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Baseline Data Collection for Habitat Restoration at the Savanna Army Depot: Vegetation Structure and Composition

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INTRODUCTION

Approximately 3,500 acres of sand prairie and savanna at the Savanna Army Depot are slated to be managed jointly by the US Fish and Wildlife Service and the Illinois Department of Natural Resources as part of the Lost Mound Unit of the Upper Mississippi River Wildlife and Fish Refuge. Although this land remains dominated by native vegetation, it has been degraded by widespread construction of roads and storage facilities and through decades of fire suppression and intense grazing. This study was undertaken to begin the process of investigating the best methods for restoring the prairies at Lost Mound. The two main objectives of the work were (1) to collect baseline vegetation structure and composition data to aid in establishing experimental units for testing restoration methods; and (2) to compare the composition and structure of the vegetation, as well as some basic soil properties, at Lost Mound to less disturbed, nearby sand prairies in order to establish restoration goals for the site.

STUDY SITES AND PLOT LAYOUT

Lost Mound is located in Carroll and Jo Daviess Counties, Illinois, approximately 10 miles north of Savanna. The majority of the uplands at Lost Mound are dry-mesic sand prairie dominated by typical sand prairie species such as *Sporobolus cryptandrus*, *Schizachyrium scoparium*, and *Koeleria macrantha*. Non-native species such as *Poa pratensis* and *Potentilla recta* are also common, however (Robertson et al. 1997). Although the whole of the uplands in Lost Mound will eventually be restored and managed as prairie, this work focused on a small part of the area, known as Whitton (Fig. 1), where preliminary studies on restoration and management techniques will be conducted. Plots at this site were divided into two sections, designated Whitton Rectangle (WR) and Whitton Triangle (WT), based on differences in their vegetation. WR is a relatively homogeneous area, approximately 15 ha (37 acres) in size, of gently rolling topography and much native vegetation. WR is similar to most of the sand prairie at Lost Mound. Seventy-six plots were placed 50 m apart in a regular, grid pattern (Fig. 2a). WT is also relatively homogeneous, approximately 1 ha (2.4 acres) in size, but is flat and dominated by non-native grassland species. This section is similar to some smaller areas of Lost Mound in which habitat degradation is more severe. Twenty-five plots were placed 25 m apart in a regular, grid pattern in this section (Fig. 2b).

Two Illinois Nature Preserves, Ayers Sand Prairie and Thomson-Fulton Sand Prairie, were sampled with similar methods to determine the vegetational make-up of higher quality sand prairies in the same region as the restoration site. The nature preserves were also divided into different sections, this time because of known differences in land-use history (summarized in Table 1). The first section of Ayers (A1) comprises approximately two-thirds of the preserve and was more recently disturbed by grazing and cultivation than the second section, A2. Although the portions of Ayers sampled are not managed with prescribed burn because of a fire-sensitive endangered species, the preserve does burn occasionally due to wild fires. This is more common in A1 than in A2. Plots were placed along seven and three randomly-placed transects of six plots each in sections A1 and A2, respectively, with plots being spaced 20 m apart (Fig 3). Thomson-Fulton was sampled in three sections. The first section (TF1) was cultivated at least between 1958 and 1964 and is relatively flat except for remaining plow furrows and a large blowout at one end. Aerial photographs and the rolling dune topography of Section 2 (TF2) indicate that this section has apparently never been cultivated, though off-road vehicle use has left trails and disturbed areas in this section. Section 3 (TF3) of Thomson-Fulton was the most heavily cultivated of all sites sampled, in that aerial photographs indicate it was cultivated from at least 1939 to 1964. Thomson-Fulton is managed with prescribed fire. Plots were placed randomly along regularly spaced transects in each section, with 18 plots each in TF1 and TF3 and 24 plots in TF2 (Fig. 4).

Figures 2, 3, and 4 illustrate plot locations and describe plot orientation. Table 2 lists plot numbers and gives exact locations for sampling sections in the nature preserves.

METHODS

Vegetation composition was measured at three sites by visually estimating the percent of canopy area covered by each species of plant in a 0.5 x 1 m plot at each sampling point. Bare ground and litter cover were also estimated so that the total cover of each plot was at least 100%. These estimates were done twice, in June and August 2000, for approximately half of the plots at Ayers and WR, but only once, in July or August 2000, for the remainder of the plots. For those plots in which cover was estimated twice, values reported are the maximum cover recorded for plant species and the average of the two values for bare ground and litter.

Vegetation structure was measured in the vicinity of each vegetation composition plot using a modified Robel pole method (Robel et al. 1970). Each Robel measurement is a combination of vegetation height and density obtained by recording two values from 1 m above ground and 2 m away from the pole. The first value recorded is the highest 10-cm interval in which more than 80% of the interval is obstructed by vegetation ("obstructed"). This value indicates the height of the most dense part of the vegetation. The second value recorded is the highest 10-cm interval in which any vegetation occurs ("highest"). This value indicates the maximum height of the vegetation. Robel measurements were made at two points for each plot, one 4 m NW and one 4 m SE of the numbered plot marker. Four readings were taken at each point, so that the Robel measurements ("obstructed" or "highest") for each vegetation plot are averages of 8 readings. Leaf litter depth was measured at the same points as the Robel readings, so that litter depth values are also averages of 8 readings. Finally, the number of trees (>2 m height) and shrubs (<2 m height) within the 10 m radius around the numbered plot marker was counted at each plot.

Soil samples were taken on 28 July and 1 & 2 August. At WR and WT, four 15 cm deep x 1 cm diameter samples were taken at each plot, one each at four points 4 m from the numbered plot parker. For these sections, each plot's sample was analyzed separately to facilitate monitoring changes in soil properties as different management practices are implemented. At the nature preserves, one 15 cm x 1 cm core was taken 1 m from the numbered plot marker for each plot. Soil cores were combined by transect so that no more than six plots were composited into a single sample for analysis. Soils were analyzed by A&L Great Lakes Laboratories (Fort Wayne, IN) for organic matter, phosphorus, potassium, magnesium, calcium, and pH.

Color slide photos were taken of each plot at WR and WT, and of each transect at Ayers and Thomson-Fulton. In addition, photo stations were established around the entire upland prairie and savanna areas of Lost Mound. Both black and white print and color slide photos were taken at these photo stations, whose locations are shown in Fig. 5 and described in Table 3.

Statistical analyses consisted of one-way analyses of variance followed by Tukey comparison of means to compare vegetation and soil characteristics among the seven sampling sections. When appropriate, data were log-transformed to better fit the assumptions of ANOVA.

RESULTS AND DISCUSSION

The vegetation at WR and WT, the sites to be restored, generally differed significantly from the vegetation in most nature preserve sections. This was less true for vegetation structure than for composition. Both the obstructed and highest Robel measurements were similar among the restoration sites and all but one of the nature preserve sites (Fig. 6a). Dense vegetation, measured by the obstructed Robel readings, was generally short (average Robel reading 10 cm) in all sections except TF2. The taller dense vegetation cover in this section is probably due to the high incidences of dense patches of *Tephrosia virginiana* and *Schizachyrium scoparium* compared to other sections. In contrast, TF1 differed significantly from all other sections in that its maximum vegetation height, measured by the highest Robel readings, was relatively low (Fig. 6a). The amount of plant litter, an important resource for grassland birds, differed among sections but the pattern of differences depended on how the litter was measured. Litter depth was lower at WR than at WT and TF2, but not significantly different from other sections (Fig. 6b). TF2's greater litter depth is probably related to the denser vegetation in this section mentioned previously. In contrast to litter depth, the amount of ground covered by litter was the greatest at WR and least at WT (Fig. 6c). As was the general pattern with depth, however, the restoration sites did not differ from nature preserve sites in their litter cover. In contrast, bare ground cover was consistently lower in the restoration sections compared to the nature preserve sections (Fig. 6c). This low level of bare ground cover may be due to the lack of fire at Whitton, but may also reflect the higher total plant cover of the two Whitton sections, especially WR, compared to the nature preserve sections (Fig. 6c). Although the number of shrubs and trees within 10 m of each plot varied significantly among sections, variability among plots was sufficient that no general patterns of woody plant abundance emerged. Thus, vertical vegetation structure does not differ much among the sections sampled, but the horizontal distributions of plant, litter, and bare ground cover do vary among sections.

This variance in horizontal distribution is caused by significant differences in vegetation composition among sections. The high total plant cover at the Whitton sites was caused by their high graminoid (grass and sedge) cover (Fig. 7a). Graminoids comprised approximately 70% of total plant cover at WR ant WT, whereas graminoids made up only about 42-62% of total plant cover in the nature preserve sections (Fig. 7b). Forb cover differed little among all sites, except that WR had significantly higher total forb cover than A2 and TF2, the least disturbed of the seven sections (Fig. 7a).

The greater total plant cover at the two restoration sites was due to a large non-native component. When non-native species were removed from the analyses and only cover by native plant species was evaluated, WR did not differ in total cover from the nature preserves. WT had significantly lower total cover than the nature preserve sections when only native plants were included (Fig. 8a). The large non-native components at the restoration sites are illustrated by the difference in the proportion of total plant cover that is native shown in Fig. 8b. WT and WR both had significantly lower proportions of their plant cover as native species compared to the nature preserve sections, but the two restoration sites also differed significantly from each other. WT was the least native of all sites, having only 30% of its cover as native species. Plant cover at WR was more on average 60% native, but this native component was low compared to the approximately 95% native cover in the nature preserve sections. The large non-native component at both restoration sites is due mostly to high non-native graminoid cover. Comparisons among sites in the proportion of graminoid cover that is native followed the total plant cover patterns and values closely (Fig. 8b). Unlike graminoid cover, the majority of forb cover at WT was native and the native proportion was similar to that of WR. Interestingly, the proportion of forb cover that was native at two nature preserve sites, TF1 and TF2, was not significantly higher than at the two restoration sites. This may indicate that native forb cover is difficult to maintain even in relatively high quality sand prairies.

As with plant cover, plant species richness differed significantly among the seven sampling sections. For species richness, however, differences among nature preserve sections and between restoration sections were nearly as large as between nature preserve and restoration sections (Fig. 9a). TF2, the uncultivated, rolling dune section of Thomson Fulton, had the lowest average number of species in the 0.5 m^2 sampling area, significantly lower than either of the Ayers sections. WR, a restoration section, had the highest diversity of plants in the small sampling area. This higher diversity seems to come more from graminoids than forbs, since graminoid diversity per plot at WR was higher than in any other section. Forb diversity at WR was significantly higher at WR than at three of the other sections, however (Fig. 9a). Interestingly, the number of graminoid and forb species in the small sampling plots was approximately equal within plots and among sections (Fig. 9b). This is different from the larger scale species richness pattern of these grasslands in which the forb to graminoid species ratio was 1.5 to 2.

As with plant cover, the high species richness of WR was due to a large non-native component. Eliminating non-native species from the analyses eliminated the difference between WR and most nature preserve sections in plot species richness but increased the difference in plot species richness between WT and all other sections (Fig. 10a). Thus, the WR restoration site has as many or more native species at the small scale as do the nature preserve sites, but the WT restoration site is quite low in small scale diversity. For diversity, unlike for cover, much of the non-native component both at nature preserve and restoration sites comes from forbs, not graminoids. Non-native graminoids comprised 20 to 40% of the graminoid diversity per plot at WR and WT, respectively, whereas non-native forbs comprised approximately 45% of the plot forb diversity at both restoration sites (Fig. 10b). Graminoid plot diversity was almost all native at the nature preserves, but forb plot diversity was only 70 to 88% native in these sections. Comparisons of total section species lists is problematic because of differences in the number of plots sampled in each section.

In summary, plant species composition in the two restoration sections differs significantly from the nature preserve sections in that non-native species comprise a major component of the vegetation in both cover and diversity. The two restoration sections differ, however, in that in Whitton Rectangle, this non-native component seems to mostly be an addition to the native component, since WR's native cover and diversity are similar to the nature preserve sections, whereas much of the native cover and diversity have been lost from WT. Although WR retains a large native component, more detailed, species-level analyses not shown here show that the site is lacking the abundance of more conservative prairie forbs found at most of the nature preserve sections. For example, the most abundant forb at WR is *Potentilla recta*, a non-native cinquefoil, whereas the most abundant forb at all but the most heavily disturbed nature preserve section (TF3) is *Tephrosia virginiana*, a native legume characteristic of Illinois sand prairies.

Soils at the Whitton sections differed somewhat from the soils of the nature preserves. This was most obvious for the minerals potassium, magnesium, and calcium, but trends for differences between Whitton and the nature preserves in soil organic matter and pH also occurred (Fig 11). The relatively high organic content of soils in the WT section may reflect the slightly lower topography, and therefore slightly more mesic conditions, of this section compared to WR and the nature preserve sections as well as the dominance of non-native cool season grasses in this section. Although these soil parameters are difficult to interpret because of the large number of factors that affect them, they do indicate that growing conditions for plants at the restoration sites may be slightly different than at the nature preserves.

FUTURE DIRECTIONS

The data from this study will be used for future management and restoration efforts at Lost Mound in two ways. First, the quantitative measurements of plant community composition show how much and what kind of native vegetation remains at the restoration sites and is directly comparable to less degraded sand prairies. This information suggests that in sections like Whitton Rectangle, which still contain a largely native plant community, restoration and management research at Lost Mound should focus more on reducing or eliminating non-native plant species than on re-introducing native prairie species. Most of the native prairie species still occur at this site, but they are in lower abundance than at less degraded nature preserves. Thus, finding methods that negatively affect the non-native species without harming the non-native species will be a focus of future research. This will be particularly challenging when native and non-native species are similar in their life history or phenology, such as the native *Koeleria macrantha* and non-native *Poa pratensis*, both cool-season, perennial grasses. On the other hand, for areas of Lost Mound more similar to Whitton Triangle in which much of the native vegetation is gone, restoration and management research may want to focus on re-constructing sand prairies from bare ground and seed because so little of the prairie matrix remains.

Second, the quantitative measurements of vegetation structure and composition and soil characteristics will serve as baseline, pre-treatment data essential for understanding how vegetation responds to burning and other management treatments that will be tested in a replicated experiment. The results of this experiment will guide further research, restoration, and management at the whole Lost Mound site. These treatments will be decided upon, using the baseline data, through close collaboration between research and management staff of the Illinois Department of Natural Resources (Natural History Survey and Natural Heritage Divisions) and U.S. Fish and Wildlife Service.

References

Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23:295-297.

Robertson, K. R., L. R. Phillippe, G. A. Levin, and M. J. Moore. 1997. Delineation of natural communities, a checklist of vascular plants, and new locations for rare plants at the Savanna Army Depot, Carroll and Jo Daviess Counties, Illinois. Illinois Natural History Survey Technical Report 1997 (2).

Table 1. Land use history of nature preserve sections.

Ayers Sand Prairie	Thomson-Fulton Sand Prairie
Total size is 109 acres	Total size is approximately 60 acres (including adjacent USFWS land)
Part of it dedicated in 1954	Dedicated in 1970
Section 1 (**A1**): cultivated at least in 1964, has some active sand movement, is occasionally burned	Section 1 (**TF1**): less recent cultivation than in section 3, flat
Section 2 (**A2**): never (?) cultivated, less active sand movement, rarely burned	Section 2 (**TF2**): never cultivated, dune topography, active sand movement
	Section 3 (**TF3**): most recent and longest cultivation of all sections, flat

Table 2. Plot locations for the nature preserve sampling sections.

Ayers Sand Prairie Nature Preserve

Marker Number	Description (L = Line/Section; T = Transect; P = Plot)	Distance (m) of transect from southern border	Direction of transect from anchor line
56	L1 T1 P1	78	East
57	L1 T1 P2	78	East
58	L1 T1 P3	78	East
59	L1 T1 P4	78	East
60	L1 T1 P5	78	East
61	L1 T1 P6	78	East
62	L1 T2 P1	231	West
63	L1 T2 P2	231	West
64	L1 T2 P3	231	West
65	L1 T2 P4	231	West
66	L1 T2 P5	231	West
67	L1 T2 P6	231	West
68	L1 T3 P1	311	West
69	L1 T3 P2	311	West
70	L1 T3 P3	311	West
71	L1 T3 P4	311	West
72	L1 T3 P5	311	West
74	L1 T3 P6	311	West
75	L1 T4 P1	460	East
76	L1 T4 P2	460	East
77	L1 T4 P3	460	East
78	L1 T4 P4	460	East
79	L1 T4 P5	460	East
80	L1 T4 P6	460	East
82	L1 T5 P1	519	West
83	L1 T5 P2	519	West
84	L1 T5 P3	519	West
86	L1 T5 P4	519	West
87	L1 T5 P5	519	West
88	L1 T5 P6	519	West
89	L1 T6 P1	570	East
91	L1 T6 P2	570	East
92	L1 T6 P3	570	East
93	L1 T6 P4	570	East
95	L1 T6 P5	570	East

Ayers Sand Prairie Nature Preserve

Marker Number	Description (L = Line/Section; T = Transect; P = Plot)	Distance (m) of transect from southern border	Direction of transect from anchor line
96	L1 T6 P6	570	East
97	L1 T7 P1	642	West
98	L1 T7 P2	642	West
99	L1 T7 P3	642	West
100	L1 T7 P4	642	West
101	L1 T7 P5	642	West
102	L1 T7 P6	642	West
103	L2 T1 P1	186	East
104	L2 T1 P2	186	East
105	L2 T1 P3	186	East
106	L2 T1 P4	186	East
107	L2 T1 P5	186	East
108	L2 T1 P6	186	East
109	L2 T2 P1	253	East
110	L2 T2 P2	253	East
111	L2 T2 P3	253	East
112	L2 T2 P4	253	East
113	L2 T2 P5	253	East
114	L2 T2 P6	253	East
115	L2 T3 P1	383	East
116	L2 T3 P2	383	East
117	L2 T3 P3	383	East
118	L2 T3 P4	383	East
119	L2 T3 P5	383	East
120	L2 T3 P6	383	East

Thomson-Fulton Sand Prairie Nature Preserve

Marker #	Description (S = Section; T = Transect; P = Plot)	Distance (m) of plot from transect anchor	Notes
188	S1T1P1	31	
189	S1T1P2	65	
190	S1T1P3	81	
191	S1T1P4	131	
192	S1T2P1	26	
193	S1T2P2	82	
194	S1T2P3	149	

Thomson-Fulton Sand Prairie Nature Preserve

Marker #	Description (S = Section; T = Transect; P = Plot)	Distance (m) of plot from transect anchor	Notes
195	S1T2P4	173	
196	S1T2P5	213	
197	S1T2P6	244	at rim of blowout
198	S1T2P7	282	
199	S1T2P8	330	
200	S1T2P9	345	
201	S1T3P1	30	
202	S1T3P2	69	
203	S1T3P3	92	
204	S1T3P4	169	approx 10 m before rim of blowout
205	S1T3P5	187	in blowout
206	S2T1P1	42	
207	S2T1P2	65	
208	S2T1P3	116	
209	S2T1P4	132	
210	S2T1P5	146	
211	S2T1P6	189	
212	S2T1P7	253	
213	S2T1P8	268	
214	S2T2P1	44	
215	S2T2P2	56	
216	S2T2P3	79	
217	S2T2P4	101	
218	S2T2P5	174	
219	S2T2P6	213	
220	S2T2P7	229	
221	S2T3P1	14	
222	S2T3P2	53	
223	S2T3P3	65	
224	S2T3P4	119	
225	S2T3P5	143	
226	S2T3P6	194	
227	S2T4P1	15	
228	S2T4P2	38	
229	S2T4P3	89	
230	S3T1P1	48	
231	S3T1P2	73	
232	S3T1P3	117	
233	S3T1P4	137	

Thomson-Fulton Sand Prairie Nature Preserve

Marker #	Description (S = Section; T = Transect; P = Plot)	Distance (m) of plot from transect anchor	Notes
234	S3T2P1	41	
235	S3T2P2	57	
236	S3T2P3	75	
237	S3T2P4	91	
238	S3T2P5	152	
239	S3T2P6	182	
240	S3T2P7	249	
241	S3T2P8	267	
242	S3T3P1	36	
243	S3T3P2	61	
244	S3T3P3	73	
245	S3T3P4	92	
246	S3T3P5	190	
247	S3T3P6	221	

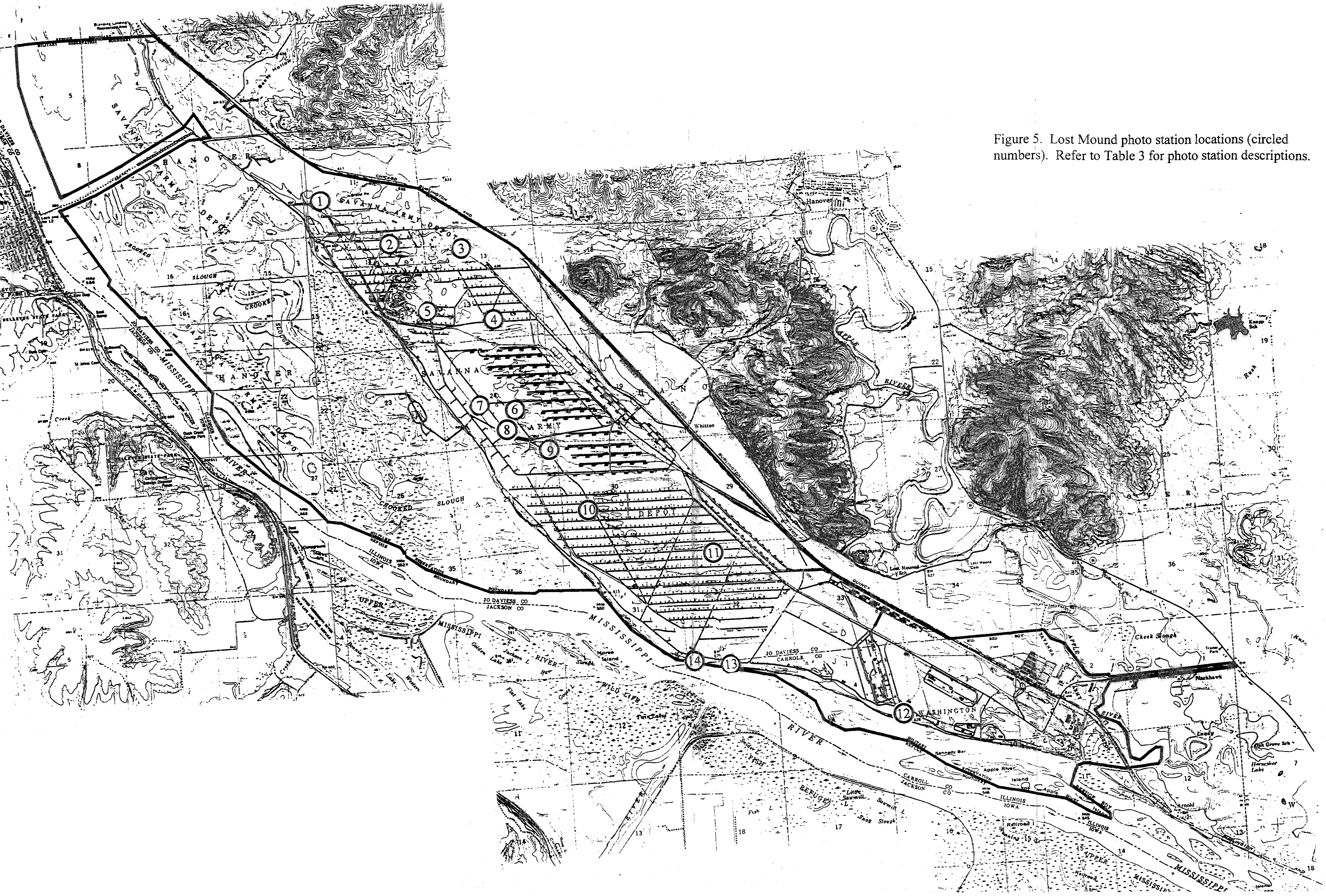
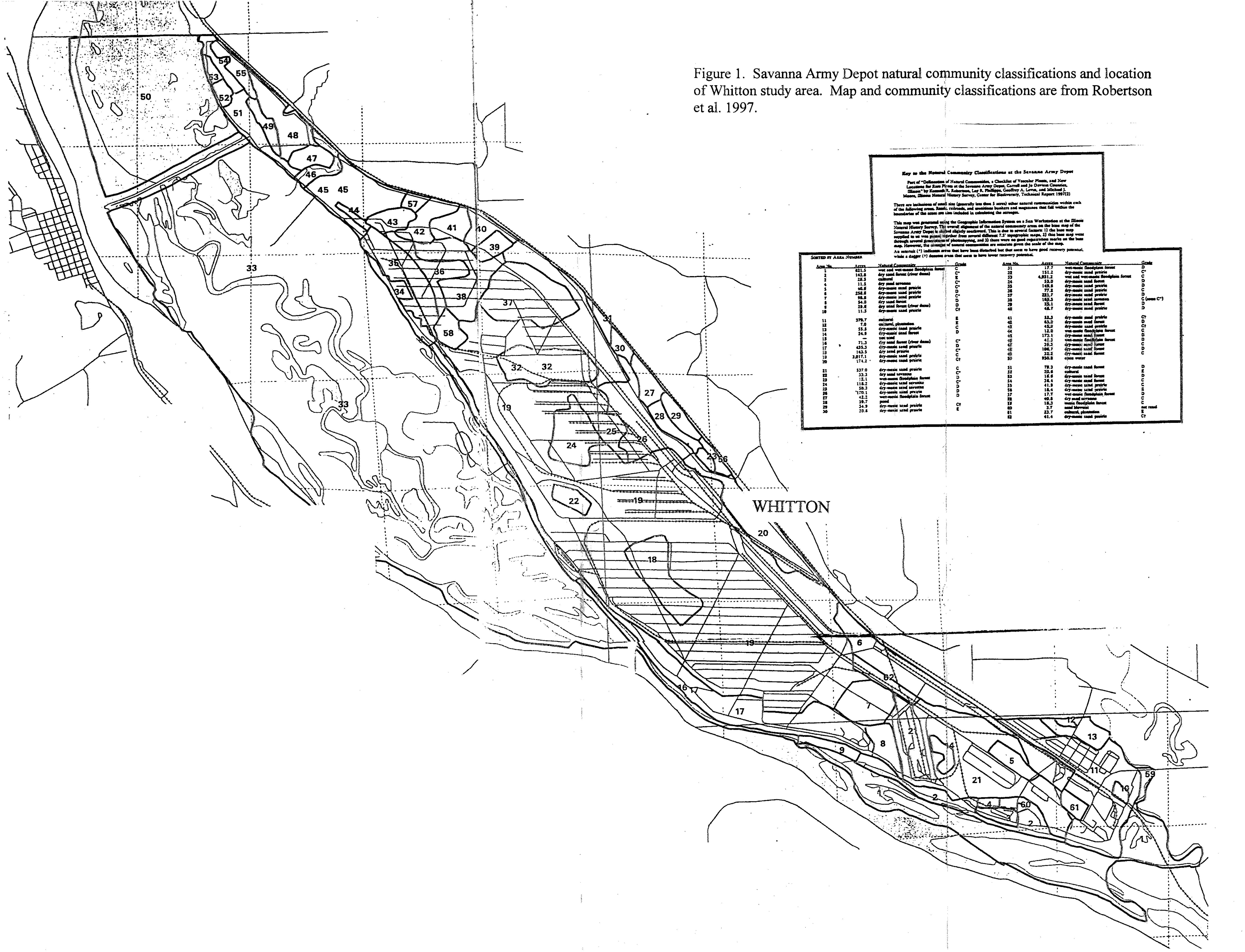


Figure 5. Lost Mound photo station locations (circled numbers). Refer to Table 3 for photo station descriptions.

Figure 1. Savanna Army Depot natural community classifications and location of Whitton study area. Map and community classifications are from Robertson et al. 1997.



Key to the Natural Community Classifications at the Savanna Army Depot

Part of "Delineation of Natural Communities, a Checklist of Vascular Plants, and New Locations for Rare Plants at the Savanna Army Depot, Carroll and Jo Daviess Counties, Illinois" by Kenneth R. Robertson, Loy R. Phillippe, Geoffrey A. Levin, and Michael J. Moore, Illinois Natural History Survey, Center for Biodiversity, Technical Report 1997(2)

There are inclusions of small size (generally less than 5 acres) other natural communities within each of the following areas. Roads, railroads, and munitions bunkers and magazines that fall within the boundaries of the areas are also included in calculating the acreages.

This map was generated using the Geographic Information System on a Sun Workstation at the Illinois Natural History Survey. The overall alignment of the natural community areas on the base map of the Savanna Army Depot is shifted slightly southward. This is due to several factors: 1) the base map supplied to us was pieced together from several different 7.5' topographic maps, 2) this base map went through several generations of photocopying, and 3) there were no good registration marks on the base map. However, the acreages of natural communities are accurate given the scale of the map.

An asterisk (*) indicates areas that have been disturbed but that seem to have good recovery potential, while a dagger (†) denotes areas that seem to have lower recovery potential.

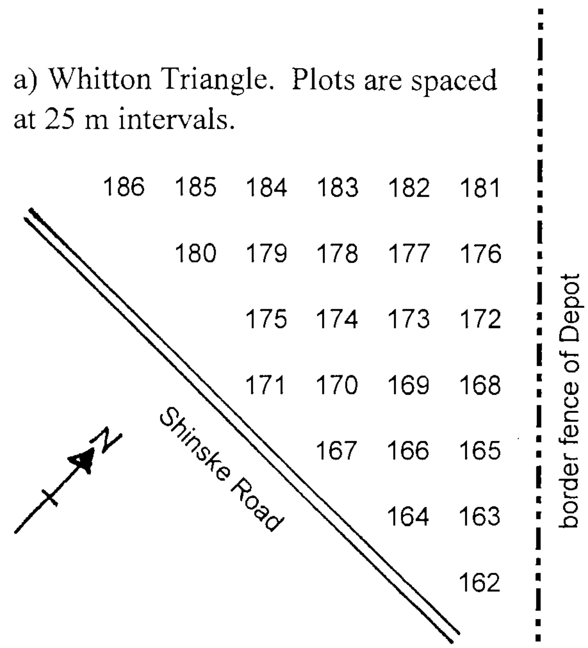
SORTED BY AREA NUMBER

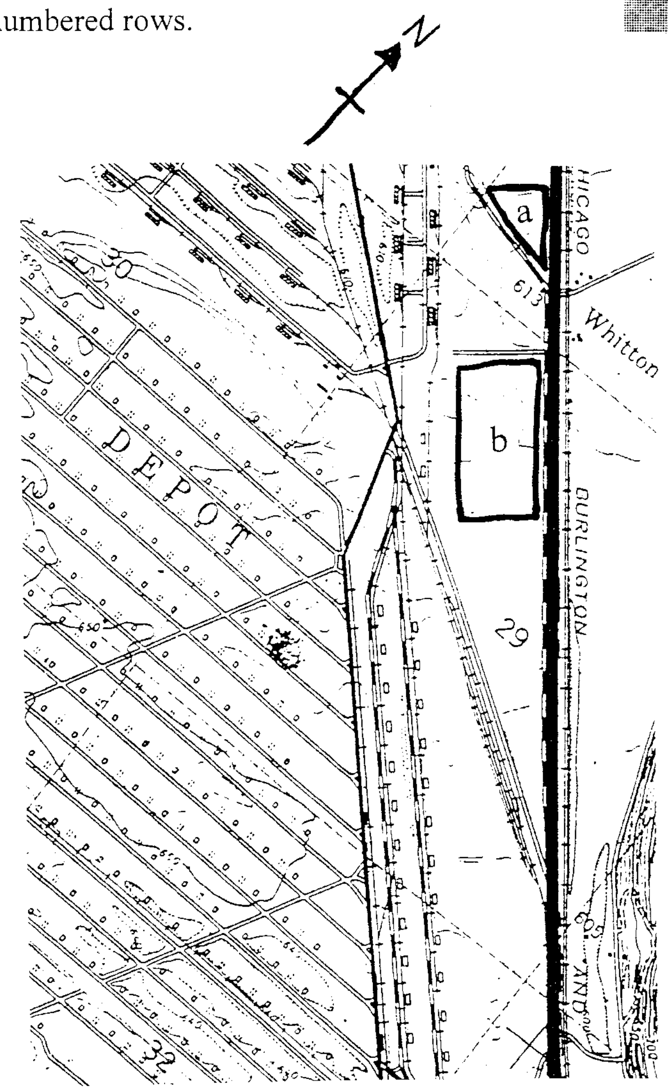
Area No.	Acres	Natural Community	Grade
1	621.5	wet and wet-mesic floodplain forest	C
2	143.8	dry sand forest (river dune)	C*
3	28.5	cultural	E
4	11.5	dry sand savanna	C*
5	40.6	dry-mesic sand prairie	C*
6	258.8	dry-mesic sand prairie	D
7	98.8	dry-mesic sand prairie	C*
8	54.0	dry sand forest	D
9	29.8	dry sand forest (river dune)	D
10	11.3	dry-mesic sand prairie	C†
11	379.7	cultural	E
12	7.0	cultural, plantation	E
13	55.5	dry-mesic sand prairie	C
14	24.9	dry-mesic sand forest	D
15	—	not used	
16	71.3	dry sand forest (river dune)	C*
17	435.3	dry-mesic sand prairie	D
18	143.5	dry sand prairie	C*
19	3,017.1	dry-mesic sand prairie	C
20	174.2	dry-mesic sand prairie	C†
21	537.0	dry-mesic sand prairie	C
22	33.3	dry sand savanna	C*
23	12.1	wet-mesic floodplain forest	D
24	118.2	dry-mesic sand savanna	C*
25	50.3	dry-mesic sand savanna	D
26	170.1	dry-mesic sand prairie	D
27	42.2	wet-mesic floodplain forest	D
28	39.7	pond	
29	34.9	dry-mesic sand prairie	C†
30	20.8	dry-mesic sand prairie	E

Area No.	Acres	Natural Community	Grade
31	17.7	wet-mesic floodplain forest	D
32	151.2	dry-mesic sand prairie	C*
33	4,931.2	wet and wet-mesic floodplain forest	C
34	53.0	dry-mesic sand forest	D
35	145.8	dry-mesic sand prairie	D
36	77.2	dry-mesic sand prairie	C
37	221.7	dry-mesic sand prairie	D
38	185.5	dry-mesic sand savanna	C (some C*)
39	35.1	dry-mesic sand forest	D
40	48.7	dry-mesic sand prairie	D
41	52.3	dry-mesic sand prairie	C†
42	63.9	dry-mesic sand forest	D
43	45.0	dry-mesic sand prairie	C†
44	12.0	wet-mesic floodplain forest	C
45	173.1	dry-mesic sand forest	D
46	41.3	wet-mesic floodplain forest	D
47	39.3	dry-mesic sand forest	C
48	106.7	dry-mesic sand forest	D
49	32.2	dry-mesic sand forest	C
50	930.8	open water	
51	78.3	dry-mesic sand forest	D
52	20.6	cultural	E
53	16.6	dry-mesic sand forest	D
54	28.4	dry-mesic sand forest	C
55	41.9	dry-mesic sand prairie	C
56	18.4	dry-mesic sand prairie	B
57	17.7	wet-mesic floodplain forest	D
58	40.8	dry sand savanna	C
59	18.3	mesic floodplain forest	C
60	3.7	sand blowout	not rated
61	23.7	cultural, plantation	E
62	41.4	dry-mesic sand prairie	C†

Figure 2. Location and plot numbering system of Whitton study area. Numbers show locations of plots. In the field, a piece of orange metal conduit is used to locate the 0.5 m^2 cover estimate plot. The cover estimate frame is placed so that its lower right* corner is 1 m away from the conduit in the direction of approximately 15 deg east of north (towards the plot in the same column). this corner is marked by a large nail sunk to nearly flush with the ground surface. Kiddy corner from this nail, in the upper left* corner of the plot, is a nail with an aluminum tag with the plot number on it. The long edge of the frame is approximately parallel to the row of plots. *Corners are designated such that "upper" is away from the person standing on the conduit side of the frame, facing higher-numbered rows.

a) Whitton Triangle. Plots are spaced at 25 m intervals.





b) Whitton Rectangle. Plots are spaced at 50 m intervals.

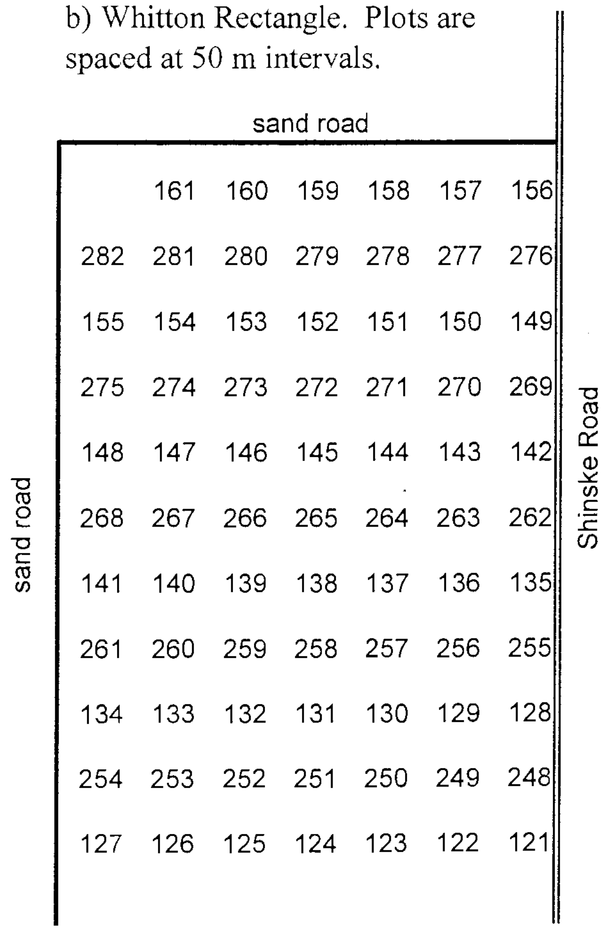
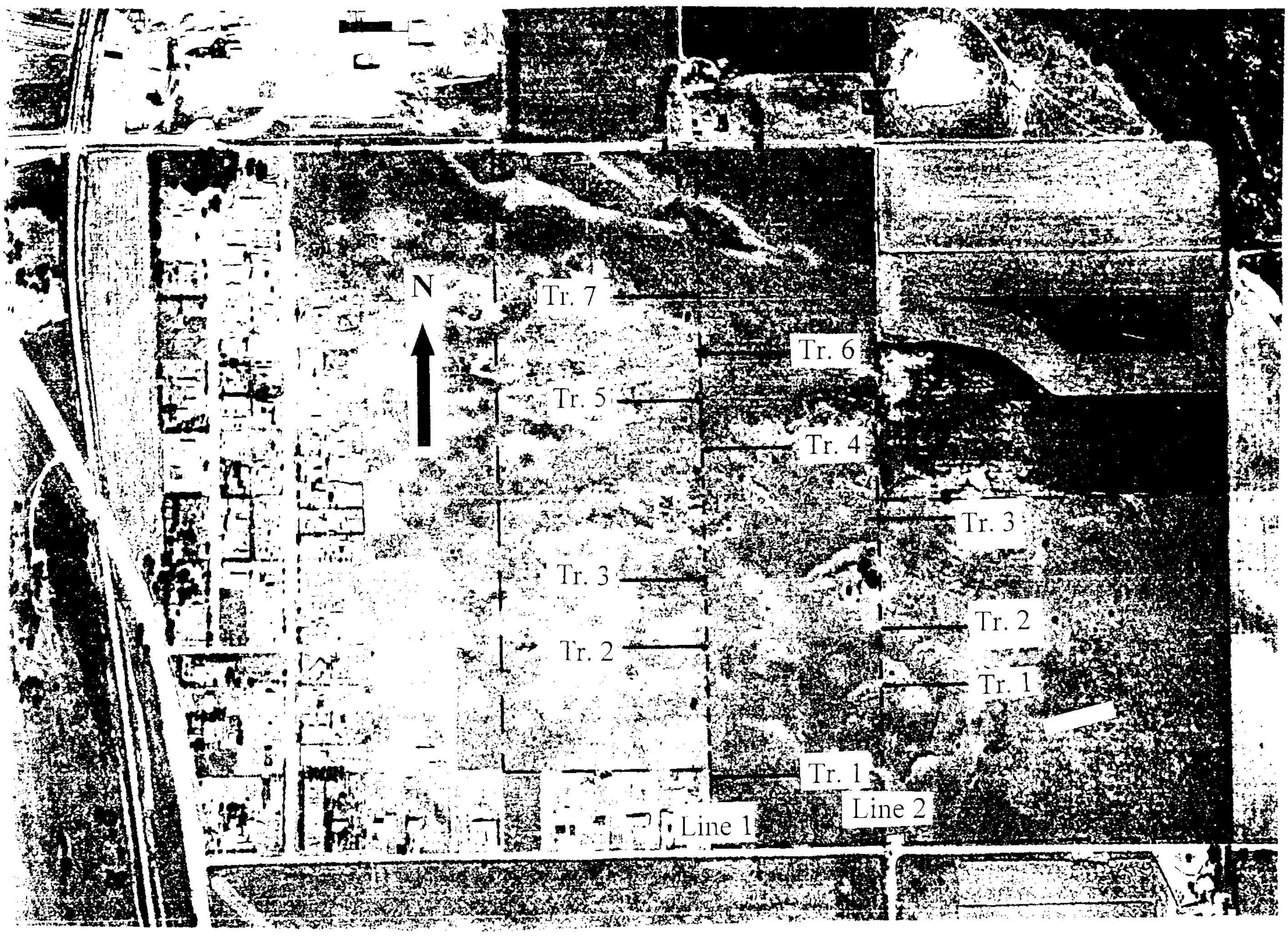


Figure 3. Transect locations at Ayers Sand Prairie Nature Preserve. Transects in Section 1 (A1) are anchored on Line 1, which heads approximately north from the southern boundary fence on the eastern edge of the east-most yard on the southern boundary of the preserve. Plot 1 of each transect in this section is 10 m from the anchor line. Transects in Section 2 (A2) are anchored on Line 2, which heads due magnetic north from a small green utility box just outside of the south-border fence near the southwest corner of the parking area. In this section, Plot 1 of each transect is a 0 meters from the anchor line, except for transect 3, which has Plot 2 at 0 m and Plot 1 at 20 m west of the anchor line. The intersection of each transect with its anchor line is marked with a piece of metal conduit. Plots are oriented such that the southwest corner of the sampling frame is on the numbered plot marker (a nail with an numbered aluminum tag), with the 1 m edge of the plot being parallel to the transect.



Preserve Boundary
Anchor line for transects
Transect

Scale: 1 cm ≈80 m

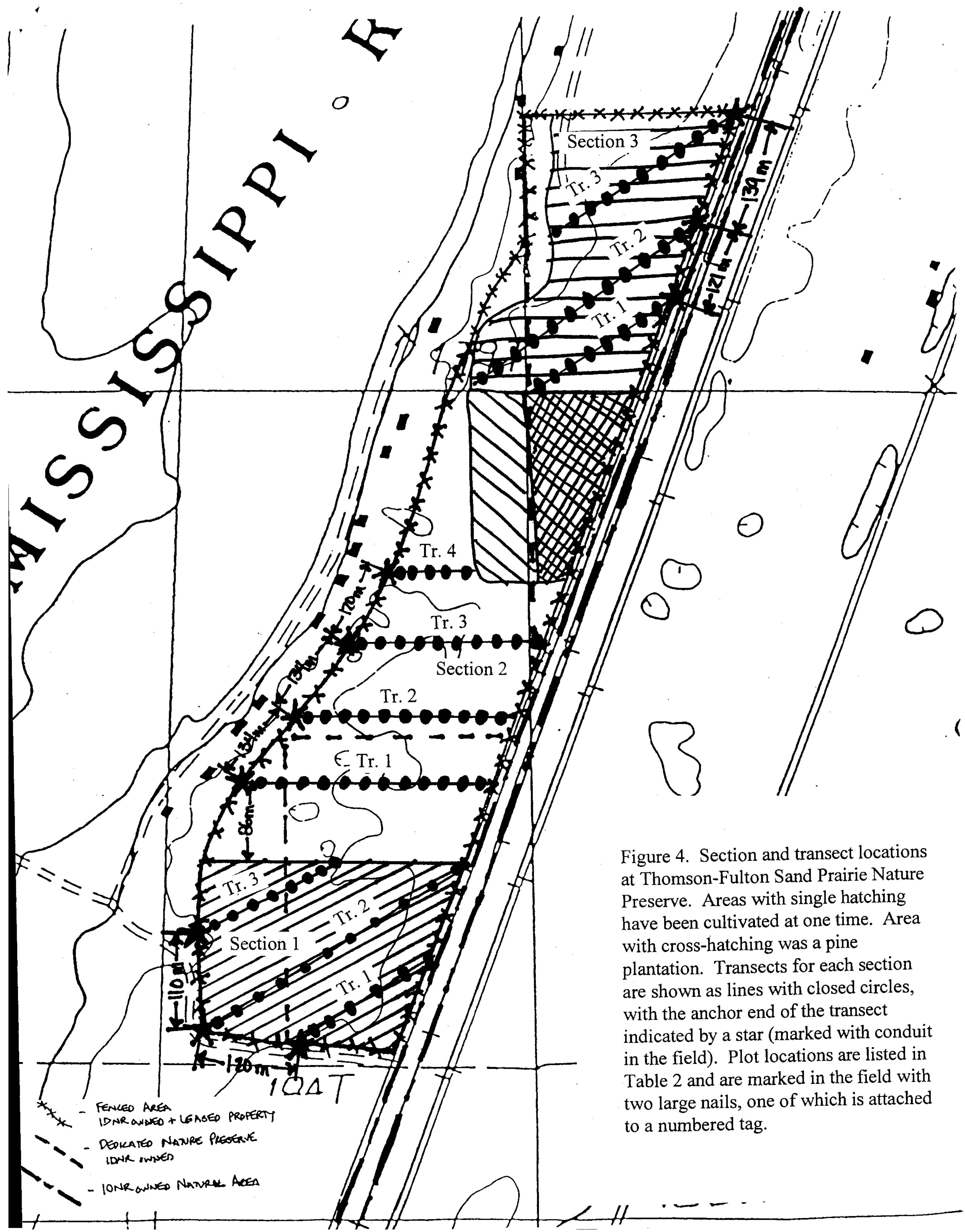


Figure 4. Section and transect locations at Thomson-Fulton Sand Prairie Nature Preserve. Areas with single hatching have been cultivated at one time. Area with cross-hatching was a pine plantation. Transects for each section are shown as lines with closed circles, with the anchor end of the transect indicated by a star (marked with conduit in the field). Plot locations are listed in Table 2 and are marked in the field with two large nails, one of which is attached to a numbered tag.

Figures 6 - 11. Vegetation structure and composition and soil properties compared among the seven sampling sections. All plots are arranged identically. Bars represent the means of the y-axis values and error bars are standard errors. Labels on the x-axis are abbreviations of section names, where A1 and A2 are from Ayers Sand Prairie Nature Preserve, TF1, TF2, and TF3 are from Thomson-Fulton Sand Prairie Nature Preserve, and WR and WT are from Whitton Rectangle and Whitton Triangle, respectively. For each similarly colored set of bars within a single plot, significant differences ($P < 0.05$) among sections are indicated by different lower case letters. Differences among bars within sections were not tested and are not implied by letters.

Figure 6

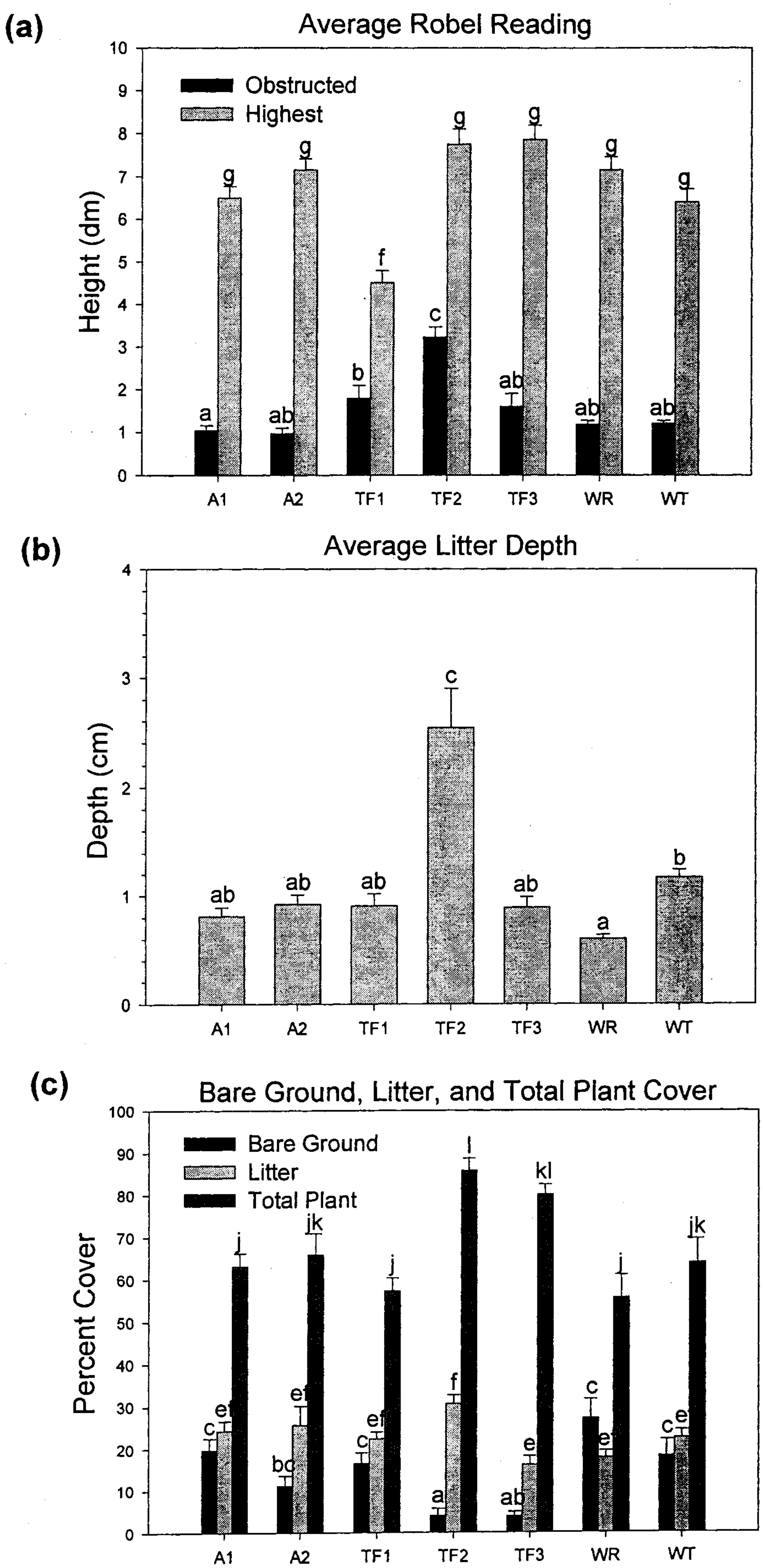
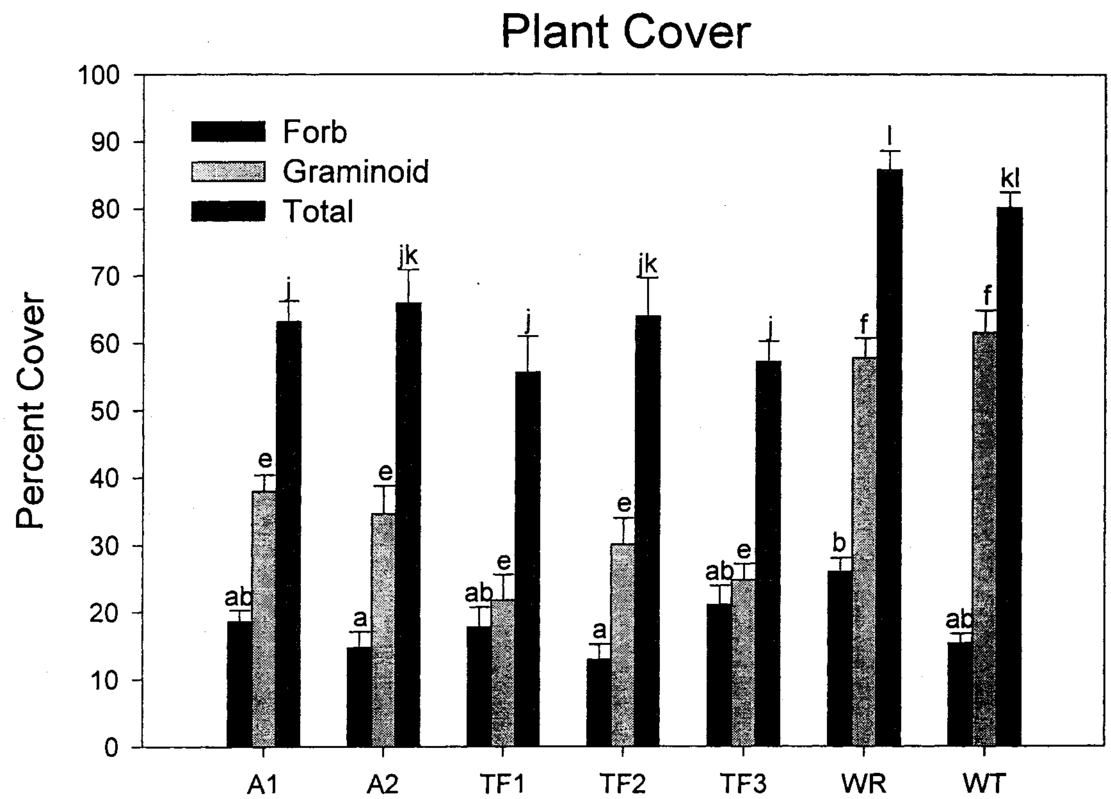

(a)
Average Robel Reading
Obstructed
Highest
Height (dm)
A1
A2
TF1
TF2
TF3
WR
WT
(b)
Average Litter Depth
Depth (cm)
A1
A2
TF1
TF2
TF3
WR
WT
(c)
Bare Ground, Litter, and Total Plant Cover
Bare Ground
Litter
Total Plant
Percent Cover
A1
A2
TF1
TF2
TF3
WR
WT

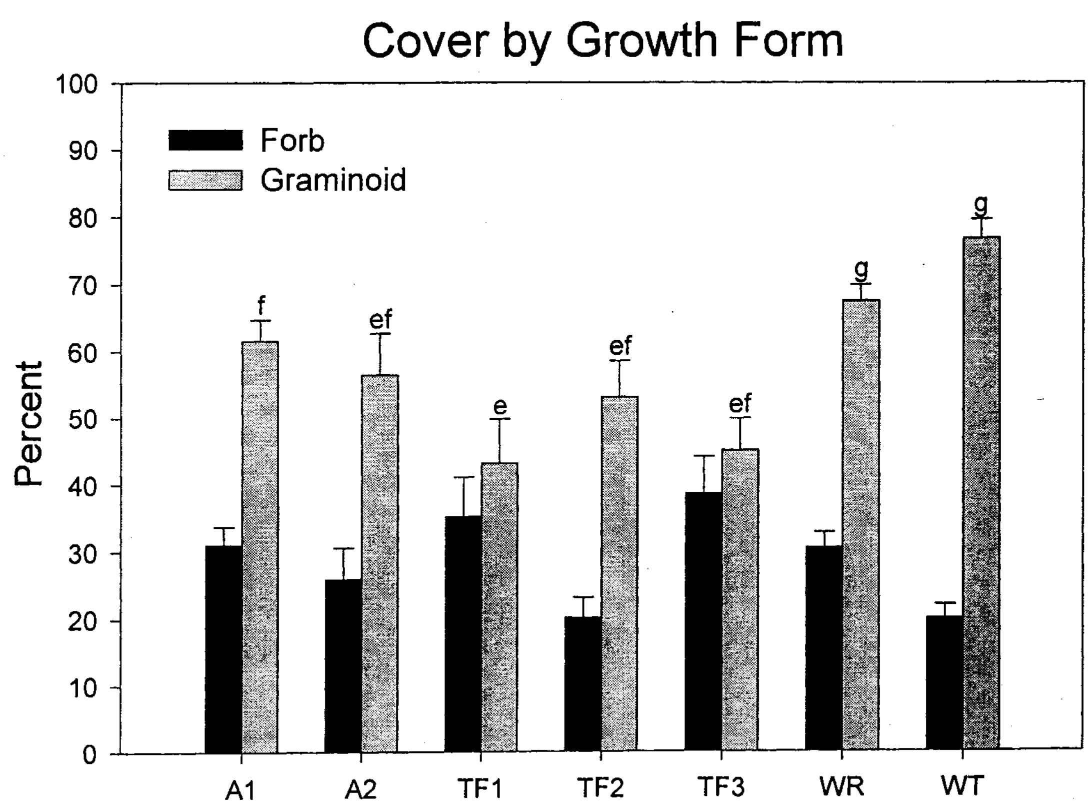
Figure 7

(a)



Plant Cover
Percent Cover
Forb
Graminoid
Total
0
10
20
30
40
50
60
70
80
90
100
A1
A2
TF1
TF2
TF3
WR
WT
ab
e
j
a
e
jk
ab
e
j
a
e
jk
ab
e
j
b
f
l
ab
f
kl

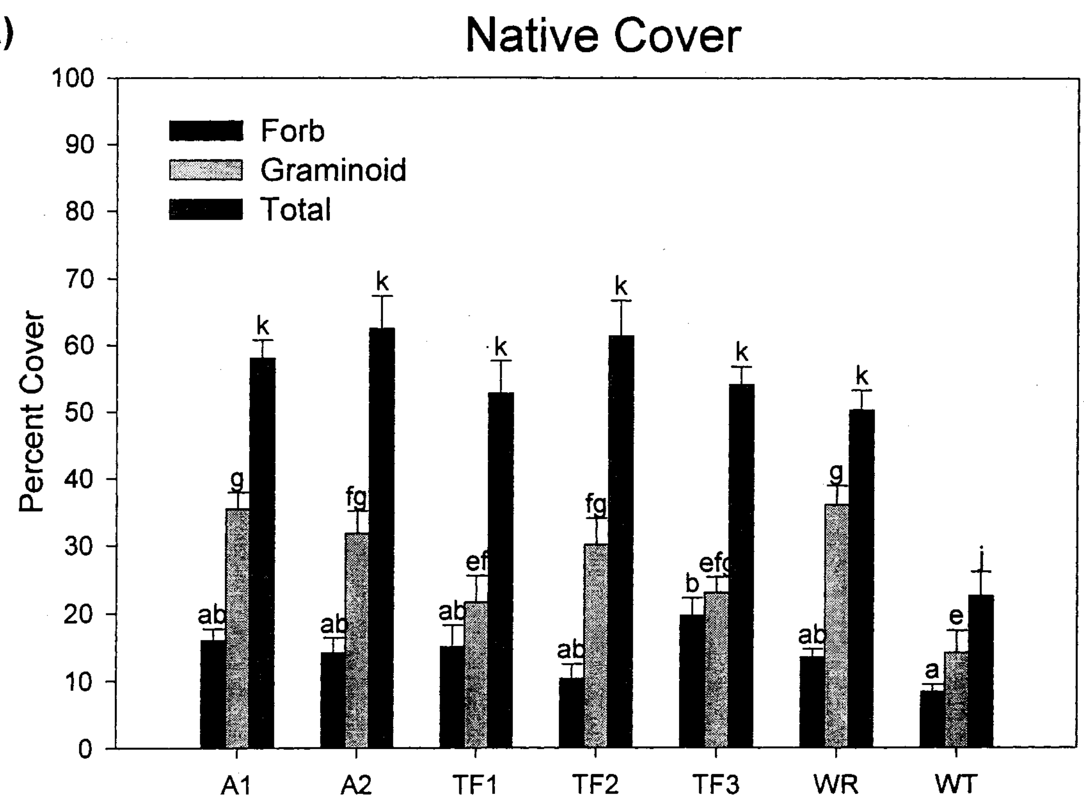
(b)



Cover by Growth Form
Percent
Forb
Graminoid
0
10
20
30
40
50
60
70
80
90
100
A1
A2
TF1
TF2
TF3
WR
WT
f
ef
e
ef
ef
g
g

Figure 8

(a)


Native Cover
Forb
Graminoid
Total
Percent Cover
100
90
80
70
60
50
40
30
20
10
0
A1
A2
TF1
TF2
TF3
WR
WT
ab
g
k
fg
ef
b
efg
a
e
j

(b)

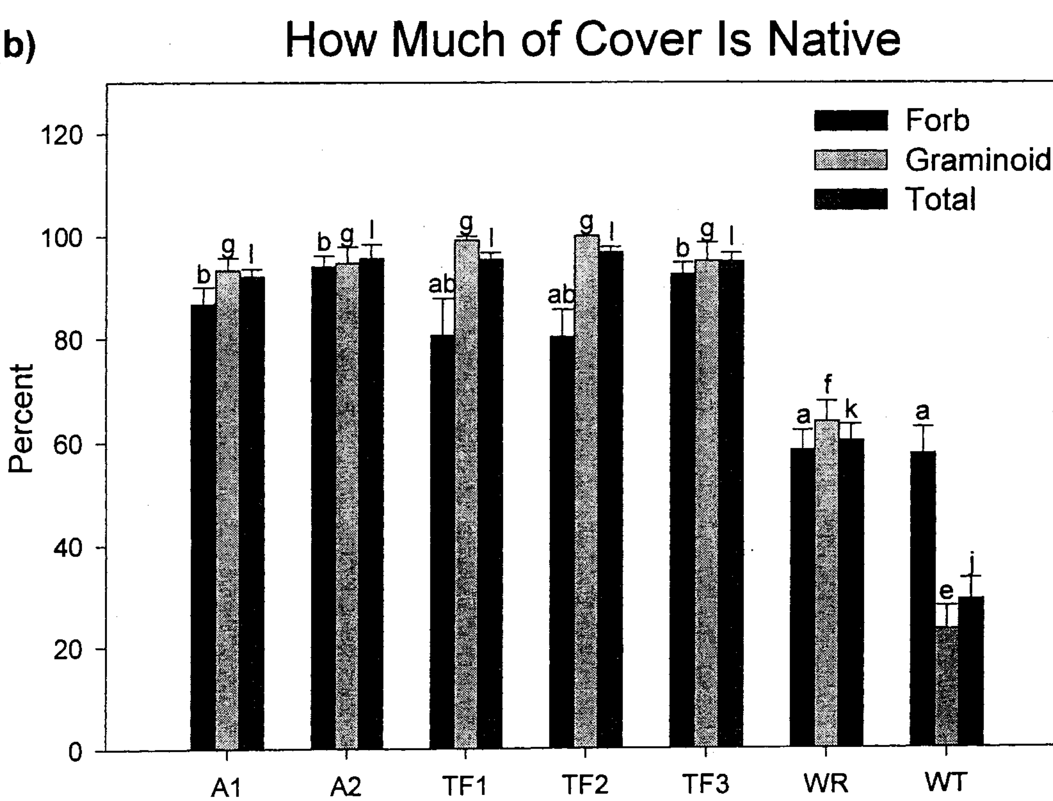
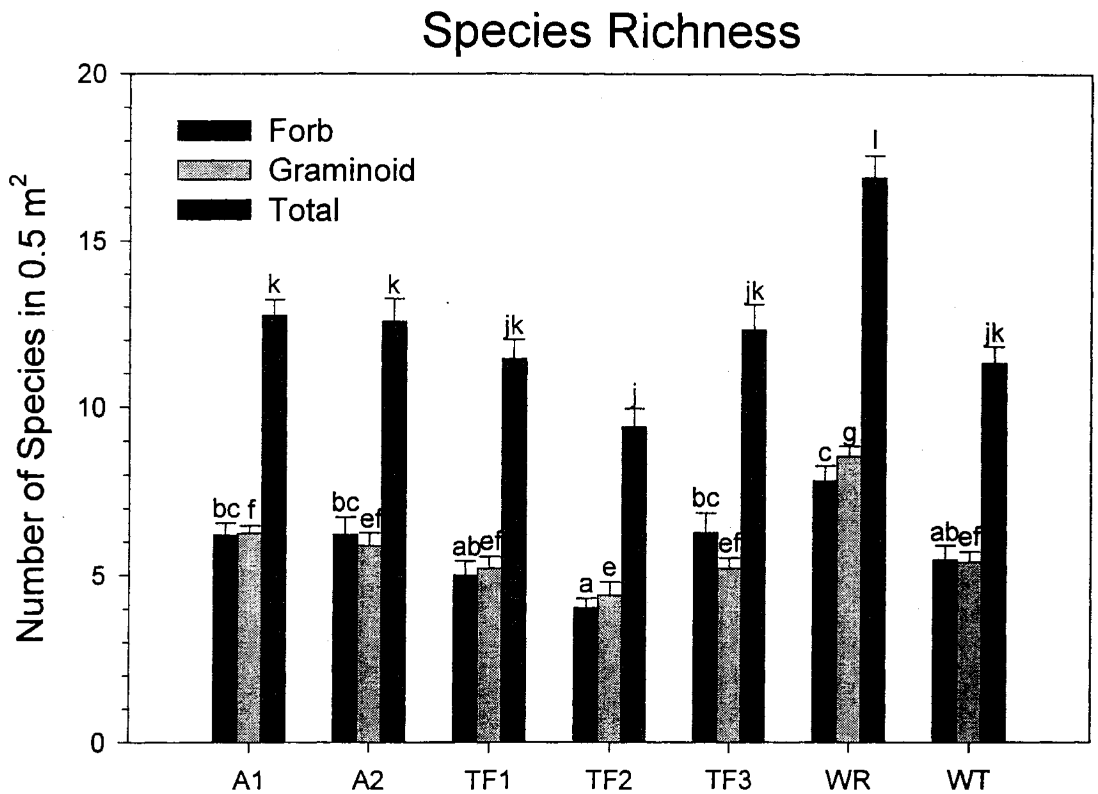

How Much of Cover Is Native
Forb
Graminoid
Total
Percent
120
100
80
60
40
20
0
A1
A2
TF1
TF2
TF3
WR
WT
b
g
l
ab
a
f
k
e
j

Figure 9

(a)


Species Richness
Number of Species in 0.5 m^2
Forb
Graminoid
Total
0
5
10
15
20
bc f k
bc ef k
ab ef jk
a e j
bc ef jk
c g l
ab ef jk
A1
A2
TF1
TF2
TF3
WR
WT

(b)

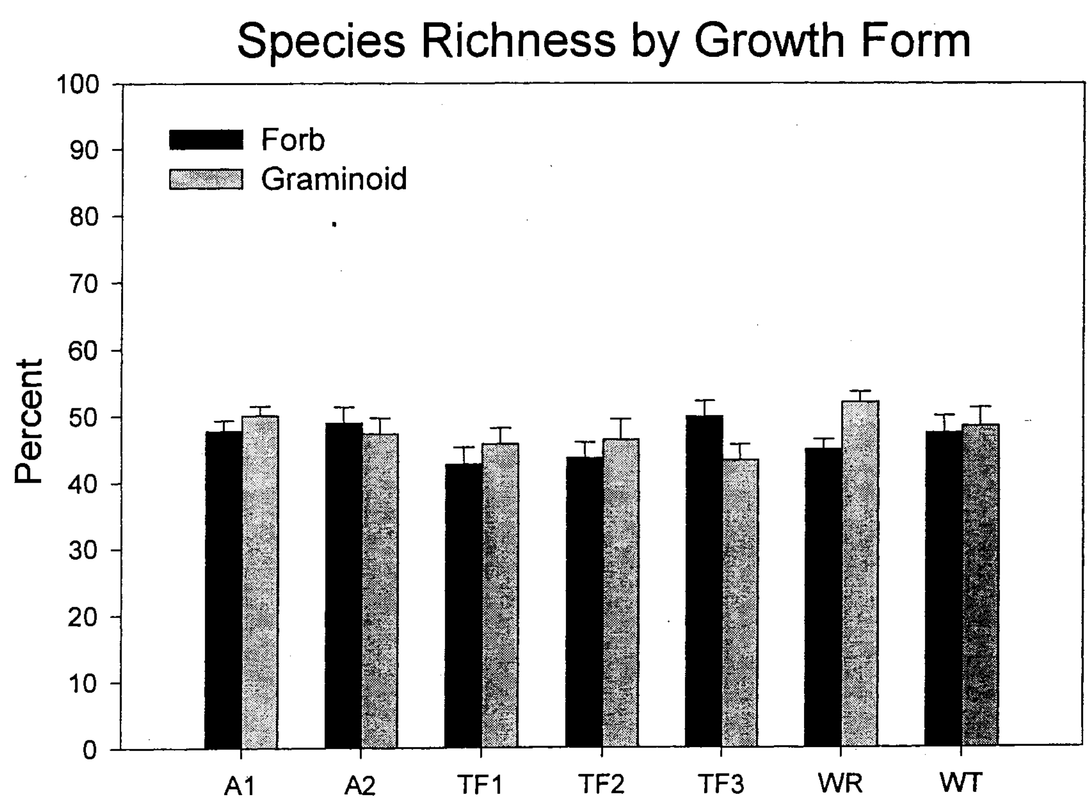

Species Richness by Growth Form
Percent
Forb
Graminoid
0
10
20
30
40
50
60
70
80
90
100
A1
A2
TF1
TF2
TF3
WR
WT

Figure 10

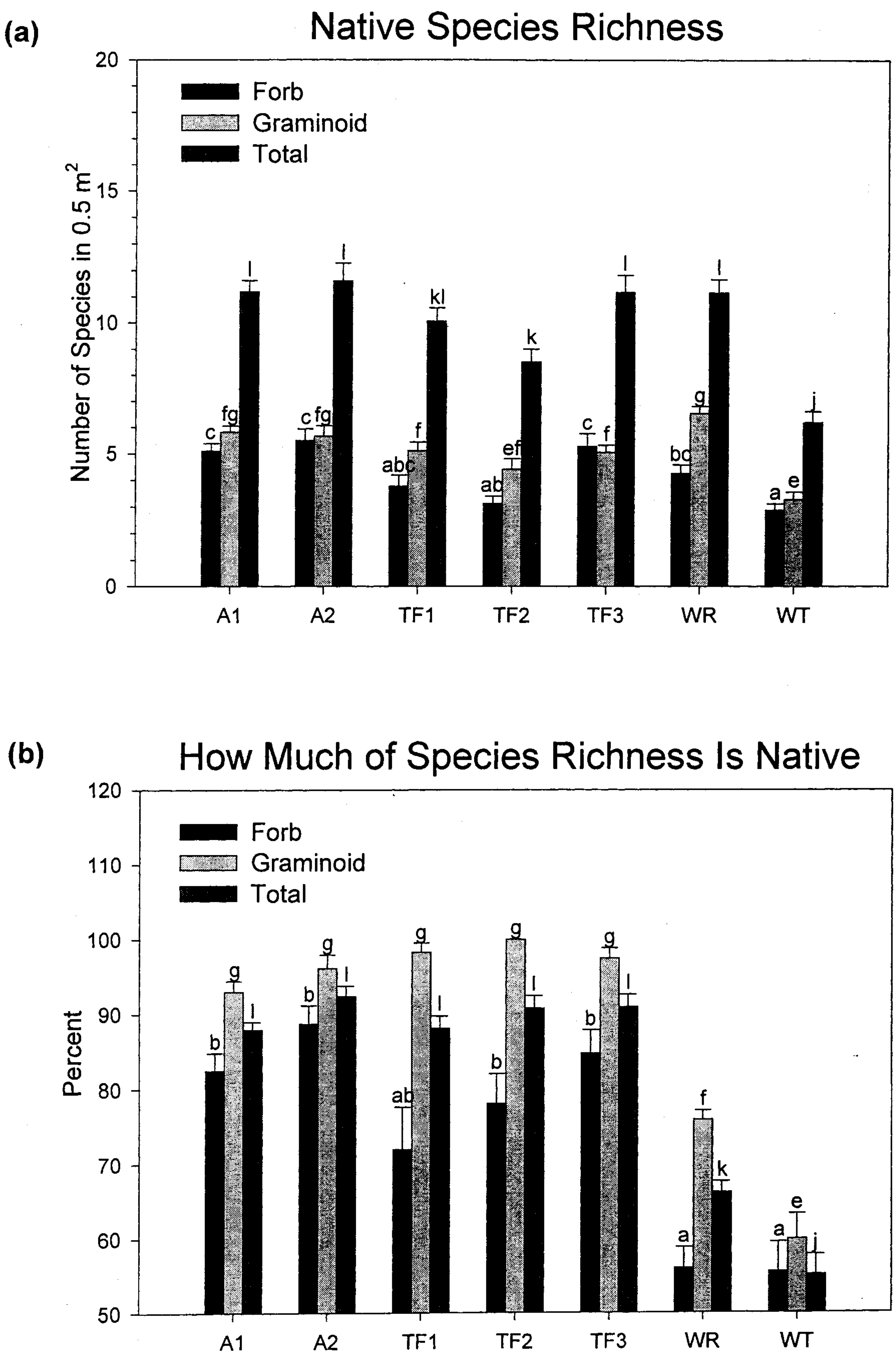
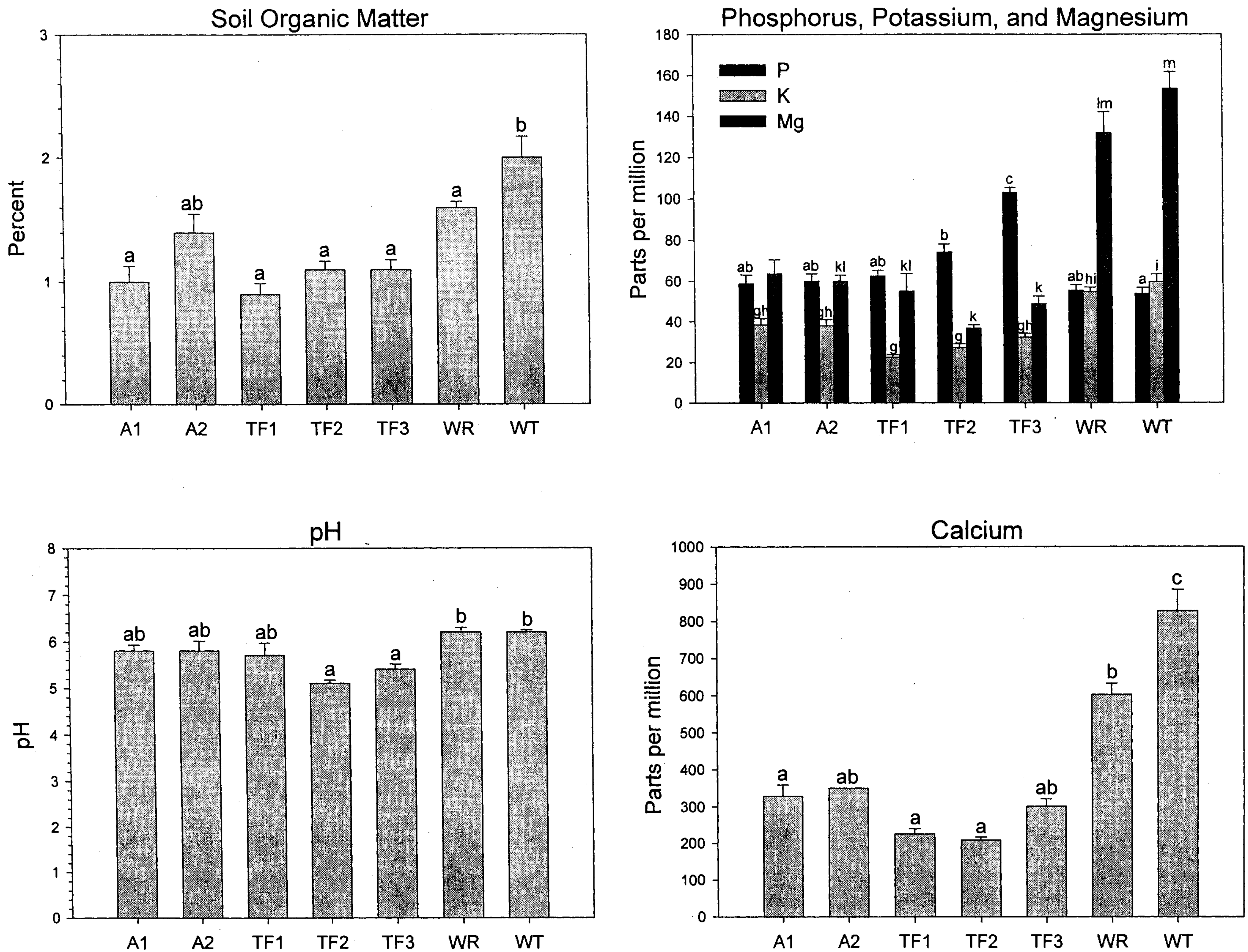

(a)
Native Species Richness
Forb
Graminoid
Total
Number of Species in 0.5 m2
0
5
10
15
20
A1
A2
TF1
TF2
TF3
WR
WT
c fg l
c fg l
abc f kl
ab ef k
c f l
bc g l
a e j
(b)
How Much of Species Richness Is Native
Forb
Graminoid
Total
Percent
50
60
70
80
90
100
110
120
A1
A2
TF1
TF2
TF3
WR
WT
b g l
b g l
ab g l
b g l
b g l
a f k
a e j

Figure 11



Soil Organic Matter
Percent
0
1
2
3
a
ab
a
a
a
a
b
A1
A2
TF1
TF2
TF3
WR
WT
Phosphorus, Potassium, and Magnesium
Parts per million
0
20
40
60
80
100
120
140
160
180
P
K
Mg
ab
gh
ab
gh
kl
ab
g
kl
b
g
k
c
gh
k
ab
hi
lm
a
i
m
A1
A2
TF1
TF2
TF3
WR
WT
pH
pH
0
1
2
3
4
5
6
7
8
ab
ab
ab
a
a
b
b
A1
A2
TF1
TF2
TF3
WR
WT
Calcium
Parts per million
0
100
200
300
400
500
600
700
800
900
1000
a
ab
a
a
ab
b
c
A1
A2
TF1
TF2
TF3
WR
WT