ROCKEFELLER PRAIRIE: A CASE STUDY ON THE USE OF PLANT GUILD CLASSIFICATION OF A TALLGRASS PRAIRIE

Kelly Kindscher
Plant Community Ecologist, Kansas Biological Survey, University of Kansas, 2041 Constant Ave. Lawrence, KS 66047-2906

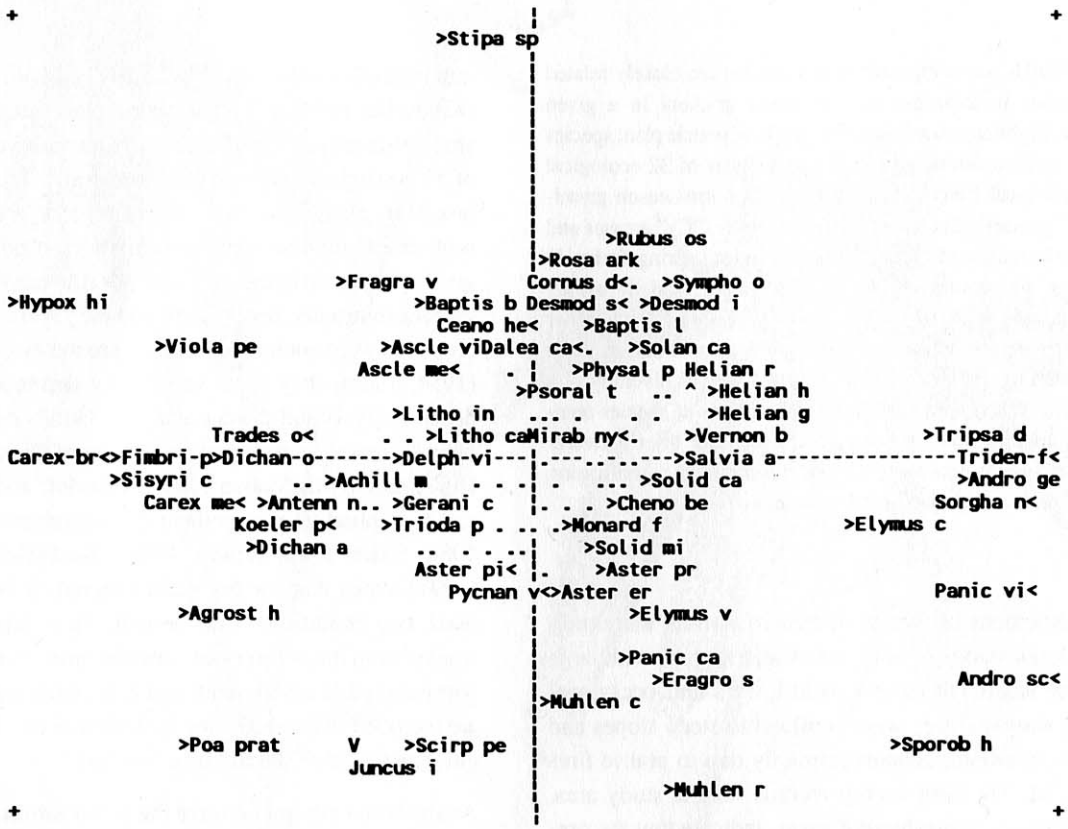
Abstract. Guilds are composed of species that are closely related to one another in their use of a resource gradient in a given community. Eight commonly-known guilds of prairie plant species have been verified through multivariate analysis of 32 ecological and morphological traits. The guilds are: 1) warm-season graminoids ("C_4" grasses); 2) cool-season graminoids ("C_3" grasses and sedges); 3) annuals and biennials; 4) ephemeral spring forbs; 5) spring forbs; 6) summer/fall forbs; 7) legumes; and 8) woody shrubs. This case study of the University of Kansas' Rockefeller Native Prairie demonstrates how these guilds can be a useful tool for understanding and interpreting the plant species diversity of a native prairie. When used with statistical analysis of species composition, it appears that the guild perspective can offer a clearer understanding of species composition and community classification of tallgrass prairie than traditional techniques.

INTRODUCTION

The pre-settlement landscape of eastern Kansas was dominated by dense stands of tall grasses interspersed with large numbers of seasonally showy wildflowers and occasional patches of shrubs. Trees were confined to steep slopes and the borders of stream courses primarily due to prairie fires (Wells 1970). The land survey records for the study area, Jefferson County in northeast Kansas, indicate that the pre-settlement vegetation was 95% prairie and only 5% forest (Kansas State Board of Agriculture 1881). Since then, there has been a dramatic change in the landscape with agriculture converting most lands to cropland. Today, only about 1 or 2% of the landscape in the study area has native prairie of high-quality as its vegetation (Lauver 1989).

The term guild has been defined by Root (1967) as a group of species that exploit the same class of environmental resources. He used this definition for different bird taxa that share the same or similar functional niche (e.g. guilds of leaf gleaners or bark gleaners.) Historically, the term guild was first used to describe groups of plants with similar lifestyles, and specifically four distinct guilds were named: lianes, epiphytes, saprophytes, and parasites (Schimper 1898). Guild is the literal translation of the German word *Genossenschaft* originally adopted by Schimper who used it in a sense similar to a medieval union of skilled craftsmen plying the same trade. The guild concept for plants usually have not been tied to resources as obviously as animal guilds have, perhaps because of the difficulty in reconciling plant diversity with notions that resource partitioning structures communities (Simberloff and Dayan 1991). In previous research (Kindscher 1991), the eight prairie plant guilds used in this study were proposed and verified using multivariate statistics of 32 ecological and morphological traits. These traits (representing plant habit, leaf characteristics, stem structures, root structures, and reproduction) were used because they give species different abilities to use environmental resources (nutrients, water, light, and etc.) Although the guilds proposed were not new, as many were mentioned by Weaver (1954, 1968), they were verified by detrended correspondence analysis and cluster analysis. Guilds of species have been discussed in the literature in terms of theory (Root 1967, Hawkins and MacMahan 1989, Simberloff and Dayan 1991) and as applied to management (Severinghaus 1981, Verner 1984, Szaro 1986, Reader 1988). Simberloff and Dayan (1991) stated that for the guild concept to be successfully used, two conditions must be met: 1) a clear statement is needed as to the criteria and considerations that have led to a particular guild assignment; and 2) if sympatric related biota are included in the study, the exclusion of one from the same guild as the other, should be explained.

Analysis and interpretation of the composition and quality of prairie remnants are often difficult. Through both vegetative sampling and traditional floristic analysis, a good understanding of the composition of a prairie can be obtained. When multivariate techniques are also included, particularly when species are grouped into guilds, a better interpretation of the area and its biodiversity may be achieved (Severinghaus 1981, Kindscher 1991, Grabherr 1989, Walker 1992). Besides determining which guilds of prairie species are present, the percentage of coverage for each guild can also be determined as can the ecological and morphological traits that are most important in determining each of these guilds. The analysis of the Rockefeller Native Prairie as a case study will demonstrate the value of these techniques for analyzing an individual prairie.



	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	.34	.26	.15	.11

Figure 1. First two axes of a detrended correspondence analysis of species positions from 32 morphological and ecological traits of 121 species on the Rockefeller Tract Prairie, and eigenvalues for the first four axes. Species names abbreviated (see Appendix 1 for abbreviations) and printed where space allows. Species located at arrows, which point to species abbreviations. Some arrows represent more than one species. Species too close together to print are marked with a "." .

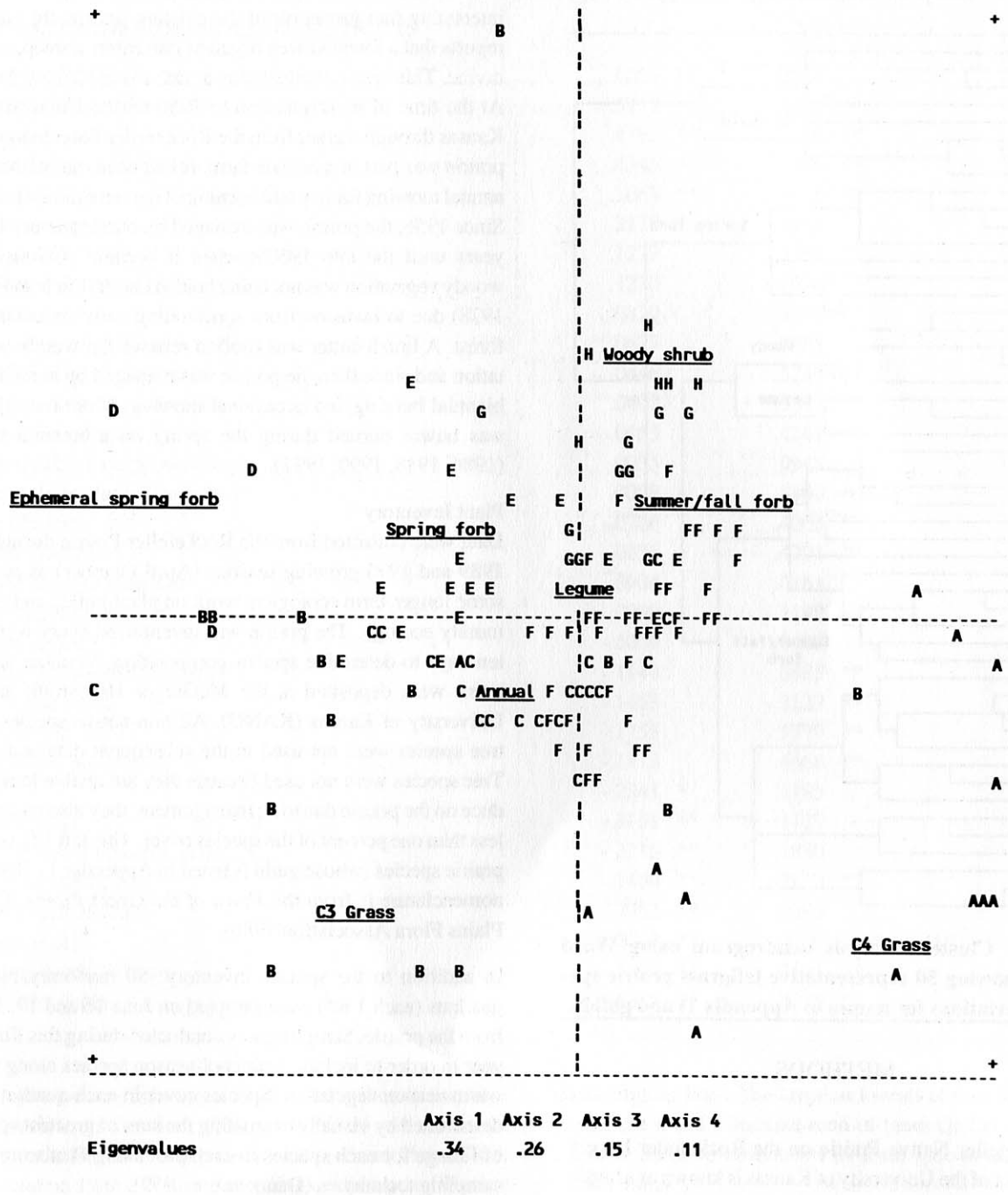


Figure 2. Guild groupings of species on first two axes of detrended correspondence analysis of species positions from 32 morphological and ecological traits of 121 prairie species on the Rockefeller Prairie, and eigenvalues for the first four axes. Letters mark individual species in the following guilds: A=C_4 grass; B=C_3 grass; C=Annual; D=Ephemeral spring forb; E=Spring forb; F=Summer and fall forb; G=Legume; and H=Woody shrub.

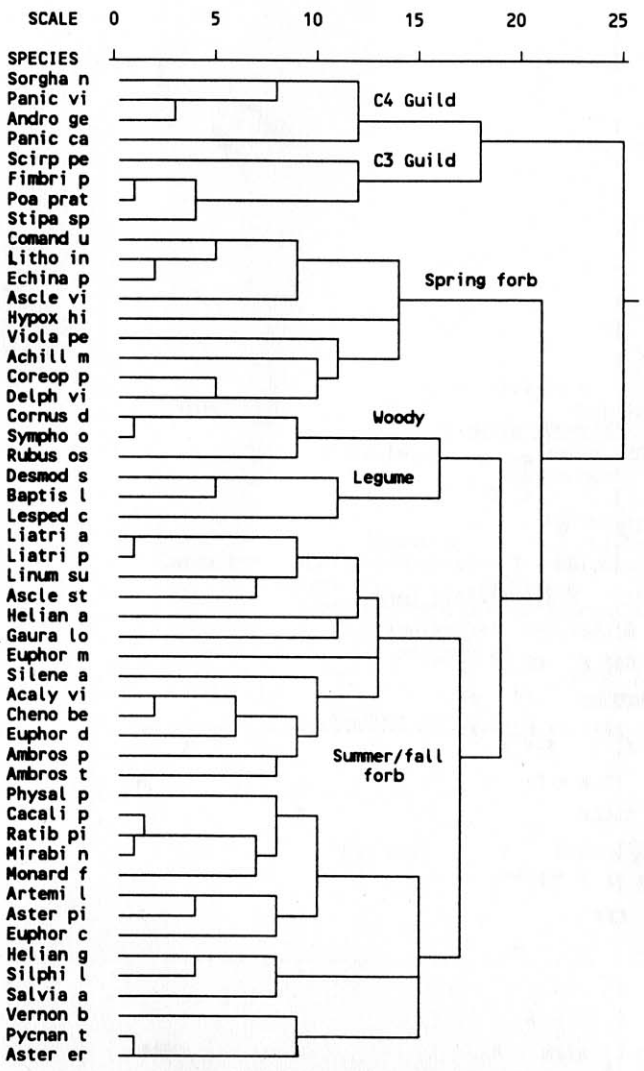


Figure 3. Cluster Analysis dendrogram using Ward method, showing 50 representative tallgrass prairie species (abbreviations for names in Appendix 1) and guilds.

METHODS

Study Site

The Rockefeller Native Prairie on the Rockefeller Experimental Tract of the University of Kansas is known as a highly diverse and floriferous remnant of the original native prairie flora (Fitch and Kettle 1988). It is a 4.6 hectare site, located 12 kilometers north of Lawrence, (Sec. 33, T11S, R20E) in Jefferson County, Kansas. Its soils are Pawnee series and Grundy silty clay loam (both are montmorillonitic, mesic, Aquic Argiudolls).

The U.S. Government land survey for Jefferson County was conducted in 1858, just prior to settlement. It reports that the Rockefeller Native Prairie was indeed in prairie vegetation at that time, as the survey followed the section lines, which included the western and southern sides of the prairie. It is interesting that just north of the existing prairie, the survey reports that a forested area began as one enters a steep, rocky ravine. This area remains today a native oak-hickory forest. At the time of its acquisition in 1956 by the University of Kansas through a grant from the Rockefeller Foundation, the prairie was part of a private farm. It had been maintained by annual mowing for hay and burning of the remaining stubble. Since 1956, the prairie was managed by burning every three years until the late 1960's when it became obvious that woody vegetation was not being held in check (Fitch and Hall 1978) due to invasion from surrounding early-successional forest. A brush cutter was used to remove the woody vegetation and since then the prairie was managed by annual and biennial burning and occasional mowing. More recently, it was buwas burned during the spring on a biennial basis (1986, 1988, 1990, 1992).

Plant Inventory

Data were collected from the Rockefeller Prairie during the 1989 and 1990 growing seasons (April-October) as part of some longer-term ecological work on plant guilds and community ecology. The prairie was inventoried every week to ten days to determine species composition. Voucher specimens were deposited at the McGregor Herbarium at the University of Kansas (KANU). All non-native species and tree species were not used in the subsequent data analysis. Tree species were not used because they are unable to reproduce on the prairie due to its management; they also comprise less than one percent of the species cover. This left 121 native prairie species (whose guild is listed in Appendix 1). Species nomenclature is from the *Flora of the Great Plains* (Great Plains Flora Association 1986).

In addition to the species inventory, 50 randomly placed quadrats (each 1 m^2) were sampled on June 16 and 17, 1989 from the prairie. Sampling was conducted during this time of year in order to include both cool-season species along with warm-season vegetation. Species cover in each quadrat was determined by visually estimating the sum of greatest spread of foliage for each species in each plot using Daubenmire's sampling techniques (Daubenmire 1959).

Guilds of prairie species were previously determined using a multivariate analysis of ecological and morphological traits for species on the Rockefeller Native Prairie and two additional prairies in northeast Kansas (Kindscher 1991). The data below are a subset of the larger data set. They were collected for 32 ecological and morphological traits for each of the 121 native prairie species on the Rockefeller Native Prairie. These 32 traits represent five broad categories: plant habit, leaf characteristics, stem structures, root structures,

Table 1. Variables and correlation coefficients for species positions on the first two axes of a detrended correspondence analysis of 121 prairie species. One-tailed significance: * - 0.01; ** - 0.001.

ECOLOGICAL & MORPHOLOGICAL TRAITS	X1		Y1	
Active growth during warm season	.6069	**	-.0644	
Photosynthetic pathway, C_4	.5732	**	-.4475	**
Flowering, late	.4793	**	-.3656	**
Height, tall	.4345	**	.2926	**
Leaf size, large	.3663	**	.3076	**
Clones, large	.2178	*	.1934	
Seed weight, heavy	.1277		.5504	**
Flowering duration, long	.1210		-.1614	
Woodiness	.0830		.3810	**
Phyllotaxy, opposite or whorled	.0677		.0888	
Zoophilous seed dispersal	.0446		.5247	**
Nitrogen fixation root nodules	.0402		.3291	**
Leaves compound	.0155		.4247	**
Not palatable to large herbivores	.0035		.0948	
Rooting habit, tap or fascicle	.0028		.3401	**
Forb life form	-.0706		.4003	**
Leaves sheathed	-.0836		.4271	**
Leaves hairy or glaucous	-.0904		.0161	
Duration, annual or biennial	-.0990		-.1192	
Leaves divided	-.1009		.0508	
Leaf length/width ratio, large	-.1144		.3885	**
Sod or mat roots	-.1453		-.3123	**
Seed weight, light	-.1755		-.5779	**
Zoophilous pollination	-.1813		.4668	**
Bulbs	-.2241	*	.1185	
Basal rosette	-.3151	**	.1127	
Decumbent or prostrate stem	-.3215	**	.1830	
Leaf size, small	-.3406	**	-.2823	**
Growth period, short	-.3952	**	.0395	
Height, short	-.5203	**	.0009	
Rooting depth, shallow	-.5477	**	-.3121	**
Flowering, early	-.6308	**	.3275	**

and reproduction. Information and data for these traits were collected from the field (Kindscher 1991) and botanical literature (Bare 1979, Steyermark 1981, Great Plains Flora Association 1986), or from the ecological literature (Weaver 1919, 1954, 1968, Weaver and Fitzpatrick 1934, Phillips Petroleum Company 1959, Downton 1975).

The data for these traits are discussed in detail in Kindscher 1991. Traits that reflected the standard or non-specialized types were coded with a 0; those with a specialized trait were coded with a 1. In an effort to make all variables discrete, for four traits (plant height, leaf size, time of flowering, and seed weight) three classes of data were coded by dividing the data into three equal-sized groups (for small or early, medium, and large or late). The large and small classes are coded as specialized traits because each of these classes may confer special adaptive advantages to plant species that have this class trait.

The ordination of species was conducted by using a detrended correspondence analysis using the program CANOCO (ter Braak 1987). Detrended correspondence analyses are useful for ordination of environmental data because they produce results that can more easily be interpreted than other multivariate techniques (Hill and Gauch 1980, Peet et al. 1988). The interpretation of the first two ordination axes was assisted by correlating (using the Pearson product moment) the location of each species in the

Table 2. Canonical discriminant functions including Wilks' lambda and Chi-square and the significance of the functions being the same. Classification results. Abbreviations: Fcn=function; Cum Pct=cummulative percent; DF=degrees of freedom; Sig=significance; ANN=annual; C3=C_3 photosynthestic pathway sedge or grass; C4= C_4 photosynthetic pathway grass; ESP=ephemeral spring forb; FAL=summer or fall forb; SPR=spring forb; LEG=legume; WOO=woody shrub.

Fcn	Eigenvalue	Pct of Variance	Cum Pct	Canonical Corr	After Fcn	Wilks' Lambda	Chisquare	DF	Sig
					0	.0000	1485.390	140	.0000
1*	38.6652	47.28	47.28	.9873	1	.0000	1095.260	114	.0000
2*	26.0233	31.82	79.10	.9813	2	.0009	745.810	90	.0000
3*	6.1848	7.56	86.66	.9278	3	.0063	536.781	68	.0000
4*	4.6567	5.69	92.36	.9073	4	.0358	353.100	48	.0000
5*	2.8269	3.46	95.81	.8595	5	.1368	210.843	30	.0000
6*	1.9337	2.36	98.18	.8119	6	.4014	96.760	14	.0000
7*	1.4914	1.82	100.00	.7737					

* marks the 7 canonical discriminant functions in the analysis.

Classification Results -

Actual Group		No. of Cases	Predicted Group Membership (species per guild) 1	2	3	4	5	6	7	8
Group 1	ANN	21	21	0	0	0	0	0	0	0
			100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Group 2	C3	14	0	13	1	0	0	0	0	0
			0.0%	92.9%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Group 3	C4	14	0	1	13	0	0	0	0	0
			0.0%	7.1%	92.9%	0.0%	0.0%	0.0%	0.0%	0.0%
Group 4	ESP	4	0	0	0	4	0	0	0	0
			0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
Group 5	FAL	34	2	0	0	0	32	0	0	0
			5.9%	0.0%	0.0%	0.0%	94.1%	0.0%	0.0%	0.0%
Group 6	LEG	10	0	0	0	0	0	10	0	0
			0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
Group 7	SPR	18	0	0	0	0	1	0	17	0
			0.0%	0.0%	0.0%	0.0%	5.6%	0.0%	94.4%	0.0%
Group 8	WOO	6	0	0	0	0	0	0	0	6
			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

Classification Processing Summary
121 Cases (species) were processed.

Percent of "grouped" cases correctly classified: 95.87%

detrended correspondence analysis with the 32 ecological and morphological traits (using the raw data matrix). To further corroborate the detrended correspondence analysis ordination, the data set was analyzed through Ward's method of cluster analysis in the program SPSS/PC+ (SPSS 1988). To test the validity of the eight guilds, a discriminant function analysis was performed using Mahalanobis distance as the selection criteria for the data set and using Wilk's lambda and F-tests as test statistics (SPSS, 1988).

Table 3. Total vegetative cover for 50 quadrats for the 20 species with greatest coverage on the Rockefeller Native Prairie. Also included are species of greatest cover for C_3 grass and spring ephemeral guilds; and percent cover/guild, listed in parenthesis adjacent to the species with the greatest cover in each guild. Note that total coverage of all 50 plots for individual species would result in a coverage figure of 50.000. Due to species overlap composite (for all species) total coverage is greater than 50.000.

SPECIES GUILD	(Cover/Guild)	COVER/SPECIES
Andropogon gerardii	C_4 grass (67.5%)	29.020
Andropogon scoparius	C_4 grass	20.320
Silphium laciniatum	Summer/fall forb (16.6%)	5.920
Sporobolus heterolepis	C_4 grass	5.680
Rhus glabra	Woody shrub (7.6%)	5.350
Sorghastrum nutans	C_4 grass	5.030
Amorpha canescens	Legume (5.3%)	2.730
Eryngium yuccifolium	Summer/fall forb	1.880
Solidago rigida	Summer/fall forb	1.685
Helianthus rigidus	Summer/fall forb	1.600
Lespedeza violacea	Legume	1.530
Aster praealtus	Summer/fall forb	1.280
Ceanothus herbaceus	Woody shrub	1.170
Tripsacum dactyloides	C_4 grass	1.020
Euphorbia corollata	Spring forb (1.3%)	0.850
Solidago canadensis	Summer/fall forb	0.680
Solidago missouriensis	Summer/fall forb	0.490
Ambrosia artemisiifolia	Annual (0.8%)	0.380
Baptisia bracteata	Legume	0.350
Apocynum cannabinum	Summer/fall forb	0.305
Dichanthelium oligosanthes	C_3 grass (0.5%)	0.115
Viola pedatifida	Spring ephemeral (0.1%)	0.065
*** Total for above species		87.450
*** Total for 176 Species ***		90.670

DISCUSSION

A total of 176 species was found on the Rockefeller Native Prairie. Of these species, 165 are native; 10 of these occur only along the forest edge, which is being encroached by successional woody species; seven others are tree species that will not reproduce on the prairie due to management (fire or mowing), which reduces them to root sprouts; and 27 were rare or uncommon and data could not be obtained for all 32 traits. The remaining 121 native prairie species were used in the multivariate analysis.

The first axis of the detrended correspondence analysis explained 34% of the variation and the first four axes explained 86% of the variation. The arrangement of species in two-dimensional space shows guild groupings (Figure 1). Eight guilds of prairie species were verified in this analysis: C_4 photosynthetic pathway grasses, C_3 grasses and sedges, annuals and biennials, ephemeral spring forbs, spring forbs, summer/fall forbs, legumes, and woody shrubs (Figure 2). These guilds were previously determined by making logical groupings of the species ordination conducted through the detrended correspondence analysis (Kindscher 1991). Each native species on the Rockefeller Prairie was assigned to a guild (Appendix 1). Some species are listed in two guilds, the primary guild being the one of greatest affinity, determined by the detrended correspondence analysis. Correlations of the 121 species positions in the detrended correspondence analysis with the 32 ecological and morphological traits allows for the interpretation of which traits most highly influence the location of these prairie species and subsequently the groups or guilds of species (Table 1). For the X axis, the following ecological and morphological traits had the most significant positive correlations ($p \leq 0.001$): tall height, active growth during the warm season, large leaf size, C_4 photosynthetic pathway, and late flowering. The most significant negative correlations for the X axis are: decumbent or prostrate stem, short height, short growth period, basal rosette, small leaf size, shallow rooting depth, and early flowering.

For the Y axis, the following ecological and morphological traits had the most significant ($p \leq 0.001$) positive correlations (Table 2): forb life form, tall height, large leaf length/width ratio, large leaf size, compound leaves, sheathed leaves, woodiness, tap or fascicle roots, shallow rooting depth, early flowering, zoophilous pollination, zoophilous seed dispersal, and heavy seed weight. The traits most negatively correlated with the Y axis are: small leaf size, C_4 photosynthetic pathway, sod or mat roots, shallow rooting depth, late flowering, and light seed weight.

The cluster analysis of the data resulted in similar groupings as identified in Figure 3, which added corroborative evidence to the existence of the guilds. The C_3 and C_4 grass guilds were the most clearly defined groups. The summer/fall forb, spring forb, woody shrub, and legume guilds are also distinguishable clusters. Due to the small number of species (four) in the early spring ephemeral forb guild, this group is not clearly distinguishable, nor is the highly variable guild of annuals. It should also be noted that on this prairie, these two guilds only comprised 0.1% and 0.8% respectively of the total vegetative cover sampled.

The discriminant function analysis (Table 2) provides statistical evidence that these eight guilds represent the data set as 95.9% of the prairie species were correctly classified into one of the eight prairie plant guilds. This was confirmed with a 95.0% correct classification for the guilds when this prairie was combined with the original two other high-quality prairies from northeast Kansas (Kindscher, unpublished).

Plant Sampling

The twenty-two species with the highest total coverage ranged from 0.065 m^2 to 29.02 m^2 of the total cover with 50 m^2 being complete cover of all plots (Table 3). Because species overlap, total estimated cover values for all species per plot were greater than 1.00 m^2 (100%), averaging 1.84 m^2 (184%) per plot. Composite plot values of greater than 1.00 m^2 (100%) occurred because almost all plots were dominated by warm season grasses that had a variety of other herbaceous species that overlapped the grass cover. The two species with the greatest total cover were the warm season, C_4 photosynthetic pathway grasses, big bluestem (*Andropogon gerardii*), and little bluestem (*A. scoparius*, synonym = *Schizachyrium scoparium*). The forb with the greatest coverage was compass plant, (*Silphium laciniatum*) (Table 3).

Guilds of Species on the Rockefeller Native Prairie

Using the cover data from quadrats and the entire species list, the eight guilds will be discussed. The traits with significant correlation coefficients will be used to characterized each guild of species. They are discussed in general terms in order that these guild descriptions could be used to classify other prairie species into guilds.

C_4 photosynthetic pathway grasses

This guild (Appendix 1) of 13 species (10.7% of the 121 prairie species in the ordination) dominates the visual appearance of the Rockefeller Native Prairie. The cover data for this prairie provide evidence for the dominance of the C_4 grasses as they compose 67.5% of the total cover. Of particular note in this prairie is the relatively high cover value of prairie dropseed (*Sporobolus heterolepis*) (5.68% of total), and the low cover (only 0.2% of total) of the often dominant switchgrass (*Panicum virgatum*).

Dominance of the C_4 grass guild is widespread (Weaver and Fitzpatrick 1934, Curtis 1959, Ray 1959, Dix and Smeins 1967, Weaver 1968, and Diamond and Smeins 1985). The guild of C_4 grasses essentially forms the matrix of vegetation within which species of other guilds occur. In addition to these ecological and morphological traits, C_4 grasses respond positively to fire and grazing (Hulbert 1969, Peet et al. 1976, and Collins and Wallace 1990).

C_3 photosynthetic pathway grasses and sedges

This guild of 13 species (10.7% of the prairie species ordered) is common to this and other prairies; however, it is not abundant (comprising only 0.5% of the cover of this prairie). The species are known as cool-season grasses, as they flower in the spring, although most have green foliage during the summer (Weaver 1954). The sedges formed a minor component of the cover of this guild.

Annuals

This guild is comprised of 20 opportunistic species (16.5% of the prairie species present) that generally colonize sites of micro-disturbance or survive in bare soil between other species. In a prairie such as this one, with a consistent management history of burning and mowing, annuals make up very little (only 0.8%) of the cover by species. The cover values of annuals generally increase through disturbance (Drew 1947, Launchbaugh 1955, Collins 1987, and Gibson 1989).

Many annual species on the Rockefeller Native Prairie, such as peppergrass (*Lepidium virginicum*) and spotted spurge (*Eupatorium maculata*), are found only along the foot path and in areas of shallowest soil. The difficulty that individual annual plants have in surviving on this prairie (and other high-quality prairies) was exemplified by the inability of the generally highly-productive annual sunflower (*Helianthus annuus*) to set seed during the droughty summer of 1989. During the same time, perennial prairie plants produced viable seeds. It should also be noted that many traits in this guild, such as seed weight, plant height, and seasonality were

extremely variable among species, reflecting the diversity of annual plant life forms.

Ephemeral spring forbs

This guild has four species (3.3% of the prairie species ordered) that appear very early in the year, never grow very tall, often have ephemeral foliage, losing their photosynthetic abilities during the summer when the taller warm-season grasses over-top them. Although this guild comprised only 0.1% of the cover, its species were frequently encountered in the quadrats sampled.

Spring forbs

This guild of 17 species (14.0% of the prairie species ordered) is similar to the ephemeral spring forb guild, but differs by appearing a few weeks later in the spring, having slightly taller heights, and they are not ephemeral. These species make up much of the showy wildflower bloom characteristic of tallgrass prairies. The cover values for this guild are less that would be assumed based on observation as they comprise only 1.3% of total. This low value exemplifies how showy species may be over-represented in visually-based inventory work. This guild also includes the federally-protected, Mead's milkweed (*Asclepias meadii*).

Summer/fall forbs

This guild of 36 species (29.6% of the prairie species present) comprises the largest number of species in any guild. These species are generally tall and coarse forbs, that grow along with the warm-season grasses, flowering and setting seed in the summer and fall. Due to the large size of species, this guild comprises 16.6% of the total cover. It also includes the federally-protected, western prairie-fringed orchid (*Habenaria leucophaea*) {synonym = *Platanthera praeclara*}. In addition, this guild contains species that have either wind-dispersal of light seed (*Aster* and *Solidago*) or gravity dispersal of heavier seeds (*Helianthus* and *Silphium*).

Legumes

This guild of 10 species (8.3% of the prairie species ordered) is comprised of a group of variable species that have compound leaves with an odd number of leaflets and apparently have a competitive advantage due to their ability to fix atmospheric nitrogen (Bare 1979). The total cover of this group is 5.3%. Two species in this guild are also part of another guild. Showy partridge pea (*Cassia chamaecrista*) is both a legume and an annual; and leadplant (*Amorpha canescens*) is both a legume and a woody shrub. Both were classified with the legume guild due to their locations in the detrended correspondence analysis.

Woody shrubs

This guild of 6 species (5.0% of the prairie species ordered) is comprised of woody species which have some of their overwintering buds above the ground's surface. These species, which persist in managed prairie remnants, are those that resist the effects of fire and mowing. Pastures are often invaded by trees, but trees do not generally reproduce when clipping (whether by grazing or machinery) is accompanied by fire. This guild represents 7.6% of the total cover. It is perhaps over-represented in cover on the Rockefeller Native Prairie due to the quadrat transects passing through a dense colony of smooth sumac (*Rhus glabra*). The spread of this colony and the invasion of other woody species from the surrounding areas of early-successional forest is of concern to the management of this prairie, and resulted in the frequency of burning or mowing being increased to every other year. The dense stand of sumac also provides habitat for some weedy understory forest species not found elsewhere in the prairie (white snakeroot {*Eupatorium rugosum*} and bittersweet {*Celastrus scandens*}), which are invading from the surrounding forest.

Other species not in prairie guilds

The species not represented in the above guilds include trees, forest edge species, and non-native species. All these species were rarely on the quadrats and had very low total cover values (their combined cover values are only 0.2% of the total). Trees such as box elder (*Acer negundo*) and slippery elm (*Ulmus rubra*) are unable to reproduce on the prairie due to management. It appears that the seed rain of early successional forest species, which surround the Rockefeller Native Prairie, would quickly change the species composition of this prairie if management by fire or mowing would cease. Forest edge species, including the weedy, black snakeroot (*Sanicula gregaria*) and gooseberry (*Ribes missouriense*), do not seem to be able to compete on the prairie and are restricted only to its shady edge or in the dense stand of smooth sumac (*Rhus glabra*). Non-native species, such as tansy mustard (*Descurainia pinnata*) and day flower (*Commelina communis*) are weedy and generally located along the edges and elsewhere in small areas of disturbed soil.

Classification of Tallgrass Prairie

The current methodologies used by ecologists for the classification, and subsequent recommended protection of prairies, such as through state natural heritage programs or state departments of natural resources, are based on species presence (especially designated indicator species) and especially presence of federally listed threatened and endangered species. In some cases, classification of prairies has been based on species coverage in quadrats; however, a considerable amount of time to conduct field work and statistical analysis is necessary for quadrat analysis and therefore it is generally not used by these programs.

Classification of tallgrass prairies, and determination of their quality, could be based on the analysis of guilds. They can be incorporated into survey work and ecological studies at various levels of analysis. At the most simplistic level, prairie species guilds can be used to quickly identify an area as native tallgrass prairie, even by those who do not know the identification of many prairie species. The identification process can be done through the use of guild identifications that follow:

Guild Identifications

C_4 photosynthetic pathway grasses--tall, warm season grasses, with flowers and fruit on stalks greater than three feet tall, flowering time mid-summer through fall; narrow, long leaves, often shades of red and orange in the fall;

C_3 photosynthetic pathway grasses and sedges--shorter (usually less than three feet tall), flowers and fruit (at least the onset) before summer, narrow long leaves, with no special coloration in the fall;

Annuals--No perennial root stock; variety of heights and leaf sizes and shapes; usually very fruitful (with many flowers, often not showy); generally found only in disturbed prairie areas;

Ephemeral spring forbs--very short, start flowering very early in the spring (March, usually), flowers usually showy, foliage dries up before summer;

Spring forbs--short, flowering occurs during the spring, often showy flowers and broad leaves; foliage persists into the summer;

Summer/fall forbs--variety of heights (many tall and coarse), flowering occurs during the summer and fall, and usually with non-linear leaves;

Legumes--usually evident during spring or summer, with odd number of leaflets, and flowers with typical pea-shape (bilaterally symmetrical); nitrogen-fixation root nodules present (but difficult to unearth and find);

Woody shrubs--medium to tall in height (but not trees), stems woody, found throughout the growing season, ability to resprout after fire or mowing.

A high-quality tallgrass prairie will probably have all of the guilds present. In three prairies previously studied, all eight guilds have been found (Kindscher 1991). June is the ideal month for survey work. If the survey work is done after June and before March, it may be difficult for the untrained person to determine if the ephemeral spring forb guild exists. The other seven guilds should be visually present.

Tallgrass prairies are relatively similar in species composition throughout their range (Weaver 1954, 1968). These guilds of species exist on tallgrass prairies in Manitoba, Canada, northern Iowa, eastern Nebraska, eastern Kansas, western Missouri, northern Oklahoma, and north-central Texas (Weaver 1954, 1968, personal observation, 1987-1990). They would also be found on tallgrass prairies outside this range, especially to the east and northeast. Midgrass and shortgrass prairies would be different, but would probably have many similarities in guild associations.

A second use of these guilds would be by those experienced in prairie plant species identification and can include guilds in their analysis. There has been much difficulty in determining which tallgrass prairie species are good indicators of high-quality prairies, that is prairies that are high in biodiversity. Even the suggested indicator species, lead plant (*Amorpha canescens*) and compass plant (*Silphium laciniatum*) (Gould 1941, Weaver 1954, Curtis 1959, Weaver 1968), are often found on non-prairie sites, especially disturbed roadsides and parcels planted to introduced cool-season grasses. Perhaps it would be easier and more informative to list the guilds of a tract of land being surveyed and two conservative or unusual species for each guild, than to use indicator species. The species listed could then give a good indication of the range of species found on the tract. This methodology will also lessen the bias of using showy forb species as the indicator species of a high-quality prairie. The use of guild classification and the listing of the most important species on the tract for each guild can also be useful in endangered species surveys and determinations of their associated species complexes.

A third, and possibly the most important, use of guilds is their incorporation into traditional statistical analysis of vegetative cover. For detailed field work that attempts to determine the actual composition of a tract of land, traditional canopy coverage analysis of plot data can be accompanied by guild analysis. The work conducted in this study of the Rockefeller Native Prairie can serve as a model example of integration of these techniques. By using the guild identifications above, native prairie species in addition to the 121 species listed in this study (Appendix 1) can easily be classified into guilds by plant ecologists who are familiar with the species in question. With the species categorized into guilds, it is then possible to supplement canopy coverage of plots with canopy coverage by guild of plots and then to determine what the coverage of each of these guilds is for a particular tract of land. The percent coverage by the guilds can help interpret the type and quality of the vegetation of a prairie remnant. As an example, on high-quality prairies, the coverage of the annual guild would be expected to be small and lower than

on a prairie that has been degraded through over-grazing by livestock, or human disturbance.

Guild groupings can be a useful tool in increasing our understanding of the tallgrass prairie. They simplify the array of species into groups in order that ecosystem processes and functions can more easily be studied. They also can allow for a better understanding and interpretation of the diversity of life forms and life history of tallgrass prairie species. For more rigorous analysis of prairies, traditional statistical techniques for analysis of both species and guild groupings can be used to give a clearer understanding of species composition and community classification of tallgrass prairies.

LITERATURE CITED

Bare, J. E. 1979. Wildflowers and weeds of Kansas. Lawrence: Regents Press of Kansas.

Collins, S. L. 1987. Interaction of disturbances in tallgrass prairie: a field experiment. Ecology 68:1243-1250

Collins, S. L. and L. Wallace. 1990. Fire in North American tallgrass prairies. University of Oklahoma Press.

Curtis, J. T. 1959. The vegetation of Wisconsin. Madison. University of Wisconsin Press.

Daubenmire, R. F. 1959. Canopy coverage method of vegetation analysis. Northwest Science 33:43-64.

Diamond, D. D. and F. E. Smeins. 1985. Composition, classification and species response patterns of remnant tallgrass prairies in Texas. American Midland Naturalist 113:294-308.

Dix, R. L. and F. E. Smeins. 1967. The prairie, meadow and marsh vegetation in Nelson County, North Dakota. Canadian Journal of Botany 45:21-58.

Downton, W. J. S. 1975. The occurrence of C_4 photosynthesis among plants. Photosynthetica 9:96-105.

Drew, W. D. 1947. Floristic composition of grazed and ungrazed prairie vegetation in north-central Missouri. Ecology 28:27-41.

Fitch, H. S. and E. R. Hall. 1978. A 20-year record of succession on reseeded fields of tallgrass prairie on the Rockefeller Experimental Tract. University of Kansas Museum of Natural History Special Publication 4.

Fitch, H. S. and W. D. Kettle. 1988. Kansas ecological reserves (University of Kansas Natural Area). Transactions of the Kansas Academy of Science 88:30-36.

Gibson, D. J. 1989. Effects of animal disturbance on tallgrass prairie vegetation. American Midland Naturalist 121:144-154.

Gould, F. W. 1941. Plant indicators of original Wisconsin prairies. Ecology 22:427-429.

Grabherr, G. 1989. On community structure in high alpine grasslands. Vegetatio 83:223-227.

Great Plains Flora Association. 1986. Flora of the Great Plains. Lawrence: University Press of Kansas.

Hawkins, C. P. and J. A. MacMahon. 1989. Guilds: The multiple meanings of a concept. Annual Review of Entomology. 34:423-451.

Hill, M. O. and H. G. Gauch, Jr. 1980. Detrended correspondence analysis: an improved ordination technique. Vegetatio 42:47-58.

Hulbert, L. C. 1969. Fire and litter effects in undisturbed bluestem prairie in Kansas. Ecology 50:874-877.

Kansas State Board of Agriculture. 1881. Second Biennial Report. 1879-80. Topeka: Geo. W. Martin, Kansas Publishing House.

Kindscher, K. 1991. Prairie plant guilds: an ordination of prairie plant species based on ecological and morphological traits. PhD. Dissertation, Department of Systematics and Ecology, University of Kansas.

Lauchbaugh, J. L. 1955. Vegetational changes in the San Antonio prairie associated with grazing, retirement from grazing and abandonment from cultivation. Ecology 25:39-57.

Lauver, C. L. 1989. Final report on the natural areas inventory of Douglas County, Kansas. Kansas Natural Heritage Program, Kansas Biological Survey. Report No. 38.

Peet, M., Anderson, R. and M. S. Adams. 1976. Effect of fire on big bluestem production. American Midland Naturalist 94:15-26.

Peet, R. K., Knox, R. G., Case, J. S. and R. B. Allen. 1988. Putting things in order: the advantages of detrended correspondence analysis. The American Naturalist 131:924-934.

Phillips Petroleum Company. 1959. Pasture and range plants. Bartlesville, Oklahoma.

Ray, R. J. 1959. A phytosociological analysis of the tall-grass prairie in Northeast Oklahoma. Ecology 40:255-261.

Reader, R. 1988. Using the guild concept in the assessment of tree harvesting effects on understory herbs: a cautionary note. Environmental Management 12:803-808.

Root, R. B. 1967. The niche exploitation pattern of the blue-gray gnatcatcher. Ecological Monographs 37:317-350.

Schimper, A.F.W. 1898. Pflanzen-geographie auf physiologischer grundlage. Jena, Germany: G. Fisher.

Severinghaus, W. D. 1981. Guild theory development as a mechanism for assessing environmental impact. Environmental Management 5:187-190.

Simberloff, D. and T. Dayan. 1991. The guild concept and the structure of ecological communities. Annual Review of Ecology and Systematics 22:115-143.

SPSS Inc. 1988. Statistical package of the social sciences. Chicago, Illinois.

Steyermark, J. A. 1981 (1963). Flora of Missouri. Ames: Iowa State University Press.

Szaro, R. C. 1986. Guild management: an evaluation of avian guilds as a predictive tool. Environmental Management 10:681-688.

ter Braak, C. J. F. 1987. CANOCO--a FORTRAN program for canonical community ordination by [partial] [detrended] [canonical] correspondence analysis, principal components analysis and redundancy analysis (version 2.1). TNO Institute of Applied Computer Science, Wageningen, The Netherlands.

Verner, J. 1984. The guild concept applied to management of bird populations. Environmental Management 8:1-14.

Walker, B. H. 1992. Biodiversity and ecological redundancy. Conservation Biology 6:18-23.

Weaver, J. E. 1919. The ecological relations of roots. Carnegie Institute of Washington, vol. 286.

Weaver, J. E. 1954. North American prairie. Lincoln, Nebraska: Johnsen Publishing Co.

Weaver, J. E. 1968. Prairie plants and their environment. Lincoln: University of Nebraska Press.

Weaver, J. E. and T. J. Fitzpatrick. 1934. The prairie. Ecological Monographs 4:109-295.

Wells, P. V. 1970. Postglacial vegetational history of the Great Plains. Science 167:1574-1582.

Appendix 1. Species (grouped by Family), Authority, Common Name, Abundance Code, Primary Guild, Secondary Guild, Total Cover in 50 m^2 Plots. Frequency Codes: C=Common; F=Frequent; I=Infrequent; E=Edge Only; and R=Rare. Guild codes are: ANN=annual; ESP=ephemeral spring forb; FAL=summer or fall forb; SPR=spring forb; LEG=legume; WOO=woody shrub; C3=C_3 photosynthetic pathway grass; and C4=C_4 grass. Additional codes for species not included in guild-determining multivariate analysis, but found at the site: INTR=introduced species; TREE=tree species; and EDGE=understory woodland species.

SPECIES	AUTHORITY	COMMON NAME	ABUNDANCE CODE	PRIMARY GUILD	SECOND GUILD	COVER
** FAMILY: Acanthaceae						
Ruellia humilis	Nutt.	Fringeleaf ruellia	I	SPR		0.040
** FAMILY: Aceraceae						
Acer negundo	L.	Box elder	I		TREE	0.000
** FAMILY: Amaranthaceae						
Amaranthus rudis	Sauer	Water hemp	I		ANN	0.000
** FAMILY: Anacardiaceae						
Rhus aromatica	Ait.	Fragrant sumac	E		WOO	0.000
Rhus copallina	L.	Dwarf sumac	I		WOO	0.000
Rhus glabra	L.	Smooth sumac	F	WOO		5.350
Toxicodendron radicans	(L.) O. Ktze.	Poison ivy	I		WOO	0.000
** FAMILY: Apiaceae						
Eryngium yuccifolium	Michx.	Button snakeroot	F	FAL		1.880
Polytaenia nuttallii	DC.	Prairie parsley	I		SPR	0.000
Sanicula gregaria	Bickn.	Black snakeroot	E		EDGE	0.000
** FAMILY: Apocynaceae						
Apocynum cannabinum	L.	Indian hemp dogbane	I	FAL		0.305
** FAMILY: Asclepiadaceae						
Asclepias meadii	Torr.	Mead's milkweed	R	SPR		0.000
Asclepias stenophylla	A.	Narrow-leaved milkweed	R	FAL		0.000
Asclepias syriaca	L.	Common milkweed	I	FAL		0.000
Asclepias tuberosa	L.	Butterfly milkweed	R	SPR		0.205
Asclepias verticillata	L.	Whorled milkweed	R	FAL		0.010
Asclepias viridis	Walt.	Spider milkweed	R	SPR		0.000
** FAMILY: Asteraceae						
Achillea millefolium	L.	Yarrow	I	ESP		0.000
Ambrosia artemisiifolia	L.	Common ragweed	I	ANN		0.380
Ambrosia psilostachya	DC.	Western ragweed	I	FAL		0.000
Ambrosia trifida	L.	Giant ragweed	I	ANN		0.000
Antennaria neglecta	Greene	Field pussy-toes	I	SPR		0.000
Artemisia ludoviciana	Nutt.	White sage	I	FAL		0.000
Aster ericoides	L.	White aster	I	FAL		0.000
Aster oolentangiensis	Ridd.	Azure aster	I	FAL		0.250
Aster pilosus	Willd.	Aster	I	FAL		0.135
Aster praealtus	Poir.	Willowleaf aster	F	FAL		1.280
Bidens polylepis	Blake	Coreopsis begger-ticks	I	ANN		0.010
Cacalia plantaginea	(Raf.) Shinners	Indian plantain	R	FAL		0.000
Cirsium altissimum	(L.) Spreng.	Tall thistle	I	FAL		0.000
Conyza canadensis	(L.) Cronq.	Horseweed	I	ANN		0.005
Coreopsis palmata	Nutt.	Finger coreopsis	I	SPR		0.000
Echinacea pallida	Nutt.	Purple coneflower	I	SPR		0.000
Erigeron strigosus	Muhl.	Fleabane	I	ANN		0.025

Appendix 1, continued.

SPECIES	AUTHORITY	COMMON NAME	ABUNDANCE CODE	PRIMARY GUILD	SECOND GUILD	COVER
Eupatorium altissimum	L.	Tall boneset	I		FAL	0.000
Eupatorium rugosum	Houtt.	White snakeroot	I		EDGE	0.040
Euthamia gymnospermoides	Greene	Viscid euthamia	I	FAL		0.000
Helianthus annuus	L.	Annual sunflower	I	ANN		0.010
Helianthus grosseserratus	Martens	Sawtooth sunflower	I	FAL		0.300
Helianthus hirsutus	Raf.	Hairy sunflower	I	FAL		0.000
Helianthus rigidus	(Cass.)	Stiff sunflower	I	FAL		1.600
Krigia caespitosa	(Raf.) Chambers	Dwarf dandelion	I	ANN		0.000
Kuhnia eupatoriodes	L.	False boneset	I	FAL		0.065
Lactuca ludoviciana	(Nutt.) Ridd.	Wild lettuce	I	SPR		0.000
Lactuca serriola	L.	Prickly lettuce	I		INTR	0.000
Liatris aspera	Michx.	Gay-feather	R	FAL		0.000
Liatris pycnostachya	Michx.	Gay-feather	I	FAL		0.000
Prenanthes aspera	Michx.	Rattlesnake-root	R		FAL	0.000
Ratibida pinnata	(Vent.) Barnh.	Grayhead prairie coneflower	I	FA		0.000
Rudbeckia hirta	L.	Black-eyed susan	I	FAL		0.000
Silphium laciniatum	L.	Compass plant	F	FAL		5.920
Solidago canadensis	L.	Canada goldenrod	I	FAL		0.680
Solidago missourensis	Nutt.	Prairie goldenrod	I	FAL		0.490
Solidago rigida	L.	Stiff goldenrod	F	FAL		1.685
Taraxacum officinale	Weber	Dandelion	E		INTR	0.000
Vernonia baldwinii	Torr.	Ironweed	I	FAL		0.000
** FAMILY: Berberidaceae						
Podophyllum peltatum	L.	May apple	E		EDGE	0.000
** FAMILY: Boraginaceae						
Hackelia virginiana	(L.)I.M. Johnst.	Stickseed	E		EDGE	0.000
Lithospermum canescens	(Michx.) Lehm.	Puccoon	I	SPR		0.000
Lithospermum incisum	Lehm.	Puccoon	I	SPR		0.000
Myosotis verna	Nutt.	Forget-me-not	I	ANN		0.005
** FAMILY: Brassicaceae						
Alliaria petiolata	(Bieb.) Cavara & Grande	Garlic mustard	E		INTR	0.000
Descurainia pinnata	(Walt.) Britt.	Tansy mustard	E		INTR	0.000
Lepidium virginicum	L.	Peppergrass	I	ANN		0.000
Thlaspi arvense	L.	Field pennycress	E		INTR	0.000
** FAMILY: Caesalpiniaceae						
Cassia chamaecrista	L.	Showy partridge pea	I	LEG	ANN	0.010
** FAMILY: Campanulaceae						
Triodanis perfoliata	(L). Nieuw.	Venus' looking glass	I	ANN		0.035
** FAMILY: Caprifoliaceae						
Symphoricarpos orbiculatus	Moench	Buckbrush	I	WOO		0.005
Triosteum perfoliatum	L.	Horse gentian	I		EDGE	0.000

Appendix 1, continued.

SPECIES	AUTHORITY	COMMON NAME	ABUNDANCE CODE	PRIMARY GUILD	SECOND GUILD	COVER
** FAMILY: Caryophyllaceae						
Silene antirrhina	L.	Sleepy catchfly	I	ANN		0.025
** FAMILY: Celastraceae						
Celastrus scandens	L.	Bittersweet	I		TREE	0.000
** FAMILY: Chenopodiaceae						
Chenopodium berlandieri	Moq.	Lamb's quarters	I	ANN		0.000
** FAMILY: Clusiaceae						
Hypericum perforatum	L.	Common St. John's-wort	I		INTR	0.000
** FAMILY: Commelinaceae						
Commelina communis	L.	Dayflower	I		INTR	0.000
Tradescantia ohiensis	Raf.	Spiderwort	R	SPR		0.000
** FAMILY: Cornaceae						
Cornus drummondii	C.	Rough-leaved dogwood	I	WOO		0.215
** FAMILY: Cuscutaceae						
Cuscuta glomerata	Choisy.	Dodder	I		EDGE	0.000
** FAMILY: Cyperaceae						
Carex brevior	(Dew.) Mack.	Sedge	I	C3		0.115
Carex davisii	Schwein. & Torr.	Sedge	I		C3	0.000
Carex meadii	Dew.	Sedge	I	C3		0.110
Fimbristylis puberula	(Michx.) Vahl.	Sedge	I	C3		0.000
Scirpus pendulus	Muhl.	Bulrush	R	C3		0.000
Scleria triglomerata	Michx.	Nut rush	I	C3		0.010
** FAMILY: Euphorbiaceae						
Acalypha virginica	L.	Three-seeded mercury	I	ANN		0.210
Croton capitatus	Michx.	Woolly croton	I	ANN		0.005
Euphorbia corollata	L.	Flowering spurge	I	SPR		0.850
Euphorbia cyathophora	Murray	Fire-on-the-mountain	I		ANN	0.000
Euphorbia dentata	Michx.	Toothed spurge	I	ANN		0.000
Euphorbia maculata	L.	Spotted spurge	I	ANN	C4	0.000
Euphorbia nutans	Lag.	Eyebane	E		ANN	0.000
** FAMILY: Fabaceae						
Amorpha canescens	Pursh	Leadplant	I	LEG		2.730
Baptisia bracteata	Muhl ex Ell.	Yellow wild indigo	I	LEG		0.350
Baptisia lactea	(Raf.) Thieret.	White wild indigo	I	LEG		0.000
Dalea candida	Michx.	White prairie clover	I	LEG		0.000
Dalea purpurea	Vent.	Purple prairie clover	I	LEG		0.000
Desmodium glutinosum	(Muhl. ex Willd.) Wood	Large-flowered tickclover	I		EDGE	0.000
Desmodium illinoense	A. Gray	Illinois tickclover	I	LEG		0.020
Desmodium sessilifolium	(Torr.) T. & G.	Sessile-leaved tickclover	C	LEG		0.030
Lespedeza capitata	Michx.	Round-head lespedeza	I	LEG		0.115
Lespedeza stipulacea	Maxim.	Korean lespedeza	I		INTR	0.000

Appendix 1, continued.

SPECIES	AUTHORITY	COMMON NAME	ABUNDANCE CODE	PRIMARY GUILD	SECOND GUILD	COVER
Lespedeza violacea	(L.) Pers.	Prairie lespedeza	I	LEG		1.530
Psoralea esculenta	Pursh	Prairie turnip	R		LEG	0.000
Psoralea tenuiflora	Pursh	Wild alfalfa	I	LEG		0.000
Strophostyles leiosperma	(T. and G.) Piper	Slick-seed bean	I		ANN	0.005
** FAMILY: Fagaceae						
Quercus muehlenbergii	Engelm.	Chinkapin oak	I		TREE	0.000
Quercus velutina	Lam.	Black oak	E		TREE	0.000
** FAMILY: Fumariaceae						
Gentiana puberulenta	Pringle	Downy gentian	R	FAL		0.060
** FAMILY: Geraniaceae						
Geranium carolinianum	L.	Cranesbill	I	ANN		0.010
** FAMILY: Grossulariaceae						
Ribes missouriense	Nutt.	Gooseberry	E		EDGE	0.000
** FAMILY: Juglandaceae						
Juglans nigra	L.	Black walnut	I		TREE	0.000
** FAMILY: Juncaceae						
Juncus interior	Wieg.	Inland rush	I	C3		0.000
** FAMILY: Lamiaceae						
Monarda fistulosa	L.	Wild bergamont	I	FAL		0.000
Pycnanthemum tenuifolium	Schrad.	Slender-mountian mint	I	FAL		0.175
Salvia azurea	Lam.	Pitcher sage	I	FAL		0.205
Teucrium canadense	L.	American germander	I	FAL		0.000
** FAMILY: Liliaceae						
Allium vineale	L.	Wild onion	E		INTR	0.000
Hypoxis hirsuta	(L.) Cov.	Yellow star grass	F	ESP		0.000
Sisyrinchium campestre	Bickn.	White-eyed grass	I	ESP		0.000
** FAMILY: Linaceae						
Linum sulcatum	Ridd.	Grooved flax	I	ANN		0.005
** FAMILY: Moraceae						
Morus alba	L.	Mulberry	I		TREE	0.030
** FAMILY: Nyctaginaceae						
Mirabilis albida	(Walt.) Heimerl.	White four o'clock	I	SPR		0.000
Mirabilis nyctaginea	(Michx.) MacM.	Wild four o'clock	I	SPR		0.000
** FAMILY: Oleaceae						
Fraxinus americana	L.	White ash	I		TREE	0.000
** FAMILY: Onagraceae						
Gaura longiflora	Spach	Large-flowered gaura	I	FAL		0.035
Oenothera villosa	Thunb.	Common evening primrose	I		FAL	0.000
** FAMILY: Orchidaceae						
Habenaria leucophaea	(Nutt.) A Gray	Prairie fringed orchid	R		FAL	0.000

Appendix 1, continued.

SPECIES	AUTHORITY	COMMON NAME	ABUNDANCE CODE	PRIMARY GUILD	SECOND GUILD	COVER
** FAMILY: Oxalidaceae						
Oxalis dillenii	Jacq.	Gray-green wood sorrel	I	SPR		0.100
Oxalis violacea	L.	Violet wood sorrel	I		SPR	0.000
** FAMILY: Plantaginaceae						
Plantago virginica	L.	Pale-seeded plantain	I		INTR	0.000
** FAMILY: Poaceae						
Agrostis hyemalis	(Walt.) B.S.P.	Ticklegrass	I	C3		0.000
Andropogon gerardii	Vitman	Big bluestem	C	C4		29.020
Andropogon scoparius	Michx.	Little bluestem	C	C4		20.320
Bouteloua curtipendula	(Michx.) Torr.	Sideoats grama	C	C4		0.000
Bromus inermis	Leyss.	Smooth brome	I		INTR	0.000
Dichanthelium acuminatum	(Sw.) Gould & Clark	Panic grass	I	C3		0.000
Dichanthelium oligosanthes	(Schult.) Gould	Scribner dichanthelium	I	C3		0.115
Elymus canadensis	L.	Canada wild rye	I	C3		0.030
Elymus virginicus	L.	Virginia wild rye	I	C3		0.000
Eragrostis spectabilis	(Pursh) Steud.	Purple lovegrass	I	C4		0.000
Koeleria pyramidata	(Lam.) Beauv.	June grass	I	C3		0.000
Muhlenbergia frondosa	(Poir.) Fern.	Wirestem muhly	I		C4	0.000
Muhlenbergia racemosa	(Michx.) B.S.P.	Marsh muhly	R	C4		0.000
Panicum capillare	L.	Common witchgrass	I	C4		0.000
Panicum virgatum	L.	Switchgrass	C	C4		0.160
Poa compressa	L.	Canada bluegrass	I		INTR	0.000
Poa pratensis	L.	Kentucky bluegrass	I	C3		0.090
Sorghastrum nutans	(L.)	Nash Indian grass	C	C4		5.030
Sporobolus asper	Torr.	Rough dropseed	F	C4		0.000
Sporobolus heterolepis	Gray	Prairie dropseed	F	C4		5.680
Stipa spartea	Trin.	Porcupine grass	I	C3		0.010
Tridens flavus	(L). Hitchc.	Redtop	I	C3		0.005
Tripsacum dactyloides	L.	Eastern gammagrass	I	C4		1.020
** FAMILY: Polemoniaceae						
Phlox pilosa	L.	Prairie phlox	I	SPR		0.005
** FAMILY: Polygalaceae						
Polygala verticillata	L.	Whorled milkwort	I		ANN	0.000
** FAMILY: Ranunculaceae						
Anemone virginiana	L.	Tall anemone	E		EDGE	0.000
Delphinium virescens	Nutt.	Prairie larkspur	I	SPR		0.000
** FAMILY: Rhamnaceae						
Ceanothus herbaceous	Raf.	New Jersey tea	I	WOO		1.170
** FAMILY: Rosaceae						
Fragaria virginiana	Duchn.	Wild strawberry	I	UNCL		0.000

Appendix 1, continued.

SPECIES	AUTHORITY	COMMON NAME	ABUNDANCE CODE	PRIMARY GUILD	SECOND GUILD	COVER
Geum canadense	Jacq.	White avens	E		EDGE	0.000
Rosa arkansana	Porter	Prairie wild rose	I	WOO		0.070
Rubus flagellaris	L.	Northern dewberry	I		WOO	0.000
Rubus ostryifolius	Rydb.	High-bush blackberry	I	WOO		0.085
** FAMILY: Rubiaceae						
Galium circaezans	T. & G.	Shining bedstraw	E		EDGE	0.060
Hedyotis crassifolia	Raf.	Small bluets	I	ANN		0.000
** FAMILY: Santalaceae						
Comandra umbellata	(L.) Nutt.	Bastard toadflax	I	SPR		0.000
** FAMILY: Scrophulariaceae						
Veronicastrum virginicum	(L.) Farw.	Culver's root	R	FAL		0.000
** FAMILY: Solanaceae						
Physalis pumila	Nutt.	Prairie ground cherry	I	FAL		0.005
Solanum carolinense	L.	Carolina horse nettle	I	FAL		0.005
** FAMILY: Ulmaceae						
Ulmus rubra	Muhl.	Slippery elm	I		TREE	0.065
** FAMILY: Verbenaceae						
Verbena canadensis	(L.) Britt.	Rose vervain	E		SPR	0.000
Verbena hastata	L.	Blue vervain	E		FAL	0.000
Verbena urticifolia	L.	Nettle-leaved vervain	I		FAL	0.000
** FAMILY: Violaceae						
Viola pedatifida	G. Don	Prairie violet	F	ESP		0.065
** FAMILY: Vitaceae						
Vitis riparia	Michx.	River-bank grape	I		WOO	0.000