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Judith F. Boettcher

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Native Tallgrass Prairie Remnants of Eastern Nebraska:
Floristics and Effects of Management, Topography,
Size, and Season of Evaluation

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 of Omaha

by
Judith F. Boettcher

May 1981

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THESIS ACCEPTANCE

Accepted 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.

Thesis Committee

Name

Department

<i>Jeffrey A. Peake</i>	<i>Geography - Biology</i>
<i>David M. Sutherland</i>	<i>Biology</i>

Thomas B. Brass, Biology
Chairman

14 April 1981
DATE

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I would like to express my appreciation to the following members of my graduate committee: Dr. Thomas Bragg for suggesting this project, serving as major advisor, critical review of this manuscript, and for sharing his knowledge, office space, and time; Dr. David Sutherland for critical assistance in plant identifications and editing species lists, for reviewing this manuscript and especially for his friendship; Dr. Jeff Peake for reviewing this manuscript.

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Special gratitude is extended to Larry Boettcher for field assistance, helping type over 5000 computer cards, taking slides of prairie plants, and especially for moral support. I would also like to thank my Parents, Rosalie and Max Warnke, for their love and encouragement throughout my college education.

Most importantly, I am grateful to have had an opportunity to spend a few brief moments in studying the tallgrass prairie. The continued destruction of the prairie ecosystem means the loss of an invaluable reservoir of information and the loss of simple irreplaceable beauty. Perhaps best expressed by the late John E. Weaver, "The prairie is a slowly evolved highly complex organic entity, centuries old. It approaches the eternal... Each grass covered hillside is a page on which is written the history of the past, conditions of the present, and predications of the future. Some see without understanding but let us look closely and understandingly and act wisely..."

J. B.

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ABSTRACT

Ten eastern Nebraska tallgrass prairie remnants, [varying² in size from 1-18 ha,] were evaluated for floristic composition at [four² times during the 1979 growing season.] A total of 153 species were recorded of which seven dominated: [Andropogon gerardii,⁴ A. scoparius, Bromus inermis, Ceanothus americanus, Heliopsis helianthoides, Poa pratensis, and Stipa spartea.] Floristic composition, however, varied with respect to management, topography, season of evaluation, and prairie size. Frequent mowing reduced canopy cover of native species, such as [Andropogon gerardii,⁴] by 21% while increasing that of non-native species, such as [Bromus inermis,⁴] by 35%. In addition, frequently mowed sites contained a greater number of disturbance species (14 species), such as [Gonyza canadensis and Setaria glauca,⁴] than less frequently mowed sites (6 species). Canopy cover on sites mowed in early summer averaged 54% higher for [warm-season⁷ species] and 26% lower for [cool-season⁷] species than on sites mowed in late summer. Total vegetative cover, total grass cover, and total forb cover were lowest for hilltops and south-facing slopes although canopy cover of individual species varied with respect to topographic setting. Total vegetative cover and number of species recorded were highest in August evaluations; canopy cover of individual species varied throughout the growing season. A significant correlation was found between prairie size and Species Richness ($P=0.02$).

INTRODUCTION

Before European settlement in the mid 1800's, eastern Nebraska was dominated by true or tallgrass prairie (Weaver 1965). Since that time, however, the prairie has been reduced to scattered remnants primarily as a consequence of extensive cultivation and development. The decline of the prairie ecosystem means a reduction in critical habitat for many organisms as well as the loss of some portion of the native gene pool (Wagner 1975).

Vegetative Composition:

Weaver (1965) described the floristic composition of tallgrass prairies of eastern Nebraska. Species dominating the tallgrass prairie included Andropogon gerardii (big bluestem) and A. scoparius (little bluestem) which together constituted 75% or more of the vegetation. Lowlands were predominately A. gerardii (80-90%) with smaller amounts of Sorghastrum nutans (Indian grass), Andropogon scoparius, and Panicum virgatum (switchgrass). In the wettest lowlands, Phalaris arundinacea (reed canary grass) and Spartina pectinata (cord grass) were also important species. Upland prairies, more xeric than lowland areas, were dominated by Andropogon scoparius with varying amounts of Koeleria pyramidata (June grass), Stipa spartea (needle grass), Sporobolus asper (dropseed), and Bouteloua curtipendula (side-oats grama). On lower and middle slopes, the bluestems intermingled in about equal amounts. Although believed to be non-native (Cronquist *et al.* 1977), Poa pratensis (Kentucky bluegrass) was frequent in upland and lowland prairies. The spread

of this species is attributed to its introduction by European settlers and the suppression of naturally caused prairie fires which are destructive to it (Weaver 1965). Forbs were an integral part of the native prairie vegetation with up to 250 species found in lowlands and 200 in uplands.

Previous studies in Nebraska did not include several of the eastern counties such as Douglas and Sarpy Counties. The only quantitative study known for this area was conducted by Hover and Bragg (1980) in which they examined aspects of burning and mowing management.

Management:

Native grasslands have recently become the focus of many studies on management and restoration, in part because of their rapid rate of disappearance from certain regions and also because of the importance of maintaining prairie remnants in a relatively natural state. Prairies in eastern Nebraska once were subject both to grazing by large herbivores, such as elk and bison (Bradbury 1819, Larson 1940), and to burning (Long 1823, Gregg 1845). Presently, however, most of the remnants are neither grazed nor burned but rather are mowed for hay. Burning has been reported to be the best known management practice for maintenance of native bluestem prairies (Aldous 1934, Ehrenreich and Aikman 1963). The season of burning and the time interval between fires are considered important aspects of burning management (Kucera and Ehrenreich 1962, Smiens 1973). In areas where the use of fire is prohibited, however, other management techniques, such as mowing need to be considered. Hover

and Bragg (1980) suggest that summer mowing favors cool season species such as Stipa spartea while spring mowing or burning favors warm season species such as Andropogon gerardii. In addition, Weaver and Rowland (1952) and Hulbert (1969) suggest that frequent mowing during a growing season reduces net production. In combination, these studies emphasize the importance of considering type of management as well as season and frequency of treatment application in studying prairie ecosystems.

Topography, Soil and Size:

Topographic and edaphic heterogeneity, which would be greater in larger than in smaller prairies, influences vegetative composition (Crockett 1964, Sniens and Olsen 1970, Van Der Maarell 1971) thus larger prairies are likely to include a greater number of species. In addition, a large prairie is more likely to support a greater number of dispersed populations of any one species (Thompson 1975) so that the chance elimination of one does not preclude the reestablishment of the species from another nearby population. In a small prairie, however, with several species occurring as only a single population, a particular type of management may result in the inadvertent destruction of a population with no nearby seed source for reestablishment. Should this occur, species diversity is more likely to decrease in small prairies than in larger ones. Nepstad and Hoffhines (1980) for example, suggest a direct relationship between prairie size and species diversity. Prairie size, thus, must be an additional consideration in studying prairie ecosystems.

Seasonal Variations:

Most studies on native prairies appear to have been conducted only once during a growing season. Since the phenology of grassland species is known to vary (Anderson and Schelfhout 1980), the season-of-evaluation is likely to be an additional and important aspect of prairie studies.

The impetus for this study was provided by the absence of quantitative descriptive data for prairies in the study area, the rapid loss of prairies to development and cultivation, and the need to develop a better understanding of maintenance procedures for remnant prairies. Specifically, this study quantitatively describes the floristic composition of ten native prairie remnants in Douglas and Sarpy Counties in eastern Nebraska. Consideration is given to management, topography, seasonal variation, and size, all of which are important parameters of grassland evaluation and of grassland management and preservation.

METHODS

Study Sites:

In 1979, a survey was conducted to locate native prairie remnants in Douglas and Sarpy Counties in eastern Nebraska. From the survey, ten sites were selected, nine in Douglas County and one in Sarpy County (Appendix Table 1). The bases for selection were: (1) domination by native vegetation, (2) no evidence of cultivation, (3) no recent history of treatment with herbicides or of interseeding, (4) ease of access, (5) homogeneity of soil type between sites, and (6) when possible, some variation between or within sites with respect to management, topography, and size.

The recent management history of each prairie was determined by contacting present landowners. All prairies evaluated had a history of mowing although the frequency of mowing varied from one to six or more times per growing season. Prairie size varied from 1-18 ha. Soils on all sites were silty loams (Bartlett 1975).

Vegetative Analyses:

Six topographic settings were separately evaluated although not all six were found on any one prairie. These settings consisted of north-facing, south-facing, east-facing, and west-facing slopes, as well as hilltops and uplands with hilltops generally smaller in area than uplands. Slopes varied from 1-30% with 3-7% being the most common; mid-slope locations were selected for evaluations. Lowland regions were not

considered because few were available and because soil type differed. A total of 21 topographic study areas were evaluated (Appendix Table 1). At each study area, three, $3 \times 10\text{m}^2$, plots were equally spaced along a centrally located transect. Within each of these plots, ten, 1m^2 , circular, microplots were systematically located and permanently marked. Vegetation within each microplot was evaluated three times during 1979; (1) May 30-June 6, (2) June 20-27, (3) July 30-August 13. Some sites were also evaluated a fourth time, from September 22-30, depending on the time of mowing or on the ability to obtain permission from landowners to establish enclosures.

Within each microplot, percent canopy cover was estimated for each species as well as for general categories including: total vegetative cover, total grass cover, total forb cover, total woody plant cover, and total moss cover. Coverage categories used were: 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, and greater than 95% (Daubenmire 1959). Data were analyzed by using midpoint values of each coverage category. Floristic composition is described using two parameters, (1) average canopy cover, and (2) frequency. "Dominant species" are defined as those with a frequency of at least 50% within a topographic study area and with the highest average canopy cover value for that topographic study area. Additional species are considered dominants, regardless of frequency, if their average canopy cover for a topographic study area is within 10% of the species initially designated as the dominant. In addition to quantitative data within each microplot, species present at a prairie but not found within study plots were recorded throughout the season.

Plant identifications were verified at the University of Nebraska at Omaha Herbarium (OMA). Common and scientific nomenclature follows Gleason and Cronquist (1963), Great Plains Flora Assn. (1977), and Sutherland (in press).

Vegetative diversity within each topographic area was calculated using the Shannon-Wiener diversity index (H') where $H' = \sum p_i (\log_2 p_i)$ and p_i = the relative canopy coverage value of each species occurring in a plot. High H' values indicate high diversity (Krebs 1978). Percent Similarity between each topographic area was calculated using Sorenson's Quotient of Similarity (Q. S.) where $Q. S. = \frac{2w}{m + n}$ and where m = the total number of species in the first study area, n = the total number of species in the second study area, and w = the number of species common to both samples. A community ordination was constructed using Sorenson's Quotient of Similarity (Bray and Curtis 1957) to evaluate similarities between prairies. Species Richness, the total number of species present in a community, was also calculated for each study area and each prairie site. Pearson's Correlation was used to determine relationships between prairie size, Species Richness, and Species Diversity (H') (Ott 1977).

RESULTS

General Floristic Composition:

Total vegetative cover ranged between 60-98% with substantial seasonal variations in grass (30-98%), forb (1-68%), woody plant (0-64%), and moss (0-33%) cover (Appendix Table 2).

A total of 153 species were recorded for the ten sites both within and outside of study plots (Appendix Table 3). Using canopy cover data from the first three evaluations, seven species were found to dominate (Table 1). Andropogon gerardii was the single most prevalent species occurring in all study areas, dominating in 13 of the 21 study areas, and averaging a higher canopy cover in all topographic settings than any other species. Poa pratensis also occurred in all study areas although it dominated in only two. Stipa spartea, a native cool-season grass, dominated in five areas and was present at all sites except one (Site 5) which was dominated by Bromus inermis (smooth brome), an introduced cool-season grass. Other dominants included Andropogon scoparius, Heliopsis helianthoides (false sunflower), and Ceanothus americanus (New Jersey Tea). Amorpha canescens (lead plant) and Aster ericoides (white aster) were common to all study areas but they were not dominants as defined in this study.

Mowing Management:

Frequency of Mowing: The effects of different frequencies of mowing are evident by comparing north-facing slopes of two adjacent sites

Table 1. Maximum average percent canopy cover \pm SE for the 1st, 2nd, or 3rd evaluation on all study areas. Only species with frequency greater than 75% in one or more study areas are included. tr = less than 0.5% coverage. Underlined values indicate the dominant species for each location.

FLORISTICS	TOPOGRAPHIC SETTINGS AND STUDY SITES											
	NORTH SLOPE						SOUTH SLOPE					
	1	2	3	4	5	10	1	3	4	5	6	7
Total Cover	91 \pm 1.5	97 \pm 0.6	98 \pm 0	98 \pm 0	74 \pm 2.5	98 \pm 0	96 \pm 0.8	91 \pm 1.2	97 \pm 0.4	76 \pm 2.6	91 \pm 1.5	94 \pm 1.4
Grass	83 \pm 1.6	92 \pm 1.8	89 \pm 1.1	88 \pm 1.4	73 \pm 2.5	97 \pm 0.6	91 \pm 1.5	84 \pm 1.4	86 \pm 1.1	76 \pm 2.6	71 \pm 2.9	85 \pm 1.8
Forbs	47 \pm 3.7	43 \pm 3.8	26 \pm 3.8	49 \pm 4.5	3 \pm 0.8	59 \pm 4.6	58 \pm 4.9	13 \pm 1.8	37 \pm 4.5	3 \pm 0.7	65 \pm 2.9	28 \pm 3.7
Woody Plants	15 \pm 4.1	2 \pm 1.2	7 \pm 1.1	71 \pm 3.3	1 \pm 0.7	8 \pm 2.4	21 \pm 4.1	17 \pm 3.6	64 \pm 6.0	1 \pm 0.7	50 \pm 3.2	18 \pm 3.9
Moss	22 \pm 2.4	2 \pm 0.2	10 \pm 1.1	12 \pm 1.0	2 \pm 0.2	18 \pm 1.7	4 \pm 0.7	7 \pm 1.4	5 \pm 1.0	7 \pm 1.5	tr	1 \pm 0.2
Equisetum	tr	14 \pm 2.6	23 \pm 3.1	0	0	0	0	1 \pm 0.2	0	0	0	0
GRASSES & SEDGES:												
<u>Andropogon gerardii</u>	61 \pm 2.6	57 \pm 2.9	76 \pm 3.1	48 \pm 4.2	27 \pm 3.6	20 \pm 2.1	54 \pm 4.6	43 \pm 3.6	44 \pm 4.9	35 \pm 4.6	34 \pm 4.5	62 \pm 3.7
<u>Andropogon scoparius</u>	6 \pm 2.2	1 \pm 0.2	0	1 \pm tr	3 \pm 0.8	50 \pm 3.7	3 \pm 0.9	4 \pm 1.8	2 \pm 0.8	3 \pm 0.8	28 \pm 3.9	18 \pm 4.4
<u>Bouteloua curtipendula</u>	4 \pm 0.7	6 \pm 1.2	tr	1 \pm 0.7	7 \pm 1.5	0	0	tr	1 \pm 0.5	8 \pm 1.8	9 \pm 1.8	tr
<u>Bromus inermis</u>	1 \pm 0.1	0	0	17 \pm 3.5	52 \pm 2.9	tr	21 \pm 5.6	2 \pm 0.1	40 \pm 5.8	59 \pm 1.9	tr	10 \pm 1.9
<u>Bromus japonicus</u>	33 \pm 4.0	0	0	48 \pm 3.2	2 \pm 0.2	0	29 \pm 5.0	0	41 \pm 3.3	2 \pm 0.2	0	10 \pm 2.8
<u>Carex brevior</u>	1 \pm 0.2	5 \pm 1.0	2 \pm 0.5	1 \pm 0.5	1 \pm 0.5	2 \pm 0.5	2 \pm 0.2	tr	0	0	tr	tr
<u>Carex meadii</u>	3 \pm 0.6	tr	2 \pm 0.2	tr	1 \pm 0.5	6 \pm 1.2	2 \pm 0.5	tr	0	0	3 \pm 0.9	tr
<u>Dichanthelium acuminatum</u>	tr	11 \pm 1.8	tr	0	0	12 \pm 1.4	1 \pm 0.2	tr	0	0	0	tr
<u>Dichanthelium linearifolium</u>	1 \pm 0.5	4 \pm 1.1	tr	tr	0	13 \pm 1.9	7 \pm 1.2	tr	tr	0	tr	tr
<u>Dichanthelium oligosanthes var scribnerianum</u>	8 \pm 1.2	8 \pm 1.8	1 \pm 0.5	1 \pm 0.5	4 \pm 1.5	4 \pm 0.8	10 \pm 1.2	1 \pm 0.5	7 \pm 2.2	0	8 \pm 1.5	5 \pm 1.0
<u>Koeleria pyramidata</u>	4 \pm 1.0	6 \pm 1.1	1 \pm 0.2	tr	tr	2 \pm 0.7	1 \pm 0.5	3 \pm 1.4	3 \pm 1.4	0	tr	tr
<u>Poa pratensis</u>	26 \pm 2.2	43 \pm 2.9	58 \pm 1.7	29 \pm 2.1	40 \pm 3.0	34 \pm 1.6	20 \pm 2.3	35 \pm 1.4	32 \pm 2.3	37 \pm 1.8	21 \pm 2.7	13 \pm 2.1
<u>Sorghastrum nutans</u>	3 \pm 1.0	17 \pm 2.7	4 \pm 1.6	10 \pm 2.0	2 \pm 0.5	2 \pm 0.7	0	9 \pm 1.7	2 \pm 0.5	tr	6 \pm 2.4	5 \pm 1.0
<u>Stipa spartea</u>	10 \pm 2.3	12 \pm 2.9	51 \pm 7.3	27 \pm 3.9	0	18 \pm 5.4	47 \pm 5.8	39 \pm 3.9	6 \pm 2.5	0	2 \pm 1.2	1 \pm 0.7
FORBS:												
<u>Aster ericoides</u>	1 \pm 0.2	10 \pm 1.8	1 \pm 0.2	3 \pm 1.4	tr	1 \pm 0.2	tr	tr	7 \pm 2.5	tr	1 \pm 0.2	6 \pm 1.6
<u>Erigeron strigosus</u>	6 \pm 1.0	tr	tr	0	0	1 \pm 1.5	10 \pm 2.5	1 \pm 0.5	1 \pm 0.2	0	tr	0
<u>Euphorbia corollata</u>	2 \pm 0.7	6 \pm 1.1	7 \pm 1.1	2 \pm 0.5	0	8 \pm 2.5	1 \pm 0.7	4 \pm 0.8	5 \pm 1.4	0	1 \pm 0.2	5 \pm 1.5
<u>Heliopsis helianthoides</u>	0	tr	2 \pm 0.8	33 \pm 4.9	0	0	0	tr	tr	0	56 \pm 3.6	tr
<u>Phlox pilosa</u>	3 \pm 0.6	4 \pm 0.7	1 \pm 0.2	4 \pm 0.8	0	0	1 \pm 0.2	tr	3 \pm 0.9	0	1 \pm 0.5	tr
<u>Potentilla arguta</u>	tr	0	tr	0	0	5 \pm 1.5	0	0	0	0	1 \pm 0.5	1 \pm 0.5
<u>Rudbeckia hirta</u>	4 \pm 0.9	1 \pm 0.2	0	0	0	2 \pm 0.8	1 \pm 0.5	tr	tr	0	1 \pm 0.5	1 \pm 0.5
<u>Trifolium pratense</u>	27 \pm 3.5	6 \pm 1.0	0	0	1 \pm 0.5	25 \pm 2.2	40 \pm 3.9	0	0	tr	0	0
WOODY PLANTS:												
<u>Amorpha canescens</u>	4 \pm 1.4	1 \pm 1.3	7 \pm 1.5	12 \pm 2.0	1 \pm 0.7	6 \pm 1.5	21 \pm 4.1	16 \pm 3.6	7 \pm 1.9	1 \pm 0.7	25 \pm 4.3	15 \pm 3.2
<u>Ceanothus americanus</u>	11 \pm 4.1	0	0	61 \pm 4.2	0	2 \pm 2.1	1 \pm 0.5	0	58 \pm 6.7	0	22 \pm 4.7	3 \pm 2.8
<u>Rosa arkansana</u>	1 \pm 0.5	1 \pm 0.5	0	tr	0	0	tr	tr	1 \pm 0.5	tr	4 \pm 1.3	0

Table 1. Maximum average percent canopy cover \pm SE for the 1st, 2nd, or 3rd evaluation.(continued)

FLORISTICS	TOPOGRAPHIC SETTINGS AND STUDY SITES									
	EAST SLOPE		WEST SLOPE		HILLTOP				UPLAND	
	1	10	9	10	3	4	6	10	8	
Total Cover	93 \pm 1.1	98 \pm 0	96 \pm 1.3	95 \pm 0.9	87 \pm 2.1	92 \pm 1.8	94 \pm 1.0	95 \pm 1.0	97 \pm 0.4	
Grass	81 \pm 1.9	98 \pm 0	91 \pm 3.1	92 \pm 1.8	79 \pm 2.0	81 \pm 2.2	85 \pm 1.9	92 \pm 1.5	97 \pm 1.6	
Forbs	51 \pm 2.8	68 \pm 4.4	39 \pm 4.5	54 \pm 4.3	15 \pm 2.9	25 \pm 2.8	19 \pm 2.5	47 \pm 3.9	57 \pm 4.3	
Woody Plants	3 \pm 2.6	12 \pm 3.3	3 \pm 0.8	7 \pm 2.7	17 \pm 4.4	47 \pm 5.3	18 \pm 3.7	10 \pm 3.2	17 \pm 4.1	
Moss	5 \pm 0.9	20 \pm 1.7	7 \pm 1.2	33 \pm 3.6	10 \pm 2.0	5 \pm 1.1	3 \pm 0.6	29 \pm 2.3	3 \pm 0.6	
Equisetum	0	3 \pm 1.4	tr	0	0	0	0	0	tr	
<u>GRASSES & SEDGES:</u>										
<u>Andropogon gerardii</u>	37 \pm 3.7	46 \pm 5.3	69 \pm 6.3	61 \pm 2.9	59 \pm 3.2	20 \pm 4.0	74 \pm 2.7	45 \pm 6.4	32 \pm 4.4	
<u>Andropogon scoparius</u>	4 \pm 1.5	22 \pm 5.2	11 \pm 4.1	15 \pm 2.7	0	tr	11 \pm 2.4	25 \pm 4.9	33 \pm 4.6	
<u>Bouteloua curtipendula</u>	tr	1 \pm 0.5	1 \pm 0.5	1 \pm 0.2	tr	5 \pm 1.1	3 \pm 0.7	1 \pm 0.5	8 \pm 1.2	
<u>Bromus inermis</u>	0	0	5 \pm 1.8	0	2 \pm 1.4	40 \pm 5.3	0	0	1 \pm 0.6	
<u>Bromus japonicus</u>	9 \pm 2.6	0	0 \pm 2.1	0	0	6 \pm 1.9	0	0	0	
<u>Carex brevior</u>	7 \pm 1.2	4 \pm 0.5	1 \pm 0.5	1 \pm 0.2	0	tr	1 \pm 0.2	4 \pm 1.1	4 \pm 0.9	
<u>Carex meadii</u>	3 \pm 0.6	2 \pm 0.5	0	3 \pm 0.7	tr	tr	tr	2 \pm 0.5	3 \pm 0.1	
<u>Dichanthelium acuminatum</u>	6 \pm 1.5	15 \pm 2.1	tr	9 \pm 1.9	0	7 \pm 0.5	tr	4 \pm 1.0	tr	
<u>Dichanthelium linearifolium</u>	3 \pm 0.8	28 \pm 3.1	0	16 \pm 3.3	tr	5 \pm 1.8	tr	7 \pm 1.8	2 \pm 0.8	
<u>Dichanthelium oligosanthes</u> var <u>scribnerianum</u>	8 \pm 1.2	11 \pm 2.6	3 \pm 1.4	4 \pm 1.5	2 \pm 0.7	4 \pm 1.1	10 \pm 1.8	7 \pm 1.2	6 \pm 1.1	
<u>Koeleria pyramidata</u>	1 \pm 0.2	4 \pm 1.5	0	3 \pm 0.8	1 \pm 0.2	4 \pm 1.5	tr	2 \pm 0.7	7 \pm 1.2	
<u>Poa pratensis</u>	13 \pm 1.6	40 \pm 2.6	36 \pm 1.8	41 \pm 1.6	48 \pm 2.8	25 \pm 2.5	28 \pm 2.9	32 \pm 1.9	67 \pm 1.2	
<u>Sorghastrum nutans</u>	1 \pm 0.5	3 \pm 1.4	25 \pm 4.2	3 \pm 1.4	2 \pm 0.8	tr	3 \pm 0.9	2 \pm 0.2	14 \pm 4.1	
<u>Stipa spartea</u>	41 \pm 4.0	42 \pm 4.9	9 \pm 2.9	22 \pm 3.7	15 \pm 4.0	30 \pm 5.7	4 \pm 1.4	19 \pm 3.6	3 \pm 1.5	
<u>FORBS:</u>										
<u>Aster ericoides</u>	1 \pm 0.2	5 \pm 1.5	12 \pm 3.8	8 \pm 2.6	1 \pm 0.2	1 \pm 0.7	4 \pm 0.9	9 \pm 2.7	1 \pm 0.2	
<u>Erigeron strigosus</u>	4 \pm 0.9	4 \pm 0.9	1 \pm 0.5	10 \pm 1.1	1 \pm 0.2	tr	1 \pm 0.2	9 \pm 1.5	1 \pm 0.2	
<u>Euphorbia corollata</u>	3 \pm 1.4	21 \pm 3.7	16 \pm 2.8	8 \pm 1.6	4 \pm 1.3	1 \pm 0.2	1 \pm 0.2	6 \pm 1.5	4 \pm 1.4	
<u>Heliopsis helianthoides</u>	0	tr	tr	tr	tr	4 \pm 0.9	5 \pm 1.5	tr	0	
<u>Phlox pilosa</u>	tr	tr	tr	1 \pm 0.5	0	1 \pm 0.2	1 \pm 0.5	tr	tr	
<u>Potentilla arguta</u>	2 \pm 0.7	8 \pm 1.6	0	2 \pm 1.3	0	0	0	2 \pm 0.8	tr	
<u>Rudbeckia hirta</u>	9 \pm 2.6	3 \pm 0.9	tr	3 \pm 0.7	tr	0	2 \pm 0.8	2 \pm 0.5	tr	
<u>Trifolium pratense</u>	20 \pm 2.9	1 \pm 0.5	0	0	0	0	0	tr	38 \pm 5.0	
<u>WOODY PLANTS:</u>										
<u>Amorpha canescens</u>	13 \pm 2.6	12 \pm 3.3	3 \pm 0.8	5 \pm 1.9	7 \pm 2.1	12 \pm 2.5	18 \pm 3.7	20 \pm 3.2	14 \pm 4.1	
<u>Ceanothus americanus</u>	0	0	0	0	11 \pm 4.5	31 \pm 5.1	0	0	0	
<u>Rosa arkansana</u>	0	0	0	0	0	2 \pm 0.5	0	tr	0	

(Sites 4 and 5) which are similar in size and topography. Site 5 had been mowed frequently throughout the growing season while Site 4 had been mowed once each year in August. Total vegetative cover, total grass cover, and total forb cover averaged 24%, 15%, and 46% lower respectively with frequent mowing than with a single mowing (Table 1). Mowing frequency also affected individual species. Bromus inermis averaged 35% and Poa pratensis 11% higher with frequent mowing than with a single annual mowing whereas frequent mowing reduced Andropogon gerardii cover an average of 21%; Stipa spartea was absent from the frequently mowed area. In addition, disturbance species such as Conyza canadensis (horseweed) and Setaria glauca (foxtail grass) were present in greater numbers on the frequently mowed area (14 species) than on the area mowed once annually (6 species) (Appendix Table 2).

Comparing the two adjacent prairies, Species Diversity (H') was 25% lower and Species Richness 28% lower with frequent mowing than with annual mowing despite the increase in disturbance species (Table 2). Similar effects on Species Diversity (H') and Species Richness were seen on south slopes of the same sites. Species Diversity (H') and Species Richness comparisons between the frequently mowed site (Site 5) and other non-adjacent sites indicate results similar to those noted when comparing adjacent sites (Table 2).

Season of Mowing: The effects of mowing during different seasons are noted by comparing hilltop settings of two sites (Sites 6 and 4) which are similar in size and topography. Site 6 had been mowed regularly in June while Site 4 had been mowed regularly in August. Total

Table 2. Species Diversity (H') and Species Richness for topographic study areas. n_3 = total number of species recorded during the first three evaluations; n_4 = total number of species including the fourth evaluation.

	EVALUATION TIME									
	SPECIES DIVERSITY (H')				SPECIES RICHNESS					
	1	2	3	4	1	2	3	4	n_3	n_4
<u>North slopes</u>										
Site 1	4.00	3.40	3.43	-	36	41	42	-	49	-
2	3.29	3.49	3.68	-	36	42	41	-	49	-
3	3.23	3.16	2.82	-	38	32	32	-	43	-
4	3.34	3.47	3.44	-	29	37	34	-	40	-
5	2.42	2.54	2.76	3.26	21	25	25	29	29	33
10	3.70	3.72	3.66	3.34	40	40	36	33	45	47
<u>South slopes</u>										
Site 1	3.47	3.34	3.44	-	34	38	39	-	45	-
3	3.05	2.94	2.73	-	39	31	34	-	46	-
4	3.53	3.39	3.40	-	40	33	34	-	42	-
5	2.08	2.12	2.46	2.84	15	18	18	18	22	24
6	3.57	3.61	3.26	3.30	31	36	30	33	41	46
7	3.41	2.96	2.97	3.19	32	29	38	25	42	44
<u>East slopes</u>										
Site 1	3.85	3.84	3.78	-	30	40	42	-	42	-
10	3.90	3.88	3.80	3.58	44	45	41	38	53	55
<u>West slopes</u>										
Site 9	3.34	3.19	2.93	3.15	31	27	25	-	42	-
10	3.66	3.50	3.61	3.63	41	38	42	34	48	49
<u>Hilltops</u>										
Site 3	2.75	2.78	2.53	-	36	31	31	-	45	-
4	3.71	3.66	3.74	-	40	42	43	-	51	-
6	2.77	2.84	2.78	2.66	27	32	31	29	40	41
10	3.70	3.69	3.71	3.63	43	39	40	33	54	56
<u>Upland</u>										
Site 8	3.26	3.19	3.67	3.27	40	40	37	32	54	55

vegetative cover was similar on the two study areas but woody plant cover averaged 29% higher and forb cover 6% higher on the site mowed in August than the site mowed in June. Differences in canopy cover of individual species were also noted. Andropogon gerardii averaged 54% higher and A. scoparius 11% higher on the area mowed in June than the area mowed in August whereas Stipa spartea averaged 26% lower with June mowing. Bromus inermis and B. japonicus (Japanese brome) were present at the site mowed in August but absent from the site mowed in June. Poa pratensis, also a cool-season species, did not appear to be differentially favored by season-of-mowing (Table 1). Similar effects on floristic composition were noted on south facing slopes of the two sites.

Species Diversity (H') and Species Richness were highest on the hilltop of the site mowed later in the summer (Site 4) although on south-facing slopes of the two sites (Sites 6 and 4) the indices were similar (Table 2).

Site Individuality:

Ordination of the 21 topographic study areas indicates that the vegetative similarity of different topographic settings from within a single site is greater than that for the same topographic setting from different sites. Thus, the effect of management appears to be greater than the effect of topography (Fig. 1).

Topography:

Using average values combined for all evaluation periods, total vegetative cover (85%), grass cover (73%), and forb cover (21%) averaged

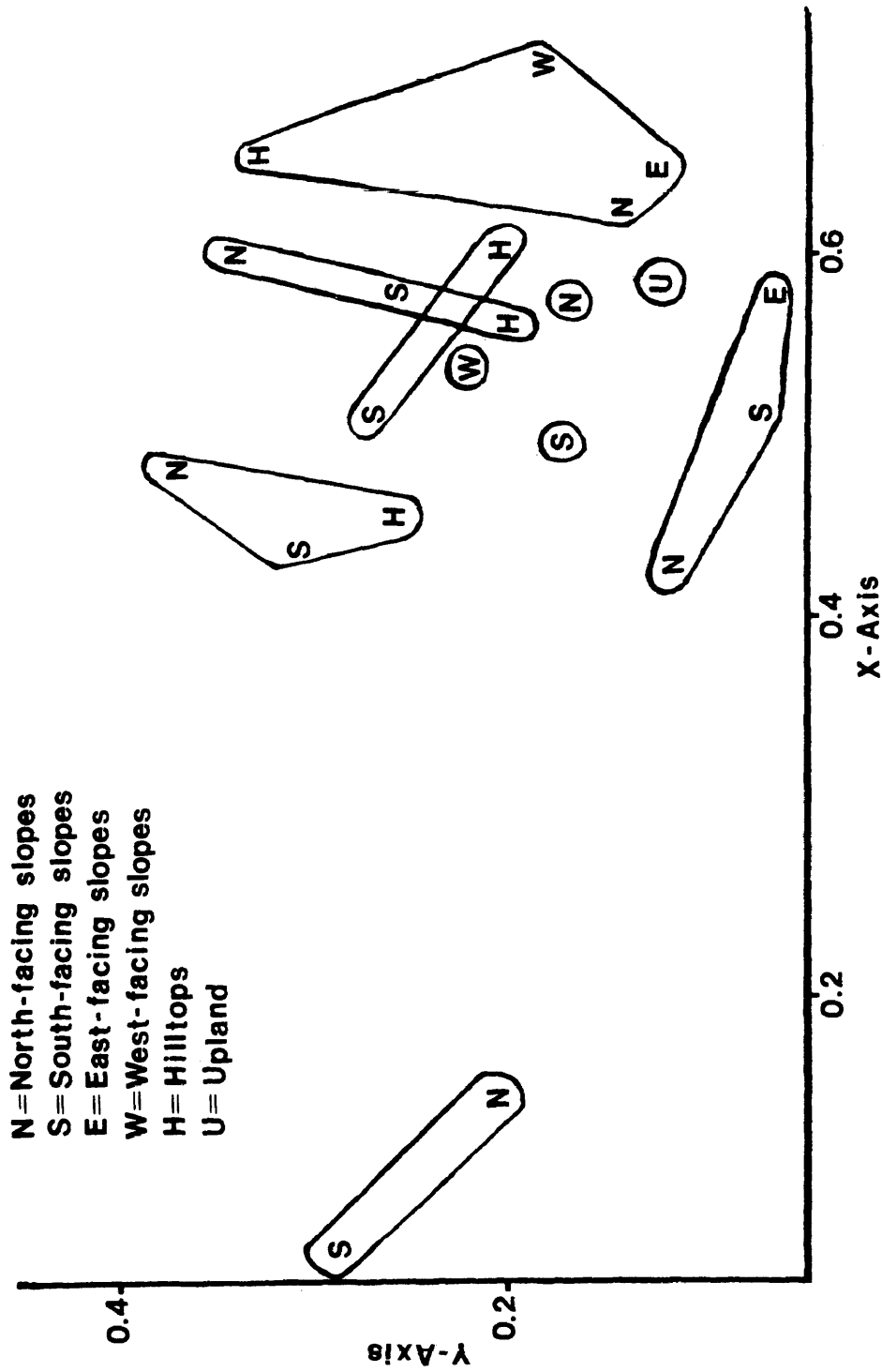


Fig. 1. Community Ordination of the 21 topographic study areas. Continuous lines surround topographic study areas of each study site.

lower on hilltops and south-facing slopes than on other topographic settings (Table 3). Considering dominant species, canopy cover of Bromus inermis, Ceanothus americanus, and Heliopsis helianthoides averaged highest (17%, 10%, and 6% respectively) on south slopes. Andropogon gerardii averaged 8% higher on west-facing slopes than on other topographic settings although it was abundant on all settings. A. scoparius and Poa pratensis averaged 13% and 24% higher on the upland area while Stipa spartea averaged 16% higher on east-facing slopes than other topographic settings. Such topographic preferences of species were also noted for individual study sites.

Species Diversity (H') and Species Richness for all evaluation times averaged highest on east-facing slopes ($H'=3.78$; 40 species). Species Richness averaged lowest on south-facing slopes (33 species) and Species Diversity averaged lowest on hilltops ($H'=3.20$) (Table 2). Such effects, however, are not reflected in data for all sites or for all seasons of the year.

The combined effect of topography and management is evidenced by comparing north- and south-facing slopes of Site 5 which was mowed frequently throughout the growing season with Site 4, mowed once each year in late July. Frequent mowing of both north- and south-facing slopes apparently favored Bromus inermis whereas mowing once annually averaged higher for Bromus inermis (23%) on south-facing slopes than on north-facing slopes. In addition, Stipa spartea and Heliopsis helianthoides averaged 21% and 33% lower on south slopes than on north slopes with mowing once annually while Ceanothus americanus was favored on both north and south slopes.

Table 3. Percent Canopy Cover by topographic setting averaged for all evaluations for general vegetative categories and for dominant species. tr = less than 0.5% coverage.

VEGETATION	TOPOGRAPHIC SETTING					
	NORTH	SOUTH	EAST	WEST	HILLTOP	UPLAND
Total Cover	87	85	90	92	85	92
Grass	79	73	84	88	77	85
Forbs	28	23	48	35	21	49
Moss	7	2	8	10	5	2
Woody Plants	14	21	8	3	16	10
<u>Andropogon</u> <u>gerardii</u>	33	31	36	50	42	26
<u>Andropogon</u> <u>scoparius</u>	10	8	10	12	8	25
<u>Bromus</u> <u>inermis</u>	11	17	0	1	8	tr
<u>Ceanothus</u> <u>americanus</u>	9	10	0	0	7	0
<u>Heliopsis</u> <u>helianthoides</u>	3	6	tr	tr	1	0
<u>Poa</u> <u>pratensis</u>	32	20	22	30	27	56
<u>Stipa</u> <u>spartea</u>	16	12	32	10	12	1

Seasonal Variations:

Combining all sites, total vegetative cover averaged lowest in the first evaluation (80%) and highest in the fourth evaluation (94%). Forb cover averaged 11-16% higher in the third evaluation than for all others (Table 4). Differences in evaluation time were reflected in data for individual species. Considering a frequently mowed site (Site 8), Andropogon gerardii averaged 18% higher during the third than during the first evaluation whereas Poa pratensis reached maximum cover (67%) during the second evaluation. Forbs showed similar seasonal peaks in canopy cover: Erigeron strigosus (daisy fleabane) was highest in the second evaluation, Aster sericeus (silky aster) averaged highest in the third, and Carex meadii (Mead's sedge) was observed during the first and second but not in the third and fourth evaluations.

Seasonal variations in species diversity also occurred with the maximum Species Diversity (H') recorded during the first evaluation for ten of the study areas (Table 2). Of the 99 species present in study plots, only 65 were found in all four evaluations. Four species, Lithospermum canescens (Indian paint), Senecio plattensis (prairie ragwort), Agoserus glauca (false dandelion), and Teucrium canadense (American germander) were found only in the first evaluation while thirteen species were present in the first, second, and third evaluations but not found in the fourth evaluations: Asclepias amplexicaulis (bluntleaf milkweed), Asclepias syriaca (common milkweed), Erigeron strigosus (daisy fleabane), Hedeoma hispida (rough penny royal), Physalis heterophylla (clammy ground cherry), Sisyrinchium

Table 4. Average Percent Canopy Cover \pm S.E. for general categories and selected species at a frequently mowed Upland site (Site 8) and for all sites combined. First = May 30-June 6, Second = June 20-27, Third = July 30-August 13, Fourth = September 22-30, 1979. tr = less than 0.5% coverage.

VEGETATION	LOCATION AND SEASON OF EVALUATION							
	UPLAND SITE 8				COMBINED STUDY SITES			
	FIRST	SECOND	THIRD	FOURTH	FIRST	SECOND	THIRD	FOURTH
Total Cover	83 \pm 2.5	89 \pm 1.7	97 \pm 0.4	97 \pm 0.4	80 \pm 0.7	84 \pm 0.5	93 \pm 0.4	94 \pm 0.4
Grass	71 \pm 2.3	74 \pm 2.5	97 \pm 0.6	97 \pm 0.6	70 \pm 0.8	74 \pm 0.6	86 \pm 0.5	89 \pm 0.8
Forbs	51 \pm 4.2	55 \pm 5.2	57 \pm 4.3	34 \pm 3.7	25 \pm 0.8	27 \pm 0.9	38 \pm 1.1	22 \pm 1.3
Woody Plants	6 \pm 1.3	7 \pm 1.9	17 \pm 4.1	12 \pm 3.1	12 \pm 0.8	15 \pm 0.9	20 \pm 1.1	7 \pm 0.7
Moss	1 \pm 0.2	1 \pm 0.2	3 \pm 0.6	1 \pm 0.5	6 \pm 0.3	4 \pm 0.2	7 \pm 0.5	3 \pm 0.2
SPECIES:								
<u>Andropogon gerardii</u>	14 \pm 1.7	29 \pm 3.2	32 \pm 4.4	27 \pm 3.5	27 \pm 0.7	36 \pm 0.9	47 \pm 1.1	31 \pm 1.5
<u>Andropogon scoparius</u>	14 \pm 2.6	26 \pm 4.9	33 \pm 4.6	29 \pm 4.5	6 \pm 0.5	8 \pm 0.6	11 \pm 0.8	21 \pm 1.4
<u>Aster sericeus</u>	0	tr	4 \pm 1.8	tr	tr	tr	1 \pm 0.2	1 \pm 0.3
<u>Carex meadii</u>	3 \pm 1.0	tr	0	0	1 \pm 0.1	tr	tr	0
<u>Erigeron strigosus</u>	tr	1 \pm 0.7	0	0	2 \pm 0.2	2 \pm 0.2	tr	0
<u>Poa pratensis</u>	56 \pm 2.3	67 \pm 2.3	46 \pm 4.0	54 \pm 2.9	32 \pm 0.7	29 \pm 0.8	29 \pm 0.7	15 \pm 1.0
<u>Stipa spartea</u>	3 \pm 1.5	1 \pm 0.5	1 \pm 0.5	1 \pm 0.2	15 \pm 0.8	15 \pm 0.9	16 \pm 0.9	7 \pm 0.9

campestre (white-eyed grass), Tragopogon dubius (goats beard), Vernonia baldwinii (western iron weed), Zizia aurea (golden alexanders), Echinacea angustifolia (purple coneflower), Erigeron annuus (annual fleabane), and Psoralea esculenta (breadroot scurf pea) (Appendix Table 2).

Prairie Size:

The preliminary survey of prairies in the Omaha area indicated the size of remaining prairie remnants range from less than 1 ha to 18 ha, thus the largest prairie located for this study was 75% smaller than the largest prairies located by investigators 40-50 years ago (Weaver and Fitzpatrick 1934). Additionally, the second largest prairie located in the study area was only 8 ha. A significant correlation was found in this study between Species Richness and prairie size when considering number of species per unit area in study plots ($P=0.02$) and for number of species in total prairie areas ($P=0.01$). The correlation is even stronger than showed when sites with extreme mowing frequency are omitted ($P=0.004$ and $P=0.001$ respectively) (Fig. 2). No significant correlation was evident between Species Diversity (H') and prairie size.

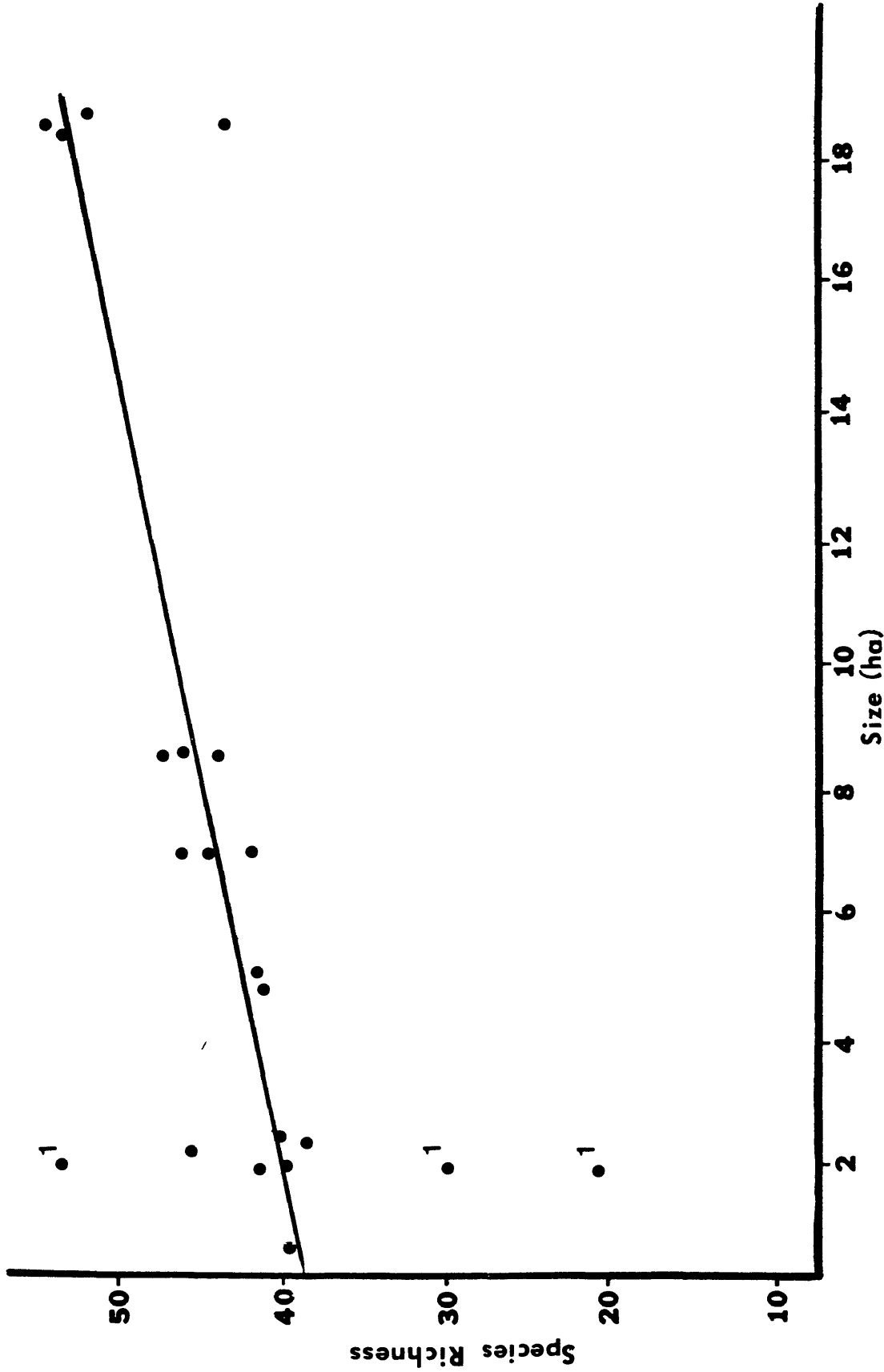


Fig. 2. Species Richness vs Prairie Size for 21 topographic study areas. Study areas with "1" indicate those with extreme mowing frequency. $\bar{P} = 0.02$, $r = 0.46$ for all study areas; $\bar{P} = 0.004$, $r = 0.59$ for all study areas except those with extreme mowing frequency.

DISCUSSION

A comparison between the overall floristic composition observed in this study and that observed in previous studies (Weaver and Fitzpatrick 1934) from Lancaster County, located approximately 80 km east of the study area, suggests that prairies in eastern Nebraska have changed to some extent during the last 40-50 years. Introduced species such as Poa pratensis, Bromus inermis, B. japonicus, and Trifolium pratense, for example, are all more common than previously recorded. There also appears to have been a general decline in the total number of species which suggests a loss of at least some native species. Other than possible differences in species distribution, causes of temporal differences in general floristic composition between the 1930's and 1970 and of vegetative differences noted between prairies of this study are likely to be related to management, topography, seasonal variation, or prairie size either individually or in combination.

Mowing frequency and season-of-mowing are types of management that appear to be capable of leading to vegetative differences such as those noted in this study. Frequently mowed sites, while more frequently mowed than might be typical, nevertheless indicate the potential for frequent mowing to (1) decrease total vegetative cover, (2) alter composition by encouraging establishment of disturbance species, and (3) substantially reduce species diversity. In addition to mowing frequency, this study suggests that season-of-mowing can affect species

composition, a conclusion also noted by Hover and Bragg (1980). Past management is unlikely to have been identical for any two prairie remnants, therefore differences between the sites used in this study are likely to reflect these variations in management history (Fig. 1). The significance of these results is twofold. First, past management may have altered species composition or caused the loss of one or more species from a prairie remnant hence preservation of a single site may not preserve all of the native species once extant. Second, future management, designed to perpetuate natural environmental conditions, is essential for the continuation of the native prairie ecosystem.

Variations in species composition were also noted between different topographic settings. These differences most likely reflect variations in microclimate. Sisson (1976), for example, found that temperature and evaporation rates are higher and humidity is lower on south-facing slopes than on other topographic settings. Moreover, different types of management appear to alter the topographic microclimate sufficiently to result in different vegetative composition. Such vegetative differences were noted in this study between the same topographic settings of sites with different management histories. Topographic variation, thus, is an important consideration both in evaluating and in selecting native prairies for preservation.

Seasonal variation in species composition is particularly important when using species diversity to make temporal, geographic, or other comparisons between ecosystems. This study suggests that substantial differences can occur through the growing season in vegetative canopy

cover whether due to characteristic phenological differences or to less apparent variations such as herbivory. Ideally, it appears that vegetation should be evaluated throughout the growing season. However, if time does not permit or if missing some early spring species is not significant, mid-summer seems to be a reasonable compromise. It is at this time of the year that total vegetative cover and Species Richness reach a maximum in eastern Nebraska. In addition, mature, flowering plants are easier to identify than those in early stages of development. The important point to be made from this aspect of the study is that seasonal variation in floristic composition should be a consideration when evaluating and when comparing data from the same or different native prairies.

The final parameter measured in this study was prairie size. The preliminary survey of prairies in the Omaha area suggests that there has been a notable decrease in the size of prairie remnants during the last 40-50 years. The importance of this decline is implicit in the significant correlation found in this study between Species Richness and prairie size. A similar relationship between size and species diversity was reported by Nepstad and Hoffhines (1980). These results emphasize the importance of preservation of large prairies as well as the preservation of more than a single prairie, as discussed earlier, in order to maintain the greatest amount of species diversity of this ecosystem. Prairie size, as well as management, topography, and seasonal variation are all important parameters of grassland evaluation and of grassland management and preservation.

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APPENDIX

Appendix Table 1. Study Sites. N = North slope, S = South slope, E = East slope, W = West slope, H = Hilltop, U = Upland, Evaluation 1 = May 30-June 6, Evaluation 2 = June 20-27, Evaluation 3 = July 30-August 13, Evaluation 4 = September 22-30, Mowed frequently = 6 or more times per year.

SITE	PRAIRIE NAME	LOCATION ¹	SIZE	MANAGEMENT	TOPOGRAPHIC EVALUATION	
					LOCATION REPRESENTED	TIME
1	Stolley	NW $\frac{1}{4}$, S15, T15N, R11E Douglas County, Nebraska	8.5 ha	Mowed in July	N, S, E	1, 2, 3
2	Bate-3	SE $\frac{1}{2}$, SE $\frac{1}{4}$, S20, T16N, R12E Douglas County	1.2 ha	Mowed in August	N	1, 2, 3
3	Bate-17	NE $\frac{1}{2}$, E $\frac{1}{2}$, S20, T16N, R12E Douglas County	6.9 ha	Mowed in August	N, S, H	1, 2, 3
4	Hwy-36	NE $\frac{1}{4}$, NE $\frac{1}{4}$, SW $\frac{1}{4}$, S14, T16N R12E Douglas County	2.0 ha	Mowed in August	N, S, H	1, 2, 3
5	Radar	NE $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, S14, T16N R12E Douglas County	2.0 ha	Mowed frequently	N, S	1, 2, 3, 4
6	Jensen/King	SW $\frac{1}{2}$, SE $\frac{1}{4}$, S12, T16N, R12E Douglas County	2.4 ha	Mowed in June	S, H	1, 2, 3, 4
7	Long	NE $\frac{1}{4}$, NW $\frac{1}{2}$, S19, T16N, R13E Douglas County	4.9 ha	Mowed in July	S	1, 2, 3, 4
8	Millard	SW $\frac{1}{4}$, SE $\frac{1}{4}$, S14, T15N, R11 Douglas County	2.0 ha	Mowed frequently	U	1, 2, 3, 4
9	Hover	NW $\frac{1}{4}$, NE $\frac{1}{4}$, S28, T14N, R13E Sarpy County, Nebraska	4.9 ha	Mowed in August	W	1, 2, 3
10	Bauermeister	NE $\frac{1}{4}$, W $\frac{1}{2}$, S3, T14N, R11E Douglas County	18.2 ha	Mowed in late August	N, E, W, H	1, 2, 3, 4

¹ For convenience, names were assigned based on ownership or location.

Appendix Table 2. Floristics for 30 May-6 June, 1979 evaluation. (continued)

Table with columns: FLORISTICS, 1-N, 1-S, 1-E, 2-N, 3-H, 3-N, 3-S, 4-H, 4-N, 4-S, 5-N, 5-S, 6-H, 6-S, 7-S, 8-U, 9-W, 10-H, 10-N, 10-W, 10-E. Rows list species like BROMUS INERMIS, BROMUS JAPONICUS, BOUTELOUA CURTIPENDU LA, CAREX BREVIOR, CAREX HELIOPHILIA, CAREX MEADII, DACTYLIS GLOMERATA, ELYMUS CANADENSIS, KOBLERIA PYRIMIDA, SORGHASTRUM NUTANS, DICHANTHELIUM ACUMIN ATUM, DICHANTHELIUM LINEAR IFOLIUM, D. OLIGOSANTHES VAR SCRIBNERIANUM, PANICUM VIRGATUM, PHLEUM PRATENSE, POA PRATENSIS, SETARIA GLAUCA, and AMORPHA CANESCENS. Each row contains numerical data points for each column.

Appendix Table 2. Floristics for 30 July-13 August, 1979 evaluation. (continued)

FLORISTICS	1-N	1-S	1-E	2-N	3-H	3-N	3-S	4-H	4-N	4-S	5-N	5-S	6-H	6-S	7-S	8-U	9-W	10-H	10-N	10-W	10-E	
BROMUS INERMIS	M	.1	20.8	0.0	0.0	1.1	0.0	.1	39.5	14.6	40.1	46.9	42.8	0.0	.1	5.2	.8	2.1	0.0	.2	0.0	0.0
	SE	.08	5.56	0.00	0.00	.70	0.00	.08	5.32	3.24	5.82	2.96	2.69	0.00	.08	1.45	.51	.82	0.00	.12	0.00	0.00
	NU	1	11	0	3	0	0	1	30	26	29	30	30	0	1	23	5	10	0	2	0	0
BROMUS JAPONICUS	M	33.1	17.5	8.3	0.0	0.0	0.0	4.8	48.2	40.6	2.2	1.8	0.0	0.0	1.7	0.0	3.9	0.0	0.0	0.0	0.0	0.0
	SE	4.02	4.78	2.99	0.00	0.00	0.00	1.56	3.18	3.31	.16	.21	0.00	0.00	.69	0.00	1.05	0.00	0.00	0.00	0.00	0.00
	NU	30	10	14	0	0	0	13	30	30	26	21	0	0	10	0	17	0	0	0	0	0
BOUTELOUA CURTIPENDU LA	M	1.0	0.0	.1	6.3	.3	.1	3	5.0	1.2	1.1	6.6	8.2	2.5	9.0	.1	8.2	.6	.9	0.0	.5	.8
	SE	.23	0.00	.08	1.15	.14	.08	.14	1.14	.70	.52	1.45	1.83	.66	1.78	.08	1.19	.50	.22	0.00	.19	.51
	NU	12	0	1	26	3	1	3	20	4	8	30	25	20	30	1	28	2	11	0	6	4
CAREX BREVIOR	M	.1	.2	.5	3.5	0.0	0.0	0.0	.5	0.0	.7	0.0	0.0	0.0	0.0	1.2	0.0	1.3	.5	1.3	.5	1.3
	SE	.08	.12	.19	.73	0.00	0.00	0.00	.19	0.00	.51	0.00	0.00	0.00	.52	0.00	.52	0.00	.52	.19	.19	.70
	NU	1	2	6	27	0	0	0	6	0	3	0	0	0	9	0	9	0	10	6	6	5
CAREX HELIOPHILIA	M	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.00	.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NU	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAREX MEADII	M	.5	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	.19	.08	0.00	0.00	.08	0.00	0.00	.08	0.00	0.00	0.00	0.00	.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NU	6	1	0	1	0	0	1	1	0	0	0	0	3	0	0	0	0	0	0	0	0
DACTYLIS GLOMERATA	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ELYMUS CANADENSIS	M	.8	.3	.7	.8	.1	.1	.2	.2	.1	.2	.1	.1	.1	.3	.3	.8	.5	.8	.5	.8	.1
	SE	.21	.14	.51	.51	.08	.08	.12	.12	.08	0.00	0.00	.08	.14	0.00	.21	.50	0.00	.08	.10	.08	.12
	NU	9	3	3	4	1	1	2	2	1	0	0	1	3	0	9	1	0	0	0	1	2
KOELERIA PYRIMIDA	M	2.4	.8	.6	3.8	.3	.4	9	3.6	.4	1.3	.1	0.0	.3	.1	0.0	6.7	0.0	.8	1.0	2.3	.3
	SE	.66	.21	.20	.96	.14	.17	.22	1.42	.17	.70	.08	0.00	.14	.08	0.00	1.19	0.00	.21	.52	.67	.14
	NU	19	9	7	20	3	5	11	14	5	5	1	0	3	1	0	25	0	9	7	17	3
SORGHASTRUM NUTANS	M	3.2	0.0	.7	16.8	.8	4.4	2.9	.3	9.9	1.6	3.2	3.2	5.7	4.8	10.5	7.5	1.5	1.6	3.2	.9	.9
	SE	1.00	0.00	.51	2.74	.51	1.58	.62	.14	2.04	.52	.52	.12	.89	2.42	1.41	3.27	1.80	.52	.69	1.37	.52
	NU	13	0	3	30	5	9	25	3	27	14	10	2	18	15	24	26	27	13	9	14	6
DICHANTHELIUM ACUMIN ATUM	M	.8	5.8	10.7	0.0	.3	0.0	.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	11.6	6.7
	SE	.08	.21	1.47	1.80	0.00	.14	0.00	.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.08	.81	1.41	1.19
	NU	1	9	25	25	0	3	0	3	0	0	0	0	0	0	0	0	0	1	14	30	25
DICHANTHELIUM LINEAR M IFOLIUM	M	.5	3.7	1.3	0.0	0.0	0.0	.1	5.3	0.0	.2	0.0	0.0	.1	0.0	0.0	1.6	0.0	6.8	6.3	16.0	22.0
	SE	.19	.85	.23	0.00	0.00	0.00	.08	1.83	0.00	.12	0.00	0.00	.08	0.00	0.00	.83	0.00	1.82	1.15	3.30	3.84
	NU	6	24	15	0	0	0	1	16	0	2	0	0	1	0	0	4	0	23	26	24	30
D. OLIGOSANTHES VAR SCRIBNERIANUM	M	5.3	8.2	8.3	4.9	1.0	1.0	1.3	3.7	1.3	7.6	4.1	0.0	10.3	8.2	5.3	6.0	2.1	6.8	3.9	3.9	11.1
	SE	1.10	1.51	1.16	1.40	.52	.52	.85	.52	2.17	1.47	0.00	1.75	1.51	.99	1.10	.82	1.18	.82	1.48	2.58	2.58
	NU	24	29	30	25	7	10	24	11	27	15	0	30	29	29	27	10	26	27	13	21	21
PANICUM VIRGATUM	M	.1	0.0	.1	.1	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	.08	0.00	.08	.08	0.00	0.00	.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NU	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLEUM PRATENSE	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0
	SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00
	NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POA PRATENSIS	M	25.8	20.1	13.2	33.8	39.8	58.3	34.3	15.6	20.4	26.0	31.9	20.2	28.2	15.5	5.8	46.2	28.6	30.1	28.1	35.8	40.2
	SE	2.20	2.25	1.59	1.94	2.80	1.73	3.19	1.57	2.39	3.16	2.26	2.02	2.91	1.84	1.03	4.02	2.35	2.29	2.67	2.41	2.64
	NU	30	30	30	30	30	26	30	30	30	30	30	30	30	30	30	29	30	30	30	30	30
SETARIA GLAUCO	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMORPHA CANESCENS	M	3.7	21.1	12.8	1.3	6.6	6.5	16.4	12.4	11.5	7.1	1.2	1.2	18.1	25.1	14.9	13.8	1.2	9.9	5.8	4.8	11.7
	SE	1.42	4.13	2.62	1.25	2.11	1.53	3.61	2.47	1.99	1.90	.70	.70	3.74	4.30	3.23	4.13	.52	3.19	1.53	1.87	3.28
	NU	15	28	28	1	17	24	24	27	26	17	4	4	21	24	25	12	9	18	21	10	20

Appendix Table 2. Floristics for 22-30 September, 1979 evaluation. (continued)

FLORISTICS	1-N	1-S	1-E	2-N	2-H	3-N	3-H	4-N	4-S	5-N	5-S	6-H	6-S	7-S	8-U	9-W	10-H	10-N	10-W	10-E
BROMUS INERMIS	M	I	I	I	I	I	I	I	I	I	36.4	32.8	0.0	.1	6.8	1.0	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.76	3.33	0.00	.08	1.25	.69	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	30	30	0	1	22	2	0	0	0	0
BROMUS JAPONICUS	M	I	I	I	I	I	I	I	I	I	2.9	1.9	0.0	0.0	1.5	0.0	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.62	.20	0.00	.69	0.00	0.00	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	25	23	0	8	0	0	0	0	0	0
BOUTELOUA CURTIPENDU M	I	I	I	I	I	I	I	I	I	I	6.6	3.9	2.1	3.8	.7	5.7	I	1.3	.3	.1
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.45	.82	.50	.70	.21	1.15	0.00	.23	.14	.14
NU	0	0	0	0	0	0	0	0	0	0	30	27	20	30	8	23	0	16	3	1
CAREX BREVIOR	M	I	I	I	I	I	I	I	I	I	5	0	0	0	0	0	I	0.0	1.3	.3
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.50	0.00	0.00	0.00	0.00	.21	0.00	0.00	.70	.14
NU	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	9	0	0	5	3
CAREX HELIOPHILIA	M	I	I	I	I	I	I	I	I	I	0	0	0	0	0	0	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAREX MEADII	M	I	I	I	I	I	I	I	I	I	0	0	0	0	0	0	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DACTYLIS GLOMERATA	M	I	I	I	I	I	I	I	I	I	0	0	0	0	0	0	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ELYMUS CANADENSIS	M	I	I	I	I	I	I	I	I	I	2	0	.1	.3	0	.8	I	0.0	0.0	.2
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.12	0.00	.08	.14	0.00	.51	0.00	0.00	0.00	.08
NU	0	0	0	0	0	0	0	0	0	0	2	0	1	3	0	4	0	0	1	2
KOBLERIA PYRIMIDA	M	I	I	I	I	I	I	I	I	I	1	0	.2	.2	0	0	I	.5	.6	1.9
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.08	0.00	.12	0.00	0.00	.69	0.00	.19	.20	.50
NU	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	10	0	6	7	18
SORGHASTRUM NUTANS	M	I	I	I	I	I	I	I	I	I	2.3	1.1	4.4	4.6	9.8	14.0	I	1.1	1.8	2.2
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.81	.70	1.44	2.15	2.39	3.51	0.00	.23	.69	.68
NU	0	0	0	0	0	0	0	0	0	0	13	3	19	16	25	23	0	13	11	16
DICHTANTHELIUM ACUMIN ATUM	M	I	I	I	I	I	I	I	I	I	0	0	0	0	0	0	I	2.4	4.2	3.2
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.81	.79	.60
NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	30	28
DICHTANTHELIUM LINEAR IFOLIUM	M	I	I	I	I	I	I	I	I	I	0	0	.1	.1	0	0	I	1.5	3.4	5.3
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.08	0.00	.08	0.00	0.00	.84	0.00	.87	1.01	2.03
NU	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	21	28	29
D. OLIGOSANTHES VAR SCRIBNERIANUM	M	I	I	I	I	I	I	I	I	I	5.8	0.0	5.8	5.3	3.3	3.6	I	4.8	3.6	2.3
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.54	0.00	1.03	.99	.59	.72	0.00	.95	.72	.48
NU	0	0	0	0	0	0	0	0	0	0	20	0	30	29	29	28	0	28	28	22
PANICUM VIRGATUM	M	I	I	I	I	I	I	I	I	I	.3	0	.0	.0	.0	.0	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
PHELOM PRATENSE	M	I	I	I	I	I	I	I	I	I	0	0	0	0	0	0	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POA PRATENSIS	M	I	I	I	I	I	I	I	I	I	21.3	14.3	11.2	5.0	4.5	54.1	I	9.2	9.6	16.1
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.24	1.73	1.43	.93	1.28	2.92	0.00	1.16	1.15	1.14
NU	0	0	0	0	0	0	0	0	0	0	30	30	30	30	30	30	0	30	30	30
SETARIA GEAUCA	M	I	I	I	I	I	I	I	I	I	11.1	8.0	0.0	0.0	0.0	.2	I	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.85	0.00	0.00	0.00	0.00	.12	0.00	0.00	0.00	0.00
NU	0	0	0	0	0	0	0	0	0	0	70	23	0	0	0	2	0	0	0	0
AMORPHA CANESCENS	M	I	I	I	I	I	I	I	I	I	1.2	1.2	5.7	2.9	9.0	12.1	I	7.2	4.8	3.2
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.70	1.55	.78	2.30	3.06	0.00	2.61	1.48	1.44	1.54
NU	0	0	0	0	0	0	0	0	0	0	4	4	19	20	22	16	0	19	19	9

Appendix Table 3. Plant Species list (continued)

SPECIES	LOCATIONS									
	1	2	3	4	5	6	7	8	9	10
<u>FORBS CONT.</u>										
<u>Aster laevis</u>								x		
<u>Aster oblongifolius</u>						x				x
<u>Aster sagittifolius</u>								x		
<u>Aster sericeus</u>	x		x	x		x	x	x	x	x
<u>Aster sp.</u>		x	x	x		x	x	x		x
<u>Astragalus canadensis</u>										x
<u>Astragalus crassicaarpus</u> var <u>crassicaarpus</u>	x		x			x		x	x	x
<u>Baptisia leucophaea</u>	x									x
<u>Cacalia tuberosa</u>	x						x			
<u>Callirhoe alcaeoides</u>								x		x
<u>Campanula americana</u>									x	
<u>Cannabis sativa</u>								x		
<u>Cassia fasciculata</u>					x		x			
<u>Cirsium altissimum</u>	x							x		x
<u>Cirsium flodmanii</u>								x		
<u>Comandra umbellata</u>		x	x	x		x	x			x
<u>Conyza canadensis</u>	x			x	x	x	x	x	x	x
<u>Coreopsis palmata</u>		x	x	x		x	x		x	x
<u>Delphinium tricorne</u>										x
<u>Delphinium virescens</u>			x					x	x	x
<u>Desmodium illinoense</u>	x		x	x		x	x	x		x
<u>Echinacea angustifolia</u>	x	x	x	x		x	x	x	x	x

Appendix Table 3. Plant Species list (continued)

SPECIES	LOCATIONS									
	1	2	3	4	5	6	7	8	9	10
<u>FORBS CONT.</u>										
<u>Erigeron annuus</u>	x						x	x		
<u>Erigeron strigosus</u>	x	x	x	x		x	x	x	x	x
<u>Erthronium mesochoreum</u>			x	x					x	x
<u>Euphorbia corollata</u>	x	x	x	x	x	x	x	x	x	x
<u>Euphorbia nutans</u>					x					x
<u>Euphorbia marginata</u>					x					
<u>Fragaria virginiana</u>	x			x				x		x
<u>Gaura longiflora</u>								x	x	
<u>Gentiana puberulenta</u>	x	x	x			x		x	x	x
<u>Glycyrrhiza lepidota</u>										x
<u>Hedeoma hispida</u>	x									x
<u>Helianthus rigidus</u>	x		x	x			x			x
<u>Helianthus tuberosus</u>									x	
<u>Heliopsis helianthoides</u>	x	x	x	x		x	x	x	x	x
<u>Hieracium longipilum</u>	x		x					x		x
<u>Kuhnia eupatorioides</u>	x		x	x	x	x	x	x	x	x
<u>Lactuca sp.</u>		x			x			x	x	x
<u>Lespedeza sp.</u>							x			
<u>Lepidium densiflorum</u>								x	x	
<u>Liatris aspera</u>								x		x
<u>Liatris sp.</u>										x
<u>Lillium superbum</u>								x		

Appendix Table 3. Plant Species list (continued)

SPECIES	LOCATIONS									
	1	2	3	4	5	6	7	8	9	10
<u>FORBS CONT.</u>										
<u>Linum sulcatum</u>	x			x				x		
<u>Lithospermum canescens</u>							x	x	x	x
<u>Lithospermum incisum</u>										x
<u>Lygodesmia juncea</u>				x		x	x	x		
<u>Medicago sativa</u>				x				x		x
<u>Melilotus officinalis</u>				x	x		x			
<u>Monarda fistulosa</u>	x	x	x	x		x		x	x	x
<u>Onosmodium molle</u>			x	x		x				x
<u>Oxalis dillenii</u>	x	x	x		x	x	x	x	x	x
<u>Oxalis violacea</u>			x				x		x	x
<u>Petalostemon candidum</u>	x	x	x	x		x	x	x	x	x
<u>Petalostemon purpureum</u>	x	x	x	x			x	x		x
<u>Phlox pilosa</u>	x	x	x	x		x	x	x	x	x
<u>Physalis heterophylla</u>		x		x						
<u>Physalis virginiana</u>	x	x	x	x	x	x	x	x	x	x
<u>Plantago rugelli</u>							x	x		
<u>Polygonatum biflorum</u>				x						
<u>Polygonum sp.</u>								x		
<u>Potentilla arguta</u>	x	x	x			x	x	x	x	x
<u>Potentilla recta</u>								x		
<u>Psoralea argophylla</u>	x									
<u>Psoralea esculenta</u>	x		x	x				x		x
<u>Ranunculus abortivus</u>				x						

Appendix Table 3. Plant Species list (continued)

SPECIES	LOCATIONS									
	1	2	3	4	5	6	7	8	9	10
<u>FORBS CONT.</u>										
<u>Ratibida columnifera</u>								x		
<u>Ratibida pinnata</u>	x	x	x			x	x		x	x
<u>Rudbeckia hirta</u>	x	x	x	x		x	x	x	x	x
<u>Rumex sp.</u>								x		
<u>Sanicula canadensis</u>							x			
<u>Scutellaria parvula</u>	x	x	x	x			x			x
<u>Senecio plattensis</u>	x		x	x				x		x
<u>Silphium integrifolium</u>	x	x	x	x		x	x	x	x	x
<u>Silphium laciniatum</u>				x			x	x		x
<u>Silphium perfoliatum</u>										x
<u>Sisymbrium loeselli</u>				x					x	
<u>Sisyrinchium campestre</u>	x	x	x	x		x	x	x	x	x
<u>Solidago canadensis</u> var. <u>gilvocanescens</u>	x		x	x		x	x	x	x	x
<u>Solidago gigantea</u>									x	
<u>Solidago missouriensis</u>								x	x	x
<u>Solidago rigida</u>	x									x
<u>Solidago sp.</u>	x							x		
<u>Taraxacum officinale</u>	x	x	x	x	x	x	x	x	x	x
<u>Thalictrum dasycarpum</u>			x	x			x			
<u>Teucrium canadense</u>	x							x		
<u>Tradescantia sp.</u>									x	
<u>Tragopogon dubius</u>	x		x	x	x	x	x	x	x	x
<u>Trifolium pratense</u>	x	x			x	x		x		x

