The Pennsylvania State University

The Graduate School

School of Forest Resources

EFFECTS OF LOCAL AND LANDSCAPE FEATURES ON AVIAN USE AND PRODUCTIVITY ON PENNSYLVANIA CONSERVATION RESERVE ENHANCEMENT PROGRAM FIELDS

A Thesis in

Wildlife and Fisheries Science

by

Kevin Loyd Wentworth

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

December 2006

The thesis of Kevin Loyd Wentworth was reviewed and approved* by the following:

Margaret Brittingham
Professor of Wildlife Resources
Thesis Advisor
Chair of Committee

Duane Diefenbach
Adjunct Associate Professor of Wildlife Ecology

Heather Karsten
Associate Professor of Crop Production/Ecology

Walter Tzilkowski
Associate Professor of Wildlife Science

Charles Strauss
Professor of Forest Economics
Director School of Forest Resources

*Signatures are on file in the Graduate School

ABSTRACT

In 2001, a federal program, the Conservation Reserve Enhancement Program (CREP), was initiated in 20 counties in south-central Pennsylvania to address soil erosion and water quality with an expected secondary benefit of providing habitat for wildlife. Because of the decline in grassland bird populations in North America I wanted to identify what species were using CREP fields. I also wanted to identify what field and landscape characteristics affected use and productivity of avian species on CREP fields. To assess the benefit of CREP fields benefit for grassland birds, I compared them to active hayfields.

The project was conducted from May 2001 – July 2004 in 9 CREP counties of south-central Pennsylvania. I randomly selected CREP fields in three size categories: 2.0 – 4.0 ha, 7.3 – 12 ha, and 16 – 28 ha to get a mixture of field sizes because small fields were much more common than either medium or large fields. Hayfields were located as near as possible to selected CREP fields. I surveyed birds in all fields twice during the breeding season, using distance sampling to generate densities for each species that had > 25 observations. I searched for nests in over half the fields that were surveyed. Nests that were located were monitored until completion (fledging, depredation or abandonment). Vegetation was measured at the nest and along the survey transects. Landscape characteristics were calculated using geographic information system data for the areas surrounding the fields.

I made a total 1,929 observations of 31 different species on 114 CREP fields. I monitored 969 nests of 19 species in 73 CREP fields. The most common species was the

red-winged blackbird (*Agelaius phoeniceus*) with 1,052 observations and 613 nests. The next most common species were field sparrows (*Spiza pusilla*; 111 obs.; 171 nests), song sparrows (*Melospiza melodia*; 343 obs.; 78 nests) and indigo buntings (*Passerina cyanea*; 130 obs.; 21 nests). The most common grassland specialists were grasshopper sparrows (*Ammodramus savannarum*; 104 obs.; 19 nests) and eastern meadowlarks (*Sturnella magna*; 31 obs.; 9 nests). Ring-necked pheasants (*Phasianus colchicus*; 3 nests), dickcissels (*Spiza americana*; 2 obs.; 1 nest), Henslow's sparrows (*Ammodramus henslowii*; 2 obs.), savannah sparrows (*Passerculus sandwichensis*; 17 obs.; 2 nests), vesper sparrows (*Pooecetes gramineus*; 10 obs.; 5 nests) and bobolinks (*Dolichonyx oryzivorus*; 50 obs.; 1 nest) were uncommon to rare. Mayfield nest success for the most common above-ground nesting species, red-winged blackbird, was 30.2 $\pm$ 2.0% and the most common ground nesting species, grasshopper sparrow, was 12.4 $\pm$ 7.1%.

I developed models to describe species density and nest abundance. Both field and landscape characteristics were significantly associated with species density and nest abundance, but the specific variables and the direction of effect varied among species and in some cases varied between density and nest abundance within a species. Consequently, there were no specific variables that were universally important to the community of birds using CREP fields.

I made 68 observations of 7 different species on 16 hayfields and 185 observations of 8 different species on the 16 matched CREP fields. Species richness was higher ($p=0.001$) on CREP fields (2.75 ± 0.233) than hayfields (1.38 ± 0.24). Densities of field sparrows, song sparrows and indigo buntings were higher on CREP fields than hayfields ($p = 0.012, 0.004, 0.006$ respectively). No other species differed in density

between hayfields and CREP fields. I located 193 nests of 10 different species on 15 CREP fields and 87 nests of 5 species on 15 hayfields. Species richness of nesting birds was higher ($p < 0.001$) on CREP fields (2.47 ± 0.40) than hayfields (0.60 ± 0.19). Field sparrow and song sparrow nest abundance was higher ($p = 0.011$, 0.001 respectively) on CREP fields (0.318 ± 0.15, 0.193 ± 0.10) than hayfields (0.006 ± 0.01, 0.006 ± 0.01). No other species differed in nest abundance between hayfields and CREP fields. However, wild turkeys, indigo buntings and eastern meadowlarks were only located nesting on CREP fields and not on hayfields. Nest success of red-winged blackbirds (the only species with multiple nests on hayfields) was higher ($p = 0.029$) on CREP fields (27.9 ± 6.2%, $n = 59$) than hayfields (12.6 ± 3.4%, $n = 73$).

My study indicated that generalist and edge species used CREP fields much more than grassland specialists. Although numbers of grassland specialists are low, overall species richness, abundance and nest success were higher on CREP fields than hayfields. To provide habitat for a diversity of farmland and grassland species and to increase the likelihood that grassland specialists will use CREP fields, the largest fields possible should be enrolled in the CREP program. Since the sizes of agricultural fields in Pennsylvania tend to be small, one way to increase effective field size would be to attempt to enroll adjoining fields in CREP even if they are owned by different people. Fields should be managed to provide heterogeneous vegetation, including heterogeneity of vegetation types (e.g. forbs and grass), species and structure (e.g. different heights and density). Some form of maintenance, such as strip mowing, burning or light disking, on the field will probably be necessary to maintain or attain heterogeneity. Monitoring of

CREP fields should continue to assess how avian species composition and abundance change as the fields mature.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

I wish to thank the CREP habitat biologists that were important in giving me field information and contacting owners. I also wish to thank Scott Klinger for his input in research design and assistance in gathering information. My committee, Duane Diefenbach, Heather Karsten and Walter Tzilkowski were important in suggesting improvements on my research design, data analysis and thesis. I would especially like to thank my advisor, Margaret Brittingham, for her help throughout my program. I would not have been able to do this research without the support of the owners that allowed us to work on their fields, including Pennsylvania Power and Light for allowing us to work on the Montour Preserve. The following people assisted in the field work: Johnathan Campbell, Nina Cohen, Melody Conklin, Patricia Donnellan, Jessica Gelnett, Justin Gross, Daniel Hinnebusch, Michael Lohr, John Masters, Scott McConnell, Lisa McGoldrick, Johnathan McGrath, Jacob Mohlman, Matthew Potter, Joshua Rupert, Jason Ryan, Matthew Schavnis, Lisa Zahuranec. I wish to thank the Pennsylvania Game Commission for funding this project. Joe Bishop was instrumental in generating landscape data. Finally, a special thanks to my family for supporting me throughout the doctoral process.

Chapter 1

Introduction

The Conservation Reserve Enhancement Program (CREP) is a federally-funded program of the United States Department of Agriculture (USDA) that offers farmers the opportunity to take highly erodible and environmentally sensitive land out of production, thereby improving water quality, and reducing soil erosion. A secondary benefit is the increase in grassland, wetland and riparian habitat for wildlife (www.fsa.usda.gov/dafp/cepd/crepqnas.htm). The program provides significant increases in the rental rate farmers are currently offered through the Conservation Reserve Program (CRP), making it more economically feasible for them to participate. Such a program is urgently needed to restore wildlife habitat, particularly that of small game and grassland-nesting birds. Twenty Pennsylvania counties within the Chesapeake Bay Watershed (a national priority area for recovery) were identified for the initial enrollment period. Within these counties there are 22,685 farms comprising 1,201,662 ha (2,970,000 acres) of farmland, 931,794 ha (2,303,000 acres) of which are cropland. Of the cropland, 288,075 ha (712,000 acres) are considered highly erodible land that should be idled (Tosiano and Capstick 1999). The goal of the CREP Program is to enroll at least 40,460 ha (100,000 acres) in the Pennsylvania program (www.dep.state.pa.us/dep/deputate/polycomm/update/05-26-00/052600u7). Enrollment of 40,460 ha (100,000 acres) of farmland in Pennsylvania has the potential to significantly benefit grassland-nesting birds, such as ring-necked pheasants (see

Appendix A for scientific names) and grasshopper sparrows. However, to maximize program benefits, managers need to know how avian use and productivity vary with field size and vegetative structure (density; height; and percent composition of grass [warm or cool-season], forb, and woody vegetation). It is also important to understand whether the immediate surroundings (e.g., wooded or agricultural edge) impact productivity and use.

From work in both forest and grassland habitats, we know that avian use and productivity vary with both local and landscape features (Askins 1993, Mcgarigal and McComb 1995, Donovan et al. 1997). For example, numerous grassland species including bobolink, vesper sparrow and grasshopper sparrow are considered to be area-sensitive and occur rarely in fields below a minimum area (Askins 1993). However, this minimum area is variable depending on geographic location (e.g. Herkert 1994, Vickery et al. 1994, Bollinger 1995, Winter and Faaborg 1999, Horn et al. 2002), with the majority of work done in the Midwest where the landscape is primarily open habitat. Consequently, it is important to understand how grassland species react in a primarily forested state such as Pennsylvania. Studies in the Midwest have been conducted to look at the effects of CRP practices on wildlife (e.g. King and Savidge 1995, Best et al. 1997, Horn 2000), but these studies may not be directly applicable to the Eastern United States where field size is smaller and the landscape matrix is primarily forest. King and Savidge (1995) examined fields that ranged from 40-80 ha; Best et al. (1995) had an average field size that ranged from 11.5 ha in MI to 39.1 ha in IA; and Horn (2000) examined fields with a median size of 28 ha in ND and 19 ha in IA. In Pennsylvania, the largest fields available in CREP are approximately 42 ha and the mean is 8.1 ha (Scott Klinger pers. comm.). Depredation may be higher on nests near a forested edge (Johnson and Temple 1990, see Johnson 2001), which may decrease productivity in a landscape dominated by forest. Productivity, a better measurement of habitat quality, for ring-necked pheasants and other grassland birds is also dependent on habitat patch area and the composition and structure of vegetative cover (e.g. Johnson and Temple 1990, Horn 2000, McCoy et al. 2001).

My objectives were to (1) determine the abundance, distribution, and productivity of grassland birds on CREP fields; (2) determine how field area affects use and productivity of grassland birds; (3) determine what vegetation characteristics affect the use and productivity of grassland birds, especially the use of warm-season and cool-season grasses, since these are the two dominant plantings within CREP fields; (4) determine if differing landscape characteristics affect the use and productivity of grassland birds; (5) determine if there is a difference in use and productivity between CREP fields and hayfields.

Chapter 2

Grassland bird density on Pennsylvania Conservation Reserve Enhancement Program fields

Introduction

Grassland birds have experienced widespread declines throughout the Midwest and eastern United States (Robbins et al. 1986, Bollinger and Gavin 1992, Askins 1993) and have declined more than any other group of birds over the last 25 years (Knopf 1994, Herkert 1995). In Pennsylvania, species such as grasshopper sparrows (scientific names given in Appendix A), vesper sparrows, bobolinks, eastern meadowlarks, northern bobwhites, and ring-necked pheasants have declined by 80% or more since the mid 1960s (Sauer et al. 2001). Declines have been attributed to habitat loss and changes on both the breeding grounds (Samson and Knopf 1994) and the wintering grounds (Fretwell 1986). In Pennsylvania, loss of habitat for these species has occurred primarily because of farmland conversion and changes in farming practices. One possible outcome of the Conservation Reserve Enhancement Program (CREP) is to reverse this trend, by providing quality habitat for grassland and farmland birds. Since 2001 the CREP program has enrolled over 40,000 ha of highly erodible agricultural land in 20 counties in south-central Pennsylvania. Fields are enrolled for a 10 or 15-year period and placed under a permanent cover, typically grass.

To maximize program potential for grassland habitat it is important to identify the local and landscape characteristics of a field that will increase use by grassland birds. Field characteristics such as area (Johnson 2001) and vegetation characteristics (Herkert

1994, Vickery et al. 1994) are correlated with abundance and distribution of grassland birds. However, the importance of landscape factors, such as the amount of forest cover, herbaceous cover, or habitat fragmentation to grassland birds is not well understood. The objectives of this study were to identify bird species that regularly use CREP fields in Pennsylvania and identify the local and landscape features that affect grassland bird density.

Methods

Study area and field selection

The study area covered 20 counties in south-central Pennsylvania containing 2,781 fields > 0.5 ha (mean 9.3 ha) enrolled in CREP. Field selection for inclusion in my study was limited to conservation practices that were grass dominated: CP1 (cool-season grass), CP2 (Warm-season grass), CP10 (grass cover already established), CP21 (grass filter strips) or a mixture of the four. Cover types that were excluded from the study were CP3A (hardwood plantings), CP4D (permanent wildlife habitat – must include trees), CP9 (shallow water area), CP12 (food plots), CP22 (forested stream buffers), and CP23 (wetland restoration). Fields that were not already under permanent cover were sown with a grass (e.g., big bluestem, tall fescue, orchard grass, smooth brome, and switchgrass; see Appendix A for scientific names) and a legume (e.g., red clover) or wildflower mixture. Other vegetation that commonly invaded the fields included goldenrod, milkweed, thistle, fleabane, sweet clover, multi-flora rose, and blackberry. Fields selected for study ranged in area from 1 ha to 41 ha (mean 11.2 ha $\pm$ 8.7 SD).

I conducted the study from May through mid July each year from 2001 to 2004, though because of a change in methodology data from 2001 were not included in this portion of the study. Fields were selected using two categories of selection: percentage of forest cover and field size. Field selection differed slightly between years as I improved my methodology. In 2002, I separated the 20 counties in CREP into three categories by the percentage of forest cover within the county (to select for landscape differences): 19 - 45% (low), 46 - 60% (medium), and 61 - 74% (high). I then randomly selected six counties (two from each level of forest cover). Within these selected counties, three fields were randomly selected from three size categories: <4.0 ha (small), 7.5 - 12 ha (medium), and >16 ha (large).

In 2003-2004, I used an analysis of vegetation cover types across Pennsylvania from satellite and aerial photographs (Myers et al. 2000), to calculate the percentage of forest cover within a 1 km radius of individual fields (digitized maps created by National Resource Conservation Service biologists). Because I now had information for individual fields, I had a larger range in forest cover and redefined my selection criteria for 2003 – 2004 as low 0 – 33%, medium 34 – 66%, high 67 – 100% and subsequently reclassified my 2002 fields using the same criteria. In 2003, I randomly selected six fields in each category (field area and forest cover). In 2004, I resurveyed 23 fields surveyed in either 2002 or 2003 to study between year differences and randomly selected an additional 18 fields (six from each field size category) to equalize the number of fields in forest cover categories. Changes were made to the selections because of changes in the status of fields (e.g., some dropped out of CREP), incorrect information (e.g., fields not actually being of the area indicated), inability to get permission, and my need to cluster fields within a 45-minute drive to minimize travel time between fields.

Avian abundance

Four different observers surveyed the fields, two observers per year. The observers surveyed each field using distance-sampling techniques, to correct for different detection probabilities among individuals and species (Buckland et al. 2001). Transects were established 100 m from an edge and then every 250 m until the field was covered. The final transect was at least 50 m from the farthest edge. Each field was surveyed twice, first from late May to mid June and secondly from late June to mid July to detect early breeders and to detect late-breeding Neotropical migrants. All visible singing males in the field were recorded with angle (along the transect) and distance from observer to the bird recorded. Surveys were conducted from sunrise to 3 hours after sunrise and were not conducted when it was raining, foggy, or the winds were greater than 16 kph (Best et al. 1977).

Using Program Distance 3.5 (Thomas et al. 1998), I calculated the density of each bird species, for which I had > 25 observations but attempted to look at differing detection functions for species that had >60 total observations (Diefenbach et al. 2003). This limited the number of species for modeling to common yellowthroats, field sparrows, grasshopper sparrows, song sparrows, bobolinks, eastern meadowlarks, and red-winged blackbirds. Outlying perpendicular distances were truncated when necessary to better model the data; the chi-square goodness-of-fit test was used to assess model fit (Burnham and Anderson 1998); and Akaike's Information Criterion (AIC; Akaike 1973 and 1985, Buckland et al. 2001) was used to select the most parsimonious model. I had enough observations of red-winged blackbirds that each observer was modeled for their own detection function. I did not have enough observations of bobolinks and field sparrows to model observer differences. For song and grasshopper sparrows the three observers who worked only one year were lumped together (to have >60 observations), and I was considered a separate observer to model for different detection functions, but the model with all observers was more appropriate. To calculate density per field, I used the formula:

$$\mathbf{(n*f(0)/2*L)*10{,}000 = birds\ ha^{-1}}$$

with n being the maximum number of birds seen in the field during either survey (this indicates the highest likely density on the field); f(0) is the probability density function of distances from transect, evaluated at zero distance for that species (and observer for red-winged blackbird); L is the total length (m) of transects in the field (Buckland et al. 2001).

Local and habitat characteristics

Field vegetation was sampled using six equally spaced points along the already established survey transects on each field concurrent with the surveys (late May to mid

June and late June to mid July; McCoy et al. 2001; see Appendix B for vegetation information on all fields). At each point, I measured vertical density using a Robel pole (Robel et al. 1970) recorded to the nearest cm from 4 m to the north of the point at a height of 1 m. I used a 0.5 m^2 Daubenmire frame (Daubenmire 1959) to measure vegetation cover centered on the point. I measured the percent cover (non-overlapping) of warm-season grass, cool-season grass, downed litter (decaying litter on the ground), standing litter (dead stems that are still standing), woody vegetation, forbs, and bare ground. I also measured the height of vegetation and litter depth by measuring the highest point of vegetation and the depth of downed litter in the middle of the Daubenmire frame to the nearest cm (Table 2.1). Coefficients of variation were calculated for each field for cover of grass (combining warm and cool-season grasses), forbs, downed litter, bare ground, and vertical density. These measurements were used to identify the homogeneity of the fields. Some fields were very homogeneous with grass or forbs cover and had continuous litter cover. The variation in bare ground and vertical density indicated whether the fields were homogeneous in structure, patchiness or verticality respectively. I trained each observer to measure the different vegetation characteristics.

Landscape level analysis

Land cover characteristics were calculated from the GAP analysis (a landscape level analysis of habitat for wildlife) of PA (Myers et al. 2000; see Appendix C for landscape information on all fields). Radii were established around each field (0.5 km, 1 km, 2 km, and 5 km) using ARCVIEW 3.4 © (ESRI) to calculate the landscape statistics. The radius was established from the edge of the field to remove the field from the analysis because field area, vegetation, and perimeter-area ratio were already measured variables. The total area included within the radius was different for each field area but all landscape statistics were calculated as proportions of the total area to allow comparisons. Because of high correlations among radii only 0.5 km and 5.0 km radii were used in the final analysis (see Appendix D for correlations of landscape variables). The landscape variables used in the final analysis were mean patch size (measured in ha; MPS), Shannon Diversity Index (measure of the proportion of the landscape in different cover types with 0 indicating only one cover type in the landscape; SDI), core area density of perennial herbaceous cover (number of patches of perennial herbaceous cover that had an interior greater than 60 m from any edge and reported as number per ha), forest edge density (the length of forest edge m/ha combining all forest classes together), road density (the length of road m/ha), and the cover percentage of forest (combined all forest classes), annual and perennial herbaceous (combined with transitional cover). The landscape metrics of mean patch size, Shannon Diversity Index, core area density of perennial herbaceous cover, and forest edge density were calculated using FRAGSTATS (McGarigal and Marks 1995; Table 2.2).

Spatial coordinates for each field were taken from digital maps provided by Natural Resource Conservation Service biologists in ARCGIS 9.0 © (ESRI). All maps were projected as 17N UTM and the fields were recorded as a distance in m, from west (123,670 m) to east (453,575 m) and from south (4,475,352 m) to north (4,570,977 m).

Data analysis

I used the Kolmogorov-Smirnov test of normality on all data to determine if the data were normally distributed. Data were transformed if not normally distributed using square root transformations for dependent variables, and logarithmic and arcsine transformations for independent variables (Zar 1999). MINITAB^{tm} (MINITAB, Inc.) was used to calculate all normality tests, Pearson correlations, Mann-Whitney, ANOVA and Principle Component Analysis (PCA). I used Program R 1.8.1 © (R Development Core Team) to analyze regression data. CONOCO 4.5. (ter Braak and Smilauer 2002) was used to analyze Canonical correspondence data. I report means with $\pm$ 1 SE, unless otherwise noted. I report statistical significance when $p \leq 0.05$, and I report a trend when $0.10 \geq p \geq 0.05$.

Comparison of densities on fields that were surveyed on multiple years was conducted using a Mann-Whitney test because the data were non-normally distributed. In addition, I used all fields to test whether density of individual species varied among years by comparing mean annual densities using GLM ANOVA with log-transformed field area as a covariate. In all other analyses, one year was randomly selected between the two years of survey information to avoid pseudoreplication (Hurlbert 1984).

Vegetation and landscape variables were inter-correlated (see Appendix C and D for correlations), and therefore it was necessary to use PCA to create independent variables that could then be used in regressions. Principle Components (PC) were selected with eigen values ≥ 1.5, and I report only those variables with a weight ≥ 0.380.

Densities of birds were changed to abundances by multiplying the density calculated for each field by its area and rounded to the nearest integer for use in Poisson regression models. Models were then weighted by log-transformed field area to equalize area between different fields. I used AIC to select the most parsimonious model.
I performed canonical correspondence analysis (CCA) to examine the community response of grassland birds to local and landscape features. CCA allows an examination of species to each other and environmental variables at the same time. Landscape and vegetation variables were log transformed prior to entering CONOCO. Only those species for which a density was calculated (common yellowthroat, field sparrow, grasshopper sparrow, song sparrow, bobolink, eastern meadowlark, indigo bunting and red-winged blackbird) were included in the analysis and the densities were log transformed within CONOCO. Variables were selected manually using Monte Carlo permutation tests and were included in the model if significant ($p \leq 0.05$). I used restricted permutations to remove the possible influence of spatial autocorrelation (ter Braak and Smilauer 2002).

Results

Species use of CREP fields

I made a total 1,929 observations of 31 different species on 114 different fields (Table 2.3). Grasshopper sparrows were found on just over one quarter of the fields, which was the highest percentage for all the grassland specialists. The least common grassland specialists found were Henslow's sparrows and dickcissels that were found on one and two fields respectively. Red-winged blackbirds had the highest average density, but song sparrows were most often found on a field (Table 2.3 and 2.4). Bobolinks were found on only 5% of the fields but had the highest density on an individual field (Table 2.3 and 2.4). When all fields were included in the analysis, the density of indigo buntings was significantly higher in 2003 than 2002 or 2004, but no other species had a significant difference (Table 2.5). Since year was significantly different for indigo buntings it was included in further analysis. The only species with a significant difference in density from year to year when restricting the analysis to fields that were surveyed multiple years was the grasshopper sparrow (W=612, p=0.018; Fig. 2.1) though a trend was indicated for field sparrows (W=607, p=0.10).

Three landscape PCs and four field PCs were used in the Poisson regressions (Table 2.6). No species models were the same (Table 2.6), though PC4 was included in the regressions of five species (bobolink, red-winged blackbird, indigo bunting, field sparrow and song sparrow).

Common yellowthroat

Common yellowthroat density was most affected by landscape characteristics (Table 2.7). Density increased with greater diversity of cover types, forest edge and greater amounts of perennial herbaceous cover and patches with core area near the field. However, in the larger context common yellowthroat density increased with increasing forest cover and a decrease in core area of perennial herbaceous cover. Within fields, common yellowthroat density increased with field area, grass cover (both warm and cool-season), standing litter cover, litter depth and vertical density of the vegetation. The one factor that negatively influenced their density was a high cover in forbs. Spatially common yellowthroat density increased from east to west.

Indigo bunting

Indigo buntings were the only species with spatial characteristics as the strongest relationship in the regression, with density increasing from north to south and west to east (Table 2.7). Indigo bunting density increased with small, patchy warm-season grass fields with standing litter cover, but thinner downed litter. Within the landscape, indigo bunting density increased with a decrease in local perennial herbaceous cover and core areas but an increase in road density.

Field sparrow

Field sparrow density was affected most by field characteristics (Table 2.7). Field sparrow density increased with regular but less dense vegetation and more standing litter and warm-season grass cover but less cool-season grass. Within the landscape, field sparrow density increased with increasing local forest edge and diversity of cover types.

Grasshopper sparrow

Grasshopper sparrow density was most affected by landscape variables (Table 2.7). Grasshopper sparrow density increased with a local increase in diversity of cover types and forest edge and a decrease in the number of core areas and cover of perennial herbaceous vegetation. At the larger landscape scale grasshopper sparrow density increased with greater road density. Within the field, density increased with smaller fields that had patchier vegetation, less litter depth, and less cover in grass and standing litter. Spatially grasshopper sparrow density increased from east to west.

Song sparrow

Song sparrows were most affected by landscape variables (Table 2.7). Song sparrow density increased with a local decrease in cover diversity and forest edge density. However, bird density increased at the larger scale with an increase in the number of core areas of perennial herbaceous cover and a decrease in forest cover. Song sparrow density had the same relationship to field characteristics as indigo buntings. Song sparrow density increased with small, patchy warm-season grass fields with standing litter cover, but thinner downed litter.

Bobolink

Bobolink density was affected most by landscape variables (Table 2.7). Bobolink density increased with a local decrease in perennial herbaceous cover and core areas, cover diversity and forest edge density. At the larger scale bobolink density increased with an increase in forest cover and road density but a decrease in perennial herbaceous core areas. Within the field, bobolink density increased with field area, litter depth and patchy cover of forbs cover but with less standing litter and warm-season grass cover. Spatially density increased from south to north and east to west.

Eastern meadowlark

Eastern meadowlark density was affected only by landscape characteristics (Table 2.7). Density increased with more local perennial herbaceous cover and core areas, and fewer roads at the larger scale.

Red-winged blackbird

Red-winged blackbird density was affected most by field characteristics (Table 2.7). Red-winged blackbird density increased with field area, vertical density, litter depth, cover in grass (both warm and cool-season grass) and standing litter. Within the landscape, red-winged blackbirds were the only species whose density increased with all the perennial herbaceous variables. Density also increased with decreasing forest cover and road density at the larger scale. Spatially density increased from north to south and west to east.

Community analysis

The canonical correspondence analysis indicated Axis 1 was related to species responses to road density and mean patch size within the larger landscape context and Axis 2 with the local cover of annual and perennial herbaceous vegetation (Fig. 2.2). The first two CCA axes accounted for 11.9% of the total variance in the species data and 66.8% of the extracted variance in the species-environment relationship. Even with down weighting, bobolinks were the most specialized species because of their location as the farthest outlier, while song sparrows were the generalist of the group. Red-winged blackbirds and eastern meadowlarks were clustered together along Axis 2 indicating a positive relationship with increasing annual and herbaceous cover around the field but also indicating a positive relationship with local road density. Common yellowthroats were the most negatively associated with annual and perennial herbaceous cover. Grasshopper sparrows had a moderate relationship to road density within the larger landscape context. This community analysis indicated grasshopper sparrows, bobolinks and eastern meadowlarks had different preferences within the field and landscape, due to their separation along the axes.

Discussion

CREP fields in south-central Pennsylvania are within an agricultural matrix (smaller context) and a forest dominated landscape (large context) because of ridge and valley geology. Partially because of this geology, field area was much smaller than in the Midwest. The avian community found within CREP fields was dominated by red-winged blackbirds, field sparrows and song sparrows. Bobolinks, grasshopper sparrows, common yellowthroats and eastern meadowlarks were uncommon and dickcissels and Henslow's sparrows were rare (two observations each). Pennsylvania CREP bird communities are different from those in Midwestern CRP fields where grasshopper sparrows and dickcissels are the most common species present (Johnson and Schwartz 1993, Best et al. 1997, Delisle and Savidge 1997, Klute 1997). Other grassland areas in Missouri, Indiana, and Iowa are similar to this study with red-winged blackbirds being dominant but grasshopper sparrows, dickcissels and eastern meadowlarks were the next most common and few had song sparrows or field sparrows as common species (McCoy et al. 2001, DeVault et al. 2002, Horn et al. 2002).

Actual densities are rarely calculated, using observer and species detection probabilities; hence, it is difficult to compare between studies (Diefenbach et al. 2003). Densities of red-winged blackbirds and grasshopper sparrows in this study were similar and bobolink density was lower than those found in Iowa prairies and all three species had lower densities than those reported from restored grasslands (Fletcher and Koford 2002). Red-winged blackbird and field sparrow densities were higher, while grasshopper sparrow density was lower than that found in Midwest studies (Johnson and Schwartz 1993, Winter and Faaborg 1999).

Lower densities of some grassland species in my study may simply be a reflection of lower regional densities for most grassland species; regional abundance is greater within the Midwest than the East (Sauer et al. 2001). In addition, for species that are area sensitive (Johnson 2001), the overall field areas in my study could be below the minimum requirement resulting in low densities overall.

Understanding the influence of field area on species occurrence and density has been a goal of many grassland bird studies (see references Johnson 2001). Bobolinks have consistently had a positive relationship with field area as I found in my study. In my study, the density of eastern meadowlarks was not correlated with field area but was positively associated with increasing amounts of perennial herbaceous cover at the landscape scale. Results from other studies have been variable with some finding meadowlarks to be area sensitive (Herkert 1994, Vickery et al. 1994) while others have not (Bollinger 1995, Winter and Faaborg 1999).

Our most surprising result was a negative relationship between field area and grasshopper sparrow density. This differs from other studies that found them to be area sensitive (e.g. Herkert 1994, Vickery et al. 1994, Bollinger 1995). Johnson and Igl (2001) found regional variability in area sensitivity for this species, and Winter and Faaborg (1999) described them as not area-sensitive. Variations in patterns of area sensitivity within species and the causes of this variation are not well understood. Variation can be a result of real differences in area sensitivity or some artifact of study design. In addition, in cases where densities are low, results are much less robust (Johnson 2001). In this study, male grasshopper sparrows would occasionally sing for only a week or two on a field during the season (pers. obs.). Consequently, they might be counted as present on a small patch though they did not stay there and breed. I suspect that my results for grasshopper sparrows do not reflect their true relationship to field area but are more a result of sampling error due to low densities and perhaps the presence of unmated mobile males on small sites.

Both common yellowthroats and red-winged blackbirds had higher densities with increasing field area. Common yellowthroat density most likely showed a positive relationship with field area due to the increased likelihood that there were wet areas within or surrounding the field, which is a good predictor of abundance or density (Johnson and Schwartz 1993a, Johnson and Igl 2001). It is possible that red-winged blackbirds like common yellowthroats were using an unmeasured variable such as tall singing posts that affected their densities with increasing area. Mixed responses of red-winged blackbirds to field area have been reported in other studies (Johnson 2001, Johnson and Igl 2001).

Edge species are often found to have no area-sensitivity or to have a negative relationship with field area. Field sparrows did not show area-sensitivity in this study in contrast to findings by Vickery et al. (1994). However, song sparrows were negatively associated with field area in this and other studies (Herkert 1994, Vickery et al. 1994), and indigo buntings also had a negative relationship with field area in this study. Indigo buntings have not been reported in other grassland bird studies.

Vegetation within the field also had an affect on species density. The presence of warm and cool-season grass cover had an affect on all the species except eastern meadowlarks. The amount of warm-season grass cover was included in seven species models to four for cool-season grass. However, the relationship of species to grass cover has had variable responses in other studies. Grasshopper sparrows were occasionally found to prefer cool-season-grass fields (McCoy et al. 2001), but more often no difference between the grass types was found (Delisle and Savidge 1997 [warm-season fields mowed], Hull 2002). In my study, grasshopper sparrow density decreased with increasing amounts of both grasses. Red-winged blackbirds seem to prefer a high percentage of grass cover and like in this study no preference to type was indicated (Delisle and Savidge 1997, McCoy et al. 2001, Hull 2002), though other studies have indicated a negative relationship to the amount of grass cover (Johnson and Scwhartz 1993a, Scott et al. 2002). Field sparrows and song sparrows have not shown a preference for warm-season grass in other studies (McCoy et al. 2001, Hull 2002) as they did in this study. Though on hayfields in Pennsylvania, song sparrows, grasshopper sparrows, and field sparrows (trend) preferred warm-season grass fields while red-winged blackbirds and bobolinks did not indicate a preference (Giuliano and Daves 2002). Part of the reason many of these studies may not have found a difference was the fields were more mature and had fully established covers of both grasses rather than the less established warm-season grasses that were on PA CREP fields. Regular mowing that would decrease the vertical density and the amount of standing litter, especially of the warm-season grass fields, may also have affected bird use (Delisle and Savidge 1997, Giuliano and Daves 2002).

Vertical density of the vegetation was another important field characteristic in species models. Common yellowthroat and red-winged blackbird density increased with an increase in vertical density of the vegetation, while grasshopper sparrow and field sparrow density decreased. However, grasshopper sparrows preferred a field with more variation in vertical density than did field sparrows. Grasshopper sparrows and eastern meadowlarks have been found to be negatively affected by increased vertical density (Smith 1963, Weins 1969, Delisle and Savidge 1997, Fletcher and Koford 2002, Scott et al. 2002). Bobolink density was not affected by vertical density in this study, while they have indicated both a positive (Fletcher and Koford 2002) and a negative relationship (Delisle and Savidge 1997) in Midwest studies. Common yellowthroats have consistently shown a positive relationship with increasing vertical density in Midwest studies (Delisle and Savidge 1997, Scott et al. 2002).

Landscape variables have been studied far less than field vegetation, but were found to be important in species density models. As would be expected in a heavily forested state such as Pennsylvania, forest cover was an important variable. However the relationship was not always in the direction expected. Bobolink density increased within the larger landscape context with increasing forest cover and a commensurate decrease in the number of core areas of perennial herbaceous cover, but in southern Wisconsin bobolinks were negatively associated with the area of wood lots within 800m of the transect (Ribic and Sample 2001). Within the local landscape, grasshopper sparrow density increased and song sparrow density decreased with increasing forest edge density. Fletcher and Koford (2002) found grasshopper sparrows were negatively related to the density of grassland-wooded edge within 1 km of a field in Iowa. Murphy (2003) found song sparrows were positively associated with the amount of farm woods within a larger landscape context.

The amount of perennial herbaceous cover and the number of core areas within the smaller landscape were also important variables. However, grassland specialists' reacted differently with bobolink and grasshopper sparrow density decreasing and eastern meadowlark density increasing with increasing amounts of perennial herbaceous cover and the number of core areas. Ribic and Sample (2001) found grasshopper sparrows were positively related to the amount of grassland area within 0.4 km, however this buffer was taken from the transect and not the edge of the field. Grasshopper sparrows and eastern meadowlarks were positively associated with an increase in agricultural grasslands in Oklahoma (Coppedge et al. 2001). However, grasshopper sparrows were more abundant in Iowa landscapes with less annual herbaceous cover and more upland area, which include more wooded area (Best et al. 2001). Grasshopper sparrows and bobolinks abundance increased from lowland to upland pastures in southern Wisconsin (Renfrew and Ribic 2003). Some of the highest density fields for bobolinks and grasshopper sparrows were found in upland fields so they may be relating more positively to upland fields than to the amount of grassland cover within the landscape. Another possible factor for bobolinks is that their density decreased with increased density of agricultural – grassland edge within 1 km of the field (Fletcher and Koford 2002) and so they would have avoided the valley bottoms with the largest amount of agricultural area. The negative relationship with agricultural edge may explain why in the community analysis bobolinks were located positively along Axis 2 indicating a negative relationship with annual and perennial herbaceous cover, while grasshopper sparrows and eastern meadowlark were found much closer to the axis.

Management Implications

Pennsylvania CREP fields are being used by grassland birds, but they are relatively uncommon. Grasshopper sparrows were the most common and they were found on 31.6% of the fields. CREP fields are being used more often by generalist species such as song sparrows and red-winged blackbirds that were found on 75.4% and

72.8% respectively. Other edge and old-field species such as indigo buntings and field sparrows were also common (located on 44.7% and 36.0% of the fields respectively) because of the brush along the edges of the fields and within the fields.

As CREP fields continue to mature they may provide better habitat for more species including more grassland birds. Though no difference was detected within the 3 years of this study, Bollinger (1995) found that grassland specialists increased as hayfields matured over a 15-year period. The increase in grassland specialists on hayfields occurred because the vegetation became more heterogeneous in species and structure. To increase or maintain heterogeneity in CREP fields some form of management may be required. Common methods for accomplishing this include mowing either in strips or the whole field, which will open up areas for competition, increase litter and slightly set back succession; burning of the field or portions of the field that will provide open areas so new species of vegetation can compete with previously dominant vegetation, and will remove litter and woody shrubs; and strip disking that can also open up some of the field to new vegetation and remove litter (Pierce et al. 2005). For all methods, care must be taken to avoid disturbance during the nesting season and avoiding increasing soil erosion.

When signing up fields, managers should attempt to signup large fields to provide habitat for area-sensitive species. However, smaller fields should not be rejected because indigo buntings, song sparrows, and even grasshopper sparrows had higher densities on smaller fields, although the later may be an artifact of low overall density.

There was no consistent relationship between vegetation type, amount, or structure and species density. Individual species responded differently from one another.

Consequently, fields should be maintained with as much heterogeneity as possible. Of the three grassland specialists that I analyzed, the only similarity was between bobolinks and grasshopper sparrows preferring less standing litter and warm-season grass cover while maintaining patches of differing vertical density of vegetation. Four other species, red-winged blackbirds, song sparrows, field sparrows and indigo buntings had the opposite preference listed above. Bobolinks and grasshopper sparrows also differed in their preference for litter depth, with bobolinks preferring a thicker layer of litter and grasshopper sparrows less. Since species like the bobolink are more sporadic in their presence, only 6.1% of the fields, in fields that they are present should be managed to increase their numbers – e.g. maintaining a thicker litter layer and having variable vertical density within the vegetation, while also having less standing litter and warm-season grass cover. This makes choosing the appropriate management methods for fields difficult, especially for small fields because it is much harder to do strips without it affecting most of the field and is another reason for larger fields. Another difficulty is that there have been mixed results from management methods like mowing. There has not been a clear response of grasshopper sparrows to mowing on reclaimed mines (Brauning et al. 2001). Grasshopper sparrows had an increase in abundance with mowing of switchgrass fields the previous year, but common yellowthroats, field sparrows, song sparrows and red-winged blackbirds had no difference in abundance whether the field was totally harvested, strip harvested or non-harvested (Murray and Best 2003). Another possibility is to sign-up fields in poor soil, which may actually benefit species such as grasshopper sparrows and eastern meadowlarks that prefer fields with lower vegetation and little maintenance would be required.

Landscape variables did play a role in field choice and were the strongest of the variables for grasshopper sparrows, song sparrows, bobolinks and eastern meadowlarks. However, as with vegetation variables there was no variable that had only a positive or negative influence on all the species. Grassland specialists were mixed in response to an increase in local amount of perennial herbaceous cover surrounding the field, eastern meadowlarks increased and bobolink and grasshopper sparrow decreased in density. Bobolinks even had a negative response to large scale perennial herbaceous cover and positive relationship to large scale forest cover. However, bobolinks and grasshopper sparrows may be selecting fields that are in upland areas that tend to have more forest cover and fewer other fields. Five other species also had a relationship with the amount of perennial herbaceous cover and forest cover over a 5.0 km radius around the field but they were evenly split in their relationship to the variables. Because of the mixed response of species to the different landscape variables managers should continue to sign up fields in varied landscapes.

The community analysis was similar to the other analyses in finding little clustering of species around particular variables. The three grassland specialists did not indicate any clustering around variables that could be used to manage for them. Indications were that annual and perennial herbaceous cover would draw red-winged blackbirds and eastern meadowlarks but would negatively affect bobolinks and common yellowthroats. Grasshopper sparrows and bobolinks were opposite in relationship to road density and mean patch size within the larger landscape context. Though it is unlikely that grasshopper sparrows were attracted to fields with more roads it still makes it very difficult to select any one variable for managers to select to manage for multiple species.

Continued monitoring of the CREP fields is important to identify increasing abundances of grassland specialists. Because even though they are uncommon on CREP fields now they may increase as birds move from possible sources on larger reclaimed strip mines in western Pennsylvania (Mattice et al. 2004) and West Virginia (Wray et al. 1982). Monitoring should continue on established fields to determine if grassland specialists increase as fields mature with a more consistent litter layer, more variation in vertical density and a more heterogeneous mix of species. Monitoring should also begin on newly established fields in new areas of Pennsylvania to compare densities and field preferences with south-central fields. There is also an opportunity to experiment and identify the most appropriate management strategies for PA CREP fields to maximize species use and density.

Table 2.1: Vegetation characteristics of 114 Conservation Reserve Enhancement Program fields in south-central Pennsylvania surveyed during the summers of 2002 – 2004.

Measurement	Mean	SE	Maximum field value
Litter depth[a] (cm)	1.21	0.10	4.71
Vegetation height (cm)	50.96	2.63	130.67
% cover[b] of:			
Forbs	46.35	2.39	97.92
Cool-season grass	27.04	1.88	75.42
Warm-season grass	4.61	1.04	51.39
Downed litter	11.35	0.84	36.33
Standing litter	1.89	0.39	27.92
Woody vegetation	1.30	0.34	24.75
Bare ground	7.27	0.80	48.33
Vertical density (cm)	45.32	2.11	108.67
CV[c] of			
Litter depth	1.18	0.06	2.68
Forbs	0.80	0.05	3.84
Grass[d]	1.69	0.07	4.90
Bare ground	1.67	0.11	5.71
Vertical density	0.53	0.03	1.99

[a] Measured at center of Daubenmire frame measured at 6 points per transect
[b] Measured within 0.5 m^2 Daubenmire frame at 6 points per transect
[c]CV = coefficient of variation calculated for each field
[d]Grass = combination of both warm and cool-season grass cover

Table 2.2: Landscape characteristics of 114 Conservation Reserve Enhancement Program fields in south-central Pennsylvania surveyed during the summers of 2002 – 2004.

Measurement	Mean	SE	Range
0.5 km radius[a]			
Mean patch size (ha)	2.64	0.07	1.32 – 5.07
Shannon Diversity Index	1.11	0.02	0.43 – 1.64
Forest edge density (m/ha)	84.24	4.03	3.40 – 205.55
CADHAY (number/100 ha)[b]	6.59	0.26	0.00 – 15.02
% Annual herbaceous	46.22	1.77	5.63 – 90.10
% Perennial herbaceous	20.68	0.97	2.94 – 58.40
% Forest	30.98	2.05	0.25 – 87.14
Road density (m/ha)	21.38	0.76	0.97 – 43.59
5.0 km radius[c]			
Mean patch size (ha)	3.84	0.09	2.56 – 6.54
Shannon Diversity Index	1.30	0.02	0.88 – 1.64
Forest edge density (m/ha)	69.47	1.68	30.07 – 131.76
CADHAY (number/100 ha)[b]	4.97	0.14	1.24 – 7.84
% Annual herbaceous	36.23	1.26	10.59 – 75.19
% Perennial herbaceous	16.19	0.57	3.69 – 32.52
% Forest	42.48	1.64	7.00 – 79.71
Road density (m/ha)	20.82	0.53	7.93 – 44.68

[a] Characteristics measured within a 0.5 km radius around each field
[b] CADHAY = number of perennial herbaceous patches with a core area (> 60 m from edge)/100ha
[c] Characteristics measured within a 5.0 km radius around each field

Table 2.3: Bird species identified during surveys of 114 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2002 – 2004.

Species	Percentage of fields with at least one male present	Number of observations	Singing males/km of transect
Mallard	0.8	1	0.008
Red-tailed hawk	1.8	2	0.016
American kestrel	0.8	1	0.008
Ring-necked pheasant	0.8	1	0.008
Common snipe	0.8	1	0.008
Northern flicker	0.8	1	0.008
Willow flycatcher	0.8	1	0.008
Eastern phoebe	0.8	1	0.008
Eastern kingbird	2.6	3	0.024
Gray catbird	0.8	1	0.008
Northern mockingbird	0.8	1	0.008
Yellow warbler	3.5	4	0.032
Common yellowthroat	17.5	30	0.242
Scarlet tanager	0.8	1	0.008
Field sparrow	36.0	111	0.895
Chipping sparrow	4.4	10	0.081
Grasshopper sparrow	31.2	104	0.839

Henslow's sparrow	0.8	3	0.024
Savannah sparrow	8.8	17	0.137
Song sparrow	75.4	343	2.766
Vesper sparrow	5.3	10	0.081
Dickcissel	1.8	2	0.016
Blue grosbeak	0.8	2	0.016
Indigo bunting	44.7	130	1.048
Bobolink	6.1	50	0.403
Eastern meadowlark	17.5	31	0.250
Red-winged blackbird	72.8	1052	8.485
Common grackle	0.8	1	0.008
Brown-headed cowbird	3.5	4	0.032
Baltimore oriole	1.8	2	0.016
American goldfinch	4.4	5	0.040

Table 2.4: Density[a] of species using distance sampling survey methods on Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2002 – 2004

Species	Field density (Singing males/ha) Mean (SE)	Maximum	Detection probability[b] (95% CI) distance[c] (m)	ESW[d] (SE)
Common yellowthroat	0.078 (0.02)	2.80	0.05 (0.02,0.12) 105	32.07 (5.21)
Field sparrow	0.114 (0.02)	0.93	0.49 (0.42,0.57) 105	51.72 (3.97)
Grasshopper sparrow	0.113 (0.02)	1.33	0.53 (0.45,0.62) 105	63.7 (5.152)
Song sparrow	0.375 (0.04)	2.03	0.49(0.45,0.54) 105	49.98 (2.27)
Indigo bunting	0.147 (0.03)	2.16	0.60 (0.53,0.68) 105	63.07 (3.88)
Bobolink	0.103 (0.05)	4.58	0.47 (0.36,0.62) 110	52.20 (6.90)
Eastern meadowlark	0.009 (0.01)	0.16	0.08 (0.03,0.23) 185	153.1(8.59)
Red-winged blackbird	0.701 (0.07)	2.87		
ML [e]			0.33 (0.29,0.38) 185	60.82 (4.25)
SM			0.47 (0.42,0.52) 110	74.61 (2.51)
JR			0.52 (0.45,0.60) 136	70.54 (5.05)
KW			0.33 (0.30,0.36) 210	68.88 (3.22)

[a] Densities were only calculated for species with >25 observations
[b] Estimated proportion of singing males detected within maximum distance from transect or truncated distance used in modeling
[c] The maximum observational distance used in modeling detection probability
[d] ESW = effective strip width (m)
[e] Observers used to calculate differing detection functions, ML = M. Lohr, SM = S. McConnell, JR = J. Ryan, KW = K. Wentworth

Table 2.5: Density (singing males/ha) of grassland bird species on Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2002 - 2004. ANOVA was used to compare years for species with over 10 observations per year.

	Mean (+SE) [a]				
Species	2002	2003	2004	F-value	P value
Field sparrow	0.15 (0.03)	0.09 (0.03)	0.04 (0.02)	2.34	0.101
Grasshopper sparrow	0.12 (0.03)	0.11 (0.03)	0.09 (0.09)	0.07	0.934
Song sparrow	0.37 (0.07)	0.37 (0.05)	0.42 (0.09)	0.12	0.889
Indigo bunting	0.09 (0.03)	0.25 (0.06)	0.02 (0.01)	5.00	0.008**
Bobolink	0.06 (0.05)	0.16 (0.12)	0.09 (0.07)	0.41	0.662
Red-winged blackbird	0.37 (0.07)	0.37 (0.05)	0.42 (0.09)	0.12	0.889

[a]The means reported are actual, but values used in ANOVA were square root + 0.5 transformed; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

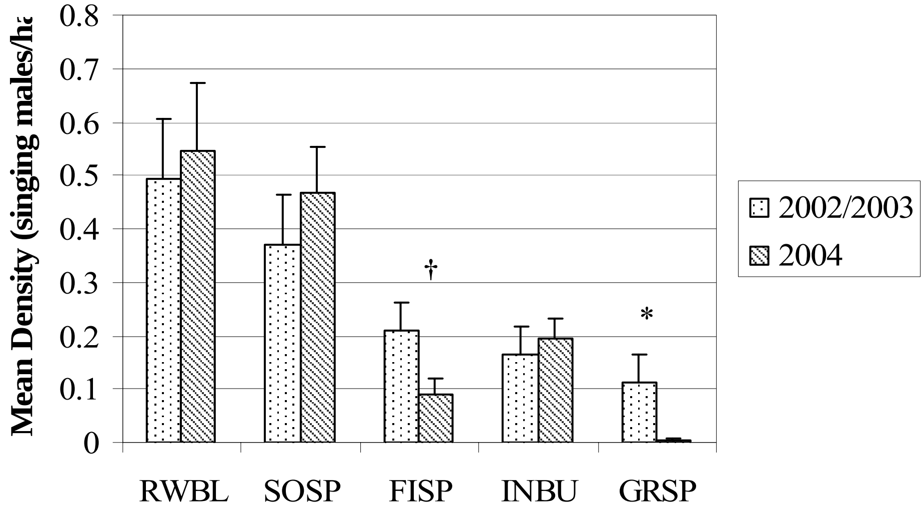

Fig. 2.1: Mean density (+ SE) of bird species on 23 fields surveyed in multiple years on Conservation Reserve Enhancement Program fields in south-central Pennsylvania. RWBL = red-winged blackbirds, SOSP = song sparrows, FISP = field sparrows, INBU = indigo buntings, GRSP = grasshopper sparrows. $p \leq 0.10^{\dagger}$; $p \leq 0.05$ *

Table 2.6: Poisson regression models of local and landscape variables associated with density of singing males/ha on Conservation Reserve Enhancement Program fields during the summers of 2002 – 2004 in south-central Pennsylvania. Principle components (PC) were created for field characteristics and for landscape characteristics due to intercorrelation. PCs were chosen when the eigen value was ≥ 1.5 and individual variables are listed with a weighting ≥ 0.380[a].

Species[b]	AIC null	AIC	Variables[c]
COYE	428.21	232.93	PC4 – LPC1 + LPC2 + PC1 + X + PC3 + PC2 – LPC3
INBU	531.96	482.36	- Y + PC4 + X – PC2 + LPC3
FISP	452.00	392.20	PC4 – PC3 + Y + LPC2
GRSP	522.84	454.78	LPC3 – X – PC3 + LPC2 – PC2 – PC4
SOSP	726.64	641.22	PC4 – LPC2 + LPC1 – PC2
BOBO	597.42	176.63	– LPC1 + Y – X – LPC2 – PC4 + PC2 + LPC3 – PC1
EAME	94.25	87.91	– LPC3
RWBL	1201.00	947.85	PC3 + X – LPC3 + PC4 – Y +LPC1+ PC2

[a] Variables with a "-" are negatively weighted; 0.5 and 5.0 km are the radii around the field in which landscape variables were measured
LPC1 = number of patches with a core area (>60 m from edge)/100km at 5.0 km; % forest cover 5.0 km (-)
LPC2 = Shannon Diversity Index 0.5 km; density of forest edge 0.5 km
LPC3 = % perennial herbaceous cover 0.5 km (-); number of patches with core area (>60 m from edge)/100km 0.5 km (-); road density within 5.0 km
PC1 = % cover of forbs (-); coefficient of variation of forb cover
PC2 = Field area; coefficient of variation of bare ground; perimeter area ratio (-); litter depth
PC3 = vertical density; % cover of cool-season grass
PC4 = % cover of standing litter; coefficient of variation of vertical density (-); % cover of warm-season grass
[b] COYE = common yellowthroat, FISP = field sparrow, INBU = indigo bunting, GRSP = grasshopper sparrow, SOSP = song sparrow, BOBO = bobolink, EAME = eastern meadowlark, RWBL = red-winged blackbird
[c] Variables are reported by level of individual significance; X = west to east spatial coordinates, Y = south to north spatial coordinates

Table 2.7: Poisson Regression model AIC values including models with intersect = 1, all variables, only landscape variables, only field variables or only spatial variables for density (singing male/ha) of species surveyed on Conservation Reserve Enhancement Program fields during the breeding seasons of 2002 – 2004 in south-central Pennsylvania. The values that are in bold indicate the individual set of variables with the lowest AIC.

Species	AIC null	AIC all	AIC field	AIC landscape	AIC spatial
COYE	428.21	232.93	396.07	**357.51**	398.10
FISP	452.00	392.20	**405.00**	442.96	502.40
GRSP	522.84	454.78	498.51	**475.47**	524.09
SOSP	726.64	641.22	690.71	**681.25**	723.42
INBU	531.96	482.36	517.04	529.71	**511.95**
BOBO	597.42	176.63	466.73	**388.23**	577.20
EAME	94.25	87.91	93.38	**87.91**	97.62
RWBL	1201.00	947.85	**1054.80**	1099.30	1194.30

COYE = common yellowthroat; FISP = field sparrow; GRSP = grasshopper sparrow; SOSP = song sparrow; INBU = indigo bunting; BOBO = bobolink; EAME = eastern meadowlark; RWBL = red-winged blackbird

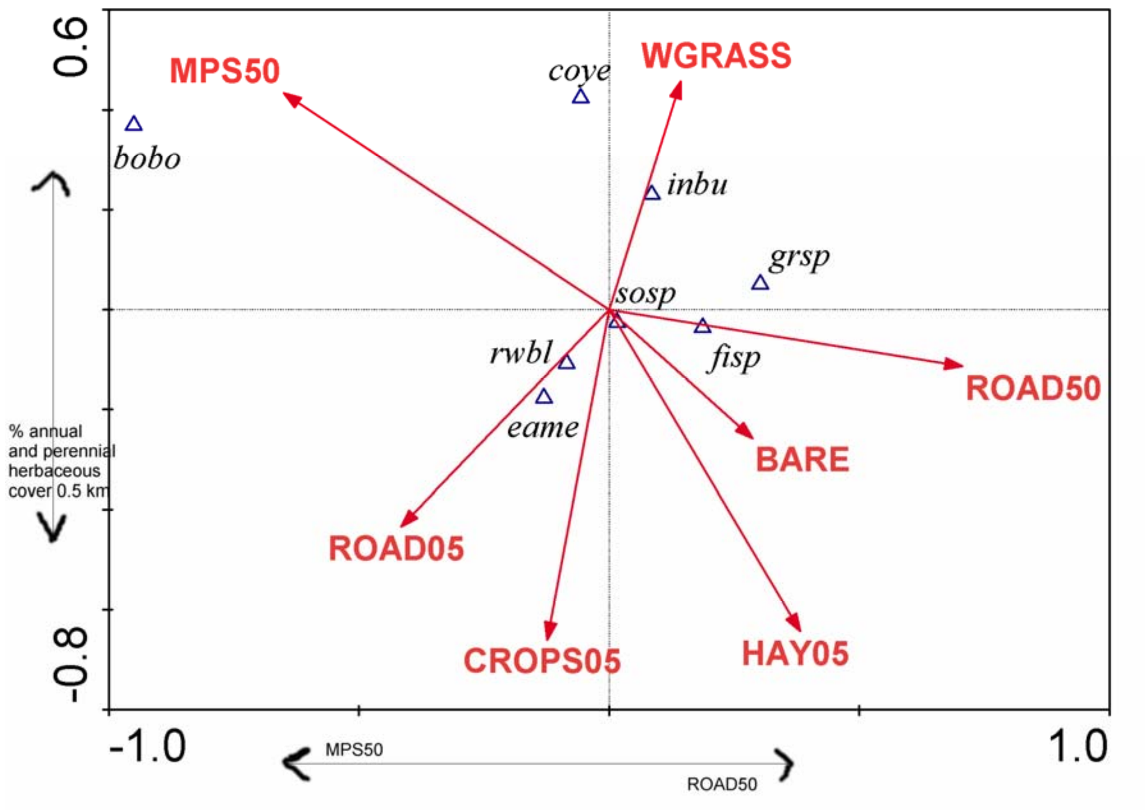

Fig. 2.2: Ordination bi-plot depicting the first two axes of the Canonical Correspondence Analysis of grassland birds with >25 observations on Conservation Reserve Enhancement Program fields in south-central Pennsylvania and landscape and field environmental variables, 2002 – 2004. The species in lower case are coye = common yellowthroat; fisp = field sparrow; grsp = grasshopper sparrow; sosp = song sparrow; inbu = indigo bunting; bobo = bobolink; eame = eastern meadowlark; and rwbl = red-winged blackbird. The field and landscape variables in uppercase are MPS50 = the mean patch size within 5.0 km radius of the field; CROPS05 = % of annual herbaceous cover within 0.5 km radius of the field; HAY05 = % of perennial herbaceous cover within 0.5 km of the field; ROAD05 = road density within 0.5 km of the field; ROAD50 = road density within 5.0 km of the field; BARE = % of bare ground within the field; WGRASS = % of warm-season grass cover within the field.

Chapter 3

Effects of local and landscape features on grassland bird nest abundance and success in Conservation Reserve Enhancement Program fields

Introduction

The Conservation Reserve Enhancement Program (CREP) is a United States Department of Agriculture program that was begun in 2001 in 20 counties within the Chesapeake Bay drainage of south-central Pennsylvania. CREP protects highly erodible land by enrolling farmlands for a 10 to 15 year period during which the field is maintained under a permanent cover typically grass. The permanent cover protects the soil from erosion and provides nesting habitat for grassland and farmland birds, some of which have declined in Pennsylvania by 80% since the mid 1960s (Sauer et al. 2001). In order to develop management plans that will maximize the benefits of CREP fields, managers need to better understand how characteristics of the field and the landscape influence field use and habitat quality. Studies on Conservation Reserve Program (CRP) fields, a similar program to CREP, have been conducted in the Midwest (Johnson and Schwartz 1993, Delisle and Savidge 1997, Horn et al. 2002) where field area is much larger than in Pennsylvania and the landscape matrix is less forested, making it not directly applicable. In addition, many of these studies have focused on abundance or density of birds, which can be a misleading indicator of habitat quality (Van Horne 1983). Consequently, as part of a larger project examining the effects of CREP on birds, I initiated a study to examine nest abundance and nesting success of birds on CREP fields. The objectives of this study were to identify bird species that regularly nest on CREP fields and to identify the local and landscape features that affect nest abundance and success.

Methods

Study area and field selection

I conducted the study during the 2001 – 2004 breeding seasons from May through mid July each year. Because CREP enrollment started in 2001 there were few counties with established cover. Montour County was an exception and had a good selection of fields already under cover – Montour Preserve fields, CRP rollover (fields moved from one program to another), and CP10 fields (fields with already established cover). In 2001, I conducted a pilot study in Montour County. I nest searched one-half of the fields used in the larger study during the summers of 2002 - 2004. For a more detailed description of the fields and the selection process, see Chapter 2. Potential fields for nest searching were randomly selected from the large set of fields based on area and landscape characteristics. They were concentrated in three areas for accessibility by field crews (three people in each of the three crews). I searched for nests on 73 different CREP fields that ranged in area from 1 ha to 25.5 ha (mean 10.4 ha $\pm$ 7.3 SD).

Nest abundance and reproductive success

To examine productivity I located active nests by walking through each field every 3-4 days watching for behavioral cues and scanning the vegetation. Nests were marked using colored flagging 10 m to the north of the nest with occasional additional flagging to the south for difficult-to-find nests. Active nests were monitored every 3-4 days to determine success (fledging of at least one young) or cause of failure (e.g.. abandonment, loss of all eggs or loss of all nestlings).

In addition, three infrared remote video cameras (Fuhrman Diversified, Inc.) were used to attempt to identify predators during the summers of 2002 – 2004. I placed cameras on 16 nests: a dickcissel, 2 field sparrows, 3 song sparrows, and 10 red-winged blackbirds. To minimize abandonment, the cameras were placed on nests after clutch completion and initiation of incubation (Thompson et al. 1999). Because of the short focal length of the camera, they must be placed within 0.5 m of the nest (usually closer because of obstructions hiding the nest). The power source (a 12 volt deep cycle marine battery) and VHS time-lapse recorder were placed 22 m from the camera. There was little disturbance to the nest when changing the battery and tape (every two days), because the nest contents could be checked from the battery station with a remote viewer without disturbing the nest any more than a nest without a camera. The cameras were left on the nest until the nest either fledged or failed. Nests were chosen at random, as a camera became available. I only placed a camera on species with multiple nests within the field, with the exception of the dickcissel.

Local and habitat characteristics

On each field, vegetation was sampled from 23 May – 12 June and again from 23 June – 12 July using six equally spaced points along already established survey transects (McCoy et al. 2001; see Appendix B for vegetation information on all fields). Survey routes were established as part of a larger study on bird use of CREP fields (see Chapter 2). Vegetation was measured at each nest within a week of completion. I measured the distance from the ground to the bottom of the nest to the nearest cm (NEST HEIGHT). I visually estimated the percent of the nest that was concealed 1 m from the nest at a height of 1 m in the four cardinal directions and directly above the nest to measure the concealment of the nest (CONCEALMENT). Vegetation measurements were also taken 3 m from the nest in each of the cardinal directions. I measured vertical density using a Robel pole (VERTICAL DENSITY; Robel et al. 1970) read to the nearest cm from 4 m in each of the four cardinal directions at a height of 1 m. I used a 0.5 m^2 Daubenmire frame (Daubenmire 1959) to measure vegetation cover centered on the nest and the four points 3 m from the nest. I measured the percent cover (non-overlapping) of warm-season grass (WGRASS), cool-season grass (CGRASS), downed litter (decaying litter on the ground; DLIT), standing litter (dead stems that are still standing; SLIT), woody vegetation (WOODY), forbs (FORB), and bare ground (BARE). I also measured the height of vegetation (HEIGHT) and litter depth (DEPTH) by measuring the highest point of vegetation and the depth of downed litter in the middle of the Daubenmire frame to the nearest cm (Table 3.1). Coefficients of variation were calculated for cover of: grass (combining warm and cool-season grasses; CV GRASS), forbs (CV FORB), downed litter (CV DLIT), bare ground (CV BARE), and vertical density (CV VERTICAL DENSITY). I trained each observer to measure the different vegetation characteristics.

Landscape level analysis

See Chapter 2 for a complete description of the calculation of land cover characteristics (see Appendix C for landscape information on all fields; see Table 3.2 for field averages).

Data analysis

I used the Kolmogorov-Smirnov test of normality on all data to determine if the data were normally distributed. If not normally distributed, data were transformed using square root transformations for dependent variables, and logarithmic and arcsine transformations for independent variables (Zar 1999). MINITAB^tm (MINITAB, Inc.) was used to calculate all normality tests, Pearson correlations, paired t-tests, Mann-Whitney, ANOVA, logistic regressions and Principle Component Analysis (PCA). Poisson and Mayfield regressions were conducted using Program R 1.8.1 © (R Development Core Team). Canonical correspondence analysis was conducted using CONOCO 4.5. (ter Braak and Smilauer 2002). All means are reported $\pm$ 1 SE, unless otherwise noted. Significance is reported as $p \leq 0.05$, but a trend is reported when $0.10 > p > 0.05$, except where a Bonferroni correction was used.

Nests with cameras were only included in count analyses and not in nest outcomes because cameras may have affected nest outcomes (no depredation events). Vegetation and landscape variables were inter-correlated (see Appendix E and F for correlations), so it was necessary to use PCA to create independent variables that could then be used in regressions. Principle Components (PC) were selected with eigenvalues $\geq$ 1.5, and I report only those variables with a weight $\geq$ 0.380. Poisson regression models of nest abundance were weighted by log transformed field area to equalize field areas. AIC was used to select the most parsimonious model.

Comparison of nest abundance on fields searched on multiple years was conducted using a Mann-Whitney test because the data were non-normally distributed. Comparisons among years for mean annual nest abundance was performed using GLM ANOVA with log transformed field area as a covariate. For all other analyses, I randomly selected one year for each field to be used.

Nest success among nesting substrates was tested using Chi-square contingency table. Only those species that regularly nested aboveground are included in the analysis. Substrates were combined with similar substrates if there were fewer than five nests in the category, e.g., warm and cool-season grasses.

To examine the effect of different edge types on nest success I used both paired t-tests and logistic regression. The paired t-tests were used to compare nest success within a field and the nest's distance to different edge types (agriculture, forest, tree line, and road). Because of the multiple tests, I used a Bonferroni correction and report significant results as $p \leq 0.01$. I used logistic regression to compare fledged and depredated nests, from all fields combined, and the nest's distance to an edge. Only species that had both successful and unsuccessful nests in multiple fields with measured distances to the edge type were included in the analysis.

I calculated nest success using the Mayfield method (Mayfield 1969, 1971). Length of time for incubation and nestling periods was calculated for each species (Ehrlich et al. 1988) to change daily nest success to success for the full nest cycle. The midpoint of time between the penultimate and final visit was used to calculate exposure days for the nest. Mayfield regressions (logistic) were used to identify nest characteristics that affected nest success (Hazler 2004). Nests were designated as either a success or failure, weighted by exposure days (Hazler 2004), and compared with year, log transformed field area, and PCs of nest vegetation characteristics. Vegetation characteristics used in PCA were nest location day (using Julian days; DATE), nest concealment, vegetation height, litter depth, vertical density, percent cover of forbs, cool-season grass, warm-season grass, standing litter, downed litter, woody vegetation, and bare ground. Models are given with all variables that were included in order by significance of the individual variable. When reporting results, the variables of the PC are included in brackets within the equation if only one PC is included in the model otherwise the variables are included in a table. For variables that are included in the model but are not individually significant, the p-values are given in parenthesis after the variable.

Community response of grassland birds to local and landscape features was conducted using canonical correspondence analysis (CCA). CCA allows an examination of species to each other and environmental variables at the same time. Landscape and vegetation variables were log transformed prior to entering CONOCO. Only those species with ≥ 10 nests (field sparrow, grasshopper sparrow, song sparrow, indigo bunting and red-winged blackbird) were included in the analysis and the densities (nests/ha) were log transformed within CONOCO. Variables were selected manually using Monte Carlo permutation tests and were included in the model if significant ($p \leq 0.05$). I used restricted permutations to remove the possible influence of spatial autocorrelation (ter Braak and Smilauer 2002).

Results

Species use of CREP fields

I located 969 nests of 19 different species during the 2001 – 2004 breeding seasons on 73 CREP fields (see Appendix G for individual field nesting information) in six different counties. The most common nesting species was the red-winged blackbird that compromised over 60% of the nests located (Table 3.3). The next most common species were field sparrows (17.6%), song sparrows (8.0%) and wild turkeys (2.7%). Grassland specialists made up 3.92% of all the nests located, grasshopper sparrows being the most common with 19 nests (2.0%). Red-winged blackbirds had at least one nest on more fields (55.1%) than any other species (Fig. 3.1). Field sparrows (39.7%), song sparrows (35.9%) and indigo buntings (21.8%) were the next most commonly present species. The percent of nests by species on each field size category had a variety of responses (Fig. 3.2). Ring-necked pheasants had only three nests so no comparison could be made, but all nests were found on large fields. Vesper sparrows were not found on medium fields, while eastern meadowlarks were more often found on medium fields (6 nests) than large fields (3 nests) though neither had sufficient sample sizes to test. Red-winged blackbirds had 56 nests in small fields, 206 in medium fields and 351 nests in large fields, but there was not a significant difference when the total area of each category was taken into account (Table 3.4). Both field sparrows and song sparrows were found significantly more frequently on medium fields (96 and 39 respectively) than large fields (42 and 29 respectively), but were close to expectations on smaller fields (14 and 9 respectively). Grasshopper sparrows had more nests located on large fields (15) than on medium fields (3) or small fields (1, this category was not included in analysis) but it was only a trend when analyzed with available areas taken into account.

Field and landscape characteristics affecting nest abundance

Three landscape PCs and four field PCs were used in Poisson regressions of nest abundance (Table 3.5). No species models were the same (Table 3.5), though five of six species models included LPC2 (wild turkey, indigo bunting, field sparrow, song sparrow, red-winged blackbird).

Wild turkey

Wild turkey nest abundance was affected most by landscape variables (Table 3.6). Wild turkey nest abundance increased with local forest edge density, cover diversity, and decreasing annual herbaceous cover. Wild turkey nest abundance also increased with increasing field area and decreasing perimeter-area ratio. Wild turkeys indicated no preference for either cool or warm-season grass cover.

Indigo bunting

Indigo buntings were most affected by landscape characteristics (Table 3.6). Indigo bunting nest abundance increased with a diversity of cover, increasing forest edge density, and increasing perennial herbaceous cover and number of core areas surrounding the field. Indigo bunting nest abundance increased with decreasing annual herbaceous cover and road density. Indigo buntings indicated no preference for grass cover.

Field sparrow

Field sparrows were most affected by field characteristics (Table 3.6). Field sparrow nest abundance increased with increasing cover of bare ground, forbs and warm-season grass, and increasing litter depth. Within the landscape, both scales affected field sparrows, though the local variables entered the model first. Field sparrow nest abundance increased with local cover diversity and forest edge density but decreased with increasing annual herbaceous cover. At the larger scale, nest abundance increased with more core areas of perennial herbaceous cover and a decrease in patch size. Of the grass cover types; field sparrow nest abundance was more affected by cool-season grass cover (negative relationship) than warm-season grass cover (positive relationship). Field sparrow nest abundance increased spatially from south to north.

Grasshopper sparrow

Grasshopper sparrows were most affected by field characteristics (Table 3.6). Grasshopper sparrow nest abundance increased with larger fields that had less edge. Grasshopper sparrows did not show a preference for cover of either grass type. Within the landscape, grasshopper sparrow nest abundance indicated a trend to increase with an increase in core areas of perennial herbaceous cover and a decrease in patch size at the larger scale. Nest abundance actually increased from west to east, because no nests were found in Somerset County, which was the farthest west county.

Song sparrow

Song sparrow nest abundance was almost equally affected by field and spatial characteristics (Table 3.6). Song sparrow nest abundance increased with larger fields with less edge and increased bare ground. Song sparrow nest abundance increased with a local increase in annual herbaceous cover, but a decrease in forest edge density and cover diversity. Univariately warm-season grass cover positively affected nest abundance while cool-season grass cover had no affect. Spatially nest abundance increased from east to west.

Red-winged blackbird

Red-winged blackbird nest abundance was most affected by field characteristics (Table 3.6). Red-winged blackbird nest abundance increased with a decrease in litter depth, warm-season grass and bare ground cover. Nest abundance increased with increasing cool-season grass cover and patches of bare ground. When taken independently red-winged blackbird nest abundance was more strongly influenced by cool-season grass cover than warm-season grass cover. Within the local landscape, red-winged blackbird nest abundance increased with an increase in herbaceous cover, both annual and perennial, but decreased with increasing forest edge density and cover diversity around the field. At the larger scale, nest abundance increased with mean patch size but decreased with increasing road density and number of core areas of perennial herbaceous cover. Spatially nest abundance increased from east to west.

Community analysis

Axis 1 is a gradient from less woody cover and diversity of cover types to more woody cover and a higher diversity of cover types surrounding the field (Fig. 3.3). Axis 2 is a gradient of decreasing cool-season grass cover. The first two CCA axes accounted for 28.5% of the total variance in the species data and 85.7% of the extracted variance in the species-environment relationship. The community was divided with song sparrows being separated by Axis 2 and red-winged blackbirds being separated by Axis 1 from wild turkeys, indigo buntings, field sparrows and grasshopper sparrows. Song sparrows were the most separated species in the community showing a strong relationship with decreasing cool-season grass cover and a relationship with patchy forb cover. Red-winged blackbirds were the only species to show a negative relationship to Aixs 1, a negative relationship with woody cover and diversity of cover around the field. Wild turkeys and indigo buntings had a strong relationship with increasing woody cover. Grasshopper sparrows had a positive relationship to woody cover, and variation in vegetation height within the field and cover diversity surrounding the field.

Nest success

The daily nest success rate for all nests was 94.6 ± 0.0002%. For individual species, nest success ranged from a high of 54.3% for ground nesting mallards to a low of 12.4% for grasshopper sparrows and eastern meadowlarks (Fig. 3.4; see Appendix G for nesting outcomes by field and species). For species that regularly nested above ground (field sparrows, song sparrows, indigo buntings, and red-winged blackbirds) nest success ranged from a high of 32.7% for song sparrows to a low of 24% for indigo buntings. Depredation was the major cause of nest loss, 53% of known nesting outcomes and 76% of nest failures. Abandonment, human disturbance, parasitism (brown-headed cowbirds or intraspecifically), and weather (heavy rains, heavy winds and freezes) were other causes of nest loss. The four field sparrow nests that were parasitized by brown-headed cowbirds (identified from eggs) were abandoned soon after the cowbird egg was laid and no nest fledged that had been parasitized.

For most species, nest success was not affected by distance to field edge. Comparisons within the field indicated a trend for field sparrows to be more successful closer to a road edge than farther away (Table 3.7). There was no significant difference between all successful and unsuccessful nests and the nests distance to an edge (Table 3.8).

Nest vegetation and success

Twenty-nine different nesting substrates were used by the different species (Appendix A for scientific names). For species that regularly nested aboveground, I examined nesting substrate in six different categories: forbs, cool-season grass, warm-season grass, ground, woody vegetation, and mixed (multiple substrates). The most commonly used nesting substrates were forbs and woody vegetation (Table 3.9). Only red-winged blackbirds did not use woody vegetation regularly, only 5.7% of nests. Indigo buntings were the only species not to be found nesting on the ground or in either grass type. Red-winged blackbirds and song sparrows nested more commonly on cool-season grasses (12.6% and 12.9% respectively) than warm-season grasses (4.1% and 2.9% respectively), but field sparrows were more common on warm-season grasses (12.6% on warm-season and 7.9% on cool-season).

Since depredation was the major cause of nest loss, I attempted to identify nest predators using infrared video cameras but never captured a depredation event. I visually identified a number of predators in the fields including raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), weasel (*Mustela*), house cat (*Felis domesticus*), red fox (*Vulpes vulpes*), and multiple species of snakes (pers. obs.).

Nesting substrate was only one of the vegetation factors to affect nest placement and success. Because each species had different nesting characteristics, each species had different values when using PCA. I report only those PCs that were accepted into the model. Weights of individual PC variables are given in brackets when only one PC is included in model; otherwise they are given in a separate table. P-values are also shown for those variables that were included in the model but are greater than 0.05.

Wild turkey

Wild turkeys only nested on the ground and the nests were commonly among cool-season grasses or under a multi-flora rose bush. Mayfield regression indicated a trend for nests to be less successful during 2003 and to be more successful with increasing standing litter cover and bare ground (WITU = - year3 – pc5 [SLIT –0.503, BARE –0.406]).

Red-winged blackbirds

There was a trend for red-winged blackbird nests in forbs or woody vegetation to be less successful than expected ($\chi^2 = 9.342$, df = 5, p = 0.096; Fig. 3.5). Mayfield regression indicated that red-winged blackbird nests were less successful in 2003 and 2001 (trend) than in 2002 or 2004 and nests were more successful in denser vegetation that increased nest concealment (RWBL = -year3 + pc3 + pc5 - year1 [0.07] + pc2 [0.08]; Table 3.11). There was also an increase in success with increased woody cover, a decrease in warm-season grass cover, and a trend for nests to be more successful later in the season in taller vegetation.

Field sparrow

Field sparrows were significantly more successful nesting in woody vegetation, and significantly less successful in forbs or on the ground than expected (χ^2 = 9.543, df = 4, p = 0.049; Fig. 3.6). Mayfield regression indicated that field sparrows were more successful when their nests were placed higher above the ground and in higher vegetation (FISP = PC1 [NEST HEIGHT 0.443, HEIGHT 0.423]).

Grasshopper sparrow

All grasshopper sparrow nests were on the ground though they did place their nests under different vegetation – cool-season grass, warm-season grass, clover, and fleabane. No variables entered the Mayfield regression model.

Song sparrow

Because song sparrows had only two nests in warm-season grass, I combined the grasses together to examine nest success. There was not a significant difference in the nest success by substrate (χ^2 = 1.540, df = 3, p = 0.673; Fig. 3.7).

Mayfield regression indicated that nest success increased with increased nest concealment in higher vegetation and greater forb cover with less cool-season grass and standing litter cover (SOSP = pc4 - pc1 - pc2 [0.06]; Table 3.12). There was a trend for increased nest success with increased downed litter, both cover and depth.

Discussion

Ninety percent of the CREP fields that I studied had been planted within 3 years of the study and had an average area of 11.2 ha. The fields were mostly located within an agricultural matrix in the valleys of south-central Pennsylvania but some were located on smaller ridges that were more forested. The species mix nesting on these fields was dominated by red-winged blackbirds that comprised 63.3% of the nests located (613 nests). Field sparrows and song sparrows were the next most common species (121 and 78 nests respectively), with grasshopper sparrows (19 nests), and eastern meadowlarks (9 nests) being uncommon and bobolinks (1 nest), dickcissels (1 nest) and Henslow's sparrows (no nests) practically absent. The game species found ranged from wild turkeys that were fairly common (26 nests), uncommon mallards (9 nests) and rare ring-necked pheasants (3 nests). Mean clutch size and nest success for species with >10 nests was within the ranges found in other studies for each species (Best 1978, Moulton 1981, Wray et al. 1982, Arcese and Smith 1988, Roberts et al. 1995, Badyaev et al. 1996, Suarez et al. 1997, McCoy et al. 1999, Winter and Faaborg 1999, Chase 2002, Balent and Norment 2003).

Nest loss and edge effect

Depredation was the major cause of nest loss (53% of nests and 76% of failures), which agrees with other studies (Best 1978, Wray et al. 1982, Best et al. 1997). Many different predators have been captured on video depredating nests in pastures (9 different species; Renfrew and Ribic 2003) and in grasslands (9 different species; Pietz and

Granfors 2000), though none were captured on film in this study. Nest abandonment accounted for 7.4% of the outcome of nests and 12.2% of nest failures on CREP fields and is commonly a minor cause of nest loss in grassland birds (Best 1978, Wray et al. 1982). Nest abandonment due to human disturbance of CREP field nests should decrease as fields' age and less activity during the breeding season is required, such as liming and weed-suppression mowing.

Edge effects have been implicated in a decrease in nest success especially within 50 m from woody edges mainly due to an increase in mid-sized mammalian predators (Gates and Gysel 1978, Paton 1994,Winter et al. 2000). However, in my study there was no difference in nest success and distance of the nest to any edge, except for wild turkeys being more successful closer to the closest edge (successful nests 41.2 m ± 11.3; unsuccessful nests 80.6 m ± 15.8). This may be attributable to the small field size and a lack of sufficient distance from edges to detect a difference. Grasshopper sparrows and red-winged blackbirds nests averaged greater than 50 m from a treed edge (77.3 m ± 9.7 and 134.3 m ± 4.3 respectively), and so were beyond the suggested range of highest mammalian depredation. Field sparrows and song sparrows average nesting distance was closer than 50m to a treed edge (41.0 m ± 3.8; 45.2 m ± 6.1 respectively) but because the nests were often in multi-flora rose mammalian predators may have been deterred. Nest density was low enough that mammalian depredation that did occur was probably incidental rather than the result of intentional searching (Vickery et al. 1992).

Nest Vegetation

For species that nested above the ground, forbs were the most used substrate (30 – 72% of nests) though field sparrows and red-winged blackbirds were less successful when nesting in forbs than expected. Woody vegetation was the next most important substrate with only red-winged blackbirds using it less than 30% of the time. Nests in woody vegetation were less successful than expected for red-winged blackbirds but more successful than expected for field sparrows, perhaps because red-winged blackbird nests in woody vegetation were less concealed than field sparrows. For most species, nests were more successful in higher, denser vegetation that concealed the nest better. Red-winged blackbirds and wild turkeys were the only species to show a difference in nest success among years.

Field and landscape characteristics

Wild turkeys, grasshopper sparrows and song sparrow nest abundance increased with an increase in field area and a decrease in perimeter-area ratio. Wild turkeys response is similar to that found for first nests of wild turkeys but not in subsequent renests (Badyaev et al. 1996**).** My results for grasshopper sparrows agree with other area-sensitivity studies that they increase with field area, but my field sparrow results did not agree because they failed to indicate a relationship to field area and other studies indicated area-sensitivity (Johnson 2001). Song sparrows had a positive relationship with field area in this study but have a negative relationship in other area-sensitivity studies (Johnson 2001), though most studies examined bird abundance and not nest abundance.

Red-winged blackbird nest abundance model did not include field area, and other area-sensitivity studies had a mixed response to field area (Johnson 2001).

The percent cover of grass entered only two models with an increase in warm-season grass and corresponding decrease in cool-season grass positively influencing field sparrow nest abundance and negatively influencing red-winged blackbird nest abundance. Song sparrows also had a positive relationship with warm-season grass cover when examined univariately. Johnson and Schwartz (1993a) found that there were more breeding pairs of red-winged blackbirds in cool-season grass CRP fields than warm-season grass fields, however they found a negative relationship with the percent cover of grass. Hull (2002) found no difference in nest abundance in cool and warm-season grass fields for red-winged blackbirds, grasshopper sparrows and song sparrows, but did find a decrease in song sparrow nest abundance with percent grass cover.

Percent forb cover was positively related to field sparrow nest abundance and negatively for red-winged blackbirds, but in fields that were in their second growth season and were heavily covered in clover (over 70% forb cover), only red-winged blackbirds nested in any abundance (pers obs.). Grasshopper sparrows in CRP fields were negatively affected by the amount of legume cover in a field (Johnson and Schwartz 1993a), but were positively influenced by the percent cover of forbs taller than 20cm in Maine (Vickery et al. 1992).

Examination of landscape characteristics indicated that local (0.5 km radius) variables had a stronger influence on models than larger scale variables (5.0 km radius). Density of forest edge, cover diversity and percent of annual herbaceous cover were the most common variables to enter species models, except grasshopper sparrows. The amount of local perennial herbaceous cover was the only variable that did not negatively affect nest abundance, though it was only included in indigo bunting and red-winged blackbird models. Road density at the larger landscape scale negatively affected indigo bunting and red-winged blackbird nest abundance. Local road density was not weighted enough in the PCs used to be included but the amount of traffic surrounding the field has been found to negatively affect nesting farmland birds in Norway (Reijnen et al. 1996).

The community analysis indicated that song sparrows and red-winged blackbirds were the most separated of the species. Grasshopper sparrow nest abundance did increase with variation in height of vegetation in fields, which related to other studies that have found a preference for shorter vegetation, less dense vegetation (Smith 1963**,** Herkert 1994**,** Bollinger 1995**,** Balent and Norment 2003). Woody vegetation was positively associated with nest abundance of wild turkeys, indigo buntings, field sparrows and grasshopper sparrows, while negatively affecting only red-winged blackbirds. The only landscape variable that entered the CCA was the diversity of cover types surrounding the field, which was different than that found in individual species regressions where landscape variables were often more important than field variables.

Nest abundance and singing male density

Red-winged blackbirds were the most common species regardless of the measurement method, nest abundance or singing male density. Field sparrows and song sparrows were the next most common in nest abundance. However, when measuring density, song sparrows were ranked second and field sparrows fourth. Song sparrows sang longer into the season and field sparrows commonly sang from within the trees surrounding the field rather than within the field (pers obs.). Grasshopper sparrows were the most common grassland specialists using either method of measurement. Bobolinks actually had the highest density on a field (4.58 singing males/ha) but had only one nest. This difference may be attributed to the difficulty in locating nests compared to identifying singing males, but also bobolinks were found on one field that was nest searched and 5 others that were only surveyed. Many of the edge species, common yellowthroat, indigo bunting, field sparrow and song sparrow may have been located during surveys but may not have nested within the field, preferring to nest in hedgerows or within the wooded edges.

There were similarities and differences in the models of nest abundance and density using field and landscape variables. More species had sufficient data to analyze for density models than nest abundance. This may simply be an artifact that there were more fields surveyed (n=114) than nest searched (n=73).

Six landscape variables were available to be included in both density and nest abundance models. However, for the species that were analyzed using both methods (indigo bunting, field sparrow, grasshopper sparrow, song sparrow and red-winged blackbird) only 35% of the variables entered both models while 45% entered only one model and the remaining 20% entered both models but with the opposite relationship. The variables that entered both models were the local diversity of cover types, forest edge density, perennial herbaceous cover, and number of perennial herbaceous core area patches and at the larger context was road density. The variable that most often was included in both models but with an opposite relationship was the number of perennial herbaceous core areas within the larger context. In many cases the nest abundance models made more biological sense. Grasshopper sparrow density increased with increasing local vegetation diversity and forest edge density but decreasing perennial herbaceous cover while none of these variables entered the nest abundance model. Indigo bunting nest abundance increased with increasing perennial herbaceous cover and number of core areas within the local context while density decreased for the same variables. Indigo bunting nest abundance also increased with increasing local forest edge density and cover diversity and decreasing annual herbaceous cover but the density model did not include these variables. Red-winged blackbirds nest abundance increased with increasing annual herbaceous cover and decreasing forest edge density and cover diversity but none of those variables entered the density model. The nest abundance model did not make as much biological sense because of the negative relationship with the number of perennial herbaceous fields with core area in the larger landscape context; however, it was the last variable to enter the model and therefore explained little of the variance in nest abundance.

Seven field variables were available to enter both measurement models. There was a stronger difference between the models than in landscape variables. Only 23% of the variables were in both of the models, 23% were in both models but had a different relationship, and 54% of the variables only entered one model. The percent cover of cool-season grass and the coefficient of variation of bare ground were the two variables that were the same in both models (field sparrow and red-winged blackbird). Field area and perimeter-area ratio were the two variables with opposite relationships between the models (grasshopper sparrow and song sparrow). Warm-season grass cover had a mixed response with field sparrow models having the same relationship and red-winged blackbirds having an opposite relationship. Part of this may be attributed to the fact that cool-season grass was included with warm-season grass in one variable in nest abundance but were in different PC variables in density. Neither of the models was consistently more biologically appropriate.

Management implications

To maximize the benefits of CREP for grassland birds, attempts should be made to sign up CREP fields that are as large as possible because three species (wild turkey, grasshopper sparrow, and song sparrow) had an increase in nest abundance on larger fields and no species had an increase on smaller fields. The only field variable to affect grasshopper sparrow nest abundance was increasing field area and decreasing perimeter-area ratio. Ring-necked pheasants were only located on large fields, though only three were located. Within the field, dense clumps of high vegetation (forbs or woody vegetation) should be maintained to provide nesting substrate for those species that nest above the ground. However, the overall vegetation should be less dense and have bare areas to attract the most species. To create areas that are less dense, the fields will need with some sort of maintenance outside of the breeding season. Maintenance could include mowing, burning, and or light disking with interseeding, though care must be taken to avoid soil erosion, to diversify the vegetation and to break up dense homogenous stands of vegetation, especially on homogeneous warm-season grass fields (McCoy et al. 2001). Some farmers may need to be convinced that birds need “weeds” (forbs) as a nesting substrate. Nest abundance increased with both warm and cool-season grasses depending on the species and so should continue to be used. I was unable to analyze differences between mixed fields, having both cool and warm-season grasses, and homogeneous fields because of a lack of mixed fields and warm-season grass fields that were fully established. The one small and medium field that had established homogeneous warm-season grasses did not have the diversity of species (1 species) or number of nests (1 nest) that other fields had (pers obs.).

There was no definitive landscape variable that increased nest abundance for all species. The variables that showed only a positive relationship with nest abundance were the increase in perennial herbaceous cover and the number of core areas within 0.5 km of the field. Local diversity of cover and forest edge density had a mixed response by different species. The local landscape variables had a stronger affect on nest abundance than large scale variables. The amount of forest within the landscape may be negatively affecting the nest abundance of grassland birds since they were uncommon on CREP fields (grasshopper sparrows, 19; eastern meadowlark, 9; ring-necked pheasant, 3; bobolink, 1; and dickcissel, 1). However, the amount of forest surrounding the fields and the amount of forest edge around the field did not negatively affect the nest abundance of grasshopper sparrows, the only grassland species that was analyzed.

In conclusion, greater field area and more perennial herbaceous cover in large tracts around the field (0.5 km radius) were only positively associated with nest abundance. Other variables were mixed in response by species. Forbs were an important component of the vegetation structure of the field especially for those species that nest above the ground and should be maintained on fields. There was a mixed response to warm and cool-season grass that indicates both should continue to be used on fields. Local landscape features were more important to most species than the larger context and should be the focus when selecting fields. Cover type diversity around the field was indicated as positively affecting many species when examining the community.

There was some difference in the species composition that was identified between surveying and nest searching. Nest searching located species such as the wild turkey and mallard that were not identified during surveying. There was also a little difference in the ranking of species as to the most common (especially the placement of field sparrows), but red-winged blackbirds were dominant in both methodologies. The field and landscape variables that entered models made somewhat more biological sense in nest abundance than density measurement but it was not enough to justify nest searching as methodology for large scale studies unless the information is going to be used to look at reproductive measures (e.g. source/sink determination).

Table 3.1: Vegetation characteristics of 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania nest searched during the summers of 2001 – 2004.

Measurement	Mean	SE	Maximum field value
Litter depth (cm)	0.96	0.13	4.50
Vegetation height (cm)	43.61	3.50	130.67
% cover of			
Forbs	45.68	2.56	93.17
Cool-season grass	25.86	2.15	66.67
Warm-season grass	4.66	1.32	51.39
Downed litter	10.40	0.99	35.83
Standing litter	3.49	0.75	36.95
Woody vegetation	1.52	0.43	24.75
Bare ground	8.25	1.04	50.92
Vertical density (cm)	48.88	2.21	107.42
CV[a] of			
litter depth	1.24	0.07	2.68
% forbs	0.73	0.05	1.93
% grass[b]	1.65	0.06	3.99
% bare ground	1.43	0.10	4.90
vertical density	0.45	0.02	0.93

[a]CV = coefficient of variation calculated for each field
[b]Grass = combination of both warm and cool-season grass cover

Table 3.2: Landscape characteristics of 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania nest searched during the summers of 2001 – 2004.

Measurement	Mean	SE	Maximum field value
0.5 km radius			
Mean patch size (ha)	2.65	0.09	5.07
Shannon Diversity Index	1.14	0.03	1.64
Forest edge density (m/ha)	82.01	4.99	190.25
CADHAY (number/ha)[b]	7.28	0.31	15.02
% Annual herbaceous	46.50	2.08	90.10
% Perennial herbaceous	23.21	1.28	58.40
% Forest	27.43	2.31	79.25
Road density (m/ha)	22.04	0.89	43.59
5.0 km radius			
Mean patch size (ha)	3.73	0.09	6.00
Shannon Diversity Index	1.31	0.02	1.64
Forest edge density (m/ha)	72.42	1.93	131.76
CADHAY (number/ha)[b]	5.21	0.17	7.27
% Annual herbaceous	37.16	1.53	75.19
% Perennial herbaceous	17.48	0.66	28.68
% Forest	41.00	1.88	79.71
Road density (m/ha)	20.03	0.57	35.56

[a] Characteristics measured within a 0.5 km radius around each field
[b]CADHAY = number of perennial herbaceous patches with a core area (> 60 m from an Edge) per 100 ha
[c] Characteristics measured within a 5.0 km radius around each field

Table 3.3: Number of nests for species found nesting on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 – 2004.

Species	Number of nests	Percent of total nests
Red-winged blackbird	613	63.3
Field sparrow	171	17.6
Song sparrow	78	8.0
Wild turkey	26	2.7
Indigo bunting	21	2.2
Grasshopper sparrow	19	2.0
Mallard	9	0.9
Eastern meadowlark	9	0.9
Vesper sparrow	5	0.5
Ring-necked pheasant	3	0.3
Chipping sparrow	3	0.3
Common yellowthroat	3	0.3
American goldfinch	2	0.2
Savannah sparrow	2	0.2
Mourning dove	1	0.1
American robin	1	0.1
Northern cardinal	1	0.1
Dickcissel	1	0.1
Bobolink	1	0.1

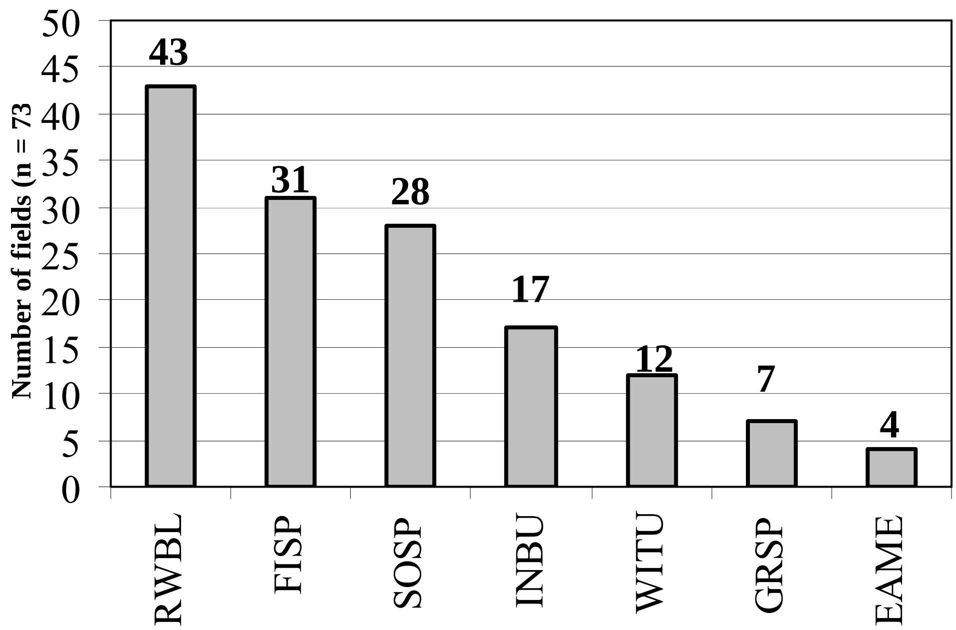

Fig. 3.1: Number of fields that had at least one nest for species with ≥ 9 nests on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. RWBL = red-winged blackbird; FISP = field sparrow; SOSP = song sparrow; INBU = indigo bunting; WITU = wild turkey; GRSP = grasshopper sparrow; EAME = eastern meadowlark

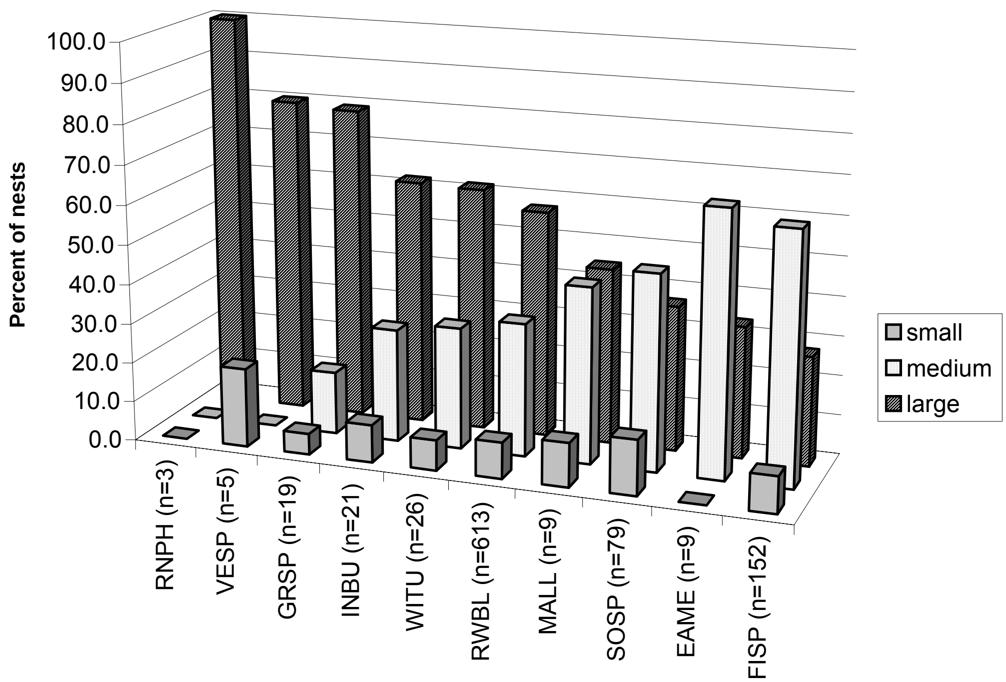

Fig. 3.2: Percent of nests present in each field size category located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. The total number of nests is included in parentheses. RNPH = ring-necked pheasant; VESP = vesper sparrow; GRSP = grasshopper sparrow; INBU = indigo bunting; WITU = wild turkey; RWBL = red-winged blackbird; MALL = Mallard; SOSP = song sparrow; EAME = eastern meadowlark; FISP = field sparrow.

Table 3.4: Chi-square analysis of the number of nests by field size category using the total available area[a] of each category to calculate the expected nest numbers using species with ≥ 5 nests in each category. Nests are combined from the 2001 – 2004 breeding seasons on Conservation Reserve Enhancement Program fields in south-central Pennsylvania.

	Large		Medium		Small				
Species	obs	exp	obs	exp	obs	exp	χ^2	df	p value
Wild turkey	16	14	8	9	3	2	0.29	1[b]	$p > 0.1$
Red-winged blackbird	351	336	206	208	56	69	3.14	2	$p > 0.1$
Indigo bunting	13	12	6	7	2	2	0.37	1[b]	$p > 0.1$
Field sparrow	42	83	96	52	14	17	59.20	2	$p< 0.0001$
Grasshopper sparrow	15	10	3	6	1	2	3.87	1[b]	$0.1 > p < 0.05$
Song sparrow	29	43	39	27	11	9	10.74	2	$p < 0.01$

[a] Large fields 414.3 ha, medium fields 256.76 ha, small fields 85.08 ha
[b] Tests are between only large and medium fields, small fields had less than 5 nests

Table 3.5: Poisson Regression Models of local and landscape variables for nest abundance during the 2001 – 2004 breeding seasons on Conservation Reserve Enhancement Program fields in south-central Pennsylvania. Principle components (PC) were created for field characteristics and for landscape characteristics due to intercorrelation. PCs were chosen when the eigen value was ≥ 1.5 and individual variables are listed with a weighting ≥ 0.380[a].

Species	AIC null	AIC	Variables [b]
WITU	107.63	82.47	– LPC2 + PC3
INBU	84.84	79.07	– LPC2 – LPC3 +Y (0.07)
FISP	460.97	342.07	Y – PC2 – LPC2 – PC1 – PC4 + LPC1 (0.09)
GRSP	89.67	71.13	PC3 + X + LPC1 (0.06)
SOSP	184.57	157.70	– X + LPC2 – PC2 + PC3
RWBL	974.79	687.33	PC4 + LPC2 – X – LPC3 + PC2 – LPC1

[a] Variables with a "-" are negatively weighted:
LPC1 = number of patches with a core area (>60 m from edge)/100km within a 5.0 km radius of the field; mean patch size within 5.0 km radius (-)
LPC2 = density of forest edge within 0.5 km radius (-); Shannon Diversity Index within 0.5 km radius (-); % annual herbaceous cover within 0.5 km radius
LPC3 = % perennial herbaceous cover within 0.5 km radius (-); road density within 5.0 km radius number of patches with core area(>60 m from edge)/100km within a 0.5 km radius (-)
PC1 = % cover of forbs (-); coefficient of variation of forb cover
PC2 = % bare ground cover (-); coefficient of variation of bare ground
PC3 = field area; perimeter/area ratio (-)
PC4 = % cover of warm-season grass (-); depth of downed litter (-); % cover of cool-season grass
X = west to east spatial coordinates, Y = south to north spatial coordinates
[b] Variables are reported by level individual significance and p-value is given when Variable is included in model but the individual p-value is > 0.05.
WITU = wild turkey, INBU = indigo bunting, FISP = field sparrow,
GRSP = grasshopper sparrow, SOSP = song sparrow, RWBL = red-winged blackbird

Table 3.6: Poisson regression model AIC values of nest abundance for models with intercept = 1; all variables; individual categories landscape, field, spatial; or only the percent grass cover of either cool or warm-season grass within the field. Nests were located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. The values in bold indicate the individual set of variables with the lowest AIC.

Species	null	full	field	landscape	spatial	cool-grass	warm-grass
WITU	107.63	82.47	98.21	**85.43**	109.55	109.80	109.10
INBU	84.84	79.07	84.05	**80.80**	87.637	87.02	86.78
FISP	460.97	342.07	**371.98**	450.51	383.89	377.73	432.85
GRSP	89.67	71.13	**74.604**	86.99	81.72	90.87	91.11
SOSP	184.57	156.35	**167.70**	177.81	**168.29**	185.58	171.81
RWBL	974.79	687.33	843.87	**817.24**	926.27	936.42	966.37

WITU = wild turkey, INBU = indigo bunting, FISP = field sparrow,
GRSP = grasshopper sparrow, SOSP = song sparrow, RWBL = red- winged blackbird

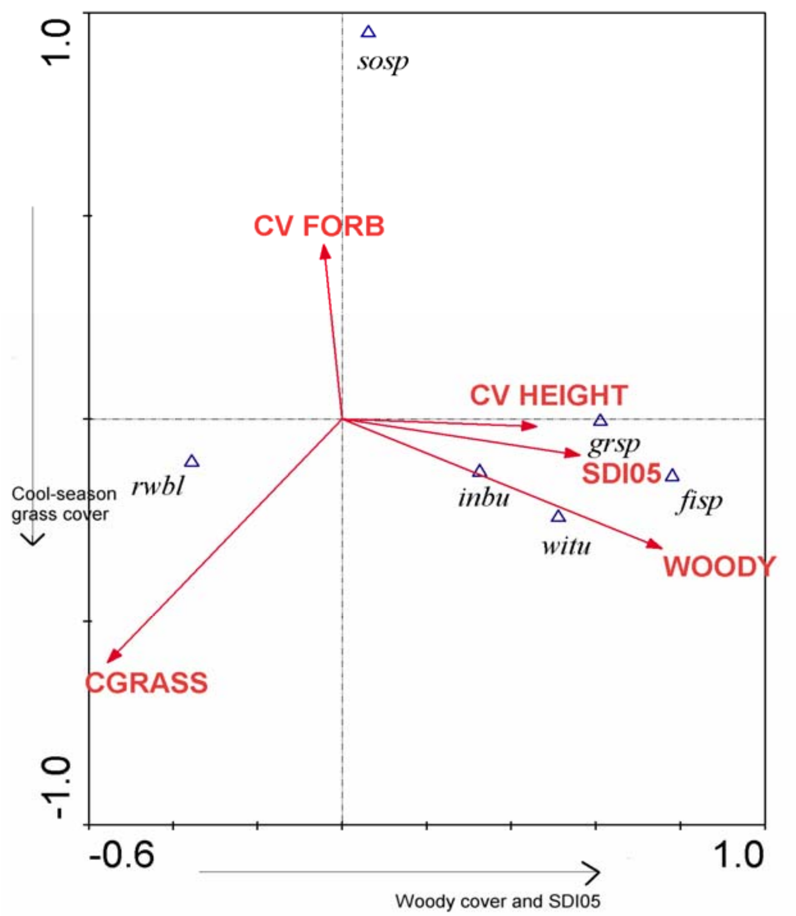

Fig. 3.3: Canonical Correspondence Analysis of grassland bird nest abundance on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. Axis 1 is a gradient of woody cover within the field and cover diversity surrounding the field. Axis 2 is a gradient of the amount of cool-season grass cover.

witu = wild turkey; fisp = field sparrow; grsp = grasshopper sparrow; sosp = song sparrow; inbu = indigo bunting; rwbl = red-winged blackbird; CVFORB = coefficient of variation of forb cover on field; CVHEIGHT = coefficient of variation of the vegetation height of the field; CGRASS = % cover of cool-season grass on the field; WOODY = % cover of woody vegetation on the field; and SDI05 = the Shannon Diversity Index of vegetation within a 0.5 km radius of the field

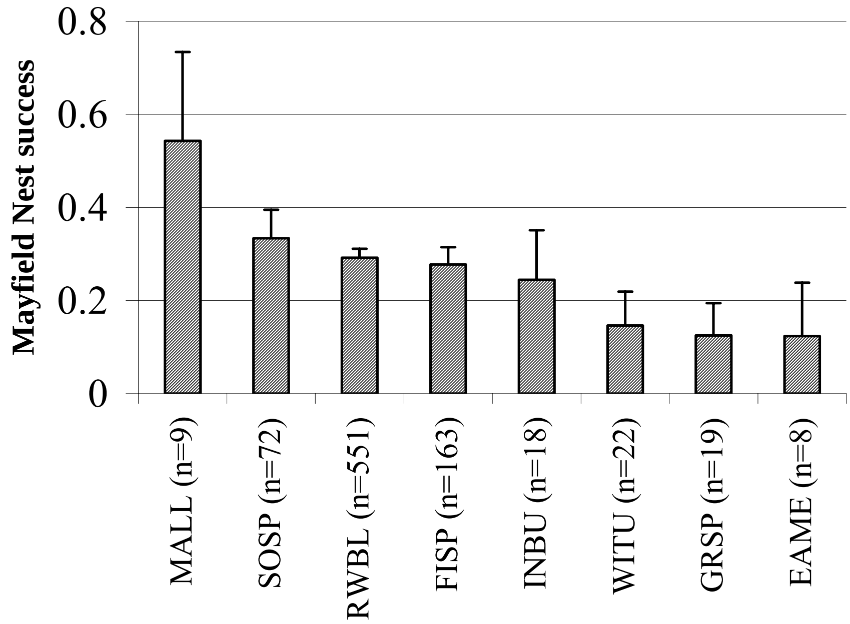

Fig. 3.4: Mayfield nest success (+1 SE) of species with greater than eight total nests located during the 2001 – 2004 breeding seasons on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania. MALL = Mallard; SOSP = song sparrow; RWBL = red-winged blackbird; FISP = field sparrow; INBU = indigo bunting; WITU = wild turkey; GRSP = grasshopper sparrow; EAME = eastern meadowlark

Table 3.7: Distances of successful and unsuccessful nests from the closest edge, road, tree line, woodlot or row crop edges using a paired t-test for nests located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. Only species with distances from the edge for successful and unsuccessful nests on multiple fields are included in the analysis.

		Mean distance from edge (±SD)		T score	
Species	Edge Type	Successful	Unsuccessful	(df)	P value[a]
FISP	Closest edge	40.5 (48.8)	45.4 (45.6)	-0.53 (14)	0.602
GRSP	Closest edge	75.0 (22.5)	64.5 (6.9)	0.36 (2)	0.754
SOSP	Closest edge	34.6 (35.1)	38.0 (37.2)	-0.20 (12)	0.842
RWBL	Closest edge	72.4 (32.4)	74.3 (28.9)	-0.38 (24)	0.709
FISP	Road	95.0 (54.0)	160.8 (35.1)	-3.56 (5)	0.016
SOSP	Road	175.9(162.1)	166.3(163.4)	0.77 (6)	0.472
RWBL	Road	136.8 (97.0)	143.3 (74.0)	-0.46 (18)	0.650
FISP	Trees	37.3 (47.4)	44.2 (11.4)	-1.07 (13)	0.305
GRSP	Trees	97.5 (2.5)	65.8 (5.8)	3.85 (1)	0.162
SOSP	Trees	60.0 (91.7)	69.1 (83.5)	-0.67 (11)	0.516
RWBL	Trees	109.5 (50.6)	124.8 (56.4)	-2.02(22)	0.056
FISP	Woodlot	67.9 (89.2)	65.8 (57.5)	0.14 (12)	0.894
GRSP	Woodlot	140 (45.0)	90.5 (19.5)	1.94 (1)	0.303
SOSP	Woodlot	30.2 (30.3)	54.3 (22.4)	-2.23 (4)	0.090
RWBL	Woodlot	141.1 (74.0)	136.8 (56.8)	0.31 (13)	0.759
RWBL	Row crop	113 (77.6)	130.2 (69.1)	-1.43 (15)	0.173

[a] Bonferroni adjustment $p \leq 0.01$*; RWBL = red-winged blackbird,
FISP = field sparrow, GRSP = grasshopper sparrow, SOSP = song sparrow

Table 3.8: Binary logistic regression of successful and unsuccessful nests and their distance from different edge types: the closest edge, road, tree line, woodlot and agricultural. Nests were located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004.

Species	Edge	Number of nests (range of distances m)		G score (z score)	p value
		Successful	Failed		
Mallard	Closest edge	4 (10-92)	2 (43-80)	0.60 (0.74)	0.440
Wild turkey	Closest edge	6 (15-79)	7 (22-153)	3.96 (-1.65)	0.046*
Indigo bunting	Closest edge	4 (10 – 52)	10 (6 – 120)	0.16 (0.38)	0.689
Field sparrow	Closest edge	54 (10-106)	71 (1-163)	1.46 (1.17)	0.227
Grasshopper sparrow	Closest edge	5 (30-120)	9 (35-106)	0.01 (-0.07)	0.944
Vesper sparrow	Closest edge	3 (28-71)	2 (57-92)	2.08 (-1.14)	0.150
Song sparrow	Closest edge	29 (5-61)	32 (9-125)	0.01 (0.10)	0.917
Eastern meadowlark	Closest edge	2 (75-125)	5 (5-58)	1.00 (0.94)	0.317
Red-winged blackbird	Closest edge	197 (0-206)	264 (0-246)	0.01 (-0.12)	0.907
Field sparrow	Road	28 (20-350)	27 (26-300)	2.74 (1.60)	0.098
Grasshopper sparrow	Road	2 (30-320)	6 (35-106)	2.21 (1.18)	0.138
Song sparrow	Road	17 (34-250)	18 (20-195)	0.32 (-0.56)	0.472

Eastern meadowlark	Road	2 (125-200)	5 (5-185)	1.08 (0.87)	0.300
Red-winged blackbird	Road	130 (5-205)	182 (5-430)	0.01 (-0.12)	0.906
Mallard	Tree line/woodlot	4 (10-141)	2 (45-80)	0.34 (-0.56)	0.563
Wild turkey	Tree line/woodlot	4 (15-208)	3 (22-153)	0.01 (-0.06)	0.950
Field sparrow	Tree line/woodlot	43 (10-105)	69 (5-190)	1.16 (1.03)	0.282
Grasshopper sparrow	Tree line/woodlot	4 (80-120)	6 (37-111)	0.33 (0.56)	0.565
Song sparrow	Tree line/woodlot	20 (5-78)	27 (9-125)	0.18 (0.41)	0.674
Eastern meadowlark	Tree line/woodlot	2 (82-175)	5 (39-180)	0.10 (0.31)	0.750
Red-winged blackbird	Tree line/woodlot	72 (10-349)	127 (5-409)	2.26 (-1.46)	0.133
Field sparrow	Woodlot	37 (10-130)	56 (5-200)	1.43 (1.14)	0.230
Grasshopper sparrow	Woodlot	4 (89-220)	5 (45-175)	1.14 (0.99)	0.285
Song sparrow	Woodlot	11 (5-165)	14 (27-130)	1.35 (1.11)	0.246
Eastern meadowlark	Woodlot	2 (82-175)	4 (58-180)	0.00 (0.04)	0.969
Red-winged blackbird	Woodlot	65 (37-245)	120 (8-300)	0.39 (-0.63)	0.531
Field sparrow	Agriculture	6 (24–470)	8 (10–379)	0.56 (-0.74)	0.454
Song sparrow	Agriculture	5 (9-286)	9 (10-150)	1.62 (-1.13)	0.203
Red-winged blackbird	Agriculture	72 (10-420)	124 (11-250)	0.58 (0.75)	0.448

Table 3.9: Nest substrates for aboveground nesting species located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004.

	Nesting substrate (% nests)					
Species (N)	Forbs	Cool-season grass	Warm-season grass	Woody vegetation	Ground	Mixed
RWBL (541)	72.0	12.6	4.1	5.7	1.8	3.9
FISP (143)	44.1	7.9	12.6	37.8	8.7	1.6
SOSP (70)	30.0	12.9	2.9	37.1	17.1	0.0
INBU (18)	50.0	0.0	0.0	50.0	0.0	0.0

RWBL = red-winged blackbird, FISP = field sparrow, SOSP = song sparrow
INBU = indigo bunting

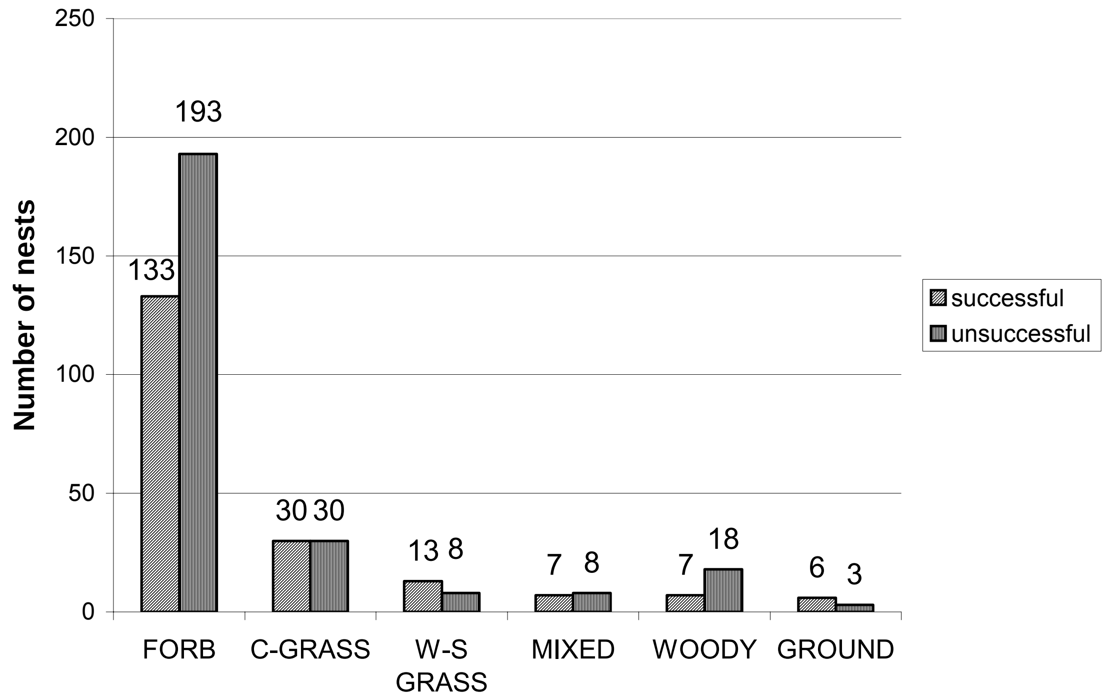

Fig. 3.5: Nest success by nesting substrate for red-winged blackbird nests during the breeding seasons of 2001 – 2004 on Conservation Reserve Enhancement Program fields in south-central Pennsylvania.

Table 3.10: Principle Components for Mayfield regression of red-winged blackbird nests located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. Only PC variables included in the model are shown and only variables with a weighting of ≥ 0.390 are shown.

Variable	Weight
PC2	
HEIGHT	0.538
DATE	0.429
PC3	
ROBEL	0.533
CONCEALMENT	0.482
PC5	
WGRASS	-0.570
WOODY	0.499

HEGHT = height of vegetation at nest, DATE = Julian day of nest location, ROBEL = vertical density, CONCEALMENT = average concealment of nest from 1 m in the four cardinal directions and above the nest, WGRASS = cover percentage of warm-season grass, WOODY = cover percentage of woody vegetation

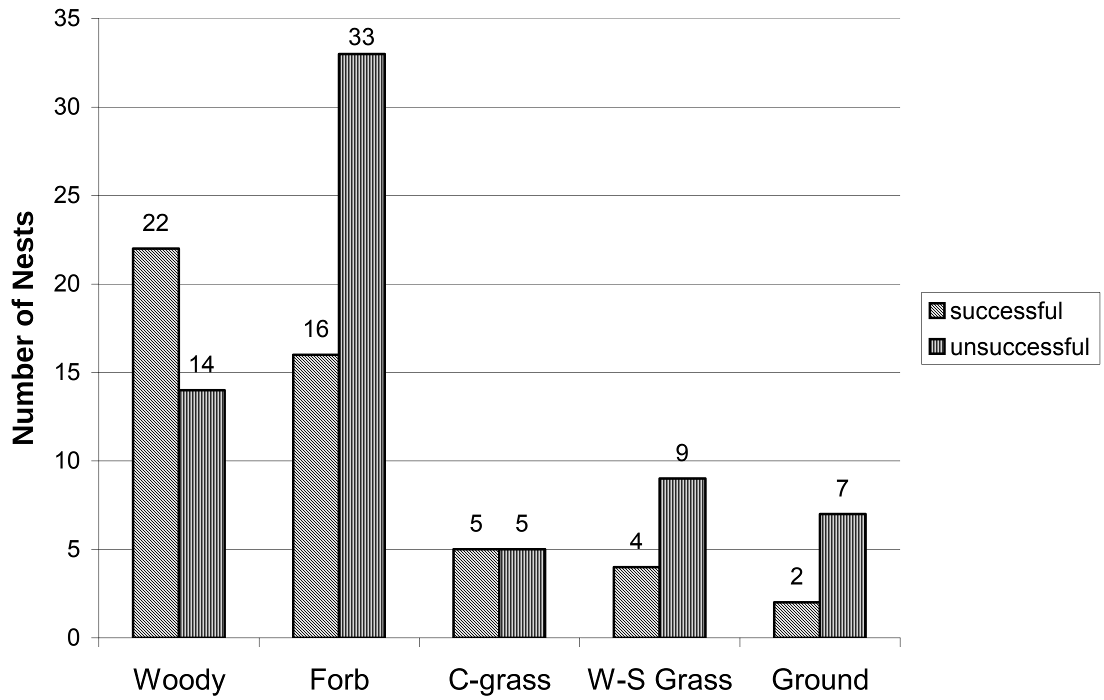

Fig. 3.6: Nest success by nesting substrate for field sparrow nests on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004.

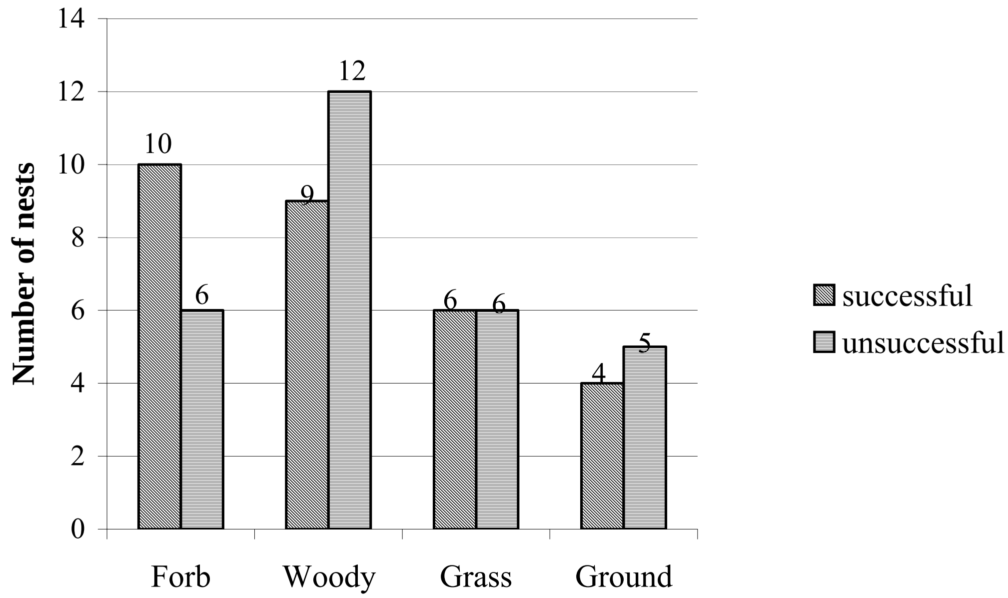

Fig. 3.7: Nest success by nesting substrate for song sparrow nests on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 – 2004.

Table 3.11: Principle Components for Mayfield regression of song sparrow nests located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 – 2004. Only PC variables included in the model and only variables with a weighting of ≥ 0.390 are shown. The PC variables are shown in the order of selection.

Variable	Weight
PC4	
CONCEALMENT	0.479
WGRASS	-0.454
ROBEL	0.402
PC1	
FORBS	-0.528
CGRASS	0.440
SLIT	0.423
PC2	
DLIT	-0.455
CONCEALMENT	-0.453
DEPTH	-0.407

CONCEALMENT = average concealment of nest from 1 m in the four cardinal directions and above the nest, WGRASS = cover percentage of warm-season grass, ROBEL = vertical density, FORBS = cover percentage of forbs, CGRASS = cover percentage of cool-season grass, SLIT = cover percentage of standing litter, DLIT = cover percentage of downed litter, DEPTH = litter depth

Chapter 4

Conservation Reserve Enhancement Program fields and hayfield use and productivity

Introduction

In 2001, the Conservation Reserve Enhancement Program (CREP) was initiated in Pennsylvania to help control soil erosion and to improve water quality. Farmers enroll highly erodible lands for a 10 to 15-year period, during which the fields are left under a permanent cover, typically grass. This permanent cover is then possible habitat for wildlife.

Because grassland birds have declined as a result of habitat loss (Knopf 1994**,** Warner 1994) they are a group of species that could benefit from enhanced grassland habitat provided through CREP. Studies from the Midwest indicate that Conservation Reserve Program (CRP) fields, a program similar to CREP, is beneficial to many farmland and grassland birds with CRP fields having a higher abundance and a higher overall diversity of species than rowcrops (Best et al. 1997**,**Johnson and Schwartz 1993**,**Johnson and Schwartz 1993a). Because hayfields are more similar to CREP fields than rowcrops in terms of the vegetative structure and composition, a better comparison is between use and productivity of birds on hayfields and CREP fields. In the eastern U.S. studies have examined the use and productivity of hayfields (Bollinger 1995, Giuliano and Daves 2002) but none have compared CREP fields with hayfields. The objectives of this portion of a larger study were to compare species use and productivity between CREP and hayfields.

Methods

Study area and field selection

The study area and field selection of CREP fields has been previously described (see Chapter 2). Hayfields were located as close as possible to CREP fields so that spatial differences could be minimized. In 2001, I tried to locate two hayfields in each size category but was unable to locate a second large field. In 2002, I decided that because there was little difference among CREP fields by field area, I would only use hayfields that were in the medium field size category and I was able to locate one in each of the six counties. In 2003 and 2004 because of difficulty getting permission to use hayfields, any size category of field was used. I surveyed a total of 114 CREP fields and 16 hayfields. I nest searched 73 CREP fields and 15 hayfields. To equalize the number of fields between CREP and hayfields, CREP fields were matched with hayfields that were of a similar area, from the same year and spatially as close as possible. If more than one CREP field fit the criteria then one was randomly selected.

Avian density, nest abundance and reproductive success

Identical methods for measuring avian density, nest abundance and reproductive success were used on hayfields as on CREP fields. The methodologies for these have been described in previous chapters (see Chapters 2 and 3).

Data analysis

I used the Kolmogorov-Smirnov test of normality on all data to determine if the data were normally distributed. Data were transformed if not normally distributed using square root transformations for dependent variables, and logarithmic and arcsine transformations for independent variables (Zar 1999). MINITAB^{tm} (MINITAB, Inc.) was used to calculate all normality, paired-t, Mann-Whitney, and 1-sample Wilcoxon tests. All means are reported $\pm$ 1 SE, unless otherwise noted. Significance reported as $p \leq 0.05$, but a trend is reported when $0.10 > p > 0.05$.

Comparison of densities and nest abundance between CREP and hayfields was conducted using a Mann-Whitney test because the data were non-normally distributed. If no value for one type of field was available, then a 1-sample Wilcoxon test was used to test whether the median was greater than zero. Nest success was compared using program CONTRAST (Hines and Sauer 1989) using Mayfield calculations (Mayfield 1961 and 1975) and calculated standard errors (Hensler 1985).

Results

I made 185 observations of 8 different species on 16 CREP fields and 68 observations of 7 different species on 16 hayfields (Table 4.1). Indigo buntings, field sparrows and song sparrows had significantly higher density on matched CREP fields than hayfields (Table 4.2). Species richness of observed species was significantly higher on CREP fields (2.75 ± 0.233) than hayfields (1.38 ± 0.24; t = 4.20, df = 15, p value = 0.001). The maximum number of birds seen per field during either survey, indicated a trend for a higher number of birds on CREP fields (7.25 ± 1.34) than hayfields (4.00 ± 0.95; t = 2.08, df = 15, p value = 0.055). However, if the total numbers of birds from both survey periods were analyzed CREP fields (11.44 ± 2.41) had significantly more birds than hayfields (4.31 ± 1.14; t = 2.81, df = 15, p value = 0.013).

I located 193 nests of 10 different species on 15 CREP fields and 88 nests of 5 species on 15 hayfields during the 2001 – 2004 breeding seasons in six different counties (Appendix B). Red-winged blackbirds were the most common nesting species in both types of fields comprising over 60% of the nests located (Table 4.3). Species richness of birds nesting on fields was significantly higher on CREP fields (2.47 ± 0.40) than hayfields (0.60 ± 0.19; t = 4.63, df = 14, p < 0.001). There was no difference in grassland specialists' presence on either CREP or hayfields, with at least one nest found on 13.3% of the fields. Field sparrows and song sparrows were the only individual species to have significantly higher nest abundance on CREP fields than hayfields (Table 4.4) though wild turkeys, indigo buntings, and eastern meadowlarks were only found on CREP fields. No species had significantly higher nest abundance on hayfields than CREP fields. Nest success of red-winged blackbirds (the only species with multiple nests on hayfields) was higher on CREP fields (0.279 ± 0.062, n = 59) than hayfields (0.126 ± 0.034, n = 73; χ^2 = 4.773, df = 1, p = 0.029). Examining nest success by year, CREP fields (0.275 ± 0.068, 49 nests) were significantly more successful than hayfields (0.126 ± 0.037, 63 nests; χ^2 = 5.260, df = 1, p = 0.022) in 2001. However, in 2002, there was no significant difference between CREP fields (0.229 ± 0.131, 10 nests) and hayfields (0.170 ± 0.120, 10 nests; χ^2 = 0.111, df = 1, p = 0.739). There were not enough nests on hayfields during 2003 or 2004 to analyze.

Discussion

Red-winged blackbirds were the most common species on both CREP and hayfields, which is similar to other eastern studies (Bollinger 1995**,** Giuliano and Daves 2002). However species richness and abundance, and nest success were higher on CREP fields than hayfields. In the Midwest, CRP fields had more nests and more species using them than row crops (Best et al. 1997). While I did not directly examine this it would be expected that CREP fields would be even more successful and richer than row crops since hayfields are more similar to grasslands and row crops are more highly managed.

Differences in species richness, density and nest abundance between hayfields and CREP fields were primarily due to higher use of CREP fields by old-field and successional species such as field sparrow, indigo bunting, and song sparrow, which commonly use woody vegetation as a nesting substrate (see Chapter 3). However, Giuliano and Daves (2002) found both field and song sparrows nesting on hayfields in

Pennsylvania. Wild turkeys, eastern meadowlarks, and indigo buntings were not found nesting on hayfields and were uncommon on the matched CREP fields; in fact there was no significant difference in nest abundance from zero. Giuliano and Daves (2002) also found these species nesting uncommonly on hayfields. Grassland specialists such as bobolinks, eastern meadowlarks, and grasshopper sparrows did not differ in abundance between CREP fields and hayfields. All of these species had a very low abundance across the study area (see chapters 2 and 3), which probably affected my results, because at very low densities I would probably be unable to detect differences even if differences in habitat preferences actually existed. In Wisconsin, grasshopper sparrows were more abundant on dry pastures and prairie than hayfields (Ribic and Sample 2001). Grasshopper sparrows may continue to increase in density on CREP fields in relation to hayfields as the amount of mowing on CREP fields decreases because their abundance has been found to remain similar or decrease the year following mowing (Bollinger 1995, Horn and Koford 2000). The hayfields that did have grasshopper sparrows had either sparse vegetation or a mowed strip so there was some very low vegetation (pers. obs.).

Other species such as bobolinks may prefer the habitat structure of hayfields. Bobolinks have commonly been found on hayfields (Bollinger 1995) and to prefer hayfields to other types of grasslands in other studies (Dale et al. 1997). Red-winged blackbirds were the only species for which adequate numbers of nests were available to compare nest success between CREP fields and hayfields. However, because red-winged blackbirds nest across all field types and in all nest substrates (Chapter 3); I assume they are a fairly good indicator of nest success for the suite of species nesting in these fields. Red-winged blackbirds were significantly more successful nesting in CREP fields than hayfields. These results differ from Best et al. (1997) study in Iowa where nest success was similar between CRP fields and rowcrops. However, the species were not separated in the analysis and may have skewed the results if species had differing nest success rates between field types. Though mowing was very late during my study (20 June – 3 July), nest loss due to mowing was high (18.2%) compared with the matched CREP fields (0.5%). This percentage may have been even higher if alfalfa fields had been used since they are usually cut earlier and more often than the cool-season grass hayfields that I studied. On row crops, that harvest later in the breeding season than hayfields but have equipment moving through them regularly had nest losses ranging from 10 – 22% due to agricultural practices (Best et al. 1997**,** Lokemoen and Beiser 1997).

Species richness and abundance, and nest success were higher in CREP fields than on hayfields suggesting that CREP fields provide an additional and better habitat for birds and suggests that the CREP program is beneficial to farmland and grassland birds even within the first three years of establishment. Abundance of grassland specialists, a program target, was low across sites but this is probably due to low regional abundance and may change as more CREP fields are established and others mature, increasing the likelihood of birds finding them. Future research should continue to monitor these fields over time and compare nest abundance and success between CREP fields and other agricultural fields such as row crops, pastures and alfalfa fields.

Table 4.1: Species of birds located during surveys on 16 hayfields and matched Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2002 - 2004.

Species	CREP		Hay	
	Total observations	Fields present % (N = 16)	Total observations	Fields present % (N = 16)
Gray catbird	1	6.3	0	0.0
Common yellowthroat	1	6.3	0	0.0
Indigo bunting	15	50.0	1	6.3
Field sparrow	22	43.8	1	6.3
Grasshopper sparrow	8	12.5	4	25.0
Savannah sparrow	0	0.0	1	6.3
Song sparrow	41	68.8	0	0.0
Eastern meadowlark	2	12.5	1	6.3
Bobolink	0	0.0	10	18.8
Red-winged blackbird	95	75.0	50	68.8

Table 4.2: Mann-Whitney test of 16 matched Conservation Reserve Enhancement Program fields and hayfield bird density during the 2002 – 2004 breeding seasons in south-central Pennsylvania for species found on both types of fields. 1-Sample Wilcoxon test of whether median was greater than zero was used for species found on only one type of field.

	CREP	HAY		
Species	Mean density (SE)		w	p value
Common yellowthroat	0.019 (0.019)	0.000	1.0	1.000
Indigo bunting	0.155 (0.054)	0.010 (0.010)	322.0	0.006**
Field sparrow	0.201 (0.073)	0.006 (0.006)	315.5	0.012*
Grasshopper sparrow	0.064 (0.049)	0.033 (0.016)	252.0	0.525
Song sparrow	0.428 (0.133)	0.000	66.0	0.004**
Eastern meadowlark	0.009 (0.007)	0.007 (0.007)	271.0	0.628
Bobolink	0.000	0.120 (0.077)	6.0	0.181
Red-winged blackbird	0.624 (0.138)	0.629 (0.208)	275.0	0.689

Table 4.3: Nesting information for species found on 15 hayfields and matching Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 – 2004.

	CREP		HAY	
Species	Nests (%)	Fields (%)	Nests (%)	Fields (%)
Wild turkey	2 (1.0)	2 (1.0)	0	0
Common yellowthroat	2 (1.0)	1 (6.7)	0	0
Indigo bunting	2 (1.0)	2 (13.3)	0	0
Field sparrow	37 (19.3)	5 (33.3)	1 (1.1)	1 (6.7)
Grasshopper sparrow	3 (1.6)	1 (6.7)	1 (1.1)	1 (6.7)
Song sparrow	26 (13.5)	9 (60.0)	1 (1.1)	1 (6.7)
Chipping sparrow	1 (0.5)	1 (6.7)	0	0
Bobolink	0	0	1 (1.1)	1 (6.7)
Eastern meadowlark	5 (2.6)	2 (13.3)	0	0
Red-winged blackbird	114 (59.4)	9 (60.0)	84 (95.4)	5 (33.3)
American goldfinch	1 (0.5)	1 (6.7)	0	0

Table 4.4: Mann-Whitney test of 15 hayfield and matched Conservation Reserve Enhancement Program nest abundance/ha in south-central Pennsylvania, 2001 – 2004. A 1-sample Wilcoxon test was used to test if the median was greater than 0 for those species found on only one type of field.

	Mean (SE)			
Species	CREP	Hay	W	p value
Wild turkey	0.024 (0.02)	0.000	3.0	0.186
Indigo bunting	0.014 (0.01)	0.000	3.0	0.186
Field sparrow	0.318 (0.15)	0.006 (0.01)	281.0	0.011*
Grasshopper sparrow	0.008 (0.01)	0.006 (0.01)	233.0	1.000
Song sparrow	0.193 (0.10)	0.006 (0.01)	302.5	0.001***
Eastern meadowlark	0.022 (0.02)	0.000	3.0	0.186
Red-winged blackbird	0.729 (0.27)	0.606 (0.43)	268.0	0.121

Chapter 5

Conclusions

The species make-up of CREP fields in south-central Pennsylvania is different from CRP fields in the Midwest, with generalists and edge species being more common than grassland specialists on Pennsylvania CREP fields. The difference may be because of the greater age and field area of CRP fields, the ridge and valley geography of south-central Pennsylvania compared with the plains of the Midwest, or because south-central Pennsylvania is at the edge of most grassland specialists' range (Sauer et al. 2001). Grasshopper sparrows and eastern meadowlarks were the most common grassland specialists found on CREP fields whether surveying (36 and 20 fields respectively) or nest searching (7 and 4 fields respectively), though they were much less common than red-winged blackbirds (83 survey fields and 43 nest searching fields). However, the species using CREP fields had a similar nest success to grassland studies in the Midwest (12.4 – 54.3%).

CREP fields were also different from hayfields in Pennsylvania. CREP fields had a higher species richness (2.75 survey, 2.47 nesting) than hayfields (1.38 surveys, 0.60 nesting). Three species (indigo buntings, field sparrows and song sparrows) had higher densities and field sparrows and song sparrows also had higher nest abundance on CREP fields than hayfields. Nest success was higher on CREP fields with red-winged blackbirds having a 27.9% success rate on CREP fields and 12.6% on hayfields. So

CREP fields were providing a better habitat for species than hayfields in Pennsylvania even though during the study hayfields were not mowed until middle to late June.

For managers it is important to understand that presently grassland specialists are not as common as they are in the Midwest and they probably never will be because they are on the edge of their ranges. However, they used CREP fields and were as successful as those found in the Midwest. Grassland specialists indicated little regard for the amount of forest cover or the density of forest edge around the field, though this may be an artifact of the low number of individuals located. Grasshopper sparrows the most common grassland specialists were found on only 31.6% of the fields during surveys and 9.5% of the fields during nest searching. There were no field or landscape variables positively associated with all species, which makes the management of CREP fields difficult. There was not even a clear similarity among the grassland specialists, because bobolinks preferred different variables than either grasshopper sparrows or eastern meadowlarks. However, to have the highest diversity of species and to have the greatest likelihood of increasing grassland species, fields should be selected that are as large as possible (including adjoining fields). These fields should be maintained with a heterogeneous mixture of plant species (especially including forbs) and structure (mixed levels of vegetation height and density).

Further research

The difference between the results of density and nest abundance indicates that there is not a perfect correlation, but a close similarity. Researchers should use the most appropriate method for the objectives of the study. I do suggest that some form of density measurement be used in order to more accurately compare among studies.

Further research needs to be conducted on the changing conditions of CREP fields to see how birds respond to vegetation, management, and landscape changes. Bollinger (1995) has indicated that, as hayfields age and become more heterogeneous they attract more grassland specialists, and monitoring should be continued to see if this occurs on CREP fields. As CREP fields mature there will be a better opportunity to examine the differences in use and productivity on warm and cool-season grass fields. There should also be research focused on grassland species using CREP fields, which may better identify areas that have a higher population of grassland species rather than the field selection approach I used in this study. This might also give a better indication if landscape features such as forest cover are influencing grassland bird use and productivity in Pennsylvania. Now that CREP has expanded, comparisons among eastern and western Pennsylvania CREP fields should be conducted to identify any differences in use and productivity. There is also the opportunity to do experimental studies using differing management tools to identify the best methods for maintaining bird populations, because species have varied in their response to tools such as mowing. Population studies (e.g., Balent and Norment 2003) should be conducted to determine if CREP fields provide source populations of any species in Pennsylvania. Genetic research should also be conducted to investigate the metapopulation context of Pennsylvania grassland species to help identify where sources are, which is important in understanding the likelihood of populations increasing on CREP fields, and the length of time needed for habitats to fill.

Bibliography

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. Pages 267-281. *In* Proceedings of the 2nd international symposium on information theory. B. N. Petran and F. Csáki (eds.). Akadémiai Kiadi, Budapest, Hungary.

Akaike, H. 1985. Prediction and entropy. Pages 1-24. In A celebration of statistics: the ISI centenary volume. A. C. Atkinson and S. E. Fienberg (eds.). Springer-Verlag, New York, New York.

Arcese, P. and J. N. M. Smith. 1988. Effects of population density and supplemental food on reproduction in Song Sparrows. Journal of Animal Ecology 57:119-136.

Askins, R.A. 1993. Population trends in grassland, shrubland, and forest birds in Eastern North America. Current Ornithology. 11: 1-34.

Badyaev, A. V., T. E. Martin, and W. J. Etges. 1996. Habitat sampling and habitat selection by female Wild Turkeys: ecological correlates and reproductive consequences. Auk 113:636-646.

Balent, K. L. and C. J. Norment. 2003. Demographic characteristics of a Grasshopper Sparrow population in a highly fragmented landscape of western New York state. Journal of Field Ornithology 74:341-348.

Best, L.B. 1978. Field Sparrow reproductive success and nesting ecology. Ardea 95:9-22.

Best, L. B., H. Campa, III, K. E. Kemp, R. J. Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks, Jr., and S. R. Winterstein. 1997. Bird abundance and nesting in CRP fields and cropland in the Midwest: a regional approach. Wildlife Society Bulletin. 25:864-877.

Best, L. B., T. M. Bergin, and K. E. Freemark. 2001. Influence of landscape composition on bird use of rowcrop fields. Journal of Wildlife Management 65:442-449.

Bollinger, E. K. 1995. Successional changes and habitat selection in hayfield bird communities. Auk. 112:720-730.

Bollinger, E.K. and T.A. Gavin. 1992. Eastern bobolink populations: Ecology and Conservation in an agricultural landscape. Pages 497-506 in J.M. Hagan and

D.W. Johnston, editors. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C.

Brauning, D., M. Grishaver, and C. Grainer. 2001. Nesting-season responses of three grassland sparrow species to previous-year mowing on reclaimed surface mines. Journal of the Pennsylvania Academy of Science 75:23-26.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. Laake, D. L. Borchers, and L. Thomas. 2001. Distance Sampling: estimating abundance of biological populations. Oxford University Press, Oxford, United Kingdom.

Burnham, K. P. and D. R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer, New York, New York.

Chase, M. K. 2002. Nest site selection and nest success in a song sparrow population: the significance of spatial variation. Condor 104:103-116.

Coppedge, B. R., D. M. Engle, R. E. Masters, and M. S. Gregory. 2001. Avian response to landscape change in fragmented southern great plains grasslands. Ecological Applications 11:47-59.

Dale, B. C., P. A. Martin, and P. S. Taylor. 1997. Effects of hay management on grassland songbirds in Saskatchewan. Wildlife Society Bulletin 25:616-626.

Daubenmire, R. 1959. A canopy-cover method of vegetational analysis. Northwest Science. 33:43-63.

Delisle, J. M. and J. A. Savidge. 1997. Avian use and vegetation characteristics of conservation reserve program fields. Journal of Wildlife Management. 61:318-325

DeVault, T. L., P. E. Scott, R. A. Bajema, and S. L. Lima. 2002. Breeding bird communities of reclaimed coal-mine grasslands in the American Midwest. Journal of Field Ornithology 73:268-275.

Diefenbach, D. R., D. W. Brauning, and J. A. Mattice. 2003. Variability in grassland bird counts related to observer differences and species detection rates. Auk 120:1168-1179.

Donovan, T.M., P.W. Jones, E.M. Annard, and F.R. Thompson 111. 1997. Variation in local scale edge effects: Mechanisms and landscape context. Ecology. 78: 2064-2075.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. The birder's handbook. Simon and Schuster New York.

Emlen, J. T. 1971. Population densities of birds derived from transect counts. Auk 88:323-342.

Emlen, J. T. 1977. Estimating breeding season bird densities from transect counts. Auk 94:455-468.

Fletcher, R. J., Jr. and R. R. Koford. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. Journal of Wildlife Management 66:1011-1022.

Fretwell, S.D. 1986. Distribution and abundance of the dickcissel. Current Ornithology. 4:211-212.

Gates, J. E. and L. W. Gysel. 1978. Avian nest dispersion and fledgling success in field-forest ecotones. Ecology 59:871-883.

Giuliano, W. M. and S. E. Daves. 2002. Avian response to warm-season grass use in pasture and hayfield management. Biological Conservation 106:1-9.

Hazler, K. R. 2004. Mayfield logistic regression: a practical approach for analysis of nest survival. Auk 121:707-716.

Hensler, G. L. 1985. Estimation and comparison of functions of daily nest survival probabilities using the Mayfield method. Pages 289-301 *in* Statistics in Ornithology (D.J.T. Morgan and P.M. North, Editors). Springer-Verlag, Berlin.

Herkert, J.R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications. 4:461-471.

Herkert, J. R. 1995. An analysis of midwestern breeding bird population trends: 1966-1993. American Midland Naturalist. 134:41-50.

Hines, J. E., and J. R. Sauer. 1989. Program CONTRAST - a general program for the analysis of several survival or recovery rate estimates. Fish and Wildlife Technical Report 24:1-7.

Horn, D. J. 2000. The influence of habitat features on grassland birds nesting in the Prairie Pothole Region of North Dakota. Iowa State University, PhD.

Horn, D. J. and R. R. Koford. 2000. Relation of grassland bird abundance to mowing of Conservation Reserve Program fields in North Dakota. Wildlife Society Bulletin 28:653-659.

Horn, J. D., R. R. Koford, M. L. Braland. 2002. Effects of field size and landscape composition on grassland birds in south-central Iowa. Journal of Iowa Academy of Sciences 109:1-7.

Hull, S. 2002. The relationships among vegetative structure, arthropod populationsm and grassland bird abundance and reproductive success on Wildlife Reproductive Areas in Ohio. M.S. thesis Ohio State University, OH.

Hurlbert, S. H. 1984. Psuedoreplication and the design of ecological field experiments. Ecological Monographs 54:187-211.

Johnson, D. H. 2001. Habitat fragmentation effects on birds in grasslands and wetlands: a critique of our knowledge. Great Plains Research 11:211-231.

Johnson, D. H. and L. D> Igl. 2001. Area requirements of grassland birds: a regional perspective. Auk 118:24-34.

Johnson, D. H. and M. D. Schwartz. 1993a. The Conservation Reserve Program and grassland birds. Conservation Biology 7:934-937.

Johnson, D. H. and M. D. Schwartz. 1993b. The Conservation Reserve Program: habitat for grassland birds. Great Plains Research 3:273-295.

Johnson, R.G. and S.A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management. 54:106-111.

King, J. W. and J. A. Savidge. 1995. Effects of the conservation reserve program on wildlife in southeast Nebraska. Wildlife Society Bulletin. 23:377-385.

Klute, D. S., R. J. Robel, and K. E. Kemp. 1997. Will conserversion of conservation reserve program (CRP) lands to pasture be detrminetal for grassland birds in Kansas. American Midland Naturalist 137:206-212.

Knopf, F. L. 1994. Avian breeding assemblages on altered grasslands. Studies in Avian Biology. 15:247-257.

Lokemoen, J. T. and J. A. Beiser. 1997. Bird use and nesting in conventional, minimum-tillage, and organic cropland. Journal of Wildlife Management 61:644-655.

Mattice, J. A., D. W. Brauning, and D. R. Diefenbach. 2004. Abundance of grasshopper sparrows on reclaimed surface mines in western Pennsylvania. Gen. Tech. Rep. PSW-GTR-191, Forest Service, U. S. Department of Agriculture.

Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456-466.

Mayfield, H. 1961. Nest success calculated from exposure. Wilson Bulletin 73:255-261.

McCoy, T. D., M. R. Ryan, and L. W. Burger, Jr. and E. W. Kurzejeski. 2001. Grassland bird conservation: CP1 vs. CP2 plantings in conservation reserve program fields in Missouri. American Midland Naturalist. 145:1-17.

McCoy, T. D., M. R. Ryan, E. W. Kurzejeski, and L. W. Burger. 1999. Conservation reserve program: source or sink habitat for grassland birds in Missouri. Journal of Wildlife Management 63:530-538.

McGarigal, K. and B. J. Marks. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. General Technical Report, PNW-GTR-351. Portland, Oregon: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 122 p.

McGarigal, K. and W. C. McComb. 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. Ecological Monographs. 65:235-260.

Moulton, W. 1981. Reproductive rate and renesting of Red-winged Blackbirds in Minnesota. Wilson Bulletin 93:119-121.

Murphy, M. T. 2003. Avian population trends within the evolving agricultural landscape of eastern and central United States. Auk 120:20-34.

Murray, L. D. and L. B. Best. 2003. Short term bird response to harvesting switchgrass for biomass in Iowa. Journal of Wildlife Management 67:611-621.

Myers, W., J. Bishop, R. Brooks, T. O'Connell, D. Argent, G. Storm, J. Stauffer, and R. Carline. 2000. Pennsylvania Gap Analysis Project: Leading Landscapes for Collaborative Conservation. School of Forest Resources, Cooperative Fish and Wildlife Research Unit, and Environmental Resources Research Institute, The Pennsylvania State University, University Park, Pennsylvania, 16802.

Paton, P. W. 1994. The effect of edge on avian nest success: how strong is the evidence? Conservation Biology 8:17-26.

Pierce, R. A., B. White, and P. Graham. 2005. Habitat management practices for bobwhite quail. G9432 MU extension report, University of Missouri-Columbia, Columbia, MO.

Pietz,. P. J. and D. A. Granfors. 2000. Identifying predators and fates of grassland passerine nests using minature video cameras. Journal of Wildlife Management 64:71-87.

Reijnen, R., R. Foppen, and H. Meeuwsen. 1996. The effects of traffic on the density of breeding birds in Dutch agricultural grasslands. Biological Conservation 75:255-

260. Renfrew, R. B. and C. A. Ribic. 2003. Grassland passerine nest predators near pasture edges identified on videotape. Auk 120:371-383.

Ribic, C. A., D. W. Sample. 2001. Associations of grassland birds with landscape factors in Southern Wisconsin. American Midland Naturalist 146:105-121.

Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The breeding bird survey: It's first 15 years, 1965-1979, U.S. Dept. Interior, Fish and Wildlife Service, Res. Publ. 157:1-196.

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

Roberts, S. D., J. M. Coffey, and W. F. Porter. 1995. Survival and reproduction of female Wild Turkeys in New York. Journal of Wildlife Management 59:437-447.

Samson, F.B. and F.L. Knopf. 1994. Prairie Conservation in North America. Bioscience. 44:418-421.

Sauer, J. R., J. E. Hines, and J. Fallon. 2001. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2000. Version 2001.2, USGS Patuxent Wildlife Research Center, Laurel, MD.*

Scott, P. E., T. L. DeVault, R. A. Bajema, and S. L. Lima. 2002. Grassland vegetation and bird abundances on reclaimed Midwestern coal mines. Wildlife Society Bulletin 30:1006-1014.

Smith, R. L. 1963. Some ecological notes on the Grasshopper Sparrow. Wilson Bulletin 75:159-165.

Suarez, A. V., K. S. Pfennig, and S. K. Robinson. 1997. Nesting success of a disturbance-dependent songbird on different kinds of edges. Conservation Biology 11:928-935.

ter Braak, C. J. F. and P. Šmilauer. 2002. CONOCO reference manual and CanoDraw for Windows User's guide: software for canonical community ordination (version 4.5). Microcomputer Power Ithaca, New York USA, 500 pp.

Thomas, L., J. L. Laake, J. F. Derry, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. Strindberg, S. L. Hedley, M. L. Burt, F. F. C. Marques, J. H. Pollard, and R. M. Fewster. 1998. Distance 3.5. rsearch Unit for Wildlife Population Assessment, university of St. Andrews, U. K. Available: http://www.ruwpa.st_and.ac.uk/distance/.

Thompson, F.R., III, W. Dijak, and D. E. Burhans. 1999. Video identification of predators at songbird nests in old fields. Auk 116:259-264.

Tosiano, M. and D. Capstick. 1999. Pennsylvania Agricultural Statistical Service. Harrisburg, PA [http://www.dep.state.pa.us/dep/deputate/polycomm/update/05-26-00/052600u7.htm].

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Vickery, P. D., M. L. Hunter, Jr., and J. V. Wells. 1992. Evidence of incidental nest predation and its effects on nests of threatened grassland birds. Oikos 63:281-288.

Vickery, P. D., M. L. Hunter, Jr. and S. M. Melvin. 1994. Effects of habitat area on the distribution of grassland birds in Maine. Conservation Biology. 8:1087-1097.

Warner, R. E. 1994. Agricultural land use and grassland habitat in Illinois: future shock for wildlife?. Conservation Biology 8:147-156.

Wiens, J. A. 1969. An approach to the study of ecological relationship among grassland birds. Ornithological Monographs 8:1-93.

Winter, M. and J. Faaborg. 1999. Patterns of area sensitivity in grassland-nesting birds. Conservation Biology. 13:1424-1436.

Winter, M., D. H. Johnson, and J. Faaborg. 2000. Evidence for edge effects on multiple levels in tallgrass prairie. Condor 102:256-266.

Wray, T. II, K. A. Strait and R. C. Whitmore. 1982. Reproductive success of grassland sparrows on a reclaimed surface mine in West Virginia. Auk 99:157-164.

Zar, J. 1999. Biostatistical Analysis. Prentice-Hall Inc., Upper Saddle River, NJ.

Appendix A

Common names, scientific names and abbreviations for bird species, and common and scientific names for plant species

Species common name (*Scientific name*)	Abbreviation
Mallard (*Anas platyrhynchos)*	MALL
Northern harrier (*Circus cyaneus*)	NOHA
Red-tailed hawk (*Buteo jamaicensis*)	RTHA
American kestrel (*Falco sparverius*)	AMKE
Northern bobwhite (*Colinus virginianus)*	NOBO
Ring-necked pheasant (*Phasianus colchicus)*	RNPH
Wild turkey (*Meleagris gallopavo)*	WITU
Upland sandpiper (*Bartramia longicauda*)	UPSA
Common snipe (*Gallinago gallinago*)	COSN
Mourning dove (*Zenaida macroura*)	MODO
Northern flicker (*Colaptes auratus*)	NOFL
Willow flycatcher (*Empidonax trailii*)	WIFL
Eastern phoebe (*Sayornis phoebe*)	EAPH
Eastern kingbird (*Tyrannus tyrannus*)	EAKI
American robin (*Turdus migratorus*)	AMRO
Gray catbird (*Dumetella carolinensis*)	GRCA

Northern mockingbird (*Mimus polyglottus*)	NOMO
Yellow warbler (*Dendroica petechia*)	YEWA
Common yellowthroat (*Geothlypis trichas)*	COYE
Northern cardinal (*Cardinalis cardinalis)*	NOCA
Indigo bunting (*Passerina cyanea)*	INBU
Dickcissel (*Spiza americana*)	DICK
Blue grosbeak (*Guiraca cearulea*)	BLGR
Field sparrow (*Spiza pusilla*)	FISP
Chipping sparrow (*Spizella passerina*)	CHSP
Grasshopper sparrow (*Ammodramus savannarum*)	GRSP
Henslow’s sparrow (*Ammodramus henslowii*)	HESP
Savannah Sparrow (*Passerculus sandwichensis)*	SAVS
Vesper Sparrow (*Pooecetes gramineus*)	VESP
Song Sparrow (*Melospiza melodia)*	SOSP
Eastern meadowlark (*Sturnella magna*)	EAME
Bobolink (*Dolichonyx oryzivorus*)	BOBO
Brown-headed cowbird (*Molothrus ater*)	BHCO
Red-winged blackbird (*Agelaius phoeniceus)*	RWBL
Common grackle (*Quiscalis quiscula*)	COGR
Baltimore oriole (*Icterus galbula*)	BAOR
American goldfinch (*Carduelis tristis)*	AMGO

Common name	scientific name
Alfalfa	*Medicago sativa*
Autmn olive	*Eleagnus umbellate*
Big bluestem	*Andropogon gerardii*
Blackberry	*Rubus* spp.
Dandelion	*Taraxacum officinale*
Garlic mustard	*Alliaria petiolata*
Goldenrod	*Solidago* spp.
Milkweed	*Asclepias* spp.
Multi-flora rose	*Rosa multiflora*
Mustard	*Brassica spp.*
Orchard grass	*Dactylis glomerata*
Red clover	*Trifolium pretense*
Smooth brome	*Bromus inermis*
Sweet clover	*Melilotus* spp.
Switchgrass	*Panicum virgatum*
Tall fescue	*Festuca arundinacea*

Appendix B

Vegetation measurements for all Conservation Reserve Enhancement Program fields used during the 2001 – 2004 summer

Year	County	Field	SIZE (ha)	LITTER (cm)	HEIGHT (cm)	FORB	CGRASS	WGRASS	DLIT	SLIT	WOODY	BARE	ROBEL
2002	Berks	Dreibelbis	3.6	0.33	50.00	78.75	10.00	0.00	5.00	0.00	0.00	6.25	24.75
2002	Berks	Kerper	43.3	1.31	47.10	69.90	15.42	0.00	8.75	0.10	0.00	5.73	25.04
2002	Berks	Luft	7.9	2.00	42.96	23.13	44.17	0.00	31.46	0.00	0.00	1.25	9.46
2002	Berks	Maleski	3.2	2.75	78.67	22.08	75.42	0.00	1.67	0.00	0.00	0.83	24.75
2002	Berks	Mensch	13.2	1.21	69.13	65.83	29.58	0.00	3.33	0.00	0.00	1.25	34.96
2002	Berks	Sabo I	12.8	0.50	33.17	29.58	18.13	1.25	13.54	0.00	0.00	37.50	3.88
2002	Berks	Sabo II	2.8	1.08	29.67	41.25	34.17	0.00	20.00	0.00	0.00	4.58	6.33
2002	Berks	Seidel	33.8	3.83	53.90	19.50	64.67	3.17	12.50	0.17	0.00	0.00	26.10
2002	Berks	Stoudt	21.7	0.71	49.60	84.52	6.43	0.00	1.55	0.00	0.00	7.50	20.10

2003	Dauphin	Danner	17.1	0.06	37.67	31.25	60.00	0.00	3.75	0.00	0.00	5.00	78.08
2003	Dauphin	Huffman	24.8	1.13	30.06	19.44	35.44	0.00	29.22	0.94	11.22	3.72	53.78
2003	Dauphin	Med Keefer	9.2	0.92	101.25	18.33	63.63	0.00	10.63	0.00	0.00	7.42	60.79
2003	Dauphin	Sm Keefer	3.7	0.67	100.33	24.58	59.17	0.00	11.25	1.25	0.00	4.17	60.75
2003	Dauphin	Stroup	24.1	1.67	51.17	44.72	34.94	0.00	14.33	0.56	0.83	4.61	34.83
2003	Dauphin	Warfel I	10.0	0.19	23.75	62.92	14.17	0.00	14.83	0.42	0.00	7.67	34.17
2003	Dauphin	Warfel II	4.0	0.13	25.08	32.17	34.17	0.00	19.50	0.33	0.00	13.83	46.67
2003	Franklin	Hoffman	11.1	1.47	42.72	60.42	22.78	7.50	6.39	1.81	0.00	1.25	49.86
2003	Franklin	Keefer	10.1	2.50	50.46	7.08	63.33	0.00	19.17	2.08	0.42	7.92	69.25
2003	Franklin	Long	9.8	1.71	48.15	5.21	51.67	0.00	24.58	8.96	1.25	7.50	45.71
2003	Franklin	Steck	2.2	1.54	33.25	63.25	23.75	0.00	1.67	1.25	3.33	0.00	42.92
2003	Franklin	Witter I	8.1	1.98	48.96	10.83	65.96	0.00	19.38	0.08	0.00	4.79	47.79
2003	Franklin	Witter II	2.1	1.04	28.71	73.33	10.42	0.00	15.00	0.00	0.00	1.67	42.67
2003	Franklin	Young	12.0	0.38	31.83	57.50	14.58	0.00	6.25	0.00	0.00	16.67	50.58
2003	Fulton	Booth	3.7	1.58	43.29	49.58	17.92	21.25	5.83	4.17	0.00	0.00	50.17
2002	Montour	Buck M	12.1	0.40	20.81	46.67	14.00	0.00	8.00	2.92	24.75	3.67	40.08

2001	Montour	Davies	19.4	0.91	20.53	39.19	15.85	0.00	28.15	2.22	8.92	5.64	40.81
2002	Montour	Davies	20.4	0.47	30.63	25.33	34.94	0.00	21.08	2.17	10.97	5.50	72.11
2002	Montour	Fetterman	3.4	0.06	14.21	57.08	24.42	0.00	3.17	3.83	0.00	11.50	27.67
2002	Montour	Hilkert I	22.3	0.43	25.00	27.56	24.25	0.00	28.78	10.64	1.11	7.67	41.19
2002	Montour	Hilkert II	8.9	0.25	15.76	22.38	25.67	0.00	25.08	5.50	1.88	19.92	20.67
2001	Montour	MP11	4.1	0.81	33.71	27.83	0.42	37.42	4.58	17.00	0.00	12.75	81.08
2001	Montour	MP17	24.3	0.53	14.59	21.22	23.65	0.10	1.59	36.95	5.93	10.53	16.03
2001	Montour	MP26	4.5	0.66	17.63	28.21	12.50	24.17	5.42	19.29	0.00	10.42	35.13
2001	Montour	MP53	10.1	0.32	11.51	56.97	9.75	0.00	3.45	11.55	0.68	17.60	21.75
2001	Montour	MP69	3.2	0.48	15.10	53.33	10.54	0.00	1.67	12.46	4.38	17.83	19.67
2001	Montour	Pharr A	24.3	0.32	20.57	51.33	0.96	16.99	3.97	11.84	3.45	11.63	40.59
2001	Montour	Pharr B	12.1	0.26	23.49	35.92	3.90	24.65	4.85	12.61	1.94	16.13	52.97
2001	Montour	Rice M	8.1	0.24	17.93	52.00	2.13	4.23	7.42	14.57	0.53	19.12	46.73
2001	Montour	Robbins	10.5	0.33	22.77	35.40	31.37	0.00	1.90	16.07	3.58	11.68	33.55
2002	Montour	Robbins	10.5	0.33	21.41	26.00	28.25	0.00	12.88	3.13	18.83	10.92	43.79
2002	Montour	Sandel	2.4	0.29	9.00	57.08	11.08	0.00	22.25	6.58	0.00	3.00	16.58

2002	Montour	Sidler I	16.4	0.07	15.93	58.42	13.29	0.00	7.67	0.58	3.13	17.33	32.58
2002	Montour	Sidler II	4.1	0.13	16.60	60.08	16.92	0.00	6.42	0.00	9.42	7.17	37.42
2001	Montour	Yeager	12.1	0.59	21.03	45.44	25.40	0.00	3.24	20.96	0.14	4.26	45.68
2001	Montour	Zeisloft	2.8	0.00	8.17	35.00	13.71	0.00	0.00	0.38	0.00	50.92	10.88
2003	Northumberland	Cunningham	12.1	0.00	66.50	83.00	12.83	0.00	0.83	0.25	1.00	2.08	39.58
2003	Northumberland	Ditty	4.5	0.00	44.67	63.83	0.33	19.17	0.00	1.67	0.00	15.00	15.00
2003	Northumberland	Fox/Martz	35.0	0.54	72.13	26.25	34.58	10.71	16.04	1.96	0.00	10.46	45.75
2002	Northumberland	Gresch	4.1	1.58	35.58	80.42	6.67	0.00	10.83	0.00	0.00	1.67	27.08
2002	Northumberland	Hoagland	10.9	0.31	21.91	48.17	0.00	14.44	10.44	17.86	5.00	4.92	43.14
2003	Northumberland	Horengic	2.2	2.33	98.67	8.33	49.17	0.00	36.33	0.33	5.83	0.00	45.17
2003	Northumberland	Kauffman	18.7	0.17	71.25	67.75	16.83	0.00	4.58	0.00	0.00	10.83	51.58
2002	Northumberland	Kitchen	31.2	1.77	43.02	93.92	0.83	0.00	4.83	0.00	0.00	0.42	23.98
2002	Northumberland	Martz	2.3	1.42	81.92	16.67	72.08	0.00	2.50	2.08	0.00	6.67	53.08
2003	Northumberland	Meckley big	19.1	1.96	48.38	2.79	0.83	35.21	17.08	23.88	0.00	20.21	38.42
2004	Northumberland	Meckley big	19.1	1.92	84.71	1.88	1.88	50.42	22.50	15.83	0.00	7.08	73.79
2002	Northumberland	Meckley I	2.3	1.17	46.67	7.50	40.83	27.50	9.58	0.00	0.00	14.58	21.50

2004	Northumberland	Meckley I	2.3	1.00	105.83	0.83	0.00	45.00	18.33	20.00	0.00	15.00	93.00
2002	Northumberland	Meckley II	28.9	1.21	54.95	34.88	28.57	17.02	2.98	0.00	0.00	16.55	22.36
2004	Northumberland	Meckley II	28.9	0.10	16.27	59.25	15.10	0.00	7.04	0.29	6.27	12.25	35.00
2002	Northumberland	Meckley III	8.9	0.42	60.04	9.79	39.17	21.88	10.00	3.33	0.00	15.83	34.79
2004	Northumberland	Meckley III	8.9	1.08	106.67	4.17	3.33	39.58	12.50	27.92	0.00	12.92	98.25
2003	Northumberland	Meckley rd	1.9	0.33	100.67	21.67	53.33	0.00	13.33	0.00	0.00	11.67	108.67
2004	Northumberland	Meckley rd	1.9	1.22	79.39	95.28	3.61	0.00	0.00	0.00	0.00	1.11	23.83
2002	Northumberland	Moore N	25.1	2.25	57.67	59.79	23.96	0.00	16.04	0.00	0.00	0.21	25.83
2003	Northumberland	Pinamontti	2.4	0.50	108.67	9.17	63.33	0.00	13.33	0.00	0.00	14.17	98.50
2002	Northumberland	Rebuck	10.4	1.92	52.75	91.67	0.83	0.00	7.50	0.00	0.00	0.00	22.83
2003	Northumberland	Weigle	18.3	0.06	22.00	69.67	27.83	0.00	1.25	0.00	0.00	1.25	47.92
2003	Perry	Morrison	10.9	0.83	64.92	50.83	41.25	0.00	2.50	0.00	0.00	5.42	53.00
2003	Perry	Rice P	10.5	0.63	35.21	24.17	56.67	0.00	8.33	0.00	5.83	5.00	49.67
2003	Perry	Shambaugh	12.7	0.56	91.44	27.83	42.72	0.28	8.06	0.00	0.00	21.11	66.22
2003	Perry	Stephens E	4.6	0.00	18.08	93.17	6.83	0.00	0.00	0.00	0.00	0.00	49.50
2003	Perry	Stephens N	2.4	0.42	32.25	4.17	66.67	0.00	16.67	0.00	0.00	11.67	67.67

2003	Perry	Stephens SW	3.0	0.08	19.50	76.67	15.83	0.00	5.83	0.00	0.00	1.67	51.67
2003	Perry	Wingert	2.8	0.17	24.50	72.00	10.50	0.00	7.50	0.00	0.00	10.00	42.67
2003	Perry	Zeigler	22.0	0.00	30.92	76.42	16.92	0.00	1.25	0.42	0.00	5.00	58.92
2002	Schuylkill	C Moyer	8.9	0.00	36.67	38.13	25.63	0.00	0.00	0.00	0.00	36.67	7.46
2002	Schuylkill	Everett	16.5	3.64	39.25	15.00	50.00	0.00	25.42	6.53	0.00	2.78	8.36
2003	Schuylkill	Fetterman	2.8	0.88	38.33	46.25	44.17	0.00	7.08	0.42	0.00	2.08	48.17
2003	Schuylkill	Hower	4.2	2.29	43.25	19.17	51.67	1.67	20.00	0.00	7.92	0.42	63.00
2003	Schuylkill	Hoy	8.8	0.54	27.81	72.92	12.50	0.00	3.75	1.46	0.00	9.17	37.75
2003	Schuylkill	Krammes	9.8	0.40	25.10	53.96	0.00	17.79	3.13	3.25	2.29	18.96	30.67
2002	Schuylkill	L Moyer	8.0	1.08	31.42	68.75	0.00	0.00	11.67	0.00	0.00	19.58	16.75
2003	Schuylkill	Lentz	9.2	0.99	34.60	24.31	0.00	51.39	14.03	0.42	0.00	10.28	39.31
2002	Schuylkill	Lesher	10.3	0.94	26.78	51.94	20.56	0.00	1.39	0.56	0.00	25.56	8.17
2002	Schuylkill	Masser	2.1	0.58	59.08	97.92	1.67	0.42	0.00	0.00	0.00	0.00	40.33
2003	Schuylkill	Peiffer	10.1	1.40	35.48	28.75	13.75	36.25	17.00	0.50	0.00	3.96	51.54
2002	Schuylkill	Peters	3.9	2.25	27.75	53.33	12.08	0.00	32.08	2.08	0.00	0.42	3.33
2003	Schuylkill	R Linder	2.1	1.98	51.25	48.75	33.33	0.00	14.17	0.42	0.00	3.33	42.25

2002	Schuylkill	Radel	19.8	2.39	42.19	65.00	13.61	0.00	16.25	2.22	0.00	2.92	20.64
2002	Schuylkill	Reigle	3.9	0.67	12.83	50.00	0.00	0.00	6.67	3.33	0.00	40.00	0.00
2003	Schuylkill	T Linder	8.7	1.92	30.67	21.67	40.00	0.00	35.83	0.00	0.00	2.50	44.75
2003	Schuylkill	Teprovich L	3.6	1.17	59.50	12.08	55.83	0.00	18.75	1.25	0.00	12.08	107.42
2003	Schuylkill	Teprovich Z	3.2	1.42	41.50	39.58	53.08	0.08	6.42	0.00	0.00	0.83	68.17
2003	Schuylkill	Wehr	16.4	1.15	33.73	84.38	10.63	0.00	3.75	0.00	0.00	1.25	47.63
2003	Schuylkill	Wehry	2.2	0.89	33.59	19.58	19.58	0.42	8.75	3.33	0.00	48.33	24.75
2002	Schuylkill	Wolfgang II	16.4	1.54	78.29	81.04	7.50	9.38	0.42	0.42	0.00	1.25	29.96
2003	Schuylkill	Wolfgang III	18.2	2.20	49.54	66.58	22.92	0.00	7.71	2.38	0.00	0.42	46.21
2002	Snyder	Byers	3.8	0.19	29.33	41.67	29.83	0.00	17.58	2.00	0.00	8.92	37.25
2004	Snyder	Byers	3.8	0.33	89.67	60.00	33.33	0.00	6.67	0.00	0.00	0.00	49.33
2002	Snyder	Inch	20.1	0.05	16.41	70.06	11.33	0.00	6.36	0.31	0.00	12.08	41.75
2004	Snyder	Inch	20.1	3.25	68.25	14.58	62.92	0.00	18.75	0.08	0.00	4.08	42.83
2002	Snyder	Klingler	17.0	0.30	21.70	44.23	37.67	0.00	8.23	2.20	0.00	7.33	55.73
2004	Snyder	Klingler	17.0	1.28	91.39	23.61	53.89	0.00	12.39	0.50	8.61	1.00	59.39
2002	Snyder	Laudermilch	8.7	0.06	19.57	51.17	30.67	0.00	5.46	1.88	0.42	10.42	46.83

2004	Snyder	Laudermilch	8.7	2.50	61.42	17.50	49.00	6.25	17.83	1.92	0.42	7.08	41.33
2002	Snyder	Robinson I	8.9	0.50	39.33	71.17	21.29	0.00	2.50	2.33	1.88	0.83	44.67
2004	Snyder	Robinson I	8.9	0.83	28.93	46.18	23.97	0.00	16.49	1.20	5.61	6.44	45.76
2002	Snyder	Robinson II	3.2	0.19	32.29	90.83	2.17	0.00	0.75	0.00	4.17	2.08	50.58
2004	Snyder	Robinson II	3.2	0.17	71.25	67.75	16.83	0.00	4.58	0.00	0.00	10.83	51.58
2002	Snyder	Robinson III	3.2	0.67	130.67	11.67	66.67	0.00	11.67	0.00	0.00	9.17	102.50
2004	Snyder	Robinson III	3.2	2.50	50.46	7.08	63.33	0.00	19.17	2.08	0.42	7.92	69.25
2002	Snyder	Robinson S	8.9	0.59	28.40	83.63	14.08	0.00	0.83	0.00	1.25	0.21	31.96
2004	Snyder	Robinson S	8.9	1.08	106.50	29.58	47.50	0.00	10.42	0.00	9.17	3.33	59.92
2002	Snyder	Spiegel	20.6	0.15	22.06	69.47	6.81	0.00	6.61	3.94	4.58	7.03	51.72
2004	Snyder	Spiegle	20.6	1.11	50.20	39.79	27.50	18.13	9.75	0.25	0.00	4.69	52.27
2004	Somerset	Brendle I	29.2	1.27	90.33	44.00	48.67	2.67	3.83	0.17	0.17	0.50	61.53
2004	Somerset	Brendle II	18.1	4.71	106.83	24.38	44.58	1.67	25.21	0.00	0.00	3.75	76.96
2004	Somerset	Brendle III	2.0	0.58	75.83	60.00	29.58	0.00	10.42	0.00	0.00	0.00	47.67
2004	Somerset	Fallon	9.0	1.08	81.67	68.33	8.75	5.00	5.00	1.25	0.00	12.08	63.33
2004	Somerset	Lambert	2.2	5.33	68.50	26.25	0.00	47.08	25.42	0.42	0.00	0.83	45.17

2004	Somerset	Mankameyer	2.6	3.33	87.83	43.75	32.50	0.00	15.42	0.00	0.00	3.33	61.17
2004	Somerset	Marisa	18.0	2.50	38.92	36.25	10.42	20.83	16.92	2.08	8.33	6.00	28.17
2004	Somerset	Mostoller	16.8	4.04	93.25	9.67	30.00	23.75	32.92	2.08	0.00	1.79	42.46
2004	Somerset	Naugle	8.3	1.00	57.33	48.33	2.50	18.33	18.50	0.17	0.00	12.08	37.08
2004	Somerset	Shrock	26.8	1.83	73.50	43.33	20.28	8.61	10.56	6.83	6.11	4.56	53.11
2004	Somerset	Thomas	2.3	1.00	41.00	27.50	23.33	18.33	9.17	0.67	0.00	21.00	25.67
2004	Somerset	Vaught	9.2	0.33	66.17	68.33	26.67	0.00	1.67	0.00	0.00	3.33	39.50
2004	Somerset	Wilcox	24.3	3.50	82.38	30.42	28.96	19.58	15.21	0.21	3.13	2.50	61.42
2004	Somerset	Zehner I	18.2	2.25	104.25	58.13	25.83	2.08	4.17	2.71	0.00	3.33	84.67
2004	Somerset	Zehner II	9.7	4.25	109.58	55.42	29.17	4.17	5.83	2.92	0.00	1.67	90.42
2002	Union	Buck U	3.2	0.13	18.54	72.50	21.67	0.00	1.75	0.00	0.00	4.08	48.50
2004	Union	Buck U	3.2	0.83	62.00	60.00	25.83	0.00	14.17	0.00	0.00	0.00	46.00
2002	Union	Fisher	8.5	0.27	22.00	61.42	34.25	0.00	2.08	0.25	0.00	2.00	58.50
2004	Union	Fisher	8.5	0.83	111.83	49.17	35.00	0.00	10.83	0.00	0.00	5.00	89.33
2002	Union	Lilley	3.0	0.63	67.57	39.17	51.58	0.00	5.42	1.75	0.00	2.08	60.33
2004	Union	Lilley	3.0	0.27	28.88	39.17	51.58	0.00	5.42	1.75	0.00	2.08	60.33

2002	Union	Moore U	12.0	3.78	76.61	78.89	17.50	3.33	0.28	0.00	0.00	0.00	28.50
2004	Union	Moore U	12.0	0.56	78.06	65.28	23.89	0.00	7.94	0.39	0.56	1.67	53.72
2002	Union	Pfleegor	22.7	0.04	20.60	87.42	4.78	0.00	1.81	1.33	1.94	2.86	49.00
2004	Union	Pfleegor	22.7	2.03	61.55	29.31	41.20	3.06	20.91	0.71	4.58	0.56	52.68
2002	Union	Stahl I	25.5	0.24	22.03	70.33	18.00	0.00	4.61	5.56	0.14	1.08	46.89
2004	Union	Stahl I	25.5	1.03	65.04	27.36	51.11	0.00	11.94	0.14	1.94	7.50	63.47
2002	Union	Stahl II	3.0	0.17	18.96	56.08	10.25	0.00	6.08	11.67	0.00	12.50	41.58
2004	Union	Stahl II	3.0	1.50	45.58	54.58	18.92	0.00	16.08	0.42	0.00	10.83	37.92
2002	Union	Stamm	18.9	1.22	79.39	95.28	3.61	0.00	0.00	0.00	0.00	1.11	23.83
2004	Union	Stamm	18.9	0.65	27.86	53.53	32.42	0.00	6.11	0.42	1.11	3.89	53.36
2002	Union	Wenner	8.8	4.00	68.17	19.17	48.33	0.00	27.50	0.00	0.00	5.00	42.67
2004	Union	Wenner	8.8	1.92	30.67	21.67	40.00	0.00	35.83	0.00	0.00	2.50	44.75

LITTER = depth of downed litter, HEIGHT = vegetation height, FORB = % cover forbs, CGRASS = % cover cool-season grass, WGRASS = % cover warm-season grass, DLIT = % cover downed litter, SLIT = % cover standing litter, WOODY = % cover of woody vegetation, BARE = % cover of bare ground, ROBEL = vegetation density

Appendix C

Landscape measurements for all Conservation Reserve Enhancement Program fields during the 2001 – 2004 summers

	0.5 km radius								5.0 km radius							
Field	MPS	SDI	EDGE	CADHAY	CROP	HAY	FOREST	ROAD	MPS	SDI	EDGE	CADHAY	CROP	HAY	FOREST	ROAD
Booth	2.07	1.02	205.55	4.17	5.63	15.01	79.30	15.50	3.99	1.19	75.63	4.06	22.59	14.47	61.24	17.49
Brendle I	3.44	0.99	39.08	7.51	62.35	24.61	12.99	36.03	4.54	1.20	50.64	5.32	38.98	17.52	42.38	19.86
Brendle II	4.04	0.85	28.62	4.83	72.17	18.58	9.18	21.37	4.30	1.21	53.20	5.60	41.36	18.64	38.85	20.14
Brendle III	3.80	0.84	37.20	3.76	73.20	15.47	11.33	18.10	3.94	1.21	56.74	6.45	46.06	21.21	31.64	22.21
Buck M	1.81	1.33	158.08	2.70	42.21	11.64	45.85	23.88	3.34	1.24	63.20	7.27	54.97	20.36	21.86	24.10
Buck U	2.36	1.47	125.88	6.91	13.60	18.57	54.86	12.82	3.22	1.57	63.17	5.36	44.51	17.88	27.55	26.21
Byers	2.10	1.33	57.66	8.60	41.56	40.09	8.94	14.20	2.72	1.41	86.44	6.45	42.35	24.15	31.55	20.09
C Moyer	1.69	1.36	180.74	5.91	34.91	12.70	52.16	15.87	2.96	1.57	109.10	2.96	22.67	7.66	52.55	31.49
Cunningham	2.15	1.21	95.02	6.47	32.05	12.39	54.56	14.27	2.97	1.56	89.25	5.44	41.03	14.41	35.49	30.85

Danner	2.72	0.87	47.97	8.05	67.55	24.59	7.87	25.05	4.60	1.23	52.36	4.47	35.72	14.68	47.16	19.21
Davies	1.93	1.31	113.92	12.11	41.90	28.87	29.17	27.57	3.46	1.25	71.17	6.24	52.36	18.51	26.94	21.38
Ditty	1.32	1.43	157.88	7.03	45.61	20.52	33.45	25.67	3.35	1.47	87.75	4.29	27.81	12.78	49.41	17.99
Dreibelbis	2.15	1.42	79.79	6.41	48.52	18.32	14.99	39.28	3.74	1.18	56.58	6.79	53.62	18.64	25.26	22.46
Everett	2.70	1.21	75.71	5.51	39.43	14.47	45.30	21.74	5.06	1.12	60.13	2.91	23.39	7.82	63.73	16.00
Fallon	4.34	0.92	84.73	3.60	21.40	13.94	64.65	9.36	3.82	1.40	62.21	5.73	34.20	23.89	37.27	20.26
Fetterman/M	2.84	0.93	114.81	0.88	35.40	2.94	61.03	21.42	6.00	1.12	64.37	1.66	17.14	4.69	71.26	10.60
Fetterman/Sc	3.88	1.00	62.99	5.94	57.40	11.52	31.08	11.46	3.58	1.32	71.05	5.04	46.14	12.16	36.64	19.52
Fisher	2.46	0.91	51.60	9.98	66.55	24.19	9.26	16.15	2.92	1.59	63.91	6.47	50.18	18.89	14.51	35.56
Fox/Martz	1.92	1.26	141.59	1.85	40.23	7.44	50.12	32.09	3.38	1.28	72.21	4.84	45.24	12.19	38.20	23.90
Gresch	2.67	0.81	34.43	7.82	68.94	26.84	4.22	21.36	3.35	1.38	71.55	6.14	53.88	19.58	22.91	24.37
Hilkert I	1.95	1.31	117.25	8.70	42.40	20.99	36.60	16.75	3.31	1.32	71.82	6.48	46.14	17.65	33.26	22.65
Hilkert II	2.16	1.25	120.88	8.33	30.95	18.68	50.38	12.74	3.36	1.33	74.32	6.35	42.00	16.89	38.11	21.84
Hoagland	2.17	1.22	113.97	8.74	41.32	15.94	42.48	14.35	3.84	1.31	75.44	2.98	24.11	8.12	60.22	26.78
Hoffman	1.83	1.24	89.82	9.76	51.90	28.00	20.10	12.98	3.23	1.36	59.86	6.83	47.02	32.52	16.09	19.85
Horengic	2.91	1.12	97.45	3.82	34.74	11.86	52.02	25.09	3.49	1.27	77.98	4.55	36.35	11.83	47.71	22.49

Hower	2.77	0.99	130.61	2.52	21.71	8.02	70.13	16.72	5.15	1.01	76.80	3.36	19.38	9.82	70.36	14.45
Hoy	2.15	1.21	153.88	5.55	25.45	11.86	62.13	20.66	2.89	1.61	109.89	3.08	23.16	8.05	50.11	33.30
Huffman	1.60	1.49	163.67	8.48	36.54	22.13	41.34	19.80	2.89	1.63	88.04	5.89	32.46	21.81	34.59	17.02
Inch	2.27	1.64	158.21	6.13	18.82	17.94	52.26	18.67	2.96	1.64	82.10	6.59	38.92	22.56	26.21	24.11
Kauffman	1.55	1.38	97.36	7.85	48.81	22.15	25.63	30.07	3.52	1.32	79.69	4.82	33.28	12.75	50.73	19.32
Keefer	4.53	0.96	98.80	7.64	15.20	16.73	68.07	5.17	6.54	0.97	50.21	2.35	19.56	13.27	67.07	7.93
Kerper	3.24	0.64	10.06	5.44	81.52	16.98	1.51	14.61	3.90	1.28	51.84	4.83	56.33	13.19	23.65	25.43
Kitchen	4.45	0.80	20.84	10.21	66.29	30.44	3.27	23.16	3.56	1.15	41.06	7.50	63.60	23.43	8.27	26.29
Klingler	1.72	1.33	131.21	8.02	38.16	23.53	37.83	24.95	2.64	1.53	80.08	7.17	43.98	25.72	23.49	27.57
Krammes	2.49	1.16	63.01	9.08	48.07	33.14	18.79	29.28	3.61	1.24	77.31	4.65	30.13	11.63	54.13	20.48
L Moyer	5.07	1.09	66.63	10.23	44.44	19.93	35.63	16.73	5.78	0.91	64.95	1.87	12.87	4.86	79.71	17.81
Lambert	3.13	1.17	36.81	7.78	56.69	22.78	9.18	40.69	3.96	1.32	58.16	4.67	30.97	16.86	45.84	24.93
Laudermilch	1.94	1.31	63.42	10.70	43.47	38.41	12.28	30.02	3.44	1.34	69.01	5.07	28.83	19.17	48.96	19.93
Lentz	1.81	1.30	93.66	5.71	41.29	22.56	33.12	32.49	5.08	1.08	58.49	2.76	17.38	7.31	69.51	17.29
Lesher	3.27	1.09	76.57	5.43	29.93	9.10	58.16	15.63	5.83	1.02	49.55	2.87	25.19	7.23	65.52	12.52
Lilley	1.85	1.38	140.73	8.44	47.61	18.30	34.01	25.43	2.96	1.37	69.18	6.91	52.06	22.62	21.48	25.63

Long	1.74	1.43	112.34	7.00	43.24	21.45	28.43	5.98	3.22	1.33	55.54	7.02	54.06	26.78	13.14	23.64
Luft	2.97	0.76	168.42	2.20	6.86	6.01	87.14	13.93	3.75	1.03	96.36	2.62	20.93	6.62	70.64	21.39
Maleski	2.11	1.15	87.73	2.63	60.13	11.42	22.46	25.97	3.45	1.19	63.42	6.91	52.86	19.71	25.47	24.60
Mankameyer	2.85	1.09	49.69	9.20	52.41	29.14	18.45	17.16	3.96	1.45	56.48	5.50	38.09	24.80	28.75	26.81
Marisa	2.74	1.17	117.23	3.71	9.02	16.30	68.17	7.72	4.00	1.56	66.78	2.44	15.93	7.94	42.44	44.68
Martz	1.92	0.95	71.70	7.30	70.03	20.12	9.85	24.98	3.29	1.32	71.33	5.64	47.50	17.74	32.80	23.38
Masser	2.37	1.00	23.63	9.38	64.64	28.27	4.14	9.39	4.52	1.23	38.27	5.00	44.66	13.51	39.24	16.14
Meckley big	2.58	0.99	51.44	9.31	63.36	24.39	12.22	32.09	2.82	1.60	91.48	5.03	37.86	16.85	32.02	21.99
Meckley I	2.73	1.22	128.18	0.00	42.80	2.97	52.94	19.71	2.88	1.57	88.32	5.40	38.92	16.98	33.06	23.12
Meckley II	3.18	1.13	79.86	3.49	44.55	8.25	47.02	14.42	2.86	1.59	88.93	5.23	38.00	17.15	32.37	22.21
Meckley III	2.62	1.12	87.34	5.46	49.78	11.08	38.93	21.01	2.78	1.60	90.83	5.30	37.52	17.68	31.36	22.26
Meckley rd	2.57	0.90	61.20	4.67	71.27	14.01	14.71	33.45	2.79	1.60	90.06	5.12	37.91	17.06	31.19	22.62
Med Keefer	1.86	1.12	65.43	11.33	38.11	52.65	8.92	33.54	2.84	1.50	72.28	6.57	38.77	24.66	31.87	24.11
Mensch	2.96	1.10	107.62	3.44	27.69	16.35	55.49	20.73	3.85	1.02	93.21	2.91	25.53	7.18	66.87	20.53
Moore N	2.64	1.04	48.18	7.92	55.11	36.59	8.29	26.53	3.23	1.39	45.80	7.11	56.16	22.87	9.39	31.95
Moore U	1.80	0.96	60.43	6.80	71.91	16.75	9.35	29.19	2.56	1.55	87.80	5.78	39.50	21.27	32.35	23.13

Morrison P	2.60	0.97	29.26	12.36	35.17	58.40	5.75	9.92	3.26	1.45	88.36	5.78	27.29	26.66	44.37	10.78
Mostoller	2.29	1.42	72.21	4.07	10.10	10.94	46.37	32.99	3.81	1.55	54.77	4.25	29.58	17.36	37.90	31.71
MP11	2.19	1.04	69.40	8.76	59.46	27.60	12.22	24.45	3.49	1.34	86.61	5.31	47.86	16.90	32.83	17.63
MP17	1.74	1.33	115.08	7.84	49.53	27.05	19.76	22.56	3.58	1.34	83.07	5.15	49.15	16.60	31.59	17.89
MP26	3.08	1.05	31.10	7.03	59.29	29.96	3.15	27.87	3.62	1.31	76.23	5.43	52.81	17.52	26.63	17.27
MP53	2.92	1.21	43.40	8.20	54.43	20.27	5.77	20.72	3.60	1.30	72.09	5.58	55.08	17.63	24.06	17.06
MP69	1.64	1.60	178.26	6.01	26.89	19.71	39.96	20.03	3.62	1.18	59.67	6.02	62.23	18.43	15.99	18.07
Naugle	3.47	0.90	86.05	6.65	16.57	14.97	68.40	14.50	3.74	1.38	69.37	4.60	28.16	15.88	48.60	22.11
Peiffer	2.08	1.39	116.98	7.90	36.22	15.29	42.38	21.23	4.01	1.29	70.08	4.57	31.39	11.16	51.77	21.13
Peters	2.06	1.06	144.80	5.49	19.68	13.75	66.49	20.90	3.92	1.26	77.61	2.59	18.39	6.80	65.12	25.38
Pfleegor	2.58	0.62	21.54	5.13	82.91	14.36	2.51	20.07	3.28	1.23	59.73	6.52	55.26	21.30	22.42	21.89
Pharr A	2.35	1.19	99.48	7.56	40.99	35.02	23.98	29.96	3.54	1.22	77.50	6.38	47.60	19.69	32.05	20.98
Pharr B	2.60	1.30	127.44	8.70	39.74	31.59	28.68	23.81	3.56	1.21	77.39	6.34	48.36	20.09	31.21	20.43
Pinamontti	2.76	1.00	68.12	6.51	62.81	20.61	16.59	31.27	3.59	1.32	80.10	3.47	27.44	9.12	56.72	25.39
R Linder	2.79	0.97	104.61	0.94	41.65	3.57	54.36	23.62	6.00	1.12	64.75	1.65	17.12	4.72	71.17	10.82
Radel	2.43	1.01	96.54	4.11	58.83	10.99	29.91	15.85	4.85	1.12	52.22	3.73	26.89	11.07	60.65	14.16

Rebuck	1.60	1.28	123.48	5.74	53.73	14.54	31.30	40.89	3.43	1.23	58.07	5.97	44.60	16.14	38.42	21.02
Reigle	1.96	1.09	134.86	4.26	35.79	9.58	54.64	25.30	5.28	1.07	53.41	2.62	21.88	7.33	66.36	19.98
Rice M	2.72	1.23	120.40	7.48	35.84	17.89	46.27	9.02	3.34	1.37	110.74	4.85	41.50	15.44	41.77	18.59
Rice P	1.88	1.62	190.25	5.33	11.15	32.02	53.00	0.97	3.43	1.41	84.93	5.02	23.79	24.07	50.52	9.91
Robbins	2.59	1.16	82.44	7.34	56.60	18.49	24.13	26.98	3.52	1.34	98.13	5.04	44.53	16.56	37.59	17.67
Robinson I	4.28	0.70	3.40	7.79	70.00	29.75	0.25	15.76	3.47	1.33	85.04	5.76	29.23	21.83	47.99	18.69
Robinson II	4.90	0.73	5.33	3.55	59.15	40.37	0.40	16.05	3.58	1.33	82.95	5.55	29.37	21.60	47.98	19.08
Robinson III	3.23	1.10	52.06	4.43	58.96	22.07	18.88	23.89	3.41	1.36	87.13	5.84	31.13	22.83	45.05	19.42
Robinson S	2.62	1.27	94.83	6.70	49.67	17.18	32.78	21.31	3.28	1.38	86.86	6.22	33.82	24.52	40.61	20.10
Sabo I	3.31	0.87	51.75	5.04	70.48	12.18	16.71	16.53	3.75	1.25	69.96	3.94	50.06	9.99	33.45	23.55
Sabo II	3.33	0.96	74.66	3.53	61.87	12.63	25.41	11.73	3.67	1.26	71.03	3.89	50.37	10.05	32.60	23.87
Sandel	2.77	1.07	25.90	7.05	60.19	23.71	3.17	35.79	3.49	1.33	72.26	5.48	35.97	16.17	42.25	23.21
Seidel	2.62	0.93	40.35	7.37	65.84	25.59	8.20	24.43	3.93	1.25	44.84	6.30	54.88	16.60	23.44	25.73
Shambaugh	2.26	1.28	63.72	7.01	34.01	45.56	17.81	18.11	3.17	1.45	87.39	6.19	28.84	28.68	40.76	12.23
Shrock	3.00	1.18	71.04	7.65	35.70	24.76	39.50	15.10	4.06	1.26	49.64	5.36	36.73	16.82	44.65	17.22
Sidler I	4.02	1.14	85.15	7.18	36.33	18.24	45.43	25.20	3.30	1.30	75.51	6.32	47.55	18.37	31.04	23.58

Sidler II	3.62	1.12	142.30	3.25	34.72	5.12	60.17	14.58	3.37	1.32	73.93	6.33	48.09	18.58	29.99	23.29
Sm Keefer	1.57	1.32	96.37	12.42	35.25	47.16	17.29	29.57	2.81	1.50	72.91	6.50	38.32	24.81	32.31	23.72
Spiegle	2.05	1.47	78.20	5.48	47.46	17.94	15.42	24.61	2.94	1.63	89.65	5.46	33.08	17.49	34.50	19.49
Stahl I	2.13	1.04	50.78	9.81	66.37	20.86	12.04	25.03	3.71	1.23	49.17	6.43	47.76	19.65	31.96	18.51
Stahl II	2.73	0.80	27.84	6.51	72.01	24.10	3.88	24.19	3.72	1.25	52.24	6.16	45.26	18.95	34.99	17.59
Stamm	2.10	1.42	119.07	8.84	44.08	25.33	29.11	15.93	4.61	1.23	52.18	4.38	27.03	14.15	56.95	12.92
Steck	2.76	0.89	123.00	2.58	15.50	8.68	75.82	9.64	6.17	1.04	44.41	3.19	26.31	9.98	62.92	14.55
Stephens E	2.91	1.23	42.21	11.47	37.44	40.74	21.54	29.99	3.88	1.29	80.73	3.43	17.94	15.68	62.94	13.97
Stephens N	3.64	1.28	61.50	8.24	25.04	29.16	45.80	15.51	3.70	1.31	85.62	3.62	18.02	16.36	62.21	14.42
Stephens SW	2.48	1.35	72.59	10.30	32.36	40.23	27.41	16.42	3.74	1.30	85.33	3.57	17.45	15.80	63.27	14.15
Stoudt	1.36	1.47	124.25	6.68	46.99	22.69	23.15	20.84	3.41	1.19	51.19	7.84	56.66	21.66	20.21	22.31
Stroup	2.82	0.66	17.97	6.66	80.83	15.98	2.75	24.25	3.46	1.29	52.36	6.33	44.87	22.56	31.34	19.78
T Linder	2.61	1.25	90.94	8.10	40.53	16.88	41.59	16.61	5.95	1.10	57.46	1.99	21.02	5.72	66.55	13.36
Teprovich lake	3.21	0.81	88.89	3.37	9.85	6.74	79.25	39.24	5.92	0.94	60.03	1.52	12.01	4.37	78.48	20.99
Teprovich Z	4.21	1.00	83.53	4.25	26.36	11.23	61.42	17.82	5.98	1.01	60.99	1.24	10.59	3.69	77.69	21.69
Thomas	3.02	1.16	74.72	6.10	40.99	30.33	28.68	29.31	4.84	1.07	58.96	3.87	23.19	11.30	63.47	16.24

Vaught	3.15	0.91	97.42	2.12	20.46	12.01	67.54	9.61	5.99	0.95	47.03	3.32	19.24	10.99	69.03	10.60
Warfel I	1.73	1.29	114.11	10.90	51.04	29.82	19.02	13.94	2.77	1.58	86.97	6.53	38.90	23.88	28.70	18.45
Warfel II	1.56	1.27	113.93	7.70	51.81	31.33	16.79	13.21	2.80	1.56	84.56	6.54	40.15	24.27	27.81	18.99
Wehr	1.89	1.25	134.98	5.61	36.51	11.78	48.01	24.66	3.89	1.15	72.20	5.80	33.96	14.92	50.15	19.76
Wehry	1.85	1.13	41.79	10.14	64.76	21.06	10.17	19.75	3.56	1.22	56.60	6.00	45.99	16.14	37.02	19.57
Weigle	2.00	1.20	92.07	6.16	62.29	16.03	16.74	25.29	3.29	1.44	105.67	5.55	44.46	16.01	37.17	22.92
Wenner	2.59	0.84	15.88	15.02	62.72	35.67	1.61	24.04	3.50	1.25	56.70	6.24	50.79	18.83	29.37	19.85
Wilcox	3.44	1.03	53.32	8.32	60.24	22.87	16.89	18.95	3.88	1.30	96.11	4.68	27.01	15.09	57.46	16.65
Wingert	1.96	1.34	125.90	8.49	31.57	38.61	29.82	32.42	3.27	1.26	95.28	4.79	20.83	15.91	62.33	13.57
Witter I	3.58	0.45	13.30	4.29	87.89	10.56	1.54	16.94	4.13	0.88	30.07	5.49	74.31	16.46	7.02	22.31
Witter II	3.29	0.43	22.15	3.28	90.10	7.38	2.51	14.09	4.10	0.88	32.08	4.82	75.19	13.30	8.79	23.01
Wolfgang I	2.22	1.21	83.11	3.55	48.53	20.25	30.53	21.29	5.17	1.14	49.22	3.49	30.15	9.18	57.31	16.74
Wolfgang II	2.29	1.21	77.76	5.53	53.07	25.05	17.02	28.41	5.10	1.16	49.73	3.58	31.03	9.35	56.07	17.45
Yeager	3.67	0.75	34.61	6.34	75.30	15.41	9.30	16.51	4.41	1.13	54.40	4.15	40.59	10.95	47.20	20.06
Young	3.48	0.75	26.47	8.31	73.82	21.46	4.61	11.90	3.77	1.03	38.16	7.02	65.46	22.09	10.70	24.83
Zehner I	2.59	1.31	60.12	6.72	48.11	16.02	25.19	43.59	3.81	1.44	58.13	5.88	40.32	23.89	27.63	27.29

Zehner II	4.14	0.90	46.12	4.45	66.72	20.01	13.27	23.65	3.85	1.51	55.82	7.12	37.10	23.47	28.13	29.77
Zeigler	1.54	1.35	98.32	10.66	51.11	27.23	17.68	29.10	2.80	1.44	131.76	4.72	21.47	15.19	61.67	11.43
Zeisloft	2.29	1.14	101.95	9.90	53.75	30.14	16.11	34.07	3.56	1.22	81.58	6.24	46.19	20.45	33.21	19.54

MPS = mean patch size, SDI = Shannon Diversity Index, EDGE = forest edge density, CADHAY = core area density of perennial herbaceous cover, CROP = % annual herbaceous cover, HAY = % perennial herbaceous cover, FOREST = % forest cover, ROAD = road density

Appendix D

Correlations of field vegetation variables

	DEPTH	HEIGHT	FORB	C-GRASS	W-GRASS	DLIT	SLIT	WOODY
HEIGHT	0.418							
FORB	-0.342	-0.325						
C-GRASS	0.251	0.332	-0.638					
W-GRASS	0.215	0.209	-0.311	-0.347				
DLIT	0.475	0.091	-0.639	0.254	0.176			
SLIT	-0.022	0.094	-0.297	-0.234	0.491	0.179		
WOODY	-0.104	-0.226	-0.097	-0.045	-0.058	0.091	0.067	
BARE	-0.299	-0.137	-0.244	-0.121	0.056	-0.070	0.102	-0.072
ROBEL	0.019	0.558	-0.328	0.355	0.145	0.026	0.211	0.019
CV FORB	0.380	0.281	-0.794	0.372	0.442	0.561	0.506	-0.001

	DEPTH	HEIGHT	FORB	C-GRASS	W-GRASS	DLIT	SLIT	WOODY
CV DLIT	-0.095	-0.153	0.529	-0.209	-0.195	-0.478	-0.210	-0.115
CV BARE	0.297	-0.040	0.200	-0.019	-0.080	0.031	-0.113	-0.043
CV ROBEL	0.032	-0.203	0.139	-0.178	-0.136	0.093	-0.157	-0.130
CV GRASS	-0.144	-0.212	0.658	-0.454	-0.216	-0.314	-0.123	0.011
SIZE	0.135	0.047	0.098	-0.067	0.011	-0.048	0.024	0.084
RATIO	-0.087	0.015	-0.078	0.035	-0.028	0.052	-0.042	-0.082

	BARE	ROBEL	CV FORB	CV DLIT	CV BARE	CV ROBEL	CV GRASS	SIZE
ROBEL	-0.197							
CV FORB	0.100	0.250						
CV DLIT	-0.204	-0.258	-0.325					
CV BARE	-0.391	-0.185	-0.086	0.238				
CV ROBEL	0.227	-0.638	-0.076	0.210	0.219			
CV GRASS	-0.236	-0.286	-0.432	0.476	0.240	0.264		

	BARE	ROBEL	CV FORB	CV DLIT	CV BARE	CV ROBEL	CV GRASS	SIZE
SIZE	-0.137	-0.075	0.035	0.260	0.282	0.108	0.208	
RATIO	0.170	0.061	-0.090	-0.137	-0.301	-0.055	-0.047	-0.673

DEPTH = litter depth; HEIGHT = vegetation height; percent cover of : FORB = forbs, C-GRASS = cool-season grass, W-GRASS = warm-season grass, DLIT = downed litter, SLIT = standing litter, WOODY = woody vegetation, BARE = bare ground; ROBEL = vegetation density; coefficient of variation for percent cover of: CV FORB = forbs, CV DLIT = downed litter, CV BARE = bare ground, CV ROBEL = vegetation density, CV GRASS = grass (cool and warm-season combined); SIZE = field size (log transformed); RATIO = perimeter/area ratio.

Appendix E

Correlations of landscape variables

	MPS05	MPS10	MPS20	MPS50	SDI05	SDI10	SDI20	SDI50
MPS10	0.764							
	0.000							
MPS20	0.549	0.832						
	0.000	0.000						
MPS50	0.377	0.605	0.743					
	0.000	0.000	0.000					
SDI05	-0.617	-0.453	-0.361	-0.253				
	0.000	0.000	0.000	0.004				
SDI10	-0.520	-0.592	-0.558	-0.418	0.854			
	0.000	0.000	0.000	0.000	0.000			
SDI20	-0.388	-0.553	-0.635	-0.493	0.603	0.832		
	0.000	0.000	0.000	0.000	0.000	0.000		
SDI50	-0.341	-0.520	-0.594	-0.768	0.385	0.567	0.744	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
EDGE05	-0.508	-0.333	-0.171	-0.044	0.625	0.430	0.238	0.115
	0.000	0.000	0.057	0.630	0.000	0.000	0.007	0.202
EDGE10	-0.496	-0.532	-0.390	-0.222	0.632	0.616	0.423	0.263
	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.003
EDGE20	-0.414	-0.535	-0.549	-0.368	0.515	0.597	0.568	0.400
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EDGE50	-0.252	-0.342	-0.376	-0.530	0.359	0.468	0.494	0.558
	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CADHAY05	-0.219	-0.204	-0.298	-0.312	0.212	0.245	0.260	0.227
	0.014	0.022	0.001	0.000	0.018	0.006	0.003	0.011

	MPS05	MPS10	MPS20	MPS50	SDI05	SDI10	SDI20	SDI50
CADHAY10	-0.271	-0.401	-0.518	-0.530	0.107	0.226	0.265	0.313
	0.002	0.000	0.000	0.000	0.236	0.011	0.003	0.000
CADHAY20	-0.210	-0.406	-0.564	-0.556	0.067	0.165	0.218	0.318
	0.019	0.000	0.000	0.000	0.456	0.065	0.015	0.000
CADHAY50	-0.212	-0.431	-0.547	-0.704	0.105	0.214	0.237	0.414
	0.018	0.000	0.000	0.000	0.245	0.017	0.008	0.000
CROP05	0.140	-0.010	-0.160	-0.225	-0.504	-0.357	-0.184	-0.008
	0.119	0.912	0.075	0.012	0.000	0.000	0.040	0.925
CROP10	0.090	-0.056	-0.217	-0.254	-0.446	-0.369	-0.159	0.013
	0.317	0.536	0.015	0.004	0.000	0.000	0.076	0.885
CROP20	0.055	-0.081	-0.247	-0.262	-0.361	-0.313	-0.196	-0.034
	0.545	0.371	0.005	0.003	0.000	0.000	0.028	0.709
CROP50	-0.077	-0.232	-0.355	-0.469	-0.182	-0.129	-0.089	0.084
	0.395	0.009	0.000	0.000	0.042	0.151	0.326	0.350
HAY05	-0.148	-0.230	-0.254	-0.292	0.185	0.280	0.239	0.218
	0.100	0.010	0.004	0.001	0.039	0.002	0.007	0.015
HAY10	-0.181	-0.347	-0.404	-0.429	0.175	0.330	0.334	0.340
	0.043	0.000	0.000	0.000	0.050	0.000	0.000	0.000
HAY20	-0.122	-0.357	-0.474	-0.506	0.136	0.291	0.319	0.379
	0.175	0.000	0.000	0.000	0.130	0.001	0.000	0.000
HAY50	-0.146	-0.374	-0.479	-0.640	0.140	0.279	0.332	0.489
	0.105	0.000	0.000	0.000	0.119	0.002	0.000	0.000
FOREST05	-0.005	0.159	0.295	0.355	0.253	0.076	-0.037	-0.140
	0.955	0.076	0.001	0.000	0.004	0.398	0.683	0.118
FOREST10	0.041	0.241	0.403	0.419	0.229	0.071	-0.107	-0.214
	0.649	0.007	0.000	0.000	0.010	0.429	0.235	0.016
FOREST20	0.034	0.232	0.415	0.417	0.185	0.061	-0.093	-0.210
	0.708	0.009	0.000	0.000	0.039	0.500	0.300	0.019
FOREST50	0.142	0.358	0.494	0.653	0.046	-0.056	-0.151	-0.403
	0.114	0.000	0.000	0.000	0.607	0.538	0.092	0.000

	MPS05	MPS10	MPS20	MPS50	SDI05	SDI10	SDI20	SDI50
ROAD05	-0.236	-0.196	-0.103	-0.110	0.122	0.144	0.078	0.040
	0.008	0.028	0.253	0.221	0.175	0.109	0.388	0.658
ROAD50	-0.050	-0.169	-0.294	-0.448	-0.044	0.030	0.130	0.430
	0.576	0.059	0.001	0.000	0.627	0.743	0.147	0.000

	EDGE05	EDGE10	EDGE20	EDGE50	CADHAY05	CADHAY10	CADHAY20	CADHAY50
EDGE10	0.842							
	0.000							
EDGE20	0.622	0.845						
	0.000	0.000						
EDGE50	0.351	0.540	0.764					
	0.000	0.000	0.000					
CADHAY05	-0.249	-0.091	0.074	0.102				
	0.005	0.312	0.410	0.258				
CADHAY10	-0.272	-0.132	0.048	0.132	0.665			
	0.002	0.141	0.592	0.142	0.000			
CADHAY20	-0.253	-0.156	-0.083	-0.030	0.430	0.801		
	0.004	0.083	0.357	0.737	0.000	0.000		
CADHAY50	-0.178	-0.062	-0.054	-0.027	0.338	0.626	0.852	
	0.047	0.489	0.547	0.766	0.000	0.000	0.000	
CROP05	-0.695	-0.588	-0.414	-0.229	0.169	0.428	0.509	0.411
	0.000	0.000	0.000	0.010	0.060	0.000	0.000	0.000
CROP10	-0.599	-0.581	-0.429	-0.276	0.120	0.441	0.572	0.479
	0.000	0.000	0.000	0.002	0.184	0.000	0.000	0.000
CROP20	-0.487	-0.495	-0.472	-0.380	0.089	0.415	0.649	0.600
	0.000	0.000	0.000	0.000	0.324	0.000	0.000	0.000
CROP50	-0.279	-0.226	-0.269	-0.287	0.140	0.370	0.617	0.759
	0.002	0.011	0.002	0.001	0.120	0.000	0.000	0.000
HAY05	-0.292	-0.081	0.042	0.127	0.741	0.574	0.385	0.347
	0.001	0.369	0.641	0.159	0.000	0.000	0.000	0.000

	EDGE05	EDGE10	EDGE20	EDGE50	CADHAY05	CADHAY10	CADHAY20	CADHAY50
HAY10	-0.291	-0.101	0.062	0.148	0.678	0.718	0.601	0.524
	0.001	0.261	0.492	0.099	0.000	0.000	0.000	0.000
HAY20	-0.270	-0.128	-0.031	0.073	0.483	0.675	0.795	0.727
	0.002	0.154	0.732	0.418	0.000	0.000	0.000	0.000
HAY50	-0.189	-0.067	-0.022	0.050	0.392	0.581	0.744	0.880
	0.035	0.459	0.811	0.580	0.000	0.000	0.000	0.000
FOREST05	0.735	0.539	0.338	0.147	-0.486	-0.637	-0.624	-0.539
	0.000	0.000	0.000	0.103	0.000	0.000	0.000	0.000
FOREST10	0.630	0.534	0.341	0.185	-0.374	-0.663	-0.728	-0.632
	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.000
FOREST20	0.491	0.450	0.401	0.292	-0.224	-0.545	-0.773	-0.729
	0.000	0.000	0.000	0.001	0.012	0.000	0.000	0.000
FOREST50	0.235	0.147	0.164	0.156	-0.204	-0.443	-0.681	-0.854
	0.008	0.102	0.068	0.082	0.023	0.000	0.000	0.000
ROAD05	-0.135	-0.019	0.016	0.039	0.118	0.181	0.085	0.103
	0.134	0.837	0.859	0.666	0.190	0.043	0.345	0.254
ROAD50	-0.013	0.017	-0.013	-0.013	-0.054	0.124	0.156	0.275
	0.882	0.848	0.885	0.886	0.548	0.168	0.081	0.002

	CROP05	CROP10	CROP20	CROP50	HAY05	HAY10	HAY20	HAY50
CROP10	0.928							
	0.000							
CROP20	0.805	0.919						
	0.000	0.000						
CROP50	0.597	0.702	0.846					
	0.000	0.000	0.000					
HAY05	0.076	0.023	-0.017	0.023				
	0.397	0.799	0.849	0.800				
HAY10	0.187	0.154	0.126	0.139	0.891			
	0.037	0.086	0.162	0.122	0.000			

	CROP05	CROP10	CROP20	CROP50	HAY05	HAY10	HAY20	HAY50
HAY20	0.275	0.291	0.341	0.344	0.663	0.858		
	0.002	0.001	0.000	0.000	0.000	0.000		
HAY50	0.250	0.293	0.380	0.516	0.512	0.701	0.883	
	0.005	0.001	0.000	0.000	0.000	0.000	0.000	
FOREST05	-0.858	-0.786	-0.683	-0.544	-0.528	-0.579	-0.557	-0.479
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FOREST10	-0.823	-0.884	-0.825	-0.667	-0.380	-0.538	-0.598	-0.550
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FOREST20	-0.710	-0.828	-0.917	-0.803	-0.196	-0.380	-0.596	-0.614
	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.000
FOREST50	-0.501	-0.607	-0.738	-0.919	-0.136	-0.295	-0.508	-0.713
	0.000	0.000	0.000	0.000	0.131	0.001	0.000	0.000
ROAD05	0.200	0.122	0.067	0.030	0.111	0.111	0.003	0.003
	0.026	0.177	0.460	0.739	0.217	0.218	0.972	0.975
ROAD50	0.113	0.163	0.223	0.343	-0.173	-0.117	-0.048	0.120
	0.208	0.070	0.012	0.000	0.053	0.193	0.597	0.182

	FOREST05	FOREST10	FOREST20	FOREST50	ROAD05
FOREST10	0.913				
	0.000				
FOREST20	0.742	0.902			
	0.000	0.000			
FOREST50	0.533	0.676	0.817		
	0.000	0.000	0.000		
ROAD05	-0.279	-0.177	-0.061	-0.014	
	0.002	0.048	0.497	0.878	
ROAD50	-0.052	-0.148	-0.261	-0.492	0.126
	0.566	0.099	0.003	0.000	0.160

All landscape variables have the distance of the radius 05 = 0.5 km, 10 = 1.0 km, 20 = 2.0 km, and 50 = 5.0 km. The variables are MPS = mean patch size; SDI = Shannon diversity index; EDGE = forest edge density (all forest classes combined); CADHAY = core area density of perennial herbaceous cover; percent cover of: CROP = annual herbaceous, HAY = perennial herbaceous, FOREST = forest (all forest classes combined); ROAD = road density.

Appendix F

Nesting information by field

<4 ha Field – County	Spp	Num nests	fledged	predated	active	mowed	abandoned	Other
Brendle	RWBL	2	2					
Buck – Union	-							
Byers 02	FISP	1						1
	GRSP	1	1					
	INBU	1			1			
	WITU	1	1					
Totals	4 spp	4	2		1			1
Byers 04	FISP	1	1					
Fetterman Montour	RWBL	7	3	4				
Fetterman Schuylkill	RWBL	2	1	1				
	SOSP	1					1	
Totals	2 spp	3	1	1			1	
Keefer Small	RWBL	5	2	1		1	1	
	SOSP	1	1					
	WITU	1		1				
Totals	3 spp	7	3	2		1	1	
Lambert	SOSP	4	1	2			1	

Lilley 02 & 04	-							
Mankameyer	RWBL	2	8	4				
	SOSP	1			1			
Totals	2spp	3	8	4	1			
MP11	SOSP	1	1					
MP26	FISP	2		1			1	
	MALL	1		1				
	RWBL	5		5				
	SOSP	1		1				
Totals	4 spp	9		8			1	
MP69	FISP	6	3	2				1
R Linder	BOBO	1		1				
	RWBL	2	2					
Totals	2 spp	3	2	1				
Robinson House 02	DICK	1						1
	FISP	2		1				1
	RWBL	1		1				
Totals	3 spp	4		2				2
Robinson House 04	SOSP	1		1				
Robinson Road 02 & 04	-							
Sandel	-							
Sidler Small	VESP	1	1					
Stahl Small 02	RWBL	3	1	1	1			
Stahl Small 04	RWBL	2				2		

Stephens N	-							
Stephens SW	RWBL	5		2		2	1	
Stephens E	RWBL	2				1	1	
Treposic Z	-							
Treposic Lake	RWBL	7	1	2		1	2	1
Warfel Small	CHSP	1		1				
	FISP	1		1				
	SOSP	1					1	
Totals	3 spp	3		2			1	
Wehry	-							
Wingert	FISP	1		1				
	INBU	1			1			
	RWBL	1						1
Totals	2 spp	3		1	1			1
Zeisloft	-							
Totals	11 spp	91	30 (33.0)	35 (38.5)	4 (4.4)	5 (5.5)	11(12.1)	6 (6.6)
7.5 – 12 ha								
Buck	FISP	14	9	3	1			1
	WITU	2		1			1	
Totals	2 spp	16	9	4	1		1	1
Fallon	MALL	1	1					
Fisher 02	SOSP	3	1	2				
Fisher 04	-							
Hilkert House	SOSP	1				1		
Hoy	CHSP	2		2				

	FISP	2		1			1	
	RWBL	1				1		
	WITU	2					2	
Totals	4 spp	7		3		1	3	
Keefer Medium	RWBL	12	3	7		2		
Krammes	COYE	1					1	
	FISP	5	3				2	
	MODO	1					1	
	RWBL	3		2		1		
	SOSP	1						1
Totals	5 spp	11	3	2		1	4	1
Laudermilch 02	FISP	6	1	3	1			1
	RWBL	2		2				
	SOSP	1	1					
Totals	3 spp	9	2	5	1			1
Laudermilch 04	FISP	6	2	4				
	INBU	2	1		1			
	SOSP	1		1				
Totals	3 spp	9	3	5	1			
Lentz	RWBL	1		1				
Moore	-							
Morrison	MALL	1	1					
	RWBL	22	7	15			1	1
Totals	2 spp	25	8	15			1	1
MP53	FISP	2		2				
	MALL	1		1				

Totals	2 spp	3		3				
Naugle	FISP	1		1				
	SOSP	3	2	1				
Totals	3 spp	4	2	2				
Peiffer	FISP	1	1					
	RWBL	5	2	2				1
	SOSP	1	1					
Totals	3 spp	7	4	2				1
Pharr B	FISP	28	11	10	2		5	
	RWBL	3	2		1			
	SOSP	1	1					
Totals	3 spp	32	14	10	3		5	
Rice - Montour	COYE	2	2					
	FISP	14	3	10	1			
	INBU	1		1				
	SOSP	1	1					
	WITU	1					1	
Totals	5 spp	19	6	11	1		1	
Rice – Perry	FISP	1		1				
	INBU	2		1			1	
	RWBL	1	1					
	WITU	2	2					
Totals	4 spp	6	3	2			1	
Robbins ‘01	EAME	1		1				
	FISP	3		1		2		
	RWBL	31	10	14	3		2	2

	SOSP	1		1				
Totals	4 spp	36	10	17	3	2	2	2
Robbins ‘02	AMGO	1			1			
	FISP	2	2					
	RWBL	15	4	6			1	4
	SOSP	16	7	4	4			1
Totals	4 spp	34	13	10	5		1	5
Robinson	FISP	4		3				1
Chick 02								
Robinson	FISP	1						1
Chick								
04	RWBL	3		3				
	SOSP	1		1				
Totals	2 spp	5		4				1
Robinson S 02	FISP	1	1					
Robinson S 04	FISP	2	1	1				
	RWBL	1		1				
Totals	2 spp	3	1	2				
Shambaugh	RWBL	11		8			1	2
T Linder	GRSP	1		1				
	WITU	1					1	
Totals	2 spp	2		1			1	
Warfel	EAME	2		2				
Medium								
	FISP	3		2				1
	GRSP	2		2				

	RWBL	8	1	5	1			1
Totals	4 spp	15	1	11	1			2
Wenner 02	FISP	1		1				
	RWBL	4	3	1				
	SOSP	1		1				
Totals	3 spp	6	3	3				
Wenner 04	INBU	1		1				
	RWBL	2	1					1
	SOSP	1	1					
Totals	3 spp	4	2	1				1
Yeager	EAME	3	1	2				
	RWBL	47	9	31	6		1	
	SOSP	1		1				
Totals	3 spp	51	10	34	6		1	
Zehner Medium	MALL	1	1					
	RWBL	32	17	13	1		1	
	SOSP	5	4	1				
Totals	3 spp	38	22	14	1		1	
Totals	13 spp	376	122(32.4)	182 (48.4)	23 (6.1)	7 (1.9)	23 (6.1)	19(5.1)
>16 ha								
Danner	RWBL	25	4	14			5	2
Davies ‘01	AMRO	1			1			
	EAME	1					1	
	FISP	2	1	1				

	MALL	1		1				
	RWBL	21	7	14				
Totals	5 spp	26	8	16	1		1	
Davies ‘02	FISP	6	3	1				2
	INBU	1		1				
	MALL	1	1					
	RNPH	1		1				
	RWBL	32	11	11	2		2	6
	SOSP	5	1	4				
	WITU	1	1					
Totals	7 spp	47	17	18	2		2	8
Hilkert Big	GRSP	6	1	3		2		
	INBU	2		1	1			
	SOSP	2		1				1
	WITU	5	1	4				
Totals	4 spp	15	2	9	1	2		1
Huffman	FISP	5	2	3				
	INBU	3		2	1			
	RWBL	2	1		1			
	WITU	5	2	2			1	
Totals	4 spp	15	5	7	2		1	
Inch 02	RWBL	4	2	2				
Inch 04	RWBL	9	5	4				
Klingler 02	GRSP	2		2				
	NOCA	1		1				
	RWBL	9	4	3			2	

Totals	3 spp	12	4	6		2
Klingler 04	FISP	6	3	2	1	
	INBU	2		2		
	RWBL	2	1	1		
Totals	3 spp	10	4	5	1	
Mosteller	SOSP	4	1	1	1	1
	WITU	1				1
Totals	2 spp	5	1	1	1	2
MP17	EAME	2	1	1		
	FISP	6	2	3	1	
	GRSP	3	2	1		
	RWBL	1		1		
	SOSP	2	1	1		
Totals	5 spp	14	6	7	1	
Pfleegor 02	FISP	3	1	2		
	INBU	1	1			
	MALL	1	1			
	RWBL	15	6	6	1	2
	SOSP	2	1	1		
	VESP	1	1			
Totals	6 spp	23	11	9	1	2
Pfleegor 04	FISP	2		2		
	RWBL	9	4	5		
	SOSP	3	1	2		
Totals	3 spp	14	5	9		
Pharr A	FISP	18	4	11	1	2

	GRSP	3	1	2				
	INBU	2		1	1			
	RNPH	1		1				
	SAVS	2		2				
	SOSP	2	1	1				
	WITU	2		2				
Totals	7 spp	30	6	20	2		2	
Sidler Big	FISP	1					1	
	GRSP	1		1				
	VESP	3	1	2				
Totals	3 spp	5	1	3			1	
Spiegel 02	FISP	2	1		1			
	RWBL	9	4	2	2		1	
Totals	2 spp	11	5	2	3		1	
Spiegel 04	FISP	2		2				
	RWBL	2	2					
	WITU	1					1	
Totals	3 spp	5	2	2			1	
Stahl Big 02	MALL	1	1					
	RWBL	48	15	23	2	1	3	4
Totals	2 spp	49	16	23	2	1	3	4
Stahl Big 04	RWBL	13	5	6			1	1
Stamm 02	INBU	1	1					
	RWBL	2		2				
	WITU	1	1					
Totals	3 spp	4	2	2				

Stamm 04	RWBL	1		1				
Stroup	AMGO	1		1				
	FISP	1		1				
	RWBL	29	10	12	3	1	1	2
	SOSP	5	1	3			1	
Totals	4 spp	36	11	17	3	1	2	2
Wehr Big	INBU	1	1					
	RWBL	20	7	5			8	
Totals	2 spp	21	8	5			8	
Wilcox	FISP	2	2					
	RNPH	1	1					
	RWBL	48	27	17			2	2
	SOSP	1		1				
Totals	4 spp	52	30	18			2	2
Wolfgang	FISP	4	1	2				1
	RWBL	3	2					1
Totals	2 spp	7	3	2				2
Zehner Big	RWBL	28	7	20				1
	SOSP	2	1	1				
Totals	2 spp	30	8	21				1
Zeigler	RWBL	19	8	5	1		2	3
	SOSP	1	1					
Totals	2 spp	20	9	5	1		2	3
Totals	13 spp	503	180(35.8)	234 (46.5)	21 (4.2)	4 (0.8)	38 (7.6)	26(5.2)
CREP Totals	19 spp	970	332(34.2)	451 (46.5)	48 (4.9)	16 (1.6)	72 (7.4)	51(5.3)

VITA

Kevin Loyd Wentworth

74 Johnson St
North Andover, MA 01845
(978)685-2008
e-mail:Birdmankevin@cs.com

Pennsylvania State University
302a Forest Resources Lab
University Park, PA 16802
klw255@psu.edu

Education:

2001 – current Doctor of Philosophy (expected graduation, December 2006), Wildlife and Fisheries Science, Pennsylvania State University, University Park, PA 16802

1998 – 2000 Master of Science, Biological Sciences, Eastern Illinois University, Charleston, IL 61920-3099

1982 – 1987 Bachelor of Science, Biological Sciences (Naturalist tract), Appalachian State University, Boone, NC 28607

Professional Experience

1. Title: Adjunct faculty member
   Employer: Biology Department, Northern Essex Community College, Haverhill, MA 01830
   Dates: 9/05 – present
2. Title: Graduate Research Assistant
   Employer: School of Forest Resources, Pennsylvania State University, University Park, PA 16802
   Dates: 1/01 – 5/05
3. Title: Graduate Research Assistant
   Employer: Biology Department, Eastern Illinois University, Charleston, IL
   Dates: 8/98 – 5/00

Funded Research Projects

2001 – 2004 The use and productivity of grassland birds on Conservation Reserve Enhancement Program fields. Pennsylvania Game Commission ($100,000/yr)

2000 Renesting of the Dickcissel. Eastern Illinois University ($1050)

1999 Renesting of the Dickcissel. U.S. Fish and Wildlife Service ($5000)