National Park Service
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Camas Lily Monitoring Protocol Narrative

Upper Columbia Basin Network

Version 1.0, October 2007

Natural Resource Report NPS/UCBN/NRR—2007/011

ON THE COVER
Camassia quamash (Pursh) Greene
NPS Photograph from Big Hole National Battlefield, courtesy of Dr. Penny Latham

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NPS D-73, October 2007

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	October 2007	UCBN	Revision following peer review		1.0

1. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, …etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
2. Notify the UCBN Data Manager of any changes to the Protocol Narrative or SOPs so that the new version number can be incorporated in the Metadata of the project database.
3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOPs. A list will be maintained in an appendix at the end of this document.

Note: Standard Operating Procedures (SOPs) are bound in a separate accompanying document.

SOP 1: Preparations and Equipment Setup Prior to the Field Season
SOP 2: Training Observers
SOP 3: Finding GPS Waypoints
SOP 4: Locating and Establishing Sampling Quadrats
SOP 5: Measuring Vegetation in Quadrats
SOP 6: Data Management
SOP 7: Data Summary, Analysis, and Reporting
SOP 8: Protocol Revision
SOP 9: Field Safety

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Executive Summary

The mission of the National Park Service is “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The Upper Columbia Basin Network has identified 14 priority park vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Our intent has been to come up with a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Camas is one particularly high priority vital sign for two UCBN parks, Big Hole National Battlefield (BIHO) and Nez Perce National Historical Park (NEPE). Camas is a unique resource for these parks because it is ecologically significant as well as culturally significant. Camas was and remains one of the most widely utilized indigenous foods in the Pacific Northwest and it is strongly associated with the interior wet prairie ecosystems of the region that have been replaced or altered by agriculture and farming, biological invasion, and altered hydrology. While not a “rare” plant per se, populations of camas are significantly reduced in size and distribution. A long-term monitoring program for detecting status and trends in camas populations at BIHO and Weippe Prairie, a subunit of NEPE, will serve as a central information source for park adaptive management decision making and will provide essential feedback on any eventual restoration efforts of park wet prairie habitats.

This protocol details the why, where, how, and when of the UCBN’s camas monitoring program. As recommended by Oakley et al. (2003), it consists of a protocol narrative and a set of standard operating procedures (SOPs), which detail the steps required to collect, manage, and disseminate the data representing the status and trend of camas populations in the Network. The protocol is a “living” document in the sense that it is continually updated as new information acquired through monitoring and evaluation leads to refinement of program objectives and methodologies. Changes to the protocol are carefully documented in a revision history log. The intent of the protocol is to ensure that a seamless and scientifically credible story about camas populations and their supporting habitat and environmental conditions can be told to park visitors and park managers alike. The story is already beginning to unfold. Three years of pilot data have been collected and park rangers have incorporated camas monitoring into their interpretive programs. The next few years of monitoring results are eagerly awaited, as outstanding questions related to inter-annual variability in camas abundance and flowering are answered, the number of required sample units stabilizes, and the current condition of park camas populations can finally be described. From there, the focus will shift toward trend analysis, in which biologically meaningful declines or increases will be detected, and appropriate management strategies can be developed.

Acknowledgments

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Servicewide Inventory and Monitoring Program. We thank the Oregon Museum of Science and Industry and members of its Salmon Camp and Northwest Ecosystem Research Teams for citizen science field assistance. Students and teachers from Highland, Lapwai, and Timberland High Schools also provided invaluable field assistance in 2007. We thank the staff of Big Hole National Battlefield and Nez Perce National Historical Park for coordinating arrangements for the citizen science teams, and to Alyse Cadez, NEPE interpretive specialist, for all her work on the citizen science component of this project. Leona Svancara, data manager for the Upper Columbia Basin Network from 2004-2006, contributed to an earlier draft of this protocol. Allen Kitchel, University of Idaho, developed the draft Microsoft Access database for this protocol. Palouse Clearwater Environmental Institute's IEEC Americorp program enabled Kira Crawford and Jannis Jocius to contribute invaluable assistance with field work, citizen science coordination, and interpretive material development. Mackenzie Shardlow, UCBN biological technician, was instrumental in 2007 field work preparation and assisted with the production of this protocol. Dr. Susan Kephart, Willamette University, Drs. Nancy Turner and Brenda Beckwith, University of Victoria, and University of Washington doctoral candidate Linda Storm graciously shared unpublished and forthcoming data and manuscripts, and provided helpful comments on ethnographic and historical content. Dr. Jeff Yeo, consultant and former science director for The Nature Conservancy-Idaho provided helpful comments on an earlier version of this document. We thank Dr. Penny Latham, NPS Pacific West Regional I&M program coordinator, and Dr. Jim Agee, University of Washington Professor, for soliciting academic peer reviews and providing their own rigorous review of this protocol. Finally, we thank the two anonymous reviewers who provided thorough and constructive comments on this protocol.

Background and Objectives

Rationale for Monitoring Camas Populations in the Upper Columbia Basin

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, where 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 *Camassia* genus 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 therefore a central element of the cultural landscapes that BIHO and NEPE seek to interpret for the public. The focal cultural resource status of camas is one of two driving rationales for establishing a camas monitoring program in the Upper Columbia Basin Network (UCBN).

Camas is also ecologically significant to the UCBN. It is considered a facultative wetland species (Reed 1988) that is strongly associated with the seasonal wet prairie ecosystems of the interior Columbia Plateau which are represented at the Weippe Prairie, a subunit of NEPE, and along the North Fork of the Big Hole River, where the Big Hole Battlefield 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 in the Columbia Basin 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 sulphur cinquefoil (*Potentilla recta*), listed as noxious plants in Idaho, are present at Weippe Prairie and part of the focus of current park weed management. Competition from invasive weed species, particularly thatch-building grasses such as timothy (*Phleum pratense*), is a likely stressor on camas populations within the UCBN. Reduced fire frequency has also allowed black hawthorn (*Cretaegus douglasii*) to become established in the prairie, and this may eventually cause an undesirable shift in prairie plant vegetation, including a reduction in camas. Park managers at NEPE have discontinued grazing as of 2007 but still permit haying, and herbicide applications at Weippe Prairie, following guidance from the Upper Columbia Basin Network and Natural Resources Conservation Service (NRCS). These activities have been primarily aimed at weed control, but have almost certainly impacted the camas populations as well (e.g. removal of photosynthesizing tissue before summer senescence and bulb dormancy) (Lambert 2001).

Camas is a geophyte that stores carbohydrates in its underground bulb, allowing it to survive harsh environmental conditions. It is therefore a reasonably robust plant and can tolerate moderate levels of disturbance. Camas reproduces both sexually, through seed, and asexually through vegetative offsets of “daughter bulbs”. Thoms (1989) noted from ethnographic sources that digging of bulbs was strongly associated with increased abundance of plants caused by offsetting from bulb wounds, and suggests that the moderate levels of soil disturbance and removal of competing plants was a fundamental method by which indigenous people managed camas prairies. Late summer burning of camas prairies was also reported by Thoms (1989) as a method for increasing site productivity, and has been noted for the wet prairies of Oregon’s Willamette Valley, where camas was also an important food source (Johannesen et al. 1971; Sultany et al. *in press*). Modern restoration literature also underscores the importance of fire in these ecosystems, and it is possible that cessation of fire and digging have contributed to the decline of camas populations in extant prairie systems (Wilson 1999; Clark and Wilson 2001; Dr. Brenda Beckwith, University of Victoria, Professor, personal communication, January 22, 2007; Linda Storm, University of Washington, doctoral candidate, unpublished data). Thoms (1989), summarizing a combination of both qualitative historical and limited quantitative botanical information, presents estimates of historical camas density as it was encountered during and shortly after the contact period of the 19^{th}-century. Density in high quality digging meadows where larger plants were favored was estimated to be 150 plants/m^2, and more typical high density stands were estimated to be approximately 300 plants/m^2. These exceptionally high numbers are supported, in part, by historical accounts by early botanists visiting the region that described camas growing “in ‘vast’ wet meadows by the ‘millions’” and “so plentiful in many places that it is no exaggeration to say that…more than one-half of the total herbaceous vegetation in the lowlands was composed of this one species” (Leiberg 1897; St. John 1937; Thoms 1989:166). Dr. Susan Kephart of Willamette University (personal communication, December 7, 2006) successfully planted camas bulbs in densities of 100 plants/m^2, and views this range of numbers to be a plausible approximation of historic high density conditions. Density estimates for the five management zones of Weippe Prairie and Big Hole Battlefield in 2007 ranged from 0.44 to 61plants/m^2. Given the historical importance of the camas harvest at these locations, it seems reasonable to conclude that current camas populations in these parks are well below historic levels.

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 the Willamette Valley, are highly productive ecosystems that exhibit a good potential for restoration (Taft and Haig 2003). A long-term monitoring program for detecting status and trends in camas populations at BIHO and Weippe Prairie will serve as a central information source for park adaptive management decision making and will provide essential feedback on any eventual restoration efforts. Camas monitoring will be particularly important at Weippe Prairie because it is the focal resource for the site, and because the site remains actively sprayed and mowed, and is a likely target for park restoration efforts in the future. The impact of these activities on the camas population as well as on the invasive plant species targeted for control remains unknown. 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 will greatly facilitate 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 will still provide an invaluable indication of overall status and trend of the camas population and its supporting wetland over time.

Figure 1 is a conceptual model that illustrates the primary rationale for monitoring camas populations in BIHO and NEPE. It begins with the driving historical events that established the park mission and includes the influence of visitor experience, scientific literature, and traditional ecological knowledge on desired future conditions, alternative management actions available for achieving those desired future conditions, and the feedback from camas population measures on management actions. Soil moisture is the fundamental driver of camas density within the prairie system, and areas that dry out too early in the spring or remain inundated through the growing season do not support camas. Historic site drainage at Weippe Prairie and the upslope irrigation canal at BIHO have interrupted subsurface flow and impacted soil moisture. At Weippe Prairie, a *fragipan*-type soil condition that allows surface soils to remain saturated after spring snowmelt has been punctured by drainage ditches in numerous places to direct water off the site and permit haying. Climate change is an additional stressor that may impact soil moisture regimes in the camas prairies of the UCBN. Unpublished botanical garden data provides evidence that early drying and excessive soil temperature can interrupt or prevent germination and flowering of camas plants (Willamette University, Dr. Susan Kephart, Professor, personal communication, December 7, 2006). Thoms (1989) also notes historical accounts of prolonged drought severely impacting the camas-dependent Kalapuyan tribe in the Willamette Valley.

Well articulated desired future condition statements have not yet been developed for the camas resource in these parks. However, the mission statements for the NPS as a whole and for the individual parks BIHO and NEPE clearly state the intent “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). Camas is one of those particularly important resources with both natural and cultural merit. It is assumed that desired future conditions for BIHO and NEPE will include a robust population of camas that, when in bloom, provides visitors a visual experience akin to viewing a “blue lake”. It also assumed that current camas densities are minimally acceptable, and that an increase in camas density is a reasonable goal for park management and restoration. It has been suggested that some form of limited camas harvest could be reintroduced to Weippe Prairie someday, particularly if digging can be used to stimulate reproduction and therefore serve as a restoration tool. The incorporation of traditional ecological knowledge into desired future condition statements is welcomed. This may be particularly helpful in refining management targets for optimal density available from secondary sources such as Thoms (1989) and from Nez Perce tribal members actively engaged in the camas harvesting tradition. Recent feedback from primary Nez Perce sources suggests that the camas bulbs at Weippe Prairie are generally too small to warrant subsistence harvest. The relationship between bulb size and density needs to be clarified with additional research, but might be used in setting restoration and management goals in the future. Plant density and flowering stem density, as the response variables for this protocol, will directly measure the population characteristics most important to park mission, visitor experience, and desired future conditions.

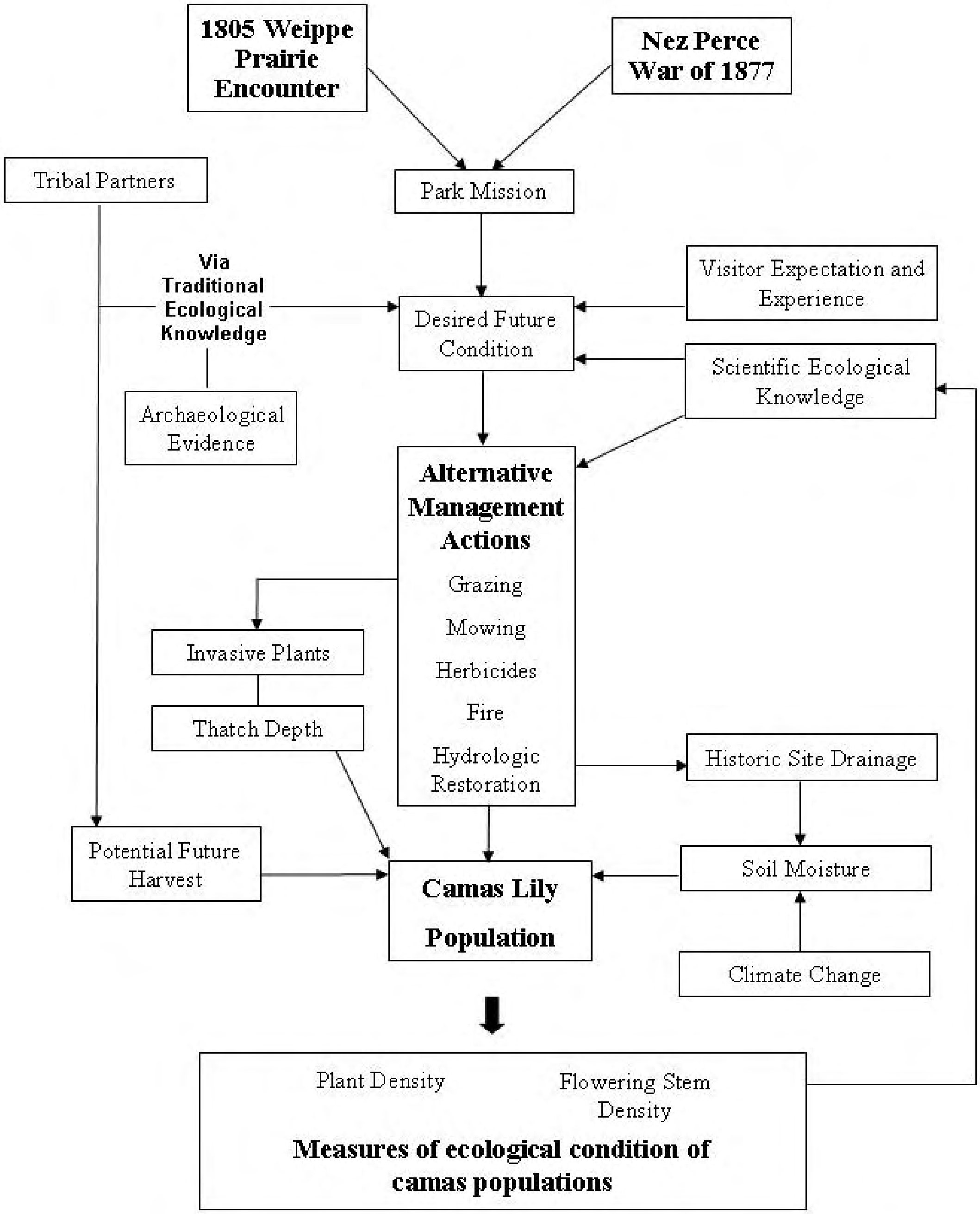

Figure 1. Conceptual model developed to illustrate the historical, cultural, and ecological framework and rationale for monitoring camas populations in the Upper Columbia Basin Network.

Objectives

The overarching programmatic goal of the UCBN camas vital signs monitoring program is to inform management decisions pertaining to the perpetuation of camas populations at Big Hole Battlefield and Weippe Prairie, a subunit of Nez Perce National Historical Park. The primary objective of current camas population management in UCBN parks is to prevent a decline in current density levels. However, given the preponderance of evidence suggesting that current levels are well below historic levels, the restoration of camas populations is of immediate secondary importance. This is particularly true at Weippe Prairie, where management options have greater latitude, and where portions of the park with seemingly suitable habitat currently support few camas plants. This protocol will also serve as part of the UCBN's integrated approach to monitoring invasive plants, in which several different monitoring protocols addressing native vegetation vital signs will also gather status and trend information on the frequency of targeted invasive plant species (Garrett et al. 2007). The UCBN is also interested in pursuing broader ecological questions on the population ecology of camas, such as the relationship between camas density and trends in annual precipitation, placed within the context of predicted climate change.

Given the lack of available ecological data on camas in general, and in UCBN parks in particular, the following fundamental questions continue to drive much of the UCBN's inquiry into camas population ecology:

- Are the camas populations at BIHO and NEPE stable, declining, or increasing?
- What is the range of inter-annual variation in camas density and flowering stem density observed at Weippe Prairie and along the Big Hole River at BIHO?
- What proportion of camas plants flower within a season, and what is the variation in that proportion?
- How does camas density respond to temporal variations in regional precipitation patterns?
- How does camas density respond to changes in specific management or restoration actions?

In light of these questions and the broader goals outlined above, this protocol will address the following specific measurable monitoring objectives:

- Estimate mean established plant and flowering stem densities (status) in the camas populations of Weippe Prairie and within the targeted portion of the Big Hole National Battlefield.
- 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 *Hieracium aurantiacum* and sulphur cinquefoil *Potentilla recta*).
- Determine the magnitude and direction of camas density response to measurable explanatory variables such as winter precipitation, graminoid thatch depth, and specific management activities.

The following sampling objectives have been developed for this protocol:

- Estimate with 90% confidence the sample mean, $\bar{y}$, within $\pm$ 25% of the true mean, μ, for established camas density (plants/m^2) in camas populations at Weippe Prairie and BIHO.
- Detect with 90% certainty (power, or 1-β) a change $\geq$ 25% between any two years (step trend) or across multiple years (continuous trend) in the mean for established camas density with a 0.10 acceptable false-change (α) error rate.

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 next section.

In the absence of sufficient knowledge about historic camas density at either park site, the ability of camas populations to rebound after a disturbance, or the natural variability in camas density, a 25% minimum detectable change level was adopted as a conservative yet biologically meaningful "assessment point" (Bennetts et al. 2007; Carter and Bennetts 2007). This value arose from discussion of camas biology and management, specifically what magnitude of decline should trigger a management response. The protocol development team believes that sampling to detect a 25% change in camas density is adequately conservative and will provide a buffer from a resource collapse threshold which is unknown but believed to be > 50%. It is also felt that detection of a 25% or greater increase in established camas density (e.g. resulting from a two-sided test for 25% change) would be a biologically meaningful increase and will be of great importance to management, particularly for park sampling areas currently exhibiting low camas density, or for those areas that receive restoration attention in the future. This conservative approach follows one recently suggested by Bennetts et al. (2007) and Carter and Bennetts (2007), where, in the absence of sufficient information, the pre-established change criterion (25% in this case) functions as an early warning-type assessment point that will trigger careful consideration of existing management strategies and available alternatives for achieving the desired resource condition. It is expected that additional assessment points will be added and clarification of the desired future condition of the camas resource will be made as additional information becomes available.

Sampling Design

Sampling Design Rationale

The objectives and sampling design were developed, revised, and refined through a process that involved site reconnaissance, pilot data collection and analysis, and thoughtful consideration of park and network information requirements. The development team consisted of this document's authors, as well as park interpretive staff and an Americorp volunteer. Dr. Penny Latham, the regional NPS I&M Program coordinator, also a botanist by training, participated in one site visit with the team as well. Pilot data were collected at Weippe Prairie in June 2005, 2006, and 2007 and at BIHO in June 2006 and 2007 through the field assistance of the Oregon Museum of Science and Industry Salmon Camp Program and high school students from communities near Weippe Prairie.

The decision to focus on established camas plant and flowering stem density followed naturally from a consideration of the direct one-to-one connection between the number of established plants, stems, and bulbs. Established plants are those with 2 or more leaves and a bulb. Seedlings possess only a single leaf blade and a bulblet. The rate of recruitment of seedlings into the established population is not known, but preliminary evidence suggests that large numbers of ephemeral seedlings are produced during favorable spring conditions (Dr. Susan Kephart, Willamette University, personal communication). The decision to eliminate seedlings from consideration in the monitoring program was made from both a biological and statistical consideration. Camas is a long-lived perennial and pulses of ephemeral seedlings do not contribute to population dynamics until they become established (recruitment), at which time they will be counted during sampling. Seedling pulses also contribute considerable variation into count estimates, making more difficult the task of obtaining density estimates with desired precision. Single-leaved seedlings can be difficult to count and identify, especially once plants begin to senesce and small camas leaves brown and resemble grass blades.

Established plant density provides a direct measure of both the biologically and culturally important information about camas populations. The number of flowering plants contributes to the aesthetic impact of camas populations (e.g. the "blue lake" effect) on visitor experience. Older plants reportedly have larger bulbs and are more likely to flower, suggesting that flowering plant density may also be an excellent indicator of bulb size and age structure (Thoms 1989). Camas is a perennial geophyte that produces a whorl of basal leaves and a racemose inflorescence borne on a single scape or leafless peduncle (a "flowering stem"; see Figure 2). Established camas plants and flowering stems are relatively easy to identify, enabling quick and easy plant and stem density counts. Camas plants can vary in size, and cover was considered as an alternative measure of abundance early in the program. This was quickly discarded because of the difficulty in estimating cover for the camas growth form, particularly by inexperienced field personnel. Frequency, measured as simple presence or absence within a quadrat, was also considered but was determined to be an insensitive indicator of abundance and population change.

Figure 2. Diagram of a typical camas plant, showing the bulb, basal leaves, scape (leafless flower stem), and racemose inflorescence (cluster of flowers arranged along an unbranched vertical axis that mature from the bottom up). Insets detail the bilaterally symmetric flower and withering tepals characteristic of *Camassis quamash* ssp. *quamash*. Original illustration by Andrea Foust Carlson, reproduced with permission.

Permanent quadrats will not be used in this monitoring program, despite the benefits such a strategy might provide. One advantage in using permanent quadrats is the higher power gained to detect trend with fewer observations. However, this advantage is greatest when year-to-year correlation within plots is very high (Elzinga 1998). We have not been able to locate information on year-to-year variability within quadrats for camas, making it impossible to assess the merits of this approach and to estimate the increase in efficiency. Status of camas populations is a major component of the monitoring objectives, and it has been found that a 1-*n* (e.g. "never revisit") panel design can outperform other panel designs involving fixed plots for this purpose (Urquhart and Kincaid 1999; MacDonald 2003). And while Urquhart and Kincaid (1999) demonstrate that an intermediate panel approach, such as a split-panel design, can meet the needs of both status and trend estimation best, significant logistical and visual impact concerns raised by park staff at the prospect of permanently marking several dozen (at a minimum) plots have precluded further consideration of these alternatives. Therefore sampling will proceed with non-permanent quadrats and pilot field work and power analyses have demonstrated that the loss in sampling efficiency can be mitigated by increasing the number of sampled points each year. The added sampling cost can be absorbed by the UCBN, given the relatively modest overall investment that this particular vital sign requires. One additional benefit to using temporary quadrats is the reduction in "response burden" or "conditioning" that may occur through trampling during regular visits to fixed points (MacDonald 2003).

Pilot Datasets

Weippe Prairie (2005): In 2005, camas density (including seedlings) was recorded in 177 0.5 m × 1.0 m quadrats. The quadrats were arrayed at 20 m intervals along transects 200 m in length. Transects were arranged systematically with a random starting point. More variability occurred within transects (49% of total) than occurred among transects (38%) and significant autocorrelation was present only between adjacent quadrats within transects. Therefore, the 2005 quadrats behaved as if they were quasi-independent observations, despite the systematic design. This enabled us to use the 2005 data in simulation exercises to design the 2006 pilot design.

Weippe Prairie (2006): Camas density and ancillary data were collected from 220 quadrats following a stratified simple random sampling design at Weippe Prairie. Strata were defined by camas density as encountered during a site visit in May, 2006, when the camas was in peak bloom. Data were collected in June, 2006, using 15 cm × 4 m quadrats. Recorded within each quadrat were number of camas plants (including seedlings), number of flowering camas plants, presence of *Potentilla recta* and *Hieracium aurantiacum,* and thatch depth.

Weippe Prairie (2007): Data collected in 2006 were used to conduct a formal power analysis following methods described by (Hamilton and Collings 1991). The sampling frame was revised to permit status and trend estimation to occur within each of five discrete management zones established for the site that followed permanent natural and anthropogenic features (creek channel, roads, drainage ditches, and property boundaries). A total of 283 sample units were measured in late May using 15 cm × 4 m quadrats. Sample units were selected following an equal-probability simple random design. Recorded within each quadrat were the number of *established* camas plants (seedlings excluded), number of flowering camas plants, presence of *Potentilla recta* and *Hieracium aurantiacum,* and thatch depth. Table 1 presents summary

estimates of density for 2007. Figure 3 shows camas density patterns across the Prairie as exhibited during the 2007 sampling period.

Big Hole (2006): Camas density and thatch depth was measured in 100 quadrats following a simple random sampling design at BIHO. No basis for stratification was available. Expert opinion and rapid site evaluation methods suggested that the density of camas plants at BIHO was similar to the low-to-middle range of densities at Weippe Prairie. Therefore, density values from Weippe Prairie were used as a rough guide for determining recommended sampling intensity at BIHO. The monitoring area at BIHO is also about one-quarter the size of the area at Weippe Prairie. Data were collected in June, 2006, following the same response design as that used for Weippe Prairie. However, the target weed species *Potentilla recta* and *Hieracium aurantiacum* were not present at BIHO in 2006 and no other weed species were included in quadrat measurements.

Big Hole (2007): Data collected in 2006 were used to conduct a formal power analysis following methods described by (Hamilton and Collings 1991). Sampling frame boundaries were modified but no stratification was introduced. No changes were made to the response design, other than the change to exclude single-leaved seedling plants in density counts. A total of 124 samples were obtained in late June using 15 cm × 4 m quadrats. Recorded within each quadrat was the number of *established* camas plants (seedlings excluded), number of flowering camas plants, and thatch depth. Table 1 presents summary estimates for 2007. Figure 5 shows the pattern of camas density across the Battlefield monitoring area as exhibited during the 2007 sampling period.

Table 1. Established camas plant density and flowering stem density estimates from the 2007 camas monitoring pilot field sampling for Weippe Prairie (5 separate zones) and Big Hole Battlefield (BIHO). Confidence intervals were calculated using the bootstrap percentile method (Efron and Tibshirani 1993; Manly 2001).

			90% percentile CI		Flowering	90% Percentile CI	
Zone	n	Plants/m^2	lower	upper	Stems/m^2	lower	upper
WEPR A	65	61.65	48.96	74.93	7.81	6.00	9.76
WEPR B	88	6.76	4.26	9.60	0.82	0.38	1.15
WEPR C	60	29.63	20.28	39.84	6.03	3.90	8.52
WEPR D	40	64.16	40.63	89.31	8.30	5.40	11.54
WEPR E	30	0.44	0.11	0.83	0.17	0.06	0.33
BIHO	124	3.86	2.53	5.52	1.90	1.25	2.68

Sampling Frame and Allocation of Samples

Weippe Prairie

The target population for estimating the status and trend of camas at Weippe Prairie is the entire NPS-owned portion within legal boundaries, excluding the bank-full portions of Jim Ford Creek. Discrepancies between legal boundaries, established fence lines, and GPS resolutions require that the sampling frame exclude a 10 m buffer strip along the boundary and creek to ensure that no sampling points are located outside accessible areas. The sampling frame has been further subdivided into 5 discrete sections that approximate five different management zones that are also biologically and statistically distinct (Figure 3). A creek and a gravel road physically separate three of the zones. Populations A and B are separated on the east by an historic drainage ditch that clearly delineates areas of high and low camas density. The western boundary of A and B is less distinct but is approximated by internal fence boundaries and also is characterized by a sharp transition between high and low densities. Each of these zones is characterized by different densities and, it is expected, different population trend trajectories. Zone D has experienced different land use than much of the remaining park site, and continues to be intensively hayed but not grazed. The four northern zones have been heavily grazed and drainage ditches occur within C as well as between A, B, and E. Zone A includes 10.5 ha, zone B includes 15.2 ha, zone C includes 49.5 ha, zone D includes 15.2 ha, and zone E includes 10.2 ha. Although NEPE park managers have not yet developed a unit management plan, agreement has been reached between park managers and the Network to proceed with this delineation and it is expected that future management and restoration treatments will be applied in conjunction with these zones in order to maximize the information potential of the camas monitoring program.

A simple random sample of non-permanent 0.6 m^2 quadrats will be drawn, without replacement, each sampling occasion. Samples will be excluded from an 8 m wide strip centered on each of the boundaries between populations A and B to ensure that navigational error does not cause mixing of samples from these two separate populations. For 2008, the number of estimated required sample units, obtained from a bootstrap approach to power analysis for a permutation test applied to both 2006 and 2007 pilot data (Hamilton and Collings 1991; Manly 2001), is 60 for population A, 80 for population B, 80 for population C, 60 for population D, and 80 for population E, for a total of 360 samples. Samples of these sizes are illustrated in Figure 4.

Big Hole

The target population for estimating the status and trend of camas at Big Hole National Battlefield is the large wet prairie system that occurs in the floodplain on the southeast bank of the North Fork Big Hole River. This is a complex riparian ecosystem and exclusion zones include the dense riparian shrub vegetation that occupies several oxbow peninsulas and an old alluvial fan on the upslope side of the floodplain. The culturally-sensitive campsite area to the northeast of the sampling frame, where teepee frames memorializing the Nez Perce camp at the time of the battle are maintained, has also been entirely excluded. The sampling frame is bounded on the south by an irrigation canal that runs along the bottom of a steep slope. Figure 5 shows the boundaries of the sampling frame, which encompasses 19 ha. This sampling frame contains the core of the existing camas population in the park and will adequately address the information needs of the UCBN and BIHO management.

A simple random sample of non-permanent 0.6 m^2 quadrats will be drawn without replacement each year. For 2008, the number of estimated required sample units, obtained from a bootstrap approach to power analysis for a permutation test applied to 2006 and 2007 pilot data (Hamilton and Collings 1991; Manly 2001), is 150, as illustrated in Figure 6.

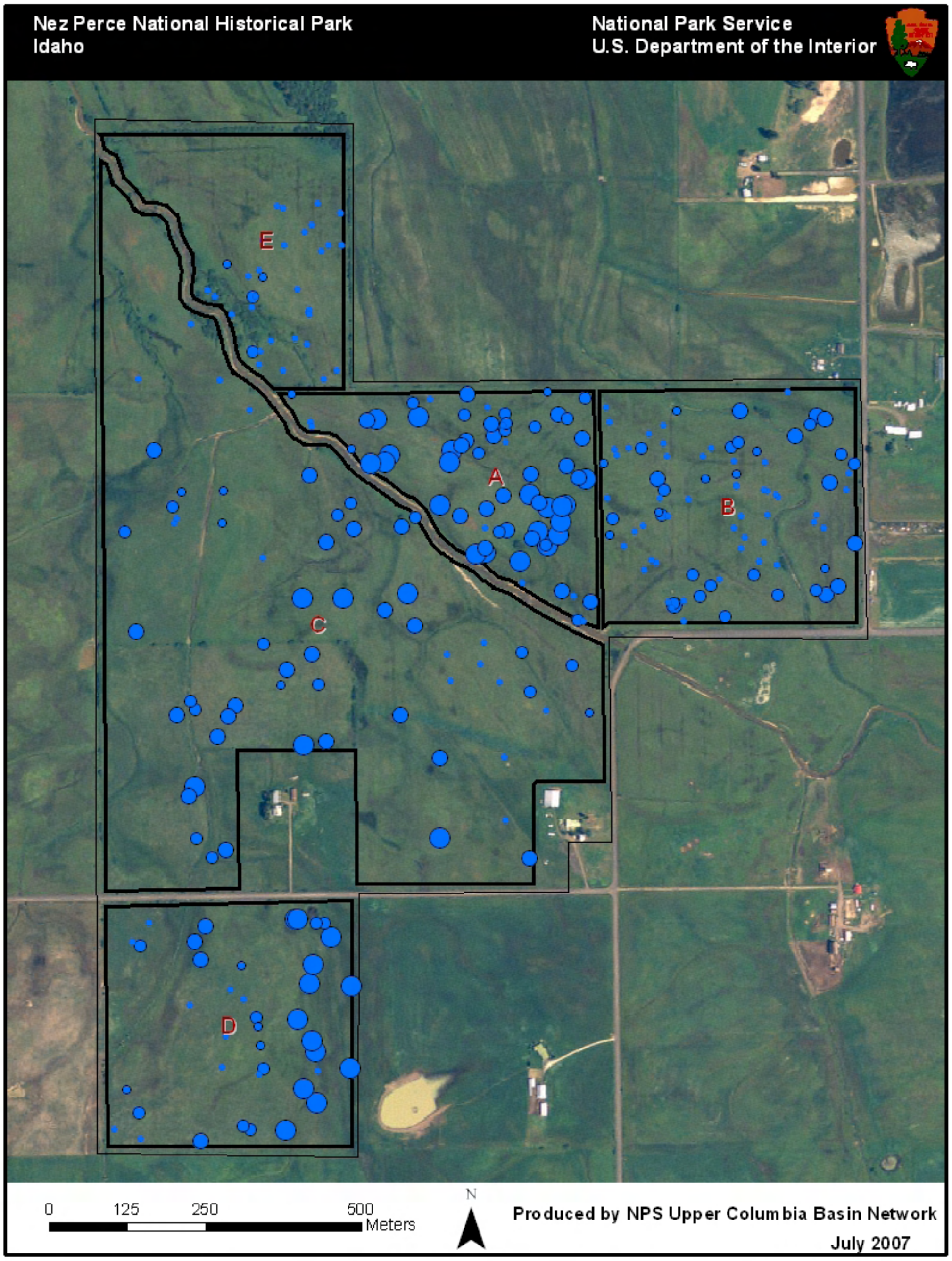

Figure 3. Weippe Prairie sampling frame for five distinct management zones, labeled A, B, C, D, and E, within the park boundary. A 10 m buffer was established within the boundary perimeter and along Jim Ford Creek. Private buildings within the boundary were also excluded from sampling. Camas density data from 2007 sampling are shown as proportionally scaled blue dots (larger dots represent higher camas density). Zones A and D exhibited the highest density in 2007.

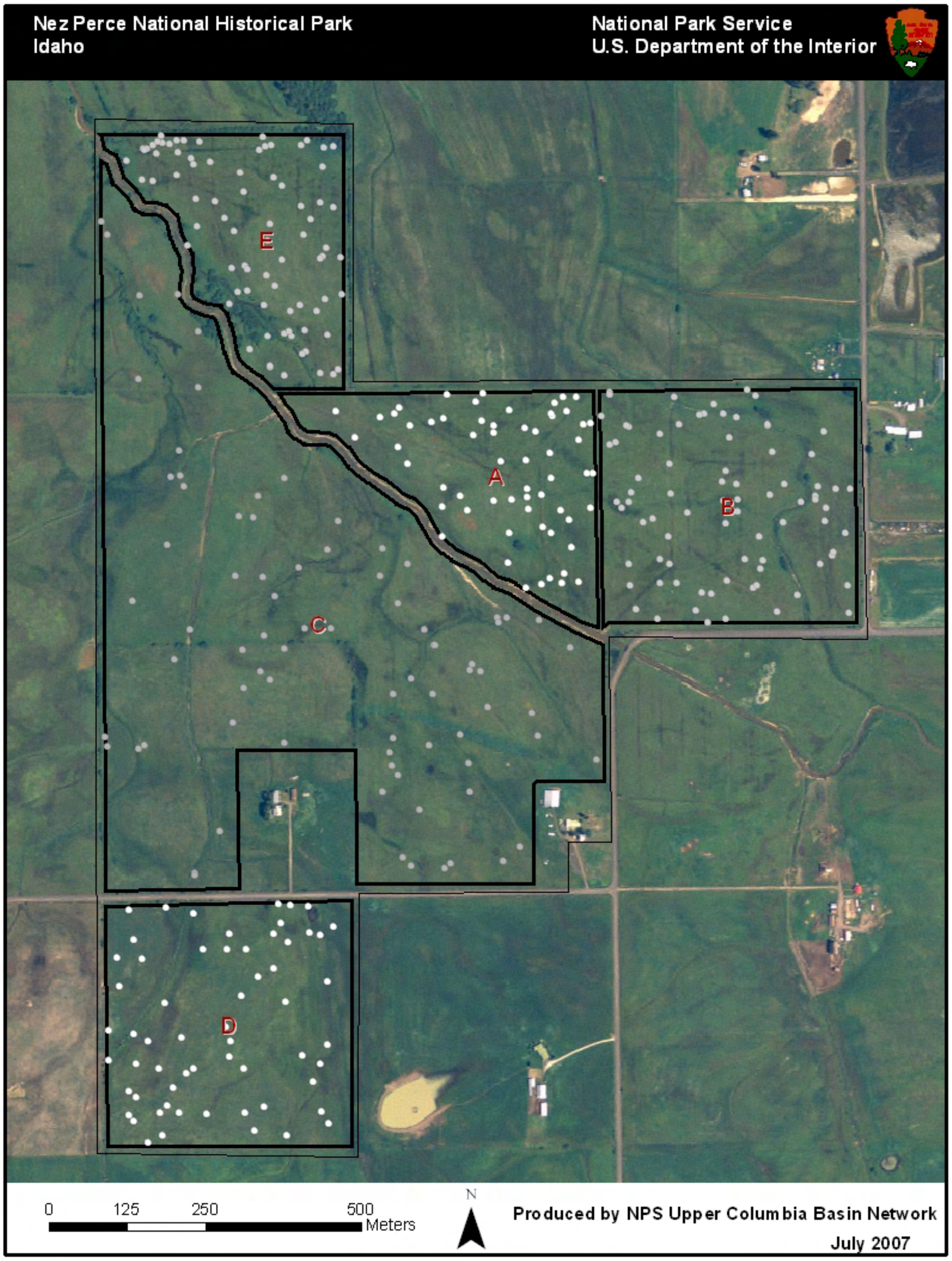

Figure 4. Simple random draw of sample points for 2008 field measurements at Weippe Prairie. The number of points for each population was determined through a bootstrap approach to power analysis for a permutation test of 2006 and 2007 pilot data and are allocated as follows; A=60, B=80, C=80, D=60, and E=80, for a total of 360 samples.

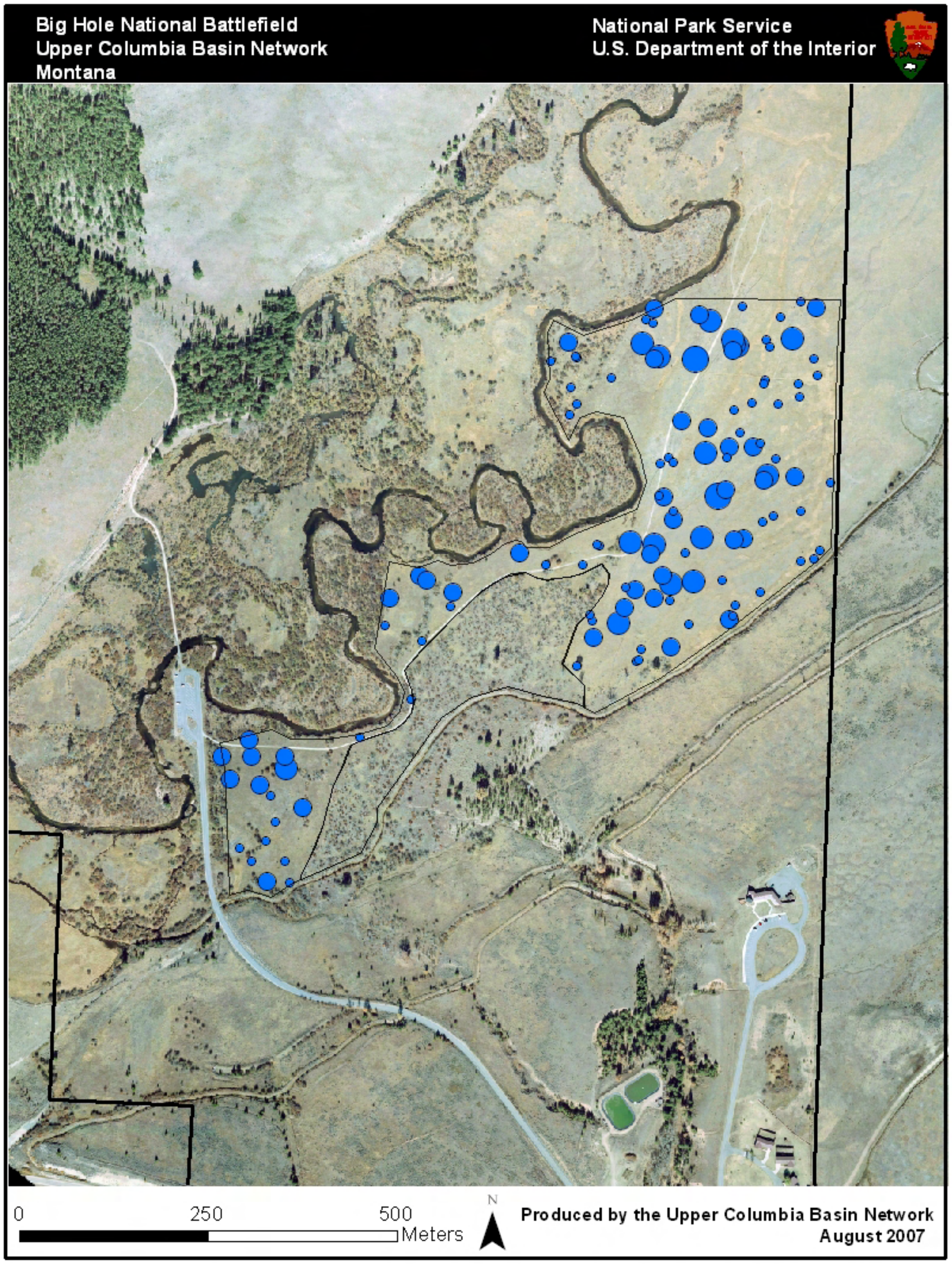

Figure 5. Sampling frame and 2007 camas density data at Big Hole National Battlefield. Exclusion zones from the sampling frame include the culturally-sensitive campsite area to the northeast of the frame, the complex willow-dominated riparian shrub vegetation and oxbow system to the north of the frame, and the willow-dominated alluvial slope south of the frame. Camas plant density data from 2007 pilot sampling are shown as proportionally scaled blue dots (larger dots represent higher camas density).

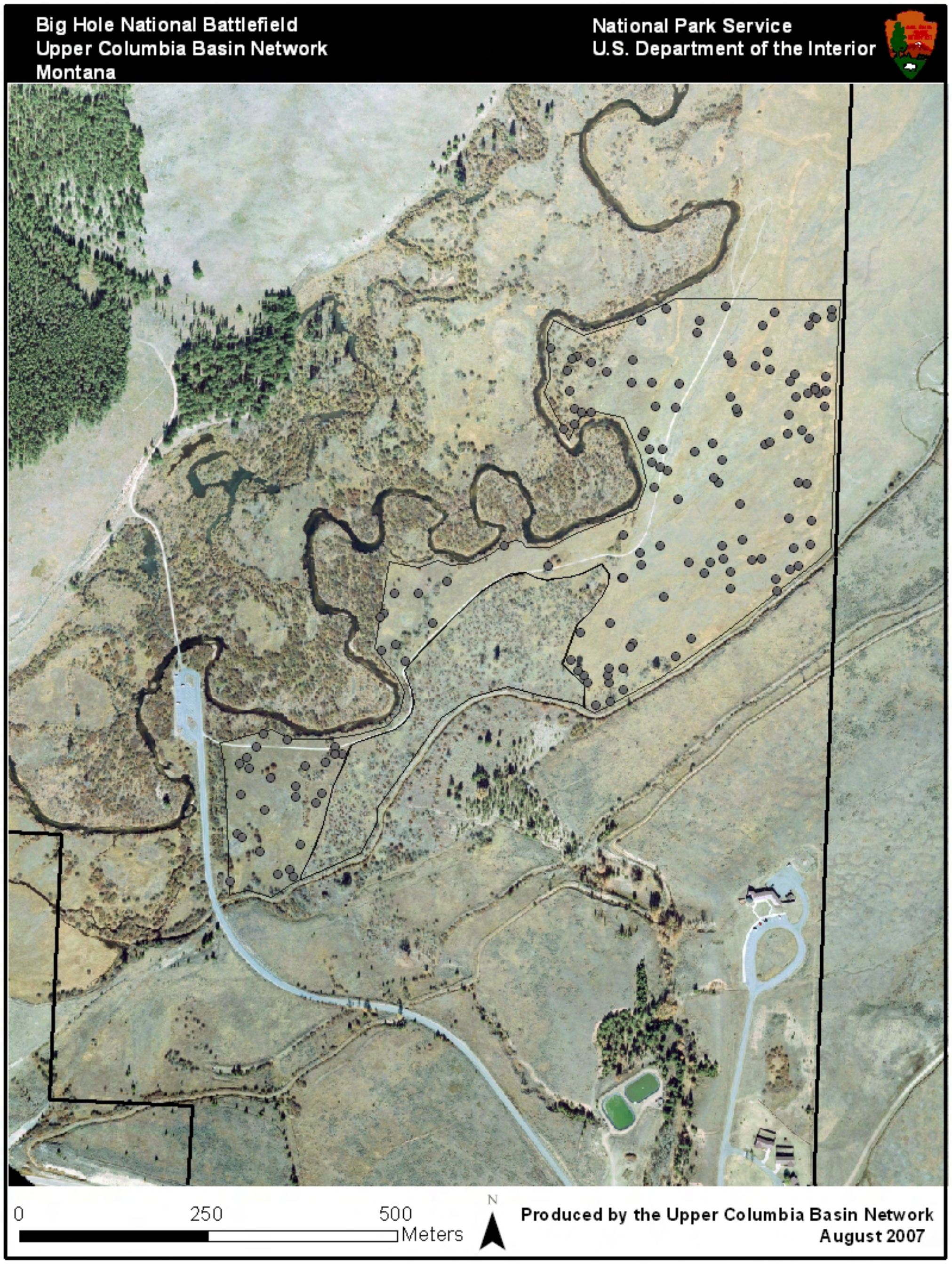

Figure 6. Simple random draw of sampling locations for Big Hole Battlefield in 2008. 150 points were drawn, as determined through a bootstrap approach to power analysis using 2007 pilot data.

Sampling Frequency and Timing

Following notation proposed by MacDonald (2003), a 1-*n* panel design will be employed for each of the populations in both parks, in which each sampling occasion includes a unique panel of quadrats that are never revisited. Sampling will occur annually to gain an understanding of annual variation resulting from variable precipitation and other potential drivers. After this annual baseline is established we predict sampling will occur biennially, although this decision may change once we begin to understand the nature of year-to-year variation. Given the successful involvement of citizen scientists in this program, there is no strong programmatic need to reduce the annual frequency. If a biennial approach is adopted, a convenient schedule for arranging field crews would be to alternate visits to the Weippe Prairie and Big Hole Battlefield (Table 2).

The time of year at which sampling occurs is important. Tall perennial grasses can overtop the camas later in the growing season. Small plants, particularly seedlings, can be difficult to identify once senescence has begun and leaves brown and curl. Sampling should occur each year based on phenology, and no earlier than when about half of the camas plants are in full bloom. At Weippe Prairie this typically occurs around the third week in May and at Big Hole Battlefield around the second week in June. Sampling at Weippe Prairie must be completed before mowing begins. Careful coordination with park staff is necessary to ensure optimal timing each year.

Table 2. Proposed 1-*n* revisit design in which new independent panels are developed for each camas monitoring sampling occasion for each population. After a period of annual sampling, revisits may follow a biennial pattern and alternate between parks.

	Sampling Occasion (1-*n* Design)								
Panel	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	BIHO, NEPE								
2		BIHO, NEPE							
3			BIHO, NEPE						
4				BIHO					
5					NEPE				
6						BIHO			
7							NEPE		
8								BIHO	
9									NEPE
10									

Response Design

Following recommendations by Elzinga et al. (1998) and others and based on data collected in 2005, 2006, and 2007, elongated rectangular quadrats (4 m × 15 cm = 0.6 m^2) will be used at each sampling point. This shape provides a significant improvement in sampling efficiency compared with more common shapes, such as the 1 m x 0.5 m quadrat used in 2005 pilot work. The proportion of "zero" counts decreased substantially in all management zones after this change in quadrat dimension was made.

Quadrats will be established by aligning the long axis along a random azimuth, with the "lower left-hand" corner of the quadrat (as viewed from the sampling point location) located at the pre-determined sampling point location. An 180^o "back-azimuth" will be used to prevent quadrats from overlapping or when an impassable feature is encountered in the quadrat. These situations are rarely encountered.

Camas density will be measured by counting all individual established camas plants with 2 or more basal leaves that are rooted within the quadrat. Flowering stem density will be measured by counting all plants with inflorescences within each quadrat. Inflorescences are conspicuous at all stages of development in camas, and should be counted in early emergence, bloom, and seed stages. Grazed inflorescences are also typically visible near the base of the plant and should be counted as well. Thatch depth will be measured along the primary, wire-rope "left-hand" axis of the quadrat at 67 cm, 200 cm, and 333 cm from the axis origin, and summarized as an average depth for each quadrat. Presence of targeted invasive plants rooted within quadrats will be recorded and analyzed for trend in frequency. Additionally, presence of targeted invasive plants will be noted within an approximate 5 m radius of the quadrat in order to direct rapid Park weed control response. This ancillary weed information will not be included in frequency estimates. Other sightings of target weeds encountered during field work may also be recorded and reported to park management as time allows.

Additional site covariates recorded from published sources will include precipitation data from the nearest Remote Automated Weather Station (RAWS) in Pierce, Idaho (Station 107046) and the cooperative weather station in Wisdom, Montana (Station 249067) (Davey et al. 2006). These stations are located approximately 11 miles northeast and 10 miles east of the respective parks and are at similar elevations. Protocol details for precipitation data collection, management, and analysis are forthcoming from the Western Regional Climate Center/NPS joint effort to develop a cooperative climate data system for the entire I&M program. SOP # 7 provides interim guidance on acquiring and analyzing precipitation data. After 5 years of camas monitoring data become available (2009), an analysis of the influence of the annual seasonal (e.g. winter and spring totals) precipitation on density and flowering will be made. A revised camas protocol will be made at that time detailing the collection, management, and analysis of weather data within the context of camas monitoring. Climate data for these two stations are currently housed and served by the Western Regional Climate Center (available at: http://www.wrcc.dri.edu/Climsum.html). Thirty-year monthly mean precipitation totals from the Pierce station illustrate the pattern of summer drought and winter precipitation maxima typical of the eastern portion of the UCBN (Figure 7; Davey et al. 2006). We will use this to organize station data into winter dormancy (Oct-Mar), spring emergence (Apr-May), peak precipitation (Nov-May), and annual (preceding growing year Jun-May) periods for analysis.

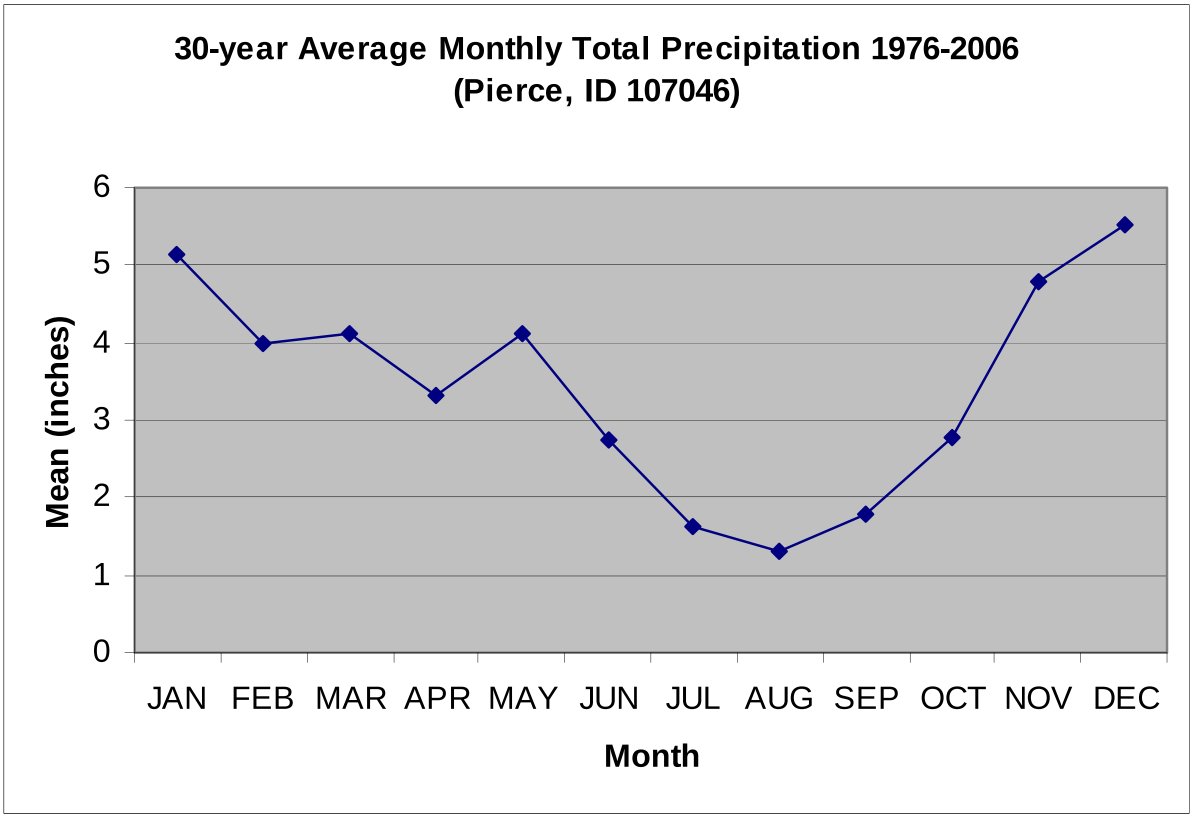

Figure 7. Thirty-year average monthly precipitation totals for the period 1976-2006 from the Pierce, Idaho RAWS weather station.

Power Analysis

As with many ecological phenomena, camas populations grow in aggregated or clumped patches, leading to density count data that are highly positively skewed. Figure 8 shows frequency histograms from the 2007 camas density data for Weippe Prairie and BIHO, showing that a few quadrats had exceptionally large numbers of plants, but most had few or zero plants. This leads to the phenomena of "overdispersion", in which observed variances are higher than expected based on theoretical distributions such as the normal or Poisson (Sokal and Rohlf 1995). Both Poisson and negative binomial distribution models are inadequate to describe camas density counts according to goodness-of-fit tests applied to 2006 pilot data (see SOP # 7 for additional details). Following recommendations by Hamilton and Collings (1991), we have developed a robust non-parametric bootstrap approach to power analysis for permutation tests that accommodates the extreme skewness of total stem density, is much more flexible, is sufficiently powerful, and requires no assumptions about underlying distributions. The sampling objectives of the protocol require the ability to detect mean differences between any two non-overlapping sampling periods, which takes the form H_0: $\delta = 0$ and H_a: $\delta \neq 0$, where δ represents a shift in location of the underlying cumulative distribution function (cdf) F from which the data are sampled. This can be thought of as "step trend" and will initially involve differences between consecutive years, but will eventually be used to test for differences at greater intervals (Helsel and Hirsch 2002). The appropriate parametric test for a step trend is the *t*-test, with the critical

region for rejection of the null hypothesis obtained from a student's *t* distribution. Our power analysis also used a *t*-statistic, but the critical region was estimated directly from the observed data. Knowledge of the shape of the cdf is not required, and the only assumption is that the cdf's of the two samples do share the same shape and differ only in location (e.g. differ in μ's). We believe this assumption can be reasonably met given the population characteristics exhibited for each management zone. Application of the Levene's test and the Fligner-Killeen test for homogeneity of variances to log-transformed pilot data provided reassuring evidence for this. Both of these tests are robust to non-normality (Conover et al. 1981; Ramsey and Schafer 1997).

Given the uncertainty in the inter-annual variability of camas density, we have focused our power analysis on step trend as a reasonable starting point for our program. We will refine and revise power analyses and sample size estimates for subsequent years as additional data become available. We have also focused power analyses on total stem density only, which exhibits considerably greater variance than flowering stem density, suggesting that sample size estimates will be adequate for both response variables. We did not calculate power to estimate status within ± 25% of the mean. Based on estimates from 2007, 90% confidence interval half-widths for Weippe Prairie zone A are within 25% of the mean. Half-widths for zones C and D are approximately 35% of the mean, and we have adjusted the 2008 sample size upward approximately 30% (e.g. from 60 to 80 for zone C, 40 to 60 for zone D). 2007 results for BIHO also showed wider than acceptable within-season precision and the 2008 sample size was adjusted upward accordingly.

A power curve for a range of sample sizes (50, 60, 70, and 90) for zone C, log-transformed, at Weippe Prairie, based on a bootstrap approach for a permutation test using 2007 pilot data is shown in Figure 9. Results of this approach illustrate that the variability between successive bootstrapped power calculations is low.

A complete description of the power analysis procedure we have developed, as well as a script written for the R statistical software language and environment (http://www.r-project.org/) is provided in SOP # 7.

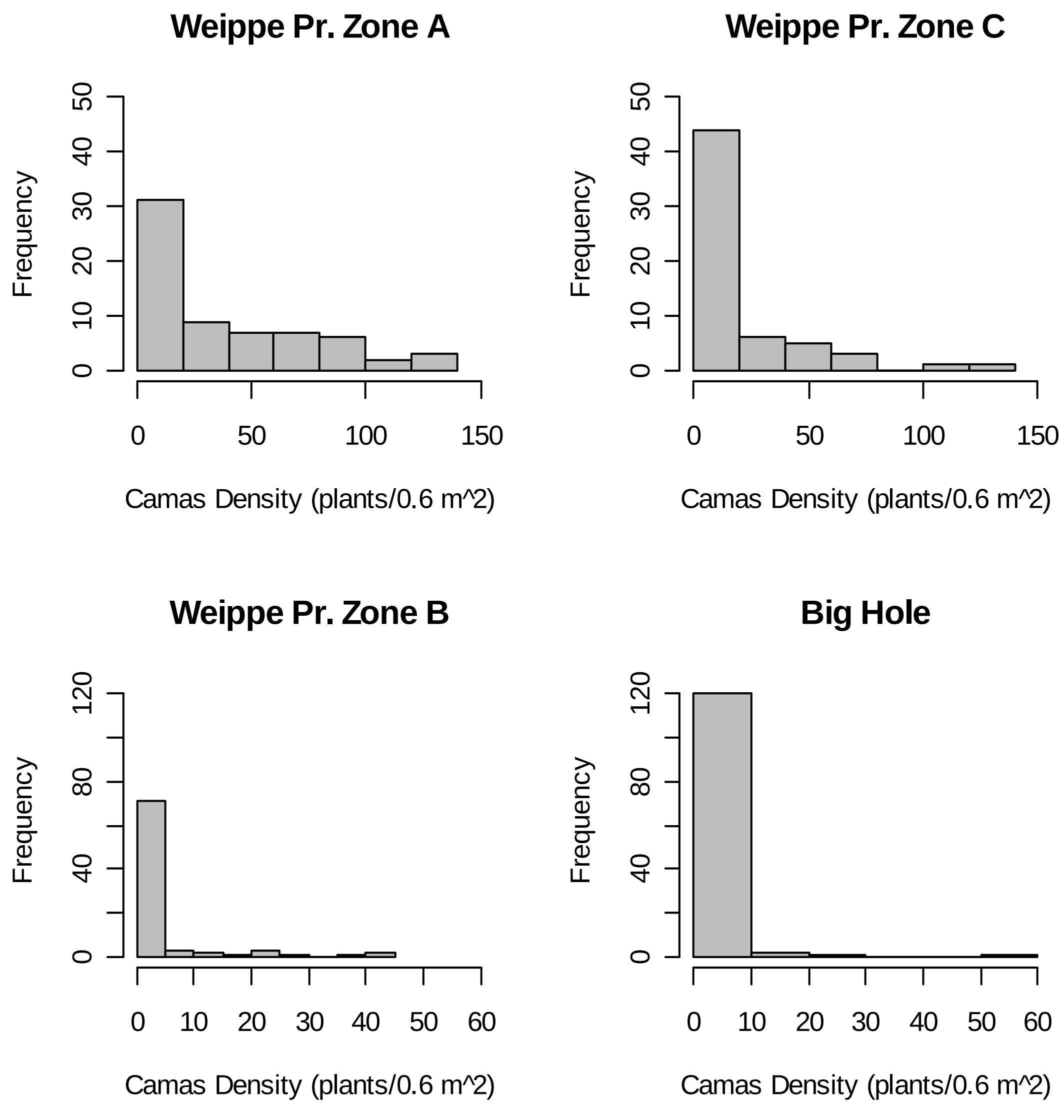

Figure 8. Histograms of 2007 camas density counts for two high density zones (Weippe Prairie A and C) and two low density count zones (Weippe Prairie B and Big Hole Battlefield) from 2007. Density units are raw plants per quadrat (0.6 m^2).

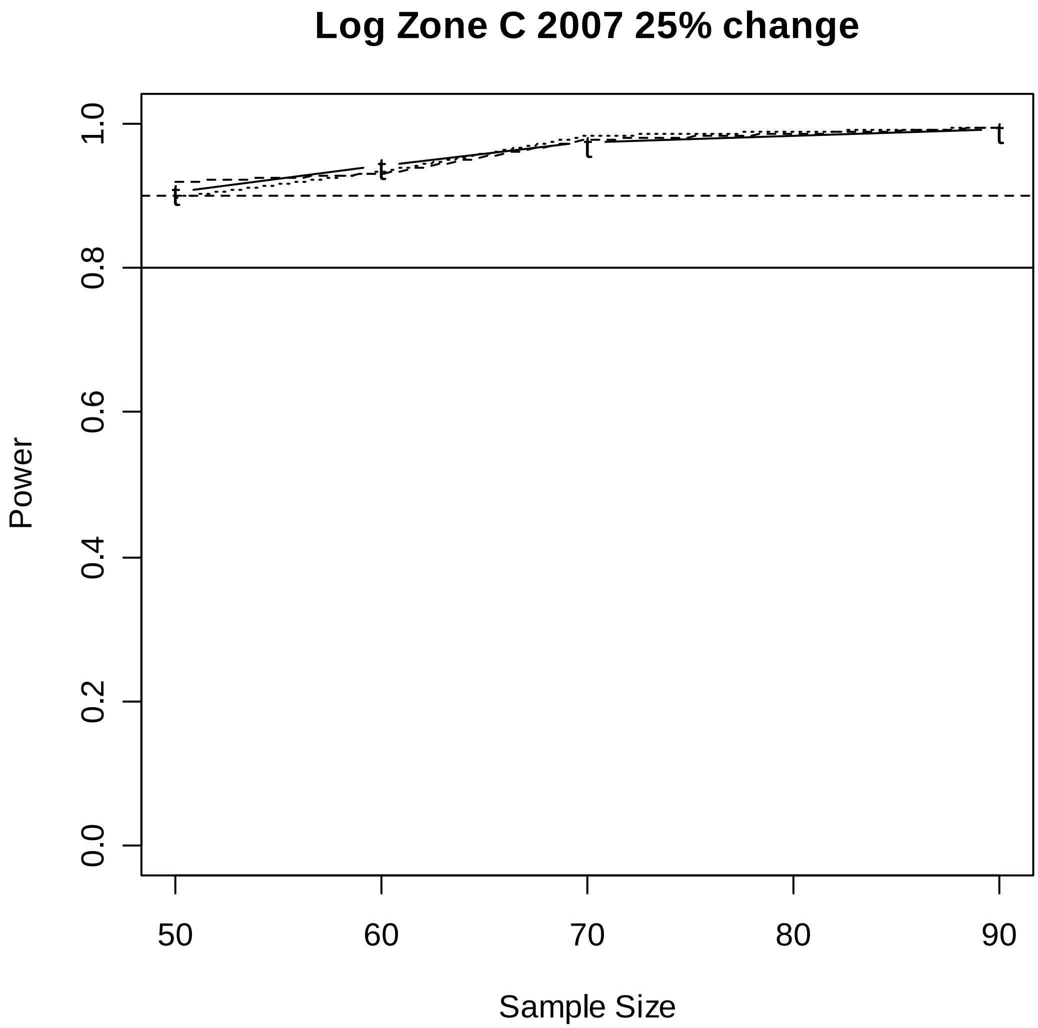

Figure 9. Power curve for a range of sample sizes (50, 60, 70, and 90) for zone C, log-transformed, at Weippe Prairie, based on a bootstrap approach for a permutation test using 2007 pilot camas density data. The dashed horizontal line represents 90% power. Three curves are plotted here (solid, dashed, and dotted), illustrating that the variability between replicate bootstrapped power calculations is low.

Summary of the Benefits of the Selected Design

- The design directly reflects the study objectives.
- Simple random sampling permits valid inference to the target populations.
- The subdivision of Weippe Prairie into 5 independent zones avoids the tenuous assumption that samples from the entire site come from a single underlying and unknown population distribution, an assumption that samples come from an underlying distribution for each individual zone or "population" has more validity.
- The subdivision of Weippe Prairie allows for increased spatial resolution of status and trend estimates, and allows for the detection of up to five different trend trajectories.
- Effects of management and restoration actions can be effectively monitored at Weippe Prairie if treatments are allocated to zones.
- The subdivision of Weippe Prairie also provides considerable logistical flexibility, where zones can be sampled in alternate years, akin to a rotating panel design, if complete sampling coverage requires more resources than are available.
- GPS technology allows easy location of random quadrat coordinates; there is no need for transects or other systematic sampling.
- The measurements are appropriate for the camas growth form and for the biologically and culturally important characteristics of camas populations.
- Measured covariates will assist in the interpretation of spatial and temporal patterns of camas density.
- The field techniques are easy to learn and use.

Field Methods

Field Season Preparations and Field Schedule

The first preparation is to revise procedures based on the experiences and results from the previous year. After any revisions are completed, preparation involves determining quadrat locations, gathering equipment, and fulfilling permitting and compliance requirements. Both study sites are NPS units, and permits will be provided through the NPS research permit and reporting system (http://science.nature.nps.gov/research/ac/ResearchIndex). GPS devices will be loaded with all the quadrat locations before the start of sampling. Batteries and spare batteries must be charged for all GPS units, including backup units. Paper data entry forms will also be updated and photocopied. SOPs should be thoroughly reviewed by directing staff well in advance of training and field work. Because of this program's unique reliance on citizen scientists for field work, scheduling with partner organizations, such as the Oregon Museum of Science and Industry (OMSI) camps program and local schools should begin as early as possible, and no later than January preceding a spring sampling occasion. Arrangements must be made in coordination with BIHO and NEPE staff. Equipment needs are relatively modest, and once sufficient amounts are constructed or purchased, replacement will be infrequent. An equipment list is included in SOP # 1. No special vehicle needs are posed by this protocol, although group transportation, typically handled with NEPE 7-passenger vans, is needed to get NPS staff to park sites. Citizen science volunteer groups provide their own transportation.

Locating and Establishing Quadrats

Driving directions to Weippe Prairie and Big Hole Battlefield are included in SOP # 4. Once on site, access to sampling areas is straightforward on flat, open terrain. Spring weather extremes can cause challenging conditions, and all team members must arrive prepared with warm clothes and rain gear, sun hats, and plenty of water. Before the start of each field session, quadrat locations will be organized into convenient and efficient routes through the study area, according to the number of field teams available. These routes will be illustrated on hard copy maps provided to each team. Absolutely precise quadrat locations are not crucial, but are important to strive for. GPS units employed by the UCBN typically allow navigation accuracies of 1-3 m.

Quadrats will be located using GPS and compass, following procedures outlined in SOP # 3. Field crews will be divided into teams of 2-3 students and an adult team leader. The team leaders are typically NPS staff and student group leaders or teachers. Each team will be assigned to a set of quadrats. When the team member navigating with the GPS unit first approaches the waypoint location, the person will focus on the coordinates and ignore the vegetation. Once the GPS unit registers "zero" (or otherwise shows that the coordinates have been reached exactly), the person stops immediately. The location is marked with a chaining pin midway between the locator's boots. Other team members should stand away from the GPS unit until the quadrat location is fixed to avoid trampling the eventual quadrat location. A random compass bearing (azimuth) will be used to orient the long axis of each quadrat. Team familiarity with the compass rose and orientation of park boundaries will allow them to anticipate the direction of a quadrat from the pre-determined azimuth and avoid trampling vegetation in that area before the quadrat starting location is staked and the cable stretched along the ground.

Measuring Vegetation

Group training and calibration will occur in the field prior to each sampling occasion under the direction of UCBN and/or park staff, as detailed in SOP # 2. The wire rope, secured with chaining pins at both ends, defines the "left-hand" edge of the quadrat. It is unnecessary to set up the three other edges. Instead, a 15 cm PVC rod will be used to determine "in" or "out" plants in question, effectively completing the boundaries of the quadrat quickly (Figure 10). Camas plants are "in" if the above-ground parts of the plant originate (are rooted) within the inside edge of the quadrat boundary. Of the plants in Figure 10, all are clearly in or out except one. The rod should be used just for this plant. However, if plants are not easily visible, the rod can be used the length of the cord to sweep out the 15 cm × 4 m quadrat. Total camas plants and total flowering camas plants should be counted simultaneously, if possible. Presence of targeted invasive weeds should be noted. As with camas, invasive plants are "in" if the above-ground parts of the plant originate (are rooted) within the inside edge of the quadrat boundary. Thatch depth will be measured at three locations along the wire rope: 67 cm, 200 cm, and 333 cm. Thatch should be measured before camas counting begins, in order to ensure that thatch is not compressed or displaced. This also gives observers an opportunity to visually assess the entire quadrat prior to initiating camas counts. Depth is measured using a calibrated stiff wire pin placed at the top of the soil. The top of the thatch layer is marked with the thumb and index finger on the pin and then measured. Measurements are recorded to the closest centimeter. If thatch is absent, depth is recorded as 0 cm. Several additional tips for efficient and reliable measurements are included in the SOPs. No collection of plant samples or vouchers is needed.

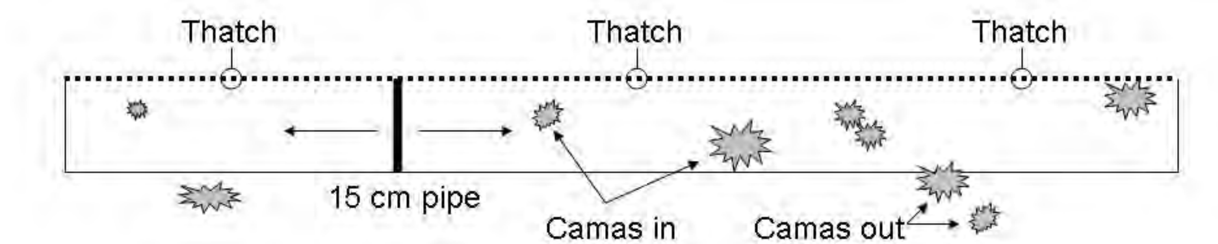

Figure 10. Graphical representation of a 4 m x 15 cm sampling quadrat. The bold dashed line is a 4 m wire rope that establishes one side of the quadrat. The solid line is the 15 cm rod used to determine if camas plants are within the quadrat. The faint solid line is the border of the quadrat, although our method does not require that this be physically outlined in the field. Stars represent camas plants; six camas plants are inside this quadrat, three are "out".

Precision and Reproducibility

Precision, defined as "the closeness of agreement between independent test results obtained under prescribed stipulated conditions", will be continually assessed by each field team during each sampling occasion. Following recommendations by Irwin (2006) and the Environmental Data Standards Council (2006), duplicate counts of established camas plant density will be made periodically during sampling in order to evaluate measurement error. Specifically, each field team will independently assess relative percent difference (RPD) on at least 10% of its quadrats, and additionally as needed on high density quadrats where missed plants frequently occur and at other quadrats in which the team leader suspects counting errors may have occurred. It is the responsibility of each team leader to carefully monitor the quality of counts. Field forms will indicate which systematically selected quadrats are to be counted twice (SOP # 1). Duplicate counts will be taken by an alternate observer. Quadrats chosen for RPD estimation will include some from the early, middle, and late periods of the sampling effort (i.e. at the beginning of the first day, end of the first day, and end of the second day). Duplicate values will be recorded in the data entry form for each quadrat's RPD measure. The RPD value will be computed as:

$$\text{RPD} = \frac{y_i - x_i}{\left(\frac{y_i + x_i}{2}\right)} * 100$$

RPD values exceeding 10% will trigger a 3rd recount of the quadrat. The count determined to be the most accurate (typically the final count) will be circled and treated as the "true" count for use in all subsequent analysis and reporting.

Data Entry and Management

The UCBN is pursuing paperless field data entry in all of its programs. Pilot camas data in 2005 and 2006 were collected with Dell and Compaq PDA data loggers with success. However, the involvement of citizen science volunteers in this particular project does pose additional burdens on the Network to ensure that team leaders are adequately trained and can troubleshoot the inevitable "digital glitches" that are encountered in the field. The Network is in a period of transition regarding its preferred digital tools (e.g., tablet PC's vs. weatherized PDAs), and is not yet in a position to provide enough devices or training to its volunteers and still ensure data quality control. Paper data sheets are also much easier to prevent data loss and their use facilitates participation by student volunteers in the entire field process. This protocol version is designed around the use of paper data sheets, but this will be revised once the shift back to digital data entry is implemented. Paper data entry was successfully conducted in 2007.

Paper data entry is relatively straightforward, and a data sheet template is included in SOP # 1. The basic structure involves a spreadsheet of columns of measured attributes and rows of quadrats. Data sheets, with quadrat ID's and pre-determined azimuths, will be prepared for each field team prior to entry into the field. Blank spreadsheets will be available to accommodate any last minute changes in team organization and quadrat grouping.

The preferred order of field operations and data entry steps are as follows:

1. Quadrat establishment
2. Thatch measurements
3. Enter each thatch measurement sequentially onto data sheet
4. Camas counts (including number of flowering camas)
5. Enter camas count data onto data sheet (recount if necessary)
6. Invasive species presence/absence
7. Enter invasive species present
8. Add any necessary comments in the “notes” column
9. Review data entry and identify the appropriate data sheet row for the next quadrat before moving to the next quadrat

Data sheets will be inspected by team leaders and the project leader at the end of each field day, as a key step in the quality assurance and quality control process (QA/QC). Data entry from paper forms into the working copy of the camas project database (a Microsoft Access database, described in detail in SOP # 6) will be done by UCBN staff or volunteer(s) in an office setting after completion of field work, and will also be treated as an additional opportunity to conduct QA/QC. Validation rules programmed into the database will help detect logical inconsistencies, such as out of range data (e.g. 20 mm thatch depth, instead of 2.0 cm). Paper data sheets will be archived by the UCBN on a short-term basis only, up to 3 years, which will allow sufficient time for all possible QA/QC problems to be resolved, at which time the archived database, including backup copies and versions served off the NPS Data store, will be the sole repository for legacy data for this project.

After the Field Season

Following field work, equipment should be stored in the UCBN or NEPE headquarters. Currently all equipment is stored at the UCBN headquarters in Moscow, ID, but this may change as NEPE interpretive staff begin to take on more responsibility in planning and implementing field work with volunteers. Non-electrical equipment, including wire ropes, stakes, pins, and compasses should be stored in well-marked plastic bins. Some of this equipment will be used by other UCBN protocols, so thorough organization and documentation of equipment will be important. Electronic equipment, including GPS units, should have the batteries removed during the winter months to prevent corrosion and leaking, and will be stored in plastic bins in the UCBN office. All camas waypoints, which are temporary for a single season, should be deleted from GPS units at the end of each field season prior to winter storage. Data entry should begin as soon as possible in order to address outstanding QA/QC problems before memories fade and personnel change. Also, it will be extremely important that the locations of targeted invasive weeds are delivered to the park immediately upon completion of field work in support of rapid response control efforts.

Data Handling, Analysis, and Reporting

While the following section outlines procedures for camas data handling, analysis, and report development, additional details and context for this chapter may be found in the UCBN Data Management Plan (Dicus and Garrett 2007), which describes the overall information management strategy for the network. The UCBN monitoring plan also provides a good overview of the Network's information management and reporting plan (Garrett et al. 2007).

Overview of Database Design

A customized relational database application, implemented in Microsoft Access, has been designed to store and manipulate the data associated with this project. The design of this database is consistent with NPS I&M Natural Resource Database Template version 3.1 and UCBN standards (National Park Service 2006). The database will continue to undergo revisions, which will be reflected in both this protocol narrative and the data management SOP. The general database strategy is to use a blank version of the protocol database (a "working copy") to enter, error-check, and validate a given season's data, then migrate that data to the read-only "master version" of the protocol database. This strategy protects validated data from corruption, and the master version will facilitate multi-year analyses. The underlying data structure (tables, fields and relationships) will always remain the same in both versions, and they will have very similar front-end database applications ("user interface" with forms, queries, etc.) accessed through a user-friendly "switchboard" (Figure 11). The user interface of the working copy database will serve data entry, quality control, and validation needs. The user interface of the master database application will serve analysis and summarization needs, including specific reporting and exporting format needs. Details of the database, including a description of core and peripheral tables and a logical model of table relationships, are presented in SOP # 6.

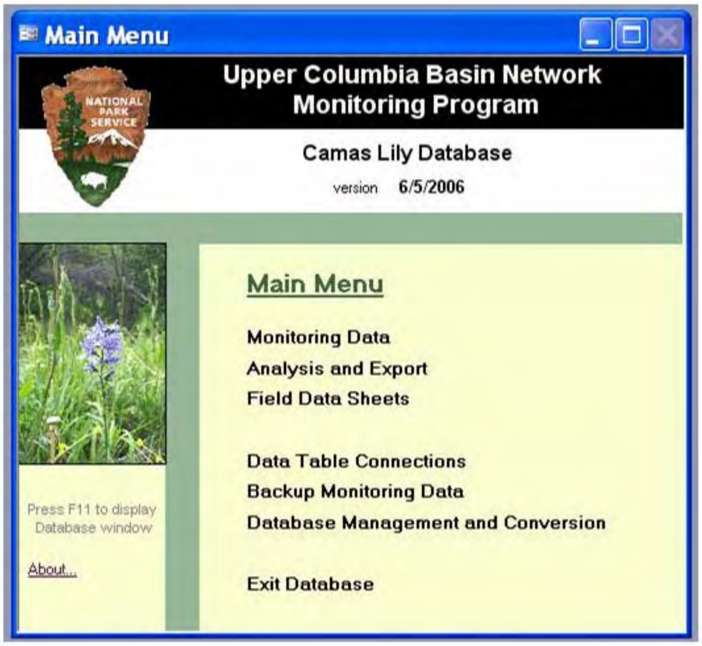

Figure 11. Draft version of the UCBN camas monitoring project database user interface.

Data Entry

Entry of data from paper field sheets to the database will be accomplished each season shortly after completion of field work. The database's data entry form will resemble the layout of the paper field sheet, and will have built-in quality assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Data entry should be viewed as an important step in the overall QA/QC process, and care should be taken to review both the input from the paper forms and the resulting entries in the database.

Quality Review

After the data have been entered and processed, they need to be reviewed by the Project Lead for quality, completeness, and logical consistency. The working database application will facilitate this process by showing the results of pre-built queries that check for data integrity, data outliers and missing values, and illogical values. The user may then fix these problems and document the fixes. If all errors and inconsistencies cannot be fixed, the resulting errors will be documented and included in the metadata and certification report.

Metadata Procedures

Data documentation is a critical step toward ensuring that datasets are useable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, and condition of data. Additionally, metadata provide the means to catalog datasets within intranet and internet systems, making data available to a broad range of potential users. Metadata for all UCBN monitoring data will conform to Federal Geographic Data Committee (FGDC) and NPS guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years then only need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in the UCBN Data Management Plan. In general, the Project Lead and the Data Manager (or Data Technician) will work together to create and update an FGDC- and NPS-compliant metadata record in XML format. The Project Lead should update the metadata content as changes to the protocol are made, and each year as additional data are accumulated. Edits within the document should be tracked so that any changes are obvious to those who will use it to update the XML metadata file. At the conclusion of the field season, the Project Lead will be responsible for providing a completed, up-to-date metadata interview form to the Data Manager. The Data Manager will facilitate metadata development by creating and parsing metadata records, and by posting such records to national clearinghouses as described below.

Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which includes specific locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Lead and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager. We do not anticipate that sensitive information will be present in the camas monitoring program at this time.

Data Certification and Delivery

Data certification is a benchmark in the project information management process that indicates that 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may not have been detected during quality assurance reviews.

To ensure that only data of the highest possible quality are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Project Lead is primarily responsible for completing certification. The completed form, certified data, and updated metadata should be delivered to the Data Manager according to the timeline tables 5 and 6 in the Operational Requirements section. Additional details of the certification and delivery processes are included in SOP # 6.

Data Analysis

Annual Status Summary and Power Analysis

Status results will be summarized after each year of data collection. Standard summary statistics will be presented separately for each management zone with content similar to that shown in Table 1, and will include estimates of central tendency and dispersion for established camas density, flowering stem density, ratio of flowering stem density to total established camas density, thatch depth, and weed frequency (by species). Precipitation will be summarized by year and season for each station. Each management zone (Weippe Prairie A-E and BIHO) will be analyzed and reported separately, as was done in Table 1. Graphical tools (e.g. scatterplots) are also important in exploratory data analysis, particularly during the early stages of an analytical exercise. Graphical presentation will aid in communicating results but can also trigger the generation of new or the refinement of existing hypotheses about pattern and process, and this will be important in the analysis and communication of camas status and trend data. Standard design-based estimators for the population mean and variance will be used as described by Thompson (2002).

Confidence intervals will be calculated in a suitable manner for the highly skewed camas data where reliance on a parametric distribution is not supported. The bootstrapped percentile method, as described by Efron and Tibshirani (1993) and Manly (2001), is the preferred method for confidence intervals around the mean. However, standard confidence intervals may also be computed using a parametric distribution if deemed appropriate for certain zones. Given the extreme densities reported for historic camas populations by Thoms (1989), recovery in an area

like population A at Weippe Prairie, already exhibiting relatively high densities (but still heavily skewed), could lead to a shape change in distribution that would justify the use of parametric tools. Bootstrapped and parametric confidence intervals calculated from 2007 pilot data for Weippe Prairie zone A are nearly equal and stable at a range of moderate sample sizes (Figure 12). The observed mean at n=65 is 61.65 plants/m^2, and the bootstrapped 90% confidence interval is 48.96 to 74.93 plants/m^2, or 22% of the mean. The parametric interval using a *t* multiplier is slightly wider, from 48.1 to 75.1 plants/m^2.

Prospective power analysis procedures as described earlier will continue to be used during the first 3 years of implementation (through 2008) in order to refine optimal sample sizes (Thomas 1997; Lewis 2006). We expect sample size estimates to stabilize by the end of this implementation period. After that point, we will rely on confidence intervals to address uncertainty in parameter estimates.

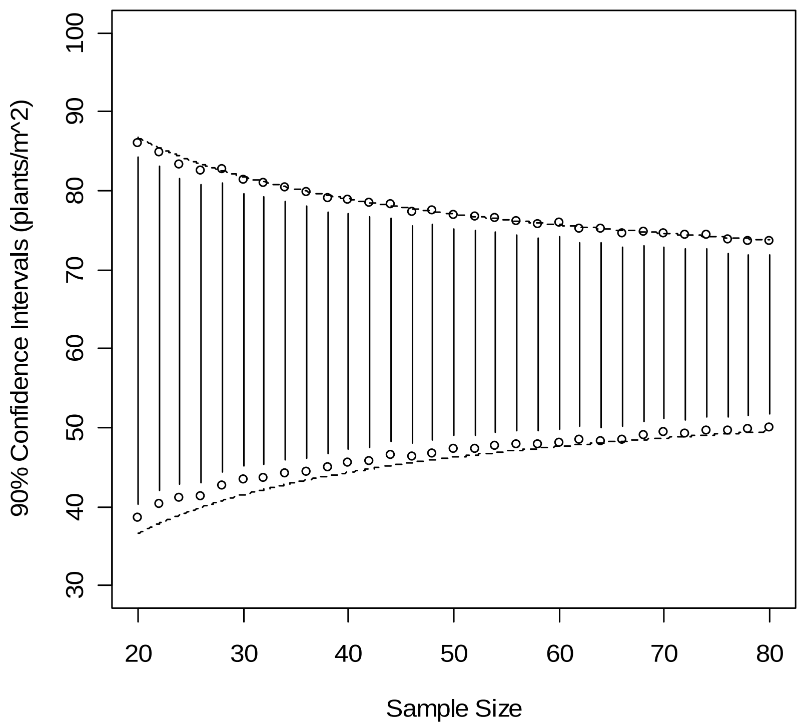

Figure 12. Confidence intervals for the estimated mean camas density for zone A at Weippe Prairie, using 2007 pilot data. Intervals (vertical lines) were determined from the 0.05 and 0.95 percentiles of each bootstrapped sampling distribution (Efron and Tibshirani 1993) for each sample size (from 20 to 80) using 10,000 bootstraps with replacement. Dashed curve lines (overlapping and difficult to see) represent parametric confidence interval end points calculated using the Student's-*t* distribution.

Trend Analysis

Trend analyses will begin in earnest after the 2009 field season and will be conducted every five years thereafter. As was described in the preceding Design Rationale and Power Analysis section, we will approach trend from two perspectives. The first will be that of "step trend" (Helsel and Hirsch 2002), which, in our case, reduces to an independent two-sample permutation

test of the form μ_1-μ_0 = 0, and where the p-value is determined through permutation (Manly 2001). Table 3 presents typical results that can be expected from such an analysis, and SOP # 7 provides the R software code required to conduct this analysis. Code for computing 90% permutation confidence intervals for the difference between two means is included as well.

Table 3. Permutation *t*-tests for log transformed count data for Weippe Prairie and Big Hole Battlefield between 2006 and 2007. Differences between years (2007-2006) are back-transformed and should be interpreted as a multiplicative (percent) difference in the median density of camas. For example, based on the observed data, zone E has undergone a 41% decrease in the median number of established camas plants between 2006-2007. Note that density counts in 2006 included seedlings as well as established plants, and these results should be interpreted accordingly.

Camas Density (plants/0.6 m^2)			
Zone	2007-2006	Direction	P
A	0.77	down	0.36
B	1.36	up	0.27
C	1.37	up	0.15
D	1.61	up	0.29
E	0.59	down	0.002*
BIHO	1.17	up	0.22
Flowering Stem Density (stems/0.6 m^2)			
Zone	2007-2006	Direction	P
A	1.85	up	0.002*
B	1.02	up	0.85
C	1.56	up	0.007*
D	1.55	up	0.08*
E	1.02	up	0.58
BIHO	1.25	up	0.007*

We will assess continuous trend while accounting for measured sources of variation through linear models of the form $Y_{ij}=\beta_0+\beta_1*(year_j)+\beta_2*(x1_{ij})+\ldots+\beta_k*(xk_{ij}) + \varepsilon_{ij}$, for site i in year j, where xk_{ij} denotes the value x of covariate k at site i in year j, and ε represents residual error. The hypothesis test for linear trend in this model is H_0: $\beta_1 = 0$ and Ha: $\beta_1 \neq 0$ (Helsel and Hirsch 1991; Urquhart et al. 1998; Manly 2001).Covariates will include year, thatch depth, weed presence, and precipitation. We have followed procedures outlined in Manly (2001) to develop a preliminary strategy for fitting linear models and estimating the significance and magnitude of regression coefficients using a non-parametric randomization procedure consistent with the approaches taken for step trend and power analysis (see SOP # 7 for R code and procedural details) (Manly 2001). The same graphical tools used in parametric linear regression (e.g. scatterplots, residual vs. fit) are available in the randomization context for evaluating equal variances between groups of response values, and for determining whether transformations of covariates are necessary. Regression coefficients that are obtained from models fit to log transformed density response variables will be interpreted in terms of a percent change in median camas density over a given

time period, which is appropriate for our stated objectives. As an example of this approach, Table 4 presents linear model results for the effect of year on densities.

Table 4. Preliminary results for the period 2005-2007 using a randomization approach to linear regression to assess the null hypothesis of no trend (β_1=0) over time in log-transformed camas density counts. Coefficients (for β_1) are back-transformed and should be interpreted as a multiplicative (percent) change in the median density of camas. For example, based on the observed data, zone C has undergone a 35% increase in the median number of established camas plants between 2005-2007. Conversely, zone E has undergone a 29% decrease in median density. 90% confidence intervals, also back transformed, were computed using a randomization approach described by Manly (2001). These results are for illustration and should be interpreted with caution, as sampling methods changed between years during protocol development. Weippe Pr. zone D and BIHO were not sampled in 2005.

Population	β_1(Year)	90%lower	90%upper	Direction	P
A	1.04	0.86	1.28	up	0.805
B	1.12	0.86	1.56	up	0.777
C	1.35	1.22	1.64	up	0.013
D	NA	NA	NA	NA	NA
E	0.71	0.60	0.81	down	0.012
BIHO	NA	NA	NA	NA	NA

Reporting

A summary will be produced annually, with a more detailed status and trend report produced every five years. The annual summary will:

- List project personnel and their roles.
- List sample quadrats measured during the current year.
- Provide a summary history of the number of quadrats completed during each year of the study (broken down by population and park).
- Provide status and trend (after 2010) estimates for each population and park.
- Estimate the ratio of flowering stem density to total established camas density.
- Provide a summary of additional measurements, including weed frequency, thatch depth, and annual and monthly precipitation from nearby weather stations.
- Provide maps of quadrats symbolizing camas density and other measured attributes
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretability.
- Evaluate and identify suggested or required changes to the protocol.

In order to reduce the reporting burden of the I&M program on UCBN staff, the annual summary will be developed for internal Network distribution only. However, a 1-2 page resource brief should be prepared for public consumption, and that can be provided to park interpretive staff for distribution to interested visitors. A template for the resource brief is included in SOP # 7. An NPS template for producing maps with ESRI ArcGIS or ArcView software is available at http://imgis.nps.gov/templates.html.

Invasive weed locations should be reported to the BIHO and NEPE resource managers immediately following completion of field activities in May (Weippe Prairie) and June (BIHO). Reported information should include GPS locations and maps of quadrats with weeds present both within quadrats and within the approximate 5 m reporting radius surrounding quadrats. Any additional weed information noted during travel between quadrats should also be included.

A more in-depth status and trend analysis and report will be produced approximately every five years, or as the importance of emerging information warrants. This report will provide greater analytical and interpretive detail, and will evaluate the relevance of findings to long-term management and restoration goals. The report should also evaluate operational aspects of the monitoring program, such as whether population boundaries need to be changed or the sampling period remains appropriate (the optimal sampling season could conceivably change over time in response to climate change).

The 5-year status and trend report should use the NPS Natural Resource Publications Natural Resource Technical Report (NRTR) template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. This template, guidelines for its use and documentation of the NPS publication standards are available at the following address: http://www.nature.nps.gov/publications/NRPM/index.cfm. This camas protocol is also an excellent example of the NPS Natural Resource Report formatting standard, which is very similar to the NRTR template.

Data Archival Procedures

Paper data sheets will be archived for three years, which allow ample time to complete QA/QC and certification steps for digital data. Long-term archiving will only be used for digital data. Upon certification, data and reports will be archived on the UCBN Network Attached Storage (NAS) unit, posted to the UCBN website, and posted to the national web-accessible secure databases hosted by the NPS Washington Areas Support Office (WASO) or National I&M program. These include:

- *NatureBib* – the master database for natural resource bibliographic references
- *NPSpecies* – the master database for biodiversity information including species occurrences and physical or written evidence for the occurrence (i.e., references, vouchers, and observations)
- *NPS Data Store* – a centralized data repository with a graphical search interface.

A review of archive and expendable data products will be undertaken by the Project Lead and Data Manager during season close-out each year. An example of an expendable data product is an intermediate draft of an annual report that was saved during report preparation.

Protocol Testing and Revision

A draft version (version 0.0) of this protocol was developed and tested in 2006 and is available upon request from the UCBN. A complete revision was undertaken in winter 2007 and a draft version 1.0 was submitted for formal peer review in February 2007. Field testing in spring 2007 resulted in several changes, which, along with reviewer comments, have been incorporated in this final version 1.0. Subsequent protocol testing will occur during each field season and

evaluation of existing protocols and recommended revisions will be documented in annual reports and during season close-out.

Revisions to this protocol and the SOPs are expected. We anticipate revisions to the detailed instructions to field crews, the number of quadrats sampled each field season, the frequency of sampling, and the listed priority of target weeds. Population boundaries should be revised only if camas distributions and management priorities shift significantly, and should be done only in consultation with park management and careful consideration of statistical consequences. Analytical techniques may change, particularly if statistical distributions change in shape such that other parametric tools can offer more power in trend detection. This possibility should be considered and evaluated with goodness-of-fit tests frequently. Revisions related to climate data and analysis is also expected. All revisions will be carefully documented using the protocol development and revision log in SOP # 8 and the change history log at the front of each SOP and this narrative.

Personnel Requirements and Training

Personnel Requirements

This monitoring project requires, at a minimum, participation and leadership from the UCBN ecologist and/or coordinator and the Network data manager, as well as a skilled field team leader that can provide sufficient expertise in methodological and botanical field operations. The roles and responsibilities outlined in Table 5 of the next section of this protocol can be provided by these three individuals. However, additional assistance from park and network technical staff will ease the annual workload generated by this effort and ensure a high quality information product. This monitoring effort is unique in its emphasis on participation by citizen scientists, and, assuming that we can sustain this participation over time, additional professional personnel are not necessary. Citizen scientists are NPS volunteers, and as such, an NPS park or network Volunteers-In-Parks (VIP) program coordinator must also participate in the organization and supervision of citizen science volunteers. Currently the UCBN ecologist is serving as a VIP coordinator for network activities, and is supported by the NEPE VIP coordinator for this particular project. Volunteers must be provided a job description, given identifying t-shirts and/or hats, and signed up with the appropriate VIP forms (including parental approval forms for minors). Volunteer hours accumulated during camas field work should be included in the UCBN 10-150 year-end VIP report.

Field crews will consist of several teams of volunteers, each consisting of a team leader and one or two assistants. Three persons per team is an ideal number. Field assistants must be able to work outdoors, learn GPS and data entry, and identify plants. Team leaders must have these skills, as well as an understanding of project objectives and experience with field work and GPS. During three years of pilot work conducted during the development of this protocol, we successfully trained and utilized high school students to collect field data. We were also successful in using the student program leaders and counselors as team leaders. We will actively pursue this approach to sustain this monitoring effort in the future. Data management staff must be able to handle the described GPS/GIS and database tasks. Data analysis staff must be able to conduct the described annual summaries, power analyses, and trend analyses. In particular, the analyst should be able to implement the R software code, or develop analogous routines for other software environments.

Experience during the 2006 field season provided a good estimate of staff time required for field sampling. In 2006, we completed team training and sampling at 220 quadrats with seven teams in 2 full days. An additional 3 hours were spent during a preceding afternoon to provide a “pre-training” in which the project was described to the students and staff, and some field practice was provided. We also spent 3 hours on a subsequent afternoon with the students working through basic data summary analysis and preparation of GIS maps. The entire group consisted of 23 people: 15 citizen science volunteers (students and program staff), an Americorp member, a seasonal technician, park interpretive ranger, park resource manager, three Network staff, and a University botanist. Based on this experience, we expect that a typical team will be able to accomplish adequate training and complete 30 quadrats in 2 days, and at least 45 quadrats in 3 days. A 5-day work week will typically be sufficient to complete sampling at both BIHO and NEPE. In 2007, 283 quadrats were comfortably sampled at Weippe Prairie in 4 days by three different high school classes. 125 quadrats were sampled at BIHO by an OMSI team within 2

days. We strongly recommend that the citizen science members of the group be given some preliminary exposure to the program objectives, ecological and cultural background, and some opportunity to practice field methods before arriving on site to begin the formal training and calibration exercises.

Roles and Responsibilities

Table 5. Roles and responsibilities for implementing the camas monitoring program in the UCBN. Current or anticipated staff and volunteers for 2008 are named here.

Role	Responsibilities	Name / Position
Project Lead	• Project oversight and administration • Track project objectives, budget, requirements, and progress toward meeting objectives • Facilitate communications between NPS and cooperator(s) • Coordinate and ratify changes to protocol • Assist in training field crews • Perform data summaries and analyses • Maintain and archive project records • Project operations and implementation • Certify each season's data for quality and completeness • Complete reports, metadata, and other products according to schedule	Tom Rodhouse, UCBN Ecologist
Field Lead	• Assist in training and safety of field crews • Plan and execute field visits • Acquire and maintain field equipment • Oversee data collection and entry, verify accurate data transcription into database • Complete a field season report	Park and/or UCBN staff persons
Technicians	• Collect, record, enter and verify data	Student Volunteers, UCBN technical staff
Data Manager	• Consultant on data management activities • Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule • Maintain and update database application • Provide database training as needed • Consultant on GPS use • Work with Project Lead to analyze spatial data and develop metadata for spatial data products • Primary steward of Access database and GIS data and products	Gordon Dicus, UCBN Data Manager
Network Coordinator	• Project leader oversight • Administration and budget • Consultant on all phases of protocol review and implementation • Review of annual and 5-year reports	Lisa Garrett, UCBN Network Coordinator

Table 5. Roles and responsibilities for implementing the camas monitoring program in the UCBN (continued). Current or anticipated staff and volunteers for 2008 are named here.

Role	Responsibilities	Name / Position
Park Resource Manager	• Consultant on all phases of protocol implementation • Facilitate logistics planning and coordination • Communicate management and restoration plans and associated information to Project Lead • Review reports, data and other project deliverables	Jason Lyon, NEPE Park Resource Manager

Training and Calibration

All team members will train together. At the start of each field season, the field lead will calibrate procedures across the crews in the field. Under the guidance of an experienced team leader, each team will practice locating and setting up a quadrat and taking measurements. Teams will measure other team's quadrats to make sure that measurements are consistent. Calibration will continue until each group is consistently counting within 5% of the "true" value, as established either by precision within successive counts, or, if necessary, as established by the lead trainer. Experience in 2006 and 2007 leads us to believe this can be accomplished during one morning of training, with the caveat being that all participants have received some preliminary exposure to the project, objectives, and basic methods prior to field training. Precision and reproducibility measuring exercises undertaken throughout the field effort will provide additional opportunity for refinement and calibration of field techniques.

Operational Requirements

Annual Workload and Schedule

The annual workload of this monitoring program is outlined in Table 5 of the preceding section on Roles and Responsibilities, and Table 1 of SOP # 6 and Table 1 of SOP # 7. Table 5 provides a good overview of the general roles and tasks (responsibilities) required to complete all aspects of this program following rigorous and comprehensive information management practices as outlined by the UCBN Data Management Plan (Dicus and Garrett 2007). The budget table demonstrates that adequate resources have been allocated to data management, analysis, and reporting activities. The SOPs provide a comprehensive step-by-step description of the annual workload and tasks required for completion, including data management tasks and product delivery. The annual round for camas monitoring begins with the recruitment of volunteer citizen scientists in January. At this time, final reporting, review and close-out activities are proceeding for the previous year. An evaluation of the protocol and any necessary changes must be made by April. Field work commences in late May or June, and data entry and QA/QC procedures begin immediately in June and July. Table 6 provides additional details of the annual schedule.

Citizen Science Partnerships

It is worth underscoring the importance of planning for citizen science participation as early as possible before the field season, and certainly no later than January preceding spring field work. Network and park staff should coordinate closely on this, determine primary contacts for outreach with outside volunteer organizations, and solicit commitments and schedules well in advance from interested groups. Currently, UCBN staff is responsible for coordinating with the Oregon Museum of Science and Industry (OMSI), which has participated in camas monitoring since 2005. NEPE interpretive staff has assumed responsibility for coordinating with area schools in the towns of Craigmont, Lapwai, and Weippe.

Table 6. Annual schedule of major tasks and events for the UCBN camas monitoring protocol.

Month	Administration	Field	Data Management/Reporting
January	UCBN annual report and work plan complete, Begin recruiting and hiring UCBN seasonal personnel	Begin recruiting volunteers and scheduling field visits	
February	Administer and modify existing agreements, if necessary	Provide GPS and other training to UCBN and park staff as needed	
March		Draw new samples, prepare maps and field data sheets	
April		Prepare field and GPS equipment	
May		Begin field work	
June		Complete field work; Report weed locations to parks	
July		Clean and store equipment	Data entry and verification
August	Budget preparation for new fiscal year	Field season report complete	Metadata production, quality review
September	Close-out of fiscal year		Preliminary analysis of current year's results, Annual resource brief prepared for UCBN Science Advisory Committee meeting
October	UCBN annual report and work plan drafted		Data certification complete; Data archival and posting
November	Cooperative task agreements prepared, if needed		Analysis, reporting, and close-out
December			Close-out complete

Equipment Needs

Equipment needs are modest for this protocol. The list of equipment is included in Table 7 and instructions for constructing field hardware are included in SOP # 1. All hardware materials can be easily purchased in local hardware stores or through coordination with NEPE facilities managers. GPS units need to be maintained and replaced, if necessary, during the late winter/early spring well in advance of field season. There are no special vehicle needs for this protocol, although transportation between UCBN and NEPE offices to WEPR must be arranged. Camping near Weippe Prairie at the Lolo Creek Campground is convenient for out-of-town staff and volunteers. Camping is also available near BIHO.

Table 7. Equipment list for monitoring camas populations in the UCBN.

Measuring Equipment	Navigation and Recording Equipment	Misc. Equipment
4 m long wire rope	GPS units	2-way radios
Steel chaining pins	Weatherized data entry forms	Sun shade canopy
15 cm x 1/2" PVC pipe	Backup copies of data forms	Portable latrine
Orienteering compass	Mechanical pencils and clip boards	
Calibrated wire pin for thatch depth		
Plant ID material		
Hard copies of SOPs		

Budget

Table 8. The detailed annual budget for camas monitoring in the UCBN.

UCBN Camas Monitoring Budget	Time allotted	% of time spent on DM*	Cost in dollars DM*	Cost in dollars (2007)
Expenditures				
Permanent NPS Personnel				
Network Coordinator (GS12)	1 week-sampling, 1 week-report review	35%	$1,260	$3,600
Data Manager (GS11)	1 week sampling, 1 week data archiving	50%	$3,000	$3,000
Ecologist and Project Leader (GS11)	Project Coordination: 1 week prep for sampling, 1 week sampling, 2 weeks data analysis and report	50%	$2,800	$5,600
Seasonal Personnel				
BioTech	1 week sampling, 1 week data input and QA/QC	50%	$750	$1,500
Park Personnel				
Interpretive Staff	2 weeks school group recruiting, 1 week sampling			In-Kind support
Resource Management Staff	1 week sampling			In-Kind support
Citizen Scientists				
2-3 School Classes or OMSI Science camp	1 week sampling (12 students)			In-Kind support
Operations/Equipment				
GPS units ($450.00/unit)				$2,250
Sampling Equipment (compass, pins, cables)				$200
Travel (permanent employees)				$2,500
Other (contingency)				$500
TOTAL			$7,810**	$19,150

* DM = data management

** More than 40% of the camas protocol budget is dedicated to data management, analysis, and reporting activities.

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Glossary of Terms Used by the UCBN I & M Program

Azimuth: Azimuth is the horizontal component of a compass direction. It is usually expressed in degrees.

Bootstrapping: In statistics, **bootstrapping** is a method for estimating the sampling distribution of an estimator by resampling with replacement from the original sample.

Density: The number of individuals or observations within a given area or volume.

Facultative wetland species: Plants which usually occur in wetlands (estimated probability 67 percent to 99 percent) but occasionally are found in non-wetlands.

Geophytes: A geophyte is an herbaceous plant with an underground storage organ. Storage organs are reserves of carbohydrates, nutrients, and water, and may be classified as bulbs, corms, tubers, rhizomes, tuberous roots, and enlarged hypocotyls. They evolved as a mechanism for plant survival through adverse climatic conditions, and as a result, geophytes in their natural habitats are capable of perennial life cycles.

Inflorescence: An **inflorescence** is a group or cluster of flowers.

Kurtosis: In probability theory and statistics, **kurtosis** is a measure of the "peakedness" of the probability distribution of a random variable. Higher kurtosis means more of the variance is due to infrequent extreme deviations, as opposed to frequent modestly-sized deviations.

Permutation test: A **permutation test** (also called a randomization test, re-randomization test, or an exact test) is a type of statistical significance test in which a reference distribution is obtained by calculating all possible values of the test statistic under rearrangements of the labels on the observed data points. Confidence intervals can then be derived from the tests.

Phenology: The time frame for any seasonal phenomena. Examples include the date of emergence of leaves and flowers, the first flight of butterflies and the first appearance of migratory birds.

Poisson distribution: In probability theory and statistics, the Poisson distribution is a discrete probability distribution. It expresses the probability of the number of events occurring in a fixed period of time or area if these events occur with a known average rate, and are independent of the time since the last event. It is characterized by a single parameter, μ.

Power analysis: The **power** of a statistical test is the probability that the test will reject a false null hypothesis, or in other words that it will not make a Type II error. As power increases, the chances of a Type II error decrease, and vice versa. The probability of a Type II error is referred to as β. Therefore power is equal to $1 - \beta$. Power is a function of effect size or minimum detectable change, variance of the parameter (e.g. standard error of the mean), and sample size. A power analysis determines the probability of correctly rejecting a false null hypothesis given fixed values of effect size, variance, and sample size.

Quadrats: In botany, a typical sampling unit is a quadrat. The purpose of using a quadrat is to enable comparable samples to be obtained from areas of consistent size and shape.

Simple random sample: In statistics, a **simple random sample** is a group of subjects (a sample) chosen from a larger group (a population). Each subject from the population is chosen randomly and entirely by chance, such that each subject has the same probability of being chosen at any stage during the sampling process.

Stratified random sample: In statistics, **stratified sampling** is a method of sampling from a population. When sub-populations vary considerably, it is advantageous to sample each subpopulation (stratum) independently. **Stratification** is the process of grouping members of the population into relatively homogeneous subgroups before sampling.

Skewness: Skewness is a measure of the asymmetry of the probability distribution of a random variable.

Status: Status is a measure of a current attribute, condition, or state, and is typically measured with population means.

Temporal variation: Variation in a population parameter, such as a mean, over time. For our purposes this typically refers to variation seasonally or annually.

Thatch: A tightly bound layer of dead grass, including leaves, stems, and roots, that builds up on the soil surface at the base of the living grass.

Threshold: A threshold is a point "…in space and time at which one or more of the primary ecological processes responsible for maintaining the sustained equilibrium of the state degrades beyond the point of repair. These processes must be actively restored before the return to the previous state is possible. In the absence of active restoration a new state is formed (Stringham et al. 2001).

Trend: Trend is a measure of directional change over time and can occur in some population parameter, such as a mean (**net trend**), or in an individual member or unit of a population (**gross trend**).

Vital Signs: A subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

Without Replacement: In statistics**,** one deliberately avoids choosing any member of the population more than once. By contrast, replacement, used, for example, in bootstrapping, permits drawing any particular member of a population more than once.

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