Survey of *Penstemon haydenii* (Blowout Penstemon) in Wyoming 2004

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

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April 2005

Agreement KAA041037

Abstract

Penstemon haydenii (blowout penstemon) is designated a federally Endangered plant species. The first confirmed discovery of *Penstemon haydenii* in Wyoming was made in 1996 (vouchered in 1999), and the first systematic survey of it was made in 2000 using a habitat model based on surface geology and elevation to identify high elevation sand dune areas across south-central Wyoming. The original discovery and prior survey project resulted in two documented populations.

The scope of survey was expanded in 2004, using digitized soils and landcover information as well as surface geology information to identify the largest sand deposits in the state. Photointerpretation was conducted using digital orthophotographs to identify the largest unsurveyed active dunes on BLM-administered lands in the major dunefields of the Rawlins and Casper field offices (Carbon, Converse and Natrona counties). Thirteen dune areas spanning 33 sections were surveyed.

This survey report updates and expands the information in the two previous *Penstemon haydenii* reports for Wyoming (Fertig 2000, 2001). All new discoveries of *Penstemon haydenii* were made within 10 miles of previously-known populations. One new population was discovered near Pathfinder Reservoir at outlying flanks of the Pedro Mountains, and six new subpopulations were discovered in the Bear Mountain - Junk Hill complex at the eastern end of the Ferris Mountains. The three Wyoming populations of *Penstemon haydenii* have subpopulations in fourteen discrete blowouts. They were mapped using GPS points and digital orthophotographs. One of the Wyoming populations was magnitudes larger than the other two Wyoming populations when surveyed in 2004, and comprises a significant share of rangewide species' numbers, so complete enumeration and multi-year documentation of its trends are priorities for further consideration.

Census and demographic monitoring of *Penstemon haydenii* were conducted in concert with survey work, highlighted in this report. At Bradley Peak and Junk Hill, variation in *Penstemon haydenii* flower morphology was noted, and pilot investigation of this phenomenon is attached to this report.

A comparison between the occupied habitat of *Penstemon haydenii* in Carbon County and potential but unoccupied habitat in Converse and Natrona counties provides hypotheses for its absence in the latter, where there are the largest dunefields that exist between existing Nebraska and Wyoming populations. Results from the Casper Field Office represent survey data on species' absence in over 80% of primary potential habitat on BLM-administered lands.

Although legally recognized under the Endangered Species Act, *Penstemon haydenii* may still be threatened by habitat loss or degradation. In Wyoming, threats include mineral claims, water resources development, impacts from ORV recreation, and other possible threats. A Wyoming BLM species conservation strategy is underway. Refined Section 7 guidelines could be derived from survey data.The US Fish and Wildlife Service developed a recovery plan with the goal of protecting at least 15,000 individuals at 10 different sites. The newly-documented populations in Wyoming may help attain the rangewide goal. The existing recovery plan is the current framework for determining species' recovery status. Amendments may be warranted if there is evidence of genetic differentiation. The results of this survey report provide a framework for addressing *Penstemon haydenii* recovery considerations and information needs in Wyoming.

Acknowledgements

Text in some sections of this report was written by Walter Fertig, who previously worked as the Wyoming Natural Diversity Database (WYNDD) botanist, and who prepared all previous reports on *Penstemon haydenii* in Wyoming. His works are central to understanding species' status in the state and this work is a credit to his. Readers are referred to earlier reports (Fertig 2000, 2001) for the origin of information presented in this report, which follows the same format. Citations are used in all cases where the text in this report represents an elaboration, revision, or alternate hypothesis compared to the previous Wyoming reports.

This project would not have happened without the help of Frank Blomquist, BLM Rawlins Field Office, and Dave Johnson and Jeff Carroll in the BLM State Office. Frank Blomquist and Kathleen Erwin (U.S. Fish and Wildlife Service) participated in *Penstemon haydenii* monitoring and discovered one of the new subpopulations in 2004. The fieldwork in the BLM Casper Field Office was coordinated with Don Whyde, Jim Wright, Charlie Fifield, Bruce Parker and Sara Bucklin-Comiskey, and they provided allotment information needed for access to study sites in the Casper Field Office. Special appreciation goes to all BLM lease-holders in the Rawlins and Casper Field Office who were contacted about visits onto their allotments.

GIS information layers to identify *Penstemon haydenii* potential habitat were assembled by Rebekah Smith (WYNDD). Help in printing digital orthophotographs for fieldwork was provided by Joy Handley (WYNDD). The interest of all who have had a hand in *Penstemon haydenii* work is acknowledged with gratitude.

The most current information on *Penstemon haydenii* distribution, numbers and status in Nebraska was generously provided by James Stubbendieck (University of Nebraska) in Stubbendieck and Kottas (2004). Readers are referred to the original Nebraska references for all sources of information on species' status in Nebraska.

This project was funded as a challenge cost-share project of the Bureau of Land Management in Wyoming and the Wyoming Natural Diversity Database, under Agreement KAA041037.

Report citation:
Heidel, B. 2005. Survey of *Penstemon haydenii* (Blowout Penstemon) in Wyoming – 2004. Prepared for the Casper and Rawlins field offices of Bureau of Land Management. Wyoming Natural Diversity Database, University of Wyoming, Laramie, WY.

Cover photo: *Penstemon haydenii*, by Walter Fertig

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INTRODUCTION

Penstemon haydenii Wats. (blowout penstemon) was listed as an Endangered species in 1987 (U.S. Fish and Wildlife Service 1987) when it was considered to be endemic to the Nebraska Sandhills. A recovery plan was written for it not long afterward (Fritz et al. 1992). In 1996 it was discovered at Bradley Peak in Carbon County, Wyoming by Frank Blomquist, and subsequently vouchered by Blomquist and botanist colleagues from that site in 1999 (summarized in Fertig 2000, 2001). The status of every plant species listed under the Endangered Species Act is determined throughout the species' ranges, so there was a compelling need to evaluate its status in Wyoming in order to meaningfully integrate it with the robust research and recovery efforts underway in Nebraska. This report updates *Penstemon haydenii* status in Wyoming.

Penstemon haydenii is currently Wyoming's only listed Endangered plant species,[1] and as of 2003 was still known only from the Seminoe and Ferris mountains area, approximately 300 km (185 miles) west of the nearest known population in Morrill County, Nebraska. In 2004, the BLM Wyoming State Office contracted with the University of Wyoming and the Wyoming Natural Diversity Database (WYNDD) to conduct a survey of additional potential *Penstemon haydenii* habitat on public lands in east-central and south-central Wyoming. Though the survey was greatly-expanded in geographic scope, all new discoveries were within 10 miles of previously-known populations. The following report discusses the results of this survey and summarizes existing knowledge on the distribution, habitat, and abundance of this species in Wyoming. A monitoring project was undertaken in tandem to document *Penstemon haydenii* numbers and trends. The monitoring results are presented in a separate establishment report but highlighted in this report. In addition, a range in morphological variation among *Penstemon haydenii* flowers was observed during 2004 fieldwork, so a pilot project was undertaken to document the novel characteristics and the expanded range of characteristics. The pilot project is appended to this report.

METHODS

Three sets of digital information were pooled to represent aeolian (wind-borne) sand deposits in Wyoming, as potential *Penstemon haydenii* habitat. The information included surface geology information (Love and Christiansen 1985) as previously used by Fertig (2001), soils information (Munn and Arneson 1998), and land cover information from the Wyoming GAP analysis (Driese et al. 1997). The units included Quaternary sands, Psamment soil order and Short Grama Prairie land cover, respectively. They were merged into a composite map that shows all areas of wind-borne sand deposits on public lands in Wyoming. The composite map of sand deposits is presented in Appendix A, with USGS 1:24,000 topographic map boundaries for reference.

Choppy sand dunes and unconsolidated sand blowout habitats are needed by *Penstemon haydenii,* absent from most sand deposit areas. Active sand dunes with blowout features were identified using

[1] Ute ladies tresses (*Spiranthes diluvialis*), Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradensis*) and Desert yellowhead (*Yermo xanthocephalus*) are listed as Threatened, and Narrowleaf moonwort (*Botrychium lineare*) is petitioned for listing as Threatened.

digital orthophotography (posted at http://www.wygisc.uwyo.edu/) spanning the Casper and Rawlins field offices of BLM. The largest unsurveyed active sand dune blowouts in these field offices of BLM were the focus of this work.

A record of past surveys (Fertig 2001) was compiled, and a couple additional surveys in intervening years were added to the original list. All sections of land that have had survey for *Penstemon haydenii* are listed in a master table and accompanying map, and the more detailed maps of survey routes covered as part of this project are also in this report (compiled in Appendix B). Previously-surveyed blowout features were not included in photointerpretation.

Active blowouts that had not been surveyed were identified as high, medium, or low priority for survey in the Casper Field Office based mainly on blowout size. Other considerations included the signature of natural blowout features on the digital orthophotograph (unconsolidated sand surface as indicated by high reflectance, and both the location and orientation of the blowout on the landscape as corroborating aeolian origin). Aggregations of multiple blowout features were noted as higher priority than isolated blowout features. Finally, the location of blowout sites were checked again with BLM 1:100,000 surface management maps so that only locations on public lands were considered. All high- and most medium-priority blowout features on BLM lands were surveyed.

In the Rawlins Field Office, there was a two-pronged approach of surveying the high-priority habitat in the immediate vicinity of known populations, and the high-priority habitat at a distance. This included blowout features that are visible from existing populations but which had not been surveyed, which were also cross-checked on digital orthophotographs. The blowouts were investigated using multiple working sets of hypotheses regarding their suitability as indicated by settings, environmental characteristics, dune morphology, and proximity to known sites. The environmental characteristics considered included elevation, topographic position, water availability, surface water features, source-sink models and distances from known populations, microhabitat features, and succession patterns.

All blowout features identified as priorities for survey were marked on digital orthophotographs printed out at the scale of quarter-quadrangle maps to match that of 1:24,000 USGS topographic maps for reference in the field. Use of digital orthophotographs provides graphic, detailed means of documenting distribution. Blowouts on private lands were ruled out (roughly half of the blowouts in the Casper Field Office area) and priorities among blowouts on public lands were noted.

Field surveys were conducted in 13 areas of dunes spanning 33 sections (Appendix B). Fieldwork took place over a total of 10 days between 24 June - 8 August 2004. At sites where *Penstemon haydenii* was not found, notes were taken on blowout succession features and the species that are typical or atypical compared to known populations. At sites where *Penstemon haydendii* was found, data were collected on habitat, phenology, population size, and associated species using WYNDD plant survey forms. Populations were initially marked on 7.5 minute USGS topographic maps and Global Positioning System (GPS) points were recorded along boundaries. Information gathered in the field was entered into the computerized Element Occurrence database of WYNDD and boundaries were mapped on digital orthophotographs using projected GPS points (Appendix C).

SPECIES INFORMATION

Classification:

Scientific Name: *Penstemon haydenii* S. Watson (1891). Watson originally spelled the specific epithet "*haydeni*", but a second "*i*" was later added to make the name etymologically correct (Fritz et al. 1992).

Common Name: Blowout penstemon; Hayden's penstemon, Blowout bluebells.

Family: Scrophulariaceae (Figwort family).

Synonyms: None.

Phylogenetic Relationships: The genus *Penstemon* contains nearly 250 species centered primarily in western North America (Cronquist et al. 1984). *Penstemon haydenii* belongs to section *Coerulei*, a group recognized by succulent and glaucous leaves, anthers that dehisce their entire length, and compact inflorescences of blue, violet, pink, or white flowers (Cronquist et al. 1984). *Penstemon haydenii* is unique within this section in having fragrant flowers (Freeman 1986). *P. haydenii* is thought to be most closely related to *P. grandiflorus* and *P. angustifolius*, and Freeman (1981) has hypothesized that *P. haydenii* may be of hybrid origin between these two taxa. It has the same diploid number of chromosomes (n=8) as the two related species (Freeman 1986).

Legal Status: *Penstemon haydenii* was listed as Endangered under the US Endangered Species Act on 1 October 1987 (U.S. Fish and Wildlife Service 1987). The plant is also protected under state law in Nebraska, but receives no comparable protection in Wyoming.

Natural Heritage Rank: NatureServe (formerly the heritage division of The Nature Conservancy) and the network of natural heritage programs gives *Penstemon haydenii* a rank of G1, indicating that the species is "critically imperiled because of extreme rarity" throughout its range. This is based on the following characterization:

"Narrowly endemic mainly to the Nebraska Sandhills Prairie where it is restricted to an open early-successional habitat. The species was probably more common in the sandhills before settlement, but control of fire and range management practices (especially dune stabilization) have reduced the amount of available habitat (blowouts). The resultant isolation of existing blowouts and populations has become a barrier to the dispersal of seeds to new blowouts. There are now only about 10 small populations remaining, and natural succession is occurring on the sites where they are found." (from NatureServe 2005)

In other words, the global rank reflects mainly the status of the indigenous Nebraska populations. The rank of "G1" is generally reserved for species with 10 occurrences or less; *Penstemon haydenii* has 16 indigenous populations rangewide. However, population sizes, their distribution, threats, trends, and vulnerability are also considerations.

At the state level, it is ranked S1 in Nebraska and Wyoming (Nebraska Natural Heritage Program 1996; Keinath et al. 2003).

Description: *Penstemon haydenii* is a perennial herb with one to many glabrous upright or decumbent stems arising from a branched caudex, rooting from buried nodes (Figures 1-3). Vegetative stems are usually less than 30 cm tall and have greenish-blue, waxy, linear leaves 2.5-12 cm long and 0.3-1 cm wide. Flowering stems have narrow basal leaves and broad-based, clasping, waxy upper stem leaves 0.7-3 cm wide that taper abruptly to a narrow tip. The inflorescence is 6-16 cm long with 6-10 compact, leafy whorls of milky-blue to pale lavender flowers (rarely pink or white). Bracts of the inflorescence are broad and heart-shaped at the base and narrow to an elongate tip. Individual flowers are 23-25 (30) mm long with tubular, bi-lobed and faintly vanilla-scented corollas that are broadly dilated above the glabrous, linear sepals. Anther sacs are 1.8-2 mm long and glabrous. The sterile staminode is glabrous or hairy. Fruits are 13-16 mm long capsules, acute, with light-brown, disc-shaped seeds that have winged margins (Stubbendieck et al. 1982, 1997; Freeman 1986; Fertig 2000, 2001, Heidel 2004 personal observation).

Figure 1. *Penstemon haydenii* illustration, by B. Heidel

During 2004 fieldwork, *Penstemon haydenii* flower variation was noted that had not been previously recorded in taxonomic literature. Morphological variables included hairy and hairless staminodes, nectar guidelines both present and absent, and occasionally, trichomes on the styles and inner corolla. In Freeman (1986), staminodes are characterized as consistently hairy and nectar guidelines are characterized as appearing among all flowers in early stages of maturation. The variation within the main Junk Hill subpopulation was documented and recorded in Appendix D. While these are minor attributes to add to the species description, this variation may be significant in understanding species' pollination adaptations and genetic variation, and awaits further research.

Similar Species: *Penstemon grandiflorus* has ovate to spoon-shaped leaves (widest above the middle), non-aromatic corollas over 35 mm long, and fruits over 16 mm long. *P. angustifolius* var. *angustifolius* has corollas less than 25 mm long and narrowly lance-shaped stem leaves over 7 times as long as wide (rarely over 1 cm wide). *P. angustifolius* var. *caudatus* has corollas under 25 mm long and lance-shaped to ovate flowering bracts (Freeman 1986; Dorn 2001).

Figure 2. Photo of *Penstemon haydenii* in flower on the steep sand dunes on the west side of Bradley Peak, Carbon County, WY, 2 July 1999. WYNDD photo by Walter Fertig.

Figure 3. Photo of *Penstemon haydenii* (whole plant) on Bear Mountain, Carbon County, WY, 25 June 2002. This also represents the steep slough slope habitat (see habitat section).
WYNDD photo by B. Heidel

Figure 4. Photo of *Penstemon haydenii*, with adventitious root development under erosion conditions, on Junk Hill, 24 June 2004. WYNDD photo by B. Heidel

Figure 5. Photo of *Penstemon haydenii* underground axillary root branching and breakage point, as example of vegetative reproduction, from the blowout outlier east of Bear Mountain and Junk Hill, Carbon County, WY, 25 June 2002. WYNDD photo by B. Heidel.

Figure 6. *Penstemon haydenii* seedling, west of Junk Hill, 30 June 2004. WYNDD photo by B. Heidel

Figure 7. *Penstemon haydenii* vegetative plant, Junk Hill, 24 June 2004. WYNDD photo by B. Heidel. (above)

Figure 8. Browsed *Penstemon haydenii* flowering plant, west of Pathfinder Reservoir, 25 June 2004. WYNDD photo by B. Heidel. (left)

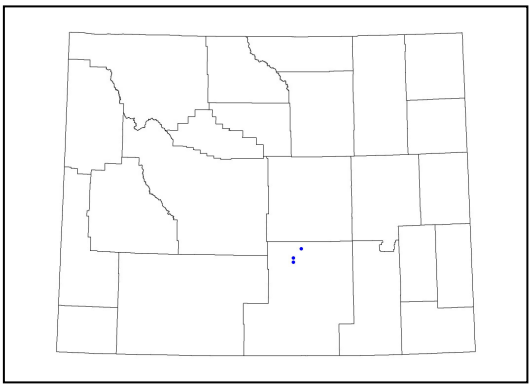
There have been no previous reports of other *Penstemon* species sympatric with *P. haydenii* in Wyoming. But in 2004, a single individual of *P. subglaber* was noted in secondary dune habitat east of Junk Hill. This species is more common in the Seminoe Mountains, where it was collected for voucher. It has discrete basal leaves, lacks the glaucous appearance of *P. haydenii*, and has conspicuously dark flower color by comparison, and may only occur as an accidental in loose sand habitat.

Geographic Range: *Penstemon haydenii* is a regional endemic of the Nebraska Sandhills in west-central Nebraska, with an outlying population center in Wyoming. The indigenous Nebraska populations occur in five counties (Box Butte, Cherry, Garden, Morrill, and Thomas counties); and transplanted populations are also present in five additional counties of Nebraska (Brown, Gordon, Lincoln, Loup, and Phelps counties; Stubbendieck et al. 1997, Stubbendieck and Landholt 2001, Stubbendieck and Kottas 2004).

Penstemon haydenii was considered locally abundant in the Nebraska Sandhills in the early 20th Century (Pool 1914), but by the 1940s was thought to be extinct (Fritz et al. 1992). Although the species was rediscovered in 1959, it remained extremely uncommon in west-central Nebraska (Lichvar 1982) and was listed as Endangered under the U.S. Endangered Species Act (USDI Fish and Wildlife Service 1987). In Nebraska, *Penstemon haydenii* is now known from 31 extant populations in the Nebraska Sandhills (13 indigenous and 18 planted populations; including three transplanted populations in the same landscape as indigenous populations; Stubbendieck and Lottas 2004). Reports from Kansas (Coulter and Nelson 1909) are probably erroneous.

By contrast, Wyoming populations are only known in northwestern Carbon County (Dorn 2001, Taylor 2000, Fertig 2001). They are on the northwest flank of Bradley Peak (western Seminoe Mountains), on the south side of Bear Mountain and north side of Junk Hill (eastern end of the Ferris Mountains), and at foothills of the Pedro Mountains that extend on the west side of Pathfinder Reservoir (Figure 9; Table 1, Appendix E).

Figure 9. Distribution of *Penstemon haydenii* in Wyoming



Each of the three Wyoming occurrences is part of a dune complex, and some have multiple blowouts that represent discrete population segments. A summary of *Penstemon haydenii* locations in Wyoming is summarized in Table 1.

Table 1. Locations of *Penstemon haydenii* in Wyoming

Site	Occurrence number	No. of occupied blowouts	Location
Bradley Peak	1	1	West end of Seminoe Mountains
Bear Mountain, Junk Hill, and intervening habitat upwind and downwind	2	11	East end of Ferris Mountains; confluent with northwest end of Seminoe Mountains
Pathfinder	3	2	West outlier of Pedro Mountains

The Wyoming populations of *Penstemon haydenii* are app. 175 miles west of the indigenous Nebraska populations. Interpretation of this unusual distribution distribution pattern is further complicated and inextricably linked with its history of discovery. It was first recognized as a distinct species by Sereno Watson (1891) based on a flowering specimen collected along the Dismal River in Thomas County, Nebraska in 1891 (Pennell 1920). At that time, the species was known from only one other record, a vegetative specimen collected by Ferdinand V. Hayden during "one of his early surveys" and originally identified as *Penstemon acuminatus* (a species now known to be endemic to the Columbia River Basin) (Watson 1891; Cronquist et al. 1984). Watson attributed the Hayden collection to "the Laramie Mountains of Wyoming", but Pennell (1935) later reported that a duplicate of Hayden's specimen at the Missouri Botanical Garden was labeled "Loup Fork", in the Nebraska Sand Hills, and presumed that both specimens were from the same area. For the next 64 years, *Penstemon haydenii* was presumed to be endemic to Nebraska (Stubbendieck et al. 1997, Fritz 1992).

The first record of *Penstemon haydenii* in Wyoming comes from an undated collection made by the Hayden expedition and attributed to the "Laramie Mountains" by Watson (1891). Pennell (1920) noted that this specimen was possibly misidentified. Later, Pennell (1935) reported that a presumed duplicate of Hayden's specimen at the Missouri Botanical Garden was labeled "Loup Fork", a site in the Nebraska Sand Hills.

In June 1996, Frank Blomquist of the Bureau of Land Management (BLM) Rawlins Field Office discovered a small population of *Penstemon haydenii* on public lands at the west end of the Seminoe Mountains in northwestern Carbon County, Wyoming. The identity of this species was not confirmed until July 1999, when Blomquist and University of Wyoming botanists Amy Roderick Taylor, B. Ernie Nelson, Courtney Ladenburger, and Walter Fertig revisited the site and secured mature voucher material. These specimens were verified as *Penstemon haydenii* by Dr. Noel Holmgren of the New York Botanical Garden and Dr. James Stubbendieck of the University of Nebraska (Fertig 1999, 2000). It is recognized in the current Wyoming flora (Dorn 2001).

Extent of Surveys in Wyoming:
In the summer of 2000, potential sand dune habitat was systematically surveyed by Walter Fertig (2000) in six areas of sandhills:

1. South of the Ferris Mountains,
2. South of Table Mountaing and Cheyenne Ridge,
3. South of Green Mountains,
4. South of the Seminoe Mountains on ID Ridge,
5. Killpecker Dunes, and
6. Northeast of Baggs.

The previous six survey areas correspond with Quaternary sand deposits mapped as a surface geology unit (Love and Christiansen 1985) above 2195 m elevation. As part of that survey, Blomquist and Fertig discovered an extensive population of *Penstemon haydenii* on July 7 on the south slopes of Bear Mountain at the eastern end of the Ferris Mountains. On a return trip on 26 July, Blomquist and Fertig located an additional colony on the north slope of adjacent Junk Hill and

a large population on the sandy apron connecting the north side of Junk Hill and the south flank of Bear Mountain (Appendix C, occurrence # 002).

Fertig (2001) noted: "The discovery of the Bear Mountain population forced a reassessment of the disputed Ferdinand V. Hayden collection reported by Watson (1891) for Wyoming. Much of the confusion regarding Hayden's whereabouts stems from the assumption of Pennell (1920, 1935) that the *P. haydenii* collections from the Missouri Botanical Garden and Gray Herbarium are duplicates, when in fact, they probably represent different collections separated by 20 years and several hundred miles. Two unnumbered (and probably duplicate) Hayden collections from the Missouri Botanical Garden are labeled "*Penstemon acuminatus* or *fendleri*" from the "Sand Hills, Loup Fork" by George Engelmann. These specimens were probably collected by Hayden during the 1856-1857 G.K. Warren expeditions through the Nebraska Sand Hills (Warren 1858). Hayden was responsible for the botany during this survey, with Engelmann providing identifications (Pound and Clements 1898). The Gray Herbarium specimen is labeled "*Penstemon acuminatus*" by Asa Gray, who was the botanist in charge of determinations for Hayden's 1877 expedition in Wyoming (Hayden 1879, p. *xx*). In August 1877, Hayden's party traveled from Casper to Rawlins through "Sandy Creek Pass" in the "Seminoe Hills" (now called the Ferris Mountains). This route would have taken them through the low divide between the main massif of the Ferris Mountains and Bear Mountain (an unimproved county road goes through the pass today). In his *Eleventh Annual Report* of 1879, Hayden describes dunes near Sandy Creek Pass where "fine sand is blown up upon the hillsides for a distance of 500 to 600 feet" (Hayden 1879, p 138) and where "[l]ooking back upon the hills, the sand was found to reach up about 400 feet along their slopes" (Hayden 1879, p 32) (Figure 5). Since Hayden's party consisted largely of geologists, it is plausible that members of the group would have explored these dunes. According to Robert Dorn (2000), the specimen was probably collected by one of Hayden's assistants on 28 August and the location data for the specimen label ("Laramie Mountains") could have easily been garbled (similar problems with incorrect labels have been noted on other Hayden collections). The phenology of the specimen (post fruiting) is consistent with a late season collection. Although it cannot be proven definitively, Hayden was clearly at the Loup Fork in 1857 and Sandy Creek Pass in 1877 and could have made separate herbarium collections at both sites, which were later incorrectly assumed to represent just the former locality. This refutes allegations that this species was introduced to Wyoming from Nebraska."

In the summer of 2004, additional sand dune habitat in the Rawlins and Casper field offices was surveyed. Information on Quaternary sand deposits (Love and Christiansen 1985), landcover (Driese et al. 1997) and soils (Munn and Arneson 1998) each showed slightly different patterns of sand deposits in the Casper and Rawlins field offices, which were all checked on digital orthophotos. Elevation ranges were not included among the screening factors so as not to rule out Wyoming settings that may have elevations closer to those in Nebraska. The survey areas included:

1. North of the Seminoe Mountains/ South of Ferris Mountains
2. South of the Seminoe Mountains,
3. Dunes west of the Pedro Mountains and Pathfinder Reservoir, and
4. Dunefields northeast of Casper

The composite GIS map of wind-blown sand desposits (Appendix A) overlain with topographic map boundaries was used to determine which topographic maps had deposits. Digital orthophotographs were reviewed with superimposed topographic lines. Only a fraction of areas with sand deposits had dune features of high, medium and low priority occurring on public land, as described in methods. The digital orthophotographs for areas with sand dunes were printed out at the same scale as quad maps onto 8 ½ x 11 inch pages that covered quarter-quads, for quick cross-reference in the field between aerial photography and topographic maps.

Survey work began after completing *Penstemon haydenii* census work, reinforcing search images of the species and its microhabitat, also providing views of plants at different stages and under all levels of browsing pressure (Figures 6-8). A population was documented near Pathfinder Reservoir on June 25. It represented habitat that was visible from the Bear Mountain population. Expansions to the Bear Mountain – Junk Hill subpopulation were documented on June 30 and July 1. They included a Bear Mountain valley filled by sand deposit, and a series of dunes near Junk Hill. The latter were only readily visible on aerial photographs. Surveys elsewhere in the Rawlins Field Office targeted unsurveyed dune areas north and south of the Seminoe Mountains.

Survey in the Casper Field Office focused on the linear dunefields northeast of Casper in both Converse and Natrona counties. Of the app. 20 dunes that were identified as high or medium priority in the area, 10 were on BLM lands and were surveyed. The presence of *Penstemon haydenii* has not been categorically ruled out but almost all primary habitat on public lands has been surveyed in the area of four topographic quad maps (Beauchamp Reservoir, Gumbo Hill, McKenzie Flat, Pratts Soda Lakes). The dunes of the Casper and Rawlins field offices are compared, and a summary of the strengths and weakness of different hypotheses to explain *Penstemon haydenii* distribution in Wyoming is presented at the end of the habitat section that follows.

Habitat: In general, *Penstemon haydenii* is restricted to sparsely vegetated, early successional, shifting sand dunes with crater-like blowout depressions created by wind erosion. In Wyoming, *Penstemon haydenii* is found primarily on the rim and lee slopes of blowouts, or the rim and steep facies of sandy slough slopes (Figures 3, 13, 14). The sand deposits are situated at the base of mountains or ridges, signifying topographic barriers to wind-born sand deposits. Occupied habitat spans elevations of 1786-2270 m (5860-7440 ft).

Penstemon haydenii is located in the Great Divide Basin of Wyoming, a closed drainage landscape traversed by the Killpecker dune field. The Killpecker dunes are a unidirectional dune field oriented like a banner across the Great Divide Basin, spanning app. 109,000 acres (Ahlbrandt 1973). The *Penstemon haydenii* population sites are at the eastern (downwind) end of the Killpecker dunefield. It appears that this dune field has been active during interglacial periods and developed in the last 20,000 years B.P. (Ahlbrandt 1973).

The largest dunes in the Killpecker dune field are transverse dunes at the west (upwind) end with ridges oriented perpendicular to the wind (Ahlbrandt 1973). By contrast, most dunes occupied by *Penstemon haydenii* are linear dunes, with more complex wind patterns and ridges oriented parallel to the prevailing wind (after Livingstone and Warren 1996). Linear dunes are usually characterized as “free” dunes, i.e., without topographic obstructions. However, all three population sites of

Penstemon haydenii represent dunes intercepted ("anchored") by topographic barriers. The linear dunes would have different blowout activity if not for the Ferris and Seminoe Mountains. At these topographic barriers, there is wind funnel action or vortex action with *in situ* churning that supports many stages of vegetation succession, a complexity that is augmented by gravity-maintained instability of steep sand deposits. At Pathfinder South, the linear dunes "climb and fall" a barrier. There is also a series of parabolic dunes occupied by *Penstemon haydenii* on the western flanks of Junk Hill. Parabolic dunes are U-shaped dunes that are anchored at their perimeter, with arms pointing upwind. Dunes of a sub-parabolic shape may also form on the downwind margins of small playas, called "lunettes" (Lancaster 1995) as formed on a small scale around the wetlands that lie between Bear Mountain and Junk Hill. Finally, on a very fine scale, there are anchored dunes that form around vegetated sand mounds (also referred to as coppice dunes, hummock dunes, and "nabkha" dunes). These vegetated sand mounds fringe the linear dunes that support *Penstemon haydenii*, and occasionally harbor the species. Appendix C presents aerial photographs to accompany the maps and element occurrences for each *Penstemon haydenii* population in Wyoming in which the linear and parabolic dune patterns are clear. The blowouts tend to be isolated, but Bradley Peak is comprised of three contiguous blowouts and a steep slough slope below (labeled in Appendix C).

Figure 10. Diagram of major dune types

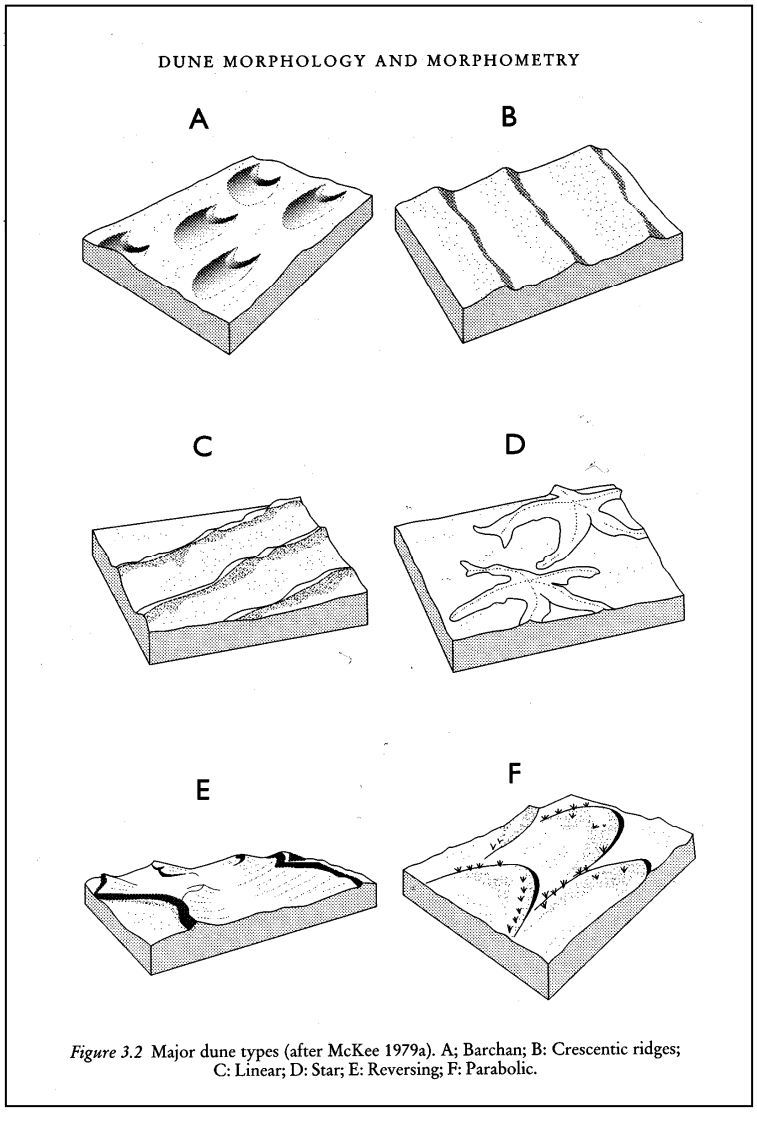
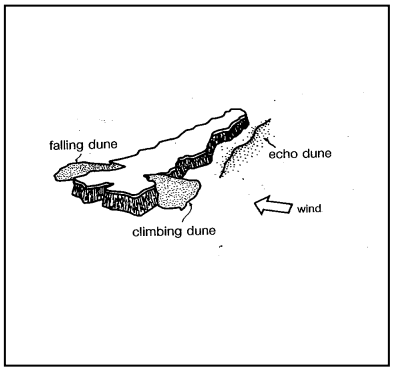


Figure 3.2 Major dune types (after McKee 1979a). A; Barchan; B: Crescentic ridges; C: Linear; D: Star; E: Reversing; F: Parabolic.

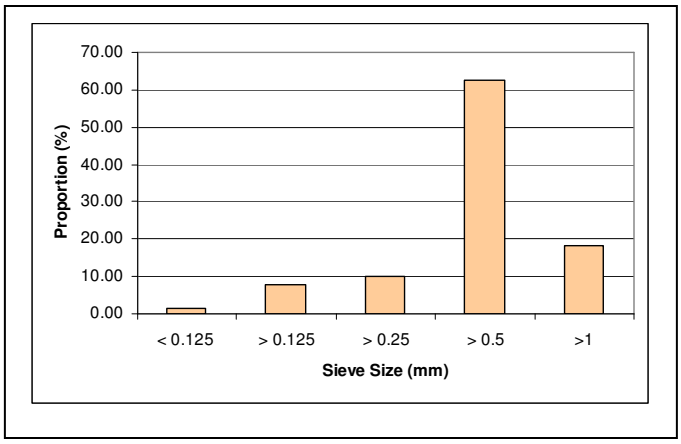
The major types of dunes are presented in Figure 10 (from Lancaster 1995). *Penstemon haydenii* habitats in Wyoming are mainly linear dunes (C). The examples shown in this figure are all free dune systems, while the topography of the Ferris, Seminoe, and Pedro mountains creates essentially anchored systems that climb and fall (Figure 11). Climbing and falling dunes are the special form of linear dunes that are the main settings for *Penstemon haydenii* ocurrences in Wyoming.

Figure 11. Diagram of climbing and falling dunes (from Livingstone and Warren 1996)



These dunes are generally 18-36 m high (60-120 ft). The descriptions made by members of the Hayden Expedition party, describing dunes that are "500-600 feet high," might apply to the current landscapes where the dunes are tall but in a discontinuous series. Such areas are found in the slopes of the Sand Creek Canyon, as well as the series of occupied habitats on Bradley Peak, on Bear Mountain, and on Junk Hill. It is also possible that there were much more extensive, continuous dunes in the past than at present.

Figure 12. Sand particle size in sample from *Penstemon haydenii* habitat (Junk Hill)



The sand dunes in the Ferris and Seminoe Mountains consist of fine psamments derived from wind-blown Quaternary alluvium (Love and Christiansen 1985; Munn and Arnesen 1998). The particle sizes are coarse and relatively uniform, as determined for a 100 g sample from the middle of the largest population (Figure 12) collected by the author in 2002 and put through a series of sieves. The majority of grains are between 0.5-1.0 mm. The coarse texture, rounded particle shape, and prevalence of quartz minerals are apparent at a glance. There is reported to be a major clay component that is not readily apparent and that is not reflected in the sieve profile (discussed in Fertig 2001). The clay fraction may adhere to the coarse particles, it may migrate to subsurface levels, or may have been winnowed out by the wind from the particular sample. Elsewhere, it was noted that the subsurface was noticeably moist only 10 cm below bare, essentially unvegetated sand when soil pits were dug in the dunes in June 2002, the middle of a drought period.

Penstemon haydenii is found in a range of slopes and topographic positions. It is usually found on the lee slopes behind a blowout (Figure 13). Occasionally *Penstemon haydenii* plants are more concentrated and numerous at the rim than on the lee slopes (Figure 14). The blowout crater is one of the most unstable microhabitats for *Penstemon haydenii* but almost all of the seedlings that were censused in 2004 were located in blowout craters (Figure 15). A blowout crater on Bradley Peak that had seedlings in 2004 was semi-vegetated in 1999, as documented in photographs. Blowout rims are periodically breached. The steepest of *Penstemon haydenii* microhabitats develop where the dunes form steep slough facies, which sometimes have high concentrations of *Penstemon haydenii* (e.g., Bradley Peak, Bear Mountain). Slopes range from 1-5% in blowout craters, rims and crests nearly 60% on Bear Mountain and Bradley Peak, inherently unstable. Localized miniature dunes, as found around *Artemisia cana*, are marginal habitat and sporadically occupied in the vicinity of primary habitat (Figure 16). On the following pages, Figures 13-20 show facets of occupied *Penstemon haydenii* habitat, and Figures 21-26 represent unoccupied habitat surveyed in 2004.

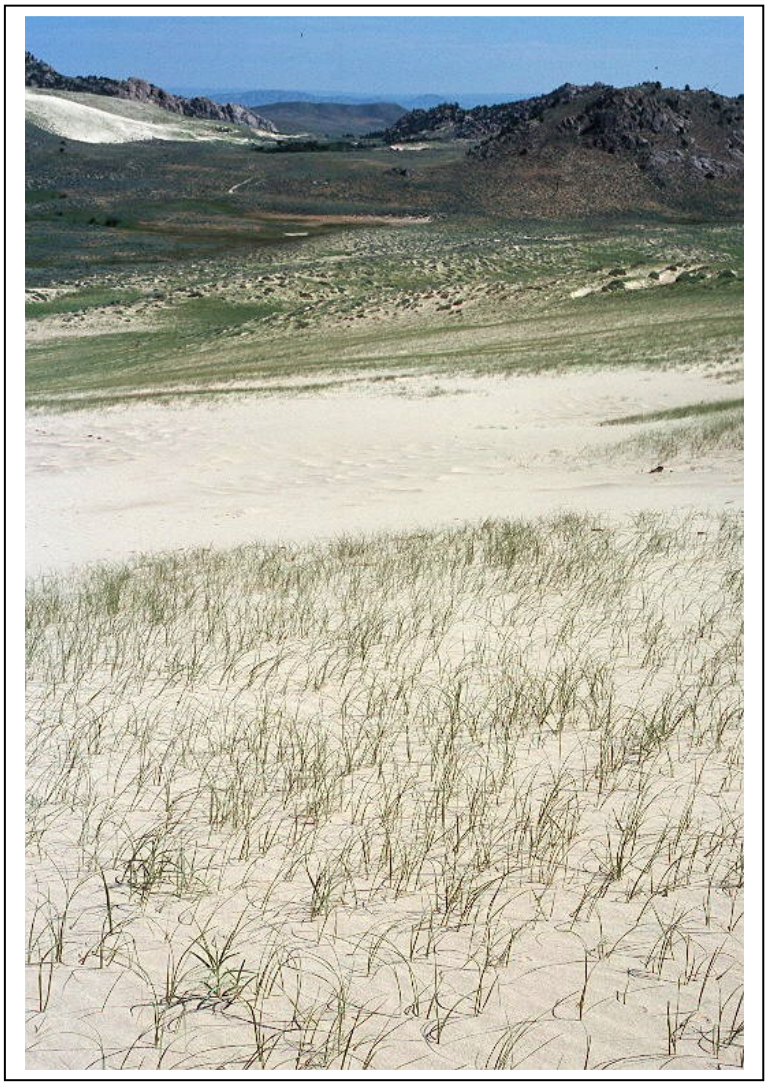


Figure 13. Typical *Penstemon haydenii* habitat with *Redfieldia flexuosa*, as found on gentle lee slopes and other deposition settings (Junk Hill in foreground, Bear Mountain in background). Note vegetative *Penstemon haydenii* plants. WYNDD photograph by B. Heidel.

Figure 14. Blowout rim habitat, with entangled roots of *Penstemon haydenii* and other pioneers.
BLM photograph by F. Blomquist.

Figure 15. Miniature "dunes" form around *Artemisia cana*, marginal habitat for *Penstemon haydenii*.
WYNDD photograph by B. Heidel.

Figure 16. Overview of the most extensive subpopulation of *Penstemon haydenii* (Junk Hill; background), from the small, perched dunes that fill a valley on Bear Mountain (foreground). WYNDD photograph by B. Heidel.

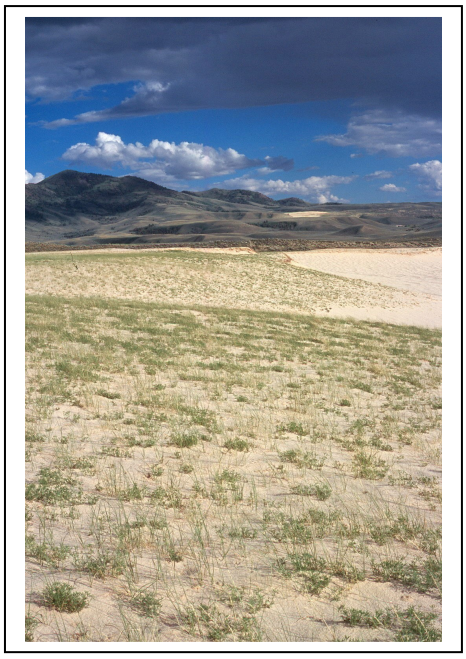


Figure 17. Dunes west of Junk Hill (foreground); Bradley Peak (background) with *Penstemon haydenii*. WYNDD photograph by B. Heidel

Figure 18. Another view from Bear Mountain Valley (foreground); Bradley Peak (background), and dunes west of Junk Hill (middle) with *Penstemon haydenii*. WYNDD photograph by B. Heidel

Figure 19. Habitat of *Penstemon haydenii* (Pathfinder – North subpopulation), linear dune bordering knoll, occupying lee slopes behind blowout.

Figure 20. Habitat of *Penstemon haydenii* (Pathfinder – South subpopulation), on falling linear dune with blowout, occupying lee slopes behind the blowout (far left).

Figure 21. Sand blowout habitat on Casper Field Office. Unoccupied habitat. Note *Redfieldia flexuosa* (foreground) and root-bound rim (background). WYNDD photograph by B. Heidel.

Figure 22. Example of largest sand blowouts on Casper Field Office. Unoccupied habitat. WYNDD photograph By B. Heidel.

Figure 23. Miniature mound "dunes" form beneath *Yucca glauca* in the Casper Field Office. Unoccupied habitat. WYNDD photograph by B. Heidel.

Figure 24. Breached blowout rims below Ferris Mountains. Unoccupied habitat. By B. Heidel.

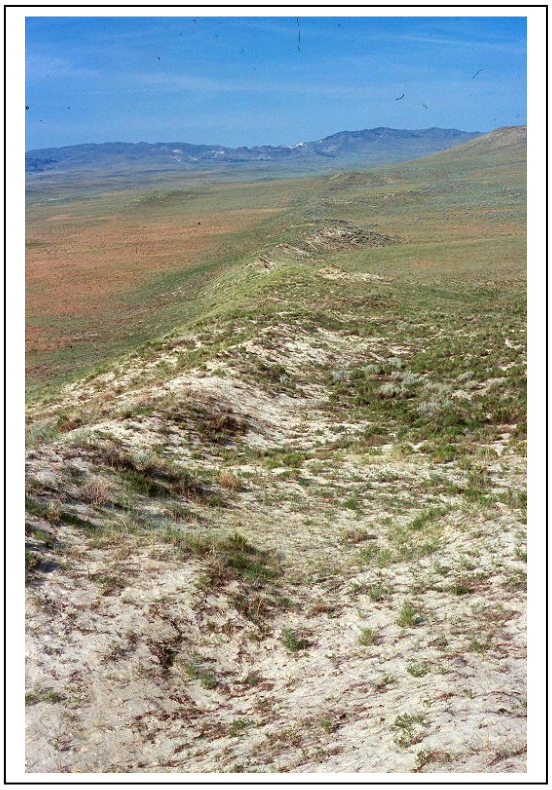


Figure 25. Linear dunes connect Bear Mountain (on horizon line) to Pathfinder dunes. The only blowout area between occupied habitats was surveyed. WYNDD photograph by B. Heidel.

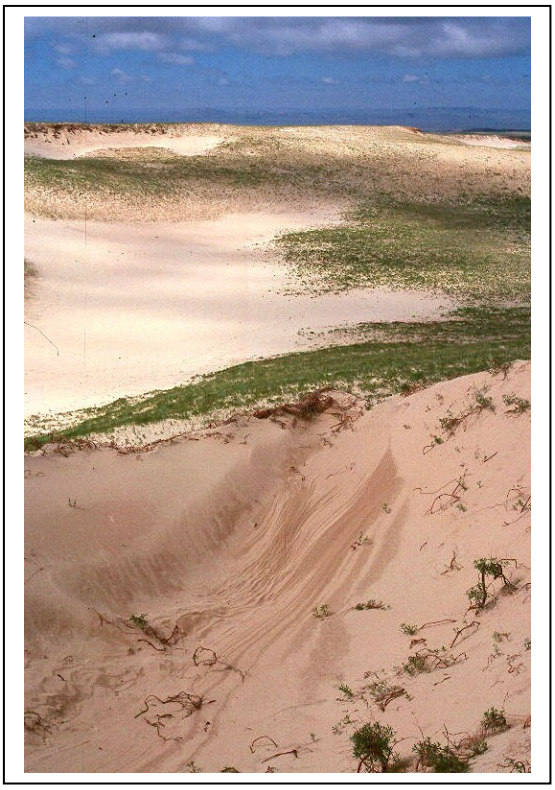


Figure 26. Another view of unoccupied habitat below Ferris Mountains. WYNDD photograph by B. Heidel.

The vegetation of *Penstemon haydenii* habitat is sparse (often less than 5%) and made up of sand-loving species. Fertig (2001) said:

> "…On unstable, windward slopes, Blowout penstemon may be found in communities of Blowout grass (*Redfieldia flexuosa*), Lemon scurf-pea (*Psoralidium lanceolatum*), and Thickspike wheatgrass (*Elymus lanceolatus* var. *lanceolatus*) with less than 5% vegetative cover (Table 2). Populations on more stable, lee slopes occur in similar communities with vegetative cover reaching 15-40%. Occasionally, populations may be found on choppy dunes associated with Silver sagebrush (*Artemisia cana*) and Thickspike wheatgrass, or on barren slopes above small stands of Chokecherry (*Prunus virginiana*) and Stinging nettle (*Urtica dioica*) associated with seep springs."

The following observations are added to this characterization. Dune colonization as found in *Penstemon haydenii* habitat is often pioneered by *Redfieldia flexuosa* (Figure 13). To a lesser extent, early-succession settings may also be dominated by other grasses like *Achnatherum hymenoides* (syn. *Oryxopsis hymenoides*), and locally, on relatively sheltered sites, by *Elymus lanceolatus*. In general, *Psoralidium lanceolatum* occurs throughout dune landscapes, but where it has high enough frequency in association with *Redfieldia flexuosa*, that plant association generally represents a stabilized pioneer dune community with little or no *Penstemon haydenii* present even though the vegetation is sparse. It is not known whether its nitrogen-fixing capacity affects habitat suitability. *Penstemon haydenii* is usually absent from settings with 15-40% cover, and is only locally associated with *Artemisia cana* on semi-vegetated sand mounds (Junk Hill; Figure 15), and with both *Prunus virginiana* and *Urtica dioica* on the lower fringes of steep dune slopes above springs (Bradley Peak).

The species associated with *Penstemon haydenii* are listed by Fertig (2001) and presented in Table 2. Except for the species mentioned above, the others are appeared to be in trace amounts or in peripheral zones that have greater vegetation development than occupied *Penstemon haydenii* habitat. The dominant grasses are very distinct when they produce heads, but some years they remain vegetative. A table comparing the vegetative characteristics of the four grasses commonly found in sand dunes is presented in Appendix F. These characteristics were used in 2004 surveys to document the prevalence of *Redfieldia flexuosa* in blowouts of both Rawlins and Casper field offices. It did head out, though not until the latter half of summer (i.e., after the Rawlins Field Office surveys, but during the Casper Field Office surveys). Almost all of the 33 blowouts surveyed had dominance by *Redfieldia flexuosa*, though the extent of it and complexity of successional vegetation varied greatly.

While the vegetation structure and dominant species of *Penstemon haydenii* habitat have similarities between Nebraska and Wyoming, a large number of associated species found in Nebraska are not present at the Wyoming sites. These species include *Cycloloma atriplicifolia* (Ringwing), *Physalis heterophylla* (Clammy groundcherry), *Polanisia trachysperma* (Clammyweed), *Muhlenbergia cuspidata* (Plains muhly)*, M. pungens* (Sandhill muhly)*, Eragrostis trichodes* (Sand lovegrass) and Yucca (*Yucca glauca*) (Fritz et al. 1992). A few of the associated Nebraska species that are absent from *Penstemon haydenii* habitat in Carbon County, Wyoming were noted during survey of the Casper dunefields, including *Cycloloma atriplicifolia, Muhlenbergia cuspidata, Polanisia trachysperma,* and *Yucca glauca*.

Table 2. Species commonly associated with *Penstemon haydenii* in Wyoming

Scientific Name	Common Name	Growth Form
Achnatherum hymenoides (Oryzopsis hymenoides)	Indian ricegrass	Perennial graminoid
Artemisia campestris var. *scouleriana*	Field sagewort	Perennial forb
Artemisia cana	Silver sagebrush	Shrub
Astragalus ceramicus var. *filifolius*	Painted milkvetch	Perennial forb
Calamovilfa longifolia	Prairie sandreed	Perennial graminoid
Chenopodium subglabrum	Smooth goosefoot	Annual forb
Cirsium canescens	Platte thistle	Perennial forb
Elymus lanceolatus var. *lanceolatus*	Thickspike wheatgrass	Perennial graminoid
Eremogone nuttallii (Arenaria nuttallii)	Nuttall's sandwort	Perennial forb
Heterotheca villosa var. *hispida*	Hairy golden-aster	Perennial forb
Lesquerella ludoviciana	Louisiana bladderpod	Perennial forb
Lupinus sericeus	Silky lupine	Perennial forb
Lygodesmia juncea	Rush-like skeletonweed	Perennial forb
Machaeranthera canescens	Hoary aster	Perennial forb
Oenothera nuttallii	Nuttall's evening-primrose	Perennial forb
Phacelia hastate	Silverleaf phacelia	Perennial forb
Psoralidium lanceolatum	Lemon scurf-pea	Perennial forb
Redfieldia flexuosa	Blowout grass	Perennial graminoid
Rumex venosus	Veiny dock	Perennial forb
Senecio spartioides var. *spartioides*	Broom groundsel	Perennial forb
Thermopsis rhombifolia	Round-leaved golden-pea	Perennial forb
Tradescantia occidentalis	Western spiderwort	Perennial forb

The complex dune landscapes of Wyoming survey areas indicate that there may have dune activity on a much larger scale in the geologic past. There have been no efforts to date dunes and their associated climates in Wyoming. Focusing on the present, we can chart out the multiple set of environmental attributes that may be factors in *Penstemon haydenii* distribution, and compare them for the occupied habitat in the two states. This exercise in comparing and contrasting the settings where *Penstemon haydenii* is present and absent is very preliminary, but it may help to make inferences on the relations between species ecology in Nebraska and Wyoming, and may be necessary in defining meaningful Section 7 guidelines for the species where it has not been surveyed in Wyoming.

Fertig (2001) postulated that the absence of *Penstemon haydenii* from the dunes in the broad valley between the Ferris and Seminoe mountains may be related to unavailability of soil moisture during the growing season. He suggested that the primary source of moisture throughout the valley dunes may be wind-blown snow and ice trapped in layers of insulating sand during winter. Accordingly, low spring and summer precipitation, coupled with high evapotranspiration rates and the natural porosity of the dunes, kept the low elevation dunes too dry to support *Penstemon haydenii* populations. Thus, only those dunes perched on the flanks of mountain slopes may receive enough supplemental moisture from local springs or additional runoff to maintain this species.

However, the ubiquity of wetlands scattered within and between the sand dunes of the broad valley setting may challenge this interpretation. Farther west, the Killpecker dunes are generally

characterized as having a high water table (Ahlbrandt 1973). Soil moisture comparisons have not been made between dunes that are occupied or not occupied by *Penstemon haydenii*.

It is interesting that there are patches in the broad valley setting where dunes have the identical vegetation attributes as occupied habitat of *Penstemon haydenii*. However, the dunes in the broad valley seem to have conditions that favor skewed vegetation patterns of stabilization on one hand, or loose, unconsolidated sand on the other. They do not have erosion augmented by the forces of gravity. The tension between stabilization and destabilization in the broad valley seems to favor the extremes rather than the intermediate states of flux, resulting in less vegetation mosaic.

Likewise, the apparent absence of *Penstemon haydenii* from the Casper dunefields calls for consideration. There are zones in the active dunes of Casper dunefields with the identical vegetation attributes as occupied habitat of *Penstemon haydenii*. However, the active blowouts in the Casper dunefield seem to have unidirectional forces and low complexity of successional vegetation, resembling the Rawlins Field Office dunes in the broad valley setting, rather than those flanking mountains and ridges. In general, it seems as though the presence of an extensive, discrete rim of sand dune pioneer plants may be an indication of conditions required by *Penstemon haydenii*. Those rims held together by a dense turf of root material (Figure 21) and those that have little or no rim, or widely-breached rims (Figures 22, 24), are not occupied.

Population Size and Trends: Rangewide, *Penstemon haydenii* is currently known from 13 extant indigenous populations locations in Nebraska in five counties (Stubbendieck and Kottas 2004; numbering app. 3,050 plants), and 18 extant transplanted population locations in Nebraska in eight counties (including overlap with three indigenous population sites; adding five more countiess; numbering app. 8050 plants). By contrast, Wyoming only has three populations in a corner of one county. However, the 2004 census results indicate that there are at least 6450 plants of *Penstemon haydenii* in Wyoming. (This is based on actual counts; though these counts are incomplete at the West Dune series, incomplete at the East Outlier dune, and wanting at the Upper Junk Hill dune.) The largest Wyoming population has 11 separate blowout areas spanning about 164.1 acres, in a scattered pattern over about an 8 square mile area. The population had at least 5900 plants in 2004. It is magnitudes larger than the other two *Penstemon haydenii* populations in Wyoming Only this population and the Bradley Peak population in Wyoming meet the *Penstemon haydenii* recovery standards of supporting a minimum of 300 individuals; 2004 census data is presented in Table 4.

Annual population census data are available rangewide, going back to 1985 in some Nebraska populations (Stubbendieck and Landholt 2001, Subbendieck and Kottas 2004). Survey marked the start of trend analysis in Wyoming. Efforts to census the largest Wyoming subpopulations began in 2001 (Blomquist and Heidel 2002, Heidel and Blomquist 2003, Heidel 2005). The population trend data in Wyoming is based on census figures for the two largest subpopulations over three consecutive years. It has yet to include the Bradley Peak population. The data is preliminary, suggesting that trends may be stable or increasing (Heidel 2005).

Long-term studies in Nebraska suggest that population size may fluctuate annually, depending on recruitment success and mortality (Flessner and Stubbendieck 1992; Fritz et al.1992, Fertig 2001). The first two survey visits to the Bradley Peak population were made by Fertig in 1999 and 2000,

and patterns of local losses between 1999-2000 were throught to be drought-related mortality (Fertig 2001). Historically, the Nebraska population has experienced a sharp decline. The exact reason for this decline is not known, although wildfire control, severe drought, improvements in range management (leading to reduced blowout production), leveling of sand dunes, and outbreaks of pyralid moths have all been identified as potential causes (Fritz et al. 1992).

Penstemon haydenii populations are being documented on digital orthophotographs in both Nebraska and Wyoming. This mapping elucidates the isolation of its habitat on the landscape. This mapping also serves to document the dynamics of population boundaries and dune morphology.

Population Biology and Ecology: The previously documented blowouts with *Penstemon haydenii* were censused in 2004, and the new blowouts have minimum counts that taken by traversing the center of the subpopulation, and then used for extrapolation (Table 3). The census conventions are recorded in Heidel (2005).

Table 3. Population information for *Penstemon haydenii* in Wyoming

Place	Occur. No.	Census Count[2]	Min. Pop. Est.	Max. Pop. Est.	Area (acres)
Bradley Peak Dunes	1	488	488	500	15.81
Junk Hill Main Dune	2	1729	1750	1800	63.72
West Dune 1 (western)	2	95	150	200	4.18
West Dune 2 (mid-north)	2	711	900	1200	6.54
West Dune 3 (mid-south)	2	603	800	1000	13.14
West Dune 4 (eastern)	2	16	25	50	7.85
Bear Mt valley Dune	2	24	24	30	1.13
Bear Mt East Dune (1)	2	1902	1902	1950	7.39
Bear Mt West Dune (2)	2	801	801	850	24.8
Bear Mt North Dune (3)	2	30	30	40	2.12
Upper Junk Hill Dune	2	~	(30)	(60)	~
East Outlier Dune	2	22	22	50	14.96
Pathfinder South Dune	3	19	19	35	0.92
Pathfinder North Dune	3	10	10	15	1.53
TOTAL	3	6450	6951	7780	164.09

[2] Complete analysis and discussion of 2004 monitoring and comparison with 2002 and 2003 results are presented in Heidel (2005). The largest of previously-documented subpopulations have ~ exhaustive counts. The "census" column represents the total numbers of individuals counted, the "minimum population estimate" column represents a conservative extrapolation if the census was not an exhaustive coverage of all potential habitat, and the "maximum population estimate" is a liberal extrapolation. Acreage figures are based on polygons that have been digitized onto orthophotos, with GPS points for reference for most. The number of browsed plants was subtallied from the number of flowering and nonflowering plants at the Bradley Peak and Pathfinder populations, but not at the Junk Hill-Bear Mountain population.

The occurrence numbers used for *Penstemon haydenii* throughout this report represent habitat-based delimitation of occurrences as a preliminary standard for treating populations or population complexes, without the benefit of additional information on genetics, dispersal, and pollination distances to date. They each represent occupied habitats separated by over 3 km from all other suitable habitats and are named by the nearest landmark. In addition, names have been added for each of the discrete blowouts of occupied habitat, which are thought of as subpopulations.

Penstemon haydenii plants are not evenly distributed across their habitat, but are instead found in sparse, non-random clusters that may correspond with habitat preferences, succession events, and chance dispersal. In Nebraska, density typically varies from 1 plant per square meter to 1-2 plants over several hundred meters (Fritz et al. 1992). In unusually favorable microsites in Wyoming, density can be 2-3 plants per square meter (Heidel 2005). Individual subpopulations may range from 10 plants to almost 2000 plants.

Penstemon haydenii flowers from May to early July in Nebraska and produces fruits from mid-June to mid-July. Occasionally, flowering may also occur from early August to early September (Fritz et al. 1992). Flowering in Wyoming occurs later than in Nebraska in the middle of June and usually extending to early July. Flowering is indeterminate (beginning at the base) and the very first flowers at Bradley Peak were beginning to open last year on June 10, 2004 (Blomquist personal communication). The late flowering in Wyoming compared to Nebraska is probably in response to drier and cooler climatic conditions. In the drought year of 2000, flowering apparently peaked in late June and less than 0.5% of all plants were still in flower on 7 July. There was peak flowering at the time of census 21-24 June, 2004 in the prolonged drought conditions. By contrast, flowering was at a peak on 3 July in 1999 (Fertig 2000), under moister conditions. In Nebraska, transplants have been observed in flower after 1 year of age, but most plants begin to bloom at 2-3 years of age (Flessner 1988).

Census of *Penstemon haydenii* subpopulations was conducted during the flowering period in 2002 and 2004, and it was observed that the ratio of flowering-to-nonflowering plants seemed to differ between subpopulations. It would also be expected to vary for individual plants over time. Demographic monitoring underway may help determine whether there are frequency- or climate-related patterns influencing whether individual plants flower from year-to-year. Census was conducted in late July in 2003 to see if there was any sign of fruit abortion that would point to pollination-limited reproduction. That year, a drought year, was one in which browsing was extreme, and almost all plants in the belt transect and the censused subpopulations were severely browsed so that few flowering stalks persisted.

Penstemon haydenii is most conspicuous when it is in flower, and it is recommended that survey be fosued during the 1-month window when it is in flower or fruit (3rd week June-3rd week July). If there are high levels of browse, then survey would ideally be conducted early. These are the recommended guidelines that accompany the monitoring report (Heidel 2005). Additional slide records are available for identifying *Penstemon haydenii* under all life history stages and levels of browse.

In Nebraska, *Penstemon haydenii* is pollinated mostly by four species of megachilid bees (*Hoplitis pilosifrons, Osmia distincta, O. cyaneonitens,* and *O. integra*), as well as wasps, ants, beetles, butterflies, and flies (Lawson et al. 1989). The plant is primarily an out-crosser, although experimental studies show that it is potentially self-fertile (Flessner and Stubbendieck 1992). Some inbreeding depression (lower mean number of fruit and seed and reduced mean seed weight) is evident in experimentally selfed plants (Flessner and Stubbendieck 1992). Three insects were photographed and two others observed on *Penstemon haydenii*, including a vespid wasp that appeared to be in the act of pollinating, a bumblebee (*Bombus* spp.) that visited yellow-flowered plants (*Thermopsis, Cryptantha*) more frequently than *Penstemon haydenii*, a megachilid bee (*Osmia* spp.), a moth (*Euxoa aurulenta* Smith) that remained sedentary in the flowers as apparent shelter from the wind (identification determination by Cliff Ferris), and a fly. The moth was collected and may represent a new state record (Scott Shaw, UW entymology cvurator, personal communication; and USGS Moths of North America homepage).

There were no signs of symbiotic relations with *Penstemon haydenii*, and it is characterized as only marginally dependent on mycorrhizae (Flessner and Stubbendieck 1992). A fungus infecting flowers was noted in 2004, but had no apparent affect on flowering activity.

Kangaroo mice and deermice have been identified as consumers of *Penstemon haydenii* seed in Nebraska (Stubbendieck et al. 1993) and mice sign were present in occupied Wyoming habitat. This was particularly evident as mice middens of sprouted seeds (less than 2 cm tall; possibly *Achnatherum hymendoides* seeds; Heidel 2004 personal observation). Other big game, upland game, small mammal and insect observations were made and suggest high levels of wildlife use of the dune habitat though not necessarily interactions. Fritz et al. (1992) suggested that the species might be dispersed by animals, as well as by wind-dispersal. The winged seeds are adapted for wind dispersal.

Each fruit contains an average of 25-35 seeds and as many as 1500 seeds may be produced by each plant. Seeds are released from late August to September and either fall near the parent plant or are dispersed by wind or animals (Fritz et al. 1992; Stubbendieck et al. 1997). *Penstemon haydenii* seeds have thick seed coats containing leachable chemical inhibitors. The seeds are often buried in shifting sand and can remain viable in the seedbank for 20 years (Stubbendieck et al. 1997). Prolonged wet conditions and abrasion are required for breaking dormancy and seed germination (Flessner 1988). Additional carryover mechanisms exist to regulate water uptake and germination of seeds, thus preventing the entire seed pool from germinating at once under seemingly favorable conditions (Caha et al. 1998). Despite potential inbreeding due to limited pollen exchange between isolated populations, *P. haydenii* seeds have a 90% germination rate under experimental conditions following seed coat scarification (Stubbendieck et al. 1982; Flessner 1988). Under natural conditions, seedling production is exceedingly low due to high levels of insect and rodent predation, plant pathogens, and unfavorable climatic conditions (Caha et al. 1998). Good seedling establishment may only occur every 8-10 years (Stubbendieck et al. 1997).

In 2003 and 2004, seedlings of *Penstemon haydenii* were observed. The presence or vestige of the cotyledon was the primary indication of the seedling stage, and seedlings tended to have similar size and occupy similar zones on a local scale. There were less than 100 seedlings included in 2004

census tallies. They were included among the vegetative plant tallies, but it is recommended that they be tallied separately from established vegetative plants in the future. Almost all were restricted to the bottoms of blowout depressions, and the highest numbers were in the series of blowouts west of Junk Hill. Comparison of Bradley Peak photographs taken in 2000 (Figure 8, in Fertig 2001) shows that this blowout crater that once had grass cover in 2000 had no grass cover in 2004 but supported 31 seedlings of *Penstemon haydenii*. Seedlings generally had only 2-4 leaves besides those of the cotyledon (Figure 6), and plants were less than 4 cm tall. There were also flushes of seedlings of *Psoralidium lanceolatum* found in dune blowouts during 2004 surveys, and they had overall similar stature and growth form. The leaves of the latter tended to have a slightly different leaf outline and a glandular-pocked surface, and the local distribution of seedlings for the two species was not observed to overlap within blowout craters.

The available demographic information and life history information for *Penstemon haydenii* to date are based on greenhouse information (Flessner and Stubbendieck 1989), experimental transplant experiments (Stubbendieck et al. 1993), and field observations. Seedling germination is enhanced by cold-moist stratification, a treatment that simulates overwintering conditions. Hand-scarification and scarification under sulfuric acid treatment greatly enhanced germination, indicating that mechanical treatment of the thick seed coat enhances germination (Flessner and Stubbendieck 1989), and wind abrasion by sand particles may serve the purpose. Seedlings become established with the development of a taproot. The growth rate of *Penstemon haydenii* seedlings is conditioned by nutrient levels, and high growth rates are prolonged by mechanical injury to the apical meristem, stimulating axillary shoots (Flessner and Stubbendieck 1989b). *Penstemon haydenii* seedlings transplanted into blowout zones had a high initial mortality in all but the blowout depression settings, where median life-span of first-year survivors ranged from three years (Thomas County) to six years (Cherry County). The authors concluded that *Penstemon haydenii* is rather short-lived, with a complete cycle from seed deposition to plant death occurring within 5-10 years (Stubbendieck et al. 1993).

Statements have been made that *Penstemon haydenii* reproduces primarily by rhizomes (Fritz 1992; citing Stubbendieck et al. 1983, 1984; Flessner and Stubbendieck 1989, and Stubbendicek and Weedon 1984). Further research showed that vegetative reproduction is not important compared to sexual reproduction (Stubbendieck 2001). Instead, axillary root branching may be more of a survival adaptation and function of vigor rather than a reproduction mechanism, to survive burial by wind-blown sand. Observations of adventitious roots in the field indicated that they have a primary anchoring function (Figure 4). Observations of axillary root branching were made by excavating around flowering stems in close proximity to evaluate how to differentiate individuals when doing census. The differentiation depends whether the plant has been subject to burial or excavation by wind, and whether the axis of flowering stems appear to converge below ground. But in general, flowering and nonflowering stems (ramets) that are not buried or eroded out, converging at a subterranean axis and within about 15 cm were interpreted to represent the same individual (genet). If vegetative reproduction were widespread, then some guidelines would have been needed to convery census counts of *Penstemon haydenii* clumps to genet counts. We did not find evidence of long-distance connectivity in digging around plants (Figure 5).

Caha et al. (1998) studied genetic variability in mitochondrial and chloroplast DNA from a subset of Nebraska populations of *Penstemon haydenii*. Although no difference could be detected in chloroplast DNA, at least 8 distinct markers were found in mitochondrial DNA, indicating a greater amount of genetic variability than would be expected in an inbreeding population. This variability could be due to high levels of gene flow between populations in the past. Such gene flow is no longer possible in today's fragmented landscapes. Intrapopulational genetic diversity may also be enhanced by the long-lived seed bank of this species, which allows new cohorts of seedlings to contain a mix of ages and genealogies (Caha et al. 1998). The genetic structure of the Bradley Peak population was recently being investigated by Dr. Allen Szalanski of the University of Nebraska using leaf tip samples collected by Frank Blomquist in 1999. Preliminary results in early 2000 found little divergence between this population and others sampled in Nebraska (Gerry Steinauer, personal communication).

Flower traits are conservative in most plant families, and the previously-undescribed variation in flower morphology documented in this report, as evidenced primarily by the presence of both glabrous and hairy staminodes within populations, is indication that further analysis of genetic variation and relationships may be warranted.

Current Management: Wyoming populations of *Penstemon haydenii* occur on lands managed by the BLM Rawlins Field Office and the State of Wyoming in two allotments, on two pastures each. At the Pathfinder occurrence, the BLM tract lies within the oversight boundaries of the Bureau of Reclamation. The fringes of subpopulations at Bradley Peak and Junk Hill may extend onto privately-owned tracts.

Under the update proposed for the Great Divide Resource Area Management Plan/ Rawlins Resource Management Plan (USDI Bureau of Land Management in progress), the BLM lands are proposed for Area of Critical Environmental Concern designation. There is also a statewide biological assessment that is in progress for Threatened and Endangered plant and animal species on BLM lands (Jeff Carroll personal communication 2004). Finally, there is a *Penstemon haydenii* conservation assessment that is in draft form whichs links all other planning documents together and to current status information. Thus, the current management is under review.

In Nebraska, *Penstemon haydenii* is protected at three sites of indigenous populations in the Valentine Lake and Crescent Lake national wildlife refuges and the Samuel R. McKelvie National Forest (administered by Nebraska National Forest). Protected populations also occur at Ballard's Marsh Wildlife Management Area (managed by the Nebraska Game and Parks Commission) and The Nature Conservancy's Graves Ranch (Gerry Steinauer, personal communication; Stubbendieck and Kottas 2004). Both national wildlife refuges and the national forest are also sites of transplanted populations, and the West Central REC site may be a nursery setting. All other known indigenous and transplanted populations are on private or state lands managed primarily for agriculture (Fritz et al. 1992).

Existing and Potential Threats: The following threats have been identified for this species in the literature (Fritz et al. 1992). Wyoming observations have been added by Fertig (2001) and the author during the course of survey and monitoring. Potential threats include mineral development,

water resources development, impacts from ORV recreation, oil and gas leasing, and over-collection. Potential threats may be associated with natural succession, fire suppression, erosion-minimizing grazing rotation practices, pesticides, and insect predation.

Mineral Claims: Sand quarrying occurs southeast of the Seminoe Mountains near the Seminoe Road, a paved county road that provides access to Seminoe Reservoir and Seminoe Dam. Sand removed from the area is used for golf courses, salt mix for road sanding in the towns of Sinclair and Rawlins, and at the City of Rawlins asphalt plant. Sand deposits in *Penstemon haydenii* habitats are distant from this activity and seem impractial at present due to the isolated location (over 7 miles from primary unpaved county roads coming from the north and east, and at least 15 miles from primary county roads from the west), rugged terrain, and limited access. Changes to access could affect the economics of sand quarrying.

In the early 1980's, an individual came into the BLM Rawlins Field Office inquiring about sand from the Seminoe Road area for glass production. Tests revealed that the clay content of the samples made it unsuitable (Mark Newman, BLM Geologist personal communication to Frank Blomquist). It is not known whether the sand deposits in *Penstemon haydenii* habitat are suitable for these or other uses.

The Seminoe Mountains to the south of *Penstemon haydenii* populations have mineral deposits of iron, copper and gold (Hausel, in Roberts 1989). In addition, dune systems often contain wind-worked rock (ventifacts), sometimes including chert.

Sand quarrying is discretionary and does not go through a permitting process like other mineral activity on BLM lands.

Water Development: Unimproved ponds and springs are present at the base of occupied *Penstemon haydenii* dunes at Bradley Peak, Bear Mountain and Junk Hill. They are water sources for livestock. There are little or no prospects for creating cultivated fields and central pivot irrigation in the vicinity of known Wyoming populations as there are in Nebraska. But water developments could potentially concentrate the levels of livestock grazing to directly or indirectly influence *Penstemon haydenii* habitats.

Oil and Gas Leasing: Oil and gas leasing occurs less than 5 miles west of the Bear Mountain – Junk Hill occurrence near the Ferris townsite. There are no oil and gas explorations in the vicinity of the three populations. Addition of no-surface-occupancy stipulations would help provide safeguards if there should be expansion into the vicinity.

Off-road Vehicles: The sand dune habitats of *Penstemon haydenii* in Nebraska are often popular for off-road vehicle (ORV) recreation, especially on state and public lands where access is not as stringently regulated as on private lands. Hill-climbing and other ORV activities can accelerate natural erosion, sometimes in excess of any plant colonization. Driving over the plants leads to high mortality (Fritz et al. 1992). This is particularly true for ORV when there are multiple ORV vehicles at a time or repeated ORV use along the same course.

The Wyoming populations are relatively remote at present. ORV tracks were noted twice in 2004 surveys, and were noted once in 2003 census. Leasees might be asked to avoid parts of the dunes when traveling by ORV. One of the three incidents was clearly a case of a local rider traveling through the dune for non-recreational purpose. One incident seemed to be a drive directly to the dune though there were no trail patterns that indicated recreational use, and there have been no botany visits made by ORV. The third incident seemed to involve ORV play in the bottom of a dune blowout crater, a locale where there were no *Penstemon haydenii* plants in the bottom but the species were located on the rim above. BLM recreation planners should be made aware of the possible impacts to these populations from ORV use in all recreation and transportation planning.

The public road access to all three population sites is limited, via county and BLM roads. They all require walking 0.25-1 mile to access the blowouts. Vehicular travels on BLM lands are limited to existing roads, which helps maintain the dune habitats.

Changes in Habitat Quality: Historically, fire and grazing by bison and livestock helped maintain the blowout habitat of *Penstemon haydenii* by removing sand-stabilizing vegetation. The implementation of fire-control policies in the 1870s following white settlement, elimination of bison, initiation of soil conservation programs, and increased usage of rotational grazing systems have reduced the influence of wind erosion in maintaining early-succession habitat, resulting in the loss of *Penstemon haydenii* habitat and a reduction in its population size in Nebraska (Fritz et al. 1992). The prospect of habitat stabilization in Wyoming under current management is limited at least in part due to its topographic settings where *Penstemon haydenii* occurs.

Habitat quality could be degraded in Wyoming by introduction of noxious weeds, exotic species in general, and native species that increase under disturbance. There are few vectors for weed introductions at present.

Livestock Trampling and Grazing: *Penstemon haydenii* is edible to cattle and horses, but is not preferred forage if other vegetation is available (Fritz et al. 1992). In Nebraska during non-drought conditions, grazing on *P. haydenii* is minor and confined mostly to occasional shoots. Such grazing can be stimulatory in breaking apical dominance (Fritz et al. 1992). When other forage is severely limited, as during drought conditions, severe grazing damage can occur (the entire above-ground portion of the plants may be eaten).

In Wyoming, the open sand dune setting of *Penstemon haydenii* has limited livestock use, and the greatest potential are at the base of the dunes adjacent to water sources such as ponds, spring seeps, and wetlands. Cattle currently graze both allotments, but up until 2002, the allotment that included the Bradley Peak occurrence was grazed by sheep (Frank Blomquist personal communication 2004).

The *Penstemon haydenii* data for all Wyoming populations apart from the Bradley Peak population have been limited to the past five years (2000-2004). This period represents one

of the three major drought periods in the last century of record-keeping, as determined from a review of Palmer Drought Severity Index for Region 10 of Wyoming (USDI NOAA 2005). Stem damage from grazing or browsing was observed on nearly 10% of the population at Bear Mountain and Junk Hill in 2000 and on 60-80% of stems at Bradley Peak in July 2000. Much of this herbivory may have been due to elk or mule deer based on the abundance of their tracks, rather than domestic stock, which seem to prefer the adjacent wet, grassy meadows to the barren dunes (Fertig 2001). The recent change in livestock operation, the local wildlife patterns of use, and the climate extremes of recent years pose a challenge in interpreting these observations.

In 2003, census was conducted in late July in a drought year. Pronghorn were present in *Penstemon haydenii* habitat on Junk Hill and livestock were present at a wetland below the Junk Hill subpopulation. The hypothesized interpretation of wildlife browse as the primary source of herbivory in 2000 and 2003 drought conditions was supported in 2004, when census was conducted in late June during flowering before livestock arrived in Bradley Peak area and Bear Mountain – Junk Hill area. Elk were noted as consistently seeking out *Penstemon haydenii* plants on Bear Mountain as evidenced by their tracks and patterns (Erwin personal communication). A pronghorn was observed browsing on *Penstemon haydenii* in the Pathfinder population, which had the most pervasive and severe levels of browse. It also had pronghorn tracks throughout. Only three of the 29 plants plants observed at Pathfinder were unbrowsed, and generally all stems of each plant were browsed (i.e., almost 90% browse; Figure 34). It is not known whether prolonged browsing can indefinitely favor vegetative sprouting, or ultimately curb reproductive output but the levels of browing are likely to reflect drought conditions.

The sparsely-vegetated sand pioneer communities that support *Penstemon haydenii* are basically in excellent range condition because they receive little use. There is a slight shift toward "increaser" species (native species that increase under disturbance) at the Pathfinder blowouts, smallest of *Penstemon haydenii* populations. There is also a shift in species composition at the lower fringes of Bradley Peak associated with heavy use of the spring-fed meadows directly below. Due to the sparse distribution of this plant and its shifting substrate, trampling damage is rarely significant (Fritz et al. 1992).

It would be appropriate to include terms to the allotments that mineral supplements or feed supplements are placed away from *Penstemon haydenii* habitat, and that all hay or other feed brought into the allotment be certified weed-free.

Over-collection: Many rare penstemon species are vulnerable to over-collection for seed or garden stock. Small populations near state highways are considered especially vulnerable to this threat in Nebraska. Specific site locations have been kept confidential to reduce the threats from overharvest (Fritz et al. 1992). The Wyoming populations appear to be relatively isolated and inaccessible to protect them from over-collection at the present time. However, it is still appropriate that species' location be treated as sensitive by WYNDD pending release of a popular article on *Penstemon haydenii*. This sensitive status precludes

posting of location data in reports and distribution of location data to data users except upon special request.

Pesticides: The direct impact of herbicides on *Penstemon haydenii* is not known, although the plant is probably vulnerable to broadleaf weed killers (Fritz et al. 1992). Due to the sparse cover of its habitat, herbicide application rates are minimal in Nebraska and are not known in Wyoming at present. The use of insecticides to combat range pests (such as grasshoppers) is a potential threat to the pollinators of this species.

Construction Activities: Construction of permanent roads within the occupied habitat of *Penstemon haydenii* is unlikely to be a threat due to the unsuitability of shifting sand as a road surface. Powerlines and pipeline construction could have short-term impacts if plants are uprooted during the building phase, though they may pose significant long-term threats that are secondary (destabilization, exotic species invasion, access development resulting in recreational use). Home construction is unlikely given the unstable substrate.

Natural Threats: Natural succession, in which formerly shifting dunes and blowouts become stabilized with a cover of prairie grasses, is a potential threat to existing populations of *Penstemon haydenii* in Nebraska. At the other extreme, extensive drought, such as the Dust Bowl drought of the 1930s, has been suspected as a cause of the serious decline of this species in the early 20th century. While drought could create new habitat by killing grass cover and making sites more prone to erosion, *Penstemon haydenii* may be vulnerable to prolonged water stress. Insect outbreaks may also pose a threat. *P. haydenii* is preyed upon by spider mites, grasshoppers, penstemon aphids, and *Endothenia hebesana* (a seed predator) (Fritz et al. 1992). The most serious pest is probably the larvae of pyralid moths, which bore into the stems and rootcrowns of *Penstemon haydenii* to pupate and can cause 75% mortality (Stubbendieck et al. 1997). Fungal root rots can also cause death through wilting (Fritz et al. 1992).

In Wyoming, there is limited basis for otherwise evaluating the natural threats of succession or drought. If there are historic aerial photographs of the area, it would be constructive to document the patterns and extent of currently-occupied blowouts. The past five years (2000-2004) represent one of the three major drought periods in the last century of record-keeping, as determined from a review of Palmer Drought Severity Index for Region 10 in Wyoming (USDI NOAA 2005). There have been no apparent signs of water stress among *Penstemon haydenii* plants noted during June and July visits over the past three years (2002-2004). It is possible that wind erosion has been exacerbated under drought conditions. A habitat photograph of one of the previously-occupied Bradley Peak blowouts taken in 2000 (Figure 8 in Fertig 2001) is evidence of change, because this same blowout bowl has filled in between 2000-2004, and was a site where seedlings appeared in 2004. Direct observation demonstrates that uninterrupted blowout rims in Junk Hill Main and the East Outlier have been breached, resulting in local burial and eroding out of *Penstemon haydenii* plants (2002-2004) that appear to have resulted in localized mortality, though net affects are unknown.

The previous pages with their summary of current management and existing or potential threats make it clear that there is a benefit in communication between states, and a compelling need for coordination within and between agencies, and collaboration among all parties.

USFWS Recovery Plan: The US Fish and Wildlife Service recovery plan for *Penstemon haydenii* (Fritz et al. 1992) has provided a framework for research into the life history and management needs of this species in Nebraska for over two decades. The primary goal of the recovery plan is defined in terms of reaching a stable population threshold of at least 15,000 individuals in 10 population groups (each with a minimum of 300 plants at the lowest ebb of a population cycle). To reach this goal in Nebraska, one of the tasks identified was to reintroduce new populations into the historic range of the plant. A minimum level of protection was also identified as a need for each of the target populations (Fritz et al. 1992).

The discovery of new *Penstemon haydenii* populations in Wyoming, well outside its' presumed historic range, may be significant for the protection and future downlisting or de-listing of this species (Fertig 2000, 2001) because the status of plant species is determined rangewide under the Endangered Species Act. The existing recovery plan apparently remains the framework for determining species' recovery status, although there is a double challenge of updating it to address the progress in Nebraska recovery efforts as well as the initial Wyoming status information. There may be fundamental revisions needed if there is genetic differentiation between Wyoming and Nebraska populations, as suggested by 2004 field observations of divergent flower traits that have not previously been reported. Not all of the recovery tasks may be relevant in Wyoming, e.g, reintroduction may not be appropriate if *Penstemon haydenii* is not known from a broad distribution in Wyoming or with documented decline.

The planning processes that are currently underway, including the Great Divide Resource Area Management Plan/ Rawlins Resource Management Plant, the statewide biological assessment for Threatened and Endangered species on BLM lands in Wyoming, and in the *Penstemon haydenii* Conservation Assessment by the Bureau of Land Management, are essential to setting the stage for recovery in the Wyoming portion of *Penstemon haydenii* distribution. These agency planning activities are separate from this survey report, but they may have bearing in ameliorating species' threats and in future determinations of species' status under the USFWS Recovery Plan.

SUMMARY

The biogeography of this species, previously considered endemic to Nebraska, and the circumstances of its Wyoming discovery after listing and recovery plan development, are highly unusual. The US Fish and Wildlife Service developed a recovery plan for Nebraska populations with the goal of protecting at least 15,000 individuals at 10 different sites. The discovery and monitoring of new populations in Wyoming, and their protection, may help attain these rangewide goals. The existing recovery plan apparently remains the framework for determining species' recovery status, though text updates may be appropriate and revisions may be needed particularly if there is evidence of genetic differentiation between states as suggested by 2004 field observations of divergent flower traits.

In order to decide how the *Penstemon haydenii* information from Wyoming fits into the recovery plan, it may first be appropriate to further investigate if there are genetic distinctions between Nebraska and Wyoming populations. It may also be appropriate to compile data on the species' habitat attributes and population attributes at each occurrence and in a standard format for direct comparisons within and between sites of both states.

The results of this survey broaden the *Penstemon haydenii* information base and highlight some of the information gaps. The addition of new subpopulations around Bear Mountain and Junk Hill underscores previous statements about the significance of this population (Fertig 2001), because it is magnitudes larger than the other two Wyoming populations when surveyed in 2004, and comprises a significant share of rangewide species' numbers. Its status and trends are a priority for further consideration. In particular, complete enumeration of population numbers in its "new" western blowouts and multi-year documentation of its trends are priorities for further consideration. The results of this survey might be applied in refining Section 7 guidelines for *Penstemon haydenii* in Wyoming and used to define the requisites for determining presence/absence. Completion of the multi-year monitoring in Wyoming, tentatively slated for 2007, will require a final trend analysis.

The indirect results of this survey include evidence of variation in flower morphology within subpopulations that slightly modifies the species description and may signify as-yet undocumented genetic variation. The results also include report of a possibly new addition to the moth fauna, other photographs of insect visitors, photographs and notes about many animal signs, and report of a widespread by unreported plant association dominated by *Redfieldia flexuosa*. The observations indicate that there may be other biological significance associated with occupied habitat of *Penstemon haydenii* if not dunefields in general.

In the upcoming 2005 monitoring of *Penstemon haydenii*, it is recommended that all occupied dune areas (polygons) that have not been mapped have GPS points recorded to delimit the extent of the subpopulation. The use of digital orthophotos in the field and in distribution documentation provides a new level of detail in distribution documentation. All high priority dunes of the Casper dunefield that are located entirely on public land were surveyed in 2004, so there are not priorities for expanded or followup surveys. One more dune area in the Ferris Mountains vicinity is recommended for survey. The west (upwind) end of the Killpecker Dunes (Rock Springs Field Office) has had limited-scale surveys but may warrant expanded surveys. Likewise, the dune fields in the Lander Field Office have had limited-scale survey, representing the west (upwind) end of the same sand deposits that are found in the Casper Field Office.

The discovery of *Penstemon haydenii* in Wyoming initially raised the possibility that the species may be more widespread and thus less imperiled than previously thought (Fertig 2001). The negative survey results from the Casper dunefields reduce the likelihood because these are the single largest intervening dunefields between Nebraska and Wyoming populations. It is recommended that this survey report be updated and expanded as a status report benchmark to include trend analysis when it becomes available, recovery information and review of Section 7 criteria pertinent to Wyoming if not otherwise available, management information from agency planning documents, and updated review of information on the species and its status in the state as new information becomes available.

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