**National Park Service**
**U.S. Department of the Interior**

**Natural Resource Program Center**

# Evaluation of fire effects and restoration progress through 21 years of prairie vegetation monitoring at Herbert Hoover National Historic Site, 1982-2005

Natural Resource Technical Report NPS/HTLN/NRTR—2007/052

**ON THE COVER**
Prescribed fire in the prairie at Herbert Hoover National Historic Site in spring 2005.
(Photograph courtesy of Herbert Hoover National Historic Site)

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# Executive Summary

Herbert Hoover National Historic Site (HEHO) was established in 1965 “to preserve …properties associated with the life of Herbert Hoover our 31st president” (HEHO GMP 2004). In 1971, tallgrass prairie reconstruction was undertaken to complement the preservation of cultural resources and to provide a quiet setting for the contemplation of Mr. Hoover’s life as well as an educational opportunity. Beginning in 1982, annual plant inventories were conducted by Dr. Paul Christiansen, a local plant ecologist. The monitoring data was used to develop annual management recommendations to park staff. As a result, a prescribed fire plan and several additional plantings were initiated. After 21 years of monitoring, however, Dr. Christiansen had not published a report on the status and long-term trends of the prairie restoration and no plans were in place for continued long-term monitoring. In 2004, the Heartland I&M Network and Prairie Cluster Prototype Monitoring Program (HTLN) was requested to both provide for long-term monitoring and analyze the wealth of existing data in light of HEHO management goals. In addition to interpreting patterns directly related to management goals, we looked for relationships with the use of prescribed fire. Through this analysis we aimed to understand patterns in the prairie reconstruction during the Christiansen era to provide context for the results of future monitoring.

Management staff at Herbert Hoover National Historic Site believed that for the prairie to provide a serene setting appropriate for the park, it must closely resemble a native prairie in species composition. Specifically, the prairie should be diverse (Shannon diversity index greater than 2.63), include appropriate abundances of species guilds, and have less than 8% relative cover of exotic species. Finally, prescribed fire was eventually accepted as an ecologically appropriate tool to accomplish these goals.

We used these HEHO prairie management goals as a foundation for completing a long-term analysis of the reconstruction’s progress (1982-2005). Observing natural phenomena at multiple scales can often elucidate patterns. Therefore, we analyzed data on the specific management goals as well as the relationship with fire at three scales: park, management unit, and transect. Here we found that the transect scale helped to provide insight into management goals at the park scale.

Over the period of monitoring (1982-2005), the prairie reconstruction developed from a grass dominated planting to a diverse community with 203 species. Although species diversity was below the stated goal of 2.63 in 2005, the total number of species detected annually more than doubled. Average relative cover of summer and fall forbs increased by 7–fold while grasses declined. Spring forbs remained a small component of the restoration; average abundance was 4.8% in 2005. Interestingly, the proportion of woody species remained low and stable. Exotic species encompassed 19-33% of the total number of species found during the 21 years of inventories. Although average relative cover of exotic plants was only 2% in 1992, it had increased by an order of magnitude by 2005.

The effect of prescribed fire on the community was not clear at the two larger spatial scales. At the transect scale, we were able to discern some local trends. In general, as time since the last fire

increased, species richness (total and exotic species) tended to decrease. Efforts to eradicate Canada thistle and augment the original planting supported positive development of the prairie community, but may have overshadowed the effect of fire in the data.

Use of prescribed fire has restored ecological processes needed for proper functioning of the prairie and maintained woody species at low levels. One potentially helpful modification to the fire plan may be varying the season of burn. The effect of season of burn on exotic species in each management unit should be carefully considered, however.

Examining Dr. Christiansen's legacy data has provided a foundation for continued long-term analysis of the reconstructed prairie at HEHO. In this report, we describe management and monitoring of the reconstructed prairie limited to Dr. Christiansen's permanent transects. These data, incorporated into an existing HTLN data management system, will be available for making comparisons to data generated within the newly installed HTLN sites. Separate reports will describe comparisons of the two data sets. It is the goal of this report and the HTLN's long-term ecological monitoring to provide park resource managers continued feedback on effective plant community monitoring to assess management strategies in maintaining or restoring prairie community composition, structure, and diversity.

## Acknowledgements

Special thanks are extended to the late Dr. Paul Christiansen for devoting his career to prairie plant ecology and for providing extensive botanical expertise in prairie management at Herbert Hoover National Historic Site. Dr. Christiansen's influence lives on in restored and reconstructed prairies throughout Iowa. His legacy includes not only a wealth of data and a better understanding of the tallgrass prairie plant community, but also the numerous colleagues and students that increased their appreciation for and fluency with this unique plant community because of his work. Additional thanks to Sherry Middlemis-Brown and those before her who have through their hard work and dedicated efforts provided a prairie oasis in the midst of urban and agricultural development. The Heartland I&M Network and Prairie Cluster Prototype Monitoring Program provided assistance to continue the prairie-monitoring legacy of Dr. Christiansen. The National Park Service Midwest Regional Fire Program and Herbert Hoover NHS (project identification PMIS 109693) provided funding for this project.

# Introduction

The Herbert Hoover Birthplace Foundation deeded 28 acres of a privately developed park to the federal government in 1964. Congress established Herbert Hoover National Historic Site (hereafter, HEHO) (Public Law 89-119, 79 Stat. 510) in West Branch, IA on August 12, 1965 "to preserve in public ownership historically significant properties associated with the life of Herbert Hoover our 31st president" (HEHO GMP 2004). This same legislation authorized transfer of all federal lands to the National Park Service (NPS) with the exception of the Herbert Hoover Library Museum. The land encompassing the prairie was sold to the park service by Dairy Industry Company, a subsidiary of the Iowa Development Corporation, in 1969. Prairie restoration began on abandoned row-cropped agricultural fields in 1971. In 1972, (omnibus act P.L. 92-272, 86 Stat. 120), Congress authorized further development and land-acquisition, resulting in the site expanding to 75.3 ha (186 ac; Figure 1).

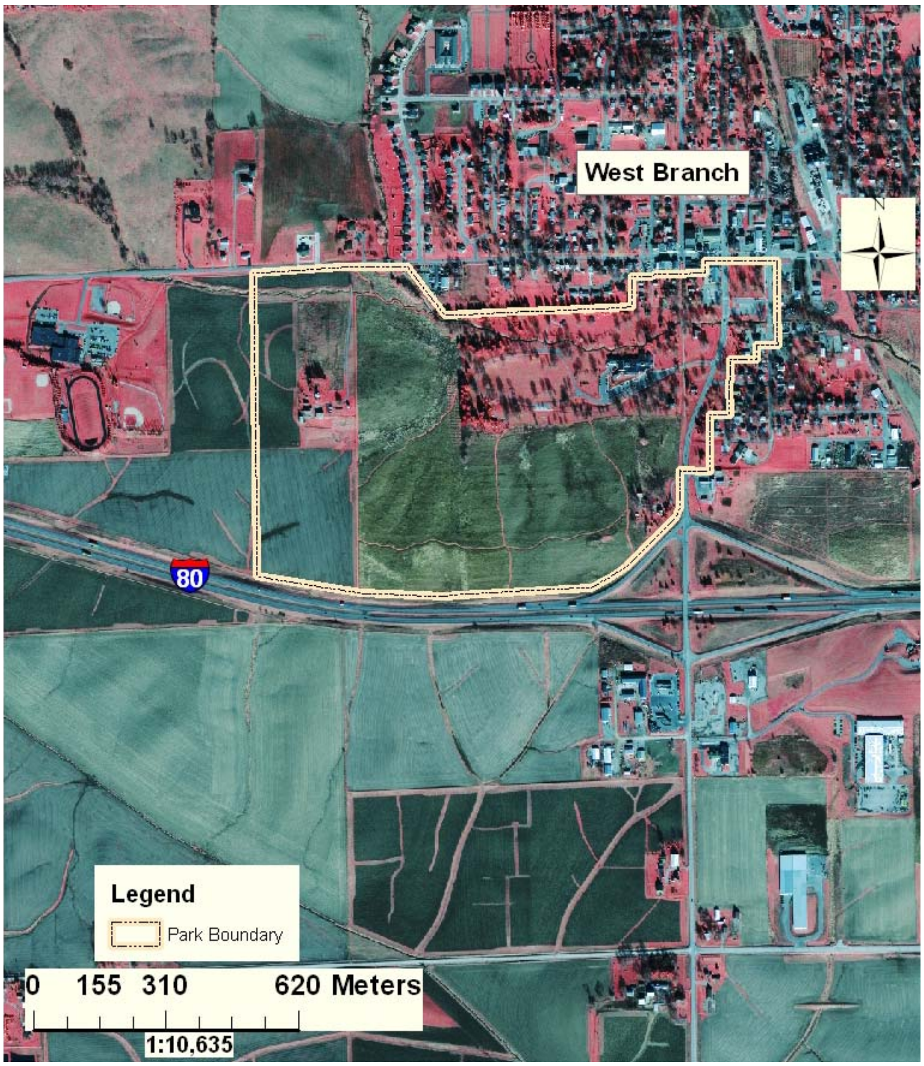



Figure 1. Location of Herbert Hoover NHS, Cedar County, Iowa. The park is imbedded in West Branch to the north and east and bordered by interstate 80 to the south.

Prairie once covered up to 80% of Iowa including the park and surrounding environs (Smith 1998). Management actions that supported the reconstructed prairie have provided a positive benefit to park cultural and natural resources. Touring the prairie allows interpreters to educate visitors on the vast landscape of grassland that once covered the Midwest and Great Plains regions. Visitors also better imagine the daily lives of families in rural Iowa during the 1800s as they walk through the prairie. Additionally, the prairie stabilizes the soil matrix and eliminates the erosion that characterized the land prior to NPS acquisition. Most importantly, the beauty and peace of the prairie provides an appropriate backdrop for those contemplating the life of Mr. Hoover (National Park Service 2003).

Management of the prairie focuses on maintaining these attributes as well as providing a land cover that complements adjacent land use, both inside and outside the park. Management plans written to support these goals for the reconstructed tallgrass prairie (32.8 ha, 81 ac) have adapted along with the maturation of the prairie through time. Dr. Paul Christiansen, a local plant ecologist, was consulted about the development of the prairie in the early 1980s (Christiansen 1982, Robinson circa 1985). Christiansen installed transects for annual plant inventories which he used to inform park staff about management needs (Christiansen annual reports 1982-2005). The inclusion of prescribed fire, additional plantings, and exotic species control were undertaken with his advice.

In an effort to plan for continued long-term monitoring and provide feedback to managers, HEHO collaborated with the National Park Service (NPS) Inventory and Monitoring (I&M) Program (NPS Management Policies 1988). The Heartland Network (HTLN) then began working with management staff to identify monitoring and information needs. Native plant diversity, dominance of grasses, woody plant encroachment, and presence of exotic species were identified as key components to monitor that would provide information critical to maintaining the integrity of the prairie and park mission (National Park Service 2003, Middlemis-Brown 2007).

Ecosystem processes and management actions take place at different spatial scales (Turner 1989, Turner et. al. 2001). For example, movement of water through the soil is measured at a different scale than individual plant use of soil water. Management recommendations, such as prescribed fire, are determined for individual units (prairie management units), but can be applied over several or all of the units in any given year. As part of this analysis we present information at multiple scales to provide a picture of change at the park scale, the management unit scale, and locally at the transect scale.

In this report, we first describe HEHO prairie history of management and monitoring to put the results in context. Data summaries and analysis were limited to Dr. Christiansen's permanent transects (1982-2005). We chose to analyze the data at three spatial scales in order to better understand patterns of change in the prairie plant community. The goals of this study were to 1) preserve the long-term dataset by entering the Christiansen legacy data into an electronic media compatible with HTLN's current monitoring system, 2) analyze the dataset for patterns in species richness, diversity, dominance of plant guilds, and exotic species, and to 3) determine what role prescribed fire played in shaping the prairie. The results of this study will be used as a foundation to formulate future monitoring efforts by the HTLN.

## Prairie Management History

Management efforts for the prairie reconstruction have adapted as the prairie itself has changed. During the first 10 years of the prairie reconstruction, management included forb seed additions, rotational mowing with hay removal, and chemical treatment of Canada thistle. Ineffectual initial efforts to enhance the prairie composition and control invasive species prompted neighbors to express concern over the growing problem with Canada thistle (National Park Service, Herbert Hoover NHS, per. com. Sherry Middlemis-Brown July 2007). Management of the prairie reconstruction became more intense once monitoring efforts were in place (Table 1). Resulting management included additional native plants and seed plantings (Figure 2), initiation of a prescribed fire plan (Appendix A), and increased exotic species treatments including the release of stem gall flies (Table 1).

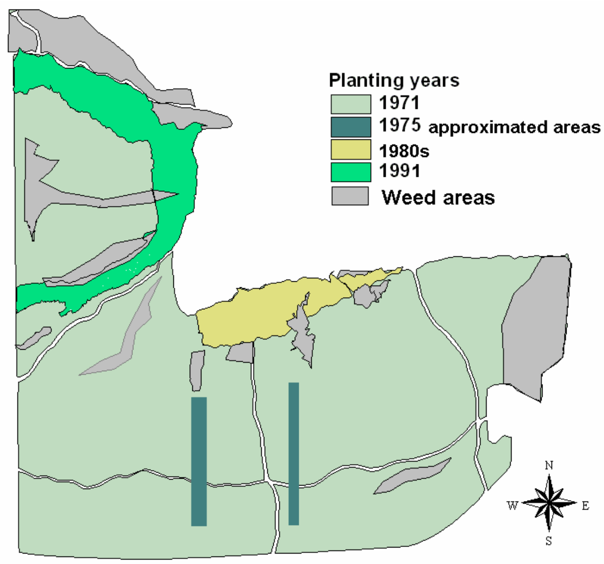



Figure 2. Areas seeded with native prairie plants at Herbert Hoover NHS. (Adapted from HEHO Prairie Management Plan 2003)

The prairie was originally seeded in 1971 with a mix of five species of native grasses (big bluestem (*Andropogon gerardii)*, switchgrass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), and side-oats grama (*Bouteloua curtipendula*) from an Illinois source (Henry 1977). The following year, 1972, the planting was mowed and then burned (Landers 1975). Subsequent seed and plug additions in 1976, 1978, 1983, 1984, and 1990-1994 included native forbs and Canada wild rye (*Elymus canadensis*). Roger Landers, a regional grassland specialist, identified Canada thistle (*Cirsium arvense*) in the prairie and eradication efforts began in 1977 (Henry 1977). Rotational mowing with hay removal was used from 1977 to 1982 as an alternative to prescribed fire (Henry 1977, Anonymous 1985).

In 1984, a group of consultants (Paul Christiansen, Bill Wilcox, Jeff Joens, Bob Dayton, Ben Holmes, and Gary Willson) agreed that mowing was not producing the desired results and that burning the prairie should be considered for forb enhancement and woody and exotic species control (Robinson circa1985). Rotational mowing was replaced with a burn program in 1984. All units of the prairie were burned at least once in 1984 and 1985, but another four years passed before fire was used again. Two aggressive series of burn treatments occurred in the 1990s

## Herbert Hoover NHS: Grassland Management Timeline

| Year | Park | Fire | Other | Christiansen | Heartland | Landers |
|---|---|---|---|---|---|---|
| | Infrastructure | Management Actions | Management Actions | Monitoring Actions | Monitoring Actions | Monitoring Actions |
| 05 | | Burn 1, 2, 3, 4, 7 | | | Add 2 plots = 6 | |
| 04 | | Burn 1, 5, 6, 7 | | Survey | Establish 4 plots and sample | |
| 03 | | | Forb plots stopped | | | |
| 02 | | Burn 1, 2, 5, 6 | | | | |
| 01 | New burn units | Burn 3, 4, 7 | | | | |
| 00 | Nut Grove planted | Burn 1, 3, 5, 6 | | Plot 11, 14 disturbed | | |
| 99 | | Burn 2, 4, 6 | | Survey, recover plot 8 | | |
| 98 | | | | | | |
| 97 | Savannah constructed | | Outplant from forb plots | Survey | | |
| 96 | | | | | | |
| 95 | | | | | | |
| 94 | | Burn 1 | Forb seeding? | Survey, add plots 13, 14 | | |
| 93 | | Burn 1, 3 | | Survey | | |
| 92 | | Burn 2, 4, 6 | Forb seeding? | Plot 8 lost, Add plots 11,12 | | |
| 91 | New burn units | Burn 1, 2, 3, 5 | Forb seeding | Survey | | |
| 90 | New burn units | Burn 1, 2, 4, 5 | Forb seeding | Survey, lot 9 lost | | |
| 89 | | | Sampled forb plot 1, 2 | Survey | | |
| 88 | | | Sampled forb plot 1 | | | |
| 87 | | | | Thistle ↓ natives ↑ | | |
| 86 | | | | No survey | | |
| 85 | | Burn 1, 2, 3, 5 | Thistle /woody treatment | Survey | | |
| 84 | Establish Burn units | Burn 1, 2, 3, 4 | Seeded 31 acres | Replace 4 plots +5 new ones | | |
| 83 | | | Seeded nursery | No survey | | |
| /82 | | | Herbicide and gall flies used | Begin sampling (5 plots and 5 walking transects | | |
| 78 | | | Mow, forb plugs | | | Nursery planted |
| 77 | | | Rotational mowing begun | | | Install 40 forb addition plots |
| 76 | | Small wildfire | Sunflowers seeded | | | |
| 75 | | | | | | NPS report |
| 74 | | | Mow NW | | | Thistle sighted |
| 73 | | | | | | |
| 72 | | Burn | | | | |
| /71 | | | Seed grasses, mow | | | |
| 1965 | NHS established | | | | | |

Table 1. Timeline for development of the prairie reconstruction at Herbert Hoover NHS (HEHO). Park infrastructure, management actions, and monitoring by R. Landers, P. Christiansen, and the HTLN played a role in guiding future management actions. Numbers following fire events indicate prairie management unit designations.

(Table 1). Attempts have been made in recent years to engage in an aggressive fire schedule targeting exotic species, but these attempts have not been successful because of environmental conditions that were outside of prescription. Once the current exotic species are under control, managers plan to continue prescribed fire as a maintenance technique on a 3-year fire return interval (Appendix A).

### Prairie Monitoring History

Roger Landers installed the first research plots at HEHO in 1975 to test establishment rates of forbs. Sunflowers (*Helianthus* spp., *H. laetiflorus*), bergamot (*Monarda fistulosa*), and others were planted along two transects (Table 1, Appendix B). These forb plots were revisited at various points in the reconstruction history (Landers 1975, 1977, Christiansen 1988, 1989, 1996). Seeds from the forbs in these transects were also distributed by staff throughout the reconstruction.

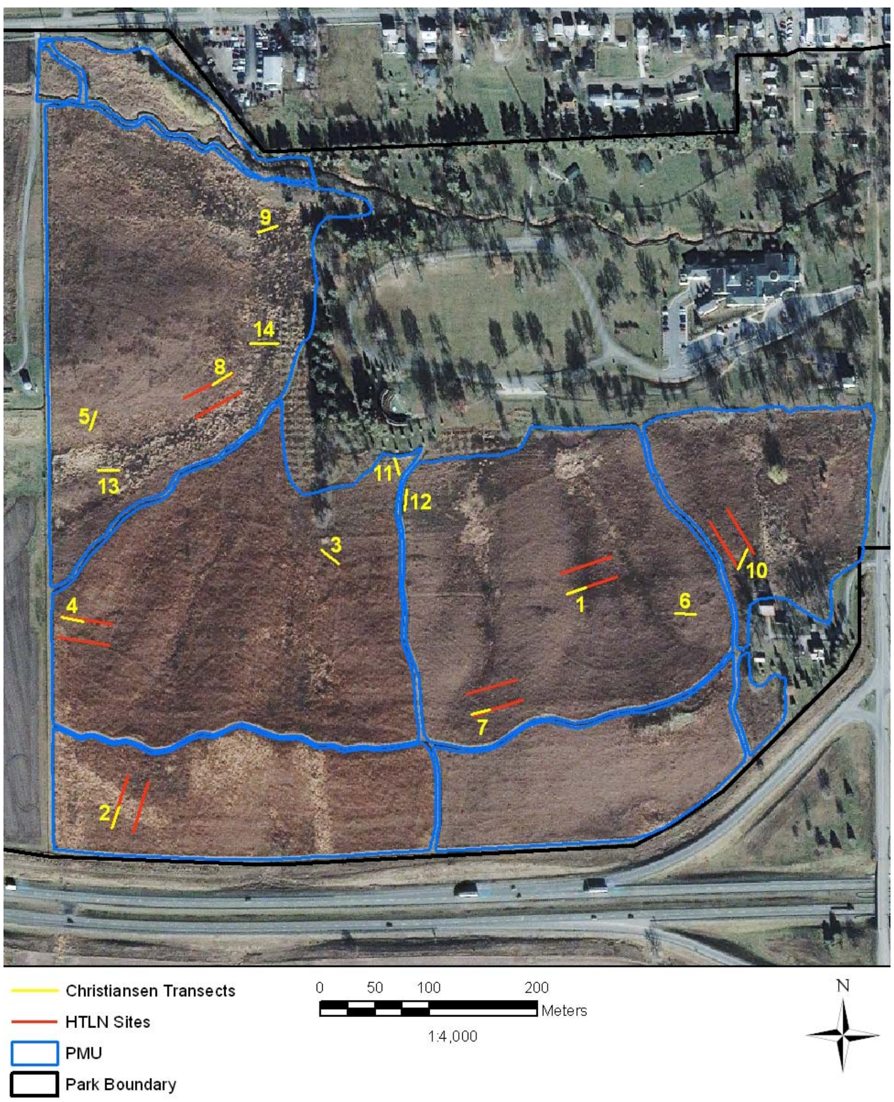



Figure 3. Monitoring locations in the prairie reconstruction at Herbert Hoover NHS.

Dr. Christiansen was consulted in 1982 to inventory and monitor the prairie. He installed five permanent transects and five "walking" transects in 1982 as part of an annual monitoring plan. Only two (1983, 1986) of the 23 years went unsampled. In 1984, several permanent transect markers were lost, so these four permanent transects were reinstalled and five new permanent transects were established to total 10 permanent transects plus five walking transects (Figure 3). In both 1990 and 1992, one transect was lost. In 1992, two additional transects were established in a newly seeded area. Two transects were also disturbed by park developments in 2000 (Table 1). Additional monitoring techniques were used to supplement the permanent transects during the 23-year period (Appendix B).

Christiansen's annual reports to the park assisted management staff to adapt plans to improve the reconstruction. In 2004, the HTLN made plans to continue the long-term monitoring legacy in Dr. Christiansen's anticipated absence. The HTLN's standard monitoring sites were overlaid on four of the original transects along with installation of two new plot locations for a total of six long-term monitoring plots (Table 1). Both the Christiansen transects and HTLN sites were monitored in 2004 and 2005.

# Methods

## Study Area

Herbert Hoover NHS (75.6 ha/186.8 ac) is located in east-central Iowa within the town of West Branch and adjacent to Interstate-80 (Figure 1). The park includes cultural resources such as the cottage where Mr. Hoover was born, the Quaker meeting house, replica blacksmith shop, gravesite, and Presidential Library-Museum as well as the reconstructed prairie.

The park is within the Southern-Iowa Drift Plain, where glacial drainages cut a pattern of abruptly rolling countryside. The landscape of the region was dominated by tallgrass prairie prior to European settlement (Smith 1998). Erosion and fracturing are constant problems in these friable clay-loess (Tama-Downs) soils. Young streams, not existing 150 years ago, have cut paths through areas that were once wetlands and seeps and are very susceptible to flash flooding or desiccation (Boetsch et. al. 2000). The mean annual temperature is 10.1°C (50.2 °F; NOAA 2007). During the period of monitoring total annual precipitation varied from 20.8 cm (8.2 in) to 159.8 (62.9 in) with an overall average annual precipitation of 89.7 cm. (35.3 in) (Figure 4, National Park Service 2007).

Current land cover in eastern Iowa differs greatly from that of presettlement times or even during Mr. Hoover's lifetime. The area of the park now restored to tallgrass prairie was farmed for approximately 100 years prior to the reconstruction and the local land use outside the park is dominated currently by row-crop agriculture (Anonymous 1994). Runoff to streams that flow through adjacent crop fields before entering HEHO may be a source of invasive plant seeds to the park. Primary exotic plant threats have included Canada thistle (*Cirsium arvense*), fescue (*Festuca* spp.), Kentucky bluegrass (*Poa pratensis*), reed canarygrass (*Phalaris arundinacea*), and smooth brome grass (*Bromus inermis*).

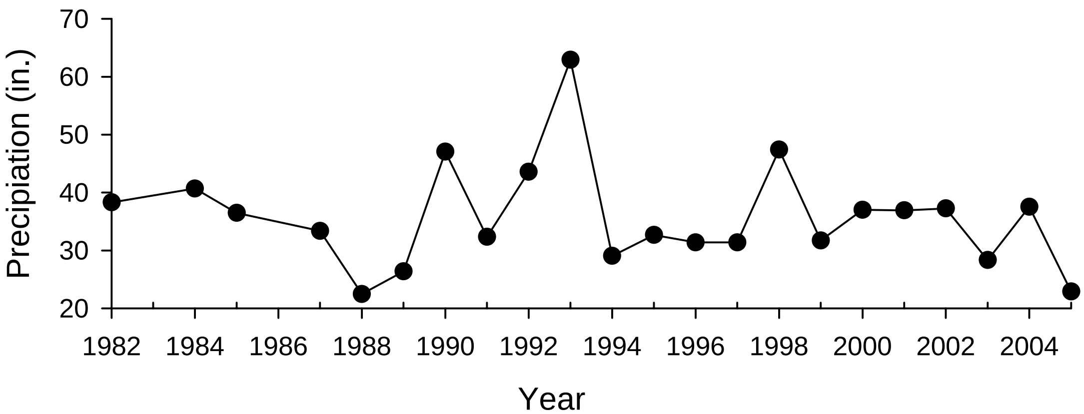


Figure 4. Total annual precipitation for West Branch Iowa during the period of monitoring.

## Monitoring

### *Christiansen permanent transects*

The first prairie inventory was conducted in late August 1982. Five permanent transects, marked with steel posts, were selected to include representative conditions in proportion to occurrence within the prairie. The 20-m long transects were sampled in August with 20-20 x 50-cm quadrats (3/8 in steel frame). Samples were taken at 1-m intervals along the left side of each transect line with the short side of the quadrat placed between 0.8 and 1.0 m. All species were identified and abundance was recorded using the following cover classes: 1 (0-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-95%), and 6 (95-100%) (Daubenmire 1959, Christiansen 1982). Nomenclature followed Gleason and Cronquist (1963), Pohl (1966), and Eilers and Roosa (1994). Transects were sampled annually through 2005 except for 1983 and 1986. Additional transects were installed in 1984, 1991, and 1994 (Table 1) until 14 transects had been designated.

### *Heartland Network*

Because of the extensive monitoring by Dr. Christiansen, the decision was made to crosswalk the standardized sampling design of the Heartland Network with Dr. Christiansen's permanent transects (Sasseen 2005). Four sample sites were overlaid on four of Dr. Christiansen's permanent transects (transects numbered 1, 2, 7 and 8) in 2004. Two additional transects were added at previously unsampled locations. Capped rebar was installed at each end of all Heartland transects for identification. A Trimble XT GPS receiver was used to collect spatial data for the newly established plots as well as all of Dr. Christiansen's permanent transects (Appendix C).

The Heartland monitoring design includes two 50-m transects spaced 20 m apart sampled with five sets of nested circular quadrats systematically spaced along each transect. Four of these longer transects include the 20-m Christiansen transects. Plots were established and sampled beginning August 9, 2004 using the Heartland Network vegetation community monitoring sample design (DeBacker et. al. 2004).

## Data Management

Christiansen field data, spatial, vegetation, and other ancillary data were entered into a MicrosoftAccess database similar to the format used for the long-term monitoring data of the

HTLN. A detailed description of the data management process and components can be found in Appendix C.

## Data Analysis

Analyses were developed around management goals stated in the parks draft Resource Stewardship Strategy (HEHO RSS 2007). The plan recommends that the prairie should closely resemble a native prairie in that it should be diverse (Shannon diversity index greater than 2.63), include appropriate abundances of species guilds, and have less than 8% relative cover of exotic species. We tested whether park goals were achieved for diversity and exotic species as well as some related descriptive variables. We also included analysis of fire management because of its important role in shaping the reconstruction.

### *Indices*

Observing phenomena at multiple scales can enhance understanding of ecological processes (Wiens 1973, Turner 1989). Management and monitoring efforts also occurred on various spatial scales throughout the life of the reconstruction, for example prescribed fires occur at the management unit scale, and exotic species treatments often occurred at smaller scales. Thus, we calculated critical indices at the park scale, prairie management unit scale (PMU), and transect scale. Management unit delineations have changed four times during the prairie's history, and assignment of PMUs was based on the most recent configuration of units (2000-present). Further delineation would have required independent analyses for each time series and that was not practical for this dataset. For each scale we calculated (1) species relative cover (relative cover of guilds also applied this formula), (2) species relative frequency, (3) species importance value (4) diversity, (5) evenness, and (6) species richness.

(1) Relative cover species X = $\text{cover}_{\text{speciesX}} * (\Sigma\, \text{cover}_{\text{all species}})^{-1}$

(2) Relative frequency species X = $\text{occurrences}_{\text{speciesX}} * (\Sigma\, \text{occurrences}_{\text{all species}})^{-1}$

(3) Species importance value (IV) = (relative cover + relative frequency)/2)*100

The importance value gives an overall estimate of the influence or importance of a plant species in the community.

(4) Shannon's Diversity Index (H") = $-\sum_{i=1}^{n} p_i \ln(p_i)$

Plant diversity for each sample unit in a study unit is calculated using Shannon Diversity Index where p*i* is the relative cover of species *i* (Shannon 1949).

(5) Species Distribution Index (J') = $= H' / H_{max}$,

Species distribution evenness is calculated by sample unit using Pielou (J) where H' is the Shannon Diversity Index and $H_{max}$ is the maximum possible diversity for a given number of species if all species are 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).

6)  Species richness (S) is determined as the total number of plant taxa recorded per unit or richness of only exotic species. Total species richness along with exotic species richness provides a more complete picture of the changing numbers of native and exotic plant groups.

Prairie plant guilds are composed of species with significant overlap in niche requirements, and that occupy similar positions along a resource gradient (Root 1967, Kindscher and Wells 1995). Information about guilds is useful for interpreting the type and quality of prairie as well as detecting compositional shifts among guilds that might result from management. Average relative abundance using cover was calculated on the basis of 10 guilds: (1) warm-season grasses, (2) cool-season grasses, (3) annuals and biennials, (4) ephemeral spring forbs, (5) spring forbs, (6) summer/fall forbs, (7) legumes, (8) ferns, and (9) woody species (shrubs) and (10) grass-like species (sedges, rushes, lilies, orchids ect.).

Exotic species form a different type of species guild. Exotic species can influence ecological processes including trophic level relationships, interspecific competition, primary and secondary succession, nutrient cycling, ecosystem productivity, diversity, and stability (Bratton 1982). Mean exotic ratio, mean relative frequency, mean relative cover of exotic species, and respective standard deviations were calculated from sample unit estimates annually.

### *Statistical Analyses*

One-way ANOVA (t statistic) was used to determine whether single indices varied significantly through time at the park scale (SPSS 2006). Once park scale relationships were determined, we calculated relationships at finer scales to elucidate park scale trends (F statistic). Regression was used to discern the relationship of species richness, exotic species richness, and diversity with time since burn (SAS Institute Inc. 2001, Kutner et. al. 2005). Nonlinear relationships were demonstrated in a restoration study of seed additions and burning (Suding and Gross 2006), so we first evaluated linear relationships (alpha $< 0.05$), and if none was found nonlinear trends were evaluated. Autocorrelation through time was assessed using a Durbin Watson test with the AUTOREG procedure (SAS Institute Inc. 2001). No transformation was needed prior to calculating statistical tests. We acknowledge that by conducting simultaneous simple multiple regressions (transect scale) we may have changed the probability for Type I error. Transect scale analyses were used to understand the influence of variation within transects at the park scale. Treatment histories at the transect scale could then be applied to understand patterns in the data. Precipitation was considered as an independent variable which might affect indices like species richness and diversity. Preliminary analysis did not yield any helpful information so further descriptions of those tests are not included within this report.

Time (number of years) since the last burn (TSB) was calculated for park and transect scales to understand the relationship of fire as a management technique. For the park scale, TSB was calculated when a burn was conducted anywhere in the park. A value of 0 was entered for an observational unit in the year it was burned; subsequent years were cumulative. For example, a spring burn occurred in 1984 and sampling was conducted that summer. A value of 0 TSB represents the conditions for 1984. If no burns were conducted the following year, TSB = 1 but if a burn was conducted TSB again equals 0. For the transect scale, TSB was calculated by matching the management units where fire was recorded with transect locations. Although the first fire at HEHO was in 1972, 1985 was used as the starting point for TSB analyses since the prairie had been burned in entirety by 1985. Because transects were installed at different times newer transects had larger TSB values and beginning the TSB calculation with 1985 provided a common starting point. We had insufficient data to calculate the effect of other types of management such as exotic species treatments or mechanical woody control.

# Results

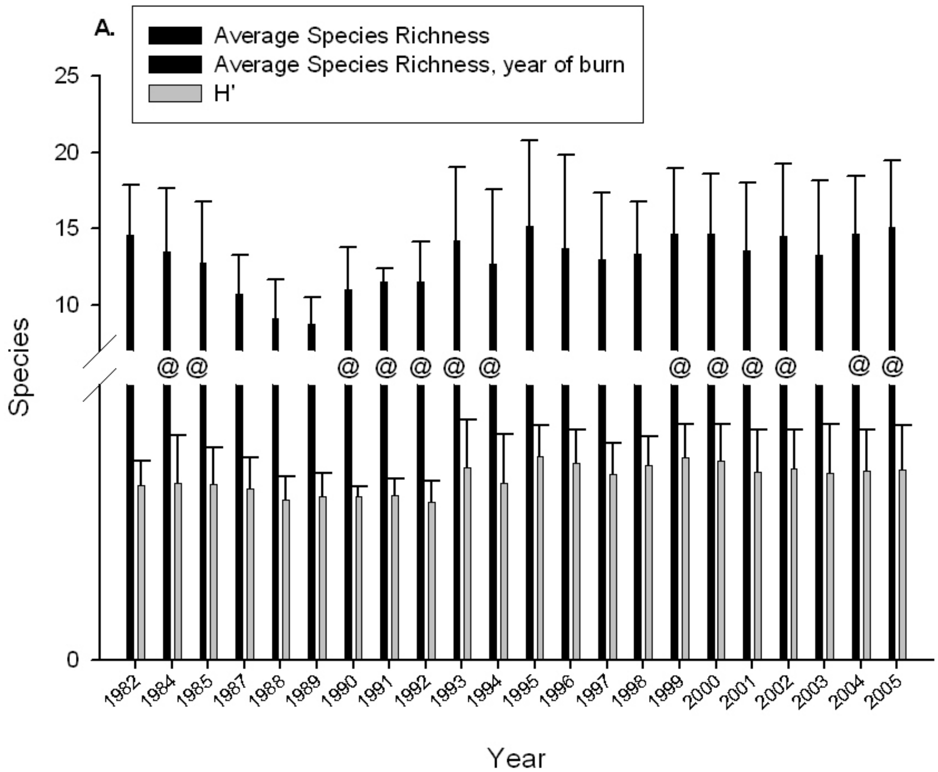
## Richness and diversity

Community indices such as species richness, diversity, and evenness can provide insight into the development of a grassland reconstruction. Over the period of 23 years, Dr. Christiansen recorded 203 plant species with 170 occurring in the permanent 20-m transects (Appendix D). Sixty-seven percent of the species were native and include common species (i.e., at least 30% occurrence among transects) such as the warm season grasses and ubiquitous forbs (Table 2). Among the ten most common plants based on importance values, four were exotic (Table 2).

Table 2. Top ten species with mean importance values > 2% (*indicates exotic species).

| Scientific Name | Common Name | IV (%) |
|---|---|---|
| *Andropogon gerardii* | Big bluestem | 8.33 |
| *Solidago canadensis* | Common goldenrod | 7.15 |
| *Panicum virgatum* | Switchgrass | 6.29 |
| *Sorghastrum nutans* | Indian grass | 6.21 |
| *Poa pratensis** | Kentucky bluegrass | 4.74 |
| *Cirsium arvense** | Canada thistle | 3.12 |
| *Senecio plattensis* | Platte groundsel | 3.08 |
| *Setaria spp ** | Foxtail | 3.00 |
| *Setaria faberi** | Nodding or giant foxtail-grass | 2.99 |
| *Lactuca canadensis* | Tall lettuce | 2.34 |

Community indices were calculated to evaluate the reconstruction status through time. Total species richness (S) and diversity (H') have varied significantly through time ($p < 0.01$, df = 21, t = 19.73, and $p < 0.01$, df = 21, t = 39.61, respectively) at the park scale (Figure 5A), and change in H' mirrors that of S at both the park and transect scales, (Figure 5). Mean H' for the park in 2005 was 1.73 (± 0.4), less than the management goal of 2.63. Transects 11 and 12, part of an additional planting event in 1980, had greater mean richness and diversity through time than the other transects (Figure 5B). Evenness was stable through time at all three spatial scales. At the park scale, evenness ranged from 0.59-0.71 throughout the time series with 2005 equaling 0.64. This means that there is moderate variability in the way that plants are distributed across the park.



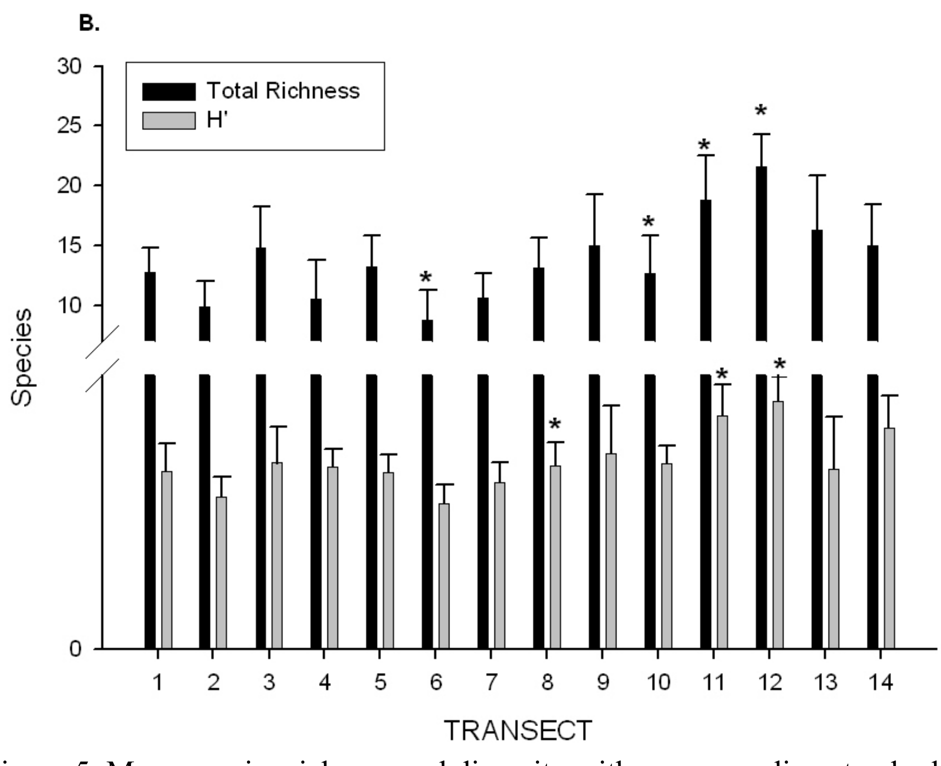




Figure 5. Mean species richness and diversity with corresponding standard deviations at A) the park scale (bars with @ at the breakpoint indicate burn years ) and B) transect scale (stars indicate transects that differed significantly through time, $p < 0.05$).where the y-axis shows change in diversity through time independent of the y-axis label for species richness.

The relationship of community indices to the occurrence of prescribed fire was also calculated at multiple scales. Species richness declined as time between burns increased at the park scale but H' did not respond in the same way (Figure 6). That means that although richness declined, abundances of plants stayed relatively the same.

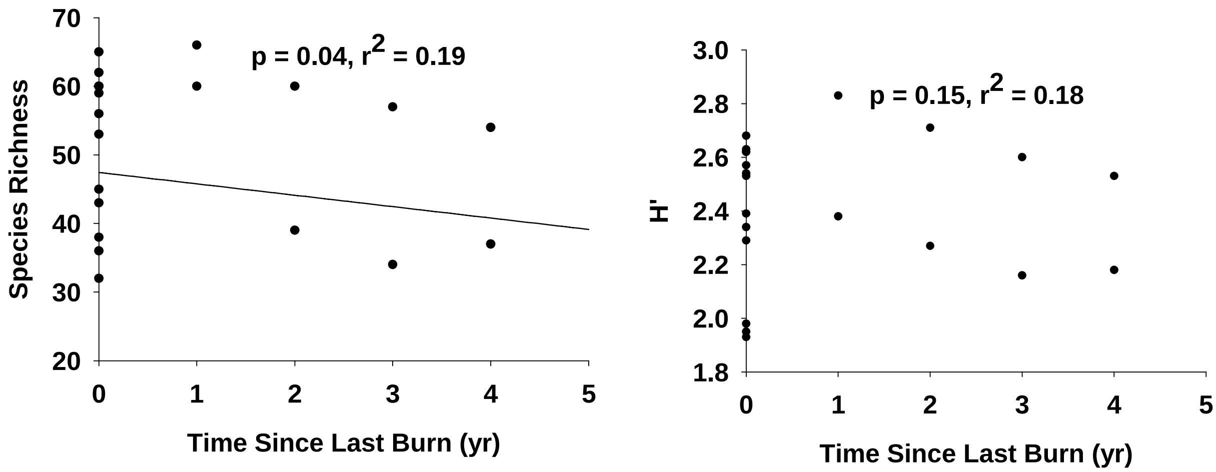



Figure 6. Relationship of burn history beginning in 1985 with: A) species richness and B) diversity (H') at the park scale.

Fire was generally applied at the prairie management unit (PMU) scale and evaluating the data at finer scales may help to understand the affects of management. At the PMU scale, species richness varied significantly through time only for PMU 7 ($p$ <0.01, F = 10.73, df = 19, y = 14.54 – 0.80x); however, there was only one transect in this PMU. H' was not significant at any PMU.

We then proceeded to the transect scale (Figure 7, 8). Although few communities on the smallest scale demonstrated a clear relationship with fire, Transects 11 and 12, which also had greater diversity and richness responded positively to fire with respect to both diversity and species richness. Transect 8 increased in diversity with time since the last burn (Figure 7) possibly indicating more frequent disturbance at that location (Denslow 1985, Hobbs and Huenneke 1992). Four transects demonstrated relationships between species richness and time since last burn. All these regressions had decreasing trends, except transect 11 which followed a quadratic function (Figure 8). When a sequential Bonferroni test was conducted for multiple comparisons, transect 11 would not be significantly different from the rest for H' and only transect 10 would be significant for species richness.

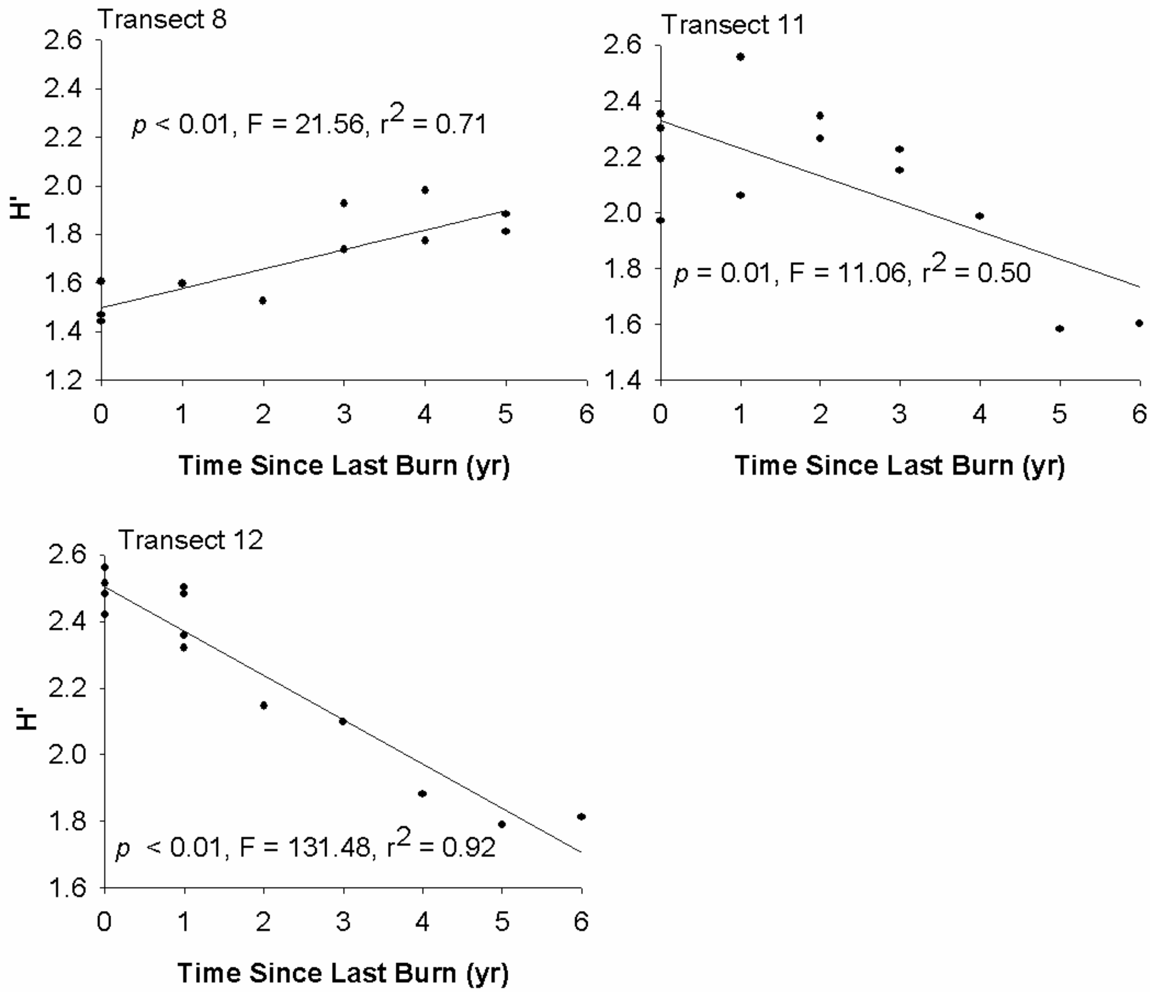



Figure 7. Transects with notable relationships between diversity (H') and time since burn beginning in 1985.

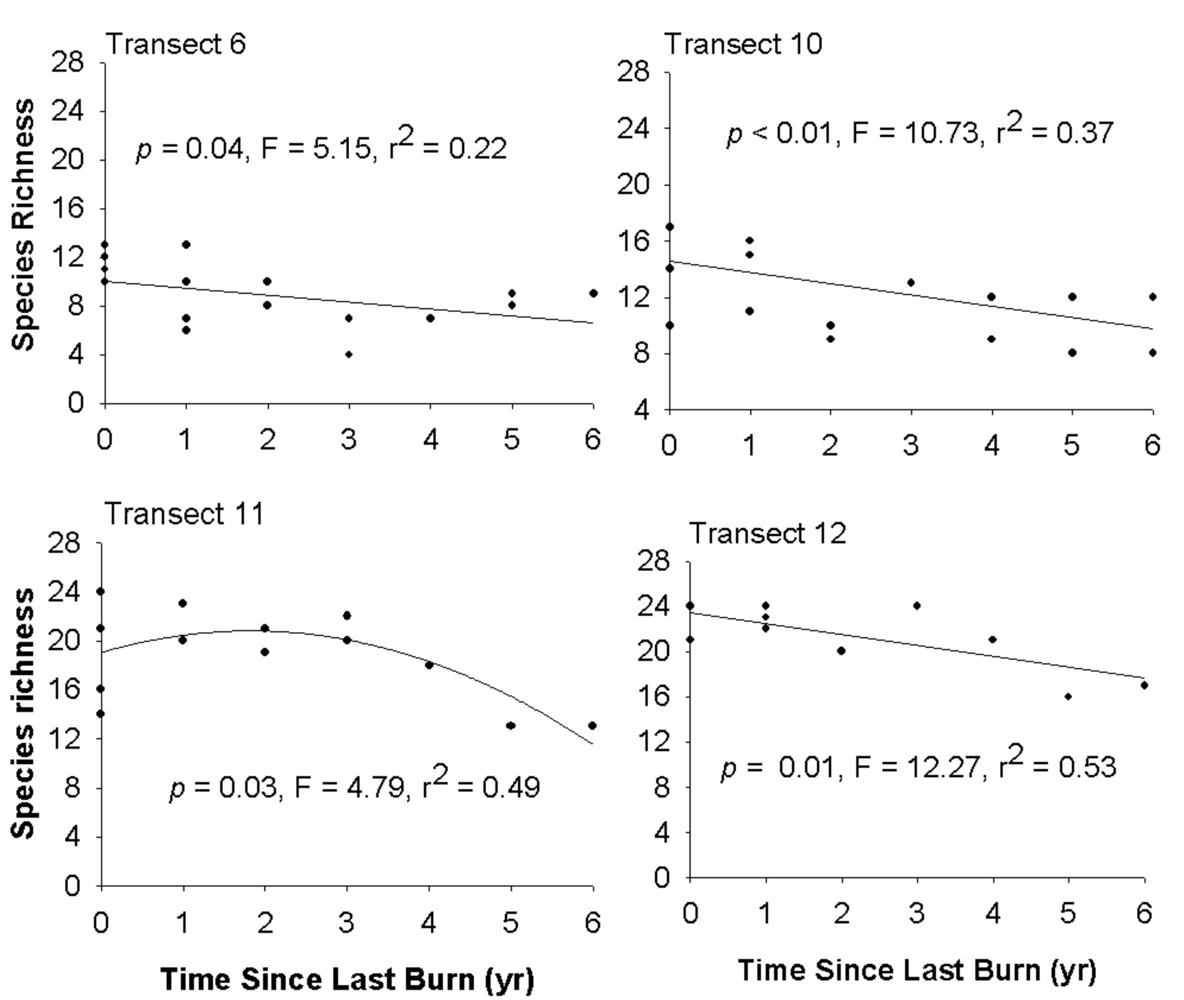



Figure 8. Transects with notable relationships between species richness and time since burn beginning in 1985.

## Exotic species

Exotic species have fluctuated in abundance through time (Figure 9). At the park scale, the exotic species ratio (number of exotic species/total number of species*100) fluctuated from 19 to 33% with 21% in 2005. Average relative cover of exotic species was 20% in 2005 but has been as low as 2% in 1992 (Appendix E). The most recent amount in 2005 exceeded the park's goal of less than 8% relative cover of exotic species. Increases in total species richness were accompanied by increases in both native and exotic species components (Figure 10).

The number of exotic species tended to decrease at the transect scale in the absence of fire, although a similar pattern could not be seen at the park scale ($p$ = 0.40 F = 1.01, df = 21; Figure 11). Only management unit seven demonstrated a significant relationship between number of exotic species and fire history, (y = 3.35-0.34x, $p$ = 0.01, F = 7.58, $r^2$ = 0.30). At the transect scale, exotic species richness tended to decline with absence of fire, but the relationship was reversed in transect 1 (Figure 11). Correlations were presented in figure 11, but when a sequential Bonferroni test was conducted for multiple comparisons, only transects 10 and 11 were significant.

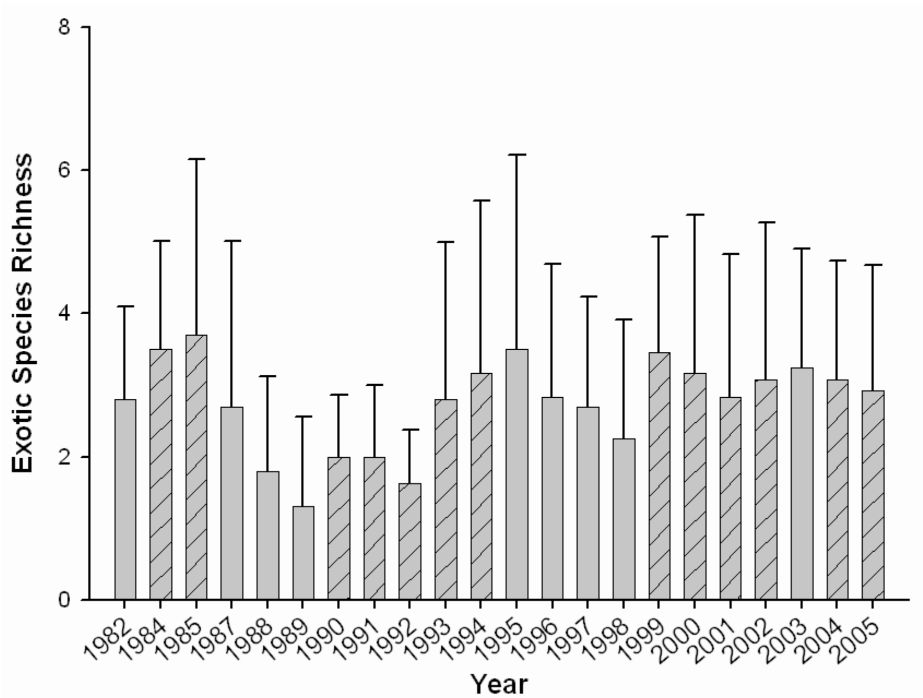



Figure 9. Mean exotic species richness and standard deviation for each sampling year. Burn years are indicated by textured bars.

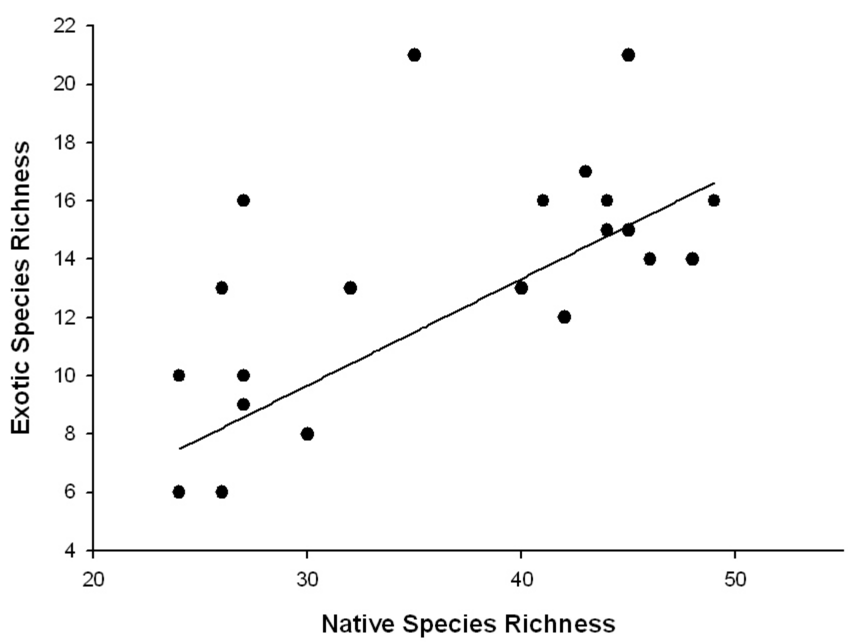



Figure 10. Exotic and native species richness have increased simultaneously in the prairie at Herbert Hoover NHS.

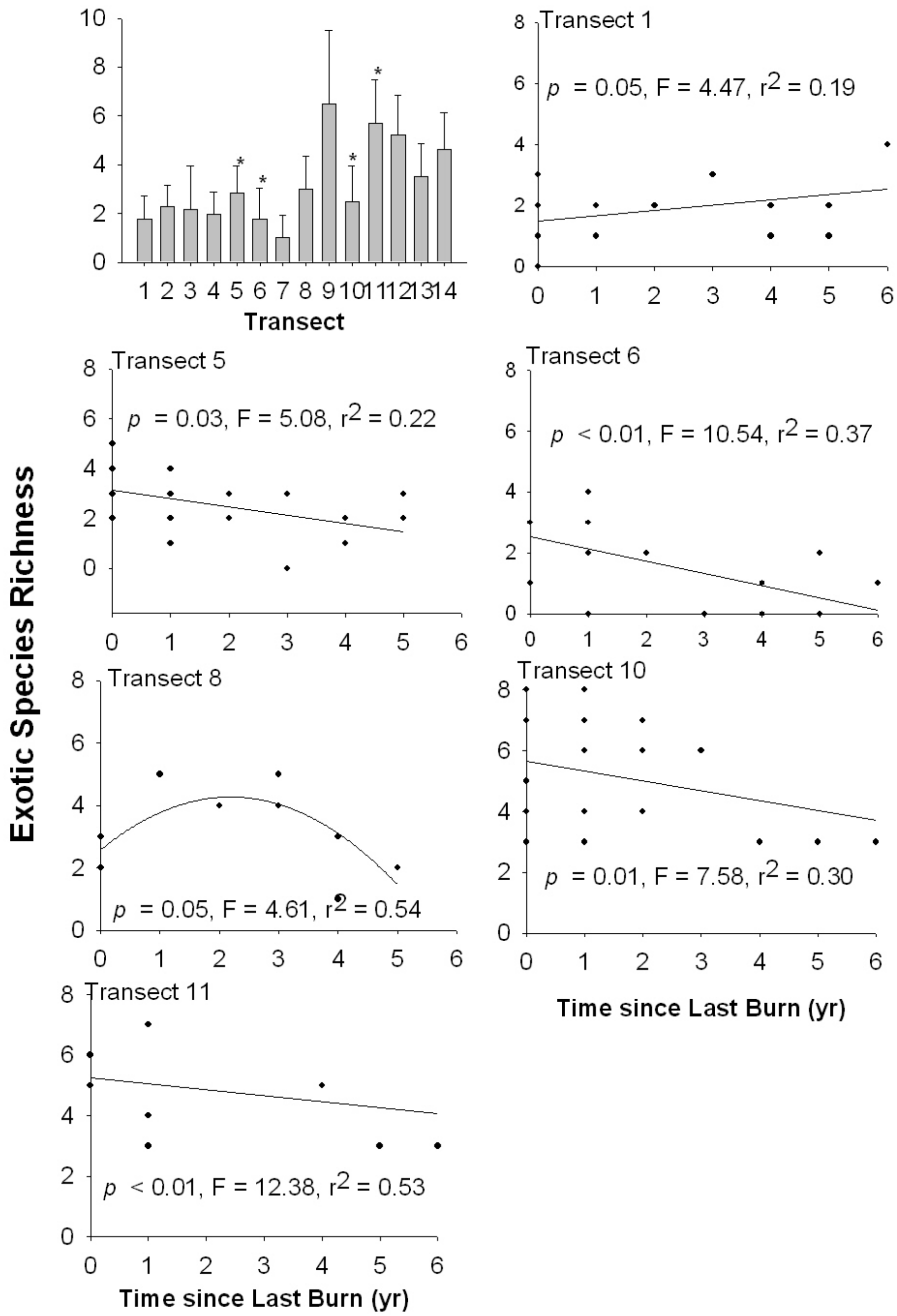



Figure 11. Relationship of exotic species richness to fire at the transect scale. Individual transects with $p \leq 0.05$ are graphed.

## Species Guilds

Using importance values calculated by guild, we examined dominant guilds through time. During the 1982 sampling period, warm season grasses dominated the community structure at all five transects (75-92% relative abundance; Figure 12A). The following year when ten transects were sampled, warm season grass abundance ranged from (67-100%) and remained the most dominant guild at the park scale. Interestingly, transects 8 and 9 were dominated by yellow nutsedge (*Cyperus esculentus*) (45 and 80%) in 1984. Warm season grasses dominated half of the transects (2, 4-8, 10) in 2005 while the remaining transects (1, 3, 11-14) were dominated by summer/fall forbs (Figure 12). Forb dominated transects tended to be situated lower on the slope than grass dominated transects.

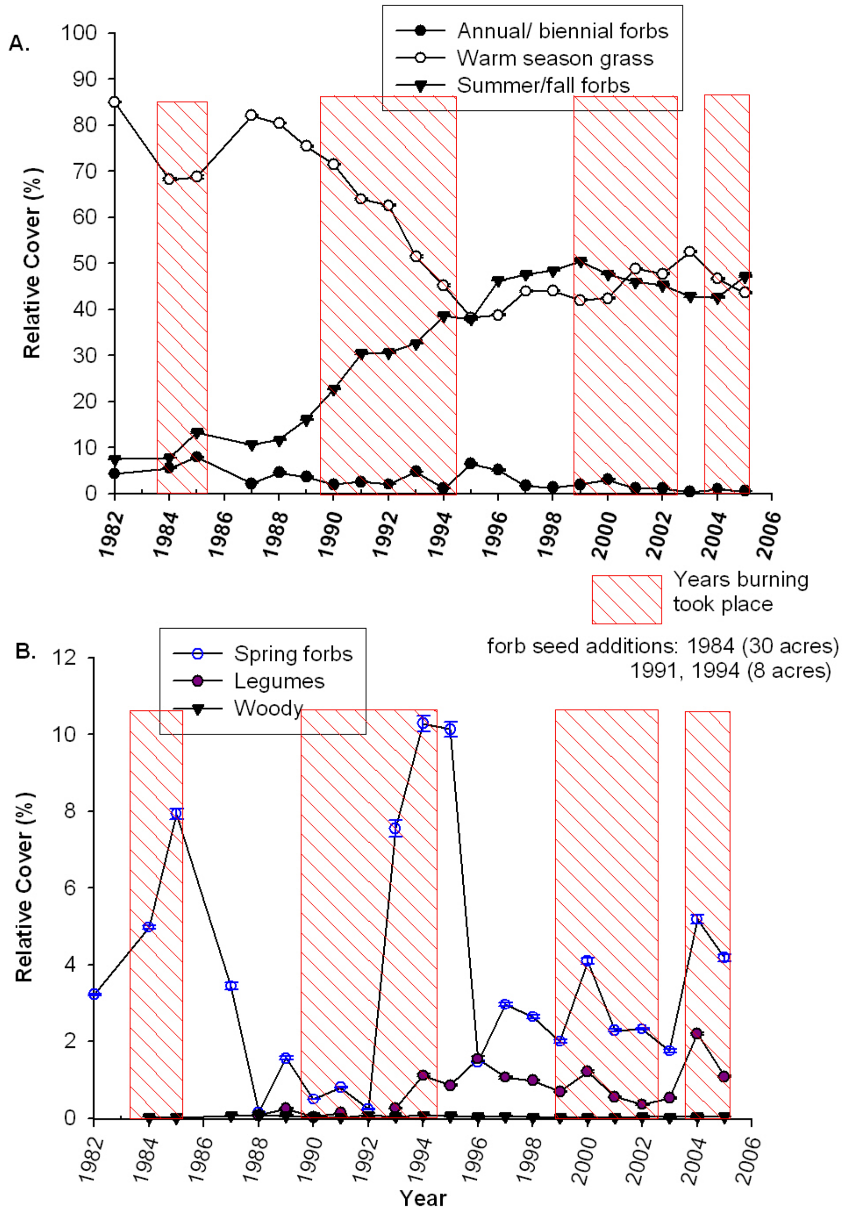



Figure 12. Distribution of guilds at the park scale and standard deviations. Error bars are so small as to not be visible in some cases. A) Mean relative cover of three guilds through time, and B) mean relative cover of three more guilds through time. Note that the y-axis maximum is only 12%.

Woody plant cover is of particular concern to grassland management. Woody cover stayed very low throughout the study (Figure 12B). While some transects lack woody cover, transects 1, 3, 6, 7, and 10 did include some component of woody plants (Figure 13). Given the steady, low abundance of woody plants, management efforts seem to be keeping this guild in balance.

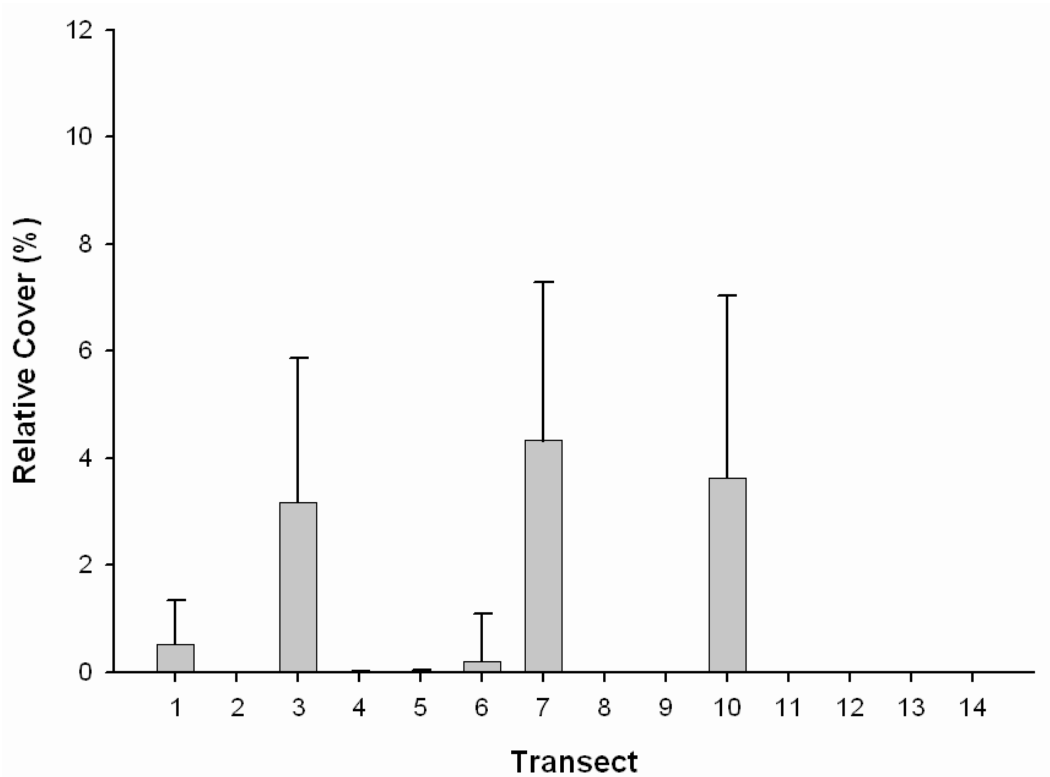


Figure 13. Mean relative cover and standard deviation of woody plants by transect at HEHO.

The cool season grasses, a contributor to exotic species abundance, were absent during the first few years of inventories and during the early 1990s. Mean cool season grass cover was greatest during 1996 (2.7% ± 0.2), but was 1.6% ± 0.03 in 2005. Smooth brome is the greatest at transect 14 and had been increasing until 2005 where it declined sharply from 322.5 to 37.5% total transect cover. Reed canarygrass, however, increased steeply at transect 13 from 445% total cover in 1996 to 1377% total cover in 2005. At transect 14, reed canarygrass fluctuated from 353% total cover in 1999 to 147.5% total cover in 2004, but in 2005 total cover increased to 427.5%. For further discussion of exotic species abundance and distributions see Young et. al. (2007).

# Discussion

Long-term monitoring at HEHO was conducted to provide insight into the response of the prairie community to management actions over time. We queried the data at three spatial scales to assess prairie community trends. Trend analyses are typically done at the park scale, but management is often conducted at smaller spatial scales. By calculating relationships at smaller scales, we gained greater insight into local influences on trends at the park scale. The HEHO prairie has matured over the 23 years of monitoring from a near totally grass dominated community to one including a variety of species guilds. Adaptive management efforts resulting from monitoring clearly had a positive effect, for example, Canada thistle was controlled, woody plants were kept in check, and the abundance of forbs grew.

Community indices, at the park scale varied significantly through time, but in 1982 and 2005 richness and diversity values were similar. Diversity values tend to increase with species richness when there are a few dominant core species and many infrequent species, but H' will remain stable in a case where species are more equally distributed. Diversity remains below the park's goal (2005 H' = 1.73). We looked at patterns within transects to try to explain the source of variation. Transects 11 and 12 made important contributions to mean species richness and diversity. Both transect 11 and 12 were located near an edge and are thus susceptible to weedy plant competition. Species richness gains across the park, but especially at transects 11 and 12, were accompanied by increases in both native and exotic species. Non-linear trends at transects 8 and 11 may indicate that the management treatments there shifted the species ratios out of the decreasing linear pattern we expected to see (Suding and Gross 2006).

Exotic species appeared to be one of the most important threats to the prairie community. Overall numbers of exotic species were reduced after a series of fires, additional plantings, and increased eradication efforts in the mid 1980s. Unfortunately, the abundance of introduced species in 2005 was more than double the park's goal of < 8%. Cool season grasses like reed canarygrass and smooth brome expanded in recent years. Detailed maps of current distributions of exotic species of concern can be found in Young et. al. (2007).

Analysis of guilds at the park level revealed a distinct change in the abundance of warm season grasses and forbs. At present, warm season grasses and forbs are nearly equal in abundance. Transect level observation revealed that distinct communities exist within different areas of the park. Half of the transects were dominated by summer forbs and half by warm season grasses. Native grasslands, historically, had greater richness of forbs, but greater abundance of grasses (Weaver 1968).

Observing each transect's history of burning, herbicide treatment, and additional planting may hold the key to understanding the community dynamics at HEHO. Overall, we expected that as native species increased exotic species would decrease as a result of competition. Unfortunately, in the HEHO prairie both groups increased simultaneously. The vigorous nature of some species like reed canarygrass and smooth brome present an ongoing challenge. For example, transects 11 and 12 were richer in both native and exotic species which may be explained by the fact that the area had been a hay field prior to restoration, was reseeded in 1980, and was close to the prairie's edge. Frequent intense disturbance at these two transects have made the communities there susceptible to invasion (Hobbs and Huenneke 1992).

Fire is an important part of grassland management with respect to native remnants as well as restorations (Packard 1997, Packard and Ross 1997, Anderson 2006). Burning removes residual litter and standing dead biomass. Increased light to the soil surface accompanied by change in nitrogen and phosphorous availability (Ojima et. al. 1990) can encourage germination of new plants and a competitive advantage to some existing plants. Another important function of fire is to reduce the incidence of woody plants (Anderson 2006).

Fire was introduced at HEHO to improve species richness, especially of the spring and summer/fall forb guilds. We predicted that total species richness would decrease with time since fire (Collins 1987, Suding and Gross 2006), but few relationships with prescribed fire were revealed. Notably, summer/fall forbs increased from being absent in the original planting to nearly equaling abundance of grasses in 2005. At the transect scale, fire produced a patchy effect in that only a subset of transects were affected by fire. Where a trend was detected, we did see a negative relationship with total and exotic species richness. The signal of fire may have been obscured in the data by the many other management related activities occurring simultaneously such as forb seed additions and invasive species treatments. Furthermore, the data were complicated by truncated transects in both space and time.

Fire can be used as a tool to reduce some invasive species if used for that targeted purpose. Smooth brome, for example, can be treated with fire if native grasses are present and when tillers begin to elongate (Willson and Stubbendieck 2000). Reed canarygrass once burned should be followed up with herbicide (Wisconsin Reed Canarygrass Management Working Group 2006). Often multiple stressors used in tandem, of which fire can be one, are more effective at weakening target populations than one independent treatment (Miller 2004, Czarapata 2005, Paschke et. al. 2005).

It is important to consider season of fire when planning prescribed fires or interpreting community change. All the known fires at HEHO have been conducted during the spring. Spring fires tend to increase dominance of warm season grasses and reduce heterogeneity despite temporary increases in species richness (Collins and Gibson 1990). Historically in the Upper Midwest, lightning strikes in the spring and fall would be accompanied by rain and thus would not spark intense or large fires (Sieg 1997, Anderson 2006). Lightning strikes from summer storms during the dry part of the year, while less frequent, would have the potential to create more intense fires. Conditions including season and soil moisture can affect plant species composition through fire intensity, extent, and phenological stage of the affected plants. Control of cool season invasive species can sometimes be more effective in the spring and fall, however (Miller 2004, Czarapata 2005). Varying burn season in some parts of the prairie could be another useful tool to shape the prairie’s development (Glenn-Lewin et. al. 1990).

It is the goal of long-term ecological monitoring, while contributing to our empirical understanding of prairie communities, to provide park resource managers effective plant community monitoring. The results of the monitoring can assist mangers to adapt management strategies for maintaining or restoring prairie community composition, structure, and diversity.

Continued monitoring of the HEHO prairie will honor the legacy of Dr. Paul Christiansen and support the National Park Service mission "to effectively manage and protect" the lands entrusted to the National Park Service. Investigation of the Christiansen data in this report has become a foundation for increased understanding of results from future monitoring efforts.

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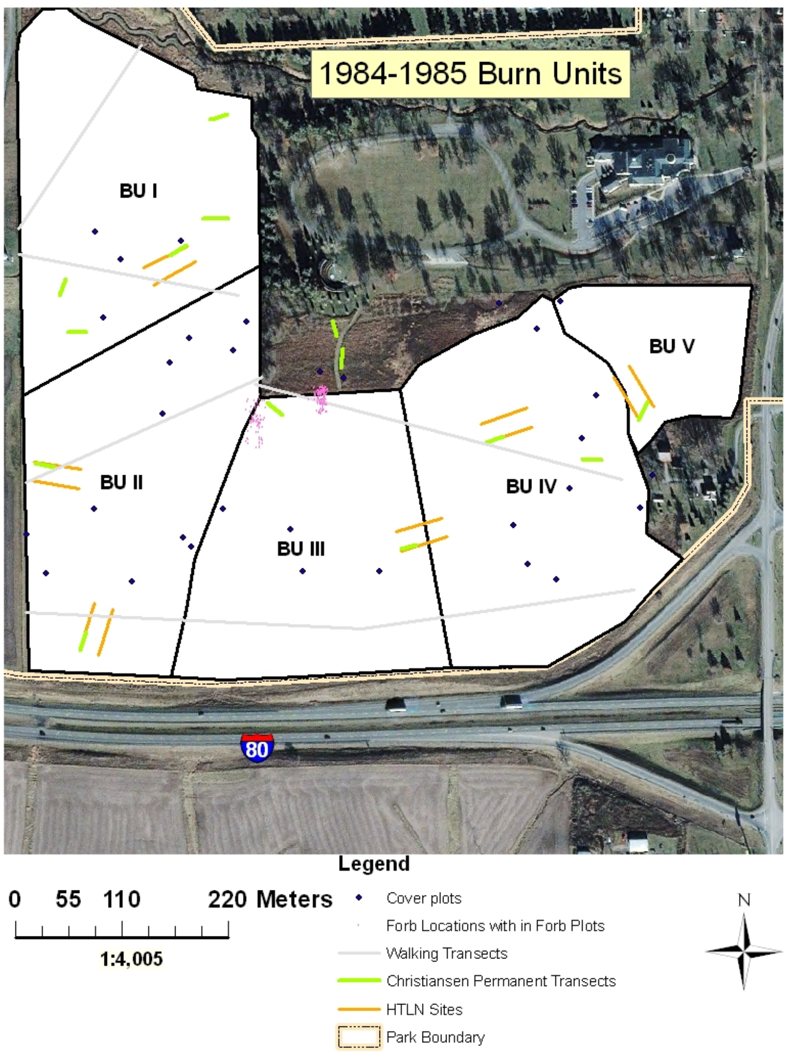
# Appendix A. Prescribed fire history at Herbert Hoover National Historic Site.

The following summarizes the known data for the fire history at the park (provided by Sherry Middlemis-Brown). Reports suggest there may have been a burn in 1972, but no confirming data exist. Burn units changed over the years and prescribed fires have been in the spring (exact dates unknown). The early fires are based on the 1984 Burn Units used in 1984 and 1985. Number of acres burned are reported for each burn unit by year.

**Burn units 1984-1985**

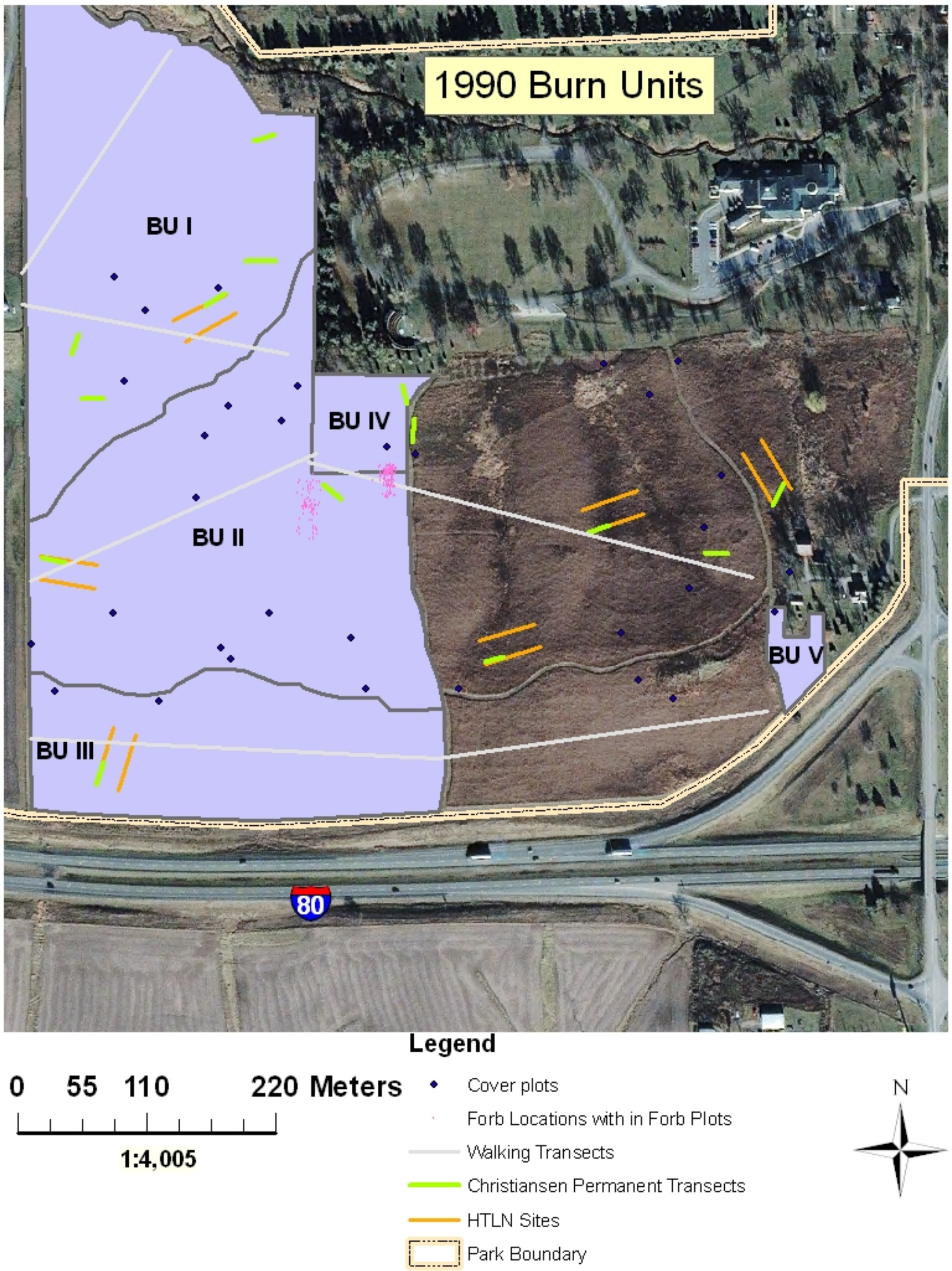
| | **Burn Unit (total unit acres)** | | | | |
|---|---|---|---|---|---|
| Year | **1** (17) | **2** (20) | **3** (10) | **4** (21) | **5** (8) |
| 1984 | All | All | All | All | unconfirmed |
| 1985 | unconfirmed | 17.3 | 7.4 | 19.6 | 3.4 |



In 1990 and 1991, there were differences in naming of Burn Units (e.g., southern portion of Burn Unit 2 was truncated and renamed Burn Unit 3).

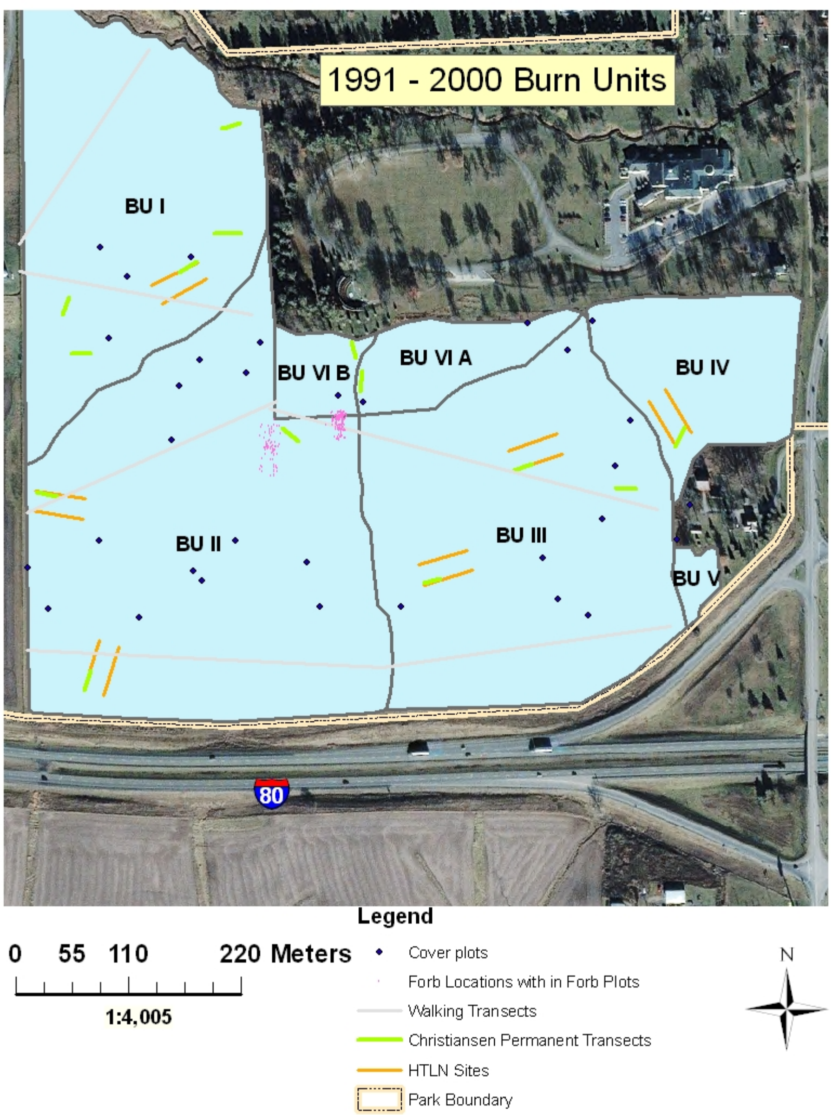
**Burn units 1990**.

| | Burn Unit (total unit acres) | | | | |
|---|---|---|---|---|---|
| **Year** | **I** (17) | **II** (20) | **III** (10) | **IV** (1.4) | **V** (0.4) |
| 1990 | 16 acres | 18 north, 6 south | Unconfirmed | 1.4 | 0.4 (nursery plot) |



**1991-2000 fires based on Burn Units realigned in 1991.**

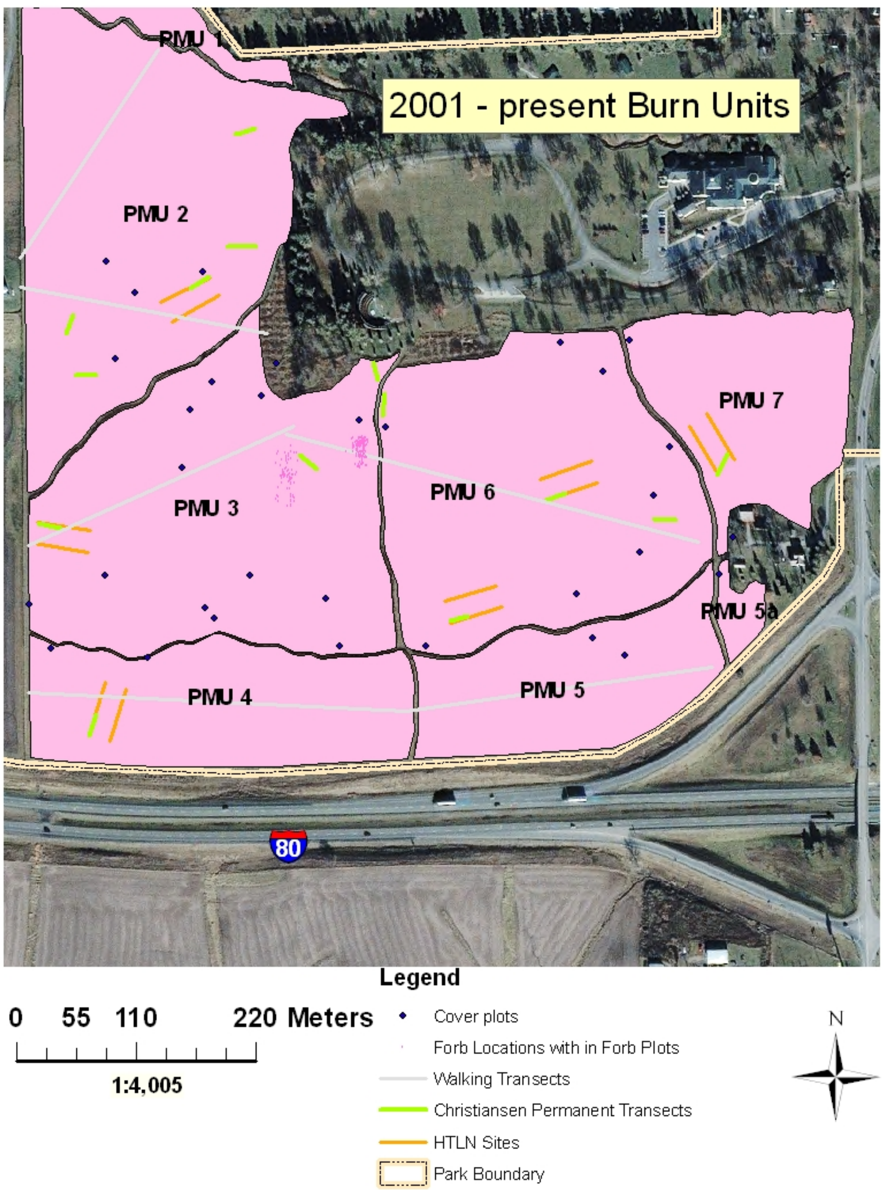
| | Burn Unit (total unit acres) | | | | | |
|---|---|---|---|---|---|---|
| Year | **1** (18.9) | **2** (27.8) | **3** (22.8) | **4** (6.2) | **5** (0.6) | **6** (3.4) |
| 1991 | 12 | 2.2 (note small polygon) | 21 | 0 | 0.4 | unknown status |
| 05/06/1992 | 0 | 21.5 | 0 | 2.3 | 0 | A 1.9 |
| 05/28/1992 | 0 | 0 | 0 | 7.3 | 0 | B 1.5 |
| 1993 | 14.4 | 0 | 15.6 | 0 | 0 | 0 |
| 1994 | 16 | 0 | 0 | 0 | 0 | 0 |
| 1999 | 0 | All | 0 | All | 0 | All |
| 2000 | All | 0 | All | 0 | All | All |



The 2001-present Burn Units were renamed Prairie Management Units (PMU) and are delineated by the park trails.

**2001-present burn units**

| | Burn Unit (total unit acres) | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | **1**(2.7 ac) | **2**(18.9 ac) | **3**(18.7 ac) | **4**(9.1 ac) | **5**(7.9 ac) | **6**(17.2 ac) | **7**(7.5 ac) |
| 05/08/2001 | 0 | 0 | All | All | 0 | 0 | All |
| 2002 | All | All | 0 | 0 | All | All | 0 |
| 2004 | All | 0 | 0 | 0 | All | All | All |
| 2005 | All | All | All | All | 0 | 0 | All |



# Appendix B. Methods for supplemental monitoring and inventories conducted as part of the long-term monitoring program at HEHO

### Christansen walking transects

Five additional transects were designated as "walking" transects. These transects, sampled 1982-2005, were used to gather information across the prairie. Walking transects were sampled at 4 rod intervals (10 paces or 20.1 m/16.5 ft) with a 20 x 50-cm quadrat. All species were identified and cover was estimated (Christiansen 1982) as with the permanent transects. Walking transect number five was much longer than the other transects and resulted in unequal sample sizes.

### Cover plots

In 2000, a suite of 30 randomly selected points were sampled using 1-$m^2$ quadrats to validate results from the permanent plots. Points were randomly selected using a random numbers table and located with a Garmin 12XL global positioning system (GPS) receiver. All sampling points were located in upland prairie-dominated vegetation with the exception of numbers 21 and 22 in the 1992 planting, 5 in the 1984 lowland planting, and 25 in a lower slope weed patch. A wooden stake with the plot number on it was placed at both the NE and NW corners of each plot were installed. Canopy cover of individual vascular plant species was estimated for each plot as >1 % (T), 1-10% (1), 10-20% (2), 20-30% (3), 30-40% (4), 40-50% (5), 50-60% (6), 60-70% (7), 70-80%(8), 80-90% (9), 90-100% (10). Plots were sampled three times during the course of the summer of 2000 (June 21, July 24 (plots 1 and 4A not sampled), and August 25 (31 plots sampled). Additional searches to document all species of the vascular flora present on the prairie were carried out on June 19, 21; July 24, 31, August 2, 3, 4, 7, 25, and October 2, 2000. Special attention was paid to habitats underrepresented in random plots (see Christiansen & Middlemis-Brown 2004).

### Forb plots

Dr. Christiansen established two forb plots (one in each 1988 and 1989) to study establishment rates of forbs in the restoration (Christiansen 1988, 1989, 1996). The ends of both 30-m long plots were marked with steel post. The first plot was located in the old field area beginning at the photopoint post. The second plot was placed 50 m east of plot one and started at the south edge of the old field running directly south. At each plot a baseline was established and each forb's location (azimuth and distance) to either side of the baseline was recorded. Flowering and fruiting status of each plant was also recorded. Dr. Christiansen sampled these plots through 2003.

# Appendix C. Data management for Herbert Hoover National Historic Site legacy data

This appendix describes data management procedures used to process the biological, spatial, and ancillary data relevant to the development of the Herbert Hoover NHS prairie monitoring geodatabase (GDB).

## Data management

Prairie plant inventories initiated by Dr. Paul Christiansen in 1982 resulted in a plethora of data in hard copy and digital format (Microsoft Excel spreadsheets, Microsoft Word and Adobe reports). Hardcopy reports not in digital format were scanned to Adobe portable document format (.pdf) and the accompanying data manually entered into digital format (Microsoft Excel). Once hard copy reports were digitized all annual reports previously generated from Dr. Christiansen's monitoring were documented in the NPS bibliographic database NatureBib (see Literature Cited for Bibkey numbers).

The HTLNs vegetation monitoring database, VegMon, served as a template for developing a database for the Herbert Hoover long-term monitoring data (DeBacker et. al. 2004). Although Dr. Christiansen's sampling methods differed from the HTLN's methods, the Christiansen data was placed within the HTLN database structure. The aim was to facilitate the integration of the two datasets for analysis and interpretation of the two long-term datasets. Data in Microsoft Excel spreadsheets were imported to individual Microsoft Access databases (i.e., one database per year of data) and appended to the appropriate tables following an initial verification to correct gross mistakes. Data were then merged to a single database and verified by visually comparing 100% of the records to the original reports. This was followed by reviewing another10% of the records for errors. Validation of the data corrected missing, mismatched, or duplicate records, as well as other transcription errors.

Validation of the data also revealed inconsistencies in reporting of species names (eg., common versus scientific and scientific name synonymy for several species). Some data tables were reported with the common name whereas others with the scientific name. For the cases where data tables listed common name, the matching scientific name was used in the species list found in the report. Where the matching scientific names were absent, park staff (Sherry Middlemis-Brown) was contacted who then contacted Dr. Christiansen to resolve naming conflicts. Additionally, the latest HEHO flora list was used to update names where multiple scientific or common names had been recorded for the same plant. Metadata for the database were entered for all database tables. Preliminary analyses were run and the results were verified.

The database was then integrated with spatial data in a geodatabase environment. Spatial data included points developed from coordinates documented in the annual reports and data collected by the HTLN using GPS units. The core spatial tables included Dr. Christiansen's permanent plots and walking transects, the newly installed HTLN plots, locations for cover plots, unique points for the mapped forbs, and a polygon layer showing the forb study areas.

## Appendix D. Species recorded in permanent monitoring plots 1982-1985. Values are averaged at the park scale for 21 years of data.

| Scientific Name | Common Name | $\bar{x}$ Frequency | $\bar{x}$ Cover (%) | $\bar{x}$ IV (%) |
|---|---|---|---|---|
| Abutilon theophrasti | Velvetleaf | 0.06 | 10.94 | 0.22 |
| Acer negundo | Boxelder | <0.01 | 2.50 | 0.02 |
| Acer saccharinum | Silver maple | <0.01 | 2.50 | 0.01 |
| Agrostis gigantea | Red top | 0.01 | 32.50 | 0.04 |
| Amaranthus retroflexus | Redroot, rough pigweed | 0.03 | 47.50 | 0.27 |
| Ambrosia artemisiifolia | Common ragweed | 0.08 | 22.28 | 0.36 |
| Ambrosia trifida | Giant ragweed | 0.30 | 31.53 | 1.68 |
| Andropogon gerardii | Big bluestem | 0.84 | 76.32 | 8.33 |
| Anemone canadensis | Canadian anemone | 0.06 | 26.41 | 0.31 |
| Anemone cylindrica | Long-headed anemone | <0.01 | 37.50 | 0.02 |
| Apocynum cannabinum | Hemp dogbane | 0.02 | 14.50 | 0.07 |
| Asclepias incarnata | Swamp milkweed | <0.01 | 2.50 | 0.01 |
| Asclepias syriaca | Common milkweed | 0.23 | 23.12 | 1.14 |
| Asclepias tuberosa | Butterfly-weed | 0.02 | 17.00 | 0.08 |
| Asclepias verticillata | Whorled milkweed | 0.01 | 10.83 | 0.05 |
| Aster ericoides | Squarrose white wild aster | 0.23 | 23.31 | 1.08 |
| Aster laevis | Smooth wild aster | 0.01 | 32.50 | 0.08 |
| Aster novae-angliae | New England wild aster | 0.01 | 23.13 | 0.07 |
| Aster pilosus | Awl wild aster | 0.34 | 17.82 | 1.52 |
| Aster sagittifolius | Arrow-leaved aster | 0.01 | 26.25 | 0.04 |
| Aster spp | Aster | 0.05 | 13.93 | 0.19 |
| Astragalus canadensis | Canada milk-vetch | 0.01 | 15.00 | 0.05 |
| Baptisia alba var. macrophylla | Largeleaf wild indigo | 0.02 | 52.08 | 0.15 |
| Barbarea vulgaris | Golden yellowrocket | <0.01 | 2.50 | 0.01 |
| Bidens cernua | Nodding bur marigold | <0.01 | 2.50 | 0.01 |
| Bouteloua curtipendula | Side-oats grama-grass | 0.13 | 29.19 | 0.73 |
| Brassica rapa var. rapa | Rape mustard | <0.01 | 62.50 | 0.04 |
| Brassica spp | Mustard | <0.01 | 15.00 | 0.02 |
| Bromus inermis | Smooth brome | 0.09 | 31.20 | 0.50 |
| Bromus japonicus | Japanese chess | 0.14 | 36.13 | 0.96 |
| Calystegia sepium | Hedge-bindweed | 0.29 | 14.10 | 1.22 |
| Capsella bursa-pastoris | Shepherd's purse | <0.01 | 2.50 | 0.01 |
| Carex spp | Sedge | 0.03 | 17.50 | 0.14 |
| Chenopodium album | Lamb's quarters, pigweed | 0.01 | 2.50 | 0.03 |
| Cirsium arvense | Canada thistle | 0.55 | 30.71 | 3.12 |
| Cirsium discolor | Tall or roadside thistle | 0.25 | 15.64 | 1.07 |
| Conyza canadensis | Horseweed | 0.13 | 14.19 | 0.55 |
| Cornus amomum | Silky dogwood | <0.01 | 37.50 | 0.02 |
| Cornus racemosa | Northern swamp dogwood | <0.01 | 15.00 | 0.02 |
| Cornus rugosa | Speckled dogwood | <0.01 | 15.00 | 0.02 |
| Cornus spp | Dogwood | 0.02 | 35.50 | 0.11 |
| Cyperus esculentus | Chufa flatsedge | 0.11 | 39.67 | 0.78 |
| Dactylis glomerata | Orchard grass | 0.02 | 46.25 | 0.15 |
| Dalea candida | White prairie clover | 0.01 | 15.00 | 0.03 |

| Scientific Name | Common Name | $\overline{X}$ Frequency | $\overline{X}$ Cover (%) | $\overline{X}$ IV (%) |
|---|---|---|---|---|
| Dalea purpurea | Purple prairie clover | 0.03 | 23.44 | 0.14 |
| Daucus carota | Wild carrot, Queen Anne's lace | 0.01 | 10.83 | 0.04 |
| Desmodium canadense | Canadian tick-trefoil | 0.09 | 15.00 | 0.36 |
| Echinacea pallida | Pale purple coneflower | <0.01 | 15.00 | 0.02 |
| Echinochloa crusgalli | Foldleaf grass | 0.01 | 15.00 | 0.05 |
| Elymus canadensis | Canada wild rye | 0.28 | 21.70 | 1.40 |
| Elymus virginicus | Virginia wild rye | <0.01 | 15.00 | 0.01 |
| Elytrigia repens var. repens | Quack-grass | 0.13 | 52.79 | 1.07 |
| Equisetum arvense | Field horsetail | 0.25 | 26.74 | 1.28 |
| Erechtites hieraciifolia | Fireweed | 0.33 | 9.95 | 1.37 |
| Erigeron annuus | Annual fleabane | 0.09 | 16.35 | 0.40 |
| Eryngium yuccifolium | Rattlesnake-master | 0.01 | 30.00 | 0.06 |
| Geum canadense | White avens | 0.01 | 15.00 | 0.05 |
| Geum laciniatum | Rough avens | <0.01 | 15.00 | 0.02 |
| Glycine max | Soybean | <0.01 | 37.50 | 0.02 |
| Helenium autumnale | Sneezeweed | 0.02 | 22.00 | 0.09 |
| Helianthus grosseserratus | Sawtooth sunflower | 0.08 | 65.60 | 0.56 |
| Helianthus laetiflorus | Aster | 0.06 | 47.21 | 0.37 |
| Helianthus maximiliani | Maximilian sunflower | <0.01 | 15.00 | 0.02 |
| Heliopsis helianthoides | Sunflower-everlasting | 0.10 | 19.64 | 0.47 |
| Hibiscus trionum | Flower of an hour | 0.01 | 6.67 | 0.04 |
| Hordeum jubatum | Foxtail-barley | <0.01 | 37.50 | 0.03 |
| Hypericum ascyron | Great St. Johnswort | 0.01 | 20.00 | 0.04 |
| Kochia scoparia | Summer-cypress | 0.01 | 38.75 | 0.06 |
| Lactuca canadensis | Tall lettuce | 0.51 | 16.07 | 2.34 |
| Lactuca serriola | Prickly lettuce | 0.02 | 10.00 | 0.07 |
| Lactuca spp | Lettuce | 0.01 | 8.75 | 0.06 |
| Lespedeza capitata | Bush-clover | 0.10 | 24.83 | 0.52 |
| Liatris spp | Liatris | <0.01 | 2.50 | 0.01 |
| Lolium arundinaceum | Tall Fescue | 0.11 | 30.73 | 0.61 |
| Lonicera spp | Honeysuckle | <0.01 | 37.50 | 0.02 |
| Lonicera tatarica | Tartarian honeysuckle | 0.02 | 38.50 | 0.11 |
| Matricaria discoidea | Pineapple weed | <0.01 | 15.00 | 0.02 |
| Medicago lupulina | Black medick | 0.04 | 20.21 | 0.19 |
| Medicago sativa | Alfalfa | 0.01 | 6.67 | 0.04 |
| Melilotus alba | White sweetclover | 0.17 | 62.50 | 1.49 |
| Melilotus officinalis | Yellow sweet clover | <0.01 | 62.50 | 0.03 |
| Melilotus spp | M. albus , M. officinalis | 0.22 | 38.81 | 1.46 |
| Monarda fistulosa | Wild bergamot | 0.24 | 37.20 | 1.42 |
| Morus alba | White mulberry | 0.06 | 28.89 | 0.44 |
| Morus spp | Mulberry | 0.03 | 20.63 | 0.18 |
| Muhlenbergia racemosa | Muhly | <0.01 | 15.00 | 0.02 |
| Muhlenbergia schreberi | Nimblewill | 0.01 | 40.63 | 0.09 |
| Muhlenbergia spp | Muhly grass | 0.02 | 16.67 | 0.09 |
| Oenothera villosa | Evening-primrose | <0.01 | 15.00 | 0.02 |
| Oxalis stricta | Yellow wood sorrel | 0.14 | 4.42 | 0.49 |
| Panicum dichotomiflorum | Fall panic grass | <0.01 | 37.50 | 0.03 |
| Panicum virgatum | Switchgrass | 0.65 | 75.39 | 6.29 |
| Parietaria pensylvanica | Pennsylvania pellitory | 0.06 | 10.44 | 0.25 |
| Parthenocissus quinquefolia | Virginia-creeper, woodbine | <0.01 | 2.50 | 0.01 |

| Scientific Name | Common Name | $\bar{x}$ Frequency | $\bar{x}$ Cover (%) | $\bar{x}$ IV (%) |
|---|---|---|---|---|
| Pastinaca sativa | Wild parsnip | 0.33 | 24.23 | 1.64 |
| Pennisetum glaucum | Grass | 0.04 | 8.18 | 0.17 |
| Pennyroyal | Pennyroyal | <0.01 | 15.00 | 0.02 |
| Phalaris arundinacea | Reed canarygrass | 0.13 | 73.07 | 1.15 |
| Phleum pratense | Timothy | 0.04 | 20.42 | 0.22 |
| Physalis heterophylla | Clammy ground cherry | 0.17 | 18.85 | 0.82 |
| Physalis spp | Nightshade | <0.01 | 2.50 | 0.01 |
| Physalis virginiana | Virginia ground cherry | 0.06 | 25.69 | 0.36 |
| Physostegia parviflora | Obedient plant | 0.02 | 28.50 | 0.10 |
| Plantago rugelii | American plantain | 0.01 | 10.83 | 0.05 |
| Poa pratensis | Kentucky bluegrass | 0.62 | 49.07 | 4.74 |
| Polygonum pensylvanicum | Pennsylvania smartweed | 0.05 | 6.35 | 0.15 |
| Polygonum spp | Smartweed | 0.28 | 16.69 | 1.34 |
| Portulaca oleracea | Common purslane | 0.04 | 40.50 | 0.31 |
| Potentilla arguta | Tall potentilla | 0.01 | 54.17 | 0.08 |
| Potentilla norvegica | Rough cinquefoil | 0.03 | 17.86 | 0.12 |
| Potentilla recta | Sulphur five-fingers | <0.01 | 37.50 | 0.02 |
| Prairie grass seedlings | Prairie grass seedlings | 0.07 | 5.79 | 0.28 |
| Prunus virginiana | Choke-cherry | 0.01 | 15.00 | 0.05 |
| Pycnanthemum virginianum | Mountain mint | 0.01 | 2<0.01 | 0.03 |
| Ratibida pinnata | Globular coneflower | 0.26 | 48.04 | 1.88 |
| Rhus glabra | Smooth sumac | <0.01 | 2.50 | 0.01 |
| Rosa arkansana | Prairie rose | <0.01 | 15.00 | 0.02 |
| Rosa multiflora | Multiflora rose | 0.01 | 8.75 | 0.03 |
| Rubus occidentalis | Black raspberry | 0.03 | 15.00 | 0.10 |
| Rubus spp | Blackberry/raspberry | 0.08 | 28.48 | 0.38 |
| Rubus subgenus eubatis | Rubus subgenus eubatis | 0.06 | 33.13 | 0.29 |
| Rudbeckia hirta | Black-eyed Susan | 0.25 | 45.18 | 1.70 |
| Rudbeckia laciniata | Cutleaf coneflower | 0.09 | 38.54 | 0.54 |
| Rudbeckia triloba | Three-lobed coneflower | 0.06 | 49.22 | 0.42 |
| Rumex acetosella | Common sheep sorrel | 0.04 | 4.77 | 0.18 |
| Rumex altissimus | Pale dock | 0.01 | 22.50 | 0.06 |
| Rumex crispus | Curly dock | 0.01 | 15.00 | 0.03 |
| Salvia azurea var. grandiflora | Pitchers' sage | <0.01 | 15.00 | 0.02 |
| Sambucus canadensis | Common elder | 0.01 | 15.00 | 0.03 |
| Sanicula canadensis | Canada blacksanicle | <0.01 | 2.50 | 0.01 |
| Schizachyrium scoparium | Little bluestem | 0.19 | 20.66 | 0.95 |
| Senecio plattensis | Platte groundsel | 0.52 | 32.36 | 3.08 |
| Setaria faberi | Nodding or giant foxtail-grass | 0.45 | 42.20 | 2.98 |
| Setaria spp | Foxtail | 0.42 | 44.44 | 3.00 |
| Setaria viridis | Green foxtail-grass | 0.15 | 25.85 | 0.80 |
| Silphium laciniatum | Compass-plant | 0.01 | 8.75 | 0.03 |
| Silphium perfoliatum | Cup-plant | 0.05 | 48.57 | 0.36 |
| Solanum americanum | Nightshade | 0.04 | 15.63 | 0.21 |
| Solanum carolinense | Horse-nettle | 0.07 | 20.13 | 0.35 |
| Solidago canadensis | Common goldenrod | 0.84 | 62.71 | 7.15 |
| Solidago gigantea | Smooth goldenrod | 0.07 | 26.00 | 0.37 |
| Solidago rigida | Stiff goldenrod | 0.10 | 29.05 | 0.53 |
| Solidago speciosa | Showy goldenrod | 0.04 | 20.50 | 0.17 |
| Solidago spp | Goldenrod | 0.27 | 33.40 | 1.48 |

| Scientific Name | Common Name | $\overline{x}$ Frequency | $\overline{x}$ Cover (%) | $\overline{x}$ IV (%) |
|---|---|---|---|---|
| Sorghastrum nutans | Indian grass | 0.78 | 55.01 | 6.21 |
| Symphyotrichum oolentangiense var. oolentangiense | Skyblue aster | 0.01 | 22.50 | 0.05 |
| Taraxacum officinale | Common dandelion | 0.36 | 12.16 | 1.47 |
| Teucrium canadense | American germander | 0.01 | 8.75 | 0.05 |
| Thalictrum dasycarpum | Purple meadow-rue | 0.01 | 26.88 | 0.08 |
| Thlaspi arvense | Field penny-cress | 0.06 | 13.09 | 0.23 |
| Tradescantia ohiensis | Smooth spiderwort | 0.02 | 12.92 | 0.08 |
| Tradescantia spp. | Spiderwort | <0.01 | 15.00 | 0.02 |
| Trifolium hybridum | Alsike clover | 0.16 | 32.50 | 0.91 |
| Trifolium pratense | Red clover | 0.03 | 21.39 | 0.15 |
| Trifolium repens | White clover | 0.01 | 26.25 | 0.04 |
| Trifolium spp | T. hybridum and T. pratense | 0.01 | 2.50 | 0.02 |
| Ulmus americana | White or American elm | 0.01 | 22.50 | 0.08 |
| Ulmus pumila | Elm | 0.06 | 15.29 | 0.35 |
| Urtica dioica | Stinging nettle | <0.01 | 2.50 | 0.01 |
| Verbena urticifolia | White vervain | 0.03 | 26.25 | 0.14 |
| Vernonia fasciculata | Smooth ironweed | <0.01 | 15.00 | 0.01 |
| Veronica spp. | Speedwell | 0.02 | 5.00 | 0.06 |
| Viburnum lentago | Nannyberry | <0.01 | 37.50 | 0.02 |
| Vitis riparia | Frost grape | 0.08 | 51.85 | 0.67 |
| Zizia aurea | Common golden alexanders | 0.15 | 27.80 | 0.76 |

# Appendix E. Abundances of guilds summarized by sampling year (1982-2005).

*missing standard deviations (sd) are the result of inadequate number of records to calculate a mean for that guild-year.

| Year | Guild Name | $\bar{x}$ Relative Cover (%) | $\bar{x}$ Relative Cover sd* | $\bar{x}$ Relative Frequency (%) | $\bar{x}$ Relative Frequency sd* |
|---|---|---|---|---|---|
| 1982 | Annuals and Biennials | 4.30 | 0.022 | 17.90 | 0.086 |
| 1984 | Annuals and Biennials | 5.55 | 0.094 | 11.21 | 0.095 |
| 1985 | Annuals and Biennials | 7.92 | 0.072 | 18.42 | 0.111 |
| 1987 | Annuals and Biennials | 2.18 | 0.029 | 6.82 | 0.047 |
| 1988 | Annuals and Biennials | 4.55 | 0.094 | 10.04 | 0.138 |
| 1989 | Annuals and Biennials | 3.65 | 0.045 | 6.12 | 0.077 |
| 1990 | Annuals and Biennials | 1.98 | 0.029 | 7.74 | 0.096 |
| 1991 | Annuals and Biennials | 2.55 | 0.034 | 8.41 | 0.067 |
| 1992 | Annuals and Biennials | 2.04 | 0.043 | 6.16 | 0.090 |
| 1993 | Annuals and Biennials | 4.74 | 0.060 | 9.70 | 0.098 |
| 1994 | Annuals and Biennials | 1.19 | 0.025 | 3.70 | 0.084 |
| 1995 | Annuals and Biennials | 6.48 | 0.129 | 8.51 | 0.110 |
| 1996 | Annuals and Biennials | 5.14 | 0.160 | 5.13 | 0.115 |
| 1997 | Annuals and Biennials | 1.70 | 0.041 | 2.85 | 0.049 |
| 1998 | Annuals and Biennials | 1.29 | 0.010 | 2.94 | 0.027 |
| 1999 | Annuals and Biennials | 1.99 | 0.037 | 3.35 | 0.041 |
| 2000 | Annuals and Biennials | 3.05 | 0.051 | 5.91 | 0.050 |
| 2001 | Annuals and Biennials | 1.18 | 0.015 | 3.06 | 0.028 |
| 2002 | Annuals and Biennials | 1.15 | 0.011 | 2.93 | 0.018 |
| 2003 | Annuals and Biennials | 0.42 | 0.007 | 1.48 | 0.042 |
| 2004 | Annuals and Biennials | 0.94 | 0.009 | 3.44 | 0.030 |
| 2005 | Annuals and Biennials | 0.56 | 0.006 | 2.50 | 0.017 |
| 1985 | Cool-Season Grasses | 0.48 | 0.023 | 0.47 | 0.003 |
| 1988 | Cool-Season Grasses | 0.98 | | 0.71 | |
| 1990 | Cool-Season Grasses | 0.01 | | 0.20 | |
| 1995 | Cool-Season Grasses | 1.56 | 0.033 | 2.37 | 0.031 |
| 1996 | Cool-Season Grasses | 2.70 | 0.153 | 2.85 | 0.130 |
| 1997 | Cool-Season Grasses | 0.86 | | 1.34 | |
| 1998 | Cool-Season Grasses | 0.28 | 0.017 | 0.72 | 0.025 |
| 1999 | Cool-Season Grasses | 0.35 | 0.003 | 0.74 | 0.007 |
| 2000 | Cool-Season Grasses | 0.12 | 0.003 | 0.39 | 0.002 |
| 2001 | Cool-Season Grasses | 0.29 | 0.009 | 0.56 | 0.015 |
| 2002 | Cool-Season Grasses | 0.42 | 0.011 | 1.19 | 0.018 |
| 2003 | Cool-Season Grasses | 0.24 | | 0.60 | |
| 2004 | Cool-Season Grasses | 0.93 | 0.012 | 1.80 | 0.015 |
| 2005 | Cool-Season Grasses | 1.64 | 0.025 | 1.90 | 0.012 |
| 1984 | Ferns | 0.51 | | 1.74 | |
| 1985 | Ferns | 0.95 | 0.065 | 2.67 | 0.158 |
| 1987 | Ferns | 0.29 | | 0.72 | |
| 1988 | Ferns | 0.35 | 0.004 | 1.03 | 0.010 |

| Year | Guild Name | $\bar{x}$ Relative Cover (%) | $\bar{x}$ Relative Cover sd* | $\bar{x}$ Relative Frequency (%) | $\bar{x}$ Relative Frequency sd* |
|---|---|---|---|---|---|
| 1989 | Ferns | 0.15 | | 0.48 | |
| 1990 | Ferns | 0.77 | 0.038 | 1.49 | 0.051 |
| 1991 | Ferns | 1.34 | 0.003 | 3.53 | 0.041 |
| 1992 | Ferns | 1.74 | 0.063 | 3.19 | 0.050 |
| 1993 | Ferns | 2.06 | 0.068 | 4.67 | 0.101 |
| 1994 | Ferns | 1.13 | 0.057 | 1.80 | 0.064 |
| 1995 | Ferns | 3.48 | 0.129 | 3.81 | 0.098 |
| 1996 | Ferns | 2.75 | 0.134 | 3.11 | 0.103 |
| 1997 | Ferns | 0.70 | 0.027 | 1.90 | 0.077 |
| 1998 | Ferns | 1.43 | 0.057 | 2.25 | 0.076 |
| 1999 | Ferns | 1.64 | 0.046 | 2.82 | 0.057 |
| 2000 | Ferns | 0.99 | 0.034 | 2.52 | 0.053 |
| 2001 | Ferns | 0.22 | 0.007 | 0.92 | 0.011 |
| 2002 | Ferns | 1.75 | 0.053 | 3.52 | 0.083 |
| 2003 | Ferns | 0.95 | 0.025 | 2.46 | 0.067 |
| 2004 | Ferns | 0.54 | 0.015 | 1.38 | 0.047 |
| 2005 | Ferns | 1.05 | 0.063 | 1.71 | 0.074 |
| 1984 | Grass-Like | 12.5 | 0.244 | 9.08 | 0.023 |
| 1985 | Grass-Like | 0.56 | | 0.51 | |
| 1987 | Grass-Like | 0.07 | | 0.21 | |
| 1989 | Grass-Like | 0.01 | | 0.19 | |
| 1993 | Grass-Like | 0.01 | | 0.19 | |
| 1994 | Grass-Like | 1.39 | | 0.52 | |
| 1996 | Grass-Like | 0.04 | | 0.15 | |
| 1997 | Grass-Like | 0.07 | 0.003 | 0.31 | 0.005 |
| 1998 | Grass-Like | 0.08 | | 0.24 | |
| 1999 | Grass-Like | 0.16 | 0.001 | 0.30 | 0.001 |
| 2000 | Grass-Like | 0.23 | | 0.29 | |
| 2001 | Grass-Like | 0.05 | | 0.14 | |
| 2002 | Grass-Like | 0.31 | 0.020 | 0.66 | 0.003 |
| 2003 | Grass-Like | 0.11 | | 0.35 | |
| 2005 | Grass-Like | 0.01 | | 0.14 | |
| 1988 | Legumes | 0.07 | | 0.71 | |
| 1989 | Legumes | 0.25 | 0.012 | 0.97 | 0.010 |
| 1990 | Legumes | 0.03 | | 0.47 | |
| 1991 | Legumes | 0.13 | | 0.30 | |
| 1993 | Legumes | 0.26 | 0.014 | 0.57 | 0.013 |
| 1994 | Legumes | 1.11 | 0.036 | 2.36 | 0.078 |
| 1995 | Legumes | 0.85 | 0.024 | 1.83 | 0.045 |
| 1996 | Legumes | 1.54 | 0.064 | 2.37 | 0.069 |
| 1997 | Legumes | 1.06 | 0.033 | 1.29 | 0.035 |
| 1998 | Legumes | 0.98 | 0.011 | 1.11 | 0.012 |
| 1999 | Legumes | 0.69 | 0.016 | 0.91 | 0.017 |
| 2000 | Legumes | 1.21 | 0.027 | 1.63 | 0.024 |
| 2001 | Legumes | 0.55 | 0.017 | 1.06 | 0.011 |
| 2002 | Legumes | 0.35 | 0.018 | 0.91 | 0.029 |

| Year | Guild Name | $\bar{x}$ Relative Cover (%) | $\bar{x}$ Relative Cover sd* | $\bar{x}$ Relative Frequency (%) | $\bar{x}$ Relative Frequency sd* |
|---|---|---|---|---|---|
| 2003 | Legumes | 0.52 | 0.016 | 0.81 | 0.014 |
| 2004 | Legumes | 2.20 | 0.032 | 2.41 | 0.034 |
| 2005 | Legumes | 1.08 | 0.021 | 1.24 | 0.029 |
| 1982 | Spring Forbs | 3.22 | 0.022 | 5.43 | 0.029 |
| 1984 | Spring Forbs | 4.97 | 0.051 | 6.44 | 0.052 |
| 1985 | Spring Forbs | 7.93 | 0.137 | 8.74 | 0.092 |
| 1987 | Spring Forbs | 3.44 | 0.094 | 5.45 | 0.107 |
| 1988 | Spring Forbs | 0.15 | 0.003 | 0.94 | 0.009 |
| 1989 | Spring Forbs | 1.56 | 0.050 | 2.50 | 0.059 |
| 1990 | Spring Forbs | 0.49 | 0.008 | 1.46 | 0.015 |
| 1991 | Spring Forbs | 0.79 | 0.012 | 2.24 | 0.028 |
| 1992 | Spring Forbs | 0.23 | 0.003 | 1.07 | 0.008 |
| 1993 | Spring Forbs | 7.55 | 0.214 | 6.02 | 0.140 |
| 1994 | Spring Forbs | 10.28 | 0.202 | 10.9 | 0.183 |
| 1995 | Spring Forbs | 10.13 | 0.198 | 7.18 | 0.117 |
| 1996 | Spring Forbs | 1.47 | 0.025 | 2.42 | 0.034 |
| 1997 | Spring Forbs | 2.96 | 0.047 | 3.48 | 0.041 |
| 1998 | Spring Forbs | 2.64 | 0.047 | 3.80 | 0.057 |
| 1999 | Spring Forbs | 2.00 | 0.039 | 3.18 | 0.045 |
| 2000 | Spring Forbs | 4.09 | 0.088 | 6.00 | 0.094 |
| 2001 | Spring Forbs | 2.28 | 0.035 | 3.92 | 0.050 |
| 2002 | Spring Forbs | 2.32 | 0.027 | 4.42 | 0.039 |
| 2003 | Spring Forbs | 1.75 | 0.036 | 4.54 | 0.070 |
| 2004 | Spring Forbs | 5.18 | 0.113 | 6.34 | 0.088 |
| 2005 | Spring Forbs | 4.18 | 0.088 | 7.57 | 0.115 |
| 1982 | Summer/Fall Forbs | 7.50 | 0.077 | 13.00 | 0.089 |
| 1984 | Summer/Fall Forbs | 7.76 | 0.082 | 16.77 | 0.106 |
| 1985 | Summer/Fall Forbs | 13.32 | 0.160 | 17.68 | 0.120 |
| 1987 | Summer/Fall Forbs | 10.65 | 0.132 | 13.82 | 0.124 |
| 1988 | Summer/Fall Forbs | 11.67 | 0.135 | 14.84 | 0.145 |
| 1989 | Summer/Fall Forbs | 16.09 | 0.127 | 18.70 | 0.100 |
| 1990 | Summer/Fall Forbs | 22.70 | 0.152 | 24.18 | 0.109 |
| 1991 | Summer/Fall Forbs | 30.52 | 0.214 | 32.17 | 0.139 |
| 1992 | Summer/Fall Forbs | 30.61 | 0.166 | 35.33 | 0.088 |
| 1993 | Summer/Fall Forbs | 32.68 | 0.116 | 36.46 | 0.065 |
| 1994 | Summer/Fall Forbs | 38.58 | 0.173 | 37.80 | 0.151 |
| 1995 | Summer/Fall Forbs | 37.94 | 0.195 | 38.58 | 0.127 |
| 1996 | Summer/Fall Forbs | 46.31 | 0.145 | 44.90 | 0.100 |
| 1997 | Summer/Fall Forbs | 47.63 | 0.189 | 46.22 | 0.144 |
| 1998 | Summer/Fall Forbs | 48.44 | 0.170 | 48.17 | 0.129 |
| 1999 | Summer/Fall Forbs | 50.54 | 0.176 | 48.33 | 0.145 |
| 2000 | Summer/Fall Forbs | 47.63 | 0.143 | 47.74 | 0.096 |
| 2001 | Summer/Fall Forbs | 45.98 | 0.254 | 48.77 | 0.188 |
| 2002 | Summer/Fall Forbs | 45.27 | 0.241 | 49.11 | 0.170 |
| 2003 | Summer/Fall Forbs | 42.88 | 0.248 | 47.96 | 0.166 |
| 2004 | Summer/Fall Forbs | 42.59 | 0.192 | 45.56 | 0.152 |

| Year | Guild Name | $\bar{x}$ Relative Cover (%) | $\bar{x}$ Relative Cover sd* | $\bar{x}$ Relative Frequency (%) | $\bar{x}$ Relative Frequency sd* |
|---|---|---|---|---|---|
| 2005 | Summer/Fall Forbs | 47.19 | 0.190 | 45.86 | 0.126 |
| 1982 | Warm-Season Grasses | 84.98 | 0.067 | 63.66 | 0.121 |
| 1984 | Warm-Season Grasses | 68.21 | 0.279 | 53.74 | 0.193 |
| 1985 | Warm-Season Grasses | 68.75 | 0.307 | 51.31 | 0.235 |
| 1987 | Warm-Season Grasses | 82.09 | 0.126 | 71.89 | 0.100 |
| 1988 | Warm-Season Grasses | 80.40 | 0.121 | 69.77 | 0.133 |
| 1989 | Warm-Season Grasses | 75.43 | 0.120 | 67.02 | 0.104 |
| 1990 | Warm-Season Grasses | 71.53 | 0.147 | 60.44 | 0.100 |
| 1991 | Warm-Season Grasses | 63.95 | 0.222 | 51.35 | 0.129 |
| 1992 | Warm-Season Grasses | 62.60 | 0.185 | 51.59 | 0.143 |
| 1993 | Warm-Season Grasses | 51.46 | 0.260 | 40.60 | 0.199 |
| 1994 | Warm-Season Grasses | 45.15 | 0.253 | 41.84 | 0.231 |
| 1995 | Warm-Season Grasses | 38.17 | 0.229 | 36.14 | 0.193 |
| 1996 | Warm-Season Grasses | 38.73 | 0.186 | 37.39 | 0.165 |
| 1997 | Warm-Season Grasses | 43.92 | 0.206 | 41.48 | 0.177 |
| 1998 | Warm-Season Grasses | 44.05 | 0.155 | 39.16 | 0.123 |
| 1999 | Warm-Season Grasses | 42.02 | 0.212 | 39.08 | 0.183 |
| 2000 | Warm-Season Grasses | 42.38 | 0.204 | 34.75 | 0.149 |
| 2001 | Warm-Season Grasses | 48.83 | 0.150 | 40.24 | 0.104 |
| 2002 | Warm-Season Grasses | 47.72 | 0.203 | 36.45 | 0.140 |
| 2003 | Warm-Season Grasses | 52.53 | 0.106 | 40.64 | 0.097 |
| 2004 | Warm-Season Grasses | 46.65 | 0.113 | 37.89 | 0.080 |
| 2005 | Warm-Season Grasses | 43.64 | 0.182 | 37.87 | 0.127 |
| 1984 | Woody Species | 0.45 | 0.018 | 1.03 | 0.028 |
| 1985 | Woody Species | 0.09 | | 0.19 | |
| 1987 | Woody Species | 1.27 | 0.007 | 1.08 | 0.014 |
| 1988 | Woody Species | 1.83 | 0.006 | 1.96 | 0.000 |
| 1989 | Woody Species | 2.87 | 0.029 | 4.02 | 0.050 |
| 1990 | Woody Species | 2.49 | 0.041 | 4.02 | 0.047 |
| 1991 | Woody Species | 0.73 | 0.011 | 2.01 | 0.035 |
| 1992 | Woody Species | 2.79 | 0.039 | 2.66 | 0.032 |
| 1993 | Woody Species | 1.23 | 0.004 | 1.80 | 0.032 |
| 1994 | Woody Species | 1.16 | 0.001 | 1.06 | 0.043 |
| 1995 | Woody Species | 1.39 | 0.015 | 1.58 | 0.027 |
| 1996 | Woody Species | 1.32 | 0.025 | 1.68 | 0.027 |
| 1997 | Woody Species | 1.11 | 0.018 | 1.12 | 0.018 |
| 1998 | Woody Species | 0.81 | 0.017 | 1.62 | 0.029 |
| 1999 | Woody Species | 0.60 | 0.021 | 1.29 | 0.022 |
| 2000 | Woody Species | 0.30 | 0.014 | 0.76 | 0.019 |
| 2001 | Woody Species | 0.62 | 0.012 | 1.34 | 0.020 |
| 2002 | Woody Species | 0.71 | 0.019 | 0.81 | 0.013 |
| 2003 | Woody Species | 0.61 | 0.015 | 1.14 | 0.017 |
| 2004 | Woody Species | 0.97 | 0.038 | 1.18 | 0.031 |
| 2005 | Woody Species | 0.44 | 0.003 | 0.89 | 0.004 |

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 Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS D-58, September 2007

National Park Service
U.S. Department of the Interior

Natural Resource Program Center

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