



Distribution and Abundance of Lemhi Penstemon (*Penstemon lemhiensis*) at Big Hole National Battlefield— 2009 Inventory Report

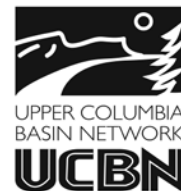
Natural Resource Technical Report NPS/UCBN/NRTR—2009/239



ON THE COVER

Penstemon lemhiensis ((Keck) Keck & Cronq.) in bloom, Big Hole National Battlefield (BIHO), Montana
NPS Photograph courtesy of the Upper Columbia Basin Network

Distribution and Abundance of Lemhi Penstemon (*Penstemon lemhiensis*) at Big Hole National Battlefield—2009 Inventory Report



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Abstract

As part of the Upper Columbia Basin Network's efforts to complete biological inventories, we censused the rare endemic *Penstemon lemhiensis* in Big Hole National Battlefield during 2007 and estimated the population from a sample in 2009. This report details our current understanding of the distribution and abundance of *P. lemhiensis*, based on these efforts. We also present the results of additional searches that were conducted in 2009 in other roadcuts and exposed slopes elsewhere in the Battlefield. In 2007, our census resulted in the counting of 520 mature plants with inflorescences. In 2009, we sampled from two discrete sampling "frames" and estimated the populations of plants with rosettes (excluding seedlings) from the two Battlefield hillslopes (the "Howitzer Hill" and adjacent road cut, and "Horse Pasture") to include 512 and 873 plants, respectively. *P. lemhiensis* appears to be restricted to these two areas on the west side of the Battlefield above the North Fork Big Hole River. Small patches of apparently suitable habitat, including roadcuts and exposed slopes elsewhere in the Battlefield, were unoccupied by the species in 2009. An area behind the park visitor center where a small population existed in 1982 (Ramstetter 1983) has apparently been extirpated. Spotted knapweed (*Centaurea beibersteinii*), a potential competitor, was found in several small patches of the Battlefield, but was not widespread in *P. lemhiensis* habitat. This report also documents methods used to survey the species, and provides recommendations for future inventory and monitoring efforts.

Introduction

Lemhi penstemon (*Penstemon lemhiensis* (Keck) Keck & Cronq.) is a short-lived (approx 5-6 years) perennial penstemon from the Family Scrophulariaceae (Hitchcock 1973, Elzinga 1997). The species is endemic to Lemhi County in eastern Idaho and 4 counties in southwest Montana (Elzinga 1997, Heidel and Shelly 2001), including Beaverhead County where Big Hole National Battlefield (BIHO) is located. The species is known from only 191 occurrences, 102 of which are in Idaho, and 89 are in Montana (Heidel and Shelly 2001). Over 50% of these populations are made up of 30 plants or less (Heidel and Shelly 2001). There are only three large population sites with over 300 plants (Elzinga 1997). One of these occurs on the Big Hole National Battelfield (BIHO), which may contain the largest known aggregation of the species (Elzinga 1997, Heidel and Shelly 2001). *P. lemhiensis* is listed as a sensitive species by the US Forest Service and the Bureau of Land Management, and is ranked G3 and S3 (rare but not imperiled with 21-100 occurrences in the state) by the Montana Natural Heritage Program (Montana Natural Heritage Program 2006).

P. lemhiensis occupies an unusually wide range of habitat types considering its endemic status. It is most notably associated with steep, sparsely vegetated slopes of southerly aspect in sagebrush steppe but it also occurs among openings and along the edges of coniferous forest (Ramstetter 1983, Elzinga 1997). Many of the extant small populations are in road cuts (Elzinga 1997). Bare soil microsites are apparently required for germination, and the species appears to be vulnerable to competition from other vegetation, including grasses and shrubs that increase into microsites over the course of natural succession (Ramstetter 1983, Heidel and Shelly 2001). Heidel and Shelly (2001) demonstrated that the species responded favorably to prescribed fire, presumably because litter and competing vegetation were removed. Competition from spotted knapweed (*Centaurea beibersteinii*) has also been reported from some locations, and *P. lemhiensis* population declines have apparently been severe in some infested areas (Elzinga 1997). Other potential threats to the species include herbicide application, especially to roadcut populations, grazing and browsing by ungulates, and soil disturbance associated with road maintenance, logging, or other anthropogenic activities (although disturbance may also create new habitat; Elzinga 1997). Elzinga (1997) reported that many monitored populations exhibited declines in the years preceding her report, but Heidel and Shelly (2001) noted that the species' risk of extirpation was buffered by seed bank persistence of up to six years. *P. lemhiensis* is capable of large population fluctuations, and it is not clear whether putative declines reported in the 1990's were monotonic or part of long-term population dynamics (Heidel and Shelly 2001).

Given the large, globally significant population sizes at BIHO, and the potential declines reported elsewhere in the species' range, documenting the distribution and abundance of *P. lemhiensis* at BIHO is important. Park management activities, including the thinning and removal of lodgepole pine (*Pinus contorta*) trees recently infested by mountain pine beetle (*Dendroctonus ponderosae*; J. Lyon, personal communication) and the absence of fire, pose risks to the populations. The BIHO populations have not been well studied (but see Ramstetter 1983) and were only cursorily addressed by Elzinga (1997). Describing the current distribution and abundance of the species at BIHO will provide an important baseline for future comparison, and

will provide the necessary information for park managers to avoid adversely impacting the populations.

The objective of our inventory was to describe and map the distribution and abundance of *P. lemhiensis* in BIHO. Because of the difficulty in detecting seedlings (Elzinga 1997), we restricted our scope of inference to populations of plants with basal leaf rosettes (i.e., seedlings were excluded). The 2007 census, which involved the use of student citizen scientists from the Oregon Museum of Science and Industry, was further restricted to flowering plants, which are particularly conspicuous. We also were interested in collecting sufficient pilot data for use in future monitoring protocol development, should the UCBN decide to pursue a *P. lemhiensis* monitoring program in BIHO.

Methods

Plant Identification

P. lemhiensis is a robust penstemon that can grow up to 70 cm tall (Figure 1). Each plant can have one to multiple basal rosettes growing from a branching caudex. Inflorescences are robust and persistent, and grow from an individual rosette resulting in an opportunity for multiple flower stems to be present on one plant. Mature plants are conspicuous and, with training, easily distinguished from other penstemon species in the area. The leaves of the gentian, whitestem fraseria, (*Frasera albicaulis*) present the closest superficial resemblance to *P. lemhiensis* in our study area (Figure 1), but are immediately recognizable upon close inspection.

The leaves of *P. lemhiensis* are distinctive from other similar looking plants in the park, and are typically finely hirtellous-puberulent, but sometimes glabrous or merely cinereous along the margins. Leaf margins are entire and basal leaves are clustered, 3-20 cm long and 1-2.5 cm wide, and petiolate. The leaf blade is oblanceolate to narrowly elliptic. Cauline leaves are sessile, opposite, lanceolate, 2-12 cm long, 0.5-2 cm wide and generally becoming progressively smaller above. The inflorescence is glabrous. Verticillasters are 3 to many, and more or less secund. The calyx is 7-11 mm long, segments are lanceolate to narrowly ovate, and evidently but not strongly scarious-margined below, tapering to a long acuminate or subcaudate tip about as long as the body. The corolla is bright blue to purplish, 40-55 mm long, and about 1.5 mm wide at the mouth. Pollen sacs are 1-3 mm long, divaricate and sometimes sigmoidally twisted, evidently dentate-ciliolate along the sutures, pubescent near the connective and on the side opposite the dehiscence. The staminode is glabrous, a distinctive characteristic among penstemon in the region. The fruits are capsules 10-15 mm long, and seeds are 2-3 mm long. (Description compiled from Keck 1940, Hitchcock et al. 1959, Dorn 1984, Elzinga 1997).

Study Design

2007

The UCBN conducted a pilot study in June, 2007 at Big Hole National Battlefield with the help of student citizen scientists from the Oregon Museum of Science and Industry. Prior information available from park staff on the current distribution of *P. lemhiensis* at BIHO suggested the

species was restricted to two main hillslope areas at the Battlefield, the Horse Pasture and the Howitzer Hill, as well as along the roadcut at the bottom of the Howitzer Hill (Figure 2). Students and NPS staff trained together at the start of the effort to learn how to recognize mature flowering plants, which are conspicuous and not easily confused with other species of plants in the area (Elzinga 1997). Observers worked together to census both the Howitzer Hill area (including the roadcut) and the Horse Pasture by spacing across slopes in 10 m gaps, to ensure all plants were counted. Dell Axim PDA units were used to enter records as each plant was encountered, and bluetooth Holux GR-230 GPS units, coupled with ArcPad GIS software (version 7, ESRI, Redlands, CA), was used to collect the UTM coordinates for each plant (UTM zone 12, NAD 83 datum).

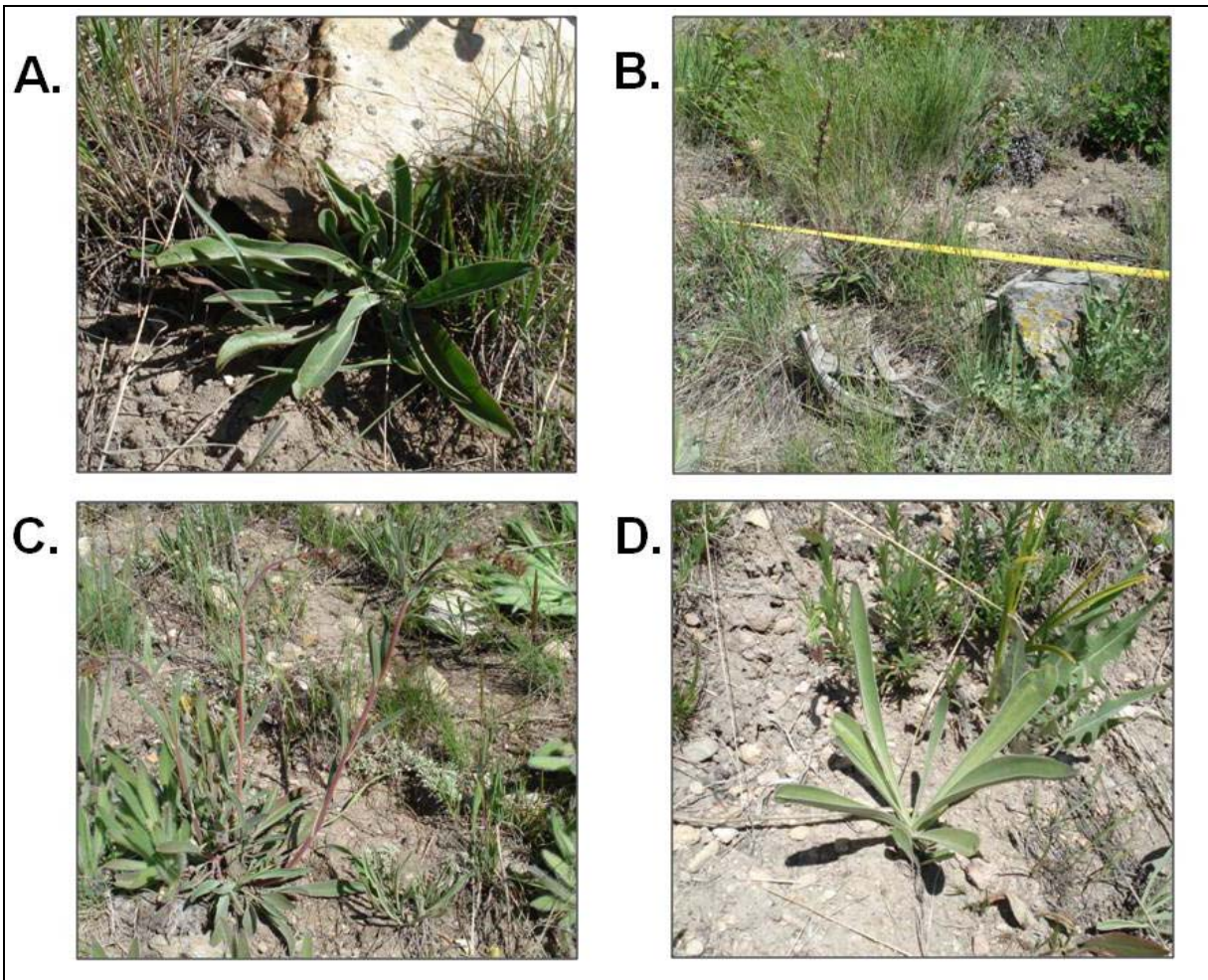


Figure 1. *Penstemon lemhiensis* plants in Big Hole National Battlefield, showing A) a basal rosette, B) a previous year's persistent inflorescence, C) a plant with three rosettes and three inflorescences in bud, and D) a *Frasera albicaulis* rosette.

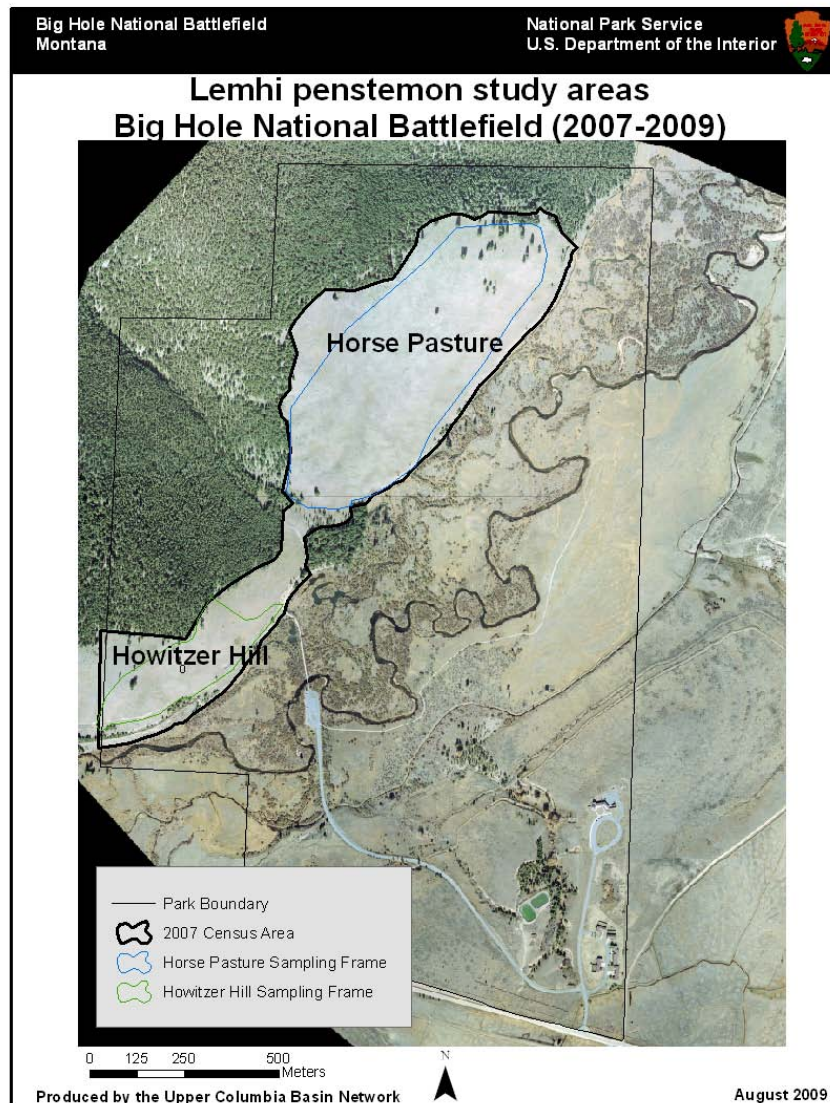


Figure 2. The census and sampling frame study areas developed to estimate the distribution and abundance of *P. lemhiensis* in Big Hole National Battlefield (2007-2009).

2009

In June 2009 we conducted a sampling exercise to estimate population sizes of *P. lemhiensis* in the Battlefield. Because the 2007 census required an exhaustive effort with many observers, we determined that a more sustainable methodology that required fewer observers was important to develop for the future. Also, a census provides no ability to estimate error and account for the possibility of overlooked plants.

We used the 2007 census data to establish a probabilistic sampling design. Two sampling frames (Figure 2) were established, one for the Howitzer Hill, which included the adjacent roadcut, and another for the Horse Pasture (Figure 2). *P. lemhiensis* has very limited seed dispersal (Ramstetter 1983, Elzinga 1997), and Ramstetter (1983) suggested these two areas, which are separated by a narrow, north-facing pine woodland, are functionally separate populations. Within

each frame, a spatially-balanced random sample of 75 point locations (50 plus 25 oversamples) was drawn using the Generalized Random Tessellation Stratified (GRTS) design (Stevens and Olsen 2004). The use of flexible GRTS samples with oversamples allowed us to “hedge our bets” in the event that we ran out of time. This was our first attempt at formally sampling *P. lemhiensis* using a quadrat-based method and we were uncertain about the time required to complete a sample, particularly given the steepness of the terrain.

We used the 2007 census data to generate estimates of required sample size and precision for estimating a population total for both sampling frames. Using Hawth's Tools (version 3.27, Beyer 2004) in ArcGIS (version 9.2, ESRI, Redlands, CA), we constructed a series of shapefiles containing long, linear quadrats (“belt transects”) of different sizes (Lesica 1987, Elzinga et al. 1998) centered on each GRTS sampling location. We overlaid these quadrat shapefiles onto the 2007 point shapefile of plant locations to simulate a population sample, and estimated the required sample size, population total and 95% confidence interval using a simple random sampling variance estimator (which was conservative, rather than the local GRTS variance estimator; Stevens and Olsen 2003). Based on this exercise and on logistical considerations (e.g., anticipated challenge of establishing quadrats on steep slopes), we settled on a 2 x 50 m quadrat (100 m²) as the sampling unit. Because of the sparse and widely scattered distribution of *P. lemhiensis* plants mapped in 2007, sample size requirements for desired precision (e.g., 20% of $\bar{x}$) were unachievable (e.g., $n > 500$), and we anticipated low precision for this first sampling effort.

We used Garmin 76 GPS units to navigate to plot locations, which were used as the origin for each quadrat. We oriented quadrats with the long axis perpendicular to the hillslope to ease tape layout. Quadrats were always directed south along the contour of the slope, except when two plots were close enough to pose a risk of overlap (which was rare), or when plots near the south boundary ran over the fenceline, in which case plots were directed north (180° back azimuth). Three independent 2-person teams were used to complete sampling. We anchored each end of a 50 m reel tape with surveyor pins and walked along the tape, which served as the quadrat centerline, with a 2 m length of 1” schedule 40 PVC to determine whether plants were “in” or “out” of the quadrat (Figure 3). We counted all *P. lemhiensis* plants within each quadrat, as well as the number of rosettes and inflorescences on each plant. We also counted the number of spotted knapweed plants in each quadrat, and noted the location of knapweed plants not in quadrats for park management records.

Finally, we searched other areas of suitable habitat within the Battlefield. In particular, we searched the road cut along the entrance road, and the exposed slopes below the maintenance yard and visitor center, as well as exposures along the irrigation canal. Ramstetter (1983) had described a small population behind the visitor center, but no recent evidence of *P. lemhiensis* from that area had been found.



Figure 3. A 50 m quadrat being measured in BIHO during the 2009 survey.

Data Analysis

We estimated the mean number of *P. lemhiensis* plants per 100 m² plot and the total number of plants for each sampling frame. We used the local GRTS variance estimator (Stevens and Olsen 2003) to estimate 95% confidence intervals around point estimates. We adjusted selection probability weights for each sample unit to account for the inclusion of additional oversample units. Analyses were conducted with the R language and software environment (R version 2.8.1, the R Foundation for Statistical Computing, 2008). The R package *spsurvey* was used to compute GRTS estimates (Kincaid 2008).

Results

In 2007, 520 plants with inflorescences were counted and mapped (Figure 4). We found plants along the periphery of the census area but the highest density areas were in the steepest portions of the mid-slope, and along the roadcut where slope instability maintained open microsites (Figure 4). Plants were found only on south-southeast slope aspects.

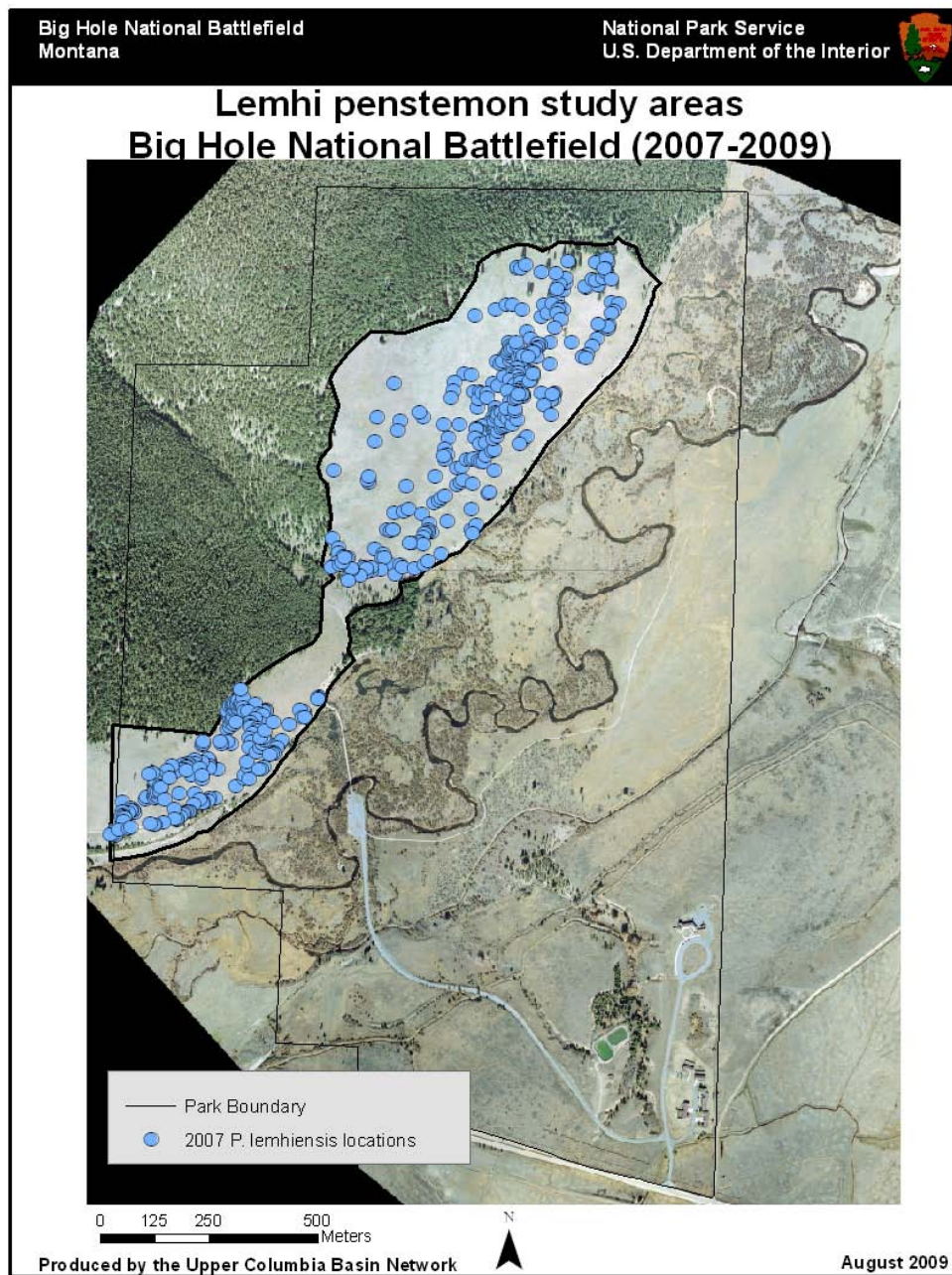


Figure 4. Locations of *P. lemhiensis* plants encountered during the 2007 census.

In 2009, we completed samples of 75 quadrats in each sampling frame over the course of two days (3 independent 2-person teams, each completing approximately 1/3 of the quadrats). We counted a total of 61 mature plants in the Howitzer Hill sampling frame, which occurred in only 19 of 75 quadrats. The counts per quadrat in that frame ranged from 0 to 18. The mean number of rosettes and flowers for the Howitzer Hill frame were 3.7 (range 1-15) and 1 (range 0-5), respectively. We counted 24 plants in the Horse Pasture frame in 9 of 75 quadrats, and counts ranged from 0 to 7 plants per quadrat. The mean number of rosettes and flowers for the Horse Pasture was 3.4 (range 1-8) and 0.5 (range 0-2), respectively. We estimated the population of the Howitzer Hill frame to be 512 ± 250 (95% confidence interval 262-762) mature plants. The Horse Pasture population was estimated to be 873 ± 640 (95% confidence interval 233-1513) mature plants. The mean number of plants per 100 m² quadrat was 0.8 ± 0.2 for the Howitzer Hill and 0.3 ± 0.1 for the Horse Pasture. The combined estimate for both populations was 1385 plants (approximate 95% interval range 495-2275 plants). We also searched the entrance road roadcuts and exposed embankments along the irrigation canal and below the maintenance yard and behind the visitor center for additional *P. lemhiensis*. No additional plants were found outside of the study area. Figure 5 shows the location of quadrats, color coded by plant counts, from the 2009 samples. Finally, we encountered spotted knapweed in only one quadrat on the upper portion of the Howitzer Hill, containing 29 plants. Scattered patches of spotted knapweed were found on other roadcuts in the Battlefield but the species was not found elsewhere in the vicinity of *P. lemhiensis*. We provided UTM coordinates of spotted knapweed patches to the park resource manager immediately upon conclusion of the survey.



Lemhi penstemon survey results (2009)

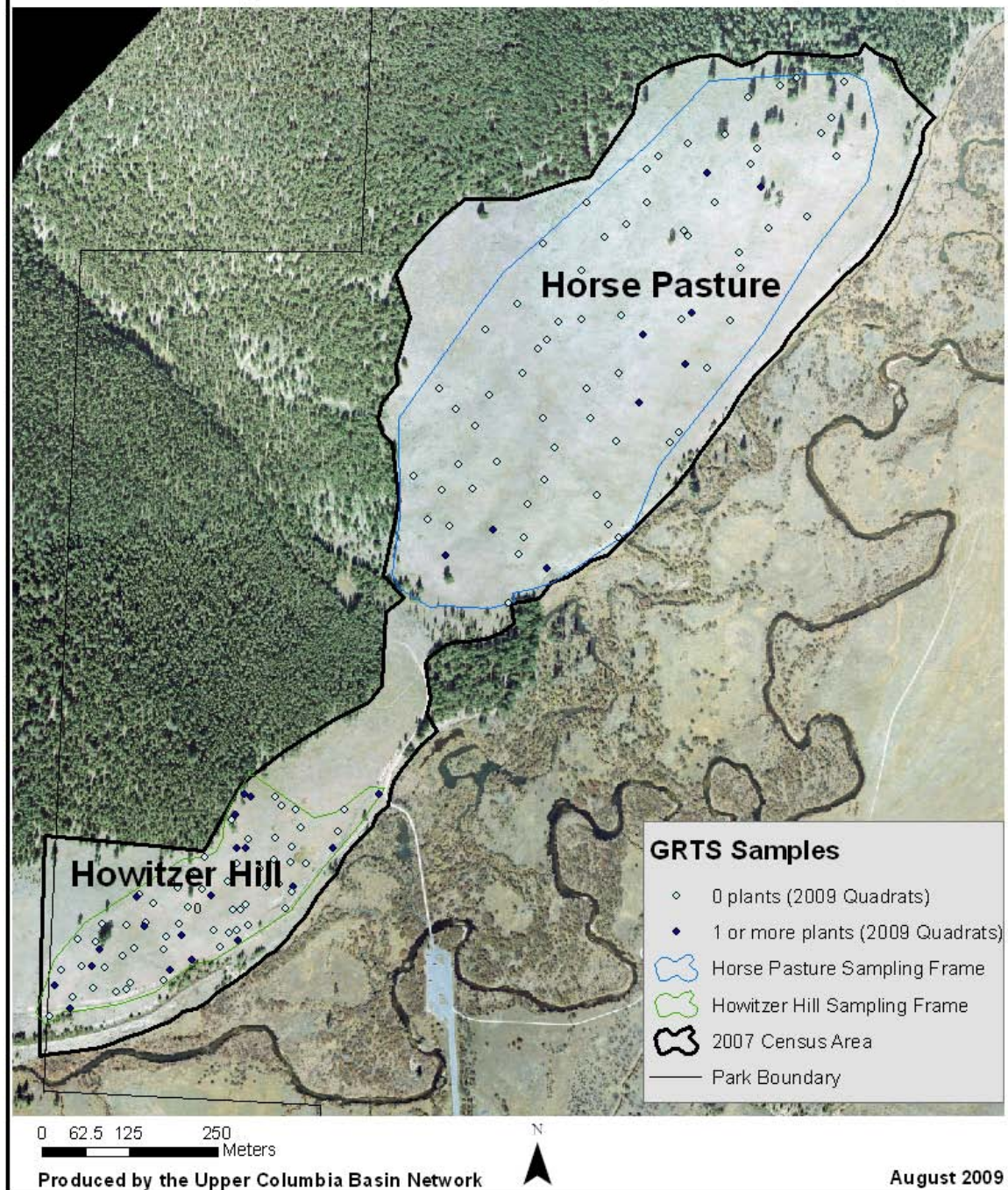


Figure 5. The location of quadrats surveyed for *P. lemhiensis* in 2009.

Discussion

Our results provide the first estimates of population sizes for *P. lemhiensis* in Big Hole National Battlefield. Despite the imprecision of our estimates, the populations each contained at least 250 plants and more likely well over 300 plants, particularly considering that we did not include seedlings in our estimates. Combined, the number of plants on the Battlefield likely exceeded 1000 plants. Elzinga (1997) recommended that populations with over 300 plants in natural habitat be considered for the highest priority in terms of monitoring and protection. Only 2 populations of this size in addition to the BIHO populations have been described (Elzinga 1997). The large size, natural habitat, and protection status of the BIHO populations makes the park site globally significant and important to the long-term persistence of the species (Elzinga 1997).

The Howitzer Hill area contained a higher density of plants, on average, than the Horse Pasture. Also, the average number of rosettes and inflorescences per plant were lower in the Horse Pasture. Our results are similar to those discussed by Elzinga (1997) from other study areas. She reported that the average number of inflorescences per plant across all studies was 2.5. However, she also noted that roadcut populations had much higher inflorescence counts per plant (5 or more) than in native habitat, suggesting that recent disturbance and exposed microsites may stimulate plant growth and reproduction. In addition, recruitment of plants into larger and older classes (i.e., with > 3 rosettes per plant) has apparently declined in studied populations, leading to populations progressively dominated by smaller plants (Elzinga 1997). Finally, the species has also been noted for its wide fluctuations in abundance in response to regional climatic conditions (Elzinga 1997, Heidel and Shelly 2001). Wet years trigger increased germination, and hot, dry years result in high mortality, particularly among young plants (Elzinga 1997). This has implications both for long-term population persistence as well as for the design and interpretation of inventory and monitoring studies.

Ramstetter (1983) included the BIHO population in her study, and described similar areas of extent for the Howitzer Hill and Horse Pasture populations. She attempted a census of the Howitzer Hill population and reported 342 plants on the slope, and 105 plants on the roadcut. She did not attempt a census of the Horse Pasture because of its large size. She counted 40 plants behind the visitor center. Our estimate of the Howitzer Hill population is similar to Ramstetter's estimate, but the apparent extirpation of the visitor center population is striking. Ramstetter noted that the plants were smaller and the percent seed set was lower in that population during her study than elsewhere in the Battlefield, and she suggested that the lush growth of grasses in that area may have been crowding out the species. *P. lemhiensis* has generally been described as a poor competitor in dense sagebrush steppe vegetation (Ramstetter 1983, Elzinga 1997). Heidel and Shelly (2001) demonstrated a strong positive response in several study populations to prescribed burning, and also recounted an anecdotal observation of the BIHO populations during the 1990's responding to a prescribed burn with a substantial increase in the number of plants. Our results suggest that the BIHO populations remain concentrated on steep slopes and along the old roadcut where slope movements maintain open microsites, and that it may be vulnerable to grass and shrub canopy closure over time. We view this as the greatest threat to the BIHO population currently. The distribution and abundance of spotted knapweed does not seem to pose a threat to *P. lemhiensis* at this time.

The sparse and scattered distribution of *P. lemhiensis* in BIHO poses a considerable challenge to probabilistic sampling for obtaining precise estimates of the population. Most 100 m² quadrats, despite their large size and long, linear shape, did not contain any *P. lemhiensis* plants, resulting in very sparse data for estimation. The inflation of variance estimates for population totals was considerable, particularly for the Horse Pasture, resulting from its large size and small mean number of plants per quadrat. Morrison et al. (2008) described a rather complex relationship between precision, cost, and fraction of area sampled in determining an optimal sampling design for a sparsely distributed annual forb. They considered simple random, adaptive, and grid-based systematic sampling designs but not a GRTS design, although that may have been similar to simple random in terms of cost and fraction of area sampled. Both adaptive and grid-based systematic sampling designs were effective in their simulations, and we recommend that a simulation study similar to theirs be taken for the BIHO *P. lemhiensis* population using 2007 plant locations. Implementing a design to obtain higher precision will probably require a substantial increase in time required for observers to be in the field, however. An additional consideration, particularly if a monitoring program is undertaken, is that the cultural sensitivity of the site precludes the use of permanently marked sample locations. The use of temporary quadrats will have lower power to detect change, and a concomitant increase in sample size will be required to offset this.

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