Penstemon jamesii Benth. (James' beardtongue): A Technical Conservation Assessment

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

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Kenneth D. Heil[1] and David L. Bleakly[2]
[1]San Juan College, 4601 College Blvd., Farmington, New Mexico 87401
[2]Bleakly Botanical & Biological LLC, 3813 Monroe, N.E., Albuquerque, New Mexico 87110

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Authors' Biographies

Kenneth D. Heil is a retired professor at San Juan College and former owner of Ecosphere Environmental Services. Heil has over 25 years of professional experience with threatened and endangered species surveys, environmental assessments, and vegetative community mapping. He has also conducted numerous plant studies within national parks and monuments throughout the southwestern United States. He is author of Familiar Cacti (Chanticleer Press 1993), Four Corners Invasive and Poisonous Plant Field Guide (San Juan College and Bureau of Land Management 2000), Endangered, Threatened and Sensitive Plant Field Guide, Farmington District (Bureau of Land Management and Ecosphere Environmental Services 1995), and Endangered, Threatened and Sensitive Plant Field Guide, Albuquerque District (Bureau of Land Management and Ecosphere Environmental Services 1998). He is currently the primary investigator for the Four Corners Flora (anticipated publication by Missouri Botanical Garden 2007). Mr. Heil received his B.S. in Biology from Fort Lewis College and M.S. in Biology from Washington State University.

David L. Bleakly is a botanist and plant taxonomist with expertise in the identification of rare and common plants as well as noxious weeds. He has performed threatened and endangered plant clearances, vegetation analyses, and wetland delineations in New Mexico and surrounding states. He has participated in botanical surveys involving highway, utility, landfill, industrial site, and mining projects on public and private lands and on Indian Trust lands. He has worked with many branches of the Federal and State governments as well as private entities. He has performed large scale and long-term vegetation sampling projects, has participated in rangeland and wetland reclamation projects, and is experienced in the environmental aspects of Section 404 permitting regarding "Waters of the United States." He has completed training in New Mexico through the Wetlands Training Institute, is an active member of the New Mexico Rare Plant Technical Council, and is the author of the treatments for the genus *Penstemon* and the plant family Euphorbiaceae in the Four Corners Flora. He received a Bachelor of University Studies from the University of New Mexico in 1973 and an M.S. in Biology from the University of New Mexico in 1994.

Cover Photo Credit

Penstemon jamesii (James' beardtongue). Photograph by David L. Bleakly.

Summary of Key Components for Conservation of *Penstemon jamesii*

Status

This species assessment for *Penstemon jamesii* (James' beardstongue) is being produced as part of the Species Conservation Project for the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). NatureServe considers this species apparently secure globally (G4). Outside of Region 2, *P. jamesii* is widely distributed throughout western Texas and eastern New Mexico. The Texas Natural Heritage Program ranks *P. jamesii* as imperiled (S2), and the species is not ranked (SNR) in New Mexico. Region 2 has designated this regional endemic a sensitive species. In Colorado, *P. jamesii* is known from only one historic occurrence, and the Colorado Natural Heritage Program ranks it as critically imperiled (S1). The Kansas Natural Heritage Inventory presumes this species to be extirpated (SX). Any extant occurrences found in Region 2 would be at the northern limit of this species' range and could have unique genetic characteristics.

Primary Threats

No actual threats to *Penstemon jamesii* have been identified to date. Potential threats throughout its range include prescribed fire and wildfire, road building and maintenance, livestock grazing, interspecific plant species competition, and global climate change. If an occurrence is found within Region 2, threats would need to be evaluated at that site.

Primary Conservation Elements, Management Implications, and Considerations

Penstemon jamesii is a perennial forb species that occurs in a range of habitats and appears to be a generalist. It grows primarily in grasslands and shrubby grasslands, on generally flat to hilly terrain; it is not typically found on steep or rocky slopes. In New Mexico and Texas, *P. jamesii* has been collected from a wide range of elevations, from 2,250 to 8,200 ft. The elevation of the historical occurrence in Colorado is about 5,825 ft.

Penstemon jamesii is the most common *Penstemon* species found in New Mexico east of the Rio Grande, and it is common in western Texas, in counties adjacent to and near New Mexico's eastern border. Although the total population of this species has never been estimated, the authors believe there are probably tens of thousands of *P. jamesii* individuals growing over hundreds of square miles.

Penstemon jamesii may have been extirpated from Region 2. There is one known herbarium specimen from Las Animas County, Colorado and an historic occurrence in Kansas that was apparently an unsuccessful introduction. The Colorado specimen was likely collected on private land near what is now the Comanche National Grassland. Although searches for this species have been conducted, it has not been relocated in Region 2. Since the historic occurrences has not been relocated, any extant occurrences found in Region 2 would likely be unique in the state and Region 2. If this species has been overlooked in Region 2 or if it were to expand its current range into Region 2, *P. jamesii* would most likely occur on the Rio Grande National Forest or the Comanche National Grassland. Given the limited information available for this species, it could be difficult to formulate conservation strategies for new occurrences. It would be important to evaluate new occurrences for distribution, abundance, threats, management implications, and possibly basic biology and ecology.

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EDITORS: Kathy Carsey, Beth Burkhart, and Kathy Roche, USDA Forest Service, Rocky Mountain Region

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2). *Penstemon jamesii* (James' beardtongue) is the focus of an assessment because it is a sensitive species in Region 2 (USDA Forest Service 2003, 2005), where it is known only from an historic occurrence on what is now the Comanche National Grassland. Within the National Forest System, a sensitive species is a plant or animal species whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance or in habitat capability that would reduce its existing distribution (USDA Forest Service 2003, 2005; FSM 2670.5 [19]). A sensitive species may require special management, so knowledge of its biology, ecology, conservation status, and management is critical.

This assessment addresses *Penstemon jamesii* throughout its range in eastern New Mexico and western Texas, which are outside of Region 2. Within Region 2, one occurrence of *P. jamesii* was identified in 1948 on private land in Las Animas County, Colorado (Weber and Wittmann 2001, Olson personal communication 2004). Since that original collection, *P. jamesii* has not been observed at the Las Animas County site (Colorado Natural Heritage Program 2003). No extant occurrences are known on National Forest System lands within Region 2. The broad nature of this 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 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, conservation status, and management 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 the 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). Furthermore, it cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope and Information Sources

This species assessment examines the biology, ecology, conservation status, and management of *Penstemon jamesii* throughout its range in eastern New Mexico and western Texas. All the literature relevant to this species originates from field investigations outside Region 2. This assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *P. jamesii* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting this synthesis but placed in a current context.

In producing this assessment, we reviewed the refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies, as well as information on related species and on the geographical and environmental context of this species. Although we did not visit every herbarium that houses vouchers of this species, we did include major sources of information on its distribution, including specimen label information provided by the Colorado and New Mexico Natural Heritage Program element occurrence records, and herbaria at University of Colorado, University of New Mexico-Albuquerque, New Mexico State University, University of Texas at Austin, and Texas A & M University. These records were important in estimating the geographic distribution of the species, but they represent a diversity of persons and methods used in data collection. Records that were associated with locations at which herbarium specimens had been collected at some point in time were considered more significant than general observations only. Although searches of other herbaria in the United States may yield a few more locations, it is unlikely that the overall distribution of this species would change. Additional habitat may exist in the Chihuahuan Desert Scrub community type in Mexico.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science includes 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, logical thinking, and models must be relied on to guide the understanding of ecological relations.

Due to the lack of experimental research efforts concerning *Penstemon jamesii*, this assessment 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. jamesii* is based on the observations of the authors and Robert Sivinski, New Mexico State Botanist. When information presented in this assessment is based on our personal communications with a specialist, we cite those sources as "personal communication."

Since there is a paucity of knowledge specific to this species, we also incorporated information, when appropriate, from other *Penstemon* species endemic to Region 2 or adjacent states. Information incorporated includes personal observations of longevity of *P. breviculus*, Flessner and Stubbendieck's (1992b) examination of mycorrhizal relationships of *P. haydenii*, and Flessner and Stubbendieck's (1992a) study of pollinator characteristics of *P. haydenii*. These comparisons are not meant to imply that *P. jamesii* is biologically identical to these species, but they represent an effort to hypothesize about potential characteristics of this species. *Penstemon* species have been the subject of preliminary investigative study (Nielson 1998). As a result, biology, ecology, and conservation issues presented for *P. jamesii* are based on inference from these published and unpublished sources. We clearly note when we make inferences based on the available knowledge to augment or enhance our understanding of *P. jamesii*.

Publication of the Assessment on the World Wide Web

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

Peer Review

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

MANAGEMENT STATUS AND NATURAL HISTORY

This section discusses the special management status, existing regulatory mechanisms, and biological characteristics of *Penstemon jamesii*.

Management and Conservation Status

Penstemon jamesii is a regional endemic species currently known from two states, New Mexico and Texas. (**Figure 1** also shows occurrences that are historic or presumed extinct). It is thought to be extinct in Kansas (Freeman personal communication 2004), and in Colorado, one occurrence was identified in 1948 on private lands in Las Animas County (Weber and Wittmann 2001, Olson personal communication 2004). No known occurrences are located on National Forest System lands within Region 2. The Bioinformatics Working Group Biota of Texas Project website shows a distribution in Texas for *P. jamesii* that is different from that shown in **Figure 1**, which is based on known voucher specimens. The Bioinformatics website map is not based on voucher specimens housed at Texas A&M or any other herbarium (Reed personal communication 2005). Instead, the map on the website is based on the distribution recorded in The Manual of the Vascular Plants of Texas (Correll and Johnston 1979). For Texas, the distribution includes Llano Estacado in the panhandle. The Bioinformatics website map has not been updated since 2003 (Reed personal communication 2005).

Federal status

USFS Region 2 has designated *Penstemon jamesii* a sensitive species (USDA Forest Service 2005). The species is not listed by the U.S. Fish and Wildlife Service (2003), USFS Region 3, or by the Bureau of Land Management in Colorado, New Mexico or Texas.

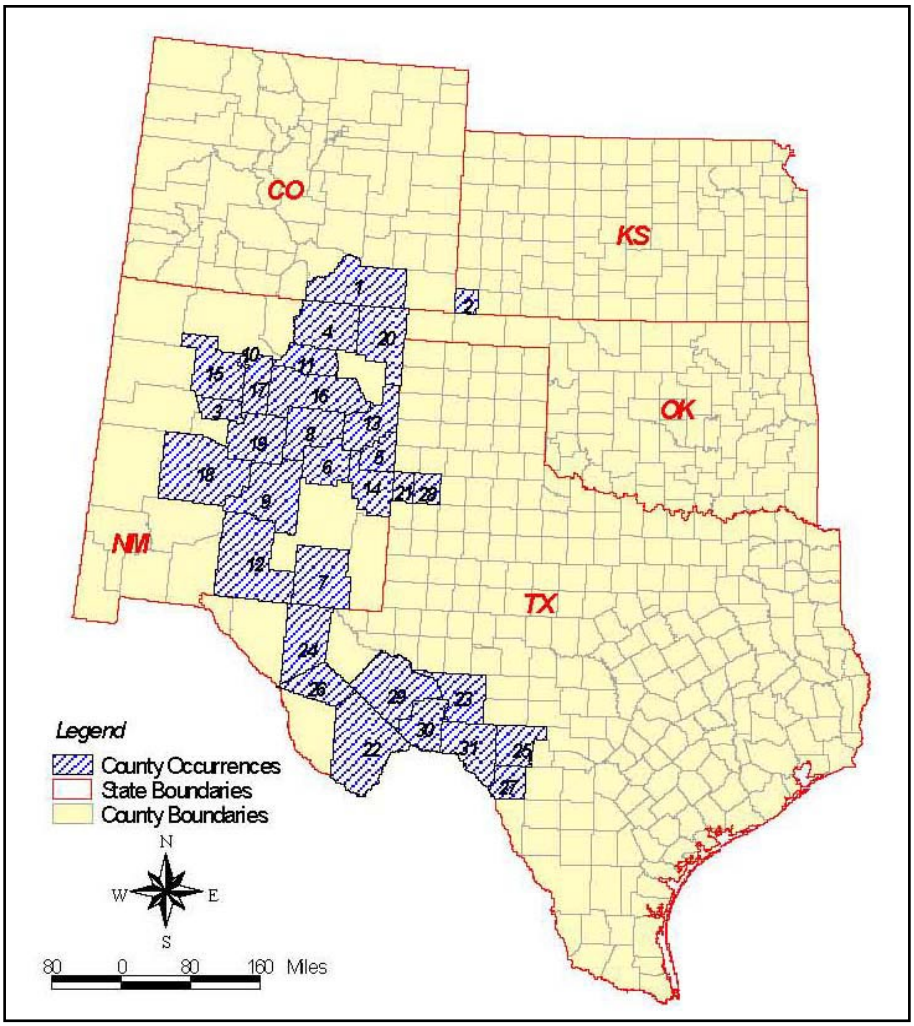

Figure 1. Distribution of *Penstemon jamesii* by state and county.

No.	State Name	County Name	No.	State Name	County Name
1	Colorado	Las Animas	17	New Mexico	Santa Fe
2	Kansas	Morton	18	New Mexico	Socorro
3	New Mexico	Bernalillo	19	New Mexico	Torrance
4	New Mexico	Colfax	20	New Mexico	Union
5	New Mexico	Curry	21	Texas	Bailey
6	New Mexico	De Baca	22	Texas	Brewster
7	New Mexico	Eddy	23	Texas	Crockett
8	New Mexico	Guadalupe	24	Texas	Culberson
9	New Mexico	Lincoln	25	Texas	Edwards
10	New Mexico	Los Alamos	26	Texas	Jeff Davis
11	New Mexico	Mora	27	Texas	Kinney
12	New Mexico	Otero	28	Texas	Lamb
13	New Mexico	Quay	29	Texas	Pecos
14	New Mexico	Roosevelt	30	Texas	Terrell
15	New Mexico	Sandoval	31	Texas	Val Verde
16	New Mexico	San Miguel			

Heritage program ranks

State natural heritage programs collect information about the biological diversity of their respective states and maintain databases of plant species of concern. Globally, *Penstemon jamesii* is ranked apparently secure (G4) by NatureServe (2003). The Colorado Natural Heritage Program ranks it as critically imperiled (S1), and the species is presumed extirpated (SX) by the Kansas Natural Heritage Inventory. Outside of Region 2, *P. jamesii* is not ranked (SNR) in New Mexico, and its rank in Texas apparently needs to be updated. The species' rank in Texas is reported as imperiled (S2), but according to the Texas Natural Heritage Program, *P. jamesii* is a "watch list" species in Texas (i.e., a species that is not actively tracked, but may be of conservation concern in the future) (Texas Conservation Data Center 2006). *Penstemon jamesii* is not listed by the New Mexico Rare Plant Technical Council (2002).

Existing Regulatory Mechanisms, Management Plans, and Conservation Practices

Penstemon jamesii is a regional endemic species currently known from two states; based on herbarium collections, more than 100 occurrences are reported in New Mexico and Texas (**Appendix**). One historic record is reported in Las Animas County, Colorado. It is currently thought that an historic occurrence reported in Kansas was the result of accidental human introduction, and *P. jamesii* is considered extinct in that state (Freeman personal communication 2004).

Known occurrences of *Penstemon jamesii* are located in a variety of land ownerships and management throughout its range. However, no occurrences have been documented on National Forest System lands within Region 2, and no extant occurrences are known from the states within Region 2. One occurrence was identified in 1948 on private lands within Las Animas County, Colorado (Weber and Wittmann 2001, Olson personal communication 2004), but *P. jamesii* has not been observed at this site since the initial collection (Colorado Natural Heritage Program 2003) although W. Weber and other botanists have made several searches (Clark personal communication 2004, Jennings personal communication 2004). The Colorado Natural Heritage Program has classified *P. jamesii* as critically imperiled (S1) due to its apparent rarity in Colorado. While state natural heritage program databases draw attention to species potentially requiring conservation strategies for long-term viability, these lists are not associated with specific legal constraints, such as limits to plant harvesting or damage to habitats supporting these plants. Although *P. jamesii* has been identified as a species of special concern in Colorado, there are few existing regulatory mechanisms at the federal or state level to regulate its conservation.

USFS Region 2 has designated *Penstemon jamesii* a sensitive species (USDA Forest Service 2005). Given this designation, if it is observed to occur on National Forest System lands within Region 2, *P. jamesii* 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 (USDA Forest Service 2005). USFS policies require a biological evaluation to assess project impacts to sensitive species (USDA Forest Service 2005). Occurrences of *P. jamesii* are not specifically protected by the National Environmental Policy Act; however, the act requires the assessment of impacts from a proposed federal project to the environment, and occurrences may be avoided when planning any projects. USFS travel management plans may protect rare species by restricting vehicle use to established roads only (USDA Forest Service 2005), and wilderness areas have restrictions on motorized travel (Wilderness Act of 1964, Act of September 3, 1964 [16 U.S.C. 1131-1136, 78 Stat. 890] - Public Law 88-577). In addition, the USFS prohibits the collection of sensitive plants without a permit (USDA Forest Service 2005). No specific management or conservation plan is in place for the protection of this species. Existing laws and regulations adequately protect the species.

Biology and Ecology

Systematics and synonymy

The genus *Penstemon*, a member of the Figwort Family (Scrophulariaceae), contains approximately 250 species, almost all of which grow in North America, from Alaska to Guatemala, but especially in the western United States. One species occurs in Kamchatka and northern Japan (Mabberley 1997).

According to Keck (1938), *Penstemon jamesii* is a member of Section *Aurator*, but more recently, Holmgren (1979a, 1979b) has placed *P. jamesii* within Section *Cristati* of subgenus *Penstemon*. **Table 1** shows the currently accepted classification of this species. Two closely related species are *P. ophianthus* Pennell and *P. breviculus* (Keck) Nisbet & R.C. Jackson (Nisbet and Jackson 1960). At one time, Keck

Table 1. Classification of *Penstemon jamesii* Benth.

Family: Scrophulariaceae

Genus: *Penstemon*

Species: *jamesii*

Authority: Bentham

Citation: *Penstemon jamesii* Benth., in Prodromus Systematis Naturalis Regni Vegetabilis 10:325. 1846.

Synonyms: *Penstemon albidus sensu* Torr. *non* Nutt.; *Penstemon brevibarbatus* Crosswhite; *Penstemon jamesii* Benth. var. *jamesii*; *Penstemon jamesii* ssp. *typicus* Keck; *Penstemon similis* A. Nels.

Vernacular Name: James beardtongue

Type: United States, New Mexico, Union County. Probably Don Carlos Hills, south of Sierra Grande and just north of Ute Creek, about 6,300 ft., July 30, 1820. *James 318* (NY)

(1938) considered them subspecies of *P. jamesii*, and indeed, they are sometimes difficult to distinguish and are partially sympatric. *Penstemon ophianthus* and *P. breviculus* are both found in northwestern New Mexico, northeastern Arizona, southeastern Utah, and southwestern Colorado; *P. jamesii* is found in eastern New Mexico and western Texas. Due to the subspecies previously identified within the species (*P. jamesii* ssp. *ophianthus* and *P. jamesii* ssp. *breviculus*), some federal agency lists and the University of Colorado herbarium website include *P. jamesii* when indeed those specimens are *P. ophianthus* or *P. breviculus* (Clark personal communication 2006, Colyer personal communication 2006). The global heritage status rank for *P. breviculus* is G3 (vulnerable) (NatureServe 2006). NatureServe (2006) also reports *P. breviculus* listed as S2 (imperiled) in Colorado, S3 (vulnerable) in New Mexico, S1? (uncertain, may be critically imperiled) in Utah, and SNR (not ranked) in Arizona.

Penstemon jamesii was first collected during the Long Expedition by Edwin James on July 30, 1820, in western Union County, New Mexico (Goodman and Lawson 1995). In 1827, John Torrey assigned the name *P. albidum* to this species; he was apparently unaware that Nuttall had already used the name *P. albidum* for a different species in 1818. During the next few years, as additional material from a range of localities was accumulated and studied, it became clear that the plant collected by James and called *P. albidum* by Torrey was distinct from true *P. albidus* Nutt. (the gender of the specific epithet was changed from neuter to masculine probably in the late 1880's). Consequently, George Bentham formally described *P. jamesii* in 1846 based on James' specimen. Nuttall's species (*P. albidus*) has remained an accepted species and has a large range across the plains of the United States, including New Mexico.

Non-technical description

Plants of *Penstemon jamesii* are perennial herbs, probably short-lived. Stems range from 1 to 5 dm tall, and are one to several, erect or ascending, glabrate or puberulous. The leaves are glabrate to strongly puberulous, entire, undulate or irregularly and sometimes sharply serrate, 2 to 12 cm long, and 0.5 to 1.5 cm wide. Lower leaves are often in threes, petiolate, linear and acute, spatulate and obtuse, or lanceolate and tapering at both ends. Cauline (stem) leaves are linear or lanceolate, and the tips are acute. Inflorescences are 5 to 25 cm long, not spreading, secund, glandular-pubescent, with two to eight verticillasters (clusters of flowers at nodes) each with 1 or 2 (4) cymes composed of (1) 2 to 5 flowers. Peduncles and pedicels are almost always less than 1 cm long, appressed or erect; bracts are leaflike, the upper ones gradually diminishing in size, glandular-pubescent. Calyces are 8 to 12 mm long, 2 to 3 mm wide, lobes lanceolate or narrowly ovate, acute to acuminate, herbaceous or narrowly scarious margined at base. Corollas are 25 to 35 mm long, 9 to 16 mm wide (when pressed), pinkish or pale lavender to violet-blue, glandular externally, strongly bilabiate. The throat has prominent purplish guidelines, is abruptly and broadly expanded from a tubular base both above and below; upper lobes are projecting, lower lobes spreading to reflexed, throat (opening) is broader than tall; palate (base of lower lobes) is bearded with long white hairs and glandular-pubescent. Anther sacs are open completely (explanate or peltate) and essentially glabrous. The staminode (sterile stamen) is narrow (tip only slightly dilated), strongly exserted, distal, 10 to 14 mm, and densely covered with long flat yellowish hairs. The fruit is a capsule, 14 to 17 mm long. Seeds are 2 to 3 mm long, angular, black. *Penstemon jamesii* flowers primarily in May and June. See **Figure 2A**, **Figure 2B**, **Figure 2C**, and **Figure 2D**.

Figure 2A. *Penstemon jamesii* (James' penstemon). Photograph by David Bleakly (DLB 3942 Near Vaughn, Guadalupe County, NM).

Figure 2B. *Penstemon jamesii* (James' penstemon). Photograph by David Bleakly (DLB 3965-10 mi. east of Carrizozo, Lincoln County, NM).

Figure 2C. *Penstemon jamesii* (James' penstemon). Photograph by David Bleakly (DLB 2745 North of Watrous, Mora County, NM).

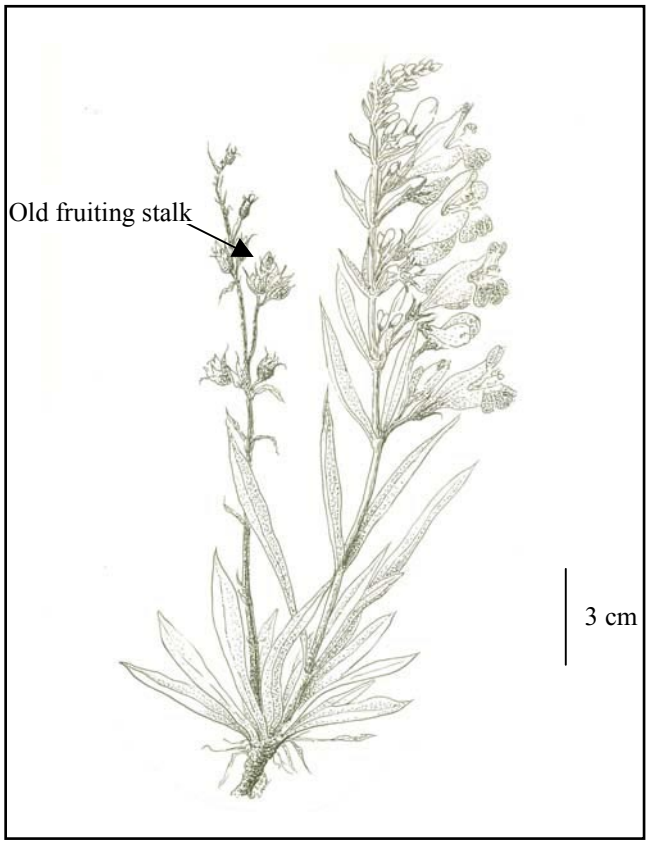

Figure 2D. Line drawing of *Penstemon jamesii* by Linda Mary Reeves©, 2004. Used with permission.

Several features of *Penstemon jamesii* are quite variable: length of the stems, puberulence of the stems and leaves, length and width of the leaves, degree of serration on the leaves, and the length and width of the corollas. On the other hand, the inflorescence is always glandular-pubescent and almost always secund, the palate is bearded and glandular-pubescent, and the staminode is bearded and exserted.

Distribution and abundance

At lower latitudes, *Penstemon* species grow in temperate or montane habitats, not in truly tropical areas. Although a number of *Penstemon* species (including their subspecific taxa), such as *P. albidus*, *P. ambiguus*, *P. angustifolius*, *P. barbatus*, *P. gracilis*, *P. grandiflorus*, *P. rydbergii*, and *P. whippleanus*, are relatively widespread in the western United States, the genus is well known for its large number of species with narrow ranges and habitat requirements. More than half, about 170, of all the *Penstemon* species are present in the Four Corners states (Arizona, Colorado, New Mexico, Utah), and approximately 70 species are endemic or nearly endemic. Colorado supports about 70 taxa and nine endemic species. Approximately 50 *Penstemon* taxa are known from New Mexico, including about eight that are endemic or very nearly so.

Penstemon jamesii is the most common *Penstemon* species in New Mexico east of the Rio Grande (Bleakly personal observation 2004, Sivinski, personal communication 2004), and it is present in parts of most eastern counties. *Penstemon jamesii* grows in only one county west of the Rio Grande, Los Alamos County. Its range may barely enter southeastern Colorado (one 1948 collection from Las Animas County), but recent searches for this occurrence have been unsuccessful (Olson personal communication 2004). One collection (early 1990's) was made in extreme southwestern Kansas (Morton County) where *P. jamesii* was apparently introduced and is now extirpated (Freeman personal communication 2004). Freeman suggests that *P. jamesii* was accidentally introduced with other seeds and did not become established. Extensive recent searches have not revealed the presence of this species in Kansas (Freeman personal communication 2004). The range of *P. jamesii* extends substantially into southwestern and western Texas (**Figure 1**). The Great Plains Flora Association (1986) states that *P. jamesii* is present in only two counties on the west edge of Texas adjacent to New Mexico (Bailey and Lamb counties), but herbarium specimens indicate a much broader distribution. Inventories specifically for *P. jamesii* in Texas have not been undertaken due to its wide distribution in New Mexico and parts of western Texas. The species may be observed in many field inventories that have not been published (Poole personal communication 2006). Potential habitat is variable and extensive throughout the range of the species, including grasslands and piñon-juniper woodlands. The University of New Mexico herbarium contains one verified collection from Brewster County, Texas. Data from herbarium labels at the University of Texas, Austin (2004) show that *P. jamesii* is present in eight additional counties in southwestern Texas. Craig Freeman stated (personal communication 2004) that although there are no herbarium specimens for many west Texas counties, *P. jamesii* is common and widespread in western Texas, (i.e., the counties adjacent to and near New Mexico's eastern border). No specimens or records have been located from Oklahoma (Taylor and Taylor 1989) or Mexico. **Figure 1** shows the potential distribution of *P. jamesii* in Colorado and Kansas as well as known occurrences in New Mexico and Texas by county. **Table 2** is a list of all the states (i.e., New Mexico, Colorado, Kansas, Texas) and counties in those states in which *P. jamesii* is documented, as well as the herbaria in which specimens are known to exist and the number of specimens therein. **Table 3** presents more detailed information on representative occurrences of *P. jamesii* for each state and county. Insufficient information was available to list occurrences by ownership and habitat type. Label data for specimens are located in the **Appendix** to this assessment.

Penstemon jamesii is widely distributed in the eastern half of New Mexico and in western Texas. Herbarium label data indicate occurrences are frequent, infrequent, or occasional. Although the total number of plants has never been estimated, the authors' personal observations, the observations of the New Mexico state botanist (Sivinski, personal communication 2004), and the relatively large quantity of herbarium collections indicate that there are probably tens of thousands of individuals growing over hundreds of square miles in New Mexico and Texas. No actual counts, however, have been taken.

Population trends

In most cases, the ownership of the land from which *Penstemon jamesii* specimens have been collected is not known. While most of the range of this species occurs on private land in eastern New Mexico and western Texas, plants have been collected from Bandelier National Monument, New Mexico; Guadalupe Mountains National Park, Texas; Sevilleta

Table 2. Summary of information from herbarium records of *Penstemon jamesii*.

State (number of specimens)	County	Herbarium[1] (number of specimens)	General abiotic/ecological description (based on available information on herbarium labels)
New Mexico (n = 97)			
	Bernalillo	UNM (3)	sandy limestone
	Colfax	UNM (12)	1) sandy-clay soil; 2) in gravel; 3) *Bouteloua gracilis/B. curtipendula*; grassland bench, shale derived soil with sandstone rocks; 4) roadside grassland
	Curry	UNM (1)	plains
	DeBaca	NMSU (1) UNM (3)	1) plains; 2) open gypsum soil, with *Hymenoxys* sp., *Aristida* sp., *Stipa* sp., and *Dalea formosa*
	Eddy	UNM (3)	grassy floodplain, flat limestone above Big Canyon Arroyo
	Guadalupe	UNM (4)	1) plains; 2) grassland
	Lincoln	NMCR (2) UNM (10)	1) low hills; 2) juniper savannah; 3) grassy slope in juniper savannah
	Los Alamos	UNM (3)	1) piñon-juniper; exposed tuff, thin layer sandy soil; 2) canyon side in juniper
	Mora	UNM (6)	roadside grassland
	Otero	NMSU (2) UNM (8)	1) limestone; 2) limestone hillside
	Quay	UNM (3)	no information recorded
	Roosevelt	UNM (2???)	1) soils: Mansker and Portales loams, Potter soils and rough broken land, slope: 3-9 degrees, aspect: 30 degrees azimuth; 2) on gravel road; in clay soil w/ limestone rocks
	Sandoval	UNM (1)	no information recorded
	San Miguel	NMSU (1) UNM (6)	*Juniperus monosperma* community
	Santa Fe	NMSU (3) UNM (8)	1) rocky ground among ponderosa and piñon; 2) roadside; 3) sandy, east-facing hill, with *Chrysothamnus nauseosus* ssp. *bigelovii*, *Bouteloua gracilis, Muhlenbergia torreyi, Opuntia phaeacantha, Gutierrezia sarothrae, Juniperus monosperma, Opuntia imbricata*, and *Pediocactus papyracanthus*
	Socorro	UNM (1)	rock and gravel soil texture with <20 degree slope, west aspect.
	Torrance	UNM (6)	no information recorded
	Union	NMSU (1) UNM (7)	1) granitic outcrop in rolling plain; 2) meadow near stream (Dry Cimarron?); 3) roadside; 4) roadside grassland
Colorado (1)			
	Las Animas	COLO (1)	frequent in field

Table 2 (concluded).

State (number of specimens)	County	Herbarium[1] (number of specimens)	General abiotic/ecological description (based on available information on herbarium labels)
Kansas (0)			
	Morton	cited in Great Plains Flora Association 1986, no data or specimen seen	one plant in prairie
Texas (26)			
	Bailey	UTA (2)	1) on sand hills; 2) on dunes, in clumps
	Brewster	UNM (1) UTA (5)	1) infrequent; 2) infrequent along gravel roadside; 3) rare; 4) infrequent
	Crockett	UTA (3)	1) limestone hills; 2) infrequent on limestone hills; 3) infrequent on limestone hills
	Culberson	UTA (3)	grassy hillside and valley
	Edwards	UTA (1)	grassy slope
	Jeff Davis	UTA (2)	hillside
	Kinney	UTA (1)	open rocky soil
	Lamb	UTA (1)	occasional in deep sands of dune area
	Pecos	UTA (3)	1) limestone soil along highway; 2) in area dominated by *Larrea* sp., *Prosopis* sp., and *Parthenium* sp.
	Terrell	UTA (2)	1) along highway; 2) limestone soil along highway
	Val Verde	UTA (2)	1) limestone soil along highway; 2) rocky limestone soil

[1]Herbaria:

COLO University of Colorado, Boulder
UNM University of New Mexico, Albuquerque
NMCR New Mexico State University, Range Science
NMSU New Mexico State University
UTA University of Texas, Austin

National Wildlife Refuge, New Mexico; and Cibola and Lincoln national forests, New Mexico. However, none of these entities consider the species or its habitat rare, and none monitor its occurrences.

There are no data on population trends for *Penstemon jamesii* or any related species. There may be annual changes in apparent abundance of *P. jamesii* that are directly related to variation and timing of precipitation. Occurrences in New Mexico appear to be reproducing and stable, based on general field observations by both authors.

Habitat

Penstemon jamesii grows primarily in grasslands and shrubby grasslands in habitats described by Dick-Peddie et al. (1993) as Plains-Mesa Grassland, Juniper Savanna, Piñon-Juniper Woodland, Desert Grasslands, and Chihuahuan Desert Scrub. Within these habitat types it appears to occur with *Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths (blue grama), *B. curtipendula* (Michx.) Torr. (sideoats grama), *B. hirsuta* Lag. (hairy grama), *Pleuraphis jamesii* Torr. (James' galetta), *B. dactyloides* (Nutt.) Engelm. (buffalograss),

Table 3. Representative occurrences of *Penstemon jamesii* by state and county.

State	County	Location	Date of Collection	Collector and Number	Abiotic/Ecological Information
Colorado	Las Animas	8 miles west of Kim	02-Jun-1948	C.M. Rogers 5853	Frequent in field
New Mexico	Bernalillo	Sandia Mountains	23-May-1977	Tafoya 18	No observations recorded
New Mexico	Colfax	Maxwell Grant	18-Jun-1997	Baker & Wright 12498	In gravel
New Mexico	Curry	North of Clovis	23-May-1939	G. Nisbet 1	Plains
New Mexico	De Baca	Near Ft. Sumner	30-May-1941	G. Nisbet 829	Plains
New Mexico	Eddy	43 miles southwest of Carlsbad	22-May-1992	W. Dunmire 1217	Grassy floodplain, flat limestone above Big Canyon arroyo
New Mexico	Guadalupe	15 mi south of Vaughn	06-Jun-1941	G. Nisbet 847	Plains
New Mexico	Lincoln	Near Tinnie	06-Jun-1941	G. Nisbet 835	Low hills
New Mexico	Los Alamos	Bandelier National Monument	31-May-1978	Foxx & Tierney 8	Piñon-Juniper Community; exposed tuff, thin layer sandy soil
New Mexico	Mora	Near Ocate	07-Jul-1976	J. Calvert 59	No observations recorded
New Mexico	Otero	Sacramento Mountains	01-Jun-1999	R. Sivinski & P. Tonne 4829	Limestone
New Mexico	Quay	San Jon Hill	20-Jun-1979	J.P. Hubbard sn	No observations recorded
New Mexico	Roosevelt	Melrose Air Force	06-May-1993	D. Bleakly & E. Debruin 97	Mansker and Portales loams, Potter soils; rough broken land; slope: 3-9 degrees, aspect: 30 degrees azimuth
New Mexico	Sandoval	Near Placitas	05-Jun-1930	E.F. Castetter 5830	No observations recorded
New Mexico	San Miguel	Anton Chico	12-May-1983	R. Fletcher 6981a	*Juniperus monosperma* community
New Mexico	Santa Fe	Junction US-285 & 8518	Jun-1955	G. Nisbet 1164	Roadside
New Mexico	Socorro	Sevilleta National Wildlife Refuge	28-May-1990	T. Maddox 397	Rock and gravel soil texture; <20 degree slope, west aspect
New Mexico	Torrance	Near Encino	19-Jun-1992	R. Sivinski 1886	On limestone balds in short grass prairie
New Mexico	Union	4 miles northeast of Folsom	20-Jun-1951	E.F. Castetter 5838	Roadside
Texas	Bailey	South of Muleshoe	04-Jun-1957	D.S. Correll 16657	On sand hills
Texas	Brewster	18 miles east of Alpine	23-Apr-1949	Warnock & Turner 8528	Rare
Texas	Crockett	25 miles west of Ozona	07-May-1947	McVaugh 8206	Limestone hills
Texas	Culberson	Guadalupe Mt. Nat. Park	30-May-1987	A.M. Powell 5429	No observations recorded
Texas	Edwards	West Fork Nueces River	29-Apr-1959	Correll & Johnston 21212	Grassy slope
Texas	Jeff Davis	Davis Mountains	03-Aug-1945	Lundell 14235	Hillside
Texas	Kinney	17 miles northeast of Brackettville	17-Apr-1957	Corell, Rollins, & Chambers 15968	Open, rocky soil

Table 3 (concluded).

State	County	Location	Date of Collection	Collector and Number	Abiotic/Ecological Information
Texas	Lamb	16 miles east of Muleshoe	06-May-1961	C.M. Rowell 8247	Occasional in deep sands of dune area
Texas	Pecos	30 miles south of Ft. Stockton	24-Apr-1977	Henrickson 15769	In *Larrea* sp., *Prosopsis* sp., *Parthenium* sp. dominated area
Texas	Terrell	7 miles east of Longfellow	30-Apr-1949	Warnock & Turner 591	Along highway
Texas	Val Verde	25 miles north of Del Rio	15-Apr-1999	Turner 99–121	Rocky, limestone soil

Krascheninnikovia lanata (Pursh) A.D.J. Meeuse & Smit (winterfata), *Achnatherum hymenoides* (Roemer & J.A. Schultes) Barkworth (Indian grass), and *Sporobolus* spp. Plants have been collected at a wide range of elevations, from about 685 m (2,247 ft.) in Crockett County, Texas, not far from the Pecos River, to about 2,500 m (8,202 ft.) near Ocate in Mora County, New Mexico. There is no recognizable correlation of plant occurrence with any single soil type or geological formation; *Penstemon jamesii* may be found on loamy, rocky, sandy, or calcareous soils. The terrain that this species occupies is generally flat to hilly, and the plant is not typically found on steep or rocky slopes. Commonly associated species include a variety of other grasses, forbs, and shrubs, depending on elevation and habitat (**Table 4**).

Annual precipitation in the range of *Penstemon jamesii* varies from 10 to 20 inches (USDA Natural Resources Conservation Service 2004). Seeds need to be cold-stratified for proper germination (Way and James 1998). Herbarium label data indicate that *P. jamesii* grows in a range of soil types derived through weathering and erosion of several geologic substrates, including shale, sandstone, limestone, granite, as well as deep, well-developed soils. See **Appendix** for a list of label data from voucher specimens.

In Colorado, the only known collection of *Penstemon jamesii* was found eight miles west of Kim (Las Animas County), in grassland at about 1,775 m (5,825 ft) elevation in 1948. Comanche National Grassland did not exist when the specimen was collected, and it is likely that the collection site is on private land. Based on occurrences elsewhere in its range, the species is most likely to be found in grasslands in Colorado and Kansas, possibly including National Forest System lands within Region 2. *Penstemon jamesii* was not observed in an intensive recent survey of the Mesa de Maya area, Colorado (Clark personal communication 2004). This personal communication revealed an error in her survey report (Clark 1996), in which she stated that *P. jamesii* was "frequent within the grassland community" when it was actually never observed.

Reproductive biology and autecology

In this section, we mainly present information from species in the subgenus *Penstemon* and in the Section *Cristati* (Nold 1999). Details of the breeding system of *P. jamesii* are not known, but the primary mechanism for natural reproduction is probably by seed. The plants are monoecious and apparently primarily or exclusively outcrossing, based on flower morphology. *Penstemon jamesii* produces an inflorescence with numerous flowers (greater than 12) from late April to early July, and the seeds mature several weeks later. The capsules dehisce nearly the entire length, and the seeds are 3.0 to 3.5 mm long (Cronquist et al. 1984).

The hypothesized life cycle of this perennial plant is depicted in **Figure 3**. The rates of growth, survival,

Table 4. Taxa documented to co-occur with *Penstemon jamesii* as reported on herbarium specimen labels.

Associated Species	Vernacular name
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama
Bouteloua curtipendula (Michx.) Torr.	sideoats grama
Bouteloua hirsuta Lag.	hairy grama
Pleuraphis jamesii Torr.	James' galleta
Juniperus monosperma (Engelm.) Sarg.	oneseed juniper

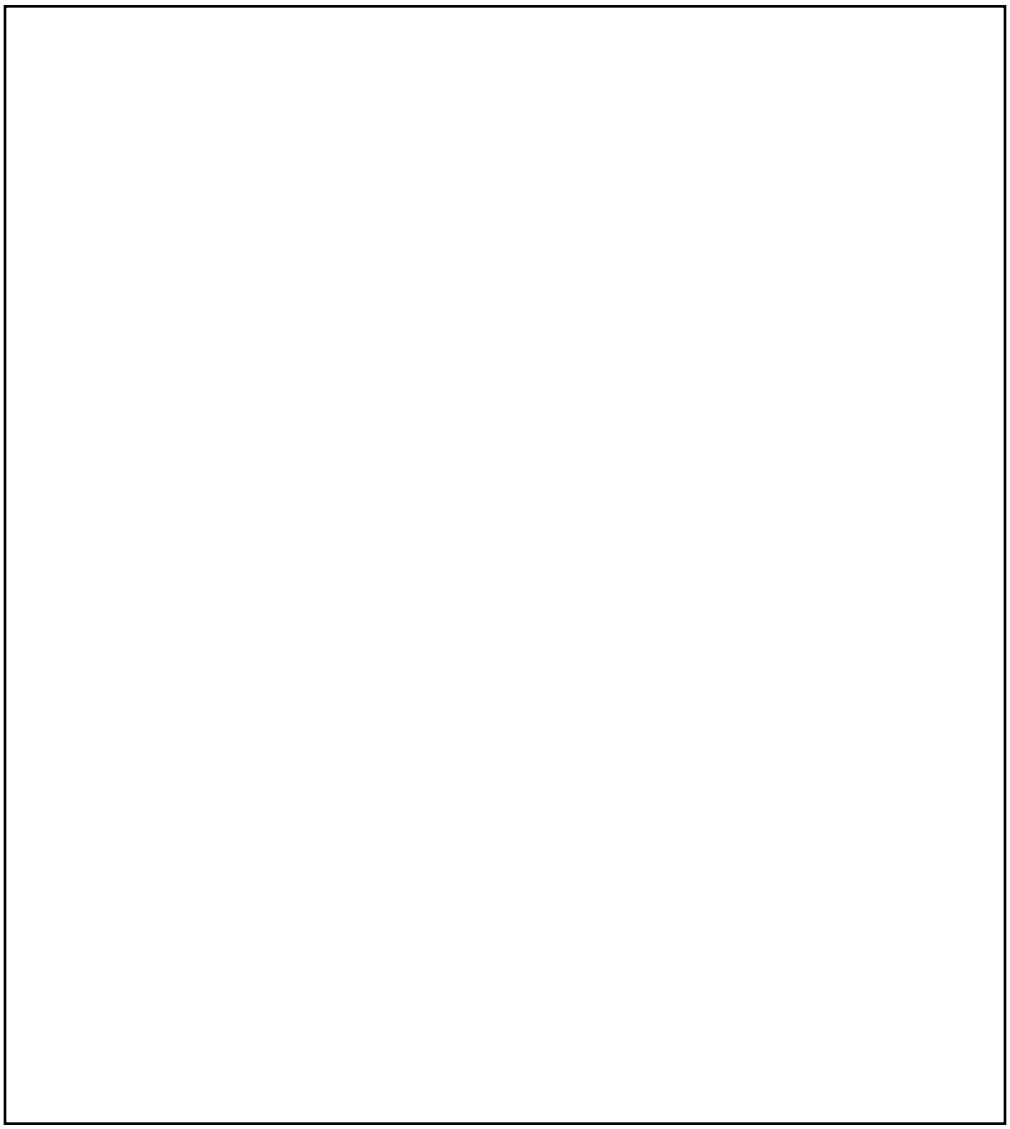

Figure 3. Generalized life cycle diagram of *Penstemon jamesii*.

recruitment, dispersal, and longevity are unknown; however, in a garden environment (personal studies), the close relative, *Penstemon breviculus*, persists for up to five years. There have been no studies on the life history, demography, fecundity, or longevity of *P. jamesii* or related species, and no reliable inferences can be made from the few studies of other *Penstemon* species. No information concerning vital rates, recruitment, survival, reproductive age, or lifespan has been recorded. Herbarium mounts represent only those occurrences that were in the flowering stage and do not include species from occurrences that were in a vegetative stage. Many *Penstemon* species are readily propagated by cuttings in gardens and greenhouses (Way and James 1998); however the extent of vegetative reproduction of *P. jamesii* in the wild is unknown.

The pollination biology of a few *Penstemon* species has been studied, but nothing specific is known about pollination or pollinators for *P. jamesii* or its close relatives. In general, the tubular flowers of *Penstemon* species attract hummingbirds, butterflies, bees, wasps, moths, and flies. There is evidence that hummingbirds are occasional pollinators of *P. strictus* individuals with number of visits based on density of plants (Castellanos et al. 2003). Although there are exceptions, pink, blue, or purple *Penstemon* flowers with wide-lobed corollas and conspicuous guidelines tend to be insect pollinated (Tepedino et al. 1999). For these reasons, *P. jamesii* is most likely insect pollinated. Many *Penstemon* species exhibit both self and cross-pollination, but it is unknown whether *P. jamesii* is partially or wholly self-incompatible. There are many issues related to

the pollination of *P. jamesii* that need to be researched, including the identity of pollinators, limitations of the pollinators to reproduction, and plant density.

Seed dispersal mechanisms for *Penstemon jamesii* or related species are not known. Mature capsules are present from the summer through the fall, depending on latitude, elevation, and microclimate. Due to the lack of wings or barbs, the seeds are not carried by the wind or animals, and one of the authors has observed that seeds fall near the parent plant after capsule dehiscence.

Little is known specifically about seed viability and germination requirements of *Penstemon jamesii* in the wild. However, some information is available in the horticultural literature. Both native and hybrid *Penstemon* species are popular garden plants, and many species, including *P. jamesii*, are readily available from seed companies. Seed available from seed companies is most likely collected from native populations and nursery stock. *Penstemon jamesii* requires cold stratification before germination (Way and James 1998, Plants of the Southwest 2002). Natural cold stratification occurs over the winter after the seeds mature in the summer or autumn. Although some may germinate after only a few weeks of chilling, most seeds probably germinate in the spring or early summer. Seeds from *P. rubicundus*, a Nevada endemic, have remained viable in dry storage for 22 years (Way and James 1998), so it is possible that seeds from other *Penstemon* species, perhaps even *P. jamesii*, could exhibit a similar adaptation to life in arid habitats.

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 appear to affect the timing of flowering; plants at lower elevations and on south-facing slopes tend to flower earlier. As stated above, several features of *Penstemon jamesii* vary among plants both within and between populations.

Cryptic phases during the life cycle include dormant individuals or overwintering seeds in the soil. Many perennial plant species fail to produce aboveground growth or senesce without flowering during drought or other unfavorable periods. It is not known if this occurs with *Penstemon jamesii*. The possibility of relatively long-term seed dormancy may be an important adaptation for survival in arid environments.

Mycorrhizal relationships with *Penstemon jamesii* have not been reported in the literature. Flessner and Stubbendieck (1992b) studied the mycorrhizal associations with *P. haydenii* on the sandy prairie soils in Nebraska. They found the mycorrhizal levels were low in the shifting sands and concluded that maintaining mycorrhizal associations was a low priority for this species. It is possible that mycorrhizal levels in the dry, sandy soils with *P. jamesii* are also low.

Natural hybrids between species of *Penstemon* have been reported (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). In addition, artificial hybridization for horticultural purposes is common (Way and James 1998). However, no natural hybrids of *P. jamesii* have been examined. Natural hybrids across sectional lines are rare or nonexistent because of their different modes of pollination; natural intrasectional hybrids are also rare because of differences in timing of flowering (Nold 1999). Other *Penstemon* species within the Section *Cristati* are not known to hybridize with *P. jamesii*.

Demography

Genetic characteristics play an important part in the reproductive fitness of plants. To date there have been no studies investigating the genetic characteristics of *Penstemon jamesii*. Beyond the base chromosome count for the genus (n = 8), little is known about hybridization, polyploidy, and genetic variability for the species. If *P. jamesii* is found in Colorado, it would represent a peripheral population at the northern extent of its range. Peripheral populations may have distinct traits that may be crucial to the species, allowing adaptation in the face of environmental change (Lesica and Allendorf 1995).

The life history of *Penstemon jamesii* remains uninvestigated at this time. No information concerning vital rates, recruitment, survival, reproductive age, lifespan or proportion of populations reproducing has been documented. A population viability analysis (PVA) is a rigorous quantitative analysis using demographic data, for predicting the future status of a given species. A literature search for PVA models for *P. jamesii* was performed, but no PVA has been accomplished for this species. PVA studies have been done for *P. arenarius* and *P. floribundus* (U.S. Bureau of Land Management 2001); both of these species are

extremely rare and belong to different sections within the genus *Penstemon*.

The factors affecting the spatial distribution of *Penstemon jamesii* have not been studied. Personal observations by the authors and the existence of at least 123 herbarium collections indicate that the plant is widely distributed in eastern New Mexico and western Texas in a range of habitats. No density estimates, such as numbers of plants per acre, are available. See also the section on Distribution and abundance.

Since *Penstemon jamesii* occurs in large numbers across a wide range of habitats over a large area, there are no known factors that would limit the species' continued growth and existence within its current range. Given the broad range of habitats, there is potential for additional populations to occur on National Forest System lands within Region 2, in addition to potential habitat in New Mexico and Texas.

Community ecology

Penstemon jamesii is found in ponderosa pine-piñon pine-Gambel oak, mixed conifer, juniper savannah, plains-mesa grassland, and desert grassland communities (Dick-Peddie et al. 1993), and it is most common in various grassland communities (see **Appendix**). *Penstemon jamesii* occurs scattered primarily along roadsides and in openings of piñon-juniper woodlands and grasslands. Distribution is patchy, varying from several individuals per square meter to hundreds of individuals across the landscape. The species is generally more common in openings in tree, shrub, and grass canopy where exposed soils provide suitable habitat.

It is not known to what extent herbivory affects *Penstemon jamesii*. Livestock grazing occurs on most of its range. One of the authors has observed that native animals browse some species of *Penstemon* in New Mexico, especially during drought or early in the season when other forage may not be available. Wildlife or livestock commonly browse *Penstemon* species when their stems are elongating. The browsing occurs before and during seed set. Once the seeds have set, the fruit is hard and prickly, and not desirable to wildlife or livestock. Browsing of young stems and foliage by ungulates and consumption of fruits, seeds, and roots by rodents have been reported for a few species (Beatty et al. 2003 and literature cited therein). The effects of animal activities, with the exception of herbivores, are not known for *P. jamesii* or near relatives of the species. Some *Penstemon* species produce secondary metabolites (iridoid glycosides) that may render the plants less palatable to herbivores (Stermitz et al. 1993, Franzyk et al. 1998). It is not known if *P. jamesii* produces such secondary metabolites; however iridoid glycosides have been found in at least three species of *Penstemon* including *P. barbatus* (Chaudhui et al. 1981), *P. virgatus* (Trigo 2000), and *P. secundiflorus* (Krull et al. 1998).

Although there is no specific information regarding competition, it is possible that in some cases, dense growth of grass or other plants could interfere with the establishment of *Penstemon jamesii* seedlings. The effects of habitat disturbance on germination and of invasive plant species on the presence of *P. jamesii* are not known. One of the authors has observed invasive species such as woollyleaf bursage (*Ambrosia grayi* (A. Nels.) Shinners), jointed goatgrass (*Aegilops cylindrica* Host), and nodding plumeless thistle (*Carduus nutans* L.) as minor constituents of habitats in which *P. jamesii* is normally found.

Nothing is known about the effects of parasites or diseases on *Penstemon jamesii* or near relatives of this species. No investigations have been conducted concerning the insect pollinators of *P. jamesii*. It is not known whether there are specialized pollinators associated with the species.

Penstemon jamesii is not restricted edaphically. It is most closely associated with grasslands and shrubby grasslands that are widespread in New Mexico, Texas, and Colorado. The common link among the habitats may be precipitation patterns since elevation and associated species appear to be less strongly correlated.

An envirogram is a useful tool for evaluating the relationship between the environment and a single species. Traditionally, it is most often applied to animal/environment interactions, but it can be used for plants as well. An envirogram traces the environmental factors that affect a species from the most indirect (distal) interactions to factors that have a direct (proximal) effect. The centrum is the most proximal level of the envirogram and directly affects the target species (Andrewartha and Birch 1984). For plants, the centra consist of resources (light, soil moisture, and nutrients), reproduction (flowering/fruiting, growth and development, and seedling establishment), and malentities (human interactions, extreme weather, and herbivory).

The envirogram is constructed as a modified dendrogram, with the centrum placed at the most

proximal level to the species. From each of the centrum components a web is constructed distally, illustrating factors that affect the centrum component, termed Web 1. Web 2 consists of factors that affect Web 1, Web 3 consists of factors that affect Web 2, and so on. One of the primary functions of an envirogram is to identify areas of research and propose hypotheses (Andrewartha and Birch 1984). To conserve space, occasionally second- and third-level webs are referred to a more complete web rooted in Web 1. Web 4 levels and above (Web *n*) generally identify areas beyond the ecological and biological scope of the species. To aid in viewing, each centrum is color coded. The resources centrum is green, the reproduction centrum is yellow, and the malentities centrum is blue.

As with all analytical tools, the best envirogram is based upon a complete data set. The envirogram constructed for *Penstemon jamesii* (**Figure 4**, **Figure 5**, **Figure 6**) depicts the lack of ecological and environmental data for this species. Entries with a question mark denote areas in need of further research, such as unknown factors affecting flowering and fruiting, seedling establishment, and growth and development. These envirograms are not presented to influence management decisions but to provide a basis for further studies. The resources centrum for *P. jamesii* (**Figure 4**) is made up of three proximal factors: light, nutrients, and available water. Vegetation structure, geology and the natural fire regime can all affect the amount of light a plant receives. Nutrient availability can be affected by such things as substrate parent material, climate, and mycorrhizal activities. Precipitation, soil porosity (permeability), and run off can influence the amount of available soil moisture. The reproduction centrum (**Figure 5**) consists of factors

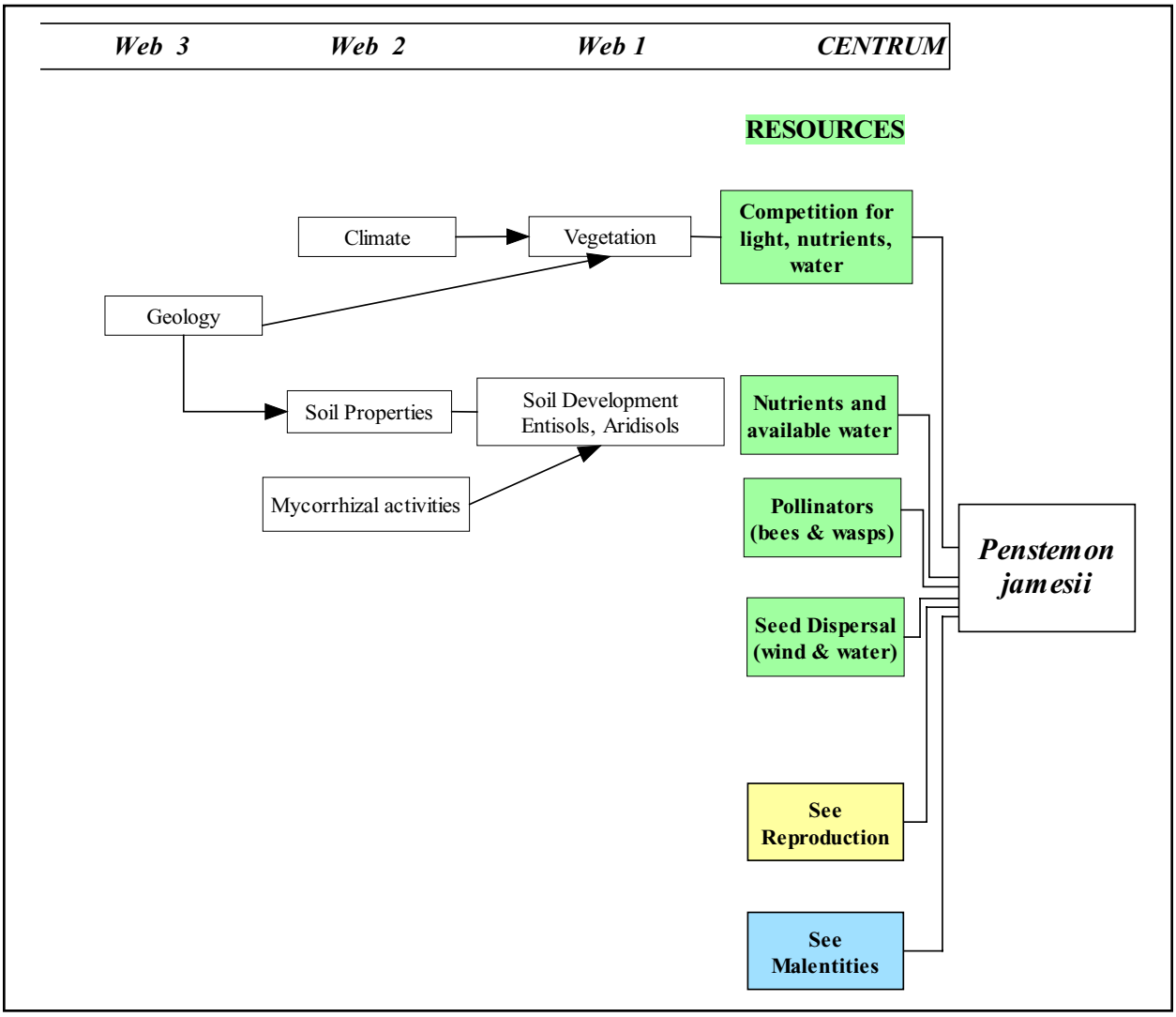

Figure 4. Resources centrum for *Penstemon jamesii* envirogram.

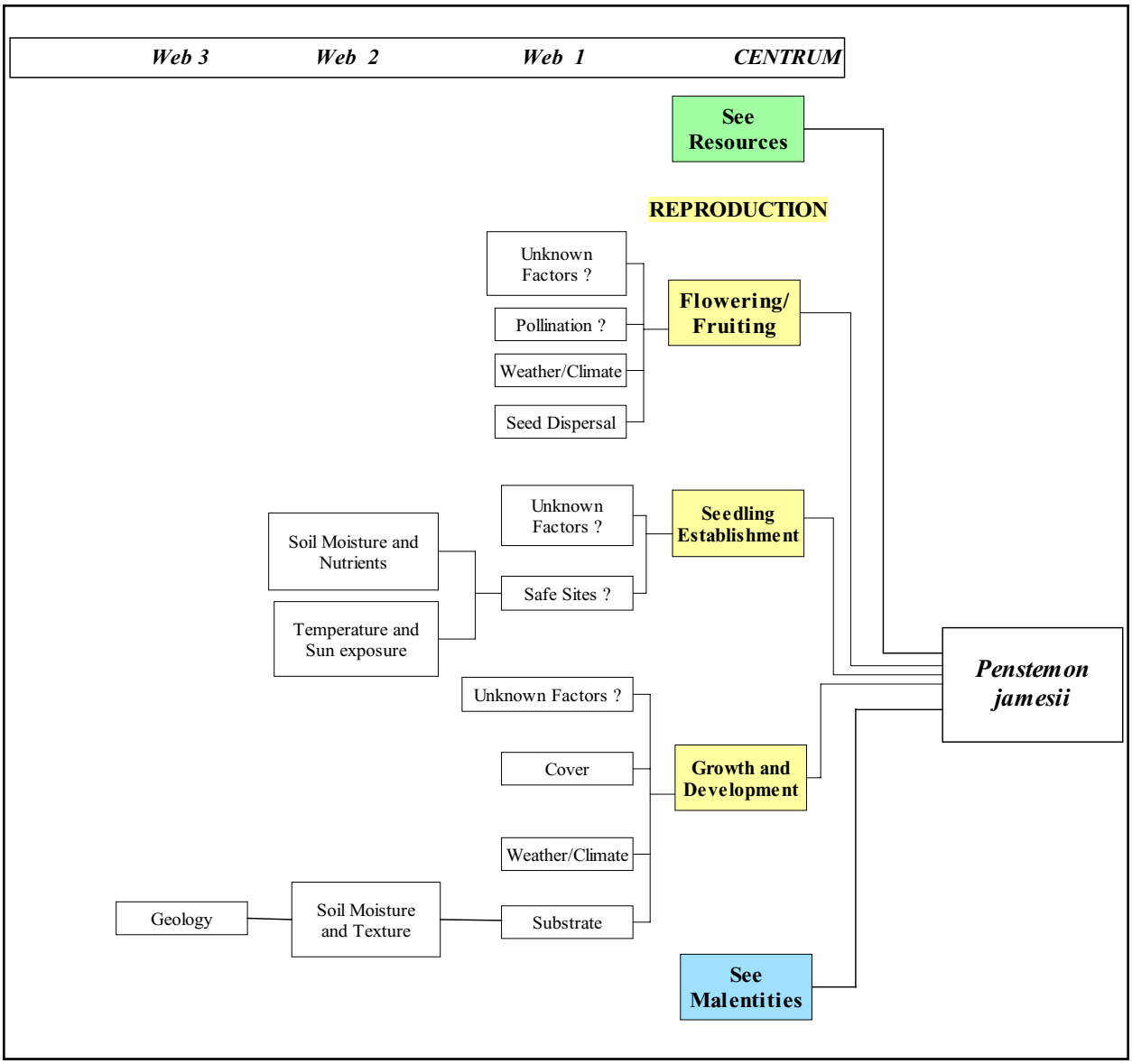

Figure 5. Reproduction centrum for *Penstemon jamesii* envirogram.

affecting flowering and fruiting (pollination, weather, dispersal), seedling establishment (possible safe sites), and growth and development (light, weather, and substrate). The malentities centrum (**Figure 6**) identifies factors that may negatively affect *P. jamesii*. These include such things as extreme weather conditions (e.g., drought, unusually cold weather during the flowering and fruiting season), herbivory, competition from invasive species, road construction and maintenance, and agriculture. Herbivory may cause damage through trampling, seed predation, or leaf damage and may be due to either domesticated livestock or native fauna, including mammals (e.g., rodents, rabbits, deer) and insects (e.g., arthropods). Competition from invasives may have a negative effect upon the ability of *P. jamesii* to occupy available habitat; road construction and agriculture may result in habitat degradation and loss.

CONSERVATION

Threats

Because the species has not been located within Region 2 since 1948, threats to the long-term persistence of *Penstemon jamesii* on Region 2 National Forest System lands are difficult to discern. Potential habitat for *P. jamesii* may exist on the Comanche National Grassland (Olson personal communication 2004). Of the management activities that typically occur or would be planned for National Forest System lands

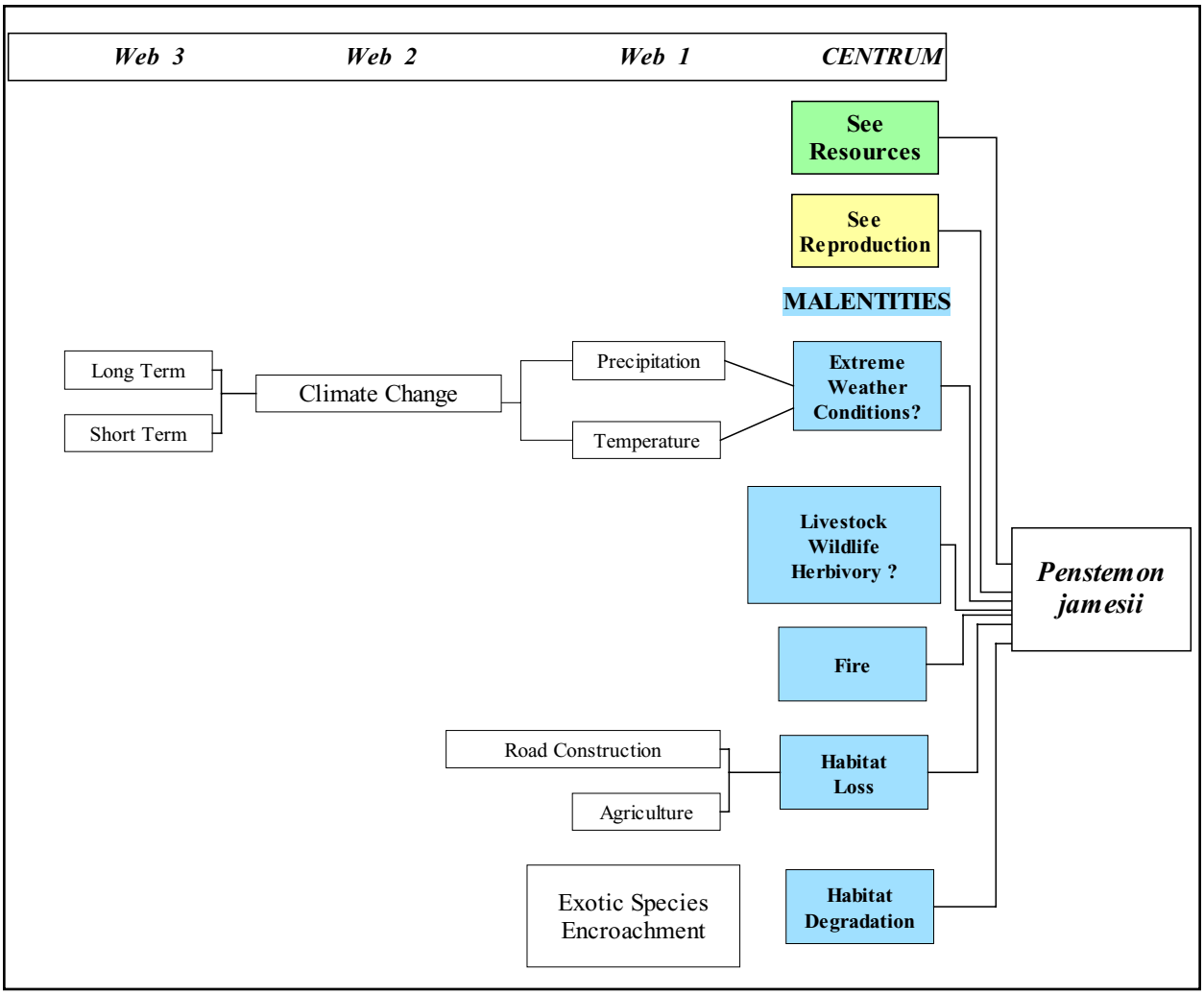

Figure 6. Malentities centrum for *Penstemon jamesii* envirogram.

within Region 2, prescribed or natural fire, livestock grazing, and road building and maintenance could affect occurrences of *P. jamesii*. Other potential threats include agricultural land conversion, invasive species encroachment, and changes to existing climatic and/or precipitation patterns.

The effects of wildfires on *Penstemon jamesii* are not known. This species grows primarily in grasslands and shrubby grasslands, and it is likely that *P. jamesii* is a fire tolerant plant (Owen personal communication 2004). However, the timing, frequency, or intensity of fire and the extent of negative impact or benefit to the species are undetermined. Although no fire history is known where *P. jamesii* occurs, it appears that this species grows best in open areas and may benefit from fire disturbance that creates openings.

It is not known to what extent livestock grazing impacts *Penstemon jamesii* (see Community ecology section). One of the authors has observed that *P. jamesii* is palatable to many herbivores including domestic livestock. Grazing could affect individuals or habitat by increasing erosion or soil compaction, or by opening habitat for exotic species. A low level of grazing might actually benefit the species by opening sites for seedling establishment. However, no quantitative monitoring data are available to support this hypothesis.

In New Mexico, one of the authors observed *Penstemon jamesii* growing in areas adjacent to existing road surfaces. Road building and road widening activities could directly damage individuals or affect this species indirectly through loss or degradation of habitat. A small disturbance may actually benefit certain plant species by breaking up the soil, eliminating competition from other plant taxa, and increasing runoff. One example of a plant species that benefits from small disturbances is *Aliciella formosa* (Aztec gilia). This New Mexican protected plant species does quite well along road cuts;

however, if disturbances continue over a period time, it will disappear (Reeves personal communication 2004). No quantitative information is available to determine the degree to which road building and maintenance may negatively affect or benefit *P. jamesii* or its habitat.

Agricultural conversion of grasslands and shrublands may have affected some populations in the past, but because past abundance of *Penstemon jamesii* is not known, this is strictly speculation. Invasive weed species may be another potential threat to *P. jamesii*, but this has not been documented. Invasive weeds alter ecological systems in various ways that include nutrient cycles, plant species displacement, negative changes in animal and bird habitats, and altered uses of private properties, farms, and rangelands (Heil 2000).

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

Conservation Status of Penstemon jamesii in Region 2

If this species occurs in Region 2, it would be at the northern limit of its natural range. Any occurrence of *Penstemon jamesii* on National Forest System lands within Region 2 would be peripheral to primary populations and could occur in slightly different conditions and have potential genetic differences from known populations in New Mexico and Texas. Peripheral populations may have distinct traits that may be crucial to a species, allowing adaptation in the face of environmental change (Lesica and Allendorf 1995). There is no evidence that this species' distribution or abundance is declining or increasing across its range. The only known occurrence of this species in Colorado is from a collection made in 1948, eight miles west of Kim, Las Animas County. This specimen is housed at the University of Colorado Herbarium and was likely collected from private land. Potential habitat for *P. jamesii* may exist on the Comanche National Grassland (Olson personal communication 2004). Prescribed or natural fire, road building and maintenance, and livestock grazing could affect any occurrences of *P. jamesii* on Region 2 National Forest System lands. Other potential threats include agricultural land conversion, invasive species encroachment, and changes to existing climatic and/or precipitation patterns. There is no evidence that current management activities are negatively or positively affecting this species or its habitat.

The common link among habitats of *Penstemon jamesii* may be solar radiation, temperature, and precipitation patterns, since elevation, soils, and associated species appear less strongly correlated. Climate is one of the main sources of environmental variation of plant species, which is reflected in worldwide vegetation zones that follow the latitudinal pattern of prevailing environmental conditions (Walter 1973).

Populations occurring at the edge of the range of *Penstemon jamesii* tend to be characterized by low density and high temporal variation. This spatial pattern is likely to generate similar patterns in genetics throughout *P. jamesii*'s range. Some edge populations will warrant special attention because they are highly vulnerable to loss of genetic diversity, while others will require attention because they contain high genetic diversity (Vucetich and Waite 2003). No genetic studies have been conducted concerning variability of *P. jamesii* across the species' range.

Management of Penstemon jamesii in Region 2

Detailed biological and ecological studies of *Penstemon jamesii* and associated habitat have not been conducted. No specific information is available documenting impacts of management on the species. Based on this lack of information, the authors can only speculate on the species' response to natural and anthropogenic disturbances.

Penstemon jamesii occurs across a broad range of habitats, elevations, and soil types. No specific information was identified limiting population growth. Activities that directly affect populations, such as agriculture, road construction or maintenance, or other surface-disturbing actions, could result in loss of individuals, habitat fragmentation, competition from invasive species, soil compaction, erosion, or alteration of habitat. A small disturbance may actually benefit certain plant species by breaking up the soil, eliminating competition from other plant taxa, or opening sites for seedling establishment. No quantitative information

is available to determine to what extent management activities positively or negatively affect this species or its habitat.

If *Penstemon jamesii* were found in Region 2, it would be important to evaluate its distribution and abundance, and threats to its persistence. Region 2 occurrences would represent outliers with possible genetic characteristics that could be important for species maintenance or even evolution of new species (Lesica and Allendorf 1995). *Penstemon jamesii* has not been found on National Forest System lands within Region 2. It is abundant in habitats throughout eastern New Mexico and western Texas and therefore does not merit sensitive status. Should new populations be identified within Region 2, they would be at the edge of their range and would likely be small. It would be important to reconsider sensitive status at that time.

Information Needs and Research Priorities

Penstemon jamesii is abundant and widespread in eastern New Mexico and western Texas and may be peripheral in Colorado (one historic occurrence). Research concerning the species' biology and ecology may be low priority at this time (Anderson personal communication 2004, Porter personal communication 2004), but inventory focusing on potential habitat, especially on the Comanche National Grassland, may be a higher priority. Although potential habitat for *P. jamesii* exists within Colorado, numerous searches in the area over decades have produced negative results (Clark personal communication 2004, Jennings personal communication 2004).

Visiting nearest locations in New Mexico may provide a search image for surveys in Colorado. The nearest population to Colorado is found in Colfax County, New Mexico (UNM 12). Observations recorded on the herbarium label indicated that the specimen occurred in roadside grassland with *Bouteloua gracilis* and *B. curtipendula*, on variable soils ranging from shale-derived soil with sandstone rocks to sandy clay or gravels.

Surveys for *Penstemon jamesii* should be conducted mid-May to mid-June, depending on elevation and aspect of the site. If the species is encountered, collecting information regarding microsite variables including soils, associated species, disturbance, and threats could provide valuable information on factors controlling its distribution in Region 2. Also, one or more specimens should be collected and placed in appropriate regional herbaria. If *P. jamesii* were identified on National Forest System lands within Region 2, it would be important to document abundance, extent of distribution, and habitat characteristics. At that time, information or research on the biology and ecology of the species might become more important. Management strategies based on the nature of the occurrence could then be developed and evaluated.

DEFINITIONS

Acuminate – tapering to the apex, the sides more or less pinched in before reaching the tip (Harrington and Durrell 1986).

Acute – tapering to the apex with the sides straight or nearly so; less tapering than acuminate (Harrington and Durrell 1986).

Bract – a more or less modified leaf situated near a flower or inflorescence (Harrington and Durrell 1986).

Capsule – a dry dehiscent fruit (Harrington and Durrell 1986).

Cauline – of or pertaining to the stem (Harrington and Durrell 1986).

Corolla – the inner series of the floral envelope; collective name for petals (Harrington and Durrell 1986).

Cyme – a flower cluster, often convex or flat-topped in which the central or terminal flower blooms earliest (Harrington and Durrell 1986).

Ecology – the study of plants and animals and their relationship to their environment (Harrington and Durrell 1986).

Endangered – defined in the Endangered Species Act as a species, subspecies, or variety likely to become extinct in the foreseeable future throughout all or a significant portion of its range (Harrington and Durrell 1986).

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 (Harrington and Durrell 1986).

Entire – leaf margins without teeth or lobes (Harrington and Durrell 1986).

Explanate – opened completely and spread out flat (Harrington and Durrell 1986).

Herbaceous – having the characteristic of an herb, not woody (Harrington and Durrell 1986).

Glabrate – becoming glabrous (having no hairs) in age (Harrington and Durrell 1986).

Glandular – bearing glands; a glandular hair has an enlargement like a hat pin at the apex (Harrington and Durrell 1986).

Inflorescence – the flowering part of a plant; almost always used for a flower cluster (Harrington and Durrell 1986).

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 (Harrington and Durrell 1986).

Lanceolate – lance-shaped; several times longer than wide; broadest toward the base and tapering to the apex (Harrington and Durrell 1986).

Linear – narrow and flat with sides parallel; lake a grass leaf blade (Harrington and Durrell 1986).

Monoecious – a plant that has the stamens and carpels in different flowers on the same plant.

Obtuse – blunt or rounded at the apex (Harrington and Durrell 1986).

Ovate – egg shaped in outline, attached at the wide end (Harrington and Durrell 1986).

Peltate – shield-shaped; attached to the center or near the center (Harrington and Durrell 1986).

Puberulent – with very short hairs (Harrington and Durrell 1986).

Pubescent – loosely used for covered with hairs; soft short hairs (Harrington and Durrell 1986).

Reflexed – abruptly bent or turned downward or backward (Harrington and Durrell 1986).

Scarious – thin, dry membranous and more or less translucent; not green (Harrington and Durrell 1986).

Secund – borne or directed to one side of the axis (Harrington and Durrell 1986).

Serrate – with sharp teeth directed forward (Harrington and Durrell 1986).

Spatulate – flattened spoon-shaped; broad and rounded at the apex; tapering at base (Harrington and Durrell 1986).

Staminode – a sterile stamen or any structure lacking an anther (Harrington and Durrell 1986).

Taxon (taxa–plural) – a biological entity which can be a species, subspecies, or variety, or at another level (Harrington and Durrell 1986).

Threatened – defined in the Endangered Species Act as a species, subspecies, or variety in danger of becoming endangered throughout all or a significant portion of its range (Harrington and Durrell 1986).

Undulate – the leaf margin gently wavy (Harrington and Durrell 1986).

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APPENDIX

List of Penstemon jamesii vouchers

State	County	Location	Elevation (ft.)	Date	Abiotic/Ecological	Collector(s) and Number	Herbarium	Acc #
CO	Las Animas	Field 8 miles west of Kim	n/a	June 2, 1948	flowers orchid. Field. Frequent here	C.M. Rogers 5853	COLO	56067
KS	Morton	9 mi north and 2 mi west of Elkhart	n/a	May 27, 1970	prairie; flowers pink; only one plant	J.E. Bare 2276	KANU	77944
NM	Bernalillo	Cibola Forest, near stream to left of La Luz Trail #137.	7,200	May 23, 1977	n/a	M.A. Tafoya 18	UNM	94402
NM	Bernalillo	Sandia Mountains, old Hwy 66 just E of Zamora.	n/a	June 12, 1999	Sandy limestone.	R.C. Sivinski 4866	UNM	101028
NM	Colfax	York Canyon, SE corner (Mine Lease)	7,170	June 1, 1979	n/a	Higgins and Campbell sn	UNM	66228
NM	Colfax	Ancho Canyon	n/a	June 21, 1983	n/a	R. Jepson 1215	UNM	83870
NM	Colfax	Private property. In swale-depression of Santa Fe Trail (Cimarron cutoff), 0.75 mi. NE of Wooten.	5,900	June 14, 1995	Sandy-clay soil	W.W. Dunmire 1236	UNM	90515
NM	Colfax	Casa Grande SW Quad; along Vermejo River	7,120	June 18, 1997	In gravel	M.A. Baker and T. Wright 12498	UNM	95031
NM	Colfax	Casa Grande SW Quad	7,280	June 21, 1997	*Bouteloua gracilis / B. curtipendula* grassland bench, shale derived soil with sandstone rocks	M.A. Baker and T. Wright 12537	UNM	95012
NM	Colfax	US-56, MP 22, about 22 mi east of Springer, ca 2.2 miles east of Abbott	6,230	May 28, 1999	roadside grassland	D.L. Bleakly 3724	UNM	None
NM	Curry	few miles north of Clovis	4,300	May 23, 1939	plains	Gladys Nisbet 1	UNM	4067
NM	De Baca	5 mi north of Fort Sumner	4,200	May 30, 1941	plains	Gladys Nisbet 829	UNM	4064
NM	De Baca	24 air km [16.5 mi] S of Fort Summer on E side of Pecos River, along rd C1, N side Cibolo Creek at top of bluffs, S2 R26E T1S	n/a	May 18, 1997	Open gyppy soil, with *Hymenoxys* sp., *Aristida* sp., *Stipa* sp., and *Dalea formosa*	Spellenberg, R, N Zucker 12413Z	NMC	68106
NM	Eddy	Near mouth of Big Canyon, ca 43 mi sw of Carlsbad	5,000	May 22, 1992	grassy floodplain, flat limestone above Big Canyon Arroyo	WW Dunmire 1217	UNM	82543
NM	Guadalupe	15 mi south of Vaughn	5,800	June 6, 1941	plains	Gladys Nisbet 847	UNM	4081
NM	Guadalupe	Near US-54, 0.35 miles south of Vaughn	6,000	May 16, 2001	grassland	D.L. Bleakly 3942	UNM	None
NM	Lincoln	near Tinnie	7,000	June 6, 1941	low hills	Gladys Nisbet 835	UNM	4080
NM	Lincoln	Fort Stanton; North pasture, 2nd entrance from road 214	n/a	June 28, 1980	n/a	Lebgue 136	NMCR	Unknown

Appendix (cont.).

State	County	Location	Elevation (ft.)	Date	Abiotic/Ecological	Collector(s) and Number	Herbarium	Acc #
NM	Lincoln	NMSU Range and Livestock Research Center (Corona Ranch); central South Johnson pasture	5,900	June 5, 1998	n/a	Adam Forbes 301	NMCR	Unknown
NM	Lincoln	Just north of roadcut, east side of US-54, 12.3 miles north of Carrizozo	5,740	May 16, 2001	juniper savannah	D.L. Bleakly 3960	UNM	None
NM	Lincoln	US-380 right of way, north side, 10.0 miles east of Carrizozo	6,250	May 17, 2001	grassy slope in juniper savannah	D.L. Bleakly 3965	UNM	None
NM	Los Alamos	Bandelier National Mounument, on a mesa north of Frijoles Canyon	n/a	June 18, 1941	n/a	O.M. Clark 9701	UNM	73067
NM	Los Alamos	Bandelier National Mounument, on a mesa north of Frijoles Canyon	n/a	June 18, 1941	n/a	O.M. Clark 9701	UNM	73068
NM	Los Alamos	Bandelier National Mounument, on a mesa north of Frijoles Canyon	n/a	June 18, 1941	n/a	O.M. Clark 9701	UNM	73069
NM	Los Alamos	Bandelier Nat. Mon., mesa north of Frijoles Canyon	n/a	June 18, 1941	n/a	O.M. Clark 9701	UNM	73067
NM	Los Alamos	Mesa betw Water and Ancho Canyons	6,500	May 31, 1978	piñon-juniper community; exposed tuff, thin layer sandy soil	Foxx & Tierney 8	UNM	67148
NM	Los Alamos	White Rock Canyon	5,700	May 26, 1980	canyon side in juniper	LASL 696	UNM	68957
NM	Mora	Les Feberas Canyon, near Ocate. Camp area of Lazy 3 Ranch	8,200	July 7, 1976	n/a	J. Calvert 59	UNM	59468
NM	Mora	I-25 right of way, about MP 367, ca 0.1 mi north of exit to Ft. Union, ca 1 mi north of Watrous	6,470	June 4, 1997	roadside grassland	D.L. Bleakly 2745	UNM	None
NM	Mora	I-25 right of way, ca MP 372.5, ca 5 air miles ne of Watrous	n/a	June 5, 1997	roadside grassland	D.L. Bleakly 2775	UNM	None
NM	Otero	Near Bent	5,500	May 16, 1936	n/a	A.L. Hershey 174	NMC	40572
NM	Otero	Sacramento Mountains, 2-Mile Canyon	1,950	June 1, 1999	limestone	R.C. Sivinski and P.C. Tonne 4822	UNM	101022
NM	Otero	Southern Sacramento Mountains, north side of Angel Canyon	n/a	June 2, 1999	limestone hillside	R.C. Sivinski and P.C. Tonne 4829	UNM	100884
NM	Otero	Guadalupe Mts., Wildhorse Well	5,965	May 27, 2001	n/a	R.D. Worthington 30546	NMC	34003
NM	Quay	2 miles west, 8 miles south of San Jon [*near/at/on San Jon Hill on The Caprock*]	n/a	June 20, 1979	n/a	J.P. Hubbard sn	UNM	85867

Appendix (cont.).

State	County	Location	Elevation (ft.)	Date	Abiotic/Ecological	Collector(s) and Number	Herbarium	Acc #
NM	Roosevelt	Melrose Air Force Range; Sheep Canyon 0.25 mi. E of Krider Rd., 2 mi. N of Mesa Rd	1,395	May 6, 1993	soils: Mansker and Portales loams, Potter soils andrough broken land, Slope: 3-9 degrees, Aspect: 30 degrees azimuth	D.L. Bleakly and E. DeBruin 97	UNM	89004
NM	Roosevelt [*Chaves*]	2.5 km S of Kenna (on US Hwy 70) at top of Railfoad Mountain, 8.5 km S of the Roosevelt - Chavez county line	n/a	May 13, 1999	on gravel rd; in clay soil w/ limestone rocks	R. Spellenberg 12928	NMC	35879
NM	San Miguel	near Pecos, near Arroyo Pecos	6,900	August 21, 1908	n/a	P.C. Standley 5168	NMC	24590
NM	San Miguel	Anton Chico Grant, Mesita de los Ladrones	5,800	May 12, 1983	*Juniperus monosperma* community	R. Fletcher 6981a	UNM	75403
NM	Sandoval	near Placitas	n/a	June 5, 1930	n/a	E.F. Castetter 5830	UNM	1415
NM	Santa Fe	Caja del Rio Grant [located 15 mi W of Santa Fe	n/a	June 8, 1936	n/a	Richardson n/a	NMC	35739
NM	Santa Fe	2 mi S of Glorieta	n/a	June 10, 1939	rocky ground among pines and piñons	G. Nisbet 5	NMC	71330
NM	Santa Fe	Junction US-285 and US 85	n/a	June 18, 1955	roadside?	Gladys Nisbet 1164	UNM	59553
NM	Santa Fe	NE corner of county, ca 4 air mi S of Chimayo, ca 1/4 mi E of NM Hwy 4	6,300	June 3, 1984	sandy, E-facing hill, with *Chrysothamnus nauseosus* subsp. *bigelovii*, *Bouteloua gracilis, Muhlenbergia torreyi, Opuntia phaeacantha, Gutierrezia sarothrae, Juniperus monosperma, Opuntia imbricata,* and *Pediocactus papyracanthus*	R. Spellenberg, J. Meents, and R. Sivinski 7786	NMC	54285
NM	Santa Fe	Mileposts 3-4, Highway 30 ca. 4 miles southwest of Espanola.	n/a	June 2, 1999	n/a	J.P. Hubbard 990602A	UNM	97238
NM	Socorro	Sevilleta Wildlife Refuge. In rock by road in Sepultura canyon	5,700-6,000	May 28, 1990	rock and gravel soil texture. <20 degree slope, west aspect	T. Maddux 397	UNM	82265
NM	Torrance	3.0 mi. west of Negra	1,900	June 6, 1977	granitic outcrop in rolling plain	W.L. Wagner and D. Sabo 3026	UNM	83813
NM	Torrance	Cibola. Forest Road # 321, Mountainair	6,700	June 25, 1977	n/a	M.A. Tafoya sn	UNM	94519
NM	Torrance	Hwy 285 between Encino and Clines Corners, between mile markers 242 and 243	n/a	June 19, 1992	on limy balds in short grass prairie	R.C. Sivinski 1886	UNM	88364

Appendix (cont.).

State	County	Location	Elevation (ft.)	Date	Abiotic/Ecological	Collector(s) and Number	Herbarium	Acc #
NM	Union	4 mi ne of Folsom	n/a	June 20, 1951	meadow near stream (Dry Cimarron?)	E.F. Castetter 5838	UNM	12852
NM	Union	Hwy 72, 4 mi west of Folsom	6,500	June 12, 1976	roadside	B. Hutchins 5819	UNM	59535
NM	Union	ca 4.3 miles ne of Clayton on NM-370	5,220	May 31, 1999	roadside grassland	D.L. Bleakly 3715	UNM	None
NM	Union	Clayton	n/a	6-Jun (no year)	n/a	F. Bartlett (Mrs.) 219	NMC	36685
TX	Bailey	just south of Muleshoe	n/a	June 4, 1957	on sand hills	D.S. Correll 16657	LL	351685
TX	Bailey	just south of Muleshoe, Rte. 214	n/a	October 28, 1962	on dunes, in clumps	D.S. Correll 26460	LL	25245
TX	Brewster	Off Forest, Texas. Brewster County, 16 miles E. of Alpine	n/a	April 28, 1929	n/a	D.C. Ingram 2828	UNM	87695
TX	Brewster	On Big Hill south of Alpine 6 miles	n/a	April 26, 1937	infrequent	Barton H. Warnock sn	TEX	351680
TX	Brewster	On Gage Ranch, Glass Mts.	n/a	June 8, 1941	infrequent along gravel roadside	Barton H. Warnock 21220	TEX	351681
TX	Brewster	along highway 90. 3 mi east of Marathon	4,000	April 18, 1949	rare	B.L Turner 534	LL	351678
TX	Brewster	Altuda Point, Glass Mts.; 18 mi E of Alpine	4,200	April 23, 1949	infrequent; lavender flowers	Barton H. Warnock & B.L. Turner 8528	TEX	25242
TX	Brewster	Paisano campground	n/a	May, 1937	n/a	L.C. Hinckley sn	TEX	351679
TX	Crockett	25 mi W of Ozona; summit of plateau	n/a	May 7, 1947	limestone hills	Rogers McVaugh 8206	TEX	25247
TX	Crockett	15 mi west of Ozona	2,250	June 7, 1957	infrequent; limestone hills	Barton H. Warnock & W.D. McBryde 15234	LL	351686
TX	Crockett	16 mi west of Ozona	2,251	June 7, 1957	infrequent; limestone hills	Barton H. Warnock & W.D. McBryde 15242	LL	351687
TX	Culberson	Pine Springs	n/a	November 21, 1931	n/a	Eula Whitehouse 8497	TEX	351677
TX	Culberson	Ca. 1/2 mi W of Bat Cave	n/a	June 10, 1973	grassy hillside and valley	Sam Sikes and Jackie Smith 504	LL	25240
TX	Culberson	Trail to Smith Spring, Guadalupe Mts. Nat. Park	n/a	May 30, 1987	n/a	A.M. Powell 5429	TEX	290617
TX	Edwards	southern part of county; along rte 674 down West Fork of Nueces	n/a	April 29, 1959	grassy slope	D.S. Correll & I.M. Johnston 21212	LL	25249
TX	Jeff Davis	On Scenic Drive, 14 mi from McDonald Obs cut off, Davis Mts; off hwy 118	n/a	August 3, 1945	hillside	C.L. & A.A. Lundell 14325	LL	25241
TX	Jeff Davis	Wood Canyon, Mt. Livermore	n/a	June, 1936	n/a	L.C. Hinckley sn	TEX	351676
TX	Kinney	Ca. 17 mi NE of Bracketville	n/a	April 17, 1957	open rocky soil	D.S. Correll, R.C. Rollins & K. Chambers 15968	LL	25250
TX	Lamb	16 mi E of Muleshoe	n/a	May 6, 1961	occasional in deep sands of dune area	Chester M. Rowell, Jr. 8247	TEX	25246

Appendix (concluded).

State	County	Location	Elevation (ft.)	Date	Abiotic/Ecological	Collector(s) and Number	Herbarium	Acc #
TX	Pecos	4 mi W of Longfellow	3,300	April 23, 1949	limestone soil along highway	Barton H. Warnock & B.L. Turner 8512	LL	351683
TX	Pecos	29.7 mi S of Fort Stockton along Hwy 385	4,000	April 24, 1977	in *Larrea* sp., *Prosopis* sp., and *Parthenium* sp. dominated area	James Henrickson & E. Lee 15769	TEX	25243
TX	Pecos	7 mi N of Irran cut off from Hwy 290 near Sheffield	2,300	no date	n/a	Barton H. Warnock 805	LL	351682
TX	Terrell	20 mi E of Dryden	n/a	April 10, 1949	limestone soil along highway	Barton H. Warnock 155	TEX	25244
TX	Terrell	7 mi E of Longfellow	2,800	April 30, 1949	along highway	Barton H. Warnock & B.L. Turner 591	LL	351684
TX	Val Verde	at Pumpville turnoff	n/a	April 3, 1953	limestone soil along highway	Barton H. Warnock 11309	LL	25248
TX	Val Verde	2.4 mi N of highway intersection of 277 and 377, ca. 25 mi N of Del Rio	n/a	April 15, 1999	rocky limestone soil	B.L. Turner 99-121	TEX	351688

[1]Herbarium:

COLO University of Colorado, Boulder
KANU University of Kansas, Lawrence
UNM University of New Mexico
NMC New Mexico State University, Las Cruces
NMCR New Mexico State University, Range Science, Las Cruces
LL Lundell Herbarium, Austin, TX; speciments now incorporated into TEX
TEX University of Texas