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Abstract. Ten eastern Nebraska tallgrass prairie remnants were evaluated up to four times during the 1979 growing season to assess vegetative composition and the effects of mowing, topographic and size differences, and season of evaluation. Frequent mowing resulted in a reduced canopy cover of some species, such as big bluestem (*Andropogon gerardii* Vitman) (21% lower with frequent mowing), but increased cover of others, particularly the introduced species smooth brome (*Bromus inermis* Leyss. subsp. *inermis*) (35% higher cover with frequent mowing). In addition, frequent mowing resulted in a higher proportion of disturbance species. Comparing the time of mowing, canopy cover of warm-season species averaged 54% higher and cool-season species 26% lower with early summer mowing. Individual species' cover also varied by topoedaphic setting; total plant cover, grass cover, and forb cover were lowest on hilltops and south-facing slopes. Additionally, canopy cover of individual species varied throughout the growing season with total plant cover and the total number of species highest in the August evaluation. A significant, positive correlation ($P = 0.05$, $r = 0.44$) was found between remnant prairie size and the number of species.

Key Words. prairie, tallgrass, management, mowing, Nebraska

INTRODUCTION

Weaver (1965) described the floristic composition of several eastern Nebraska tallgrass prairie remnants and identified nearly 250 species in lowlands and 200 species in uplands. Dominant grasses included big bluestem (*Andropogon gerardii* Vitman), little bluestem (*Andropogon scoparius* Michx.), indiangrass [*Sorghastrum nutans* (L.) Nash], switchgrass (*Panicum virgatum* L.), reed canary grass (*Phalaris arundinacea* L.), prairie cordgrass (*Spartina pectinata* Link), and porcupine-grass (*Stipa spartea* Trin.). Kentucky bluegrass (*Poa pratensis* L.), a non-native grass species (Cronquist *et al.* 1977), occurred in upland and lowland prairies (5% frequency). Invasion of this species was attributed to its introduction by European settlers and the suppression of naturally occurring prairie fires. Flowering spurge (*Euphorbia corollata* L.), prairie phlox (*Phlox pilosa* L.), wholeleaf rosin-weed (*Silphium integrifolium* Michx.), and white prairieclover (*Dalea candida* Michx. *ex* Willd.) were some of the common forbs in these native prairies.

Prairies in eastern Nebraska once were subject both to grazing by large herbivores, such as elk (*Cervus canadensis*) and bison (*Bison bison*) (Bradbury 1819), and to burning (Long 1823, Higgins 1986). Burning continues to be used to maintain many native prairies for cattle grazing, however, many remnants in eastern Nebraska are neither grazed nor burned but rather are managed for hay production. Prairie remnants are most commonly mowed in late summer or early fall. The season and frequency with which mowing occurs, however, affects species composition and productivity. With respect to season of mowing, Hover and Bragg (1980) and Holderman and Goetz (1981) reported increases in porcupine-grass in Nebraska and needle-and-thread (*Stipa comata* Trin. & Rupr.) in western North Dakota with mid-growing season mowing. Forbs, such as soft goldenrod (*Solidago mollis* Bartl.), also increased with annual late summer mowing (Launchbaugh and Owensby 1978). On the other hand, spring mowing favored warm-season species like big bluestem and also increased total net tallgrass prairie production (Launchbaugh and Owensby 1978, Hover and Bragg 1980, Gillen and McNew 1987). With respect to effects of frequent mowing (i.e. mowing more than once during the growing season), Biswell and Weaver (1933), Weaver and Rowland (1952) and Hulbert (1969) suggested that this type of management reduced net primary production.

Topographic and edaphic heterogeneity are additional factors that are reflected in prairie remnants (Diamond and Smeins 1985). Variability in these parameters is expected to be greater in large than in small prairies thus influencing vegetative composition such that larger prairies are likely to include a greater number of species (Crockett 1964, Van der Maarel 1971). In addition, a large prairie remnant is more likely to support a greater number of dispersed populations of any one species than is a smaller remnant (Thompson 1975) so that the chance elimination of one population does not preclude the reestablishment of the species from another nearby population. In a small prairie remnant, however, with some 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 prairie remnants than in large ones. Nepstad and Hoffhines (1980), for example, suggested a direct relationship between prairie size and species diversity. Similar relationships between the size of an area and species diversity have been reported for many other ecosystems including islands (Case and Cody 1987) and terrestrial landscape patches (Forman and Godron 1981), such as isolated prairie remnants surrounded by cropland.

An additional factor reflected in data obtained from prairie remnants may, in fact, be an artifact of sampling procedures. Most studies on native prairies appear to have been conducted only once during a growing season. The phenology of grassland species, however, is known to vary (Anderson and Schelfhout 1980), thus, the season of evaluation may affect the results obtained, particularly with respect to species richness.

This study was designed to provide quantitative information on the floristic composition of ten, extant native prairie remnants in eastern Nebraska and also to consider the effects of season and frequency of mowing, topoedaphic variability, prairie remnant size, and season of evaluation. The principal limitation of the study was the absence of a suitable number of replicates of each treatment due to the limited number of extant prairie remnants.

METHODS

Study Sites

In 1979, 10 native prairie remnants in Douglas and Sarpy counties in eastern Nebraska were selected for study. The specific location of each study site is available in Boettcher (1981). The bases for selection were domination by native vegetation; no evidence of cultivation, herbicide use, or interseeding; ease of access; and topoedaphic similarity. Recent management history of each prairie remnant (Table 1) was determined by contacting present landowners. Soils on all sites were deep, nearly level to steeply sloping, silty loams or silty clay loams formed in loess (Table 1). Six topoedaphic settings were separately evaluated; north-, south-, east-, and west-facing slopes, hilltops (narrow ridge tops of uplands), and broad uplands. Evaluations were conducted midslope or centered on hilltops or uplands.

Table 1. Study sites. Mowed frequently = mowed 6 or more times during a growing season. Soil Type Symbols (from Bartlett 1975): Ma = Marshall silty clay loam, Mf = Marshall silty clay loams and Ponca silt loams, Ms = Monona and Ida silt loams, C = 3-7% slopes, D = 7-11% slopes, E = 11-17% slopes, F = 17=30% slopes. Topoedaphic Settings: N = north-facing slope, S = south-facing slope, E = east-facing slope, W = west-facing slope, H = hilltop or narrow ridgetops, U = broad upland.

Site number	*Size (ha)*	*Management*	*Topoedaphic setting*	*Soil type*
1	8.5	Mowed annually in July	N,S,E	MaD
2	1.2	Mowed annually in August/September	N	MoE
3	6.9	Mowed annually in August/September	N,S H	MoE MoC
4	2.0	Mowed annually in August	N,S H	MoD MsE
5	2.0	Mowed frequently	N,S	MoD
6	4.9	Mowed annually in June	S H	MsF MoC
7	2.0	Mowed annually in July	S	MsF
8	2.0	Mowed frequently	U	MaB
9	4.9	Mowed annually in August	W	MoD
10	18.2	Mowed annually in late August	N,E,W H	MfE MaC

Vegetative Analysis

A total of 21 transects (10 m long) were evaluated. These transects included seven topoedaphic settings (Table 1), although all settings were not present at any one site. Each topoedaphic setting within a site was evaluated by dividing the area into thirds and then establishing three replicate plots centered within each third. Ten circular microplots (1 m^2) were systematically located 1 m apart on alternate sides of each 10-m transect. Vegetation within each microplot was evaluated three times during 1979: 30 May-6 June, 20-27 June, and 30 July-13 August. Some sites were also evaluated from 22-30 September depending on the time of mowing or the ability to obtain permission from landowners to establish exclosures from mowing.

Within each microplot, percent canopy cover was estimated for each species as well as for total vegetative, grass, forb, woody plant, and moss cover. Coverage categories used were: 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, and >95% (Daubenmire 1959). Data were analyzed by using mid-point values of each coverage category. Floristic composition was described using two parameters, average canopy cover and frequency. Dominant species are defined as those with the highest average canopy cover value for a topoedaphic setting that also have a frequency of at least 50% within that area. Additional species were considered dominants, regardless of frequency, if their average canopy cover for a topoedaphic setting was within 10% of the species initially designated as dominant. In addition to quantitative data within each microplot, species present at a site, but not found within study plots, were recorded throughout the season. Plant identifications were verified at the University of Nebraska at Omaha Herbarium

Table 2. Maximum canopy (% ± S.E.) from the 1st, 2nd, or 3rd evaluation for north-facing slopes. Only dominants and selected species are included. tr = < 0.5% cover. Underlined values indicate the dominant species for each topoedaphic study area. A complete listing of species is available in Boettcher (1981). For scientific names, see text or Great Plains Flora Association (1986).

Floristics	*Study sites of the north-slope topoedaphic setting*					
	1	*2*	*3*	*4*	*5*	*10*
	% ± S.E.					
Total Cover	91 ± 1.5	97 ± 0.6	98 ± 0.0	98 ± 0.0	74 ± 2.5	98 ± 0.0
Grass Cover	83 ± 1.6	92 ± 1.8	89 ± 1.1	88 ± 1.4	73 ± 2.5	97 ± 0.6
Forb Cover	47 ± 3.7	43 ± 3.8	26 ± 3.8	49 ± 4.5	3 ± 0.8	59 ± 4.6
Woody Cover	15 ± 4.1	2 ± 1.2	7 ± 1.1	71 ± 3.3	1 ± 0.7	8 ± 2.4
Moss Cover	22 ± 2.4	2 ± 0.2	10 ± 1.1	12 ± 1.0	2 ± 0.2	18 ± 1.7
Grass and Sedges:						
big bluestem	61 ± 2.6	57 ± 2.9	76 ± 3.1	48 ± 4.2	27 ± 2.1	0 ± 2.1
little bluestem	6 ± 2.2	1 ± 0.2	0	1 ± tr	3 ± 0.8	50 ± 3.7
smooth brome	1 ± 0.1	0	0	17 ± 3.5	52 ± 2.9	tr
Japanese brome	33 ± 4.0	0	0	48 ± 3.2	2 ± 0.2	0
Mead's sedge	3 ± 0.6	tr	2 ± 0.2	tr	1 ± 0.5	6 ± 1.2
Kentucky bluegrass	26 ± 2.2	43 ± 2.9	58 ± 1.7	29 ± 2.1	40 ± 3.0	34 ± 1.6
yellow foxtail	0	0	0	0	3 ± 0.9	0
porcupine-grass	10 ± 2.3	12 ± 2.9	51 ± 7.3	27 ± 3.9	0	18 ± 5.4
Forbs:						
silky aster	tr	0	1 ± 0.	0	0	1 ± 0.5
white aster	1 ± 0.2	10 ± 1.8	1 ± 0.2	3 ± 1.4	tr	1 ± 0.2
daisy fleabane	6 ± 1.0	tr	tr	0	0	1 ± 1.5
horseweed	tr	0	0	0	0	0
false sunflower	0	tr	2 ± 0.8	33 ± 4.9	0	0
red clover	27 ± 3.5	6 ± 1.0	0	0	1 ± 0.5	25 ± 2.2
Woody Plants:						
leadplant	4 ± 1.4	1 ± 1.3	7 ± 1.5	12 ± 2.0	1 ± 0.7	6 ± 1.5
New Jersey tea	11 ± 4.1	0	0	61 ± 4.2	0	2 ± 2.1
Equisetum spp.:	tr	14 ± 2.6	23 ± 3.1	0	0	0

Table 3. Maximum canopy (% ± S.E.) from the 1st, 2nd, or 3rd evaluation for south-facing slopes. Only dominants and selected species are included. tr = < 0.5% cover. Underlined values indicate the dominant species for each topoedaphic study area. A complete listing of species is available in Boettcher (1981). For scientific names, see text or Great Plains Flora Association (1986).

Floristics	*Study sites of the south-slope topoedaphic setting*					
	1	*3*	*4*	*5*	*6*	*7*
	% ± S.E.					
Total Cover	96±0.8	91±1.2	97±0.4	76±2.6	91±1.5	94±1.4
Grass Cover	91±1.5	84±1.4	86±1.1	76±2.6	71±2.9	85±1.8
Grass Cover	91±1.5	84±1.4	86±1.1	76±2.6	71±2.9	85±1.8
Forb Cover	58±4.9	13±1.8	37±4.5	3±0.7	65±2.9	28±3.7
Woody Cover	21±4.1	17±3.6	64±6.0	1±0.7	50±3.2	18±3.9
Moss Cover	4±0.7	7±1.4	5±1.0	7±1.5	tr	1±0.2
Grasses and Sedges:						
big bluestem	54±4.6	43±3.6	44±4.9	35±4.6	34±4.5	62±3.7
little bluestem	3±0.9	4±1.8	2±0.8	3±0.8	28±3.9	18±4.4
smooth brome	21±5.6	3±0.1	40±5.8	59±1.9	tr	10±1.9
Japanese brome	29±5.0	0	41±3.3	2±0.2	0	10±2.8
Mead's sedge	2±0.5	tr	0	0	3±0.9	tr
Kentucky bluegrass	20±2.3	35±1.4	32±2.3	37±1.8	21±2.7	13±2.1
yellow foxtail	0	0	0	2±0.7	0	0
porcupine-grass	47±5.8	39±3.9	6±2.5	0	2±1.2	1±0.7
Forbs:						
white aster	tr	tr	7±2.5	tr	1±0.2	6±1.6
daisy fleabane	10±2.5	1±0.5	1±0.2	0	tr	0
horseweed	1±0.5	0	tr	tr	0	0
false sunflower	0	tr	tr	0	56±3.6	tr
red clover	40±3.9	0	0	tr	0	0
Woody Plants:						
leadplant	21±4.1	16±3.6	7±1.9	1±0.7	25±4.3	15±3.2
New Jersey tea	1±0.5	0	58±6.7	0	22±4.7	3±2.8
Equisetum spp.:	0	3±0.2	0	0	0	0

(OMA). Common and scientific nomenclature follows that in the Great Plains Flora Association (1986).

Vegetative diversity within each topoedaphic setting was calculated using the Shannon-Wiener diversity index (H'); higher values indicate higher diversity (Krebs 1978). Species richness, the total number of species present, was also calculated for each topoedaphic setting and for each site. Pearson's correlation was used to determine relationships between prairie remnant size, species richness, and species diversity (Ott 1977).

RESULTS

Floristic Composition

During the study, 153 species were recorded for all sites combined, of which 99 occurred within evaluated microplots (Boettcher 1981). Average vegetative cover for all sites varied between 60-98% with substantial seasonal variations in cover for grasses (30-98%), forbs (1-68%), woody plants (0-64%), and mosses (0-33%). Using canopy cover data from the first three evaluation periods, seven species were found to dominate (Tables 2, 3, 4, and 5). Big bluestem was the single most prevalent species occurring in all 21 of the transects evaluated, dominating in 13, and averaging a higher canopy cover in all topoedaphic settings than any other species. Kentucky bluegrass also occurred in all study areas although it dominated in only two. Porcupine-grass, a native cool-season grass, dominated in five areas and was present in all sites except one which was predominantly smooth brome. Other dominants included little bluestem, false sunflower [*Heliopsis helianthoides* (L.) Sweet var. *scabra* (Dun.) Fern.], and New Jersey tea (*Ceanothus americanus* L. var. *pitcheri* T.& G.). Leadplant (*Amorpha canescens* Pursh) and white aster (*Aster ericoides* L.) were common in all study areas although they were not dominants as defined in this study.

Mowing Management

Frequency of mowing.

Effects of mowing frequency were compared on north-facing slopes of two adjacent sites (Sites 4 and 5). These sites were similar in size and topography and thus are most likely to differ only in management. Site 5 had been mowed frequently throughout the growing season while Site 4 had been mowed only once each year in August. Total vegetative cover, grass cover, woody plant cover (primarily New Jersey tea), and forb cover averaged, respectively, 24%, 15%, 70%, and 46% lower with frequent mowing than with a single annual mowing (Tables 2 and 3). Mowing frequency also affected individual species. For example, the more frequently mowed site averaged 35% higher cover for smooth brome and 11% higher for Kentucky bluegrass, but 21% lower for big bluestem. Porcupine-grass was absent from the frequently mowed area but averaged 27% cover on the annually mowed site. In addition, disturbance species such as horseweed [*Conyza canadensis* (L.) Cronq.] and yellow foxtail [*Setaria glauca* (L.) Beauv.] were present in greater numbers on the frequently mowed areas (14 species) than on the area mowed once annually (7 species) (Boettcher 1981). Despite this increase in disturbance species, species diversity (H') was 25% lower and species richness 28% lower with frequent mowing than with annual mowing (Boettcher 1981). Similar effects on species diversity and species richness were seen both on south slopes of the same sites and on other non-adjacent sites.

Table 4. Maximum canopy (% ± S.E.) from the 1st, 2nd, or 3rd evaluation for east- and west-facing slopes. Only dominants and selected species are included. tr = < 0.5% cover. Underlined values indicate the dominant species for each topoedaphic study area. A complete listing of species is available in Boettcher (1981). For scientific names, see text or Great Plains Flora Association (1986).

Floristics	*Topoedaphic setting and study site*			
	East slope		*West slope*	
	1	*10*	*9*	*10*
	------% ± S.E.------			
Total Cover	93 ± 1.1	98 ± 0.0	96 ± 1.3	95 ± 0.9
Grass Cover	81 ± 1.9	98 ± 0.0	91 ± 3.1	92 ± 1.8
Forb Cover	51 ± 2.8	68 ± 4.4	39 ± 4.5	54 ± 4.3
Woody Cover	3 ± 2.6	12 ± 3.3	3 ± 0.8	7 ± 2.7
Moss Cover	5 ± 0.9	20 ± 1.7	7 ± 1.2	33 ± 3.6
Grasses and Sedges:				
big bluestem	37 ± 3.7	46 ± 5.3	69 ± 6.3	61 ± 2.9
little bluestem	4 ± 1.5	22 ± 5.2	11 ± 4.1	15 ± 2.7
smooth brome	0	0	5 ± 1.8	0
Japanese brome	9 ± 2.6	0	tr	0
Mead's sedge	3 ± 0.6	2 ± 0.5	0	3 ± 0.7
Kentucky bluegrass	13 ± 1.6	40 ± 2.6	36 ± 1.8	41 ± 1.6
porcupine-grass	41 ± 4.0	42 ± 4.9	9 ± 2.9	22 ± 3.7
Forbs:				
white aster	1 ± 0.2	5 ± 1.5	12 ± 3.8	8 ± 2.6
daisy fleabane	4 ± 0.9	4 ± 0.9	1 ± 0.5	10 ± 1.1
horseweed	1 ± 0.2	0	0	0
false sunflower	0	tr	tr	tr
red clover	20 ± 2.9	1 ± 0.5	0	0
Woody Plants:				
leadplant	13 ± 2.6	12 ± 3.3	3 ± 0.8	5 ± 1.9
Equisetum spp.:	0	3 ± 1.4	tr	0

Season of mowing.

The effects of mowing during different seasons are apparent when comparing the hilltops and south-facing slopes of Site 4, mowed in August, and Site 6, mowed in June. While general vegetative characteristics did not indicate specific trends, such trends were consistently shown by individual species for both topoedaphic settings. June mowing resulted in higher cover for little bluestem (+ 19%) and leadplant (+ 12%). Whereas, August mowing resulted in higher cover values for New Jersey tea (+ 44%) and porcupine-grass (+ 18%) (Tables 3 and 5). The design of this study was such that it is not clear whether these different treatments actually favor the species that increase or if they only indicate different degrees to which the species are adversely affected by late-season mowing. The higher amount of Japanese brome (*Bromus japonicus* Thunb. *ex* Murr.) (+ 24%), does, however, suggest that late-season mowing provides conditions suitable for such annual, disturbance species. Also, the high cover for the introduced grass, smooth brome (40% for August mowing; trace for June mowing), suggests that late-season mowing results in conditions that encourage the expansion of this species into native prairie.

Topography

Using average values combined for each transect for each topoedaphic setting, total vegetative cover, grass cover, and forb cover averaged respectively 92%, 83% and 30% lower on hilltops and south-facing slopes than on other topoedaphic settings (Tables 3 and 5). Of the dominant species, big bluestem averaged highest (65%) on west-facing slopes and, in addition, averaged higher than any other species on all topoedaphic settings except the one upland site evaluated (Tables 2, 3, 4, and 5). Canopy cover of smooth brome, false sunflower, and New Jersey tea averaged highest on south slopes (22%, 19%, and 14% respectively), while little bluestem and Kentucky bluegrass cover averaged highest on uplands (33% and 67% respectively). Porcupine-grass averaged highest on east-facing (42% cover) and south-facing (43% cover) slopes. Such topographic preferences of species were also noted for individual study sites and for species other than dominants.

The complexity of the response of species to management was indicated by considering different effects of management on different topoedaphic settings. While not conclusive due to the absence of replicates, one such comparison involved the contrast in species composition of the north-facing and south-facing slopes between Site 5 (mowed frequently throughout the growing season) and Site 4 (mowed annually in August). This comparison suggested that frequent mowing favored smooth brome to the extent that it dominated both topoedaphic settings (52% and 59% cover for north-facing and south-facing slopes respectively). A single annual mowing, however, resulted in 23% higher cover for smooth brome on north-facing slopes (40% cover) than on south-facing slopes (17% cover). Frequent mowing, however, did not result in similar coverage on all topoedaphic settings for all species. Porcupine-grass and false sunflower, for example, averaged 21% and 33%, respectively, higher on north-facing than on south-facing slopes in the frequently mowed area.

Species diversity (H') and species richness were more commonly highest on east-facing slopes, hilltops, and uplands (H' = 3.79, 3.14, and 3.67, respectively) (Boettcher 1981). Such effects, however, are not reflected in data for all sites or for all seasons of the year.

Table 5. Maximum canopy (% ± S.E.) from the 1st, 2nd, or 3rd evaluation for hilltop and upland topoedaphic settings. Only dominants and selected species are included. tr = < 0.5% cover. Underlined values indicate the dominant species for each topoedaphic study area. A complete listing of species is available in Boettcher (1981). For scientific names, see text or Great Plains Flora Association (1986).

Floristics	*Topoedaphic setting and study site*				
	Hilltop			*Upland*	
	3	*4*	*6*	*10*	*8*
	% ± S.E.				
Total Cover	87 ± 2.1	92 ± 1.8	94 ± 1.0	95 ± 1.0	97 ± 0.4
Grass Cover	79 ± 2.0	81 ± 2.2	85 ± 1.9	92 ± 1.5	97 ± 1.6
Forb Cover	15 ± 2.9	25 ± 2.8	19 ± 2.5	47 ± 3.9	57 ± 4.3
Woody Cover	17 ± 4.4	47 ± 5.3	18 ± 5.3	10 ± 3.2	17 ± 4.1
Moss Cover	10 ± 2.0	5 ± 1.1	3 ± 0.6	29 ± 2.3	3 ± 0.6
Grasses and Sedges:					
big bluestem	<u>59 ± 3.2</u>	20 ± 4.0	<u>74 ± 2.7</u>	<u>45 ± 6.4</u>	32 ± 4.4
little bluestem	0	tr	<u>11 ± 2.4</u>	<u>25 ± 4.9</u>	33 ± 4.6
smooth brome	2 ± 1.4	<u>40 ± 5.3</u>	0	0	1 ± 0.6
Japanese brome	0	<u>6 ± 1.9</u>	0	0	0
Mead's sedge	tr	tr	tr	2 ± 0.5	3 ± 0.1
yellow foxtail	0	tr	0	0	0
porcupine-grass	15 ± 4.0	<u>30 ± 5.7</u>	4 ± 1.4	19 ± 3.6	3 ± 1.5
Forbs:					
white aster	1 ± 0.2	1 ± 0.7	4 ± 0.7	9 ± 2.7	1 ± 0.2
daisy fleabane	1 ± 0.2	tr	1 ± 0.2	9 ± 1.5	1 ± 0.2
horseweed	0	0	tr	0	tr
false sunflower	tr	4 ± 0.9	5 ± 1.5	tr	0
red clover	0	0	0	tr	38 ± 5.0
Woody Plants:					
leadplant	7 ± 2.1	12 ± 2.5	18 ± 3.7	20 ± 3.2	14 ± 4.1
New Jersey tea	11 ± 4.5	31 ± 5.1	0	0	0
Equisetum spp.:	0	0	0	0	tr

Seasonal Variations

Combining all sites, the general category "Total Vegetative Cover" averaged lowest in the first and highest in the fourth evaluation although forb cover averaged 11-16% higher in the third evaluation than for all others (Boettcher 1981). Differences in evaluation time also were reflected in individual species data. For example, Kentucky bluegrass, a cool-season species, averaged 3-17% higher during the first than during subsequent evaluations. On the other hand, big and little bluestem, warm-season species, averaged 11-20% and 10-15% higher, respectively, during the third than during the fourth evaluation.

Seasonal variations in species diversity were detected with the maximum diversity occurring during the first evaluation for 10 of the 21 transects (Boettcher 1981). Only the frequently mowed site (Site 5) consistently had higher diversity during the third and fourth evaluations for all topoedaphic settings. Of the 99 species present in study plots, only 65 were found in all four evaluations. Four species, hoary puccoon [*Lithospermum canescens* (Michx.) Lehm.], false dandelion [*Microseris cuspidata* (Pursh) Sch.-Bip.], prairie ragwort (*Senecio plattensis* Nutt.), and American germander (*Teucrium canadense* L.), were found only in the first evaluation. Thirteen species were present in the first, second, and third evaluations but not in the fourth: bluntleaf milkweed (*Asclepias amplexicaulis* Sm.), common milkweed (*Asclepias syriaca* L.), Mead's sedge (*Carex meadii* Dew.), purple coneflower (*Echinacea angustifolia* DC.), annual fleabane [*Erigeron annuus* (L.) Pers.], daisy fleabane (*Erigeron strigosus* Muhl. *ex* Willd.), rough false pennyroyal (*Hedeoma hispidum* Pursh), clammy ground cherry (*Physalis heterophylla* Nees), breadroot scurf-pea (*Psoralea esculenta* Pursh), white-eyed grass (*Sisyrinchium campestre* Bickn.), goatsbeard (*Tragopogon dubius* Scop.), western ironweed (*Vernonia baldwinii* Torr.), and golden alexanders [*Zizia aurea* (L.) Koch.] (Boettcher 1981). Of all the seasons available for sampling, however, mid-summer sampling was found to be the best time to locate all but a few early spring plants.

Prairie Remnant Size

The preliminary survey of remnant prairies in the Omaha area revealed that the size of extant remnants ranged from < 1 ha (not used in this study) to 18 ha with the second largest only 8 ha in size. A significant correlation ($P < 0.05$, $r = 0.44$) was found between species richness and prairie remnant size when considering both species density within study plots and the total number of species listed for the entire remnant prairie, both inside and outside of study plots (Fig. 1). No significant correlation was found between Species Diversity (H') and the size of remnant prairies.

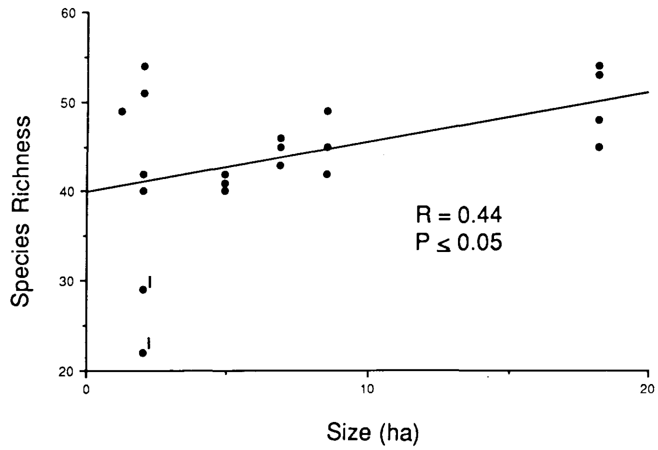

FIG 1. Species Richness and prairie size relationships for all transects ([1]areas mowed more frequently than once annually).

DISCUSSION

A comparison between the present study and an earlier study conducted approximately 80 km to the east (Weaver and Fitzpatrick 1934) suggests that species composition of prairie remnants has changed during the last 40-50 years. Big bluestem and porcupinegrass, which were both dominants circa 1934, still dominate but introduced species, such as Kentucky bluegrass, smooth brome, Japanese brome, and red clover (*Trifolium pratense* L.), are all more common than previously recorded. There also appears to have been a decline in the total number of native upland species as suggested by the difference between a total of 200 species mentioned by Weaver (1965) and the 153 identified by Boettcher (1981).

While the difference in the number of native species between 1965 and 1981 may be attributable to original site differences, this study suggests that the fewer species noted in 1981 is a consequence of different mowing management being applied during the intervening years. Frequent mowing reduced species diversity, decreased total vegetative cover, and altered composition by encouraging disturbance species or aggressive, introduced species. In addition, the season of mowing effected species composition, a conclusion also reached by Hover and Bragg (1980). Such effects clearly could explain the differences in species composition between 1965 and 1980.

Individual prairie locations were unlikely to have been identical even prior to European settlement. This study, however, suggests that differences in prairies today are more likely to reflect different types of management over the past decades than original site differences. The significance of this observation is twofold: first, extant prairie remnants are unlikely to duplicate the composition and diversity of the presettlement ecosystem, and second, future management may continue to cause prairies to degenerate as, for example, introduced species increase in number and possibly outcompete and replace native species. Natural evolutionary and environmental changes cause compositional changes over long periods of time but, for the short term, careful and continued monitoring of on-going management is essential to assess the effects of any management plan. Additionally, in those locations where it is possible to do so, consideration should be given to reestablishing the natural factors, such as the fire and large-herbivore grazing and their related frequency and intensity of occurrence, that affected ecosystem "management" prior to European settlement.

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