Extensive Monitoring of *Penstemon haydenii* (Blowout penstemon) – 2016 Interim Report

Carbon County, Wyoming

Prepared for
Bureau of Land Management –Rawlins Field Office and State Office

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ABSTRACT

This interim report represents the second year of extensive *Penstemon haydenii* (blowout penstemon) monitoring in Wyoming, intended to run a minimum of three consecutive years. The objective is to document population numbers and trends for the species in all of the blowouts on public land that have ever had high numbers (i.e., census records of more than 300 established plants). There has been one previous round of extensive monitoring (2004-2006) as basis for comparison. There has been scaled-back monitoring in most of the intervening years so that at the end of the current phase, we will have both a short-term and a long-term data set. The 2016 monitoring results reinforce 2015 results:

1) The *P. haydenii* numbers were low at most dunes relative to 2004-2006 numbers.
2) Most dunes with seedlings in 2015 also produced new seedlings in 2016, and survival of the 2015 seedlings was mixed.

In addition, the completion of private lands survey took place in 2016, as conducted for U.S. Fish and Wildlife Service, filling geographic gaps in the distribution picture, providing comparisons with 2016 public land monitoring results, and providing basis for summary statistics that compare public and private land data for the first time.

ACKNOWLEDGEMENTS

The 2016 monitoring was co-conducted by Frank Blomquist (Bureau of Land Management; BLM - Rawlins Field Office) with the Jessie Horn and Nick Armand (BLM), and BLM intern Gayle Tyree. An expanded monitoring team carried out work at Bradley Peak including BLM botanist Emma Freeland, WYNDD botanist/biologist Joy Handley and Kaylan Hubbard, and U.S. Fish and Wildlife Service biologists Brooke Stansberry, Julie Reeves, Doug Keinath, Lynn Gemlo and Nathan Darnell. The support and coordination with BLM is acknowledged with gratitude, including that of Tanya Skurski, Chris Keefe and Frank Blomquist. This project was funded as a challenge cost-share project of the BLM and the Wyoming Natural Diversity Database, under Agreement No. L12AC20036, Supplement 4.

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Cover photo: *Penstemon haydenii* (Blowout penstemon) at Bear Mountain East, 22 June 2015

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INTRODUCTION

Penstemon haydenii Wats. (Blowout penstemon) was listed as an Endangered species in 1987 under the Endangered Species Act (ESA; USDI Fish and Wildlife Service 1987; FWS) when it was regarded as endemic to the Nebraska Sandhills. A recovery plan was prepared for *P. haydenii* (Fritz et al. 1992) that set recovery objectives based on a minimum population numbers (300 plants) at a minimum number of populations where it is naturally reproducing and self-sustaining over time. Long-term monitoring has been conducted in Nebraska to gauge progress in meeting recovery goals (e.g., Stubbendieck and Kottas 2004).

In 1996, *P. haydenii* was discovered at Bradley Peak in Carbon County of south-central Wyoming by Frank Blomquist (Bureau of Land Management; BLM) who photographed the species. Vouchers were collected in 1999 (Roderick et al. 1999, Taylor 2000, Fertig 2000, 2001). Information on *P. haydenii* distribution and trend information was scant in Wyoming for understanding status and addressing species' recovery. This prompted surveys in Wyoming dune fields (Fertig 2001, Heidel 2005, Heidel 2012) and extensive monitoring from 2004-2006 (Heidel 2007) following the same monitoring conventions used in Nebraska. After the 3-year monitoring project, scaled back monitoring ensued (2007, 2009-2013) to census at least one dune per year as a check on the populations.

Recently, *P. haydenii* was addressed in a 5-year review (USDI Fish & Wildlife Service 2012). The review called for a recovery plan update incorporating the most current status information and refining recovery criteria. It also identified research needs:

> "The revised recovery plan should include objective, measurable criteria which address all listing factors and which, when met, will result in a determination that the species be downlisted and eventually removed from the Federal List of Endangered and Threatened Plants. Recovery criteria should include population growth rates over time and documentation of populations dispersing to unoccupied habitat" (USDI Fish & Wildlife Service 2012).

Thus, the central purpose of this project was to replicate extensive monitoring of *P. haydenii* plants (2015 through at least 2017) at all of the dunes on public lands that have ever had 300 plants. This includes all of the five dunes that were monitored earlier (2004-2006) with addition of one more dune that was first found in 2011. Monitoring data based on current census figures are needed to determine population growth rate and set recovery objectives. This monitoring work represents baseline monitoring as needed to understand population trends and set meaningful recovery objectives in the sense of Elzinga et al. (1998). This interim report is a prototype for a final report at the end of the current phase, and a springboard for discussion during the interim.

STUDY AREA

Penstemon haydenii is present in parts of the Ferris Dunes of northwestern Carbon County, Wyoming. Table 1 represents an overview of all 22 occupied dunes, highlighting those

six dunes addressed in 2015-2016 monitoring. The six dunes represent all dunes on public lands public lands that have or once had over 300 plants, as mapped in Appendix A.

The dune areas are named in this report by local land features. In areas of high concentration, they are numbered in the order in which they were discovered. The Bradley Peak population where *P. haydenii* was first discovered is a monitored dune area. The Pathfinder population has only one of three widely-separated dunes with high enough numbers of plants to warrant monitoring. The third population, the Bear Mountain – Junk Hill – Ferris population stretches for almost nine miles, made up of scattered active dune areas that are all on the same wind currents and close to one another for pollinator and seed dispersal connectivity. Two of the dune areas in it were among the three originally monitored dune areas (2004-2006), in addition to that of the Bradley Peak population. Two additional dune areas with high numbers of plants were discovered and added in 2005 (monitored in 2005-2006). Finally, in 2015-2016, one more dune area with high numbers of plants was discovered on private land, but it is excluded from consideration because of private ownership. In total, six discrete dune areas on public land have, or once had, over 300 *P. haydenii* plants.

Climate data provide valuable context for the recent survey work, and has not previously been reported with monitoring results. Peak precipitation is early in the growing season, with the highest values averaging 5 cm in May, closely followed by April and June (Figure 1, 1980-2010; PRISM). Mean annual precipitation in the Ferris Dunes is 28.8 cm (1946-2015; PRISM). In an expanded evaluation of PRISM data for the same locale (1947-2015), only three months in the past 49 years had monthly precipitation less than 0.1 cm and two of those three were shortly before the study period (June 2013 – 0.069 cm; June 2012 – 0.088 cm). At the other end of the spectrum, only four months in the past 49 years have had monthly precipitation over 10.0 cm, and the highest one was at the start of the current monitoring phase (May 2015 – 12.58 cm).

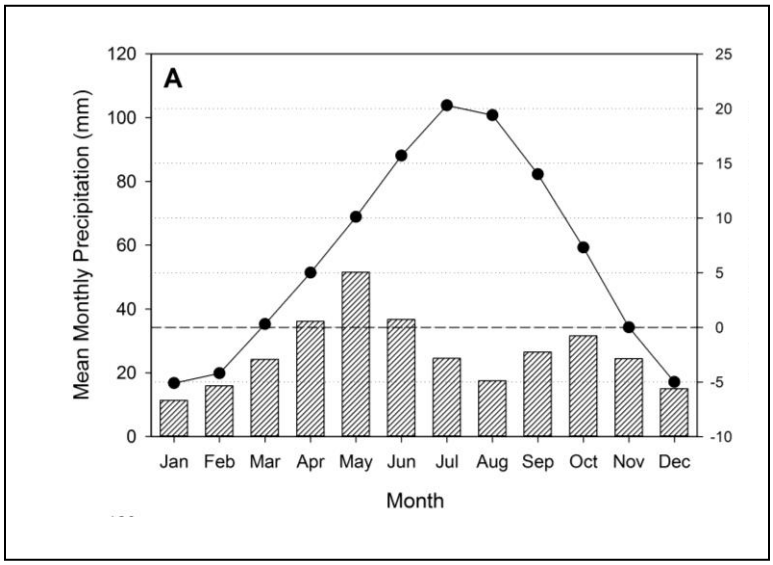

Figure 1. Climogram showing monthly mean precipitation and mean temperature averages for the period 1980-2010 in the Ferris Dunes (Bear Mountain; data from http://www.prism.oregonstate.edu/explorer/). (From Tilini et al. In Press).

In other words, meteorological conditions have been highly dynamic, as has dune movement (Heidel et al. In progress), even though the management framework has remained the same over the course of monitoring.

The six dunes addressed in this monitoring study are represented in Table 1 among the complete list of occupied dunes. Their locations are detailed in *Penstemon haydenii* distribution maps (Appendix A). Four of the six are on BLM lands and the other two are on state and Bureau of Reclamation (BOR) land.

Table 1. Monitoring priorities among dunes occupied by *Penstemon haydenii* in Wyoming[1]

Dune Name	Population No.	Population Name	Priority? (>300 plants, past or present)	First Discovery	Agency/ Ownership[2]
Bradley Peak	001	Bradley Peak	Y	1996	BLM
Junk Hill Main	002	Bear Mtn-Junk Hill-Ferris	Y	2000	BLM / R2
Junk Hill West 1	002	Bear Mtn-Junk Hill-Ferris		2004	BLM / R1
Junk Hill West 2	002	Bear Mtn-Junk Hill-Ferris	Y	2004	BLM / R1
Junk Hill West 3	002	Bear Mtn-Junk Hill-Ferris	Y	2004	BLM / R1
Junk Hill West 4	002	Bear Mtn-Junk Hill-Ferris		2004	BLM
Junk Hill West 5	002	Bear Mtn-Junk Hill-Ferris	No – mostly on pvt	2011	BLM / R1
Bear Mt Valley	002	Bear Mtn-Junk Hill-Ferris		2000	State
Junk Hill Upper Outlier	002	Bear Mtn-Junk Hill-Ferris		2000	BLM
Bear Mt [East+West][3]	002	Bear Mtn-Junk Hill-Ferris	Y	2000	State/R2
Bear Mt Outlier	002	Bear Mtn-Junk Hill-Ferris		2002	BLM
Ferris 1	002	Bear Mtn-Junk Hill-Ferris		2005	BLM/R2
Ferris 2	002	Bear Mtn-Junk Hill-Ferris		2005	BLM
Ferris 3	002	Bear Mtn-Junk Hill-Ferris		2005	BLM
Ferris 4	002	Bear Mtn-Junk Hill-Ferris		2011	BLM
Ferris 5	002	Bear Mtn-Junk Hill-Ferris		2016	R2
Ferris 6	002	Bear Mtn-Junk Hill-Ferris		2016	R2
Ferris 7	002	Bear Mtn-Junk Hill-Ferris		2016	R2
Ferris 8	002	Bear Mtn-Junk Hill-Ferris		2016	R2
Pathfinder Reservoir	003	Pathfinder	Y	2011	BOR
Pathfinder South	003	Pathfinder		2004	BOR
Pathfinder North	003	Pathfinder		2004	State

BACKGROUND INFORMATION

Information updates on the biology and ecology of *Penstemon haydenii* were presented in the last year's monitoring report (Heidel 2016) regarding seedbank formation, seasonal

[1] In last year's report, the Bear Mountain – Junk Hill – Ferris population complex was described as having 15 dune areas but since that time we merged two of them based on the fact that they had been just one continuous dune area in 1946 imagery. Then, in 2016, four new occupied dune areas were discovered in private land surveys. This brings the total to 22 occupied dune areas.

[2] R1 refers to private property of Ranch 1, surveyed in 2015. R2 refers to private property of Ranch 2, surveyed in 2016. The cases in which the dune is split between private and public land cover the spectrum, and some dunes have over 90% of *P. haydenii* plants on public land, and others have over 90% on private land.

[3] Bear Mountain East and West are treated together based on their continuity in 1946 aerial imagery.

dormancy and germination phenomena. They signify updates to the most recent status report (Heidel 2012), and shed light on the life history of *P. haydenii* and our ability to census it.

Since last year, two seed ecology papers were published or submitted (Tilini et al. 2016, In progress). Dune migration data analyzed in 2013-14 (Heidel et al. 2014) has been re-analyzed (Heidel et al. In progress). Finally, a separate report has been submitted to FWS with the compiled positive and negative results of 2015-2016 surveys on private land (Heidel 2017). Completion of private lands survey fills the gaps in distribution across the landscape and enables compilation of information of total occupied dunes, total numbers, and relative contributions of public and private lands.

A highlight of *P. haydenii* monitoring is presented here, treating just the dunes with high numbers, not including any with low numbers that were also censused. This monitoring history is intermixed with survey history because survey work fed into monitoring work. Monitoring work has also been a venue for fostering related research and interaction with other experts. The extensive monitoring projects (i.e., the funded ones) were in 2004-2006 (Heidel 2007) and in 2015-2017.

- June 1999 – *P. haydenii* plant numbers were estimated at Bradley Peak and a voucher collected for the first time. A later visit was made in the company of Dr. James Stubbendieck, Nebraska researcher.
- June 2000 – *P. haydenii* plant numbers were estimated at Bradley Peak and at two new dunes as part of surveys (Bear Mountain, Junk Hill Main)(This resulted in the first status report - Fertig 2001)
- June 2002 - *P. haydenii* plants were censused in a pilot approach (Bear Mountain – just East, Junk Hill Main) and Geographic Positioning System (GPS) coordinates were collected at population boundaries for the first time
- July 2003 – Two *P. haydenii* demographic belt transects were established in advance of monitoring (Junk Hill Main) and *P. haydenii* plants were censused in a pilot approach (Bear Mountain, Junk Hill Main)
- June 2004 – *P. haydenii* census was standardized compared to previous pilot years, using population maps printed onto aerial photos and systematic traverses for extensive monitoring (Bradley Peak, Bear Mountain, Junk Hill Main). Nine new subpopulations were documented and their plant numbers censused in surveys (two of them supported high numbers and were just estimated in 2004 but added the next year to extensive monitoring: Junk Hill West 2 and 3). (The surveys resulted in the second status report - Heidel 2005)
- June 2005 – Replication of census and demographic monitoring (five dunes). Separate trips made in the company of Dr. Vince Tepedino, pollination biology researcher, and later pollination research was conducted by Tepedino et al. (2006) including Hawk and Tepedino (1997).
- June 2006 – Replication of census and demographic monitoring (five dunes).
  (Heidel 2007 represents final monitoring report, updating and replacing prior annual monitoring reports)
  June 2007 – Scaled-back census (Junk Hill Main)
- June 2008 – No monitoring. Specimens were collected for genetics research - Buerkle lab and the visit was made in the company of Dr. Kay Kottas, Nebraska researcher

- June 2009 – Scaled-back census (Junk Hill Main) and the visit was made in the company of Dr. Ron Weedon, Nebraska researcher (A separate trip to collect seeds at the start of seed ecology research was made in August in the company of Dr. Susan Meyer, seed biology researcher). (A Masters thesis was later completed under Meyer: Tilini 2013, followed by two publications Tilini et al. 2016, In Progress).
- June 2010 – Scaled-back census (Bear Mountain East)
- June 2011 – Three new subpopulations were documented (one of them supported high numbers and was added to extensive monitoring) and the rest of surveys were negative. Scaled-back census (Bradley Peak, Junk Hill Main). (Surveys and other data resulted in the third and most recent status report - Heidel 2012).
- June 2012 – Scaled-back census (Junk Hill Main)
- June 2013 – Scaled-back census (Bradley Peak, Junk Hill) and excavation trials. The visit was made in the company of Dr. Craig Freeman, taxonomic researcher. (Taxonomic reports were later completed – Freeman 2016).
- June 2014 – No monitoring. Seedlings were sought at select places (Bear Mountain, Junk Hill Main) but not found. Dune migration study completed (Heidel et al. 2014)
- June – July 2015 – Replication of extensive census (six dunes). Two transects established for seedlings (Junk Hill West 2 and 3). Concurrent surveys on private lands of Ranch 1 were conducted for U.S. Fish and Wildlife Service (FWS).
- June – July 2016 - Replication of extensive census (six dunes). Two transects established for seedlings were re-read (Junk Hill West 2 and 3). Concurrent surveys on private lands of Ranch 2 were conducted for FWS (Heidel 2017).

METHODS

Census

The 2016 *Penstemon haydenii* monitoring work was conducted at six dunes by teams of one to ten people, between 21 June – 8 July. Monitoring took place at all six dunes on public lands in Wyoming that have had more than 300 plants (excluding one such dune on private land), the second year in what is to be a minimum of three consecutive years. In order to provide location documentation to go with the monitoring results, enlarged annotated maps superimposed on aerial photos are presented in Appendix A for each of the six dunes.

The census methods follow 2004-2006 practices, consistent with Nebraska conventions. Monitoring was conducted with use of annotated aerial photos for orientation. It involved pacing the habitat in series of traverses across discrete segments of the dune. Census requires consistency in distinguishing individuals. In census of *P. haydenii*, any stems (ramets) that are within about 15 cm apart were inferred to be part of the same individual (genet). This threshold was adjusted slightly if they were further apart but buried and converging (Heidel 2007).

Work was generally conducted during flowering for ease of locating plants and distinguishing them from nonflowering plants. Separate tallies were kept for flowering (reproductive) vs. nonflowering (vegetative) plants. A single plant may produce 1-many stems that are all flowering, all nonflowering, or mixed states. Usually most plants in flower also have nonflowering stalks (see cover photo). For purposes of this census, plants with any flowering stalks were recorded as flowering plants. A third tally was kept of browsed plants (except for

2004 tallies). This was originally intended to evaluate the effects of herbivory on flower production, but in many cases, it was not possible to differentiate browse on a flowering stem from browse on a nonflowering stem if little remained of the stem. For purposes of this census, plants with any stalks browsed were recorded as browsed plants. In general, the herbivory that was documented represents the influence of antelope and elk before livestock are brought into the pastures, as observed from tracks and wildlife behavior.

Seedling and First-year Plant Sampling

Seedling sampling was added to monitoring study design in 2015 because we were not able to census seedlings as we did established plants. They can be in high densities of 216 seedlings per m^2, and are easily trampled or their substrate destabilized. They can be over a magnitude smaller than established plants, so they are not as readily spotted. On Bear Mountain, they overlap with established plants, but everywhere else they are isolated from established plants and restricted to blowout bowls.

The concept of what constituted a seedling has evolved during monitoring. True seedlings have cotyledons and are generally about 2 cm tall. In 2004 I saw what I thought were seedlings having very slender stems and a few pairs of leaves but generally ~10 cm tall. They were seen again by Blomquist in the same area in 2005. Then in 2015 we saw true seedlings, growing side-by-side with the larger plants, now interpreted to represent first-year plants. They appear to still be in the process of becoming established. Reference sets of seedling and first-year plant photos are presented in last year's monitoring report (Heidel 2016).

To address seedlings and first-year plants, two permanent belt transects within high density areas of seedlings totaling 17.5 m^2 were established in 2015 and reread in 2016. They tended to be in a narrow band so the belt was only 0.5 m wide. They tended to be in a straight band so the belts were set within continuous occupied habitat of 25 m and 10 m. The coordinates for each seedling or first-year plant were recorded so to allow for determination of survival. Outside of the belt transects, we did not try to get seedling counts on unstable slope settings but did try to get estimates in blowout bowl settings. The two transects have different placement within two different blowout bowls.

RESULTS

Census

A decadenal comparison of 2005-2006 mean *Penstemon haydenii* plant numbers with 2015-2016 mean plant numbers shows decline in each of the five dunes that have data for the period (Figures 2-3). The original mean sum of 15,846 plants (mean value from 2005-2006 data at five dunes) is almost 5X greater than the recent-period mean sum of 3,855 plants (mean value from 2015-2016 at the same five dunes).

An annual comparison between 2015 and 2016 census results show trends that are mixed with overall net decline between consecutive years. The 2015 tally of *P. haydenii* plants counted in the six monitored dunes was 5,009 (Heidel 2015). In 2016, the total number of *P. haydenii* plants counted in the same six dunes was 4,819.

Data collected from the Pathfinder Reservoir dune are inconsistent from the rest, in that tallies of established plants and first-year plants were combined. The first-year plants at this dune are taller and more robust than those observed elsewhere. It is expected that tallies they can be reconciled in 2017 monitoring because the first-year plants were located in separate portions of dune habitat. So we still expect to document the absolute levels of recruitment and mortality, at least between the start and end of monitoring from 2011 to 2017.

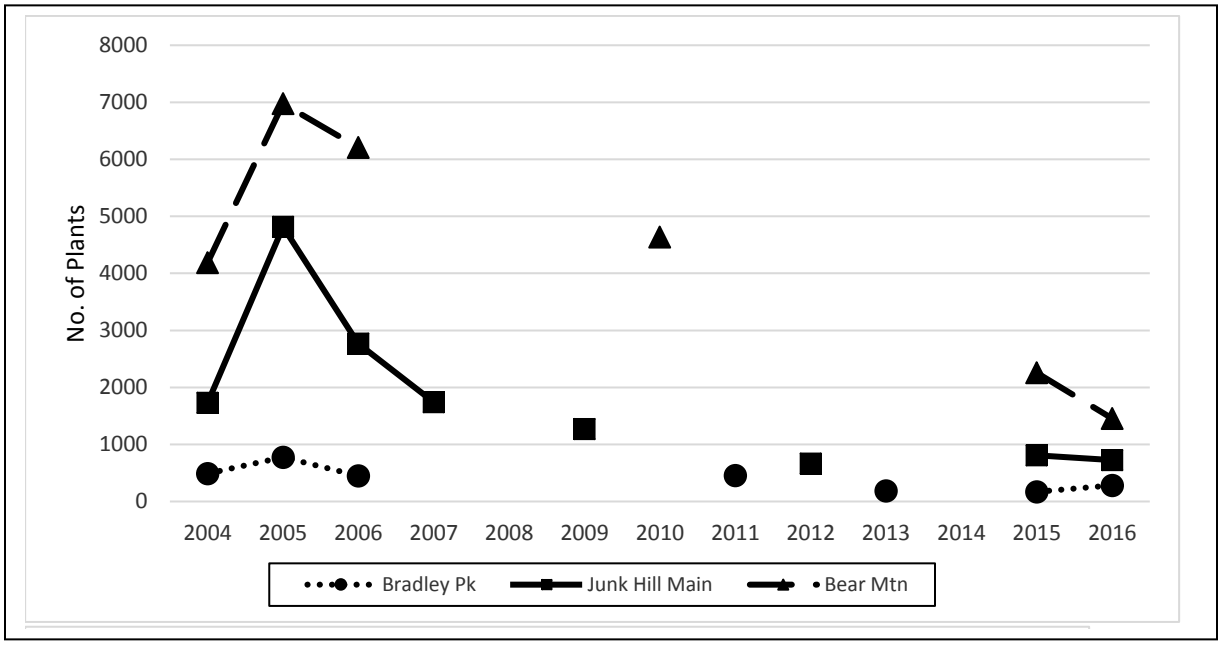

Figure 2. (above) *Penstemon haydenii* numbers at the three dunes monitored from 2004-2016

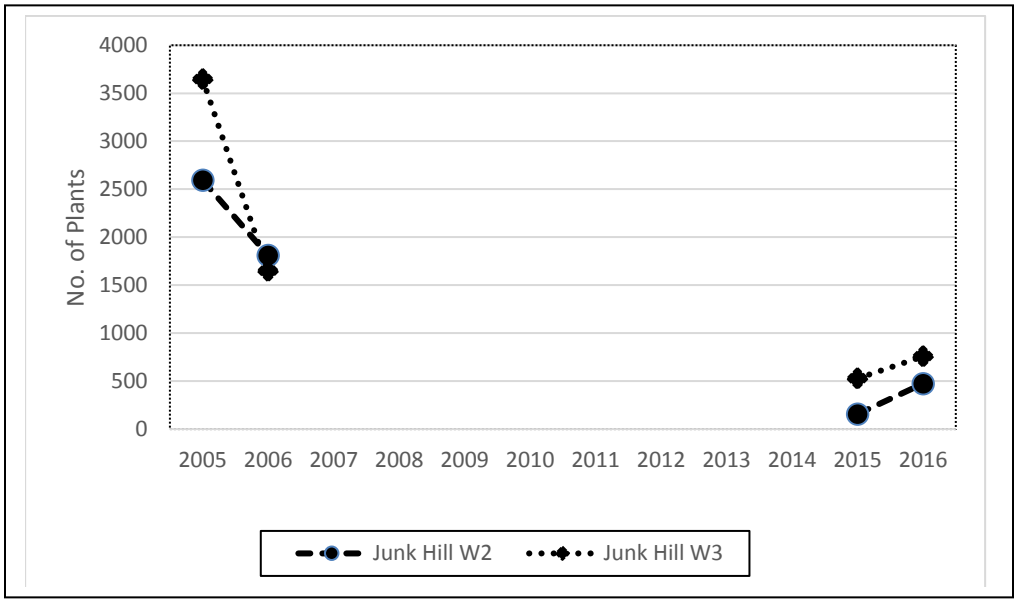

Figure 3. (left) *Penstemon haydenii* numbers at two dunes monitored from 2005-2016

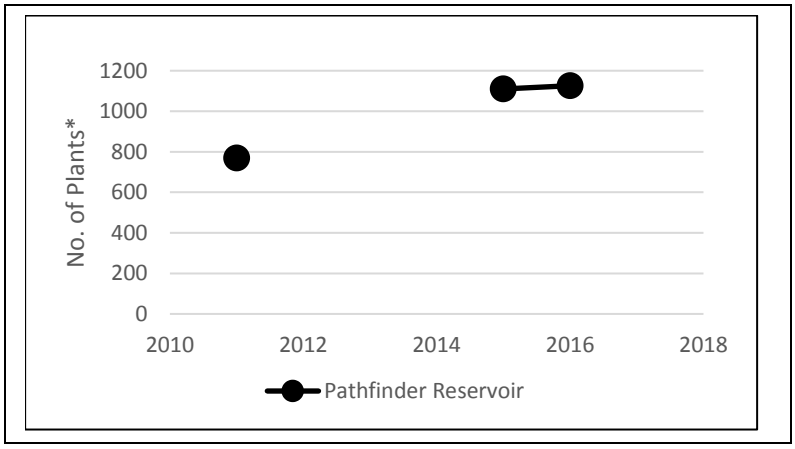

Figure 4. *Penstemon haydenii* numbers at a dune monitored from 2011-2016

Seedling and First-year Plant Sampling

There are a couple important results coming out of the sampling set up around seedlings and first-year plants (Tables 2 and 3). A tally of 1026 seedlings in Transect 1 for 2015 surpassed by magnitudes all reports of seedlings observed in prior years. Those prior reports from 2004-2005 were from the same two blowouts where seedlings were sampled in 2015-2016. They represent high densities, with a peak tally of 54 seedlings in a single 0.25 m² area as the highest recorded seedling density (216 seedlings per m² within Transect 1) and more seedlings in the 12.5 m² belt transect area than are found for established plants across many hectares of occupied habitat.

The second important results coming out of the sampling set up around seedlings is that survival rates are very low, from what we can tell by looking aboveground the next year. The seedlings of Transect 2, though present in low density compared with Transect 1, appeared to have had high survival rates. The 72 first-year plants of 2016 are interpreted to represent survival among the 83 seedlings of 2015. Further comparison between years is warranted to determine survival rates for 2015 individuals counted as seedlings or first-year plants in 2016.

Table 2. *Penstemon haydenii* sample results in Transect 1 (25 m x 0.5 m)

Year	Seedling tally	Seedling density (per m²)	1rst -yr plant tally	1rst-yr plant density (per m²)
2015	1026	82.1	8	0.64
2016	689	55.1	3	0.24

Table 3. *Penstemon haydenii* sample results in Transect 2 (10 m x 0.5 m)

Year	Seedling tally	Seedling density (per m²)	1rst-yr plant tally	1rst-yr plant density (per m²)
2015	83	16.6	38	7.6
2016	3	0.6	72	14.4

DISCUSSION

Census

The goal of monitoring *Penstemon haydenii* is to obtain baseline trend data. We could not determine trends from the 2004-2006 monitoring period with its spike in 2005 numbers. By 2006, it became apparent that there might not be a stable population when the habitat itself was changing over the course of monitoring. By 2006 in particular, the wetlands in the dune landscape were markedly dry and the discrete blowout rim features of most dunes were eroding out. Two recent studies help quantify environmental changes that are occurring in occupied habitat, including local-scale burial and deposition (Tilini et al. In progress) and landscape-scale dune migration (Heidel et al. In progress).

Decadenal population trends show decline of *P. haydenii* numbers since the numbers peaked in 2005. In that year, there were almost as many plants in one dune (Bear Mountain) as there were in all dunes combined in more recent years (2015 or 2016). It is hypothesized that the decadenal *P. haydenii* decline reflects large-scale sand deposition that buried established plants. We hope to integrate the final results of the habitat dynamic studies (above) with final monitoring results.

We also looked for evidence of mortality and recruitment information to support population census numbers going up and down. There was almost complete absence of seedlings observed during all the years of census up until numerous seedlings were observed in 2015. Everything that we have learned since then suggests that seedling recruitment is episodic and localized within active sand dune areas, so that to monitor seedlings, one needs to be monitoring in the right year in exactly the right spot. It is hypothesized that spring drought conditions of 2012 and 2013 exacerbated erosion to bring deep seedbanks close to the surface, then fostering mass germination in the wake of the high May 2015 precipitation levels. Excavation trials conducted in 2013 were recently summarized (Heidel 2016) and suggest that established plants survive burial for an unknown amount of time, so that it is not possible to distinguish mortality from survival belowground, unless there is a maximum length of time that plants can survive belowground.

The population size threshold of 300 plants was the numeric framework provided in the recovery plan (Fritz et al. 1992) and it corresponded with a natural split in the original Wyoming census data in which most dunes seemed to have less than 100 plants or over 300 plants. This is based on Nebraska monitoring data and observations that dunes with high numbers tended to retain high numbers over time and dunes with low numbers tended to retain low numbers over time, later supported with Wyoming monitoring data.

Context from completion of surveys

In 2015, *P. haydenii* surveys were conducted on private land for the first time in the same allotments as the monitored ones. All four of the dunes where it was found on private lands in 2015 were split between public and private lands (Heidel 2015). Four new dunes were found to support the species in 2016, boosting the total of occupied dunes to 22, though none of the four had anything close to 300 plants (Heidel 2017). Most importantly for this study, it completed population mapping at other dunes that are split by property lines. Four of the six dunes in this extensive monitoring project are split between public and private lands; two have numbers that

are over 90% on public land and two have numbers that are over 99% on public land. Tallies from private land tallies are not included in this report, but a series of graphs that reflects the one-time surveys on private lands have been prepared to represent their relative contributions for *P. haydenii* in terms of occupied habitat area, and species' numbers (Figures 5-6) as part of this year's interim report.

A tally of the total area of digitized habitat occupied by *P. haydenii* indicates that the largest extent of occupied habitat - 71.2% - is on BLM-administered lands (Figure 5). The total area of occupied habitat is about 274.6 ha (678.5 ac).

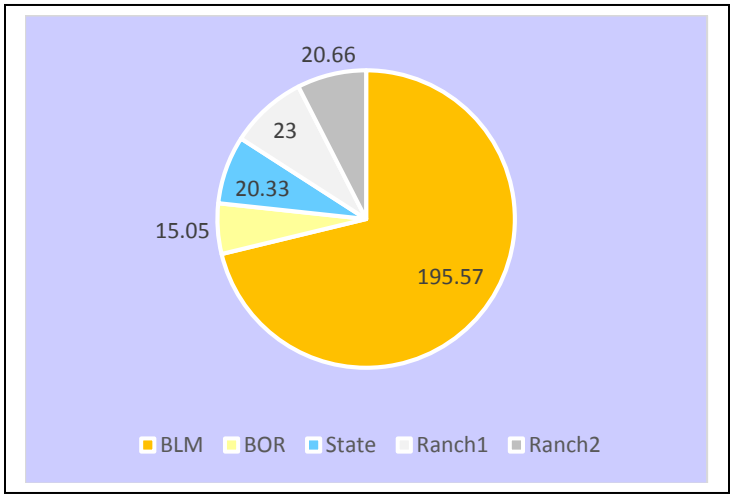

Figure 5. Area of occupied dune habitat supporting *Penstemon haydenii*, by owner/agency

If we take the high *P. haydenii* count from the most recent tallies (2015, 2016) and add any pre-existing data from the rest of dunes, then the relative proportion of species' numbers also shows that BLM lands harbor the highest proportion (2,888 of 7,947 plants; or 36.3%) (Figure 6). However, *P. haydenii* seedlings are almost all on private, state, or Bureau of Reclamation (BOR) lands rather than BLM lands. It is recommended that the boundaries of seedlings and first-year plants be mapped on public lands for spatial reference to accompany their sampling and estimates as part of 2017 monitoring.

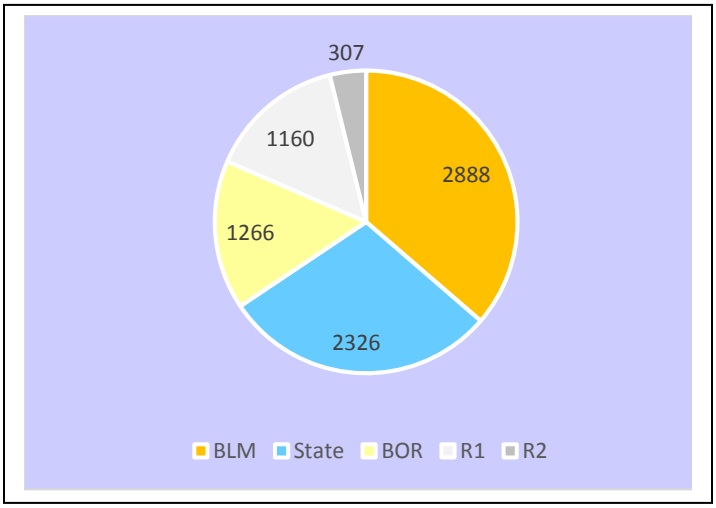

Figure 6. Number of *Penstemon haydenii* plants, by owner/agency

Future plans

Plans for the 2017 field season are to complete extensive monitoring of *Penstemon haydenii* to produce a final monitoring report, representing culmination of 2015-2017 monitoring phase. To further evaluate trends, it may be constructive to explore the trends of the three established plant categories (flowering, nonflowering, browsed plant numbers) rather than just the tally of them. Pertinent dune succession information will be incorporated as critical context for monitoring data. In order to enhance the robustness of trend interpretation after 2017 monitoring, it is also recommended that:

1. Correlations between monitoring data and climate monthly extremes be evaluated.
2. The merit of a new, more rigorous seedling survival study be explored. The distribution of established plants seems to be 100X more extensive than that of seedlings so it is not known if major germination episodes can compensate for decline in established plants in either absolute numbers or area of occupancy.
3. This interim report be distributed among people working with *P. haydenii* to solicit input and realize the fullest potential of this work for the benefit of the species after completion of monitoring.

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