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Community Composition of Dry Prairie in Iowa and Southeast Nebraska

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Results from quantitative research on the community composition of dry prairies across Iowa were consolidated from three different studies completed since 1983. Information is provided on the distribution and abundance of 204 dry prairie species. The most abundant species included little bluestem (*Schizachyrium scoparium* (Michx.) Nash), big bluestem (*Andropogon gerardii* Vitman), side-oats grama (*Bouteloua curtipendula* (Michx.) Torrey), prairie dropseed (*Sporobolus heterolepis* (Gray) Gray) and Kentucky bluegrass (*Poa pratensis* L.). Multivariate analyses were completed using two independent measures of species abundance—relative cover and community constancy. When relative cover was used to determine community composition, the abundance of graminoids (tallgrasses vs. mid-grasses) had a strong effect on community composition and variation was mostly influenced by soil moisture. When community constancy was used to determine community composition, forbs had a higher representation and plant biogeography had a strong effect on variation in community composition.

INDEX DESCRIPTORS: mid-grass prairie, tallgrass prairie, hill prairie, gravel prairie, loess hill prairie, community composition, relative cover, community constancy, Iowa prairie, Nebraska prairie.

Research on the community composition of Iowa prairies has occurred along several fronts. Descriptive studies have primarily been qualitative in nature (e.g., Pammel 1901, Hayden 1911, Shimek 1911, 1917, 1924, Morrill 1953, Weaver 1958, Sorenson 1962, Crum 1972, Baringer 1974, Glenn-Lewin 1976, Vander Zee 1977, Novacek et al. 1985). Other research has focused on the effects of management activities (e.g., Aikman 1955, Ehrenreich 1959, Richards 1969, Christiansen 1972, Hill and Platt 1975) or the vegetation dynamics occurring during succession or in ecotones (e.g., Aikman 1928, 1930, Costello 1931). Most of the earliest quantitative community work was restricted to single locations (Kennedy 1969, Brotherson and Landers 1973, Crist and Glenn-Lewin 1978).

During the 1980's and early 90's, quantitative community studies were completed at the scale of landforms. White (1983) described the community composition of prairie throughout Iowa. His study included many of the prairies in Iowa's state preserve system and encompassed habitats from wet mesic prairies to dry gravel prairies. However, other dry prairie communities, in particular northeast Iowa hill prairies and western Iowa Loess Hill prairies, were not included in his work. Following the initiative of White, Ugarte (1987) completed a quantitative study of the hill prairies in northeast Iowa, and Rosburg (1994) delineated community types in the Loess Hills.

The objectives of these analyses were: 1) to provide information on the distribution and abundance of plant species inhabiting dry prairie communities in Iowa and southeast Nebraska, 2) to assess and compare the community composition of these dry prairie remnants, and 3) to evaluate the influence of two contrasting approaches in assessing the abundance of a species in a community. Quantitative descriptions of species composition were assembled for 13 dry prairie community types. Data were compiled from three sources: 1) White (1983)—gravel hill prairie, sand prairie, and dry mesic tallgrass prairie in Iowa and southeast Nebraska, 2) Ugarte (1987)—four northeast Iowa hill prairie communities, and 3) Rosburg (1994)—five Loess Hill prairie communities.

This database represents the measurement of species in approximately 10,500 quadrants and is the first data set that furnishes quantitative information and compares species abundance from prairie remnants on all of the major landform regions in Iowa. It is also the first time that the results of Ugarte (1987) have been made available outside of his dissertation. The thesis by White (1983) was summarized in White and Glenn-Lewin (1984) and components of the dissertation by Rosburg (1994) were presented in Rosburg and Glenn-Lewin (1996) and Rosburg (1997).

METHODS

Although methods of assessing abundance of species were different in each study, there were general similarities. All three studies delineated a community sample, (i.e., a specified area), in which species abundance was measured (Table 1). Ugarte (1987) and Rosburg (1994) measured abundance in subplots within the community sample, while White (1983) utilized the entire area of the community sample for vegetation measurement. White (1983) and Ugarte (1987) based the abundance of species on estimates of aerial cover, while Rosburg (1994) used a frequency index that was based on the basal cover of graminoid tillers and the density of stems or root crowns. For each community sample, White (1983) measured vegetation in twice as much area as Ugarte (1987), and Ugarte measured vegetation in four times as much area as Rosburg (1994) (Table 1).

In the White (1983) and Ugarte (1987) studies, only those species that were present in at least five community samples overall were included in further analyses and description. Rosburg (1994) utilized all species in classification and ordination analyses. Both White (1983) and Rosburg (1994) utilized TWINSPAN (Hill 1979a) to objectively identify community types (Table 2). Ugarte (1987) supposedly use DECORANA (Hill 1979b) to identify groups of community samples as community types, however his ordination suggests that community samples were subjectively classified a priori as one of four community types (Table 2). Information on the soil series represented by the study sites was used to compile a summary of the topographic and edaphic characteristics associated with the 13 dry prairie community types (Table 2).

Table 1. Summary of methods used in individual studies.

Study	Community Sample Size	Sample Area of Vegetation	Sampling Phenology	Measurement of Species Abundance	Species Abundance in Community Sample
White 1983	2 × 10 m	20 m^2	2 or 3 times	cover estimated as percentage of total sample area	maximum percentage cover observed over the season
Ugarte 1987	two 2 × 5 m	10 m^2	?	percentage cover estimated in 10 1-m^2 quadrats	total cover (m^2) in all 10 quadrats
Rosburg 1994	2 × 5 m	2.5 m^2	once	frequncy index for stems or tillers in 40 25 × 25 cm subplots	sum of indices in all subplots

In each of the individual studies, species abundance in community types was compiled by calculating the average absolute abundance for each species from the community samples representing a community type. Community constancy of a species is defined as the percentage of the community samples in which a species was present relative to the total number of community samples that represent a community type. Since White (1983) and Ugarte (1987) included only the species originally present in five or more community samples overall, the same criterion was applied to the five dry prairie community types representing the Loess Hills. Only the species present in five or more community samples were included in this analysis.

Because measurements of abundance were reported differently in each study, cover data (White 1983, Ugarte 1987) and frequency indices (Rosburg 1994) were converted to relative abundance data to facilitate comparisons. The species compositions of each community type were used to ordinate the 13 dry prairie community types. The pattern of variation among community types was examined using DECORANA. DECORANA produces a multi-dimensional ordination by detrended correspondence analysis, which reduces problems associated with arch effects in the calculation of second and higher order axes and with the scaling of axes (Hill 1979b). Two DECORANA ordinations were performed, one using relative abundance data (i.e., relative cover for 8 of the 13 community types, relative frequency for 5 types) and one using community constancy data.

Nomenclature throughout this paper follows Eilers and Roosa (1994).

RESULTS AND DISCUSSION

Individual Species Distribution and Abundance

Altogether a total of 204 species occurred in five or more samples within the individual studies and were thus included in the data set for this analysis. The relative abundance and community constancy of these species are presented for the 13 dry prairie community types (Table 3). Keep in mind that abundance of species was determined by quantitatively measuring species in plots, thus there are species that occur in these communities that are not represented in Table 3 because they were not observed in enough plots. For example, smooth aster (*Aster laevis* L.) and rough blazing star (*Liatris aspera* Michx.) both occur in Loess Hill prairie (Rosburg 1994), but they were recorded in fewer than five community samples from among the dry prairie community types and therefore were not included for the Loess Hills. Restricting inclusion of species to those in five or more samples overall emphasizes those species that are truly more representative, but also limits ability to distinguish between species that are truly absent and those present in relatively low amounts.

An important outcome of this analysis is the information pertaining to the natural distribution and abundance of many dry prairie species. This information (Table 3) is a critical element in planning the restoration or reconstruction of prairie, thus this paper is intended to serve primarily as a source of reference information for prairie ecologists, managers, and reconstructionists. For example, purple prairie clover (*Dalea purpurea* Vent.) was recorded in all of the dry prairie types except the bluff mid-grass community type in the Loess Hills. Its relative abundance was highest in the gravel hill, the northeast Iowa dry mesic tallgrass, the Loess Hill mid-grass, and the Loess Hill tall/mid-grass transition community types (Table 3). The distribution of purple prairie clover indicates that it does well in a variety of dry habitats, especially those with less dominance from tallgrasses and higher relative abundance of mid-grasses. In another example, prairie coreopsis (*Coreopsis palmata* Nutt.) had the highest relative abundance in the northeast Iowa hill prairies (particularly in the ungrazed tallgrass and mid-grass types) and the Iowa dry mesic tallgrass (Table 3). Although it was not represented in the Loess Hill prairies (Table 3), prairie coreopsis does occur in the Loess Hills, albeit very sparingly (Rosburg 1994). It also is well represented in more mesic prairie communities (White 1983).

Understanding species biogeographic patterns is also important for restoration and reconstruction. Because some community types were restricted to specific landforms, species abundance within geographical regions can be detected. For example, some species were represented only in the dry prairie of the Loess Hills, e.g., scarlet gaura (*Gaura coccinea* Pursh), bluets (*Hedyotis nigricans* (Lam.) Fosb.) and purple locoweed (*Oxytropis lambertii* Pursh) (Table 3). Other species were represented only in northeast Iowa hill prairie, e.g., blazing star (*Liatris cylindracea* Michx.) and Kalm's brome (*Bromus kalmii* Gray), or on sand prairie, e.g., hairy puccoon (*Lithospermum carolinense* (Walter) MacM.) and nut sedge (*Cyperus filiculmis* Vahl).

Likewise, it is just as informative to note species that are not present in certain regions—or present in such low amounts that they were either deleted from the original data or overlooked in sampling and should be considered marginal species for seeding. For example, downy gentian (*Gentiana puberulenta* J. Pringle) and pale spike lobelia (*Lobelia spicata* Lam.) are common prairie species in Iowa, but neither was represented in prairie communities in the Loess Hills or in the hill prairies in northeast Iowa (Table 3). Plains muhly grass (*Muhlenbergia cuspidata* (Torrey) Rydb.) and Missouri goldenrod (*Solidago missouriensis* Nutt.) are both fairly common in dry prairie, but they were not represented in northeast Iowa hill prairie. If the goal of prairie reconstruction and restoration is to promote natural prairie communities, the identification of species not to include, which often receives too little attention, is also an important component of species selection.

The species that were the most abundant in dry prairie were arbitrarily determined by summing relative abundance of each species

Table 2. Summary of dry prairie community types. Abbreviations for community types are in () and correspond to abbreviations used in Table 3 and in Fig. 1 and 2.

Community Type	No. Community Samples	Geographic Location(s) or Topo-Geomorphology	Principal Parent Materials	Relative Permeability[a]	Solum Depth (cm)
White 1983:					
Sand (S)	9	east central Iowa	aeolian sand	rapid	61 to 114
Gravel Hill (GH)	10	northwest Iowa	glacial till, coarse glacial debris	moderately rapid to very rapid	28 to 56
IA Dry Mesic Tallgrass (IDT)	23	northwest, north central, and west central Iowa	glacial till coarse glacial debris	slow to moderate	57 to 114
NE Dry Mesic Tallgrass (NDT)	11	southeast Nebraska	glacial till	slow to moderate	10 to 53
Ugarte 1987 (all in northeast Iowa):					
Ungrazed Tallgrass (HT)	28	ungrazed upper to middle slopes	loamy sediments overlying limestone residuum and limestone residuum	moderate to moderately rapid	7 to 29
Dry Mesic Tallgrass (HDT)	45	various slopes and grazing intensities	loamy sediments overlying limestone residuum and limestone residuum	moderate to moderately rapid	7 to 29
Mid-grass (HM)	58	various slopes with intermediate grazing	loamy sediments overlying limestone residuum and limestone residuum	moderate to moderately rapid	7 to 29
Overgrazed Mid-grass (HMz)	43	various slopes with high grazing intensity	loamy sediments overlying limestone residuum and limestone residuum	moderate to moderately rapid	7 to 29
Rosburg 1994 (all in northwest, west central, and southwest Iowa in the Loess Hills):					
Bluff Mid-grass (LBM)	15	very steep west-facing slopes along the western bluffline	loess	slow	0 to 15
Dry Mid-grass (LDM)	17	steep south- & west-facing slopes at high relative elevation (spur slopes)	loess	slow	0 to 15
Mid-grass (LM)	79	ridgelines and south-facing slopes at medium to high relative elevation	loess	very slow to slow	0 to 20
Tall/Mid-grass Transition (LTM)	45	northwest- and east-facing slopes at medium to high relative elevation	loess	very slow to slow	28 to 66
Dry Mesic Tallgrass (LDT)	37	all slopes at medium to low relative elevation	loess	very slow to slow	56 to 107

[a]Permeability categories: very slow (0.7–2.5 cm/hr), slow (2.5–18 cm/hr), moderate (18–57 cm/hr), moderately rapid (57–180 cm/hr), rapid (180–570 cm/hr), very rapid (>570 cm/hr).

for all 13 community types. There were 69 species whose sum of relative abundance was greater than 2.0% (Table 4). A total of 20 families was represented, with Asteraceae (22 species, 32%), Poaceae (18 species, 26%), and Fabaceae (6 species, 9%) accounting for the majority of species. Little bluestem (*Schizachyrium scoparium* (Michx.) Nash) was by far the most abundant, followed by three other warm-season grasses—big bluestem (*Andropogon gerardii* Vitman), side-oats grama (*Bouteloua curtipendula* (Michx.) Torrey) and prairie dropseed (*Sporobolus heterolepis* (Gray) Gray) and one introduced cool-season species—Kentucky bluegrass (*Poa pratensis* L.).

Among the nine species rated as common (Table 4) were two grasses—porcupine grass (*Stipa spartea* Trin.) and plains muhly, two shrubs or semi-shrubs—lead plant (*Amorpha canescens* Pursh) and smooth sumac (*Rhus glabra* L.), and five forbs—western ragweed (*Ambrosia psilostachya* DC.), skeleton plant (*Lygodesmia juncea* (Pursh) D. Don), heath aster (*Aster ericoides* L.), Missouri goldenrod, and gray goldenrod (*Solidago nemoralis* Aiton).

Community Composition

When abundance of species was measured with relative cover (or frequency for the Loess Hills), the sand prairie community was very distinct from the other dry prairie community types (Fig. 1). There was also a general association of tallgrass community types (i.e., dominated by big bluestem) and an association of mid-grass community types (i.e., dominated by little bluestem and/or side oats grama).

Table 3. Quantitative species composition of dry prairie community types in Iowa and southeast Nebraska.

	Species Constancy and Abundance Community Constancy[a] (%)·Relative Abundance[b] (%)													
	White (1983)				Northeast Iowa—Ugarte (1987)				Loess Hills—Rosburg (1994)					
Species () indicate probable species	Sand (S)	Gravel Hill (GH)	IA Dry Mesic Tall-grass (IDT)	NE Dry Mesic Tall-grass (NDT)	Tall-grass (HT)	Dry Mesic Tall-grass (HDT)	Mid Grass (HM)	Grazed Mid Grass (HMz)	Bluff Mid Grass (LBM)	Dry Mid Grass (LDM)	Mid Grass (LM)	Tall/Mid Grass Trans. (LTM)	Dry Mesic Tall-grass (LDT)
Achillea millefolium	78·2.2	50·0.5	13·T	73·0.2	—	—	—	—	—	—	—	—	—
Agalinus aspera	—	—	—	—	11·T	20·0.1	14·0.1	35·0.2	—	24·0.2	9·0.1	7·T	3·T
Agropyron smithii	—	—	—	27·0.1	—	—	—	—	—	—	—	—	—
Agropyron trachycaulum	—	40·0.7	43·0.3	—	—	—	—	—	—	—	—	—	—
Agrostis gigantea	—	—	4·T	—	—	—	—	—	—	—	—	—	—
Allium stellatum	—	90·0.6	22·0.1	9·T	—	—	—	—	—	—	—	—	—
Ambrosia artemisiifolia	—	70·2.9	13·0.8	55·0.4	—	4·0.1	2·T	9·T	—	—	—	—	—
Ambrosia psilostachya	100·6.9	40·0.6	9·0.4	18·T	—	—	—	—	47·5.8	71·4.1	32·1.8	29·0.8	38·1.6
Amorpha canescens	11·0.9	90·2.4	22·0.1	100·6.6	75·2.0	76·2.3	67·0.9	72·0.7	33·1.3	18·0.3	52·4.0	42·1.7	84·7.4
Andropogon gerardii	22·1.1	40·0.7	91·13	100·31	75·8.3	100·41	90·9.3	93·19	53·11	24·0.7	75·8.0	93·6.4	100·18
Anemone cylindrica	56·0.4	20·0.2	52·0.3	—	4·T	2·T	7·T	2·T	—	—	29·0.3	91·4.2	49·1.1
Antennaria neglecta	—	—	35·0.1	82·0.2	—	—	—	—	—	6·0.1	24·0.4	82·4.0	16·0.1
Antennari plantaginifolia	—	—	—	—	21·0.1	36·0.4	16·0.2	39·1.2	—	—	—	—	—
Apocynum sibricum	—	20·0.2	4·T	—	—	—	—	—	—	—	—	—	—
Aquilegia canadensis	—	—	—	—	4·T	4·T	2·T	2·T	—	—	—	—	—
Artemisia campestris	—	50·0.5	4·T	—	7·T	29·0.1	24·0.1	63·0.9	—	—	—	—	—
Artemisia ludoviciana	100·8.6	—	17·0.2	18·T	—	—	—	—	—	—	—	—	—
Asclepias stenophylla	—	—	—	45·0.1	—	—	—	—	—	—	—	—	—
Asclepias tuberosa	—	—	13·0.1	—	—	—	—	—	—	—	—	—	—
Asclepias verticillata	33·0.2	40·0.6	57·0.4	—	21·0.1	24·0.1	21·0.2	9·T	40·1.3	18·0.5	54·3.4	60·1.8	62·2.2
Asclepias viridiflora	—	30·0.3	26·T	45·T	—	—	—	—	7·0.1	6·T	5·T	4·T	—
Aster azureus	—	—	30·0.7	—	86·1.9	80·1.9	86·2.4	77·1.2	—	—	16·0.6	—	14·0.2
Aster ericoides	22·0.3	70·3.4	78·4.6	36·0.1	29·0.4	36·0.3	43·0.6	16·T	20·0.3	53·2.3	84·3.6	84·3.9	84·5.3
Aster laevis	—	—	65·0.6	—	4·T	—	7·T	—	—	—	—	—	—
Aster oblongifolius	—	80·1.4	74·0.8	—	18·0.6	18·0.3	22·0.4	2·0.1	—	—	—	—	—
Aster pilosus	—	—	—	—	14·0.2	49·0.2	12·0.1	74·1.3	—	—	—	—	—
Aster sericeus	—	80·1.4	74·0.8	—	86·1.2	91·1.6	91·1.7	91·1.3	7·0.1	6·T	53·1.2	89·3.7	35·0.6
Astrogalus canadensis	—	—	4·T	—	—	—	—	—	—	—	—	—	—
Astrogalus crassicarpus	—	20·0.2	9·0.3	55·0.2	—	—	—	—	—	—	—	—	—
Astrogalus lotiflorus	—	—	—	—	—	—	—	—	13·0.2	65·1.6	34·0.4	24·0.1	—
Astrogalus missouriensis	—	—	—	—	—	—	—	—	—	—	4·T	4·T	—
Baptisia bracteata	—	—	26·0.3	18·0.4	11·0.1	11·0.1	2·T	19·0.4	—	—	—	—	—
Betula papyrifera	—	—	—	—	4·T	2·T	4·T	2·0.1	—	—	—	—	—
Bouteloua cutripendula	—	80·3.6	83·1.3	100·5.2	93·3.8	98·4.0	98·3.6	100·15	93·19	100·20	100·16	100·10	97·9.7
Bouteloua gracilis	—	40·4.0	—	27·0.4	—	—	—	—	—	—	8·0.1	7·T	—
Bouteloua hirsuta	11·0.5	70·7.5	—	—	11·T	22·0.3	33·1.1	49·2.0	—	—	—	—	—
Brickellia eupatorioides	—	—	17·0.1	9·T	29·0.2	27·0.3	29·0.3	7·0.2	—	12·0.1	3·T	—	5·T
Bromus inermis	—	—	—	45·0.7	—	—	—	—	—	—	—	—	—
Bromus japonicus	—	—	—	100·0.4	—	—	—	—	—	—	—	—	—
Bromus kalmii	—	—	—	—	18·0.1	2·T	3·T	2·T	—	—	—	—	—
Calylophus serrulatus	11·0.1	40·0.5	22·0.1	18·T	—	—	—	—	13·0.3	—	10·0.1	7·T	8·0.1
Calystegia sepium	—	—	9·0.2	45·0.2	—	—	—	—	—	—	—	—	—

Table 3. Continued.

Species ( ) indicate probable species	White (1983) Sand (S)	Gravel Hill (GH)	IA Dry Mesic Tall-grass (IDT)	NE Dry Mesic Tall-grass (NDT)	Northeast Iowa—Ugarte (1987) Tall-grass (HT)	Dry Mesic Tall-grass (HDT)	Mid Grass (HM)	Grazed Mid Grass (HMz)	Loess Hills—Rosburg (1994) Bluff Mid Grass (LBM)	Dry Mid Grass (LDM)	Mid Grass (LM)	Tall/Mid Grass Trans. (LTM)	Dry Mesic Tall-grass (LDT)
	Species Constancy and Abundance — Community Constancy[a] (%)·Relative Abundance[b] (%)												
Campanula rotundifolia	—	—	—	—	11·0.1	38·0.1	28·0.1	51·0.3	—	—	—	—	—
Carex brevior	—	—	9·T	82·11	—	—	—	—	7·0.3	—	4·0.2	7·T	—
Carex heliophila	—	—	—	—	—	—	—	—	—	—	22·1.8	100·9.5	68·5.8
Carex meadii	78·0.9	10·0.1	83·0.7	64·0.6	—	—	—	—	—	—	—	—	—
Carex sp.	—	—	—	—	93·1.9	96·2.0	95·2.9	100·3.8	—	—	—	—	—
Castilleja sessiliflora	—	—	—	—	—	—	—	—	—	12·0.2	11·0.2	16·0.3	3·T
Ceanothus americanus	—	—	30·1.4	18·0.1	—	—	—	—	—	—	—	—	—
Ceanothus herbaceus	—	—	—	—	7·T	7·0.2	14·0.2	7·0.1	—	—	—	2·T	27·1.5
Celastrus scandens	—	—	—	—	21·0.4	9·0.2	21·0.6	5·T	—	—	—	—	—
Cirsium altissimum	11·0.2	60·0.5	39·0.1	9·T	—	—	—	—	—	—	—	—	—
Cirsium undulatum	—	—	4·T	73·0.2	—	—	—	—	—	—	1·T	7·T	5·T
Comandra umbellata	11·T	60·0.9	61·0.6	—	46·0.1	22·0.2	43·0.4	37·0.3	7·0.2	59·4.0	48·3.0	33·1.3	27·1.4
Coreopsis palmata	—	10·0.2	57·1.7	—	86·2.5	76·0.2	52·1.4	65·0.8	—	—	—	—	—
Cornus drummondii	—	—	—	—	—	—	—	—	20·0.8	—	14·0.1	20·0.1	68·5.1
Cornus foemina	—	—	—	—	7·1.4	20·0.7	5·0.2	—	—	—	—	—	—
Croton monanthogynus	—	—	—	—	—	—	—	—	27·0.9	—	5·0.1	2·T	3·T
Cyperus filiculmis	78·1.0	—	—	27·0.2	—	—	—	—	—	—	—	—	—
Dalea candida	—	30·0.3	74·0.4	100·0.7	—	7·T	9·T	2·T	—	6·0.9	27·0.9	31·0.6	5·T
Dalea enneandra	—	—	—	—	—	—	—	—	7·0.1	47·2.3	27·0.6	18·0.2	—
Dalea purpurea	11·T	100·1.8	61·0.6	55·0.2	75·0.3	89·1.1	67·0.4	93·0.5	—	24·0.7	35·1.4	60·1.3	43·0.5
Delphinium virescens	11·T	10·0.1	1·T	—	—	—	—	—	—	—	—	—	—
Desmodium canadense	—	—	39·0.1	27·T	—	—	—	—	—	—	—	—	—
Dichanthelium leibergii	—	—	—	—	7·T	7·T	3·T	5·T	—	—	—	—	—
Dichanthelium oligosanthes	100·3.4	20·0.2	87·2.8	100·2.9	11·0.1	11·0.1	17·0.1	5·T	—	24·0.3	47·1.3	60·0.8	84·2.0
Dichanthelium oligosanthes var. *wilcoxianum*	11·0.1	—	48·0.2	91·0.9	—	—	—	—	7·0.3	18·0.2	28·0.5	96·1.9	14·0.2
Dichanthelium perlongum	—	—	—	—	54·0.7	80·0.8	83·2.5	86·1.2	—	—	—	—	—
Echinacea angustifolia	—	—	—	—	—	—	—	—	—	—	56·1.4	60·1.0	43·0.9
Echinacea pallida	—	90·2.1	57·0.6	9·T	—	—	—	—	—	—	—	—	—
Elymus canadensis	—	10·0.1	57·0.3	—	4·0.1	9·0.1	2·T	—	—	—	—	—	—
Equisetum arvense	78·0.5	—	—	—	—	—	—	—	—	—	—	—	—
Equisetum hyemale	—	—	—	—	4·T	2·T	2·T	5·T	—	—	—	—	—
Equisetum laevigatum	11·0.1	30·0.3	43·0.3	—	—	—	—	—	—	—	11·0.2	47·0.9	8·0.2
Eragrostis spectabilis	—	—	—	—	7·T	—	2·T	7·T	—	—	—	—	—
Erigeron strigosus	—	43·1.8	43·0.2	91·0.5	14·T	11·T	10·T	35·0.1	—	12·0.1	19·0.2	13·0.1	3·T
Eryngium yuccifolium	—	—	9·0.1	—	—	—	—	—	—	—	—	—	—
Eupatorium altissimum	—	—	—	—	4·T	7·T	5·T	—	—	—	—	—	—
Eupatorium rugosum	—	—	—	—	—	—	4·T	—	—	—	—	—	—
Euphorbia corollata	78·1.7	30·0.3	35·0.4	—	79·0.7	93·0.7	66·0.5	70·1.3	—	—	—	—	—
Euphorbia glyptosperma	—	—	—	—	—	—	—	—	7·0.1	41·0.8	3·T	2·T	—
Euphorbia marginata	—	—	—	—	—	—	—	—	27·0.3	29·0.4	9·0.1	7·T	14·0.1
Fragaria virginiana	11·0.1	—	11·0.1	—	—	—	—	—	—	—	—	—	—

Table 3. Continued.

Species () indicate probable species	Species Constancy and Abundance Community Constancy[a] (%)·Relative Abundance[b] (%) — White (1983): Sand (S)	Gravel Hill (GH)	IA Dry Mesic Tall-grass (IDT)	NE Dry Mesic Tall-grass (NDT)	Northeast Iowa—Ugarte (1987): Tall-grass (HT)	Dry Mesic Tall-grass (HDT)	Mid Grass (HM)	Grazed Mid Grass (HMz)	Loess Hills—Rosburg (1994): Bluff Mid Grass (LBM)	Dry Mid Grass (LDM)	Mid Grass (LM)	Tall/Mid Grass Trans. (LTM)	Dry Mesic Tall-grass (LDT)
Galium boreale	—	—	—	—	—	2·0.1	—	—	—	—	—	—	—
Galium obtusum	—	—	9·0.5	45·0.1	—	—	—	—	—	—	—	—	—
Gaura coccinea	—	—	—	—	—	—	—	—	7·0.1	41·2.2	25·1.2	4·0.1	8·0.3
Gentiana andrewsii	—	10·T	—	—	—	—	—	—	—	—	—	—	—
Gentiana puberulenta	—	10·0.2	43·0.1	18·T	—	—	—	—	—	—	—	—	—
Machaeranthera spinulosa	—	—	—	—	—	—	—	—	7·0.1	18·0.5	10·0.1	9·0.1	—
Hedeoma hispidum	11·T	70·0.8	—	55·0.1	—	—	—	—	—	12·0.1	11·0.1	24·0.2	5·T
Hedyotis nigricans	—	—	—	—	—	—	—	—	47·2.8	35·0.7	25·0.4	27·0.9	14·0.4
Helianthus bicknellii	100·0.8	—	—	—	—	—	—	—	—	—	—	—	—
Helianthus grosseserratus	—	—	9·0.2	—	—	—	—	—	—	—	—	—	—
Helianthus occidentalis	—	—	—	—	71·1.2	53·1.9	43·1.2	79·2.2	—	—	—	—	—
Helianthus rigidus	—	2·00.3	78·3.5	27·T	14·0.3	13·0.3	7·0.1	—	27·0.7	41·1.8	18·0.7	2·0.1	30·1.1
Heliopsis helianthoides	—	—	48·0.3	—	—	—	—	—	—	—	—	—	—
Heuchera richardsonii	—	30·0.3	17·0.2	—	—	—	—	—	—	—	—	9·0.3	5·0.5
Hieracium longipilum	—	—	22·T	—	—	—	—	—	—	—	—	—	—
Juncus sp.	33·0.1	—	—	36·T	—	—	—	—	—	—	—	—	—
Juniperus communis	—	—	—	—	14·1.8	24·3.1	14·0.9	23·4.9	—	—	—	—	—
Juniperus virginiana	—	—	—	—	18·1.0	56·1.4	38·1.6	81·6.2	7·0.3	—	13·0.7	11·1.1	14·0.4
Koeleria macrantha	67·3.0	70·1.1	74·0.2	100·1.7	—	—	—	—	—	—	—	36·1.1	5·0.1
Lactuca canadensis	—	—	—	—	7·T	2·T	3·T	—	—	—	—	—	—
Lactuca (serriola)	33·0.2	10·0.1	26·0.1	36·0.1	—	—	—	—	—	—	—	—	—
Lactuca tatarica	—	—	—	—	—	—	—	—	13·0.7	—	1·0.1	2·T	3·T
Lathyrus venosus	—	—	4·T	—	—	—	—	—	—	—	—	—	—
Lechea stricta	44·0.4	—	—	—	—	—	—	—	—	—	—	—	—
Lespedeza capitata	100·1.0	10·T	57·0.3	18·T	—	—	—	—	—	—	—	—	—
Lespedeza leptostachya	—	—	17·0.1	—	—	—	—	—	—	—	—	—	—
Liatris apsera	100·2.1	10·0.5	52·0.8	—	—	—	—	—	—	—	—	—	—
Liatris cylindracea	—	—	—	—	36·0.2	36·0.3	36·0.5	35·0.4	—	—	—	—	—
Liatris punctata	—	40·0.3	—	9·T	—	—	—	—	—	6·0.1	32·0.7	31·0.3	3·T
Liatris pycnostachya	—	—	4·0.2	—	—	—	—	—	—	—	—	—	—
Linu rigidum	—	—	—	—	—	—	—	—	—	18·0.3	22·0.2	24·0.2	3·T
Linu sulcatum	33·0.2	100·1.1	35·T	55·0.1	21·T	44·0.1	64·0.1	81·0.3	7·0.1	6·T	9·0.1	18·0.1	3·T
Lithospermum canescens	—	10·0.1	39·0.2	9·T	71·0.3	53·0.3	36·0.1	49·0.1	—	—	—	—	—
Lithospermum caroliniense	89·1.9	—	—	—	—	—	—	—	—	—	—	—	—
Lithospermum incisum	—	10·T	—	55·0.1	7·T	7·T	21·0.1	14·T	—	12·0.4	22·0.3	33·0.2	3·T
Lobelia spicata	—	10·T	30·0.1	—	—	—	—	—	—	—	—	—	—
Lygodesmia juncea	—	—	—	—	—	—	—	—	100·4.2	100·11	56·3.6	44·1.5	19·0.7
Melilotus alba	—	—	—	—	7·0.1	7·T	5·T	16·0.1	—	24·1.4	1·T	2·T	3·T
Nothocalais cuspidata	—	—	—	—	—	—	—	—	—	—	5·T	7·T	—
Mirabilis hirsuta	—	30·0.7	—	—	—	—	—	—	—	—	—	—	—
Monarda fistulosa	—	—	43·0.3	—	25·0.6	33·0.5	24·0.3	19·0.1	—	—	—	—	—
Muhlenbergia cuspidata	—	100·6.8	35·0.6	9·0.1	—	—	—	—	87·12	47·1.0	42·0.7	67·0.9	46·0.5

Table 3. Continued.

Species ( ) indicate probable species	Sand (S)	Gravel Hill (GH)	IA Dry Mesic Tall-grass (IDT)	NE Dry Mesic Tall-grass (NDT)	Tall-grass (HT)	Dry Mesic Tall-grass (HDT)	Mid Grass (HM)	Grazed Mid Grass (HMz)	Bluff Mid Grass (LBM)	Dry Mid Grass (LDM)	Mid Grass (LM)	Tall/Mid Grass Trans. (LTM)	Dry Mesic Tall-grass (LDT)
	Species Constancy and Abundance Community Constancy[a] (%)·Relative Abundance[b] (%)												
	White (1983)				Northeast Iowa—Ugarte (1987)				Loess Hills—Rosburg (1994)				
Muhlenbergia racemosa	—	—	9·T	—	—	—	—	—	—	—	—	—	—
Oenothera biennis	67·0.8	10·0.1	13·0.1	9·T	4·T	4·T	4·T	7·T	27·0.8	6·T	1·T	2·T	—
Onosmodium molle	—	30·0.3	13·0.1	—	—	—	—	—	—	—	—	—	—
Oxalis stricta	22·0.1	40·0.4	26·0.1	100·0.6	—	2·T	2·T	7·T	—	—	—	—	—
Oxytropis lambertii	—	—	—	—	—	—	—	—	—	6·0.8	3·T	13·0.3	—
Panicum sp.	—	—	—	18·T	—	—	—	—	—	—	—	—	—
Panicum virgatum	22·8.6	—	13·0.6	27·T	—	2·T	5·T	—	—	—	—	—	—
Parthenocissus quinquefolia	—	—	—	—	4·T	4·0.2	2·T	7·0.1	—	—	—	—	—
Paspalum setaceum	89·1.5	—	—	—	—	—	—	—	—	—	—	—	—
Pedicularis canadensis	—	—	13·T	—	18·0.1	11·0.1	—	14·0.1	—	—	—	—	—
Pediomelum argophyllum	—	—	17·0.1	9·0.1	—	—	—	—	33·0.7	6·0.4	—	—	—
Pediomelum esculentum	—	40·0.2	30·T	9·T	—	—	—	—	—	6·0.1	13·0.2	13·T	3·T
Pellaea glabella	—	—	—	—	7·T	—	2·T	7·T	—	—	—	—	—
Penstemon grandiflorus	—	—	—	—	—	—	—	—	80·2.4	24·0.3	6·0.1	—	5·T
Phlox pilosa	—	10·0.2	78·1.1	—	7·T	7·T	14·0.1	—	—	—	—	—	—
Physalis heterophylla	—	—	39·0.3	—	11·T	4·T	3·T	2·T	—	—	—	—	—
Physalis virginiana	33·0.2	30·0.4	65·0.5	73·0.4	—	—	—	—	—	6·T	5·T	11·0.1	62·0.9
Physocarpus opulifolius	—	—	—	—	7·0.4	11·0.8	5·0.6	2·T	—	—	—	—	—
Poa compressa	78·12	20·0.3	4·T	64·0.8	—	2·0.1	7·0.1	14·0.1	—	—	—	—	—
Poa pratensis	56·20	50·2.9	100·11	91·9.0	14·0.2	18·0.9	7·0.1	28·0.9	7·0.1	—	9·0.4	69·3.8	35·2.6
Polygala verticillata	—	—	—	—	—	—	—	—	13·0.2	—	6·0.1	2·T	5·T
Populus tremuloides	—	—	—	—	—	2·T	3·0.1	—	—	—	—	—	—
Potentilla arguta	56·0.6	80·1.2	70·0.4	27·0.5	18·T	24·0.1	26·0.1	16·0.1	—	—	—	—	—
Potentilla recta	—	—	—	—	—	2·0.2	3·T	7·T	—	—	—	—	—
Potentilla simplex	78·0.4	—	—	—	—	—	—	—	—	—	—	—	—
Prunus americana	—	—	—	—	—	—	—	—	—	—	1·T	—	11·0.2
Psoralidium batesii	—	—	—	73·3.0	—	—	—	—	—	—	—	—	—
Pulsatilla patens	—	—	26·1.2	—	—	—	—	—	—	6·0.1	8·0.3	44·3.5	5·0.6
Pycnanthemum virginianum	22·0.2	—	—	—	18·0.2	16·0.3	7·0.2	—	—	—	—	—	—
Quercus macrocarpa	—	—	—	—	—	—	—	—	—	—	·1T	2·T	8·0.4
Ratibida pinnata	—	20·0.1	74·0.8	—	14·T	16·0.1	17·0.1	5·T	—	—	—	—	—
Rhus glabra	—	—	—	—	64·8.1	42·1.6	59·3.9	19·1.2	53·1.6	18·0.4	27·0.4	20·0.3	54·0.9
Rosa arkansana	22·0.2	30·0.3	83·0.8	27·0.3	—	—	—	—	20·2.1	6·0.4	8·0.1	29·0.2	49·1.4
Rosa blanda	—	—	—	—	4·T	4·T	2·T	—	—	—	—	—	—
Rosa carolina	—	—	—	—	4·T	1·0.4	2·0.1	2·T	—	—	—	—	—
Rubus (*occidentalis*)	—	—	—	—	4·T	11·0.6	10·0.1	4·T	—	—	—	—	—
Rudbeckia hirta	11·0.1	—	—	—	—	—	—	—	—	—	—	—	—
Rumex acetosella	78·0.8	—	—	—	—	—	—	—	—	—	—	—	—
Salsola (*iberica* or *collina*)	—	—	—	—	—	—	—	—	—	18·0.3	3·T	4·T	—
Schizachyrium scoparium	56·2.5	100·19	100·11	100·19	96·12	96·11	100·45	88·8.4	87·17	100·28	100·27	100·16	89·7.0
Scutellaria parvula	—	—	—	—	14·T	18·T	29·T	46·0.1	—	—	—	—	—
Senecio plattensis	—	10·T	—	73·0.3	—	9·T	10·T	19·T	—	24·0.4	28·0.5	87·2.1	11·0.1

Table 3. Continued.

Species (T) indicate probable species	Species Constancy and Abundance Community Constancy[a] (%)·Relative Abundance[b] (%)												
	White (1983)				Northeast Iowa—Ugarte (1987)				Loess Hills—Rosburg (1994)				
	Sand (S)	Gravel Hill (GH)	IA Dry Mesic Tall-grass (IDT)	NE Dry Mesic Tall-grass (NDT)	Tall-grass (HT)	Dry Mesic Tall-grass (HDT)	Mid Grass (HM)	Grazed Mid Grass (HMz)	Bluff Mid Grass (LBM)	Dry Mid Grass (LDM)	Mid Grass (LM)	Tall/Mid Grass Trans. (LTM)	Dry Mesic Tall-grass (LDT)
Setaria glauca	—	20·0.2	17·T	—	—	—	—	—	—	—	—	—	—
Silene antirrhina	—	30·0.1	—	36·0.1	—	—	—	—	—	—	—	—	—
Silphium integrifolium	—	—	26·1.6	—	—	—	—	—	—	—	—	—	—
Silphium laciniatum	—	—	22·0.1	—	36·2.0	31·1.6	29·0.7	9·0.2	—	—	—	—	—
Sisyrinchium campestre	—	10·0.1	65·0.2	91·0.4	25·T	40·T	33·T	60·0.1	—	24·0.8	71·2.2	91·2.8	54·1.2
Solidago canadensis	—	20·0.5	22·0.5	—	—	—	3·T	—	—	—	1·T	—	16·0.5
Solidago missouriensis	89·2.4	70·3.3	43·0.8	—	—	—	—	—	33·2.7	65·3.6	61·1.7	71·1.4	32·0.6
Solidago nemoralis	67·0.4	10·0.2	13·0.1	—	71·1.3	84·1.3	98·2.4	98·5.2	13·0.1	24·0.4	42·1.4	78·3.0	11·0.1
Solidago ptarmicoides	—	—	—	—	39·0.4	42·0.3	16·0.1	53·0.6	—	—	—	—	—
Solidago rigida	—	90·4.0	48·0.8	—	29·0.3	47·0.6	31·0.5	21·0.1	20·0.5	6·0.1	56·1.7	60·1.0	35·1.2
Solidago speciosa	11·0.1	—	13·0.2	—	11·0.8	9·0.1	9·0.1	2·T	7·0.1	—	9·0.2	2·T	8·0.3
Sorghastrum nutans	33·0.7	—	83·5.8	36·0.4	54·1.7	53·1.2	71·1.4	23·0.3	7·0.3	6·T	15·0.5	20·0.8	81·6.0
Spiranthes cernua (magnicamporum)	—	—	—	—	4·T	5·T	—	—	—	—	—	—	—
Sporobolus asper	—	20·0.3	22·0.1	73·0.2	—	—	—	—	—	12·0.1	16·0.3	7·0.1	46·1.5
Sporobolus cryptandrus	67·6.1	—	—	—	—	—	—	—	40·3.2	47·2.9	14·0.2	7·0.1	—
Sporobolus heterolepis	11·0.2	70·1.9	91·6.2	91·2.3	100·39	82·10	84·7.0	67·2.6	—	—	—	—	—
Sporobolus (vaginiflorus)	—	—	—	—	11·0.1	11·T	2·T	70·13	—	—	—	—	—
Stipa spartea	11·3.2	100·7.9	91·8.3	64·5.6	—	9·T	5·0.1	—	33·1.9	—	5·0.1	7·0.1	—
Strophostyles leiosperma	—	—	—	—	—	—	—	—	7·0.1	12·0.1	1·T	—	3·T
Symphoricarpos spp.	—	—	—	—	—	—	—	—	—	6·0.3	11·0.4	13·0.3	65·4.3
Taraxacum officinale	—	—	4·T	45·0.1	—	—	—	—	—	—	—	—	—
Teucrium canadense	—	—	—	—	—	—	—	—	—	—	3·T	—	11·0.7
Thalictrum dasycarpum	—	—	13·0.1	—	—	—	—	—	—	—	—	—	—
Tragopogon dubius	44·0.3	80·0.8	13·T	27·0.2	—	—	—	—	—	—	—	—	—
Trifolium pratense	—	—	17·T	18·0.7	—	—	—	—	—	—	—	—	—
Triodanis leptocarpa	—	—	—	73·0.2	—	—	—	—	—	—	—	—	—
Ulmus rubra	—	—	—	—	—	4·T	7·0.1	—	—	—	11·0.1	18·0.1	24·0.5
Verbena stricta	56·0.4	80·1.0	13·0.1	18·T	4·T	4·T	14·T	26·0.1	20·0.3	29·0.5	8·0.1	13·0.1	30·0.4
Vernonia baldwinii	—	—	9·T	9·T	—	—	—	—	—	—	—	—	—
Veronicastrum virginicum	11·0.3	—	9·T	—	—	—	—	—	—	—	—	—	—
Vicia americana	—	—	4·T	—	—	—	—	—	—	—	—	—	—
Viola pedata	—	—	9·0.2	—	61·0.4	47·0.3	47·0.7	60·0.6	—	—	—	—	—
Viola pedatifida	11·T	50·0.8	74·0.5	64·0.3	—	—	—	—	—	—	6·0.1	38·0.7	30·0.5
Viola pratincola	—	—	—	—	—	—	—	—	—	—	5·T	22·0.2	14·0.2
Vitis riparia	—	—	—	—	14·0.1	16·0.6	9·0.8	5·T	—	—	—	—	—
Yucca glauca	—	—	—	—	—	—	—	—	73·3.7	47·0.7	43·0.8	36·0.2	8·0.1
Zizia aurea	—	—	65·1.7	—	—	—	—	—	—	—	—	—	—
Species Richness	57	75	109	74	78	86	88	74	57	45	82	78	71

[a]Percentage of community samples within a community type in which the species was present.
[b]Abundance in White (1983) and Ugarte (1987) based aerial cover; abundance in Rosburg (1994) based on frequency of stems or tillers in small quadrats. Relative abundance values less the 0.05% are indicated with T (Trace), values greater than 10% are rounded off to nearest whole number.

Table 4. Summary of the most abundant species in Iowa and southeast Nebraska dry prairie communities. Sixty-nine species with a sum of relative abundance in the 13 dry prairie communities greater than 2% are included and their presence in general community types indicated with a (X). Parentheses indicate a probable identification. Overall abundance is one of the following four categories, determined by the sum of relative abundance overall 13 community types: Very Common (VC) >30%; Common (C) 15–30%; Frequent (F) 7–15%; Occasional (O) 2–7%.

Species	Overall Abun.	General Community Types: Sand	Gravel Hill	IA–NE Dry Mesic Tall Grass	North East IA Hill	Loess Hills
AGAVACEAE						
Yucca glauca	O					X
ANACARDIACEAE						
Rhus glabra	C				X	X
ASCLEPIDACEAE						
Asclepias verticillata	F	X	X	X	X	X
ASTERACEAE						
Achillea millefolium	O	X	X	X		
Ambrosia artermisiifoli	O		X	X	X	
Ambrosia psilostachya	C	X	X	X		X
Antennaria neglecta	O			X		X
Artemisia ludoviciana	F	X		X		
Aster azureus	F			X	X	X
Aster ericoides	C	X	X	X	X	X
Aster oblongifolius	O		X	X	X	
Aster sericeus	F		X	X	X	X
Coreopsis palmata	O		X	X	X	
Echinaceae angustifolia	O					X
Echinacea pallida	O		X	X		
Erigeron strigosus	O		X	X	X	X
Liatris aspera	O	X	X	X		
Lygodesmia juncea	C					X
Helianthus occidentalis	O				X	
Helianthus rigidus	F		X	X	X	X
Senecio plattensis	O		X	X	X	X
Silphium laciniatum	O			X	X	
Solidago missouriensis	C	X	X	X		X
Solidago nemoralis	C	X	X	X	X	X
Solidago rigida	F		X	X	X	X
CORNACEAE						
Cornus foemina	O				X	
CUPRESSACEAE						
Juniperus communis	F				X	
Juniperus virginiana	F				X	X
CYPERACEAE						
Carex heliophila	F					X
Carex meadii	O	X	X	X	X	
Carex sp.	F				X	
EUPHORBIACEAE						
Euphorbia corollata	O	X	X	X	X	
FABACEAE						
Amorpha canescens	C	X	X	X	X	X
Astragalus lotiflorus	O					X
Dalea candida	O		X	X	X	X
Dalea enneandra	O					X
Dalea pupurea	F	X	X	X	X	X
Psoralidium batesii	O			X		
IRIDACEAE						
Sisyrinchium capmestre	O		X	X	X	
LINACEAE						
Linum sulcatum	O	X	X	X	X	X
ONAGRACEAE						
Gaura coccinea	O					X
POACEAE						
Andropogon gerardii	VC	X	X	X	X	X
Bouteloua curtipendula	VC		X	X	X	X
Bouteloua gracilis	O		X	X		X
Bouteloua hirsuta	F	X	X		X	
Dichanthelium oligosanthes	F	X	X	X	X	X
Dichanthelium oligosanthes var *wilcoxianum*	O	X		X		X
Dichanthelium perlongum	O				X	
Koeleria macrantha	F	X	X	X		X
Muhlenbergia cuspidata	C		X	X		X
Panicum virgatum	F	X		X	X	
Poa compressa	F	X	X	X	X	
Poa pratensis	VC	X	X	X	X	X
Schizachyrium scoparium	VC	X	X	X	X	X
Sorghastrum nutans	F	X		X	X	X
Sproobolus cryptandrus	F	X				X
Sporobolus heterolepis	VC	X	X	X	X	
Sporobolus (vaginiflorus)	F				X	
Stipa spartea	C	X	X	X	X	X
RANUNCULACEAE						
Anemone cylindrica	O	X	X	X	X	X
Pulsatilla patens	O			X		X
RUBIACEAE						
Hedyotis nigricans	O					X
SANTALACEAE						
Comandra umbellata	F	X	X	X	X	X
SCROPHULARIACEAE						
Penstemon grandiflorus	O					X
ROSACEAE						
Potentilla arguta	O	X	X	X	X	
Rosa arkansana	O	X	X	X		X
VERBENACEAE						
Verbena stricta	O	X	X	X	X	X
VIOLACEAE						
Viola pedata	O			X	X	
Viola pedatifida	O	X	X	X		X

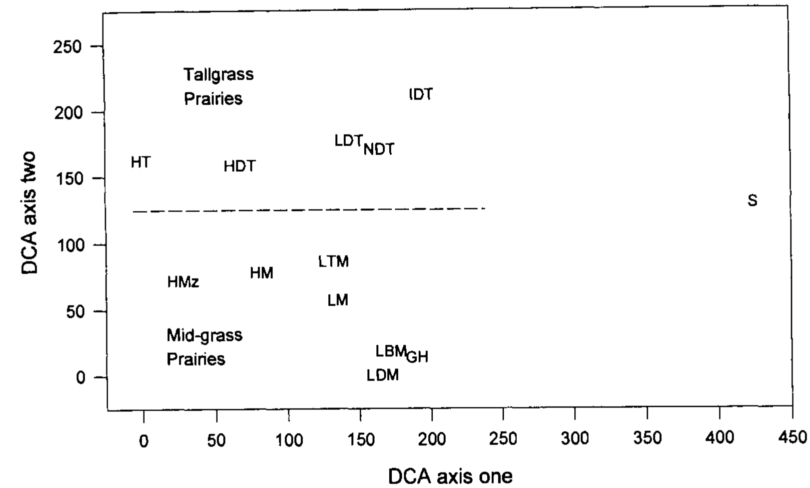

Fig. 1. DECORANA ordination of dry prairie community types with relative abundance data (primarily aerial cover). Locations represent the average composition of many samples. Sand (S), Gravel Hill (GH), Iowa Dry Mesic tall grass (IDT), and Southeast Nebraska Dry Mesic Tallgrass (NDT) are types delineated by White (1983). Northeast Iowa types, delineated by Ugarte (1987), include Ungrazed Tallgrass (HT), Dry Mesic Tallgrass (HDT), Mid-grass (HM), and Overgrazed Mid-grass (HMz). Community types in the Loess Hills identified by Rosburg (1994) include Bluff Mid-grass (LBM), Dry Mid-grass (LDM), Mid-grass (LM), Transitional Tall/Mid-grass (LTM), and Dry Mesic Tallgrass (LDT).

Based on the soil moisture gradient identified by Rosburg (1994) in the Loess Hills, a moisture gradient was also represented within the dry prairie community types along DCA axis two (Fig. 1). Low scores on DCA axis two (e.g., Loess Hill bluff mid-grass, Loess Hill dry mid-grass, and gravel hill) correspond to community types with relatively low soil moisture, while high scores (e.g., Iowa dry mesic tallgrass) correspond to community types with relatively high soil moisture. These results demonstrate that soil moisture, which has been shown to be the most important factor affecting community composition of prairies in many studies (e.g., Umbanhowar 1992, Faber-Langendoen and Maycock 1987, Coxson and Looney 1986, Lieffers and Lakin-Lieffers 1986, White and Glenn-Lewin 1984, Nelson and Anderson 1983, Barnes and Harrison 1982), is an important factor even when only the dry segment of the prairie moisture gradient is represented.

The driest of the dry prairies is represented by mid-grass prairie in the Loess Hills, by gravel hill prairie, and by grazed mid-grass hill prairie in northeast Iowa. While all of these prairies exhibit some uniformity in composition, namely dominance by mid-grasses such as little bluestem and/or side oats grama, their occurrence on the dry segment of the moisture gradient is caused by different mechanisms. Any of the following environmental conditions could contribute to xeric conditions: 1) rapid permeability, 2) shallow soil, 3) southwesterly slope azimuth, 4) high relative elevation, and 5) low annual precipitation. The first four are microclimate variables (i.e., small-scale) while the last one exhibits effects on climate (large-scale). In the gravel prairie, xeric conditions are caused primarily by rapid permeability due to coarse soil texture (Table 2). Soil depth is at least moderate and topography is variable, thus these factors are apparently less important.

In contrast, the xeric conditions in the Loess Hills are primarily a function of topography. Southwest-facing slopes with high relative elevation contain the driest prairie (Table 2). Unlike the gravel prairie, soil permeability is slow or very slow for all Loess Hill prairies due to the high amount of silt in the parent material. The shallow solum depth characteristic of dry Loess Hill prairies (Table 2) should be considered a result rather than a cause of the dry microclimate. However, the shallow solum does function as a positive feedback loop that reinforces the dryness of the environment. The xeric conditions caused by topography result in lower productivity and limit organic matter deposition, which is a critical component of soil formation and water-holding capacity. The shallow solum has a relatively lower water-holding capacity due to low levels of organic matter, which furthers a decrease in productivity. Because the solum and parent material exist in a fairly homogenous unit, the shallow solum in the Loess Hills does not restrict root penetration or permeability. Roots could conceivably extract water from the parent material.

In the hill prairies of northeast Iowa, the shallow solum is formed from limestone residuum (Table 2), which does restrict root penetration and permeability. The solum provides all of the water-holding capacity for the ecosystem, and its limited development is the primary mechanism for creating and maintaining a xeric environment. Topography is also an important feature of the northeast Iowa hill prairies. Many exist on southerly orientations, but the occurrence of prairies on various slopes and elevations suggests that topographic variables have secondary importance to the shallow solum.

The primary mechanism for each of the three types of dry prairie is different—rapid permeability for gravel prairie, topographic variables for the Loess Hills, and shallow solum for northeast Iowa hill prairies. Each of these represents a feature of the microclimate. The greater similarity between Loess Hill prairie and gravel prairie probably arises from their geographic proximity and similarity in climate. Both occur in western Iowa where annual precipitation is 10 to 15 cm less than in northeast Iowa.

Soil moisture was not the most important factor affecting variation in community composition because it was associated with DCA axis two. DCA axis one represents the greatest variation in the species composition of dry prairie. However, it is not apparent from information available in the individual studies what factor(s) may be causing this variation. Clearly factors related to the distinctive composition of the sand prairie are important (Fig. 1). Unlike the other dry prairie community types, the sand prairie was more dominated by the introduced cool-season grasses Kentucky bluegrass and Canada bluegrass (*Poa compressa* L.), switchgrass (*Panicum virgatum* L.), and the ruderal perennials western ragweed and prairie sage (*Artemisia ludoviciana* Nutt.). Cedar Hills Sand Prairie, the sand prairie sampled by White (1983), has a high incidence of gopher activity and such soil disturbances are often habitat for ruderal species and

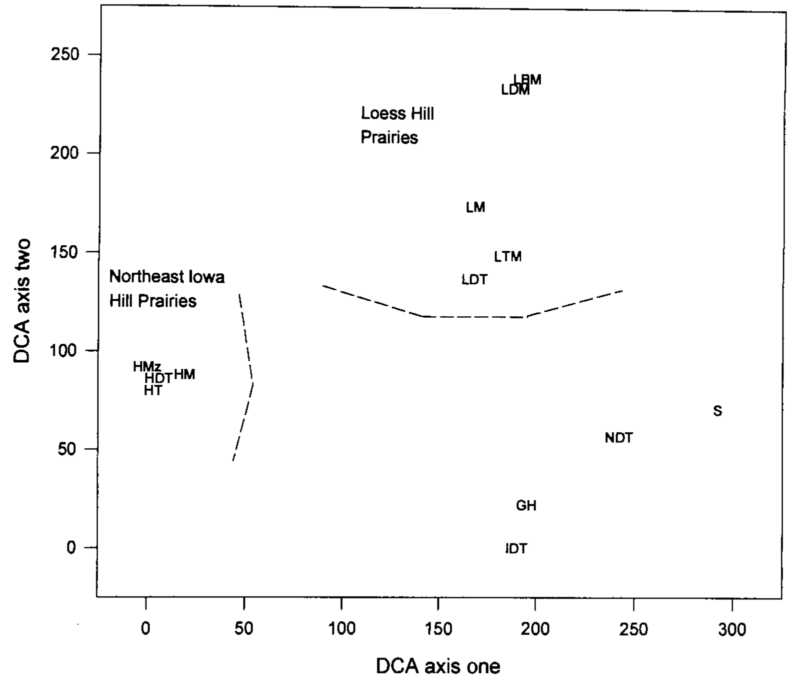

Fig. 2. DECORANA ordination of dry prairie community types with community constancy data. Locations represent the average composition of many samples. Sand (S), Gravel Hill (GH), Iowa Dry Mesic Tallgrass (IDT), and Southeast Nebraska Dry Mesic Tallgrass (NDT) are types delineated by White (1983). Northeast Iowa types, delineated by Ugarte (1987), include Ungrazed Tallgrass (HT), Dry Mesic Tallgrass (HDT), Mid-grass (HM), and Overgrazed Mid-grass (HMz). Community types in the Loess Hills identified by Rosburg (1994) include Bluff Mid-grass (LBM), Dry Mid-grass (LDM), Mid-grass (LM), Transitional Tall/Mid-grass (LTM), and Dry Mesic Tallgrass (LDT).

cool-season grasses (Platt 1975). The factor associated with variation on DCA axis one may be frequency of soil disturbance by burrowing mammals.

When the abundance or importance of species was measured by community constancy, the community composition of dry prairie was considerably different from the results with relative cover (Fig. 2). Community constancy is more individual-based and results in relatively less dominance by species with high productivity (e.g., the graminoids) and more representation of species with medium to low productivity (e.g., many forbs). Methods that utilize measurements of aerial cover tend to accentuate highly productive species and result in descriptions of community composition that are dominated by fewer species and which emphasize the success of a species in producing biomass. Only the high-biomass species functionally contribute to measurements of community similarity. Whereas methods that are individual-based (e.g., community constancy or frequency based data) result in measurements of community composition that emphasize success of a species in establishing individuals. Because species with medium to low productivity can be just as abundant as species with high productivity, relatively more species contribute to measurements of community similarity. Also, because populations are collections of individuals co-existing in time and space, it is theoretically more suitable to measure the abundance of populations in communities with individual-based methods.

The sand prairie community was not nearly as distinctive when forbs had a higher representation in community composition (Fig. 2). There was also a strong biogeographical effect on composition. The four northeast Iowa hill prairie communities were much more similar to each other, as were the five Loess Hill prairie communities (Fig. 2), than they were when ordinated with relative cover (Fig. 1). The very high similarity among the northeast Iowa hill prairies is likely a function of certain species that are restricted to the Paleozoic Plateau, for example Kalm's brome, *Dicanthelium perlongum* (Nash) Freckm., and western sunflower (*Helianthus occidentalis* Riddell). Another factor is the small geographic area represented in Ugarte's studies relative to White (1983) and Rosburg (1994).

The forb component of the Loess Hill prairies is represented by several species with western affinity (Novacek 1985), and these species most likely contribute to the high similarity of Loess Hill prairies and their separation from the other dry prairies. The uniqueness of dry prairie in the Loess Hills is highlighted in this study by the dissimilarity in composition between Loess Hill prairies with both the gravel hill prairie and the Nebraska dry mesic tallgrass prairie, which both physically adjoin the Loess Hills on the north and south, respectively, and which are also more similar in composition to one another than to any of the Loess Hill prairies. It is also clear that when forbs are given more importance in community composition (Fig. 2) the Loess Hill dry prairie communities can be united into two main groups. Western species are more abundant in the bluff mid-grass and dry mid-grass communities than in the other Loess Hill dry prairie communities.

When forbs have higher representation in community composition, soil moisture is not as important as an environmental factor affecting composition as when graminoids and productivity are emphasized. The gravel hill prairie and Iowa dry mesic tallgrass, which were at opposite ends of the moisture gradient when community composition was based on relative cover (Fig. 1), were more similar to one another than to any other community type when community composition was based on community constancy and more forb dependent (Fig. 2).

Although it is evident that plant biogeography is a more important factor than soil moisture for determining the forb component of dry prairies (Fig. 2), it is not possible to determine the nature of the environmental gradients represented without comparable environmental information on the community types. Also, the importance of biogeography appears to be limited to a local scale. The sand prairie represented (Cedar Hills Sand Prairie in Black Hawk County) is geographically close to the northeast Iowa hill prairies, but they occur at opposite ends of the environmental gradient along DCA axis one. In fact, Cedar Hills Sand Prairie was most similar compositionally to the southeast Nebraska dry mesic tallgrass prairie, both which were sampled by White with the same methods but were the most distant geographically.

These analyses clearly demonstrate that the methods utilized to measure species abundance and composition can yield very different pictures of a community. If the goal is to have species abundance or importance be representative of the function of a species in an ecosystem and its potential for exerting interspecific effects, then cover or productivity-based measurements should probably be used. Much of the time, however, the goal of a community study is to describe and classify community types and to determine how environmental factors affect variation in community composition. Methods that are individual-based such as community constancy or, better yet, frequency in small quadrats within a community sample (Rosburg 1994) will do a better job of assessing the success of a species in establishing individuals. Arguably this is a better method for delineating the species composition of communities because species abundance is less dependent on species-specific growth habits.

Although species richness varies among the dry prairie community types (Table 3), the differences in both the size of area sampled (Table 1) and in the number of community samples measured (Table 2) prevent any valid comparisons of richness or diversity. More species could be expected in the communities delineated by White because his community sample was the largest (20 m^2) whereas fewer species would be expected for the Loess Hill prairies because the community sample used by Rosburg was the smallest (2.5 m^2). The number of community samples that were grouped to represent a community type ranged from 9 for the sand prairie to 79 for the Loess Hills mid-grass, thus the amount of total area used to represent the community type varies greatly. Community types represented by more area are likely to have more species.

Obviously differences in methods among the three studies affect the results to some extent. Two differences are paramount. One is the difference in area sampled, which is the major problem in making comparisons of species richness or diversity (and the reason no comparisons were attempted). The integrity of the data in terms of representing the communities sampled will also vary with the amount of area sampled. Larger community samples may better represent the community. All three studies compared in this analysis used a community sample larger than or equal to 2.5 m^2, which is the optimum sample area indicated by the species-area curve obtained by White (1983) for grasslands. Therefore the differences in area sampled should not be a problem for the objectives of these analyses.

The second difference is the use of relative cover by the White (1983) and Ugarte (1987) studies and a weighted frequency by Rosburg (1994). Since these methods determined the absolute abundance of species, there is some potential for effects on the results of the first ordination (using relative cover). The species composition for community types delineated by White (1983) and Ugarte (1987) is productivity-based (favors grasses) while the species composition for the Loess Hill types delineated by Rosburg (1994) is more individual-based (sensitive to forbs). Thus it is possible that any distinctive pattern for the Loess Hill dry prairie represented in Fig. 1 could be due to slight differences in sampling method. This does not appear to be a significant problem because all the mid-grass prairie samples from the Loess Hills ordinate between the gravel prairie (White 1983) and the northeast Iowa hill prairie (Ugarte 1987) samples. The sites measured with relative cover did not cluster together and separate from the sites measured with weighted frequency.

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