamin/Cummings Publishing Company, Inc., Menlo Park, CA.

Begon, M., J.L. Haper, and C.R. Townsend, 1990. Ecology: Individuals, Occurrences, and Communities, Second Edition. Blackwell Scientific Publications, Cambridge, MA.

Brackley, F.E. 1989. Jesup's milkvetch recovery plan. U.S. Fish and Wildlife Service, New England Field Office.

Brinton, Sarah. 2004. Ecologist, USDA Forest Service, San Juan National Forest, Pagosa Springs, CO. Personal communication.

Brown, P.M. and G.W. Argus, 2002. *Epipactis. In*: Flora of North America, Vol. 26. Web version at http://hua.huh.harvard.edu/FNA.

Brunton, D.F. 1986. Status of the giant helleborine, *Epipactis gigantea* (Orchidaceae) in Canada. Canadian Field Naturalist 100(3):414-417.

Bureau of Land Management. 1999. Unaweep Seep Natural Area Management Plan, including the Environmental Assessment. United States Department of Interior. BLM, Grand Junction Resource Area.

Bureau of Land Management. 2001a. BLM Wyoming Sensitive Species Policy and List. Available at http://www.wy.blm.gov/.

Bureau of Land Management. 2001b. Riparian Area Management: A Guide to Managing, Restoring, and Conserving Springs in the Western United States. Technical Reference 1737-17. Bureau of Land Management, Denver, CO. BLM/ST/ST-01/001+1737. 70 pp.

Bureau of Land Management. 2004a. Colorado BLM State Director's Sensitive Species List (Animals and Plants) June, 2000. Available at: http://www.co.blm.gov/botany/sens_species.htm.

Bureau of Land Management. 2004b. Wyoming BLM State Director's Sensitive Species List (Animals and Plants) June, 2000. Available at: http://www.wy.blm.gov/wildlife/02species.pdf.

Burkhart, B.A. and E. Ebbert. 2001. Monitoring plan development and implementation for selected sensitive species along Cascade Creek. Unpublished report on file at the South Dakota Department of Game, Fish, and Parks, Wildlife Division, Pierre, SD.

Burns-Balogh, P., D.L. Szlachetko, and A. Dafni. 1987. Evolution, pollination, and systematics of the tribe Neottieae (Orchidaceae). Plant Systematics and Evolution 156:91-115.

Carsey K., D. Cooper, K. Decker, G. Kittel, and D. Culver. 2003. Statewide Wetlands Classification and Characterization: Wetland and Riparian Plant Associations of Colorado. Final report and CD-ROM. Colorado Natural Heritage Program, Colorado State University, Ft. Collins, CO.

Caswell, H. 2001. Matrix Occurrence Models. Second Edition. Sinauer Associates, Inc., Sunderland, MA.

Chamberlain, T.C. 1897. The method of multiple working hypotheses. Journal of Geology 5:837-848 (Reprinted in Science 148:754-759).

Center for Plant Conservation. 2002. National Collection of Endangered Plants. Available at: http://www.mobot.org/CPC/NC_Choice.html.

Coleman, R.A. 1986. The habitat and variation of *Epipactis gigantea* in the Santa Monica Mountains. The Orchid Digest 50 (2):66-68.

Coleman, R.A. 1987. *Epipactis gigantea* revisited. The Orchid Digest 51(4):203-204, 206.

Coleman, R.A. 1988. The *Epipactis* of California. Fremontia 16(1):24-27.

Coleman, R.A. 2002. The Wild Orchids of Arizona and New Mexico. Cornell University Press, Ithaca, NY.

Colorado Natural Heritage Program. 2005. *Epipactis gigantea* Element Occurrences and Plant Characterization Abstract as of February, 2004. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, and P.K. Holmgren. 1977. Intermountain Flora Vascular Plants of the Intermountain West, USA: Vol. 6. New York Botanical Garden, Bronx, NY.

Dahl, T.E. 1990. Wetlands: Losses in the United States, 1780s to 1980s U.S. Department of the Interior, Fish and Wildlife Service, St. Petersburg, FL.

Dahl, T.E. 2000. Status and trends Of wetlands in the conterminous United States 1986-1997. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Doyle, G., J. Rocchio, and D. Culver. 2002. Survey of seeps and springs within the Bureau of Land Management's Grand Junction Field Office Management Area (Mesa County, CO). Unpublished report prepared for the Bureau of Land Management, Grand Junction Field Office, Grand Junction, CO. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Dressler, R.L. 1981. The Orchids: Natural history and classification. Harvard University Press, Cambridge, MA.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and Monitoring Plant Occurrences. Bureau of Land Management Technical Reference 1730-1.

Ferguson, Jim. 2004. Wildlife Biologist. Uncompahgre Field Office, USDI, Bureau of Land Management, Montrose, CO. Personal communication.

Fertig, W., C. Refsdal, and J. Whipple. 1994. Wyoming Rare Plant Field Guide. Wyoming Rare Plant Technical Committee, Cheyenne. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/tools/wyplant/wyplant.htm (Version 16JUL97).

Grime, J.P. 2001. Plant Strategies, Vegetation Processes, and Ecosystem Properties. Second edition. John Wiley & Sons, Chichester, West Sussex, England.

Hall, F.C. 2002. Photo Point Monitoring Handbook – Parts A and B. General Technical Report PNW-GTR 526. USDA Forest Service Pacific Northwest Research Station, Portland, OR.

Harris, J.G. and M.W. Harris. 1994. Plant Identification Terminology: An Illustrated Glossary. Spring Lake Publishing, Spring Lake, UT.

Hillborn, R. and M. Mangel. 1997. The Ecological Detective: Confronting Models with Data. Princeton University Press, Princeton, NJ.

Hornbeck, J.H., D. Reyher, C.H. Sieg, and R.W. Crook. 2003. Conservation Assessment for Southern Maidenhair Fern and Stream Orchid in the Black Hills National Forest, South Dakota and Wyoming. United States Department of Agriculture, Forest Service, Rocky Mountain Region, Black Hills National Forest. Custer, SD. Available on-line at: http://www.fs.fed.us/r2/projects/scp/assessments/.

Idaho Fish and Game. 2004. Rare Plant Guide to the Pocatello and Idaho Falls Field Offices, Bureau of Land Management. Idaho Conservation Data Center, Idaho Fish and Game, Boise, ID. Available online at: http: //www2.state.id.us/fishgame/info/cdc/plants/seid_plant_guide_plantlist.htm.

Jurkiewicz, A.K. Turnau, J. Mesjasz-Przybytowicz, W. Przybytowicz, and B. Godzik 2001. Heavy metal localisation in mycorrhizas of *Epipactis atrorubens* (Hoffm.) Besser (Orchidaceae) from zinc mine tailings. Protoplasma 218:117–124.

Kartesz, J.T. 1999. A Synonymized Checklist and Atlas with Biological Attributes for the Vascular Flora of the United States, Canada, and Greenland. First Edition. *In*: J.T. Kartesz and C.A. Meacham. Synthesis of the North American Flora [computer program]. Version 1.0 . North Carolina Botanical Garden, Chapel Hill, NC.

Keddy, P.A. 2000. Wetland Ecology: Principles and Conservation. Cambridge University Press. Cambridge, UK.

Kindlmann, P. and Z. Balounova. 2001. Irregular flowering patterns in terrestrial orchids: theories vs. empirical data. Web Ecology 2:75-82.

Las Pilitas Nursery. 2004. Information accessed via: http://www.laspilitas.com/plants/782.htm.

Leonard, S., G. Kinch, V. Elsbernd, M. Borman, and S. Swanson. 1997. Riparian Area Management: Grazing Management for Riparian-Wetland Areas. Technical Reference 1737-14. U.S. Department of Interior, Bureau of Land Management, Denver, CO.

Levine, J. 2000. Complex interactions in a streamside plant community. Ecology 81(12):3431-3444.

Lincoln, R., G. Boxshall, and P. Clark. 1998. A Dictionary of Ecology, Evolution, and Systematics. Second Edition. Cambridge University Press, Cambridge, UK.

Lindborg, R. and J. Ehrlén. 2002. Evaluating the extinction risk of a perennial herb: demographic data versus historical records. Conservation Biology 16:683-690.

Luer, C.A. 1975. The Native Orchids of the United States and Canada, Excluding Florida. New York Botanical Garden, New York, NY. 362 pp.

Lyon, Peggy. 2004. Botanist/Ecologist, Colorado Natural Heritage Program, Fort Collins, CO. Personal communication.

MacArthur, R.H. and E.D. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, NJ.

MacDonald, L.H. and J.D. Stednick. 2003. Forests and Water: A State of the Art Review for Colorado. Published by the Colorado Water Resources Research Institute, Colorado State University, Fort Collins, CO. Completion Report No. 196. Available at: http://cwrri.colostate.edu/pubs/series/completionreport/cr196.pdf.

Manabe, S. and R.T. Wetherald. 1986. Reduction in summer soil wetness induced by an increase in atmospheric carbon dioxide. Science 232:626-628.

Mancuso, M. 1991. Field Investigation of *Epipactis gigantea* (giant helleborine), a Region 4 Sensitive Species, on the Payette National Forest. Idaho Department of Fish and Game, Boise, ID.

Mantas, M. 1993. Ecology and Reproductive Biology of *Epipactis gigantea* Dougl. (Orchidaceae) in Northwestern Montana. M.S. Thesis, University of Idaho.

Marriott, H.J. 1993. Letter from the Nature Conservancy dated January 12, 1993, Wyoming Field Office to Robert Moltzen, Black Hills National Forest Supervisor. Laramie, WY: Wyoming Nature Conservancy. 7 leaves. On file at: U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, SD. (as cited in Hornbeck et al. 2003).

Miller, Annette. 2004. Biological Science Laboratory Technician, USDA Agricultural Research Service, National Center for Genetic Resource Preservation, Fort Collins, CO. Personal communication.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands. Second Edition. Van Nostrand Reinhold, New York, NY.

Montana Natural Heritage Program. 2004. Montana Rare Plant Field Guide. Montana Natural Heritage Program, Helena, MT. Available online at: http://nhp.nris.state.mt.us/plants/index.html?guidebook.asp.

National Park Service. 2004. Research Permit and Reporting System. Available at: http://science.nature.nps.gov/research/ac/ResearchIndex.

van der Pijl, L. and C.H. Dodson. 1966. Orchid Flowers: Their pollination and evolution. The Fairchild Tropical Garden, University of Miami Press, Coral Gables, FL.

National Research Council. 2001. Compensating for Wetland Losses under the Clean Water Act. Committee on Mitigating Wetland Losses, Board on Environmental Studies and Toxicology, Water Science and Technology Board, Division on Earth and Life Studies, National Research Council. National Academy of Sciences, Washington, D.C.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life (web site) Version 1.8. Arlington, VA. http://www.natureserve.org/explorer/ (accessed on March 4, 2004).

Northen, R.T. 1986. *Epipactis gigantea*. Pacific Horticulture 47(4):31-31.

Pavlovic, N.B., M. DeMauro, and M. Bowles. 1992. Perspectives on plant competition- Plant collection rate should be positively correlated with plant population size. Plant Science Bulletin 38:8.

Platt, J.R. 1964. Strong inference. Science 146:347-353.

Prendergast, G. 1994. Growing *Epipactis* species from seeds at Kew. The Orchid Review 102:199-203.

Puckett, Jeremy. 2004. Assistant Director, Western Slope Environmental Resource Council, Paonia, CO. Personal communication.

Rach, N. 2003. *Epipactis gigantea* Douglas ex Hooker – General Information and Cultural Notes. The Houston Orchid Society. Available at http://www.houstonorchidsociety.org/HOS/Epipactis.html.

Reid, L.M. 1993. Research and cumulative watershed effects. General Technical Report PSW-GTR-141. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. 118 pp.

Rocchio, J., J. Sovell, and P. Lyon. 2001. Survey of seeps and springs within the Bureau of Land Management's Grand Junction Field Office Management Area (Garfield County, CO). Unpublished report prepared for the Bureau of Land Management, Grand Junction Field Office, Grand Junction, CO. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Romero-Gonzalez, G.A., G.C. Fernandez-Concha, R.L. Dressler, L.K. Magrath, and G.W. Argus. 2002. Orchidaceae. *In*: Flora of North America, Vol. 26. Web version at http://hua.huh.harvard.edu/FNA.

Ross, E.S. 1988. Does *Epipactis gigantea* mimic aphids? Fremontia 16:28-29.

Sala, A.S., S.D. Smith, and D.A. Devitt. 1996. Water use by *Tamarix ramosissima* and associated phreatophytes in a Mojave Desert floodplain. Ecological Applications 6:888-898.

Sugiura, Naoto. 1996. Pollination of the orchid *Epipactis thunbergii* by syrphid flies (Diptera: Syrphidae). Ecological Research 11:249-255.

Schassberger, L.A. 1988. Status review of *Epipactis gigantea*. USDA Forest Service, Region 1, Flathead National Forest, Montana. Order No. 43—385-8-0676.

Schemske, D.W., B.C. Husband, M.H. Ruckelshaus, C. Goodwillie, I.M. Parker, and J.G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology 75:584-606.

South Dakota Natural Heritage Program. 2005. Epipactis gigantea Element Occurrences Record as of February, 2004. South Dakota Natural Heritage Program, Pierre, SD.

Spackman, S., B. Jennings, J. Coles, C. Dawson, M. Minton, A. Kratz, and C. Spurrier. 1997. Colorado Rare Plant Field Guide. Prepared for the Bureau of Land Management, U.S. Forest Service, and U.S. Fish and Wildlife Service by the Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. Available online at: http://www.cnhp.colostate.edu/rareplants/intro.html.

Squirrell, J., P.M. Hollingsworth, R.M. Bateman, M.C. Tebbitt, and M.L. Hollingsworth. 2002. Taxonomic complexity and breeding system transitions: Conservation genetics of the *Epipactis leptochila* complex (Orchidaceae). Molecular Ecology 11:1957-1964.

Stewart, Leslie. 2004. Ecologist, USDA Forest Service, Dolores, CO. Personal communication.

Swink F. and G. Wilhelm. 1994. Plants of the Chicago Region. Fourth Edition. Morton Arboretum, Lisle, IL.

Thornhill, A. 1996. Species and occurrence-level patterns of genetic variation in *Epipactis gigantea* (Orchidaceae), with examination of local genetic and clonal structure in riparian and bog occurrences inferred from allozyme analysis. Ph.D. Dissertation, University of California, Irvine, CA.

U.S. Army Corps of Engineers. 1987. Wetlands Delineation Manual. Wetland Research Program, Technical Report Y-87-1, Waterways Experiment Station, Environmental Laboratory, U.S. Army Corps of Engineers, Department of the Army, Vicksburg, MS.

U.S. Congress. 1982. The National Environmental Policy Act of 1969, as amended 1982. U.S. Congress, Washington, D.C. Available at http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm.

USDA Forest Service. 1995. Title 2600 – Wildlife, Fish and Sensitive Plant Habitat Management. U.S. Forest Service Manual, Amendment No. 2600-95-7. U.S. Department of Agriculture, Washington, D.C. Available at: http://www.fs.fed.us/im/directives/fsm/2600/2670-2671.txt.

USDA Forest Service. 1999. Region 2 TES Plant Management Strategy, Grand Mesa, Uncompahgre & Gunnison, San Juan, Rio Grande, Pike-San Isabel National Forests and Comanche-Cimarron National Grasslands: 5 Year Action Plan, FY 1999 to FY 2003. USDA Forest Service, Region 2. Available at: http://www.fs.fed.us/r2/nebraska/gpng/r2pltstrategy.html.

USDA Forest Service. 2001. Black Hills Forest Plan, Monitoring and Evaluation Report, Fiscal Year 2001. U.S. Department of Agriculture, Black Hills National Forest, Custer, SD.

USDA Forest Service. 2003. Forest Service Manual Rocky Mountain Region. Chapter 2670. Threatened, Endangered, and Sensitive Plants and Animals. USDA Forest Service Region 2, Lakewood, CO.

USDA Natural Resources Conservation Service. The PLANTS database [Web Page]. 2004. Located at: National Plant Data Center, Baton Rouge, LA. http://plants.usda.gov/plants/index.html.

U.S. Environmental Protection Agency. 1997. Climate Change and Colorado. EPA 230-F-97-008f. Office of Policy, Planning, and Evaluation, Climate and Policy Assessment Division. Washington, D.C.

U.S. Environmental Protection Agency. 2002a. Methods for Evaluating Wetland Condition: Introduction to Wetland Biological Assessment. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. EPA-822-R-02-014.

U.S. Environmental Protection Agency. 2002b. Methods for Evaluating Wetland Condition: Using Vegetation to Assess Environmental Conditions in Wetlands. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. EPA-822-R-02-020.

U.S. Fish and Wildlife Service. 1988. National List of Plant Species that occur in Wetlands Intermountain (Regions 3,4,8,9). Biological Report 88(26.8).

Wagner, D.H. 1991. The 1 in 20 rule for plant collectors. Plant Science Bulletin 37:11.

Walker, L.R. and R. del Moral. 2003. Primary Succession and Ecosystem Rehabilitation. Cambridge University Press, Cambridge, UK.

Washington Natural Heritage Program. 2000. Washington Natural Heritage Program Field Guide to Selected Rare Plants. Washington Natural Heritage Program, Olympia, WA. Available online at: http://www.dnr.wa.gov/nhp/refdesk/fguides.html.

Welsh, 1989. On the distribution of Utah's hanging gardens. The Great Basin Naturalist 49(1):1-30.

Whipple, Jennifer. 2004. Botanist, Yellowstone National Park, WY. Personal communication.

Windell, J.T., B.E. Willard, D.J. Cooper, S.Q. Foster, C. Knud-Hansen, L.P. Rink, and G.N. Kiladis. 1986. An Ecological Characterization of Rocky Mountain Montane and Subalpine Wetlands. Biological Report 86(11). U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Wyoming Natural Diversity Database. 2004. *Epipactis gigantea* Element Occurrences and Plant Characterization Abstract as of February, 2004. Wyoming Natural Diversity Database, Laramie, WY.

Wyoming Natural Diversity Database. 2005. *Epipactis gigantea* Element Occurrences and Plant Characterization Abstract as of February, 2004. Wyoming Natural Diversity Database. Laramie, WY.