

Natural Resource Conservation in a Cultural Park: Evaluating the Importance of Big Hole National Battlefield to the Endemic Lemhi Penstemon (*Penstemon lemhiensis*)

Author(s): Devin S. Stucki, Thomas J. Rodhouse, Jason W. Lyon, Lisa K. Garrett

Source: Natural Areas Journal, 33(1):50-58.

Published By: Natural Areas Association

DOI: <http://dx.doi.org/10.3375/043.033.0106>

URL: <http://www.bioone.org/doi/full/10.3375/043.033.0106>

BioOne (www.bioone.org) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/page/terms_of_use.

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

•

Natural Resource Conservation in a Cultural Park: Evaluating the Importance of Big Hole National Battlefield to the Endemic Lemhi Penstemon (*Penstemon lemhiensis*)

Devin S. Stucki¹

¹National Park Service
Craters of the Moon National
Monument and Preserve
PO Box 29
18 miles SW of Arco
Arco, ID 83213

Thomas J. Rodhouse²

Jason W. Lyon³

Lisa K. Garrett^{4,5}

²National Park Service
Upper Columbia Basin Network
63095 Deschutes Market Road
Bend, OR 97701

³National Park Service
Nez Perce National Historical Park
39063 US Hwy 95
Spalding, ID 83540

⁴National Park Service
100 Alabama St., Bldg. 1924
Atlanta, GA 30290

•

⁵ Corresponding author:
Lisa_Garrett@nps.gov; 404-507-5820

ABSTRACT: The ecological significance of cultural parks and protected areas, such as battlefields, has frequently been overlooked. Yet small cultural parks with rare populations can provide refugia and colonists for re-establishment elsewhere, and thus are likely to become increasingly important as climate change leads to range shifts and accelerated population declines. We estimated the abundance of the regional endemic plant Lemhi penstemon (*Penstemon lemhiensis*) in Big Hole National Battlefield in western Montana. We estimated during 2009 and 2010 that approximately 1500 adult plants occurred in two subpopulations clustered on steep south-facing slopes where down-slope soil movement is highest. Results from 2011 provided evidence for an increase to approximately 3000 adult plants. The battlefield contains the largest reported population of this geographically restricted species and is, therefore, a globally-significant reserve for Lemhi penstemon. However, inflorescence rates were lower and the mean number of basal rosettes per plant, a proxy for plant age, was greater than reported elsewhere. Lemhi penstemon requires open soil microsites for regeneration and appears vulnerable to land-use change, particularly when it involves disruption of fire regimes. Spotted knapweed (*Centaurea stoebe*) abundance is also increasing in the study area, presenting another threat. Managing Big Hole Battlefield to simultaneously reflect a fixed historic period and support Lemhi penstemon will be a persistent challenge that will require a more active, adaptive management strategy. Our study has helped to integrate cultural and natural resource management in the Battlefield and provides a model for conservation in other cultural parks.

Index terms: abundance, cultural parks, disturbance regime, Lemhi penstemon, plant population persistence, rare species

INTRODUCTION

The ecological significance of cultural parks and protected areas, such as those preserved at historic monuments and battlefields, has frequently been overlooked; and these areas are not typically considered important to conservation reserve systems (Falkner and Stohlgren 1997). This is particularly evident with enabling legislation and mission statements that routinely make no mention of ecological values. Often the designation of cultural parks occurred shortly after the focal historic events and decades before any awareness of the existence of rare plant or animal populations or plant communities. While understandable, these oversights demand reexamination in the current era of accelerating climate change and habitat loss. Emphasis in conservation reserve establishment has been on identifying and securing areas dedicated to maintaining particular species or communities or on preserving large tracts of land to minimize fragmentation and other threats to habitats (Falkner and Stohlgren 1997; Shafer 1999). This strategy has largely been founded on an expectation of environmental stationarity, an assumption that is no longer tenable (Peters and Darling 1985; Smith et al. 2001; Milly et al. 2008; Heller and Zavaleta 2009). Conservation reserve designation and preservation efforts have not kept pace with the rapid rate of species

loss and habitat degradation, nor are they likely to do so for the various scenarios of accelerated global climate change now under consideration (Root and Schneider 2006). Falkner and Stohlgren (1997) proposed that small publicly managed sites can serve as biological refuges for low-mobility endemic species as well as stepping stones for long-distance migration, an idea echoed by Shafer (1999) and others (e.g., Laguna et al. 2004). While it is also clear that small fragmented populations may not be viable or may not contribute meaningfully to species survival over long periods of time (e.g., due to Allee effects or population sink dynamics; Howe et al. 1991), broader recognition and evaluation of the potential of small atypical conservation areas is urgently needed, particularly for those areas already enjoying some kind of protected status (Groves et al. 2002).

One reason for this urgency is that management of cultural reserves to protect natural, as well as cultural, resources presents unique challenges. Historic sites and battlefields are often legislated to preserve a particular point or condition in time. Given the dynamic nature of ecosystem development and succession (Odum 1969), land management prescriptions for these sites typically require active management that in some way mimics indigenous or pre-historical disturbance regimes (Anderson

and Barbour 2003). Often the populations of rare species harbored in cultural parks are themselves dependent on indigenous disturbance regimes (e.g., Foster and Motzkin 1998; Storm and Shebitz 2006). But the use of active management tools such as prescribed fire may not be permitted due to overriding concerns for fragile cultural resources or potential impacts to significant viewsheds and landscapes. Non-historical disturbance regimes, such as cultivation of nonnative species or continuation of historic land uses such as farming and grazing, may also be used to promote visitor experience and site interpretation. These kinds of practices may be in direct conflict with those required by rare species, and may result in unintended ecological consequences.

Actively evaluating and promoting the potential value of cultural parks to biological conservation within the framework of historic preservation can create opportunities to develop management strategies that meet the needs of both cultural and natural resources. Identification of these opportunities requires a multi-disciplinary approach involving close coordination between cultural resource managers and conservation biologists. In particular, if rare species or other important natural resources are found to contribute to the cultural landscape or historic setting being preserved or maintained, then alignment of cultural and natural resource management strategies is more likely. These important natural resources need not be of central concern to cultural site managers for alignment to be successful, and may even be minor and overlooked components of the cultural landscape. What is necessary, however, is a process whereby cultural and natural resource specialists can work together to evaluate important resources and identify shared management goals. Such a process can offer tremendous opportunities to integrate site management strategies for cultural resource protection with those for biological conservation. These situations perhaps offer the most immediate and effective opportunity to advance conservation in small parks and protected areas because the costs for doing so may be quite small.

The National Park Service (NPS) Inventory and Monitoring Program (Fancy et al. 2009) has provided an excellent framework for cultural and natural resource specialists to work together to evaluate and identify conservation opportunities on small U.S. National Park units. Through this program, numerous historic sites, monuments, and battlefields that previously had been given little support to evaluate natural resources now have complete vertebrate and vascular plant inventories that can be used to inform site managers about the potential utility and importance of focused biological conservation and natural resource protection. The outcome of a focal species inventory conducted in Big Hole National Battlefield, located in western Montana, provides an excellent illustration. We use this example to present new information on a little-studied rare endemic forb, Lemhi penstemon (*Penstemon lemhiensis* [Keck] Keck & Cronq.), and to motivate discussion of the importance small parks and cultural reserves play in the future of biological conservation. The proximate goal of our study was to estimate the population size of Lemhi penstemon within Big Hole National Battlefield (BIHO). Our ultimate goal, however, was to provide park cultural resource managers with the information necessary to more effectively address biological conservation at the site. We describe how the results of our study are now influencing management decisions, including efforts to eradicate the invasive non-native plant spotted knapweed (*Centaurea stoebe* L.) and the possible use of prescribed fire to simultaneously maintain the battlefield scene and stimulate Lemhi penstemon population growth.

STUDY SPECIES

Lemhi penstemon is a rare regionally endemic forb found only in Lemhi County of eastern Idaho and four counties in western Montana, including Beaverhead County where BIHO is located. To date, only a few unpublished reports describing the species' ecology, prepared for state and federal agencies (Moseley et al. 1990, unpubl. data; C. Elzinga 1997, unpubl. data; Heidel and Shelly 2001, unpubl. data) and an unpublished thesis (Ramstetter 1983),

are available.

Species Biology

Lemhi penstemon is a robust and showy blue-flowering perennial penstemon (family Plantaginaceae) that can grow to a height of 70 cm (Hitchcock and Cronquist 1973; C. Elzinga 1997, unpubl. data). Plants consist of one or many basal rosettes of leaves growing from a branching underground caudex (Hitchcock et al. 1959). Inflorescences are produced on stems that arise from the center of the rosettes, allowing for a single plant with multiple rosettes to also have multiple flowering stems. Lemhi penstemon reproduces only through seed and is a near-obligate out-croser, which requires cross-pollination to reproduce (Ramstetter 1983; Heidel and Shelly 2001, unpubl. data). The primary pollinator for the species is a vespid wasp (*Pseudomasaris vespoides*; Ramstetter 1983). The species does not have any specialized morphological adaptations or known animal hosts for seed dispersal, and the seeds fall to the ground within 1 m of the base of the parent plant after the seed capsules dehisce and open in late summer (Heidel and Shelly 2001, unpubl. data). Such a low dispersal capacity may partially explain its restricted distribution, and likely contributes to its overall rarity. Seeds of the species are reportedly viable for at least eight years and considerable year-to-year variability in germination associated with variable winter and spring precipitation patterns has also been reported (Heidel and Shelly 2001, unpubl. data).

Habitat

Occurring in early- to mid-successional habitats, Lemhi penstemon is usually found in association with big sagebrush (*Artemisia tridentata*) on steep, sparsely vegetated slopes (Heidel and Shelly 2001, unpubl. data) but is also found in other habitat types, including edges and open spaces within coniferous forest (Ramstetter 1983; C. Elzinga 1997, unpubl. data). Road cuts also provide habitat for small populations, probably because of the species' need for bare soil microsites for germination (C. Elzinga 1997, unpubl. data). Competition

from other vegetation due to natural succession, including grasses, shrubs, and invasive plants, such as spotted knapweed, appear to have negative consequences on Lemhi penstemon populations (Ramstetter 1983; C. Elzinga 1997, unpubl. data; Heidel and Shelly 2001, unpubl. data). Heidel and Shelly (2001, unpubl. data) provided evidence from a small experiment that the species might respond favorably to prescribed fire, presumably because of reduced litter accumulation and competition from other plants.

Status

There are approximately 191 reported occurrences of Lemhi penstemon, with 102 in Idaho and 89 in Montana (Heidel and Shelly 2001, unpubl. data). Based on past surveys, the average population size is small, and NatureServe reports global abundance of approximately 3000 – 10,000 individuals, and assigned a global ranking for the species of vulnerable (G3; NatureServe 2010). There are three large populations reported to contain over 300 individuals each (C. Elzinga 1997, unpubl. data; NatureServe 2010), while half of all other occurrences have populations made up of 30 plants or less (C. Elzinga 1997, unpubl. data; NatureServe 2010). The population at BIHO has been included among the three core populations noted in the species conservation assessment (C. Elzinga 1997, unpubl. data) and has been suspected of containing more individuals than any other population (C. Elzinga 1997, unpubl. data; Heidel and Shelly 2001, unpubl. data), although no formal assessment of the population size in the Battlefield had been attempted prior to our study.

STUDY SITE

Big Hole National Battlefield is located in the upper Big Hole valley of southwestern Montana (Figure 1) along the North Fork Big Hole River. Elevation in the battlefield ranges from 1913 m to 2134 m, and the climate is semi-arid with a thirty-year precipitation average of approximately 30 cm (weather station 249067, Western Regional Climate Center, <http://www.wrcc.dri.edu/>). BIHO is the site of an intense battle that

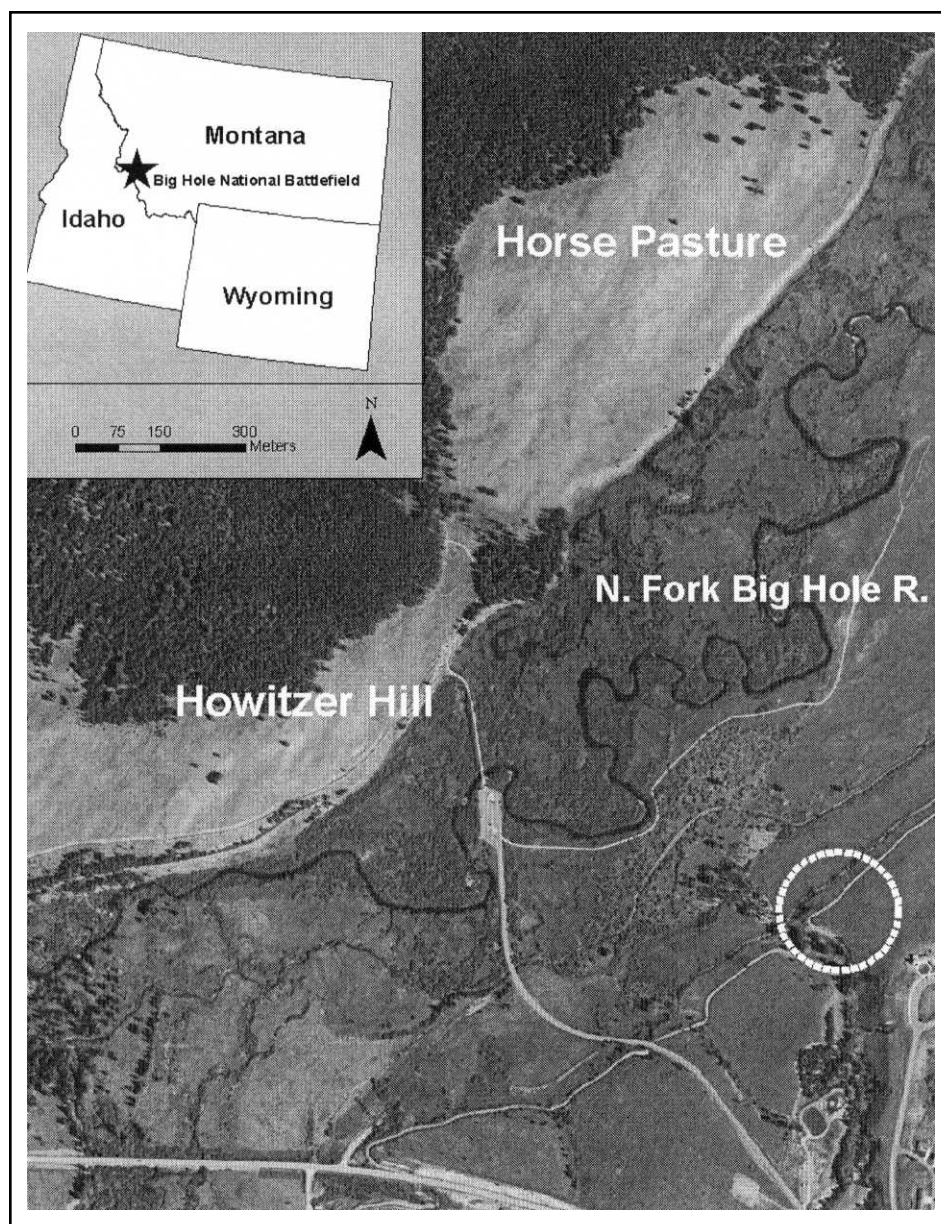


Figure 1. Big Hole National Battlefield, located in southwestern Montana, and the location of the Howitzer Hill and Horse Pasture hillslopes where Lemhi penstemon (*Penstemon lemhiensis*) subpopulations were surveyed in 2009-2011. A subpopulation described by Ramstetter (1983) that was thought to have been extirpated but rediscovered during the study is encircled.

occurred in August 1877 between the U.S. Army and the Nez Perce people. The Battle at Big Hole was one of several battles between the U.S. Army and the Nez Perce during that summer and an estimated 70 to 80 Nez Perce and 31 soldiers and volunteers lost their lives in the two-day battle. The Battlefield was recognized by Congress in 1883 and was administered by the War Department and later the U.S. Forest Service before becoming a unit of the NPS in 1936.

The NPS currently manages a 265-hectare area that includes two steep southeast-facing slopes (the “Horse Pasture” and “Howitzer Hill”; Figure 1) overlooking the river that are composed of lodgepole pine (*Pinus contorta*) forest and sagebrush steppe dominated by mountain big sagebrush (*Artemisia tridentata vaseyana*), perennial bunchgrasses including bluebunch wheatgrass (*Pseudoeregeria spicata*) and Idaho fescue (*Festuca idahoensis*), and perennial forbs including arrowleaf

balsamroot (*Balsamorhiza sagittata*), sulphur buckwheat (*Eriogonum umbellatum*), and Lemhi penstemon. The low-lying areas of the battlefield are made up of a willow- (*Salix spp.*) dominated floodplain surrounding the river and includes wet meadow dominated by rushes (*Juncus spp.*) and camas (*Camassia quamash*). These extant vegetation patterns, including the open and historically fire-maintained slopes where the core of the Lemhi penstemon population occurs, have remarkable resemblance to the period of historic significance and are crucial to the interpretation of the site and for visitor experience (NPS 2008, unpubl. data). An artist's sketch from 1878 (Figure 2a) and a modern day photo of the Horse pasture in 2011 (Figure 2b) illustrate that the historic setting and rare plant habitat have not dramatically changed in over one hundred years.

METHODS

Survey Design and Field Methods

Survey plots were 100 m² belt transects 50-m long and 2-m wide, modified from an approach described by Lesica (1987). Plots originated at the randomly-selected point locations generated from Generalized Random Tessellation Stratified (GRTS), and were walked perpendicular to slope fall lines with a 2-m long PVC pole used to determine plot boundaries. We counted all mature Lemhi penstemon plants rooted within plots, as well as the number of basal rosettes and inflorescences on each plant. Multiple rosettes and inflorescences can provide some evidence of the relative vigor and age of the plant (C. Elzinga 1997, unpubl. data). We also counted all spotted knapweed plants within the plots. In 2011, we also searched for seedlings under and around some mature plants.

We surveyed for mature Lemhi penstemon plants in the Battlefield during late June 2009, and again in 2010 and 2011, when the species was in flower, or nearly so. Lemhi penstemon plants were considered mature when one or more fully developed basal rosette(s) of leaves were present. Seedlings were excluded from surveys in order to

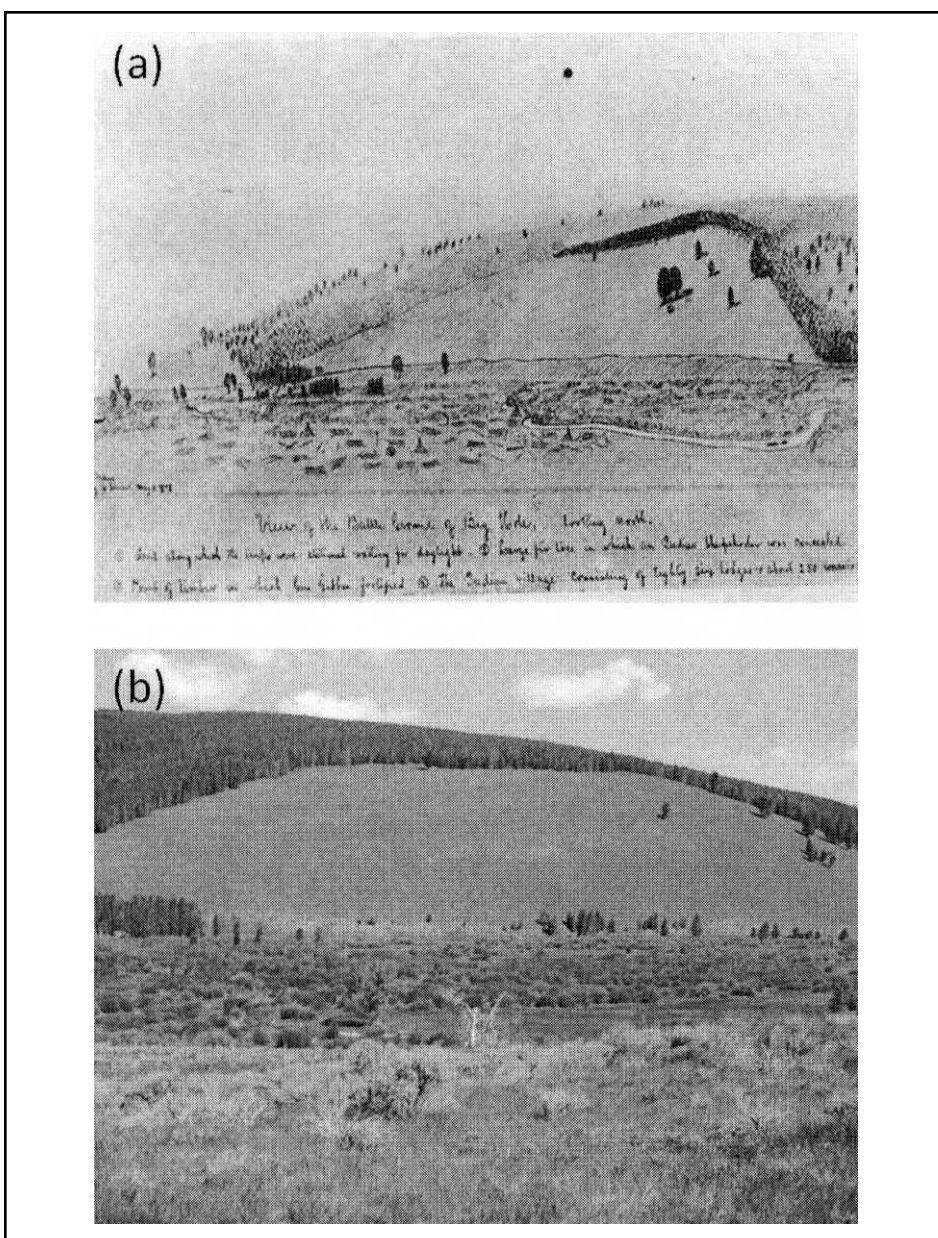


Figure 2. (a) Pioneer sketch of Horse pasture drawn by Granville Stewart in 1878 (courtesy Montana Historical Society Collection, X1968.43.17), (b) NPS photo of Horse pasture shown here in 2011.

reduce observer bias associated with imperfect detection, although we searched for seedlings growing under some mature plants in 2011. We used pilot data from an incomplete walking search census of mature plants conducted by student volunteers in 2007 to identify two subpopulations on the Howitzer Hill and Horse Pasture (Figure 1). We established convex polygons around these two areas using a Geographic Information System (GIS) from which to draw stratified random samples to locate plots in subsequent years.

In 2009, we treated the two polygons as continuous domains and drew a stratified spatially-balanced sample of plot locations using the GRTS algorithm (Stevens and Olsen 2004), with sample sizes of 75 in each subpopulation. The GRTS approach is a practical improvement over other designs such as simple random sampling (SRS) because it maintains spatial balance and representativeness of the sample while allowing for sample unit replacement and changes in realized sample size (i.e., when the sample is smaller or larger than

the initial target sample size). This was important because we did not have enough experience surveying Lemhi penstemon to know how long the survey would take and whether our target sample size was achievable with the time and personnel we had available to us.

In 2010, we modified the two polygons to contain two finite grids (for each subpopulation) of cells 50-m $\times$ 2-m long (the plot size). This approach allowed us to consider each polygon as a finite domain with a fixed total number of possible sample units from which to draw a sample. We drew a GRTS sample of size 75 from each polygon and also an SRS sample of 75 from each polygon in order to support a detailed investigation into the performance of different sampling designs for this spatially-structured population. In order to utilize both the 2010 GRTS and SRS samples together in a statistically valid way, we treated them as a dual frame survey, with each sample providing slightly different sample unit inclusion probabilities which were accounted for in subsequent population estimates (Thompson 2002). In this way, we were able to use the full sample of 300 plot locations to estimate the population size in 2010.

In 2011, we used the same polygons and design as in 2009, except we allocated more sampling effort to the Horse Pasture to accommodate its much larger size than the Howitzer Hill. Using GRTS, we drew a sample of 250 plot locations in the Horse Pasture polygon and a sample of 60 locations in the Howitzer Hill polygon, resulting in a stratified sample with equal inclusion probabilities in each subpopulation. In addition to the formal surveys, we also conducted ancillary searches along exposed roadcuts and slopes elsewhere in the Battlefield, and placed particular attention on searching the area in the eastern portion of the Battlefield below the visitor center (Figure 1) where Ramstetter (1983) mapped a small subpopulation containing 43 plants. We used the statistical program R (version 2.11.0, 2010; R Development Core Team, Vienna, Austria) and R package *spsurvey* (Kincaid et al. 2009) to draw GRTS samples. We used Hawth's Analysis Tools (version 3.27; H. L. Beyer,

<http://www.spatial ecology.com/htools/>) in ArcGIS (version 9.1; ESRI, Inc., Redlands, CA) to develop the finite sampling frame of rectangular grid cells and draw SRS samples.

Data Analysis

We estimated the mean number of Lemhi penstemon and spotted knapweed plants per plot in each subpopulation and for the entire population using the Horvitz-Thompson (H-T) estimator following Thompson (2002), which accounts for unequal sample unit inclusion probabilities resulting from stratification, unequal sample sizes, and use of the dual frame approach in 2010. Population totals were estimated by multiplying the mean by the total sampling frame area in 2009 and 2011 and by the total number of possible belt transects included in the finite sampling grid used in 2010.

We estimated sample variances for each subpopulation in 2010 with an approximation of the H-T variance estimator for SRS designs with variable inclusion probabilities following Stevens and Olsen (2003:599). Their modified SRS variance estimator is approximately unbiased under the assumption of independent random sampling and generally performs better than the standard H-T estimator, which can be unstable and produce negative variance estimates (Thompson 2002; Stevens and Olsen 2003). Because the 2009 and 2011 surveys used only a GRTS survey design, we used the neighborhood-weighted ("local") GRTS variance estimator developed by Stevens and Olsen (2003) for data collected in those years. This alternative variance estimator is also approximately unbiased and takes advantage of the spatial structure of the sampled population and is generally more efficient than the SRS estimator (Stevens and Olsen 2003; Rodhouse et al. 2011).

We estimated the variance of the population total of each year's stratified sample by summing individual stratum variances. Our samples represented $> 5\%$ of the polygon and we used the finite population correction factor (Thompson 2002), which

further reduced our variance estimates by approximately 1%. We estimated 95% confidence intervals around population totals by multiplying the Z-multiplier, 1.96, by the square root of the variances (the standard error) and adding and subtracting this to the estimated totals. All calculations were performed in the statistical environment R using the *spsurvey* package (Kincaid et al. 2009).

RESULTS

In 2009, following a probabilistic spatially-balanced sampling design, we estimated the total population of mature Lemhi penstemon plants to be 1362 ($n=148$; 95% confidence interval 690 – 2034). Note that two plots were dropped and not replaced in 2009, resulting in a final realized sample size of 148 instead of 150. In 2010, we estimated the total population of mature plants to be 1618 ($n=299$ [1 plot missed]; 95% confidence interval 974 – 2262). In 2011, the estimate for the total population of mature plants was 2974 ($n=310$; 95% confidence interval 1816 – 4131), approximately double the size of the 2009 and 2010 estimates (Figure 3).

Relatively few plants were encountered relative to the number of plots surveyed and the size of those plots (Table 1). Plant counts per 100 m² plot ranged from 0 – 59, but the average number of plants per plot was consistently < 1 during the three years from 2009 – 2011 except for the Howitzer Hill where number of plants per 100 m² was 1.6 in 2011. The frequency of occurrence within plots for each subpopulation was low ($\leq 30\%$; Table 1). The number of basal rosettes per plant averaged ≈ 3.5 and ranged from 1 – 19. The number of inflorescences also averaged < 1 , but reached as high as 1.2 in the Horse Pasture in 2011. There was a general pattern of more plants, rosettes, and inflorescences in the Howitzer Hill than the Horse Pasture, despite the larger size of the Horse Pasture sampling frame (Table 1). Also, we noted a higher density of plants in plots that intersected the exposed roadcut at the base of the Howitzer Hill. The average number of plants in those plots was 1.64 ($n=14$; $SD=2.1$) in 2009, 0.7 ($n=23$; $SD=1.06$) in 2010, and 15 ($n=4$,

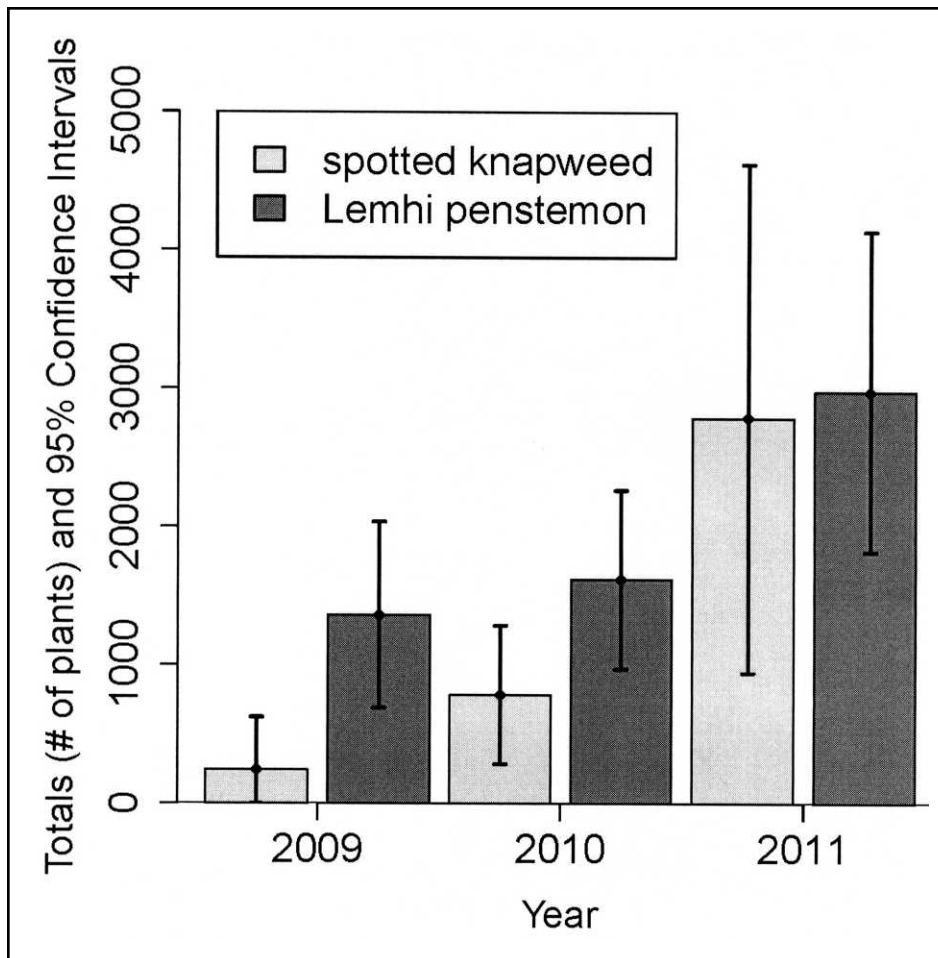


Figure 3. Graph showing trend for population estimates of Lemhi penstemon (*Penstemon lemhiensis*) and spotted knapweed (*Centaurea stoebe*) in Big Hole National Battlefield for 2009-2011.

$SD=29$) in 2011; higher than the overall averages for that subpopulation (Table 1). Note that the unusually high count of 59 plants occurred along the roadcut in 2011, inflating the variances for that year.

The spotted knapweed population also ap-

peared to increase steeply over the study period. In 2009, we estimated the total number of spotted knapweed plants within the stratified sampling area to be 244 ($n=148$; 95% confidence interval 0 – 622). For 2010, the estimate was 785 ($n=299$; 95% confidence interval 285 – 1284). In 2011,

the estimate was 2784 ($n=310$; 95% confidence interval 945 – 4622). The frequency of spotted knapweed occurrence in plots increased by ≈ 1.7 times each year (Figure 3). Small clusters of knapweed were found only in the Howitzer Hill during 2009 and 2010, including four sizeable patches with 10 – 42 plants. In 2011, spotted knapweed plants were also found in the Horse Pasture with one patch containing 42 plants, and a maximum count of 94 plants in one patch on the Howitzer Hill.

We found Lemhi penstemon to be predominantly restricted to the Horse Pasture and Howitzer Hill (Figure 1). Ancillary searches that took place elsewhere in BIHO resulted in no additional discoveries of Lemhi penstemon in 2009 and 2010. However, in 2011 we located a small subpopulation of Lemhi penstemon in the general area that Ramstetter (1983) had previously identified as supporting a small subpopulation (Figure 1). It seems likely that these plants are part of the same population that she described. A census of this subpopulation found 33 individual mature plants with a mean number of rosettes of ≈ 4.7 per plant and a mean number of inflorescences ≈ 1.9 per plant. There were several unusually large plants with as many as 22 rosettes and 19 inflorescences, providing further evidence of the advanced age of the subpopulation.

We searched for seedlings in 2011 around a few plants in the Horse Pasture and in the rediscovered subpopulation. In general we found very few seedlings, and almost none in the Horse Pasture. However, underneath and within a 4 m² vicinity of one plant

Table 1. Summary results by subpopulation and year for the number of Lemhi penstemon plants encountered, frequency of occurrence in 100 m² plots (# of plots with ≥ 1 plant), estimated mean number of plants, and estimated mean number of rosettes and inflorescences per plant for surveys conducted in Big Hole National Battlefield. Standard deviation estimates are included in parentheses.

Subpopulation	Year	Plots	Plants	Frequency	$\bar{x}_{\text{Plants}}$	$\bar{x}_{\text{Rosettes}}$	$\bar{x}_{\text{Inflorescences}}$
Howitzer Hill	2009	75	61	0.25	0.8(2.4)	3.7(3.1)	1.0(1.3)
	2010	149	76	0.19	0.5(1.5)	4.2(2.6)	0.5(0.8)
	2011	60	97	0.30	1.6(7.7)	2.7(2.7)	1.0(1.5)
Horse Pasture	2009	73	24	0.12	0.3(1.2)	3.4(2.0)	0.6(0.6)
	2010	150	65	0.18	0.4(1.4)	3.5(2.7)	0.4(0.6)
	2011	250	184	0.20	0.7(2.5)	2.7(2.1)	1.2(1.5)

in the visitor center subpopulation, we counted 47 seedlings. This was the only flush of seedlings that we encountered during our study.

DISCUSSION

We confirmed that Big Hole National Battlefield supports a large Lemhi penstemon population, estimated in 2011 to have as many as 3000 plants, and no fewer than 1800 plants as indicated by the lower confidence interval bound. This is, by far, one of the largest reported populations of this species within its restricted range (C. Elzinga 1997, unpubl. data; B. Heidel and J.S. Shelly 2001, unpubl. data). There are only a few sites that are known to contain > 300 plants, and the majority of the known occurrences are reported to contain only a few dozen plants (C. Elzinga 1997, unpubl. data). Therefore, we submit that Big Hole National Battlefield is deserving of recognition as a site for biological conservation as well as cultural resource protection. The large size, natural habitat (as opposed to only anthropogenic road cut habitat), and protected status of the BIHO population makes the park site globally significant and important to the long-term persistence of the species (C. Elzinga 1997, unpubl. data).

Our results provide some evidence for an increasing trend in Lemhi penstemon in the Battlefield. This may be the result of several consecutive years of wet spring weather. B. Heidel and J.S. Shelly (2001, unpubl. data) also noted that the species responded favorably to above-average spring precipitation. However, our results also suggest there may be some cause for concern for the species' long-term persistence in the Battlefield. We found clear evidence that the noxious invasive weed, spotted knapweed, is increasing in the two hillslope areas. This may also be the result of the recent above-average precipitation. Spotted knapweed was noted by Elzinga (1997, unpubl. data) as a competitive threat to Lemhi penstemon in some areas of its range, and the rapid increase observed in BIHO is cause for concern.

Furthermore, Elzinga (1997, unpubl. data)

reported from other study areas that the average number of inflorescences per plant across all studies was 2.5, whereas combined averages of inflorescence rates from our subpopulations were ≤ 1 from 2009 – 2011. She noted that roadcut populations had much higher inflorescence counts per plant (five or more) than in native habitat, suggesting that recent disturbance and exposed microsites may stimulate plant growth and reproduction. We found a similar pattern, with above-average plant counts in plots crossing the road cut at the base of Howitzer Hill. Elzinga (1997, unpubl. data) also noted that recruitment of plants into larger and older classes with > 3 rosettes per plant had apparently declined in studied populations, leading to populations progressively dominated by smaller plants. Our results indicated an opposite pattern: the average number of rosettes per plant, and hence plant age class, in all three subpopulations was approximately ≥ 3 , indicating a possible decline in reproduction and seedling establishment. Our failure to encounter seedlings under most plants searched is additional anecdotal evidence of this possibility.

Ramstetter (1983) included the Battlefield population in her study, and described a small subpopulation of 43 plants on a flat bench below the visitor center on the opposite side of the river from the two large hillslope populations (Figure 1). She noted that the plants were smaller and the percent seed set was lower in that subpopulation than the hillslope subpopulations, suggesting that the lush growth of grasses in that area may have been crowding out the species. The results from our 2011 ancillary search of this area indicate that this subpopulation still exists, though it is not clear whether it is in decline as was originally suggested. However, the advanced age of plants in that population, as indicated by the number of rosettes, was striking. Despite the large flush of seedlings under one plant in that area, we found no young established plants, and several plants showed clear signs of senescence and were being overtaken by sagebrush. Lemhi penstemon has generally been described as a poor competitor in dense sagebrush steppe vegetation (Ramstetter 1983; C. Elzinga 1997, unpubl. data), and Heidel and

Shelly (2001, unpubl. data) demonstrated a strong positive response to prescribed burning by Lemhi penstemon in several study populations. Heidel and Shelly (2001, unpubl. data) also recounted an anecdotal observation that the Battlefield population responded positively to a prescribed burn during the 1990s (presumably the 1997 burn). Our results suggest that the Battlefield population remains concentrated on steep slopes and along the old roadcut at the base of the Howitzer Hill where down-slope soil movements maintain open microsites. This pattern is particularly evident in the Horse Pasture, where plants were largely restricted to the steep convex area in the central portion of the slope. These observations provide compelling evidence that the species may be vulnerable to decline in the Battlefield despite its large population size, particularly in the absence of fire.

MANAGEMENT IMPLICATIONS

How should park resource managers approach their mission to protect a rare plant population within a historic site like Big Hole National Battlefield? Conflicts with cultural landscape management practices are clearly possible, particularly given the apparent need for active intervention in order to stimulate reproduction and successful seedling establishment. Furthermore, Lemhi penstemon is not known to have been utilized by the Nez Perce and is not considered a species of historical interest. In the absence of the recent emphasis by NPS to systematically inventory even obscure species like Lemhi penstemon, it likely would have continued to be overlooked by cultural resource managers.

Fortunately, in this case, the positive relationship between Lemhi penstemon and fire presents an opportunity to align cultural landscape management objectives with penstemon population management. In fact, the results of our surveys have helped clarify the need for more active management in the Battlefield. The Battlefield management team is now considering use of prescribed fire to help maintain the open shrub-steppe vegetation on the hillslopes. Downslope encroachment by lodgepole pine, particularly into parts of the

Howitzer Hill, has been a recurring management challenge (NPS 2008, unpubl. data). This suggests that these slopes were likely maintained as open under natural fire regimes in the past, although the history of fire intervals of the hillslopes is not well known (NPS 2008, unpubl. data). The persistence of such a large Lemhi penstemon population on these slopes is likely explained by fire history as well. As their names imply, the Howitzer Hill and the Horse Pasture both are integral to the history of the Battlefield. Significant moments in the 1877 battle occurred on these slopes and interpretation of the battle and visitor experience is greatly enhanced by the maintenance of these open slopes (Figure 2).

The use of fire as a cultural resource management tool is not unprecedented in the Battlefield and we know that prescribed fire was applied to the hillslopes at least once, in 1997, though there is little information about the extent or intensity of that burn. We noted old burned sagebrush stumps in the Horse Pasture during penstemon surveys that presumably date to that event. It is also certainly possible, perhaps even likely, that the Nez Perce themselves applied fire to the BIHO hillslopes during the historic period, but this has not been documented (NPS 2008, unpubl. data). The development of a resource management strategy that uses fire to simultaneously benefit the historic scene and biological diversity and that mimics indigenous practices is appealing, particularly for cultural parks and protected areas (Anderson and Barbour 2003). Unfortunately, the use of fire as a management tool is complicated by the spotted knapweed infestation, which could also spread rapidly following a burn. Our study has brought this issue to the attention of the management team, and a redoubling of effort to control the noxious species is planned. Any use of prescribed fire to meet cultural and ecological management objectives must be accompanied by an aggressive strategy to control knapweed.

Our study has created an important opportunity for Battlefield resource managers to develop an adaptive and integrated strategy to preserve and protect both the historical scene of the Battlefield as well

as the ecological integrity of the upland steppe slopes. The spatial arrangement of the open hillslopes where the core of the Lemhi penstemon population occurs is well suited for this. Fire or other management treatments, such as mechanical removal of lodgepole pine, could be applied conservatively to part or all of one hillslope, keeping untreated areas as a control. Quantitative evaluations of the effectiveness of these treatments could be made within the context of long-term monitoring of both the penstemon and knapweed populations. This would not only serve the immediate needs of Battlefield managers but would make an important contribution for researchers and managers involved in restoration and preservation of biological diversity in small cultural parks and protected areas. While the details of our study are certainly unique to Lemhi penstemon at Big Hole National Battlefield, we suspect that there are other analogous opportunities for biological conservation, particularly in the U.S. National Park system (Falkner and Stohlgren 1997; Anderson and Barbour 2003), and we hope that our study provides a model for others to follow.

ACKNOWLEDGMENTS

This study was supported by the National Park Service Upper Columbia Basin Network, Nez Perce National Historical Park, and Big Hole National Battlefield. We thank Jimmer Stevenson, Mandi Wick, Jannis Jocius, Heidi Becker, Eric and Paulina Starkey, and Dan Esposito for assistance in the field. We thank Steve Shelly for joining us in the field in 2011 and showing us how to identify Lemhi penstemon seedlings. Gerry Wright provided helpful comments during manuscript preparation.

Devin Stucki earned his BS degree in Botany from Oregon State University in 2011. He is in his fifth year working for the National Park Service as a biological technician for the Upper Columbia Basin Network Inventory and Monitoring Program. Devin is involved with a variety of monitoring projects, including plants and animals, with focus being directed towards monitoring the rare endemic

Lemhi penstemon, as well as population dynamics and pathology of high elevation 5-needle pines.

Tom Rodhouse received his MS degree in Biogeography from Oregon State University in 2002 before joining the National Park Service as an ecologist for the Upper Columbia Basin Network Inventory and Monitoring Program. He recently earned a PhD from the University Of Idaho College Of Natural Resources, and he continues to lead a variety of vegetation and vertebrate monitoring projects for the Network. His research focuses on applying principles of biogeography together with quantitative models to benefit conservation in parks and protected areas.

Jason Lyon received his MA degree in Anthropology from the University of Idaho in 2000. He is currently employed by the National Park Service as the Integrated Resource Program Manager for Nez Perce National Historical Park. Prior to his 12 years with the NPS, Mr. Lyon served seven years as the Tribal Archeologist for the Nez Perce Tribe in central Idaho. His research interests focus on the study of past human adaptation and use of natural environments and applying those in modern resource management contexts.

Lisa Garrett received her MS degree in Wildlife Sciences from the University of Idaho in 1995 before joining the National Park Service as a program manager for the Upper Columbia Basin Network Inventory and Monitoring Program. She accepted the position of Southeast Regional Inventory and Monitoring Division Chief in 2012 and is located in Atlanta, Georgia. Her research interests focus on monitoring the dynamic nature and condition of park ecosystems.

LITERATURE CITED

- Anderson, M.K., and M.G. Barbour. 2003. Simulated indigenous management: a new model for ecological restoration in national parks. *Ecological Restoration* 21:269-277.
- Falkner, B., and T.J. Stohlgren. 1997. Evaluating the contribution of small National Park areas to regional biodiversity. *Natural Areas Journal* 17:324-330.

- Fancy, S.G., J.E. Gross, and S.L. Carter. 2009. Monitoring the condition of natural resources in US National Parks. *Environmental Monitoring and Assessment* 151:161-174.
- Foster, D.R., and G. Motzkin. 1998. Ecology and conservation in the cultural landscape of New England: lessons from nature's history. *Northeastern Naturalist* 5:111-126.
- Groves, C.R., D.B. Jensen, L.L. Valutis, K.H. Redford, M.L. Shaffer, J.M. Scott, J.V. Baumgartner, J.V. Higgins, M.W. Beck, and M.G. Anderson. 2002. Planning for biodiversity conservation: putting conservation science into practice. *Bioscience* 52:499-512.
- Heller, N.E., and E.S. Zavaleta. 2009. Biodiversity management in the face of climate change: a review of 22 years of recommendations. *Biological Conservation* 142:14-32.
- Hitchcock, C.L., and A. Cronquist. 1973. *Flora of the Pacific Northwest*. University of Washington Press, Seattle.
- Hitchcock, C.L., A. Cronquist, M. Ownbey, and J.W. Thompson. 1959. *Vascular Plants of the Pacific Northwest*, Pt. 4. University of Washington Press, Seattle.
- Howe R.W., G.J. Davis, and V. Mosca. 1991. The demographic significance of sink populations. *Biological Conservation* 57:239-255.
- Kincaid, T., T. Olsen, D. Stevens, C. Platt, D. White, and R. Remington. 2009. *spsurvey*: spatial survey design and analysis. R package version 2.1. Available online <<http://www.epa.gov/nheerl/arm/>>. Accessed 05 May 2009.
- Laguna, E., V.I. Deltoro, J. Perez-Botella, P. Perez-Rovira, Ll. Serra, R. Olivaes, and C. Fabregat. 2004. The role of small reserves in plant conservation in a region of high diversity in eastern Spain. *Biological Conservation* 119:421-426.
- Lesica, P. 1987. A technique for monitoring nonrhizomatous perennial plant species in permanent belt transects. *Natural Areas Journal* 7:65-68.
- Milly, P.C.D., J. Betancourt, M. Falkenmark, R.M. Hirsch, Z.W. Kundzewicz, D.P. Lettenmaier, and R.J. Stouffer. 2008. Stationarity is dead: whither water management? *Science* 319:573-574.
- NatureServe. 2010. NatureServe explorer: an online encyclopedia of life. Version 7.1. NatureServe, Arlington, Va. Available online <<http://www.natureserve.org/explorer>>. Accessed 08 May 2011.
- Odum, E.P. 1969. The strategy of ecosystem development. *Science* 164:262-270.
- Peters, R.L., and J.D.S. Darling. 1985. The greenhouse-effect and nature reserves. *Bioscience* 35:707-717.
- Ramstetter, J. 1983. An ecological study of the regional endemic *Penstemon lemhiensis* (Keck) Keck and Cronq. (Scrophulariaceae). M.S. Thesis, University of Montana, Missoula.
- Rodhouse, T.J., K.T. Vierling, and K.M. Irvine. 2011. A practical sampling design for acoustic surveys of bats. *Journal of Wildlife Management* 75:1094-1102.
- Root, T.T., and S.H. Schneider. 2006. Conservation and climate change: the challenges ahead. *Conservation Biology* 20:706-708.
- Shafer, C.L. 1999. National park and reserve planning to protect biological diversity: some basic elements. *Landscape and Urban Planning* 44:123-153.
- Smith, T.B., S. Kark, C.J. Schneider, R.K. Wayne, and C. Moritz. 2001. Biodiversity hotspots and beyond: the need for preserving environmental transitions. *Trends in Ecology and Evolution* 16:431.
- Stevens Jr., D.L., and A.R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. *Environmetrics* 14:593-610.
- Stevens Jr., D.L., A.R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99:262-278.
- Storm, L., and D. Shebitz. 2006. Evaluating the purpose, extent, and ecological restoration applications of indigenous burning practices in southwestern Washington. *Ecological Restoration* 24:256-268.
- Thompson, S.K. 2002. *Sampling*, 2nd ed. J. Wiley, New York.