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Natural Resource Stewardship and Science

Camas Monitoring in Nez Perce National Historical Park's Weippe Prairie

2013 Annual Report

Natural Resource Technical Report NPS/UCBN/NRTR—2013/816

ON THE COVER
Illustration of *Camassia quamash* (Pursh) Greene.
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Data in this report were collected and analyzed using methods based on established peer-reviewed protocols and were analyzed and interpreted within guidelines of the protocols.

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Contents

Figures

Page

Tables

Page

Abstract

As part of the Upper Columbia Basin Network's effort to conduct vital signs monitoring, we completed monitoring of camas (*Camassia quamash*) in 2013 in Nez Perce National Historical Park's (NEPE) Weippe Prairie. This is the ninth year of camas monitoring in Weippe Prairie. Camas is a unique resource for NEPE because it is both culturally and ecologically significant. Camas was and remains one of the most widely utilized indigenous foods in the Pacific Northwest and it is strongly associated with the wet prairie ecosystems of the region that have been degraded or lost due to historic land use practices. A long-term monitoring program for detecting status and trends in camas populations at Weippe Prairie serves as a central information source for park adaptive management decision making and has provided essential feedback on ongoing and planned restoration efforts of the prairie.

This annual report details findings from 2013, and puts these findings within the context of the entire 9-year monitoring program. Trend analysis for the Weippe Prairie camas population over the period 2005-2010 was provided by Rodhouse et al. (2011), reporting an overall estimate of 9% per year increase, on average, in the median number of established camas plants/ m^2, excluding seedlings, but with a relatively wide 95% credible interval of 0-19%, reflecting the variation in observed trend among the 5 management zones of the prairie. The NPS acquired the Weippe Prairie site in 2003, after many years in which the site was intensively grazed and mowed for livestock hay. Interpretation of this positive trend is that the effect of the NPS management, de facto "passive restoration", has benefitted the wetland ecosystem of the site and facilitated a rebounding camas population. Based on the 2011 and 2012 surveys, this trend abated somewhat. However, in 2013 counts were higher than in 2012 in all zones except in zone D. Using spatial regression modeling that accounted for the effects of microtopography and residual spatial autocorrelation, the trend in median established camas density through 2013 was estimated to be slightly increasing at an overall average 3% per year (95% CRI was -1 to 7%), and ranged from a low of 2% in zones A and B to a high of 5% in zone C. Estimated mean density of flowering camas plants/m^2 remained the same or increased slightly in all zones in 2013. Winter 2013 was drier than average, followed by a wet April and dry May. The patterns of weed frequency in quadrats for two species targeted by park management for control and eradication, orange hawkweed (*Hieracium auranticum*) and sulphur cinquefoil (*Potentilla recta*), increased from 2012. Fortunately, no alarming increase in either species is apparent. It is important to note that these patterns of trend are potentially confounded by variation in microtopography, and, more generally, spatial autocorrelation. Rodhouse et al. (2011) demonstrated the importance of accounting for spatial variation in the first formal model-based trend analysis. A second formal trend analysis will be conducted after the 10th year of monitoring in 2014. A 10-year time series will allow for the influences of winter and spring precipitation to be investigated as well. Therefore, the trends reported here should be considered preliminary and contingent on subsequent modeling.

Acknowledgments

This project is made possible by the strong support of Nez Perce National Historical Park staff and high school students and their teachers from Lapwai High School, Timberline High School, and Craigmont High School. Each year since 2005, staff and students from the park and schools have joined the Upper Columbia Basin Network I&M staff in the field at Weippe Prairie to survey for camas. This teamwork allows for camas surveys to be conducted very efficiently in just 1 week.

Introduction

Camas (*Camassia quamash* [Pursh] Greene) is a perennial bulb-producing lily (Family Liliaceae; alternatively Agavaceae, APG 2003) that was and remains one of the most widely utilized plant foods of the Nez Perce people (Harbinger 1964, Hunn 1981, Turner and Kuhnlein 1983, Thoms 1989, Mastrogiuseppe 2000). Camas was also a focal resource at many of the significant historical events memorialized by Big Hole National Battlefield (BIHO) and Nez Perce National Historical Park (NEPE). It was during the camas harvest at Weippe Prairie, a subunit of NEPE, that the Lewis and Clark Corps of Discovery first encountered the Nez Perce. The battle at Big Hole occurred at a traditional Nez Perce camas harvesting campsite. It is also noteworthy that the botanical "type" specimen for the *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 considered a facultative wetland species (Reed 1988) that is strongly associated with the seasonal wet prairie ecosystems of the interior Columbia Plateau and northern Rocky Mountains which are represented at the Weippe Prairie and along the North Fork of the Big Hole River, where BIHO is located. Large expanses of camas in bloom were noted by numerous explorers and botanists that entered the Pacific Northwest in the 19th century, including the Lewis and Clark expedition, and which were frequently described as "blue lakes" when viewed from a distance (Havard 1895, Leiberg 1897, Murphey 1987, Thoms 1989). The extent of the wet prairie ecosystem type has been drastically reduced throughout the Pacific Northwest as a result of agricultural conversion, irrigation and flood control development, and other land use practices (Thoms 1989, Dahl 1990, Taft and Haig 2003). Remaining wet prairies in the region are often structurally altered and compromised by non-native and woody native invasive species. The NPS-owned portions of Weippe Prairie and the Big Hole valley are no exception. Both sites have historic agricultural developments that have altered site hydrology, are impacted by invasive weeds, and Weippe Prairie has also been used for intensive haying and grazing. Orange hawkweed (*Hieracium aurantiacum*), sulfur cinquefoil (*Potentilla recta*), oxeye daisy (*Leucanthemum vulgare*), and reed canarygrass (*Phalaris arundinacea*), noxious invasive plants in Idaho, are present at Weippe Prairie and part of the focus of current park weed management. Canada thistle (*Cirsium arvense*) is an emerging invader along the floodplain where the BIHO camas population is now being monitored. Competition from invasive weed species, including the aforementioned forbs as well as thatch-building grasses such as timothy (*Phleum pratense*), may impact camas populations within the UCBN through competition. Herbicide applications at Weippe Prairie, and to a lesser extent at BIHO, continue as part of the parks' integrated weed management programs.

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

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

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

We report here on the 2013 sampling results from Weippe Prairie, and include results from 2005-2012 to provide context for current estimates of camas density, which were also reported by Rodhouse and Stucki (2013a). Changes were made in design and methodology of the sampling protocol during the first three years. We have made some adjustments to the data from these early years, enabling preliminary comparisons among years and identification of baseline patterns of density. Some interesting patterns are emerging in these data, which will serve to stimulate new hypotheses and assessment points. With the protocol complete and the design and methodology stabilized, we have begun to accumulate a robust long-term data set. Given the predictions of climate change in the Pacific Northwest and the legacy of past land use, monitoring UCBN camas prairies over time is sure to shed new light on the important issues of ecosystem recovery and ecological resilience.

Objectives

The monitoring objectives for this program are:

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

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

This report summarizes estimates of established camas density and flowering plant density in the Weippe Prairie camas population over the period 2005-2013. A companion report for BIHO over the period 2006-2012 is also available (Rodhouse and Stucki 2013b). We consider the trends reported here to be encouraging but somewhat preliminary, given the highly variable nature of population fluctuations of camas and the target weed species. A second formal trend analysis report following the one provided by Rodhouse et al. (2011) will be made after the 10th field season in 2014.

Methods

The UCBN initiated camas monitoring at Weippe Prairie, located near the town of Weippe, Idaho, in 2005. The site was subdivided into 5 management zones for purposes of both park management and for monitoring in 2007 (Rodhouse et al. 2007). Figure 1 shows the sampling frame, with each of the management zones labeled, and the 2013 quadrat locations. Sampling methods followed those detailed by Rodhouse et al. (2007). The approach is quadrat-based and involves the measurement of camas plant density, camas flowering stem density, and the presence of targeted invasive plant species in a random sample of 0.6 m^2 quadrats from within a sampling frame that captures the entire site camas population. In 2013, oxeye daisy and reed canarygrass were included on the watch list of weeds in addition to orange hawkweed and sulphur cinquefoil. Quadrats are 4 m long x 15 cm wide, designed to reach across the patchy distribution of camas in the prairie and reduce the number of plots without camas. Quadrats were placed at randomly-selected locations, and locations were generated from the Generalized Random Tessellation Stratified (GRTS) sampling design algorithm. This sampling design results in a well dispersed, spatially-balanced sample (Figure 1). Sample sizes for each year beginning in 2009 were set at 70 per zone (350 total). Prior to 2009, sample sizes varied somewhat as methods were finalized (Table 1). In 2013, crews picked up oversample quadrat locations provided from the GRTS draw as well, increasing the sample size to 75 zones in A-D and 73 in zone E. All camas plants were included in camas density counts in 2005 and 2006, but a protocol change beginning in 2007 led to the exclusion of single-leaved seedlings. Camas seedlings are ephemeral and highly variable in their germination, and this led us to focus the protocol on *established* camas plants beginning in 2007. This is the most significant methodological change and one that requires careful and cautious consideration of comparisons among the first 2 years and the subsequent 7 years.

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

Early monitoring results indicated that density counts were extremely skewed and required alternative analytical procedures that did not require assumptions of normality (Rodhouse et al. 2007). We used a non-parametric bootstrap computer-intensive method to conduct power analyses with 2006 and 2007 data following methods outlined by Hamilton and Collings (1991). For this report, 90% confidence intervals around means were calculated using the simple bootstrap percentile method described by Efron and Tibshirani (1993) and Manly (2001). All nine years of data are displayed graphically using a control or “conformance” chart approach following recommendations by Beauregard et al. (1992) and Morrison (2008). Because of our initial interest in “assessment points” $\pm$ 25% of a baseline mean value, the charts displayed here are a-statistical in the sense that control or “action” limits are not based on an underlying probability distribution but arbitrarily established at assessment point values. We used the running mean over the study period as a baseline, but note that baseline decisions will be updated as additional years of data become available. We used ordinary kriging (Fortin and Dale 2009) to produce an interpolated density map for Weippe Prairie using 2013 data (Figure 1). Predictive density maps provide useful interpretive tools to illustrate density patterns across the site. We used a Bayesian regression modeling technique previously developed by Rodhouse et al. (2011) to provide an estimate of trend in established camas plant density. Finally, We summarize recent weather patterns from the Pierce, Idaho NOAA co-op weather station (station # 107046, western regional climate center) using the capabilities of the Climate Analyzer (www.climateanalyzer.org) developed by NPS contractor Dr. Mike Tercek. All analyses and graphics were prepared in the R software and computing environment (R version 2.8, http://www.r-project.org/) and ArcGIS (ESRI, Inc., Redlands, California).

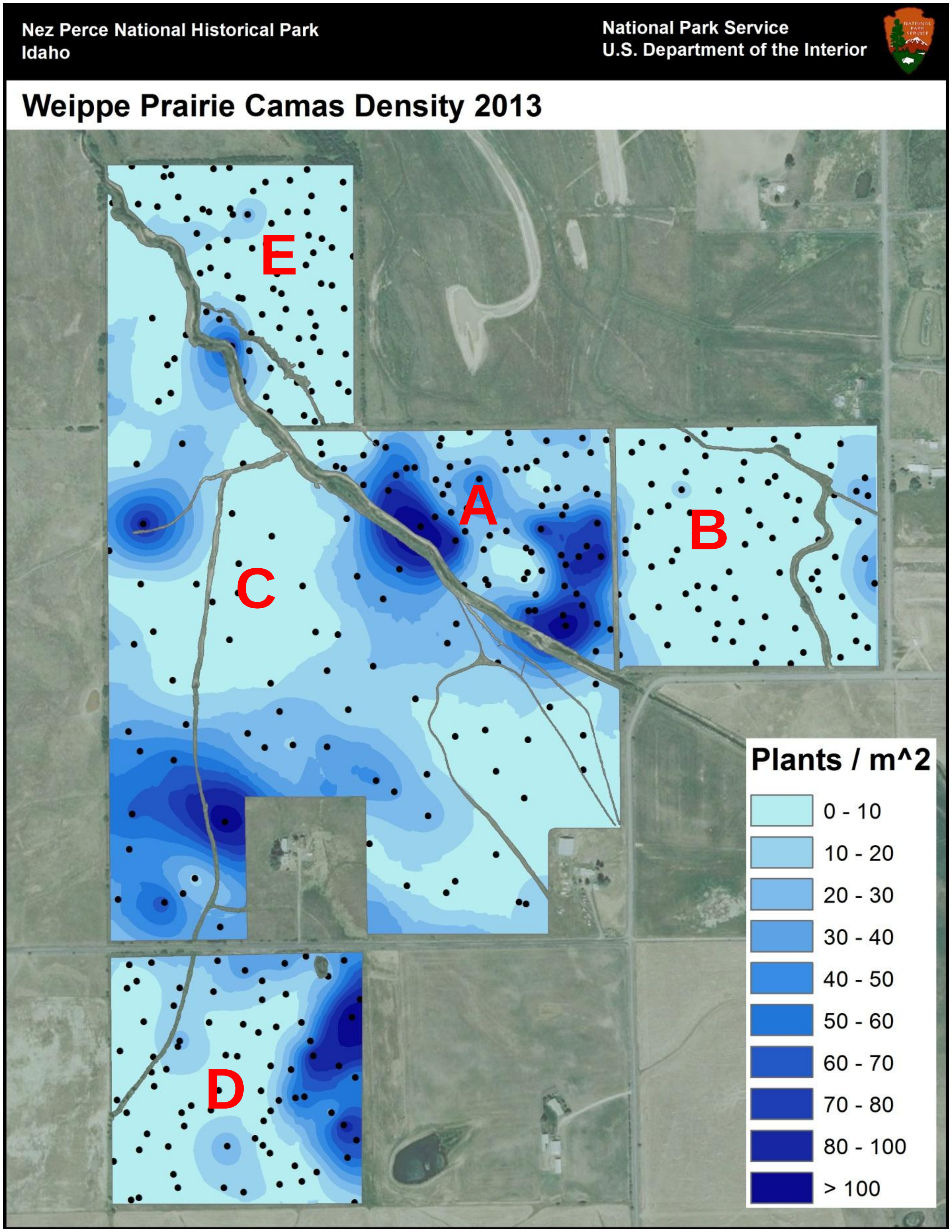

Figure 1. The sampling frame for monitoring camas, divided into 5 management zones labeled A-E, with 2013 quadrat locations (black points) and predicted patterns of camas density based on a kriging interpolation from 2013 established camas plant counts.

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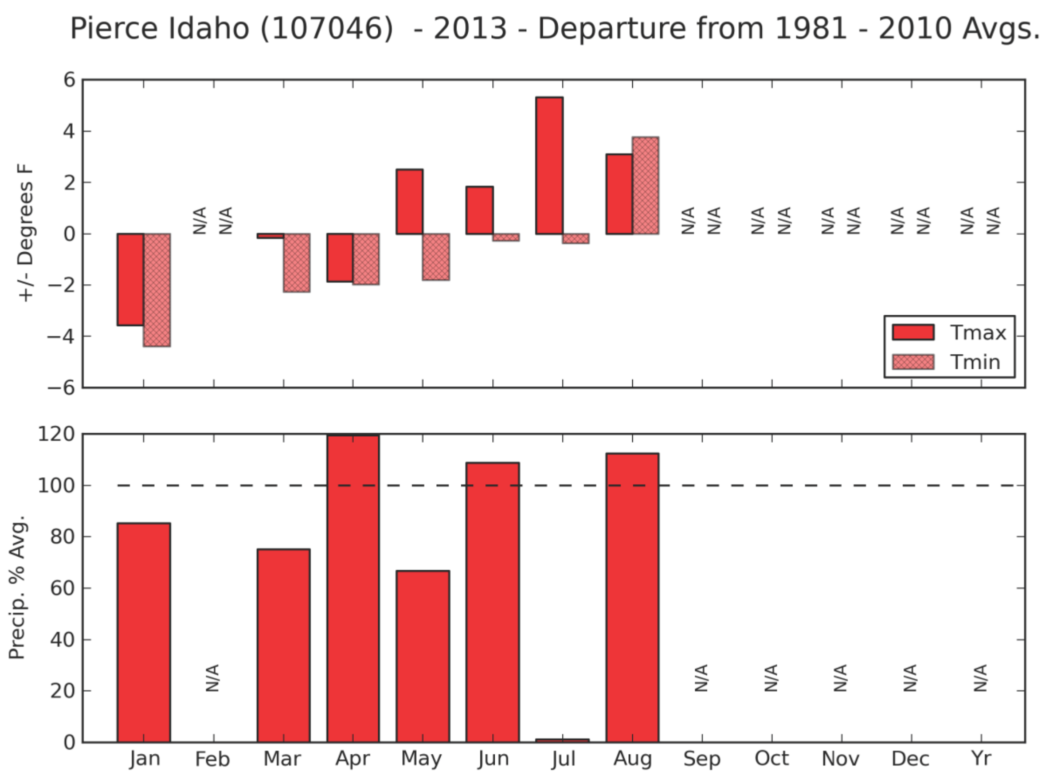

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Figure 2. 2013 precipitation and temperature departures from the long-term average. This figure indicates that 2013 late winter weather was cooler and drier than average, followed by a very wet April and very dry May.

Results

In 2013, late winter weather at Weippe Prairie was drier and colder than average. April was wetter than average, but May was drier and somewhat warmer than average (Figure 2). Based on counts of camas in three-hundred-seventy-three 0.6 m^2 quadrats, estimated mean density of established camas plants/m^2 at Weippe Prairie was up from 2012 counts in all zones except D (Table 1). Figure 3 shows the density counts for each year. Zones A, B, C, and E all appear to have generally increased in camas densities over the study period until 2012. Zone D appears to have experienced decline in camas density since a peak in 2007, with an uptick in 2011 and declines again in 2012 and 2013 (Figure 3). However, using Bayesian spatial regression to account for the influence of microtopography and residual spatial autocorrelation (*sensu* Rodhouse et al. 2011), the overall estimated mean trend in the median established camas plant density remained positive at 3.2% (95% CRI -1.1 – 7.3%). Table 2 shows the estimates for each zone. Zone E continues to maintain the clearest evidence of sustained trend since 2007 when livestock grazing was discontinued in that zone. Flowering pant density was the same or slightly increased in 2013 (Table 1 and Figure 4). Orange hawkweed and sulphur cinquefoil patterns of frequency of occurrence continue to be highly variable among zones and over time (Figures 5 and 6). There was a notable increase in both species in most zones between 2012 and 2013. A single plot record for sulphur cinquefoil in zone D is the first recod for that species in that zone over the entire monitoring period. Fortunately, there does not appear to be a clear sustained increase in any zone for either species. In 2013, oxeye daisy was found in 53 plots (14%) and reed canarygrass was found in 9 plots (2%).

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

Zone	Year	n	Density (Plants/m^2)	90th percentile CI		Flowering Stems	90th percentile CI		Flowering Ratio
A	2013	75	63.93	50.76	78.05	8.70	6.79	10.19	0.14
B	2013	75	7.27	4.22	10.71	1.46	0.70	2.34	0.20
C	2013	75	30.54	22.59	39.24	5.35	4.02	6.81	0.18
D	2013	75	33.86	23.99	44.95	5.86	4.27	7.60	0.17
E	2013	73	9.68	4.83	15.59	1.63	0.90	2.49	0.17
A	2012	70	54.07	42.69	66.73	8.73	6.81	10.81	0.16
B	2012	70	6.17	3.44	9.44	1.30	0.64	2.06	0.21
C	2012	70	25.56	18.97	32.65	4.43	3.15	5.81	0.17
D	2012	70	36.92	25.78	49.45	2.87	1.99	3.82	0.08
E	2012	70	7.07	4.60	9.75	1.68	1.09	2.32	0.24
A	2011	70	72.68	58.36	87.46	10.79	8.37	13.37	0.15
B	2011	70	8.80	5.38	12.71	1.97	1.19	2.92	0.22
C	2011	70	27.44	20.11	35.55	5.07	3.65	6.62	0.18
D	2011	70	43.90	30.78	58.55	4.86	3.56	6.24	0.11
E	2011	70	10.88	7.56	14.39	2.58	1.68	3.58	0.24
A	2010	70	71.40	57.96	86.01	13.87	11.24	16.58	0.19
B	2010	70	5.74	2.94	9.06	1.64	0.81	2.68	0.29
C	2010	70	45.74	34.81	57.27	8.94	6.19	12.17	0.20
D	2010	70	30.07	21.03	39.86	5.53	3.98	7.23	0.18
E	2010	70	6.40	4.39	8.58	1.57	0.95	2.25	0.24
A	2009	70	75.71	61.27	90.50	12.90	10.23	15.84	0.17
B	2009	70	16.38	11.50	21.70	3.12	2.27	4.05	0.19
C	2009	70	27.66	19.14	38.13	5.59	3.92	7.32	0.20
D	2009	70	44.22	30.78	59.00	5.66	3.92	7.59	0.13
E	2009	70	5.03	3.17	7.09	0.50	0.32	0.68	0.10
A	2008	60	57.65	46.48	69.31	9.32	7.25	11.56	0.16
B	2008	80	7.14	4.13	10.54	1.22	0.64	1.97	0.17
C	2008	80	35.46	27.47	43.74	9.52	7.10	12.14	0.27
D	2008	60	56.94	37.02	79.18	9.43	6.45	12.81	0.17
E	2008	80	5.94	4.09	8.01	0.17	0.06	0.29	0.03
A	2007	65	61.65	48.96	74.93	7.81	6.00	9.76	0.13
B	2007	88	6.76	4.26	9.60	0.82	0.38	1.15	0.12
C	2007	60	29.63	20.28	39.92	6.03	3.90	8.52	0.20
D	2007	40	64.16	40.63	89.31	8.30	5.40	11.54	0.13
E	2007	30	0.44	0.11	0.83	0.17	0.06	0.33	0.37
A	2006	43	61.73	49.22	74.58	2.55	1.66	3.51	0.04
B	2006	17	2.64	0.39	5.27	0.68	0.00	1.46	0.26
C	2006	115	17.44	13.16	22.06	1.88	1.41	2.38	0.11
D	2006	30	33.31	17.76	51.68	3.65	2.05	5.42	0.11
E	2006	15	2.77	1.22	4.76	0.11	0.00	0.33	0.04

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

Zone	Year	n	Density (Plants/m^2)	90th percentile CI		Flowering Stems	90th percentile CI		Flowering Ratio
A	2005	25	48.67	32.93	65.87	NA	NA	NA	NA
B	2005	40	4.48	1.66	6.39	NA	NA	NA	NA
C	2005	87	20.78	14.18	28.07	NA	NA	NA	NA
D	2005	0	NA	NA	NA	NA	NA	NA	NA
E	2005	25	5.51	2.32	9.30	NA	NA	NA	NA

Table 2. Annual % trend for each zone estimated from a spatial regression model for 2005-2013.

Zone	Estimate	95% credible interval	
Zone A	2.0	-2.5	5.6
Zone B	2.2	-2.1	5.7
Zone C	5.0	1.7	9.0
Zone D	3.2	-1.1	7.5
Zone E	3.7	0.0	8.0

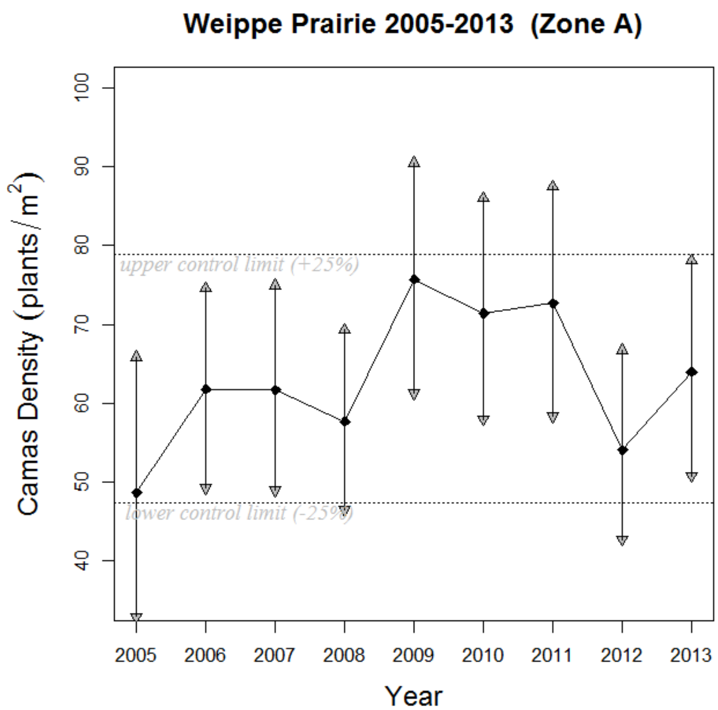
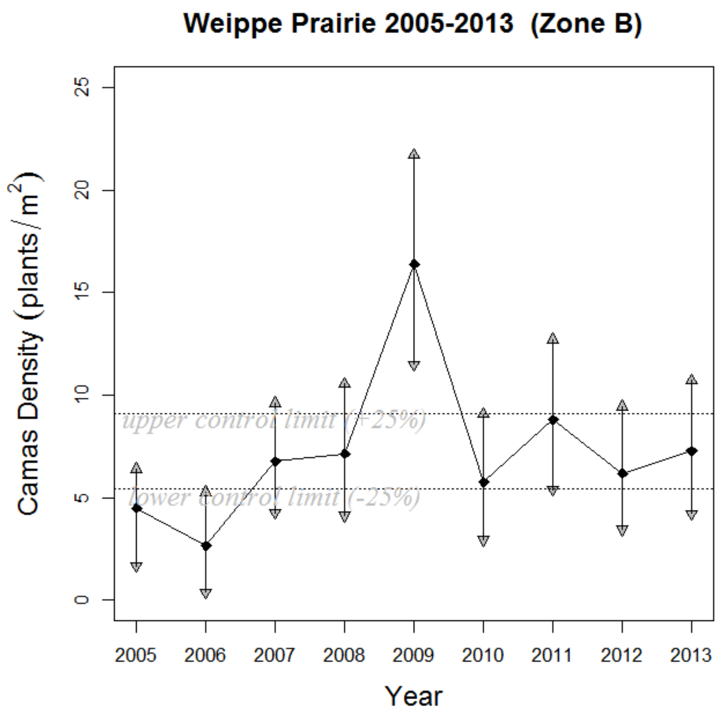


Figure 3. "Conformance" or control charts that plot annual established camas plant densities and 90% confidence intervals relative to control limits that are ±25% of the average density, for each of the 5 management zones.



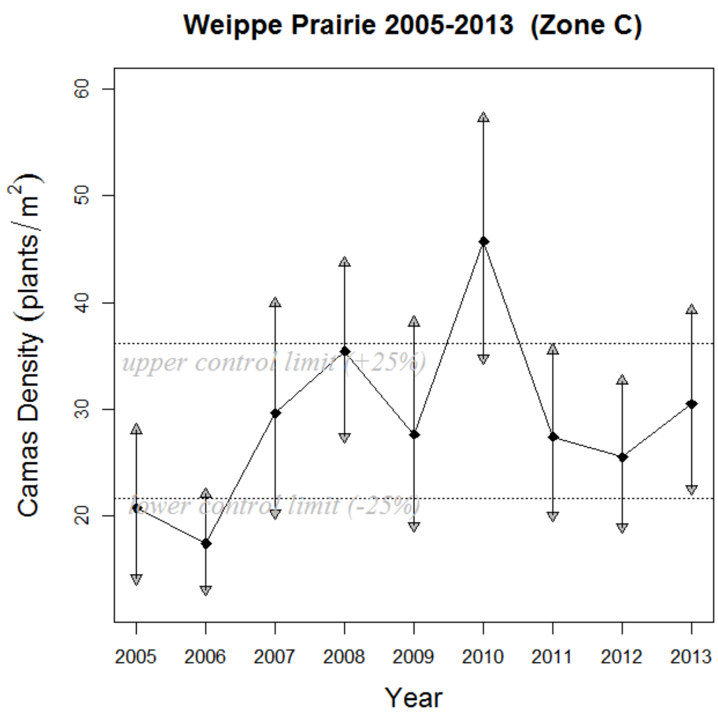
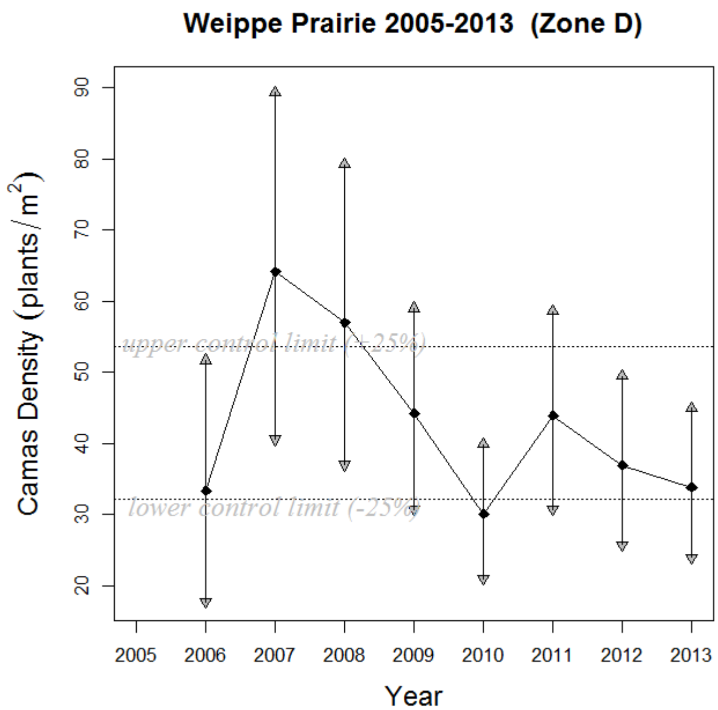
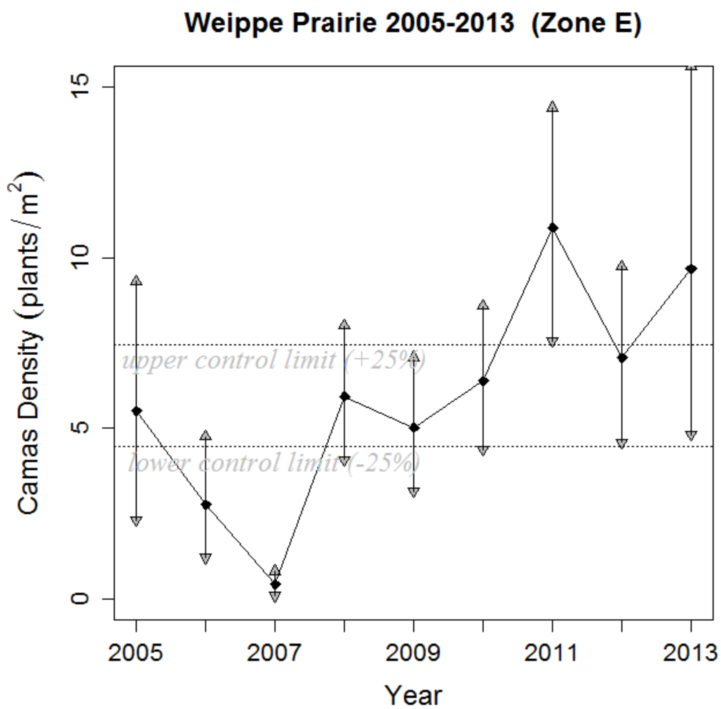


Figure 3 (continued). Conformance" or control charts that plot annual established camas plant densities and 90% confidence intervals relative to control limits that are ±25% of the average density, for each of the 5 management zones.





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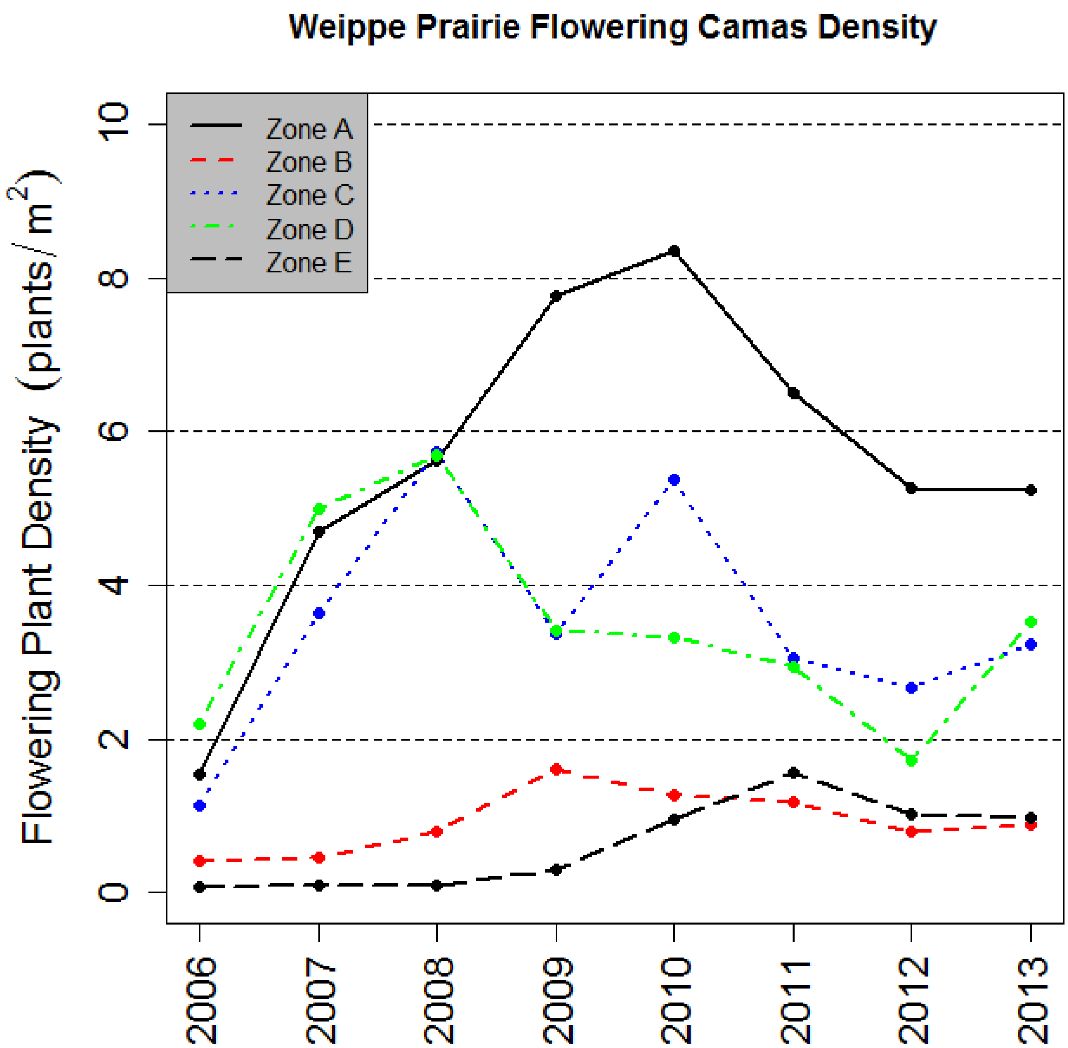

Figure 4. Flowering camas plant density estimated in each of the 5 management zones at Weippe Prairie. Note that counts of flowering plants were not made in 2005.

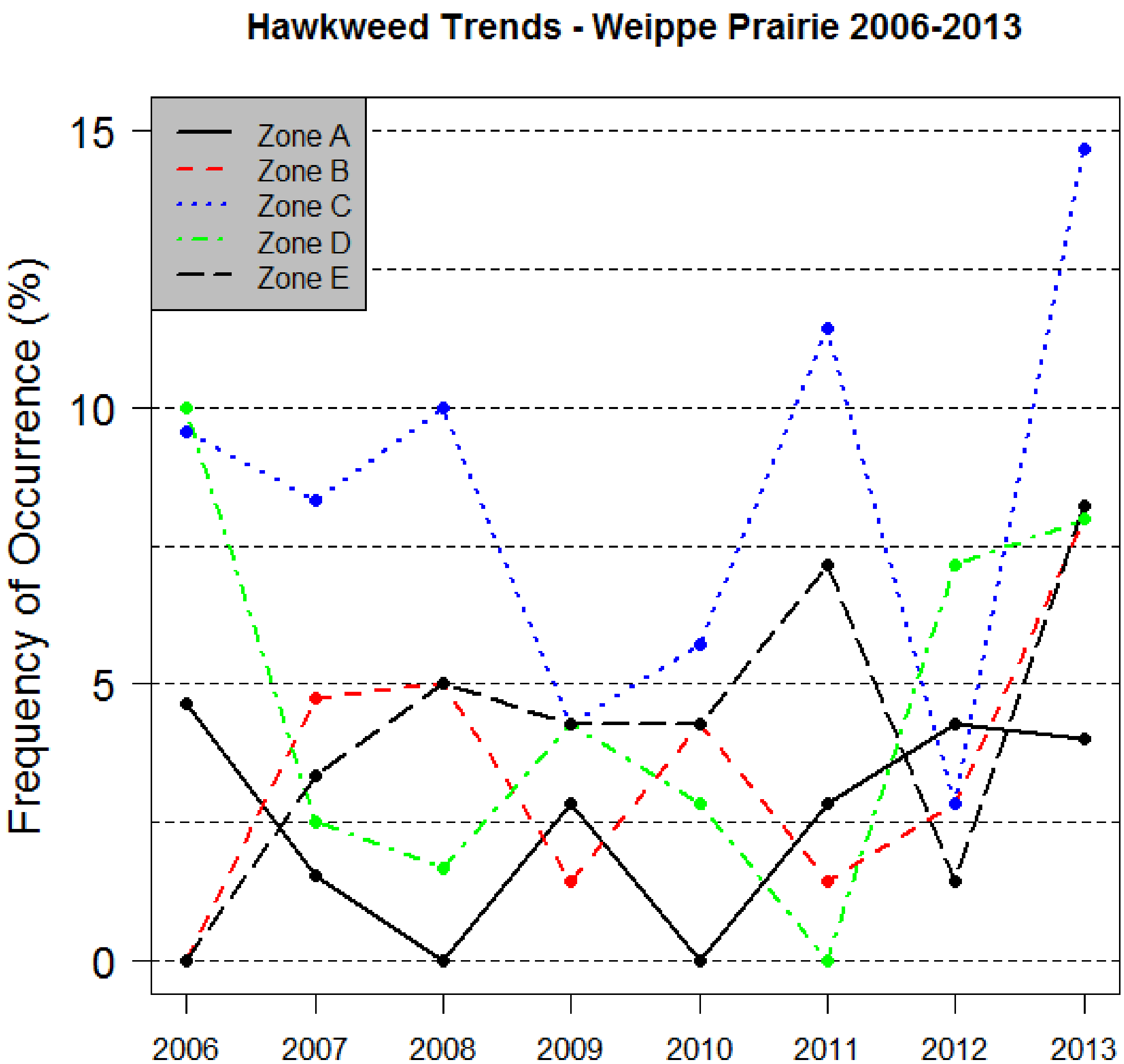

Figure 5. Orange hawkweed frequencies of occurrence (proportion of quadrats in which the species was found) over the 8-year study period for each of the 5 Weippe Prairie management zones. Note that weed data were not collected in 2005.

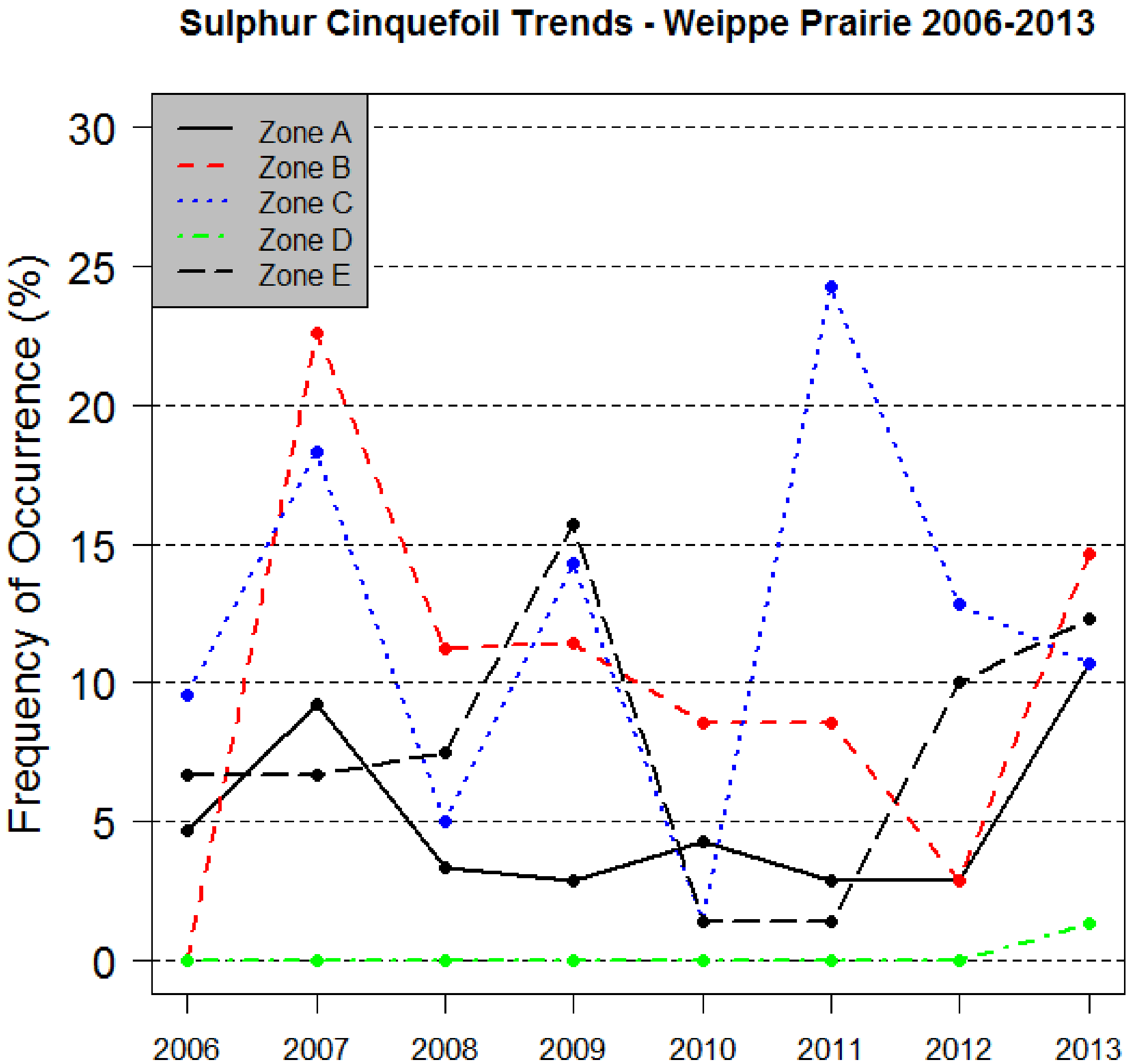

Figure 6. Sulphur cinquefoil frequencies of occurrence (proportion of quadrats in which the species was found) over the 8-year study period for each of the 5 Weippe Prairie management zones. Note that weed data were not collected in 2005.

Discussion

Based on results from surveys in 2013, placed within the context of the previous 8 years of surveys, the camas population no longer appears to be enjoying a strongly increasing trend in established plant and flowering plant densities, as was apparent from observations through 2011 (Rodhouse and Stucki 2013). However, there continues to be some evidence of an overall sustained positive trend from regression modeling over the period, and there is no clear evidence of sustained decline in zone D. Zone E continues to enjoy the clearest positive trend since 2007 when livestock grazing was discontinued. There is a very notable lack of synchrony in patterns of camas population fluctuation as well as in weed population fluctuations among zones. However, until more formal model-based trend analyses is conducted and potential confounding effects of microtopography and spatial autocorrelation (Rodhouse et al. 2011) can be accounted for, the patterns reported here should be considered preliminary and interpreted cautiously. The influence of weather patterns also needs to be accounted for, and it is not yet clear how winter and spring precipitation and prairie inundation affects the camas population. These potential issues will also be addressed in 2014 trend analyses, after 10 years of survey data are available.

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