Pilot Study of Bird Populations in Grassland Habitats of Southwest Virginia

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Introduction

As a group, grassland birds are in rapid decline throughout the eastern United States (Askins 1993). The primary cause of this decline is habitat loss and habitat fragmentation (Johnson and Temple 1986). Less than 1% of the native grasslands once common in the east remain on the landscape today. Agricultural practices that once provided additional grassland habitat and natural vegetation succession are in decline from recent farm abandonment. As a result, the numbers of grassland birds have declined.

An often-overlooked aspect of this widespread habitat decline is the changing landscape. This landscape, once dominated by smaller grass crops such as hay and wheat, is now primarily corn, soybeans or other non-grass flora planted in larger fields in more concentrated areas. The increase of forest on the landscape has also replaced many areas once considered “old field” or open land. The result is fewer types of grassland spaced farther apart with less connectivity. Contributing still more pressure is a rapidly increasing human population and a subsequent demand on open lands for suburban housing.

Although programs such as the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP) provide incentives to increase the acreage of non-production grassland area, there has been little planning for building a grassland network at the landscape scale. Previous studies have shown a distinct relationship between landscape elements such as patch size, connectivity, and edge ratio to the abundance and diversity of grassland birds. However, most of these studies have been completed in the mid-western US (Herkert 1994, Dejong 2001).

In this pilot study, we examined the relationship between grassland size and the abundance and diversity of grassland birds. In addition, we examined two potential factors affecting grassland birds, vegetation and the presence of predators. We will provide insight to factors that require additional investigation. It is our hope that these data will further our ability to promote better grassland habitat management in western Virginia.

Study Area

All the grasslands selected for this study were located in the valley regions of the Appalachian Mountains in Southwest Virginia. These valleys are predominantly open, grazed, or mowed grasslands mixed with forested tracts of various size and composition. We selected fields in close proximity to each other with similar edaphic characteristics. The fields selected were undisturbed by agricultural management (e.g., no mowing or burning) preceding and during the study period.

We selected 11 different grassland tracts on privately owned farms, state owned wildlife management lands, and forest service owned lands. Size ranged from approximately 4 acres to 1,700 acres (Table 1.). The grasslands contained cool season grasses, some woody species and occasional warm season grasses (depending on time since last mowing/burning). Some tracts contained warm season grasses as a result of direct planting or past disturbance, and some contained isolated tree and shrub patches.

Table 1. Fields included in this study (maps are included in Appendix 5)

Area Name (Property Code)	Field Area (ac.)	Transect Area (ha.)	No. of Transect Segments	Transect Dist. (m)	Transect Width
RAAP (RAAP)	1700	3	1	300	50
Level Green (LG)	80	3	3	3 @ 100	50
Oriskany (ORISK)	63	3	2	1 @ 100 1 @ 200	A @ 25 B @ 50
Harrison Ridge (CCHR)	62	3	2	100 200	50 50
Village at Tom's Creek (VATC)	48	2.5	1	250	50
LaRue Fields (CCLF)	36	3	1	100	50
Glen Alton Large (GLEN)	32	2	1	200	50
Caldwell Fields (CALD)	22	1	1	100	50
Glen Alton Small (GASM)	6	0.5	1	100	25
Murphy (MURPH)	4	0.5	1	100	25
Leslie (LES)	4	0.5	1	100	25

<u>Methods</u>

We completed three field studies during June through August 2002. These were bird surveys, vegetation structure surveys, and nest predator surveys.

Bird Survey

Bird surveys were conducted to determine the total number of grassland birds in each field. We followed a procedure similar to those used by Emlen (1977) which employed both transect surveys and time-constrained searches to 1) identify species using the study fields and 2) to develop density estimates. Transects were surveyed 3 times between 25 June and 10 July, usually between sunrise and 1000. We placed a 3 ha (100m x 300m) transect in each field (or field complex) provided it would fit completely in the area. When odd shaped fields (field complexes) were encountered, we divided them into multiple transect segments to cover a larger potion of the total field area. When the field was too small to accommodate a 3 ha transect, we used a smaller transect of 0.5 ha (50 m x 100m) or 1 ha (100m x 100 m) which was determined for each field based on shape and size (Table 1).

Bird survey transects were marked at beginning and end points with navigation flags. Observers were instructed to maintain a steady pace (500 m per hour) to minimize time differences between observers, but were encouraged to take additional search time as necessary to survey birds completely. Birds were observed both aurally and visually and were identified to species. We recorded temperature, wind speed/direction, and cloud cover. No method of attraction (e.g., "spishing") was permitted. Only birds observed within the survey area were recorded, including flyovers, if it was determined that the bird was using the field (e.g., hawking, soaring).

Table 2. Transect times, additional search times, and total search times for each study field.

Area Name	Approx. Transect Time (min)	Approx. Additional Search (min)	Total Time (min)**
RAAP (Dublin)	36	2740*	720
Oriskany	36	90	378
LaRue Fields (Crooked Creek)	36	47	249
Level Green	36	117	459
Harrison Ridge (Crooked Creek)	36	88	372
Glen Alton (Large)	24	39	189
Caldwell Fields	12	24	108
Glen Alton (Small)	12	8	60
Murphy	12	5	51
Leslie	12	4	48
Village at Tom's Creek	30	48	234

*Surveyors will bird from the end of their transect time until 10:00
** Total time includes all 3 surveyor visits

Surveyors completed the bird surveys by spending a predetermined amount of time conducting "expert searches" of the remaining field area. A total survey time of 12 min/ ha was chosen and used with the field area to calculate the total time of expert search. This time was then divided into 3 equal intervals with each observer completing an interval each time a field was visited (Table 2.).

All bird species were categorized as ground nesting/grasslands (group 1), ground nesting/brush-shrub-occ. tree-open habitat (group 2), small tree-shrub nesting/brush-shrub-occ. tree-open habitat (group 3), or cavity nesting/occ. tree-open habitat (group 4) (Appendix 2). We examined the possible relationships between grassland size and species diversity. In order to investigate this relationship, we looked at observed diversity for 0.5 ha sections of each field. When the transect area was greater than 0.5 ha, we randomly selected a section matching that size. We compared diversity estimates across fields to determine the affect field size has on grassland bird diversity.

We analyzed data relative to survey effort in an attempt to improve future survey efficiency. We examined the number of species observed as a function of total search time. The cumulative effort of each observer was used to estimate the total time to achieve a "complete" species list for a particular field.

Vegetation Surveys

We measured vegetation characteristics of all the study fields (except the Leslie property for logistical reasons). Data were collected using a point-intercept method (Herkert 1994) along the same transect lines followed during bird surveys. We used a 0.6-cm diameter rod 1 m in length to tally the number of stem intercepts at 1-2 m intervals. Intercepting vegetation was categorized as live grass, live forb, woody stem, or dead stem for each 0.1-m section of the rod.

Nest Predator Surveys

We used artificial ground nests to determine the presence and species of nest predators in each study field (Martin 1987,1988). We used artificial ground nests centered on a 23 cm diameter ring of sand baited with three northern bobwhite quail (*Colinus virginianus*) eggs (Gillis 2000). The sand mixture was concrete-grade sand blended with mineral oil, designed to capture tracks (approximately 3 16 oz. bottles of mineral oil / 50 lbs sand).

We randomly chose nest locations using GIS (Geographic Information System) and located field points with a GPS unit (Garmin 12 Channel). We conducted 2 three-day sampling periods at each field consisting of 20 nests. We prepared the nest site by removing existing vegetation with a fire rake or hand rake down to the soil. The ring was then compacted with a masonry trowel to provide a firm surface for the sand (Figure 1.). The sand mixture was sifted over the circle to a depth sufficient for recording a track (typically about 15 mm). The artificial nest was placed in the center of the sand ring and baited with 3 eggs. Care was taken to minimize human odor at the site by using latex gloves and foam kneeling pads (Figure 2).

Figure1. Tools used for artificial nest monitoring were (from top left): garden trowel, wooden float, quail eggs, artificial nest, sand bucket with sand mixture, kneeling pad, GPS unit, and sifter.

Figure 2. Artificial nests were placed in the center of a sand ring and baited with bobwhite quail eggs.

Artificial nests were checked once every 24 hours (usually between 7:00 and 11:00) for 3 consecutive days. If inclement weather, such as a hard rain shower, occurred with the trapping period, the sand was replaced and the period continued until 3 days of appropriate weather were completed. Each trap was recorded as having no visit, a visit, or a predation. Nests were considered predated if any one of the eggs were damaged or removed. We recorded the type of predator by track (or, in rare cases, by direct observation) and made specific notes regarding track condition and the confidence of the observer. Once a nest was predated it was removed and not re-baited. In cases where the nest was visited but not predated, we recorded the species of animal visiting the nest and sifted more sand mixture to resurface tracking plot for smoothness and depth. In the event of multiple species observations, we recorded all species observations and attributed predation events based on other information (e.g., egg shell condition) where possible. If tracks could not be determined or the observer was not confident in attributing a predation to species, then the observation was recorded as unknown.

Each property was sampled twice during June through early August 2002. Once the sampling period was complete, all nests and eggs were removed from study field to avoid attraction of potential predators.

Results

Bird Density and Diversity

We observed grassland species from all 4 categories, during transect and time-constrained searches (Table 3 and Table 4.). Only 3 species of grassland, ground nesters (group 1) were observed. These were the eastern meadowlark (*Sturnella neglecta*), grasshopper sparrow (*Ammodramus savannarum)*, and Henslow's sparrow (*Ammodramus henslowii*). A total of 15 grassland species were observed. The most ubiquitous species observed were the song sparrow (*Melospiza melodia)*, and the American goldfinch (*Carduelis tristis)*, which were observed in every field.

Table 3. Number of species detected on transects for each study field. The number in parenthesis indicates the total number of species in that grouping (see Appendix 2).

Transect	Group 1 (3)	Group 2 (3)	Group 3 (7)	Group 4 (2)	Total (15)
RAAP	3	3	5	1	12
LG	2	2	2	1	7
ORISK	0	1	2	0	3
CCHR	0	1	1	1	3
VATC	1	2	3	0	6
CCLF	0	2	2	1	5
GLEN	1	1	5	1	8
CALD	0	1	1	1	3
GASM	0	0	2	0	2
MURPH	2	2	1	0	5
LES	0	2	1	0	3

Table 4. Number of species detected during time-constrained searches in each study field.

Transect	Group 1 (3)	Group 2 (3)	Group 3 (7)	Group 4 (2)	Total (15)
RAAP	3	3	6	2	14
LG	2	3	3	1	9
ORISK	0	1	3	1	5
CCHR	1	2	3	1	7
VATTC	1	2	4	1	8
CCLF	1	2	2	1	6
GLEN	1	1	4	1	7
CALDWELL	0	2	2	1	5
GASM	0	1	1	1	3
MURPHY	2	2	4	1	9
LESLIE	1	2	2	0	5

Diversity estimates changed when we examined equal areas across all fields. All the data from the Leslie, Murphy, and Glen Alton Small were used, where as only a randomly selected 0.5 ha (50m) section was used for the remaining fields. The number of grassland bird species observed in these sections was greatly reduced (Table 5).

Table 5. Results of bird diversity from 0.5 ha surveys for each property.

Fields	Location on transect (m)	Group 1	Group 2	Group 3	Group 4	Total
RAAP	150-200	1	2	2	1	6
LG	50-100	2	0	0	0	2
ORISK	100-150	0	1	0	0	1
CCHR	50-100	0	1	0	0	1
VATC	150-200	0	1	1	0	2
CCLF	250-300	0	0	0	1	1
GLEN	100-150	0	0	1	1	2
CALD	50-100	0	1	0	0	1
GASM	0-100*	0	1	2	1	4
MURPH	0-100*	2	2	3	1	8
LES	0-100*	1	2	2	0	5

* Survey area constitutes the entire transect

When the number of grassland bird species is plotted as a function of field area, we see a strong, positive relationship for estimates derived from time-constrained searching (Figure 3). The R^2 value of this relationship is 0.67 suggesting a strong relationship. We do not observe a similar relationship when we plot the estimates based on equal-area transects.

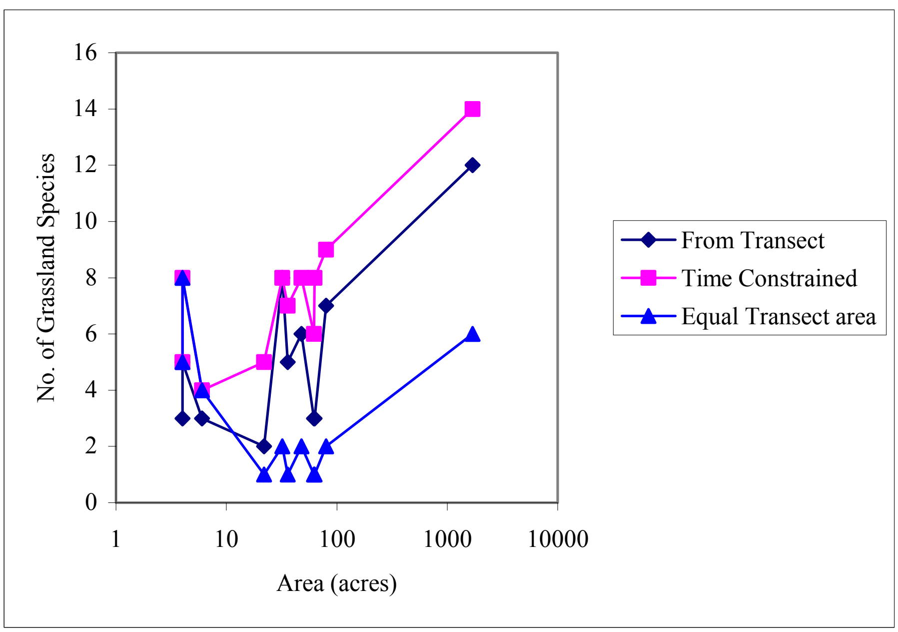

Figure 3. Number of grassland birds as a function of area using both estimates of bird diversity.

We used the transect data to calculate the average density (where present) for each grassland species per field (Table 6). These estimates are for transect density only and cannot be applied to the entire field. They are provided for reference only.

Survey Effort

We examined our survey results to evaluate our sampling effectiveness and to determine where possible improvements could be made for future sampling efforts. First, we examined the contribution of each observer visit to the overall number of grassland species detected for each property (Figure 4). The mean proportion of the total diversity observed by the first, second, and third observers was 62%, 27%, and 13% respectively.

We created species accumulation curves by plotting the total time it took for observers to record a new species of grassland bird. All logistic regression trend lines are characteristic of complete surveys in that they become asymptotic to the actual number of species. Although we have no way of knowing the actual number of species per field, we assumed this pattern indicated our sampling time was sufficient to record 95% of the actual number of species found in these areas. We reported the total time to observe all the grassland species in each field (Table 7). As expected, observers required more time to reach 100% of the total grassland species for the larger fields than for the smaller fields. By plotting the time to reach 100% as a function of area, we obtained an equation relating field size to the time to reach 100% (Figure 5), which should be useful in planning for future surveys.

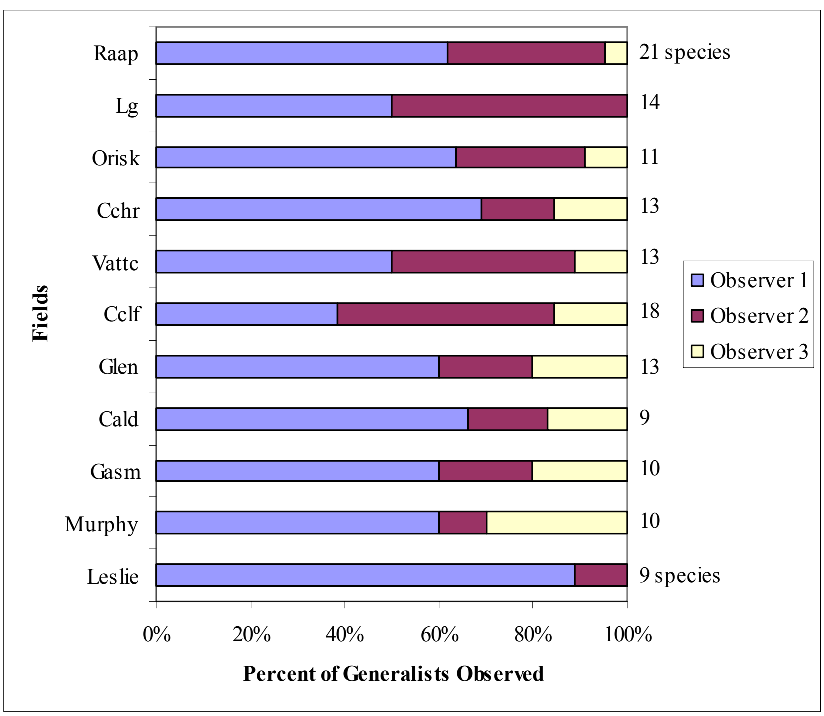

Figure 4. Proportion of grassland generalist species recorded by each successive observer.

Table 6. Number of grassland bird species per hectare for each field in which the species was encountered. See Appendix 1 for species codes and Table 1 for field codes.

Species	LES	MURPH	GASM	CALD	GLEN	CCLF	VATC	CCHR	ORISK	LG	RAAP
AMGO	4.00	0.67	3.33	0.67	1.00	1.11	1.20	1.11	0.80	1.11	1.00
COGR	...	...	...	...	0.50	0.11	0.13	...	...	0.33	0.22
EABL	...	...	...	0.33	0.67	1.11	...	0.56	...	0.11	0.22
EAKI	...	...	0.67	...	0.50	...	0.27	...	...	...	0.33
EAME	...	1.33	...	...	0.17	...	0.27	...	...	1.33	0.44
FISP	10.00	2.00	...	2.33	...	1.89	0.53	2.33	...	1.00	1.67
GRSP	...	0.67	...	...	...		...	...	...	0.89	0.67
HESP	...	...	...	...	...	...	...	...	...	...	1.89
LOSH	...	...	...	...	0.17	...	...	...	...	...	...
MODO	...	...	...	...	...	0.22	...	...	...	0.11	0.11
NOBO	...	...	...	...	...	...	...	...	0.27	...	0.67
NOMO	...	...	...	...	...	...	...	...	0.13	...	...
RWBL	...	...	...	...	0.17	...	...	...	...	...	0.11
SOSP	2.67	0.67	...	...	1.17	0.22	3.07	...	0.27	0.11	...

Table 7. Total time for recording all grassland species observed.

Fields	Size (acres)	Total No. Grassland Species	Time to Record All (min)
RAAP	1700	24	299
LG	80	16	156
ORISK	63	11	186
CCHR	62	14	228
VATC	48	19	128
CCLF	36	14	111
GLEN	32	11	136
CALD	22	9	74
GASM	6	10	27
MURPH	4	12	23
LES	4	10	15

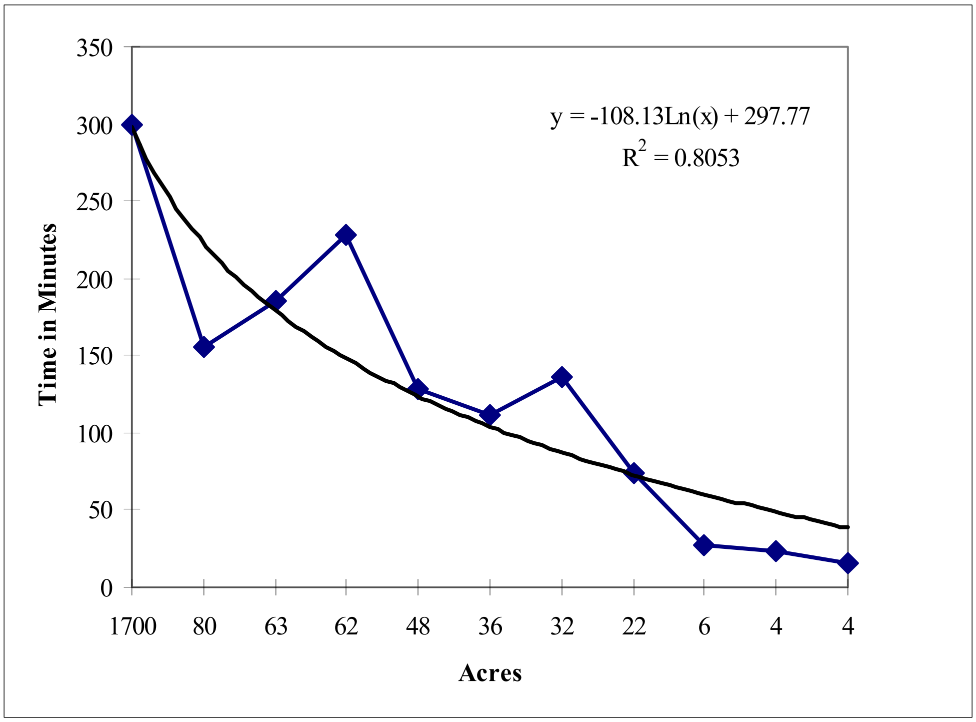

Figure 5. Graph of species detection rate and time to completion for each field.

Vegetation Surveys

A total of 1,240 vegetation intercepts were taken across 10 fields (the Leslie field was not sampled for vegetation characteristics). These included leaf litter depth and the number of intercepts for forbs, grasses, and live or dead woody stems.

We analyzed each transect or transect segment separately due to differences in vegetation characteristics between them. This applied to the fields at Level Green (3 transects), Oriskany (2 transects), and Crooked Creek - Harrison Ridge (2 transects).

The dominant vegetation type (as determined by this method) was live grass with nearly 94% of all the recorded stems followed by live forbs (~ 6%). Very few woody stems were recorded and no dead woody vegetation was recorded. We measured the leaf litter at each point with a ruler (Table 8). The maximum litter depth was found on the Oriskany B transect and was 69% higher than the next closest transect (RAAP).

Table 8. Summary of leaf litter depth for each field and statistical grouping.

Transect	N	Mean (mm)	Std Dev	Groups*
GASM	75	4.72	2.34	**A**
GLEN	80	9	3.878	**B**
VATC	160	15.019	28.56	**C**
ORISK A	75	23.6	14.945	**D**
CCHR B	80	25.137	27.956	**D**
LG C	75	25.787	18.556	**D**
LG A	75	30.573	25.536	**DE**
LG B	75	33.667	29.751	**DE**
CALD	75	35.547	30.942	**E**
CCHR A	80	54.475	41.136	**F**
CCLF	160	61.538	49.866	**G**
MURPH	75	64.2	39.627	**G**
RAAP	80	69.365	60.537	**G**
ORISK B	75	101.133	69.528	**H**

* Fields with the same letter are not statistically different (p-value < 0.05)

We also examined the mean number of stem intercepts for each field (Table 10). The Oriskany fields had the highest mean number of stems per point (the entire 1-m rod combined). The total number of stems is provided in Appendix 3.

We examined vegetation height and heterogeneity. We calculated the grass stem percent occurring in each of the ten 0.1-m sections of the rod (Appendix 4) by dividing the number of intercepts for that section by the total for the field (Figure 7). We created the heterogeneity index by summing the absolute difference between the percentage of each section and 10% (the most heterogeneous arrangement possible is to have 10% coverage in each of the 10 sections resulting in an index value of 0). The maximum possible value is 1.8, which is achieved when one section has all homogeneous stems and height. The most heterogeneous grass height was found on the Oriskany A transect (Table 9) and the least heterogeneous grass height was on Caldwell Fields (1.2).

Table 9. Summary of heterogeneous grass height by field transects.

Field	Grass Heterogeneity *
ORISK A	0.25
ORISK B	0.59
CCHR A	0.66
VATC	0.76
RAAP	0.85
CCLF	0.93
LG A	1.00
LG B	1.02
CCHR B	1.07
GASM	1.08
GLEN	1.11
LG C	1.19
MURPH	1.22
CALD	1.24

*Scale ranges from 0 (maximum heterogeneous height) to 1.8 (maximum homogeneous height).

Table 10. Summary of mean stem intercepts by category and field.

Field	Forbs	Grass	Dead Wood	Woody Stems
MURPH	0.09	6.25	0.00	0.00
GASM	0.27	8.44	0.00	0.00
CALD	0.60	5.33	0.00	0.00
GLEN	0.34	7.96	0.00	0.00
CCLF	0.19	3.34	0.00	0.06
VATC	1.13	3.85	0.00	0.00
CCHR A	0.75	6.23	0.00	0.04
CCHR B	0.68	4.23	0.00	0.00
ORISK A	0.37	11.87	0.00	0.00
ORISK B	0.19	13.20	0.00	0.00
LG A	0.69	8.12	0.00	0.00
LG B	0.29	7.85	0.00	0.00
LG C	0.07	7.52	0.00	0.00
RAAP	0.49	9.88	0.00	0.00

The vegetation is best characterized when considering both height and stem density together. For example, the Oriskany A transect has both a high mean grass stem intercept value (11.87) and a heterogeneous height characterizing a very dense grassland up to 1 meter in height (Figure 6a). In contrast, the Caldwell Field (CALD) transect vegetation characteristics depicts a moderately dense, low grassland (~95% below 0.4 m) with scattered taller stems (Figure 6b).

Figure 6a. Grassland at Oriskany A.

Figure 6b. Caldwell Fields Grassland.

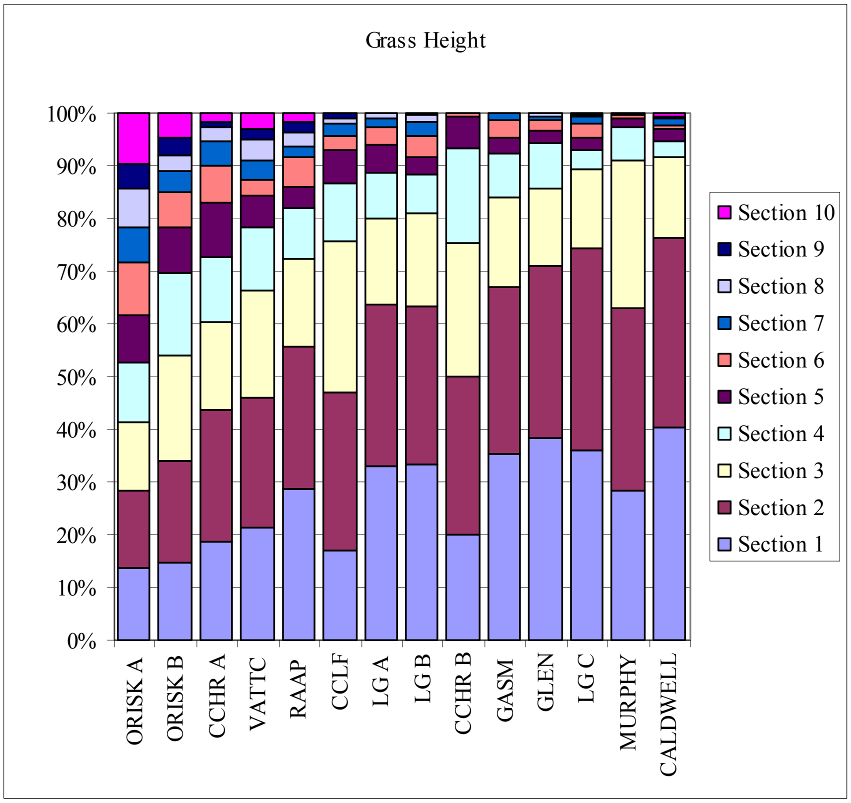

Figure 7. Overall percentages of grass stems by height category.

Using several calculated vegetation variables (Table 11), we clustered the fields into groups with the most similar vegetation characteristics (Figure 8). We noted that while some properties with segmented transects (e.g., Level Green) had very similar vegetation characteristics, segmented transects on other properties (e.g., Oriskany, Crooked Creek-Harrison Ridge) had very different vegetation characteristics.

Table 11. Variables used in clustering vegetation transects.

Vegetation Variables
Leaf Litter
Percent Cover of Forbs
Percent Cover of Grass
Percent of Dead Wood
Percent of Wood Stem
Percent of forbs below 0.5 m
Percent of grass below 0.5 m
Mean number of forb intercepts per 1 m
Mean number of grass intercepts per 1 m
Mean number of dead wood intercepts per 1 m
Mean number of woody stem intercepts per 1 m

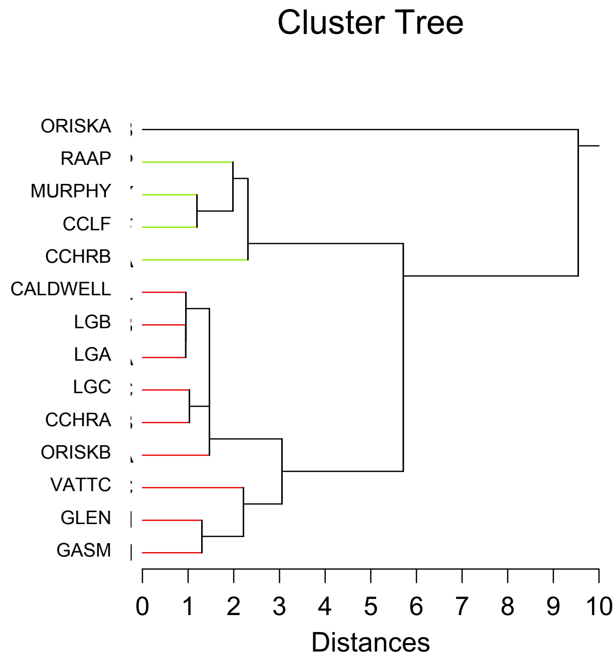

Figure 8. Results of hierarchical clustering of vegetation variables.

Vegetation and Grassland Birds

We examined the potential relationships between vegetation characteristics and grassland birds with logistic regression. We used the same variables selected to cluster the fields (Table 11). We examined the vegetation values to determine the field presence or absence for both eastern meadowlarks and grasshopper sparrows. None of the variables were found to be significant.

We examined landscape characteristics of each study area. We used a geographic information system (GIS) with digital orthophotoquads to label land cover features for a 1 km buffered area around the delineated field boundary. We delineated the land cover of each area into 9 habitat categories (forest, row crops, long grassland, short grassland, open water, industry/built-up-area, hedge rows, residential, and wetland). Once we completed the delineations, we calculated percent composition of grassland within the buffered area (Table 12).

Table 12. Characteristics of landscapes surrounding study fields.

Field	Total Field Area (ac.)	Total Grass Area (ac.)	Total Buffer Area (ac.)	Percent of Landscape in Grass
LES	4	466	912	51.1%
MURPH	4	443	930	47.6%
GASM	6	51	967	5.3%
CALD	22	39	966	4.0%
GLEN	32	54	1164	4.6%
CCLF	36	394	1287	30.6%
VATC	48	651	1248	52.2%
CCHR	62	323	1695	19.1%
ORISK	63	396	1715	23.1%
LG	80	758	1628	46.6%
RAAP	1700	3193	5414	59.0%

Predator Surveys

We completed 2 rounds of 3-day sample periods for each study field. These were completed from June through early August. We monitored 440 individual traps for a total of 1,205 trap nights. We had 117 nest predations and 251 visits without predation. We were able to identify 108 predating species (92.3%) and 238 (94.8%) visiting species. The highest observed predation was at Glen Alton Large with all (100%) of the nests lost. The lowest predation percent was observed at the Murphy field where no (0%) nests were predated (Table 13).

We observed 6 species as nest predators and 12 species as visitors (Table 14). The striped skunk (*Mephitis mephitis*) was the most frequently identified nest predator with 67 (56%) nest predations (Figure 9). The most frequently observed visitor group was small mammals with 125 visits (50%), although only 1 actual nest depredation event was attributed to a small mammal (Figure 10). This may be due to the abundance of these species in the grassland habitats sampled and may reflect chance visitation.

Table 13. Percent of nests predated and percent predated per trap night for all study fields. Fields are arranged from smallest area to largest.

Fields	% Nests Predated	Daily Survival Rate*
LES	17.5	0.94
MURPH	0.0	1.00
GASM	47.5	0.77
CALD	3.3	0.97
GLEN	100.0	0.57
CCLF	15.0	0.95
VATC	12.5	0.96
CCHR	22.5	0.92
ORISK	35.0	0.87
LG	20.0	0.93
RAAP	12.5	0.95
Total	26.8	0.9

* Daily survival rate is calculated by 1 – (# predations/total # trap nights) (Small and DeMaster, 1995).

Table 14. Summary of nest visitors/predators.

Predators	Visitations	Depredation Events
Bear	0	1
Bobcat	3	0
Bird	15	0
Coyote	2	0
Cow	0	1
Domestic cat	11	0
Domestic dog	19	8
White-tailed deer	9	0
Opossum	2	0
Raccoon	22	30
Rabbit	9	0
Skunk	16	67
Small mammals	125	1
Snake	5	0
Unknown	13	10
Total	251	117

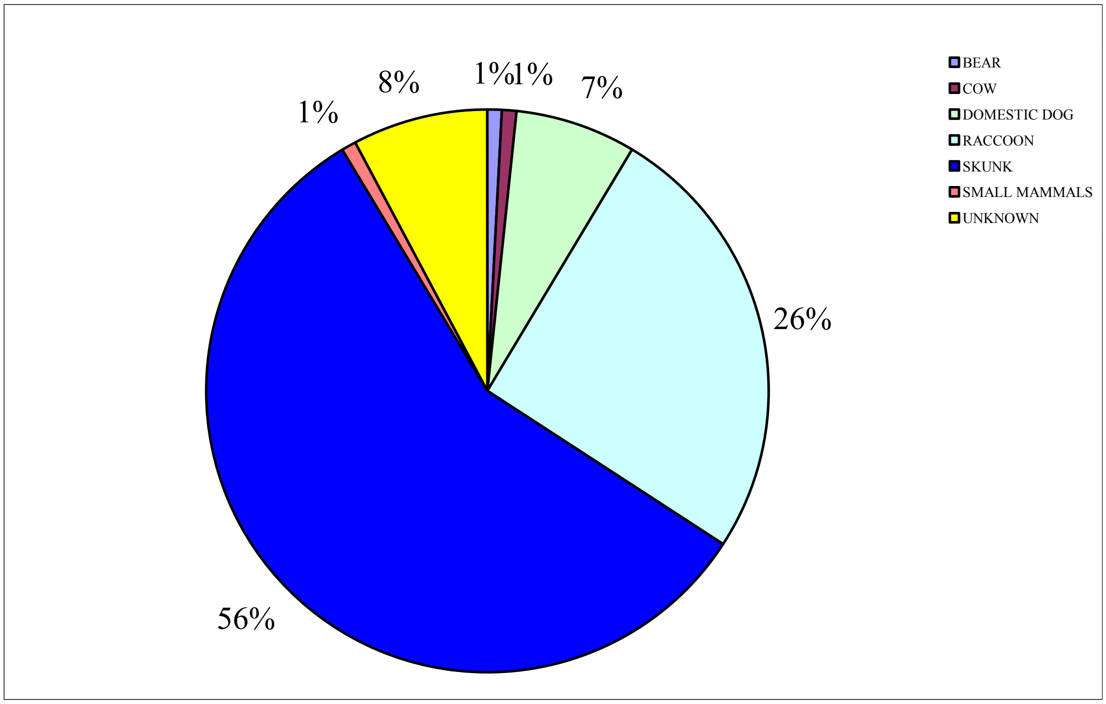

Figure 9. The total proportion of nest predations by species.

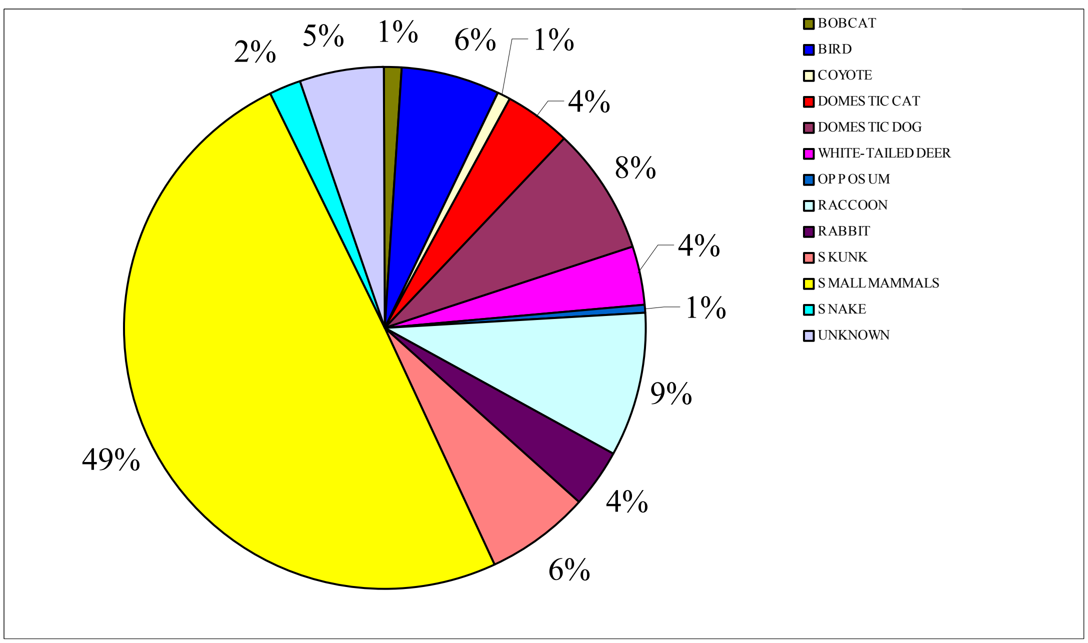

Figure 10. The total proportion of visits by species.

The next most common species to visit nests was the raccoon (*Procyon lotor*) with 22 visits (8.9%). Raccoons were the most commonly observed predator, if we were to omit the observations from the Glen Alton sites (which was nearly completely depredated by skunks) (Table 15).

Table 15. The frequency of nest depredation by species and field.

Field	Bear	Domestic Dog	Raccoon	Skunk	Small Mammal	Cow	Unknown	Total
LES	0	7	0	0	0	0	0	7
MURPH	0	0	0	0	0	0	0	0
GASM	0	0	0	19	0	0	0	19
CALD	0	0	0	4	0	0	0	4
GLEN	0	0	0	38	0	0	2	40
CCLF	0	0	4	0	0	0	2	6
VATC	0	0	3	2	0	0	0	5
CCHR	1	0	8	0	0	0	0	9
ORISK	0	1	7	2	0	0	4	14
LG	0	0	5	2	0	1	0	8
RAAP	0	0	3	0	1	0	1	5
Total	1	8	30	67	1	1	9	117

We examined the relationship between predation and field size by plotting the daily survival rate as a function of field size (Figure 11). No apparent significant relationship exists between these two factors.

We also measured the distance between nest stations and woody edge to determine if this distance had any affect on whether or not a nest was depredated. The average distance to an edge for predated nests was 36.0 m (N=117, SD=31.3) and the average distance to edge for surviving nests was 27.2 (N=322, SD=23.7). Although a two sample t-test showed these means to be statistically different (P-value = 0.007), we do not feel the difference has any biological meaning as the real difference between the means was only 8 m and the standard deviations of these distances are high.

We completed similar two sample t-tests on each individual field (Table 16). In only one field, Village at Tom's Creek was the distance to edge for predated nests significantly different from the distance to edge for surviving nests. This difference (16.63 m) was quite large compared to other differences observed.

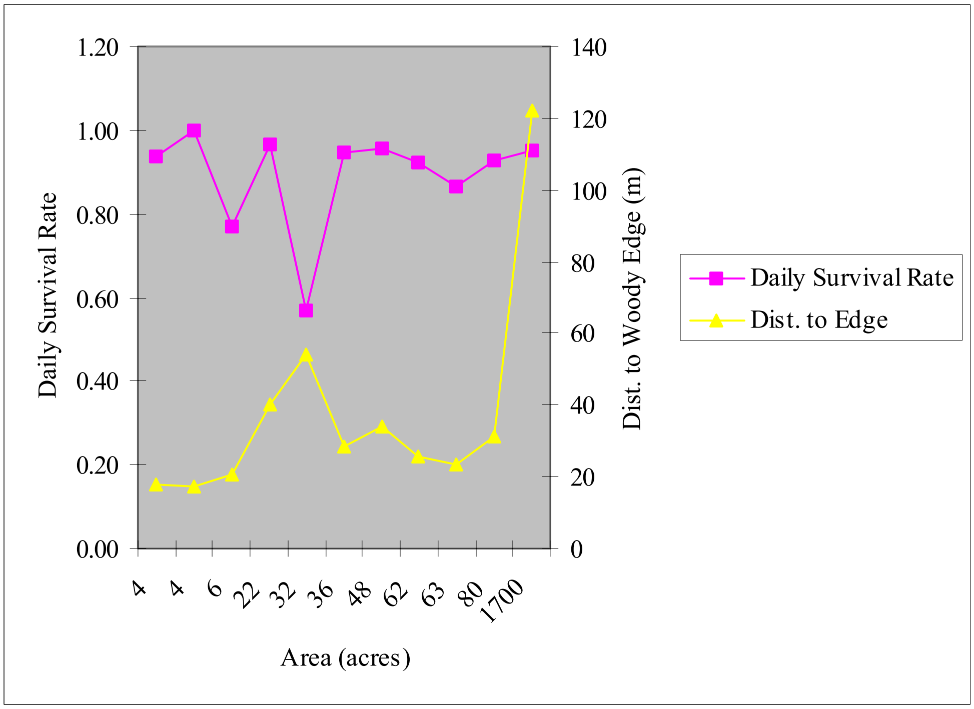

Figure 11. Graph of daily survival rate as a function of field size.

Table 16. Summary of two paired t-tests comparing the distance to woody edge between predated and surviving nests. The lower of the two means is indicated by bold type.

Field	Survived			Predated			P-value
	N	Mean	SD	N	Mean	SD	
LES	33	18.070	11.44	7	**17.000**	11.75	0.84
MURPH	40	17.275	11.50	---	---	---	---
GASM	21	**19.476**	10.80	19	21.42	12.27	0.60
CALD	36	**39.778**	24.21	4	44.000	20.05	0.72
GLEN	---	---	---	40	53.85	36.24	---
CCLF	34	30.00	24.46	5	**17.20**	17.81	0.20
VATC	35	36.23	30.27	5	**19.60**	10.78	0.03*
CCHR	30	**21.43**	20.98	10	37.30	34.85	0.20
ORISK	26	**21.89**	15.86	14	25.86	25.23	0.60
LG	32	31.47	28.89	8	**28.88**	20.30	0.77
RAAP	35	**120.26**	90.4	5	136.2	100.13	0.75

* Significant at the 0.05 level

Discussion

Bird Surveys

Although we observed a positive relationship between the number of grassland species and the area of the field, it is impossible to remove the effects of search area. Both the total species number and the number of species observed on the transect increased with field area, but transect size and search area also increased. When we attempted to compensate for this area affect by examining equal areas in each field, we saw no relationship. This is also confounded because the entire transect was included for the smaller properties whereas random segments were used for larger properties.

The methods used to observe and record species diversity followed those used by Herckert (1994). He used fixed area transects of 4.5 ha, but reported diversity estimates for patches smaller than 1-ha. It is not clear how he obtained estimates for these smaller parcels, since a 4.5 ha transect cannot be completely contained in a single parcel. This problem was recognized early in the planning stages of this project, but we did not adequately address the affect of variable sized survey transects on overall diversity measures. This problem must be addressed more appropriately in future studies.

Although each of these study fields was considered a single unit, some were actually field complexes in close proximity to each other. Several sites were comprised of 3 to 5 fields separated by woody hedgerows or small forest patches. The effect of these features is unknown, but may have some effect on their use by grassland birds. For example, both Oriskany and Crooked Creek- Harrison Ridge were actually complexes of several fields. When put together they constitute larger fields, but do not seem to contain the expected number of species for there transects. The next 3 sites (VATC, CCLF, and GLEN) are not complexes and have higher observed diversity than the previous complexes with larger grassland area.

The same concept can be applied to some of the smaller sites in this study. Although these fields were considered to be separate they were often surrounded by more open field habitat, which may affect the observed species number. For example, during the bird survey portion of the study, uncut hay field surrounded the 4-acre Murphy field. It is likely that the observation of group 1 species (grasshopper sparrow and eastern meadowlark) was a result of this larger grassland landscape. This would explain the relatively high number of species found in this smaller field compared to larger fields without supporting nearby habitat (e.g., Glen Alton Small and Caldwell).

It is interesting to note that the largest grassland (RAAP) contained the highest bird diversity in each category. These included the only known breeding population of Henslow's sparrow in Southwest Virginia. Of the 15 species categorized in this study, only the Loggerhead Shrike (*Lanius ludovicianus)* was not observed at RAPP, however this species is known to breed on the RAAP.

Since birds observed in this study used the study fields to fulfill a variety of life requisites, additional consideration as to which species should be included in the analysis is required. The categorization of species will greatly affect the results and should be completed before additional investigations. These categorizations can be driven by biological, behavioral, or managerial considerations.

Survey Effort

We examined the effectiveness of our survey techniques for future investigations. Primarily, researchers faced with resource limitations are forced to choose between the number of times a particular field is visited and the total number of fields under consideration. For this study, this question relates to a choice between reducing the variability introduced by daily weather, observers, and season with multiple visits and reducing the affects of fields of various sizes, vegetation composition, and geographic characteristics. By summarizing the length of time it took researchers to achieve the total number of species observed for each field, we see that often the first observer identified over 60% of the total species found, the second observer contributed another 25% and the third approximately 10%. Since the first three observers observed over 90% of the species, a fourth visit is unnecessary. This also suggests if more fields are added to the study, we might be able to sacrifice a third visit, since 85% of the species are recorded on average in 2 visits. There is no ideal situation given limited time and resource constraints, but these summaries will help to plan future studies.

Vegetation Survey

The vegetation survey was useful for describing the structure and height of each grassland. With the hierarchical cluster, we were able to examine which grassland transects were most alike and compare them to observed patterns of grassland bird usage. In general, the most similar grasslands had similar recent disturbance. The cluster with RAAP, Murphy, and the 2 Crooked Creek transects were typical of grasslands that had remained undisturbed for several years. The remaining 6 fields' transect vegetation clusters showed characteristics similar to disturbed areas, likely due to mowing. The Oriskany B transect with its dense, tall-planted grass stands was unlike any of the other fields in the study. Despite these obvious similarities, we cannot discern any parallel pattern in the diversity, or even presence/absence of birds within these groups. This suggests that these vegetation characteristics are not as important as other factors for higher bird diversity.

We could not find any significant vegetation variables for specific bird models. This could be due to the relatively small number of fields in the study or the small suite of variables we collected. Future studies should incorporate more comprehensive vegetation sampling objectives and more fields in each size class to truly understand the contribution vegetation characteristics have on observed patterns of species presence.

The landscape variables used did reveal some interesting trends. The seemingly small grasslands at the Leslie and Murphy sites were found on predominantly grass landscapes (or nearly so) and had group-1 grassland birds (eastern meadowlark and grasshopper sparrow) present. In contrast, a similarly sized field at Glen Alton Small (GASM) on a predominantly forested landscape did not have any group-1 grassland birds. This indicates that our identification of these fields as "small" may, in fact, be in error. This is not surprising; we did use the grassland complex idea in delineating larger "fields" at

Oriskany, Level Green, and Crooked Creek- Harrison Ridge. In effect, we included these grassland complexes but described them as only small field patches.

When we re-ordered the fields by percent of the landscape in grassland, we see an interesting pattern emerge. The largest grassland landscape is at RAAP followed by VATC, LES, MURPH, LG, CCLF, ORISK, CCHR, GASM, GLEN, and finally CALD. The first 5 of these properties all had eastern meadowlarks on them and 3 of the 5 had grasshopper sparrows.

Perhaps this provides initial evidence that non-grassland areas such as hedgerows and forest patches do not negatively affect the grassland bird's recognition of the area as viable habitat. However, this study has not provided any information as to how large a forest patch, hedgerow, or field border would have to be to prevent grassland birds from using the habitat. This idea has implications for future studies, as large unbroken tracts of grassland are rare on the landscape. It would be difficult to conduct an experiment with replications of fields differing in sizes, if the single large tracts were required. Our results indicate that groups of smaller fields could function as larger grassland habitat assuming the vegetation characteristics of each were appropriate (i.e., not recently disturbed by row crop, mowing, etc.).

To illustrate this point, we recalculated the "actual" size of the grasslands observed in this study by using GIS. The "actual" field size was taken from the GIS as the area of the field (rather than field complex) that contained the vegetation transect. Sub-fields where no vegetation data were recorded were not included, so the newly reported areas may not add up to the previous field complex total. We also used the measured vegetation characteristics and observations of structure taken in the field (Table 17). When compared to our group 1 grassland bird category we see that all fields greater than 30 acres had eastern meadowlarks in them.

Table 17. Adjusted field sizes compared to original field sizes (in acres).

Field	Original Field Area	Adjusted Field Area	Observed EAME	Observed GRSP
RAAP	1700	1700	**Yes**	**Yes**
LG	80	80	**Yes**	**Yes**
VATC	48	48	**Yes**	No
MURPH	4	38.4	**Yes**	**Yes**
LES	4	37.1	**Yes**	No
CCLF	36	36	**Yes**	No
GLEN	32	32	**Yes**	No
CCHRB	62	25.5	No	No
ORISKB	63	22.6	No	No
CALD	22	21.2	No	No
ORISKA	63	11	No	No
CCHRA	62	11	No	No
GASM	6	6	No	No

Predator Surveys

Our artificial nest survey study provided a great deal of data on what predators are present in these fields and which ones may impact the nesting success of grassland birds. The methods used allowed us to identify over 90% of all visited and predated nests. Although the methods used were very labor intensive, we were able to establish and monitor nests efficiently and accurately with few problems.

The most frequent predator overall was the striped skunk, but the clear majority of these events occurred at the Glen Alton fields (both large and small). The most abundant predator over the remaining fields was the raccoon with nearly 50% of the observed nests depredated. We cannot say whether or not the high rate of nest predation at the Glen Alton sites was due to a high population of skunk, or from a single individual but it is clear that predation can be detrimental for a field. This is an important consideration for managers instituting any sort of grassland habitat management or re-stocking program.

Nearly half of the recorded visits to nests were attributed to small mammals. This is likely the result of animals crossing the sand rings by chance or to investigate the new disturbance created. Although small mammals such as white-footed mice (*Peromyscus leucopus)* have been identified as egg scavengers (Fies and Puckett 2000), we attributed one of our predation events to these species. Likewise, the single observation of a rabbit's (*Sylvilagus sp.)* tracks at a predated nest was accompanied by other unidentified tracks. Other visits resulting in nest destruction (e.g., cows stepping on nests) were considered to be nest predations.

We did not observe any relationship between field size and daily survival rate. We also saw no relationship between the distance from edge between predated and undisturbed nests. Burger et al. (1994) reported that nests located <60m from woody cover were three times as likely to be predated than those located further away. They also found that the mean distance to woody edge increased with increasing fragment size. Similar analysis in our study showed that the highest distance to woody edge occurred on our medium-sized properties (Figure 11). This is likely due to the shape and composition of our study fields. The highest mean distance to woody edge was observed in our largest single-fields, Glen Alton large and Caldwell Fields. Hedgerows and forest patches often dissected "large" field complexes, which decrease the mean distance to edge. We cannot say whether these woody areas are acting as travel corridors for predators as would the edges of "clean" fields. Field complexes like those at Oriskany or Crooked Creek – Harrison Ridge were often linear in shape, which results in a smaller core field area and higher area to edge ratio.

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APPENDICES

Appendix 1. Bird species codes.

Species Code	Common Name
AMGO	American goldfinch
AMKE	American Kestrel
COGR	Common Grackle
EABL	Eastern bluebird
EAKI	Eastern kingbird
EAME	Eastern meadowlark
FISP	Field sparrow
GRSP	Grasshopper sparrow
HESP	Henslow's Sparrow
LOSH	Loggerhead shrike
MODO	Mourning dove
NOBO	Northern bobwhite
NOMO	Nothern mockingbird
RWBL	Red-winged blackbird
SOSP	Song sparrow

Appendix 2. Grassland obligate species and grassland generalist species categories used in study.

Groups (NO.)	(1) Ground nesting/ Grassland	(2) Ground nesting/Brush-shrub-occ. tree-open habitat	(3) Small tree-shrub nesting/Brush-shrub-occ. tree-open habitat	(4) Cavity nesting/occ. tree-open habitat
Species	GRSP, HESP, EAME	NOBO, SOSP, FISP	LOSH, RWBL, MODO, EAKI, NOMO, AMGO, COGR	AMKE, EABL

Appendix 3. Total number of stems per field.

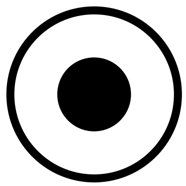
Field	Forbs	Grass	Dead Wood	Woody Stems
MURPH	7	469	0	0
GASM	20	633	0	0
CALD	45	400	0	0
GLEN	27	637	0	0
CCLF	30	534	0	10
VATC	181	616	0	0
CCHR A	60	498	0	3
CCHR B	54	338	0	0
ORISK A	14	990	0	0
ORISK B	14	990	0	0
LG A	52	609	0	0
LG B	22	589	0	0
LG C	5	564	0	0
RAAP	39	790	0	0

Appendix 4. Percent of grass stems occurring in each of the ten 0.1-m sections.

Section	1	2	3	4	5	6	7	8	9	10
Field	G	G	G	G	G	G	G	G	G	G
ORISK A	13.7%	14.6%	13.0%	11.2%	9.1%	10.0%	6.5%	7.3%	4.9%	9.6%
ORISK B	14.6%	19.2%	20.1%	15.7%	8.7%	6.7%	4.0%	2.9%	3.3%	4.7%
CCHR A	18.7%	24.9%	16.9%	12.2%	10.4%	7.0%	4.6%	2.4%	1.2%	1.6%
VATC	21.4%	24.5%	20.3%	12.0%	6.0%	3.1%	3.7%	3.9%	1.9%	3.1%
RAAP	28.7%	27.1%	16.5%	9.6%	4.1%	5.7%	2.2%	2.7%	1.8%	1.8%
CCLF	17.0%	30.0%	28.7%	11.0%	6.2%	2.8%	2.2%	1.1%	0.9%	0.0%
LG A	32.8%	30.9%	16.4%	8.4%	5.6%	3.1%	1.8%	1.0%	0.0%	0.0%
LG B	33.4%	29.9%	17.8%	7.1%	3.4%	3.9%	2.9%	1.2%	0.3%	0.0%
CCHR B	20.1%	29.9%	25.4%	18.0%	5.9%	0.6%	0.0%	0.0%	0.0%	0.0%
GASM	35.4%	31.6%	17.1%	8.2%	3.2%	3.2%	1.3%	0.2%	0.0%	0.0%
GLEN	38.3%	32.8%	14.4%	8.8%	2.2%	2.0%	0.8%	0.6%	0.0%	0.0%
LG C	36.0%	38.3%	15.1%	3.7%	2.1%	2.8%	1.2%	0.5%	0.2%	0.0%
MURPH	28.4%	34.8%	27.9%	6.4%	1.7%	0.6%	0.0%	0.2%	0.0%	0.0%
CALD	40.3%	36.0%	15.5%	2.8%	2.5%	0.8%	1.3%	0.3%	0.3%	0.5%

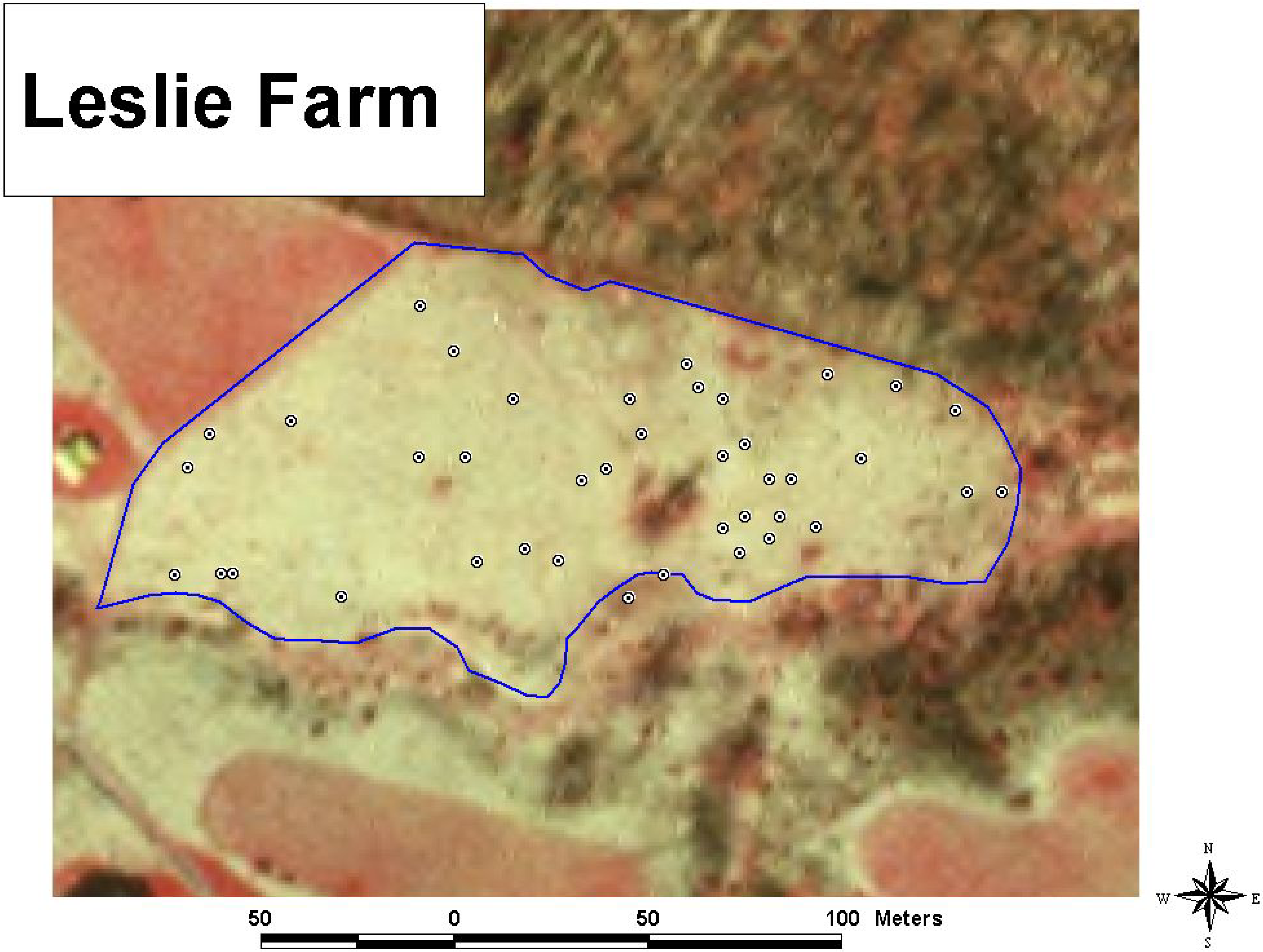
Appendix 5. Study area maps

Legend Symbols



Nest location

Transect line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50
100 Meters
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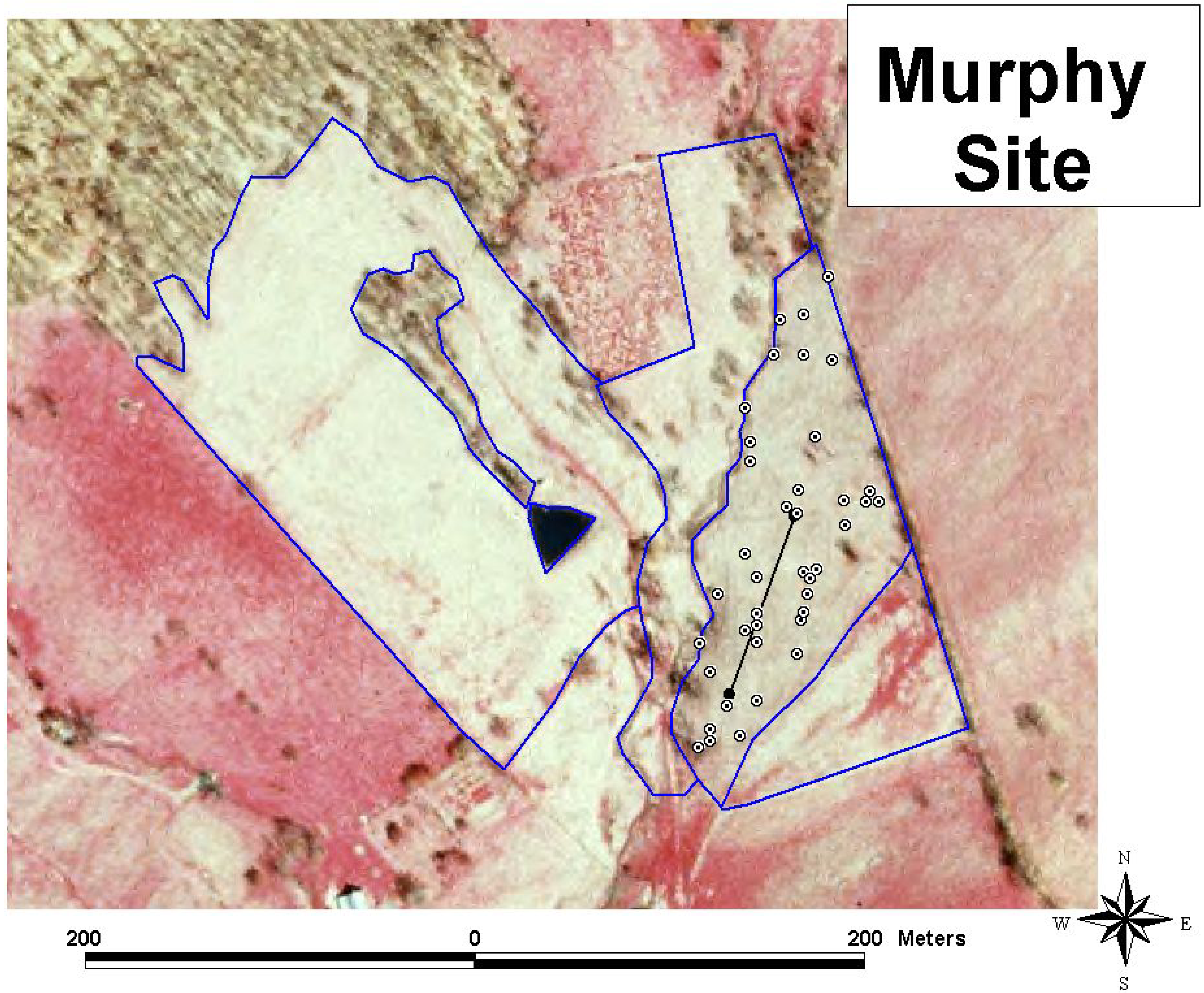
W
E
S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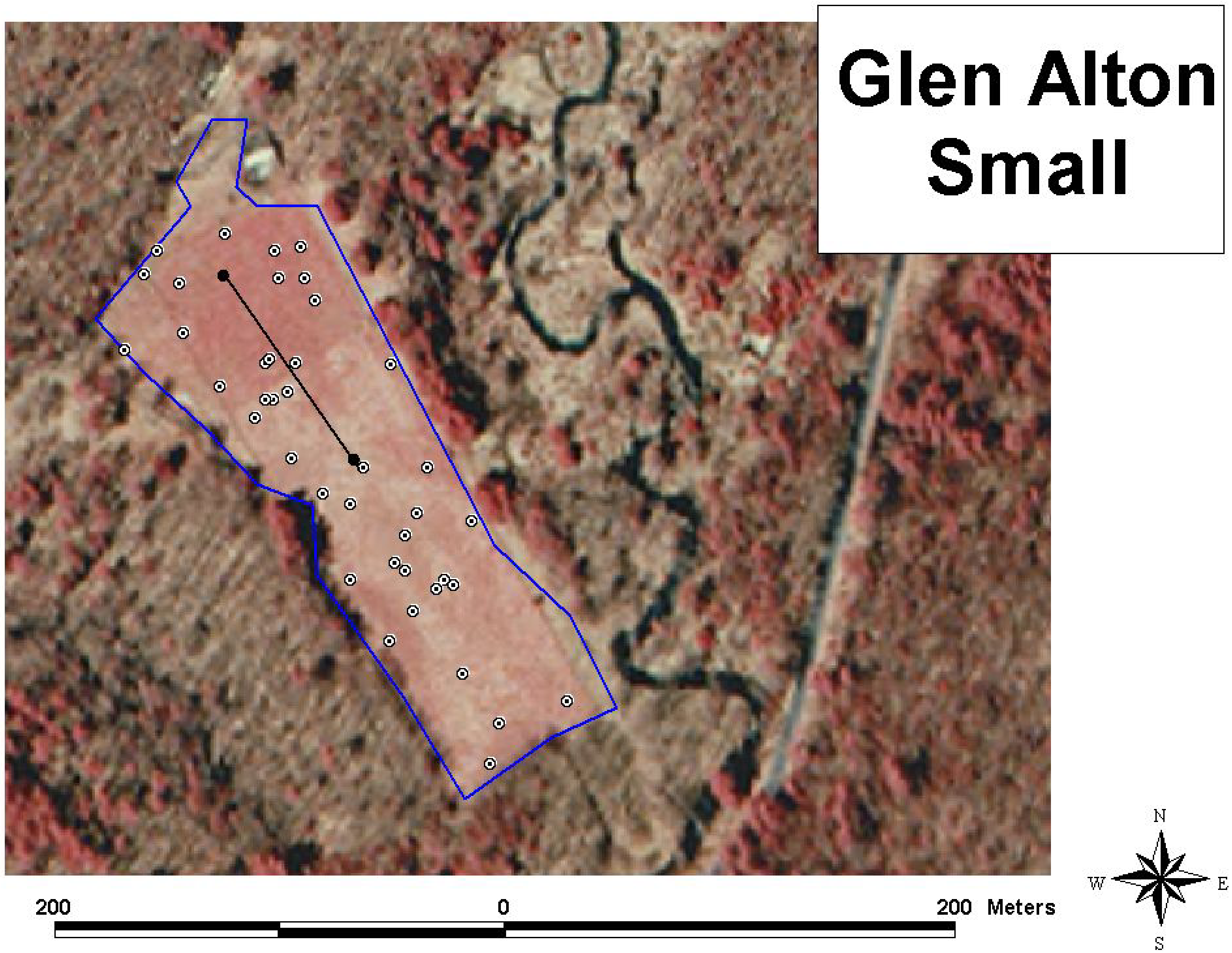
0
200 Meters
N
W
E
S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Small
200
0
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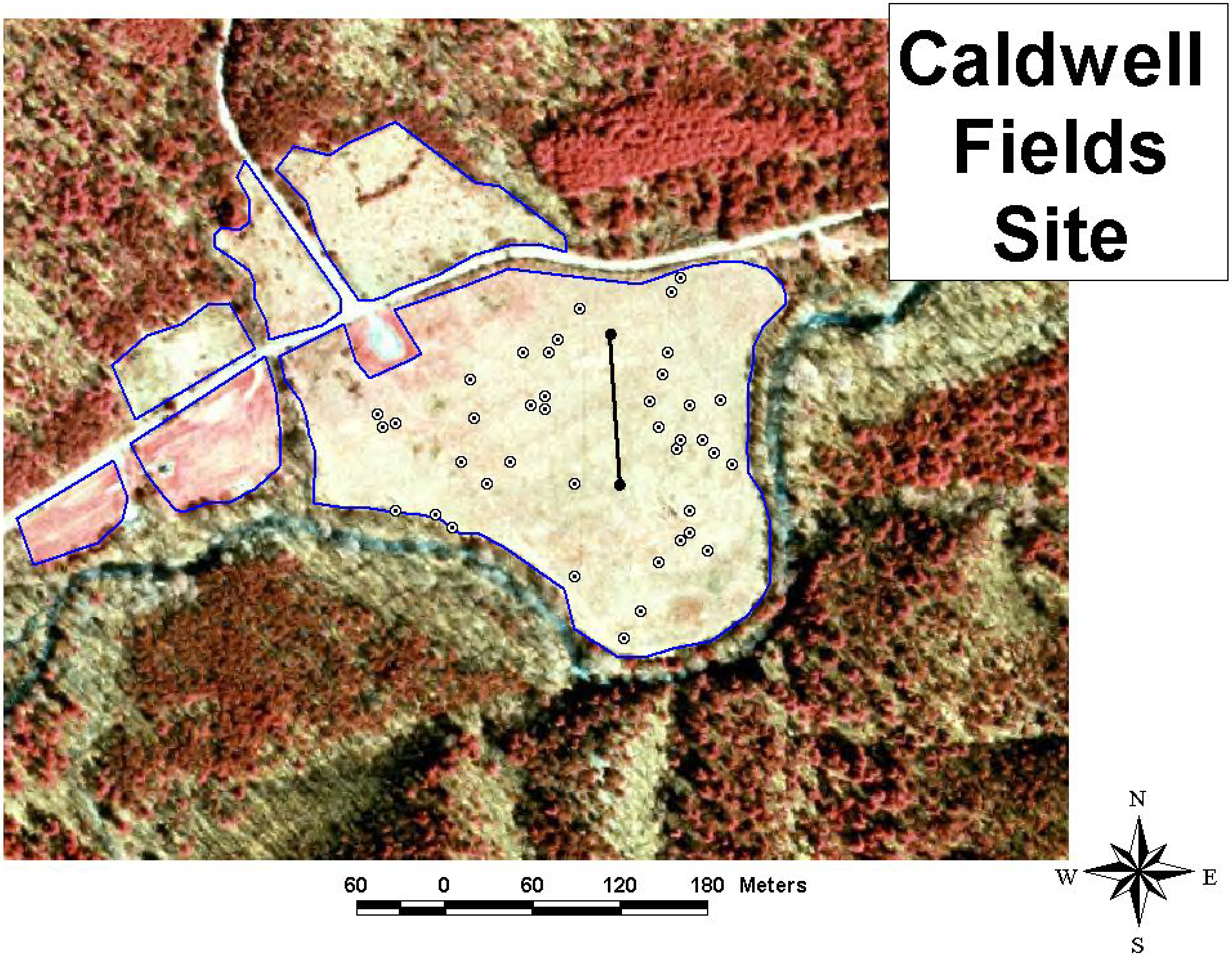
N
W
E
S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Fields
Site
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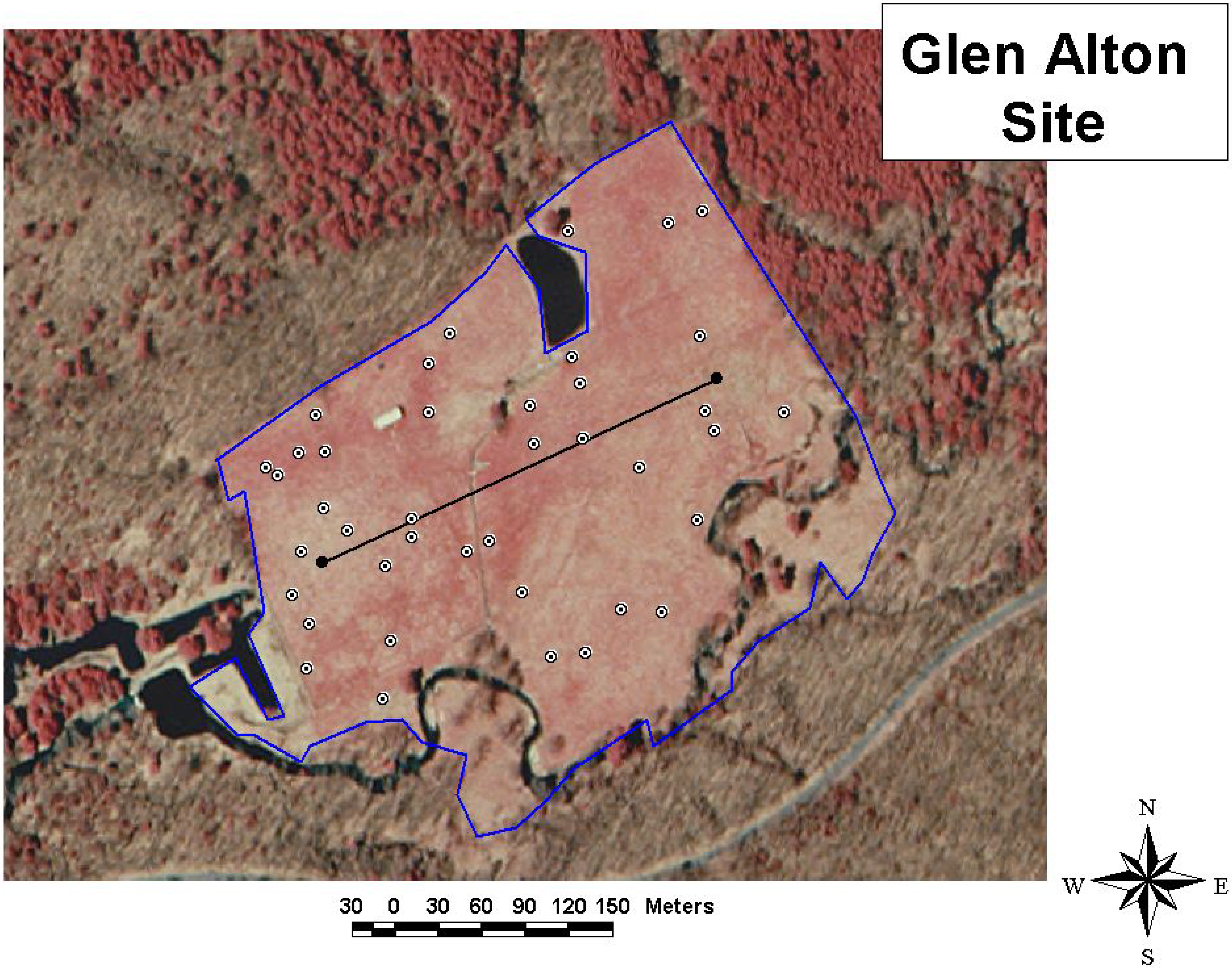
N
W
E
S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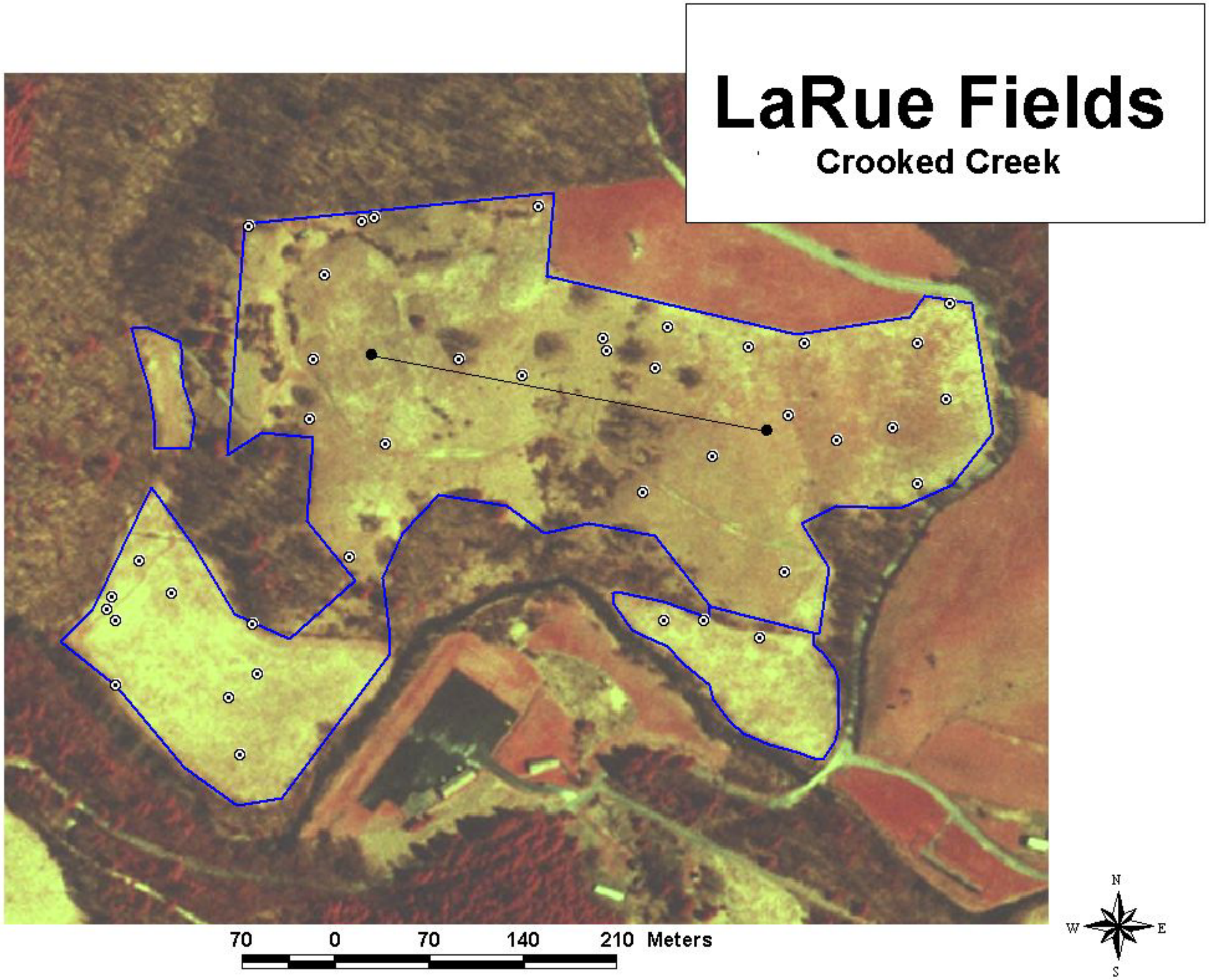
W
E
S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Crooked Creek
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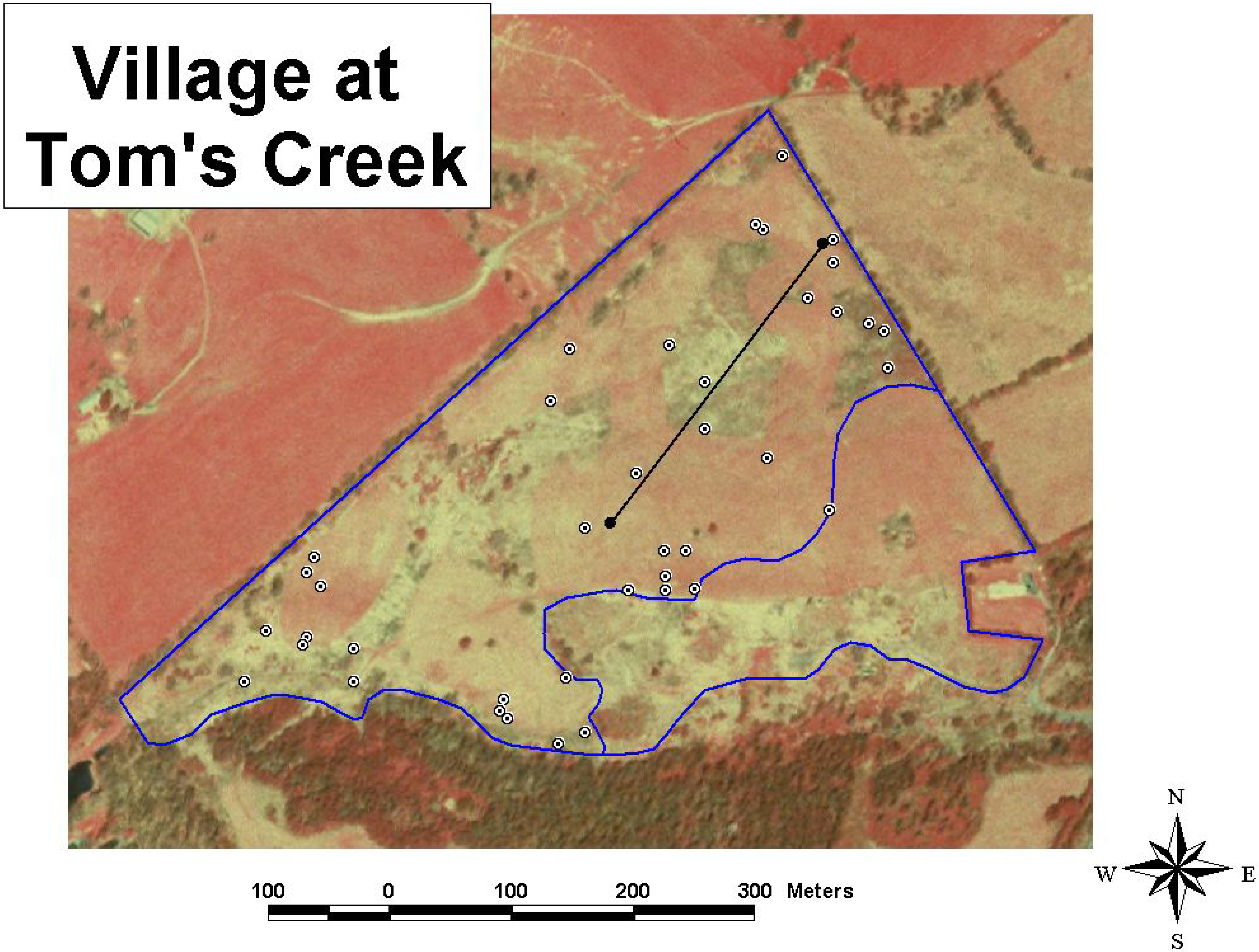
W
E
S


Village at
Tom's Creek
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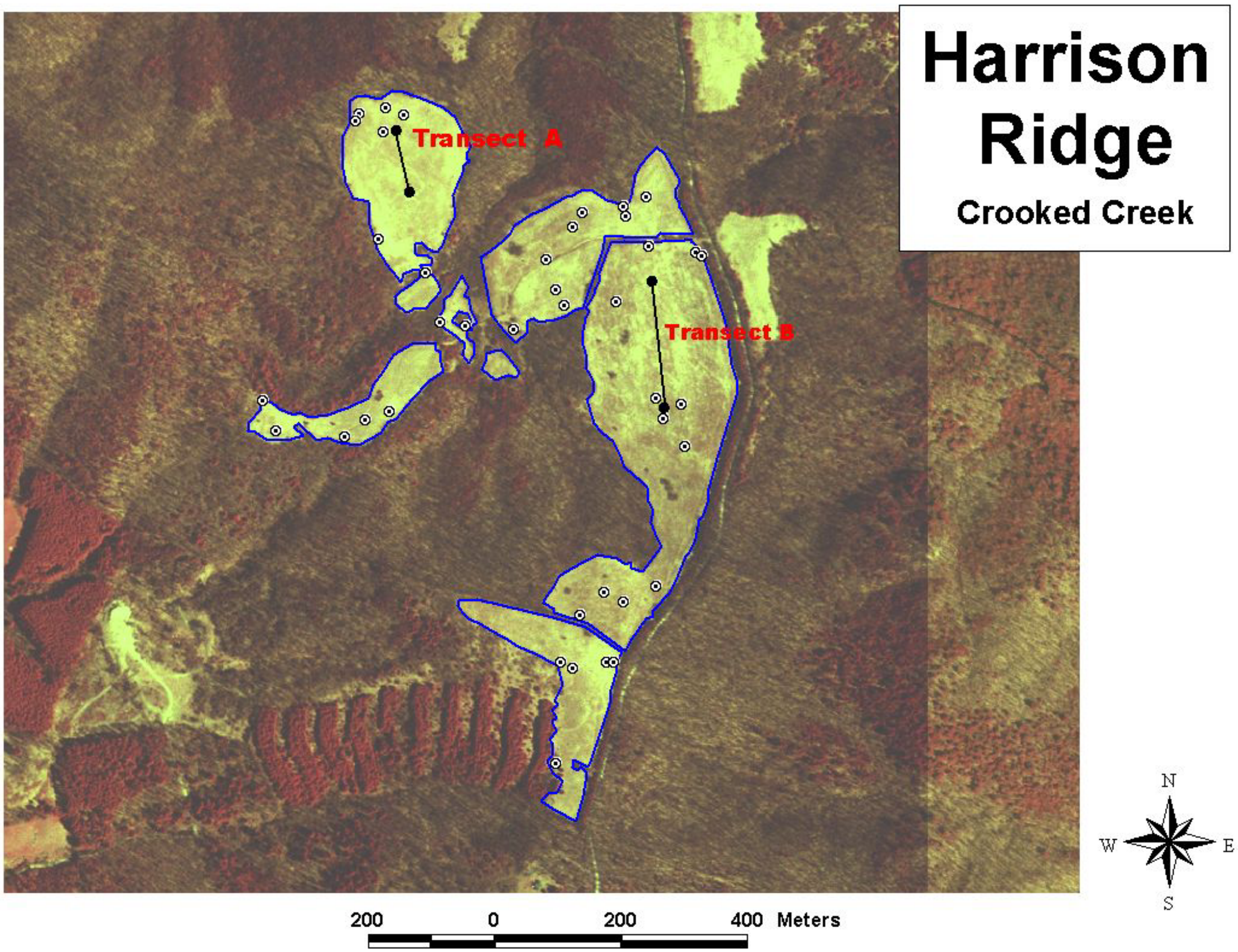
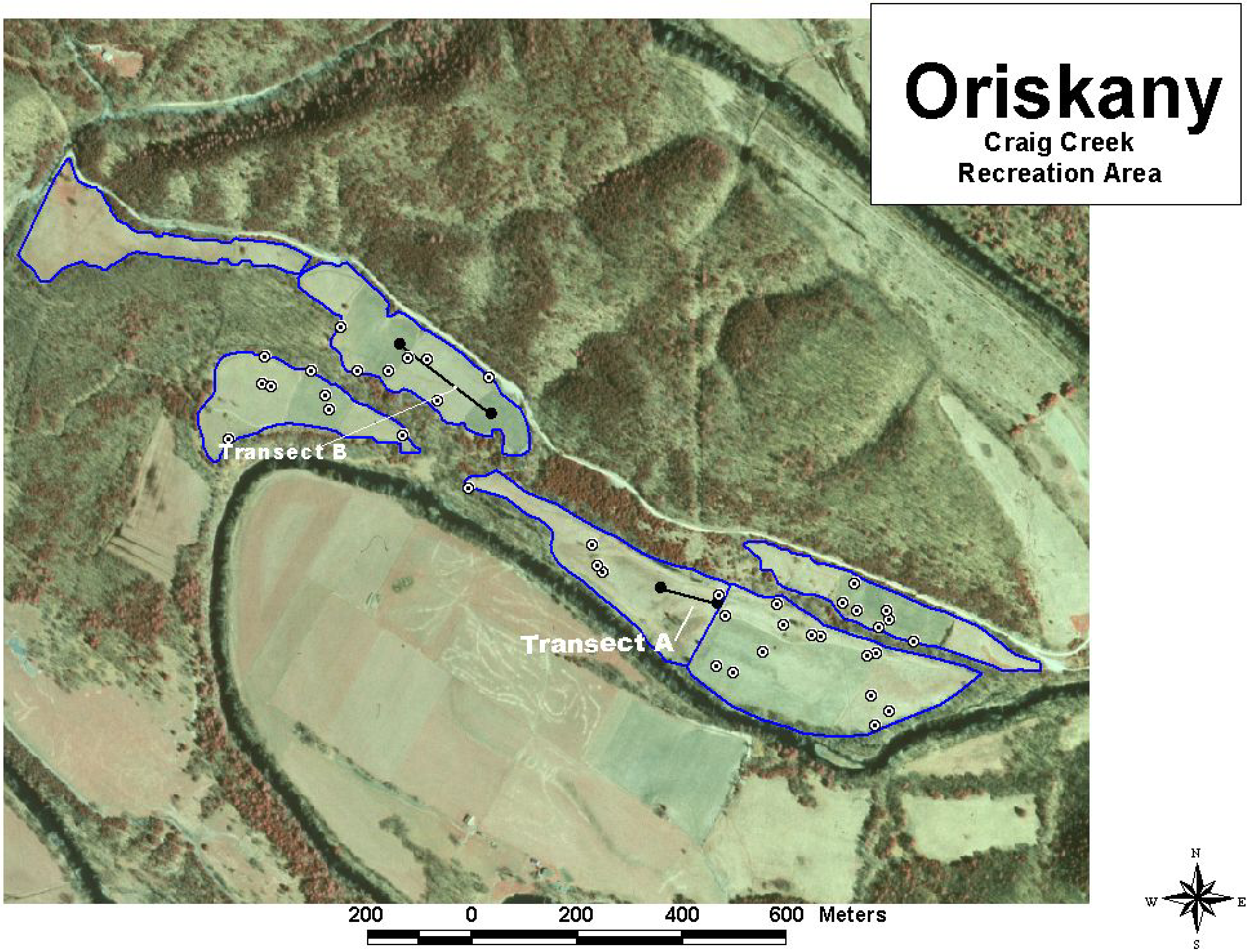
N
W
E
S


Harrison
Ridge
Crooked Creek
Transect A
Transect B
N
W
E
S
200
0
200
400 Meters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Craig Creek
Recreation Area
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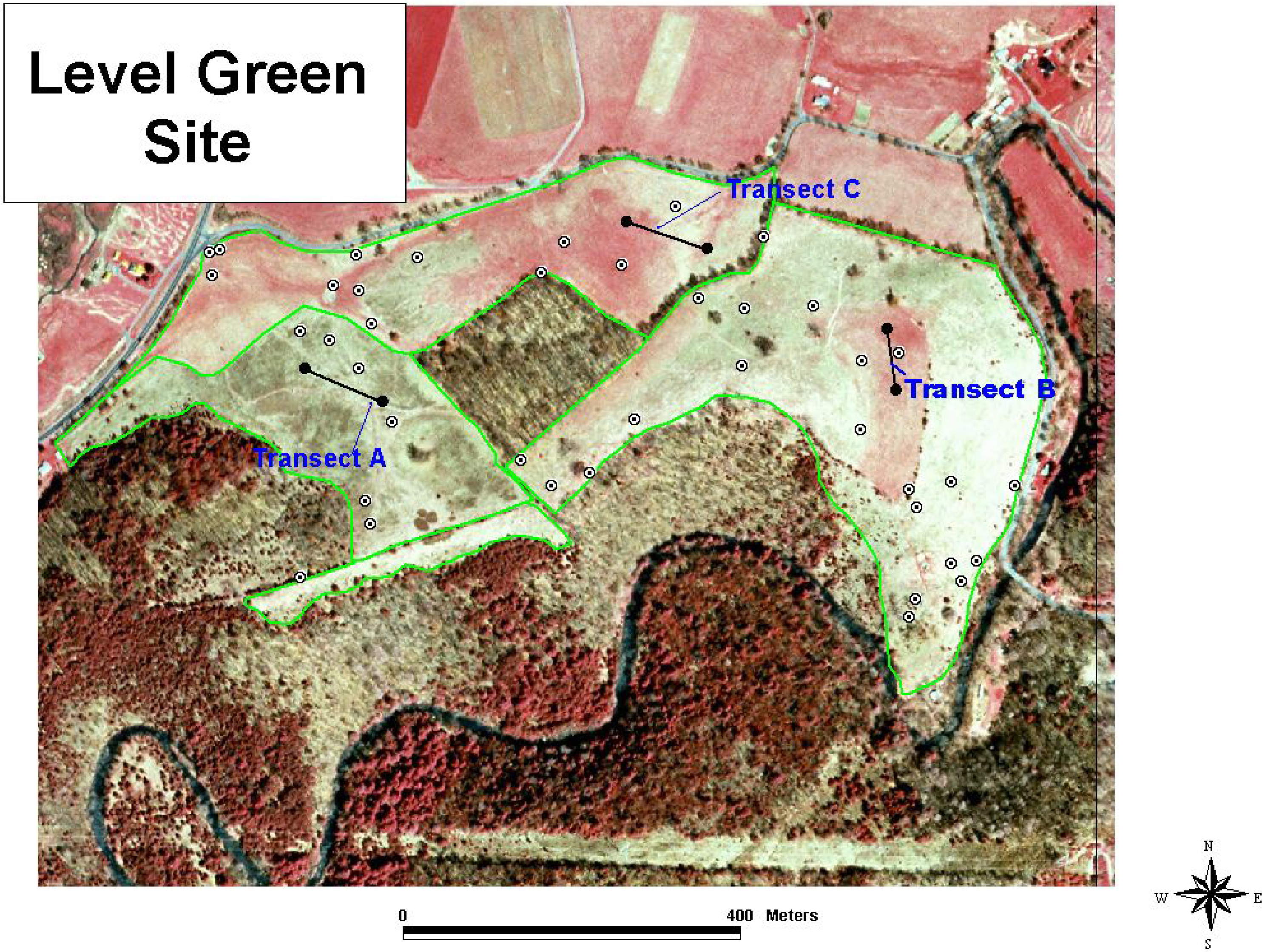
W
E
S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Transect B
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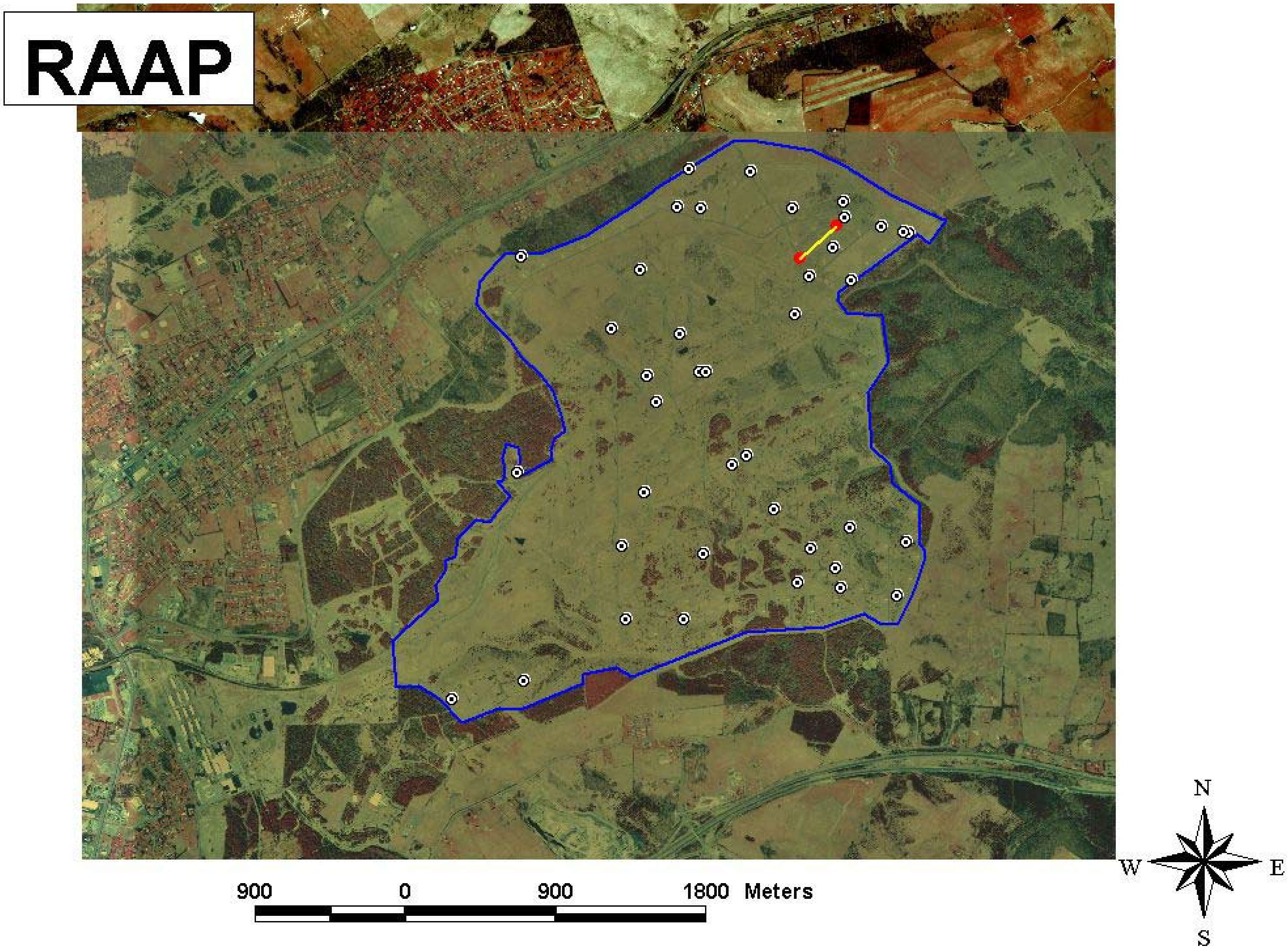
W
E
S


RAAP
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900
1800 Meters
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W
E
S