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ABSTRACT

This study involved a vegetation analysis of 15 permanent plots established on the short-grass and mixed grass prairie slopes at the Cedar Point Biological Station in Keith County, Nebraska. Ninety-nine species were found in the plots, including members of 75 genera and 31 families. Twenty-one were graminoids, 71 were forbs or succulents, 6 were shrubs and one was a tree. *Bouteloua gracilis* (19 % cover) and *Carex filifolia* (15 % cover) were the dominant graminoids at the site, while *Yucca glauca* (1% cover) and *Artemisia frigida* (1% cover) were the most frequent forbs. Comparisons of species richness by slope categories showed no significant differences.

† † †

The Nebraska short-grass and mixed-grass prairie mosaic occurs throughout the panhandle and eastward to Dawes County where it meets the mixed-grass prairie (Kaul and Rolfsmeier 1993). The mosaic system is a mixture of short-grass prairie on the more xeric, upland or south facing slopes and can be dominated by *Bouteloua gracilis*, *Bouteloua hirsuta*, *Andropogon scoparius*, *Carex filifolia*, and *Buchloë dactyloides* (Kaul and Rolfsmeier 1993). Mixed-grass prairie occurs on more mesic sites and low areas and can be dominated by *Bouteloua gracilis*, *Stipa comata*, *Artemisia filifolia*, and *Agropyron smithii*. The Cedar Point Biological Station (CPBS) has a climate typical of the High Plains with cold winters and hot summers (Scheinost 1995). The average first frost occurs in September and the last in May. Most of the land at CPBS is untilled prairie although some of the property is former cropland seeded with native species (Kaul et al. 1983). The canyons at CPBS are often rocky and lined with *Juniperus virginiana*, which gives way to mixed-grass prairie on the slopes and short-grass prairie on the hilltops. This survey was meant to be the initial step of a long term monitoring program of vegetation at the Cedar Point Biological Station.

METHODS

Study site

The study site (Fig. 1) was located at the Cedar Point Biological Research Station on the south shore of Lake Ogallala in Keith County, Nebraska (W 101° 38′ 36″, N 41° 12′ 5″). The station, operated by the School of Biological Sciences, University of Nebraska–Lincoln since beginning operations in 1975, consists of 360 hectares of prairie dissected by dry canyons and draws situated near the junction of four grassland types: short-grass prairie, sand-sage prairie, sandhills prairie, and mixed-grass prairie (Kaul and Rolfsmeier 1993). Annual precipitation for the site averaged 47.3 cm for the period 1948 to 2004 (SNR-UNL 2005) although precipitation for the year of the study was 43.5 cm. Annual temperature for the years 1948 to 2004 was 10.4°C and the average temperature for the year of the study was 10.7°C. Thus the sampling was done in a year that was drier and hotter than normal. Soil types range from sand on the lowlands and hillsides to gravel on the hillsides and uplands. Loam is intermittently present throughout (Scheinost 1995).

Uplands of the site are dominated by gravely mixed-grass prairie (Fig. 2) and sandhills border mixed-grass prairie types (Fig. 3). The canyons are often rocky and lined with *Juniperus virginiana* on the slopes (Fig. 4) and occasional deciduous trees such as *Fraxinus pennsylvanica* and *Celtis occidentalis* on the canyon floor. An abandoned agricultural field, replanted with native prairie species, is situated along the southern border of the site. The prairie portion of the CPBS property was divided into two grazing sections, which were either grazed in the spring and early summer or the late summer and fall. At the time of this study, grazing had been alternated yearly in the two sections and had been leased to a private cattle owner.

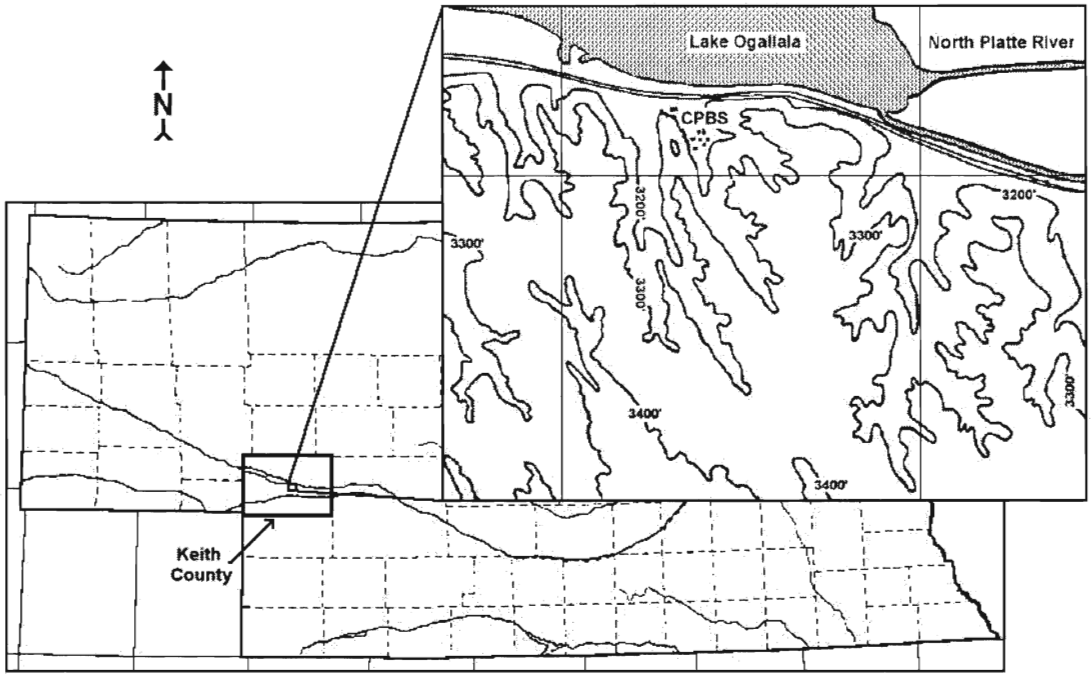

Figure 1. Map of Nebraska showing location of Keith County and the Cedar Point Biological Station. Plots are located to the south, west, and east of the CPBS buildings.

Figure 2. Top of plot M with showing gravely substrate and associated plants.

Figure 3. Top of plot N showing "sandhills" nature of some areas in the site.

Figure 4. Top of plot Q showing *Juniperus virginiana* on slopes and in draws.

Table 1. Latitude and longitude of plots.

Plot	Latitude	Longitude
A	N 41° 12′ 14.7″	W 101° 38′ 47.5″
AB	N 41° 12′ 12.7″	W 101° 38′ 41.4″
D	N 41° 12′ 7.7″	W 101° 38′ 38.5″
F	N 41° 12′ 4.6″	W 101° 38′ 26.9″
H	N 41° 12′ 2.4″	W 101° 38′ 12.2″
K	N 41° 12′ 9.5″	W 101° 38′ 21.2″
L	N 41° 11′ 53.8″	W 101° 38′ 46.1″
M	N 41° 11′ 58.5″	W 101° 38′ 45.4″
N	N 41° 12′ 5.8″	W 101° 39′ 2.5″
P	N 41° 12′ 12.1″	W 101° 39′ 5.4″
Q	N 41° 12′ 24.1″	W 101° 39′ 7.6″

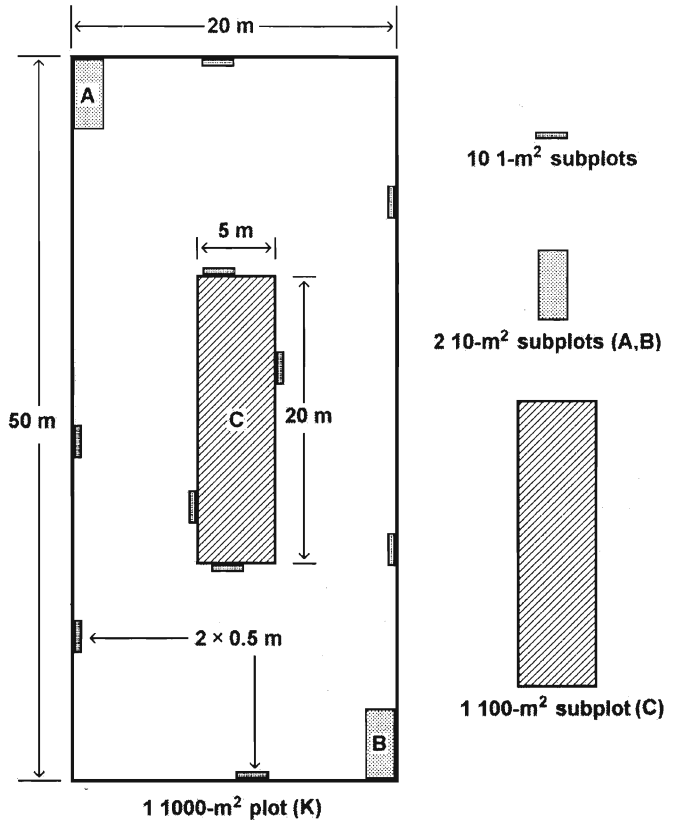

Figure 5. Modified Whittaker plot diagram (after Stohlgren et al. 1995). Map not to scale.

Field sampling

After randomly selecting 40 potential plots for evaluation, I selected fifteen that most efficiently allowed for sampling the topographic gradient that characterized the upland prairie portion of the site. These plots were selected to include each of the prairie types found at CPBS as well as hilltops and slopes. The corner of each plot was permanently marked with a metal pole and numbered tag and GPS coordinates were recorded (Table 1). All plots were set to cross the topographic gradient, and compass bearings were recorded. Plots were placed in one of the slope categories based on the average slope taken at the center of each plot: gentle (0–12°; 3 plots), moderate (13–24°; 9 plots), and steep (25–36°; 3 plots). A One-Way ANOVA test was used to compare species richness means. Much of the land covered by trees was deemed unsafe to sample because of cliffs or extremely steep slopes and was not sampled. Also not sampled were canyons, canyon bottoms, and riparian zones.

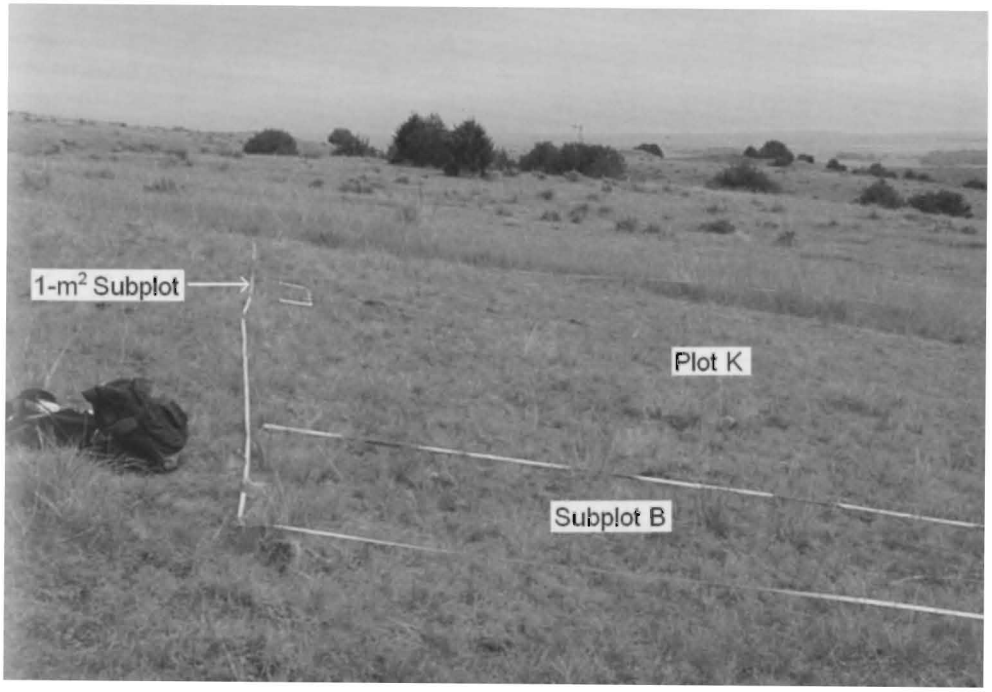

Figure 6. Plot K. Shows general topographic and vegetative appearance of gentle slope and top right corner of (K) plot, 10-m² subplot (B) and 1-m² subplot along top edge.

Each plot (Fig. 5) was organized as a modified-Whittaker nested plot (Stohlgren et al. 1995). The main plot (K) was 20 m × 50 m in size within which three different types of subplots were located (Fig. 6). Two 10-m² (2 m × 5 m) subplots (designated subplots A and B) were situated in opposite corners. A single 100-m² (5 m × 20 m) subplot, designated subplot C, was centered in the plot. In addition, ten 1-m² (0.5 m × 2 m) subplots (designated by their distance along the edge of the

plots K and C) were placed along the outer edges of plot K and subplot C following procedures described by Stohlgren et al. (1995).

Field sampling was conducted between 25 July 2002 and 11 August 2002. The ten 1-m^2 subplots were sampled first to minimize trampling inside the plot. The botanical composition of each 1-m^2 subplot was sampled for percent canopy cover by approximating 1% increments. The botanical composition of subplots A, B, C and plot K was sampled by recording the presence of any species not found in the 1 m^2 subplots. Species nomenclature followed Great Plains Flora Association (1986). Succulents and semi-succulents such as *Opuntia* species and *Yucca glauca* were assigned to the forb category. All non-living components including litter, sand/gravel, and feces were assigned to the abiotics category. Where field identification was not possible, specimens from outside the plot were collected and keyed or compared with specimens in the Cedar Point herbarium.

RESULTS AND DISCUSSION

A total of 99 species of vascular plants, representing 75 genera and 31 families, were identified in the study. Of these, twenty-one were graminoids, 71 were forbs or succulents, 6 were shrubs and one was a tree (Table 2). Grasses were the most abundant cover type with 48% overall cover while forbs had 6% overall cover (Table 3). Leaf litter (19% cover) and soil/sand (19% cover) were the most abundant abiotics in the site. Species richness for the slope categories gentle, moderate, and steep was 32, 39, and 38 species respectively, and these richness values were not significantly different (Table 4). There was greater percent cover in the graminoids but greater species richness in the forbs (71 species of forbs as opposed to 21 graminoid species). Species composition varied along the topographic gradient. *Bouteloua gracilis* (19% cover), *Carex filifolia* (15% cover), *Buchloë dactyloides* (5% cover), *Sporobolus cryptandrus* (5% cover), and *Stipa comata* (5% cover)

Table 2. Species list, including average percent cover per plot and growth habit. F = forb, G = graminoid, S = shrub. T = tree, X = not present in 1-m^2 subplots but found within main plot, dash = not present.

	Plot															
Species	**A**	**D**	**F**	**H**	**K**	**L**	**M**	**N**	**P**	**Q**	**T**	**X**	**Y**	**Z**	**AB**	**Habit**
Agropyron smithii	<1	<1	<1	-	-	2	-	1	2	-	-	-	-	-	-	G
Amaranthus albus	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	F
Amaranthus retroflexus	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	F
Ambrosia psilostachya	-	-	-	-	X	-	-	-	-	-	-	7	X	-	-	F
Amorpha canescens	-	-	-	-	-	-	<1	X	-	-	-	-	-	-	-	S
Andropogon scoparius	1	-	-	3	-	-	<1	-	4	X	X	1	X	-	-	G
Antennaria parvifolia	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F
Argemone polyanthemos	-	-	-	-	X	-	-	-	-	X	-	-	X	X	X	F
Aristida purpurea	1	X	X	<1	-	3	4	1	2	X	X	X	X	1	2	G
Artemisia campestris subsp, *caudata*	-	-	-	-	-	-	-	<1	-	-	-	-	-	-	-	F
Artemisia dracunculus	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	F
Artemisia filifolia	2	-	-	X	-	-	-	-	X	X	-	-	-	X	X	S
Artemisia frigida	3	X	X	X	-	2	4	<1	1	X	X	3	2	-	<1	F
Artemisia ludoviciana	-	-	-	-	-	X	-	-	-	-	-	X	-	-	X	F
Asclepias incarnata	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	F
Asclepias pumila	-	X	X	<1	-	-	-	X	<1	-	-	-	-	<1	-	F
Asclepias speciosa	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	F
Asclepias viridiflora	-	X	-	-	-	-	-	-	-	<1	-	-	-	-	-	F
Aster ericoides var. *commutatus*	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	F
Aster falcatus	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	F
Astragalus gracilis	-	-	-	-	-	-	-	-	-	-	<1	-	-	-	-	F
Astragalus mollissimus	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	F
Bouteloua curtipendula	5	1	1	14	-	-	2	4	2	5	X	-	4	7	X	G
Bouteloua gracilis	4	18	18	22	18	16	12	19	26	20	31	<1	40	20	14	G
Bouteloua hirsuta	<1	X	-	-	-	1	1	3	-	2	X	-	X	-	-	G
Bromus tectorum	-	-	-	-	-	8	-	X	-	-	-	-	-	-	-	G
Buchloë dactyloides	3	-	-	5	-	17	1	7	5	5	-	23	-	6	7	G
Calamovilfa longifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	X	<1	G
Calylophus serrulatus	X	X	X	X	-	-	2	<1	-	<1	X	X	X	-	<1	F
Carex filifolia	20	21	21	17	16	4	32	17	14	16	20	-	X	11	15	G

Table 2. Continued.

Species	Plot															
	A	D	F	H	K	L	M	N	P	Q	T	X	Y	Z	AB	Habit
Carex praegracilis	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	G
Chenopodium pratericola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	F
Chloris verticillata	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	G
Chrysopsis villosa	-	X	X	<1	-	<1	<1	X	X	-	-	-	-	-	-	F
Cirsium arvense	-	-	-	X	-	-	-	-	-	X	-	-	-	-	X	F
Cirsium undulatum	<1	X	X	X	X	-	X	1	X	X	-	X	<1	X	X	F
Cleome serrulata	-	X	-	-	-	X	-	-	-	-	-	-	-	X	-	F
Dalea candida var. *oligophylla*	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	F
Dalea enneandra	<1	X	X	X	-	<1	-	-	-	1	X	-	-	-	X	F
Dalea purpurea var. *arenicolaa*	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	F
Dichanthelium oligosanthes var. *scribnerianum*	-	-	-	-	-	-	-	X	-	-	-	-	-	-	1	G
Erysimum asperum	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	F
Euphorbia dentata	-	-	-	-	-	-	-	-	-	-	-	X	<1	-	-	F
Euphorbia glyptosperma	<1	X	X	-	8	2	-	X	X	<1	X	<1	<1	3	X	F
Euphorbia marginata	-	-	-	-	-	X	-	X	-	-	-	X	X	-	-	F
Evolvulus nuttallianus	-	-	-	-	-	<1	X	X	-	X	-	-	-	-	X	F
Gaura coccinea	X	X	X	<1	X	X	<1	<1	X	X	<1	X	-	X	<1	F
Grindelia squarrosa	-	-	-	-	-	-	-	-	-	-	-	<1	-	-	-	F
Gutierrezia sarothrae	-	-	-	-	-	-	-	-	-	-	<1	-	X	-	-	F
Haplopappus spinulosus	-	-	-	X	X	<1	<1	-	X	<1	-	-	X	X	<1	F
Helianthus annuus	-	-	-	-	-	-	-	-	-	X	X	-	-	X	-	F
Helianthus petiolaris	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	F
Hymenopappus tenuifolius	<1	X	X	-	-	<1	X	<1	<1	X	-	X	X	-	<1	F
Ipomoea leptophylla	-	-	-	-	X	X	X	X	X	-	X	-	-	-	1	F
Juniperus virginiana	3	-	-	X	-	-	X	-	X	-	-	-	10	-	-	T
Kochia scoparia	-	-	-	-	-	-	-	-	-	-	-	<1	X	-	-	F
Koeleria pyramidata	-	-	-	2	-	-	-	-	<1	<1	-	<1	-	-	-	G
Kuhnia eupatorioides	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	F
Lesquerella ludoviciana	-	-	-	-	-	-	<1	-	-	-	-	-	-	-	-	F
Liatris punctata	-	<1	<1	X	<1	<1	X	<1	X	X	<1	-	-	<1	X	F
Lithospermum incisum	X	-	-	-	-	-	-	X	-	-	-	-	-	-	X	F
Lygodesmia juncea	<1	<1	<1	<1	<1	X	<1	2	<1	<1	<1	-	-	X	X	F
Mentzelia nuda	-	-	-	-	-	X	X	X	-	-	-	-	-	-	X	F
Mirabilis linearis	-	X	X	X	<1	<1	-	<1	-	X	<1	-	<1	-	X	F
Monarda pectinata	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	F
Muhlenbergia cuspidata	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	G
Opuntia fragilis	X	X	X	X	X	<1	<1	<1	X	<1	<1	-	-	X	<1	F
Opuntia macrorhiza	-	X	X	X	<1	X	X	X	<1	X	<1	X	X	X	<1	F
Opuntia polyacantha	<1	-	-	-	X	-	-	-	-	X	X	-	X	-	-	F
Oryzopsis micrantha	-	-	-	-	-	-	X	-	1	-	-	-	<1	-	-	G
Panicum capillare	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	G
Penstemon albidus	X	-	-	<1	-	-	-		-	X	X	-	X	-	X	F
Physalis heterophylla	-	3	3	X	X	X	-	-	-	-	-	-	-	-	X	F
Physalis virginiana	-	X	X	-	1	-	-	X	-	X	X	X	<1	<1	X	F
Polygala alba	-	-	-	X	-	-	-		-	-	-	-	-	-	-	F
Psoralea argophylla	-	X	X	-	<1	X	-	X	X	X	X	-	X	X	<1	F
Psoralea tenuiflora	X	<1	<1	X	X	X	1	<1	X	X	X	-	X	-	<1	F
Ratibida columnifera	-	-	-	-	X	<1	X	X	X	-	-	X	X	X	<1	F
Rhus aromatica	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	S
Rosa arkansana	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	S
Salsola iberica	-	-	-	-	-	-	-	-	-	-	X	-	14	-	-	F
Scirpus pungens	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	G
Senecio plattensis	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F
Sitanion hystrix	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	G

Table 2. Continued.

Species	Plot															
	A	D	F	H	K	L	M	N	P	Q	T	X	Y	Z	AB	Habit
Solanum rostratum	-	X	X	-	X	X	-	X	X	X	X	-	<1	X	X	F
Solidago mollis	-	-	-	-	-	X	-	-	X	-	-	-	-	2	2	F
Sphaeralcea coccinea	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	<1	<1	1	F
Sporobolus cryptandrus	<1	8	8	<1	10	4	X	6	X	5	5	7	10	6	5	G
Stipa comata	1	9	9	7	4	X	4	10	8	8	7	-	-	3	1	G
Symphoricarpos occidentalis	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	S
Taraxacum officinale	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	F
Thelesperma megapotamicum	-	<1	<1	-	X	1	<1	<1	<1	<1	-	X	<1	-	<1	F
Toxicodendron rydbergii	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	S
Tradescantia occidentalis	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F
Tragopogon dubius	-	-	-	<1	-	-	-	X	-	X	-	-	-	-	-	F
Tribulus terrestris	-	-	-	-	-	-	-	-	-	-	-	X	<1	-	-	F
Verbena bracteata	-	-	-	-	-	-	-	-	-	-	-	<1	-	-	-	F
Verbena stricta	-	-	-	X	-	-	-	-	-	-	X	X	X	X	X	F
Yucca glauca	1	1	X	2	-	-	3	X	4	3	-	-	X	X	7	F

were the dominant graminoids across the site, while *Yucca glauca* (1% cover) and *Artemisia frigida* (1% cover) dominated the forbs. Trees did not appear in the analysis as a dominant land cover (<1%), but observation suggested that they were much more common on the rocky canyon slopes. Kaul et al. (1983) found similar species to be most dominant as determined by individual plant counts.

The total number of species found in my sampling was 99, while the total number of species from Cedar Point in the herbarium, which includes all habitats encountered at CPBS, was 318 and the number recorded in Keith County is 612 (Sutherland and Rolfsmeier 1989, Rolfsmeier et al. 1991). Stohlgren has shown that this sampling technique is very effective at capturing species richness at multiple spatial scales (Stohlgren 1995).

CONCLUSION

This project was meant to be the baseline survey of a long-term monitoring of the mixed-grass prairie at the Cedar Point Biological Station. Canyons, bottomlands and riparian zones at Cedar Point were places with large tree populations and were not included and

Table 3. Percent cover of most abundant prairie components with 1% cover or greater.

Prairie Component	Plot															Mean % Cover
	A	D	F	H	K	L	M	N	P	Q	T	X	Y	Z	AB	
Litter	6	12	16	20	40	29	17	32	15	10	11	13	6	36	27	19
Bouteloua gracilis	4	18	18	22	18	16	12	19	26	20	31	<1	40	20	14	19
Soil/Sand	36	14	20	5	12	6	12	10	19	33	29	46	15	11	13	19
Carex filifolia	20	21	21	17	16	4	32	17	14	16	20	-	-	11	15	15
Buchloë dactyloides	3	-	-	5	-	17	1	7	5	5	-	23	-	6	7	5
Standing dead	5	7	10	7	2	10	9	3	4	4	5	1	5	4	3	5
Sporobolus cryptandrus	<1	8	8	<1	10	4	-	6	-	5	5	7	10	6	5	5
Stipa comata	1	9	9	7	4	-	4	10	8	8	7	-	-	3	1	5
Gravel	8	11	3	-	-	19	19	2	<1	-	-	2	2	-	1	5
Bouteloua curtipendula	5	1	1	14	-	-	2	4	2	5	-	-	4	7	-	3
Feces	1	<1	7	1	4	1	<1	<1	1	2	1	1	2	3	2	2
Yucca glauca	1	1	-	2	-	-	3	-	4	3	-	-	-	-	7	1
Artemisia frigida	3	-	-	-	-	2	4	<1	1	-	-	3	2	-	<1	1

Table 4. One-way ANOVA of slope categories.

One-way ANOVA: 0-12%, 13-24%, 25-36%

Source	DF	SS	MS	F	P
Factor	2	76.7	38.4	1.70	0.223
Error	12	270.2	22.5		
Total	14	346.9			

$S = 4.745$, *R-Sq* = 22.11%, *R-Sq(adj)* = 9.13%

need to be sampled in the future. Many of the questions regarding changes in species composition that could not be answered are time-dependant and will be answered in years to come. Projects such as this one can be used by land managers and conservation biologists who are interested in species fluctuations in diversity and abundance through time. Further studies should incorporate grazing as a disturbance factor, as it is a major part of this station's management. The raw data for this study can be obtained by contacting the author or the Environmental Studies-Biology emphasis advisor at University of Nebraska-Lincoln.

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