Penstemon haydenii (blowout beardtongue) monitoring, 2018-2021

Carbon County, Wyoming

Prepared for BLM Rawlins Field Office and BLM State Office

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ABSTRACT

This report marks the culmination of monitoring *Penstemon haydenii* (blowout beardtongue) at dunes with highest numbers in Wyoming, from 2018-2021, building on earlier decadal datasets (2004-2006 and 2015-2017). The simple goal of determining the contribution of Wyoming's *Penstemon haydenii* populations to rangewide recovery goals for the species required determining its distribution, numbers, and habitat trends. This monitoring report is the first one to integrate decadal monitoring data with historic habitat data and field observations to offer a robust assessment of overall trends. The original recovery goal of population stability for an early succession species may not be feasible. Available information suggests that occupied habitat is in a prevailing destabilization phase with increased sand movement. Evidence is presented that the "Wyoming contribution" of *P. haydenii* species' numbers is likely to remain in the realm of 5,000-10,000 mature, established plants as long as there is continuation of current management and adequate protection from land-use changes, barring prolonged drought.

ACKNOWLEDGEMENTS

The author thanks all BLM State Office botanists supporting *Penstemon haydenii* work, and all people who have participated in the field studies. A separate page would be needed for full acknowledgements. The 2021 fieldwork was conducted with help of Frank Blomquist (BLM). The access permissions from private landowners to cross their land in order to reach public land are gratefully acknowledged. All photographs in this report are by the author unless otherwise noted. This project was conducted under Agreement No. L16AC00389 as coordinated by Chris Keefe, Brad Jost and Frank Blomquist.

Cover photos: *Penstemon haydenii* and *P. haydenii* habitat, by B. Heidel

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INTRODUCTION

The first discovery of *Penstemon haydenii* (blowout beardtongue; previously called blowout penstemon) in Wyoming was made by Frank Blomquist in 1996 in a dune below Bradley Peak. It was scientifically documented by a voucher specimen in 1998 (*Roderick and Blomquist 5013 RM*), and duplicates were collected in 1999, for confirmation by experts on the species and the genus. It was reported by Taylor (2000) and addressed in a compilation of all available information on the species in Wyoming (Fertig 2000)[1]. Prior to this discovery, the species was regarded as endemic to the Nebraska Sandhills. It had once been common in the Sandhills, but there were few remaining populations and major loss of habitat when it was list as endangered under the Endangered Species Act (ESA; U.S. Fish and Wildlife Service 1987).

A plan to recover *Penstemon haydenii* was prepared (Fritz et al. 1992) when it was only known from Nebraska (Freeman 1986). The primary recovery goal was set at maintaining stable populations at or above 300 plants at a given number of populations. Under the ESA, plant species designations apply throughout their range and so Wyoming survey work started immediately in 2000 (Fertig 2001). Surveys continued in tandem with monitoring work in Wyoming populations beginning in 2003-2004.

The most recent report on *Penstemon haydenii* status in Wyoming presents all distribution on public land and early trend data (Heidel 2012). Also in 2012, *P. haydenii* was addressed in a 5-year review (USDI Fish & Wildlife Service 2012). The review called for an update to the 1992 recovery plan, incorporating complete and current status information on the species to include Wyoming distribution. It also called for refining recovery criteria that would:

> "… 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)."

Penstemon haydenii is currently the only Endangered plant species in Wyoming. The goal of determining the contribution of Wyoming's *Penstemon haydenii* populations to its rangewide status turned into a set of tasks aimed at determining its distribution, collecting trend data at two stages of life history, and evaluating habitat trends.

The primary purpose of this report is to address *Penstemon haydenii* trends as monitored from 2018-2021, in the context of decadal census. It is the most complete synthesis of information on the contribution of Wyoming's *P. haydenii* populations to rangewide recovery goals

[1] The intriguing history of *Penstemon haydenii* discovery in Wyoming involves an 1877 collection of the species by Ferdinand Hayden that was mistakenly attributed to collecting he did in Nebraska rather than Wyoming, as explained in reports and popular articles (Fertig 2000, 2001 and Heidel 2018). Botanists currently interpret Blomquist's discovery as a rediscovery, made in proximity to the original Hayden Expedition route.

STUDY AREA[1]

All monitoring work represented in this report was conducted in the Ferris Dunes, in northwestern Carbon County, Wyoming. The Ferris Dunes cover about 500 km² (Gaylord 1984) at the eastern end of the Ferris Mountain Range as it converges with the Seminoe Mountains in central Wyoming (42.19°,−107.16°). The dune field has an abundant supply of loose sand in a dry, windy climate (Kolm 1982, Gaylord 1984) with a range of conditions from stabilized to active dunes. Soils of the Ferris Dunes are Typic Torripsamments (Munn and Arneson 1998). The dune sands are considered soil habitat even though pedogenic horizons are essentially absent in the active dunes. Plant growth on these dunes provides evidence that these unconsolidated substrates that might otherwise be considered parent materials are functioning as soils (Buol et al. 2003). More detailed soils data in occupied habitat is provided by Williams (2021).

The Ferris Dunes are typical parabolic dunes with bowl-like blowouts, U-shaped rims above the blowouts, and slopes to the side and downwind from the blowouts. They also include dunes confluent with steep slopes at foothill positions that are semiparallel to the wind directions and appear as more or less linear steep sand slopes interrupted by blowouts. Together these zones of loose sand constitute a continuous dune area. Mean annual precipitation in the Ferris Dunes is 28.8 cm (1946–2015; PRISM Climate Group 2016), with the peak monthly precipitation mean of 5 cm occurring in May, closely followed by the April and June monthly means (Fig. 1, 1980–2010; PRISM Climate Group 2016).

Rain gauge data from the Ferris Dunes has been collected from Ferris Townsite (Township 26 North, Range 87 West, Section 25, SENE) by the BLM as the best representation of precipitation patterns before and during discovery of *Penstemon haydenii* (USDI BLM 2019; Appendix A). It shows that most precipitation arrives in winter and spring, with overall decline in annual precipitation particularly during winter months. Nearest NOAA data (Alcova Dam) and PRISM data have also been used to identify months of almost no precipitation or extreme precipitation.

Eolian activity of the Ferris Dunes in the Holocene has been reconstructed by Gaylord (1984) and treated in Schmeisser et al. (2010). Gaylord also provided a basis for characterizing current activity in measuring wind and sand grain size and found that the largest grain size (0.5+ mm) required wind speed >4.7 m/s for sustained movement (Gaylord 1983). Wind above this threshold commonly occurs in December through April, with higher wind speeds in the eastern part of the Ferris Dunes, lower wind speeds near the Ferris-Seminoe Mountain barrier, and increased atmospheric instability and wind turbulence with terrain irregularity (Dawson and Marwitz 1982, Marrs and Gaylord 1982, Gaylord 1983, 1984, Gaylord and Dawson 1987).

The Ferris Dunes are colonized by three rhizomatous grasses—*Redfieldia flexuosa* (blowout grass), *Elymus lanceolatus* (thickspike wheatgrass), and *Achnatherum hymenoides* (Indian ricegrass)—and by the dicot, *Psoralidium lanceolatum* (lemon scurfpea) (Fertig 2001, Heidel 2012), which has a deep and extensive root system (Weaver and Fitzpatrick 1934, McGregor 1986). *Penstemon haydenii* is restricted to bare sand or sparsely vegetated early-succession dune habitat in association with these species.

[1] The following information is reprinted from Heidel et al. (2018)

METHODS

Recent trend data for *Penstemon haydenii* in Wyoming draws from surveying work and prior census work.

Surveys

Surveys to determine *Penstemon haydenii* distribution in Wyoming were conducted in four different studies. The first survey of *Penstemon haydenii* was conducted by Walter Fertig in 2000 to map species' extent at Bradley Peak, survey for it elsewhere in the Ferris Dunes, and initiate surveys in the Seminoe Dunes, Killpecker Dunes and other isolated active sand area of southcentral Wyoming. In the Ferris Dunes landscape, he targeted large dune areas near Bradley Peak Dune that were visible from it, or mapped as sand deposits on the same USGS topographic map (Bradley Peak 7.5'; (Fertig 2001) and he documented three more dune areas without finding it outside the Ferris Dunes.

Another new dune area occupied by the species was discovered by the author and Frank Blomquist, in seeking shorter access routes to the newest locations in 2002. As a result of the discovery, expanded surveys in the Ferris Dunes were proposed. The second survey of *P. haydenii* was conducted in 2004 using aerial imagery to fill gaps in the local distribution picture in the Ferris Dunes. At the same time, the Casper Dunes were surveyed, and the species was not found there. Outer boundaries of occupied habitat were recorded as waypoints for mapping and for later use as census reference. An updated status report was produced (Heidel 2005) to document nine additional dune areas.

In 2011, the least-accessible parcels of public land in the Ferris Dunes were surveyed using aerial imagery to ensure completeness. Also, a thorough survey of the Killpecker Dunes was completed as part of a separate species study (Heidel 2012a, b). Ferris Dunes surveys documented six additional dune areas without find it outside this area.

Finally, in 2015-16, private lands that adjoin occupied habitat on public land were surveyed using aerial imagery (Heidel 2015, 2017) as funded by U.S. Fish and Wildlife Service. Four small dune areas were added. The resulting map of occupied dune areas is comprised of about 23 discrete dune areas mapped as polygons, clustered in what is interpreted as representing three populations, based on separation distances and wind stream patterns.

Initial census

Penstemon haydenii census was conducted annually (2004-2006) targeting the five dune areas with numbers that have ever exceeded 300 plants (Figure 1) under one agreement with both survey and monitoring objectives. Three dunes met the criteria in 2004, but two more dunes with high numbers were documented in 2004 surveys, and one more dune area with high numbers was added in surveying isolated public lands in 2011 (Pathfinder Reservoir Dune). Later, a seventh dune with high numbers was found on private land in 2015 surveys funded by U.S. Fish and Wildlife Service in the same landscape.

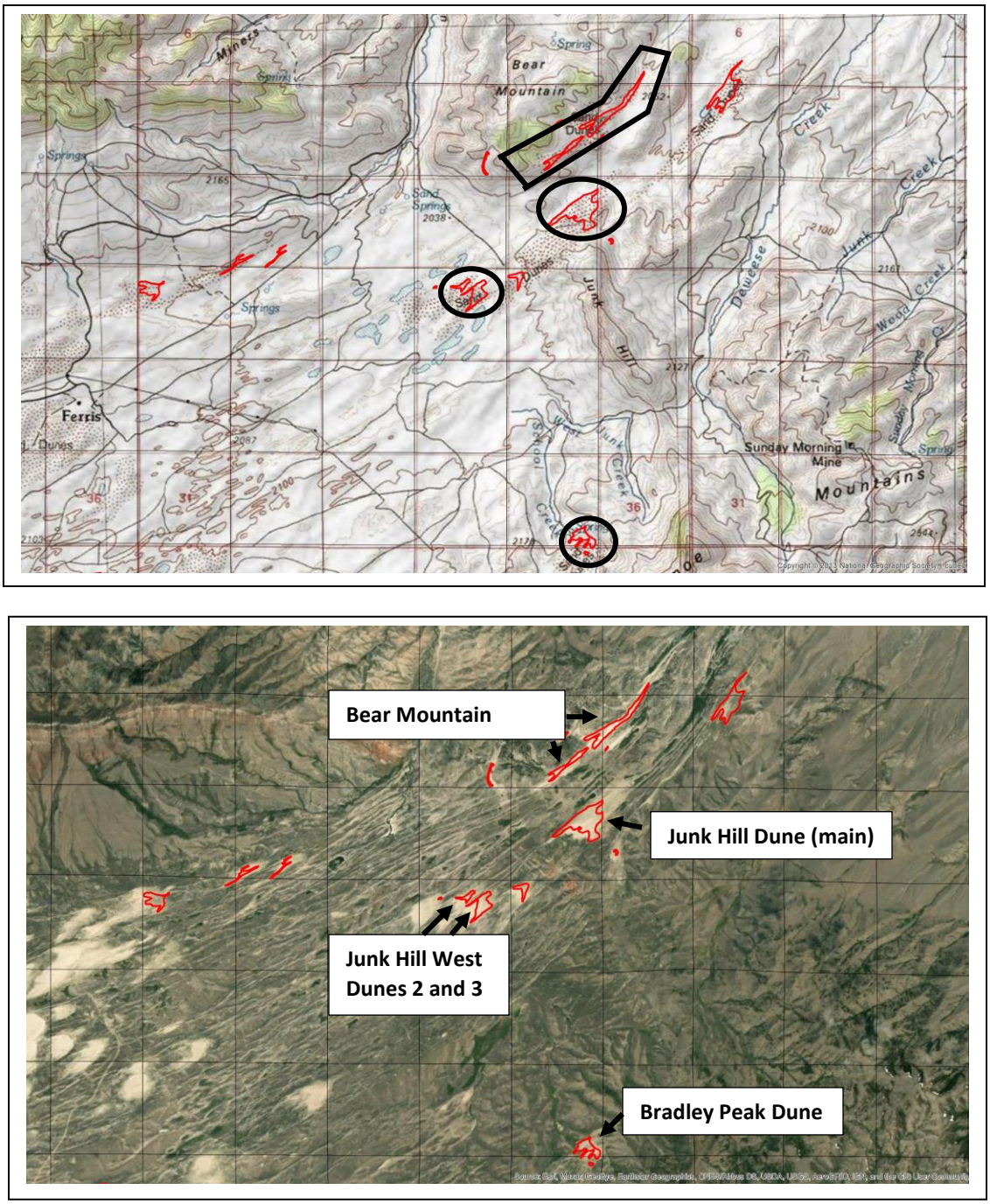

Figure 1. A portion of *Penstemon haydenii* distribution in the Ferris Dunes, showing the five dune areas on public land where annual census was conducted (2004-2006 and 2015-2017), as circled on the map and labelled on the aerial. Section lines are superimposed for scale, with 1.6 km (1 mi) borders. Each occupied dune area was given a name reflecting local landmarks. Note: there are slight name variations in reports over time.

Fieldwork was usually conducted by two or more people traversing the occupied habitat, walking in a series of parallel lines. Printed copies of population boundaries superimposed on aerial imagery were carried for reference, along with a GPS unit that had boundary waypoints from previous years. The final monitoring report documented 2006 decline in all dune areas (Heidel 2007).

Census of *Penstemon haydenii* in Wyoming followed the general methods used in Nebraska. It targeted mature, established plants and was timed during flowering when plants were at full height and most conspicuous. For Wyoming populations, this was usually the third or fourth week of June.

Figure 2. Census categories of *Penstemon haydenii* plants in photographs, from upper left, clockwise, including: seedling (inferred), vegetative plant, flowering plant, and browsed plant. From: cover of first monitoring report (Heidel 2007). Each of the plants show in this panel would be tallied as one plant.

Populations in Nebraska apparently had high flowering levels so census there did not differentiate between flowering and nonflowering plants. However, most Wyoming plants were vegetative, so we differentiated plants and tallied them in one of three categories: flowering, nonflowering (vegetative), or else browsed (Figure 2). The latter phenomenon had not been reported in Nebraska, and rather than trying to sort the complete gradient of browsing levels, or puzzle whether any heavily-browsed plants had been flowering or nonflowering before herbivory, we treated browsed plants as a separate category. At heavy levels of browse, only stubs of stems appeared above ground and reproductive status could not be determined. Browse was attributed to elk and antelope, as consistent with hoof prints and all observations. Most census was conducted before livestock were released into the pastures with occupied habitat. There were no observations of grazing when cattle were present at times of census in June.

Census of established plants was replicated a little over a decade later (2015-2017) at the five original dune areas, and at the sixth dune area (Pathfinder Reservoir Dune) not documented until 2011. This decadal replication of census was based on a U.S. Fish and Wildlife Service call for current data (2012).

Demographic monitoring

Demographic monitoring was set up as part of the 2004-2006 monitoring work to provide alternative or augmenting data for census results. Three permanent belt transects were read for 3-4 years at Bradley Peak and Junk Hill (Main) Dunes, consistent with study design frameworks in Lesica (1987) and Elzinga et al (1998). The belts were placed in areas of high density and endpoints were marked by rebar. Two belts of 2 m x 50 m were set up at one dune in 2003, and one belt of 2 m x 20 m was set up at another in 2004. Belt transects were read concurrent with census work. The coordinates of individual plants were recorded in a 1 m x 1 m frame to track the fate of individual plants for demographic transition calculations, and to distinguish original plants from any new plants.

Individual *Penstemon haydenii* plants were mapped on graph paper to the nearest 5 cm. Each point was labelled to represent the number of flowering stems, nonflowering stems, and browsed flowering stems pere individual, e.g., B1I2N6 represented a browsed plant with one browsed flowering stem, two intact flowering stems, and six nonflowering stems. As another example, N2 represents a nonflowering plant with two nonflowering stems.

Scaled-back census

After the 2004-2006 period, at least one of the five dune areas was censused per year to see if declines continued and to check for any new disturbances. It was conducted apart from any formal monitoring project, and ran most years between 2007-2013.

Separate from WYNDD projects, tandem studies were conducted as valuable context, including a study of pollination biology in 2005 (Tepedino et al. 2006, Hawk and Tepedino 2007), an initial study of plant taxonomy in 2013 (Freeman 2015), and a study of seed biology from 2011-2013 (Tilini et al. 2016, 2017).

The presence of *Penstemon haydenii* in Wyoming was recognized by U.S. Fish and Wildlife Service in the first five-year review (2012) which also called for updated information. This lead to proposing another round of census work. Before doing so, we evaluated the merit of census conventions, including the practice of tallying individual *Penstemon haydenii* stems as one plant if they emerge within 15 cm of one another. We excavated in proximity to 20 plants, at distances of 0 cm-15 cm and 15 cm-1 m from them, and to depths of about 30 cm, looking for connectivity. This provided important context for the later census work.

Habitat trends

Habitat trend information was proposed in 2014 before further census work. This is because habitat loss and resulting population loss were the original reasons for listing *Penstemon haydenii* when only known from Nebraska. Evidence of habitat loss was evaluated by reconstructing 16 currently occupied dune areas back in time over a 70-year period using digital imagery and georectified orthophotographs at 12 points over time (Heidel et al. 2014, 2018).. We calculated rates of dune movement, changes of dune area over time, and presence/absence of discrete blowout rims. Seed ecology results and evaluation of census methods lead us to

hypothesize that *Penstemon haydenii* is really a long-lived perennial and that Wyoming population trends are influenced by habitat trends.

Both total active dune area and what we called downwind habitat for *Penstemon haydenii* were digitized (Heidel et al. 2018). The latter was defined based on observed distribution of mature *Penstemon haydenii* plants located downwind from blowout bowls, as delimited by the blowout rim. Blowout rims appeared on aerial imagery as a distinct, continuous line in a horseshoe shape or an elongated "U" separating the bowl-like blowout (upwind) from sideslope arms, and downwind lee slopes (downwind). At the start of surveys and monitoring, most occupied dunes had distinct, continuous blowout rims.

RESULTS

Separate study results leading up to the 2018-2021 work are presented in chronological order.

Surveys

Distribution of *Penstemon haydenii* in Wyoming was documented in four rounds of surveys from 2000 to 2016. There are 23 occupied dune areas, clustered in at least three populations based on separation distances, wind stream patterns and inferred gene exchange between them. All surveys through 2011 were conducted on public land, but the most recent surveys and resulting additions to species' distribution were on private land[1].

Initial census

The numbers of *Penstemon haydenii* plants in most dune areas during census years peaked in 2005. The tally of plants in the five dune areas was 18,806 plants as representing an estimated 97% of all plants known at that time. In general, the drop in numbers of plants between 2005 and 2006 was sharper at the dune areas with gentle slopes than at the dune areas with steep slopes.

Demographic monitoring

We also launched demographic monitoring to learn about population transitions, without knowing if permanent transects in successional habitat would persist from year to year. Between 2003-2006, one of the three transects was partially eroded out by wind erosion. No new plants appeared in any of the transects, parts of each belt transect area were buried, and various rates of decline in plant numbers were documented in the transects. The demographic study provided evidence of active erosion and burial as context for census results. The initial census results and accompanying demographic monitoring results are presented in Heidel (2007).

[1] Occupied dune areas are mapped as polygons if there were more than 10 plants. In some dune areas, there was more than one discrete zone that was occupied, so that the dune area has 1-few polygons. In addition, there were a small number of locations where only 1-few plants are present and they were mapped as points. Further complicating the map work, all occupied habitat on private land that straddled public-private boundaries was mapped as having polygon boundaries that followed the boundary, in keeping with the WYNDD data sensitivity policy precluding release of any private land data. There are cases in which over 90% of an occupied dune area is on public land, and cases in which less than 10% of the occupied dune area is on public land.

One of the most important results of demographic monitoring was the information indicating that sampling within an occupied dune area was not a meaningful substitute for census across an occupied dune area. Both approaches to monitoring have pitfalls but the relation between any given subsampling of occupied habitat to the species' numbers across a given dune area changee over time.

Scaled-back census

No fundamental changes in trends were found between 2007-2014, nor any new disturbances. Annual monitoring memos were prepared as a record of results in most years, but are represented in full with later replication of another three-year census period.

We confirmed the merit of the 15 cm separation distance in delimiting individual plants. In a few cases, there were prostrate branches farther than 15 cm away, but upon excavation, they were found to be buried stems. Though they had no rhizome development, eroded branches sometimes had adventitious roots. Reports of this species having rhizomes introduced the possibility of vegetative reproduction, but we found no evidence of this, and more fully characterized subsurface rooting.

Two more discoveries came from trial excavations. In excavating 15 cm-1 m away from individual plants, we found that *Penstemon haydenii* shoots can be present but buried below sand with no aboveground stems at the time when other plants are flowering. These buried shoots were without chlorophyll at depths approaching or exceeding 15 cm. This adds an element of uncertainty to census results if plants survive belowground for some unknown duration and depth in a cryptic stage in which they cannot be seen for census. This further contradicts the characterization of the species as a short-lived perennial and lead us to hypothesize that population trends are affected by habitat trends of deposition and erosion. We do not know if this is a routine phenomenon or only in times of high dune activity when excavation was done in 2013.

We also learned that *Penstemon haydenii* plants can survive burial by sand in which buried root crowns send shoots upward to the new surface-level, forming new surface-level root crowns. It were as though stems were able to function as roots. We partially excavated 20 plants having different numbers of stems and sizes, and found one plant with up to at least two buried crowns, in addition to three plants with one buried crown. It is not possible to determine mean longevity without knowing the age of plants at the onset of monitoring, but this observation suggests that the species can be a long-lived perennial. Photo records from this investigation went into the baseline monitoring report at the start of the census period (Heidel 2016).

Habitat trends

Average downwind dune area was digitized as what was considered to be the best approximation of dune areas supporting *Penstemon haydenii*, traced back in time. It averaged 34.0 ha (4.5 ha – 124.0 ha) from 1946-2015 and the mean migration of the leading edge was 2.9 m per year. No new dunes appeared during the 70-year period and none disappeared (Heidel et al. 2018) though the extent of downwind dune area diminished 16.1% between 1946-2015.

By projecting the earliest and latest "*Penstemon haydenii* downwind habitat", we see that the occupied area changes have ranged from almost complete displacement (Junk Hill, A in Figure 3) to relatively unchanged positions in case the advancing edge of one dune even retreated (Bear Mountain, C in Figure 3).

The occupied habitat areas occasionally changed shape over time as they advanced over irregular topography. One of the most conspicuous changes seen on aerial imager was in recent years at Bradley Peak Dune, where the change was also obvious on the ground (Bradley Peak, B in Figure 3). There, the dune doubled in length between 2001-2015 as represented by the six most recent dots marking migration of the leading edge from six successive aerial images. No new *Penstemon haydenii* plants have been found colonizing the recent sand deposits, which include settings that may not be conducive to germination.

We do not have *Penstemon haydenii* distribution data that goes back in time, except for the current interpretation that the species was first collected in the Ferris Dunes in 1877 in a setting that, based on journal entries, passed dunes with steep slopes. Two of the three dune areas in Figure 3 have steep slopes occupied by *P. haydenii*: the northern margin of Bradley Peak Dune, and the Bear Mountain Dune. They are also the only dune areas occupied by *P. haydenii* that have steep slopes, although there are other steep sand slopes in the area that do not currently have *P. haydenii*.

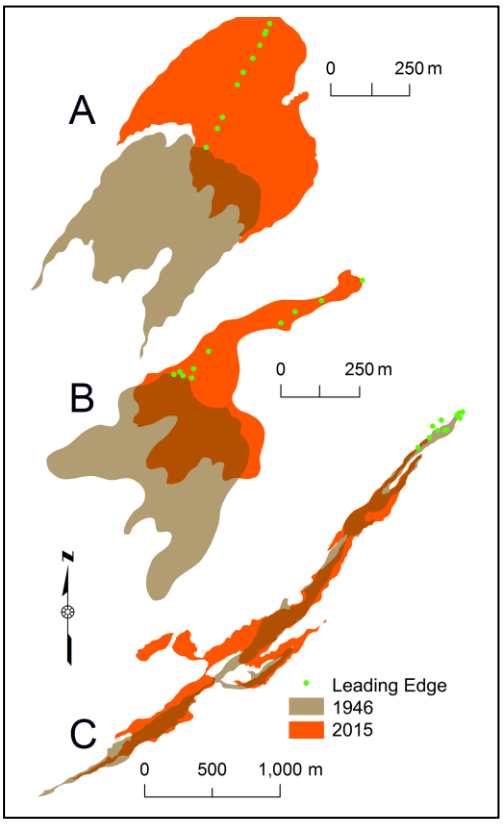

Figure 3. Digitized extent of active dune areas among three locations where *Penstemon haydenii* numbers top 300 plants, between 1946-2015 (70 years). They include: A. Junk Hill Dune (main), B. Bradley Peak Dune, and C. Bear Mountain Dune (from Heidel et al. 2018). Green points mark outer edges of dune areas for different age aerial imagery, a record of dune advancement.

Replicate census

At the decadal scale, comparison of *Penstemon haydenii* plant numbers in 2004-2006 with those in 2015-2017 showed that there has been some rebound, particularly at the dune with highest numbers(Figure 4). That dune is the Bear Mountain Dune, which is also the place where seedlings were first observed in 2013. The peak census tally in early years was 18,806 plants (2005), much greater than the peak tally of 7,802 plants (2017) in the same five dune areas later years. The latter tally does not include a sixth major dune area, the Pathfinder Reservoir Dune because it was not documented until 2011, adding up to 1126 more plants (2016 data). Five of the six dunes that have ever had over 300 plants still have high numbers at or above this count as determined between 2015-2017 (Heidel 2018) and ensuing years (this report).

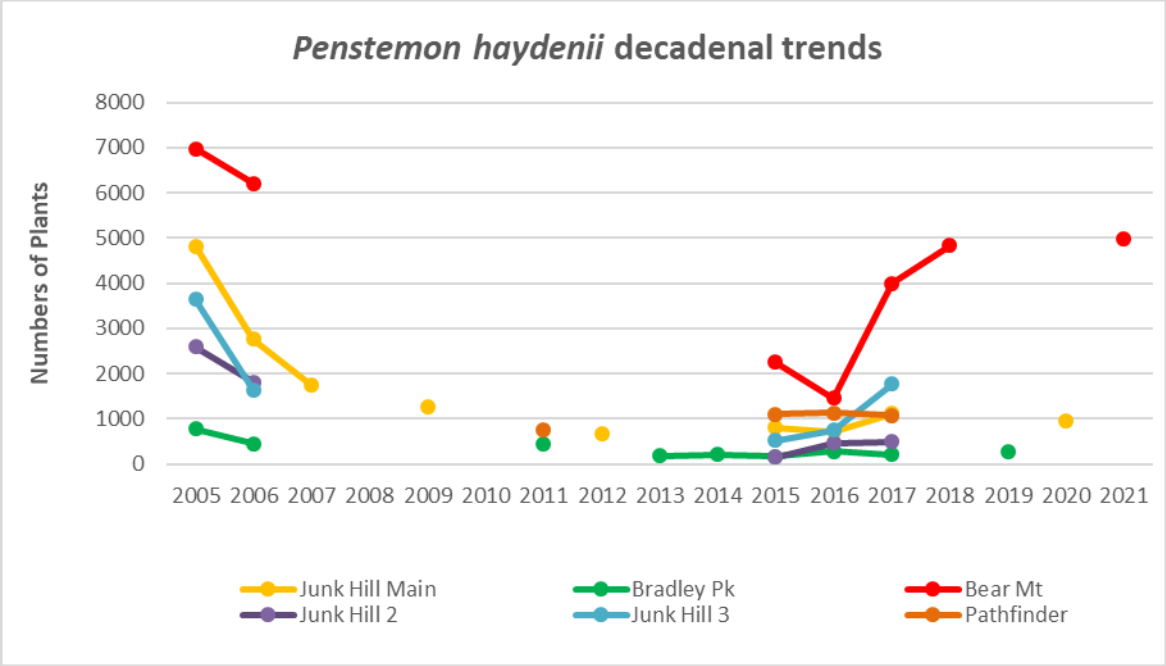

Figure 4. *Penstemon haydenii* decadal trends in census of dune areas with high numbers (2004-2021)

Additional results were assembled as part of the data collected including proportion of plants in each category (flowering, vegetative, and browsed) and different zones of the dune area at those dunes where occupied habitat is in distinctly different places and settings.

Another way to think of *Penstemon haydenii* results is their distribution by ownership (Figure 5). Of the 23 dune areas where *P. haydenii* is present, eight of the dune areas support numbers of 100+ or more plants (adding one dune area when the threshold is lowered from 300 to 100 plants) and half are completely or predominantly on BLM lands. Of the eight, the highest numbers of *Penstemon haydenii* mature plants were on State lands; a total of 86% were on public land. Of the 23 occupied dune areas, only seven have been found to have *P. haydenii* seedlings based on the regular or intermittent fieldwork to date. They are also ones with high numbers of established plants. Of these eight, private lands and state land harbor the great majority of seedlings.[1]

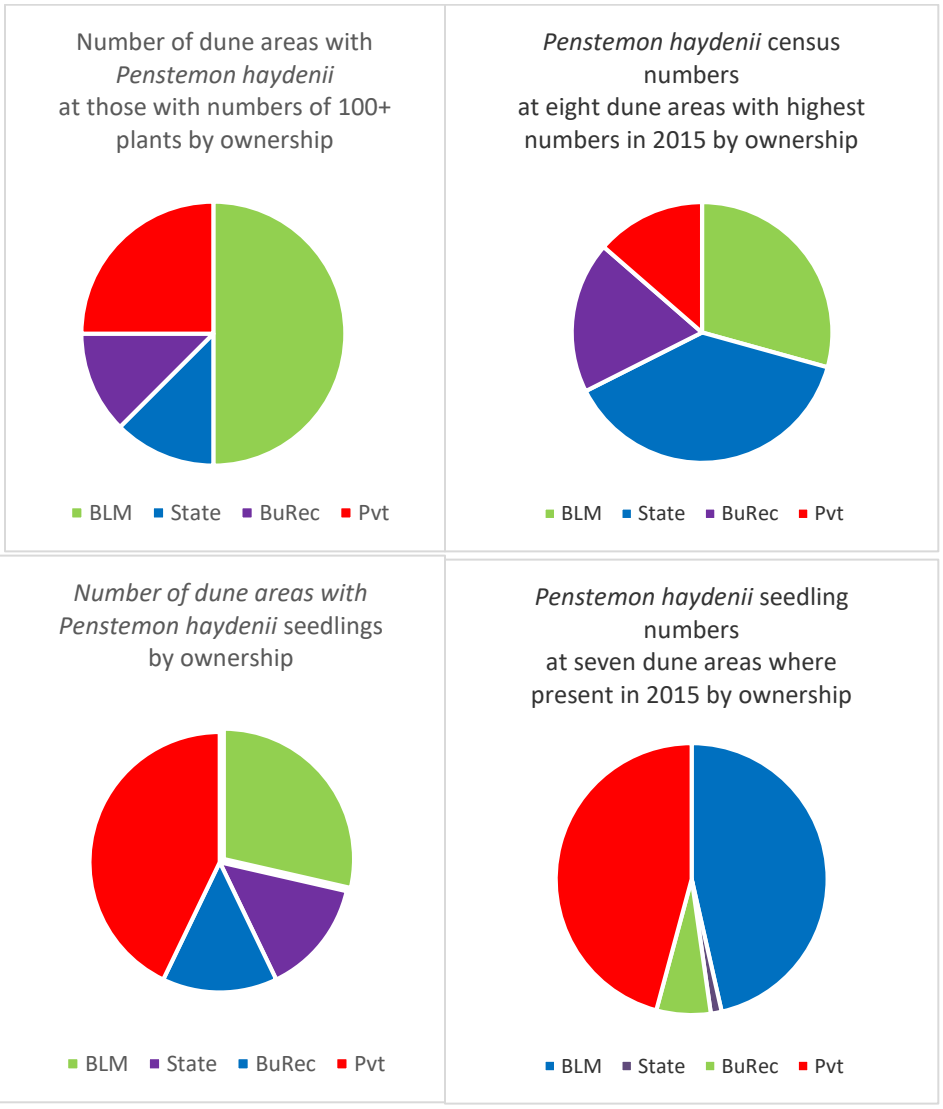

Figure 5. *Penstemon haydenii* distribution, both mature and seedling plants, by ownership (2015)

[1] It is pertinent to note that the Endangered Species Act does not apply to state or private land management in Wyoming except as federal actions are involved.

DISCUSSION

Penstemon haydenii population numbers remained relatively low during the past five years (2018-2021) compared to the peak counts in 2005. This is consistent with the widespread sand dune destabilization observed and chronicled in digitized imagery (2001-2015), the resulting burial/erosion of occupied habitat, and the episodic nature of germination and recruitment.

Ever since the initial census period, *Penstemon haydenii* numbers of mature plants appeared to remain in the 5000-10,000 range. This report provides evidence that the "Wyoming contribution" of *P. haydenii* species' numbers is likely to remain in this realm as long as there is continuation of current management and adequate protection from land-use changes, and barring prolonged drought.

With very few exceptions, we have not directly witnessed *Penstemon haydenii* mortality apart from the seedling transects. The survival of mature established plants belowground defies census, and cryptic stages of life history that involve random environmental circumstances preclude analytical methods as has been used for other plant species with predictable duration of their cryptic stages. We conducted pilot excavation work in 2013, the same year that Tilini et al. (2017) documented rates of burial and erosion on the Bear Mountain Dune area. So we do not know whether surviving subsurface plants are present in most years or if the exceptional dune activity in 2013 was responsible for this phenomenon.

Documentation of seedling trends is addressed in a separate report (Heidel 2021) that presents the case that the flush of germinating seedlings in recent years may at least locally compensate for loss of mature plants. We note that seedlings have only been found in seven of 23 occupied dune areas.

Figure 6. *Penstemon haydenii* habitat connectivity, view from Bradley Peak looking north, with Bear Mountain and Junk Hill (Main) dunes in upper right. Photo by Kaylan Hubbard.

The majority of upwind dunes as sources of sand and seed for downwind ones are on private land. The Blowout Penstemon Area of Critical Environmental Concern (ACEC) was established in 2008 (USDI BLM 2008) and its boundaries expanded to include subsequent additions to distribution in in 2018 (Figure 6). This represents a landscape-scale approach to management and BLM lands predominate within ACEC boundaries. These management and protection provisions apply to BLM-administered land, i.e., four of the seven dunes supporting over 300 plants (or four of eight supporting over 100 plants in Figure 5). The dune area with consistently highest numbers is the Bear Mountain Dune on Wyoming Trust Land.

Succession in the Ferris Dunes appears to be a natural process, unless there are changes to dune succession associated with climate change or management change. The fact that *Penstemon haydenii* occupies a dune complex, with upwind dunes contributing sand and seed to downwind ones, buffers the system as a whole.

The more immediate threats, ORV use and other motorized recreation, are currently constrained by the access restrictions to the area by private landowners. There are currently four access routes to the six public dune areas with highest Penstemon haydenii numbers on public land, but there are no travel routes connecting them. Any change of landowner practices, change of landowners, or any agency transportation development that connected them would elevate the threat of ORV use. One dune area with high numbers on public land is directly accessible to the public via watercraft.

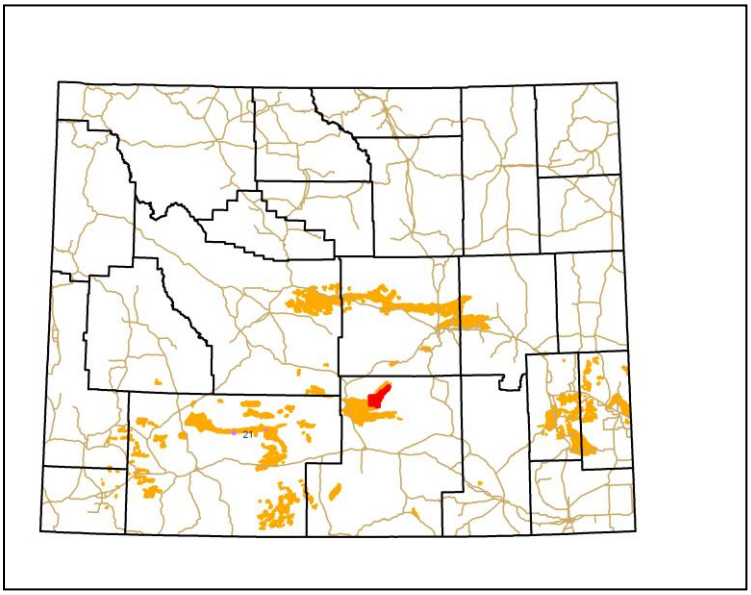

Figure 7. The Blowout Penstemon Area of Critical Environmental Concern (USDI BLM 2018) is shown in red, superimposed on the rest of Quaternary eolian sand deposits in the state also surveyed for *Penstemon haydenii*, as shown in orange. The map of sand deposits are based on Love and Christiansen (1985).

It is possible that ORV use may impact seedlings more than established plants. There have only been a couple instances of ORV traffic in blowout bowls with seedlings crushed in at least one case, but not involving a level of use that appreciably affected seedling survival levels.

Current oil exploration and development are outside of the ACEC boundaries. Wind energy proposals are not active at present. The distribution of *Bromus tectorum* (cheatgrass) is also encroaching active sand dune areas, more so at the west end of occupied habitat than the east end. Its encroachment is not at the levels seen in vegetated uplands and swales, or with apparent influence on succession but may influence landscape fire regime.

What are the directions and considerations for *Penstemon haydenii* going forward? This report marks the end of a census period, and this report is being distributed to circulate that question. The six dune areas with high numbers on public land may warrant periodic census.

An updated Wyoming status report on *Penstemon haydenii* could be prepared to integrate all of the available information on the species, its distribution and habitat that has been collected since 2012. In any case, all documentations provided with earlier reports in the past are still available including: GIS layer of P. haydenii distribution, GIS layer of seedling monitoring transects, GIS layer of negative surveys where the species was sought but is absent, establishment reports prepared for the most recent phases of annual census and seedling monitoring, and photographs documenting each stage of study as well as the species and its habitat in different times and places.

This report does not begin to address all of the *Penstemon haydenii* literature and work conducted in Nebraska, and the ways it has informed or perplexed the execution of work in Wyoming. Whether or not there is a status report update prepared for the species in Wyoming, it would be appropriate for botanists familiar with the species and dune systems in both states to articulate known life history differences (incorporating Kottas 2008), population trend differences, and habitat differences before there were ever any compilation of species' information in a rangewide document under the Endangered Species Act.

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