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Plant Community Monitoring Trend Report, Tallgrass Prairie National Preserve

Natural Resource Technical Report NPS/HTLN/NRTR—2007/030

ON THE COVER
Boutaloua gracilis (Willd. ex Kunth) Lag. ex Griffiths
Line drawing from Hitchcock (1950).

Plant Community Monitoring Trend Report, Tallgrass Prairie National Preserve

Natural Resource Report NPS/HTLN/NRTR—2007/030

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Executive Summary

The tallgrass prairie ecosystem once spread across more than 60 million hectares and extended from southern Texas to southern Manitoba. Now, however, it is estimated that as little as 1-4% of the original tallgrass prairie remains. In addition to being highly fragmented and disparate, tallgrass prairie remnants tend to occur on sites of marginal agricultural use, usually steep slopes with rocky soils.

Tallgrass Prairie National Preserve (TAPR) is the first National Park Service area established specifically for the preservation, protection, and interpretation of the tallgrass prairie ecosystem. Initially known as the Spring Hill Ranch area and continuously grazed for beef production for over 120 years, TAPR is over 9,000 acres of unplowed tallgrass prairie in the Flint Hills physiognomic province of Kansas. Land management of TAPR, under the current grazing lease, calls for intensive early stocking (IES) of cattle and annual spring burning. This management does not fully simulate the temporal or spatial variability characteristic of a native tallgrass ecosystem, particularly the seasonality and behavior of fire. The approved TAPR General Management Plan calls for a shift to a spatially and temporally variable fire and grazing regime.

The Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program (HTLN) implemented monitoring at TAPR in 2000 to provide analysis of baseline conditions and to assess future change in floral communities. Current analyses focus on 18 core sites that have been monitored for the last five years (2002-2006), encompass the major soils and correspond to four pastures under management at TAPR. Data were summarized for all core sites among pastures for each of the five sample years. Individual species frequency and percent foliar cover were calculated for each site.

A total of 201 unique species have been sampled between 2002 and 2006 in the HTLN core monitoring sites. Species diversity is partitioned within sites rather than among sites at the preserve scale. Sites, when grouped to pasture, could not be separated based on a combination of factors including management history, soil type or slope position. Sites among pastures represent a single tallgrass plant community across the portion of the preserve being monitored.

Exotic or invasive species do not occur in great abundance in any monitoring site. This finding is encouraging and maintaining or decreasing current levels of exotic species should be a priority to help ensure the integrity and function of the native community remains.

Overall management has not fragmented the prairie plant community. Preserve managers have been successful at balancing management actions with interpretation of the native prairie.

Introduction

The tallgrass prairie ecosystem once spread across more than 60 million hectares and extended from southern Texas to southern Manitoba (Collins and Glenn 1988). Now, however, it is estimated that as little as 1-4% (0.6-2.4 million ha) of the original tallgrass prairie remains (Weaver 1954). In addition to being highly fragmented and disparate, tallgrass prairie remnants tend to occur on sites of marginal agricultural use, usually steep slopes with rocky soils.

Historically, native tallgrass prairie was characterized by heterogeneity, with vegetation communities occurring in a patchwork of various conditions. The interaction of fire, grazing, and climate formed a landscape in which few patches were burned or grazed at the same time or intensity every year (Hiebert 1998). It is estimated, using time until tree invasion under fire suppression, that historic grassland fire return intervals ranged from 3 to 5 years (Collins and Glenn 1995). In general, fires occurred throughout the year (Bragg 1995) and varied in size according to season (Earls 2006). Variability in fire frequency and size led to spatially variable grazing as native ungulates preferentially grazed newly burned patches. Non-grazing behaviors, such as wallowing, also increased landscape heterogeneity (Plumb and Dodd 1993).

The interaction of fire, grazing, and climate affect ground flora composition and abundance in any given year (Hartnett *et al.* 1996, Albertson *et al.* 1957), often making tallgrass prairies difficult communities to manage. The complexity of these ecosystems, however, creates the potential for high biodiversity.

Tallgrass Prairie National Preserve (TAPR) is the first National Park Service area established specifically for the preservation, protection, and interpretation of the tallgrass prairie ecosystem (Hiebert 1998). Initially known as the Spring Hill Ranch area and continuously grazed for cattle production for over 120 years, TAPR contains over 9,000 acres of unplowed tallgrass prairie in the Flint Hills physiognomic province of Kansas. Land management of TAPR, under the previous long-term grazing lease, called for intensive early stocking (IES) of cattle and annual spring burning. This management does not fully simulate the temporal or spatial variability characteristic of a native tallgrass ecosystem (Robbins and Ortega-Huerta 2002), particularly the seasonality and behavior of fire. The approved TAPR General Management Plan (GMP) calls for a shift to a spatially and temporally variable fire and grazing regime.

Starting in 2001, initial changes were made to decrease fire frequency and implement IES with lighter stocking rates (Barnard 2001, 2006) and in 2006 expanded to include patch-burn grazing management in two combined pasture areas. The aim of patch-burn grazing is to apply previously used management (prescribed fire and grazing) to increase differences in habitat within pastures that more closely resemble the natural disturbance regimes (Fuhlendorf and Engle 2001). Rather than apply fire to an entire pasture, only one-third of the pasture is burned annually, thus creating a burned patch in the pasture. The patch provides higher quality forage for grazing and attracts cattle more so than the unburned areas of the pasture. This type of management is designed to increase heterogeneity of vegetation structure at the pasture scale. Patches are burned on a three-year fire return interval. To accommodate the patch-burn grazing management system, a fence was removed between West Branch and Gas House pastures, creating one large pasture called Big Pasture.

Prior to 2006 both annual burning and grazing were applied to pastures with minimal temporal or spatial variability. Annual disturbances at the preserve scale tend to make the landscape more similar over time rather than increase heterogeneity and diversity. Furthermore, the disturbance regime as applied to the preserve was designed to promote warm season grass production for the benefit of beef production. Preserve management aims to balance cattle grazing and representation of Flint Hills culture with an example of the tallgrass prairie ecosystem.

Methods

Field methods

The Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program (HTLN) implemented monitoring at TAPR in 2000 to provide analysis of baseline conditions and to assess future change in floral communities (see DeBacker *et al.* 2004 for detailed information on the monitoring protocol). Current analyses focused on 18 core sites that had been monitored for the last five years (2002-2006), encompassed the major soils and corresponded to plant communities at TAPR. The years of 2000-2001 primarily focused on establishing permanent sample sites and the small amount of data from these years was not a focus for analysis. Thirty five primary (non-core) sites within pastures were also established to encompass the range of soils present at TAPR, but were sampled on a rotating basis (Fig. 1, Table 1). In 2006 ten additional sites were established in West Branch (Big) pasture (five core sites and five non-core sites) to examine the vegetative response to patch-burn grazing. Core sites in West Branch pasture were omitted from the analyses. The focus of this work was based on data from 18 core sites sampled 2002 – 2006.

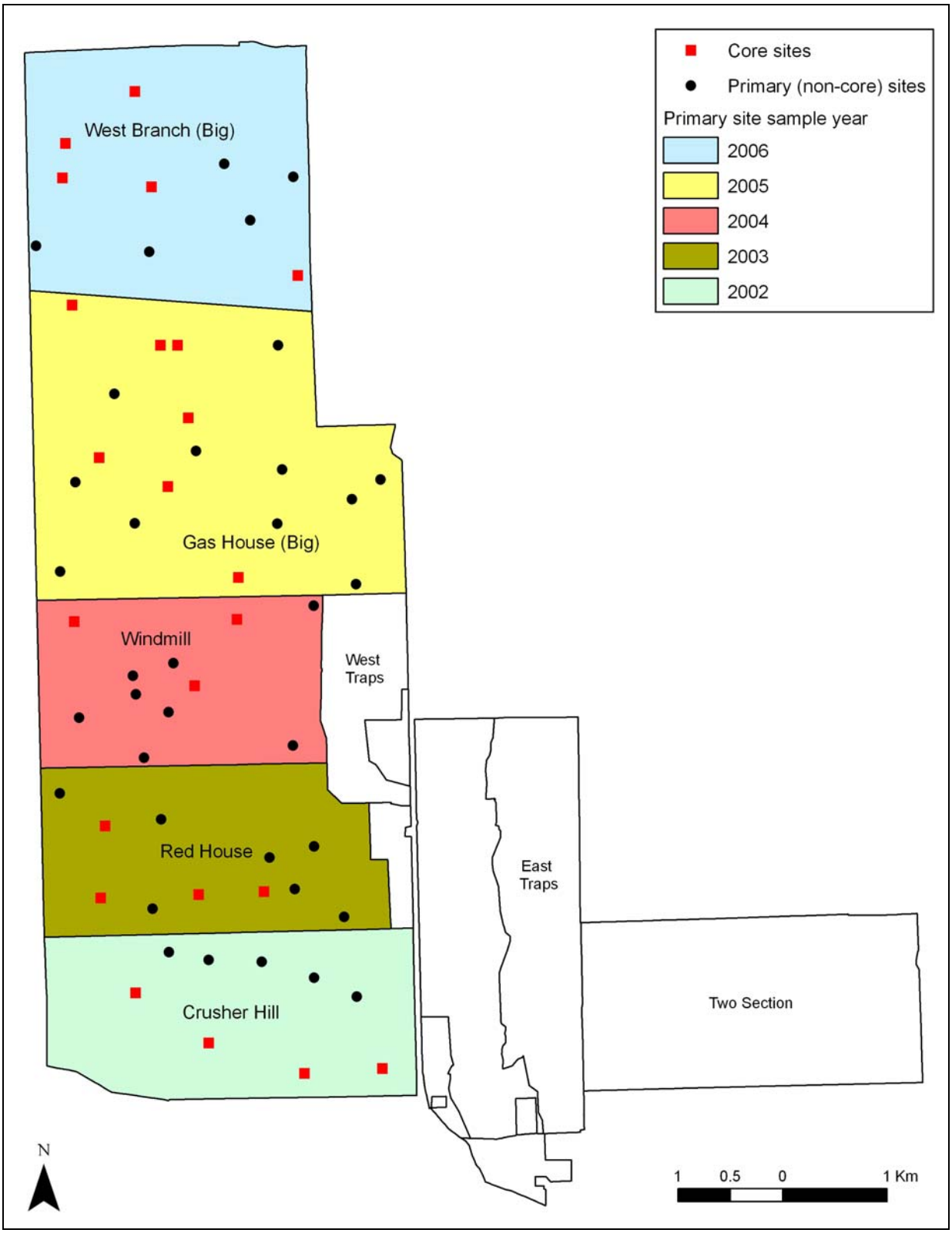

Figure 1. Map of Tallgrass Prairie National Preserve with HTLN vegetation monitoring sites.

Table 1. Monitoring schedule for five pastures at TAPR. Core sites were sampled annually. Primary sites within pasture were sampled only during indicated year. West Branch core sites were not included in 2002-2006 core site analyses.

Year	Pasture	Core Sites	Primary (non-core) Sites	Total Sites
2002	Crusher Hill	4	5	9
2003	Red House	4	6	10
2004	Windmill	3	8	11
2005	Gas House (Big)	7	11	18
2006	West Branch (Big)	5	5	10

Data were collected each year in two sampling trips, one in late spring and one in early fall. In this way, accurate cover estimates and identification of warm season grasses and summer/fall flowering forbs could occur. Data were summarized for all core sites among pastures for each of the five sample years.

The HTLN sampling design consisted of randomly located, permanent, paired transects 50 meters in length and 20 meters apart with five circular $10m^2$ plots systematically spaced along each transect (Fig. 2).

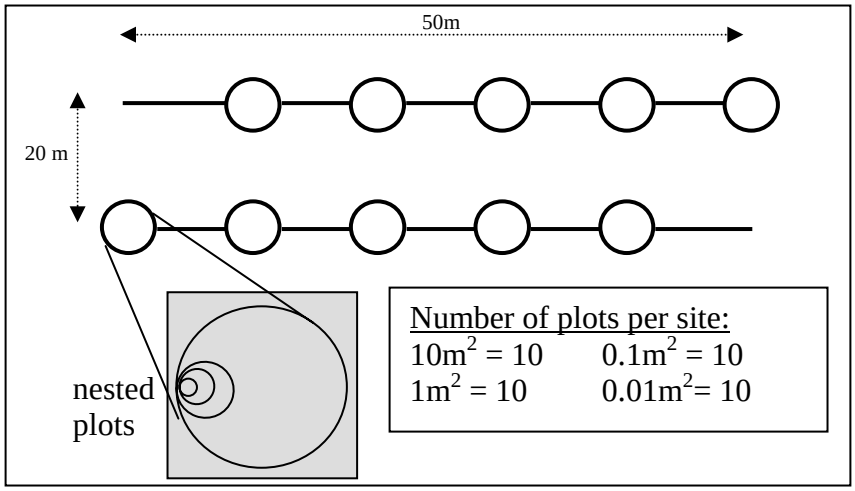

Figure 2. HTLN vegetation community sample design showing transects and plots including nested plots.

Each $10m^2$ plot also included nested subplots of $1m^2$, $0.1m^2$, and $0.01m^2$ for frequency estimates at multiple scales. Working systematically from the smallest subplot ($0.01m^2$) to the largest ($10m^2$), all species were identified and foliar cover was estimated.

Management activities

Cattle stocking rates were adjusted annually within each pasture between 2002 and 2006 (Barnard 2006; Table 2). In addition, Crusher Hill and Red House pastures were not burned annually (Table 3).

Table 2. Prescribed Cattle stocking rates at TAPR (lbs/acre). Intensive early stocking rate set at 275 lbs/acre. Stocking rate (% change from 275 lbs/acre IES; a negative number indicates a reduction in stocking rate) presented for each pasture across sample years where a value of 0 indicates no grazing for that pasture and therefore a 100% reduction from the set IES rate.

Year	Crusher Hill	Red House	Windmill	Gas House (Big)	West Branch (Big)
2002	200 (-27.3)	200 (-27.3)	275 (0)	247.5 (-10)	247.5 (-10)
2003	200 (-27.3)	200 (-27.3)	275 (0)	247.5 (-10)	247.5 (-10)
2004	200 (-27.3)	200 (-27.3)	275 (0)	247.5 (-10)	247.5 (-10)
2005	275 (0)	275 (0)	0 (-100)	275 (0)	275 (0)
2006	228.25 (-17)	184.25 (-33)	0 (-100)	178.75 (-35)	178.75 (-35)

Table 3. Prescribed fire management where Rx was a pasture-wide prescribed burn; PB is part of patch-burn grazing management where prescribed fire was applied to 1/3 of the pasture; blank cell indicates no prescribed fire for that pasture during that year.

Year	Crusher Hill	Red House	Windmill	Gas House (Big)	West Branch (Big)
2002		Rx	Rx	Rx	Rx
2003	Rx		Rx	Rx	Rx
2004	Rx		Rx	Rx	Rx
2005	Rx	Rx	Rx	Rx	Rx
2006		Rx	PB	PB	PB

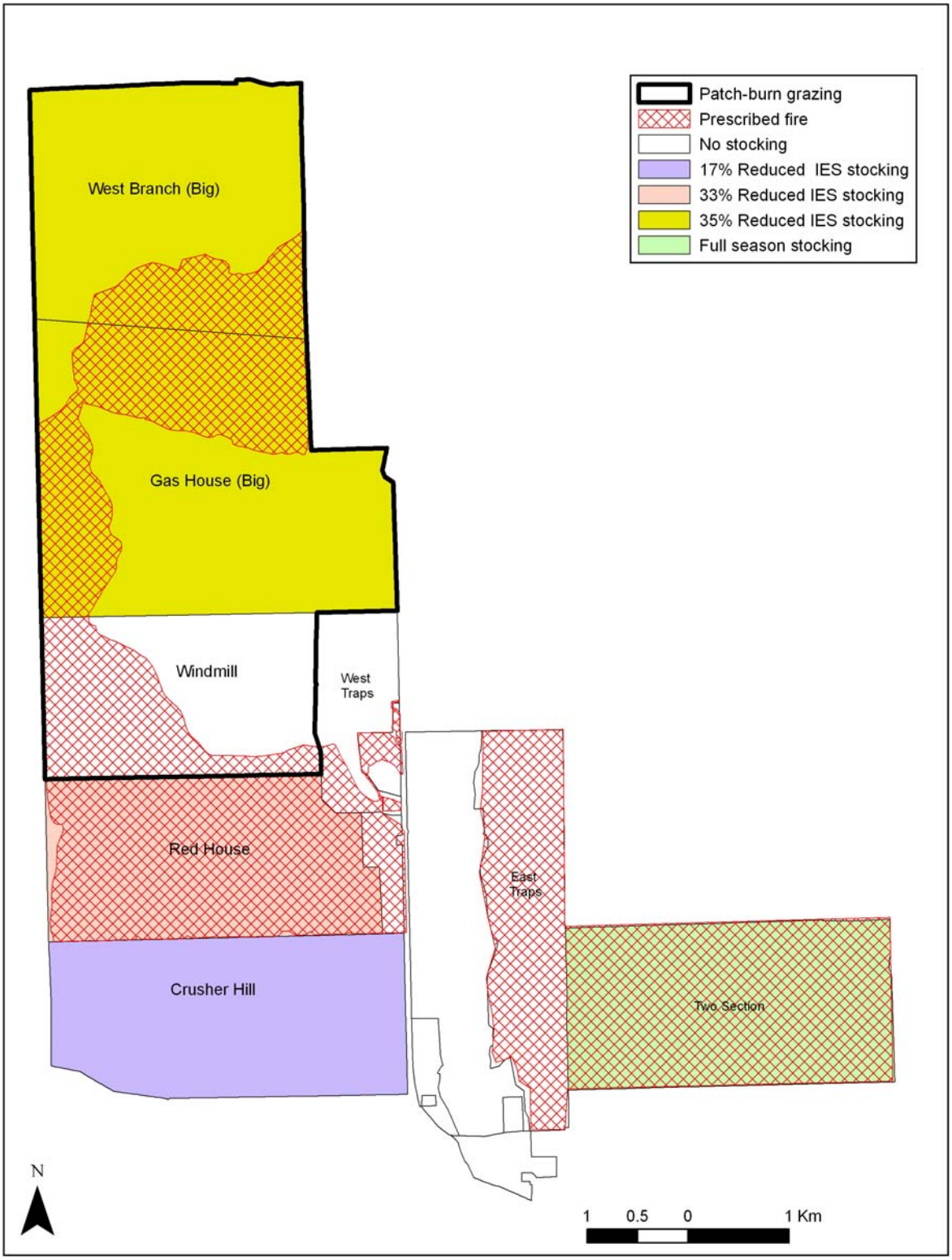

Figure 3. Fire management, including patch-burn grazing, applied in 2006.

Climate

Temperature and precipitation data collected at the Tallgrass Prairie National Preserve weather station (station identification number 148061) were obtained from National Oceanic and Atmospheric Association (http://www.noaa.gov). Temperature (F) and precipitation (inches) data were summarized to monthly averaged values for the summer half year (April – September) for each sample year.

Analytical methods

For analyses, the site was used as the unit of replication and plots were pooled or averaged. Once estimates for all parameters were obtained for each site, averages and a measure of variability (standard deviation or standard error of the mean) were calculated among sample sites.

Individual species abundances and frequencies

Individual species frequency and percent foliar cover were calculated for each site. With the site as the replicate, species frequency was reported as the proportion (or percentage) of plots in which the species occurred within each site.

Foliar cover served as an estimate of abundance for herbaceous species. Cover class intervals were converted to median values to estimate percent cover for each herbaceous and shrub species. Mean percent cover was then calculated as the species percent cover for a site, averaged for all plots in which the species occurred (i.e., plots within a site with zero values for a species were excluded).

From these basic estimates of foliar cover and frequency were generated the following metrics for each site: (1) species relative cover and (2) species relative frequency. Relative frequency and relative cover were calculated using the following formulas:

$$\text{Relative cover, species X} = \frac{cover_{speciesX}}{\Sigma\ cover_{\ all\ species}}$$

$$\text{Relative frequency, species X} = \frac{occurrences_{speciesX}}{\Sigma\ occurrences_{\ all\ species}}$$

Where occurrence was the number of plots in which a species was present within a site.

Species frequency within sites and among years was used to identify core species for the entire sample period 2002-2006. Core species were defined as occurring in every site (n = 18) for each sample year. Core species did not vary spatially (present in all core sites) or temporally (present in all sample years).

For each core species the optimum sample frame size was identified. The nested plot frame sampling design allowed species to be detected at multiple scales (Fig. 2). Species presence was recorded for the smallest plot frame in which it was encountered (sample plot frames were surveyed from smallest to largest). As plot frame size in which a species was found decreased, the inferred density for that species increased. Although the amount of structure in a population distribution influenced the optimal plot size, a plot frame size that returned a species frequency

between 40 – 60% was considered optimum to detect a change in frequency and inferred change in density (Heywood and DeBacker 2007).

Plant species richness, diversity and evenness

Plant diversity for each site was calculated using the **Shannon index**:

$$H' = -\sum_{i=1}^{n} p_i \ln p_i$$

where p*i* was the relative cover of species *i* (Shannon 1948). Species distribution **evenness** was calculated by site using Pielou (1977)(J):

$$J' = H' / H_{max}$$

where H' was the Shannon index and H_{max} was the maximum possible diversity for a given number of species if all species were present in equal numbers ((ln(species richness)). J' is a measure of distribution of species within a community as compared to equal distribution and maximum diversity (Pielou 1969). **Species richness** was determined as the total number of plant taxa recorded per site. Species richness was calculated with all species (native and exotic) included in the estimate. **Simpson's index** of diversity for an infinite population (D) was calculated by site (McCune and Grace 2002). It was the likelihood that two randomly chosen individuals from a site would be different species and emphasized common species (McCune and Grace 2002). It was calculated by site using the complement of Simpson's original index of dominance:

$$\text{Simpson's index} = 1 - \sum_{i}^{n} p_i^2$$

Shannon and Simpson's index values were converted into effective number of species for each community (H_e and D_e, respectively). This allowed for both diversity measures to be compared directly to species richness of the sites (S) within and among sample years based on counts of distinct species in the community (Joust 2006). Shannon index was converted into effective number of species (H_e) using the following formula:

$$H_e = \exp^{(H)}$$

where H was the Shannon index value. The effective number of species based on Simpson's index (D_e) was the inverse of the index value or:

$$D_e = 1/(1-D)$$

where D was the Simpson's index value.

When interested in measuring diversity in a single community it is best to use all three diversity measures to most accurately reflect diversity (Joust 2006). At the most basic level of species diversity, species richness provides a total number of distinct species sampled per unit area. Richness is insensitive to species abundance. Therefore a single individual species occurring only once in a community is treated the same as a species with thousands of individuals in the community. This measure is an indicator of species diversity but does not provide any

information about the composition of species within the community. The Shannon index weights species by their abundance. It is intermediate between species richness and Simpson's index in its sensitivity to rare species. Therefore this diversity measure provides information on both the count of unique species and their abundance in the community. Simpson's index goes one step further by disproportionately favoring dominant species based on species abundance and is little affected by gain or loss of rare species.

Dominance takes into account species abundance and evenness of distribution in the community. The degree of species abundance and dominance in the community is reflected by the degree to which $S > H_e > D_e$ when evenness (E) remains constant in a single community. The difference in number of species between the diversity measures reflects the presence of uncommon species and how species diversity is partitioned within the community. If all species occur in equal abundance in the community within and among sample years then $S = H_e = D_e$. Effective number of species for each diversity measure reflects the number of species found in a similar community when all species occur in equal abundance. That is to say if $S = 100$ and $D_e = 20$, then the community is dominated by 20 species and 80 species occur in low abundance. Such a community would be equivalent to a community with just 20 species all occurring in equal abundance.

Alpha, beta and gamma diversity

Analyzing patterns in species richness at both the site and preserve scale allowed three kinds of diversity to be calculated for TAPR (Whittaker 1972). Alpha diversity, local level diversity, was calculated as the average species richness per site, while gamma diversity, landscape level diversity, was estimated as the total number of species across all sites (McCune and Grace 2002). Each measure of diversity was summarized for the preserve and each pasture. Beta diversity, as a measure of the heterogeneity in the data, was calculated as (Whittaker 1972):

$$\beta_w = (S_c / S) - 1$$

where:
β_w = beta diversity,
S_c = the number of species in the composite sample,
S = the average species richness in the sample units.

As a rule of thumb, values of $\beta_w < 1$ are rather low and $\beta_w > 5$ are considered high beta diversity (McCune and Grace 2002). If $\beta_w = 0$, then all sample units have all of the species. The one is subtracted to make zero beta diversity correspond to zero variation in species presence. Beta diversity could be interpreted as an indicator of heterogeneity for the area of interest. While this measure does not have any formal units, the result could be thought of in approximate units as the "number of distinct communities" (McCune and Grace 2002).

Prairie plant guild and exotic species summary

Average relative frequency and cover and associated standard error of the mean are also calculated for 10 plant guilds: warm-season grasses, cool-season grasses, annuals and biennials, ephemeral spring forbs, spring forbs, summer/fall forbs, legumes, ferns, woody species (shrubs) and grass-like species. Ecological prairie plant guilds are composed of species with significant

overlap in niche requirements, and that occupy similar positions along a resource gradient in a community (Kindscher and Wells 1995). Guilds simplify the array of species into groups making ecosystem processes and functions more easily understood (Kindscher 1994).

Exotic species form a different type of species guild, specific to species intentionally or unintentionally introduced into an area outside of their natural range. Exotic species can influence ecological processes including trophic level relationships, interspecific competition, primary and secondary succession, nutrient cycling, and ecosystem productivity, diversity, and stability (Bratton 1982). Relative frequency of exotic species is calculated for each community. For park-wide review of exotic species at TAPR see Young et al. (2007).

Vegetation structure summary

Measuring horizontal cover provides an estimate of vegetation structure at core sites across the preserve. Vegetation profile data is collected during the fall sample at all core sites (see DeBacker *et al.* 2004 for detailed information). The vegetation profile is estimated at five points within the core sites, three on transect A (at 5, 25 and 45 meters) and two on transect B (at 15 and 35 meters). At each point along transects, the profile is estimated at a distance of 5m from the profile board. The area of the cover board obscured by vegetation is measured in seven height intervals (0-0.5, 0.25-0.75, 0.5-1.0, 0.75-1.25, 1.0-1.5, 1.25-1.75, 1.5-2.0m) using the same cover classes as foliar cover estimation. Both the percent cover of the vegetation and the height at which the board is obscured provides data that are used to monitor the differences in plant community structure across the preserve and through time.

Data summary and trend analysis

For each calculated metric a mean value was presented along with one standard error of the mean. Standard error of the mean is a measure of how closely the sample mean estimates the entire population mean. This measure of variability was used to describe how accurately the sample mean represented the broader area of interest, such as the pasture or entire plant community.

Repeated measures Analysis of Variance (ANOVA) tests were performed on core site data for the sample period 2002-2006. This was used to test for differences in core sites among sample years and to detect any linear trends at the preserve-wide scale (Sokal and Rohlf 1995). This test was applied to species diversity measures (S, H_e and D_e) and core species frequency.

Multi-response permutation procedure (MRPP; McCune and Grace 2002) with Sørensen's distance measure was used to test for differences in core sites within sample years. MRPP is a nonparametric method that used multivariate data to test for differences between groups. Species frequency data for core sites within sample years was used along with topo-edaphic, climate, and management data to group core sites by pasture for each sample year. Each MRPP comparison provided a P-value for a test of no difference in species composition between pastures. In addition, the chance-corrected within-group agreement (A) was reported. This was a measure of relative within-pasture homogeneity where higher values indicated tighter groupings of sites within pasture. The maximum value, A=1, occurred when species composition of sites were identical within pastures. When A = 0, the heterogeneity within groups equaled expectation by chance.

Results

Findings are presented for the original core sites established in 2002 (n = 18). The additional core sites established in West Branch in 2006 were not included in the analyses. Between 2002 and 2006 all eighteen core sites across four pastures were sampled.

Climate

Climate is highly variable as measured at TAPR by temperature and precipitation during the sample period 2002 -2006. Fluctuation throughout the summer months in precipitation did not appear to follow any annual pattern for the sample period (Fig. 4). In contrast summer temperature trend was similar from year to year with temperatures peaking in late summer each sample year (Fig. 5). 2004 was noticeably more variable in precipitation along with a lower maximum temperature than other sample years. Both precipitation and temperature readings were at the preserve scale. Thus climate data could not be used to discern differences at the pasture scale. These data were used to illustrate climatic variability and trends at the preserve scale through time.

The variability in seasonal rainfall within and among years or the annual trends in seasonal temperature at TAPR were not able to account for mean differences in species composition among sample years for all core sites (see MRPP results below). Climate patterns at TAPR between 2002 and 2006 were within the range characteristic of the region (Hayden 1998).

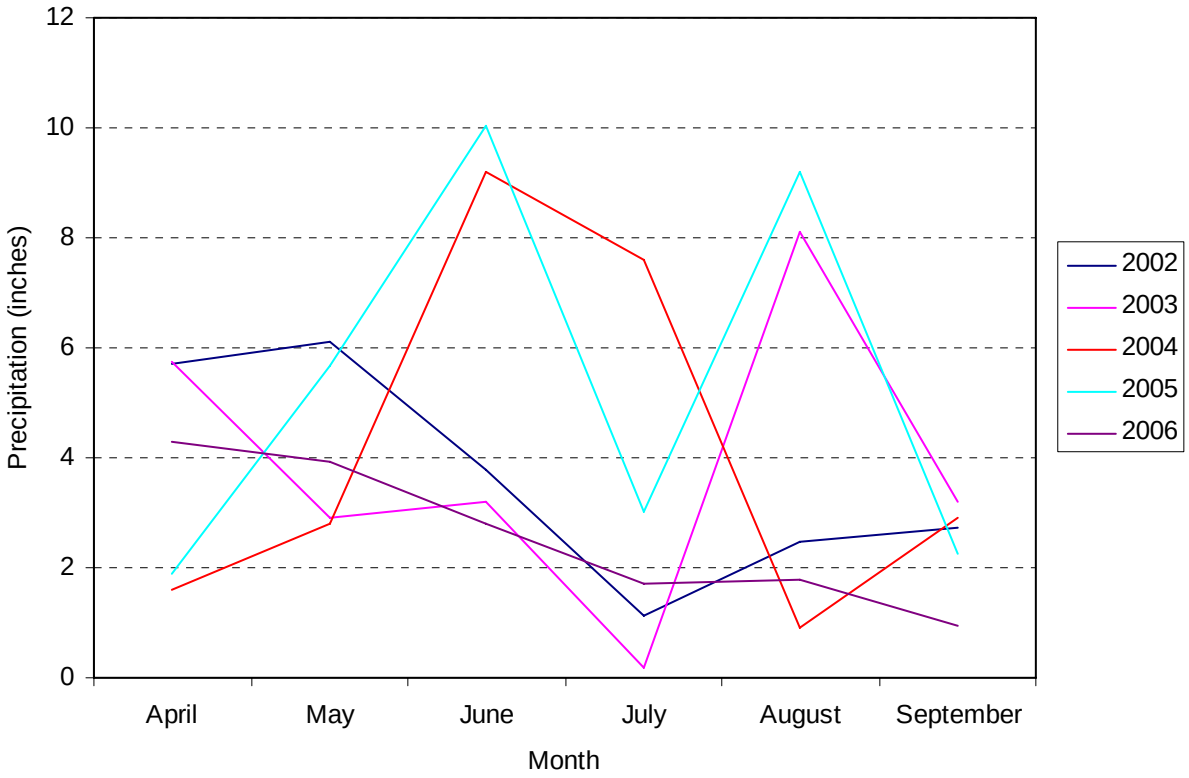

Figure 4. Monthly mean precipitation (inches) for sample years 2002 -2006 across the summer half year.

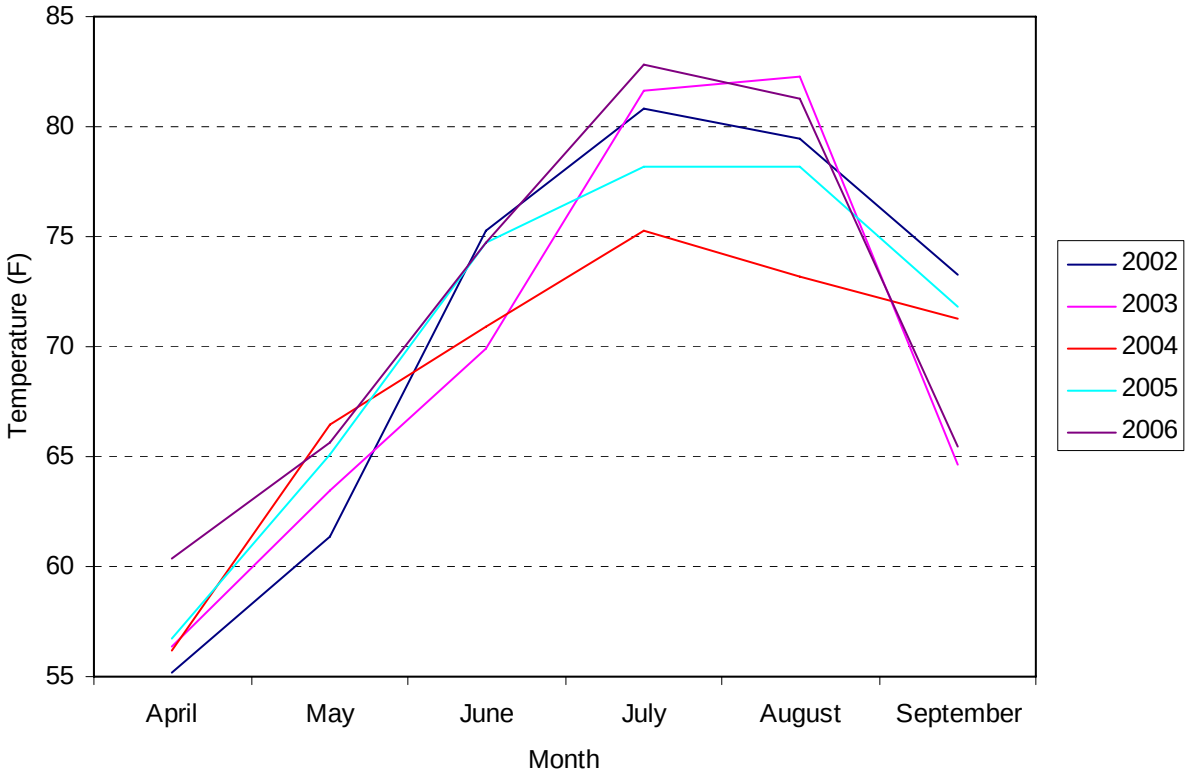

Figure 5. Monthly mean temperature (F) for sample years 2002 -2006 across the summer half year.

Diversity indices

A total of 201 unique species have been sampled between 2002 and 2006 in the HTLN core monitoring sites (Appendix 1). The average number of unique species sampled among sites (R or gamma diversity) across six sample years was 138.6 ± 7.2 species (mean ± 1 standard deviation). The average number of species sampled per site (S or alpha diversity) was 58.8 ± 9.9 species. Therefore a site contained on average 42% of the total species richness for that sample year. Average beta diversity for the preserve for all five years was 1.36 ± 0.13 (Table 4). Beta diversity was less than one for all years within each pasture (Table 4).

Table 4. Three levels of diversity for entire TAPR preserve, as well as four pastures for all sample years 2002 - 2006.

		Alpha				
Area	N	2002	2003	2004	2005	2006
Preserve	18	51.7	62.1	64.3	58.6	57.6
Crusher Hill	4	48	61	59.8	56	57.3
Red House	4	53	63	65	55	49
Windmill	3	60	62.3	69.3	61.7	59
Gas House (Big)	7	49.4	62.1	64.3	60.7	62.1

		Beta				
Area	N	2002	2003	2004	2005	2006
Preserve	18	1.46	1.32	1.16	1.47	1.4
Crusher Hill	4	0.77	0.75	0.62	0.88	0.8
Red House	4	0.7	0.6	0.55	0.67	0.61
Windmill	3	0.52	0.43	0.4	0.51	0.49
Gas House (Big)	7	0.74	0.95	0.88	0.84	0.82

		Gamma				
Area	N	2002	2003	2004	2005	2006
Preserve	18	127	144	139	145	138
Crusher Hill	4	85	107	97	105	103
Red House	4	90	101	101	92	79
Windmill	3	91	89	97	93	88
Gas House (Big)	7	86	121	121	112	113

Values were only slightly greater than one each sample year when measured at the preserve scale. Beta values indicated low species heterogeneity at both the pasture and preserve scale for the sample period.

Mean site evenness (E) among sample years was statistically significant ($p = 0.02$, Table 5). This finding was due to lower mean evenness in 2002 ($E = 0.608$) as compared with the other sample years. Although E was significantly different among sample years, sites had similar evenness (E) values within and among sample years (0.661 ± 0.077). Mean site values of species richness, H_e and D_e were not statistically different among years for the sample period (Table 5).

Table 5. Repeated measures ANOVA results for effect of sample year on diversity measure response variable. Bold values are significance at the P < 0.05 level.

Diversity measure	df	F-ratio	P-value
Species richness (S)	4	1.42	0.28
Evenness (E)	4	4.67	**0.02**
Shannon index (H_e)	4	2.89	0.07
Simpson's index (D_e)	4	2.54	0.09

Patterns of species distribution within the preserve became more evident when comparing measures of species diversity that considered species abundance differently. Effective number of species for Shannon index (H_e) and Simpson's index (D_e) followed the same trend as species richness (S) across sample years. Further mean annual variability for each measure was low within year among sites and among years as indicated by the range of the standard error of the mean (Fig 6).

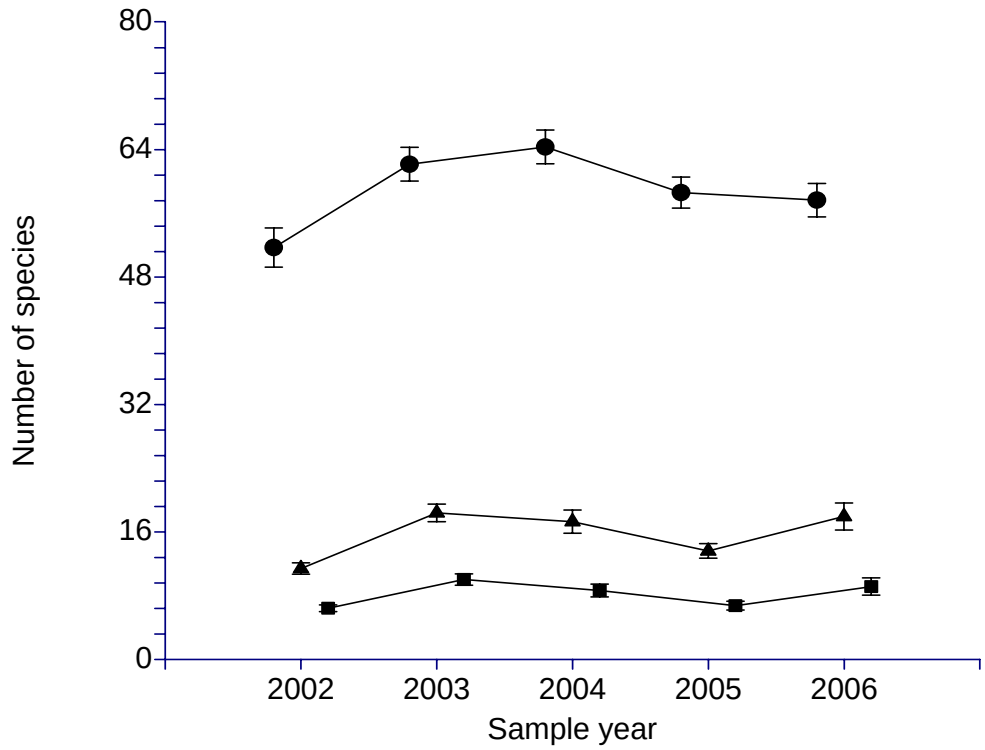

Figure 6. Species richness (circle) and effective number of species for two diversity measures (Shannon index, triangle; and Simpson's index, square) for core sites (n = 18) across sample years. Symbol is the mean and error bars are ± 1 standard error of the mean.

On average S and H_e differed in number of species by 73% (58.8 ± 9.9 vs. 15.7 ± 5.8 species, respectively) while the average difference increased to 86% when comparing S and D_e (58.8 ± 9.9 vs. 8.2 ± 3.4 species, respectively). There were no linear trends in species diversity in the

core plots through time as indicated by the repeated measures ANOVA. All three measures of species diversity followed a similar pattern of increasing and decreasing number of species sampled through time. The lack of any detectable pattern in species diversity within core sites across the sample period made it difficult to attribute annual changes to specific management actions.

Differences among sites

Differences between sites within pasture for each sample year were minimal as indicated by similar within-pasture distance values (Table 6). Increased distance values reflected increased differences in species composition among sites within pastures. In terms of species composition, both sites within and among pastures overlapped considerably. Therefore the low distance values for each pasture in a sample year indicated that species diversity and composition were partitioned within sites rather than among sites at the preserve scale. These findings support low beta values seen within and among pastures.

Table 6. Multi-response permutation procedure (MRPP) results for core sites average within pasture distance measure and the chance-corrected within-group agreement (*A*). Bold values are significant differences between pastures for that sample year at the P < 0.05 level.

Year	Crusher Hill	Red House	Gas House	Windmill	*A*	P-value
2002	0.291	0.308	0.335	0.339	0.0067	0.356
2003	0.343	0.312	0.288	0.358	0.0427	0.072
2004	0.313	0.288	0.287	0.353	0.0542	**0.025**
2005	0.353	0.335	0.313	0.35	0.0092	0.325
2006	0.338	0.33	0.32	0.359	0.0349	0.084

The multi-response permutation procedure resulted in only a single statistically significant result (bold value, Table 6). In 2004, the observed *A* was statistically different from expected, while within-group heterogeneity remained similar to all other sample years. Furthermore, the chance-corrected within-group agreement (*A*) values were all close to zero, indicating that species heterogeneity of sites within pastures was not different from that expected by chance alone. Core sites all overlapped in terms of species composition and frequency both within and among pastures across all years.

Core species

Thirteen species were core species (i.e., occurred at all 18 sites in every year). The frequency of core species at their optimum plot frame size was based on presence/absence within site at the optimum frame size. Therefore, core species that occurred in high frequency in the larger plot frame sizes were less abundant than those core species with lower frequency in the smaller plot frame sizes. The presence/absence of a species as measured by frequency for each plot frame size was distinct from the inferred density of individual species as they occurred in different plot frame sizes. Percent frequency measured at the optimum scale illustrated the variability of single species across time at the preserve scale.

As optimum plot frame size increased, the inferred density of core species decreased. Variability in percent frequency of a core species measured at its optimum frame size reflected the variability in abundance of that species across sample years. Statistical significance reflected differences in mean frequency among sample years. The mean annual percent frequency represented the average number of plots in which the species was found. Annual frequency trends at the optimum plot frame scale were inspected visually along with repeated measures ANOVA P-values presented for each core species.

Three core species had an optimum plot frame size of 0.01 m^2, indicating that they occurred in greater density across the preserve (Fig. 7). Big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*) and side-oats grama (*Bouteloua curtipendula*) all were statistically significant at the $p < 0.05$ level, indicating significant differences in mean frequency among sample years at the optimum plot frame scale. Big bluestem increased in annual frequency between 2002 and 2005 then decreased significantly in 2006 while side-oats grama mean frequency declined annually.

The 0.1 m^2 plot frame was optimal for three core species based on frequency. Although these species were detected in all core sites during all sample years, their distribution and inferred density was less than those core species with a smaller optimum plot frame size and greater than those core species with a larger optimum sample frame size. Of western ragweed (*Ambrosia psilostachya*), white aster (*Aster ericoides*) and *Carex* spp., only *Carex* spp. was not statistically significant among sample years (Fig. 8).

Two of the four core species with an optimum plot frame size of 1m^2 showed a statistically significant difference among years (Fig. 9). The annual variability for leadplant (*Amorpha canescens*) and Indian grass (*Sorghastrum nutans*) did not follow a linear temporal trend.

Variability in optimum frequency for core species at the 10m^2 plot frame scale was minimal for all species except purple lovegrass (*Eragrostis spectabilis*) in 2006 (Fig. 10). Even though core species with an optimum plot frame size of 10m^2 occurred in every site during each sample year and at frequencies above 50%, it was important to remember that as plot frame size increased the abundance of the species decreased.

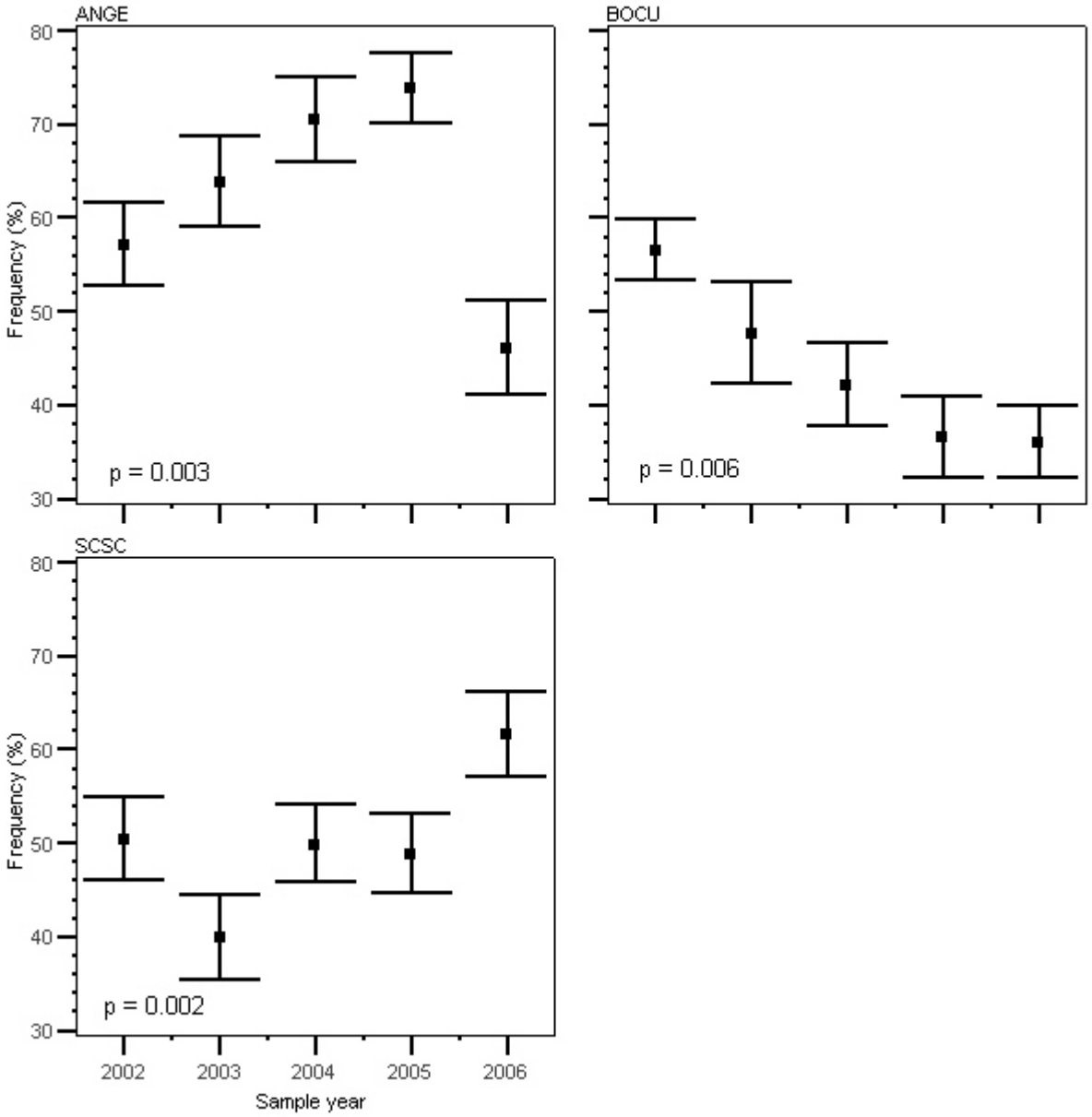

Figure 7. Core species optimum frame size = 0.01 m^2. P-values from repeated measures ANOVA. Symbol is the mean and error bars are ± 1 standard error of the mean. ANGE = *Andropogon gerardii*; BOCU = *Bouteloua curtipendula*; SCSC = *Schizachyrium scoparium*.

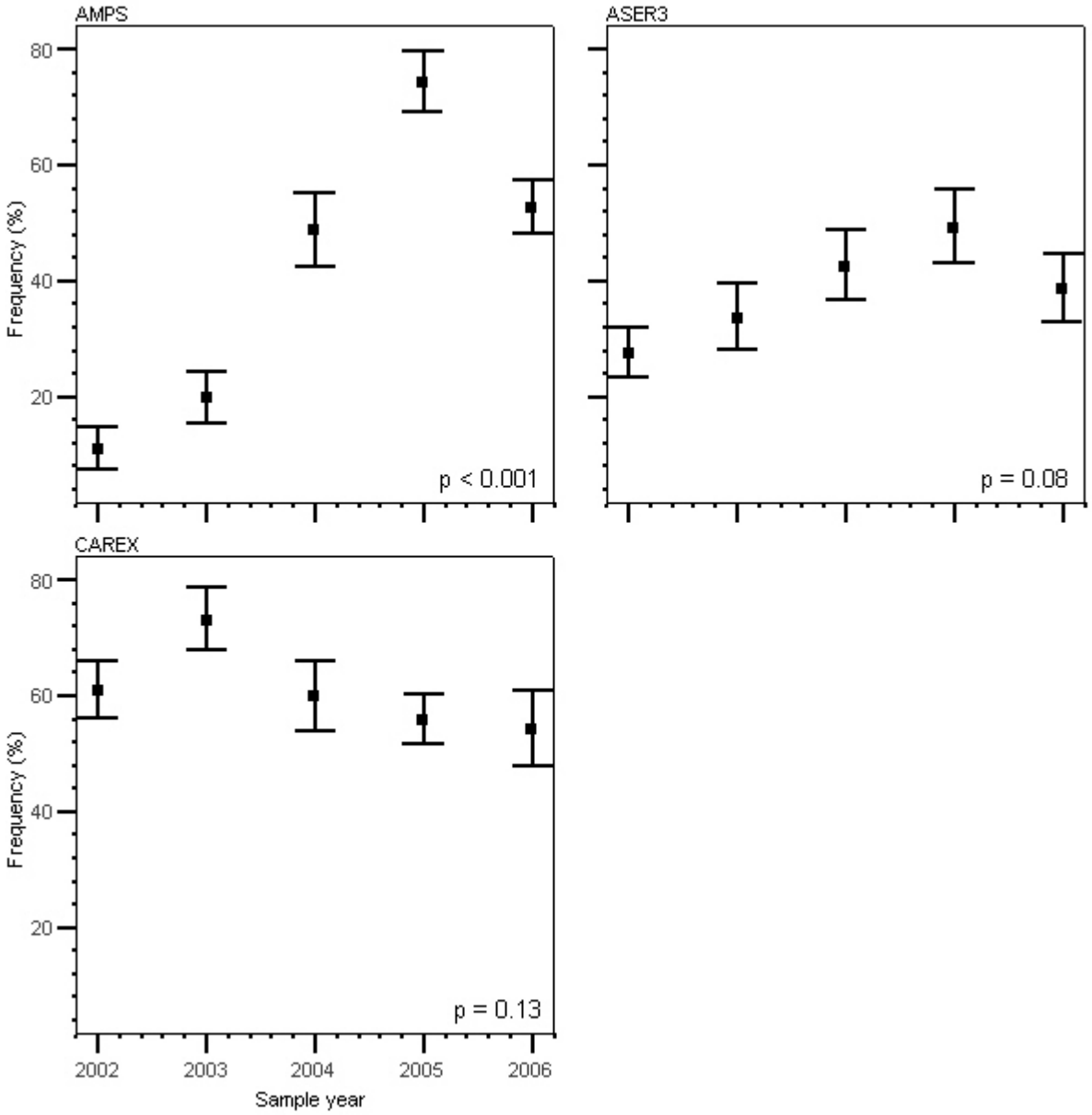

Figure 8. Core species optimum frame size = 0.1 m^2. P-values from repeated measures ANOVA. AMPS = *Ambrosia psilostachya*; ASER3 = *Aster ericoides*; *Carex* = *Carex* spp.

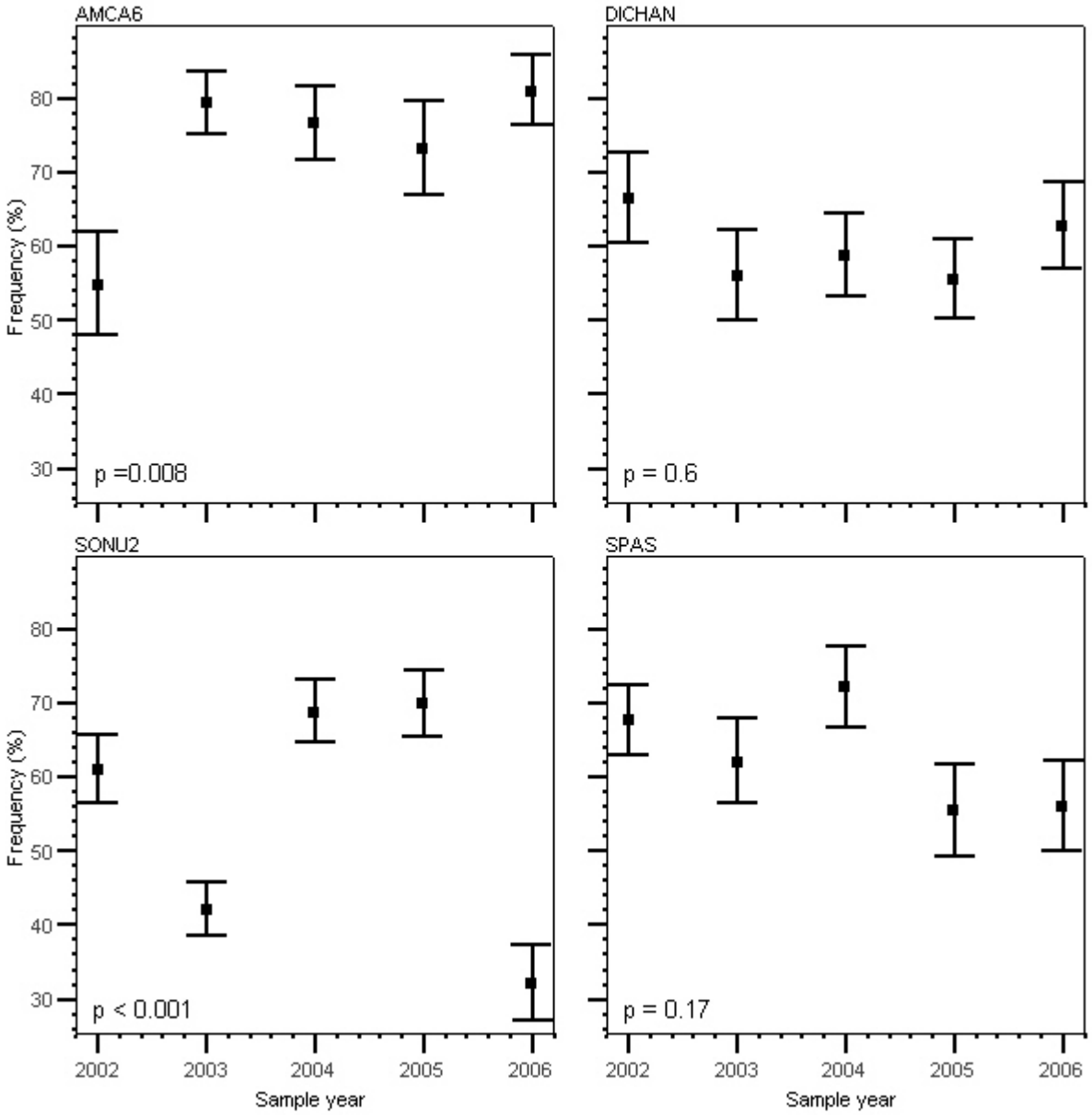

Figure 9. Core species optimum frame size = 1 m^2. P-values from repeated measures ANOVA. AMCA6 = *Amorpha canescens*; DICHAN = *Dichanthelium* spp.; SONU2 = *Sorghastrum nutans*; SPAS = *Sporobolus asper*.

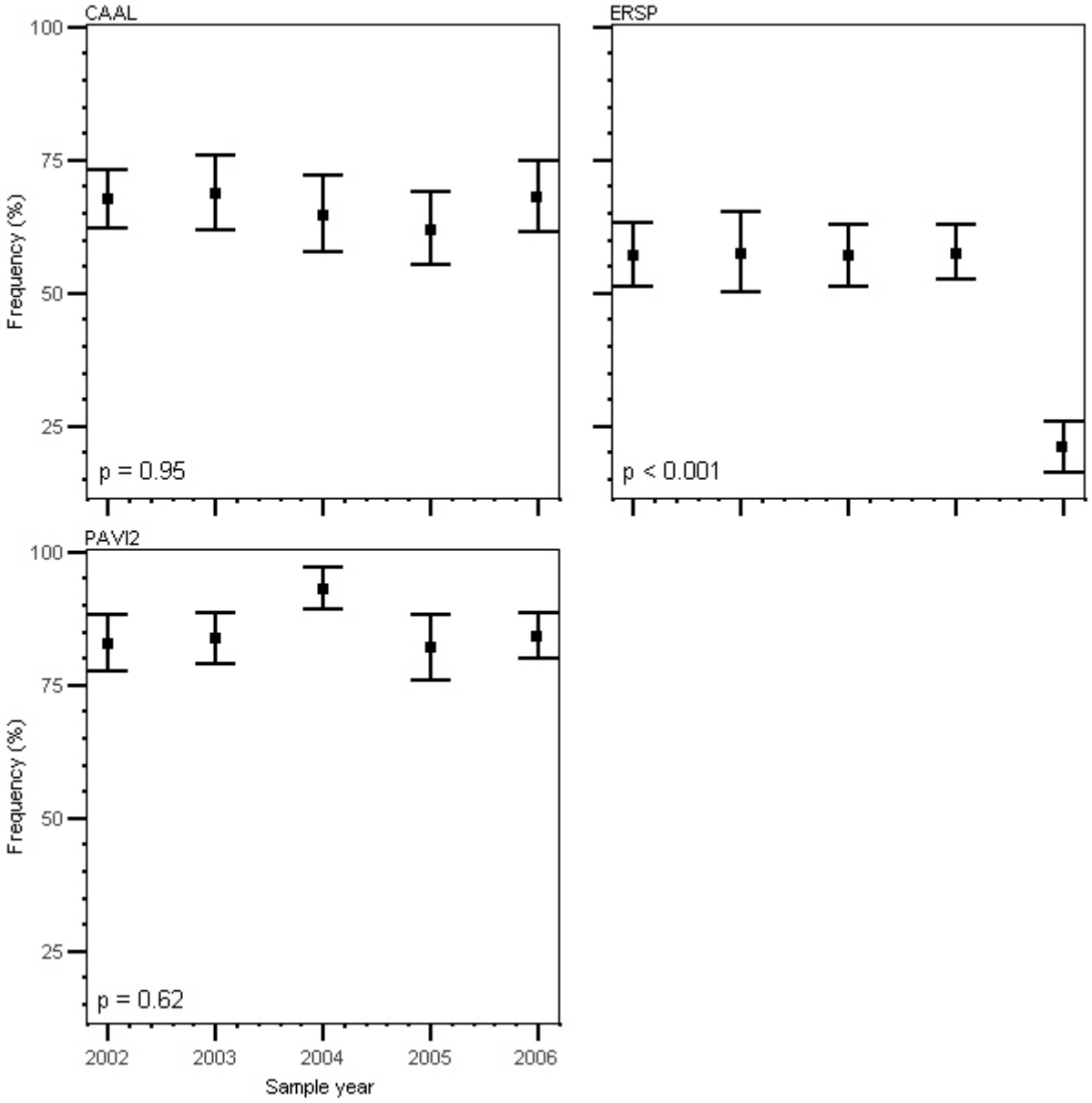

Figure 10. Core species optimum frame size = 10 m^2. P-values from repeated measures ANOVA. CAAL = *Callirhoe alcaeoides*; ERSP = *Eragrostis spectabilis*; PAVI2 = *Panicum virgatum*.

Relative cover

Core species were composed of warm-season grasses and summer/fall forbs. A similar pattern of dominance among years was seen with relative cover of guild types at the preserve scale (Fig. 11).

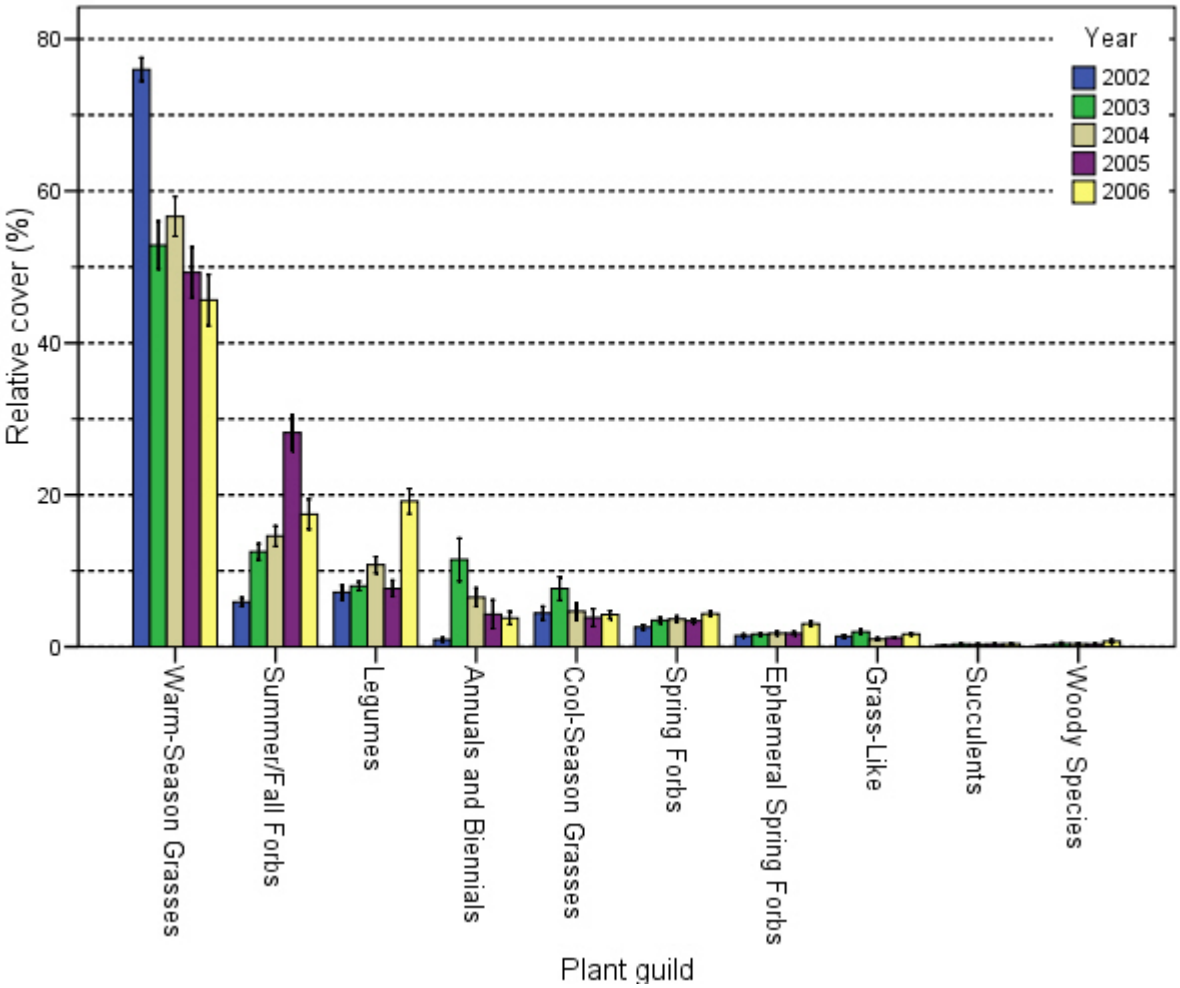

Figure 11. Relative cover of species guilds among sample years. Error bars indicate one standard error of the mean.

Relative cover of grasses as determined from foliar cover estimates was a conservative measure of dominance. Due to morphology and growth habit, grasses found at TAPR did not occupy large foliar space. They achieved high relative cover estimates by having a large number of individuals within and among sites. The converse held for summer and fall forbs. Space not occupied by grasses was typically filled by a few forbs with higher foliar cover. Among sample years, grasses dominated relative cover estimates and thus left little space for other guild species to be present in high cover estimates (Fig. 11). In addition, there was little variability within sample years across all core sites as indicated by the narrow range of standard error of the mean estimates for each guild type.

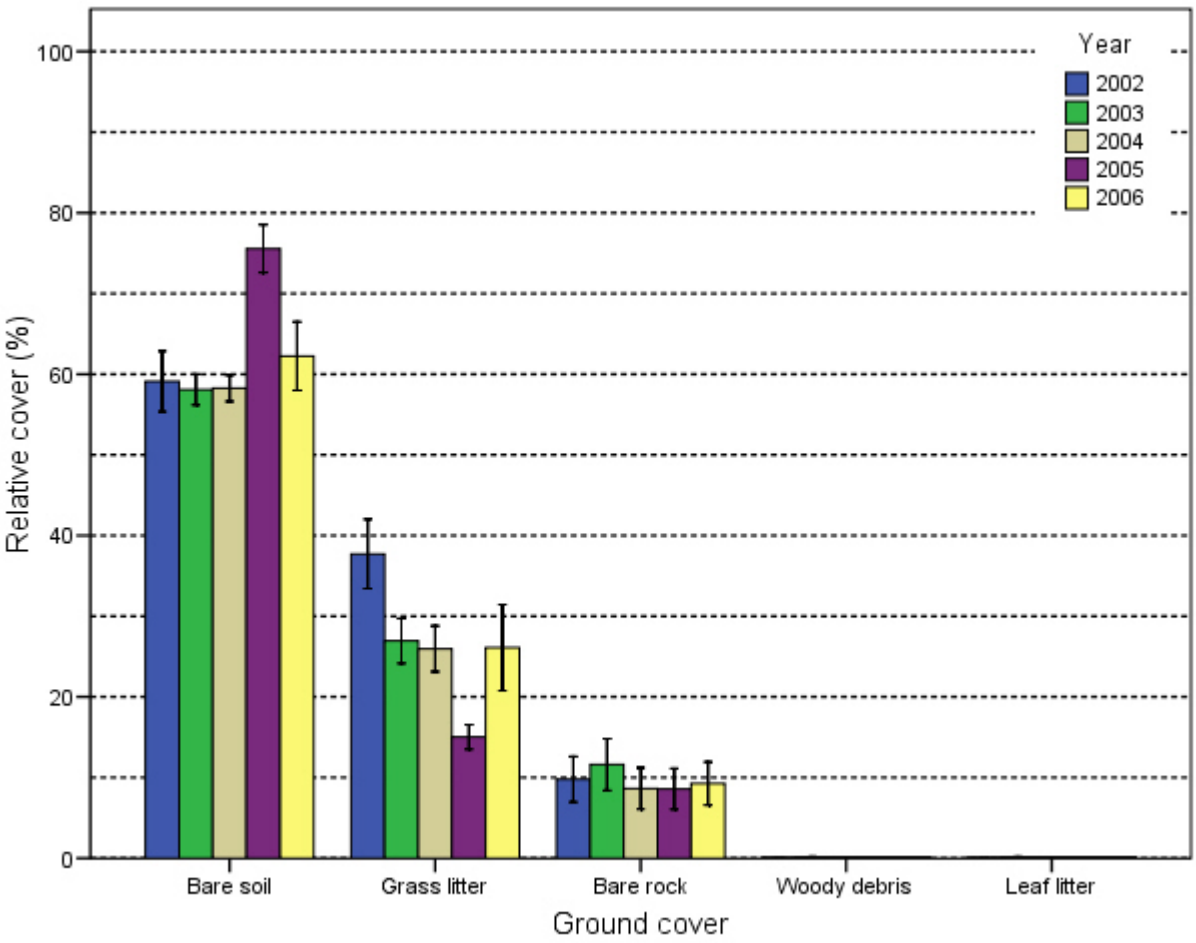

Figure 12. Relative ground cover of core sites among sample years. Error bars indicate one standard error of the mean.

Of the unvegetated areas in the core sites, bare soil was the most dominant (Fig 12). With few woody species among core sites, it followed that there would be only trace amounts of woody debris and leaf litter. Relative cover of bare rock was a function primarily of core sites in soil types composed of exposed rock. Grass litter cover was a function of the prescribed burning regime at the pasture scale.

Invasive species

The preserve was not infested with invasive species. Kentucky bluegrass (*Poa pratensis*) is the only invasive species detected in the core sites and yet it always occurred in less than five percent relative frequency (Fig. 13). No other exotic or invasive species occurred with > 1% relative frequency in all sample years. For a complete analysis of exotic species at the preserve see Young et al. (2007).

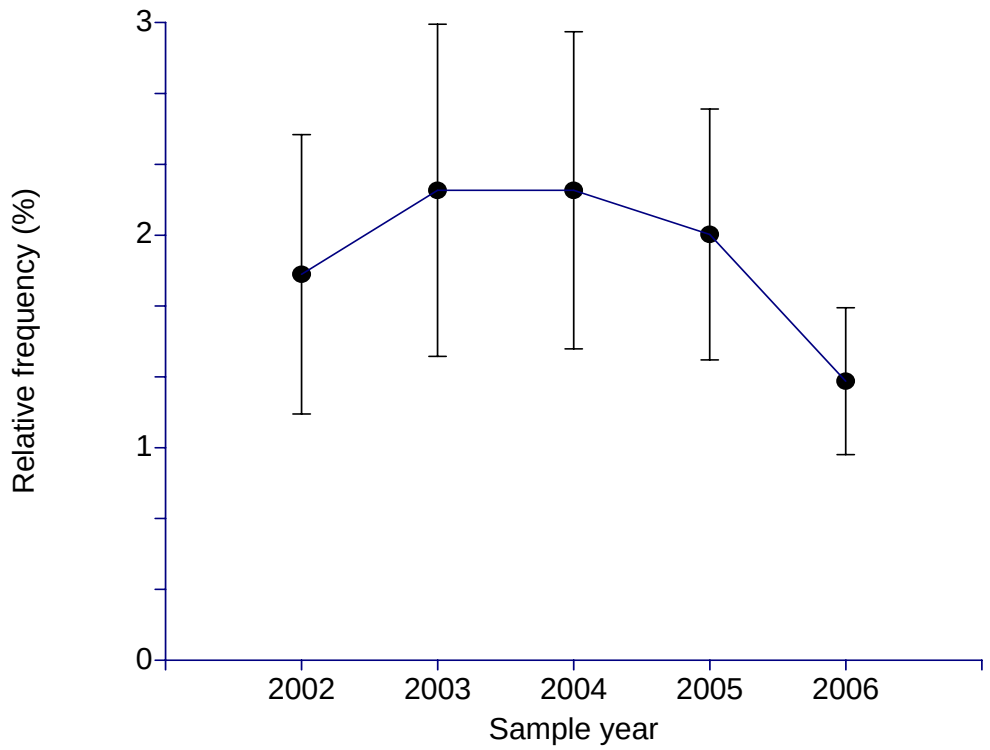

Figure 13. Relative frequency of *Poa pratensis* (mean ± one standard error of the mean).

Vertical structure

The vertical structure of the prairie community at TAPR was a result of past ranching use and continued management actions. Range management practices minimized the vertical structure of vegetation across the preserve (Fig. 14). Nearly all of the vertical structure occurred within 25cm of the soil surface. Vertical profile at core sites was measured in the fall after grazing had ended. The presence of tallgrass growing to heights above one meter were lacking in the core sites across the four pastures of the preserve.

Vertical structure of the plant community at TAPR was most impacted by the management actions of the preserve. The height of warm season grasses was kept nearly at ground level in those areas where grazing occurred. At the preserve scale visible tallgrass structure was absent.

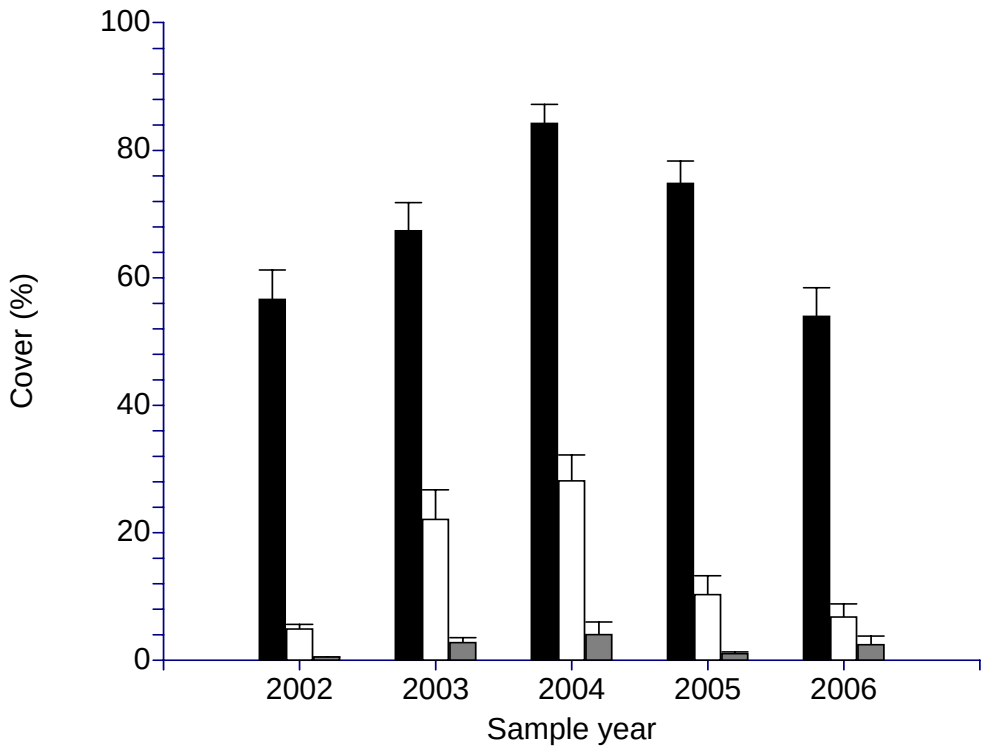

Figure 14. Vegetation profile for core sites (n = 18) observed at 5m. Black bar = 0.25m observation height; white bar = 0.5m observation height; gray bar = 0.75 observation height. Bars and error bars represent mean cover and one standard error of the mean.

Discussion

The tallgrass plant community in the four pastures of the preserve included in this study displayed low species heterogeneity. Based on core site species composition and frequency results, all four pastures represented a single plant community. The managed disturbance regime over the last 20 years had selected for species that were able to persist under early spring burning followed by cattle grazing. Preserve wide management had applied equal selection pressure annually throughout the pastures.

Species diversity was partitioned within sites rather than among sites for all pastures and sample years. That is to say that core sites were more similar than different based on their species richness and diversity. This type of partitioning within a community followed from a disturbance regime with an annual return interval. In a given year between 2002 and 2006, any one of the 18 core sites was representative of the species diversity found at TAPR for that year. Species composition of the community was supported by low beta diversity values, similar site evenness values and effective number of species within and among years. The difference in number of species between Simpson's index and species richness was an indicator of the number of locally rare or unevenly distributed species among sites for each sample year. Effective number of species derived from Shannon's index more closely approximated total species composition within sample year by weighting number of species by their abundance. Sites were similar within

year and the annual variability in species composition or frequency could not be attributed to any single factor or combinations of factors as demonstrated with MRPP analyses.

The four pastures were dominated by a few matrix-forming species that effectively controlled community structure (low D_e counts for the preserve). A large number of less abundant species, referred to as satellite species, contributed to the diversity of TAPR (Collins 1987, Collins and Glenn 1988). Core species were defined as being ubiquitous both spatially and temporally at the preserve scale. These species could be thought of as comprising the matrix-forming species at TAPR (Hanski 1982, Grubb 1986). At the preserve scale, matrix-forming species did not exhibit any variability however at their optimum plot frame size changes in frequency were observed. Core species had different optimum plot frame sizes for detecting changes in frequency, indicating that even though they were always present across the preserve each occurred in varying abundance and fine scale distribution. Satellite species (defined here as the difference in number of species between S and D_e) composition within and among sites across sample years was stochastic. Site, pasture or sample year could not be distinguished based on satellite species composition.

Pastures remained similar based on species composition within sample year regardless of management action. Furthermore, pastures remained similar through time even as their management actions changed. Changes in management actions within pastures and among years between 2002 and 2006 did not produce measurable differences in species cover or frequency that could be used to distinguish sites or pastures. Management maintained the pastures as a single community and did not fragment the community of the preserve. This type of community integrity provided an increased buffer against exotic species.

A characteristic of tallgrass plant communities is vertical structure mainly as a result of tall warm season grasses. The lack of vertical structure in the plant community not only affects the function of the plant community, but also decreases the variability in wildlife habitat in the prairie. The introduction of patch burn grazing management in 2006 was initiated with a goal of returning vertical structure and litter to the plant community and increasing wildlife habitat. In areas where this management is being applied, patches will be burned on a three year cycle which begins to more closely approximate the natural fire return interval. In these areas, grazing will still occur, but differential effects are expected between pastures not subjected to patch burn grazing management. The addition of core sites in the northern pastures prior to the 2006 field season was done to increase monitoring sites in areas of patch burn grazing. Further monitoring is required to determine if patch burn grazing has any impact on species composition or vertical structure at the pasture and preserve scale.

The preserve is a remnant piece of a historically large and varied ecosystem. The level of species richness and diversity reflects past land use, yet the plant community continues to persist with a high degree of integrity. The lack of invasive species as detected in the core sites was encouraging for TAPR. The preserve has the unique and challenging position of being charged with protecting both the cultural and natural history of the landscape. Preserve managers have been successful at balancing management actions with interpretation of the native prairie.

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Appendix

Appendix 1. Native species sampled in TAPR core sites (2002 – 2006) with relative frequency and cover ≥ 0.01 %. Core species are in bold. Mean relative percent frequency (± 1 standard deviation) and mean relative percent cover (± 1 standard deviation) is calculated at the 10m frame size.

Scientific Name	Guild	Optimum frame size	Relative frequency	Relative cover
Acalypha virginica	Annuals and Biennials	10	0.34 (0.25)	0.11 (0.08)
Achillea millefolium	Ephemeral Spring Forbs	10	1.14 (0.71)	0.27 (0.17)
Allium canadense	Spring Forbs	10	0.18 (0.16)	0.04 (0.03)
Alopecurus carolinianus	Cool-Season Grasses	10	0.17 (0.2)	0.04 (0.05)
Ambrosia psilostachya	Summer/Fall Forbs	0.10	3.3 (0.44)	6.81 (3.08)
Amorpha canescens	Legume	1	3.42 (0.41)	6.56 (2.9)
Amphiachyris dracunculoides	Annuals and Biennials	1	1.79 (0.46)	3.19 (4.3)
Andropogon gerardii	Warm-Season Grasses	0.01	3.48 (0.41)	24.42 (9.88)
Androsace occidentalis	Annuals and Biennials	10	0.3 (0.29)	0.09 (0.09)
Anemone caroliniana	Spring Forbs	10	0.17 (0.08)	0.11 (0.19)
Antennaria neglecta	Spring Forbs	10	0.95 (0.89)	0.36 (0.44)
Apocynum cannabinum	Spring Forbs	10	0.08 (0.01)	0.01 (.01)
Aristida oligantha	Warm-Season Grasses	10	0.56 (0.58)	0.18 (0.16)
Artemisia ludoviciana	Summer/Fall Forbs	10	1.24 (0.73)	0.61 (0.67)
Asclepias stenophylla	Summer/Fall Forbs	10	0.18 (0.13)	0.05 (0.04)
Asclepias tuberosa	Spring Forbs	10	0.16	0.03
Asclepias verticillata	Spring Forbs	10	0.82 (0.76)	0.18 (0.17)
Asclepias viridis	Spring Forbs	10	1.72 (0.86)	0.82 (0.85)
Aster ericoides	Summer/Fall Forbs	0.10	3.06 (0.87)	1.91 (1)
Aster oblongifolius	Summer/Fall Forbs	10	0.98 (0.86)	0.66 (1.07)
Aster sericeus	Summer/Fall Forbs	10	1.17 (1.33)	0.44 (0.62)
Astragalus canadensis	Legume	10	0.07	0.02
Astragalus crassicarpus	Legume	10	0.5 (0.45)	0.15 (0.13)
Baptisia australis	Legume	10	0.53 (0.26)	0.19 (0.15)
Baptisia bracteata	Legume	10	0.71 (0.62)	0.76 (0.85)
Bouteloua curtipendula	Warm-Season Grasses	0.01	3.39 (0.39)	6.87 (3.34)
Bouteloua gracilis	Warm-Season Grasses	10	1.11 (0.87)	2.05 (2.96)
Bouteloua hirsuta	Warm-Season Grasses	10	1.67 (1.12)	3.04 (4.2)
Brickellia eupatorioides	Summer/Fall Forbs	10	1.33 (1.03)	0.36 (0.3)
Buchloe dactyloides	Cool-Season Grasses	1	2.33 (0.93)	3.67 (3.81)
Cacalia plantaginea	Summer/Fall Forbs	10	0.45 (0.44)	0.11 (0.12)
Callirhoe alcaeoides	Ephemeral Spring Forbs	10	2.34 (0.81)	0.63 (0.28)
Calylophus serrulatus	Spring Forbs	10	0.07 (0.01)	0.02

Appendix 1. Native species sampled in TAPR core sites (2002 – 2006) with relative frequency and cover ≥ 0.01 %. Core species are in bold. Mean relative percent frequency (± 1 standard deviation) and mean relative percent cover (± 1 standard deviation) is calculated at the 10m frame size. Continued.

Scientific Name	Guild	Optimum frame size	Relative frequency	Relative cover
Carex spp	Grass-Like	0.10	3.31 (0.55)	1.19 (0.42)
Ceanothus spp	Woody Species	10	0.61 (0.5)	0.3 (0.38)
Cerastium brachypodum	Annuals and Biennials	1	0.44	0.13
Chamaesyce prostrata	Annuals and Biennials	10	1.4 (0.46)	0.37 (0.17)
Chloris verticillata	Warm-Season Grasses	10	0.46 (0.45)	0.15 (0.18)
Cirsium undulatum	Summer/Fall Forbs	10	0.88 (0.6)	0.38 (0.41)
Comandra umbellata	Spring Forbs	10	0.07 (0.02)	0.02
Conyza canadensis	Annuals and Biennials	10	0.16 (0.11)	0.04 (0.03)
Corydalis micrantha	Annuals and Biennials	10	0.18 (0.18)	0.05 (0.05)
Croton monanthogynus	Annuals and Biennials	10	0.65 (0.69)	0.3 (0.47)
Cyperus esculentus	Grass-Like	10	0.56 (0.44)	0.13 (0.1)
Dalea aurea	Legume	10	0.11	0.04
Dalea candida	Legume	10	0.36 (0.27)	0.08 (0.07)
Dalea multiflora	Legume	10	0.59 (0.3)	0.44 (0.43)
Dalea purpurea	Legume	10	1.96 (1.06)	0.57 (0.41)
Delphinium carolinianum	Spring Forbs	10	0.26 (0.21)	0.06 (0.05)
Descurainia pinnata	Annuals and Biennials	10	0.15 (0.08)	0.05 (0.03)
Desmanthus illinoensis	Legume	10	0.08	0.02
Desmodium illinoense	Legume	10	0.21	0.06
Dichanthelium spp	Cool-Season Grasses	1	3.19 (0.68)	0.89 (0.31)
Digitaria cognata	Warm-Season Grasses	10	1.23 (0.66)	0.3 (0.16)
Draba brachycarpa	Annuals and Biennials	10	0.09 (0.05)	0.02 (0.01)
Draba cuneifolia	Annuals and Biennials	10	0.26 (0.22)	0.08 (0.08)
Draba reptans	Annuals and Biennials	10	0.41 (0.26)	0.11 (0.08)
Echinacea angustifolia	Summer/Fall Forbs	10	0.92 (0.45)	0.27 (0.14)
Eleocharis spp	Grass-Like	10	0.85 (0.71)	0.21 (0.17)
Elymus canadensis	Cool-Season Grasses	10	0.23 (0.14)	0.05 (0.03)
Eragrostis spectabilis	Warm-Season Grasses	1	2.99 (0.64)	1.08 (0.48)
Erigeron philadelphicus	Ephemeral Spring Forbs	10	0.81 (0.41)	0.19 (0.14)
Erigeron strigosus	Annuals and Biennials	10	0.71 (0.49)	0.21 (0.23)
Erythronium mesochoreum	Ephemeral Spring Forbs	10	0.07	0.02
Escobaria missouriensis	succulent	10	0.28 (0.15)	0.08 (0.06)
Euphorbia spathulata	Annuals and Biennials	10	0.53 (0.46)	0.14 (0.13)
Euthamia gymnospermoides	Summer/Fall Forbs	10	0.96 (1.05)	0.24 (0.21)
Evolvulus nuttallianus	Spring Forbs	10	0.07	0.02

Appendix 1. Native species sampled in TAPR core sites (2002 – 2006) with relative frequency and cover ≥ 0.01 %. Core species are in bold. Mean relative percent frequency (± 1 standard deviation) and mean relative percent cover (± 1 standard deviation) is calculated at the 10m frame size. Continued.

Scientific Name	Guild	Optimum frame size	Relative frequency	Relative cover
Grindelia squarrosa	Annuals and Biennials	10	0.14	0.03
Hedeoma hispidum	Annuals and Biennials	10	0.31 (0.37)	0.09 (0.13)
Hieracium longipilum	Summer/Fall Forbs	10	0.24 (0.26)	0.06 (0.06)
Hordeum pusillum	Cool-Season Grasses	10	0.35 (0.42)	0.09 (0.1)
Hybanthus verticillatus	Ephemeral Spring Forbs	10	0.93 (1.16)	0.4 (0.57)
Hymenopappus scabiosaeus	Spring Forbs	10	0.97 (0.8)	0.41 (0.38)
Juncus spp	Grass-Like	10	0.22 (0.14)	0.05 (0.04)
Koeleria macrantha	Cool-Season Grasses	10	1.08 (1.04)	0.3 (0.32)
Krigia biflora	Spring Forbs	10	0.08	0.02
Krigia cespitosa	Annuals and Biennials	10	0.35 (0.45)	0.08 (0.1)
Lactuca spp	Summer/Fall Forbs	10	0.15	0.03
Lepidium densiflorum	Annuals and Biennials	10	0.9 (0.4)	0.25 (0.16)
Lespedeza capitata	Legume	10	0.9 (0.72)	0.25 (0.21)
Lespedeza violacea	Legume	10	0.55 (0.5)	0.31 (0.49)
Lespedeza virginica	Legume	10	0.06	0.02
Liatris spp - tapr	Summer/Fall Forbs	10	0.26 (0.28)	0.07 (0.07)
Linum sulcatum	Annuals and Biennials	10	1.28 (0.5)	0.32 (0.13)
Lithospermum incisum	Spring Forbs	10	0.28 (0.23)	0.08 (0.05)
Lomatium foeniculaceum	Ephemeral Spring Forbs	10	0.99 (0.67)	0.35 (0.27)
Mirabilis albida	Spring Forbs	10	0.25 (0.18)	0.08 (0.07)
Monarda fistulosa	Summer/Fall Forbs	10	0.26 (0.04)	0.08
Muhlenbergia cuspidata	Warm-Season Grasses	10	0.37 (0.4)	0.13 (0.21)
Myosotis verna	Annuals and Biennials	10	0.29 (0.22)	0.07 (0.05)
Nothoscordum bivalve	Ephemeral Spring Forbs	10	0.98 (1)	0.22 (0.21)
Oenothera biennis	Summer/Fall Forbs	10	0.24 (0.25)	0.06 (0.05)
Oenothera macrocarpa	Spring Forbs	10	0.22 (0.03)	0.07 (0.01)
Oenothera speciosa	Spring Forbs	10	0.41 (0.28)	0.11 (0.1)
Onosmodium molle	Spring Forbs	10	1.03 (0.73)	0.54 (0.59)
Opuntia macrorhiza	succulent	10	0.5 (0.49)	0.25 (0.24)
Oxalis spp	Spring Forbs	10	1.33 (0.71)	0.33 (0.18)
Oxalis violacea	Spring Forbs	10	1.79 (1.17)	0.64 (0.48)
Panicum capillare	Warm-Season Grasses	10	0.37 (0.3)	0.1 (0.08)
Panicum virgatum	Warm-Season Grasses	10	3.18 (0.73)	2.68 (2.8)
Pascopyrum smithii	Cool-Season Grasses	10	0.3 (0.32)	0.07 (0.08)

Appendix 1. Native species sampled in TAPR core sites (2002 – 2006) with relative frequency and cover ≥ 0.01 %. Core species are in bold. Mean relative percent frequency (± 1 standard deviation) and mean relative percent cover (± 1 standard deviation) is calculated at the 10m frame size. Continued.

Scientific Name	Guild	Optimum frame size	Relative frequency	Relative cover
Paspalum laeve	Warm-Season Grasses	10	0.28 (0.36)	0.1 (0.17)
Penstemon cobaea	Ephemeral Spring Forbs	10	0.19	0.06
Physalis heterophylla	Spring Forbs	10	0.18 (0.15)	0.04 (0.03)
Physalis pumila	Spring Forbs	10	0.54 (0.46)	0.17 (0.2)
Physalis virginiana	Spring Forbs	10	0.63 (0.64)	0.14 (0.12)
Plantago patagonica	Annuals and Biennials	10	0.17 (0.12)	0.04 (0.03)
Plantago pusilla	Spring Forbs	10	0.13	0.03
Plantago rhodosperma	Annuals and Biennials	10	1.12 (0.57)	0.3 (0.18)
Psoralea argophylla	Legume	10	0.52	0.10
Psoralea esculenta	Legume	10	0.89 (0.58)	0.25 (0.18)
Psoralidium tenuiflorum	Legume	10	2.11 (1.17)	1.33 (1.48)
Ratibida columnifera	Summer/Fall Forbs	10	0.55 (0.41)	0.15 (0.13)
Ratibida pinnata	Summer/Fall Forbs	10	0.06 (0.01)	0.02
Rhus glabra	Woody Species	10	0.32	0.18
Rosa arkansana	Woody Species	10	0.61 (0.37)	0.13 (0.05)
Ruellia humilis	Summer/Fall Forbs	10	2.87 (1.08)	0.75 (0.28)
Salvia azurea	Summer/Fall Forbs	10	1.87 (0.76)	1.02 (0.93)
Schizachyrium scoparium	Warm-Season Grasses	0.01	3.48 (0.41)	11.14 (4.97)
Schrankia nuttallii	Legume	10	0.81 (0.57)	0.18 (0.14)
Scutellaria parvula	Spring Forbs	10	0.32 (0.36)	0.09 (0.1)
Senecio plattensis	Summer/Fall Forbs	10	0.92 (0.87)	0.25 (0.25)
Senecio riddellii	Summer/Fall Forbs	10	0.14	0.03
Silene antirrhina	Annuals and Biennials	10	0.47 (0.29)	0.13 (0.1)
Silphium laciniatum	Summer/Fall Forbs	10	0.28	0.07
Sisyrinchium campestre	Ephemeral Spring Forbs	10	1.58 (0.72)	0.39 (0.18)
Solanum carolinense	Spring Forbs	10	0.07	0.02
Solidago missouriensis	Summer/Fall Forbs	10	0.89 (0.4)	0.25 (0.12)
Solidago rigida	Summer/Fall Forbs	10	0.35	0.09
Solidago spp	Summer/Fall Forbs	10	0.06	0.02
Sorghastrum nutans	Warm-Season Grasses	1	3.29 (0.46)	2.93 (2.1)
Spermolepis inermis	Annuals and Biennials	10	0.46 (0.42)	0.13 (0.11)
Spiranthes cernua	Summer/Fall Forbs	10	0.35	0.09
Sporobolus asper	Warm-Season Grasses	1	3.25 (0.57)	2.46 (2.13)
Sporobolus neglectus	Warm-Season Grasses	10	0.25 (0.12)	0.08 (0.06)

Appendix 1. Native species sampled in TAPR core sites (2002 – 2006) with relative frequency and cover ≥ 0.01 %. Core species are in bold. Mean relative percent frequency (± 1 standard deviation) and mean relative percent cover (± 1 standard deviation) is calculated at the 10m frame size. Continued.

Scientific Name	Guild	Optimum frame size	Relative frequency	Relative cover
Symphoricarpos orbiculatus	Woody Species	10	0.37 (0.13)	0.1 (0.07)
Tradescantia bracteata	Spring Forbs	10	0.24 (0.18)	0.06 (0.06)
Tradescantia ohiensis	Spring Forbs	10	0.42	0.09
Tridens flavus	Warm-Season Grasses	10	0.21 (0.23)	0.06 (0.06)
Triodanis perfoliata	Annuals and Biennials	10	0.67 (0.46)	0.19 (0.15)
Verbena simplex	Spring Forbs	10	0.09 (0.02)	0.02 (0.01)
Verbena stricta	Spring Forbs	10	0.39 (0.37)	0.1 (0.09)
Vernonia baldwinii	Summer/Fall Forbs	10	2.71 (0.86)	2.04 (1.11)
Veronica peregrina	Annuals and Biennials	10	0.07 (0.01)	0.02
Viola bicolor	Annuals and Biennials	10	0.43 (0.53)	0.11 (0.13)
Viola pedatifida	Spring Forbs	10	1.22 (0.88)	0.28 (0.2)
Viola pratincola	Ephemeral Spring Forbs	10	0.43 (0.26)	0.14 (0.11)
Viola sororia	Spring Forbs	10	0.07 (0.02)	0.02
Viola spp	Ephemeral Spring Forbs	10	0.13	0.04
Vulpia octoflora	Cool-Season Grasses	10	0.26 (0.22)	0.08 (0.06)
Zigadenus nuttallii	Spring Forbs	10	0.65 (0.51)	0.28 (0.16)

The NPS has organized its parks with significant natural resources into 32 networks linked by geography and shared natural resource characteristics. HTLN is composed of 15 National Park Service (NPS) units in eight Midwestern states. These parks contain a wide variety of natural and cultural resources including sites focused on commemorating civil war battlefields, Native American heritage, westward expansion, and our U.S. Presidents. The Network is charged with creating inventories of its species and natural features as well as monitoring trends and issues in order to make sound management decisions. Critical inventories help park managers understand the natural resources in their care while monitoring programs help them understand meaningful change in natural systems and to respond accordingly. The Heartland Network helps to link natural and cultural resources by protecting the habitat of our history.

The I&M program bridges the gap between science and management with a third of its efforts aimed at making information accessible. Each network of parks, such as Heartland, has its own multi-disciplinary team of scientists, support personnel, and seasonal field technicians whose system of online databases and reports make information and research results available to all. Greater efficiency is achieved through shared staff and funding as these core groups of professionals augment work done by individual park staff. Through this type of integration and partnership, network parks are able to accomplish more than a single park could on its own.

The mission of the Heartland Network is to collaboratively develop and conduct scientifically credible inventories and long-term monitoring of park "vital signs" and to distribute this information for use by park staff, partners, and the public, thus enhancing understanding which leads to sound decision making in the preservation of natural resources and cultural history held in trust by the National Park Service.

www.nature.nps.gov/im/units/htln/

Heartland Network

Natural Resource Monitoring

The U.S. Department of the Interior (DOI) is the nation's principal conservation agency, charged with the mission "*to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities."* More specifically, Interior protects America's treasures for future generations, provides access to our nation's natural and cultural heritage, offers recreation opportunities, honors its trust responsibilities to American Indians and Alaska Natives and its responsibilities to island communities, conducts scientific research, provides wise stewardship of energy and mineral resources, fosters sound use of land and water resources, and conserves and protects fish and wildlife. The work that we do affects the lives of millions of people; from the family taking a vacation in one of our national parks to the children studying in one of our Indian schools.

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