SURVEY AND MONITORING OF

PENSTEMON GIBBENSII (GIBBENS' BEARDTONGUE)

IN SOUTH-CENTRAL WYOMING

Prepared for the Bureau of Land Management
Wyoming State Office and Rawlins Field Office

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ABSTRACT

Survey and monitoring of Gibbens' beardtongue (*Penstemon gibbensii*) was conducted in 2007-2008 to update the status of the species in Wyoming as treated in two prior status reports. Data on new occurrences from intervening years were incorporated, a potential distribution model and photointerpretation were used as the basis for expanding systematic surveys, and one new occurrence was documented. The area of occupied habitat has been greatly expanded to 270 acres, but at least three of the six known occurrences have experienced significant declines in population numbers. The total population numbers in Wyoming are estimated at 6000-9000 plants. Prolonged drought appears to be responsible for the population declines in the state, as documented at two monitored sites and estimated at a third. Population declines exceed an order of magnitude at Cherokee Basin, where they appear to be associated with extreme erosion. Information on impacts and potential threats are also updated.

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Cover photo: *Penstemon gibbensii* close-up, by B. Heidel

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ACKNOWLEDGEMENTS

This report is an update that reflects on past work of many people. Robert Dorn conducted more taxonomic research on *Penstemon gibbensii* than any other botanist, and prepared the first state status report on the species in Colorado and Wyoming. Walter Fertig coordinated new surveys, prepared a subsequent Wyoming status report, added a monitoring site, developed a potential distribution model used in 2008 surveys, and synthesized species' information for the Wyoming Rare Plant Field Guide and state species abstract. Amy Roderick Taylor (UW graduate student), Sara Davis (WEST, Inc. biologist) and Jill Larson (Wyoming Natural Diversity Database; WYNDD employee participating in the 2008 study) discovered new populations. Beth Rintz, Kurt and Jeanette Flaig made revisits and provided documentation of the population discovered by WEST, Inc. Susan Spackman-Punjabi (Colorado Natural Heritage Program), Jill Handwerk (Colorado Natural Heritage Program), and Ben Franklin (Utah Natural Heritage Program) kindly provided occurrence data, shapefiles and comments on current *Penstemon gibbensii* status in their state.

Joy Handley (WYNDD) entered occurrence data prior to the start of this study, assembled digital orthophotograph sets for fieldwork, prepared the rangewide distribution maps, the map of survey extent, and the Wyoming occurrence exports. Mark Andersen (WYNDD) provided area- of-occupancy calculations. Jill Larson assisted in 2008 surveys and monitoring for WYNDD. Ramona Belden (University of Wyoming Soils Testing Lab) oversaw soils analysis. The facilities and resources of the Rocky Mountain Herbarium were fundamental to this study and are gratefully acknowledged.

Mark Andrew Warren initiated monitoring and previously provided an interim report on the monitoring of *Penstemon gibbensii* in the Cherokee Basin for the Rock Springs Field Office of the Bureau of Land Management (BLM). Frank Blomquist coordinated the current *P. gibbensii* project for the Rock Springs Office of the BLM, provided information updates for two populations, provided copies of Cherokee Basin monitoring data, and helped monitor at Cherokee Basin and Flat Top Mountain. Mark Newman facilitated x-ray spectroscopy analysis of the soil samples for the Rock Springs Field Office with help of the Worland Field Office. Tyler Abbott and Adrienne Pilmanis provided Wyoming BLM state office coordination. This project would not have been possible without the contributions of many people.

I. INTRODUCTION

This status report provides updates and additions to the two prior *Penstemon gibbensii* status reports for the species in Wyoming (Dorn 1989, Fertig and Neighbours 1996), also cross-referencing the most current out-of-state information (Spackman and Anderson 1999, Colorado Natural Heritage Inventory 2009, Utah Natural Heritage Inventory 2009). A need for updating the information on *P. gibbensii* in the state was identified based upon five considerations.

1. The most current *Penstemon gibbensii* status report for Wyoming (Fertig and Neighbours 1996) was prepared when there were three known occurrences in the state. Two new occurrences were subsequently discovered (Roderick et al. 1999, Flaig 2006) that had not been addressed as they modify status information.
2. A potential distribution model was developed for *Penstemon gibbensii* (Fertig and Thurston 2003) based on the first four known occurrences, which identified additional areas of potential habitat that had never been surveyed in prior status surveys.
3. Collection label data for two historical specimens of *Penstemon gibbensii* collected by Robert Gibbens were found in the Rocky Mountain Herbarium historical collections database in 2007, though the specimens themselves were sent off and regarded as lost. The two putative *P. gibbensii* collection stations had never been surveyed in prior state status surveys.
4. Long-term monitoring studies at the only monitored occurrence of *Penstemon gibbensii* showed major declines in species' numbers (USDI BLM unpublished monitoring data 2004). Previously, the species' trends were characterized as stable or increasing (Fertig and Neighbours 1996).
5. Long-term monitoring set up at a second *Penstemon gibbensii* occurrence (Fertig and Neighbours 1996) intended for annual monitoring had never been revisited to assess trend and to collect demographic information.

The following introductory information represents a brief history of species' documentation, incorporating the background information and results of prior status surveys (Dorn 1989, Fertig and Neighbours 1996, Spackman and Anderson 1999), but with additions, updates, and review of current supporting data (Colorado Natural Heritage Program 2008, Utah Natural Heritage Program 2008, and Wyoming Natural Diversity Database 2008).

Robert Gibbens, a doctoral student in range management at the University of Wyoming, made the first collection of *Penstemon gibbensii* in 1967 or 1968. The collection was provisionally identified as *P. mensarum* and noted as one of four new additions to the state flora collected in his study plots in northern desert shrub scrub (Appendix A in Gibbens 1972). Dr. Robert Dorn studied the material while preparing his "Manual of the Vascular Plants of Wyoming" (Dorn 1977) and tentatively assigned it to *P. saxosorum*. The original specimens were later sent out for examination by a *Penstemon* specialist, lost, and never returned (Dorn 1989, Fertig and Neighbours1996).

Dorn resurveyed the locale west of Baggs for Gibbens' unusual *Penstemon* in 1981, using the prior collection label information (Dorn pers. commun. to B. Heidel 2008), and relocated it on BLM-administered land at the northeast end of Cherokee Basin. Comparative studies with related species revealed that the material belonged to a new, undescribed species which Dorn (1982) named *P. gibbensii* in honor of its discoverer.

Meanwhile, the species was discovered in Colorado at Brown's Park (Spitzie Draw) in Moffat County in 1978 by J. Scott Peterson, Sandy Emrich, Elizabeth Painter and Carolyn Pease, but was not determined as *P. gibbensii* until after 1982 (Dorn 1989). An additional occurrence was discovered farther east in Moffat County (Sterling Place) by Karen Wiley-Eberle in 1984 and an extension to it by Betsy Neely in 1986. In 1989, the species was found in Brown's Park in Daggett County, Utah by J. Anderson and F. Smith little more than three miles away from the original Colorado occurrence. The extent of these two Colorado occurrences and one Utah occurrence have since been systematically surveyed and new surveys were conducted on Brown's Park Formation outcrops, but no new occurrences have been found (Spackman and Anderson 1999, Handwerk pers. commun. to B. Heidel 2009).

Penstemon gibbensii was designated as a Category 2 candidate for listing under the Endangered Species Act by the U.S. Fish and Wildlife Service (USFWS) in 1983. Under Bureau of Land Management (BLM) Manual 6840, the BLM is directed to manage USFWS candidate species in such a manner that ensures these species and their habitats are conserved and that agency actions do not contribute to the need to list these species as Threatened or Endangered (Willoughby et al. 1992). To protect the plant and prevent the need for listing it, plans were developed for constructing an exclosure, discussed in both the Divide Grazing EIS (1983) and a separate environmental assessment (Warren 1992). The BLM exclosure around the *P. gibbensii* occurrence was completed in 1985. This also lead the BLM to collect *P. gibbensii* monitoring data from the Cherokee Basin exclosure (1987-2007), with one interim summary (Warren 1992),collected by BLM at 3-6 year intervals with results stored in manual agency files. The Category 2 status also lead USFWS to contract the first status survey for the species in 1987-1989, as a result of which two additional *P. gibbensii* occurrences were documented at Flat Top Mountain and Sand Creek in 1987 (Dorn 1989).

Sometime after 1991, when electronic databases were initiated at the Rocky Mountain Herbarium (RM), data from two collection labels for *Penstemon gibbensii* specimens were entered in a database for storing information on historical specimens. The corresponding specimens were not in the cabinet accessions at the RM, and the particular collection locales were not mentioned or surveyed by Dorn (1989) or by Fertig and Neighbours (1996). These electronic records were retrieved in 2007 and it was not clear whether the long-lost *P. gibbensii* specimens had been returned and misfiled, the collection label data had been entered apart from the specimens, or else the collection label entries represented some sort of error.

In 1995, the BLM Wyoming State Office and Rawlins Field Office contracted on a cost-share basis with the Wyoming Natural Diversity Database (WYNDD) to conduct field surveys for *Penstemon gibbensii* on public lands in south-central Wyoming. The objectives of this project were to collect additional information on the biology, distribution, habitat use, population size, and potential threats to this species to be used in guiding management decisions. In addition, the existing monitoring at Cherokee Basin was resurveyed and new monitoring at Flat Top Mountain was established to study demographic trends by Walter Fertig, Mary Neighbours and Jane Struttman (Fertig and Neighbours 1996). Later, on 19 July 1995, USFWS reviewed its policy on candidate species and replaced the C2 designation with a new category "Species at Risk" (Davis 1995). Species in this new category were no longer considered formal candidates for listing, so *P. gibbensii* had no official status.

In 1997, Amy Roderick Taylor documented a new location of *Penstemon gibbensii* in the Upper North Platte River valley north of Saratoga as part of floristic inventory representing master thesis research (Roderick et al. 1999, Taylor 2000), a site that was later surveyed in detail by Walter Fertig in 1999. An adjoining private landowner requested a survey, extending the population boundaries as surveyed by Bonnie Heidel in 2005. In 2004, Sara Davis of WEST, Inc. found a new location of *P. gibbensii* in Willow Creek (a Sand Creek tributary northwest of the Sand Creek occurrence) in late summer as part of a pipeline survey. The latter was mapped in detail on the corridor by Kurt Flaig, Jeanette Flag and Beth Rintz in 2005 (Flaig 2006).

In 2001, the BLM Wyoming State Office released the first sensitive species list for the state, and *Penstemon gibbensii* was included among 40 vascular plant species recognized as sensitive in the state (USDI BLM 2001). In 2003, potential distribution maps were completed for all BLM sensitive species, including *P. gibbensii*, were produced from known distribution (four records) by Walter Fertig and Rob Thurston (Fertig and Thurston 2003). The potential distribution map, as well as reported declines in *P. gibbensii* population numbers (USDI BLM 2004) spurred discussion of prospective monitoring and survey needs. In 2006, the Sand Creek occurrence of *P. gibbensii* was mapped in greater detail by BLM (Frank Blomquist 2007).

The current *Penstemon gibbensii* project was originally proposed as a monitoring study in 2004 and contracted by BLM on a challenge cost-share basis with WYNDD in 2007. Most of the fieldwork was conducted in 2008. The objectives of the current project were to compile the most complete distribution and habitat information at all known occurrences, test the potential distribution model in new surveys, conduct surveys at the historic *P. gibbensii* collection sites, collect and help interpret monitoring data from the ongoing Cherokee Basin monitoring project, gather and interpret monitoring data from the Flat Top Mountain occurrence, and update habitat information as appropriate.

In 2008, a petition was filed to list 206 species in the Mountains and Plains Region of the U.S. Fish and Wildlife Service under the Endangered Species Act, including *Penstemon gibbensii.* Subsequently, a 90-day finding for 165 of the species among the original 206 determined that the petition did not present substantial information indicating that listing may be warranted for those particular species (USDI Fish and Wildlife Service 2009). *P. gibbensii* was not included among the 165 species that were addressed, and thus remains among those for which a finding is pending.

II. METHODS

Information on the habitat and distribution of *Penstemon gibbensii* was obtained from previous status reports (Dorn 1989, Fertig and Neighbours 1996), Rocky Mountain Herbarium (RM) collections and databases, the literature, WYNND files and computer databases, and knowledgeable individuals. A map of the potential distribution of *P. gibbensii*, generated with use of a range/intersection model (Fertig and Thurston 2003), was compared with known distribution.

In preparation for fieldwork, the potential distribution map was printed out with topographic map boundaries superimposed. The most recent status report (Fertig and Neighbours 1996) provided a compiled record of places where *Penstemon gibbensii* had been surveyed but not

found (Appendix B in Fertig and Neighbours 1996), and they were transcribed onto a printed potential distribution map to eliminate those areas already surveyed. Digital aerial orthphotograph quarter-quads were printed out with the polygons of potential habitat superimposed.

Field surveys were initiated in late June of 2007, monitoring at the Cherokee Basin site was conducted in mid-July 2007, monitoring at the Flat Top Mountain site was conducted in early July 2008, and all other surveys were conducted in July 2008. Data on biology, habitat, population size, and management matters were collected using WYNDD plant survey forms. Copies of status reports and all previously-collected data entered as part of records was printed out to use as reference in the field, along with boundaries of previously-surveyed populations, digitized from hand-drawn boundaries recorded onto U.S. Geological Survey topographic maps (7.5' quads).

The three permanent monitoring transects established at the Cherokee Basin, Wyoming site by the BLM in 1985 were re-read by Mark Warren and Frank Blomquist (BLM), Chicago Botanical Garden interns, and the author in 2007. The three permanent monitoring transects established at Flat Top Mountain, Wyoming by Walter Fertig and Walter Fertig and Jane Struttmann (WYNDD) in 1995 were re-read by the author, Jill Larson (WYNDD), and Frank Blomquist (BLM) in 2008.

In addition, Geographic Positioning Satellite (GPS) points were taken at known and new *Penstemon gibbensii* occurrences to check and map new boundaries (Blomquist 2007, and this study). Prior to this, population boundaries were digitized from hand-drawn boundaries marked onto topographic maps in the field (Fertig and Neighbours 1996).

Soil samples were collected at every site to a depth of 15 cm in order to document soil Munsell color (wet and dry), texture, calcium carbonate equivalent (%), check for high selenium levels, and to determine the mineralogy as indication of volcanic ash through mass spectrometry. In addition, x-ray diffraction analysis was also conducted. For the spectroscopy, soil samples collected from each site were reduced to a very fine powder via hand grinding in a sapphire-diamond mortar and pestle, and then compacted into the opening of an x-ray slide. The samples were analyzed in x-ray diffractometer using a Rigaku Miniflex, Model 2005 unit and CuK'v' radiation, driven by DataScan software and interpreted by Jade v.7 software, as conducted at the Worland Field Office of the Bureau of Land Management. The output included a plot of the x-ray response and tabular identification of peaks by Jade software. A quantitative analysis of each sample was also produced using the Jade Easy-Quant feature, provided that there were at least two or three mineral phases present in the sample.

III. SPECIES INFORMATION

A. Classification

1. Scientific name: *Penstemmon gibbensii* (Dorn), described in Dorn (1982)

2. Synonyms: None

3. Common name: Gibbens' beardtongue, Gibbens' penstemon

4. Family: Scrophulariaceae (Dorn 2001), but treated by some authors as subsumed in the Plantaginaceae based on molecular genetics (Wolfe et al. 2006)

5. Size of genus: The *Penstemon* genus is comprised of about 271 species (Lodgewick and Lodgewick 1999, cited in Wolfe et al. 2006), representing the largest genus of vascular plants that is entirely endemic to North America.

6. Phylogenetic relationships: Dorn (1982) placed *Penstemon gibbensii* in Section Glabri and noted its strong resemblance to *P. cyanthus, P. fremontii*, and *P. saxorum*. He later hypothesized that *P. gibbensii* may be at least partly derived from *P. fremontii*, which grows in adjacent sagebrush habitats (Dorn 1989). Subsequently, Dorn and Lichvar (1990) described a new variety of *Penstemon fremontii, P. f.* var. *glabrescens*, that resembles *P. gibbensii* but lacks glands in the inflorescence and tends to have broader leaves. The new variety is endemic to Colorado and differs from the type variety in growing on barren habitats of Green River Shale. In addition, O'Kane (1988) also suggested a possible affinity between *P. gibbensii* and *P. penlandii*, another Colorado endemic. Some genetics researchers (Wolfe et al. 2006), following taxonomic treatments of the American Penstemon Society (Lodewick and Lodewick 1999), have rejected the subgenera treatments of taxonomists like Cronquist et al. (1984) and treat the Section Glabri as part of the Habroanthus Section.

Genetics analysis of *Penstemon gibbensii* and *P. penlandii* was initiated by a University of Colorado graduate student through Denver Botanical Gardens using alloenzyme techniques, and three diagnostic loci were found (Gibson No Date. a). However, only two of the loci could effectively be used, and 1991 attempts to increase the sample size with material from the field had poor results (Gibson No Date. b). Methodology recommendations were made and the conclusion was drawn that more thorough genetic analysis was warranted, including *P. fremontii* among the species compared.

Penstemon gibbensii is currently one of several species being studied in comparative population genetic analysis, in which initial results from two Wyoming populations document high variation at the loci examined to date (Buerkle pers. commun. to B. Heidel 2009). The between-population differentiation analysis has yet to be conducted.

Genetics research is needed for more than understanding relationships between species and origin. Botanists have noted in the field that populations of *Penstemon gibbensii* exhibit morphological differences in leaf characteristics (Dorn 1989, Dorn and Lichvar 1990, Fertig and Neighbours 1986) as represented in Table 1. This may or may not be significant because vegetative characteristics are generally more strongly influenced by environment than reproductive traits of flowers and fruits. The environmental distinctions between populations are presented in the habitat section of this report as contribution towards evaluating this idea. There have not been seed collections made from *P. gibbensii* populations for growing under common environmental conditions (common garden experiment) to confirm that population differences are truly genetic differences. It is possible that between-population genetics are divergent in the three isolated areas of distribution, as characteristic of a paleoendemic.

B. Present legal or other formal status
1. National
a. Legal status: *Penstemon gibbensii* was listed as a USFWS Category 2 (C2) candidate in 1983 (US Fish and Wildlife Service 1983). In 1995, USFWs revised its policy on candidate species and replaced the C2 designation with a new category "Species at Risk" (Davis 1995). Species in this category were no longer considered formal candidates for listing. In 2008, it was included among 206 species petitioned for listing in the Mountain-Plains region of the U.S. Fish and Wildlife Service under the Endangered Species Act, and was not addressed in the set of species subsequently dropped from consideration (USDI Fish and Wildlife Service 2009).

The Wyoming Bureau of Land Management included *Penstemon gibbensii* on the first Sensitive species list (USDI BLM 2001), a list that has undergone one revision in 2002. The Colorado Bureau of Land Management recognized *P. gibbensii* as sensitive, and the Utah Bureau of Land Management also recognized *P. gibbensii* as sensitive, though it is present on state lands and it not known to extend onto federal lands.

b. Heritage rank. *Penstemon gibbensii* was ranked G1 at the time of the previous status surveys (Fertig and Neighbours 1996, Spackman and Anderson 1999) when it was known from four occurrences rangewide (treating the out-of-state records as a single occurrence). The information compiled in this report provided information for updating the rank in an expanded framework and automated process as supporting a global rank of "G1G2" (Appendix A).

2. State
a. Legal status: This species is not protected by state government statutes in any of the states within its range.

b. Heritage rank: *Penstemon gibbensii* was ranked S1 when it was known from four occurrences statewide, considered critically imperiled because of extreme rarity or other factors of its life history making it especially vulnerable to extinction statewide. It is also ranked S1 in Colorado (Spackman et al. 1997, Spackman and Anderson 1999, Colorado Natural Heritage Program 2008) and Utah (Utah Natural Heritage Program 2008). The information compiled in this report provides a basis reviewing the state rank, but no state rank changes have been made.

C. Description
1. General non-technical description: *Penstemon gibbensii* is a perennial herb with one to many erect, pubescent (rarely glabrous) stems 4-14 in (10-35 cm) tall. The leaves are linear to linear-lanceolate and often folded down the length of the midrivb, opposite, smooth-margined, pubescent to glabrate, and mostly less than 3.16 in (5 mm) wide. The inflorescence and flowers (including the sepals) are glandular-hairy. The corolla is tube-shaped, bright blue, and ½-3/4 in (15-20 mm) long. Anther sacs are short pubescent on the back, dark purple-brown, horseshoe-shaped and 1/16 in (1.2-1.5 mm) long. Fruits are oval, tawny-brownish capsules (Dorn 1982, 1989, 2001; Welsh et al. 2003, Fertig et al. 1994, Fertig and Neighbours 1996; Fig.1, 2 and 3).

2. Technical description: Perennial herb with stems several to many from root crown, 1-2 dm high, hairy usually to near base, rare glabrous below inflorescence. Leaves opposite, entire,

linear to linear-lanceolate or lance-linear, to 9 cm long, mostly 5 (8) mm or less wide, at least the lower mostly glabrous. Inflorescence glandular-hairy, sepals lanceolate, 4-8 mm long, corolla blue, 15-20 mm long, hairy inside and out, the inner hairs long and broad, the outer smaller and mostly glandular. Anthers hairy, dehiscing not quite to the base, staminode sparsely bearded at the tip. Seeds 2-3 mm long (Fertig and Neighbours 1996, adapted from Dorn 1982, 1989).

Figure 1. *Penstemon gibbensii* illustration, by K. Thorne

Figure 2. *Penstemon gibbensii* close-up, by B. Heidel

Figure 3. *Penstemon gibbensii* whole plant, by W. Fertig

3. Local field characters: *Pentemon gibbensii* can be recognized by its pubescent stems, narrow, often folded leaves, glandular inflorescence, and hairy, horseshoe-shaped anthers.

Three distinctive and geographically restricted morphological forms of *Penstemon gibbensii* were described among the original populations, based on differences in leaf width and degree of pubescence (Dorn 1989). Plants from Cherokee Basin and Sand Creek, Wyoming, typically have narrow, sparsely pubescent leaves. Plants from Flat Top Mountain, Wyoming, tend to have wider and more glabrous leaves than individuals from other sites. By contrast, plants from Colorado-Utah have very narrow, extremely hairy leaves. Plants at subsequently-documented populations in Wyoming (Red Rock Rim, T84N R18W, and Willow Creek) have glabrous leaves of intermediate width (B. Heidel personal observation 2009). The amount of morphological variability exhibited by *P. gibbensii* was interpreted as evidence that these populations have been reproductively isolated for a long period of time (Dorn 1989, Fertig and Neighbours 1996).

2. Similar species: *Penstemon saxorum* has leaves over 5 mm wide and glabrous stems and sepals. *P. fremontii* (both varieties) and *P. cyananthus* have non-glandular inflorescences and wider leaves (Dorn 1982, 1989; Fertig et al. 1994). *P. scariosus* (an endemic of Utah and Colorado) has glabrous lower stems and leaves and typically has wider leaves and larger flowers (Dorn and Lichvar 1990; Table 1).

Table 1. Selected characteristics for *Penstemon fremontii* and related taxa[1]

Species or variety	**Lower stems hairy**	**Leaf width (mm)**	**Leaves hairy**	**Inflorescence**	**Calyx length (mm)**	**Corolla length (mm)**	**Anther length (mm)**
Penstemon cyanthus	No	5-15 (20)	No	Glandular	4.5-7.5	(18) 20-30	1.5-2.1 (2.5)
Penstemon fremontii var. *fremontii*	Yes	2-18(-27)	Yes	Pubescent	2.5-6.5	12-(14-23(-28)	(10)1.2-1.5(-18.)
P. f. var. *glabrescens*	Yes	2-12	Midrib and margin	Pubescent	2-5	(15-)16-28(-20)	1-1.5
P. gibbensii	Yes (No)	2-7(-8)	Yes (No)	Glandular	3.5-7(-8)	(15-)16-18(-20)	1-1.3
P. penlandii	Yes	1-1.5	Yes	Glabrous	4-5	12-15	1.0-1.6
P. saxorum	No	3-19	No	Glabrous	3.5-8	17-25(-30)	1-1.5
P. scariosus	No	2-15(-23)	No	Glandular (Glabrous)	(3-)4-9(-13)	(15-)16-30(-33)	(1.3-)1.5-2.2(-2.6)

D. Geographical distribution

1. Range: *Penstemon gibbensii* is a regional endemic of south-central Wyoming (Carbon and Sweetwater counties), northwest Colorado (Moffatt County) and northeastern Utah (Daggett County) (Dorn 1989). In Wyoming, this species is mainly restricted to the southern Washakie

[1] Reproduced from Dorn and Lichvar 1990, with addition of *Penstemon cyanthus* and *P. penlandii*. information, taken from Weber (1986) and Cronquist et al. (1984).

Basin, north and west of Baggs. It is also in the Upper North Platte River valley, north of Saratoga. In Colorado and Utah, it is found in the Green River watershed. The three areas of distribution span a distance of about 120 miles (100 km) and are all part of intermontane basins within the Wyoming Basins Ecoregion.

2. Extant sites: Six occurrences of *Penstemon gibbensii* are known in Wyoming as of 2008. The type locality, rediscovered by Dorn in 1981, is on a ridge on the north side of Cherokee Basin, approximately 2 miles north of the Wyoming-Colorado state line in Sweetwater Co. (Dorn 1982). Two other Wyoming occurrences, on Sand Creek and Flat Top Mountain, were discovered by Dorn in 1987 (Dorn 1989), both in adjoining Carbon Co. The Upper North Platte River occurrence was discovered by Amy Roderick in 1997 (Roderick et al. 1999) in Carbon Co. The Willow Creek occurrence was discovered by Sara Davis in 2004 in Sweetwater Co. In 2008 surveys, one new occurrence was found at Red Creek Rim, discovered by Jill Larson in Carbon Co. as part of this study. The latter is not part of an incised valley setting like the Sand Creek occurrence, and is about three air miles away, with mainly rolling uplands between the two. All Wyoming occurrences are presented in Table 2.

Out-of-state, *Penstemon gibbensii* was collected in Moffat Co., Colorado at the Spitzie Draw (Brown's Park area) in 1978, but not determined as *P. gibbensii* until after 1982 (Dorn 1989). Slightly over three miles upstream, a separate Brown's Park occurrence was found in Daggett Co., Utah in 1989 (Utah Natural Heritage Program 2003-2008, Utah Native Plant Society 2008). *P. gibbensii* was later found downstream at Sterling Place in 1986, a second Moffat Co., Colorado site, southeast of Spitzie Draw. These separate out-of-state occurrences were referred to as a single occurrence in Fertig and Neighbours (1996) but as two occurrences for Colorado (Spackman and Anderson 1999, Colorado Natural Heritage Program 2008). In total, there are nine separate occurrences, or populations. However, all three of the out-of-state occurrences, and three of the Wyoming occurrences are within 3-5 miles of one another so there might be rare genetic exchange events. Species' global and state distribution is represented in Figure 4, and summarized in Table 2.

The detailed Wyoming records and accompanying maps are presented in Appendix B. Throughout this report, the term "occurrence" is used to refer to discrete areas that are the working hypothesis of what constitutes a population. Each occurrence is referred to by a site name rather than a number because, for example, there are three records identified as #001 as present in each of the three states. The Wyoming occurrence that is partially on private land is referred to by its township-range, in keeping with WYNDD policy on sensitive data.

3. Historical sites: There are no valid historical records. However, historical collection label data for two *Penstemon* specimens by Robert Gibbens were entered in the Rocky Mountain Herbarium (RM) historical database as records of *P. gibbensii*, collected in 1969 and 1970. Intensive surveys for *P. gibbensii* were conducted across the two areas in 2008 without success. Both areas had *P. pachyphyllus* var. *mucronatus* present. A review of the folders for *P. pachyphyllus* var. *mucronatus* folders at RM after the field season showed that the historical data was entered by mistake for *P. gibbensii* when the entries with their collection numbers actually corresponded to two *P. pachyphyllus* var. *mucronatus* specimens.

4. Unverified/Undocumented reports: None known.

Table 2. Location information for known occurrences of *Penstemon gibbensii*

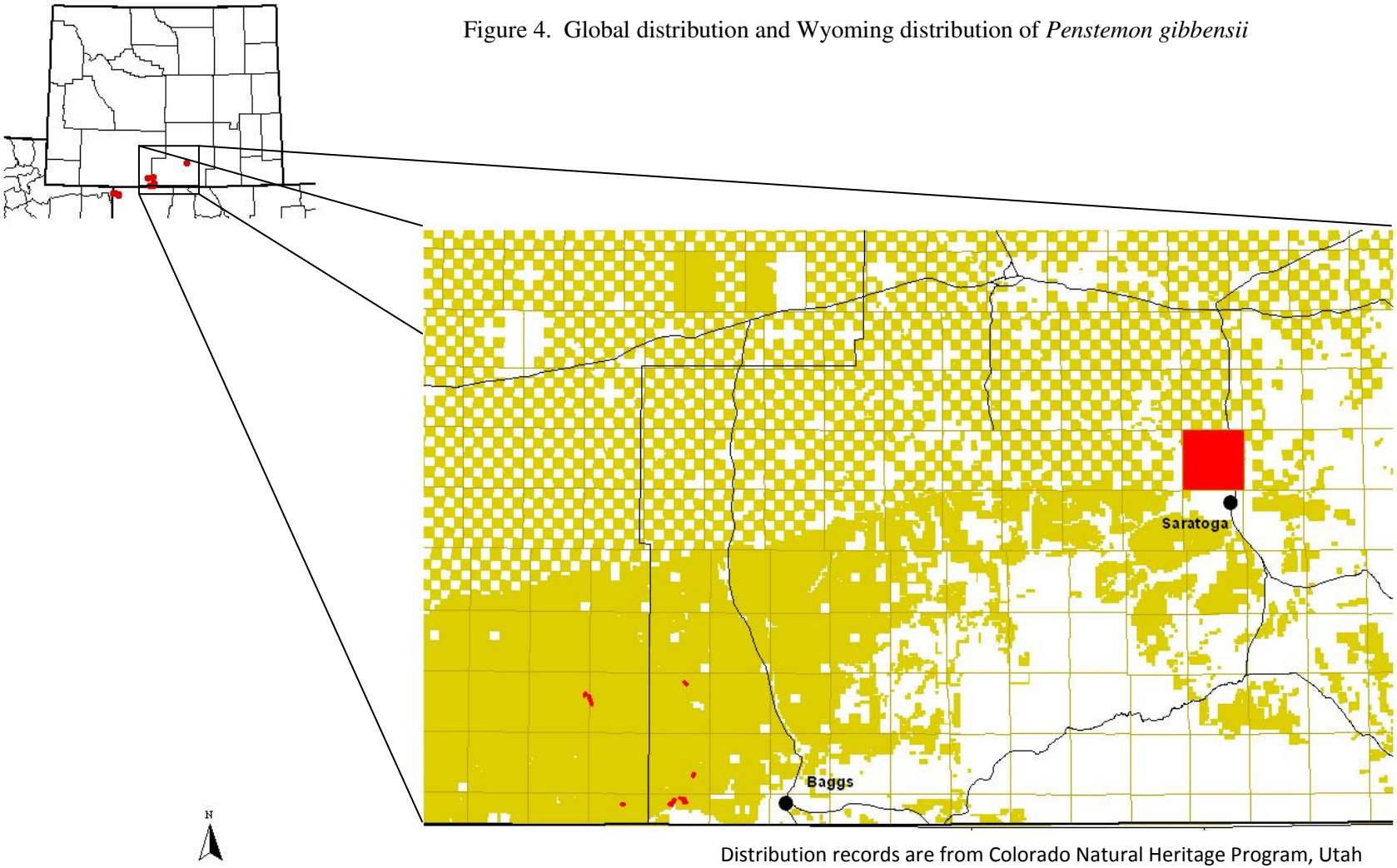
EO#	Site Name	County, State	Legal Description	Elevation (ft)	USGS 7.5' Quad	Location
001	Cherokee Basin	Sweetwater Co., WY	T12N R94W S10	6500-6600	McPherson Springs	Northeast end of Cherokee Basin, ca 17 air miles west of Baggs
002	Sand Creek	Carbon Co., WY	T12N R93W S3, 4, 8, and 9	6200-6260	McPherson Springs, Poison Basin	Both sides of Sand Creek above mouth on Little Snake River, ca 10 air miles west of Baggs
003	Flat Top Mountain	Carbon Co., WY	T14N R93W S3 and 10	7500-7700	Flat Top Mountain	Flat Top Mountain, ca 15 air miles north-northwest of Baggs
004	T84N R18W	Carbon Co., WY	T18N R84W [sensitive data]	7000-7240	Overland	North of Saratoga
005	Willow Creek	Sweetwater Co., WY	T14N R94W S18 and 19; T14N R95W S12 and 13	6440-6540	Powder Mountain NE	West side of Willow Creek, ca 20 air miles northwest of Baggs
008[2]	Red Creek Rim	Carbon Co., WY	T13N R93W S23 and 26	6400-6420	Poison Basin	Red Creek Rim, ca 10 air miles northwest of Baggs
001	Spitzie Draw	Moffat Co., CO	T10N R103W S3, 8, 9, and 10	5500-5600	Lodore School, Swallow Canyon	Brown's Park north of Hwy 318 along Spitzie Draw
002	Sterling Place	Moffat Co., CO	T10N R102W S20, 21 and 29	5420-5760	Lodore School	Brown's Park north of Hwy 318 and south of Sterling Spring
001	Brown's Park	Daggett Co., UT	T1N R25E S2	5570	Swallow Canyon	Brown's Park, 0.25 miles west of the state line

5. Sites where present status not known: In 2008, concerted efforts were made to survey *Penstemon gibbensii* on public land identified as potential habitat using the potential distribution model of Fertig and Thurston (2003). The potential distribution model is represented in Figure 5 and was interpreted as having merit because the two newest *P. gibbensii* occurrences documented after the model was produced fall within areas identified as suitable. The areas mapped in the potential distribution map that are not yet surveyed are appropriate to consider as potentially suitable areas and sites where present status is not known.

6. Areas surveyed but species not located: Systematic surveys for *Penstemon gibbensii* were conducted by Dorn (1989) and Fertig and Neighbours (1996) in the Washakie Basin and immediate vicinity. The 1996 report included a mapped compilation of all places searched in the two studies.

[2] There is a gap in assigning occurrence numbers in Wyoming, starting with the Red Creek Rim occurrence, because the next available number is always used. Two historic collections of Gibbens of *Penstemon pachyphyllus* had been entered based on an error in an herbarium database reporting them as P. gibbensii accessions, and later deleted.

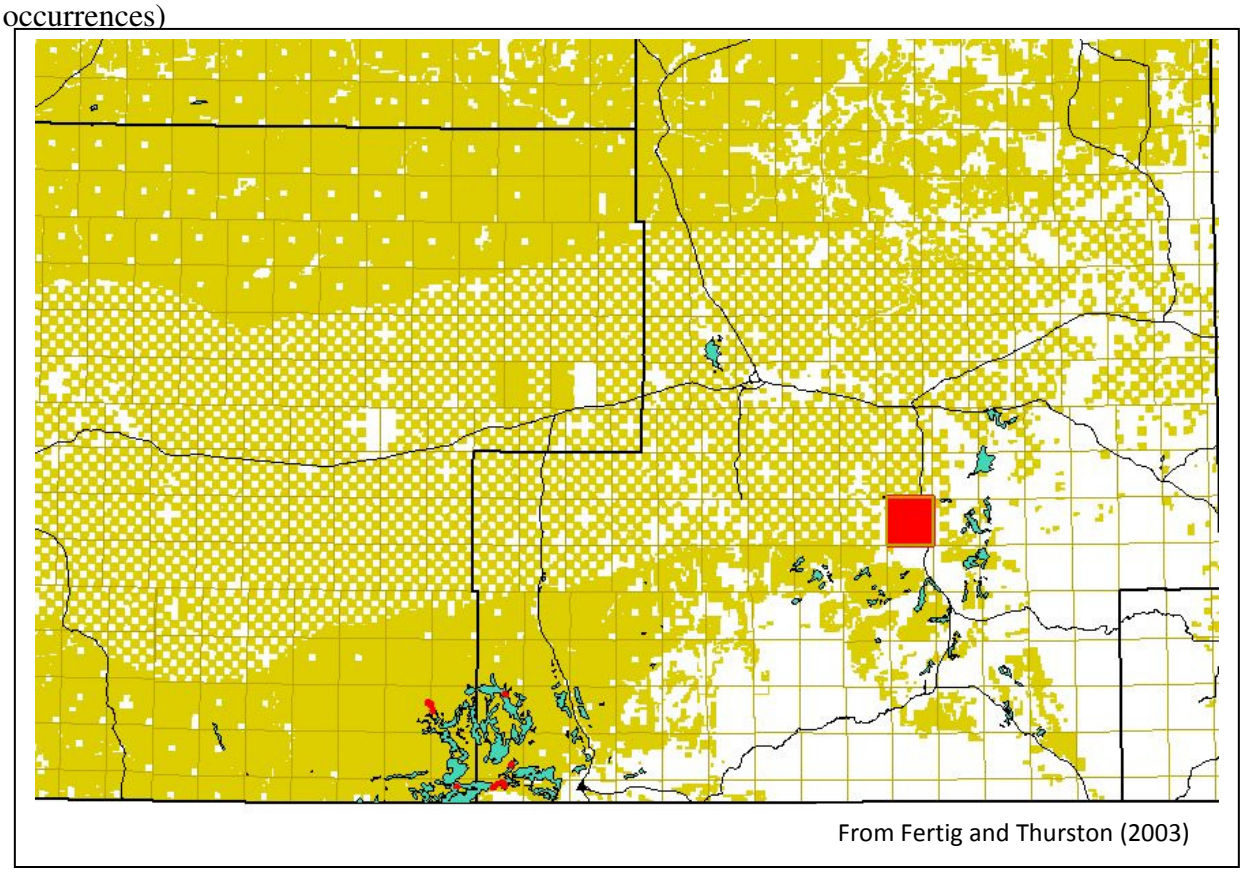
Figure 4. Global distribution and Wyoming distribution of *Penstemon gibbensii*



Distribution records are from Colorado Natural Heritage Program, Utah Natural Heritage Program, and Wyoming Natural Diversity Database, 2008

*Distribution on private lands is represented at the township scale

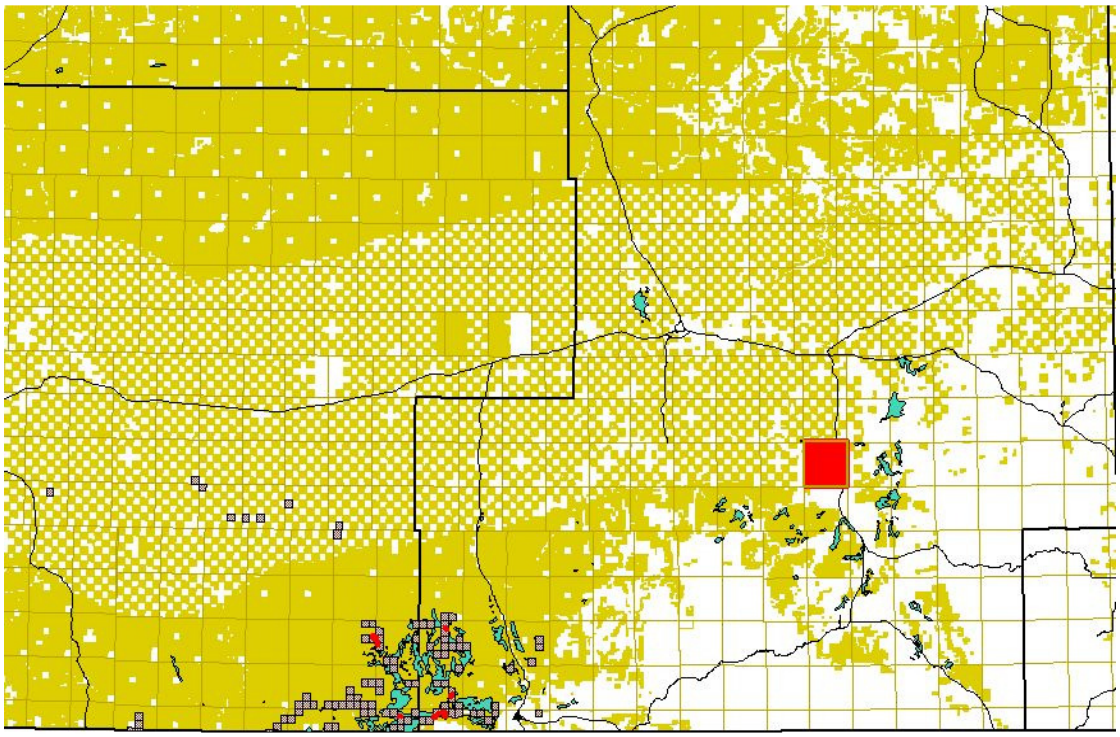
Figure 5. Potential distribution of *Penstemon gibbensii* in Wyoming (with addition of known occurrences)



In 2008, the *Penstemon gibbensii* potential distribution map of Fertig and Thurston (2003) was used to identify additional areas of potentially suitable habitat. Results of past surveys were superimposed to narrow down the search to areas not surveyed in prior studies. After the field season, the locations of prior surveys and 2008 surveys were transcribed into a list of township-range and section to produce an overview map of all survey efforts. This is an oversimplification in that not all potential habitat has necessarily been covered in any given section. But it shows at a glimpse that *P. gibbensii* surveys have been conducted in over 100 sections concentrated in the Washakie basin near the Carbon-Sweetwater county line (Figure 6). The map compilation of surveys has also been updated and is a more detailed record that should be used in determining where within any given section the site surveys have been conducted (Appendix C).

It is noteworthy that the Colorado surveys of *Penstemon gibbensii* targeted settings consistent with Wyoming criteria later used in the Wyoming potential distribution model tand 2008 surveys. Colorado surveys focused on suitable substrates (Brown's Park Formation) at less than 7700 ft elevation (the maximum known elevation of the species in Wyoming; Spackman and Anderson 1999). The remaining inventory priorities identified in Colorado include 12 sites (Spackman and Anderson 1999). Potential habitat mainly outside the Washakie Basin has been identified in Wyoming that in light of positive model evaluation, remain areas to consider for evaluation.

Figure 6. Sections where *Penstemon gibbensii* has been surveyed in Wyoming



Survey information from Dorn (1989), Fertig and Neighbours (1996) and 2008 study

E. Habitat: Gibbens' beardtongue is found primarily on barren shale or sandstone slopes of the Browns Park Formation or Laney member of the Green River shale. Often, habitat is located below cap rock, on the steep, upper or middle slopes eroding out below the resistant layer. The settings are sparsely vegetated grasslands with scattered shrubs (6200-7700 feet). A profile of collective *Penstemon gibbensii* habitat environmental attributes is reprinted from the potential distribution model in Appendix D (Fertig and Thurston 2003). The model was based on environmental commonalities among five Wyoming data points (two data points came from the large Sand Creek population), and is referenced throughout this section.

1. Associated vegetation: *Penstemon gibbensii* is found on sparsely-vegetated settings in which grasses, cushion plants or subshrubs have the highest cover. Common grasses include *Elymus spicatus* (Bluebunch wheatgrass), *Achnatherum hymenoides* (Indian ricegrass), *Hesperostipa comata* (Needle-and-thread), and *Elymus dasystachum* (Thick-spike wheatgrass). Subshrubs and cushion plants may be dominant or co-dominant and include *Eriogonum brevicaule* (Shortstem wild-buckwheat), *Eremogone hookeri* (Hooker's sandwort), *Minuartia nuttallii* (Nuttall's stitchwort), *Stenotes acaulis* (Stemless mock goldenweed), *Atriplex confertifolia* (Shadscale), and *Artemisia frigida* (Fringed sagewort). The Cherokee Basin site is the only site where vegetation data has been collected, repeated as part of species monitoring (Warren 1992), documenting that the two most frequent and abundant species are *Achnatherum hymenoides* and *Eriogonum brevicaule*.

Woody vegetation often prevails in landscapes adjoining *Penstemon gibbensii* habitats, variously including *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush), *Atriplex gardneri* (Gardner's saltbush), *Juniperus osteosperma* (Utah juniper), and *Cercocarpus montanus* (Mountain mahogany). The Cherokee Basin vegetation plot studied by Robert Gibbens that was nearest to *P. gibbensii* was documented as dominated by *Machaeranthera glabriuscula* (syn. *Xylorhiza glabriuscula*; Woody aster), a species that is favored under heavy grazing and is still present in the immediately-adjoining area but not as a dominant (B. Heidel personal observation).

Colorado sites were noted as supported well-developed cryptobiotic crusts that lent stability to the relatively steep, unconsolidated substrate (Spackman and Anderson 1999). Cryptobiotic crusts were not noted in any Wyoming sites, even though there was frequent soil inspection in taking soil samples as part of 2008 surveys. It is possible there were cryptic forms of the crusts present but not discernible under drought conditions, that they had previously been present but were impacted and eliminated by past land use (e.g., the history of heavy sheep-grazing reported by Gibbens 1972); or that the habitats at the higher-elevations in Wyoming are not suited for cryptobiotic crust.

2. Frequently associated species: Thirty species were reported as frequently associated with *Penstemon gibbensii* by Fertig and Neighbours (1996). Almost 20 more species are reported as common, as reported in Cherokee Basin plots (Warren 1992) and at the subsequent Wyoming sites, or else noted as being common at the Colorado and Utah sites (Spackman and Anderson 1999, Colorado Natural Heritage Program 2008). Associated species are presented in Table 3.

Table 3. Species frequently associated with *Penstemon gibbensii*

Scientific name	**Common name**	**WY (F&N 1996)[3]**	**WY Addition**	**CO (S&A)[4]**
Achnatherum hymenoides	Indian ricegrass	X		
Artemisia frigid	Fringed sagewort	X		
Artemisia longifolia	Long-leaf wormwood		X	
Artemisia tridentata var. *wyomingensis*	Wyoming big sagebrush	X		
Asclepias cryptoceras	Humboldt Mountain milkweed		X	X
Astragalus convallarius	Lesser rushy milkvetch		X	
Astragalus jejunus var. *jejunus*	Starveling milkvetch	X		
Astragalus nelsonianus	Nelson's milkvetch		X	
Astragalus spatulatus	Spoonleaf milkvetch	X		
Astragalus tenellus	Loose-flowered milkvetch		X	
Astragalus vexilliflexus	Bent-flowered milkvetch	X		
Atriplex confertifolia	Shadscale		X	

[3] Reported in Fertig and Neighbours 1996

[4] Reported in Spackman and Anderson 1999

Chaenactis douglasii	Hoary chaenactis	X		
Comandra umbellate	Bastard toadflax	X		
Cryptantha caespitosa	Caespitose cat's-eye	X		
Cryptantha flava	Yellow miner's candle	X		
Cymopterus terebinthinus	Terpentine cymopterus	X		
Elymus elymoides	Squirreltail	X		
Elymus lanceolatus	Thickspike wheatgrass	X		
Elymus spicatus	Bluebunch wheatgrass	X		
Eremogone eastwoodiae	Eastwood's sandwort	X		
Eremogone hookeri	Hooker's sandwort	X		
Ericameria nauseosus	Rubber rabbitbrush	X		
Erigeron pulcherrimus	Basin daisy	X		
Eriogonum brevicaule	Shortstem wild-buckwheat	X		
Glossopetalon spinescens	Spiny greasebush			X
Gutierrezia sarothrae	Broom snakeweed	X		
Hedysarum boreale	Northern sweet-vetch			X
Hesperostipa comate	Needle-and-thread	X		
Hymenopappus filifolius	Fine-leaf woolywhite		X	X
Lepidium montanum	Mountain pepperwort		X	
Leptodactylon pungens	Prickly phlox	X		
Leptocactylon spp.	Phlox			X
Lesquerella alpine	Alpine bladderpod		X	
Lupinus argenteus	Silvery lupine	X		
Machaeranthera grindelioides	Nuttall's goldenweed	X		
Minuartia nuttallii	Brittle stitchwort		X	
Packera cana	Silver-woolly groundsel		X	
Penstemon fremontii	Fewmont's beardtongue		X	
Penstemon pachyphyllus var. *mucronatus*	Thick-leaf beardtongue		X	
Phacelia glandulosa	Glandular phacelia	X		
Phlox hoodii	Hood’s phlox		X	
Purshia tridentate	Bitterbrush	X		
Sphaeromeria capitata	Cluster-head chicken-sage		X	
Stanley pinnata	Bushy prince's-plume	X		
Stanley spp.	Prince’s-plume			X
Stenotus acaulis	Stemless mock goldenweed		X	
Stephanomeria runcinata	Runcinate-leaved skeletonweed	X		
Thermopsis rhombifolia	Round-leaved golden-pea	X		
Wyethia scabra	Badland mule's-ears		X	X
Zuckia brandegei	Western hop-sage	X		

Species that are common at the Utah and Colorado sites but localized or absent from the Wyoming sites include *Wyethia scabra* (Badland's mule's-ears), *Hedysarum boreale* (Northern sweet-vetch), *Glossopetalon spinescens* (Spiny greasebush), and *Pinus edulis* (Two-needle pinyon).

Six other Wyoming plant species of concern (Heidel 2007) were newly-documented at *Penstemon gibbensii* sites or in accessing potential habitat (Appendix E).

3. Topography: Originally, *Penstemon gibbensii* populations were characterized as occurring on south- and west-facing slopes of 20-30 degrees (Fertig and Neighbours 1996). Two of the three most recently-documented Wyoming occurrences do not fit this generalization. The T84N R18W occurrence is most abundant on northwest-facing slopes, though also present on west-facing aspect. The Willow Creek occurrence is present on gentle, east-facing slopes and nearly level terrain associated with high valley terraces, as well as north- and south-facing finger ridges. With these exceptions, the generalization still represents most of the local species distribution patterns for seven of the nine occurrences. Elevations range from 6200-7700 ft in Wyoming, higher than the out-of-state occurrences.

The slope and aspect may not be as important as the erosion-prone nature of the habitat or the low levels of competition. Most habitat of *Penstemon gibbensii* is located below caprock, on the steep, upper or middle slopes eroding out below the resistant layer. At some sites, the sparsely-vegetated *Penstemon gibbensii* habitat is in a single uninterrupted band on ridges below caprock (Cherokee Basin, Flat Top Mountain), and a typical habitat profile was illustrated by Fertig (Fertig and Neighbours 1996), reprinted in this report (Figure 7). The Sand Creek setting differs somewhat in having repeated bands of outcrop across the stratigraphic profile where the species occurs, not all associated with caprock.

At a couple sites, the suitable habitat is discontinuous along the contour because of convolutions in the contour slope. Patches of woody vegetation separate suitable habitat in places. For example, *Penstemon gibbensii* habitat is mainly in *Cercocarpus montanus* openings between dense shrub cover at T84N R18W, and in *Juniperus osteosperma* openings in Red Creek Rim below caprock. The Willow Creek setting differs from those at other sites in being associated with a high valley bench. It is more highly dissected terrain than the other Wyoming sites, and has *P. gibbensii* habitat at different sparsely-vegetated settings, not all of which have caprock, including: badlands toe slopes, caprock margins of sandstone finger ridges, and a cushion plant community across low mounds on top of the valley terraces (Figure 8). The perimeters of sandstone finger ridges have slopes of at least 20 degrees, but the other settings are on very gentle slopes (mostly 0-5 degrees). The plants are more common on north-facing aspects of finger ridges than south-facing ones. The low mounds (on the horizon in Figure 8) are dominated by *Minuartia nuttallii* and have *P. gibbensii* plants concentrated at the outwash perimeter.

Habitat photographs of *Penstemon gibbensii* are represented in Figures 9-14, in addition to monitoring site photographs. More detailed setting descriptions are provided in each element occurrence record (Appendix B).

Figure 7. Typical topographic setting for *Penstemon gibbensii* (looking north), from Fertig and Neighbours (1996), by W. Fertig

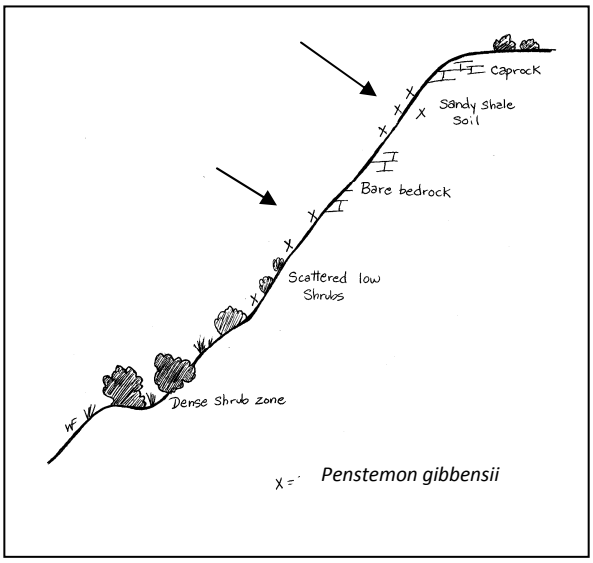
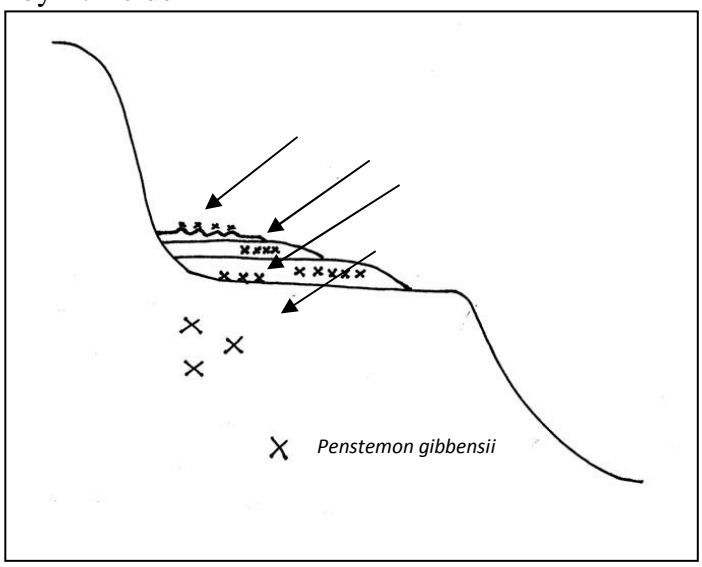


Figure 8. Willow Creek topographic setting for *Penstemon gibbensii* (looking north), on bench, rims, mounds and outwash of bench, by B. Heidel



3. Soil relationships: Warren (1992) characterized the soils at the type locality as sandstone/ clay derived, high in selenium, and fairly erosive. The juxtaposition of an erosion-resistant caprock and erosive underlying bedrock are conducive for a mixed texture classes.

All populations in Wyoming and elsewhere are found on soils derived from the Miocene Brown's Park Formation (Dorn 1989, Spackman and Anderson 1999, Newman 2009 personal communication). The Browns Park formation is described as fine to medium grade sandstones, tuff and limestone. At Brown's Park, CO soils are developed from white shales with high clay content (Dorn 1989, Colorado Natural Heritage Program 2009). The Flat Top Mountain soils appear to be derived from the Laney Shale member of the Eocene Green River Formation (Dorn 1989), where soils are characterized as yellowish sandy-clays formed from sandstone (Fertig and Neighbours 1996).

Soils at *Penstemon gibbensii* sites in Wyoming are all well-drained entisols of similar color but variable texture (Table 4). Gravel and skeletal rock fragments were not included in the texture analysis and are conspicuous at Flat Top Mountain, T84N R18W, and Willow Creek sites, but are not as extensive at other sites. Calcium carbonate concentrations were high at Cherokee Basin and T84N R18W to the point that phosphorus is usually deficient. Tests for high selenium (greater than 0.1 mg/kg) were run and all samples were below this level. Some sites appeared to have high variation in soil conditions among occupied habitat, especially the Sand Creek habitat with yellowish sandy-clay band as well as white silt bands (not sampled). The Willow Creek habitat is on pale yellowish sandy-silts with platy-block pavement. The texture classes are not necessarily indication of the parent material but particle size, as at Cherokee Basin with its relatively high clay-size particle content but no clay properties, and at T84N R18W classified as loamy sand but appearing to be derived from tuffaceous silty limestone.

Figure 9. *Penstemon gibbensii* habitat at Sand Creek, looking upslope to occupied habitat at rim and calcareous zones, by B. Heidel

Figure 10. *Penstemon gibbensii* habitat at Sand Creek, looking across occupied habitat to opposite ridge with more habitat, by B. Heidel

Figure 11. *Penstemon gibbensii* habitat at Red Creek Rim, by J. Larson

Figure 12. *Penstemon gibbensii* habitat at Cherokee Basin, by W. Fertig

Figure 13. *Penstemon gibbensii* habitat at T84NR18W, northwest aspect, by B. Heidel

Figure 14. *Penstemon gibbensii* bench habitat at Willow Creek (foreground), by B. Heidel

Table 4. Soil characteristics at *Penstemon gibbensii* sites in Wyoming

	SAND	SILT	CLAY	TEXTURE	CACO3 EQ	COLOR	COLOR
	%	%	%		%	DRY	WET
Cherokee Basin	27	40	33	Clay Loam	5.45	2.5 Y 7/3	2.5 Y 5/2
Sand Creek	77	13	10	Loamy Sand	0.71	2.5 Y 6/4	2.5 Y 6/4
Flat Top Mountain	45	43	12	Loam	0.14	2.5 Y 7/3	2.5 Y 4/3
T84N R18W	82	10	8	Loamy Sand	4.82	2.5 Y 7/3	2.5 Y 4/3
Willow Creek	35	43	22	Loam	0.46	2.5 Y 6/6	2.5 Y 4/4
Red Creek	85	3	12	Loamy Sand	0.18	2.5 Y 7/3	2.5 Y 6/3

Soil samples at *Penstemon gibbensii* sites in Wyoming were run through x-ray diffraction. Results indicated that either clinoptilolite (Na,K,Ca)2-3 Al3(Al,Si)13 O36 – 12H2O, a zeolite mineral; or anothorite Ca (Al2Si2O8), a feldspar mineral are present (Table 5). The geology of the areas where the samples were taken would indicate that the program used to identify minerals present confused anorthite with clinoptilolite and that the latter is present in all samples or that a mix of both minerals with clinoptilolite dominating is present (Newman 2009 personal communication). Zeolites form from volcanic ash deposits in a marine environment. They are generally characterized by their ability to lose and absorb water without damage to their crystal structures. Clinoptilolite in particular is like a natural molecular sieve having a large amount of pore space, high resistance to extreme temperatures, and a chemically neutral basic structure. It forms as a result of devitrification of volcanic glass in tuff. Only one site has significant gypsum, a marine evaporate, at Willow Creek.

Table 5. Mineralogy of *Penstemon gibbensii* soil samples

	Analcime (a zeolite) %	Anorthite (a feldspar) %	Calcite %	Clinoptilolite (a zeolite) %	Gypsum %	Microcline (a feldspar) %	Quartz %
Cherokee Basin		45.2?	4.6	X			50.2
Sand Creek				X			100
Flat Top Mountain				X			X
T84N R18W		88.7?		X			11.3
Willow Creek	5.5			X	14.8		79.7
Red Creek		28.9?		X		56.9	14.1

4. Regional climate: Average annual precipitation in the southern Washakie Basin of Wyoming is approximately 10 in (254 mm) with peak levels in May and June (Martner 1986). Mean annual temperature is 40º F (4.4º C), with mean maximum and minimum temperatures in January of 31º F and 4º F (-0.6º- -15.6 º C) and mean maximum and minimum temperatures in July of 84º F and 48º F(28.9º - 8.9º C) (Martner 1986).

In the Brown's Park area of Colorado and Utah, average annual precipitation is about 16 in (406 mm). Annual, January, and July temperatures are slightly higher than in Wyoming (Dorn 1989).

Information on climate condition patterns as they differ from these averages are documented at the nearest NOAA monitoring station in Baggs, WY (USDI NOAA 2007), including annual precipitation and mean monthly temperature/year (Figures 15 and 16) starting at least three years before the start of the first monitoring in 1982. It was hypothesized that decline in *Penstemon gibbensii* numbers at the two monitoring sites may be a consequence of drought conditions. Climate trends are presented below and discussed in the monitoring studies that are presented in the appendix. Warren (1992) reported 10 years of rain gauge measurements from the vicinity of Cherokee basin and found average annual temperature to be slightly lower than the long-term regional averages (i.e., at Baggs).

5. Local microclimate: Many of the *Penstemon gibbensii* occurrences are on south- and west facing upper slopes, facing the prevailing wind (Fertig and Neighbours 1996). These conditions reduce percolation and increase evaporation. The absence of cryptobiotic crusts at Wyoming sites reduces the microclimate buffering affect that they confer in retaining moisture and reducing evaporation and surface temperatures, as well as in reducing erosion.

Figure 15. Annual precipitation in Baggs, WY (1982-2006)[5]

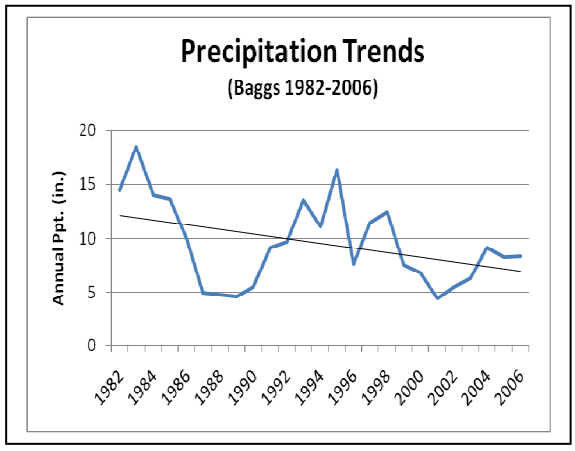
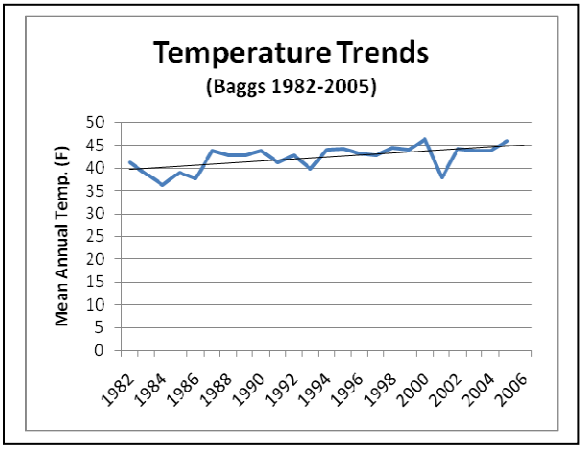


Figure 16. Annual temperature in Baggs, WY, (1982-2006)



F. Population biology and demography

1. Phenology: The flowering phenology was previously characterized as "typically occurs from early June to late July, depending on summer moisture conditions" (Fertig and Neighbours 1996). There also appear to be differences between populations as to the start of flowering. The two highest elevation populations flower the earliest. Both Flat Top and T84N R18W were collected in full flower on 11 and 12 June (*Dorn 4644* and *Fertig 18688*, respectively). This is in contrast to the statement in Warren (1992) that *P. gibbensii* doesn't flower at Cherokee Basin until "late July or early August." Dorn (1990) stated that the lower elevation population seems

[5] NOAA data from 2004-2006 includes more than one month in which data are missing for most of the month.

to flower last. Out-of state populations are at the lowest elevation, and were in bud at the time of the most recent survey (2 July 1999). Prolonged flowering of *P. gibbensii* into September has been reported by Dorn (1989) and in 2008 (Figure 3) as moisture conditions and growing season temperatures allow. It appears that flowering activity at most occurrences may run for a couple months. This is consistent with *P. gibbensii* having indeterminate inflorescences and axillary branches with buds at different stages of development at any given time. A more accurate phenology statement for *P. gibbensii* in Wyoming does not use the word "typical" and is as follows: "Flowers from mid June to early August (September), depending on spring and summer moisture conditions and site differences."

2. Population size and condition: Based on 1995 survey results of three Wyoming occurrences the total Wyoming population numbers were estimated to be 3900-4200 individuals (Fertig and Neighbours 1996). This did not include the T84N R18W population, a later discovery estimated by Fertig as having 4500-5000 plants in 1999 (a hypothetical total of 8400-9200 plants). Based on 2008 survey results, there are now six Wyoming occurrences, and the new Willow Creek occurrence is as extensive if not as large numerically as the Sand Creek population. However, the current total number of plants in Wyoming is estimated at the 6000-9000 plants because of declining numbers at previously known sites. In Colorado, there were no more than 5000 plants in Colorado (Spackman and Anderson 1999), so the total numbers are about 11,000 – 14,000.

Surveys in 1995 found that 30-40% of all mature plants were in reproductive states. Earlier studies showed that seedling individuals can account for 21-50% of all plants (Warren 1992). As a rule, seedlings are not used in population tallies because they are not established and often the most vulnerable life history stage to stress factors. Seedlings were not observed to be abundant in 1995, possibly as a result of drought conditions in 1994 and dry summer conditions in 1995. Seedlings were noted as rare at Flat Top Mountain and none were found at Cherokee Basin in 2008 despite the return of relatively normal precipitation patterns that began in the preceding winter.

In general, *Penstemon gibbensii* seems to have minimal reproductive success in most years because of dry conditions (Dorn 1990). It responds favorably to late summer moisture when many other plants have senesced, and late summer rains in 1988 were suggested as influencing the increase in species' numbers in 1989 (Warren 1992). Extended below-normal precipitation has also been hypothesized to account for below-normal seedling numbers, as noted in 1995 on the heels of summer drought conditions (Fertig and Neighbours 1996).

Tallies have also been made of *Penstemon gibbensii* extent taken from digitized population boundaries. Based on 1995 survey results, the total occupied area was reported to come to about 62 acres. However, the boundaries drawn for the Sand Creek population in 1995 corresponded closely to the area digitized in 2005 yet were only estimated as totaling 35 acres even though digitized boundaries span 118.7 acres. The most recent three occurrences have approximately doubled the total extent and the outer limits of all six digitized boundaries now total 270 acres. It is important to note that the species' local distribution patterns are not continuous where they are present, and the species may occupy anywhere from 5-50% of the area as mapped so any map of population boundaries over-represents occupied habitat. In Colorado, a tally of occupied habitat

in the two occurrences amounts to about 25 acres, and the Utah occurrence is less than 10 acres, for a ballpark total of 300 acres.

In addition to occupied habitat, biologists are considering new standards for species' effective range extent. Quite a few occurrences straddle section lines, and the species is present in 23 different sections (Table 6). A more orderly way to characterize spatial patterns is to calculate range extent using alpha hulls (Figure 17, Appendix F). By this method, *P. gibbensii* has a range extent that spans about 27,310 ha (105 mi²).

Figure 17. Area of Occupancy (alpha hull extent) for *Penstemon gibbensii*

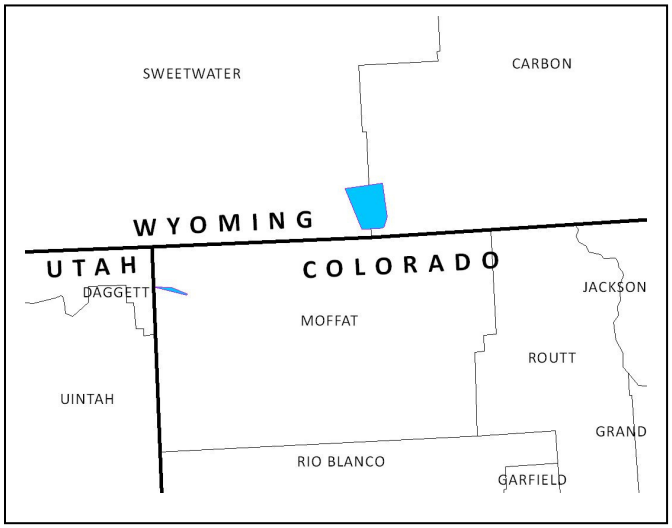


Table 6. Size and extent of *Penstemon gibbensii* occurrences

	Numbers	**Digitized Extent (ac)**	**Trends**
Cherokee Basin	450 est. in 1985 1400 est. in 1988 2766 est. in 1991 1000 est. in 1995 50-100 est. in 2007	15.2	Severe Decline
Sand Creek	2000 est. in 1989 1900-2000 est. in 1995 3000 est. in 2005	118.7	Decline?
Flat Top Mountain	300 est. in 1989 1000-1200 est. in 1995 300 est. in 2008	17.9	Moderate Decline
T84N R18W	4500-5000 est. in 1999 500-1000 est. in 2008	71.2	Moderate Decline
Willow Creek	At least 2200 est. in 2008	38.5	Unknown
Red Creek Rim	120 est. in 2008	8.1	Unknown
TOTAL	6420 est. (6000-9000) in 2008	269.6	

Two monitoring studies provide insights into *Penstemon gibbensii* life history and species' vulnerabilities from monitoring data re-collected along permanent belt transects. The methods,

results and discussion for them are presented in Appendix G and H; and highlighted in this section. They provide a basis for hypothesizing that the seedling establishment stage has been the most restrictive life history stage in recent years, that the sites without gravel and skeletal material on the soil surface may be far more vulnerable to erosion as exacerbated by drought, and that available seed biology information suggests that this species is likely to have a seed bank and that the phenology of germination is set in large part by spring precipitation. The dynamics in species' numbers has not previously been addressed, the nature and degree of such dynamics are important to consider, the 1995 survey results may represent peak estimates rather than mean estimates or low estimates.

The highest recorded numbers of *Penstemon gibbensii* on record are from T84N R18W, with estimates of at least 4500 plants in 1999. This same site had numbers estimated at 500-1000 in 2008. The type locality at Cherokee Basin had peak counts of 922 established plants in 1991 that provided the basis for estimating total numbers over 2000, but only 22 plants were counted in 2007 as basis for estimating total numbers of 50-100. When Cherokee Basin plots were monitored in 2007, severe wind erosion was evident from shrubs having about 10 cm of substrate eroded out below the base of the plant (Appendix G, last photo). The highest Wyoming population numbers in recent years were from Sand Creek with an estimated 3000 plants in 2005, and while numbers may have declined since, there are no more recent estimates. Sand Creek and Willow Creek are the two most extensive occurrences with scattered colonies and array of microhabitats. The 2008 surveys provided the first demarcation of the Willow Creek occurrence where the multiplicity of occupied habitats and complex local distribution patterns make the estimate of 2200 plants a conservative minimum that could benefit by more intensive census. The highest estimate at Flat Top Mountain was 1400 plants in 1995, whereas there were estimated to be close to 300 plants in 2008.

Population-wide estimates are tempered by monitoring within permanent belt transects at two occurrences. Figures 18 and 19 are from the longest running *Penstemon gibbensii* monitoring study, repeated seven times at Cherokee Basin. An initial increase following construction of the exclosure was demonstrated (Warren 1992). An episode of high seedling numbers around 1997 and sharp decline of both seedlings and established plants of over 10X are prevailing trends. No seedlings were found in 2008 despite moist spring conditions.

Figure 18.

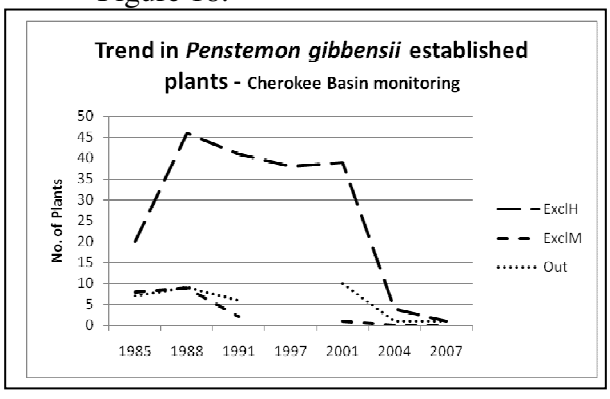
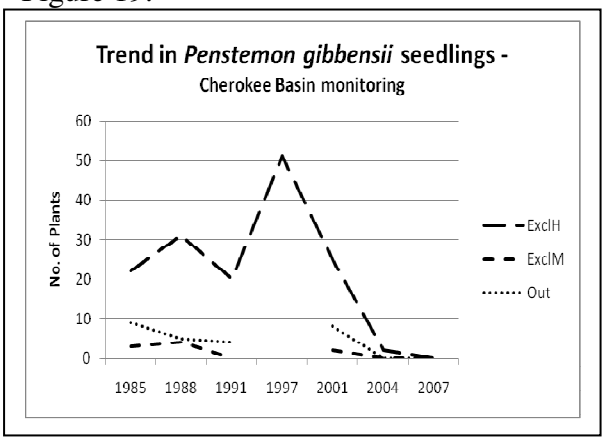


Figure 19.



Figures 20 and 21 are from the *Penstemon gibbensii* monitoring study set up in 1995 at Flat Top Mountain, repeated for a second time in 2008. The plants monitored at Flat Top Mountain have declined greater than 5X over the 13-year interval. The additional information collected on stem numbers and condition shows that flowering levels were much higher at the onset of monitoring, and that the total number of stems declined at a rate similar to the total number of plants. The Flat Top Mountain monitoring also differentiated seedlings, but none were noted in 1995 and only three were noted in 2008. Spatial patterns were also evaluated, by plotting the trends for each separate plot along the three transects over time (Appendix H). It indicates that almost all 2008 plants were in the uppermost segment of the transect, even more skewed to the upper segment than in the original 1995 monitoring. It is hypothesized that the extensive Flat Top Mountain site cap rock and concentration of coarse gravel immediately below may help retain subsurface moisture and curtail erosion, while the narrow band of Cherokee Basin site cap rock and paucity of surface gravel, as well as the direct south exposure are less conducive to retaining subsurface moisture.

Figure 20.

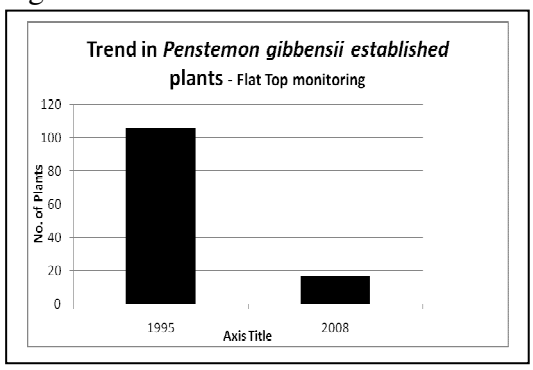
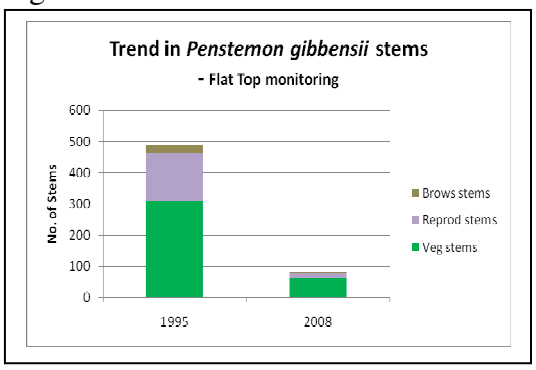


Figure 21.



The plot-by-plot change along all three of the Flat Top Mountain monitoring transects (Appendix H) also indicates that trends are localized; two showed sharp declines whereas a third had modest declines. This underscores the interpretation drawn earlier in the monitoring at Cherokee Basin that any given "monitoring belt" are not a statistical profile of the population at large (Warren 1992).

The data on browsed *Penstemon gibbensii* plants from Flat Top Mountain showed browse levels close to 5% in both 1995 and 2008 regardless of plant numbers and stem numbers. This does not indicate high levels of herbivory at the Flat Top Mountain site, as originally suggested, but any interpretations are tempered by the patchiness of herbivory patterns and the adequacy of nonrandom belts for gauging the phenomenon. The primary herbivore was characterized as mule deer (Fertig and Neighbours 1996). All of the herbivory took place on multi-stemmed plants, and the levels of herbivory may be more obvious in years when there are more vigorous, multi-stemmed plants produced. This particular monitoring study was set up as a demographic study, which would have value in characterizing life expectancy and stage-based transitions. However, this requires annual revisits. The layout running perpendicular to the slope rather than parallel to it introduces a great degree of habitat variability across the transect and risks habitat destabilization and accelerated erosion associated with reading the transect. If life history data is

a priority to collect, then demographic monitoring needs to be re-designed and commitments made to annual monitoring.

2. Reproductive biology

a. Type of reproduction: *Penstemon gibbensii* is a perennial that reproduces by seed (Dorn 1989). Flowering appears to be influenced strongly by summer moisture availability and plant size (Fertig and Neighbours 1996). At the Flat Top Mountain site, flowering individuals possessed as many as 10 or more stems per plant as noted in 1995, compared with 2-3 stems for vegetative plants. There were just a couple many-stemmed plants found at the Flat Top Mountain site in 2008 and the plants having highest stem numbers were found at Willow Creek. There is no evidence of vegetative reproduction in this species, but separate shoots within a short distance of one another may be connected underground, a source for overestimating population size that is more likely when plants are growing among gravel or have low vigor and shoots are more apt to appear isolated.

A limited *Penstemon gibbensii* set of seeds were collected by Denver Botanical Garden in 1992 (Jennifer Ramp Neale pers. commun. to B. Heidel 2009), and accessioned at the National Center for Genetic Resources Preservation (NCGRP) in Fort Collins. It may be appropriate to update the collections. Depending on the results from current genetics research (A. Buerkle pers. commun. to B. Heidel 2009), it may also be appropriate to expand the collection from all three geographic areas. The type collection at Cherokee Basin corresponds with a population that has at least a slight chance of extirpation, and is a priority for representing in seed accessions.

b. Pollination biology: The *Penstemon* genus is insect-pollinated, but the specific pollinator is not known. Dorn (1989) reports minimal reproductive success most years because of dry conditions, which could affect pollinator visitation or plant energy allocations.

c. Seed dispersal and biology: Seeds of *Penstemon gibbensii* are probably dispersed by gravity and wind near the parent plant. Depending on the setting, this may favor downslope and downwind dispersal patterns. Germination requirements are poorly understood, but scarification of the seed coat may be necessary for germination (Carol Dawson, Center Botanical Garden, pers. commun. to W. Fertig). Seedling establishment is probably episodic and dependent on climate conditions. The fact that seedlings have been reported in Cherokee Basin monitoring as conducted in mid-summer suggests that germination is in spring. The absence of seedlings in 2008 despite moist spring conditions may mean that there is not a seed bank, whether because the seed bank was depleted by the length of drought, or else the seeds were eroded out of suitable habitat under the severe erosion that has occurred at the Cherokee Basin site.

There have not been studies to date on the seed biology of *Penstemon gibbensii*, but the work of Meyers and Kitchen (1992, 1994) and Meyers et al. (1995) provide a frame of reference for evaluating it against other intermontane species of *Penstemon*, other species of similar habitat, and other species in Section Glabri. They have shown that adaptive radiation in the *Penstemon* genus has included evolution of habitat-specific germination timing strategies in multiple lineages within the genus. It is possible for such species to maintain a seed bank from year to year even without burial of seeds if they have a cyclic dormancy pattern that effectively confines

germination to autumn or early spring, as documented for *P. palmeri* (Meyer and Kitchen 1992). They studied *P. fremontii*, a closely-related mid-elevation species within the broad Section Glabri that similarly experiences cold winters but scanty snowpack. Seeds of *P. fremontii* failed to respond significantly to chilling periods of less than 12 weeks, reaching maximum germination after chilling 16 weeks, as overwintering conditions. The set of over 20% that did not respond to chill treatment was a "carryover" fraction that may represent a strategy for adaptation to unpredictable climates (Meyer and Kitchen 1994, Meyer et al. 1995). These results indicated that the majority of *P. fremontii* seeds germinate in early spring but that there is a fraction that forms a seed bank, and which may respond to other environmental cues over time.

G. Population ecology

1. General summary: *Penstemon gibbensii* is restricted to bare, sparsely vegetated sandy-shale slopes with poor soil development. Its capacity for high reproductive output, as represented by the potential to flower for over three months, is dependent on climate, and consistent with the life history of a short-lived perennial. Population expansion may be restricted by the availability of specific soil types, episodic climatic conditions favoring seedling establishment, and the degree of herbivory. At several sites on both the east and west sides of Sand Creek, it appears to be capable of colonizing disturbed, bare ground though only in areas where a suitable substrate has been exposed.

2. Competition: *Penstemon gibbensii* is restricted to sparsely vegetated sites with large areas of bare soil where competition with other plant species is minimal (Fertig and Neighbours 1996). Warren (1992) characterized its Cherokee Basin habitat as having less than 5% cover. It is almost always absent from adjacent areas with high graminoid or shrub cover. As mentioned under seed biology, the other species of sparsely-vegetated slopes may facilitate seed germination or possibly entrap seeds on the unstable slopes. There have been similar cases of short-lived perennials having dual competition/facilitation relationships with surrounding long-lived vegetation depending on climate conditions of any given year and on the local setting (Greenlee and Calloway 1996).

2. Herbivory: *Penstemon gibbensii* is relatively succulent and was reported to be grazed by mule deer, pronghorn, cattle, and other herbivores during late summer when other green vegetation is sparse (Whiskey Basin Consultants 1982, Dorn 1989, Warren 1992). This herbivory appears to be restricted almost entirely to inflorescences (Fertig and Neighbours 1996). Limited herbivory was noted in 2008, and may vary within and between years.

In addition, there may be secondary effects of herbivores on *Penstemon gibbensii*. The most unconsolidated substrates and the more steeply-sloping settings are very prone to erosion that may uproot mature plants and alter seed dispersal patterns.

3. Hybridization: No direct evidence of hybridization has been observed in the field. The closely related *Penstemon fremontii* occurs in the immediate vicinity of *P. gibbensii* at the Cherokee Basin, Sand Creek and Willow Creek sites, but appear to be reproductively isolated by ecological and temporal barriers. An albino *P. gibbensii* plant was noted in the Willow Creek population, but this is a variant within the species.

4. Land ownership: Almost all known Wyoming occurrences of *Penstemon gibbensii* are found on lands managed by the BLM Rawlins Field Office. The exception is the T84N R18W population that is on State Land and private land. Also, a small portion of the Sand Creek population is on State Land. In Colorado, the Spitzie Draw occurrence is on the Browns Park National Wildlife Refuge (U.S. Fish and Wildlife Service) and lands managed by the BLM Little Snake Field Office. The Sterling Place occurrence is entirely on BLM lands. The Utah occurrence lies on State Land. In total, seven of the nine occurrences are entirely or in large part on BLM-administered lands.

IV. ASSESSMENT AND MANAGEMENT RECOMMENDATIONS

A. Potential threats to currently known populations: The restricted and specialized habitat of *Penstemon gibbensii* makes this species vulnerable to habitat degradation and loss. Grazing, mineral development, recreation, roads and weeds are potential threats. Drought, climate conditions and big game herbivory may directly or indirectly impact the species and erode its habitat.

…

1. Grazing: Summer grazing by livestock and large native ungulates (mostly mule deer) has been cited as the primary threat to *Penstemon gibbensii* (Whiskey Basin Consultants 1982, Spackman and Anderson 1999). Surveys in 1995 found that most herbivory was restricted to flowering stems. This reduction in reproductive output could have a significant negative impact on seed production, seed bank replenishment, and long-term viability of this species (Fertig and Neighbours 1996). The influence of livestock grazing was questioned by Warren (1992) with reference to the Cherokee Basin habitat, citing steep slope, unstableness of footing, and low forage production, exacerbated by water unavailability in the area. A windmill is located 1 ½ miles to the west of Cherokee Basin and its operation could potentially influence wildlife use patterns. Winter use by sheep does not appear to be a concern at the Cherokee Basin site (Warren 1992). Wild horses and signs of their presence were noted in the Willow Creek population but direct signs of grazing were wanting.

Three lines of evidence indicate that past grazing may have had an influence. First, the exclosure study has documented an increase in *Penstemon gibbensii* numbers in the years of near-normal precipitation up until 2001 (Warren 1992 and unpublished data). Second, the original Gibbens' vegetation plot near *P. gibbensii*, presumably sampled in the late 1960's, documented dominance of a poisonous unpalatable species, *Xylorhiza glabriuscula*, that is still present but no longer dominant in the immediate vicinity. This dominance of a putative "increaser" species suggests a level of grazing intensity in adjoining gentle terrain that may have had incidental livestock use on steeper adjoining slopes no matter how unproductive the *P. gibbensii* habitat. The absence of cryptogamic crusts in *P. gibbensii* habitat of Wyoming contrasts with that in Colorado, and might possibly reflect the effects of trampling from past grazing practices. In Colorado, summer grazing was thought to have the greatest impact, resulting from direct removal of biomass, trampling, and increased erosion (Spackman and Anderson 1999).

2. Mineral and energy development: Dorn (1989) listed oil and gas exploration as a potential threat to *Penstemon gibbensii* populations, though activity was low at that time. Since 1989, exploration activity has increased greatly throughout the Washakie Basin of Wyoming. Most sites occupied by *P. gibbensii* are on unstable slopes that are unlikely to be developed for access, roads, pipeline routes, or well pad sites (Fertig and Neighbours 1996). The authors also identified seismic exploration utilizing explosives or trampling by vehicles transporting testing equipment as potential threats.

One pipeline has been laid across a western colony of *Penstemon gibbensii* at the Sand Creek occurrence, one pipeline has been laid through or adjoining a southern colony of the Willow Creek occurrence, and another pipeline was put in across Willow Creek between colonies. In addition, a wellpad has been constructed above a southeast colony of the Sand Creek occurrence (immediately upslope of Figure 10), and the road that crosses the colony has been upgraded for heavy machinery. The aforementioned developments dissect limited areas of habitat and suggest that the degree of energy development threats are not severe. However, they have not necessarily been instituted to their full potential in *P. gibbensii* habitat, and other forms of development may be possible. Any developments also introduce the possibility of additional indirect impacts like ORV use and spread of exotic species, that may be more difficult to gauge and that may change in the future later than the ground-disturbing development.

Uranium is mined in Poison Basin near the Red Rim Creek population. The Washakie Basin area is underlain by sub-bituminous coal that is not regarded as suited for strip mining. It is also underlain by oil shale-bearing rock (Roberts 1989). The Upper North Platte River valley area has quarries in the same township as *Penstemon gibbensii* used for road surfacing material, and mineral and energy developments often promote road construction and other infrastructure.

Wind energy has not been developed to date in the vicinity of *Penstemon gibbensii* habitat, though there is ridgetop cap rock above most of its habitat that might be considered in wind farm developments. Any wind energy developments at ridgetops might affect downslope habitats.

There are no high-value commercial uses of the substrates constituting *Penstemon gibbensii* habitat (Table 5), or overlying caprock. However, the gravelly occurrence sites, particularly those with easy access, might be at risk of quarry developments. Roads in the vicinity of the site at T18N R84W are built up with gravel material that bears similarity to the nearby *Penstemon gibbensii* habitat.

3. Recreation: Trampling by off-road vehicles may result in direct mortality of plants and lead to soil erosion. ORV use was identified as a potential threat to Colorado populations (Spackman and Anderson 1999). Although plants may colonize disturbed areas at the margins, they do not become established within roadbeds that receive active vehicle use.

Trampling by botanists and any other visitors to *Penstemoni gibbensii* habitat is also a potential threat, especially in those sites with steep, loose soils under repeated visits. Visitation of occupied habitat should be kept to a minimum to prevent excessive erosion, discussed further in the monitoring studies (Appendix G).

4. Roads: A new access road has been built around the north side of Hog Lake in the Browns Park National Wildlife Refuge within 200 m of the cliffs that support *Penstemon gibbensii* (Spackman and Anderson 1999). The relatively new road that crosses Willow Creek at the edge of *P. gibbensii* habitat provides ready access to the very edge of the population. As mentioned above, a road that was upgraded for oil and well use cuts across a limited part of the Sand Creek population. It was previously suggested by Fertig and Neighbours (1996) that some existing roads on Flat Top Mountain would be appropriate to close or re-route to minimize trampling impacts.

5. Weeds: In addition to the above-mentioned threats, exotic species competition and noxious weed encroachment have been identified as potential impacts to *Penstemon gibbensii* in Colorado (Spackman and Anderson 1999). They might be fostered by any of the above-mentioned activities. In general, weedy annual numbers are low in and adjoining *P. gibbensii* habitats of Wyoming, and are most common locally near roads. They are not new on the landscape but were noted, e.g., in 1987 surveys of the Cherokee Basin occurrence. In general, noxious species and weedy annuals were generally scarce in *Penstemon gibbensii* habitat surveyed in 2008. Their presence to date has been noted (Table 7).

Table 7. Non-native species in *Penstemon gibbensii* habitat

Species	**Site**
Alyssum desertorum	Cherokee Basin, Red Rim Creek
Bromus tectorum	Cherokee Basin, Red Creek Rim, Sand Creek, Sterling Place (where abundant in parts of adjoining habitat)
Halogeton glomeratus	Cherokee Basin, Sand Creek, Spitzie Draw, Sterling Place
Salsola australis	Spitzie Draw. Sterling Place

6. Finally, the affects of drought on *Penstemon gibbensii* warrant careful consideration as "natural threats," whether as possible harbinger of climate change or chance events. The estimated *P. gibbensii* population numbers are significantly down in the Cherokee Basin, Flat Top Mountain and T84N R18W occurrences. There is no trend data available for Willow Creek but it appears that its habitat with gentle slopes and east aspect is less harsh than all other settings. It would be valuable to know if Colorado populations have undergone sharp decline since the time of pre-drought surveys. The results of monitoring within and between the Cherokee Basin and Flat Top Mountain suggest that species' habitat is highly vulnerable to erosion under prolonged drought, particularly in the steeper slope segments and where gravel and skeletal rock fragments are wanting. The two monitoring sites are appropriate to revisit to evaluate trends in the wake of drought. If erosion has removed most of the seed bank with surface substrates at Cherokee Basin, then recovery will take multiple life cycles rather than just a moist year or two.

B. Management practices and response: An 8 foot high wire mesh exclosure was established by the BLM in 1985 to enclosed 80% of the occupied habitat of *Penstemon gibbensii* at the Cherokee Basin site, preventing entry by big game and livestock. A smaller, 3-strand barbed wire exclosure covered 15% of the habitat, preventing entry by livestock. The remaining 5% of

the occupied habitat was unfenced, outside of the exclosures. As noted previously, results from the Cherokee Basin originally documented upward trends in *P gibbensii* numbers of established plants, particularly in the tall exclosure (1985-2001). However, numbers showed sharp declines in 2004 and 2007, apparently under drought conditions. This exclosure has been critical in ruling out grazing as the cause of decline. The exclosure appeared to be intact, despite past reports of the fence being cut (Dorn 1989). The uniformly steep, south-facing slope and soil properties of this site might account for the severity of trend instead.

C. Conservation recommendations

1. Recommendations regarding present or anticipated activities: Whiskey Basin Consultants (1982) recommended fencing the Cherokee Basin population to protect *Penstemon gibbensii* from the impacts of grazing. Based on the upward trend of this species during most of the initial 16 years, this fence should remain in place, consistent with Warren (1992). Additional fencing was described as desirable for the Flat Top Mountain population if mule deer herbivory became too great of a threat (Fertig and Neighbours 1996) but was not identified in 2008 as a priority.

Periodic inspection of all sites is probably warranted at 3-5 year intervals for checking management practices as they affect the species, following a checklist of potential threats and potential invasive species, and looking for signs of impact. This includes an inspection of all pipelines that cross the population. This also includes monitoring of the Cherkoee Basin and Flat Top Mountain occurrences, at least until a recovery is documented. Neither study design are suited for producing life history data, which is important to pursue if P. gibbensii does not recover at Cherokee Basin. In the case that it is extirpated is documented at Cherokee Basin, then propagation and re-introduction is appropriate to consider. The connection between threats warrants special consideration, as with weed encroachment or escalated ORV use commonly associated as facilitated by energy developments.

2. Notification of BLM personnel of locations on BLM lands: To prevent inadvertent impacts to known populations, all appropriate BLM personnel involved in planning and on-the-ground land management activities should be provided with location data for *Penstemon gibbensii*. It is especially important that BLM minerals, engineering, and range staff know precise locations so that disturbances can be avoided. Towards this end, *P. gibbensii* is featured on the cover of the 1994 Wyoming Rare Plant Field Guide (Fertig et al. 1994), and the state species abstract is updated and posted by WYNDD as part of this project (Appendix I).

3. Areas recommended for protection: Ten acres of habitat encompassing the Cherokee Basin population of *Penstemon gibbensii* were proposed for designation as an Area of Critical Environmental Concern (ACEC) in the draft Great Divide Resource Area Resource Management Plan (RMP)(USDI BLM 1988). This area and Flat Top Mountain were identified as warranting consideration (Fertig et al. 1998). ACECs were not designated in the final Record of Decision for the RMP (USDI BLM 1990). ACEC designation at *P. gibbensii* sites was not included in the Rawlins Resource Management Plan (USDI BLM 2009). ACEC priorities for *P. gibbensii* were discussed by Fertig and Markow (1998).

In Colorado, both population sites have been identified as potential conservation sites warranting strong conservation actions. The Spitzie Draw population and The Sterling Place have been recommended for designation as ACECs (Spackman and Anderson 1999), a proposal that was included in the Little Snake River RMP but not listed as the preferred alternative.

The private property on which *Penstemon gibbensii* occurs has been protected by The Nature Conservancy as part of a conservation easement, but this does not address the adjoining state land.

C. Status recommendations: It may be appropriate for the Wyoming BLM to continue recognizing *Penstmon gibbensii* as a sensitive species as a way to ensure that agency actions do not contribute to the further endangerment of the species and the subsequent need for listing under the Endangered Species Act.

As part of this status report update, the global ranking information for *Penstemon gibbensii* was updated. It was analyzed using the NatureServe rank calculator and supports a global rank change from G1 to G1G2. The analysis was run using a range of values in cases where there are uncertainties (e.g., in estimating effective population size, trend reversibility, and the severity of combined threats) (discussed in Appendix A).

The new occurrences and broadened area of occupancy reduce the endangerment of this taxon on one hand, but the steep declines of population numbers in recent years, unknown capacity to recover population numbers, and uncertain degree of threats counterbalance the original information.

D. Summary: *Penstemon gibbensii* is a regional endemic of the Washakie Basin, Wyoming, the Upper North Platte River valley, Wyoming, and the Brown's Park area near the Colorado-Utah border. It is presently known from nine occurrences spanning a distance of 120 miles but an area of occupancy of ca 27,310 ha (105 mi^2) and only occupying about 270 acres total in Wyoming, in addition to about 25 acres in Colorado plus roughly 5 acres in Utah. The new occurrences documented in recent years expanded this range extent, an increase that is tempered by results from the two monitored populations showing dramatic drop in numbers under prolonged drought since 2001. It appears that current population sizes may be much lower than previous estimates made during more favorable climate cycles, so despite the new populations, the current total is estimated at between 11,000-14,000 individuals. Soils data collected from the six Wyoming occurrences provides a basis for hypothesizing that the species is restricted to tuffaceous deposits. The severity of threat from energy developments may have previously been over-estimated but not all potential developments have been instituted and the vulnerability of *P. gibbensii* population numbers to prolonged drought was not previously identified.

The following summary addresses the five original reasons for preparing this update.

1. The two *Penstemon gibbensii* occurrences documented since the most current Wyoming status report (Fertig and Neighbours 1996) represent significant geographic expansion of its range to the North Platte Valley (T18N R84W), and significant expansion of the total

species numbers and occupied habitat. The T18N R84W occurrence had the highest reported population numbers in Wyoming, and the Willow Creek occurrence had an extensive population on par with the extensive Sand Creek occurrence.

2. The potential distribution model developed for *Penstemon gibbensii* (Fertig and Thurston 2003) is meaningful for the Washakie Basin, most of which has been surveyed at some level. One new occurrence was documented at Red Creek Rim. The utility of the model warrants further testing in the North Platte area and in outlying areas to the extent that they identify potential habitat on public lands.
3. Collection label data for two historical specimens of *Penstemon gibbensii* collected by Robert Gibbens were false reports that were artifacts of the past data entry process at the Rocky Mountain Herbarium. This was not determined until after extensive searches were conducted in the two areas. Both fell within potential habitat identified by the model.
4. Monitoring was continued at Cherokee Basin, which had only one *Penstemon gibbensii* plant remaining in the five original transects. The entire site was estimated as supporting 2000 *P. gibbensii* plants in 1995, but was estimated at 50-100 plants in 2007. Continuation of whole-site census is the most meaningful approach for the future. Maintenance of the exclosure has been and will continue to be critical for differentiating drought response from grazing response.
5. Monitoring was repeated for the first time at Flat Top Mountain, showing major decline as found at Cherokee Basin. But the declines were less severr than those at Cherokee Basin. Comparisons between the two sites suggest that the Cherokee Basin site has much more highly erodible substrate. Continuation of the monitoring at Flat Top complements and helps interpret Cherokee Basin monitoring.

V. LITERATURE CITED

Blomquist, F. 2007. *Penstemon gibbensii* survey information and shapefiles from Sand Creek, conveyed to Wyoming Natural Diversity Database. Bureau of Land Management, Rawlins.

Buerkle, A. 2009. Message regarding *Penstemon* genetics research. Personal communication to B. Heidel. University of Wyoming Department of Botany.

Colorado Natural Heritage Program. 2008. *Penstemon gibbensii* element occurrence data, exported and conveyed by J. Handwerk, 5 August 2008.

Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, and P.K. Holmgren. 1984. Volume 4, Subclass Asteridae (Except Asteraceae). Intermountain Flora: Vascular Plants of the Intermountain West, USA. Columbia University Press, New York.

Davis, C.P. 1995. Letter discussing changes in USFWS C1, C2 and 3C candidates. Letter from U.S. Fish and Wildlife Service, Cheyenne, WY dated 21 August 1995.

Dawson, C. No Date. Personal communication to Walter Fertig. Denver Botanical Garden, Denver, CO.

Dorn, R.D. 1977. Vascular plants of Wyoming. Mountain West Publishing, Cheyenne, WY.

Dorn, R.D. 1982. A new species of *Penstemon* (Scrophulariaceae) from Wyoming. Brittonia 34(3): 334-335.

Dorn, R.D. 1989. Report on the status of *Penstemon gibbensii*, a candidate Threatened species. Unpublished report for the U.S. Fish and Wildlife Service. Mountain West Environmental Services, Cheyenne, WY.

Dorn, R.D. and R.W. Lichvar. 1990. A new variety of *Penstemon fremontii* (Scrophulariaceae) from Colorado. Madrono 37(3):195-199.

Dorn, R.D. 2001. Vascular plants of Wyoming. Mountain West Publishing. 3rd ed., Cheyenne, WY.

Dorn, R.D. 2008. Information used in original surveys. Personal communication to B. Heidel.

Fertig, W., C. Refsdal, and J. Whipple. 1994. Wyoming Rare Plant Field Guide. Wyoming Rare Plant Technical Committee, Cheyenne, WY.

Fertig, W. and M.L. Neighbours. 1996. Status report on *Penstemon gibbensii* in south-central Wyoming. Unpublished report prepared for the Bureau of Land Management Wyoming State Office and Rawlins District by the Wyoming Natural Diversity Database, Laramie, WY.

Fertig, W., L. Welp, and S. Markow. 1998. The status of rare plants in southwest Wyoming. Report prepared for the Bureau of Land Management by the Wyoming Natural Diversity Database, Laramie, WY.

Fertig, W. and R. Thurston. 2003. Modeling the Potential Distribution of BLM Sensitive and USFWS Threatened and Endangered Plant Species in Wyoming. Unpublished report prepared for the Bureau of Land Management Wyoming State Office by Wyoming Natural Diversity Database, University of Wyoming, Laramie, WY.

Flaig, Kurt. 2006. *Penstemong gibbensii* survey forms and photos from Willow Creek, conveyed to Wyoming Natural Diversity Database. WEST, Inc.

Gibbens, R.P. 1972. Vegetation pattern within northern desert shrub communities. Unpublished dissertation, University of Wyoming, Laramie.

Gibson, J.P. No Date-a. Electrophoretic differences between *Penstemon penlandii* and *Penstemon gibbensii*. Unpublished report to Denver Botanical Garden, University of Colorado, Boulder.

Gibson, J.P. No Date-b. Final report on comparison between *Penstemon penlandii* and *Penstemon gibbensii*. Unpublished report to Denver Botanical Garden, University of Colorado, Boulder.

Greenlee, J.T. and R.M. Calloway. 1996. Abiotic stress and the relative importance of interference and facilitation in montane bunchgrass communities in western Montana. Am. Nat. 148(2):386-396.

Handwerk, J. 2009. Personal communication to B. Heidel. Colorado Natural Heritage Program, Fort Collins, CO.

Heidel, B. 2007. 2007 Wyoming plant species of concern list. Wyoming Natural Diversity Database, Laramie, WY.

Lodewick, K., and R. Lodewick. 1999. Key to the genus *Penstemon* and its related genera in the tribe Cheloneae (Scrophulariaceae). Eugene, OR.

Love, J.D. and A.C. Christiansen. 1985. Geologic map of Wyoming. U.S. Geological Survey.

Martner, B. 1986. Wyoming climate atlas. University of Nebraska Press, Lincoln, NE.

Meyer, S.E. and S.G. Kitchen. 1992. Cyclic seed dormancy in the short-lived perennial *Penstemon palmeri*. J. Ecol. 80:115-122.

Meyer, S.E. and S.G. Kitchen. 1994. Habitat-correlated variation in seed germination response to chilling in *Penstemon* Section Glabri (Scrophulariaceae). Am. Midl. Nat. 132:349-365.

Meyer, S.E., S.G. Kitchen ands.L. Carlson. 1995. Seed germination timing patterns in Intermountain *Penstemon* (Scrophulariaceae). Am. J. Bot. 82(3):377-389.

Neal, J.R. 2009. Confirmation of seed accessions. Personal communication to B. Heidel. Denver Botanical Garden, Denver, CO.

Newman, M. 2009. Comments accompanying spectroscopy results for soil samples collected at each *Penstemon gibbensii* site in Wyoming. Bureau of Land Management, Rawlins.

O'Kane, S.L. 1988. Colorado's rare flora. Great Basin Naturalist 48 (4):434-484.

Roberts, S. 1989. Wyoming Geomaps. Geological Survey of Wyoming, Educ. Series 1. Laramie, WY.

Roderick, A.J., B.E. Nelson, and R.L. Hartman. 1999. Final report on the general floristic inventory of the Upper North Platte and Laramie River drainages. Report prepared for the Bureau of Land Management Rawlins and Casper Districts by the Rocky Mountain Herbarium, University of Wyoming, Laramie, WY.

Spackman, S. and D. Anderson. 1999. Field survey for the globally imperiled Gibbens' beardtongue, Penstemon gibbensii Dorn in Colorado. Report prepared for the Colorado Natural Areas Program by the Colorado Natural Heritage Program, Fort Collins, CO.

Spackman, S., B. Jennings, J. Coles, C. Dawson, M. Minton, A. Kratz, and C. Spurrier. 1997. Colorado Rare Plant Field Guide. Prepared for the Bureau of Land Management, US

Forest Service, and US Fish and Wildlife Service by the Colorado Natural Heritage Program, Ft. Collins, CO.

Taylor, A.R. 2000. The vascular flora of the Upper North Platte River drainage, Wyoming. Master's thesis, Dept. of Botany, University of Wyoming, Laramie, WY.

USDI Bureau of Land Management. 1988. Proposed resource management plan and final environmental impact statement for the Great Divide Resource Area, Rawlins District, Wyoming.

USDI Bureau of Land Management. 1990. Great Divide Resource Area, Record of Decision and approved Resource Management Plan. BLM Rawlins District Office, Wyoming.

USDI Bureau of Land Management. 2001. Wyoming Bureau of Land Managment sensitive species policy and list; instruction memorandum no. WY02001-040. BLM Wyoming State Office, Cheyenne.

USDI Bureau of Land Management. 2009. Proposed resource management plan and final environmental impact statement for the Rawlins Field Office, Wyoming.

USDI Fish and Wildlife Service. 1983. Endangered and Threatened Wildlife and Plants; Supplement to Review of Plant Taxa for Listing; Proposed Rule. Federal Register 48(229): 53640-53670.

USDI Fish and Wildlife Service. 2009. Endangered and Threatened Wildlife and Plants; Partial 90-Day Finding on a Petition To List 206 Species in the Midwest and Western United States as Threatened or Endangered With Critical Habitat. Federal Register / Vol. 74(23):6122-6128. Printed February 5, 2009 under Rules and Regulations.

USDI National Oceanic and Atmospheric Association. 2007. Wyoming climate summaries. Posted at: http://www.wrcc.dri.edu/summary/climsmwy.html .

Utah Native Plant Society. 2003-2008. Utah Rare Plant Guide. Posted electronically at http://www.utahrareplants.org/rpg.html.

Utah Natural Heritage Program. 2008. *Penstemon gibbensii* element occurrence information and pdf maps, emailed by M. Franklin, 5 August 2008.

Warren, A. 1992. Monitoring/evaluation report on *Penstemon gibbensii*. Bureau of Land Management Great Divide Resource Area Memorandum, dated 16 January 1992.

Weber, W.A. 1986. Phytologia 60(6): 459-461.

Welsh, S. L., N. D. Atwood, S. Goodrich, and L. C. Higgins. 2003. A Utah Flora, 3rd ed. Brigham Young University, Great Basin Naturalist Memoirs 9: 1-894.

Whiskey Basin Consultants. 1982. Final report, Threatened and Endangered plants inventory. Unpublished report prepared for the Bureau of Land Management, Rock Springs District.

Willoughby, J., E. Hastey, K. Berg, P. Dittberner, R. Fellows, R. Holmes, J. Knight, B. Radtkey, and R. Rosentreter. 1992. Rare Plants and Natural Plant Communities: a Strategy for the Future. Bureau of Land Management, Washington, D.C.

Wolfe, A.D., C.P. Randle, S.L. Datwyler, J.J. Morawetz, N. Arguedas and J. Diaz. 2006. Phylogeny, taxonomic affinities, and biogeography of *Penstemon* (Plantaginaceae) based on ITS and CPDNA sequence data. Amer. J. Bot. 93(11):1699-1713.

Wyoming Natural Diversity Database. 2008. *Penstemon gibbensii* element occurrence records, exported upon completion of 2008 data entry.