Penstemon absarokensis Evert (Absaroka Range beardtongue): A Technical Conservation Assessment

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Rocky Mountain Region,
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COVER PHOTO CREDIT

Penstemon absarokensis (Absaroka Range beardtongue).

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SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *PENSTEMON ABSAROKENSIS*

Status

Penstemon absarokensis (Absaroka Range beardtongue) is a rare, endemic penstemon species occurring only in the Absaroka Range of northwest Wyoming. Of 20 known occurrences of *P. absarokensis*, 18 occurrences are on U.S. Forest Service Shoshone National Forest lands, one occurrence is on Wyoming Bureau of Land Management lands, and one occurrence is on Wind River Indian Reservation lands (Dorn 1989, Fertig 1998, Fertig 2000a, Wyoming Natural Diversity Database 2003). In the Shoshone National Forest, at least 10 *P. absarokensis* occurrences are within the Washakie and Northern Absaroka wilderness areas, and three occurrences are in part within the proposed Grizzly Creek and Sheep Mesa Research Natural Areas (Jones and Fertig 1999a, Jones and Fertig 1999b).

The Global Heritage Status Rank for *Penstemon absarokensis* is G2 (globally imperiled) (NatureServe 2003). The Wyoming Natural Diversity Database ranks this species as S2 (imperiled) (Wyoming Natural Diversity Database 2003). The species is considered sensitive by U.S. Forest Service, Rocky Mountain Region (U.S. Forest Service 2003), and it is on the Wyoming Bureau of Land Management sensitive species list (U.S. Bureau of Land Management 2001).

Primary Threats

Penstemon absarokensis is vulnerable because of its restricted geographic range, strict habitat requirements, small number of documented occurrences, small area occupied by populations, and low abundance. Most populations of *P. absarokensis* have few imminent threats at present, as a result of its rugged, largely inaccessible habitat. Lower-elevation populations and populations near roads and trails may be at higher risk. Human-related vulnerabilities include damage to individuals and habitat by trail-use, domestic livestock activities, highway construction activities, possible natural resource exploration and development, or non-native species invasion. Environmental or biological threats to populations or habitats of *P. absarokensis* could include inadequate pollination, genetic isolation, scouring during flooding events, herbivory, landscape fragmentation, global climate changes, or changes to the natural disturbance regime that would affect natural succession, erosion, or precipitation patterns.

Primary Conservation Elements, Management Implications and Considerations

Penstemon absarokensis is a perennial forb species that mainly occurs on steep, sparsely vegetated, scree slopes of volcanic (andesite) substrates. Little is known about the current abundance, basic biology, ecological requirements, or vulnerability to environmental stochasticity of this species. Based on the few available data on abundance and distribution, we can speculate that this species appears to be viable within Rocky Mountain Region under current natural disturbance regimes and with current levels of recreation and management activities. However, it is difficult to predict the ability of this species to tolerate environmental stochasticity in the future (e.g., global environmental changes, drought) and any future management changes (e.g., livestock grazing, natural resource development). Features of *P. absarokensis* biology that may be important to consider when addressing conservation of this species (i.e., key conservation elements) include its edaphic specialization on andesitic substrates, potential reliance on a natural disturbance regime to create/maintain open habitat and possibly function in dispersal, poor competitive abilities evidenced by its preference for barren areas, scattered distribution of both individuals and populations, and possible outcrossing needs requiring efficient pollination. Key conservation tools for this species may include monitoring the effects of current land-use practices and management activities, reducing human-related threats to existing high-risk populations, preventing disruption to natural disturbance regimes, monitoring the effects of environmental fluctuations, and assessing the effects of any future management activities or changes in management direction.

Priorities of future research studies include re-locating and mapping existing populations, surveying for additional populations within U.S. Forest Service, Rocky Mountain Region, investigating factors affecting spatial distribution (especially role of natural disturbance regime), studying reproductive biology (especially vegetative

reproductive potential and outcrossing requirements), producing information related to demographics and genetic structure, studying the possibility of hybridization with other *Penstemon* species, investigating the taxonomic status of disjunct populations, and exploring potential biological and ecological limitations.

TABLE OF CONTENTS

EDITOR: Beth Burkhart, 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), U.S. Forest Service (USFS). *Penstemon absarokensis* is the focus of an assessment because it is listed as a sensitive species in USFS Region 2 (U.S. Forest Service 2003). Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a regional forester because of significant current or predicted downward trends in population numbers, density, or habitat capability that would reduce its existing distribution (U.S. Forest Service 1995). A sensitive species may require special management, so knowledge of its biology and ecology is critical.

This assessment addresses the biology of *Penstemon absarokensis* throughout its range, all of which is in USFS 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

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, and conservation status of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations but provides the ecological background upon which management must be based. While the assessment does not provide management recommendations, it does focus on the consequences of changes in the environment that result from management (i.e., management implications). Additionally, the assessment cites management recommendations proposed elsewhere and, when management recommendations have been implemented, the assessment examines the success of those implementations.

Scope and Information Sources

The *Penstemon absarokensis* species assessment examines the biology, ecology, conservation status, and management of this species with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Where supporting literature used to produce this species assessment originated from investigations outside the region, this document placed that literature in the ecological and social context of the central Rockies. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *P. absarokensis* 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, we performed an extensive literature search to obtain material focusing on *Penstemon absarokensis*, as well as related information on related species and on the geographical and environmental context of this species. We collected and reviewed refereed literature (e.g., published journal articles), non-refereed publications (e.g., unpublished status reports), theses and dissertations, data accumulated by resources management agencies (e.g., Natural Heritage Program [NHP] element occurrence records), and regulatory guidelines (e.g., USFS Forest Service Manual). We did not visit every herbarium with specimens of this species but did include specimen label information provided by herbarium staff and available in NHP element occurrence records. Additionally, we incorporated information from studies of closely-related *Penstemon* species or *Penstemon* species in USFS Region 2 or adjacent areas, and avoided extrapolating from studies of distantly-related *Penstemon* species or *Penstemon* species of drastically different geographic areas. While the assessment emphasizes refereed literature because this is the accepted standard in science, non-refereed publications and reports are used extensively in this assessment because they provide information unavailable elsewhere. These unpublished, non-refereed reports were regarded with greater skepticism, and we treated all information with appropriate uncertainty.

Treatment of Uncertainty

Science represents a rigorous, synthetic 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, it is difficult to conduct critical experiments in the

ecological sciences, and often observations, inference, good thinking, and models must be relied on to guide the understanding of ecological relations.

Because of a lack of experimental research efforts concerning *Penstemon absarokensis*, this assessment report relies heavily on the personal observations of botanists and land management specialists from throughout the species' range. Much of the knowledge about the biology and ecology of *P. absarokensis* is based on the observations of Robert Dorn (1989, personal communication 2003), Walter Fertig (Fertig 1998, Fertig 2000a, Mills and Fertig 2000), and Erwin Evert (1984, personal communication 2003). When information presented in this assessment is based on our personal communications with a specialist, we cite those sources as "personal communication". Unpublished data (e.g., NHP element occurrence records and herbarium records) were also important in estimating the geographic distribution and describing habitat of this species. These data required special attention because of the diversity of persons and the variety of methods used to collect the data, and unverified historical information.

Because there is a paucity of knowledge specific to this species, we also incorporated information, where available, from other *Penstemon* species endemic to USFS Region 2 or adjacent states to formulate this assessment. These comparisons are not meant to imply that *P. absarokensis* is biologically identical to these species, but they represent an effort to hypothesize about *potential* characteristics of this species. Although the breeding system and reproductive biology of other *Penstemon* species has been the subject of preliminary investigative study (e.g., Nielson 1998, McMullen 1998, Tepedino et al. 1999, Chari and Wilson 2001, Glenne 2003), details concerning the reproductive biology of *P. absarokensis* are largely unknown. As a result, biology, ecology, and conservation issues presented for *P. absarokensis* in USFS Region 2 are based on inference from these published and unpublished sources. We clearly noted when we were making inferences based on the available knowledge to augment or enhance our understanding of *P. absarokensis*.

Publication of Assessment on the World Wide Web

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

Peer Review

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

MANAGEMENT STATUS AND NATURAL HISTORY

Penstemon absarokensis is an endemic species found within one state of USFS Region 2, Wyoming (**Figure 1**). This section discusses the special management status, existing regulatory mechanisms, and biological characteristics of this species.

Management and Conservation Status

Federal status

The Endangered Species Act of 1973 (16 U.S.C. 1531-1536, 1538-1540) was passed to protect plant and animal species placed on the threatened or endangered list. The listing process is based on population data (e.g., trends) and is maintained and enforced by the U.S. Fish and Wildlife Service (USFWS). In 1985, *Penstemon absarokensis* was ranked as a Category 2 species, a taxa for which proposal as endangered or threatened is appropriate, but conclusive data on biological vulnerability and threats were not currently available (U.S. Fish and Wildlife Service 1985, Dorn 1989). After a status survey, Dorn (1989) recommended that this species be downranked to Category 3C, because there were no significant threats. However, the category program was eliminated by the USFWS in 1996, and those species are no longer being considered as candidate species (U.S. Fish and Wildlife Service 1996). Therefore, *P. absarokensis* is not currently ranked under the Endangered Species Act (Mills and Fertig 2000).

Penstemon absarokensis is listed as a sensitive species within USFS Region 2 (U.S. Forest Service

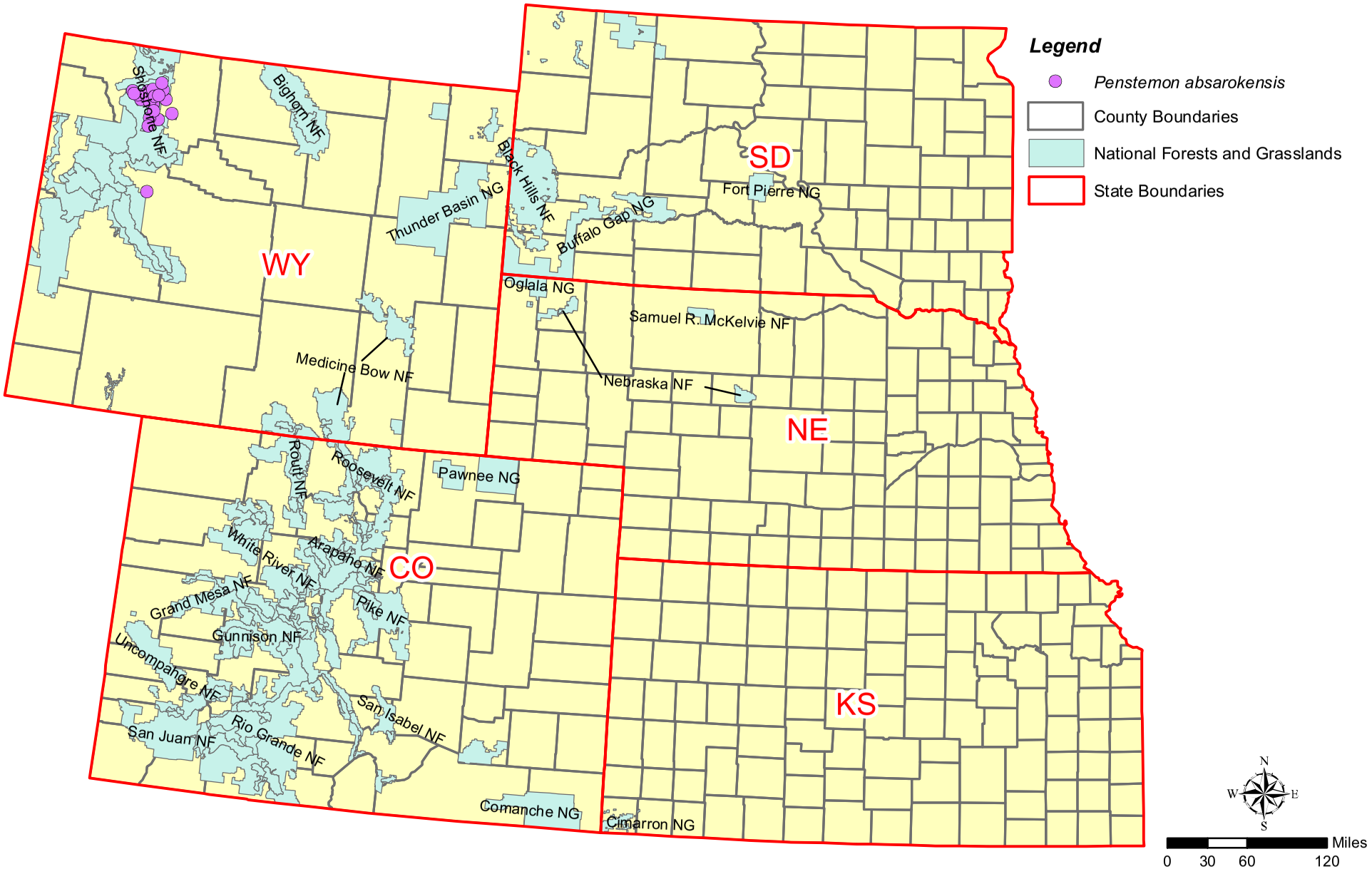

Figure 1. Map of U.S. Forest Service (USFS) Region 2 illustrating distribution of 20 *Penstemon absarokensis* occurrences in Fremont and Park counties, Wyoming. Each occurrence may include one to several populations. Refer to document for abundance and distribution information. Source: Wyoming Natural Diversity Database, Laramie, Wyoming (2003).

2003), and it is listed as sensitive by the Wyoming Bureau of Land Management (BLM) (U.S. Bureau of Land Management 2001).

Heritage program ranks

Natural Heritage Programs collect information about the biological diversity of their respective states and maintain databases of plant species of concern. *Penstemon absarokensis* is currently known from 20 occurrences in northwest Wyoming (Wyoming Natural Diversity Database 2003). The Global Heritage Status Rank for *P. absarokensis* is G2 (globally imperiled) as a result of its limited abundance and distribution (NatureServe 2003). Because of its small distribution and rarity, WYNDD has ranked *P. absarokensis* as S2 (imperiled) (Fertig and Heidel 2002). In Wyoming, plant species of special concern are also prioritized for conservation attention within the state on a three-part scale (low, medium, and high), based on global rankings. *Penstemon absarokensis* is ranked as medium priority for conservation attention in the state of Wyoming. Medium priority species are regional endemics ranked G3, G2, or G1 that receive some protection or have low threats or disjunct species that are poorly protected (Fertig and Heidel 2002).

Penstemon absarokensis is not known to occur in the other four states of USFS Region 2 (i.e., Colorado, Kansas, Nebraska, or South Dakota) and is thus not currently listed or ranked in those states (Colorado Natural Heritage Program 1999, Kansas Natural Heritage Inventory 2000, Nebraska Natural Heritage Program 2001, South Dakota Natural Heritage Program 2002).

Existing Regulatory Mechanisms, Management Plans, and Conservation Practices

Known populations of *Penstemon absarokensis* occur in a variety of land ownership and management contexts in Wyoming. Of the 20 occurrences of *P. absarokensis* in USFS Region 2, 18 occurrences are on USFS Shoshone National Forest lands, one occurrence is on Wyoming BLM lands, and one occurrence is on Wind River Indian Reservation lands (**Table 1**; Dorn 1989, Fertig 1998, Fertig 2000a, Wyoming Natural Diversity Database 2003). In the USFS Shoshone National Forest, at least 10 *P. absarokensis* occurrences are within the Washakie and Northern Absaroka Wilderness Areas, and three occurrences are in part within the proposed Grizzly Creek and Sheep Mesa Research Natural Areas (**Table 1**; Jones and Fertig 1999a, Jones and Fertig 1999b).

Although *Penstemon absarokensis* has been identified as a species of special concern, there are few existing regulatory mechanisms at the federal or state level to regulate its conservation. This species was previously considered a USFWS Category 2 plant (U.S. Fish and Wildlife Service 1985, USFWS 1996), but the category program has been eliminated and there is no legal protection for this species.

Penstemon absarokensis has been recently designated as a USFS Region 2 sensitive species. As a result, it may obtain some protection under various conservation strategies designed to protect plants and animals within federal lands. The USFS is directed to develop and implement management practices to ensure that sensitive species do not become threatened and endangered (U.S. Forest Service 1995). U.S. Forest Service policies require a Biological Evaluation to assess project impacts to sensitive species (U.S. Forest Service 1995). Although *P. absarokensis* is not specifically protected by the National Environmental Policy Act (U.S. Congress 1982), which requires an assessment of impacts from a proposed federal project to the environment, population locations are avoided when planning any projects (Houston personal communication 2003). U.S. Forest Service travel management plans may protect rare species by restricting vehicle use to established roads only (U.S. Forest Service and Bureau of Land Management 2000), and wilderness areas have restrictions on motorized travel (Office of the Secretary of the Interior 1964). In addition, the USFS prohibits the collection of sensitive plants without a permit (U.S. Forest Service 1995). Populations of *P. absarokensis* on proposed Research Natural Areas (RNAs) on USFS Region 2 lands will be protected as part of a national network to preserve representative areas for research, education, and maintenance of biological diversity (U.S. Forest Service 1997) once these areas have been approved as RNAs in the next planning cycle (K. Houston personal communication 2003). Although the Grizzly Creek and Sheep Mesa areas are proposed RNAs, USFS Shoshone National Forest resource specialists are currently managing that land for conservation by restricting land uses (e.g., cattle grazing, motorized travel) and minimizing new projects (e.g., trail building) (K. Houston personal communication 2003).

The Wyoming Natural Diversity Database has classified *Penstemon absarokensis* as a species of special concern due to its regional endemic status. Natural Heritage Program databases draw attention to species potentially requiring conservation strategies for long-term viability. However, these lists are not associated

Table 1. Summary information for *Penstemon absarokensis* occurrences in Wyoming. Includes county, Natural Heritage Program occurrence identifier, date of recorded observations, estimated abundance, estimated area, and land management context.

County	NHP Occurrence Identifier	Date of Recorded Observation	Estimated Abundance[1,2]	Estimated Area	Management Area/Ownership
Park	001	1982, 1989, 1996, 1997	205-350 plants in 8 out of 10 suboccurrences.	12 to 13 acres	USFS Shoshone NF, Wapiti RD - Washakie Wilderness and proposed Sheep Mesa RNA
	002	1982, 1989	No information on number of plants or suboccurrences.	NA	Wyoming Bureau of Land Management - Cody Field Office
	003	1981, 1987, 1988	About 12 plants in 1 out of 4 suboccurrences.	5 acres	USFS Shoshone NF, Wapiti RD - Washakie Wilderness
	004	1982, 1987, 1989, 1996, 1997	435-870 plants in 7 out of 26 suboccurrences.	52 acres	USFS Shoshone NF, Wapiti RD - North Absaroka Wilderness and proposed Grizzly Creek RNA
	005	1982, 1996, 1997	400-700 plants in 7 out of 9 suboccurrences.	8 acres	USFS Shoshone NF, Wapiti RD - Washakie Wilderness
	006	1981, 1989, 1996	6500-10000 plants in 12 out of 14 suboccurrences.	75 acres	USFS Shoshone NF, Wapiti RD - Washakie Wilderness
	008	1988, 1989, 1997	550-850 plants in 3 out of 9 suboccurrences.	25 acres	USFS Shoshone NF, Wapiti RD
	009	1988, 1997	25 plants; no information on number of suboccurrences.	NA	USFS Shoshone NF, Wapiti RD - Washakie Wilderness
	010	1988, 1989	100 plants; no information on number of suboccurrences.	NA	USFS Shoshone NF, Wapiti RD
	011	1988	Several hundred plants in 2 suboccurrences.	NA	USFS Shoshone NF, Wapiti RD
	013	1984, 1997	2000-3000 plants in 5 suboccurrences.	10 acres	USFS Shoshone NF, Wapiti RD - North Absaroka Wilderness
	014	1984, 1985	No information on number of plants in 2 suboccurrences.	NA	USFS Shoshone NF, Wapiti RD - North Absaroka Wilderness
	015	1996	250-300 plants; no information on number of suboccurrences.	2 to 3 acres	USFS Shoshone NF, Wapiti RD
	016	1997	No information on number of plants or suboccurrences.	NA	USFS Shoshone NF, Wapiti RD
	018	1996	No information on number of plants in 2 suboccurrences.	NA	USFS Shoshone NF, Wapiti RD - North Absaroka Wilderness

Table 1 (concluded).

County	NHP Occurrence Identifier	Date of Recorded Observation	Estimated Abundance[1,2]	Estimated Area	Management Area/Ownership
Park	019	1987	No information on number of plants or suboccurrences.	NA	USFS Shoshone NF, Wapiti RD - North Absaroka Wilderness
	020	1997	522-850 plants in 3 suboccurrences.	20 acres	USFS Shoshone NF, Wapiti RD - proposed Grizzly Creek RNA
	023	1987	No information on number of plants or suboccurrences.	NA	USFS Shoshone NF, Wapiti and Clarks Fork RD - North Absaroka Wilderness
	029	1989	No information on number of plants or suboccurrences.	NA	USFS Shoshone NF, Wapiti RD
Fremont	026	1947, 1989, 1991	20 plants; no information on number of suboccurrences.	NA	Wind River Indian Reservation

Source: Wyoming Natural Diversity Database, Laramie, WY (2003).

USFS – U.S. Forest Service NF – National Forest RNA – Research Natural Area

NHP – Natural Heritage Program RD – Ranger District NA – Not Available

BLM – Bureau of Land Management

[1]Abundance information (number of plants and suboccurrences) is based on estimates available in NHP element occurrence records. The estimate for the entire occurrence is presented if available, otherwise, the abundances presented are a sum of available suboccurrence abundance estimates. For more detailed abundance information, the reader is referred to NHP records.

[2]Suboccurrences are defined as subpopulations, colonies, or clusters as described by botanists reporting the element occurrence records.

with specific legal constraints, such as limits to plant harvesting or damage to habitats supporting these plants.

Penstemon absarokensis may be protected in part by the fact that it inhabits largely inaccessible terrain (Dorn 1989). However, existing regulations do not seem adequate to conserve *P. absarokensis* over the long term, considering that the abundance and distribution of this species is largely unknown and specific populations may possibly be threatened by human-related or environmental/biological threats.

Biology and Ecology

Classification and description

Systematics and synonymy

Penstemon absarokensis E.F. Evert is a member of the genus *Penstemon* of the family Scrophulariaceae (Figwort or Snapdragon) of phylum Anthophyta (flowering plants) (Evert 1984). *Penstemon* is one of the largest genera of the Scrophulariaceae in North America (approximately 270 species) stretching from Alaska to Guatemala, and the main center of diversity for this genus is Intermountain North America (Zomlefer 1994, Meyer et al. 1995, U.S. Department of Agriculture 2002). The genus *Penstemon* has been the focus of extensive research and horticultural efforts concerning germination, pollination, and genetics, although no research to date has focused on *P. absarokensis*.

The evolutionary origin and systematics of *Penstemon absarokensis* have not been studied (Dorn 1989). *Penstemon* species are arranged into different sections based largely on anther characteristics, such as dehiscence and pubescence (Dorn 1992, Nold 1999). The anthers of *P. absarokensis* do not dehisce their full length and are hairy on the side opposite dehiscence (Dorn 1992). *Penstemon absarokensis* is thought to be most closely allied to *P. paysoniorum* Keck, *P. glaber* Pursh, and *P. alpinus* Torr., suggesting that it may belong in the *Habroanthus* subgenus and *Glabri* section of *Penstemon* (Evert 1984, Nold 1999). This section is comprised of approximately 30 closely related species found throughout the Intermountain west (Holmgren 1979). There are no known synonyms for *P. absarokensis* (U.S. Department of Agriculture 2002). Common names for *P. absarokensis* include Absaroka Range beardtongue and Absaroka beardtongue.

History of species

Penstemon absarokensis was first collected by H. Dwight Ripley and Rupert Barneby in 1947 in Fremont County, Wyoming. Evert collected specimens in 1974 in Park County, Wyoming and described the species in 1984 (Evert 1984). The type specimen (E.F. Evert 4345) is housed at the Rocky Mountain Herbarium (Laramie, WY), and additional specimens are at New York Botanical Garden (Bronx, NY) and Missouri Botanical Garden (St. Louis, MO). Although the Fremont County occurrence of *P. absarokensis* is included in Evert's 1984 description and WYNDD (2003) occurrence records, the current consensus is that this population may represent a different, undescribed taxon based on habitat and morphological differences observed in the field (Dorn 1989, Dorn personal communication 2003, Evert personal communication 2003). This assessment report focuses mainly on the Park County occurrences of this species.

Twenty occurrences of *Penstemon absarokensis* have been recognized and observed by WYNDD since 1984; twelve occurrences have been surveyed since 1996. The Northern Absarokas and North Fork Shoshone River drainage were the focus of floristic surveys by Rocky Mountain Herbarium staff, graduate students, and associates from 1985 to 1997. Robert Dorn performed an extensive survey for this species on behalf of the USFWS in 1989. A fine filter analysis of Shoshone National Forest was completed by Welp and others in 2000. Walter Fertig and Erwin Evert have continued to provide occurrence information for *P. absarokensis* over the last decade. No in-depth demographic, ecological, or biological studies of this species have been initiated.

Morphological characteristic

Members of the Scrophulariaceae are characterized by colorful, zygomorphic flowers that often take the form of a sympetalous tube with petals flaring outward at the end. *Penstemon* species of the section *Glabri* are herbaceous perennials with showy, blue flowers (Evert 1984).

Penstemon absarokensis is a perennial herb from 7 to 18 centimeters (cm) tall, with several glabrous stems, except sometimes glandular in inflorescence (**Figure 2**; Evert 1984, Clark et al. 1989, Dorn 1989, Mills and Fertig 2000). The thickened, underground caudex has numerous cord-like fibrous roots that have been observed to ramify approximately 30 to 60 cm horizontally through the soil (Evert personal communication 2003). The leaves are elliptic to ovate, entire, somewhat fleshy, slightly glossy, have papillate margins, and are up to 9 cm long and 25 millimeters (mm) wide. The lower leaves are petioled, while the upper leaves are sessile. The leaves can be purple when young. The inflorescence is leafy, somewhat one-sided, with two to eight flowers crowded toward the tip of the stem. The corolla of the flowers is 14 to 33 mm long, with a purplish-blue tube, bright blue mouth, and slightly reflexed upper lobe. The flowers also have a sparsely bearded staminode that just reaches the orifice and short hairy anther sacs on stamens that project 2 to 4 mm beyond the orifice. The ragged-edged sepals are 7 to 12 mm long, with elongated tips often exceeding the basal portions in length. The dark brown seeds are ovoid, acuminate, narrowly winged, and 2 to 4 mm long.

Penstemon absarokensis is generally distinguished from other *Penstemon* species by its distinctive sepals, large glabrous flowers, relatively broad and fleshy thickened leaves, low stature, and distinctive shifting scree slope habitat (Evert 1984, Clark et al. 1989, Dorn 1992). Adequate identification of *P. absarokensis* requires the flowers (Welp et al. 2000). The low stature, tufted habit, and sepal shape of *P. paysoniorum* resembles *P. absarokensis*, but the former species has larger corollas, sepals, leaves, and anthers and is restricted to southwestern Wyoming (Evert 1984). *Penstemon glaber* and *P. alpinus* have a larger stature, more completely dehiscent anthers, different sepal shape, and internally pubescent corollas (Evert 1984). *Penstemon subglaber* and *P. cyaneus* have shorter sepals with a short, pointed tip (Mills and Fertig 2000). *Penstemon deustus* has a more whitish, smaller corolla, coarsely dentate leaves, and glabrous anthers (Dorn 1992). *Penstemon arenicola* has glabrous and more completely dehiscing anthers; *P. montanus* has woolly-hairy anthers; and *P. eriantherus* is hairy below the inflorescence (Dorn 1992). The Fremont County population of *P. absarokensis* may represent a different, undescribed taxon based on morphological differences observed in the field but not seen in pressed herbarium specimens, such as stem, leaf, and flower color (Dorn personal communication 2003). These differences may reflect phenotypic plasticity or genetic variation, and the taxonomic status of this population needs to be studied.

A technical description and an illustration of this species are presented in Evert (1984). Dorn (1992) includes a key to *Penstemon* in Wyoming. Additional photos and illustrations are available in Dorn (1989) and WYNDD online state species abstract (Wyoming Natural Diversity Database 2003).

(A)

Photograph by Walter Fertig. Reprinted with permission from: Fertig, W., C. Refsdal, and J. Whipple. 1994. Wyoming Rare Plant Field Guide. Wyoming Rare Plant Technical Committee, Cheyenne, WY.

(B)

Illustration by Walter Fertig. Reprinted with permission from: Fertig, W., C. Refsdal, and J. Whipple. 1994. Wyoming Rare Plant Field Guide. Wyoming Rare Plant Technical Committee, Cheyenne, WY.

Figure 2. *Penstemon absarokensis* photograph in its natural habitat (A), and illustration of its vegetative and reproductive structures (B).

Distribution and abundance

Distribution

Penstemon absarokensis is known only from the Absaroka Range of northwest Wyoming (**Figure 1**; U.S. Department of Agriculture 2002). **Figure 1** and **Table 1** present the distribution of *P. absarokensis* based on 20 element occurrence records reported by WYNDD (2003). Of the 20 occurrences of *P. absarokensis* in USFS Region 2, 18 occurrences are on USFS Shoshone National Forest lands, one occurrence is on Wyoming BLM lands, and one occurrence is on Wind River Indian Reservation lands (**Table 1**; Dorn 1989, Fertig 1998, Fertig 2000a, Wyoming Natural Diversity Database 2003).

Each of the 20 occurrences of *Penstemon absarokensis* may include several populations or colonies, or may represent only one part of a population. For example, Dorn (1989) described the distribution of this species as two extensive populations containing several sub-sites; one population extends 25 miles up the North Fork of the Shoshone River with 33 sites, and the other population extends about 20 miles up the South Fork of the Shoshone River with 10 sites. He estimated the occupied area of the North Fork population at 140 acres and the occupied area of the South Fork population at 50 acres (Dorn 1989). An additional population with 20 plants described from Fremont County may be a different, undescribed taxon based on habitat and morphological differences observed in the field (Dorn 1989, Dorn personal communication 2003, Evert personal communication 2003).

Aside from the Fremont County location, no populations of *Penstemon absarokensis* have been found north of the North Fork of the Shoshone River or south of the South Fork of the Shoshone River (Clark et al. 1989). Undiscovered populations of *P. absarokensis* may occur where suitable habitat of andesitic substrates extends into Yellowstone National Park (Evert personal communication 2003). Searches of areas with rhyolitic substrates in Yellowstone National Park have not yielded any populations.

Penstemon absarokensis has not been identified within the other states of USFS Region 2, Colorado, Kansas, Nebraska, or South Dakota (Colorado Natural Heritage Program 1999, Kansas Natural Heritage Inventory 2000, Nebraska Natural Heritage Program 2001, South Dakota Natural Heritage Program 2002).

Abundance

The extremely small, widely scattered occurrences and the rugged, inaccessible habitat of *Penstemon absarokensis* make estimating total abundance difficult. Surveys have occurred in selected areas of the North Fork Shoshone River drainage, but additional areas along the Absaroka Range (i.e., South Fork Shoshone River, Clarks Fork River) remain to be thoroughly investigated, and additional populations may exist (Welp et al. 2000, Evert personal communication 2003). There are currently 20 occurrence records for this species, and each occurrence record usually consists of several populations or colonies over a wide area several miles long. It is difficult to ascertain total abundance or population trends from the occurrence records because (1) specific populations or colonies are difficult to identify and demarcate because the spatial distribution of individuals and populations is scattered; (2) some researchers estimated population size based on potential habitat, while others provided more conservative census information; and (3) researchers presented ranges of population sizes (e.g., "individual populations ranged from 1 to 15 plants") or only presented information for one subpopulation cluster out of several, making it difficult to summarize the data. Dorn (1989) estimated the total abundance of *P. absarokensis* at 1,100 individuals for the entire North Fork population and 800 individuals for the South Fork population. Dorn (1989) also noted that, "There are undoubtedly many more plants in these areas." Mills and Fertig (2000) suggested that this species may number from 8,000 to 15,000 individuals total, based on survey work in 1997.

Population trends

There are no data on population trends for *Penstemon absarokensis*. Although individual population sizes have been occasionally estimated, multi-year population or demographic monitoring has not been initiated for any sites. Of the 20 known occurrences, all have been discovered or re-observed since 1984, and 12 locations have been re-observed since 1996 (Handley et al. 2000). Although locations were revisited over the years, abundance information was rarely recorded for specific populations or colonies. In addition, the size and extent of the colonies are difficult to define due to the scattered nature of the populations, making it difficult to extrapolate population trends from the information presented in the occurrence records. As discussed above, the abundance was greater in 1997 than 1989, but the cause of the difference may be attributed to different estimating techniques, survey intensity, time of year, or environmental conditions.

Overall, the abundance numbers of *Penstemon absarokensis* are thought to be relatively stable, because the isolation and ruggedness of the habitat minimizes human-related potential threats (Dorn 1989, Welp et al. 2000). The abundance probably varies from year to year, likely based on moisture availability and erosion patterns (Handley et al. 2000, Welp et al. 2000, Evert personal communication 2003). Evert (personal communication 2003) noted that when conditions are not optimal, some plants do not grow any aboveground stems or leaves for that growing season. In addition, he also observed that erosion gullies formed during thunderstorms can wash an entire group of plants down the slope. It is unknown if those plants can continue to grow from their rhizomatous-like roots. Additional populations may exist in areas that have not been thoroughly surveyed (Evert personal communication 2003).

Habitat characteristics

Penstemon absarokensis inhabits steep terrain in montane and subalpine zones of the Absaroka Range in Wyoming at elevations ranging from 1800 to 3044 meters (5,920 to 10,000 ft) (Evert 1984, Dorn 1989, Rosenthal 1998, Handley et al. 2000, Mills and Fertig 2000, Welp et al. 2000, Wyoming Natural Diversity Database 2003). **Table 2** presents habitat descriptions provided in element occurrence records for *P. absarokensis* (Wyoming Natural Diversity Database 2003). The Absaroka Range is a dissected volcanic plateau formed by volcanic accumulation (e.g., breccias) within the Middle Rocky Mountain physiographic province. The parent material includes Wapiti Formation (Eocene) and Quaternary landslide deposits (Dorn 1989, Rosenthal 1998). The mean annual precipitation in this area is 41 to 61 cm (16 to 24 inches [in]), and the climate includes humid winters and cool summers. Mean temperatures range from -14.5 to -1.1 ºC (6 to 30 ºF) in January and 2.2 to 22.2 ºC (36 to 72 ºF) in July (Dorn 1989). This region is especially rich in endemic plant species that are restricted to volcanic talus and scree slopes (Rosenthal 1998, Welp et al. 2000).

Penstemon absarokensis grows on loose, shifting scree of volcanic (andesite) substrates found on sparsely vegetated slopes, open rocky ridgetops, and rarely river gravel bars (Evert 1984, Dorn 1989, Wyoming Natural Diversity Database 2003). The soils are poorly developed and derived directly from the parent material; often the fine, loose scree is only a few inches thick on top of bedrock (Evert personal communication 2003). These dry, brownish or reddish, sandy-clay or gravel-clay, andesitic soils can sometimes have a surface layer of irregular rock or gravel. Descriptions of microhabitats fall into three main categories: (1) andesite talus and scree slopes below summit rim of crumbly, andesite cliffs; (2) andesite bedrock outcrops or ridgecrests above loose, sandy-clay slopes; and (3) gravel bars beside streams (Evert 1984, Dorn 1989, Wyoming Natural Diversity Database 2003). The populations in Fremont County grow in sandy soil from yellowish-red sandstone, and this population is hypothesized to be a different taxon (Dorn 1989). The taxonomic status of this population is unknown and needs to be studied (Dorn personal communication 2003).

Because *Penstemon absarokensis* occurs along an elevational gradient, the microclimates can vary from one population location to another. Generally, slopes with *P. absarokensis* range from 40 to 55 degrees, with a south, southwest, or occasionally west facing aspect (Dorn 1989). The temperature may be increased by the dark color of the substrate (Dorn 1989). Although the steep slopes may decrease effective precipitation due to runoff (Dorn 1989), the fine-grained scree soils that *P. absarokensis* prefers may act as a mulch to hold moisture (Mills and Fertig 2000). Thunderstorm events can cause severe erosion and gullying on these steep slopes (Evert personal communication 2003).

The slopes with *Penstemon absarokensis* are considered sparsely vegetated slopes (i.e., "Sparse Vegetation" subclass [Grossman et al. 1998]) rather than representatives of a distinct plant community (Jones and Fertig 1999a, 1999b, 1999c). The talus/scree communities in this habitat tend to consist of scattered patches of plants, and *P. absarokensis* does not have any consistently associated plant species (Evert personal communication 2003). Reported vegetation cover on these slopes ranges from 5 to 20 percent (up to 30 to 70 percent), bare soil cover is about 35 percent, and rock cover ranges from 25 to 90 percent (Wyoming Natural Diversity Database 2003). Trees on these slopes and ridgecrests are occasional and scattered and can include *Pseudotsuga menziesii* (Douglas fir), *Pinus flexilis* (limber pine), *Pinus albicaulis* (whitebark pine), or *Picea engelmannii* (Engelmann spruce). Common grass and shrub species can include *Leucopoa kingii* (spike fescue), *Pseudoroegneria spicata* (bluebunch wheatgrass), *Achnatherum hymenoides* (Indian ricegrass), *Elymus elymoides* (squirreltail), and *Artemisia tridentata* ssp. *vaseyana* (mountain big sagebrush). Jones and Fertig (1999a, 1999b, 1999c) analyzed vegetation communities in the Shoshone National Forest and described several communities adjacent to talus/scree slopes: Douglas-fir/Shiny-leaf Spiraea (*Pseudotsuga menziesii*/*Spiraea betulifolia* var. *lucida*) woodlands (*Pseudotsuga menziesii* forest

Table 2. Habitat information for 20 *Penstemon absarokensis* occurrences in Wyoming. Includes county, occurrence identifier, elevation range, general habitat description, landscape context, and associated plant species information.

County	Occurrence Identifier	Elevation Range (ft)	General Habitat Description	Landscape Context	Associated Plant Species
Park	001	7,000 to 10,000	Three main habitat types: (1) In patches on steep, south-facing andesite talus and scree slopes below summit rim of andesite cliffs at timberline; community of scattered forbs and bunchgrasses with occasional trees; (2) Semi-barren andesite gravel-clay slopes below subalpine andesite cliffs at timberline with vegetative cover about 10 to 20 percent; (3) Occasional on hard, andesite bedrock outcrops above steep, south-facing slopes of loose, sandy-clay.	Slopes along trail and ridges; crest of ridge; about 0.5 air miles from campground and 0.6 air miles from highway.	*Artemisia michauxiana*, *Astragalus vexilliflexus*, *Chaenactis alpina*, *Cirsium eatonii*, *Cymopterus nivalis*, *Delphinium bicolor*, *Elymus elymoides*, *Elymus spicatus*, *Haplopappus acaulis*, *Leucopoa kingii*, *Lomatium cous*, *Lupinus argenteus*, *Oenothera caespitosa*, *Oryzopsis hymenoides*, *Penstemon montanus*, *Phacelia hastata*, *Physaria didymocarpa*, *Picea engelmannii*, *Pinus albicaulis*, *Townsendia condensata* var. *anomala*
	002	Not Available (NA)	Talus and scree slopes of volcanic rock.	On ridge west of creek, about 5 air miles from town; on foothills on north side of mountain, about 3 air miles from reservoir.	*Artemisia tridentata*, *Cryptantha celosioides*, *Elymus smithii*, *Oxytropis lagopus*, *Physaria didymocarpa*
	003	7,400 to 9,800	Sparsely vegetated coarse volcanic soil on south-facing slopes and open rocky ridgetops with scattered trees.	North slopes of ridge from head of creek to ridgeline; on ridgecrests; about 3 to 5 miles from highway.	*Delphinium bicolor*, *Penstemon montanus*, *Pinus flexilis*, *Pseudotsuga menziesii*, *Trifolium dasyphyllum*
	004	6,400 to 8,800	Two main habitat types: (1) Gravel bars in and beside streams; (2) Steep south and east-facing slopes of dry, loose, brown andesite clay-gravel below andesite cliffs; substrate dry, brownish sandy-clay with surface layer of fine bluish-brown irregular volcanic gravel, loose andesite gravel and scattered rock, and exposed bedrock; community of scattered bunchgrasses or sagebrush on open slopes within woodlands; vegetation cover as low as 5 percent.	Along ridges on east and west side of creek; along ridgecrest.	*Antennaria flagellaris*, *Artemisia tridentata*, *Astragalus vexilliflexus*, *Cymopterus acaulis*, *Cymopterus terebinthinus*, *Elymus spicatus*, *Ipomopsis spicata* var. *robruthiorum*, *Leucopoa kingii*, *Lomatium attenuatum*, *Machaeranthera canescens*, *Minuartia nuttallii*, *Oryzopsis hymenoides*, *Phacelia hastata*, *Pinus flexilis*, *Pseudotsuga menziesii*, *Stephanomeria runcinata*, *Townsendia condensata* var. *anomala*, *Zauschneria garrettii*
	005	6,300 to 8,300	Two main habitat types: (1) Upper slopes and gently south-dipping summit flats of andesite volcanic ridges. Community of scattered bunchgrasses and low forbs in openings of woods; (2) Creek bottom/ riparian community of diverse species assemblage.	Ridge east of creek, about 0.5 air miles from highway; north-south trending ridge about 1.1 miles from highway; south end of ridge, about 0.3 to 0.6 air miles from highway.	*Astragalus vexilliflexus*, *Chaenactis douglasii*, *Gayophytum diffusum*, *Haplopappus acaulis*, *Physaria didymocarpa*, *Townsendia condensata* var. *anomala*, *Stephanomeria runcinata*, *Zauschneria garrettii*

Table 2 (cont.).

County	Occurrence Identifier	Elevation Range (ft)	General Habitat Description	Landscape Context	Associated Plant Species
	006	6,600 to 10,200	Two main habitat types: (1) Steep, southwest-facing slopes and ridgecrests of brown andesite volcanic clay soil with surface of irregular gravel. Bare soil cover ca 35 percent and vegetative cover ca 25 to 30 percent, but occasionally as high as 50 to 70 percent; foothills community of scattered bunchgrasses and low forbs with occasional sagebrush in openings in woods; (2) Semi-bare eroded slopes of light brownish-white clay-gravel volcanic soil with surface rock derived from andesite at base of cliffs just below timberline. Absent from adjacent turf communities.	Ridge between creeks, extending from highway 5 miles to north side of mountain.	*Antennaria microphylla*, *Arenaria hookeri*, *Arenaria nuttallii*, *Artemisia nova*, *Artemisia frigida*, *Artemisia tridentata*, *Astragalus vexilliflexus*, *Castilleja nivea*, *Chaenactis douglasii*, *Chrysothamnus nauseosus*, *Cirsium eatonii*, *Cryptantha celosioides*, *Cymopterus nivalis*, *Cymopterus terebinthinus*, *Delphinium bicolor*, *Elymus spicatus*, *Eriogonum brevicaule*, *Eriogonum pauciflorum*, *Ipomopsis spicata* var. *robruthiorum*, *Lupinus argenteus*, *Oryzopsis hymenoides*, *Penstemon arenicola*, *Penstemon eriantherus*, *Phacelia hastata*, *Pseudotsuga menziesii*, *Pinus flexilis*, *Stephanomeria runcinata*, *Townsendia condensata* var. *anomala*, *Trifolium dasyphyllum*
	008	7,520 to 9,480	Three main habitat types: (1) Steep upper slopes just below palisades rimrock in loose, reddish gravel or sandy-clay brown andesite; occurs on rocky and loose sandy soils in woods; (2) Barren, west-facing eroded faces of brown andesite in semi-open tree/bunchgrass communities on loose, shifting, sandy soils with little rock cover of hard, dry clays with surface gravel; (3) Steep, sparsely vegetated slopes on rocky volcanic soil.	Northwest slope of mountain; ridges south of creek; west slope of mountain; east side of river.	*Arenaria hookeri*, *Artemisia tridentata*, *Cryptantha celosiodes*, *Cymopterus evertii*, *Elymus spicatus*, *Erigeron compositus*, *Lupinus argenteus*, *Mertensia viridis*, *Oryzopsis hymenoides*, *Pinus flexilis*, *Pseudotsuga menziesii*, *Ribes cereum*, *Silene menziesii*, *Solidago multiradiata*
	009	NA	Very sparsely vegetated coarse volcanic soil on steep slopes and windswept ridges in openings in forest.	In small area along trail near windswept summit ridge.	*Pinus flexilis*, *Pseudotsuga menziesii*
	010	NA	Open, steep, very sparsely vegetated volcanic scree.	Along trail on ridge.	*Hulsea algida*, *Rubus idaeus*
	011	NA	Rocky, sparsely vegetated volcanic soil on summits and adjacent upper slopes of knolls.	North slope of mountain near head of creek.	Not Available
	013	6,500 to 7,400	South and west-facing andesite gravel slopes and loose sandy-clay slopes (with low gravel cover) in openings in grove; community of scattered grasses with 5 to 10 percent vegetation cover. Rock cover ranges from 25 to 90 percent; open dry slopes and ridges with scattered trees.	Ridge west of creek about 1-2 air miles from highway; ridge north of mountain about 0.1 to 1 air miles from highway.	*Astragalus vexilliflexus*, *Elymus spicatus*, *Lomatium cous*, *Oryzopsis hymenoides*, *Physaria didymocarpa*, *Pinus flexilis*, *Pseudotsuga menziesii*, *Townsendia condensata* var. *anomala*
	014	NA	Just below lava cliffs on loose, rocky, shifting scree on open, south-facing slopes.	On ridge about 1.5 to 2.5 air miles from campground and highway.	Not Available

Table 2 (concluded).

County	Occurrence Identifier	Elevation Range (ft)	General Habitat Description	Landscape Context	Associated Plant Species
	015	6,600 to 7,000	Steep south and southwest-facing slopes of loose, gray-brown andesite clay-gravel with large patches of bare soil. Rock cover high in some sites (especially below cliffs), but otherwise lower than on lower slopes. Found in low forb and bunchgrass community with 5 to 10 percent total vegetative cover in openings in forest.	North-south trending ridge on west side of creek, about 0.3 air miles from highway.	*Artemisia michauxiana*, *Astragalus vexilliflexus*, *Cymopterus nivalis*, *Elymus spicatus*, *Minuartia nuttallii*, *Phacelia hastata*, *Phacelia sericea*, *Pseudotsuga menziesii*, *Stephanomeria tenuiflora*, *Townsendia condensata* var. *anomala*
	016	NA	Scattered rocky ridges with rocky outcrops amid forested, north-facing slopes.	From trailhead to peak, about 2.5 air miles from town.	Not Available
	018	NA	Ridge top with rocky, volcanic slopes.	On ridge on west side of creek on southeast flank of mountain.	Not Available
	019	NA	Loose soil in open rocky areas.	North-south trending ridge between creeks, about 5 air miles from highway.	Not Available
	020	7,200 to 7,440	South and west-facing steep to gentle slopes of loose, shifting, brown andesite sandy-clay with surface of small rock and gravel. Community of sagebrush or scattered bunchgrasses and cushion plants in sparsely vegetated openings within woods.	On ridge between peaks; about 1 air mile from highway and 5 air miles from town.	*Artemisia tridentata*, *Elymus spicatus*, *Leucopoa kingii*, *Lomatium attenuatum*, *Lupinus argenteus*, *Penstemon eriantherus*, *Physaria didymocarpa*, *Pinus flexilis*, *Pseudotsuga menziesii*, *Townsendia condensata* var. *anomala*
	023	NA	Open rocky ridgetop with trees.	On ridge about 13 air miles from highway.	*Picea engelmannii*, *Pinus albicaulis*
	029	NA	No information on number of plants or suboccurrences.	Along creek about 1.5 to 2 air miles from highway.	Not Available
Fremont	026	NA	Loose, fine gravelly-sandy reddish colluvium.	Foothills on the west bank of river.	*Rhus trilobata*

Source: Wyoming Natural Diversity Database, Laramie, WY (2003).

alliance I.A.8.N.c.22), Idaho fescue-King spikefescue (*Festuca idahoensis*-*Leucopoa kingii*) grasslands (*Festuca idahoensis* alpine herbaceous alliance V.A.5.N.h.2), and Mountain big sagebrush/Idaho fescue (*Artemisia tridentata* var. *vaseyana*/*Festuca idahoensis*) shrublands (*Artemisia tridentata* ssp. *vaseyana* shrub herbaceous alliance V.A.7.N.e.6), among others (Grossman et al. 1998).

Other plant species that occur with *Penstemon absarokensis* are low or cushion forbs, bunchgrasses, and shrubs (**Table 2**). Reported co-occurring species include: *Achillea millefolium*, *Antennaria microphylla*, *Arenaria hookeri*, *Arenaria nuttallii*, *Artemisia frigida*, *Artemisia michauxiana*, *Artemisia nova*, *Astragalus kentrophyta*, *Astragalus vexilliflexus*, *Castilleja nivea*, *Chaenactis alpina*, *Chaenactis douglasii*, *Chrysothamnus nauseosus*, *Cirsium eatonii*, *Cryptantha celosioides*, *Cymopterus acaulis*, *Cympoterus nivalis*, *Cymopterus terebinthinus*, *Delphinium bicolor*, *Erigeron compositus*, *Eriogonum brevicaule*, *Eriogonum ovalifolium*, *Eriogonum pauciflorum*, *Eriogonum spicatus*, *Haplopappus acaulis*, *Hulsea algida*, *Lomatium cous*, *Lupinus argenteus*, *Machaeranthera canescens*, *Mentzelia albicaulis*, *Mertensia viridis*, *Minuartia nuttallii*, *Oenothera caespitosa*, *Oxytropis lagopus*, *Penstemon arenicola*, *Penstemon deustus*, *Penstemon eriantherus*, *Penstemon montanus*, *Phacelia hastata*, *Phacelia sericea*, *Physaria didymocarpa*, *Poa secunda*, *Psoralea* spp., *Ribes cereum*, *Rubus idaeus*, *Silene menziesii*, *Solidago multiradiata*, *Stephanomeria runcinata*, *Stephanomeria tenuiflora*, *Trifolium dasyphyllum*, *Vicia americana*, and *Zauschneria garrettii*. Other rare species, such as *Cymopterus evertii*, *Ipomopsis spicata* var. *robruthiorum*, *Lomatium attenuatum*, and *Townsendia condensata* var. *anomala*, are also associated with *P. absarokensis* and scree habitats.

Reproductive biology and autecology

Reproduction

Details concerning the breeding system of *Penstemon absarokensis* are largely unknown. In this section, we mainly present information from other rare, endemic congeners in the subgenus *Habroanthus* in an effort to elucidate potential reproductive mechanisms for *P. absarokensis*.

Penstemon absarokensis produces an inflorescence with 2 to 18 blue, tubular flowers from mid-June through July, and seeds mature several weeks later. The capsules dehisce nearly the entire length, and the seeds are narrowly winged, 2 to 4 mm long, (Evert 1984, Dorn 1989). There is no information concerning the extent of vegetative reproduction. Dorn (1989) presumed that all reproduction occurred by seed, but Evert (personal communication 2003) hypothesized that vegetative reproduction could take place because he observed that the roots of some individuals spread and seemed to be producing ramets. *Penstemon haydennii* (on sandy blowout habitats) and *P. debilis* (on loose shale scree) reproduce primarily by rhizomes as a response to replace ramets damaged by continuously shifting terrain (Flessner 1989, McMullen 1998).

Many *Penstemon* species exhibit both self- and cross-pollination, but it is unknown if *Penstemon absarokensis* is partially or wholly self-incompatible. For example, *P. bicolor*, *P. debilis*, *P. haydennii*, *P. lemhiensis*, and *P. penlandii* are largely outcrossers with some self-pollination, whereas *P. procerus* is mainly self-pollinated (Flessner and Stubbendieck 1992b, McMullen 1998, Tepedino et al. 1999, Glenne 2003). There have also been no studies on other vital aspects of *P. absarokensis* reproduction, such as which insect species are effective pollinators, germination requirements and success, demographic parameters, or genetic aspects of reproduction.

Observations of *Penstemon absarokensis* indicate that most populations had a mix of vegetative, flowering, or fruiting individuals. The proportions of each depended on the date of the observation; the reported percentage of flowering individuals ranged from 10 to 90 percent at different sites and dates (Dorn 1989, Wyoming Natural Diversity Database 2003). Juvenile or young individuals comprised up to 10 percent of some populations, indicating that successful recruitment from seed was occurring at these sites (Dorn 1989, Evert personal communication 2003, Wyoming Natural Diversity Database 2003). One occurrence record reported that many fruits at that location were aborted (Wyoming Natural Diversity Database 2003).

Life history and strategy

There have been no studies on the life history, demography, fecundity, or longevity of *Penstemon absarokensis*. In general, this species is a perennial forb growing in dry, sparsely vegetated, erodible environments. The hypothesized life cycle of this perennial plant is depicted in **Figure 3**. The rates of growth, survival, recruitment, dispersal, and longevity are unknown. Although *Penstemon* species in section *Glabri* tend to have short life spans in their inhospitable environments, some *Penstemon* individuals can persist for five to ten years in garden environments (Nold 1999).

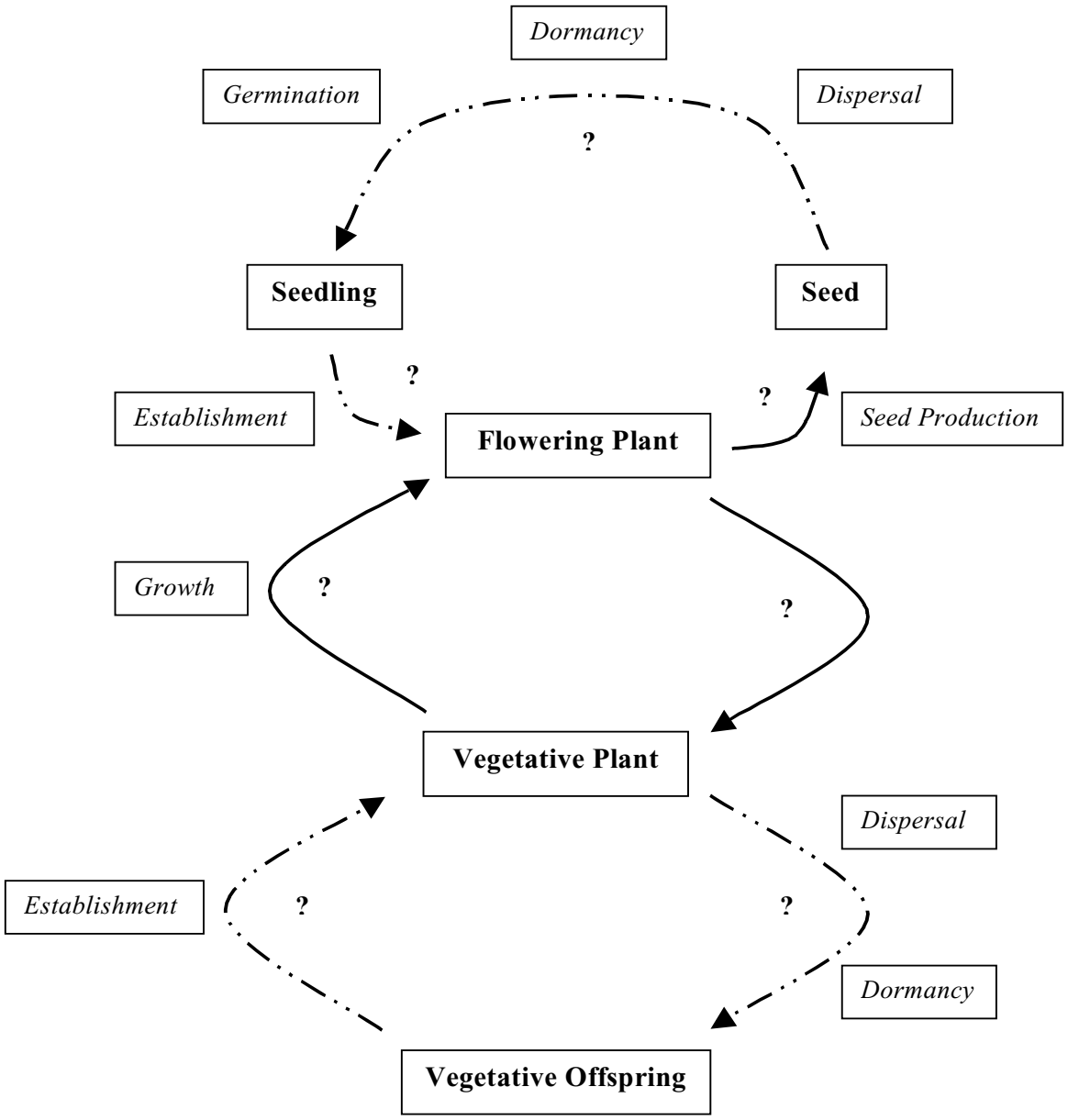

Figure 3. Schematic representation of the hypothesized life cycle of *Penstemon absarokensis*. Dotted lines indicate juvenile phases of the life cycle and solid lines indicate mature phases of the life cycle. The extent of sexual and vegetative reproduction is unknown for this species. Rates of growth, dispersal, and seed production are also unknown and are indicated by "?". Figure adapted from Grime (1979).

The competitive relationships, ecological limitations, and reproductive biology of *Penstemon absarokensis* are really not adequately known to assess the life history and strategy of this species based on vegetation strategies described by Grime (1979). Stress-tolerant, or s-selected species, have a perennial life history, an ability to withstand harsh or unproductive environments, and a capability to access resources with well-developed roots (Grime 1979, Barbour et al. 1987). Ruderal, or r-selected species, can exploit low stress, high disturbance environments by minimizing vegetative growth and maximizing reproductive output (Grime 1979, Barbour et al. 1987). Good competitors, or c-selected species, tend to be robust, perennial plants that can maximize resource capture in relatively undisturbed conditions and allocate resources to growth (Grime 1979, Barbour et al. 1987). Dorn (1989) described the successional role of *P. absarokensis* as "An exploiter of barren sites so a pioneer species." (p. 8). Although *P. absarokensis* may be considered a "pioneer" species because it exploits barren sites, the extent to which this species can actually colonize disturbed areas is unknown (Handley et al. 2000, Mills and Fertig 2000). The caudex and fleshy roots of *P. absarokensis* presumably aid this plant to access water resources, anchor it in loose soil, store resources, mediate the effects of disturbance, and perhaps function in vegetative reproduction. It is possible that this species could be considered a stress-tolerant (s-selected) species with potential capabilities to exploit ruderal environments.

Several *Penstemon* species in USFS Region 2 (e.g., *P. debilis*, *P. bicolor*, *P. palmeri*) are early successional species that can colonize disturbed areas (McMullen 1998, Glenne 2003). For example, *P. debilis*, a rare endemic of oil shales in Colorado, inhabits barren, loose, shifting substrates on steep slopes, somewhat similar to the barren, loose, shifting volcanic substrates of *P. absarokensis*. The shaley slopes of *P. debilis* habitat are characterized by continual disturbance, unstable surface layers, minimal vegetation cover, and poorly developed surface soils with high rock fragment content. As a result, McMullen (1998) described *P. debilis* as a pioneer species because it disperses to recently disturbed areas, flourishes, and then is extirpated if soil conditions become stable. The optimal habitat conditions or successional stage for *P. absarokensis* or other issues related to competitive abilities and ecological tolerances have not been studied.

Pollinators and pollination ecology

The pollination biology of other *Penstemon* species has been studied in a multitude of field and greenhouse studies (e.g., Scogin and Freeman 1987, Reid et al. 1988, Flessner and Stubbendieck 1992b, Clinebell and Bernhardt 1998, Mitchell et al. 1998, Nielson 1998, Nold 1999, Lange and Scott 1999, Tepedino et al. 1999, Mitchell and Ankeny 2001, Reed 2002, Glenne 2003), but the specific pollination mechanisms for *P. absarokensis* are unknown.

In general, penstemons are well equipped with colorful, tubular flowers that attract pollinators such as hummingbirds, butterflies, bees, wasps, moths, and flies. Although there are exceptions, red penstemon flowers with narrow corollas are generally associated with hummingbird pollination, while blue, pink, and purple penstemon flowers with wide-lobed corollas tend to be insect pollinated (Tepedino et al. 1999). *Penstemon absarokensis* is most likely insect pollinated, because its inflorescence consists of several blue, bilaterally symmetric flowers on an erect stem. Common visitors to *Penstemon* flowers in Colorado, Nebraska, and Nevada (e.g., *P. bicolor*, *P. debilis*, *P. haydennii*, *P. harringtonii*) include a wide variety of bees, wasps, flies, butterflies, and beetles (Crosswhite and Crosswhite 1966, McMullen 1998, Nielson 1998, Tepedino et al. 1999, Glenne 2003). However, the most consistent and effective pollinators of these *Penstemon* species, those pollinators that actually transport pollen to contact reproductive structures, include bees of the Megachilidae family (e.g., *Atoposmia* spp., *Osmia* spp.,), Apidae family (e.g., *Bombus* spp.), and one pollen-collecting wasp species of the Masaridae family (*Pseudomasaris vespoides*). Some of these bee species seem to specialize on visiting blue and purple flowers of *Penstemon* species (Crosswhite and Crosswhite 1966, Nielson 1998). *Pseudomasaris vespoides* is considered an oligolege on *Penstemon* species because it has behavioral and morphological specializations to collect pollen and efficiently pollinate *Penstemon* flowers (Tepedino et al. 1999). Based on flower morphology, it is very likely that these insect species are also among the most important pollinators for *P. absarokensis* (Tepedino personal communication 2003). Effective pollination depends on the timing of reproductive maturity of anthers and stigmas, activity and behavior of pollinators, and flower and insect morphologies. Unidentified bees were seen visiting the flowers of *P. absarokensis* by Dorn (1989), but the effectiveness of those pollinators is unknown. Studies on other *Penstemon* species in USFS Region 2 and adjacent areas have found that reproductive success is generally not limited by pollinators (McMullen 1998, Nielson 1998, Tepedino et al. 1999, Reed 2002, Glenne 2003).

Important issues related to the pollination of rare plants that need to be researched for *Penstemon absarokensis* include the identity and effectiveness of pollinators, the role of plant density on pollinator behavior, pollinator limitations to reproduction, annual fluctuations in pollinator activity and timing of flowering, and genetic implications of cross-pollination. For example, the abundance of different species of pollinators fluctuates from year to year, and the timing of pollinator activity does not always match the reproductive timing of flowers (Nielson 1998, Tepedino et al. 1999). As a result, conservation of the full complement of pollinators is an important feature of a rare plant species conservation plan. In addition, researchers have discovered that distance to other flowering individuals and plant population densities may affect the attraction and behavior of pollinators (Mitchell and Ankeny 2001). In contrast, Nielson (1998) failed to find greater seed set for *P. harringtonii* in dense aggregates due to greater pollinator visitation. Her research found that solitary individuals produced more fruits per plant than plants in aggregates. *Penstemon absarokensis* tends to be widely scattered, and this distribution could potentially have implications for the attraction of pollinators or reproductive success.

Dispersal mechanisms

Details of seed dispersal mechanisms in *Penstemon absarokensis* are not known (Handley et al. 2000). Similar to the capsules of *P. debilis* and *P. bicolor* (Nielson 1998, Glenne 2003), it is likely that the capsules of *P. absarokensis* split or explode open at maturity and drop seeds near the parent plant when jostled by wind or animals. The small, narrowly winged seeds are likely dispersed downslope by erosion, wind, or water (Dorn 1989, Evert personal communication 2003).

In addition, Evert (personal communication 2003) saw evidence where a thunderstorm event had created an erosional gully and washed away a cluster of individuals. These erosional events could disperse vegetative pieces (rhizomes/ramets), as well as seeds. It is likely that the populations of *Penstemon absarokensis* on gravel bars in riparian areas were founded by propagules that washed down the slope and became established (Evert personal communication 2003). Presumably, dispersal success depends on wind patterns, topographic heterogeneity, precipitation amount and frequency, depth of eroded material, and availability of suitable "safe" sites for seed germination.

Seed viability and germination requirements

Little information is available concerning the fertility, seed viability, and germination requirements of *Penstemon absarokensis* in the field. Because *Penstemon* species are desirable horticultural species, much work has been performed with the germination requirements of these showy ornamentals (e.g., Flessner 1989, Kitchen and Meyer 1992, Meyer and Kitchen 1992, Meyer and Kitchen 1995, Meyer et al. 1995, Nielson 1998, Nold 1999). In general, penstemons are easy to grow in the garden and are prolific seed producers (Nold 1999). *Penstemon* species appear to have evolved habitat-specific germination regulation strategies, such as moist cold stratification to break dormancy for high elevation species and scarification to remove thick coats of seeds in buried seed banks (Flessner 1989, Kitchen and Meyer 1992, Meyer and Kitchen 1992, Meyer and Kitchen 1995, Meyer et al. 1995). Horticultural experience indicates that *P. absarokensis* can be germinated by sowing seeds on a planting mix with barely any cover for 8 weeks at 4 ºC (40 ºF) and then moving to 10 to 16 ºC (50 to 60 ºF) with light (Swayne 2000). Seeds that were collected from a *P. absarokensis* population before extirpation during highway construction were planted in a garden in Scotland and have flourished for many years (Evert personal communication 2003). Transplanted seedlings were used in a *P. haydenii* recovery program, because direct seeding into suitable habitat was not successful (Stubbendieck et al. 1993).

Phenotypic plasticity

Phenotypic plasticity is demonstrated when members of a species vary in morphology, phenology, or other attributes, with change in light intensity, latitude, elevation, or other macrosite or microsite characteristics. Elevation and aspect seem to affect the timing of flowering; plants at lower elevations and on south facing slopes tend to flower earlier (Dorn 1989).

Cryptic phases

Cryptic phases during the life cycle of *Penstemon absarokensis* could include dormant individuals or overwintering seeds in the soil. Evert (personal communication 2003) observed entire populations that did not produce aboveground growth for a growing season if conditions were not optimal, but then reappeared in subsequent years. Failure to produce aboveground growth or senescing without flowering

during droughts or other inadequate conditions is also seen with other perennial species, including other *Penstemon* species such as *P. harringtonii* (Buckner 1991). It is not known whether a persistent seed bank exists or what the extent of seed dormancy is for *P. absarokensis*. Seed dormancy can be an important adaptation for plant populations to exploit favorable conditions in harsh environments (Kaye 1997).

Mycorrhizal relationships

The existence of mycorrhizal relationships with *Penstemon absarokensis* was not reported in the literature. Flessner and Stubbendieck (1992a) investigated the mycorrhizal associations with *P. haydennii* on sandy prairie soils in Nebraska. They discovered that mychorrhizal levels were naturally low in the shifting sands and concluded that maintaining mychorrhizal associations was a low conservation priority for this species. It is possible that mycorrhizal levels in the dry, shifting scree slopes with *P. absarokensis* are also low.

Hybridization

There were no reported occurrences of hybridization with *Penstemon absarokensis*, although other *Penstemon* species occur within the range. In four of the 20 element occurrence records for *P. absarokensis*, co-occurring species included *P. arenicola*, *P. eriantherus*, and/or *P. montanus* (Wyoming Natural Diversity Database 2003). In addition, two element occurrence records noted that *P. absarokensis* "Appears to be replaced by *Penstemon deustus* on lower, rockier slopes." and "Often replaced by *Penstemon arenicola* in ridge saddles."(Wyoming Natural Diversity Database 2003). However, the extent to which observers were looking for hybrids in regions where other *Penstemon* species occurred is not known. In addition, the flowering phenology for these species has not been researched in order to assess the potential for synchronous flowering and possible hybridization between these species.

Current and historical hybridization (leading to speciation) has been demonstrated for other *Penstemon* species, including species from different sections (Crosswhite 1965, Wolfe and Elisens 1994, Wolfe and Elisens 1995, Wolfe et al. 1998a, 1998b, Chari and Wilson 2001, Wilson and Valenzuela 2002, Glenne 2003). The genus *Penstemon* has the second largest number of hybrids of any genera in the Intermountain Region of the United States (Ellstrand et al. 1996). Glenne (2003) identified several areas in Nevada where the rare *P. bicolor* hybridizes with the more common *P. palmeri*. The spread of *P. palmeri* caused by human-related and natural disturbances has increased the contact between these two species and potentially threatens the existence of *P. bicolor* through hybridization. Hybridization, whether natural or anthropogenic, can lead to rare species extinction when a more abundant congener genetically swamps the rare species, when hybrid offspring outcompete the rare parent species, or when the production of hybrid seed reduces reproductive success of the rare species (Glenne 2003). Because *P. absarokensis* does come in contact with more common *Penstemon* species at some locations, the occurrence of hybridization or the existence of pre-zygotic or post-zygotic isolating mechanisms is an important area of research for this species.

Demography

Life history characteristics

There is no information regarding population parameters or demographic features of *Penstemon absarokensis*, such as metapopulation dynamics, life span, and age at maturity, recruitment, and survival. Refer to Figures 4 and 5 for envirograms outlining resources and malentities potentially important to *P. absarokensis*.

Life cycle diagram and demographic matrix. Demographic parameters, such as recruitment and survival rates, have not been investigated for *Penstemon absarokensis*, and so there are no definitive data regarding the vital rates that contribute to species fitness. Although stage-based models based on population matrices and transition probabilities can be used to assess population viability (Caswell 2001), adequate quantitative demographic data are needed for input into the model. A corresponding life cycle diagram could also be constructed if data were available. A life cycle diagram is a series of nodes that represent the different life stages connected by various arrows that represent the vital rates (i.e., survival rate, fecundity). *Penstemon grandiflorus*, a perennial prairie species, exists as a rosette for the first year, flowers in subsequent years, and may persist as a rosette or flowering individual depending on conditions and resources stored in the woody caudex (Davis et al. 1991, 1995, 1997). The specific events in the life cycle or longevity of *P. absarokensis* are unknown. For *P. absarokensis*, the stages that could potentially be incorporated into a demographic matrix include seed, seedling, vegetative individuals, reproductive adults, and dormant individuals (**Figure 3**).

Presumably, there are seeds or propagules in the soil at existing population locations of *Penstemon absarokensis*. The probability of germination and subsequent establishment depends on the longevity of these propagules and whether appropriate environmental conditions exist for germination and growth. Seeds that germinate will grow, assimilate resources, and become established plants. Growth rates may be influenced by the intensity and frequency of disturbance and availability of resources, such as space, light, moisture, and nutrients. If appropriate conditions exist, then individuals in the population can produce flowers. Davis et al. (1991) found that larger, more established *P. grandiflorus* individuals were more likely to flower than smaller individuals. Successful seed set will depend on the rate of pollen and ovule formation, pollination, fertilization, and embryo development. If adequate conditions do not exist, then plants may exist as vegetative individuals until dormancy at the end of the season and senesce before flowering. Fecundity rates depend on the production of seeds and the percentage of those seeds that overwinter and survive to germination the next year.

Population viability analysis. In order to initiate a population viability analysis for *Penstemon absarokensis*, the rates of germination, fecundity, survival, and other important parameters require additional study.

Ecological influences on survival and reproduction

No information exists about the ecological factors affecting growth and establishment of *Penstemon absarokensis*. The long-term persistence of this species at a location most likely depends on a range of ecological influences on reproduction and growth, including climatic fluctuations, microsite conditions (e.g., moisture), availability of suitable germination sites, pollinator activities, disturbance patterns, and interspecific competition. In addition, the time since establishment of a population and the age of the individuals in that population, hence plant size and root growth, may mediate the effect of disturbances. For instance, fire and gopher activity differentially affected the growth of *P. grandiflorus* individuals; larger (2 year) individuals with well-developed caudices were more likely to survive the effects of disturbance and flower earlier than smaller individuals (Davis et al. 1991). The establishment of new populations most likely depends on barriers to dispersal and the availability of suitable germination sites. Refer to **Figure 4** for an envirogram outlining resources potentially important to *P. absarokensis*.

Spatial characteristics

The factors affecting the spatial distribution of *Penstemon absarokensis* have not been studied. The size and extent of populations is difficult to define because of the rugged, inaccessible nature of the habitat and the scattered distribution of individuals. Observers used the terms "colony," "population," "subpopulation," and "cluster" to describe groups of individuals, but definitions of these terms varied among observers (Wyoming Natural Diversity Database 2003). Density of *P. absarokensis* populations ranged from 2 to 3200 acres and a few to several thousand individuals (Dorn 1989, Wyoming Natural Diversity Database 2003). Overall, this species has a wide spatial extent, but the actual coverage is low because it occurs at low densities. One account reported the density to be five plants per 3 square meter area in favorable sites (Wyoming Natural Diversity Database 2003). Populations are small, numbering 20 to 100 plants, and there is significant distance between populations in some cases (Evert personal communication 2003). Individual plants occurred in clusters of two to 12 plants or not clustered at all (Wyoming Natural Diversity Database 2003).

Penstemon absarokensis clusters seem to be restricted to openings in talus and vegetation where suitable soil substrate is exposed and minimal competition from other plants is encountered (Wyoming Natural Diversity Database 2003). However, several observers noted that much suitable habitat for *P. absarokensis* existed but was unoccupied by this species. This would indicate that the distribution of *P. absarokensis* was not limited by habitat availability. Other characteristics that could influence the spatial distribution of rare species may include seed/ramet dispersal, presence of other vegetation, landscape and microsite heterogeneity, ecological fluctuations, and disturbance patterns. Individuals or populations may be dormant during unsuitable environmental conditions (e.g., drought), which would affect the spatial distribution of aboveground individuals from year to year. In addition, *P. absarokensis* tends to grow on volcanic soils in barren areas with a high percentage of bare soil or rock (Wyoming Natural Diversity Database 2003). This may indicate its inability to survive in closed communities and a reliance on natural disturbances to reduce competition and maintain open soil (Mosely et al. 1990).

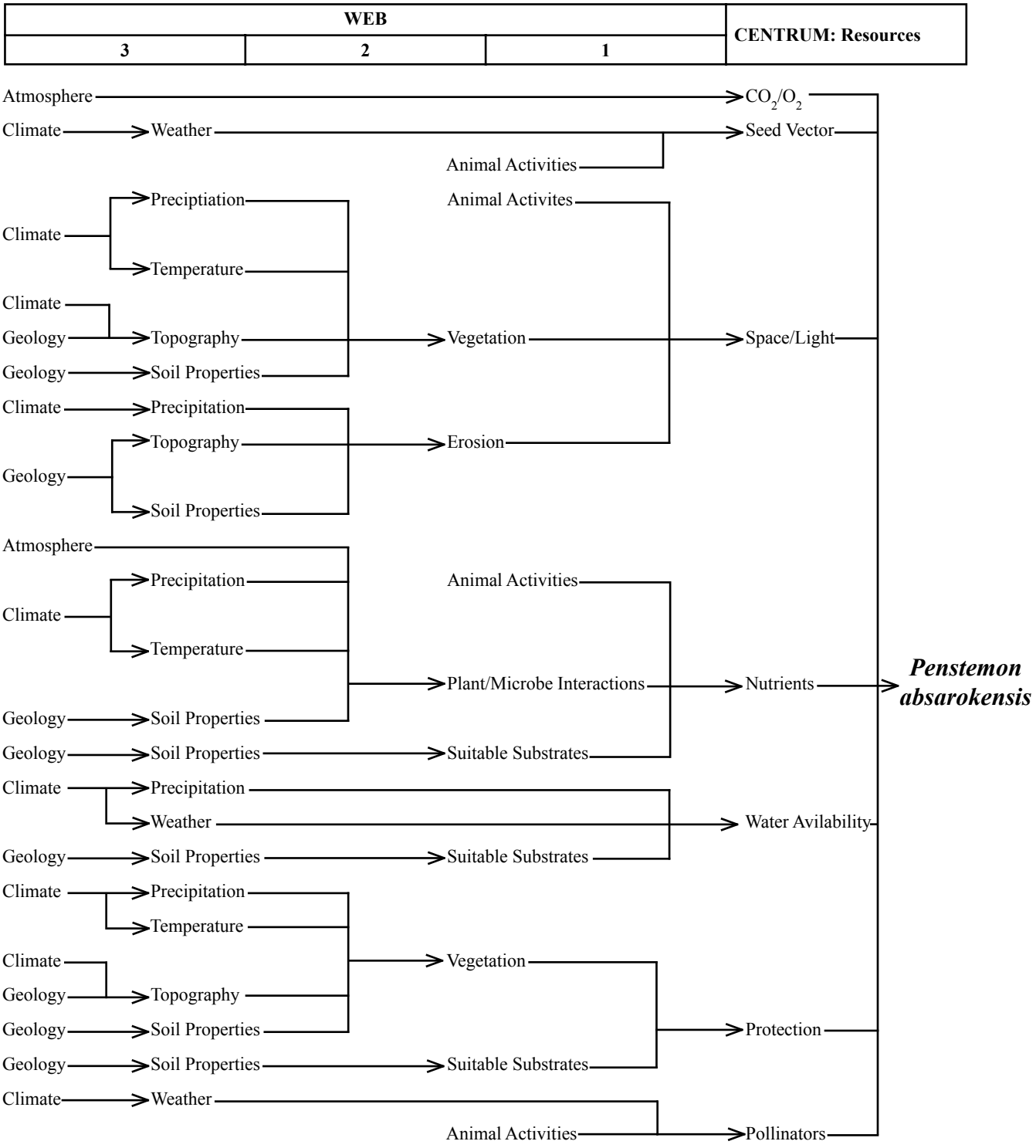

Figure 4. Envirogram outlining resources for *Penstemon absarokensis*.

Disturbances in mountainous environments can include water erosion, rockslide, fire, blowdowns, frost heaving, wind-scouring, small mammal activity, and human influences (Zwinger and Willard 1996). *Penstemon absarokensis* is unlikely to be directly affected by blowdowns or fire because it grows in areas with scattered tree cover and minimal ground fuels. Populations of *P. absarokensis* growing on gravel bars in riparian corridors are susceptible to scouring during spring runoff events. Several populations exist on or near hiking and pack trails and could be affected by any trail-related damage, such as trampling or soil movement (e.g., erosion and deposition). Similar to the formation of erosional gullies in the andesitic volcanic material on Mount St. Helens as a result of snowmelt (Tsuyuzaki and Titus 1996), erosional gullies were observed in the andesitic volcanic material of the Absaroka Range after thunderstorm events (Evert personal communication 2003). Disturbances such as erosion on steep slopes most likely play a role in creating suitable habitat throughout the landscape as well as directly impacting existing populations. The type, size, frequency, and intensity of disturbances that define the natural disturbance regime are unknown. It is also unclear to what extent *P. absarokensis* is capable of dispersing, colonizing, and establishing new populations around the landscape.

Genetic characteristics and concerns

In general, the genetic status of this plant, including issues related to hybridization, polyploidy, and genetic variability, is largely unknown for *Penstemon absarokensis*. A base chromosome count of 2n=16 is common for species within the *Penstemon* genus, including several species in Colorado and Wyoming (i.e., *P. eriantherus*, *P. glaber*, *P. haydenii*, and *P. virens*) (Freeman 1983). Polyploidy is relatively infrequent, and has been observed in only 20 percent of the species within the genus *Penstemon*. Issues related to gene flow, inbreeding, and genetic isolation could affect the demography, ecology, and management considerations for this species. For example, *P. haydenii*, an endangered species in Nebraska, has virtually nonexistent interpopulation gene flow but has maintained enough genetic variability to avoid detrimental inbreeding depression (Caha et al. 1998). The genetic variability and extent to which gene flow occurs between populations of *P. absarokensis* is unknown.

Factors limiting population growth

Based on the information presented in the preceding sections, population growth or establishment of *Penstemon absarokensis* could be limited by competition with other species (e.g., invasive species), inadequate pollinators, excessive erosion disturbance, or inappropriate environmental conditions for germination or growth. The rate at which colonization and establishment of new, persistent populations occurs is unknown.

Community ecology

Herbivores and relationship to habitat

The extent and effects of herbivory by mammals or insects on the stems, leaves, or fruits of *Penstemon absarokensis* are not fully known. Some Intermountain *Penstemon* species produce secondary metabolites (e.g., iridoid gycosides) that may function in plant defense by reducing palatability to some herbivores (Stermitz et al. 1993, Franzyk et al. 1998). Some *Penstemon* species are known to be palatable to livestock and are heavily grazed; *P. palmeri* is planted to supplement feral horse diets (Glenne 2003, Tepedino personal communication 2003). The production of secondary plant compounds by *P. absarokensis* or its palatability to mammalian or insect herbivores is unknown.

Of the 18 occurrences of *Penstemon absarokensis* on USFS lands, seven are within active livestock grazing allotments (Hicks personal communication 2003). The grazing regime on those allotments generally consists of 16 to 650 yearling cattle or cow/calf pairs during a period from mid-June to mid-October, as part of a deferred rotation grazing system (Hicks personal communication 2003). Although livestock grazing occurs in those seven active grazing allotments, the uneven, loose terrain and dry, barren nature of the habitat preferred by *P. absarokensis* at six of the occurrences would most likely preclude extensive livestock activity at microsites occupied by the species (Dorn personal communication 2003, Houston personal communication 2003). One of the *P. absarokensis* locations within an active grazing allotment is also within a riparian area, and it is possible that grazing (30 yearling cattle from mid-June to mid-October) could affect plants at that site, especially during flower and fruit production in June and July. No declines of this species specifically attributed to livestock grazing have been reported. Overall, direct impacts to *P. absarokensis* from livestock activities, such as grazing or trampling, are most likely minimal as a result of steep, loose, barren habitat (Dorn personal communication 2003, Houston personal communication 2003). The possible indirect impacts of grazing activities, such as importation of invasive weed seeds, soil erosion or compaction, or

destruction of pollinator habitat, on *P. absarokensis* habitat have not been studied.

Two element occurrence records for *Penstemon absarokensis* indicated that, "Many plants small and grazed.", "Most show evidence of herbivory.", and "Many plants show evidence of herbivory (probably by native species)." (Wyoming Natural Diversity Database 2003). The herbivores were not identified, the extent of herbviory was not quantified, nor was the damage described in these records. These two records were from *P. absarokensis* populations located in allotments without any active livestock grazing (Hicks personal communication 2003), so *P. absarokensis* clearly experiences herbivory by native species. Evert (personal communication 2003) suggested that there is a population of bighorn sheep in the North Fork Shoshone River watershed, and the succulent leaves of *P. absarokensis* probably provide palatable browse. Other herbivores could include other large mammals (e.g., elk, deer), small mammals (e.g., ground squirrels, gophers), and insects.

In Colorado, many *Penstemon penlandii* fruits were eaten by Wyoming ground squirrels (*Spermophilus elegans*) (Tepedino et al. 1999), but golden-mantled ground squirrel (*Spermophilus lateralis*) and Uintah chipmunks (*Tamias ubrinus*) did not eat the fruits of *P. debilis* (McMullen 1998). A prairie penstemon, *P. grandiflorus*, was susceptible to root herbivory by plains pocket gophers (*Geomys bursarius*) (Davis et al. 1991, 1995, 1997). While many *Penstemon* species can be susceptible to fruit predation by insects, *P. debilis* did not experience significant fruit predation (McMullen 1998). A significant number of fruits and seeds of *P. digitalis* were destroyed by micro-lepidopterans (Tortricidae), and many inflorescences were damaged by stem and bud feeding caterpillars (Mitchell and Ankeny 2001). Small melyrid beetles fed on the nectar of *P. bicolor* by entering the flowers or sucking nectar from holes in the corolla (Glenne 2003).

Competitors and relationship to habitat

The interactions of *Penstemon absarokensis* within the plant community are not well known. This penstemon is found only in barren areas and sparsely vegetated openings, suggesting that it is a poor competitor with other species and/or a superior competitor in stressful environments. One observation noted that this species was absent from vegetated meadow communities adjacent to occupied habitat (Wyoming Natural Diversity Database 2003). Succession is likely to be a slow process in these highly erodible and stressful alpine environments. Erosion by wind, water, and gravity may play a role in maintaining suitable open habitat for *P. absarokensis* and reducing competition with shrub, forb, and grass species. *Penstemon grandiflorus* relies on disturbances from pocket gopher activity and fire to reduce woody encroachment and maintain open areas for germination and establishment (Davis et al. 1991, 1995, 1997).

Intraspecific competition for *Penstemon absarokensis* is minimal. The distribution of *P. absarokensis* is mostly scattered, with a typical density of five plants per 3 square meter area and sub-population clusters of up to 12 plants (Wyoming Natural Diversity Database 2003).

There are no reports of invasive plant species affecting *Penstemon absarokensis*. Many invasive species can invade disturbed (e.g., roads, trails) or undisturbed sites, form dense, monospecific stands, and outcompete native species by using space, nutrients, and water (Cronk and Fuller 1995, Luken and Thieret 1997, Mack et al. 2000). *Penstemon absarokensis* grows in dry, erodible areas that may not be readily colonized by invading species. Invasive species currently constitute a minor part of the vegetation in surveyed areas of Shoshone National Forest (Jones and Fertig 1999a, 1999b, 1999c). Invasive species present in the proposed Grizzly Creek RNA include *Bromus tectorum* (cheatgrass), *Poa pratensis* (Kentucky bluegrass), and *Cirsium arvense* (Canada thistle) (Jones and Fertig 1999b), but the presence of these species in microsites with *P. absarokensis* is unknown. Within the RNA, *Bromus tectorum* only exists as scattered plants where it occurs in barren areas, and *Poa pratensis* and *Cirsium arvense* mainly occur in riparian areas (Jones and Fertig 1999b). Invasive species are rare in the Sheep Mesa RNA (Jones and Fertig 1999a). Other invasive species introduced to the Absaroka region include *Bromus inermis* var. *inermis* (smooth bromegrass) and *Phleum pretense* (meadow timothy grass) (Jones and Fertig 1999b). *Linaria vulgaris* (yellow toadflax), *Centaurea biebersteinii* (spotted knapweed), and *Matricaria perforata* (scentless chamomile) have been reported at or above treeline on USFS Region 2 lands (Ray 2001). *Centaurea biebersteinii* is proving to be a management concern for conservation of *P. lemhiensis* in Idaho (Mosely et al. 1990). All of these species have the potential to spread, become established, and affect community and ecosystem dynamics in the future.

Parasites and disease

Dorn (1989) did not observe evidence of parasites or diseases on *Penstemon absarokensis*. Evidence for parasites or diseases on related *Penstemon* species was not reported in the reviewed literature.

Symbiotic interactions

Insect pollination of flowering plants is an example of an important symbiotic interaction. Plants lure insects to a pollen or nectar reward, and the insects carry pollen to other flowers, thus, helping to cross-fertilize. Specific details concerning pollination ecology of *Penstemon absarokensis* are largely unknown; see Pollinators and pollination ecology section for more details.

Habitat influences

The cause of endemism for rare plant species is generally a subject for discussion. Endemism may be related to the geologic age of an area (i.e., has there been adequate time for a species to expand its distribution) and/or the factors behind speciation (i.e., has the species evolved to tolerate only a certain habitat), as well as other issues related to life history, gene flow, and adaptation to stochasticity (McMullen 1998, Rosenthal 1998). Cases of edaphic endemism in barren, toxic, or other harsh conditions may be related to physiologic adaptations to survive those conditions (i.e., tolerance) and/or intolerance of interspecific competition at less stressful sites (i.e., avoidance) (McMullen 1998).

Penstemon absarokensis appears to be geographically and edaphically restricted, and the causes of endemism are unknown. This penstemon is a habitat specialist because it seems to require steep, sparsely vegetated slopes of rocky, loose, volcanic (andesite) substrates found only along the Absaroka Range (Rosenthal 1998, Wyoming Natural Diversity Database 2003). *Penstemon absarokensis* has not been found on rhyolitic habitat located in adjacent Yellowstone National Park (Evert personal communication 2003). A few populations have been found in riparian gravel bar habitats, which have similar fine-grained andesitic soils and are also sparsely vegetated (Evert personal communication 2003). The population in Fremont County grows on a sandstone-derived soil and may be a different taxon (Dorn 1989, Evert personal communication 2003). However, the taxonomic status of this population has not been studied, and this occurrence could possibly represent the ability of this species to colonize different substrates.

Many observers mentioned that much suitable habitat is present but not utilized (Wyoming Natural Diversity Database 2003). This suggests 1) this species may have strict microhabitat requirements, 2) it cannot tolerate interspecific competition, or 3) there are barriers to dispersal or colonization. The availability and quality of suitable habitat most likely ranges from area to area, depending on heterogeneity in topography, substrate, disturbance factors, and competition with other species. The ability of this species to colonize disturbed areas is unknown (Mills and Fertig 2000).

CONSERVATION

Threats

Threats to the long-term persistence of *Penstemon absarokensis* in USFS Region 2 are mostly unknown because of the lack of species understanding and research. The information presented in this section is based on preliminary assessments (Dorn 1989, Mills and Fertig 2000), observations in occurrence records (Wyoming Natural Diversity Database 2003), and personal communications with forest botanists and botanical consultants (Dorn personal communication 2003, Evert personal communication 2003, Houston personal communication 2003, Wyoming Natural Diversity Database 2003).

Of the 20 occurrences of *Penstemon absarokensis* in USFS Region 2, 18 occurrences are on USFS Shoshone National Forest lands, one occurrence is on Wyoming BLM lands, and one occurrence is on Wind River Indian Reservation lands (**Table 1**; Dorn 1989, Fertig 1998, Fertig 2000a, Wyoming Natural Diversity Database 2003). In the USFS Shoshone National Forest, at least 10 *P. absarokensis* occurrences are within the Washakie and Northern Absaroka Wilderness Areas, and three occurrences are in part within the proposed Grizzly Creek and Sheep Mesa RNAs (Jones and Fertig 1999a, Jones and Fertig 1999b). Overall, most populations of *P. absarokensis* have few imminent threats at present as a result of their rugged, largely inaccessible habitat and the protection afforded by the designated wilderness areas and proposed RNAs (Clark et al. 1989, Fertig 1998, Mills and Fertig 2000, Welp et al. 2000). Motorized travel is currently prohibited in the designated wilderness areas and proposed RNAs (Houston personal communication 2003). Although the Grizzly Creek and Sheep Mesa areas are proposed RNAs, USFS Shoshone National Forest resource specialists are currently managing that land for conservation of biological

diversity by restricting land uses (e.g., cattle grazing, motorized travel) and minimizing new projects (e.g., trail building) (K. Houston personal communication 2003). However, all populations of *P. absarokensis* on National Forest System lands could still potentially be threatened by human-related activities (e.g., recreation, invasive species establishment) or environmental changes (e.g., global climate changes). These activities could either affect the existing individuals or reduce reproductive success, available habitat, establishment of new populations, or other factors important for the long-term persistence of the species. In general, disturbances can either create suitable habitat throughout a landscape or directly impact an existing population, depending on frequency, intensity, size, and location. Refer to **Figure 5** for an envirogram outlining potential malentities to *P. absarokensis*.

Direct or indirect negative impacts to *Penstemon absarokensis* populations or habitat by human-related activities could occur from motorized and non-motorized recreation, trail or road construction and maintenance, domestic livestock activities, or invasive species introduction. In general, human-related activities probably do not pose much direct hazard to most populations of *P. absarokensis* because of the isolation and steep habitat of this species (Houston personal communication 2003); lower elevation populations and those populations closest to roads and trails are at the most risk (Mills and Fertig 2000).

Recreational activity (e.g., camping, hiking, backpacking, horseback riding, fishing, hunting, off-highway vehicle and snowmobile use) is popular within Shoshone National Forest, and existing *Penstemon absarokensis* individuals near trails, campgrounds, and roads could potentially be damaged by trampling, maintenance activities, or erosion/deposition causing burial of existing individuals (Mills and Fertig 2000, Welp et al. 2000). Of the known occurrences, approximately seven are located along a trail or near to the highway (Wyoming Natural Diversity Database 2003). However, the volcanic scree substrate is loose and the slopes are steep so that scrambling off-trail is both difficult and treacherous (Dorn personal communication 2003, Evert personal communication 2003). Jones and Fertig (1999a, 1999b) noted that the topography and inaccessibility of the areas would be unattractive for snowmobile use. In addition, at least 10 occurrences are protected from motorized travel under wilderness area or proposed RNA restrictions. Populations near highways are at the most risk to be damaged by highway widening or right-of-way maintenance (Dorn personal communication 2003); highway reconfiguration extirpated one low-elevation population of *P. absarokensis* on the North Fork of the Shoshone River (Evert personal communication 2003). On the other hand, exposing substrate during highway maintenance or construction activities could possibly create favorable habitat for new populations of *P. absarokensis* to establish (Dorn personal communication 2003).

Overutilization of *Penstemon absarokensis* for educational or scientific purposes is unknown, but any increased horticultural demand for this species could be a future threat (Dorn 1989). Horticultural collecting has been implicated as a threat to *P. lemhiensis* in Idaho (Mosely et al. 1990).

Copper mineralization occurs in the Wapiti formation in at least one site, and *Penstemon absarokensis* individuals and habitat could be negatively impacted if mining or other natural resource development occurred in its habitat (Dorn 1989). Resource extraction is not currently planned in the vicinities of *P. absarokensis* populations, but this land use is always a possibility in the future (Houston personal communication 2003). Jones and Fertig (1999a, 1999b) noted during their surveys of potential RNAs in USFS Shoshone National Forest that, "No evidence was observed during field survey to suggest that mineral resources would conflict with RNA designation."

Penstemon absarokensis habitat (i.e., steep slopes of volcanic substrates with sparse vegetation) is typically unsuitable for some management activities, such as timber harvest, thinning, livestock grazing, fire suppression, or prescribed fires. These areas typically have few trees and low fuel loads and issues related to wildfires/fire suppression or prescribed fires are unlikely to be relevant to this species (Houston personal communication 2003). Additionally, livestock grazing are prohibited in the wilderness areas and proposed RNAs of the USFS Shoshone National Forest (Jones and Fertig 1999a, 1999b, 1999c; Houston personal communication 2003). As discussed earlier, seven occurrences of *P. absarokensis* are located in active grazing allotments. However, the uneven, loose terrain and dry, barren nature of the habitat would most likely preclude extensive livestock activity at occupied microsites (Dorn personal communication 2003, Hicks personal communication 2003, Houston personal communication 2003). Grazing activities near *P. absarokensis* plants in riparian areas, especially during flower and fruit production in June and July, could possibly cause direct damage or reduce reproductive success. No declines of this species specifically

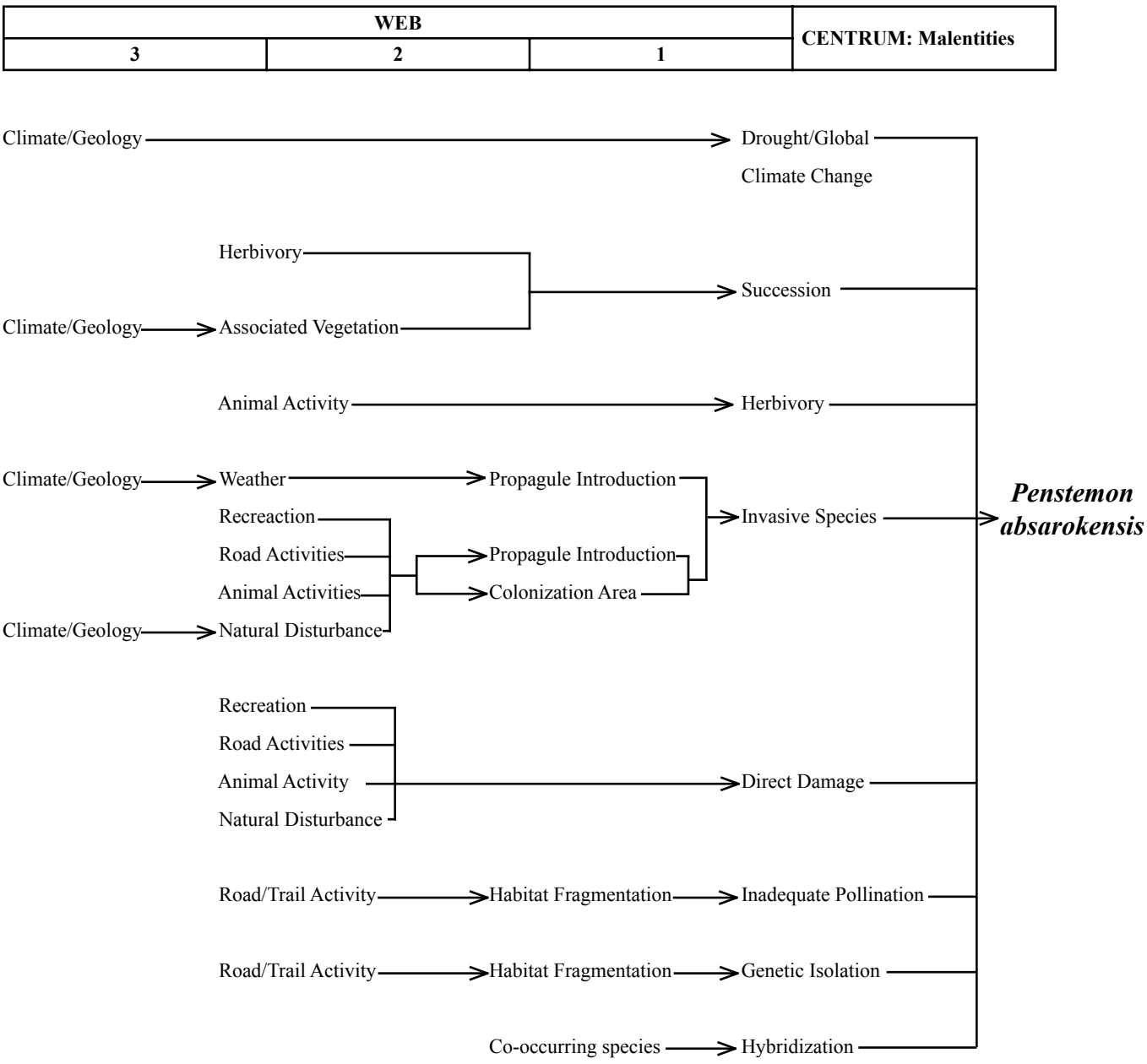

Figure 5. Envirogram outlining malentities to *Penstemon absarokensis*.

attributed to livestock grazing have been reported. The possible indirect impacts of grazing activities, such as importation of invasive weed seeds, soil erosion or compaction, or destruction of pollinator habitat, on *P. absarokensis* habitat have not been studied.

At present, invasive species currently constitute a minor part of the vegetation in surveyed areas of the Shoshone National Forest (Jones and Fertig 1999a, 1999b, 1999c). In addition, *Penstemon absarokensis* grows in dry, erodible areas that may not be readily colonized by invading species. However, any increase in species invasion is a future risk for competition with *P. absarokensis*, especially for lower elevation populations along trails, roads, and riparian areas (Mills and Fertig 2000). Invasive species of potential concern for increased establishment in the Shoshone National Forest include *Bromus tectorum*, *Poa pratensis*, *Cirsium arvense*, *Bromus inermis* var. *inermis*, and *Phleum pratense* (Jones and Fertig 1999a, 1999b).

Other environmental or biological threats to populations or habitats of *P. absarokensis* could include inadequate pollination, genetic isolation, scouring during flooding events, herbivory, landscape fragmentation, global climate changes, or changes to the natural disturbance regime that would affect natural succession, erosion, or precipitation patterns. The extent and effects of atmospheric pollution (e.g., deposition of nitrogen oxides) in this region are unknown.

There is evidence of some native herbivory on *Penstemon absarokensis* in two populations (Wyoming Natural Diversity Database 2003), possibly by bighorn sheep. The extent and effects of this herbivory on the long-term persistence of those populations are unknown. Current levels may or may not be affecting the persistence of certain populations of *P. absarokensis*, depending on how the timing and intensity of the herbivory affects individual longevity, reproductive success, and development of seedlings. It is possible that if other *P. absarokensis* populations are affected by intense herbivore activity, perhaps as a result of an increase in the population of native herbivores, this could potentially affect the global persistence of this species.

Penstemon absarokensis is typically found in sparsely vegetated areas on highly erodible scree slopes. If natural erosion and successional patterns were altered, then appropriate open habitat for *P. absarokensis* might not exist. Erosional events, caused by runoff from thunderstorms, rockslides, or river flooding events, can impact existing populations and/or create habitat suitable for the establishment of new populations (Evert personal communication 2003).

Changes to existing climatic and precipitation patterns, perhaps as a result of global environmental change, could also impact this species. For example, average temperatures are projected to increase and precipitation is projected to decrease over some areas in the interior regions of North America (Watson et al. 2001). Climate change and other potential changes to a suite of environmental variables have the potential to affect plant community composition by altering establishment, growth, reproduction, and death of plants. It is possible that the apparent ability of *Penstemon absarokensis* to tolerate dry, stressful environments and grow at a range of elevations may help it to persist.

If *Penstemon absarokensis* is largely dependent on outcrossing for maximum seed set, like other *Penstemon* species, then the reductions in pollinator efficiency could potentially reduce reproductive success. For example, environmental stochasticity could potentially cause fluctuations in pollinator activity and behavior. In addition, the amount of gene flow, genetic variability, and inbreeding depression is unknown for *P. absarokensis*. At present, the landscape with this species is largely intact and not highly fragmented. Any increase in road and trail construction or other barriers to pollinators could potentially decrease geneflow.

Threats to the long-term persistence of *Penstemon absarokensis* populations or habitats likely differ for each of the 20 occurrences. The most significant threats to the 18 occurrences on USFS Region 2 lands probably include global environmental changes, road maintenance or construction, non-native plant invasion, erosional events, hybridization, and grazing or herbivory. Lower-elevation populations and populations near roads or trails are probably at higher risk for the detrimental effects of road maintenance, non-native plant invasion, stream flooding events, and livestock grazing.

Conservation Status of the Species in USFS Region 2

Penstemon absarokensis is a species of special concern because it has a small number of occurrences in a narrow geographic range and is apparently restricted to habitat with volcanic (andesite) substrates (with one exception). The majority of known populations of *P. absarokensis* occur on National Forest System lands (**Figure 1**, **Table 1**). As a result, the conservation of those populations is especially important to the global

conservation status of this species and is the focus of the discussion presented in this document. The viability of this species within USFS Region 2 is difficult to ascertain because the full distribution and abundance is unknown, demographic parameters have not been studied, and the effects of management activities (i.e., livestock grazing, recreational trail use) have not been determined. Based on the few available data on abundance and distribution, we can speculate that this species appears to be viable within USFS Region 2 under current natural disturbance regimes and with current levels of recreation and management activities. However, it is difficult to predict the ability of this species to tolerate environmental stochasticity in the future (e.g., global environmental changes, drought) and any future management changes (e.g., livestock grazing, natural resource development).

Population declines

Based on the existing estimates of abundance, we are unable to conclude that the distribution or abundance of *Penstemon absarokensis* populations is declining, expanding, or remaining stable throughout its range. Occurrence reports provide some abundance and location information for comparison with any future surveys (Welp et al. 2000). Additional areas within the range have not been extensively surveyed, and there may be more occurrences yet to be found (Evert personal communication 2003). On the other hand, many observers mentioned that suitable habitat within the range was unoccupied by *P. absarokensis* (Wyoming Natural Diversity Database 2003). The rate at which this species disperses and colonizes new locations is unknown, and we know little of its dispersal and establishment capabilities. At best, we can conclude that there are several established, locally abundant occurrences comprised of scattered populations, with possible threats to some populations and potentially more populations to be discovered.

Life history and ecology

The lack of information regarding the basic biology, colonizing ability, vegetative and sexual reproductive potential, or genetic variability of *Penstemon absarokensis* makes it difficult to pinpoint the biological or ecological characteristics important for long-term persistence of this species.

Persistence of *Penstemon absarokensis* individuals most likely depends on the establishment of a well-developed root system to access moisture, store resources, and anchor it in unstable soils and windy conditions. An existing plant could be negatively impacted by disruption to the soil surface that jeopardizes its "hold" on the soil. The apparent stress-tolerating abilities of this species may possibly aid it to persist, despite short-term environmental fluctuations, such as drought. In addition, the physiological capabilities of the species to exist at a range of elevations may also help to buffer the possible effects of global environmental changes. The extent to which reproductive success of *P. absarokensis* (i.e., persistence of populations and the species) depends on vegetative or sexual reproduction, pollinator dynamics, genetic variability, and gene flow is unknown. If *P. absarokensis* is largely dependent on outcrossing for maximum seed set, like other *Penstemon* species, then the reductions in pollination efficiency could potentially reduce reproductive success. Successful germination and establishment of new seedlings could be affected by changes to moisture conditions, soil surface disruption to the topsoil horizons, lack of suitable germination sites, or competition with other plant species. In addition, factors related to metapopulation dynamics, such as the amount of gene flow, genetic variability, inbreeding depression, and minimum viable population size, are unknown for *P. absarokensis*. It is possible that peripheral populations, such as the population identified in Fremont County, may harbor rare alleles important to conserve for the long-term persistence of this species. The possibility of hybridization with other co-occurring *Penstemon* species has not been assessed but is a possible threat, based on conservation issues raised for other rare *Penstemon* species (Glenne 2003).

Habitat variation and risk

Penstemon absarokensis is a habitat specialist restricted to loose, sparsely vegetated, volcanic soils within Wyoming's Absaroka Range. These areas are often dry and dynamic environments, susceptible to erosion by wind, water, or gravity. In general, disturbances can either create suitable habitat throughout a landscape or directly impact an existing population, depending on frequency, intensity, size, and location. As a whole, habitats of *P. absarokensis* do not appear to be at immediate risk or severely threatened by consequences of current land management. Because of the ruggedness and barren nature of volcanic scree slopes, management and recreation activities such as timber harvest, livestock grazing, prescribed fires, off-highway vehicle activity, and hiking are unlikely to occur in the vicinity of *P. absarokensis* populations. Specific populations located near trails or roads or populations at lower elevations (i.e., in riparian areas) could be at a greater risk than other populations (Mills and Fertig

2000). Severe surface-disturbing activities, such as off-trail use, intense livestock grazing, or mining, could endanger specific populations of *P. absarokensis*.

Other limiting factors or risks within the habitat could include competition from surrounding vegetation (including invasive species), possible hybridization with co-occurring *Penstemon* species, lack of suitable germination sites, extensive herbivory, inadequate pollinator habitat, barriers to gene flow, or conditions too harsh for adequate growth and development. Fluctuations in natural disturbance processes could positively or negatively affect existing populations or creation of habitat. For example, erosional events could damage or bury existing individuals, or aid in dispersal and creation of habitat for establishment of new populations. The colonizing ability of this species has not been studied, but anecdotal evidence suggests that populations at slope bottoms may be the result of dispersal via erosional events (Evert personal communication 2003). Individuals and populations of *P. absarokensis* tend to be scattered throughout apparently suitable habitat; the factors affecting spatial distribution and the relationships between this species and its habitat have not been studied. The availability and quality of suitable habitat most likely ranges from area to area, depending on heterogeneity in topography, substrate, disturbance factors, and competition with other species. Marginal habitats for this species may include areas where competition from other species is intense. Invasive species have been identified in USFS Shoshone National Forest, but they have not been recorded in the direct vicinity of *P. absarokensis* populations. The dry, erodible habitats of *P. absarokensis* may not be suitable for the establishment and spread of any invasive plants, or it may just be a matter of time for an invasive species to exploit those habitats. Thus, competition from invasive species is not a current concern for *P. absarokensis* or its habitats. However, invasive species are being introduced all the time, and it may become a threat in the future. Hybridization between *P. absarokensis* and co-occurring *Penstemon* species has not been documented or studied, so the potential hybridization risk for populations of *P. absarokensis* in contact with populations of other *Penstemon* species is difficult to quantify.

Management of the Species in USFS Region 2

Currently, there are no regulations or management actions specifically protecting populations of *Penstemon absarokensis* on National Forest System lands. In addition, assessments of quantitative demographic monitoring and detailed biological and ecological studies of *P. absarokensis* populations and its habitat have not occurred. Based on the available information, we can only hypothesize how current and future management activities and other environmental influences may affect the abundance, distribution, and long-term persistence of this species.

Management implications

Penstemon absarokensis populations and habitat do not appear to be at immediate risk as a result of current management activities within the range. Because of the characteristics of *P. absarokensis* habitat (rocky, bare, steep), management activities such as timber removal and prescribed fires are unlikely to occur near this penstemon. Potential human-related threats to existing populations of this species could include off-trail hiking, highway construction activities, livestock grazing, or mining activities. Threats to *P. absarokensis* habitat include introduction of invasive plant species or changes to natural disturbance regimes. Key conservation tools for this species may include monitoring the effects of current USFS Region 2 land-use practices and management activities, reducing human-related threats to existing high-risk populations, preventing disruption to natural disturbance regimes, monitoring the effects of environmental fluctuations, and assessing the effects of any future management activities or changes in management direction.

Some examples of management practices that would protect *Penstemon absarokensis* habitat and minimize possible plant destruction by human-related activities include re-routing trails away from existing populations, encouraging hikers to stay on trails, restricting off-road vehicle traffic, preventing the spread and establishment of non-native invasive species, and regulating livestock activities to avoid sensitive riparian areas with potential populations of this species. Habitat management could also consider issues related to the surrounding landscape, such as pollinator habitat needs, herbivore movement patterns, trail proximity and position in relation to population locations, hydrologic changes upstream from existing populations, barriers to dispersal, and landscape fragmentation.

Potential conservation elements

Despite its high regional endemism, small number of recorded populations, and low abundance, *Penstemon absarokensis* currently seems to be at low risk for drastic population declines or habitat destruction under current management. *Penstemon absarokensis* exists in

harsh, stochastic environments susceptible to erosion, wind-scouring, and dry conditions. Features of *P. absarokensis* biology that may be important to consider when addressing conservation of this species include: 1) its edaphic specialization on andesitic substrates, 2) its potential reliance on a natural disturbance regime to create/maintain open habitat and possibly function in dispersal, 3) its possibly poor competitive abilities, evidenced by its preference for barren areas, 4) its scattered distribution of both individuals and populations, and 5) its possible outcrossing needs requiring efficient pollination. Changes in the timing, intensity, or frequency of natural disturbances have the potential to damage existing populations and/or reduce habitat for future recruitment. For example, increasing soil erosion on slopes through recreation, construction, or trampling may negatively impact existing plant populations, although it may create future suitable habitat. Invasive plant introduction could encroach on the "open" habitats that this plant prefers. The lack of information regarding the colonizing ability, vegetative and sexual reproductive potential, or genetic variability of this species makes it difficult to predict its vulnerability. Management decisions could consider the effect of management activities on landscape fragmentation, erosion/deposition, pollinator habitat, and introduction of invasive species.

Tools and practices

There are no existing population monitoring protocols for *Penstemon absarokensis*, and very little is known about the biology, ecology, and spatial distribution of this penstemon. Thus, additional habitat surveys, quantitative species monitoring, and ecological studies are priorities for constructing a conservation plan.

Species inventory and habitat surveys

Current reports of existing *Penstemon absarokensis* populations provide a useful base of information, but the distribution and total abundance of this species is not sufficiently known to formulate regional conservation strategies. Additional surveys of potential habitat are needed to discover any additional populations and document the full spatial extent of this species. For example, populations of *P. absarokensis* may exist in areas within its range that have not been intensively surveyed (e.g., suitable andesitic habitat extending into Yellowstone National Park, Clarks Fork River, and additional areas between Highways 16 and 20) (Welp et al. 2000, Evert personal communication 2003). As a result, the actual distribution and abundance of the species may be underestimated. The Northern Absaroka area was the focus of floristic surveys by associates of the Rocky Mountain Herbarium from 1985 to 1997, but it is unlikely that continued work will occur by herbarium staff in that area (E. Nelson personal communication 2003). Because the Absaroka Range is a hotspot for rare, endemic species (Rosenthal 1998), surveys could be conducted for several species simultaneously.

The distribution of *Penstemon absarokensis* is widely scattered, with populations or groups of populations spread over the range. This pattern is probably a combination of preference for open habitat and low density populations, habitat heterogeneity (i.e., variability in the habitat suitability over space), and undocumented populations. Because *P. absarokensis* appears to grow on specific substrates and topographies throughout its range, researchers could identify areas of potential habitat using topographic maps, geologic maps, aerial or satellite images, and existing Geographic Information System (GIS) databases (i.e., Colorado Natural Heritage Program database). Dorn (1989) mapped existing populations on U.S. Geological Survey 7.5-minute topographic maps. New surveys could use existing populations as starting points because habitat zones may extend along the length of a ridge or slope (Wyoming Natural Diversity Database 2003). For example, the south end of Boulder Ridge encompasses habitat similar to the north end and may contain additional populations of *P. absarokensis* (Welp et al. 2000). In addition, locations downslope, downwind, or downstream from existing populations should be surveyed because *P. absarokensis* seeds are most likely wind, water, and gravity dispersed. The Colorado NHP and NatureServe have developed databases and GIS components to assist in habitat modeling (D. Anderson personal communication 2003).

Once located, the size and extent of populations could be mapped, labeled, and recorded using GIS and global positioning system (GPS) technology. Mapping the extent of and providing a unique label for each known population of *Penstemon absarokensis* will maintain consistency for future observations and help in making estimates of density and abundance. Mapping exercises will also clarify the spatial distribution of populations at the local and regional levels and provide a framework for creating a metapopulation study. Populations in areas slated for various management, maintenance, or disturbance activities could be readily identified. A detailed assessment could be undertaken before activities such as highway reconfiguration or natural resource exploration occurs (Dorn 1989).

Population monitoring and demographic studies

Additional information is also needed to gain an understanding of the life cycle, demography, and population trends of *Penstemon absarokensis*. Information is lacking on longevity, germination requirements, seed survival, extent of asexual reproduction, factors affecting flower development, pollination ecology, role of the seed bank, and gene flow between populations. This type of species-specific information would be useful in assessing threats to this species and in developing mitigation and restoration strategies, if necessary. For example, seed bank studies could assess the abundance and spatial distribution of seeds to reveal dispersal patterns in this species. Studies of germination needs in the field might elucidate potential limiting factors for the establishment of new individuals and populations.

No data are available on population trends for *Penstemon absarokensis*. The existence of several populations has been noted over time, but no long-term demographic monitoring has been initiated. Long-term monitoring studies could yield helpful information, such as temporal and spatial patterns of abundance and dormancy; environmental factors that influence abundance (e.g. precipitation fluctuations); whether populations are increasing, decreasing, or remaining stable; and the minimum number of plants necessary to perpetuate the species. For example, long-term monitoring in conjunction with mapping may elucidate the temporary disappearance of aboveground individuals during unsuitable conditions. This would, in turn, aid in understanding the effects of environmental fluctuations as well as provide better estimates of abundance.

In addition, further studies on the morphological and genetic differences between and among populations will clarify metapopulation dynamics. Additional morphological, genetic, and cross-breeding studies of the *Penstemon absarokensis* population in Fremont County are necessary to define the taxonomic status of this population. Understanding the status of this isolated population is necessary to ascertain the full geographic range, habitat requirements, and genetic resources of *P. absarokensis*. However, this Fremont County population is located on the Wind River Indian Reservation, and previous attempts to obtain permission to study this population have not been successful (Dorn personal communication 2003).

Understanding certain aspects of demography is a priority in order to provide basic population information and is indicated by these questions:

- What are the rates of survival, longevity, and recruitment?
- What is the extent of vegetative and sexual reproduction?
- What are the role, status, and longevity of the seed bank?
- What are the population fluctuations from year to year?
- What is the age at which individuals become reproductive?
- What is the age structure of the population?
- What is the gene flow between populations?

Long-term monitoring programs are required to answer these kinds of questions, but it may take decades for clear patterns to emerge. Several groups have developed protocols for monitoring population and demographic trends of rare plant species. These protocols can be easily accessed and used to develop specific monitoring plans for use in USFS Region 2. For example, Measuring and Monitoring Plant Populations (Elzinga et al. 1998) and Monitoring for Conservation and Ecology (Hutchings 1994) are general references that provide concrete guidance on designing and implementing quantitative monitoring plans for rare plant species. Lesica (1987) has developed a technique for monitoring perennial plants on permanent belt transects that has been used by other *Penstemon* studies in Wyoming to gauge population density and changes in age classes over time (Fertig and Welp 2001). In addition, population matrix models that measure individual fitness and population growth provide flexible and powerful metrics for evaluating habitat quality and identifying the most critical feature of the species' life history (Hayward and McDonald 1997). Deterministic demographic models of single populations are the simplest analyses and are used as powerful tools in making decisions for managing threatened and endangered species (Beissinger and Westphal 1998).

Habitat monitoring and management

The general habitat characteristics of this species have been identified, but there are many unknowns regarding microhabitat requirements and basic population dynamics to determine which factors are critical in maintaining or restoring its habitat. For example, it is currently not known what types, intensities, or frequencies of disturbance create and maintain habitat and are tolerated by existing populations of this species. Habitat monitoring should occur in conjunction with population monitoring efforts, in order to associate population trends with environmental conditions. Habitat management could also consider issues related to the surrounding landscape, such as pollinator habitat needs, herbivore movement patterns, and trail proximity and position in relation to population locations.

Biological and ecological studies

Much of the information regarding habitat requirements, establishment, reproduction, dispersal, hybridization with co-occurring species, relationship with herbivores, competition with other species, and overall persistence has not been studied for *Penstemon absarokensis*. The species' response to habitat changes is not known in sufficient detail to evaluate the effects of changes in natural disturbance patterns. Research studies to evaluate the effects of drought, succession, and floods at several scales (local and regional) would provide valuable input to the development of conservation strategies and management programs. The types of monitoring studies required to understand how this species responds to environmental fluctuations, changes in the disturbance regime, or natural succession would be complex and could take decades. For example, precipitation fluctuations have the potential to affect erosion rates, germination success, pollinator population trends, timing of flowering, and/or growth of surrounding vegetation. It will be difficult to determine to what extent disturbances are necessary to create habitat and/or maintain a population, what disturbance intensity and frequency may be most appropriate, and what factors would result in local extirpation of a population.

There is a body of research on the biology and conservation of other *Penstemon* species that would provide useful information and tools for designing future studies of *P. absarokensis* (e.g., Grey 1982, Flessner 1989, Flessner and Stubbendieck 1992a, Kitchen and Meyer 1992, Davis et al. 1997, Caha et al. 1998, Nielson 1998, McMullen 1998, Wolfe et al. 1998a, Wolfe et al. 1998b, Tepedino et al. 1999, Fertig 2000b, Chari and Wilson 2001, Glenne 2003). For example, McMullen (1998) undertook studies to identify the causes of effects of physical and chemical edaphic characteristics on the survival of *P. debilis*. Researching issues related to hybridization of *P. absarokensis* with other more common, co-occurring *Penstemon* species is important for the conservation of this rare species. Glenne (2003) and Chari and Wilson (2001) provide examples of research efforts to assess hybridization barriers between *Penstemon* species through crossing experiments, pollinator observations, and morphological measurements. Wolfe et al. (1998a, 1998b) used genetic markers to assess variability among natural populations of *Penstemon* species and detect evidence of hybridization. In addition, status reports and recovery plans for the conservation of other rare and endangered species in USFS Region 2 also discuss important issues to consider (e.g., Mosely et al. 1990, Fritz et al. 1992, McMullen 1998, Nielson 1998, Fertig 2001). For example, the recovery of *P. haydennii* depends on the protection of the known occurrences of the species, field surveys to discover new populations and habitat suitable for restoration, research and long-term monitoring to understand its basic natural history, reintroduction of new populations, maintaining an artificial seed bank, and developing public awareness (Fritz et al. 1992).

Availability of reliable restoration methods

The successful production and germination of seedlings in garden/greenhouse environments introduces the possibility of restoration efforts if necessary. Evert (personal communication 2003) transplanted adult individuals that were going to be extirpated by highway reconfiguration, but they did not survive for more than a year. Seeds collected from that population readily germinated and flourished in a garden environment. Germination and transplantation studies in natural environments would be helpful if additional populations are similarly at risk of habitat destruction. In addition, there has been no research to date involving the harvest or storage needs of *Penstemon absarokensis* seed for use in a restoration projects. The collections of the National Genetic Resources Program or Royal Botanic Gardens do not include *P. absarokensis* material (National Genetic Resources Program 2003, Royal Botanic Gardens 2003).

Information Needs and Research Priorities

Based on our current understanding of *Penstemon absarokensis*, we can identify research priorities where additional information will help to develop management

objectives, initiate monitoring and research programs, and form a conservation plan. To address these data gaps, information can be obtained through surveys, long-term monitoring plans, and extended research programs. There is so little known about the biology and ecology of this species that there are a large number of research projects that could be implemented.

The location of populations, population dynamics, and role of disturbance are of primary importance to further the understanding of this species in USFS Region 2. The following types of studies would supplement basic knowledge regarding this species:

- Re-location and detailed mapping of existing populations
- Surveys for new populations
- Determination of the taxonomic status of the Fremont County population
- Identification of any imminent threats to known populations
- Identification of disturbance types, frequencies, and intensities
- Microhabitat characterizations and measurements
- Studies related to reproductive biology, including pollinator surveys, germination trials, vegetative reproduction, mycorrhizal associations, and seedbank analyses
- Identification of possible causes of individual plant mortality (e.g., parasites, diseases)
- Genetic analyses to assess gene flow, variability, and possible hybridization throughout range

Additional research and data that may be useful but are not incorporated into this assessment include aspects related to managing data for efficient use. Data acquired during surveys, inventories, monitoring programs, and research projects are most easily accessible if they are entered into an automated relational database. The Colorado NHP and NatureServe have developed databases and GIS components to assist in information storage and habitat modeling (D. Anderson personal communication 2003). Such a database should be integrated with GIS and allow queries and activities such as the following:

- Efficient incorporation of data in the field
- Generation of location and habitat maps
- Characterization of associated habitat types
- Identification of population trends over time
- Identification of data gaps that require further information gathering
- Easy modification of the database, as additional information becomes available

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DEFINITIONS

Acuminate – Gradually tapering to a sharp tip.

Andesite – Volcanic rock usually medium dark in color and containing 54 to 62 percent silica and moderate amounts of iron and magnesium.

Annual – A plant that completes its entire life cycle (germinates, flowers, sets seed, and dies) in a single year.

Anther – Part of the flower reproductive structure (stamen) that bears pollen.

Asexual reproduction – Any form of reproduction not involving the union of gametes.

Basalt – Volcanic rock usually dark in color and containing 45 to 54 percent silica and generally rich in iron and magnesium.

Bilabiate – Two-lipped; usually referring to a flower corolla.

Calyx – The collective name for sepals.

Caudex – Short, swollen, often woody portion of a plant stem that is at or beneath ground level. This structure functions in new stem production, serves as a storage organ, and/or produces short rhizomes.

Congener – A member of the same genus.

Corolla – Portion of flower comprised of petals.

Dehisce – To split or open, discharging seeds, pollen, or other contents, as the ripe capsules or pods of some plants.

Demographics – The study of fecundity and mortality parameters that are used to predict population changes.

Disjunct – A geographically isolated population or species outside of the range of other similar populations or species.

Dormancy – A period of growth inactivity in seeds, buds, bulbs, and other plant organs even when environmental conditions normally required for growth are met.

Endangered – Defined in the Endangered Species Act as any species which is in danger of extinction throughout all or a significant portion of its range.

Endemic – A population or species with narrow physiological constraints or other restrictions, which limit it to a special habitat or a very restricted geographic range, or both.

Entire – Having a margin that lacks any toothing or division, as the leaves of some plants.

Fertility – Reproductive capacity of an organism.

Fitness – Success in producing viable and fertile offspring.

Forb – An herbaceous plant, other than grass.

Fruit – The ripened, seed-containing reproductive structure of a plant.

Genotype – Genetic constitution of an organism.

Glabrous – Smooth, without hairs or glands.

Habitat fragmentation – The breakup of a continuous landscape containing large patches into smaller, usually more numerous, and less connected patches. Can result in genetic isolation.

Habitat isolation – When two or more habitats are separated (i.e., geographically) to an extent to prevent cross breeding, thereby genetically isolating two parts of a once continuous population.

Herbaceous – Adjectival form of herb (an annual or perennial plant that dies back to the ground at the end of the growing season because it lacks the firmness resulting from secondary, woody growth).

Hybridization – The result of a cross between two interspecific taxa.

Indeterminate – Not terminating growth with flowering; continuing to grow at apex.

Inflorescence – The flowering part of a plant, referring to a cluster of flowers on a single stem.

Interspecific competition – Competition for resources between individuals of different species.

Intraspecific competition – Competition for resources among individuals of one species.

Introgression – Transfer of genetic material from one taxonomic species to another, and its spread among individuals of the second species.

Invasive species – A species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Iteroparous – Capable of reproducing several or many times over a lifetime (e.g., perennial plants.

Monocarpic – Flowering and bearing fruit only once.

Mycorrhiza – Symbiotic association between a fungus and the root of a higher plant.

Oligolege – Pollinator that visits one or a few related plant species for pollen.

Ovary – The enlarged portion of the female reproductive structure (pistil) that contains the ovules and develops into the fruit.

Ovate – Egg-shaped (two-dimensional), with the broadest end toward the base.

Ovoid – Egg-shaped (three-dimensional).

Ovule – Part of "female" plant reproductive system that becomes a seed after fertilization.

Palate – The raised part of the lower lip of a corolla, constricting or closing the throat.

Papillate – Covered with short, rounded, blunt projections.

Perennial – A plant that lives for 3 or more years and can grow, flower, and set seed for many years; underground parts may regrow new stems in the case of herbaceous plants.

Perfect flower – Flower with both "male" (stamens) and "female" (pistils) reproductive organs.

Petiole – Leaf stalk.

Phenotype – The external visible appearance of an organism.

Phenotypic plasticity – When members of a species vary in height, leaf size or shape, flowering (or spore-producing time), or other attributes, with changes in light intensity, latitude, elevation, or other site characteristics.

Pioneer species – Generally the first species to colonize an area during primary succession.

Pistil – The seed-producing organ of a flower, consisting of a stigma, style, and ovary.

Polycarpic – Flowering and bearing fruit multiple times.

Polyploidy – Having more than two complete sets of chromosomes per cell.

Population Viability Analysis – An evaluation to determine the minimum number of plants needed to perpetuate a species into the future, the factors that affect that number, and current population trends for the species being evaluated.

Propagule – A reproductive body, usually produced through asexual or vegetative reproduction..

Pubescent – Bearing hairs

Ramet – An individual member of a clone.

Ramify – To send out branches or subordinate branchlike parts.

Recruitment – The addition of new individuals to a population by reproduction.

Reflexed – Bent backward.

Rhizomatous – Bearing rhizomes.

Rhizomes – Prostrate stem growing beneath the ground surface, usually rooting at the nodes.

Rhyolite – Volcanic rock usually light in color, containing 69 percent silica or more and rich in potassium and sodium.

Ruderal habitat – Temporary or frequently disturbed habitats.

Ruderal species – Species that can exploit low stress, high disturbance environments.

Saccate – In the shape of a sac or pouch.

Scree – Accumulation of small rock debris (generally smaller than talus), often at base of cliff or steep slope.

Semelparous – Reproducing only once throughout a lifetime, usually followed by death (e.g., annual plants)

Senescence – Changes that occur in an organism (or part of an organism) between maturity and death (i.e., ageing).

Sepals – A segment of the calyx.

Sessile – Lacking a stalk.

Sexual reproduction – Reproduction involving the union of gametes.

Solitary – Single, sole.

Stamen – The pollen-producing structures of a flower; the "male" part of a flower.

Staminode – A sterile stamen or any structure lacking an anther but corresponding to a stamen.

Stigma – The surface of the plant reproductive structures (pistil) on which pollen grains land.

Succession – The orderly process of one plant community replacing another.

Symbiosis – An intimate association between two dissimilar organisms that benefits both of them.

Sympatric – Occupying the same geographic region.

Sympetalous – Having united petals, at least at the base.

Talus – Accumulation of coarse rock debris (generally larger than scree), often at base of cliff or steep slope.

Terminal – Occurring at the tip or end.

Threatened – Defined in the Endangered Species Act as any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Throat – The opening of a sympetalous corolla.

Vegetative reproduction – A form of asexual propagation whereby new individuals develop from specialized multicellular structures that often detach from the mother plant.

Viability – The capability of a species to persist over time. A viable species consists of self-sustaining and interacting populations that have sufficient abundance and diversity to persist and adapt over time.

Zygomorphic – Bilaterally symmetrical; displaying symmetry along one plane only.

Zygote – Cell formed from the union of two gametes.

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