National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Camas Monitoring at Big Hole National Battlefield

2015 Annual Report

Natural Resource Data Series NPS/UCBN/NRDS—2017/1077

ON THE COVER
Photograph of Big Hole National Battlefield, Montana.
Photograph by Devin Stucki, NPS.

Camas Monitoring at Big Hole National Battlefield

2015 Annual Report

Natural Resource Data Series NPS/UCBN/NRDS—2017/1077

Devin S. Stucki

National Park Service
63095 Deschutes Market Road
Bend, Oregon 97701

Thomas J. Rodhouse

National Park Service
63095 Deschutes Market Road
Bend, Oregon 97701

January 2017

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established peer-reviewed protocols and were analyzed and interpreted within guidelines of the protocols.

This report is available in digital format from the Upper Columbia Basin Network website and the Natural Resource Publications Management website. To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Stucki, D. S. and T. J. Rodhouse 2017. Camas monitoring at Big Hole National Battlefield: 2015 annual report. Natural Resource Data Series NPS/UCBN/NRDS—2017/1077. National Park Service, Fort Collins, Colorado.

NPS 341/135934, January 2017

Contents

Page

Figures

Page

Tables

Page

Abstract

As part of the Upper Columbia Basin Network's long-term vital signs monitoring, we completed monitoring of camas lily (*Camassia quamash* (Pursh) Greene) in 2015 in Big Hole National Battlefield (BIHO). This is the tenth year of camas monitoring in BIHO.

In 2015, based on counts of camas in one-hundred-fifty-one 0.6 m^2 quadrats, mean density of established camas plants/m^2 was estimated to be 1.4 (90% confidence interval 0.9-2.1). This was considerably lower than the 2014 estimate of 3.4 plants/ m^2 and represents the lowest estimated density since monitoring began at BIHO in 2006. Estimated mean density of flowering camas plants/m^2 was 0.6 (90% confidence interval 0.3-0.9), also down from 2014. Canada thistle was found in 8 plots (~5% frequency of occurrence) in 2015. Canada thistle was found in 3 plots in 2013 and was not found in any plots in 2014.

Weather patterns in the Big Hole Valley have been warmer and drier than average. Monthly average temperatures during the 2015 water year were mostly above average, especially during the winter and spring months. Monthly average precipitation totals were more variable with a wetter than average fall and a drier than average winter and spring. It is unclear what has led to the decline in camas density. A further trend analysis investigating these declines in camas density, as well as accounting for the effects of average monthly temperature and precipitation on camas populations and flowering rates, will be available in 2017.

Acknowledgments

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Inventory and Monitoring Program. This project is made possible by the strong support of both Big Hole National Battlefield and Nez Perce National Historical Park staff. Each year since 2006, staff from these parks has joined the Upper Columbia Basin Network I&M staff to survey for camas. This teamwork allows for surveys to be conducted very efficiently in a short amount of time. This document relies heavily on previous versions of this annual report, as well the Camas Lily Monitoring Protocol (Rodhouse et al. 2007).

Introduction

Common camas (*Camassia quamash* [Pursh] Greene) is a perennial bulb-producing lily (Family Liliaceae; alternatively Agavaceae, APG 2003) that was and remains one of the most widely utilized plant foods of the Nez Perce people (Harbinger 1964, Hunn 1981, Turner and Kuhnlein 1983, Thoms 1989, Mastrogiuseppe 2000). Camas was also a focal resource at many of the significant historical events memorialized by Big Hole National Battlefield (BIHO) and Nez Perce National Historical Park (NEPE). It was during the camas harvest at Weippe Prairie, a subunit of NEPE, that the Lewis and Clark Corps of Discovery first encountered the Nez Perce. The battle at Big Hole occurred at a traditional Nez Perce camas harvesting campsite. It is also noteworthy that the botanical "type" specimen for the genus *Camassia* as well as for *C. quamash* itself was collected by the Lewis and Clark expedition returning through the Weippe Prairie during the spring of 1806 (Meehan 1898, Gould 1942).

Camas is considered a facultative wetland species (Reed 1988) that is strongly associated with the seasonal wet prairie ecosystems of the interior Columbia Plateau and northern Rocky Mountains which are represented at the Weippe Prairie and along the North Fork of the Big Hole River, where BIHO is located. Large expanses of camas in bloom were noted by numerous explorers and botanists that entered the Pacific Northwest in the 19th century, including the Lewis and Clark expedition, and which were frequently described as "blue lakes" when viewed from a distance (Havard 1895, Leiberg 1897, Murphey 1987, Thoms 1989). The extent of the wet prairie ecosystem type has been drastically reduced throughout the Pacific Northwest as a result of agricultural conversion, irrigation and flood control development, and other land use practices (Thoms 1989, Dahl 1990, Taft and Haig 2003). Remaining wet prairies in the region are often structurally altered and compromised by non-native and woody native invasive species. The NPS-owned portions of Weippe Prairie and the Big Hole valley are no exception. Both sites have historic agricultural developments that have altered site hydrology, are impacted by invasive weeds, and Weippe Prairie has also been used for intensive haying and grazing. Orange hawkweed (*Hieracium aurantiacum*) and sulfur cinquefoil (*Potentilla recta*), invasive plants in Idaho, are present at Weippe Prairie and part of the focus of current park weed management. Canada thistle (*Cirsium arvense*) is an emerging invader along the floodplain where the BIHO camas population is now being monitored. Competition from invasive weed species, including the aforementioned forbs as well as thatch-building grasses such as timothy (*Phleum pratense*), may impact camas populations within the UCBN through competition. Herbicide applications at Weippe Prairie, and to a lesser extent at BIHO, continue as part of the parks' integrated weed management programs.

Despite the continued impacts of modern anthropogenic stressors on what appear to be markedly reduced camas populations, the wet prairies of BIHO and NEPE, like their better studied analogues in Oregon's Willamette Valley, are highly productive ecosystems that exhibit a good potential for restoration (Pendergrass et al. 1998, Taft and Haig 2003). A long-term monitoring program for detecting status and trends in camas populations at BIHO and Weippe Prairie serves as a central information source for park adaptive management decision making and will provide essential feedback on any eventual restoration efforts (Rodhouse et al. 2011). Camas monitoring is particularly important at Weippe Prairie because it is the focal resource for the site, and because invasive plant treatment is an ongoing management concern there. The site is also a target of park restoration efforts. The National Park Service acquired the Weippe Prairie property in 2003 and does not yet have a developed management plan. The implementation of camas monitoring early in the process of NPS management at Weippe Prairie is timely and is greatly facilitating science-based decision making. Park management has considerable latitude in the strategies and tools employed there. At BIHO, where management is less intense and opportunities for restoration are few, given the cultural sensitivity of the battlefield, camas monitoring still provides a valuable indication of overall status and trend of the camas population and its supporting wetland over time.

It is hoped that the UCBN camas monitoring program will deliver timely and helpful information to park managers. Both park sites are managed to preserve the historic landscapes of which camas is a central component. Camas is a facultative wetland species that should respond conspicuously to perturbations in the wet prairie ecosystems of BIHO and Weippe Prairie, thus making it an effective indicator of overall ecological condition. An initial restoration-oriented trend assessment was published by Rodhouse et al. (2011) for both BIHO and Weippe Prairie over the 2005-2010 period, which provided encouraging evidence of increasing trend. We have adopted the recommendations made by Bennetts et al. (2007) and begun the identification of early-warning assessment points. Our first assessment point is a 25% decline in mean camas density. A concomitant 25% increase is also an assessment point, but one better described as an initial desired future condition benchmark rather than an early-warning sign (Bennetts et al. 2007). These were arrived at as starting points in the face of considerable uncertainty concerning camas synecology, were logistically and statistically feasible, and inherently conservative. We will look to add new assessment points as our knowledge about camas and the wet prairie ecosystem grows. Annual reports such as this are important elements in this process.

The National Park Service initiated a camas monitoring program at NEPE in 2005 and at BIHO in 2006, assisted in large part by student “citizen scientists” who participate in annual spring field data collection. The field effort involves counting all established camas plants within quadrats, as well as those plants that flower during that growing season. Thatch depth and the presence of target invasive weeds have also been measured in each quadrat, although thatch depth measurements were discontinued in 2010 following recommendations made by Rodhouse and Jocius (2009). Weather is an additional important driver of camas population dynamics, and summaries from weather stations near each of the parks will be used in modeling long-term trends. The monitoring protocol developed by Rodhouse et al. (2007) was reviewed and approved for implementation by the Pacific West Regional I&M Program Coordinator in October 2007.

We report here on the 2015 sampling results from BIHO, and include results from 2006-2014 to provide context for current estimates of camas density, which were also reported by Stucki and Rodhouse (2015). Some interesting patterns are emerging in these data, which will serve to stimulate new hypotheses and assessment points. With the protocol complete and the design and methodology stabilized, we have begun to accumulate a robust long-term data set. Given the predictions of climate change in the Pacific Northwest and the legacy of past land use, monitoring UCBN camas prairies over time is sure to shed new light on the important issues of ecosystem recovery and ecological resilience.

Objectives

The monitoring objectives for this program are:

- Estimate mean established plant and flowering stem densities (status) in the camas populations of Weippe Prairie and within the targeted portion of BIHO.
- Determine trends (net trend, as reviewed by MacDonald 2003) in the densities of established camas populations in Weippe Prairie and BIHO.
- Determine trends in the proportion of flowering to non-flowering camas plants in Weippe Prairie and BIHO.
- Determine trends in the frequency of occurrence of targeted invasive plants (currently these are orange hawkweed and sulfur cinquefoil at Weippe Prairie and Canada thistle at BIHO).
- Determine the magnitude and direction of camas density response to measurable explanatory variables such as winter precipitation and specific management activities.

Note: "Established camas plants" are those plants expressing 2 or more leaves and excludes single-leaved seedlings. The significance of this distinction is discussed in greater detail in the UCBN camas monitoring protocol (Rodhouse et al. 2007).

This report summarizes estimates of established camas density and flowering plant density in the BIHO camas population over the period 2006-2015. A companion report will be available for Weippe Prairie covering the same time period.

Methods

The UCBN initiated camas monitoring at BIHO, located near Wisdom, Montana, in 2006. Figure 1 shows the sampling frame and 2015 quadrat locations. Sampling methods followed those detailed by Rodhouse et al. (2007). The approach is quadrat-based and involves the measurement of camas plant density, camas flowering stem density, and the presence of targeted invasive plant species in a random sample of 0.6 m^2 quadrats from within a sampling frame that captures the most important portion of the BIHO camas population. Cultural concerns led to the development of a targeted sampling frame with arbitrary boundaries that encompassed the largest and most abundant portion of the camas population in the park (Figure 1). Therefore, the scope of inference from monitoring is strictly limited to this core area rather than to the entire population in the Battlefield. Quadrats are 4 m long x 15 cm wide, designed to reach across the patchy distribution of camas in the meadow and reduce the number of plots without camas. Quadrats were placed at randomly-selected locations, and locations were generated from the Generalized Random Tessellation Stratified (GRTS) sampling design algorithm. This sampling design results in a well dispersed, spatially-balanced sample (Figure 1). Sample sizes at BIHO were 81, 124, 150, 150, 160, 154, 150, 151, 152, and 151 for the years 2006-2015 (Table 1). Sample sizes were increased following power analysis in 2007 (Rodhouse et al. 2007) and as field capacity increased through the support of park staff. The target sample size has remained 150 plots since 2008, although oversamples have been picked up during some surveys. All camas plants were included in camas density counts in 2006, but a protocol change beginning in 2007 led to the exclusion of single-leaved seedlings. Camas seedlings are ephemeral and highly variable in their germination, and this led us to focus the protocol on *established* camas plants beginning in 2007. This is the most significant methodological change and one that requires careful and cautious consideration of comparisons among the first 2 years.

Camas flowering stem density was also measured at each quadrat. Mature camas plants can produce one conspicuous and persistent inflorescence each year (see cover illustration), making flowering stem counts reliable and direct. Not all mature plants flower in a given year, however, and variability in flowering is of interest to the UCBN. Graminoid thatch depth was measured at each quadrat beginning in 2006 as well. Thatch depth was measured in three pre-established locations along the quadrat long axis and averaged. This practice was discontinued in 2010 due to lack of evidence of any relationship between thatch depth and density (Rodhouse and Jocius 2009).

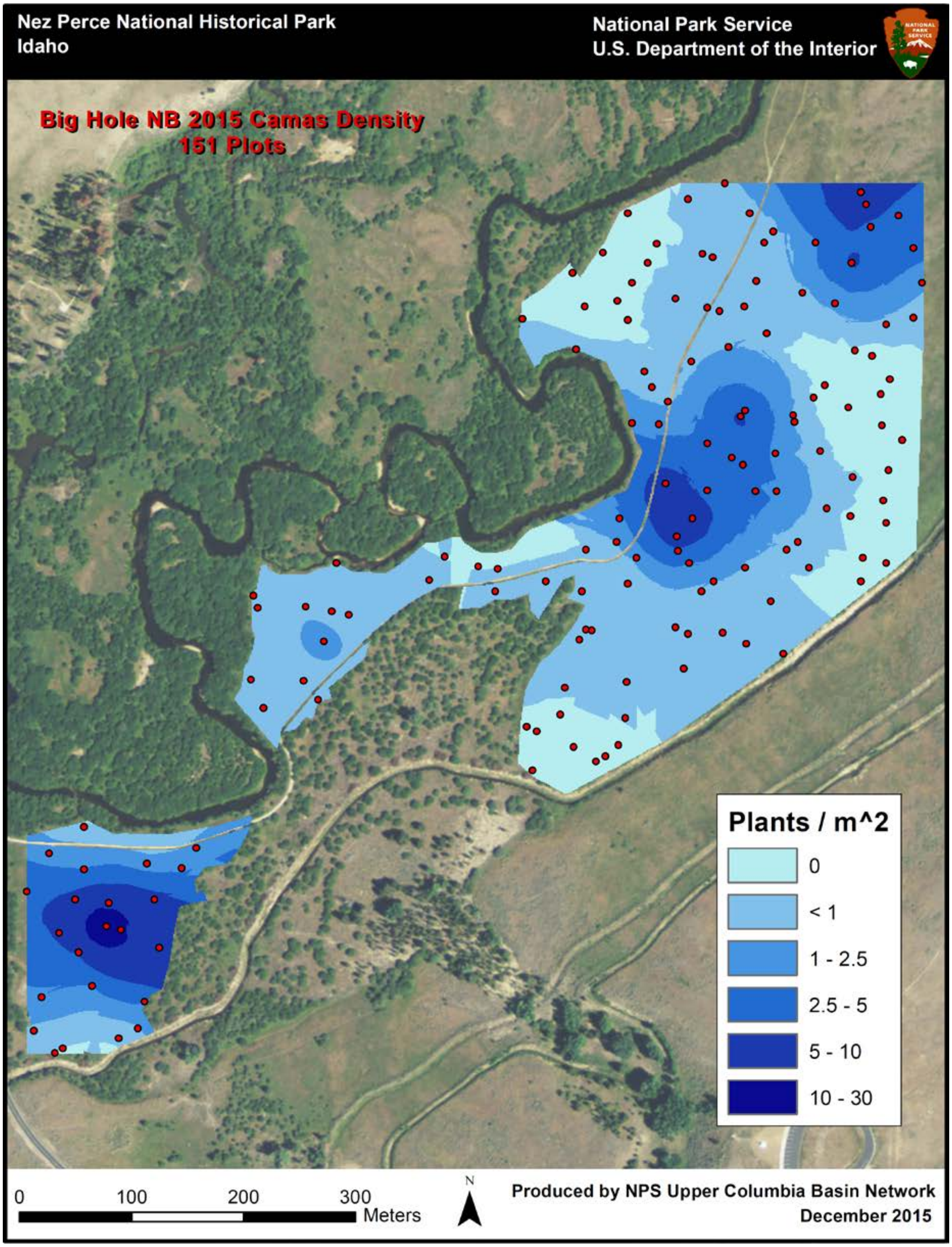

Figure 1. The sampling frame along the Big Hole River floodplain in BIHO, with 2015 quadrat locations (red points) and predicted patterns of camas density based on a kriging interpolation from 2015 established camas plant counts.

Early monitoring results indicated that density counts were extremely skewed and required alternative analytical procedures that did not require assumptions of normality (Rodhouse et al. 2007) (Figure 2). Rodhouse used a non-parametric bootstrap computer-intensive method to conduct power analyses with 2006 and 2007 data following methods outlined by Hamilton and Collings (1991). For this report, 90% confidence intervals around means were calculated using the simple bootstrap percentile method described by Efron and Tibshirani (1993) and Manly (2001). Ordinary kriging (Fortin and Dale 2009) was used to produce an interpolated density map for BIHO using 2015 data. Predictive density maps provide useful interpretive tools to illustrate density patterns across the floodplain. Finally, we summarize recent weather patterns from the Calvert Creek SNO-TEL weather station located approximately 24 miles northeast of the Battlefield using the capabilities of the Climate Analyzer (www.climateanalyzer.org) developed by NPS contractor Dr. Mike Tercek. All analyses and associated graphics were prepared in the R software and computing environment (R version 3.1, http://www.r-project.org/) and ArcGIS (ESRI, Inc., Redlands, California).

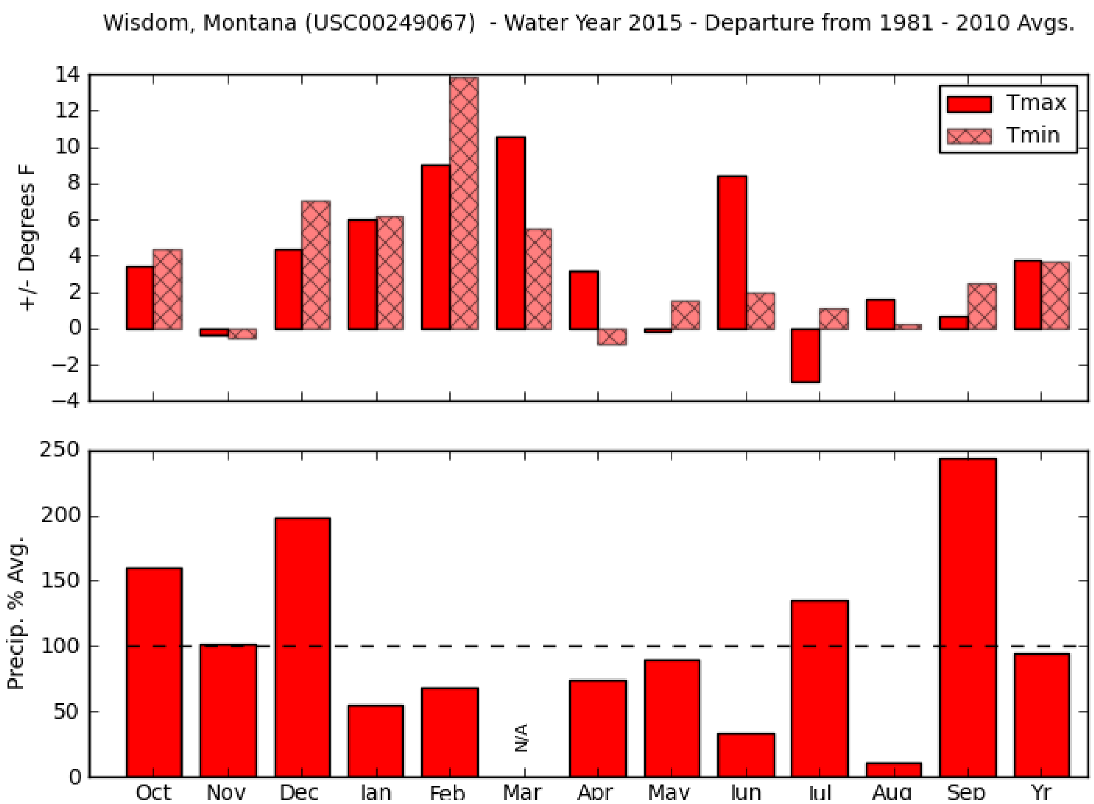

Figure 2. 2015 water year monthly temperature and precipitation departures from 30-year averages (1981-2010). This figure illustrates that winter temperatures were considerably warmer than average and precipitation totals from January-June 2015 were below average. N/A represents missing precipitation values. Data from the Wisdom, Montana National Weather Service Cooperative Observer Network, located 10 miles east of the Battlefield.

Results

In 2015, based on counts of camas in one-hundred-fifty-one 0.6 m^2 quadrats, mean density of established camas plants/m^2 at BIHO was estimated to be 1.4 (90% confidence interval 0.9-2.1). This was considerably lower than the 2014 estimate and represents the lowest camas density estimate in BIHO since camas monitoring was initiated in 2006 (Table 1 and Figure 3). Estimated mean density of flowering camas plants/m^2 was 0.55 (90% confidence interval 0.3-0.9), also representing the lowest flowering camas density estimate (Table 1 and Figure 4). Spatial variation in camas density is described by the predicted density map (Figure 1).

Table 1. Estimated means and 90% confidence intervals for established camas plant density and flowering plant density.

		Plants/m^2	90% percentile		Stems/m^2	90% Percentile		Flowering
Year	n	Density	lower	upper	Flowers	lower	upper	Ratio
2015	151	1.44	0.87	2.11	0.55	0.30	0.85	0.49
2014	152	3.39	2.32	4.58	0.82	0.57	1.10	0.32
2013	151	6.14	3.98	8.65	1.33	0.86	1.83	0.26
2012	150	6.18	4.33	8.27	1.16	0.75	1.63	0.26
2011	154	6.79	4.80	9.00	1.53	1.08	1.99	0.22
2010	160	5.40	3.82	7.14	0.56	0.38	0.76	0.1
2009	150	5.78	4.18	7.52	1.58	1.06	2.16	0.27
2008	150	5.71	3.97	7.67	2.69	1.83	3.69	0.47
2007	124	3.86	2.53	5.52	1.90	1.25	2.68	0.49
2006	81	4.22	2.19	6.58	0.68	0.37	1.02	0.16

In 2013, Canada thistle (*Cirsium arvense*) was found in 3 plots (~2% frequency of occurrence). This was the first year that this invasive species was encountered in plots, although observations outside of plots have been increasing in recent years. In 2014, no Canada thistle plants were encountered within plots. In 2015, Canada thistle was recorded in 8 plots (~5% frequency of occurrence).

Weather patterns in the Big Hole Valley have been warmer and drier than average (Figure 2). Monthly average temperatures during the 2015 water year were mostly above average, especially during the winter and spring months. Monthly average precipitation totals were more variable with a wetter than average fall and a drier than average winter and spring. A second formal trend analysis report following the one provided by Rodhouse et al. (2011) will be available in 2017 and will take into account the effects of average monthly temperature and precipitation on camas populations and flowering rates at BIHO.

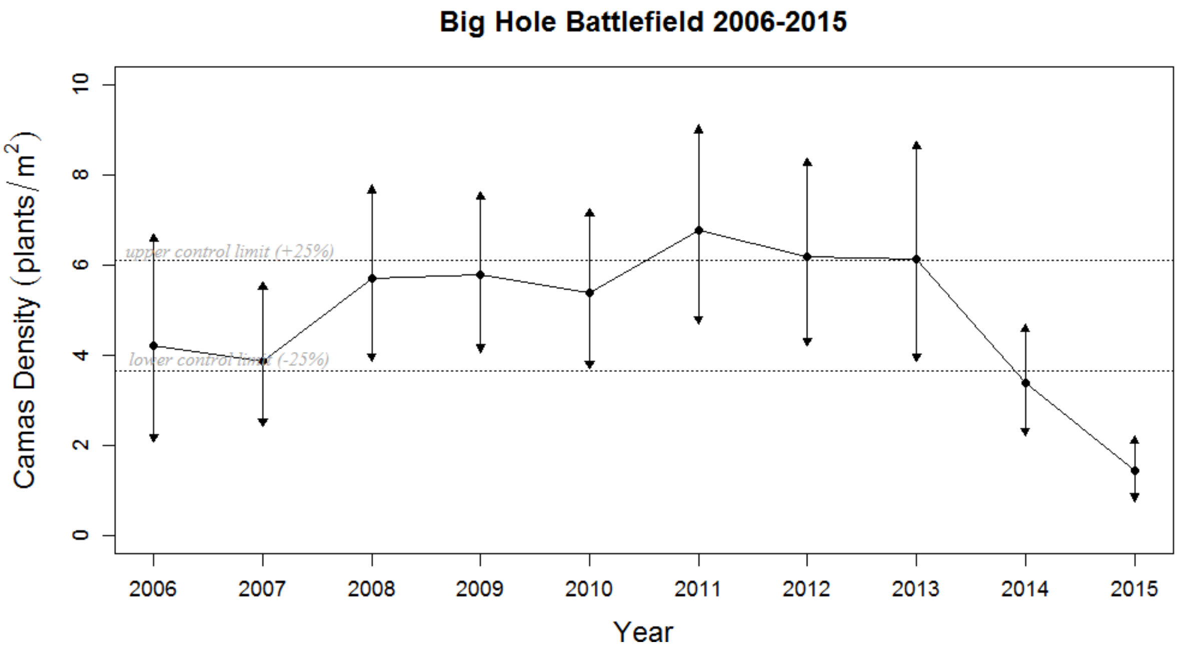

Figure 3. "Conformance" or control chart that plots annual established camas plant densities and 90% confidence intervals relative to control limits that are ±25% of the average density, over the monitoring period 2006-2015.

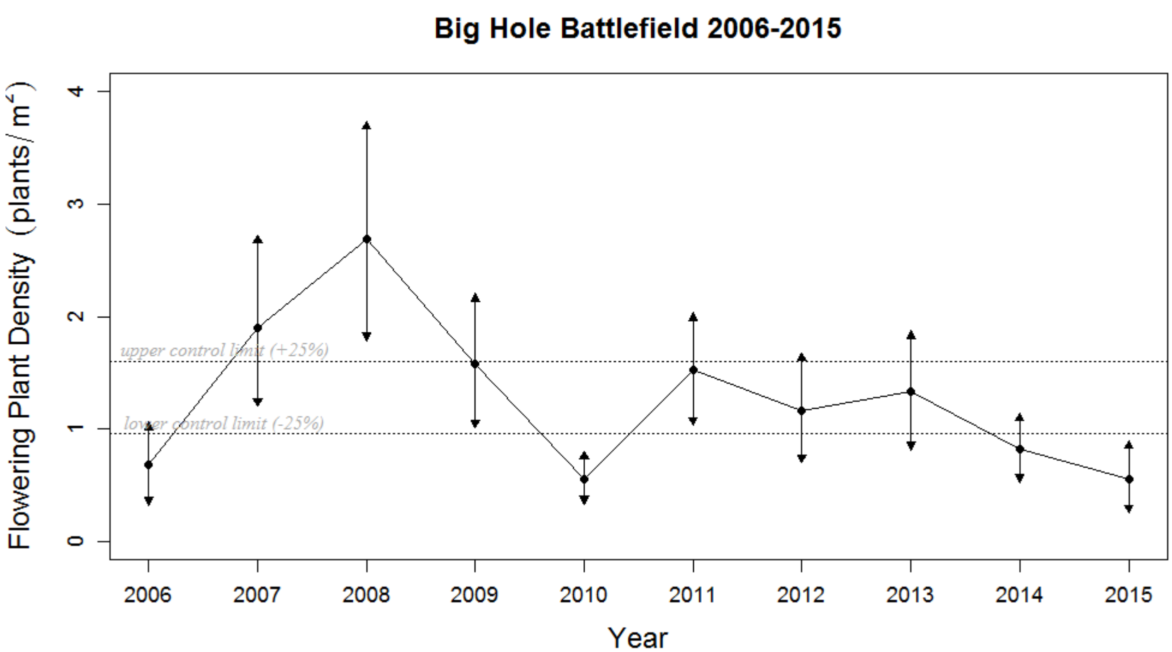

Figure 4. "Conformance" or control chart that plots annual established flowering camas plant densities and 90% confidence intervals relative to control limits that are ±25% of the average density, over the monitoring period 2006-2015.

Literature Cited

Angiosperm Phylogeny Group (APG). 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141:399-436.

Bennetts, R. E., J. E. Gross, K. Cahill, C. McIntyre, B. B. Bingham, A. Hubbard, L. Cameron, and S. L. Carter. 2007. Linking monitoring to management and planning: assessment points as a generalized approach. George Wright Forum 24:59-77.

Beauregard, M. R., R. J. Mikulak, and B. A. Olson. 1992. A practical guide to statistical quality improvement: opening up the statistical toolbox. Van Nostrand Reinhold, New York.

Dahl, T. E. 1990. Wetlands: losses in the United States: 1780's to 1980's. US Fish and Wildlife Service, Washington DC.

Efron, B., and R. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, London, England.

Fortin, M.-J, and M. Dale. 2005. Spatial analysis: a guide for ecologists. Cambridge University Press, Cambridge, England.

Gould, F. W. 1942. A systematic treatment of the genus *Camassia* Lindl. American Midland Naturalist 28:712-742.

Hamilton, M. A., and B. J. Collings. 1991. Determining the appropriate sample size for nonparametric tests for location shift. Technometrics 33:327-337.

Harbinger L. J. 1964. The importance of food plants in the maintenance of Nez Perce cultural identity. Thesis. Washington State University, Pullman, Washington.

Havard, V. 1895. Food plants of the American Indians. Bulletin of the Torrey Botanical Club 22:98-123.

Hunn E. S. 1981. On the relative contribution of men and women to subsistence among hunter-gathers of the Columbia Plateau: a comparison with *Ethnographic Atlas* summaries. Journal of Ethnobiology 1:124-134.

Leiberg, J. B. 1897. General report on a botanical survey of the Coeur d'Alene mountains in Idaho. Contributions of the U.S. National Herbarium. Vol V., No. 1., Washington DC.

MacDonald, T. 2003. Review of environmental monitoring methods: survey designs. Environmental Monitoring and Review 85:277-292.

Manly, B. F. J. 2001. Randomization, Bootstrap and Monte Carlo Methods in Biology. Chapman and Hall/CRC, Boca Raton, Florida.

Mastrogiuseppe, J. 2000. Nez Perce ethnobotany: a synthetic review. Report to Nez Perce National Historic Park, Spalding, ID. Project # PX9370-97-024.

Meehan, T. 1898. The plants of Lewis and Clark's expedition across the continent, 1804-1806. Proceedings of the Academy of Natural Sciences of Philadelphia 50:12-49.

Morrison, L. 2008. The use of control charts to interpret monitoring data. Natural Areas Journal 28:66-73.

Murphey, E. V. A. 1987. Indian Uses of Native Plants. Mendocino County Historical Society, Ukiah, California.

Pendergrass, K. L., P. M. Miller, and J. B Kauffmann. 1998. Prescribed fire and the response of woody species in Willamette Valley wetland prairies. Restoration Ecology 6:303-311.

Reed, P. B., Jr. 1988. National list of plant species that occur in wetlands: 1988 national summary. U.S. Fish and Wildlife Service. Biological Report 88 (24).

Rodhouse, T. J., and D.S Stucki. 2013a. Camas monitoring in Big Hole National Battlefield: 2012 Annual Report. Natural Resource Technical Report NPS/UCBN/NRTR—2013/826. National Park Service, Fort Collins, Colorado.

Rodhouse, T. J., and D.S. Stucki. 2013b. Camas monitoring in Nez Perce National Historical Park's Weippe Prairie: 2013 annual report. Natural Resource Technical Report NPS/UCBN/NRTR—2013/816. National Park Service, Fort Collins, Colorado.

Rodhouse, T. J., K. M. Irvine, K. T. Vierling, and L. A. Vierling. 2011. Modeling temporal trend in the presence of spatial complexity: a Bayesian approach for a wetland forb population undergoing restoration. PLoS ONE 6:e28635.

Rodhouse, T. J., M. V. Wilson, K. M. Irvine, R. K. Steinhorst, G. H. Dicus, L. K. Garrett, and J. W. Lyon. 2007. Camas lily monitoring protocol. Version 1.0. Natural Resource Report NPS/UCBN/NRR—2007/011. National Park Service, Fort Collins, Colorado.

Rodhouse, T. J., and J. L. Jocius. 2009. Camas monitoring at Nez Perce National Historical Park and Big Hole National Battlefield: 2009 annual report. Natural Resource Technical Report NPS/UCBN/NRTR—2009/265. National Park Service, Fort Collins, Colorado.

Rodhouse, T. J., and J. L. Jocius. 2011. Camas monitoring at Nez Perce National Historical Park and Big Hole National Battlefield: 2010 annual report. Natural Resource Technical Report NPS/UCBN/NRTR—2011/430. National Park Service, Fort Collins, Colorado.

Stucki, D. S., and T. J. Rodhouse. 2015. Camas monitoring at Big Hole National Battlefield: 2014 annual report. Natural Resource Data Series. NPS/UCBN/NRDS—2015/974. National Park Service. Fort Collins, Colorado

Taft, O. W., and S. M. Haig. 2003. Historical wetlands in Oregon's Willamette Valley: implications for restoration of winter waterbird habitat. Wetlands 23:51-64.

Thoms, A. 1989. The northern roots of hunter-gatherer intensification: camas and the Pacific Northwest. Dissertation. Washington State University, Pullman, Washington.

Turner, N. J., and H. V. Kuhnlein. 1983. Camas (*Camassia* spp.) and riceroot (*Fritillaria* spp.): two liliaceous "root" foods of the Northwest Coast Indians. Ecology of Food and Nutrition 13:199-219.

NPS 341/135934, January 2017

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA ™