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Response of Grassland Birds to Prairie Restoration at Lost Mound NWR: Baseline Data Collection

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Introduction

Typical tallgrass prairie management consists of prescribed fires, approximately every three years, in early spring (March-April) when many non-native plants are green but many native prairie species remain dormant. However, before European settlement of this region, fires were not confined to March and April, with summer fires occurring during drought periods (Steinauer and Collins 1996) and fall fires common due to Native American land management practices (Pyne 1983). The variation of burning times may have been important for maintaining a variety of habitats for animals and plants, since the reactions of individual species to fire depends on the season of its occurrence (Howe 1994). In addition, grazing by ungulates affected the height of grassland vegetation, which in turn influences grassland birds selecting breeding sites (Renken and Dinsmore 1987, Renfrew and Ribic 2001, Walk and Warner 2000). Although grassland birds are known to use grasslands differently depending on their fire history (Herkert 1994), little systematic research has been done to compare the effects of fire in different seasons on either grassland birds or the plants that provide their habitat. Even less has been done to investigate interactive effects of fire season and grazing on grassland birds and plant communities. Instead, this type of research has typically been done in small areas with no replication for sound statistical analysis. The large expanse of grassland at Lost Mound NWR provides an excellent opportunity for an experimental approach to investigating the effects of different fire and grazing management regimes.

In 2002, we collected baseline data from 24 compartments within an approximately 1,000 ha area at Lost Mound NWR that will be used for this experimental approach. The area for the experiment was chosen for its relative consistency in vegetation structure and composition (i.e., sand prairie/grassland with low densities of trees). Divisions among the compartments were determined by existing fire breaks (generally roads). The objective of the 2002 data collection was to have pre-treatment information on the avian and plant communities in all 24 compartments. In this report we summarize the avian and plant community data for each compartment and use this information to establish four experimental blocks of six compartments each based on differences in existing vegetation. This will allow for a factorial complete block design, in which all six treatments (three fire regimes x grazed/not grazed) can be randomly assigned to a compartment within each block. Blocking in an experiment allows for statistical control of differences among compartments before experimental treatments are established that may later affect results of the manipulations. In addition, we document differences in vegetation within compartments due to a past disturbance.

Site Description

Lost Mound NWR is located at the former Savanna Army Depot in Carroll and Jo Daviess Counties, Illinois. The area surveyed in this study lies on an upland sand prairie within the former ammunition storage area of the Depot. Although the establishment of the Depot in 1917, before agriculture in the infertile, sandy soils was feasible, prevented the prairie from ever being plowed, three other factors have led its degradation. First, more than 400 underground storage bunkers ("igloos") and U-shaped earthen berms for outdoor munitions storage ("ramparts"), as well as miles of roads to access them, were constructed in the 1920's and early 1940's. This construction involved significant amounts of earth-moving, and therefore disturbance to the vegetation. In addition, igloos were planted with non-native, cool-season grasses to reduce erosion of sand from their surfaces (R. Speaker, personal communication). Outside of the lines of construction, however, the prairie remained relatively undisturbed except for the other two degradation factors, cattle grazing and fire suppression. From approximately 1950 until October 1999, cattle grazing throughout the upland prairies kept fuel loads low and prevented fire from occurring in this fire-dependent ecosystem. Over-trampled areas were occasionally planted with "forage species" (non-native legumes and cool-season grasses), according to the contractor who managed the grazing program during its last two decades (D. Porth, personal communication). Despite the disturbance and non-native species that these three factors introduced into the prairies of Lost Mound NWR, the vegetation still contains a significant number and abundance of native prairie species (Robertson et al. 1997) and provides habitat for 29 species of grassland birds (Wenny 2001).

Methods

Plant community: The plant community sampling scheme was designed to capture the potential differences in vegetation within experimental compartments due to storage facility construction. A variation of the Modified-Whittaker method of Stohlgren et al.(1998) was used. In each compartment, percent cover of all plant species, bare ground, and litter was visually estimated in twelve 0.5m × 1m plots. In addition, complete species lists were comprised for two 1m × 5m plots, one 5m × 10m plot, and one 20m × 25m plot within each compartment. All plots were placed randomly within each compartment subject to the following restrictions: (1) Plots were not placed in roads. (2) Plots were allocated between areas disturbed or undisturbed by construction according to the proportion of the compartment's area falling into each category. For most compartments, this resulted in eight 0.5 m^2 plots and one 5m^2 plot in the undisturbed area (designated by "**U**"), one 0.5 m^2 plot on an igloo ("**I**"), one 0.5 m^2 plot on a rampart ("**R**"), and two 0.5 m^2 plots in the area between igloos and ramparts from which soil was scraped to cover igloos or ramparts ("**S**"). (3) 50m^2 and 500m^2 plots were always in undisturbed areas and extended out from a 0.5m^2 **U** plot. Figure 1 illustrates this design.

The 0.5m^2 (cover estimate) plots are located by placing the SW corner of a plastic frame at the NE corner of the concrete block marking the plot's location. (Blocks are aligned with their long edge running compass north-south.) The frame is placed so that its1m-long, western edge runs compass north-south. 5m^2 plots are marked with four red bricks, one at each corner, with the dimensions being 1 m in the east-west direction and 5 m in the north-south direction. 50m^2 plots are 10 m east and 5 m north of the associated 0.5m^2 plot marker (other corners marked with red bricks), and 500m^2 plots are 25 m east and 20 m north of the associated 0.5m^2 plot marker (other corners marked with red bricks).

Cover estimates were done twice during the growing season, once in mid June-early July, and once in August, with the order of compartments randomized differently in each sampling period. Species lists for larger plots were compiled in July.

Data from cover estimates were analyzed separately for each sampling period in the following manner: Total vascular plant cover for each plot was calculated, then used to calculate the proportional cover of each species occurring in the plot. For the first set of analyses, proportional cover of each of the 50 experiment-wide most abundant species was averaged over all parts in each compartment. In addition, proportional cover of important plant groups was calculated for each plot, then averaged over compartment. Cluster analysis using compartment averages of absolute cover of lichens, *Selaginella rupestris* (a bryophyte typical of sand prairies) and bare ground, plus proportional cover of either the 50 individual species or of plant groups, was used to look for spatial patterns of vegetation across the entire experiment that would suggest appropriate experimental blocks. Principal Components Analysis (PCA) on each of these data sets was used to assess the factors determining differences in vegetation among compartments. After blocks were constructed using these methods, analysis of variance (ANOVA) and Tukey's pairwise comparison of means were used to test for significant differences in vegetation composition and species richness among blocks.

For the second set of analyses, ANOVAs on log-transformed absolute cover of lichens, *Selaginella rupestris* and bare ground and proportional cover of vegetation groups were used to test for differences in vegetation among plot types (**U, I, R, S**).

Bird community: Bird species richness and relative density were estimated in 200m × 400m transects within each compartment. (Due to a misunderstanding, however, no bird data were collected for compartments 17 and 18.) In each experimental compartment the location of all birds seen and heard within the transect area was marked on a map while the observer walked slowly through the middle of the transect. A laser rangefinder was used to measure the distance of each bird from the transect. Birds flying over but not landing in a the plot were not counted. Bird counts were conducted twice during the breeding season, once during June17-21 and once during July 8-9.

Data from both counts were combined for analysis. Species richness of all birds, obligate grassland species, secondary grassland species, and non-grassland species (Herkert et al. 1993; Sample and Mossman 1997) were calculated for each compartment. In addition, for species with sufficient numbers of occurrences, we used the "Distance" program to estimate their individual densities. This program uses the field-collected data to correct for differences in detectability among species. ANOVAs and pairwise comparison of means were used to detect differences in bird community composition and densities of individual species among experimental blocks.

Statistical significance: PC-ORD version 4.25 (McCune and Medford 1999) was used for Cluster Analysis and PCA, and Systat version 8.0 (SPSS Inc. 1998) was used for ANOVA. Because the goal of these analyses was to detect pre-existing differences in plant and bird communities among experimental compartments, we did *not* adjust significance levels of ANOVAs for the multiple tests done with each data set. By doing so, we are erring on the side of detecting differences where they might not exist instead of missing differences where they do exist.

Results

A total of 145 plant species were encountered in the cover estimate plots, and an additional 36 species were recorded in the larger vegetation sampling plots (Appendix 1.) Species richness in 0.5 m^2 cover estimate plots averaged 14 species with a range of 2 to 28 species in the early sampling, and averaged 10 species with a range of 2 to 20 species in the late sampling period. Native species richness was slightly lower, with an average of 10 and 8, and ranges of 0-21 and 0-18, in the early and late sampling periods respectively.

The relative abundance of the most common plant species shifted considerably from the early to late sampling period. In the early sampling, the ten most abundant species based on proportional cover were, in decreasing order of abundance: *Poa pratensis, Ambrosia psilostachya, Schizachyrium scoparium, Potentilla recta, Rhus aromatica, Panicum villosissimum, Koeleria macrantha, Medicago lupulina, Coronilla varia,* and *Sorghastrum nutans.* Four of these (*Poa, Potentilla, Medicago,* and *Coronilla*) are non-native, and *Coronilla* is an invasive species that significantly alters the structure and composition of a grassland. Late-season vegetation had only one non-native species (*Poa pratensis*) in the top ten list, which consisted of *Ambrosia psilostachya, Schizachyrium scoparium, Poa pratensis, Rhus aromatica, Panicum villosissimum, Sporobolus clandestinus, Sporobolus cryptandrus, Sorghastrum nutans, Opuntia humifusa,* and *Koeleria macrantha.*

A total of 36 bird species were encountered during sampling (Appendix 2). Species richness per compartment averaged 13 species and ranged from 10 to 19. The average percentage of bird species richness comprised by obligate grassland species and secondary grassland species was 36% and 17%, respectively. The most abundant species, in order of decreasing density, were Grasshopper Sparrow, Western Meadowlark, Dickcissel, Field Sparrow, Eastern Meadowlark, Mourning Dove, Chipping Sparrow, Eastern Kingbird, Brown Thrasher, Bobolink, Orchard Oriole, and Northern Mockingbird. Five of these are obligate grassland species (Bobolink, Dickcissel, Eastern and Western Meadowlarks, and Grasshopper Sparrow) and five are secondary grassland species (Eastern Kingbird, Field Sparrow, Mourning Dove, Northern Mockingbird, and Orchard Oriole). Table 1 shows bird species richness and density of common species for each compartment.

Experimental block designation: Table 2 summarizes vegetation and bare ground cover for each compartment. Cluster analysis of the four different data sets based on compartment averages (early sampling, cover of species; early sampling, cover of groups; late sampling, cover of species; and late sampling, cover of groups) revealed no strikingly consistent large clusters of compartments. However, analyses of both early data sets consistently clustered compartments 7, 8, 12, 13, 14, and 16 together (Figure 2). Results of the PCA suggest that this is due to their relatively high abundance of introduced legumes and cool-season graminoids and low abundance of native forbs and cool-season graminoids (Figure 3). Small numbers of compartments did cluster consistently across all four data sets, or in three of the four. Based on these clusters, four blocks of six compartments each (one compartment for each of 6 proposed experimental treatments) can be designated (Figure 4):

Block	Compartments
1	7, 8, 12, 13, 14, 16
2	1, 2, 3, 6, 9, 18
3	4, 5, 10, 11, 15, 17
4	19, 20, 21, 22, 23, 24

Differences among blocks: Not surprisingly, Block 1 was significantly different from other blocks in its plant community composition (Figure 5). Total plant cover in Block 1 in the early sampling period was higher, but not significantly, than all other blocks ($P < 0.075$). Non-native cool-season graminoids made up a significantly higher proportion of the cover in Block 1 compared to all others in the early sampling period ($P < 0.02$) and compared to Blocks 3 and 4 in the late sampling period ($P < 0.02$). Block 1 also tended to have a higher proportion of introduced legume cover and lower proportion of native cool-season graminoid cover than other blocks. Although Block 1 was the most different, other differences also occurred. Block 3 had a high proportion of shrub cover, significantly higher than blocks 1 and 4 in both sampling periods. Block 4 had significantly higher *Selaginella rupestris* cover ($P < 0.03$), and somewhat higher lichen cover, than all other blocks. Although total plant species richness did not differ among blocks ($P > 0.3$ both sampling periods), native plant species richness was significantly lower in Block 1 than in Block 4 in the early sampling period and lower than Blocks 2 and 4 in the late sampling period ($P < 0.5$). Figure 5 illustrates these and other differences in vegetation among the Blocks.

Bird species richness, either total or separated by grassland preference, and community composition did not differ significantly among blocks, with one exception. Bobolink density was significantly higher in Block 1 than in Blocks 2 and 4 ($P < 0.03$), and was marginally significantly higher in Block 1 than in Block 3 ($P = 0.07$).

Vegetation differences among plot types: Not surprisingly, **I** plots had significantly higher proportional cover of non-native cool-season graminoids than did any other plot type ($P < 0.001$ for both sampling periods). **I** plots also had significantly lower proportional cover of native cool-season ($P < 0.005$) and warm-season ($P < 0.01$) graminoids than all other plot types, and lower native forb cover than **S** and **U** plots ($P < 0.05$), in both sampling periods. **R** plots had significantly higher ($P < 0.002$), and **I** plots marginally significantly ($P < 0.08$) higher, proportional cover of non-native forbs than **S** and **U** plots. In the late sampling period, bare ground cover was significantly higher in the **R** and **S** plots than in **I** and **U** plots ($P < 0.008$). The pattern was similar in the early sampling period, though at that time bare ground cover in **R** and **U** plots did not differ significantly ($P = 0.13$). These differences in vegetation among plot types are illustrated in Figure 6.

Discussion

Although at first glance the upland prairies of Lost Mound appear to be quite uniform in their plant composition, our results show that there are some differences. These differences may affect community responses to management treatments imposed in the future. For example, prescribed spring burns have long been used in the attempt to reduce the abundance of non-native cool-season grasses such as *Bromus inermis* (Smooth Brome) and *Poa pratensis* (Kentucky Bluegrass). From the data presented here and from previous work (Symstad 2000), it is clear that this is one of the main challenges in restoring the prairies of Lost Mound. However, if desirable native species are not abundant enough to compete with the temporarily weakened non-natives, this management practice will not accomplish its goal (Willson and Stubbendieck 2000). Thus, Block 1, where non-native cool-season grasses are approximately twice as abundant as native warm-season graminoids and other native plants are also in relatively low abundance, may react differently than the other blocks to various burn regimes. Another difference in vegetation among blocks that may affect reaction to management is the relatively high cover of *Selaginella rupestris* and lichens in Block 4. Although total vascular plant cover was not significantly lower in this Block compared to most others (Block 1 being the exception), *Selaginella* and lichens are often indicative of lower fertility soils. This and field observations suggest that the fuel load in this block may be lower or less continuous than that of other blocks. (Vegetation structure data, may support this hypothesis, have not yet been processed.) Thus, differences in fire behavior caused by differences in vegetation may also influence treatment effects. Accounting for these and other differences in vegetation when designing the experiment will make the analyses of experimental results stronger.

In addition to significant differences in vegetation among blocks, we found that there were significant differences within compartments among plot types – those on igloos or ramparts, within scrapes, or out of the igloo construction zones. The most strikingly different vegetation occurred on igloos, where non-native cool-season grasses planted decades ago remain dominant. The greater bare ground cover in plots on ramparts and in scrapes indicate that even half a century after the initial earth-moving disturbance, the plant community has not fully recovered through processes of natural succession. [This is not entirely bad, however, because the more open soil of these areas provides crucial habitat for many state-listed plant species (Robertson et al. 1997).] Thus, any future ground-disturbing activities (such as igloo and road removal) should be followed up by vigorous planting efforts if long-lasting scars are not desired. Also, the differences in vegetation within compartments may affect plant community responses to experimental management manipulations just as those among blocks do. Therefore, careful attention should be paid when analyzing data to account for these differences.

Although bird species richness and densities of individual species for the most part did not vary across blocks based on vegetation, this does not mean that community composition was uniform across compartments. Visual inspection of the data and preliminary analyses indicate some spatial patterning of individual bird species across the experimental area. Further analyses might also reveal relationships between vegetation and the avian community. For the purposes of this report, however, it is sufficient to say that birds can move around in response to experimental manipulations of their habitat a lot more than plants can. Thus, the experimental setup should be based much more heavily on pre-existing vegetation conditions than on pre-existing bird communities. The pre-treatment data on bird communities will be extremely valuable, though, when analyzing results of experimental manipulations.

Conclusions

The data presented in this report provide a baseline for future research at Lost Mound National Wildlife Refuge. The report has been written under the assumption that a long-term, large-scale experiment will take place in the near future. This will very likely not happen, however, if Lost Mound does not actually become a Refuge. We sincerely hope that our efforts, undertaken under the assurances that the Refuge would be established by January 2002 (that's 11 months ago), will not have been for naught.

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Table 1. Bird community data for experimental compartments. **A.** Bird species richness, total and by habitat preference. **B.** Density (number of individuals per compartment) of common species.

A. Compartment	All Species	Obligate Grassland Species	Secondary Grassland Species	Non-Grassland Species
1	12	4	4	4
2	16	5	8	3
3	14	5	6	2
4	15	4	7	4
5	11	5	5	1
6	17	6	8	3
7	16	4	7	5
8	13	5	6	2
9	10	5	3	2
10	13	4	4	4
11	15	5	6	4
12	11	5	4	2
13	15	5	7	2
14	12	5	5	2
15	11	5	5	1
16	14	6	5	3
17	.	.	.	.
18	.	.	.	.
19	11	3	6	2
20	11	5	3	2
21	19	4	6	9
22	14	5	6	3
23	12	4	7	1
24	15	6	5	4

B. Compart-ment	BOBO*	BRTH	CHSP	DICK	EAKI	EAME	FISP	GRSP	MODO	NOMO	OROR	WEME
1	0.00	0	0.59	4.12	0.59	2.35	2.35	8.24	1.76	0.00	0.00	4.12
2	0.59	0.59	0	4.12	2.35	1.18	4.12	10.59	1.18	0.59	0.59	3.53
3	0.00	0	0	2.94	0.59	1.76	3.53	10.00	0.59	1.18	0.59	4.12
4	0.00	1.18	0.59	2.35	2.35	3.53	2.94	12.94	0.59	0.59	3.53	2.35
5	0.00	0.59	0.00	7.06	1.18	2.35	4.12	6.47	1.76	0.00	0.00	5.88
6	0.00	0.59	1.18	1.18	0.59	1.18	2.35	10.59	2.94	0.00	1.18	5.29
7	0.00	1.76	4.12	1.18	0.59	1.18	2.35	7.06	1.76	0.59	0.59	6.47
8	1.76	0.00	0.59	4.12	0.00	2.35	2.94	7.65	1.76	1.18	0.00	5.88
9	0.59	0.00	2.94	7.06	0.00	1.18	2.94	8.82	1.18	0.00	1.18	5.29
10	0.00	0.59	4.12	7.06	1.18	2.35	2.35	7.06	0.59	0.00	0.00	4.71
11	1.18	1.18	2.94	8.24	1.18	1.76	3.53	8.24	3.53	0.00	0.00	4.12
12	3.53	0.59	0.59	5.88	0.00	0.59	1.76	6.47	0.00	0.59	0.00	3.53
13	1.76	0.59	2.35	1.76	1.18	0.00	1.76	8.24	2.94	1.18	0.00	8.24
14	0.59	0.59	0.00	4.71	0.00	2.35	3.53	7.65	1.76	0.00	0.00	2.94
15	1.18	0.00	1.18	8.82	1.18	1.76	1.18	10.00	1.18	0.00	0.00	5.88
16	2.94	1.76	0.59	5.88	2.94	1.76	2.94	10.00	1.76	1.18	0.59	5.29
17	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.
19	0.00	1.18	0.59	1.18	1.76	0.00	0.00	11.18	2.94	0.00	0.00	4.71
20	0.59	1.18	0.59	2.35	1.76	0.59	0.00	8.24	0.00	0.59	0.00	2.35
21	0.00	1.18	0.00	6.47	0.00	1.18	1.76	13.53	1.18	0.00	2.35	0.00
22	0.00	0.59	0.00	2.94	1.18	1.76	1.76	9.41	1.18	0.00	1.18	2.35
23	0.00	0.00	0.00	4.12	0.59	5.88	1.18	7.06	0.59	1.76	0.00	3.53
24	0.00	1.18	1.18	4.71	0.00	0.59	4.71	11.76	1.18	1.76	0.00	8.82

*BOBO = Bobolink; BRTH = Brown Thrasher; CHSP = Chipping Sparrow; DICK = Dickcissel; EAKI = Eastern Kingbird; EAME = Eastern Meadowlark; FISP = Field Sparrow; GRSP = Grasshopper Sparrow; MODO = Mourning Dove; NOMO = Northern Mockingbird; OROR = Orchard Oriole; WEME = Western Meadowlark

Table 2. Summary of vegetation and bare ground cover for each experimental compartment. Values shown are averages over all 0.5 m^2 plot types within a compartment. A graminoid is a grass or sedge. Forbs are non-leguminous, herbaceous, broad-leaved plants. Legumes are herbaceous species belonging to the family Fabaceae, and often are have a symbiotic relationship with nitrogen-fixing bacteria. The shrub category includes both woody species and cacti. **A.** Early sampling period. **B.** Late sampling period.

A. Early	PROPORTIONAL COVER										ABSOLUTE COVER			
Origin	Non-native				Native									
Form	Graminoid		Forb	Legume	Graminoid		Forb	Legume	Shrub	Tree		*Selaginella*	Bare	Vascular Plant
Season	Cool	Warm	-	-	Cool	Warm					Lichens	*rupestris*	Ground	Cover
Compartment	ICGRAM	IWGRAM	IFORB	ILEG	NCGRAM	NWGRAM	NFORB	NLEG	NSHRUB	NTREE	LICHEN	SELRUP	BG	TOTCOV
1	15	0	18	1	14	26	19	0	6	0	0	1	1	63
2	15	0	10	9	13	25	18	0	8	0	2	0	2	68
3	20	0	6	4	11	27	24	0	8	0	0	0	6	69
4	17	0	11	0	15	24	27	0	7	0	0	5	2	51
5	24	0	12	0	8	19	29	0	7	0	0	0	6	64
6	20	0	1	0	22	28	23	1	5	0	0	1	6	40
7	31	0	9	6	5	25	18	0	4	0	0	0	0	84
8	23	0	8	12	6	21	20	0	5	3	0	0	1	72
9	18	0	8	5	19	19	25	2	3	0	0	4	11	56
10	8	1	10	0	15	19	33	1	12	0	0	2	9	50
11	18	0	10	0	19	16	30	1	4	0	1	0	15	53
12	36	0	10	3	14	9	27	2	1	0	0	0	11	71
13	34	0	7	1	11	17	29	0	2	0	0	0	1	69
14	23	0	15	10	5	17	28	0	2	0	3	1	1	77
15	15	0	15	1	15	15	29	0	10	0	0	0	2	70
16	29	0	21	5	15	9	18	0	2	1	0	0	8	66
17	19	0	7	0	13	17	26	7	10	0	0	1	10	73
18	23	0	6	0	14	24	28	0	5	0	1	1	1	65
19	17	0	3	0	22	24	24	4	3	1	1	6	2	55
20	15	0	21	2	17	18	21	0	6	0	1	1	7	58
21	17	0	18	2	10	22	23	0	7	0	0	5	6	70
22	16	0	11	1	17	27	25	0	2	0	3	4	9	57
23	19	0	13	4	15	25	21	0	1	0	1	5	3	62
24	8	0	9	0	19	19	38	0	6	0	2	9	3	57

B. Late	PROPORTIONAL COVER										ABSOLUTE COVER			
Origin	Non-native				Native									Vascular
Form	Graminoid		Forb	Legume	Graminoid		Forb	Legume	Shrub	Tree		*Selaginella*	Bare	Plant
Season	Cool	Warm	-	-	Cool	Warm					Lichens	*rupestris*	Ground	Cover
Compart-ment	ICGRAM	IWGRAM	IFORB	ILEG	NCGRAM	NWGRAM	NFORB	NLEG	NSHRUB	NTREE	LICHEN	SELRUP	BG	TOTCOV
1	12	0	5	0	14	37	24	0	7	0	0	1	2	59
2	11	0	2	1	14	38	24	0	10	0	1	0	2	57
3	6	0	1	5	9	42	28	0	8	1	0	0	6	61
4	3	0	3	0	14	34	36	0	10	0	0	2	3	53
5	13	0	4	0	8	30	36	0	9	0	0	0	4	55
6	4	0	0	0	21	35	26	1	12	0	0	0	8	47
7	15	0	5	6	9	37	20	0	7	0	0	0	0	76
8	9	0	4	8	6	30	32	0	8	4	0	0	0	65
9	9	0	1	0	18	31	33	4	4	0	0	6	9	48
10	3	1	6	0	13	26	35	1	14	0	0	2	8	53
11	8	0	1	0	15	24	42	3	6	0	1	0	14	52
12	21	0	2	0	17	12	44	3	1	0	0	0	7	60
13	14	0	2	0	11	25	44	0	4	0	0	0	1	59
14	15	0	7	4	6	26	39	0	3	0	1	1	1	49
15	7	0	3	0	16	28	34	0	13	0	0	0	2	62
16	14	0	3	1	17	32	29	0	4	1	0	0	7	62
17	6	1	2	0	13	25	30	9	14	0	0	2	6	60
18	12	0	1	0	16	30	34	0	7	0	1	1	1	54
19	1	0	0	0	20	35	33	5	4	2	1	7	2	56
20	10	0	0	0	18	28	37	0	6	0	1	1	4	48
21	5	0	2	0	10	42	35	0	6	0	0	6	6	52
22	3	0	1	0	18	42	32	0	4	0	0	3	7	46
23	13	0	2	0	16	36	30	0	3	0	1	4	2	51
24	4	0	1	0	20	25	43	0	7	0	2	6	3	45

Figure 1. Example of plot layout within a compartment. (Compartment 6 is shown here). Gridlines are spaced at 100 foot intervals.

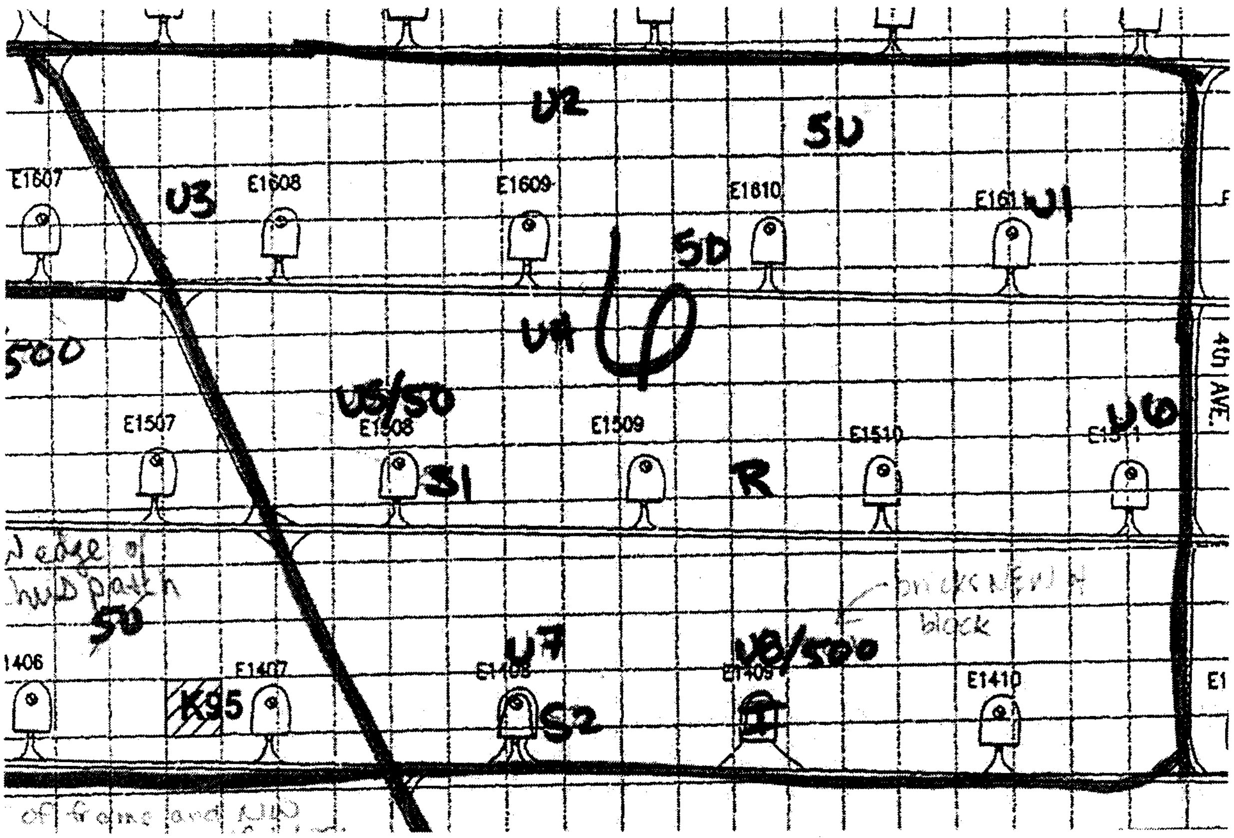


Figure 2. Cluster Dendrograms for vegetation data. Green shading highlights plots that cluster together as Block 1.

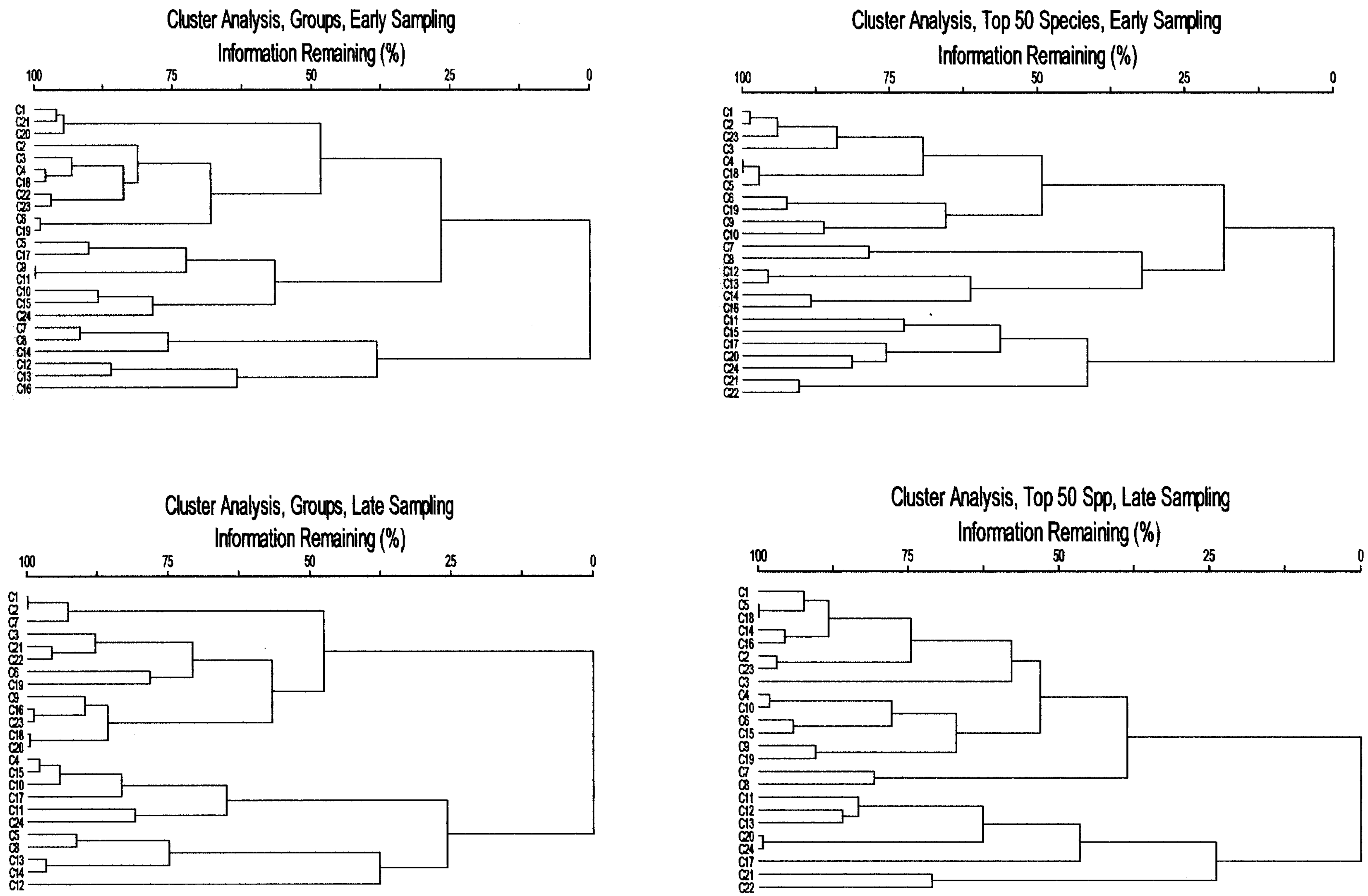
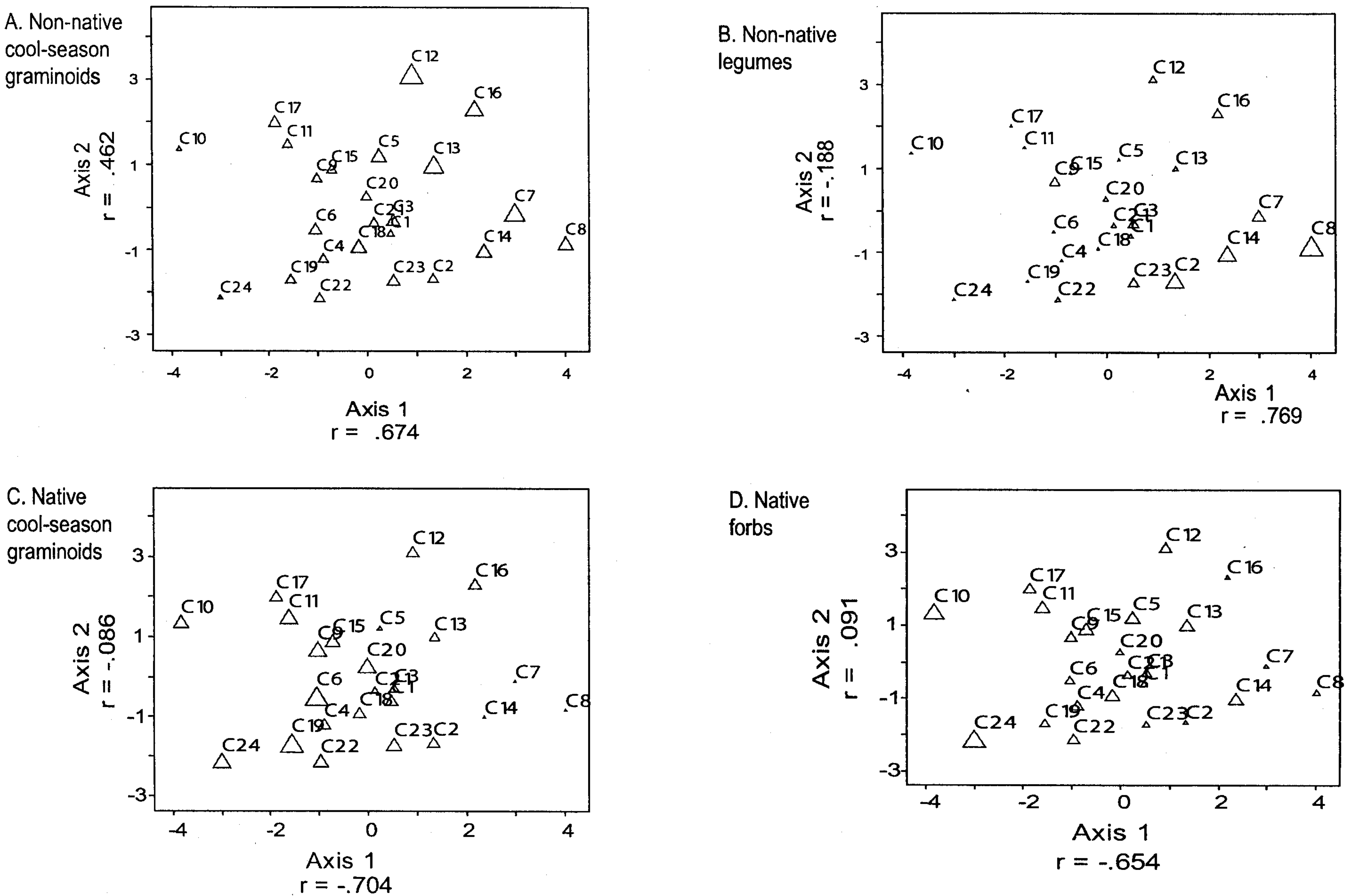


Figure 3. Ordination graphs from PCA of compartment averages of plant group and bare ground cover. Scores for each compartment on the first two axes are plotted, and symbol size is proportional to the value of the plant group/bare ground cover. Pearson's correlation coeficients for the relationship between the group and each axis are shown.



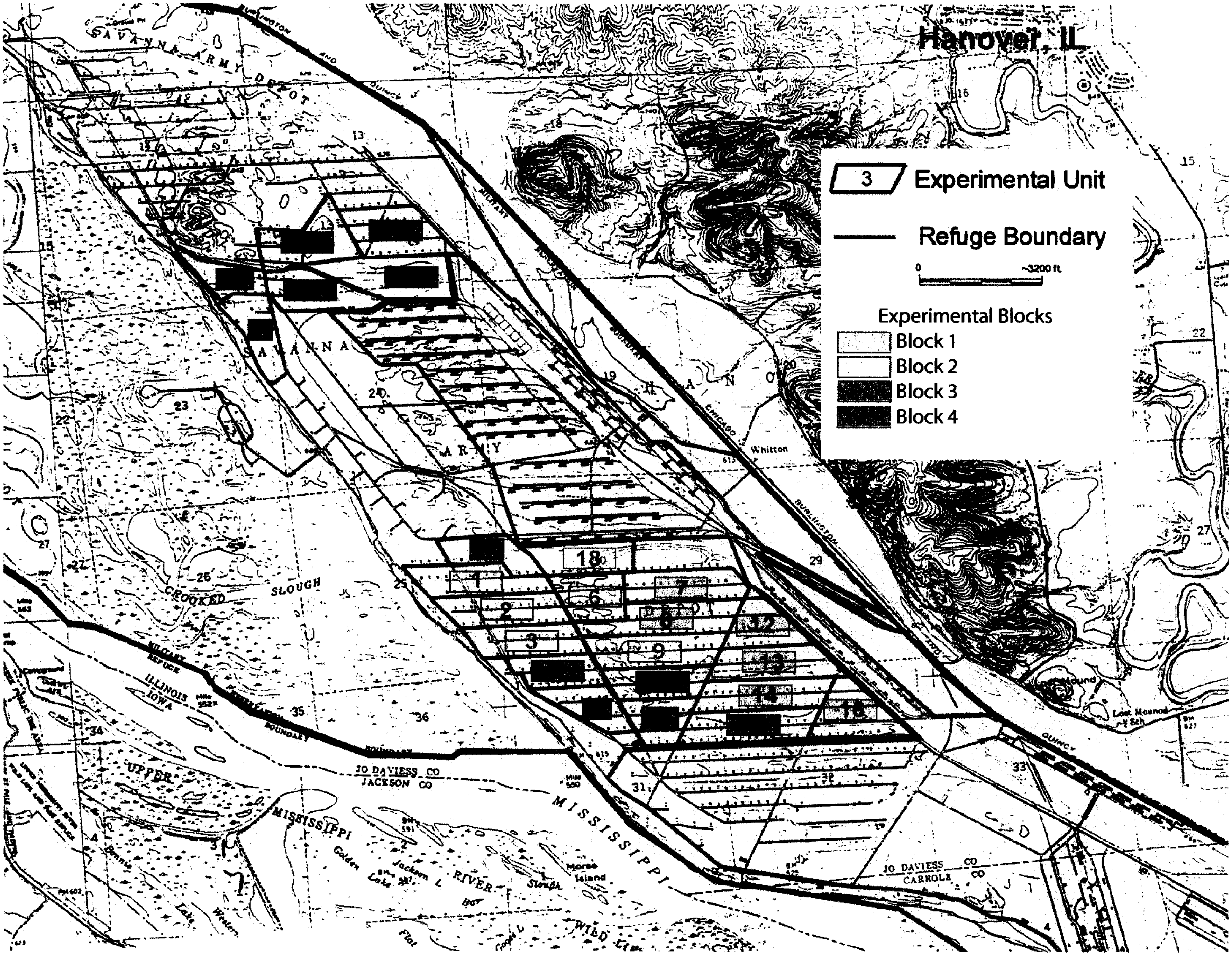

Hanover, IL
3
Experimental Unit
Refuge Boundary
0
~3200 ft
Experimental Blocks
Block 1
Block 2
Block 3
Block 4
SAVANNA ARMY DEPOT
MISSISSIPPI
CROOKED SLOUGH
UPPER
JO DAVIESS CO
JACKSON CO
CARROLL CO
ILLINOIS
IOWA
BURLINGTON
QUINCY
CHICAGO
Whitton
RIVER

Figure 5. Cover of important plant groups and bare ground. Bars are averages for block, error bars are 1 SE. For all but bare ground, values are proportion of total vascular plant cover. For bare ground, values are absolute cover (% of plot area). Black and gray bars are for the early and late sampling periods, respectively.

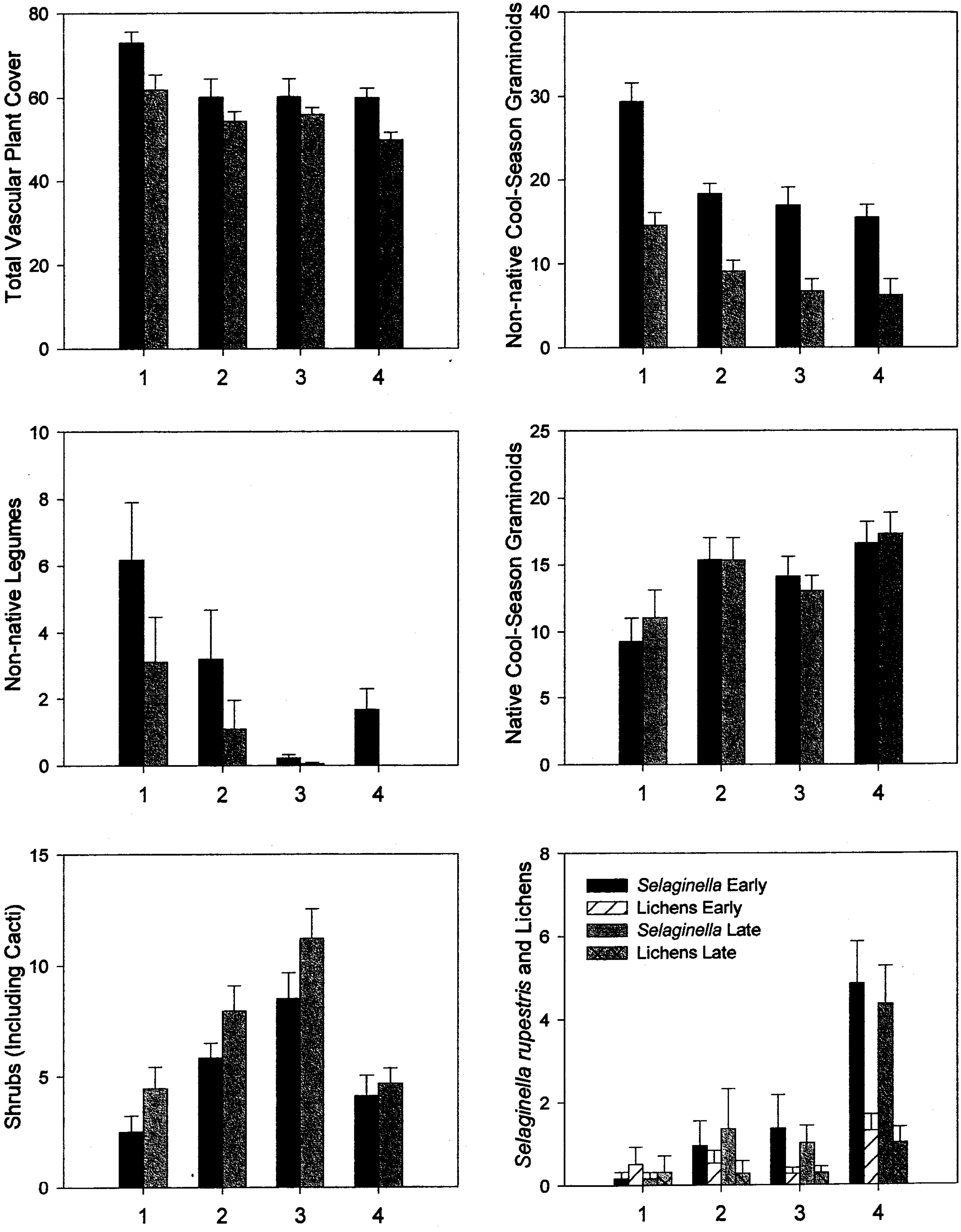
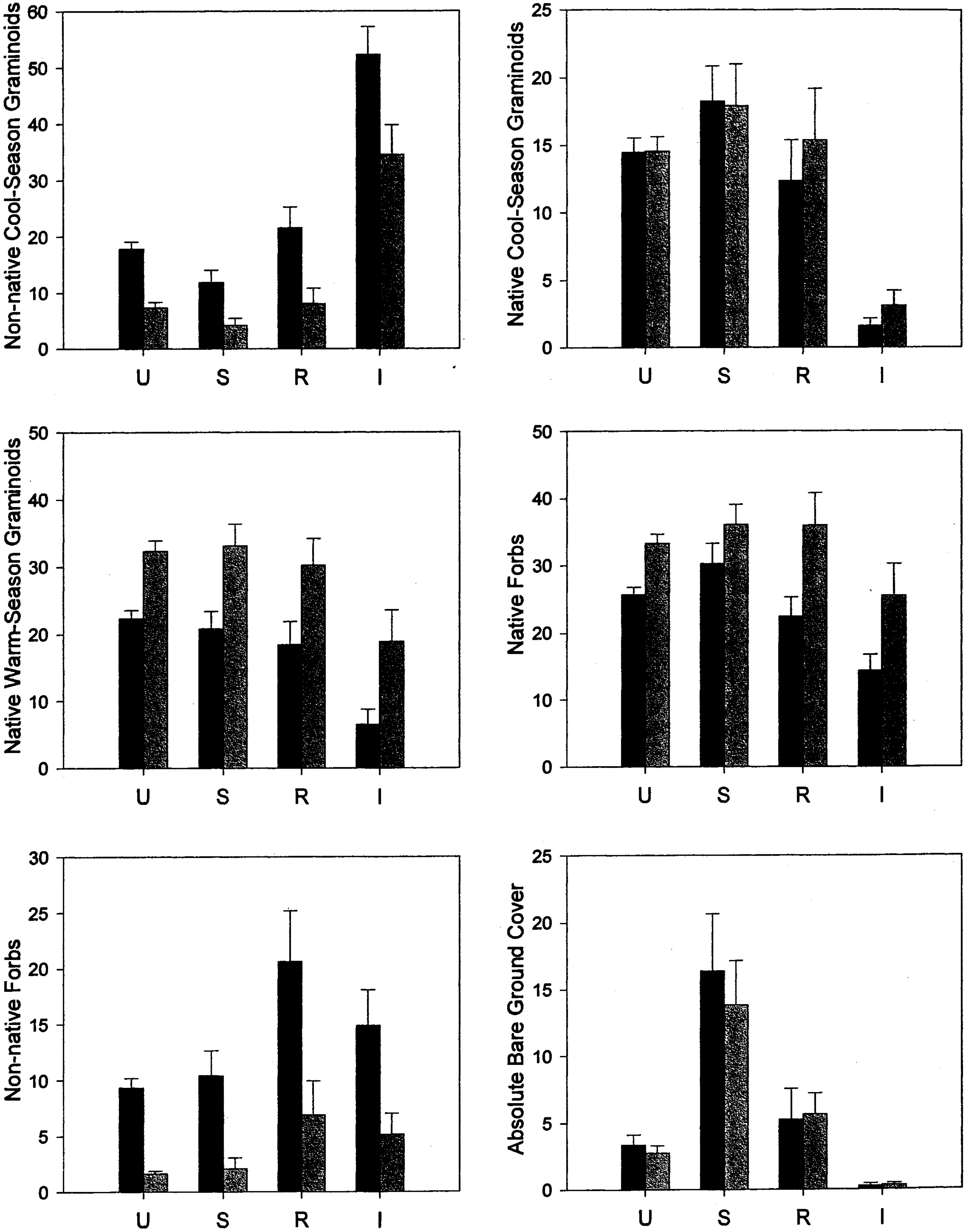


Figure 6. Cover of important plant groups and bare ground. Bars are averages for plot type, error bars are 1 SE. For all but bare ground, values are proportion of total vascular plant cover. For bare ground, values are absolute cover (% of plot area). Black and gray bars are for the early and late sampling periods, respectively.



Appendix 1

Plant Species Identified in Cover Estimate (0.5 m^2) Plots

Acalypha gracilens

Achillea millefolium
Agropyron repens
Ambrosia artemisiifolia
Ambrosia psilostachya
Amorpha canescens
Andropogon gerardii
Anemone cylindrica
Antennaria neglecta
Antennaria plantaginifolia
Arabis lyrata
Arenaria serpyllifolia
Aristida sp.
Asclepias verticillata
Asclepias viridiflora
Aster laevis
Aster lanceolatus
Aster linariifolius
Aster ontarionis
Aster pilosus
Aster sericeus
Berteroa incana
Besseya bullii
Bouteloua hirsuta
Brickellia eupatorioides
Bromus inermis
Bromus racemosus
Bromus tectorum
Calamovilfa longifolia
Callirhoë triangulata

Carex cf. *brevior* - interrupted
Carex cf. *muhlenbergii* - compact
Carex gravida
Carex pensylvanica
Carex sp.
Carex tonsa

Ceanothus herbaceus
Chamaecrista fasciculata
Chamaesyce sp.
Conyza canadensis
Coronilla varia
Croton glandulosus var. *septentrionalis*
Cyperus filiculmis var. *filiculmis*
Cyperus schweinitzii

Cyperus sp.
Dalea purpurea
Dianthus armeria
Diodia teres
Draba reptans

Equisetum laevigatum

Eragrostis spectabilis
Erigeron annuus
Erigeron strigosus
Erysimum cheiranthoides
Erysimum inconspicuum
Euphorbia corollata
Froelichia sp.
Gleditsia triacanthos
Gnaphalium obtusifolium
Hedeoma hispida
Helianthus occidentalis
Helianthus rigidus
Heterotheca camporum
Hieracium longipilum
Hypericum perforatum
Juniperus virginiana
Koeleria macrantha
Krigia virginica
Lactuca serriola
Lepidium sp.
Leptoloma cognatum
Lespedeza capitata
Liatris aspera
Linaria canadensis
Linum sulcatum
Lithospermum caroliniense
Medicago lupulina
Melilotus sp.
Mollugo verticillata

Monarda punctata
Oenothera rhombipetala

Opuntia macrorhiza
Opuntia humifusa
Opuntia fragilis
Oxalis dillenii

Panicum oligosanthes
Panicum perlongum
Panicum villosissimum
Panicum virgatum
Paspalum sp.
Penstemon pallidus

Physalis virginiana
Plantago patagonica var. *brevicarpa*
Plantago virginica
Poa compressa
Poa pratensis
Poinsettia dentata
Polanisia jamesii

Polygala polygama var. *obtusata*
Polygonella articulata
Polygonum tenue
Potentilla argentea
Potentilla recta
Prunus americana
Prunus sp.
Rhus aromatica var. *arenaria*
Rumex acetosella
Saponaria officinalis
Schizachyrium scoparium
Senecio plattensis
Setaria glauca
Silene antirrhina
Sisyrinchium campestre
Solanum carolinense
Solidago nemoralis
Solidago rigida
Sorghastrum nutans
Spermolepis inermis
Sporobolus asper
Sporobolus clandestinus
Sporobolus cryptandrus
Stellaria media
Stipa spartea
Strophostyles leiosperma
Talinum rugospermum
Taraxacum officinale
Tephrosia virginiana
Teucrium canadense var. *virginicum*
Thistle
Tradescantia ohiensis

Tragopogon dubius
Trichostema brachiatum
Trifolium arvense
Triodanis perfoliata var. *perfoliata*
Unknown Brassicaceae
Unknown Euphorbiaceae
Unknown forb
Unknown forb #16-1
Unknown grass
Unknown grass confused w/*Bouteloua hirsuta*
Unknown rosette #16-2
Verbascum thapsus

Verbena stricta
Veronica arvensis
Viola pedata
Vulpia octoflora

Plant Species Occurring in Larger Plots Only

Alyssum alyssoides
Arabis glabra
Asclepias syriaca
Cannabis sativa
Celtis occidentalis
Chenopodium album
Cornus sp.
Desmodium illinoense
Festuca ovina
Festuca pratensis
Helianthemum bicknelli
Helianthemum canadense
Hudsonia tomentosa
Juncus sp.
Lechea tenuifolia
Lithospermum incisum
Mirabilis nyctaginea
Morus sp.
Nepeta cataria
Panicum linearifolium
Panicum wilcoxianum
Physalis heterophylla
Polygonum convolvulus
Prunus serotina
Quercus velutina
Ribes sp.
Rumex crispus
Silene latifolia
Smilax hispida
Solidago canadensis
Solidago cf. gigantea
Solidago speciosa
Trifolium repens
Viola rafinesquii
Vitis sp.
Xanthium strumarium

Appendix 2
Bird Species Recorded in Experimental Compartments

Common name	Scientific name	Habitat Preference*	Number of Compartments	Number of Individuals
American Goldfinch	*Carduelis tristis*	G2	1	2
American Kestrel	*Falco sparverius*	G2	1	1
American Robin	*Turdus migratorius*	NG	5	5
Baltimore Oriole	*Icterus galbula*	NG	3	3
Brown-headed Cowbird	*Molothrus ater*	G2	11	23
Blue Grosbeak	*Guiraca caerulea*	NG	1	1
Blue Jay	*Cyanocitta cristata*	NG	3	3
Bobolink	*Dolichonyx oryzivorus*	OG	12	32
Brown Thrasher	*Toxostoma rufum*	NG	18	31
Cedar Waxwing	*Bombycilla cedrorum*	NG	3	16
Chipping Sparrow	*Spizella passerina*	NG	15	41
Common Nighthawk	*Chordeiles minor*	G2	5	8
Dickcissel	*Spiza americana*	OG	24	203
Downy Woodpecker	*Picoides pubescens*	NG	1	1
Eastern Bluebird	*Sialia sialis*	G2	2	3
Eastern Kingbird	*Tyrannus tyrannus*	G2	20	49
Eastern Meadowlark	*Sturnella magna*	OG	21	75
European Starling	*Sturnus vulgaris*	NG	4	9
Field Sparrow	*Spizella pusilla*	G2	23	106
Gray Catbird	*Dumetella carolinensis*	NG	1	1
Grasshopper Sparrow	*Ammodramus savannarum*	OG	24	381
Horned Lark	*Eremophila alpestris*	OG	2	3
Lark Sparrow	*Chondestes grammacus*	G2	7	9
Loggerhead Shrike	*Lanius ludovicianus*	G2	6	13
Mourning Dove	*Zenaida macroura*	G2	22	66
Northern Cardinal	*Cardinalis cardinalis*	G2	1	1
Northern Mockingbird	*Mimus polyglottos*	G2	16	30
Northern Flicker	*Colaptes auratus*	NG	12	18
Orchard Oriole	*Icterus spurius*	G2	11	28
Red-headed Woodpecker	*Melanerpes erythrocephalus*	G2	1	1
Red-winged Blackbird	*Agelaius phoeniceus*	G2	9	25
Tree Swallow	*Tachycineta bicolor*	NG	1	8
Unidentified Meadowlark	*Sturnella sp*	OG	4	6
Upland Sandpiper	*Bartramia longicauda*	OG	2	4
Vesper Sparrow	*Pooecetes gramineus*	OG	6	8
Western Meadowlark	*Sturnella neglecta*	OG	23	224

G2 = secondary grassland; NG = non-grassland; OG = obligate grassland