5-1-1993

Plant Species Distribution Along Topographic Gradients in Tallgrass Prairies of Eastern Nebraska.

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Plant Species Distribution Along Topographic Gradients in Tallgrass Prairies of Eastern Nebraska.

A Thesis

Presented to the

Department of Biology

and the

Faculty of the Graduate College

University of Nebraska

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

University of Nebraska at Omaha

by

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May 1993

THESIS ACCEPTANCE

Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts, University of Nebraska at Omaha.

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Acknowledgements

I would like to express my appreciation to Dr. Thomas B. Bragg for general assistance in completion of my thesis research, Ann Antlfinger for assistance in experimental design and statistical analysis, David M. Sutherland for assistance in computer graphics, and Mr. Frank Hartranft for assistance in computer use.

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Abstract

Plant species composition was evaluated along a slope gradient in two native tallgrass prairies of eastern Nebraska. Forb cover differed significantly ($P < 0.05$) along the topographic gradient at both sites, however, grass cover differed only at one site ($P < 0.05$). A site-by-site comparison by topographic location indicates significant differences between lower slopes for grass and between upper slopes for forbs. Big bluestem (*Andropogon gerardii* Vitman) dominated all topographic locations at both sites (average cover = 64%) with no significant differences in the topographic distribution. Kentucky bluegrass (*Poa pratensis* L.), little bluestem (*Andropogon scoparius* Michx.), false boneset (*Kuhnia eupatorioides* L.), prairie wild rose (*Rosa arkansana* Porter), prairie violet (*Viola pedatifida* G. Don), and sedge (*Carex* L. spp.) also showed no significant topographic preference at either site. Mid-slope locations contained the greatest number of species that differed significantly along the topographic gradient. Leadplant (*Amorpha canescens* Pursh) and indiangrass (*Sorghastrum nutans* (L.) Nash) were the two most common species showing high canopy cover values in mid-slope locations at both sites. Significant topographic distributions were also noted for scouring rush (*Equisetum laevigatum* A. Br.) at both sites and for finger coreopsis (*Coreopsis palmata* Nutt.) found at only one site. Flowering spurge (*Euphorbia corollata* L.) and sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) were significantly higher on the hilltop locations of one site.

Introduction

The tallgrass or bluestem prairie (*Andropogon-Panicum-Sorghastrum*; Küchler 1964), was once an extensive ecosystem dominating the eastern portion of the prairie region of central North America. Within the tallgrass prairie region there is considerable latitudinal variability in species composition (for example, see White and Glenn-Lewin 1984 and Umbanhowar 1992). In addition, within this broad-scale heterogeneity there is also variability such as that resulting from slope angle (Umbanhowar 1992) that affects soil moisture and that is an important correlate of compositional variation (White and Glenn-Lewin 1984). Additional local heterogeneity, such as those resulting from different soil, climatic, and biotic processes result in a heterogeneity that is often recorded over gradients of only a few centimeters and that suggesting different histories of plant establishment. Such diversity has been associated with factors such as soil moisture, soil texture, nutrient composition (especially phosphorus, nitrogen, calcium and sodium), and salinity (Curtis 1955, Dix and Butler 1960, Partch 1962, Bliss and Cox 1964, Dix and Butler 1960, Dix and Smeins 1967, Ungar 1970, Redmann 1972, Barnes and Harrison 1982, Barnes et al. 1983, Nelson and Anderson 1983, Archer 1984, Polley and Collins 1984, Polley and Wallace 1986, Tatina 1987, Schimel et al. 1991, Umbanhowar 1992).

Abiotic gradients resulting from regional and local heterogeneity have been correlated with various plant gradients. Partch (1962) and Umbanhowar (1992), for example, found considerable variation in local plant distribution in Wisconsin due to the great range in water-holding capabilities of soils. Some species like tall cinquefoil (*Potentilla arguta* Pursh) were found in more xeric sites while others, like indiangrass (*Sorghastrum nutans* (L.) Nash) were found in more mesic areas. Other species, such as big and little bluestem (*Andropogon gerardii* Vitman.

and *A. scoparius* Michx.), prairie phlox (*Phlox pilosa* L.), and the non-native Kentucky bluegrass (*Poa pratensis* L.) were found in all soil moisture classes except those lowland or wet areas where moisture was highest. In these areas, sedges (*Carex* L. spp.), and switchgrass (*Panicum virgatum* L.) were most prevalent. Similar species distributions for some of the same species were noted by White and Glenn-Lewin (1984).

The present study examines a gradient from upland to lowland in an eastern Nebraska tallgrass prairie in order to identify any relationship between slope-location and plant species composition. While soil moisture was not measured due to 1992 being a wet year, slope locations were considered to represent a soil moisture gradient as suggest in several studies including those by Tolstead (1942), Barnes and Harrison (1982), Abrams and Hulbert (1987), and Tatina (1987).

Methods

Study Sites

The study was conducted at two native, tallgrass prairies located approximately 16 km. west of Omaha in Douglas County, Nebraska: Stolley Prairie, a 10 ha site, and Bauermeister Prairie, a 12.5 ha site. These prairies are two of the largest tallgrass prairie remnants in the Omaha area. Both sites are maintained using prescribed fire but neither site had been burned for two growing seasons prior to this study. Species descriptions of these sites by Boettcher and Bragg (1989) and Bragg (1991) address general composition but do not evaluate within- or between-site gradients.

Stolley prairie (NW1/4, Section 15, Township 15N, Range 11E), privately owned by

William Stolley, is situated approximately 6 km. north of Bauermeister Prairie (NE1/4, W1/2, Section 3, Township 14N, Range 11E). Bauermeister Prairie is presently owned the City of Omaha and is located on one of the recreational dam sites. Elevations at Bauermeister Prairie range from a hilltop location of 358m to a lower slope at 340m above mean sea level. Those at Stolley Prairie range from an upper slope varying from 354-360m to a lower slope at 341m.

Monthly temperatures for the region average from -6C in January to 24C in July. Precipitation from 1961 to 1990 averaged 75 cm. annually, with most occurring from May through September (National Oceanic and Atmospheric Administration 1990). Neither site has a history of grazing by cattle. General soils of the study area are *Typic Hapludolls* of the *Mollisol* soil order. At Stolley Prairie, soils are of the Marshall silty clay loam soil series while those at Bauermeister Prairie belong to the Marshall and Ponca silty clay loam soil series (Bartlett 1975).

Vegetative Analysis:

At each site, three principal, east-west transects were established that extended from hilltop (Bauermeister Prairie) or upper-slope (Stolley Prairie) locations to lower-slope locations. These transects were systematically located on east-facing slopes, the only topographic setting found at both sites. The transects were labelled from A (north) to C (south). Five points were equally spaced along each of the three principal transects representing five points along a topographic gradient. Twenty-meter-long subtransects were established at right angles to the main transect at each of the five points. These subtransects, referred to as topographic locations in this study, were numbered from 1 (hilltop or upper-slope) to 5 (lower-slope). Along each 20m-subtransect, ten, 30 x 50 cm ($0.15m^2$) plots were systematically located. In each plot, canopy cover was evaluated by species and by total-grass and total-forb cover, using a modified Daubenmire (1959) canopy cover technique (Bragg 1991). Coverage categories used were: less than 1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-95%, 95-99%, and greater than 99%. The mid-point values for each cover category were used for analysis.

Species diversity is measured as Species Richness (S), a count of the number of species. Plant species were identified and verified at the University of Nebraska at Omaha (OMA) Herbarium. Species nomenclature is from the Great Plains Flora Association (1986). Plot sampling was conducted in August and September 1992.

Statistical Analysis

A non-parametric (NPAR1WAY procedure) (SAS Institute 1985) was used to analyze significant effects because the type of data used in this study were not normally distributed (Zar 1984). This procedure performs analysis of variance on rank scores of a response variable. Species occurring in less than two plots were not statistically analyzed. The *a priori* level of significance was set at $P=0.05$.

Results and Discussion:

General Results

Differences between the two sites included a slightly higher plant diversity at Stolley Prairie ($S=42$) than at Bauermeister Prairie ($S=38$) (Tables I and II). In addition, total grass cover along the topographic gradient differed significantly ($P<0.05$) at Bauermeister but not at Stolley

Prairie. Forb cover, however, which differed significantly along the topographic gradient at both sites (Table III), was generally higher in mid-slope (topographic location 2-4) than on hilltop, upper, or lower slopes (Fig. 1, Table IV). These results differ from those of a study on both sites by Boettcher (1989) in which grass and forb cover were lowest on hilltops. Boettcher's study, however, was not designed to assess a topographic gradient. The results of the present study suggest a general gradient in grasses and forbs but one that, in the absence of a clear upland-to-lowland gradient, may not be solely related to soil moisture.

A site-by-site comparison by topographic location indicates significant differences ($P < 0.05$) between lower-slopes (topographic locations 3-5) for grass and between upper slopes (topographic location 1) for forbs (Table IV). These results suggest some basic differences between the two sites evaluated, a conclusion also reached by Hickey (1992). More importantly, these results emphasize the need for adequate site replication in studies, even those on such broad, vegetative characteristics as grasses and forbs.

Species Gradients

Big bluestem dominated all topographic locations at both Stolley Prairie (average cover = 69%) and Bauermeister Prairie (59%) (Tables I and II). Differences between the sites, however, were significant ($P < 0.05$) only for mid-slope locations (topographic locations 2-4) (Fig. 2, Table IV). No significant differences in the topographic distribution of big bluestem were noted for either site (Table III), a result previously reported by Abrams and Hulbert (1987). Other species also showing no significant topographic distributions at either site included Kentucky bluegrass, little bluestem, false boneset (*Kuhnia eupatorioides* L.), prairie wild rose (*Rosa arkansana* Porter), prairie violet (*Viola pedatifida* G. Don), and sedge. The lack of topographic

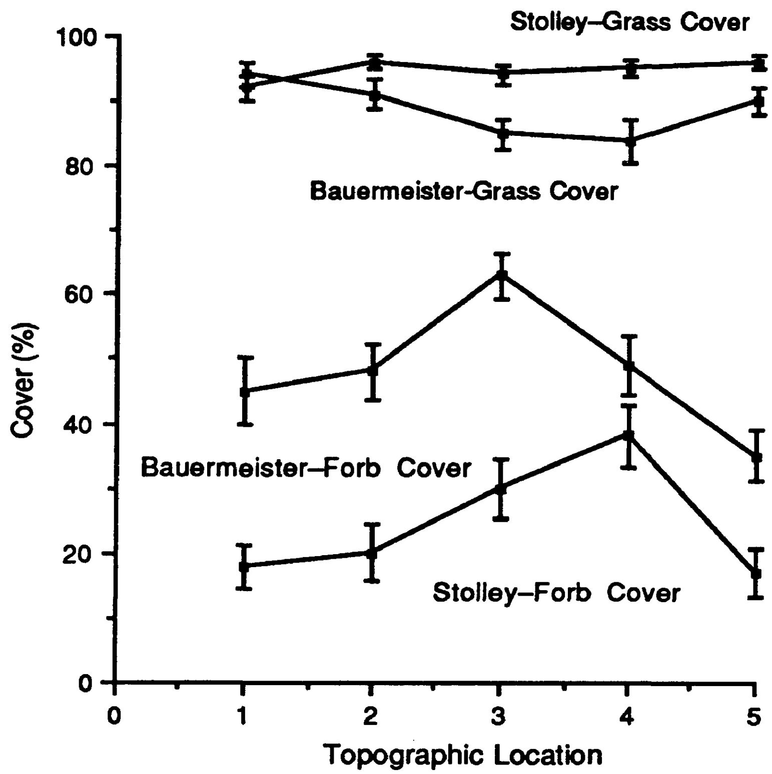

Fig. 1. Grass and forb canopy cover from hilltop (Topographic Location 1) to lowlands (Topographic Location 5) at Stolley and Bauermeister Prairies. Vertical lines are Standard Error bars.

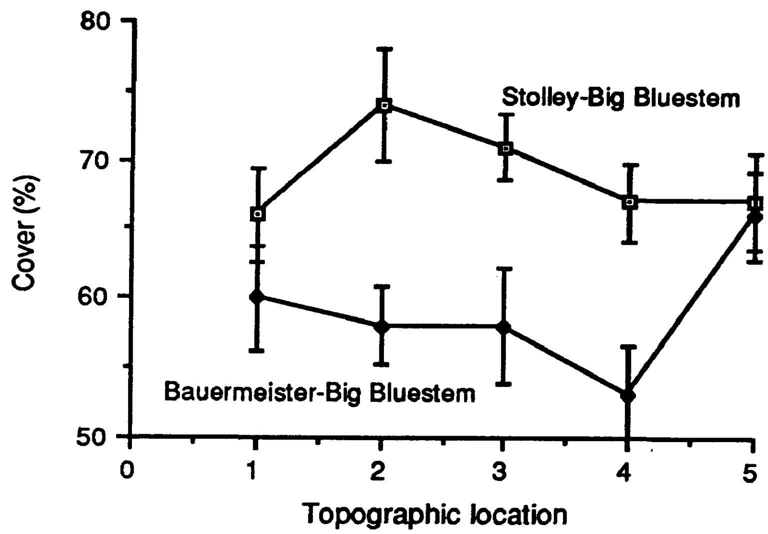

Fig. 2. Canopy cover of big bluestem from hilltop (Topographic Location 1) to lowlands (Topographic Location 5) at Stolley and Bauermeister Prairies. Vertical lines are Standard Error bars.

effect on the distribution of Kentucky bluegrass and little bluestem is the same as reported by Abrams and Hulbert (1987). Black-eyed susan (*Rudbeckia hirta* L.) differed significantly along the topographic gradients ($P < 0.10$ and $P < 0.05$) but no pattern was apparent (Table IV). This result is not surprising given the annual nature of the species and its tendency to become established in areas of bare soil.

Other species, however, were consistent in showing patterns of topographic distribution. Leadplant (*Amorpha canescens* Pursh), smooth brome (*Bromus inermis* Leyss. spp. *inermis*), scouring rush (*Equisetum laevigatum* A. Br.), and indiangrass were the only species to show significant ($P < 0.05$) topographic distributions at both sites. Species with statistically significant ($P < 0.05$) topographic distributions, but only at one site included white aster (*Aster ericoides* L.), Scribner dichanthelium (*Dichanthelium oligosanthes* (Schult.) Gould var. *scribnerianum* (Nash) Gould), flowering spurge (*Euphorbia corollata* L.), stiff sunflower (*Helianthus rigidus* (Cass.) Desf.), and switchgrass at Stolley and whorled milkweed (*Asclepias verticillata* L.), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), finger coreopsis (*Coreopsis palmata* Nutt.), false sunflower (*Heliopsis helianthoides* (L.) Sweet var. *scabra* (Dun.) Fern.), prairie phlox, black-eyed susan, and prairie goldenrod (*Solidago missouriensis* Nutt.) at Bauermeister Prairie (Table III). Of the species with statistically significant topographic distributions, flowering spurge at Stolley Prairie (Fig. 3) and sideoats grama at Bauermeister Prairie were significantly higher on hilltops or uplands (topographic locations 1-2) (Table III). No species showed this topographic distribution at both sites. For each of these species, the highest cover on the replicate site also occurred on hilltops although the statistical differences along the topographic gradient were not significant. Prairie phlox at Bauermeister Prairie was also significantly higher on hilltops although there were too few

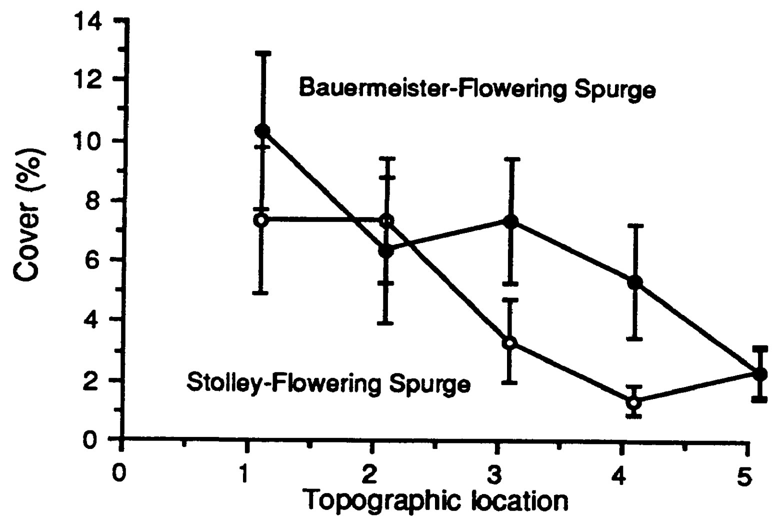

Fig. 3. Canopy cover of flowering spurge showing a decline from hilltop (Topographic Location 1) to lowland (Topographic Location 5) at Stolley and Bauermeister Prairies. Vertical lines are Standard Error bars.

plants from Stolley Prairie for a statistical comparison.

Mid-slope locations (topographic locations 2-4) contained the greatest number of species that differed significantly at one or both sites (Tables I and II). Leadplant was the only species with a similar, significant topographic distribution occurring at both sites (Fig. 4). Indiangrass also showed significant topographic distributions at both sites. This species' canopy cover was highest on upper- and mid-slope locations although there were significant, between-site differences in hilltop and upland (topographic locations 1-2) and slope (topographic location 5) locations. Abrams and Hulbert (1987), however, observed that neither leadplant nor indiangrass were significantly affected by topographic location although they only considered hilltop and lowland settings.

A significant pattern of topographic distribution, although only at one site, was also recorded for eight other species. Of these, those with the highest canopy cover on mid-slope locations were whorled milkweed, white aster, Scribner dichanthelium, stiff sunflower, and switchgrass at Stolley Prairie and false sunflower and prairie goldenrod at Bauermeister Prairie. All but false sunflower and Scribner dichanthelium were found also to have the highest average canopy cover on mid-slope locations at the other, replicate site although there was no significant difference detected along the topographic gradient (Table III). Abrams and Hulbert (1987), however, reported that white aster was not significantly affected by topographic location although they only contrasted an upland with a lowland setting and did not evaluate slope locations. Switchgrass, usually a species of more mesic habitats (e.g. see Partch, 1962), was uncommon at Stolley Prairie occurring only in a swale on the slope evaluated. Cover of this species is normally highest in lowland settings (Abrams and Hulbert 1987).

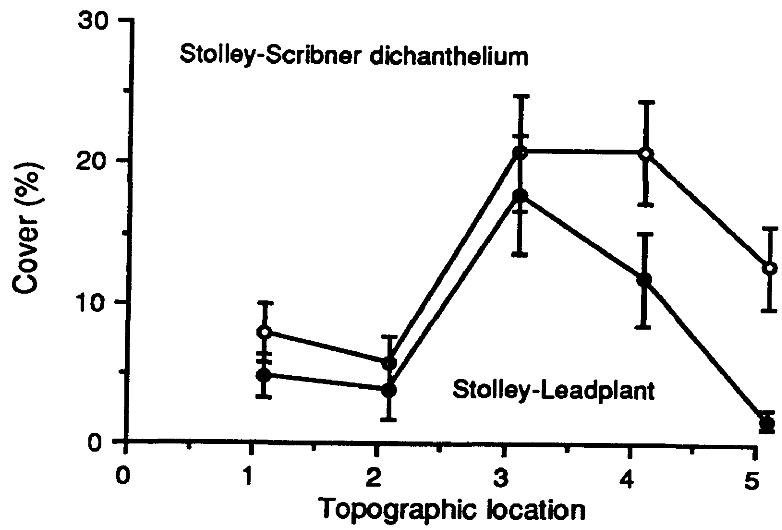

Fig. 4. Canopy cover of Scribner dichanthelium and leadplant at Stolley Prairie showing maximum cover at mid-slope locations. Hilltop = Topographic Location 1, Lowland - Topographic Location 5. Vertical lines are Standard Error bars.

Species whose topographic distributions were significant at both sites and which were highest in canopy cover in the lower-slope (topographic location 5) were scouring rush, found at both sites, and finger coreopsis, found only at Bauermeister Prairie. However, much of the truly lowland habitat has been lost, at Stolley Prairie, to cultivation, and at Bauermeister Prairie, to inundation resulting from construction of a flood-control dam.

Conclusions drawn from species data are similar to those for the general vegetative categories (grass and forb). The lack of a gradient from upland to lowland, shown in other studies to represent a moisture gradient, suggests basic differences between the two sites that does not solely represent a distribution based on soil moisture. Additionally, the data suggest some basic differences between the two sites that emphasizes the need for adequate site replication in grassland studies, whether the study be focussed at micro-scale or macro-scale events.

Table I. Species composition (canopy cover ± Standard Error) of Stolley Prairie by species and topographic location. tr = <0.05% cover.

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
STOLLEY PRAIRIE (SITE 1)					
Total grass	92 ± 1.8	96 ± 1.0	94 ± 1.6	95 ± 1.1	96 ± 1.0
Total Forb	18 ± 3.3	20 ± 4.3	30 ± 4.6	38 ± 4.6	17 ± 3.8
Species Richness	25	23	25	28	22
GRASS AND GRASS-LIKE:					
big bluestem (*Andropogon gerardii* Vitman)	66 ± 3.4	74 ± 4.0	71 ± 2.4	67 ± 2.8	67 ± 3.5
little bluestem (*Andropogon scoparius* Michx.)	3 ± 1.4	1 ± 0.5	2 ± 0.8	0.5 ± 0.2	2 ± 1.3
sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.)	1 ± 0.7	tr	tr	0.8 ± 0.5	2 ± 1.3
smooth brome (*Bromus inermis* Leyss. ssp. *inermis*)	38 ± 5.9	32 ± 5.3	18 ± 4.1	18 ± 4.6	53 ± 3.8
sedge (*Carex* spp.)	0.7 ± 0.51	2 ± 1.3	1 ± 0.5	1 ± 1.2	2 ± 0.8

Table I. Species composition (canopy cover ± Standard Error) of Stolley Prairie by species and topographic location. tr = <0.05% cover.

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	**2**	**3**	**4**	**5 lower-slope**
slimleaf dichanthelium (*Dichanthelium linearifolium* (Scribn.) Gould)	0	0	0	0	0
Scribner dichanthelium (*Dichanthelium oligosanthes* (Schult.) Gould var. *scribnerianum* (Nash) Gould)	7 ± 2.1	5 ± 1.9	20 ± 4.1	20 ± 3.6	12 ± 3.0
Canada wild rye (*Elymus canadensis* L.)	0	4 ± 3.8	0	0	0
muhly (*Muhlenbergia* sp.)	0	0	tr	0	0
switchgrass (*Panicum virgatum* L.)	0	3 ± 1.8	0	0	0
Kentucky bluegrass (*Poa pratensis* L.)	14 ± 1.8	15 ± 2.8	17 ± 2.2	20 ± 2.8	11 ± 1.8
green foxtail (*Setaria viridis* (L.) Beauv.)	2 ± 1.5	0	0	0	0
indiangrass (*Sorghastrum nutans* (L.) Nash)	7 ± 2.3	3 ± 1.0	16 ± 3.5	13 ± 3.1	4 ± 1.8
porcupine-grass (*Stipa spartea* Trin.)	0.5 ± 0.5	0	0	0	0.5 ± 0.5

Table I. Species composition (canopy cover ± Standard Error) of Stolley Prairie by species and topographic location. tr = <0.05% cover.

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
FORBS AND OTHER SPECIES					
yarrow (*Achillea millefolium* L.)	0	0	0	tr	0
common ragweed (*Ambrosia artemisiifolia* L.)	0	0	0	3 ± 2.0	0
leadplant (*Amorpha canescens* Pursh)	4 ± 1.6	3 ± 2.1	17 ± 4.2	11 ± 3.3	1 ± 0.7
common milkweed (*Asclepias syriaca* L.)	0	0	0	2 ± 2.1	0.5 ± 0.5
whorled milkweed (*Asclepias verticillata* L.)	0	0	0	0	0
white aster (*Aster ericoides* L.)	0.7 ± 0.51	1 ± 1.2	4 ± 2.9	14 ± 4.3	1 ± 0.7
smooth blue aster (*Aster laevis* L.)	0	0	0	0	0
hedge bindweed (*Calystegia sepium* (L.) R. Br. subsp. *angulata* Brummitt)	5 ± 2.3	0	0	6 ± 6.2	0

Table I. Species composition (canopy cover ± Standard Error) of Stolley Prairie by species and topographic location. tr = <0.05% cover.

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
tall thistle (*Cirsium altissimum* (L.) Spreng.)	0	2 ± 1.5	0	0	0
horse-weed (*Conyza canadensis* (L.) Cronq.)	1 ± 1.2	0	0.5 ± 0.5	tr	3 ± 1.4
finger coreopsis (*Coreopsis palmata* Nutt.)	0	0	0	0	0
white prairie clover (*Dalea candida* Michx. ex Willd.)	1 ± 1.3	0	0	0.5 ± 0.5	0
Illinois tickclover (*Desmodium illinoense* A. Gray)	0	0	0	0.6 ± 0.5	0
purple coneflower (*Echinacea angustifolia* DC.)	tr	0	tr	0	0
smooth scouring rush (*Equisetum laevigatum* A. Br.)	0	0.5 ± 0.5	tr	0	2 ± 0.8
flowering spurge (*Euphorbia corollata* L.)	7 ± 2.4	7 ± 2.1	3 ± 1.4	1 ± 0.5	2 ± 0.8
fire-on-the-mountain (*Euphorbia cyathophora* Murray)	1.0 ± 0.5	0	0	0	tr

Table I. Species composition (canopy cover ± Standard Error) of Stolley Prairie by species and topographic location. tr = <0.05% cover.

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
velvety gaura (*Gaura parviflora* Dougl.)	tr	0	0	0	0
stiff sunflower (*Helianthus rigidus* (Cass.) Desf.)	0	0	5 ± 3.1	7 ± 3.2	0
false sunflower (*Heliopsis helianthoides* (L.) Sweet var. *scabra* (Dun.) Fern.	6 ± 3.1	7 ± 3.1	5 ± 2.1	8 ± 2.1	8 ± 2.4
false boneset (*Kuhnia eupatorioides* L.)	0.5 ± 0.5	3 ± 1.7	0	1 ± 1.2	0
wild lettuce (*Lactuca* spp.)	tr	tr	tr	1 ± 1.2	0
round-head lespedeza (*Lespedeza capitata* Michx.)	0	0	0	0	0
evening primrose (*Oenothera* sp.)	0	0	0	0	0
common evening primrose (*Oenothera villosa* Thunb.)	0	0	tr	tr	0
gray-green wood sorrel (*Oxalis dillenii* Jacq.)	tr	0	tr	tr	0

Table I. Species composition (canopy cover ± Standard Error) of Stolley Prairie by species and topographic location. tr = <0.05% cover.

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	**2**	**3**	**4**	**5 lower-slope**
prairie phlox (*Phlox pilosa* L.)	tr	0	tr	tr	0
ground cherry (*Physalis* sp.)	0	0	0	0	0
clammy ground cherry (*Physalis heterophylla* Nees)	0	tr	2 ± 1.3	0	tr
tall cinquefoil (*Potentilla arguta* Pursh)	0	0	0	0	0
silver-leaf scurf-pea (*Psoralea argophylla* Pursh)	0	0	0	0	8 ± 5.0
grayhead prairie coneflower (*Ratibida pinnata* (Vent.) Barnh.)	0	0	0	0	0
smooth sumac (*Rhus glabra* L.)	0	0	0	0	0
prairie wild rose (*Rosa arkansana* Porter)	0	1 ± 0.8	0.5 ± 0.5	1 ± 1.2	1 ± 1.2
black-eyed susan (*Rudbeckia hirta* L.)	0	tr	0	0	0

Table I. Species composition (canopy cover $\pm$ Standard Error) of Stolley Prairie by species and topographic location. tr = $<0.05\%$ cover.

SPECIES	**TOPOGRAPHIC LOCATION**				
	1 hilltop	**2**	**3**	**4**	**5 lower-slope**
prairie goldenrod (*Solidago missouriensis* Nutt.)	0	7 ± 3.9	3 ± 1.8	4 ± 1.6	0.5 ± 0.5
western ironweed (*Vernonia baldwinii* Torr.)	0	0	0	0	0
prairie violet (*Viola pedatifida* G. Don)	1 ± 0.5	1 ± 0.5	1 ± 0.5	2 ± 0.7	1 ± 0.5

Table II. Species composition (canopy cover ± Standard Error) of Bauermeister Prairie by species and topographic location. For full scientific citation, see Table I. tr = <0.05%. cover

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
BAUERMEISTER PRAIRIE (SITE 2)					
Total grass	94 ± 1.8	91 ± 2.3	85 ± 2.3	84 ± 3.3	90 ± 2.1
Total Forb	45 ± 5.2	48 ± 4.3	63 ± 3.5	49 ± 4.5	35 ± 3.8
Species Richness	29	25	28	23	26
GRASS AND GRASS-LIKE:					
Andropogon gerardii	60 ± 3.8	58 ± 2.8	58 ± 4.1	53 ± 3.5	66 ± 3.2
Andropogon scoparius	7 ± 3.1	8 ± 2.4	2 ± 0.7	5 ± 1.9	3 ± 1.0
Bouteloua curtipendula	1 ± 0.7	tr	0	0	tr
Bromus inermis	5 ± 1.2	2 ± 1.3	1 ± 0.5	tr	2 ± 0.7
Carex spp.	12 ± 1.2	10 ± 1.6	11 ± 2.0	6 ± 1.3	10 ± 1.2
Dichanthelium linearifolium	0	0	0	0	tr
Dichanthelium oligosanthes	6 ± 2.2	3 ± 0.8	5 ± 1.5	3 ± 1.0	5 ± 1.0
Elymus canadensis	0	0	0	0	0
Muhlenbergia sp.	0	0	0	0	0
Panicum virgatum	0	0	0	0	0

Table II. Species composition (canopy cover ± Standard Error) of Bauermeister Prairie by species and topographic location. For full scientific citation, see Table I. tr = <0.05%. cover

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
Poa pratensis	10 ± 1.2	4 ± 1.1	7 ± 1.6	5 ± 1.4	6 ± 1.1
Setaria viridis	0	0	0	0	0
Sorghastrum nutans	14 ± 4.0	29 ± 3.2	14 ± 2.8	10 ± 2.6	10 ± 1.9
Stipa spartea	0	0	0	0	0
FORBS AND OTHER SPECIES					
Achillea millefolium	0	0	0	0	0
Ambrosia artemisiifolia	0	0	0	0	0
Amorpha canescens	3 ± 1.5	9 ± 2.8	4 ± 2.2	5 ± 1.9	tr
Asclepias syriaca	0	0	0	0	0
Asclepias verticillata	3 ± 1.0	3 ± 1.4	9 ± 2.3	1 ± 0.5	tr
Aster ericoides	4 ± 1.8	3 ± 1.1	6 ± 1.6	8 ± 1.9	4 ± 1.6
Aster laevis	0	0	0	0	0
Bouteloua curtipendula	1 ± 0.7	tr	0	0	tr
Cirsium altissimum	0	0	0	0	0
Calystegia sepium	0	0	0	0	0

Table II. Species composition (canopy cover ± Standard Error) of Bauermeister Prairie by species and topographic location. For full scientific citation, see Table I. tr = <0.05%. cover

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
Conyza canadensis	tr	tr	tr	1 ± 0.5	1 ± 0.2
Coreopsis palmata	0	1 ± .05	0	0	4 ± 2.1
Dalea Candida	tr	0	tr	0	0
Desmodium illinoense	0.5 ± 0.5	0	tr	1 ± 0.5	0
Echinacea angustifolia	0	0	0	0	1 ± 1.2
Equisetum Laevigatum	0	0		0	tr
Euphorbia corollata	10 ± 2.6	6 ± 2.4	7 ± 2.1	5 ± 1.9	2 ± 0.9
Euphorbia cyathophora	0	0	0	0	0
Gaura parviflora	0	0	0	0	0
Helianthus rigidus	5 ± 1.9	6 ± 2.9	10 ± 2.6	4 ± 1.5	6 ± 2.4
Heliopsis helianthoides	12 ± 3.0	11 ± 4.3	24 ± 4.2	23 ± 4.2	10 ± 2.6
Kuhnia eupatorioides	tr	0	1 ± 0.5	tr	0
Lactuca spp.	0	0	tr	tr	tr
Lespedeza capitata	0	0	0	4 ± 3.8	0
Oenothera sp.	tr	1 ± 0.5	tr	0	0
Oenothera villosa	1 ± 0.7	0	tr	0	0

Table II. Species composition (canopy cover ± Standard Error) of Bauermeister Prairie by species and topographic location. For full scientific citation, see Table I. tr = <0.05%. cover

SPECIES	TOPOGRAPHIC LOCATION				
	1 hilltop	2	3	4	5 lower-slope
Oxalis dillenii	tr	tr	tr	tr	tr
Panicum virgatum	0	0	0	0	0
Phlox pilosa	9 ± 3.7	tr	1 ± 0.5	1 ± 0.2	tr
Physalis heterophylla	1 ± 1.2	0	0	0	0
Potentilla arguta	1 ± .5	1 ± 0.7	2 ± 1.0	0	0
Physalis sp.	tr	1 ± 0.5	0	0	0
Psoralea argophylla	0	0	0	0	0
Ratibida pinnata	0	2 ± 1.5	0	0	0
Rhus glabra	0	tr	0	0	0
Rosa arkansana	0.5 ± 0.5	0	2 ± 0.8	0	tr
Rudbeckia hirta	3 ± 0.9	8 ± 2.4	5 ± 1.9	4 ± 1.5	12 ± 3.1
Solidago missouriensis	3 ± 1.8	4 ± 2.1	8 ± 2.9	1 ± 1.2	0
Vernonia baldwinii	0	0	tr	0	tr
Viola pedatifida	tr	0	1 ± 0.5	tr	tr

Table III. Statistical comparison of topographic locations within sites. Only species with a sufficient frequency are included on the table.

SPECIES	SITE	F VALUE	P VALUE
Grass	1	1.381	0.2435
	2	2.961	0.0218
Forbs	1	4.745	0.0013
	2	5.319	0.0005
Amorpha canescens	1	6.168	0.0001
	2	2.759	0.0301
Andropogon gerardii	1	1.070	0.3738
	2	1.731	0.1462
Andropogon scoparius	1	0.868	0.4846
	2	1.777	0.1366
Asclepias syriaca	1	0.887	0.4737
Asclepias verticillata	2	7.048	0.0001

Table III. Statistical comparison of topographic locations within sites. Only species with a sufficient frequency are included on the table.

SPECIES	SITE	F VALUE	P VALUE
Aster ericoides	1	5.101	0.0007
	2	1.513	0.2014
Bouteloua curtipendula	1	1.127	0.3462
	2	4.300	0.0026
Bromus inermis	1	9.467	0.0001
	2	4.979	0.0009
Carex spp.	1	0.327	0.8592
	2	1.933	0.1081
Conyza canadensis	1	1.855	0.1215
	2	1.084	0.3669
Coreopsis palmata	2	3.604	0.0078

Table III. Statistical comparison of topographic locations within sites. Only species with a sufficient frequency are included on the table.

SPECIES	SITE	F VALUE	P VALUE
Dalea candida	1	0.828	0.5096
	2	1.365	0.2491
Desmodium illinoense	1	1.339	0.2582
	2	0.738	0.5675
Dichanthelium oligosanthes	1	5.407	0.0004
	2	0.799	0.5276
Echinacea angustifolia	1	0.904	0.4635
	2	1.00	0.4097
Equisetum laevigatum	1	3.239	0.0140
	2	2.949	0.0222
Euphorbia corollata	1	2.717	0.0321
	2	1.833	0.1255

Table III. Statistical comparison of topographic locations within sites. Only species with a sufficient frequency are included on the table.

SPECIES	SITE	F VALUE	P VALUE
Euphorbia cyathophora	1	1.686	0.1563
Helianthus rigidus	1	2.848	0.0261
	2	0.895	0.4688
Heliopsis helianthoides	1	0.256	0.9055
	2	3.459	0.0099
Kuhnia eupatorioides	1	1.304	0.2713
	2	1.075	0.3709
Lactuca sp.	1	0.970	0.4259
	2	0.657	0.6230
Oenothera sp.	2	1.858	0.1209
Oenothera villosa	1	1.365	0.2491
	2	2.234	0.0682

Table III. Statistical comparison of topographic locations within sites. Only species with a sufficient frequency are included on the table.

SPECIES	SITE	F VALUE	P VALUE
Oxalis dillenii	1	1.948	0.1057
	2	2.380	0.0544
Panicum virgatum	1	2,829	0.0269
Physalis heterophylla	1	1.641	0.1670
	2	1.00	0.4097
Physalis sp.	2	1.237	0.2978
Poa pratensis	1	2.049	0.0906
	2	2.381	0.0543
Phlox pilosa	1	0.500	0.7358
	2	4.981	0.0009
Potentilla arguta	2	1.116	0.3513

Table III. Statistical comparison of topographic locations within sites. Only species with a sufficient frequency are included on the table.

SPECIES	SITE	F VALUE	P VALUE
Rosa arkansana	1	0.490	0.7433
	2	2.145	0.0782
Rudbeckia hirta	1	2.071	0.0875
	2	3.059	0.0187
Solidago missouriensis	1	1.857	0.1211
	2	2.580	0.0398
Sorghastrum nutans	1	4.898	0.0010
	2	6.951	0.0001
Stipa spartea	1	0.750	0.5595
Vernonia baldwinii	2	0.750	0.5595

Table III. Statistical comparison of topographic locations within sites. Only species with a sufficient frequency are included on the table.

SPECIES	SITE	F VALUE	P VALUE
Viola pedatifida	1	0.459	0.7656
	2	1.183	0.3207

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Grass	1	0.435	0.5120
	2	3.114	0.0829
	3	9.868	0.0026
	4	9.993	0.0025
	5	5.653	0.0207
Forbs	1	19.655	0.0001
	2	20.454	0.0001
	3	32.231	0.0001
	4	3.152	0.0811
	5	11.136	0.0015
Amorpha canescens	1	0.050	0.8245
	2	2.941	0.0917
	3	7.838	0.0069
	4	2,872	0.0955
	5	2.037	0.1589

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Andropogon gerardii	1	1.255	0.2673
	2	10.329	0.0021
	3	7.619	0.0077
	4	9.194	0.0036
	5	0.050	0.8237
Andropogon scoparius	1	1.533	0.2206
	2	8.175	0.0059
	3	0.086	0.7708
	4	5.567	0.0217
	5	0.308	0.5812
Aster ericoides	1	2.560	0.1150
	2	1.357	0.2489
	3	0.108	0.7436
	4	1.374	0.2460
	5	3.247	0.0767

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Bouteloua curtipendula	1	0.115	0.7359
	2	0.000	0.9999
	3	4.462	0.0390
	4	2.157	0.1473
	5	2.081	0.1546
Bromus inermis	1	29.115	0.0001
	2	30.450	0.0001
	3	17.337	0.0001
	4	14.801	0.0003
	5	172.303	0.0001
Carex spp.	1	75.120	0.0001
	2	15.821	0.0002
	3	24.593	0.0001
	4	7.803	0.0071
	5	28.159	0.0001

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Conyza canadensis	1	0.550	0.4615
	2	1.403	0.2410
	3	0.050	0.8246
	4	1.817	0.1829
	5	2.044	0.1582
Dalea candida	1	0.745	0.3917
	3	1.00	0.3215
	4	1.00	0.3215
Desmodium illinoense	1	1.00	0.3215
	3	2.071	0.1555
	4	0.000	0.9999

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Dichanthelium oligosanthes	1	0.088	0.7678
	2	1.518	0.2229
	3	13.070	0.0006
	4	19.232	0.0001
	5	4.855	0.0316
Echinacea angustifolia	1	1.00	0.3215
	3	1.00	0.3215
	5	1.00	0.3215
Equisetum laevigatum	2	1.00	0.3215
	3	1.00	0.3215
	5	3.799	0.0561
Euphorbia corollata	1	0.666	0.4178
	2	0.001	0.9796
	3	2.395	0.1272
	4	3.943	0.0518
	5	0.204	0.6532

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Helianthus rigidus	1	7.663	0.0076
	2	4.883	0.0311
	3	1.208	0.2763
	4	0.618	0.4351
	5	6.270	0.0151
Heliopsis helianthoides	1	2.133	0.1495
	2	0.619	0.4345
	3	17.596	0.0001
	4	10.131	0.0023
	5	0.450	0.5050
Kuhnia eupatorioides	1	0.676	0.4144
	2	2.369	0.1292
	3	1.339	0.2519
	4	0.745	0.3917

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Lactuca spp.	1	2.071	0.1555
	2	3.222	0.0779
	3	1.962	0.1666
	4	1.139	0.2904
	5	1.00	0.3215
Oenothera villosa	1	2.425	0.1249
	3	0.000	0.9999
	4	1.00	0.3215
Oxalis dillenii	1	2.539	0.1165
	2	5.800	0.0192
	3	1.255	0.2673
	4	0.159	0.6915
	5	1.867	0.1771

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Phlox pilosa	1	5.487	0.0226
	2	1.000	0.3215
	3	1.748	0.1913
	4	12.142	0.0009
	5	2.977	0.0898
Physalis heterophylla	1	1.00	0.3215
	2	1.00	0.3215
	3	1.731	0.1935
	5	1.00	0.3215
Poa pratensis	1	3.976	0.0509
	2	12.130	0.0010
	3	13.235	0.0006
	4	22.434	0.0001
	5	7.502	0.0082

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Rosa arkansana	1	1.000	0.3215
	2	3.301	0.0744
	3	1.055	0.3087
	4	1.000	0.3215
	5	0.867	0.3556
Rudbeckia hirta	1	7.250	0.0093
	2	10.429	0.0020
	3	6.693	0.0122
	4	7.126	0.0098
	5	14.752	0.0003
Solidago missouriensis	1	2.829	0.0979
	2	0.529	0.4699
	3	1.842	0.1800
	4	1.568	0.2156
	5	1.000	0.3215

Table IV. Comparison of topographic location (TOPO) between sites: 1 = hilltop, 5 = lower-slope). Only species with sufficient frequency to be statistically tested are included.

SPECIES	TOPO	F VALUE	P VALUE
Sorghastrum nutans	1	2.945	0.0915
	2	60.881	0.0001
	3	0.111	0.7403
	4	0.672	0.4156
	5	4.251	0.0437
Viola pedatifida	1	1.243	0.2696
	2	3.551	0.0645
	3	0.803	0.3740
	4	5.303	0.0249
	5	1.316	0.2561

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