MONITORING *PENSTEMON GIBBENSII* (GIBBENS' BEARDTONGUE) IN SOUTH-CENTRAL WYOMING – 2011 AND 2016 UPDATES

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

By Bonnie Heidel
Wyoming Natural Diversity Database
Dept. 3381, University of Wyoming
1000 E. University Ave.
Laramie, WY 82071

July 2017

Cooperative Agreement No. L12AC20036, Supplement 7

ABSTRACT

Monitoring of *Penstemon gibbensii* (Gibbens' beardtongue) was conducted in 2011 and 2016 to update population trend information for the species in Wyoming as treated in prior monitoring reports. Population numbers have continued to decline at Cherokee Basin to precariously low levels while those at Flat Top might have turned around. A third monitoring site was added for comparative purposes that is close to Cherokee Basin and with essentially the same climate but gentle slopes for comparing population trends at the steep-slope setting at Cherokee Basin with those at a gentle-slope setting. New information on seed ecology is presented. This monitoring report tries to integrate the two different monitoring studies by steps that include re-projecting results in the same units (plants/m^2), examining the plant category conventions, presenting climate context, and discussing experimental design to increase the data comparison value. Future directions potentially include adding an annual monitoring cycle at Sand Creek, scoping the feasibility of using existing seed accessions from Cherokee Basin for propagation if a trial transplanting program is warranted, and at the minimum, replication of all three monitoring sites in the same year in the near future (within 2019-2021).

Report citation:

Heidel, B. 2017. Monitoring *Penstemon gibbensii* (Gibbens' penstemon) in south-central Wyoming – 2011 and 2016 updates. Prepared for the Bureau of Land Management. Wyoming Natural Diversity Database, Laramie, WY.

Cover photo: A view of the *Penstemon gibbensii* population at Cherokee Basin, located on distant south-facing outcrops, at the center and to right of center. By B. Heidel

TABLE OF CONTENTS

TABLES AND FIGURES

APPENDIX

ACKNOWLEDGEMENTS

This monitoring reflects significant initiative and labor of Bureau of Land Management (BLM) and Wyoming Natural Diversity Database (WYNDD) staff. Mark Andrew ("Andy") Warren (BLM) initiated monitoring of *Penstemon gibbensii* in 1985 at Cherokee Basin. Walter Fertig (WYNDD) initiated monitoring of *P. gibbensii* in 1995 at Flat Top Mountain. The two monitoring studies were pursued jointly by BLM and WYNDD starting in 2007. Monitoring in 2011 took place with the help of Andy Warren, Frank Blomquist, Susan Chambers and Emma Stewart (BLM). It took place in 2016 with the help of Andy Warren, Frank Blomquist and Gayle Tyree (BLM). Frank Blomquist coordinated the *P. gibbensii* project logistics and provided review for the Rawlins Field Office of the BLM and Tanya Skurski and Chris Keefe provided the recent Wyoming BLM state office coordination.

I. INTRODUCTION AND OVERVIEW

This monitoring report provides updates to the three prior *Penstemon gibbensii* monitoring reports in Wyoming (Warren 1992, Fertig and Neighbours 1996, Heidel 2009). It augments the most current status information (Heidel 2009) particularly with regard to trends. It also represents the addition of a third monitoring site to the prior monitoring studies. This report reviews methdological commonalities and differences in all monitoring work to date, charting a course for interpreting trends.

The *Penstemon gibbensii* monitoring history and stages of species' status reviews by U.S. Fish and Wildlife Service are highlighted in the following text. The reader is referred to Heidel (2009) as the most current source of information on biology, distribution and environmental information. This report does not update species' information on environment or on species biology except as necessary context for monitoring work and presenting more recent information.

Penstemon gibbensii was published as new to science by Robert Dorn (Dorn 1982) and 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. At that time, the only known population was the type locality at Cherokee Basin. 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). Construction of the exclosure around the *P. gibbensii* occurrence was completed in 1985.

Mark Andrew ("Andy") Warren of the Bureau of Land Management (BLM), initiated monitoring of *Penstemon gibbensii* in 1985 after the exclosure was constructed at the Cherokee Basin population, Rawlins Field Office. Monitoring of *P. gibbensii* at this population was replicated in 1988 and 1991, with the first monitoring/evaluation report prepared in 1992. Monitoring was later replicated in 1997, 2001 and 2004 by BLM, i.e., at 3-6 year intervals with results stored in manual agency files. The Cherokee Basin monitoring represents the longest-running monitoring study of the species throughout its range.

The Category 2 status also lead USFWS to contract the first status survey for *Penstemon gibbensii* in 1987-1989, as a result of which two additional occurrences were documented at Flat Top Mountain and Sand Creek in 1987 (Dorn 1989). Walter Fertig and Jane Struttmann initiated monitoring of *P. gibbensii* in 1995 in three belt transects at the Flat Top population, with a baseline monitoring report prepared the next year (Fertig and Neighbours 1996). Meanwhile, a total of two *P. gibbensii* populations in Colorado were documented by 1989, and another documented in adjoining Utah. One of the Colorado records that had first been collected in 1978 but not recognized as a new species.

In 2007-2008, a combined survey-plus-monitoring study was initiated to survey *Penstemon gibbensii* using potential distribution modeling (Fertig and Thurston 2003) and to repeat monitoring at both prior monitoring sites. Monitoring work was conducted jointly by BLM and WYNDD, and survey work was conducted by WYNDD.   Currently there are six *P. gibbensii* populations known in Wyoming and a total of four in Colorado and Utah.

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*. A subsequent 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) but *P. gibbensii* remained under consideration. Finally, the listing of *P. gibbensii* was not warranted on June 9, 2011 (USDI Fish and Wildlife Service 2001). [Federal Register 76(111):33924-33965].

Monitoring of *Penstemon gibbensii* was replicated in full in 2011 at the Cherokee Basin population and established at the Sand Creek population to provide trend comparison with a large population that is not on steep slopes. The need for evaluating trends was identified in 2016 and monitoring was replicated at the Cherokee Basin population and at the Flat Top population (Table 1). This report focuses on trends with addition of 2011 and 2016 data.

Table 1. *Penstemon gibbensii* monitored populations and monitoring dates in Wyoming

Investigators	**Cherokee Basin (#001)**	**Flat Top (#003)**	**Sand Creek (#002)**
Warren, Nelson	1985-08-02		
Warren, Greenquist	1988-07-29		
Warren, Fradl	1991-08-01		
Fertig, Struttmann		1995-08-05	
Warren, Blomquist	1997	-	
Warren, Blomquist	2001-07-26	-	
Warren, Blomquist	2005-08-06	-	
Warren, Blomquist, Heidel, Biasotti, Wade	2007-07-16	-	
Blomquist, Heidel, Larson	-	2008-07-16	
Warren, Blomquist, Heidel, Chambers, Stewart	2011-08-04	-	2011-08-05
Warren, Blomquist, Heidel, Tyree	2016-08-01	2016-08-02	-

The earliest *Penstemon gibbensii* monitoring, at Cherokee Basin, was set up to be re-read every 3-5 years based on the premise that *P. gibbensii* is a short-lived perennial and that an intermittent monitoring frequency can provide the most substantive population trend results for the time invested.

In addition to regular transect monitoring at Cherokee Basin, seedlings of *Penstemon gibbensii* were sought there in 2008 by Bonnie Heidel and Jill Larson (WYNDD) focusing the search for seedlings within belt transects, in 2010 by Bonnie Heidel and Joy Handley (WYNDD) traversing the length of the population in the "walk through" monitoring, and in 2017 by Bonnie Heidel and Frank Blomquist. All three years of seedling searches at Cherokee Basin were unsuccessful and though no seedlings were present, the 2017 search revealed two plants appearing to be second-year plants. In addition, Blomquist and Heidel searched for seedlings in the two Sand Creek transects, the same date as searches were conducted at Cherokee Basin. They found small plants but rather than being new shoots, closer examination determined that most of them were offshoots from established plants. There was at least one seedling found in the East Transect at Sand Creek in addition to several second-year plants in the same area. Seedling searches did not replicate transect monitoring but strongly suggest that seedlings are generally absent in the Cherokee Basin population and uncommon at other populations, information that provides context for monitoring results. Colorado and Utah populations do not have monitoring data for *P. gibbensii*, and though there have been revisits, different segments have been covered by different people with different objectives, complicating interpretation. There might be slight decline in one Colorado population area and stability in another (Colorado Natural Heritage Program 2017).

II. METHODS

Permanent monitoring belt transects have been established at three of the six Wyoming populations of *Penstemon gibbensii* to date. The original establishment reports at the two earliest monitoring locations provided all necessary location and design information, detailed by the persons who set them up (Warren 1992, Fertig and Neighbours 1996). A third monitoring location was added in 2011; as presented in this report. A compilation of monitoring location and design information are detailed and accompanied by aerial imagery, mapping, schematic monitoring diagrams, and record of data collected for all three monitoring locations (Appendix A) so that they are presented and elaborated in one document. The Appendix serves to draw parallels and it represents an establishment report and results from the newly-established Sand Creek monitoring. An overview of the three monitoring designs is presented in Table 2.

The Cherokee Basin *Penstemon gibbensii* monitoring design is the only study that addresses species' management response to different grazing regimes (ungrazed, grazed by native ungulates only, and open to all grazing). An 8 foot high wire mesh exclosure was established by the BLM in 1985 to enclosed 80% of the occupied habitat of *P. 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 exclosures.

Table 2. *Penstemon gibbensii* monitoring design overview

Population/ EO#	**No. of transects**	**Establishment year**	**Management variable(s)**	**Total area monitored**	**Plant categories (original)**	**Veg. composition**
Cherokee Basin/ #001	5	1985	Exclosure (high, med, outside)	500 ft^2 x 5 transects = 2500 ft^2 (232.25 m^2)	Medium, Small height	Yes
Flat Top/ #003	3	1995	None	55 m x (0.5 x 0.5 m within 3 transects = 13.75 m^2	Veg., Reprod., Seedling	Yes - Added in 2016
Sand Creek/ #002	2	2011	None	1000 ft^2 x 2 transects = 2000 ft^2 (185.8 m^2)	Medium, Small height	Yes

Other differences of design, data-recording conventions and metrics exist between the three monitoring locations. The Cherokee Basin monitoring placed individual plants in “mature” or “immature” categories based on a size distinction among established plants (medium vs small heights). It was also the only design that sought to address *Penstemon gibbensii* total population numbers by a “walk-through” census, and the only one that collected vegetation composition data. The Flat Top monitoring is the only one designed to map and record coordinates so that individual plants can be tracked over time. It also recommended addressing a “seedling” category through none were found in the first year of monitoring. The Sand Creek monitoring design is similar to the Cherokee Basin design for direct comparison of results except that it does not address management questions. At Cherokee Basin, the “mature” plants were noted on raw data forms as being in vegetative or flowering states; all “immature” plants were vegetative.

Despite design difference, we are able to make direct trend comparisons between the two earlier monitoring studies and the addition of a Sand Creek monitoring site increases the potential for interpreting the two prior studies. The presence of multiple transects also allows for the possibility of detecting differences between locales. For purposes of simplified analysis, this report just shows the pooled datasets without size- or stage-related distinctions through 2016.

III. ENVIRONMENTAL CONDITIONS

Climate data is updated and addressed as context for monitoring results and habitat differences between the monitoring stations are highlighted for context though no other environmental information were collected as part of recent rounds of monitoring. Hypotheses about the uniqueness of *Penstemon gibbensii* habitat including soils analysis were made previously (Heidel 2009).

The nearest NOAA monitoring station was in Baggs, WY (USDI NOAA 2006), but data collecting there was discontinued after 2006. Average annual precipitation is reported as 10.72 in (based on 1979-2006), and mean annual temperature is reported as 42.8 °F (based on 1979-2006). Superimposing a linear regression line on data from 1982-2006 suggests overall decreases in precipitation and increases in temperature, with a couple pronounced multi-year periods of subnormal precipitation (Figures 1 and 2).

Warren (1992) reported 10 years of rain gauge measurements near the Cherokee Basin population and found that average annual temperature in particular to be slightly lower than the long-term regional NOAA averages at Baggs.

Figure 1. Annual precipitation in Baggs, WY (1982-2006)[1]

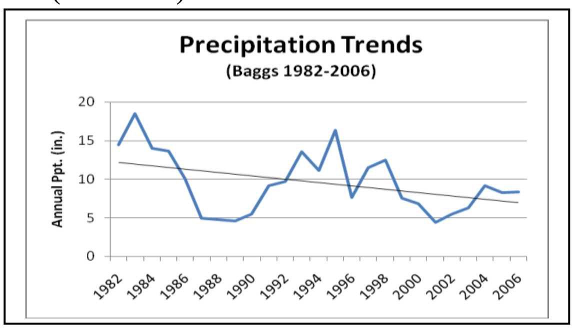
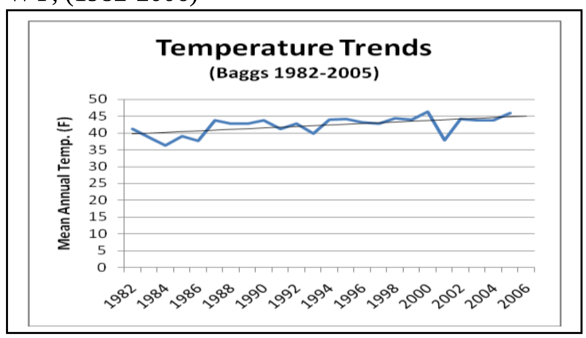


Figure 2. Annual temperature in Baggs, WY, (1982-2006)



A different characterization of climate at *Penstemon gibbensii* locations is provided by Tilini et al. (2016) that used PRISM data to characterize just that portion of precipitation that arrives during the dormancy months of the year (November thru March) for a 30-year period (1980-2010) (Table 3) for the three populations where *P. gibbensii* seeds were collected for study. Much of this precipitation falls as snow. Their data synthesis suggests that *P. gibbensii* occupies a range of settings with over three-fold difference in dormancy-period precipitation. The three populations span most of the range in elevation for the species from the lowest elevation (Brown's Park, UT) to the Flat Top, WY monitoring site at higher elevation.

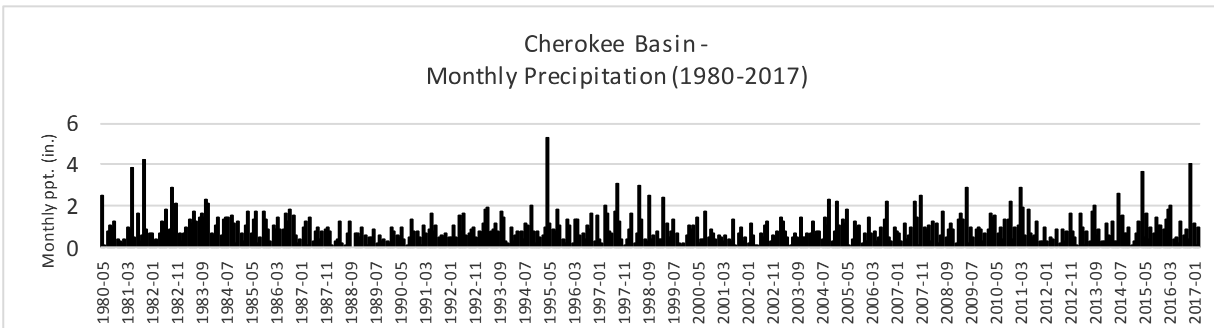
In addition to these annual climate data summaries and trends, monthly patterns have been compiled based on PRISM data (PRISM 2017) for *Penstemon gibbensii* populations that represent the two monitoring studies (Figures 3-4). PRISM data were selected by topographic maps for Cherokee Basin (McPherson Springs) and Flat Top (Flat Top Mountain). The period 1980-2017 was selected. Average annual and monthly precipitation differed by 25% between Cherokee Basin at 0.88 in./mo. and Flat Top Mountain at 1.18 in./mo. Both datasets represented

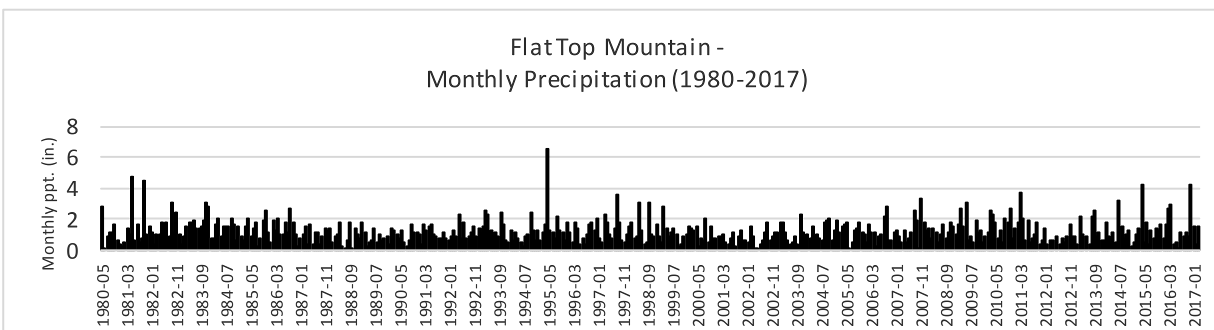
[1] NOAA data from 2004-2006 includes more than one month in which data are missing for most of the month.

Table 3. Climate for three *Penstemon gibbensii* population locations addressed in seed ecology research[2]

Population location	**Elevation (m)**	**Setting**	**Nov-Mar ppt (mean, mm)**	**Nov-Mar temperature (mean, °C)**
Brown's Park, UT	1700	?	59	-1.1
Sand Creek, WY	1900	Toe slope	116	-3.3
Flat Top, WY	2320	Upper slope	189	-2.6

Figures 3-4. Monthly precipitation totals at two *Penstemon gibbensii* populations (from PRISM data)





by Figures 3 and 4 indicate similar high- and low-precipitation events with markedly wet conditions in May of 1995 (the spike in the middle of both graphs) in which over 50% of annual precipitation fell in that single month at each station (over 5- and 6-inches of rainfall). There were also recurring periods of low precipitation months that span consecutive years (2000-2006). All of these precipitation data are strongly influenced by temperature conditions, and both precipitation and temperature can be influenced or masked by the microclimate conditions experienced by *P. gibbensii* as conditioned by aspect, slope, and related water budget.

[2] Note: The Sand Creek, WY population is located close to and at similar elevation as the Cherokee Basin, WY population so climate is similar.

IV. SPECIES INFORMATION

Species information on *Penstemon gibbensii* is treated selectively on the following pages, particularly that which has bearing on monitoring and which is not treated in the prior report (Heidel 2009). New seed ecology information is reviewed and incorporated.

Phenology: The flowering phenology was previously described as typically flowering " from early June to late July, depending on summer moisture conditions" (Fertig and Neighbours 1996), so these are discussed as they have bearing on monitoring. Monitoring is best conducted during flowering to easily categorize plants as reproductive or vegetative. This timing also allows for qualitative description of the level of flowering activity, and an opportunity to characterize grazing or browsing influence on reproduction.

The preceding phenology text warrants editing. The two highest elevation populations have plants that flower the earliest, one of which is monitored (Flat Top). It has been collected in full flower on 11 June (*Dorn 4644*). By contrast, Warren (1992) stated that *Penstemon gibbensii* doesn't start to flower at Cherokee Basin until "late July or early August." Dorn (1989) stated that the lower elevation population seems to flower last (reversing a pattern found among many other species by which lowest elevation populations flower first). 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 explicitly flags site differences as follows: "Flowers from mid June to early August (September), depending on spring and summer moisture conditions and site differences."

Weather conditions can shift the start and end of flowering significantly from year-to-year and the length of the flowering period. The high elevation population at Sheep Mountain had all but finished flowering on 22 June 2012 when visited in a tour by Wyoming Native Plant Society, whereas lower elevation populations do not ordinarily start flowering by this date.

One of the reasons phenology and the timing of monitoring are important is if fecundity data are collected, and for consistent distinction between plant categories. If seedlings are to be distinguished, then the later in summer monitoring is conducted, the more likely they will not be overlooked.

Life history: Flat Top monitoring explicitly addressed the seedling category but found none at the time of establishment (Fertig and Neighbours 1996). The first report on Cherokee Basin results (Warren 1992) substituted the word "seedling" for "small plants" but in more recent years of monitoring, it appeared as though this category also addressed small, established plants in part or exclusively. Warren (1992) showed that this class can account for 21-50% of all plants. Seedling categories are discussed in the Discussion section of this report. It is possible that the first report of true seedlings was at Flat Top in 2008 (Heidel 2009), followed by Flat Top in 2016 and Sand Creek in 2011 (this report).

Mean longevities of the species in general or for any given population are unknown. The monitoring of the Flat Top population was designed to collect life history information that would provide such data, and recommended that it be read in consecutive years, though not pursued to date. It is not possible to determine the age of any given individual plant and mean longevity unless the species monitoring begins at the seedling stage and is pursued for consecutive years. If there are years with high seedling numbers, then it would be appropriate to add small monitoring plots around them.

Germination: Seed collecting was conducted in 2010 at the Flat Top population and the Sand Creek population, and in 2011 at the only Utah population (Tilini 2013, Tilini et al. 2016). Seed ecology research has been conducted in recent years for these three populations that represent contrasts in elevation and climate (Table 3). The species has "predictive dormancy" as broken by specific environmental cues that precede optimal conditions for field establishment (Tilini et al. 2016). The seed germination research was conducted using seeds from two Wyoming populations (Flat Top and Sand Creek) plus the Utah population (Brown's Park) that were incubated at 10 to 20 °C with or without chilling at 2 to 4 °C for 4, 8, 12 or 26 weeks. It was determined that the species doesn't germinate unless subject to at least an 8 week chill treatment (highest at 16 weeks), and that the species at the highest elevation (Flat Top) required the longest chill treatment. Germination levels of post-chilling seeds also increasing with time (0-16 weeks after chilling). This is consistent with patterns detected in other *Penstemon* species for which seedling establishment success is maximized by timing germination to follow shortly after snowmelt (Meyer and Kitchen 1994, Meyer et al. 1995) while avoiding false cues and premature cues until arrival of the warming temperatures of spring.

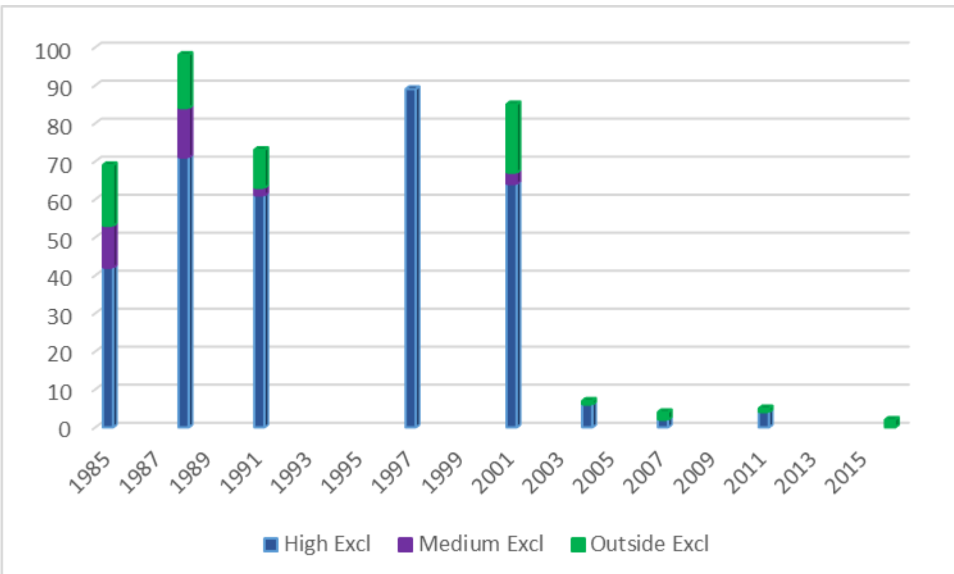
The authors also compared dormancy responses between the three populations of *Penstemon gibbensii* and determined that "the depth of primary dormancy appeared to vary inversely with elevation, which along with winter precipitation served as a proxy for habitat in our study" (Tilini et al. 2016. In other words, the highest elevation population at Flat Top did not require the as long a chill treatment to germinate as the lowest elevation population at Brown's Park.

Finally, the authors compared germination responses of freshly-harvested *Penstemon gibbensii* seeds with those collected two years prior that had been placed in dry storage. They found no significant difference between the two seed lots. The dry storage treatment simulated belowground seed burial and results indicate that the species has the capacity to form a seed bank.

V. MONITORING RESULTS

Monitoring results at Cherokee Basin have shown less difference between management treatments (high exclosure, medium exclosure, outside exclosure) than the dramatic changes for the population overall over time (Figure 5). After 31 years, there is limited difference in trends of plants in management treatment categories (Figure 5).

Figure 5. *Penstemon gibbensii* established plant trends at Cherokee Basin (1985-2016) – showing trends by exclosure category[3]



Monitoring results for established plants at both Cherokee Basin and Flat Top are graphed consistently between monitoring areas for direct comparison, using scatter plots for discontinuous time series data with linear regression lines superimposed for reference. Results show that established plants have declined 81-98% overall between peak numbers in early data and 2016 data (Figures 6 and 7). However, there have been upticks in that both of the monitored populations have had intervals that showed modest increases (Cherokee Basin between 2007 and 2011; and Flat Top between 2008 and 2016). The slope of the linear regression line is steeper at Flat Top than it is for Cherokee Basin, indicating sharper decline, but

[3] High Excl is the 8 ft tall high exclosure. Med Excl is the 3 ft tall medium exclosure. Outside Excl is outside both exclosures. Note: 1997 had the highest tally of plants in the High Exclosure of any monitoring year. Transects were not read that year in the Medium Exclosure or Outside the Exclosure.

which may reflect the paucity of monitoring data at Flat Top. There are time intervals at Cherokee Basin that if taken in isolation, would have steeper trend lines than Flat Top data.

Figure 6. *Penstemon gibbensii* established plant trends at Cherokee Basin (1985-2016)

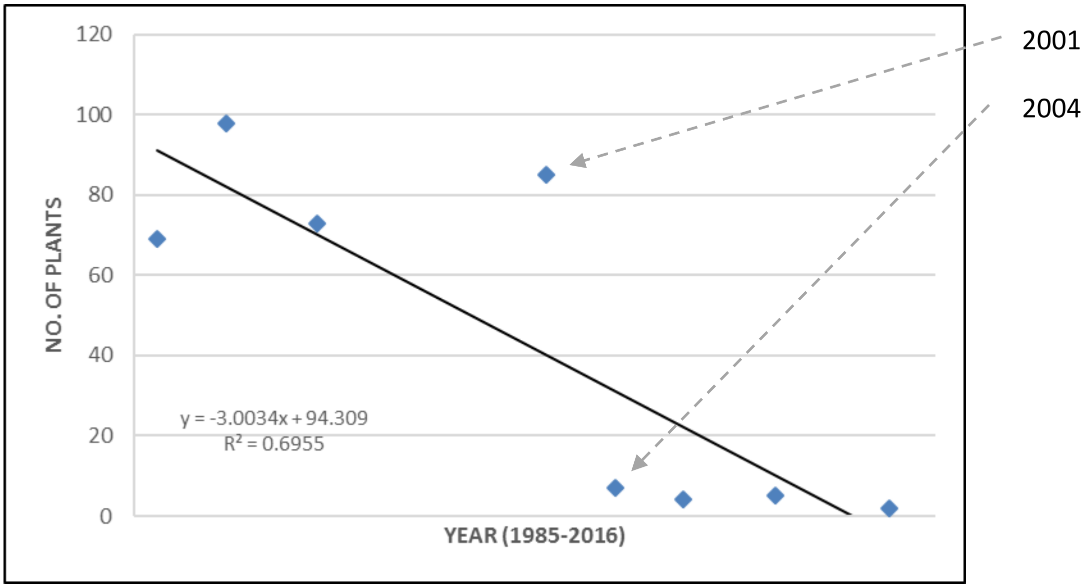
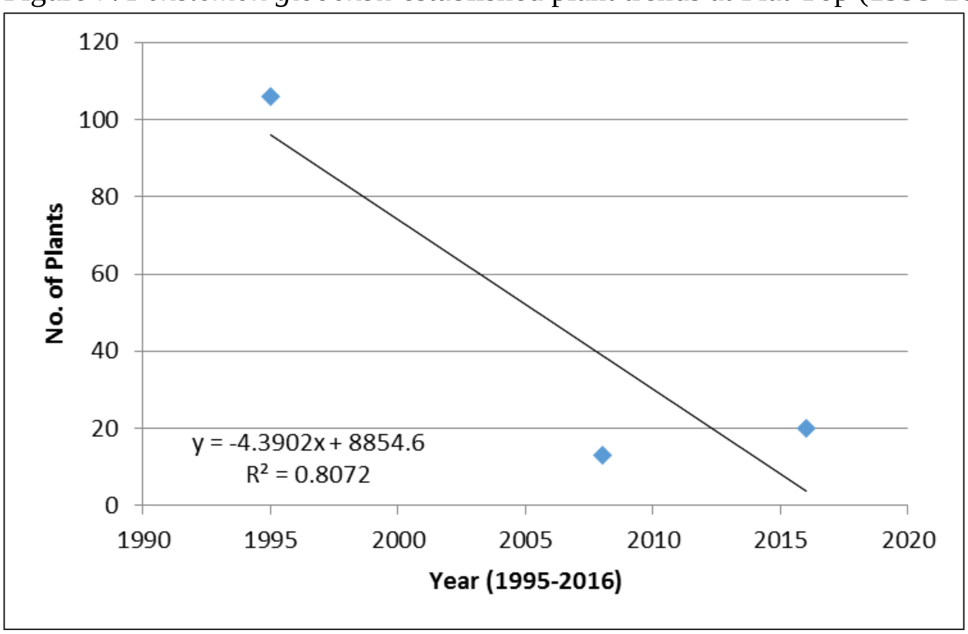


Figure 7. *Penstemon gibbensii* established plant trends at Flat Top (1995-2016)



There is no reason to expect that population changes are linear. The Cherokee Basin data show an abrupt decline in population numbers between 2001 and 2004. There are no Flat Top monitoring data for this interval but the period corresponds with a drought period from which neither populations have rebounded to anything approaching earlier numbers.

The addition of Sand Creek to the monitoring study set will provide a basis for evaluating the trends at Cherokee Basin, whether due to climate differences or setting differences. It may also provide a chance to investigate the seedling stage of life history whereas the only monitoring site with seedling data to date is at Flat Top that had zero seedlings in 1995, three in 2008, and ten in 2016.

Trends in established plants have been converted to density values to indicate the original density at the start of monitoring and as replicated in 2016 (Table 4), for direct comparison. It would seem to indicate that Cherokee Basin had far lower plant density when it was first established as compared to Sand Creek and Flat Top populations. This may be at least in part an artifact of plot design in which the Cherokee Basin sampling area includes more unoccupied habitat than the other monitoring sites, and the Flat Top monitoring area is over a magnitude smaller (see Table 2).

Table 4. Summary of *Penstemon gibbensii* plant densities at monitoring sites (all transects)

	Density of established plants at start of monitoring (plants/m²)	**Density of established plants in 2016 monitoring (plants/m²)**
Cherokee Basin	0.3	0.009[4]
Flat Top	7.7	1.5
Sand Creek	1.5	(not read in 2016)

VI. DISCUSSION

Decline of *Penstemon gibbensii* is documented at both Cherokee Basin and Flat Top. The linear regression trend lines superimposed on scatterplot data from Cherokee Basin and Flat Top (Figures 6 and 7) are a reference for indicating the degree of decline and for making preliminary comparisons between the two monitoring datasets rather than a refined statistical analysis. It is hypothesized that trends are not linear but that there was a break in trends associated with a period of drought that occurred at both locations, and that the outstanding question is whether or not the two populations can rebound.

The steepness of the Flat Top decline is an artifact of the data coverage, with only one monitoring data point prior to drought. The 2016 numbers at Flat Top show moderate density and slight rebound (Table 4), and the presence of increased seedling numbers that same year also bodes well.

The absolute density of *P. gibbensii* at Cherokee Basin vs. Flat Top, like the steepness of the linear regression line, may be a little misleading if Cherokee Basin monitoring design included

[4] In 2017, there were 0 plants found within monitoring transects at Cherokee Basin.

much more unoccupied habitat than Flat Top, There was over 16X greater sample area at the former than the latter so density results reflect sampling design superimposed on habitat suitability.

Importance of seedling data

During the course of Sand Creek monitoring in 2011, halfway through the first transect, true seedlings were noted that were shorter than 2 cm and with cotyledons attached. Unfortunately, we didn't create a new category for true seedlings but added them to the tally of plants already placed in the category for small, young plants. There were less than 10% of the ~200 plants tallied in this category that were true seedlings. The Flat Top study never recorded any seedlings in the 1995 establishment year and apparently the "immature plant" category used at Cherokee Basin corresponded to a size class that may or may not relate to age, perhaps analogous to single-stemmed vegetative plants at Flat Top. A few true seedlings showed up at Flat Top in 2008. A photo of what appear as true seedlings (cover, Figure 8) shows about seven *Penstemon gibbensii* seedlings in the center, and a couple more in the upper lefthand corner as seen at Sand Creek. This represents a much higher density than observed for established plants, or observed for seedlings in the East Sand Creek transect or in Flat Top transects. It may indicate that *P. gibbensii* seeds are sometimes cached by small mammals. The prospect of including seedlings in monitoring would provide a measure of exact age determination with the conversion of census monitoring to demographic monitoring.

Figure 8. Putative true seedlings of *Penstemon gibbensii*, at Sand Creek (2011). Note: the ~ten seedlings present in this photo approach or exceed that in the entire sampling area of Flat Top transects in 2016.[5]

[5] These seedlings were located outside of the Sand Creek transects (but immediately west of Transect 2) in 2011. By contrast, the few seedlings located inside the belt transects were isolated and not in groups such as this.

Recruitment may be affected by substrate conditions. Populations on steeply-sloped habitat may be doubly-challenged by low percolation of moisture and by the fact that those slopes with no gravel or skeletal material on the soil surface are prone to erosion that can also wash out seeds and seedlings from suitable habitat. It appears that Cherokee Basin may be far more vulnerable to erosion as exacerbated by drought than the other five population settings in Wyoming. During 2011 monitoring, signs of sheet erosion on steep occupied slopes was noted, transitioning to more rill erosion on lower slopes. No seedlings were found at Cherokee Basin during 2011 monitoring, unlike Sand Creek monitoring (Figure 11).

Flat Top transects have high plant density compared to Cherokee Basin or Sand Creek transects. It is hypothesized that the extensive Flat Top Mountain site cap rock and concentration of coarse gravel immediately below offer a high concentration of "safe sites" for seedlings with microhabitat conducive to both germination and establishment, and less prone to erosion.

Monitoring results indicate that recruitment may be a limiting life history stage in recent years, whether from low levels of germination, establishment, or both. Conditions with extended below-normal precipitation have been hypothesized to account for below-normal seedling numbers, as noted in 1995 on the heels of summer drought conditions (Fertig and Neighbours 1996). Another explanation is reflected in statements by Dorn (1989) who noted that the species appears to have limited reproductive success in most years because of dry conditions. The question of whether it consistently produces seeds and consistently germinates them are both relevant. The former is tempered by the apparent capacity of the species to form a seed bank to take advantage of the suitable conditions when they arrive.

<u>Importance of climate</u>

Climate data indicate that the dry summer of 1995 was preceded by heavy rains of May 2015 that may have eroded out seeds and seedlings at Flat Top. In May of 1995, over half of normal annual precipitation fell in that one month. The erosion factor might be evaluated better in the future if monitoring years were linked to high precipitation events within the late-summer monitoring window to compare trends between Sand Creek with its gentle terrain and those at the other two populations. The relative significance of erosion and summer precipitation might be better compared and evaluated if there were annual monitoring cycles, and if individual plants were tracked. In any case, we missed a chance to document true seedling numbers in 2011 and to follow them in 2012.

Climate data also show a prolonged drought from about 2001-2007. If drought were combined with sporadic storm cells, then it is possible that *Penstemon gibbensii* seeds could be eroded out of the most unstable settings such as Cherokee Basin.

Unaddressed factors – Pollination

The presence of numerous fully-formed fruit were noted in 2010 when collecting seed at Flat Top and Sand Creek, indication that pollination occurred. By contrast, Cherokee Basin had only one (of 11) established plants in flower noted in 2017 when searching for seedlings, and the one flowering plant may have had only one mature capsule (the others being aborted or immature). In future monitoring, the presence or tally of mature, immature and aborted fruit on each plant might specifically be addressed to gauge if pollinators are limiting. The presence of alternate nectar sources flowering at the same time as *Penstemon gibbensii* might also be inventoried in future monitoring. Depending on results, pollination biology research may be warranted.

Possible intervention at Cherokee Basin

Based on the 2017 walk-through count of 11 established plants, it appears that there are at best only 15-20 plants estimated in the entire Cherokee Basin population. No plants were found in the five transects though two of those counted were nearby, and the Cherokee Basin population is at risk of extirpation. The significance of potential extirpation at the type locality (one of nine populations, worldwide) warrants discussion. The occupied habitat is very unstable so any action needs to be taken with care. If germination is a rare or episodic event, and *Penstemon gibbensii* is a short-lived perennial, then extirpation is a near-certainty at Cherokee Basin.

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. However, they were collected in Colorado, at some distance and contrasting environment from Cherokee Basin so there is no seed source available for the population. The nearest known population of similar climate if not environment is at Sand Creek.

The feasibility of propagating a limited number of established plants from the nearest known population (e.g., 50-100 of 1rst- or 2nd-yr plants) and transplanting them during a moist time in spring or early summer into the relatively stable/ least unstable of microhabitats (i.e., directly above or amid perennials that stabilize the locale, such as *Achnatherum hymenoides* and *Eriogonum brevicaule*) could serve as a stopgap measure and trial intervention that circumvents the recruitment bottleneck in life history. Annual checks of their success for the following three years would provide basis for evaluating the effectiveness of this treatment.

Transplant trials for *P. gibbensii* at Cherokee Basin might be addressed if there were a transplant policy or at least a robust articulation of rationale in place, the nearest appropriate seed source were used (Sand Creek), and it were done on a trial basis with followup monitoring to document outcome. Transplant trials might be pursued during or else delayed until after a 3-year period of annual monitoring at Sand Creek, if demographic data would help set the bar for transplant trials, also allowing time to work through preparations.

<u>Monitoring recommendations</u>

Replication of periodic Cherokee Basin and Flat Top monitoring is recommended by 2019 with special attention to the true seedling category. Annual monitoring at Sand Creek is identified as appropriate to collect demographic data as context for the rest of species' monitoring, e.g., 2017-2019. It might be pursued before considering any transplant practice, or concurrent with it. If plants can live for over a decade, then we have a less dire viability scenario. The Sand Creek population is better suited to demographic monitoring because:

1. The Sand Creek population setting is much less erodible compared to the other two sites an least likely of the three to be affected by monitoring activity,
2. The Sand Creek population setting would be informative because it has much the same climate as the Cherokee Basin one, and provides a basis to address climate-related trends independent of erodibility, and
3. The Sand Creek population had a flush of seedlings in 2011 indicating this life history stage might be found in suitable numbers, at least in some years, raising the possibility of getting robust demographic data over time.

Any accompanying methods for documenting erosion may also be appropriate and warrant further consideration. Spatial patterns were evaluated in comparing 1995 with 2008 Flat Top data, by plotting the trends for each separate plot along the three transects over time (Appendix H in Heidel 2009). It indicated that almost all 2008 and 2016 plants were in the upper ends of transects, even more skewed than in the original 1995 monitoring. It is hypothesized that the extensive Flat Top Mountain site cap rock and concentration of coarse gravel if not gentler shoulder slope immediately below may help retain subsurface moisture and curtail erosion at the upper end of transects compared to the erodible lower ends. This spatial information provides context for trend results and supports the hypothesis that the seedbank can be eroded out of steep-slope settings. While there is not a simple metric to gauge erosion, the slope and cohesion of the soil surface are indicators. Vegetation data-gathering was added to the Flat Top monitoring in 2016 compatible with the other two sites as indication of trends in vegetation cover. Any visible signs of erosion are noteworthy.

This report provides a framework for data-collecting consistency, distinguishing established plants from seedlings, and the possibility of distinguishing flowering plants from vegetative plants. The number of stems per flowering plant is another possible elaboration. In any case, more frequent monitoring as proposed for Sand Creek provides opportunity to evaluate phenomenological patterns and context for past patterns in the interest of conserving the species.

VII. LITERATURE CITED

Colorado Natural Heritage Program. 2017. Comment on updates to 2008 *Penstemon gibbensii* element occurrence data, exported and conveyed by J. Handwerk, with comments in May 2017.

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.

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.

Heidel, B. 2009. Survey and monitoring of *Penstemon gibbensii* (Gibbens' beardtongue) in south-central Wyoming. Unpublished report prepared for the Bureau of Land Management Rawlins Field Office by the Wyoming Natural Diversity Database, Laramie, WY.

Lesica, P. 1987. A technique for monitoring nonrhizomatous, perennial plant species in permanent belt transects. Nat. Ar. J. 7(2):65-68.

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

PRISM Climate Group. 2017. Oregon State University, http://prism.oregonstate.edu, created 4 Feb 2004.

Tilini, K.L. 2013. The seed ecology of rare and Endangered Gibbens’ beardtongue (*Penstemon gibbensii*) and blowout penstemon (*Penstemon haydenii*). M.Sc. Thesis. Department of plant and Wildlife Sciences, Brigham Young University, Provo, UT.

Tilini, K.L., S.E. Meyer and P.S. Allen. 2016. Breaking primary seed dormancy in Gibbens’ beardtongue (*Penstemon gibbensii*) and blowout penstemon (*Penstemon haydenii*). Native Plants 17(3):256-265.

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 .

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