2010 Final Report

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<u>PROJECT NUMBER:</u> T-36-P-1

<u>PROJECT TITLE:</u> Interrelationships of grassland birds with sand prairie plants and insects.

PURPOSE:

Grassland bird habitat is typically described only in structural terms such as height and density of vegetation, amount of bare ground, and extent of woody vegetation. At the same time, prairie restoration efforts, which often focus on high native plant species diversity, are in need of appropriate planting mixtures for grassland birds. In addition, little is known of links, if any, between grassland bird abundance and prairie insect diversity and abundance. This project collected data on grassland birds, plants, and insects at a large remnant sand prairie to examine the consequences of varying management regimes on prairie biodiversity.

METHODS AND RESULTS:

Avian point counts, vegetation structure and composition, and insect composition were estimated at 24 study plots throughout the sand prairie at the former Savanna Army Depot (SAD) 2007-2009 in northwestern Illinois. A map of study plot locations is provided as Figure 1. SAD contains one of the largest remnant sand prairies in Illinois and is an ideal location for ecosystem studies. All plots were intensively grazed until 1999. Since then habitat management has occurred as resources were available potentially allowing comparisons between tracts of actively managed and passively managed sand prairie. The five objectives of the study are listed below with a description of the relevant methodology and a summary of observations.

1. Estimate grassland bird population densities.

Bird populations were assessed with unlimited-distance point counts centered at 24 locations (See Figure 1). The distance between point count locations varied so all observations more than 250 m from the survey points were eliminated to avoid double-counting of distant species. Analysis with Distance software (Buckland et al. 2001) which adjusts densities for detectability of each species confirmed that observations beyond 250 m should not be used in estimating detectability and density. These counts yielded total species occurrence as well as relative density. Counts were conducted for 5-minutes between 5 a.m. and 11 a.m. three times at each. One count was conducted in each of three seasonal time periods: late May, mid-June, and early July. However, the July 2008 survey was incomplete because of scheduling conflicts so the July data from all three years were dropped from detailed analyses.

A summary of the count data is listed in Table 1. Most species were not numerous enough to analyze trends individually so each species was classified in terms of reliance on grassland habitat as either obligate grassland (OG), secondary grassland (G2), or non-grassland (NG) species as defined for this region (Herkert et al. 1993, Sample and Mossman 1997). Bird count data was analyzed with Distance software (Buckland et al. 2001) to provide density estimates adjusted for detectability of each species. Density and population estimates from Distance analysis (Table 2) demonstrate that obligate grassland birds declined significantly over the three-year study across the combined 24 study plots. The densities and populations of secondary grassland guilds clearly declined between 2007 and 2008 across combined plots. The numbers of non-grassland birds were similar in 2007 and 2008 with an obvious decline observed in 2009 (Table 2). Of the five obligate grassland species abundant enough for individual analysis all showed declines in the numbers of observations from 2007 to 2009 (Table 3), though statistically significant declines (at the 95% confidence interval) were unequivocal for only the grasshopper sparrow (*Ammodramus savannarum*) and Western meadowlark (*Sturnella neglecta*).

2. Evaluate grassland habitat structure and composition at point count locations

Vegetation structure was measured at four points within a 100m-radius circle centered on each bird-count point. Each of the four points is at a randomly selected compass direction and distance from the bird-count point. At each of these four points, structure was measured using a modified Robel pole method (Robel et al. 1970). Each Robel measurement is a combination of vegetation height and density obtained by observing the pole 1 m above ground and 4 m away from the pole and recording the highest 10-cm interval in which more than 80% of the interval is obstructed by vegetation. This value indicates the height of the most dense part of the vegetation. Robel measurements are made at four evenly spaced locations around each point (approximately in cardinal directions). Vegetation structure values reported for each site therefore are the mean of 16 measurements (4 locations x 4 readings/location). Leaf litter depth was measured at the same points as the Robel readings, so that litter depth values are also the means of 16 measurements.

Vegetation structure and composition were estimated at study plots centered at the same 24 points as the bird-count points (Figure 1) throughout the sand prairie. Vegetation composition was measured at all sites by visually estimating the percent of canopy area covered by each species of plant in ten 0.5 x 1 m plots. These plots are spaced at 20 m intervals along two randomly located, 100m-long transects within the 100m-radius circle centered at the bird-count point. Bare ground was also estimated so that the total cover of each plot is at least 100%. In addition, any species occurring within 0.5 m of the transect lines was recorded in order to compile a more complete species list for each plot. Woody vegetation (trees and shrubs) was counted within the 100-m radius central point count location within each plot.

Vegetation measurements were done three times during each growing season: late May-early June, mid July, and mid August, except in 2007; means for 2007 are based on16 plots measured twice, in early and late summer. Shifting to three measurements early, mid, and late summer in 2008 and 2009 provided better resolution of the phenology of vegetation changes. Vegetation data was summarized into the following parameters for each site: obstructed height, litter depth, total plant species richness (from transect species lists over entire season), and cover of bare ground graminoids, forbs, cacti, legumes, native plants and introduced plants.

The decline in litter depth (Tables 4,5) was significant each year over the three-year period (Figure 2) but the decline in Robel Index (Tables 4,5) was only significant between 2007 and 2008 (Figure 2), i.e., the visual obstruction was higher in 2007 than either 2008 or 2009, while the latter years were similar. Vegetation composition is summarized in Table 6. The average cover of bare ground, forbs, grasses, sedges, introduced species, and native species all differed significantly among years (Table 7). The average cover of Native Species decreased and that of

Introduced Species increased (Figure 3). Cover of legumes tended to increase and cover of shrubs tended to decrease but neither was significantly different among years (Table 7). Cover of bare ground and introduced species increased generally from 2007 to 2009 with significant and dramatic increases between 2008 and 2009 (Table 6, 7). Cover of grasses displayed the opposite trend generally declining across all three years with significant and dramatic decline the last two years. Cover of sedges, and native species decreased over the three year period (Table 6, 7).

3. Assess insect diversity and abundance

Insects were surveyed using sweep nets at avian point count locations. We covered 15 sites in 2007, 16 in 2008, and 19 in 2009. In each plot 100 sweeps through the vegetation was taken along the 100-m transects used for the plant composition sampling in late May-early June; mid July; and mid August. Contents of each 100-sweep sample were placed in an extractor which collects the insects in ethanol. These samples were sorted and identified to 18 Arachnid and Insect Orders. Planthoppers (Hemiptera), grasshoppers (Orthoptera), flies (Diptera), bees, (Hymenoptera) and beetles (Coleoptera) were the most abundant groups (Table 8). These groups account for the majority of insect biomass at SAD and are likely the primary sources of food for the avian species of SAD as discussed below.

4. Examine links among birds, plants, and insects

Principle components analysis (PCA) was used to assess relationships among plant diversity, vegetation structure, insect and bird abundance variables. PCA uses all the independent variables and constructs new ones, each of which is a different combination of the independent variables. These new variables, called principle components or factors, can be used to depict the data. PCA identifies the amount of variation in the data that is explained by each component as well as which independent variables are most important for each component. PCA generates for each avian point count location a component score for each of the principle components. These values can be used for a comparison of the study plots. These analyses can determine the most important predictors of bird abundance and occurrence.

For the PCA of the plant structure and composition variables, the first three principle components explained 57% of the variation (Table 9). The first principle component or factor one was a positive function of native plants, species richness, and forb cover, and negatively correlated with introduced species, legume cover, and dead plants. Factor two was positively correlated with grass cover, litter depth, Robel Index, and dead plant cover and negatively correlated with amount of bare ground. Factor three was a positive function of sedge cover and negatively associated with forb cover.

The PCA on the insect data suggested less correlation between variables. The first 3 factors explained only 41% of the variation. The first factor was a positive function of the abundances of Hemiptera, Lepidoptera, Diptera, Coleoptera, Orthoptera, and Phasmatodea (Table 10). The second factor was positively correlated with Ephemeroptera and Opiliones while the third factor was primarily a function of Odonata abundance.

The relationships between the abundance of the three bird guilds and the plant and invertebrate factors are shown in Table 11. The most important results here are the positive correlations between abundance of obligate grassland birds, invertebrate PCA factor 1, and plant

PCA factor 2. In other words the key group of grassland birds of conservation concern is positively associated with several invertebrate orders, and with grass cover, litter depth, vegetation height/density (Robel Index), and cover of dead vegetation. The plant variables which correlate with the abundance of obligate grassland birds may suggest selection of habitats by grassland birds based on its potential for providing nesting sites. The insect orders included as the main contributors to Invert PCA factor 1 here are all important prey items for these birds and the two most important insect orders for factor 1 (Hemiptera and Lepidoptera) both include many species, including several rare species that are specialists on native grasses.

Overall, obligate grassland bird abundance is positively correlated with total insect abundance (Table 12). This result further emphasizes that grassland bird habitat use and selection goes beyond just vegetation structure (although certainly vegetation structure variables are convenient to measure and useful in predicting some aspects of bird occurrence, see Table 13).

5. Determine effects of management on bird populations

Management at SAD during the study consisted of Spring prescribed burns in 2008. The objective of prescribed burning is to alter the vegetation in favor of native grassland species. Before we consider whether management had an effect on avian populations, we must first consider whether the management undertaken had the intended effect upon the vegetation (to avoid spurious correlations. Seven of the 24 study plots were burned in the Spring of 2008, and two additional plots were burned by a wildfire in Summer of 2008. To explore the benefits of prescribed burning we first graphed the mean annual percent cover of native species for plots burned in the Spring of 2008 where data were available (Figure 4) and for study plots burned by wildfire in the Summer of 2008 (Figure 5). The use of annual means corrects for shifts in phenology associated with weather differences in the three years. If you compare these with the graph of the mean annual percent cover of native species on unburned plots (Figure 6) it is obvious that there was a general decrease in native plant cover over time in most plots whether burned or not. In fact no significant differences in the means between burned and unburned plots in the same year were detected (Table 14). To gain clues about the nature of the vegetation shift away from native species it is instructive to look at the most unexpected outcome among burned plots. The study plot at point E10 experienced the most dramatic decline in native vegetation among the plots burned in the Spring of 2008. Figure 7 clearly demonstrates this decline in native species was the result of a dramatic loss of forbs and C4 warm season grasses and a slight increase in legumes, in this case crown vetch (*Coronilla varia*). This is consistent with the overall trends discussed in Part 2 above. The decline in native species cover was primarily attributable to an increase in crown vetch a legume; increases in bare ground cover; and general decreases in grass cover with significant declines in warm season grasses. Since prescribed burning did not have the hoped impact on the vegetation, any differences in avian densities between burned and unburned plots would be due to other causes.

DISCUSSION AND CONCLUSIONS:

The shifts in vegetation irrespective of burning suggested that other perhaps more potent environmental variables may have been in play during the course of the study. Weather data were secured from the Midwest Regional Climate Center, hosted by the Illinois State Water Survey for the State of Illinois. Figures 8-10 and 11-13, suggest that during the Summer of 2007 SAD experienced much warmer and drier weather than normal, with near normal temperatures and precipitation in the summer of 2008, and much cooler and wetter weather than normal in the summer of 2009. Warmer and drier weather would have favored the native vegetation typical of Illinois sand prairies, while cooler and wetter weather may have favored cool season species and other non-native invasive species.

It appears that by chance this short-duration study actually captured an “average” summer in 2008, flanked on one side by a warmer and drier summer in 2007, and a cooler and wetter summer in 2009. Essentially capturing a microcosm of climate variability that provides clues to how sand prairies may respond to broader shifts in climate. Unfortunately these data also hint at the possibility that shifting climate may complicate management of these communities. It appears from these data that the use of prescribed burning may not produce the desired effect in sand prairies if followed by cooler and wetter weather patterns. In may be that the disturbance cause by fire may under cooler and more most conditions actually allow non-native species to compete better for niches opened by that disturbance. It may be necessary to take advantage of consecutive dry summers to aggressively implement burning to use it alone, or perhaps to follow burns with seeding of warm season grasses if wetter conditions develop post-burning.
One of the outcomes of this study was the recognition of an increase in crown vetch. Notice from the data collected in this study that from 2008 to 2009 there is a significant increase in the percentage of bare ground cover. This phenomenon might be related to a loss of native vegetation as legumes expand their coverage and compete for water. Since crown vetch fixes its own nitrogen, nutrients may not be a limiting factor, and in the droughty soils of the sand prairie, the shallow but dense roots of crown vetch may be very effective at intercepting water that might otherwise be exploited by deep rooted prairie species. Subsequent to this study SAD staff have secured funds to implement crown vetch reduction using herbicides. INHS is providing some support to assist INHS researchers in monitoring the outcomes of these efforts, since it is not clear that sand prairie vegetation will be particularly effective in re-colonizing areas where crown vetch has been removed, particularly under the very wet conditions experienced in 2010 and 2011.

The data generated by this study also afford the opportunity to explore ecological relationships that were not in the scope of this study. Illinois Natural History Survey researcher, Sam Heads, is being supported by INHS to undertake a more detailed assessment of the relative abundances of the various insect groups, particularly the Orthoptera, collected from study plots in relation to weather variability.

Finally, researchers on this project may have discovered significant numbers of the federally endangered American Burying Beetle (*Nicrophorus americanus*) at SAD. Those specimens currently await verification of the preliminary identification by experts.

Table 1. Birds recorded at 24 unlimited distance point counts at Savanna Army Depot 2007-2009. For each year columns list the average number of individuals observed over three count periods (2 for 2008) and the average number of points at which each species was observed.

	2007		2008		2009	
	AVG	#PTS	AVG	#PTS	AVG	#PTS
AMCR	12.3	8.7	11.7	7.0	13.3	7.3
AMGO	5.3	4.0	6.7	4.7	10.3	6.7
AMKE	2.0	2.0	1.7	1.7	2.5	2.0
AMRO	3.0	3.5	3.0	3.0	4.0	3.7
BAOR	4.0	3.3	4.0	3.3	12.0	5.0
BARS	6.0	5.7	7.7	6.0	18.3	4.0
BHCO	22.7	10.0	17.0	8.7	5.0	3.7
BLGR	2.0	2.3	1.5	1.5	6.0	5.0
BLJA	6.3	4.7	3.7	2.7	8.0	5.3
BOBO	2.5	3.0	4.0	3.0	6.0	5.0
BRTH	6.7	6.7	3.7	3.0	18.3	4.3
CEDW	1.5	2.0	1.0	1.0	3.0	2.3
CHSP	4.7	4.0	3.3	3.3	4.5	3.5
CHSW	5.3	4.7	10.0	9.0	5.3	3.3
COGR	8.0	4.5	3.0	3.0	6.5	2.5
CONI	4.0	4.0	6.7	5.7	10.0	4.0
COYE	1.7	2.0	1.0	1.0	8.5	4.0
DICK	37.7	17.3	27.3	14.3	21.0	9.3
DOWO	1.0	1.0	1.0	1.0	2.3	2.3
EABL	7.0	5.0	7.7	4.0	8.3	6.0
EAKI	4.0	3.7	4.3	3.7	19.7	11.3
EAME	36.7	17.7	31.3	18.3	24.3	9.7
EATO	1.7	2.0	3.0	2.0	6.0	4.7
EUST	13.0	2.3	22.7	2.7	46.0	19.0
FISP	42.7	20.7	40.3	19.3	38.0	14.7
GCFL	2.0	2.0	3.0	2.3	3.5	2.0
GRCA	3.5	2.5	2.0	2.0	29.0	10.0
GRSP	87.0	23.0	84.3	23.3	50.3	15.7
HESP	2.3	2.0	4.0	3.3	11.3	6.3
HOWR	10.7	8.3	9.0	7.3	8.3	6.7
INBU	2.0	2.0	1.7	1.7	7.0	5.0
LASP	2.0	2.3	2.0	2.0	6.0	2.3
LOSH	1.0	1.0	1.0	1.0	3.5	3.0
MODO	33.0	18.7	25.7	17.0	20.0	10.0
NOBO	2.3	2.3	3.0	2.0	3.0	2.7
NOCA	2.7	3.0	1.5	1.5	2.7	2.7
NOFL	2.7	3.0	4.0	4.0	5.0	4.0

NOMO	11.3	9.7	7.0	6.3	7.3	5.7
OROR	5.3	5.0	2.7	2.3	3.0	1.7
PIWO	1.0	1.0	1.0	1.0	1.0	1.0
RBWO	1.5	2.0	1.0	1.0	1.3	1.3
RNPH			1.5	1.5	8.0	3.0
RTHA	1.7	2.0	2.3	2.3	2.0	2.0
RWBL	9.7	6.3	6.7	4.7	7.3	4.0
SOSP	2.0	2.3	3.3	3.0	4.0	3.3
TUVU	2.0	2.0	3.0	2.0	5.5	4.5
UPSA	5.0	5.0	1.0	1.0	2.0	1.5
VESP	6.7	6.3	9.5	8.5	2.0	1.5
WEME	47.3	18.7	33.0	15.3	25.7	8.3
WITU	2.0	2.0	4.0	3.0	5.5	1.0
YBCH	1.0	1.0	1.0	1.0	1.0	1.0
YBCU	2.0	2.3	1.0	1.0	2.0	2.0
YBSA	2.0	2.0	2.3	2.3	3.3	2.3

Table 2. Density and population estimates of Obligate grassland (OG), Secondary grassland (G2) and non-grassland (NG) bird guilds from Distance analyses.

Group	Truncation	Year	Obs	Parameter	Estimate	Std Error	95% CI	
OG	20-150	2007	351	Density	3.4128	0.12019	3.1846	3.6575
				# birds	1607	56.595	1500	1723
		2008	295	Density	2.8683	0.16244	2.5632	3.2098
				# birds	1351	76.510	1207	1512
		2009	270	Density	2.6253	0.10943	2.4180	2.8503
				# birds	1236	51.519	1139	1342
G2	20-250	2007	271	Density	1.5090	0.10423	1.3173	1.7286
				# birds	711	49.112	620	814
		2008	205	Density	1.1415	0.0076	1.0019	1.3005
				# birds	538	35.707	472	613
		2009	227	Density	1.264	0.0093	1.0933	1.4613
				# birds	595	43.821	515	688
NG	20-250	2007	100	Density	0.425	0.069	0.308	0.585
				# birds	200	32.66	145	276
		2008	84	Density	0.463	0.084	0.323	0.661
				# birds	218	39.55	153	311
		2009	106	Density	0.204	0.019	0.169	0.246
				# birds	96	9.16	79	116

Table 3. Density and population estimates of grasshopper sparrow (GRSP), dickcissel (DICK), eastern (EAME) and western meadowlark (WEME), and field sparrow (FISP) from Distance analyses.

Species	Truncation	Year	Obs	Parameter	Estimate	Std Error	95% CI	
GRSP	10-106	2007	169	Density	3.384	0.325	2.802	4.088
				# birds	1594	152.96	1320	1925
		2008	142	Density	1.836	0.216	1.457	2.314
				# birds	866	101	686	1090
		2009	135	Density	1.860	0.248	1.430	2.419
				# birds	876	116.98	674	1140
DICK	0-200	2007	69	Density	0.462	0.067	0.347	0.615
				# birds	217	31.59	163	289
		2008	49	Density	0.313	0.077	0.129	0.509
				# birds	147	36.20	91	240
		2009	66	Density	0.267	0.041	0.197	0.361
				# birds	126	19.16	93	170
EAME	50-250	2007	80	Density	0.249	0.043	0.178	0.352
				# birds	118	20.41	84	166
		2008	60	Density	0.639	0.189	0.358	1.139
				# birds	301	88.89	169	537
		2009	47	Density	0.145	0.042	0.082	0.257
				# birds	68	19.67	39	121
WEME	0-300	2007	99	Density	0.205	0.034	0.149	0.283
				# birds	97	15.96	70	133
		2008	69	Density	0.143	0.024	0.103	0.198
				# birds	67	11.15	49	93
		2009	53	Density	0.11	0.019	0.078	0.154
				# birds	52	9.076	37	73
FISP	0-200	2007	78	Density	0.539	0.077	0.406	0.715
				# birds	254	36.27	191	337
		2008	64	Density	0.289	0.029	0.236	0.354
				# birds	136	13.88	111	167
		2009	69	Density	0.355	0.075	0.234	0.539
				# birds	167	35.20	110	254

Table 4. Vegetation structure at the 24 points used to count birds and insects at the Savanna Army Depot. For each year, the columns list the average height/density index (Robel) and average leaf litter (Litter).

	2007		2008		2009	
Point	Robel	Litter	Robel	Litter	Robel	Litter
A5	2.50	3.94	2.19	2.50	1.50	3.63
B3	3.50	1.19	0.94	2.69	0.88	0.00
B5	2.50	1.50	0.44	0.19	0.50	0.25
B6	0.63	1.19	0.63	1.75	1.00	0.88
C1	1.19	1.38	1.38	0.94	1.00	1.38
D2	2.13	3.88	0.88	0.00	3.44	1.69
E1	1.88	2.44	2.25	2.06	0.88	0.25
E10	3.44	4.19	1.94	6.25	2.06	3.94
E11	2.94	0.75	1.06	0.94	1.13	1.00
E14	2.06	2.44	0.13	0.13	2.50	1.13
E15	4.06	4.38	0.00	0.00	1.81	1.06
E16	2.75	4.13	0.19	0.00	0.88	1.00
E2	0.88	1.38	1.38	4.38	1.19	0.25
E3	1.19	1.75	1.38	3.31	1.06	1.44
E6	3.00	1.38	2.19	2.25	1.44	2.75
E7	2.38	3.88	2.25	6.00	2.44	5.25
E8	1.38	2.19	1.88	6.25	2.38	5.50
E9	2.25	2.25	2.31	3.13	1.19	2.00
F0	1.38	1.63	1.06	2.13	0.63	1.56
F1	1.19	1.69	1.50	2.00	0.25	0.06
F11	1.56	0.88	1.31	0.00	2.13	1.19
F12	1.25	1.94	0.56	0.31	1.50	1.19
F6	0.19	1.00	0.56	1.06	0.44	0.31
J4	1.50	5.13	1.81	2.56	1.94	2.56

Table 5. ANOVA test results comparing vegetation structure among years

A. Visual Obstruction Index

Groups	*Count*	*Sum*	*Average*	*Variance*
Robel 2007	24	47.6875	1.986979	0.954477
Robel 2008	24	30.1875	1.257813	0.540867
Robel 2009	24	34.125	1.421875	0.604704

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	7.023546	2	3.511773	5.016704	0.009243
Within Groups	48.30111	69	0.700016		
Total	55.32465	71			

B. Litter Depth

Groups	*Count*	*Sum*	*Average*	*Variance*
Litter 2007	24	56.4375	2.351563	1.733972
Litter 2008	24	50.8125	2.117188	3.930133
Litter 2009	24	40.25	1.677083	2.373868

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	5.628364	2	2.814182	1.050333	0.355347
Within Groups	184.8734	69	2.679324		
Total	190.5017	71			

Table 6. Vegetation cover at the 24 points used to count birds and insects at the Savanna Army Depot. Values are average % cover +/- SEM for each category, except species richness, which is an estimate of the average number of species in each sampling plot. Within each row means followed by different letters are significantly different. Variables with no letters were not tested.

	2007	2008	2009
Bare Ground	7.62 +/- 2.03 (a)	7.77 +/- 1.17 (a)	20.02 +/- 3.23 (b)
Cacti	3.84 +/-0.89	2.30 +/- 0.46	2.99 +/- 0.63
Dead Plant	13.71 +/-1.64	18.13 +/- 1.40	15.66 +/- 1.73
Fern	4.03 +/-1.70	1.402 +/- 0.66	3.01 +/- 1.16
Forb	12.65 +/-1.56 (a)	18.45 +/- 1.67 (b)	13.57 +/- 0.87 (a)
Grass	36.65 +/-3.45 (a)	37.27 +/- 1.85 (a)	26.00 +/- 2.32 (b)
Legume	6.87 +/-2.25 (a)	10.06 +/- 2.10 (a)	12.22 +/- 3.59 (a)
Lichen/Moss	0.75 +/-0.34	0.66 +/- 0.24	2.14 +/- 0.85
Sedge	9.15 +/-2.11 (a)	4.98 +/- 0.65 (b)	1.21 +/- 0.18 (c)
Shrub	6.81 +/-2.19 (a)	4.64 +/- 1.26 (a)	2.87 +/- 0.60 (a)
Introduced	14.78 +/-2.75 (a)	28.26 +/- 3.59 (b)	28.12 +/- 4.19 (b)
Native	68.031 +/-3.90 (a)	52.60 +/- 3.38 (b)	37.11 +/- 3.78 (c)
Species Richness	25.50 +/-1.32 (a)	31.84 +/- 0.96 (b)	26.19 +/- 1.10 (a)

Table 7. Analysis of Variance tests on selected plant variables from Table 6.

Dep Var: BAREGRND   N: 64   Multiple R: 0.488   Squared multiple R: 0.238

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	2276.336	2	1138.168	9.540	0.000
Error	7277.928	61	119.310		

Dep Var: GRASS   N: 64   Multiple R: 0.441   Squared multiple R: 0.195

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	1822.627	2	911.314	7.376	0.001
Error	7536.472	61	123.549		

Dep Var: LEGUME   N: 64   Multiple R: 0.161   Squared multiple R: 0.026

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	276.507	2	138.253	0.810	0.450
Error	10411.665	61	170.683		

Dep Var: SEDGE   N: 64   Multiple R: 0.562   Squared multiple R: 0.316

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	610.245	2	305.122	14.111	0.000
Error	1319.038	61	21.624		

Dep Var: SHRUB   N: 64   Multiple R: 0.253   Squared multiple R: 0.064

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	149.389	2	74.694	2.081	0.134
Error	2189.481	61	35.893		

Dep Var: INTRO   N: 64   Multiple R: 0.327   Squared multiple R: 0.107

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	2159.653	2	1079.827	3.659	0.032
Error	17999.623	61	295.076		

Dep Var: NATIVE   N: 64   Multiple R: 0.591   Squared multiple R: 0.350

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	9320.612	2	4660.306	16.413	0.000
Error	17320.608	61	283.944		

Dep Var: SR   N: 64   Multiple R: 0.505   Squared multiple R: 0.255

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	532.919	2	266.460	10.420	0.000
Error	1559.920	61	25.572		

Table 8. Invertebrate diversity at Savanna Army Depot 2007 – 2009. For each year the three columns list the average number (AVG) and standard deviation of individuals (SD) in each invertebrate Order, and the number of transects on which each order was found (count).

	2007 - 45 transects			2008 - 68 transects			2009 - 84 transects		
	AVG	SD	count	AVG	SD	count	AVG	SD	count
Acari	0.44	1.36	7	0.28	1.36	6	5.58	20.65	35
Araneae	12.93	9.54	45	9.16	9.13	66	12.82	9.56	76
Coleoptera	34.93	27.69	45	27.82	23.12	67	29.20	18.88	78
Collembola	12.44	23.25	29	8.43	23.35	28	6.56	16.06	48
Diptera	55.96	47.69	44	66.03	71.84	66	52.34	35.51	79
Ephemeroptera	0.18	0.44	7	0.07	0.26	5	0.37	1.05	13
Hemiptera	260.58	214.51	44	129.59	164.17	68	145.61	122.87	79
Hymenoptera	43.40	23.63	44	31.49	23.36	68	35.67	17.46	79
Lepidoptera	7.89	6.13	44	4.96	4.98	63	5.92	5.33	72
Neuroptera	0.58	1.42	15	0.49	0.95	19	0.30	0.76	14
Odonata	0.33	0.67	11	0.65	1.50	19	0.24	0.84	11
Opiliones	0.02	0.15	1	0.03	0.17	2	0.05	0.22	4
Orthoptera	100.95	79.96	43	68.79	53.01	68	46.37	36.11	83
Phasmatodea	0.04	0.21	2	0.19	0.83	4	0.05	0.27	3
Psocoptera	1.49	2.50	19	0.31	1.14	8	0.37	0.82	16
Solifugae	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Thysanoptera	5.27	5.49	39	4.01	7.85	40	10.89	24.73	69
Trichoptera	0.00	0.00	0	0.00	0.00	0	0.37	1.22	12

Table 9. Principle component analysis of vegetation structure and composition variables. For each factor the most important variables (based on factor loadings > 0.5) are in bold.

	Factors				
Variable	1	2	3	4	5
BAREGRND	0.206	**-0.711**	-0.319	-0.275	-0.400
CACTUS	0.039	-0.194	0.403	**-0.512**	0.142
DEAD	**-0.558**	**0.536**	-0.136	-0.002	0.320
FORB	**0.512**	0.232	**-0.510**	0.108	0.060
GRASS	0.168	**0.817**	-0.124	-0.020	0.176
LEGUME	**-0.796**	-0.238	0.231	0.219	-0.048
SEDGE	0.443	-0.074	**0.610**	0.050	0.333
SHRUB	0.112	0.019	0.364	**0.724**	-0.409
INTRO	**-0.867**	0.100	-0.102	0.214	0.032
NATIVE	**0.839**	0.191	0.382	0.102	0.092
SR	**0.636**	0.299	-0.348	0.154	-0.180
ROBEL	-0.013	**0.570**	0.308	-0.307	**-0.564**
LITTER	-0.342	**0.638**	0.161	-0.269	-0.329
Variance Explained by Components (Eigenvalues)	3.466	2.484	1.514	1.172	1.065
Percent of Total Variance Explained	26.660	19.111	11.646	9.016	8.195

Table 10. Principle component analysis on abundance of Invertebrate Orders. For each factor the most important variables are in bold.

	Factors				
Variable	1	2	3	4	5
ACARI	-0.143	0.482	-0.296	-0.301	**0.503**
ARANEAE	0.485	-0.191	-0.387	0.408	0.036
COLEOPTERA	**0.617**	0.181	0.063	-0.155	-0.360
COLLEMBOLA	0.490	0.422	-0.446	0.300	-0.025
DIPTERA	**0.687**	-0.034	0.264	0.181	0.268
EPHEMEROPTERA	-0.235	**0.726**	0.216	0.162	-0.137
HEMIPTERA	**0.786**	0.028	0.197	0.012	0.175
HYMENOPTERA	0.299	0.021	0.189	**-0.601**	-0.351
LEPIDOPTERA	**0.724**	0.414	-0.190	-0.155	-0.048
NEUROPTERA	0.161	0.007	0.219	0.118	-0.104
ODONATA	-0.083	0.258	**0.642**	0.322	0.144
OPILIONES	-0.127	**0.549**	0.016	-0.316	**0.585**
ORTHOPTERA	**0.557**	-0.199	0.445	-0.166	0.128
PHASMATODEA	**0.530**	0.293	-0.275	0.153	-0.208
PSOCOPTERA	0.364	-0.305	0.326	-0.132	0.270
SOLIFUGAE	-0.259	0.442	0.450	0.452	-0.229
THYSANOPTERA	0.064	-0.312	-0.198	0.446	0.370
TRICHOPTERA	-0.184	0.002	-0.268	-0.104	-0.191
Variance Explained by Components (Eigenvalues)	3.510	2.061	1.821	1.515	1.364
Percent of Total Variance Explained	19.502	11.450	10.117	8.416	7.579

Table 11. Pearson Correlation coefficients for bird guilds with top three principle component factors from PCA analyses summarized in Tables 8 and 9. Significant correlations (P < 0.05) in bold.

	G2	NG	OG	INVFAC1	INVFAC3	INVFAC2
INVFAC1	-0.047	-0.132	**0.320**	1.000		
INVFAC2	0.101	-0.047	0.066	0.013		1.000
INVFAC3	0.181	0.226	-0.108	-0.038	1.000	-0.001
PLANFAC1	0.183	0.119	-0.067	-0.146	0.175	**0.357**
PLANFAC2	-0.173	-0.066	**0.324**	**0.416**	-0.117	-0.158
PLANFAC3	**0.309**	-0.206	0.253	0.099	0.080	-0.124

Table 12. Pearson Correlation coefficients for selected insect bird and plant variables: Insects – total abundance of all insects per point; G2- average # secondary grassland birds per point; NG – non-grassland birds; OG – obligate grassland birds; Intro – average cover of introduced plant species per point; Native - average cover of native plant species per point; Plant SR – average number of plant species per point. Significant correlations (P < 0.05) in bold.

	INSECTS	G2	NG	OG	INTRO	NATIVE
INSECTS	1.000					
G2	0.003	1.000				
NG	-0.064	**0.433**	1.000			
OG	**0.313**	-0.227	**-0.434**	1.000		
INTRO	0.175	-0.193	-0.122	-0.033	1.000	
NATIVE	-0.010	0.122	-0.067	0.179	**-0.761**	1.000
PLANT SR	-0.234	0.099	0.161	-0.179	**-0.420**	**0.428**

Table 13. Pearson Correlation coefficients for selected bird and plant variables: G2- average # secondary grassland birds per point; NG – non-grassland birds; OG – obligate grassland birds; Robel – average visual obstruction index per point; Litter – average litter depth; Brgrnd – average cover of bare ground; Forb - average cover of forbes; average cover of grasses; average cover of legumes.

	G2	NG	OG	ROBEL	LITTER	BRGRND	FORB	GRASS	LEGUME
ROBEL	-0.041	-0.145	**0.360**	1.000					
LITTER	-0.150	-0.130	**0.276**	**0.543**	1.000				
BRGRND	0.230	0.087	**-0.286**	-0.241	**-0.367**	1.000			
FORB	**-0.264**	0.088	-0.017	-0.095	-0.142	-0.043	1.000		
GRASS	**-0.310**	-0.085	0.235	**0.383**	**0.345**	**-0.508**	0.129	1.000	
LEGUM	-0.176	-0.216	0.089	-0.087	0.144	-0.168	**-0.449**	**-0.340**	1.000
SHRUB	0.146	-0.061	-0.041	0.069	-0.065	-0.121	-0.044	-0.075	0.057

Table 14: Comparison of Native Species Cover in Burned and Unburned Plots		
	Burned 2008	**Burned 2009**
Mean	52.31% Native Cover	40.47% Native Cover
St. Dev.	13.78	18.93
	Unburned 2008	**Unburned 2009**
Mean	52.53% Native Cover	34.83% Native Cover
St. Dev.	17.68	18.42

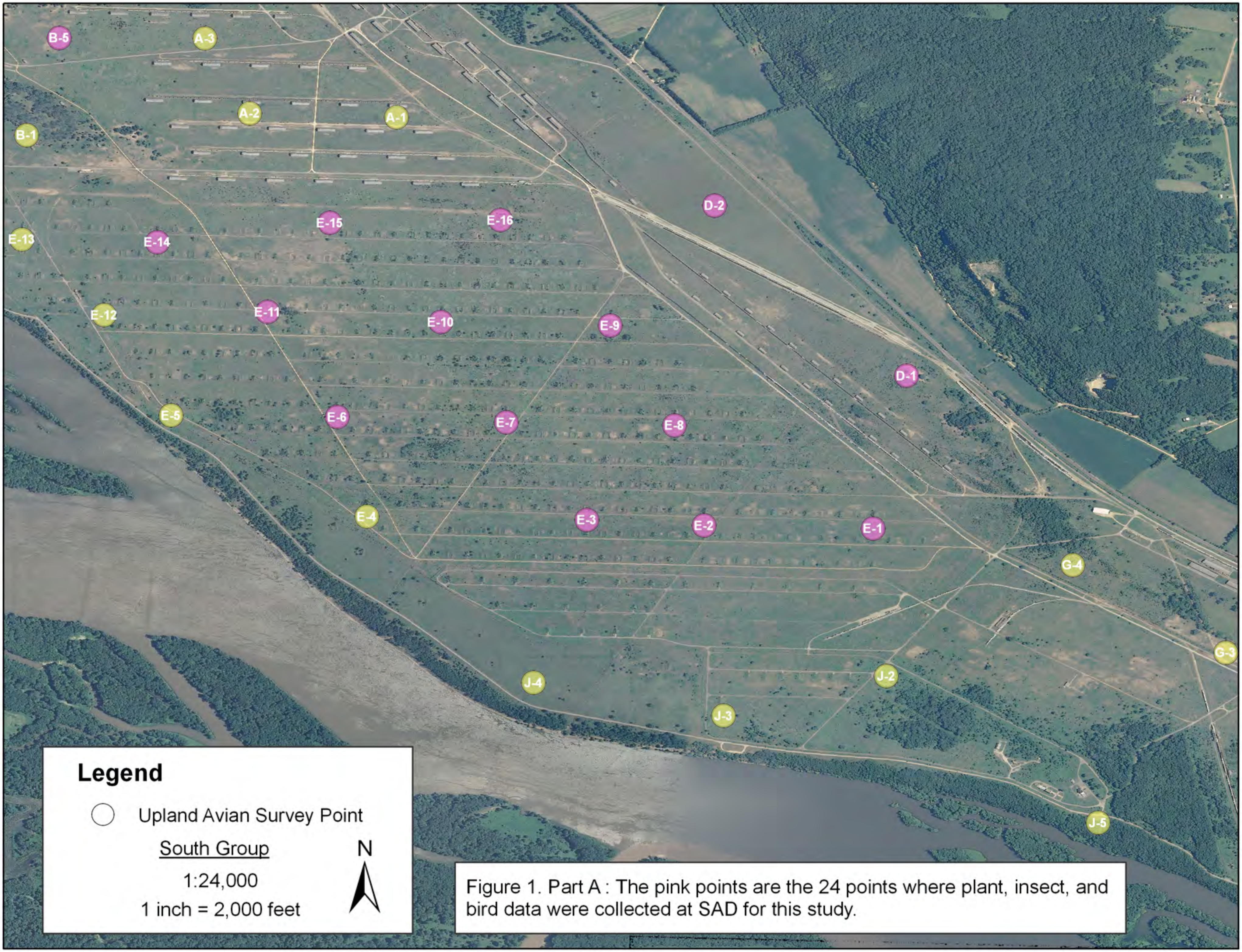


Figure 1. Part A : The pink points are the 24 points where plant, insect, and bird data were collected at SAD for this study.

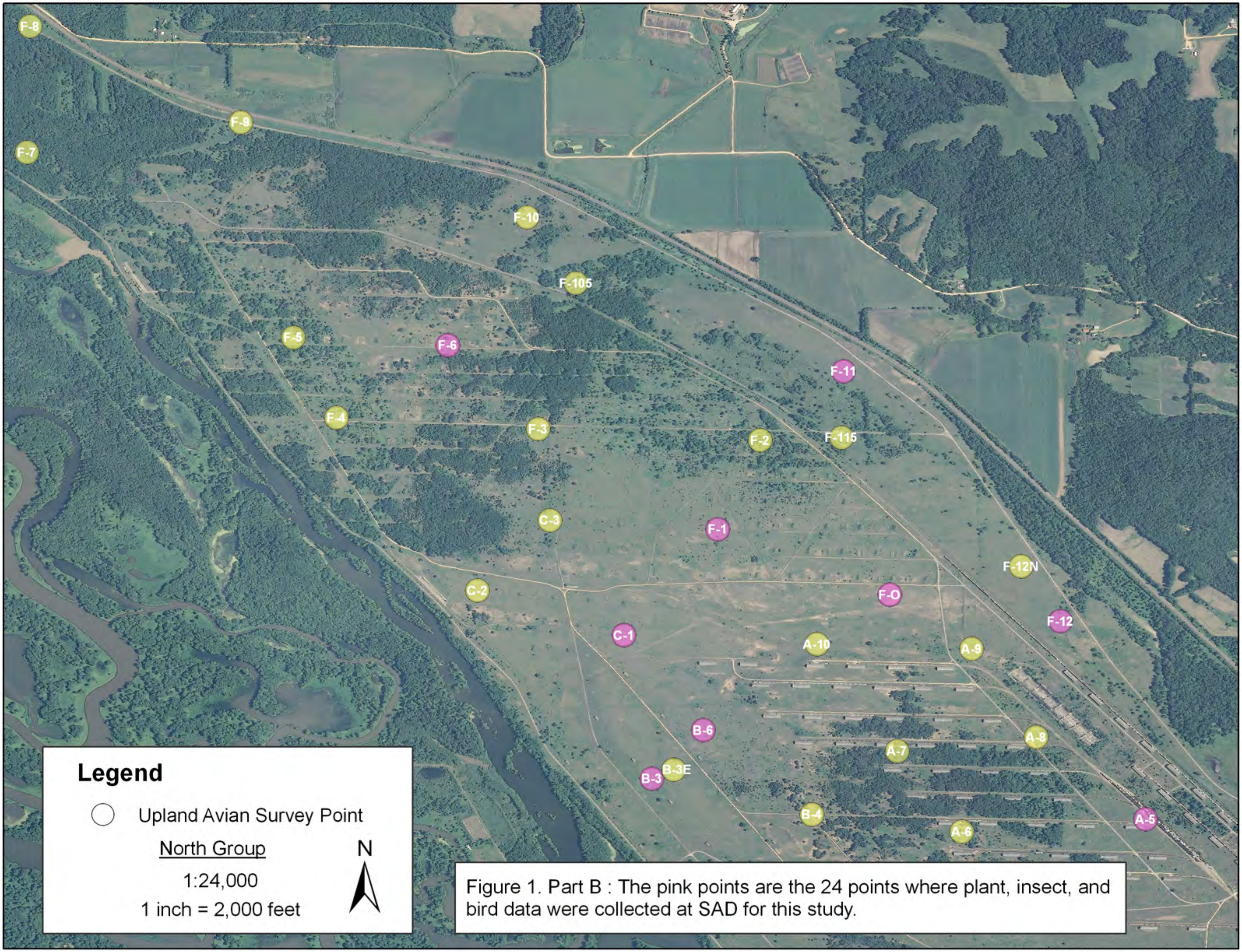


Figure 1. Part B : The pink points are the 24 points where plant, insect, and bird data were collected at SAD for this study.

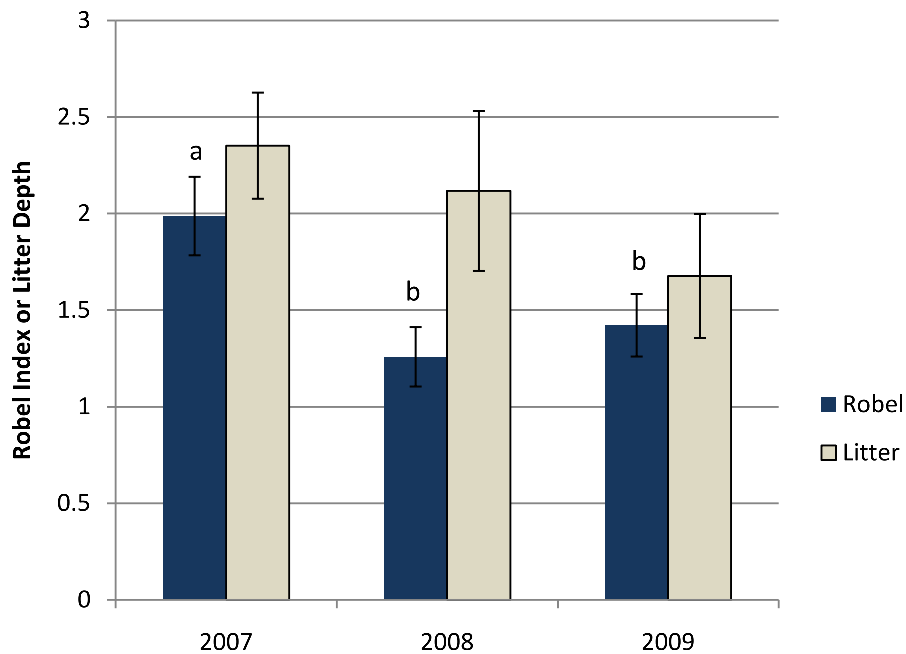


Figure 2. Average (+/- SEM) Visual Obstruction Index (Robel) and Litter depth (cm). Among the Robel measurements , bars with different letters are significantly different (P < 0.05)

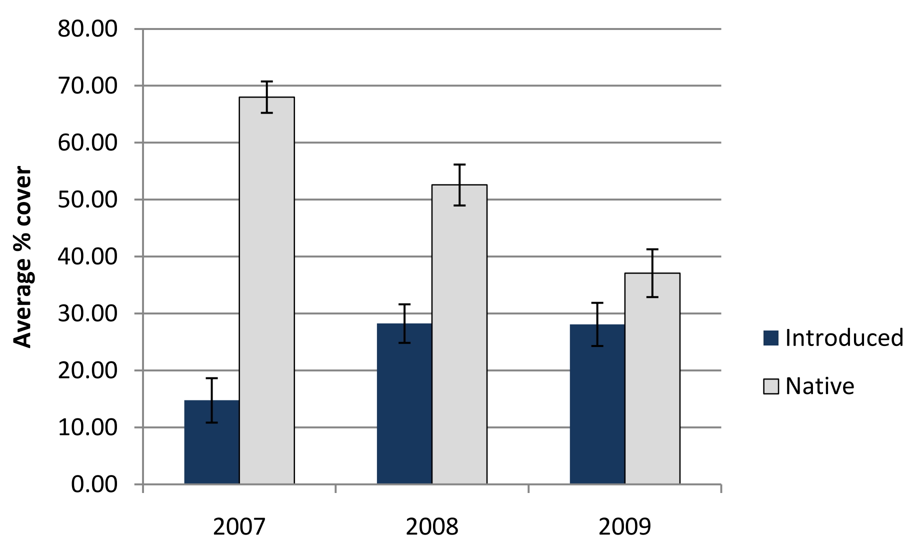
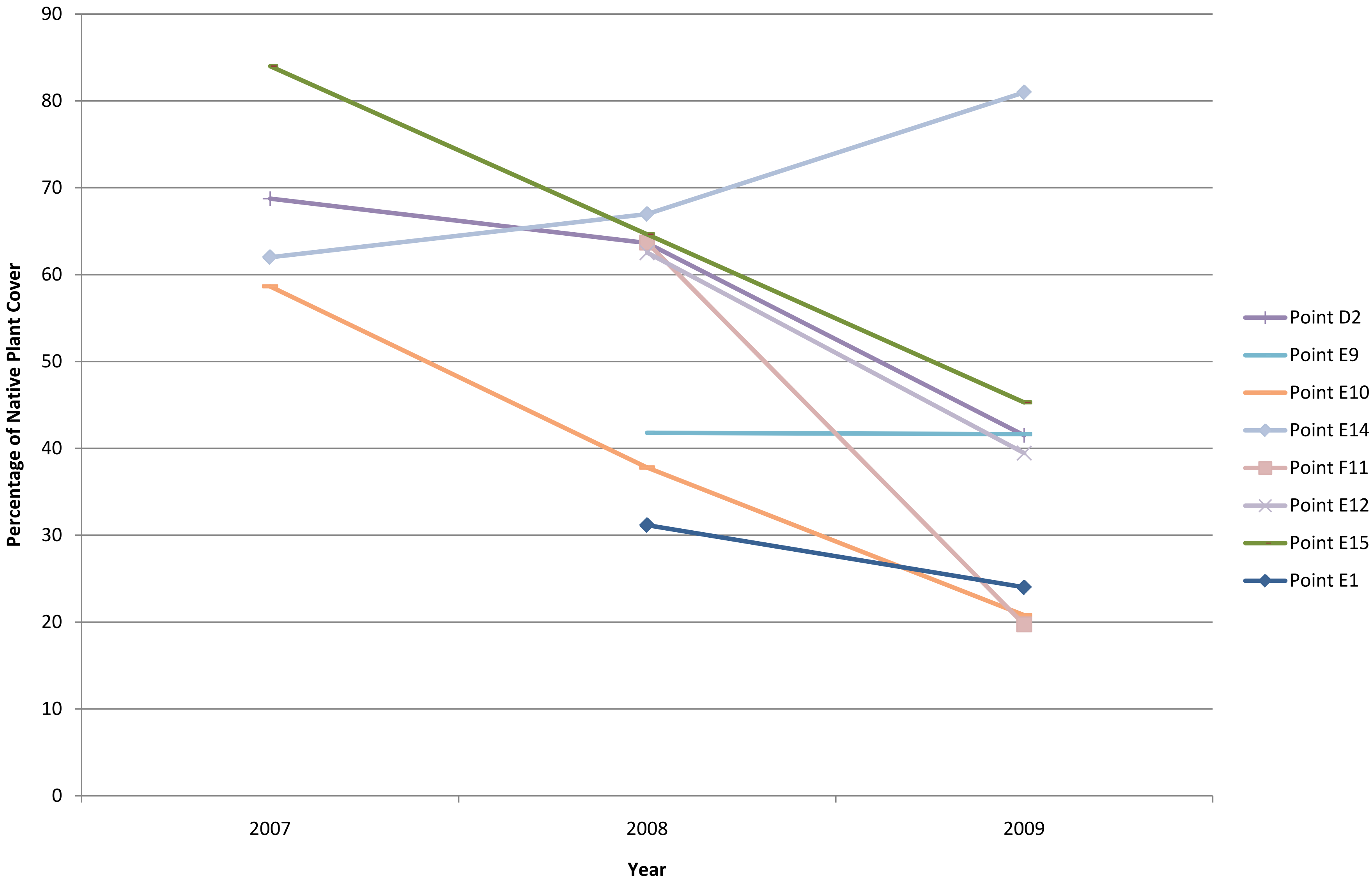


Figure 0. Average cover (+/- SEM) of introduced and native plant species. Within Native plant cover each year is significantly different from the others (all P<0.05). For Introduced plants 2007 differs from 2008 and 2009.

Figure 4.
Mean Percentage Native Plant Cover at Plots Burned in Spring 2008



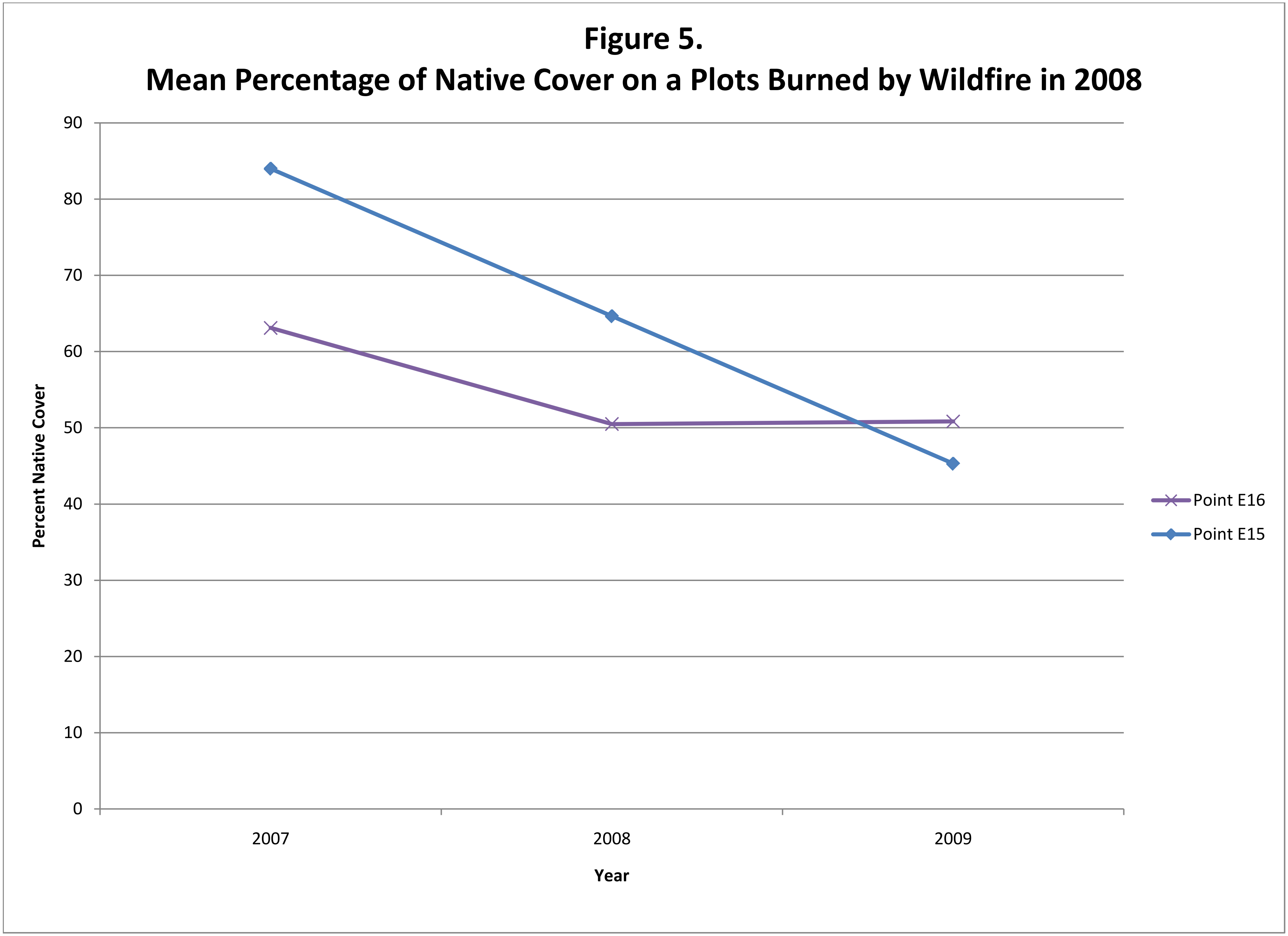


Figure 5.
Mean Percentage of Native Cover on a Plots Burned by Wildfire in 2008
90
80
70
60
50
40
30
20
10
0
Percent Native Cover
2007
2008
2009
Year
Point E16
Point E15

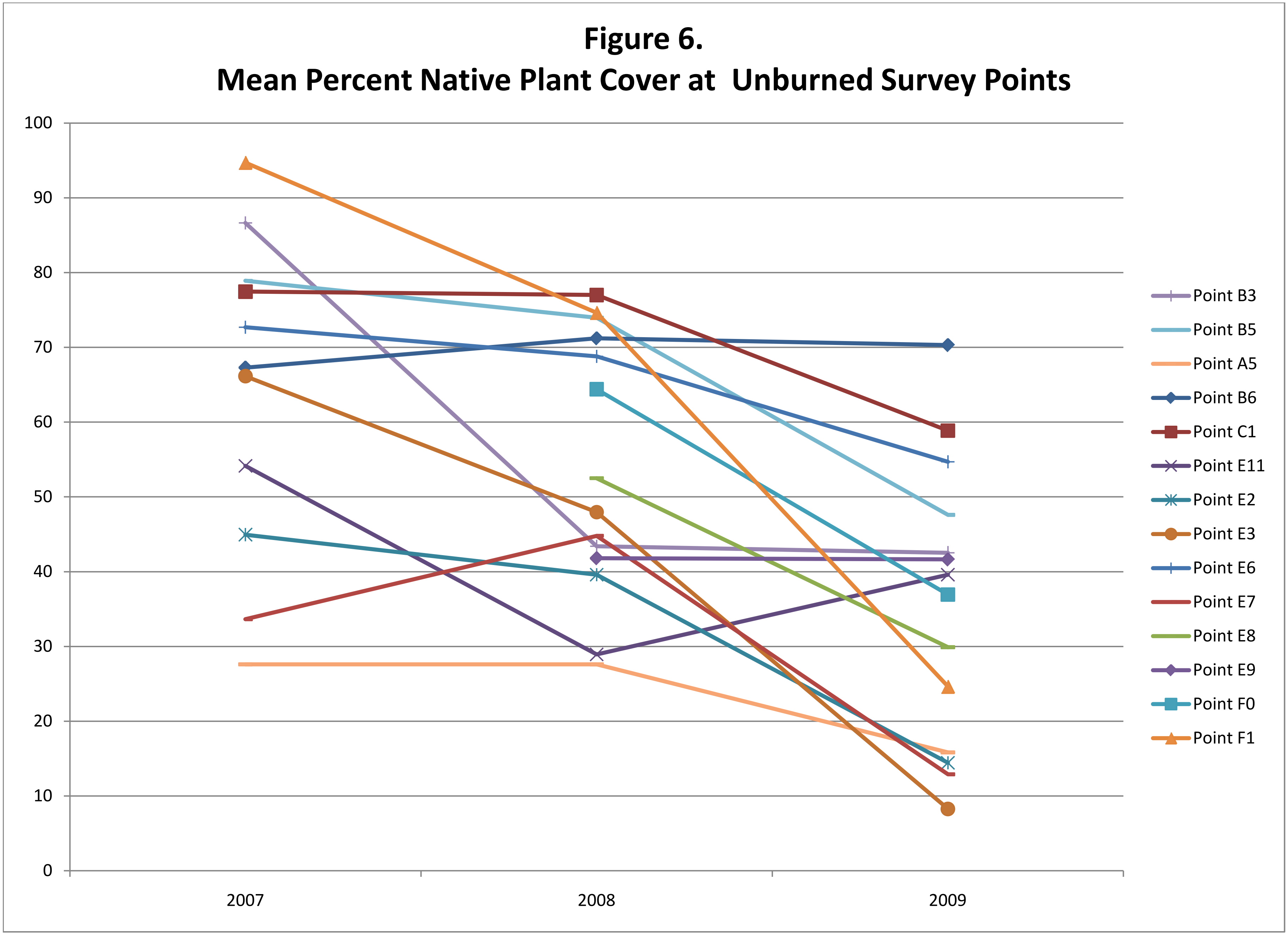


Figure 6.
Mean Percent Native Plant Cover at Unburned Survey Points
100
90
80
70
60
50
40
30
20
10
0
2007
2008
2009
Point B3
Point B5
Point A5
Point B6
Point C1
Point E11
Point E2
Point E3
Point E6
Point E7
Point E8
Point E9
Point F0
Point F1

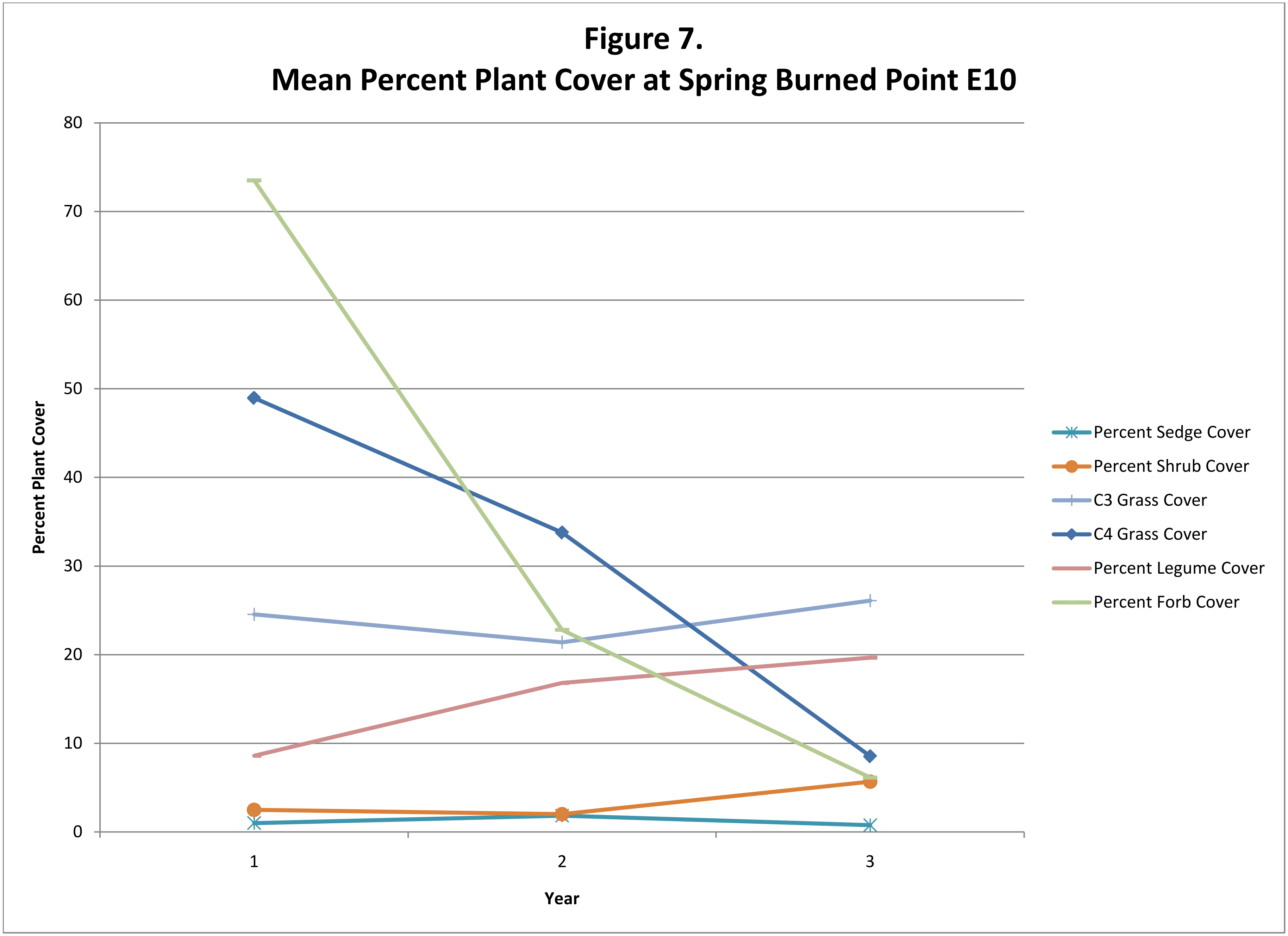
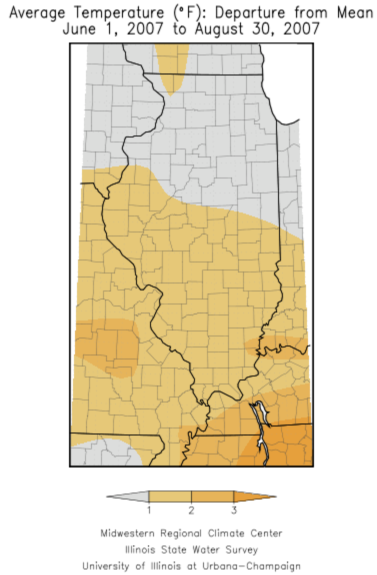


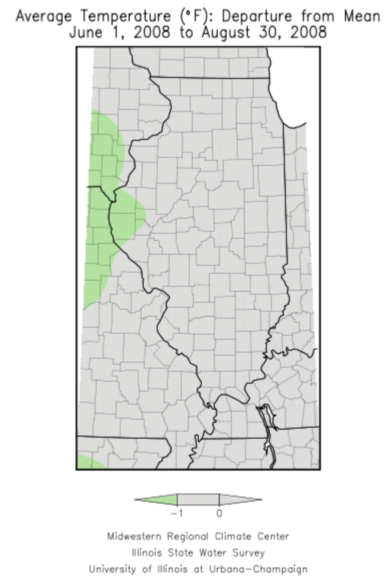
Figure 7.
Mean Percent Plant Cover at Spring Burned Point E10
80
70
60
50
40
30
20
10
0
Percent Plant Cover
1
2
3
Year
Percent Sedge Cover
Percent Shrub Cover
C3 Grass Cover
C4 Grass Cover
Percent Legume Cover
Percent Forb Cover

Illinois Temperatures
Departure From Mean
Figures 8, 9, 10

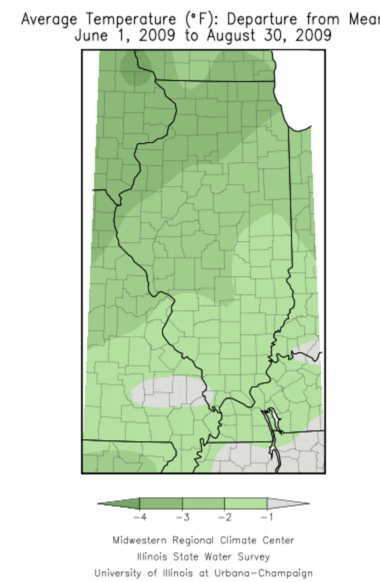
2007



2008



2009

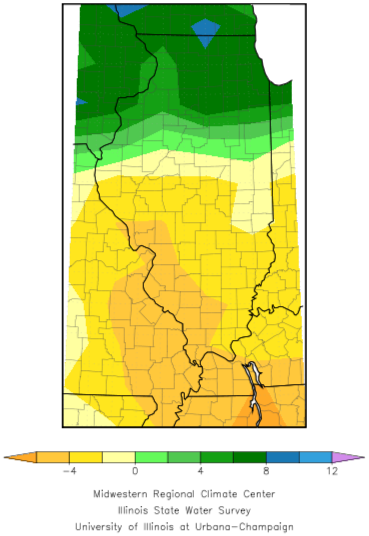


Courtesy of the Midwest Regional Climate Center, Illinois State Water Survey 2011

Illinois Precipitation Departure From Mean Figures 11, 12, 13

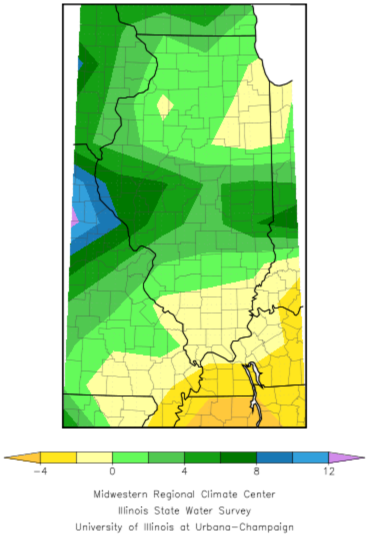
2007

Total Precipitation (inches): Departure from Mean
June 1, 2007 to August 30, 2007



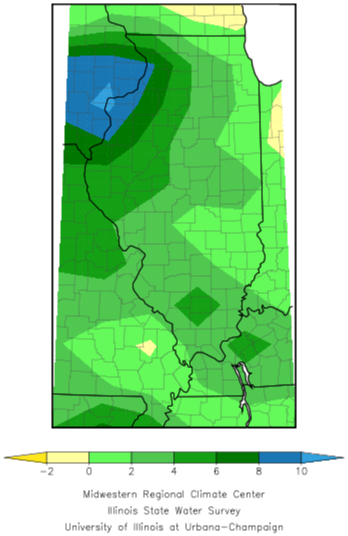
2008

Total Precipitation (inches): Departure from Mean
June 1, 2008 to August 30, 2008



2009

Total Precipitation (inches): Departure from Mean
June 1, 2009 to August 30, 2009



Courtesy of the Midwest Regional Climate Center, Illinois State Water Survey 2011