Effects of Local and Landscape Features on Avian Use and Productivity on Conservation Reserve Enhancement Program Fields[a]

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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 problems and to provide habitat for wildlife. We examined avian use and productivity of CREP fields and how this compared with hayfields. We wanted to identify what field and landscape characteristics affected use and productivity of CREP fields. We randomly selected CREP fields in three size categories: 2.0 – 4.0 ha, 7.3 – 12 ha, and 16 – 28 ha. Hayfields were located as near as possible to selected CREP fields. We surveyed birds in all fields, using distance sampling, and nest searched half the fields. We made a total 1,929 observations of 31 different species on 114 CREP fields and 68 observations of 7 different species on 16 hayfields. From 2001 - 2004, we monitored 969 nests of 19 species in 73 CREP fields and 87 nests of 5 species on 15 hayfields. We found both landscape and field characteristics affected nest abundance and bird density on CREP fields, using Poisson regressions. The most common species were red-winged blackbirds (*Agelaius phoeniceus*), field sparrows (*Spiza pusilla*) and song sparrows (*Melospiza melodia*). The most common grassland specialists were grasshopper sparrows (*Ammodramus savannarum*) and eastern meadowlarks (*Sturnella magna*) though they were both uncommon. Ring-necked pheasants (*Phasianus colchicus*), dickcissels (*Spiza americana*), Henslow's sparrows (*Ammodramus henslowii*), savannah sparrows (*Passerculus sandwichensis*), vesper sparrows (*Pooecetes gramineus*) and bobolinks (*Dolichonyx oryzivorus*) were rare. No field or landscape variables were positively associated with all species. However, fields should include greater area, heterogeneous vegetation, dense clumps of vegetation for nests (especially forbs), and cover diversity surrounding the field to attract the most species. Grassland specialists were located in fields that were surrounded by forests and showed little regard for forest cover or forest edge density. CREP fields had a significantly higher species richness and nest success than hayfields after equalizing search area. Our study shows that grassland birds will use CREP fields in landscapes dominated by forest cover. Species nest success falls within the range found in the Midwest. CREP fields are more successful and have a higher diversity of species than hayfields.

METHODS

See attached report for a description of the methods used.

RESULTS

See attached report for a summary of the results from the 2001 through 2005 seasons.

RECOMMENDATIONS

This represents the final report for our project. CREP is providing habitat for grassland and farmland species, but the species make-up of CREP fields in south-central Pennsylvania is different from CRP fields in the Midwest. This may be in part because of the greater age and field size of CRP fields or because southcentral Pennsylvania is at the edge of most grassland specialists' range. On Pennsylvania CREP fields, grasshopper sparrows and eastern meadowlarks were the most common grassland specialists whether measured by singing male density or nest abundance. However, both were much less common than reports from the Midwest. Bobolinks had the highest density on an individual field, but we only located one nest on our CREP fields and one on a hayfield. Red-winged blackbirds were the most common species overall. Field sparrows and song sparrows were the next most common though their respective rank changed depending on whether the measurement tool was density or nest abundance. Nest success was similar to that found in other studies, and nest success was significantly higher on CREP fields than on hayfields.

Attempts should be made to sign up CREP fields that are as large as possible because three species showed an increase in nest abundance in larger fields and no species showed an increase in smaller fields. 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. This will need to be accomplished with some sort of maintenance on the field, e.g., mowing, burning, and or light disking to break up dense homogenous stands of vegetation. Some farmers may need to be convinced that birds need "weeds" (forbs) as a nesting substrate. Both warm and cool-season grasses positively affected species and so should continue to be used. There were too few fields with mixed warm and cool-season grasses, though many warm-season grass fields had cool-season grass borders, to determine whether there was a difference with homogenous fields. Many of the warm-season grass fields were still not fully established, so the results should be interpreted with this in mind.

Within the landscape, no variable entered all models with the same relationship with nesting abundance. This indicates that a continued mixture of landscape composition will provide for the most diversity of species. There is no indication that a fragmented forest landscape will not be used by grassland birds.

The community analysis also indicated that there is little clustering of species. 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. This 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. Monitoring needs to continue on established fields to identify if use by grassland specialists will increase as fields age. Monitoring should also begin on newly established fields in new areas of Pennsylvania to compare with the south-central fields. There is little information on sources of grassland specialists to colonize Pennsylvania CREP fields. It is possible that the larger reclaimed strip mines in western Pennsylvania and West Virginia are sources; hence, it may take a few years for the fields to become more suitable for some species and time to fill in the new habitat.

The difference between the results of density and nest abundance indicates that there is not a perfect correlation and nest data, when possible, is probably a better measurement tool of field productivity. 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 shown that, as hayfields age they become more attractive to many grassland specialists and monitoring should be continued to see if this occurs on CREP fields. 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 tools such as mowing have shown a different response by species. Population and genetic studies should be conducted to investigate the metapopulation context of Pennsylvania grassland species and 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.

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Effects of local and landscape features on avian use and productivity on Conservation Reserve Enhancement Program Fields

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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, reducing soil erosion and increasing 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) have been identified for enrollment. 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 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 size (Askins 1993). However, this minimum size 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 the landscape matrix is primarily forest and field size is smaller. 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 in different landscapes of 28 and 27 ha in ND, 15 and 26 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.). It has been suggested that predation is higher on nests near a forested edge (Johnson and Temple 1990, see Johnson 2001), which may indicate higher predation in a landscape dominated by forest. In addition, there is evidence that productivity for ring-necked pheasants and other grassland birds, a better measurement of habitat quality, is also dependent on habitat patch size and the vegetative cover (e.g. Johnson and Temple 1990, Horn 2000, McCoy et al. 2001).

Our objectives were to (1) determine if there is a difference in use and productivity between CREP fields and hayfields; (2) determine the abundance, distribution, and productivity of grassland birds on CREP fields; (3) determine how field size affects use and productivity of grassland birds; (4) 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; (5) determine if differing landscape characteristics affect the use and productivity of grassland birds.

Chapter 2

Grassland bird density on Conservation Reserve Enhancement Program fields in Pennsylvania

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 goal 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.

In order to maximize program potential it is important to identify the local and landscape characteristics of a field that will increase use by grassland birds. Field characteristics such as size (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 and had 2781 fields > 0.5 ha (mean 9.3 ha) that were enrolled in within CREP. Field selection for inclusion in our 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, 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 size from 1 ha to 41 ha (mean 11.2 ha ± 8.7 SD).

We 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 we improved our methodology. In 2002, we 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). We 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 in order to get a more equal distribution of larger fields: <4.0 ha (small), 7.5 - 12 ha (medium), and >16 ha (large).

In 2003-2004, we 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 we now had information for individual fields, we had a larger range in forest cover and redefined our selection criteria for 2003 – 2004 as low 0 – 33%, medium 34 – 66%, high 67 – 100% and subsequently reclassified our 2002 fields using the same criteria. In 2003, we randomly selected six fields in each category (field size and forest cover). In 2004, we 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 size indicated), inability to get permission, and our need to concentrate groups of fields within a 45-minute drive to decrease travel time between fields.

Avian abundance

Four different observers surveyed the fields, two observers per year. To correct for different detection probabilities among the individuals and among different species, we surveyed each field using distance-sampling techniques (Emlen 1971 and 1977, 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, from late May to mid June and 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 (to calculate perpendicular distance from transect). 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), we calculated the density of each bird species, for which we had > 25 observations but attempted to look at differing detection functions for species that observers had >60 total observations (Diefenbach et al. 2003). This limited the number of species for modeling to bobolinks, eastern meadowlarks, red-winged blackbirds, common yellowthroats, field sparrows, grasshopper sparrows, and song sparrows. 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. We had enough observations of red-winged blackbirds that each observer was modeled for their own detection function. We 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 the senior author 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, we used the formula:

$$(n*f(0)/2*L)*10000 = \text{birds ha}^{-1}$$

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 detection function for that species (and observer for red-winged blackbird); L is the total length 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 (McCoy et al. 2001; see Appendix B for vegetation information on all fields). At each point, we measured vertical density using a Robel pole (ROBEL; Robel et al. 1970) read to the nearest cm from 4 m to the north of the point at a height of 1 m. We used a 0.5 m^2 Daubenmire frame (Daubenmire 1959) to measure vegetation cover centered on the point. We 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). We also measured the height of vegetation (HEIGHT) and litter depth (LIT 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 cover of grass (combining warm and cool-season grasses; CV GRASS), forbs (CV FORB), downed litter (CV DLIT), bare (CV BARE), and vertical density (CV ROBEL). We trained each observer to measure the different vegetation characteristics.

Landscape level analysis

Land cover characteristics were calculated from the GAP analysis 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 in order to remove the field from the analysis since field size, vegetation, and perimeter-area ratio were already included in the model. The total area included within the radius was different for each field size but all landscape statistics are calculated as proportions of the total area to allow comparisons. Because there was a high correlation between the different radii only 0.5 km and 5.0 km radii were used in the analysis (see Appendix D for correlations of landscape variables). The landscape variables used in the final analysis were mean patch size (MPS), Shannon Diversity Index (measure of the proportion of the landscape by 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; CADHAY), forest edge density (the length of forest edge per ha combining all forest classes together; EDGE), road density (the length of road per ha; ROAD), and the cover percentage of forest (combined all forest classes; FOREST), annual (CROP) and perennial herbaceous (combined with transitional cover; HAY). The metrics of MPS, SDI, CADHAY, and EDGE 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), and 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

We 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™ (MINITAB, Inc.) was used to calculate all normality tests, Pearson correlations, Mann-Whitney, ANOVA and Principle Component Analysis (PCA). 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 $0.10 > p > 0.05$.

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, we 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 size as a covariate. In all other analyses, one year was randomly selected between the two years of survey information in order not to confound the analyses with 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 we report only those variables with a weight ≥ 0.380.

Densities of birds were changed to counts by multiplying the density calculated for each field by its size and rounded to the nearest integer for use in Poisson regression models. Models were then weighted by log-transformed field size to equalize area between different fields. AIC was used to select the most parsimonious model. 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 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 CANOCO. Variables were selected manually using Monte Carlo permutation tests and were included in the model if significant ($p < 0.05$). We used restricted permutations to remove the possible influence of spatial autocorrelation (ter Braak and Smilauer).

Results

Species use of CREP fields

We 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 2.1 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). Though some species were uncommon, there was little difference in their annual mean density (Table 2.5). Indigo buntings had a significantly higher mean density in 2003 than either 2002 or 2004. Year was included as a variable in the further analysis of indigo buntings because they showed a significant difference in density by year. The only species that showed a significant difference in density from year to year when comparing fields that were surveyed multiple years was the grasshopper sparrow ($W=612$, $p=0.018$; Fig. 2.1) though field sparrows showed a trend ($W=607$, $p=0.10$).

Three landscape PCs and four field PCs were used in the Poisson regressions (Table 2.6). No species models were the same (Table 2.7), 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 2.8). 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 size, 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. Common yellowthroat density was also affected by location with density increasing from east to west.

Field sparrow

Field sparrow density was affected most by field characteristics (Table 2.8). 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 affected most by landscape variables (Table 2.8). 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 2.8). Song sparrow density increased with a local decrease in cover diversity and forest edge density. However, 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 increased with small, patchy warm-season grass fields with standing litter cover, but thinner downed litter.

Indigo bunting

Indigo buntings were the only species to show the strongest relationship to spatial characteristics, being denser from north to south and west to east (Table 2.8). Indigo bunting density showed the same relationship to field characteristics that song sparrows did. 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.

Bobolink

Bobolink density was affected most by landscape variables (Table 2.8). 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 size, 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 most by landscape characteristics (Table 2.8). They related positively to 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 2.8). Red-winged blackbird density increased with field size, 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 a strong response of species to road density and mean patch size within the larger landscape context for Axis 1 and the local cover of annual and perennial herbaceous vegetation for Axis 2 (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 Bobolink was the most specialized because of their location as the farthest outlier, while song sparrows were the most general being positioned almost on the origin. Red-winged blackbirds and eastern meadowlarks were clustered together along Axis 2 showing a positive relationship with increasing annual and herbaceous cover around the field but also showing a positive relationship with local road density. Common yellowthroats were the most negatively associated with annual and perennial herbaceous cover. Grasshopper sparrows showed a moderate relationship to road density within the larger landscape context. This community analysis shows that the grassland specialists each have a different need within the field and landscape because of their separation.

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 size is much smaller than in the Midwest. Within this make-up, CREP fields were composed mainly of 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). 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 prairie 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 that calculated abundance per area (Johnson and Schwartz 1993, Winter and Faaborg 1999).

The difference between Pennsylvania and the Midwest in density or abundance may be smaller field sizes. Many species are considered area-sensitive (see Johnson 2001 for review), and field size was selected in six of the eight species models. However, common yellowthroats (positive), grasshopper sparrows (negative), and red-winged blackbirds (positive) showed the opposite relationship than has been found previously (Johnson 2001). Bobolinks (positive) and song sparrows (negative) were found to have the same relationship with field size as other studies. Field sparrows and eastern meadowlarks have been found to be area sensitive in other studies but were not in this study. Indigo buntings were found to have a negative relationship with field size but were not included in the review (Johnson 2001). Common yellowthroat density may increase with field size because large fields were more likely to have wet areas, a predictor of increased abundance (Johnson and Schwartz 1993a), within the field or near the field edge than smaller fields (pers. obs.). Field size may be smaller than the minimum field size required by grassland specialists, which would increase the likelihood of a negative relationship due to already low densities.

Within the field, density increased more often with an increase in the percent cover of warm-season grass than cool-season grass. Common yellowthroats, field sparrows, song sparrows, and red-winged blackbirds all showed an increase in density with an increase in warm-season grass cover. Grasshopper sparrows and bobolinks density increased with a decrease in warm-season grass cover. Common yellowthroats and red-winged blackbirds showed an increase in density with an increase in cool-season grass cover, but field sparrows and grasshopper sparrows showed a negative relationship. When examining the difference between cool-season and warm-season grass fields there has been a mixture of results. Grasshopper sparrows have been found to prefer cool-season-grass fields (McCoy et al. 2001), but more often no difference has been found (Delisle and Savidge 1997 [warm-season fields mowed], Hull 2002). Red-winged blackbirds prefer grass cover and show no preference to the type (Delisle and Savidge 1997, McCoy et al. 2001, Hull 2002) and have been shown to have 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 either grass cover type in other studies (McCoy et al. 2001, Hull 2002). On hayfields in Pennsylvania, song sparrows, grasshopper sparrows, and field sparrows (trend) preferred warm-season grass fields and red-winged blackbirds, and bobolinks showed no preference (Giuliano and

Daves 2002). Part of the reason that 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 the CREP fields in Pennsylvania. Regular mowing of warm-season grass fields may also have affected bird use (Delisle and Savidge 1997, Giuliano and Davess 2002).

Vertical density was another important field characteristic in species models. Common yellowthroat and red-winged blackbird density increased with an increase in the density of the vegetation, while grasshopper sparrow and field sparrow density decreased with increasing vertical density. However, grasshopper sparrows preferred a field with more variation in the density than did field sparrows. Grasshopper sparrows and eastern meadowlarks have been found to be negatively affected by increased vegetative density (Smith 1963, Weins 1969, Delisle and Savidge 1997, Fletcher and Koford 2002, Scott et al. 2002). Bobolinks showed no relationship with vertical density in this study, while they have been found to have both a positive (Fletcher and Koford 2002) and a negative relationship (Delisle and Savidge 1997) in Midwest studies. Common yellowthroats have shown a positive relationship with vegetative density in Midwest studies (Delisle and Savidge 1997, Scott et al. 2002).

Landscape variables were as important as the field variables, but there have been far fewer studies looking at landscape effects. Diversity of cover types and forest edge density at 0.5 km related positively to common yellowthroat, field sparrow, and grasshopper sparrow density but negatively to song sparrow and bobolink density. Diversity of cover types has been negatively associated with bobolinks (0.8 km) and grasshopper sparrows (0.2 and 0.4 km) though diversity of cover types were also highly correlated with total area of hay and grasslands within the landscape (Ribic and Sample 2001). A preference for a higher diversity of cover types surrounding the field may be an indication of the need for other areas beyond the field for feeding. For wooded edge grasshopper sparrows were negatively related to the density of grassland-wooded edge within 1 km of the field in Iowa (Fletcher and Koford 2002). Bobolinks were negatively associated with area of woodlots within 800 m of the transect and eastern meadowlarks were positively associated with the distance to a woodlot from the transect (Ribic and Sample 2001). However, on a larger scale common yellowthroats, song sparrows, and eastern meadowlarks were positively associated with the amount of farm woods (Murphy 2003).

Two of the grassland specialists, bobolinks and grasshopper sparrows, related negatively to the amount of perennial herbaceous core area and cover at 0.5 km while eastern meadowlarks related positively. 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 have also been shown to increase in abundance from lowland to upland pastures (Renfrew and Ribic 2003). This may indicate that bobolinks and grasshopper sparrows are relating more positively to upland fields than they are to the amount of grassland cover within the landscape. Another possible factor is that bobolink density has decreased with the density of agricultural – grassland edge within 1 km of the field (Fletcher and Koford 2002). This may be a reason 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

CREP is providing habitat for grassland birds, and as fields continue to mature, they will provide even better habitat for grassland specialists than at this early state (Bollinger 1995), though no difference was detected within 2 years at fields in this study. Field size should be considered when signing up fields in an attempt to increase field size for species like bobolinks. However, smaller fields had higher densities of some species and should also be selected. Grasshopper sparrows had higher density on smaller fields in this study, but this may be a result of males moving from mowed fields later in the season or an artifact of the overall low density. In other studies, they are considered an area sensitive species (Johnson 2001).

An important task of management will be to create fields with different cover structure and types since different species showed different preferences. Many species preferred fields that were less dense, had a thinner litter layer, and more bare areas. To maintain patches in this state will require periodic burning, mowing or light disking after the breeding season. The effects of mowing on grasshopper sparrows and other species has been mixed. Only grasshopper sparrows showed an increase in abundance with mowing of switchgrass fields the previous year while common yellowthroats, field sparrows, song sparrows and red-winged blackbirds showed no difference whether totally harvested, strip harvested or non-harvested (Murray and Best 2003). There has not been a clear response of grasshopper sparrows to mowing on reclaimed mines (Brauning et al. 2001). Fields in poor soil may actually be of benefit to species such as grasshopper sparrows and eastern meadowlarks that prefer fields with lower vegetation, and these might be created by mowing at least one strip in the field in late April or early May to attract males.

Landscape variables did play a role in field choice. Bobolinks and grasshopper sparrow density decreased with locally increasing herbaceous cover. This may be an indication of their preference for fields that are in upland areas that tend to have more forest cover and less agricultural cover. However, common yellowthroats, eastern meadowlarks and red-winged blackbirds showed an increase in density with increasing amounts of large patches of perennial herbaceous cover. This indicates that managers should continue to sign up fields in both forested and agricultural landscapes with a mix of cover types surrounding the fields.

The community analysis also indicated that there is little clustering of species. 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. This 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. Monitoring needs to continue on established fields to identify if grassland specialists will increase as fields age. Monitoring should also begin on newly established fields in new areas of Pennsylvania to compare with the south-central fields. There is little information on sources of grassland specialists to colonize Pennsylvania CREP fields. It is possible that the larger reclaimed strip mines in western Pennsylvania and West Virginia are sources; hence, it may take a few years for the fields to become more suitable for some species and time to fill in the new habitat. There is also an opportunity to identify the most appropriate management strategies for Pennsylvania CREP fields to maximize species use and density.

Table 2.1: Vegetation characteristics of 144 Conservation Reserve Enhancement Program fields in south-central Pennsylvania surveyed during the summers of 2002 – 2004.

Measurement	Mean	SE	Maximum field value
Litter depth (cm)	1.21	0.10	4.71
Vegetation height (cm)	50.96	2.63	130.67
% 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	1.30	0.34	24.75
% Bare ground	7.27	0.80	48.33
Vertical density (cm)	45.32	2.11	108.67
CV litter depth	1.18	0.06	2.68
CV % forbs	0.80	0.05	3.84
CV % grass	1.69	0.07	4.90
CV % bare ground	1.67	0.11	5.71
CV % vertical density	0.53	0.03	1.99

Table 2.2: Landscape characteristics of 144 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/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/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 Edge) per 100 ha
[c] Characteristics measured within a 5.0 km radius around each field

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

Species	Number of fields present (N = 114)	Number of observations	Birds/km of transect
Mallard	1	1	0.008
Red-tailed hawk	2	2	0.016
American kestrel	1	1	0.008
Ring-necked pheasant	1	1	0.008
Common snipe	1	1	0.008
Northern flicker	1	1	0.008
Willow flycatcher	1	1	0.008
Eastern phoebe	1	1	0.008
Eastern kingbird	3	3	0.024
Gray catbird	1	1	0.008
Northern mockingbird	1	1	0.008
Yellow warbler	4	4	0.032
Common yellowthroat	20	30	0.242
Scarlet tanager	1	1	0.008
Field sparrow	41	111	0.895
Chipping sparrow	5	10	0.081
Grasshopper sparrow	36	104	0.839
Henslow's sparrow	1	3	0.024
Savannah sparrow	10	17	0.137
Song sparrow	86	343	2.766

Vesper sparrow	6	10	0.081
Dickcissel	2	2	0.016
Blue grosbeak	1	2	0.016
Indigo bunting	51	130	1.048
Bobolink	7	50	0.403
Eastern meadowlark	20	31	0.250
Red-winged blackbird	83	1052	8.485
Common grackle	1	1	0.008
Brown-headed cowbird	4	4	0.032
Baltimore oriole	2	2	0.016
American goldfinch	5	5	0.040

Table 2.4: Density[a] of species 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	ESW[c] (SE)
Red-winged blackbird	0.701 (0.07)	2.87		
ML[b]			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)
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)
Field sparrow	0.114 (0.02)	0.93	0.49 (0.42,0.57) 105	51.72 (3.97)
Common yellowthroat	0.078 (0.02)	2.80	0.05 (0.02,0.12) 105	32.07 (5.21)
Eastern meadowlark	0.009 (0.01)	0.16	0.08 (0.03,0.23) 185	153.1(8.59)
Grasshopper sparrow	0.113 (0.02)	1.33	0.53 (0.45,0.62) 105	63.7 (5.152)
Bobolink	0.103 (0.05)	4.58	0.47 (0.36,0.62) 110	52.20 (6.90)

[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] ESW = effective strip width (m)
[d] Observers used to calculate differing detection functions, ML = Michael Lohr, SM = Scott McConnell, JR = Jason Ryan, KW = Kevin Wentworth

Table 2.5: Density (males/ha) of grassland bird species during the 2002 – 2004 breeding seasons on Conservation Reserve Enhancement Program fields in south-central Pennsylvania. ANOVA was used to compare years.

	Mean (+SE) [a]				
Species	2002	2003	2004	F-value	P value
Bobolink	0.06 (0.05)	0.16 (0.12)	0.09 (0.07)	0.41	0.662
Red-winged blackbird	0.58 (0.10)	0.87 (0.11)	0.62 (0.14)	2.29	0.106
Indigo bunting	0.09 (0.03)	0.25 (0.06)	0.02 (0.01)	5.00	0.008**
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

[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

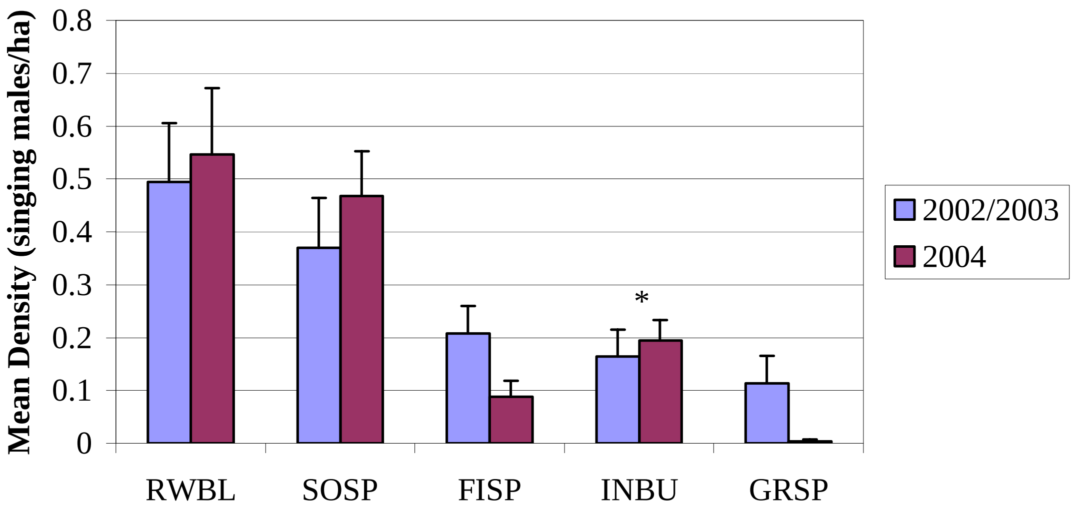

Fig. 2.1: Mean density (+ SE) of bird species on 23 fields surveyed in multiple years on Conservation Reserve Enhancement Program fields in south-central Pennsylvania. RWBL = red-winged blackbirds, SOSP = song sparrows, FISP = field sparrows, INBU = indigo buntings, GRSP = grasshopper sparrows. $p <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

Table 2.6: Principle Component variables and weighting (in parenthesis) for field and landscape characteristics used in regression models of bird density on Conservation Reserve Enhancement Program fields, 2002 – 2004, south-central Pennsylvania.

Principle Component	Variables (weighting)
Landscape	
LPC1	CADHAY50 (0.380); FOREST50 (-0.375)
LPC2	SDI05 (0.442); EDGE05 (0.391)
LPC3	HAY05 (-0.540); CADHAY05 (-0.466); ROAD50 (0.408)
Field	
PC1	FORB (-0.441); CV FORB (0.382)
PC2	SIZE (0.443); CV BARE (0.443); P/A RATIO (-0.420); DEPTH (0.402)
PC3	ROBEL (-0.408); CGRASS (-0.380)
PC4	SLIT (0.421); CV ROBEL (-0.406); WGRASS (0.389)

50 = 5km radius; 05 = 0.5km radius; CADHAY = core area density of cover; HAY = % perennial herbaceous cover; FOREST = % forest cover; EDGE = of forest edge; ROAD = density of roads; SDI = Shannon Diversity Index; FORB = % forb cover; CGRASS = % cool-season grass cover; WGRASS = % warm-season grass cover; SLIT = % standing litter cover; LIT DEPTH = ROBEL = vegetative density; CV ROBEL = variation in vegetative density; CV variation in bare ground cover; SIZE = field size; P/A RATIO = perimeter-

Table 2.7: Poisson regression models of local and landscape variables for density of singing males/ha on Conservation Reserve Enhancement Program fields during the summers of 2002 - 2004 in south-central Pennsylvania

Species	AIC null	AIC	Variables[a]
COYE	428.21	232.93	PC4 – LPC1 + LPC2 + PC1 + X – PC3 + 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
INBU	531.96	482.36	– Y + PC4 + X – PC2 + LPC3
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 are reported by level of individual significance; COYE = common yellowthroat, FISP = field sparrow, GRSP = grasshopper sparrow, SOSP = song sparrow, INBU = indigo bunting, BOBO = bobolink, EAME = eastern meadowlark, RWBL = red-winged blackbird; X = west to east spatial coordinates, Y = south to north spatial coordinates

Table 2.8: Comparison of model AIC values for models with all variables, landscape variables, field variables or spatial variables on Conservation Reserve Enhancement Program fields during the breeding seasons of 2002 – 2004 in south-central Pennsylvania

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
SOSP = song sparrow; INBU = indigo bunting; BOBO = bobolink;
EAME = eastern meadowlark; RWBL = red-winged blackbird

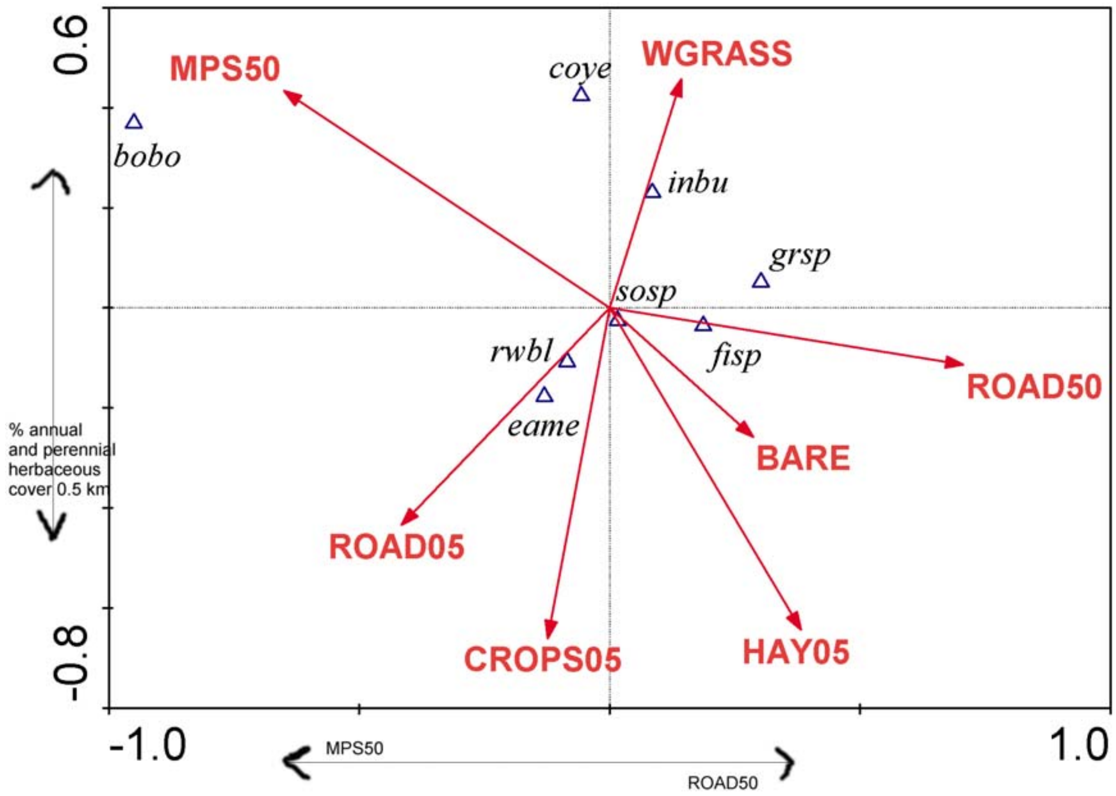

Fig. 2.2: Ordination bi-plot depicting the first two axes of the Canonical Correspondence Analysis of grassland birds with >25 observations on Conservation Reserve Enhancement Program fields in south-central Pennsylvania and landscape and field environmental variables, 2002 – 2004.

Chapter 3

The effect 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. This 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 on eligible 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 size 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 looking at the effects of CREP on birds, we 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

We 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, we conducted a pilot study in Montour County. For 2002 – 2004, we nest searched half of the fields used in a larger study. 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 size and landscape characteristics. They were concentrated in three areas for accessibility by field crews (three people in three crews). We searched for nests on 73 different CREP fields that ranged in size from 1 ha to 25.5 ha (mean 10.4 ha ± 7.3 SD).

Nest abundance and reproductive success

To examine productivity we 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. We 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 22m 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. We 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. We measured the distance from the ground to the bottom of the nest to the nearest cm (NEST HEIGHT). We 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. We measured vertical density using a Robel pole (ROBEL; 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. We 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. We 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). We 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 ROBEL). We 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

We 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™ (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 ± 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 predation 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 eigen values ≥ 1.5, and we report only those variables with a weight ≥ 0.380. Poisson regression models of nest abundance were weighted by log transformed field size 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 size as a covariate. For all other analyses, we 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.

In order to examine the effect of different edge types on nest success we used both paired t-tests and logistic regression. The paired t-tests were used to compare nest success within a field and distance to different edge types (agriculture, forest, tree line, and road). Because of the multiple tests, we used a Bonferroni correction and report significant results as $p < 0.01$. We 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 distances to the edge were included in the analysis.

We 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 size, 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 CANOCO. Variables were selected manually using Monte Carlo permutation tests and were included in the model if significant ($p < 0.05$). We used restricted permutations to remove the possible influence of spatial autocorrelation (ter Braak and Smilauer 2002).

Results

Species use of CREP fields

We 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 (Fig. 3.1). The next most common species were field sparrows, song sparrows and indigo buntings. Grassland specialists made up 3.92% of all the nests located, grasshopper sparrows being the most common with 19 nests. The number of fields where a species had at least one nest present showed the same pattern as nest abundance, with red-winged blackbirds being the most common, followed by field sparrows and song sparrows (Fig. 3.2). However, when the percent of nests present by field size category is examined there is a different composition of dominant species for each category (Fig. 3.3). Most species did not have enough nests on small fields to analyze a difference with all size categories. 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 commonly found on medium fields than large fields though neither had sufficient sample sizes to test. When taking total area of categories into account red-winged blackbirds did not show a significant difference among categories (Table 3.3). Field sparrows and song sparrows showed a significant difference among categories with field sparrows having more nests on medium fields than expected, and song sparrows having fewer nests on large fields. Grasshopper sparrows showed a trend for more nests to be found on large fields than medium.

Field and landscape characteristics affecting nest abundance

Three landscape PCs and four field PCs were used in Poisson regressions of nest abundance (Table 3.4). 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 size and decreasing perimeter-area ratio. Wild turkeys showed 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, higher forest edge density and increasing perennial herbaceous cover and core areas surrounding the field. Indigo bunting nest abundance increased with decreasing annual herbaceous cover and road density. Indigo buntings showed 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 also increased with fields to the 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 percent cover of either grass type. Within the landscape, grasshopper sparrow nest abundance showed a trend to increase with an increase in core areas of perennial herbaceous cover and a decrease in patch size at the larger scale.

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. Nest abundance increased with fields to the west. Individually warm-season grass cover positively affected nest abundance while cool-season grass cover showed no affect. Song sparrow nest abundance increased with increasing annual herbaceous cover and decreasing forest edge density and cover diversity.

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 landscape, red-winged blackbird nest abundance increased with an increase in herbaceous cover, both annual and perennial, with decreasing forest edge density and cover diversity around the field. At the larger scale, nest abundance increased with mean patch size while decreasing with increasing road density and number of core areas of perennial herbaceous cover. Nest abundance increased with fields to the 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. 3.4). 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 showed a strong relationship with increasing woody cover. Grasshopper sparrows showed 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. 3.5; 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. Predation was the major cause of nest loss, 53% of known nesting outcomes and 76% of nest failures. Abandonment, human disturbance, parasitism, and weather (heavy rains, heavy winds and freezes) were other causes of nest loss. The four field sparrow nests that were parasitized were abandoned immediately afterwards and no nest fledged that had been parasitized.

For most species, nest success was not affected by distance to field edge. When comparing within a field there was a trend for field sparrows to be more successful closer to a road edge than farther away (Table 3.7). There was also no significant difference in nest success when comparing all successful and unsuccessful nests and 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, we 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. 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 than warm-season grasses but field sparrows were more common on warm-season grasses.

Since predation was the major cause of nest loss, we attempted to identify nest predators using infrared video cameras but never captured a predation event. We 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 PCs and we report only those variables that were found to be significant (weights of PC variables are given in brackets when only one PC is included in model).

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 showed 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 (χ^2 = 9.342, df = 5, p = 0.096; Fig. 3.6). 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 3.10). 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 less successful in forbs or on the ground than expected (χ^2 = 9.543, df = 4, p = 0.049*; Fig. 3.7). Mayfield regression indicated that field sparrows were more successful when their nests were placed higher above the ground 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. Mayfield regression had no significant results.

Song sparrow

Because song sparrows had on two nests in warm-season grass, we 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. 3.8).

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 3.11). There was a trend for increased nest success with increased downed litter, both cover and depth.

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 size is much smaller than in the Midwest. Within this make-up, CREP fields were composed mainly of red-winged blackbirds, field sparrows and song sparrows, with grasshopper sparrows, and eastern meadowlarks being uncommon and bobolinks, dickcissels and Henslow's sparrows practically absent (one nest each for bobolinks and dickcissels). Mean clutch size and nest success for species with >10 nests was within the ranges found in other studies (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

Predation was the major cause of nest loss, which agrees with other studies (Best 1978, Wray et al. 1982, Best et al. 1997). Many different predators have been captured on video predating nests in pastures (9 different species; Renfrew and Ribic 2003) and in grasslands (9 different species; Pietz and Granfors 2000). Nest abandonment for grassland birds is commonly a minor cause of nest loss (Best 1978, Wray et al. 1982). Human disturbance of CREP field nests

should decrease as fields age and less activity during the breeding season is required, liming and mowing for weed suppression.
Edge effects have been implicated in a decrease in nest success especially within 50m 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 our study there was no difference in nest success and distance of the nest to any edge, except for wild turkeys being more successful farther from the closest edge. This may be attributable to the small field size and lack of sufficient distance from edges to detect a difference. Grasshopper sparrows and red-winged blackbirds avoided nesting within 50m of tree edges and so were beyond the range of highest mammalian predation. Field sparrows and song sparrows nested closer than 50m to a tree edge but were often nesting in multi-flora rose that may deter mammalian predators. Nest density was low enough that mammalian predation 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 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

All PCs entered a model. Wild turkeys, grasshopper sparrows and song sparrow nest abundance increased with an increase in field size 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). Our results for grasshopper sparrows agrees with area-sensitivity studies but field sparrows did not show a relationship to field size and they have been found to be area sensitive in other studies (Johnson 2001). Song sparrows showed a positive relationship with field size in this study but have a negative relationship in other studies (Johnson 2001), though most studies examined bird abundance and not nest abundance. Red-winged blackbird nest abundance model did not include field size, and other studies have shown a variable response to field size (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 showed 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 entered positively for field sparrows 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).

When examining the landscape characteristics, the local (0.5 km radius) variables had a stronger influence on models than larger scale variables (5.0 km radius). The density of forest edge, cover diversity and percent of annual herbaceous cover were the most common variables to enter species models only being absent from grasshopper sparrows. The amount of local perennial herbaceous cover was the only factor that only positively affected 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 showed song sparrows and red-winged blackbirds to be 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 in both measuring methods. Field sparrows and song sparrows were the next most common in nest abundance but when measuring density song sparrows were ranked second and field sparrows fourth. Grasshopper sparrows were the most common grassland specialists by both measuring methods. Bobolinks were found much more often by surveying than nesting, which may be because of the difficulty in locating nests. 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 using hedgerows or wooded edges to nest in.

There were similarities and also differences in the models of nest abundance and density using field and landscape variables. First of all there were more species that had enough data to analyze for density models than was found for nest abundance, which may simply be an artifact that there were more fields surveyed than nest searched.

Landscape variables were very similar between models but the variables either did not enter both models or were opposite in relationship. In many cases the nest abundance models made more biological sense, e.g. field sparrow nest abundance increased with increasing forest edge density but density decreased with increasing forest edge density. Grasshopper sparrow and bobolink density decreased with increasing perennial herbaceous cover but grasshopper sparrows showed no relationship in nest abundance. However, red-winged blackbirds showed a consistently positive response to the amount of local perennial herbaceous cover in both models and though the nest abundance model showed a negative relationship with the number of perennial herbaceous fields with core area in the larger landscape context it was the last variable to enter the model and therefore explained little of the variance in nest abundance.

Field variables were more different than landscape variables in variable weighting of principle components. The response of species to field size was different between models. Both grasshopper sparrow and song sparrow decreased with increasing field size when modeling density but their nest abundance increased with field size. Field size was also included in more species in density models than in nest abundance models. The response to the amount of cool-season and warm-season grass cover was similar between models though the variables were different, with both grass cover types being in one PC in nest abundance but separate in density. Red-winged blackbirds showed a preference for cool-season grass cover in both models but when the grasses were weighted in the same PC nest abundance increased with increasing cool-season grass and decreasing warm-season grass.

Management implications

Attempts should be made to sign up CREP fields that are as large as possible because three species showed an increase in nest abundance in larger fields and no species showed an increase in smaller fields. 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. This will need to be accomplished with some sort of maintenance on the field, e.g., mowing, burning, and or light disking to break up dense homogenous stands of vegetation. Some farmers may need to be convinced that birds need “weeds” (forbs) as a nesting substrate. Both warm and cool-season grasses positively affected species and so should continue to be used. There were too few fields with mixed warm and cool-season grasses, though many warm-season grass fields had cool-season grass borders, to determine whether there was a difference with homogenous fields. Many of the warm-season grass fields were still not fully established, so the results should be interpreted with this in mind.

Within the landscape, no variable entered all models with the same relationship with nesting abundance. This indicates that a continued mixture of landscape composition will provide for the most diversity of species. There is no indication that a fragmented forest landscape will not be used by grassland birds, because even grasshopper sparrows only showed a negative trend with forest cover at 5.0 km and did not show any influence by forest edge density around the field (0.5 km).

In conclusion, greater field size was the only variable that was 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.

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
% 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 litter depth	1.24	0.07	2.68
CV % forbs	0.73	0.05	1.93
CV % grass	1.65	0.06	3.99
CV % bare ground	1.43	0.10	4.90
CV vertical density	0.45	0.02	0.93

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

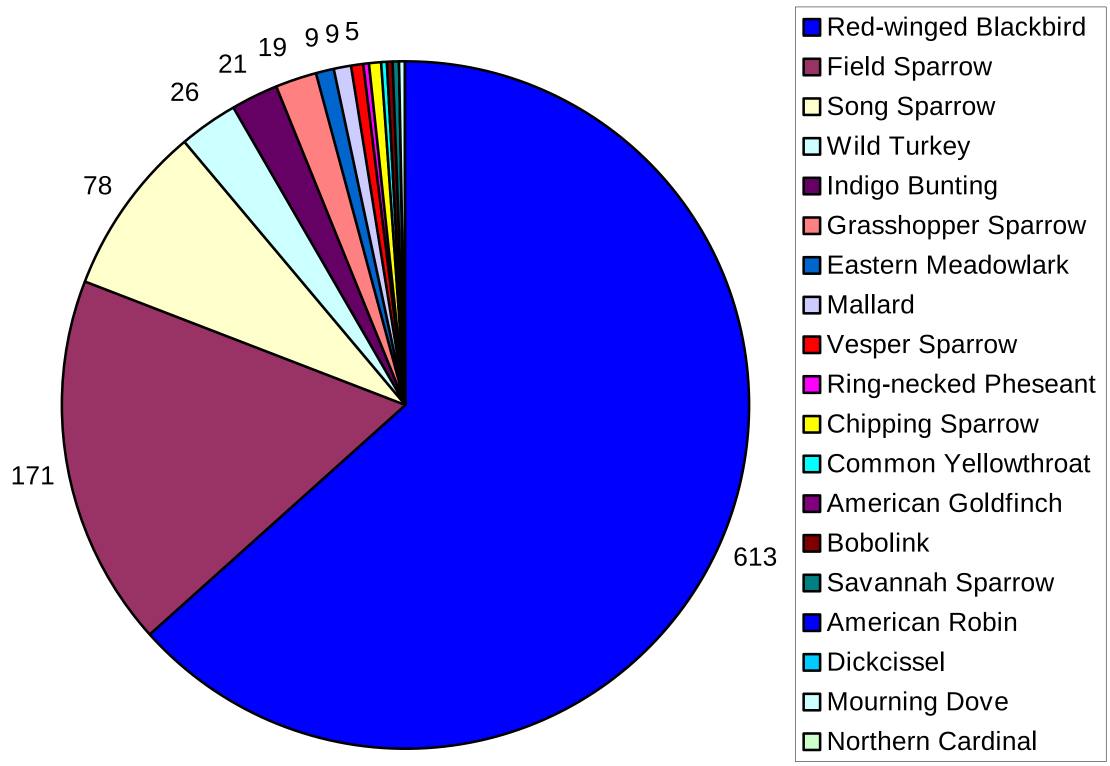

Fig. 3.1: Number of nests located on 73 Conservation Reserve Enhancement Program fields during the 2001 - 2004 breeding seasons in south-central Pennsylvania

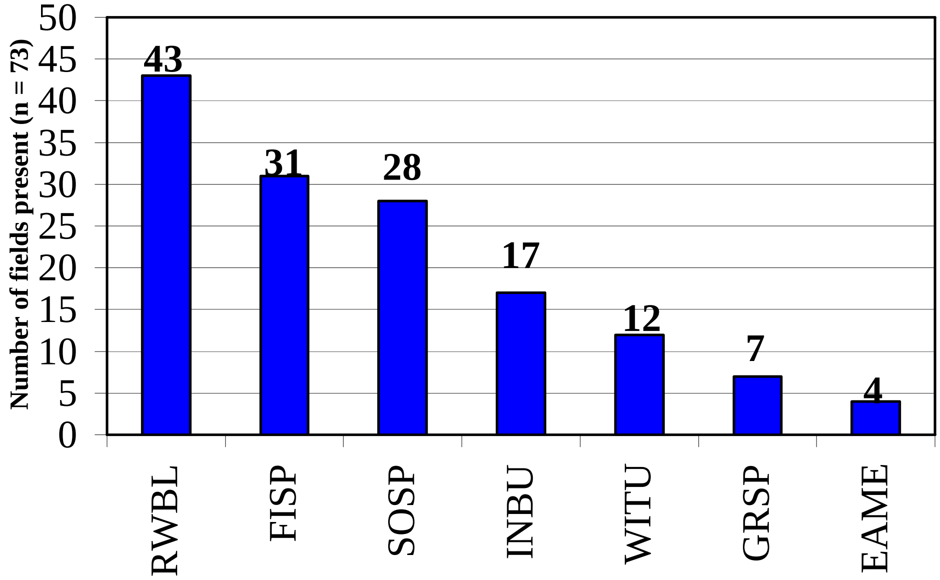

Fig. 3.2: Number of fields that had at least one nest for species with > 9 nests on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. RWBL = red-winged blackbird; FISP = field sparrow; SOSP = song sparrow; INBU = indigo bunting; WITU = wild turkey; GRSP = grasshopper sparrow; EAME = eastern meadowlark

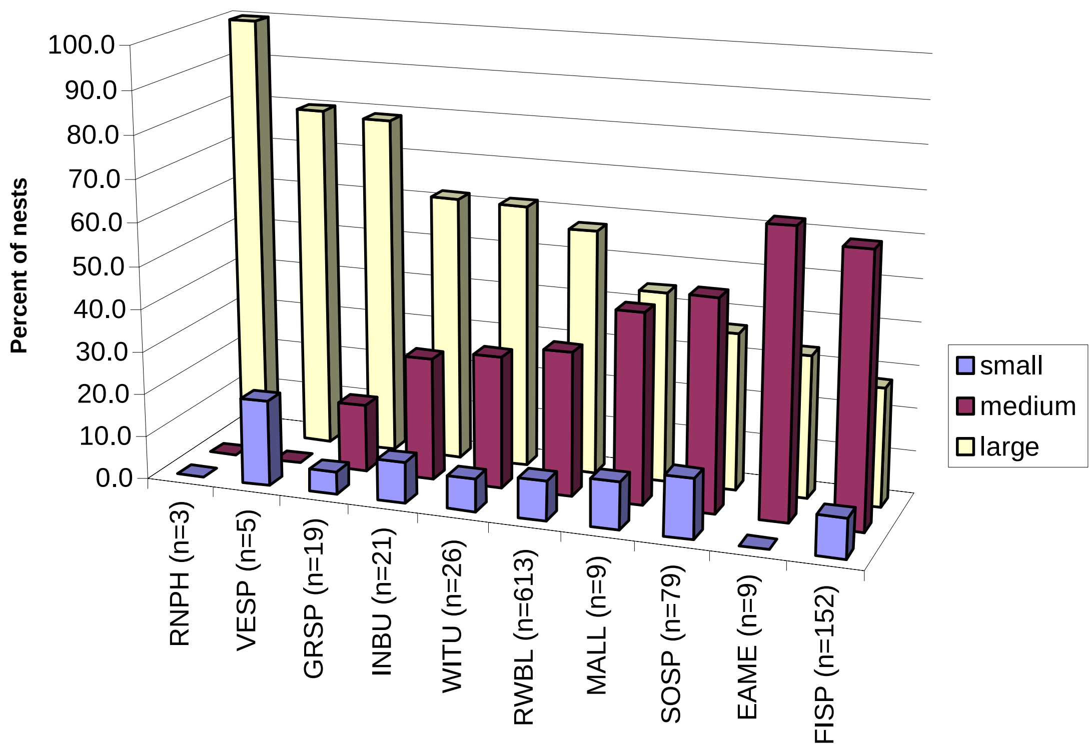

Fig. 3.3: Percent of nests present in each field size category of nests located during the breeding seasons of 2001 - 2004 on Conservation Reserve Enhancement Program fields in south-central Pennsylvania. The total number of nests is included in parentheses. RNPH = ring-necked pheasant; VESP = vesper 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 3.3: 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	3	2	8	9	16	14	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 3.4: Principle Component variables and weighting (only variables > 0.375 are shown) for field and landscape characteristics on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 – 2004.

Principle Component	Variables (weighting)
Landscape	
LCP1	CADHAY50 (0.401); MPS50 (-0.392)
LPC2	EDGE05 (-0.482); SDI05 (-0.464); CROP05 (0.439)
LPC3	HAY05 (-0.504); ROAD50 (0.415); CADHAY05 (-0.393)
Field	
PC1	FORBS (-0.388); CV FORB (0.387)
PC2	BARE (-0.479); CV BARE (0.389)
PC3	SIZE (0.517); P/A RATIO (-0.418)
PC4	WGRASS (-0.520); DEPTH (-0.411); CGRASS (0.395)

50 = 5km radius; 05 = 0.5km radius; CADHAY = number of perennial herbaceous fields with core areas (area > 60 m from an edge; number/100 ha); MPS = mean patch size (ha); EDGE = density of forest edge (m/ha); SDI = Shannon Diversity Index (proportion of cover types within landscape); CROPS = % annual herbaceous cover; HAY = % perennial herbaceous cover; ROAD = road density(m/ha); FORBS = % forb cover; CV FORB = variation in forb cover; BARE = % bare ground cover; CV BARE = variation in bare ground cover; SIZE = field size (ha); P/A RATIO = perimeter-area ratio (m/ha); WGRASS = % warm-season grass cover; DEPTH = litter depth (cm); CGRASS = % cool-season grass cover

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.

Species	AIC null	AIC	Variables [a]
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 are reported by level of individual significance; WITU = wild turkey, INBU = indigo bunting, FISP = field sparrow, GRSP = grasshopper sparrow, SOSP = song sparrow, RWBL = red-winged blackbird; X = west to east spatial coordinates, Y = south to north spatial coordinates

Table 3.6: Comparison of Poisson regression AIC values for models with no variables, all variables, landscape variables, field variables, spatial variables, and percent grass cover (cool and warm-season) for nest abundance on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004.

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

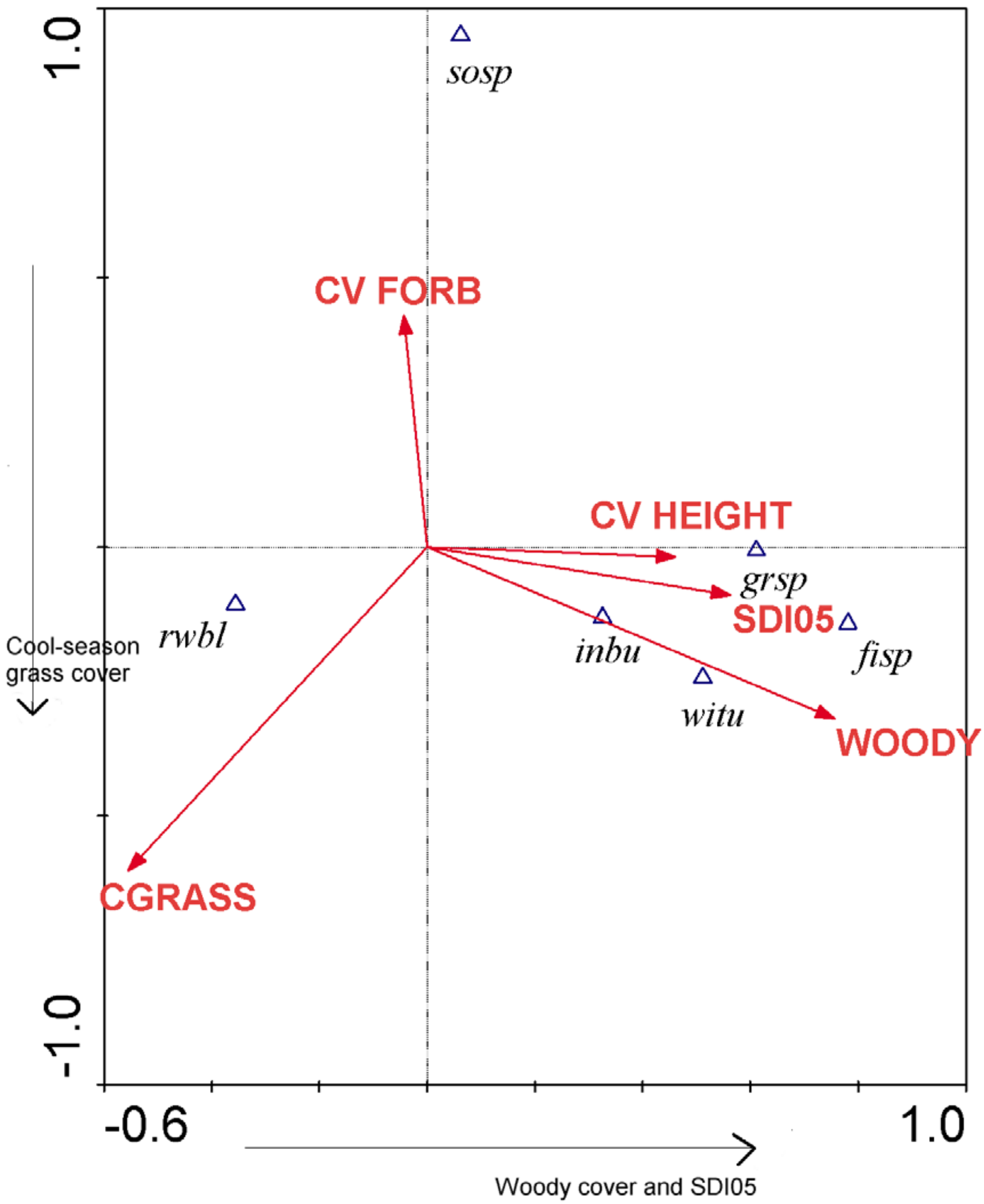

Fig. 3.4: Canonical Correspondence Analysis of grassland bird nest abundance on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. Axis 1 is a gradient of woody cover within the field and cover diversity surrounding the field. Axis 2 is a gradient of the amount of cool-season grass cover.

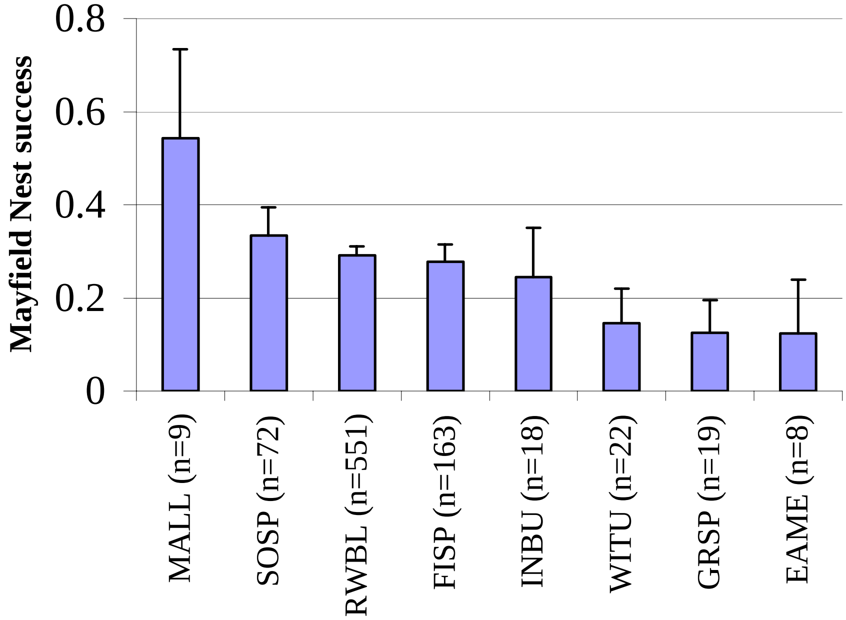

Fig. 3.5: Mayfield nest success (+1 SE) of species with greater than eight total nests during the 2001 – 2004 breeding seasons on Conservation Reserve Enhancement Program fields in south-central Pennsylvania. MALL = Mallard; SOSP = song sparrow; RWBL = red-winged blackbird; FISP = field sparrow; INBU = 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 $p < 0.01$*; RWBL = red-winged blackbird, FISP = field sparrow, GRSP = grasshopper sparrow, SOSP = song sparrow

Table 3.8: Distances of successful and unsuccessful nests from the closest edge, road, tree line, woodlot or agriculture edge using a binary logistic regression for nests located on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004. Range of distances from edge in parenthesis for successful and unsuccessful nests.

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
		4	2		

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

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

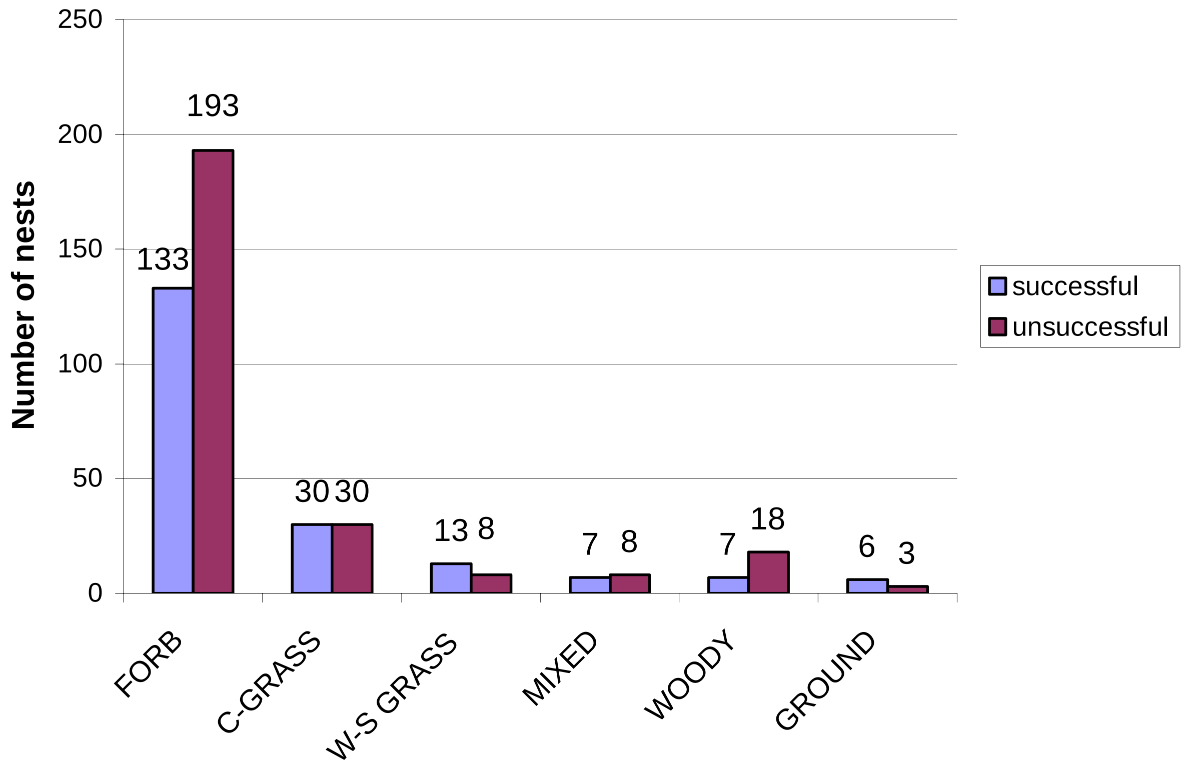

Fig. 3.6: Nest success by nesting substrate for red-winged blackbird nests during the breeding seasons of 2001 – 2004 on Conservation Reserve Enhancement Program fields in south-central Pennsylvania.

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

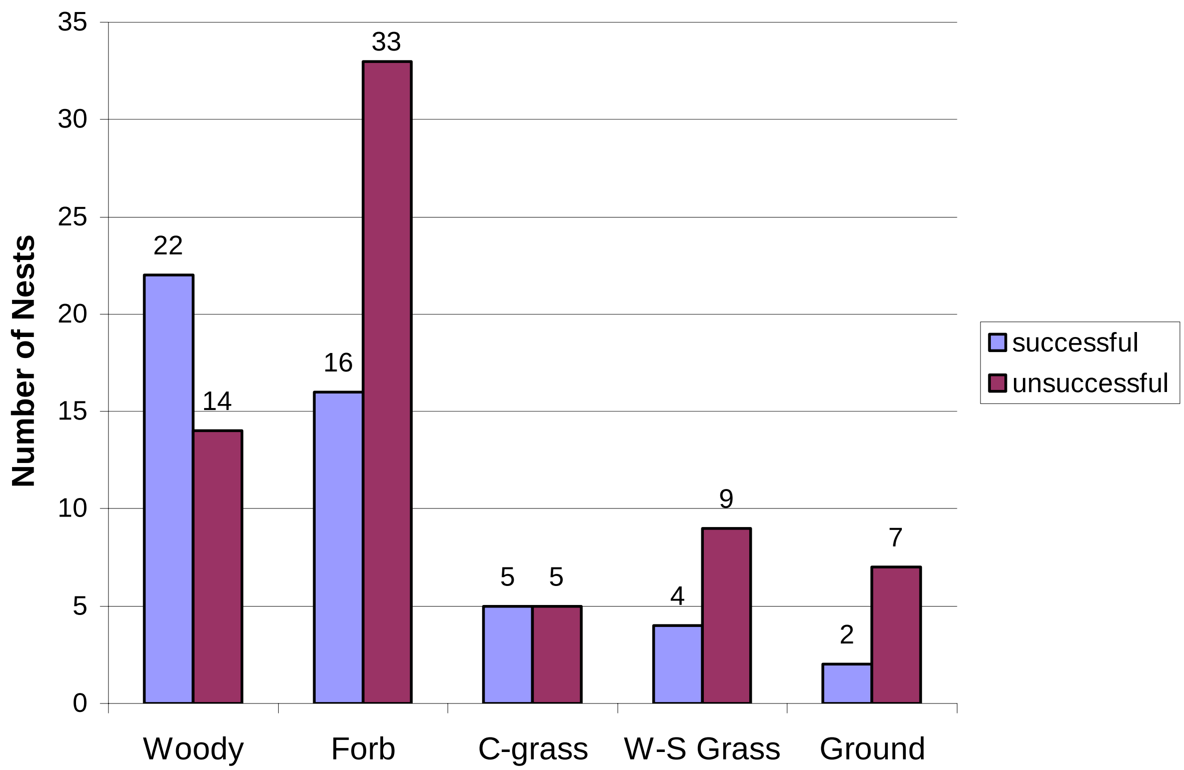

Fig. 3.7: Nest success by nesting substrate for field sparrow nests on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 - 2004.

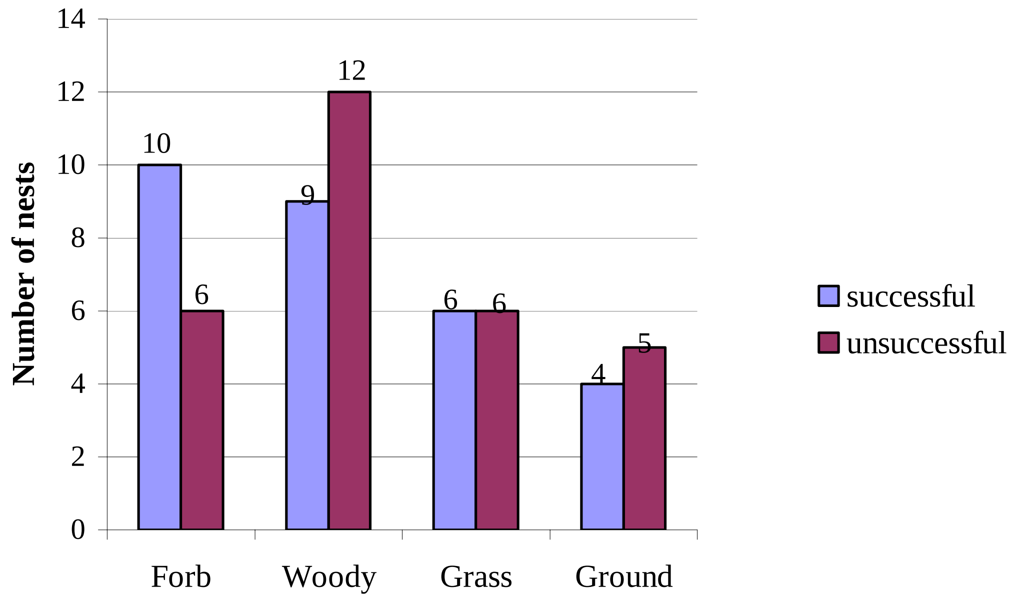

Fig. 3.8: Nest success by nesting substrate for song sparrow nests on 73 Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2001 – 2004.

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

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

Comparison of 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 provide habitat for wildlife. Farmers enroll highly erodible lands for a 10 to 15-year period, during which the fields are left under a permanent cover, typically grass.

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, we tried to locate two hayfields in each size category but were unable to locate a second large field. In 2002, we decided that because there was little difference showing up by field size that we would only use hayfields that were in the medium field size category and were 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. We surveyed a total of 114 CREP fields and 16 hayfields. In order to equalize the number of fields between CREP and hayfields, we randomly selected 16 CREP fields paired with the 16 hayfields. CREP fields were matched with hayfields that were of a similar size, 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

We 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 ± 1 SE, unless otherwise noted. Significance is 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

We made 185 observations of 8 different species on 16 CREP fields and 68 observations of 7 different species were made on 16 different 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 nesting 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***). When examining the highest number of birds seen during one survey there was only 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 are included CREP fields (11.44 ± 2.41) have significantly more birds than hayfields (4.31 ± 1.14; t = 2.81, df = 15, p value = 0.013*).

We located 192 nests of 9 different species on 15 CREP fields and 87 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 (Fig. 4.1 and 4.2). Species richness was significantly higher on CREP fields (2.47 ± 0.40) than hayfields (0.60 ± 0.19; t = 4.63, df = 14, p < 0.001***). Both CREP and hayfields had a grassland specialist present nesting 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 4.3). No species had significantly higher nest abundance on hayfields than CREP fields and nests of wild turkeys, eastern meadowlarks, and indigo buntings were not located on hayfields. 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*). When 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, there was no significant difference in red-winged blackbird nest success 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) in 2002.

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). Since, hayfields are much more like grassland than a row crop field and would be expected to be more attractive to grassland birds, we suspect that CREP fields would also have a higher species richness and abundance than row crops.

Differences in species richness and 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).

Field sparrows and song sparrows also had significantly higher nest abundance on CREP fields than hayfields, again probably due to the lack of woody vegetation on hayfields in which to nest. However, in other studies they have been found to occasionally nest on hayfields (Giuliano and Daves 2002). Wild turkeys, eastern meadowlarks, and indigo buntings were not found nesting on hayfields but were also uncommon on the matched CREP fields showing no significant difference 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 affects our results. At very low densities, we would 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 were either sparse in vegetation or had a mowed strip so that 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), we 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 a study in Iowa (Best et al. 1997) where nest success was found to be 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. Though mowing was very late during our study (20 June – 3 July), nest loss due to mowing was still 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. On row crops, passerine nest loss for passerines due to agricultural operations has been found to be from 10 – 22% (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 are providing an additional important habitat element for birds and providing data that suggests that 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.

	CREP		**Hay**	
Species	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 Conservation Reserve Enhancement Program 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.

Species	CREP	HAY	w	p value
	Mean density (SE)			
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

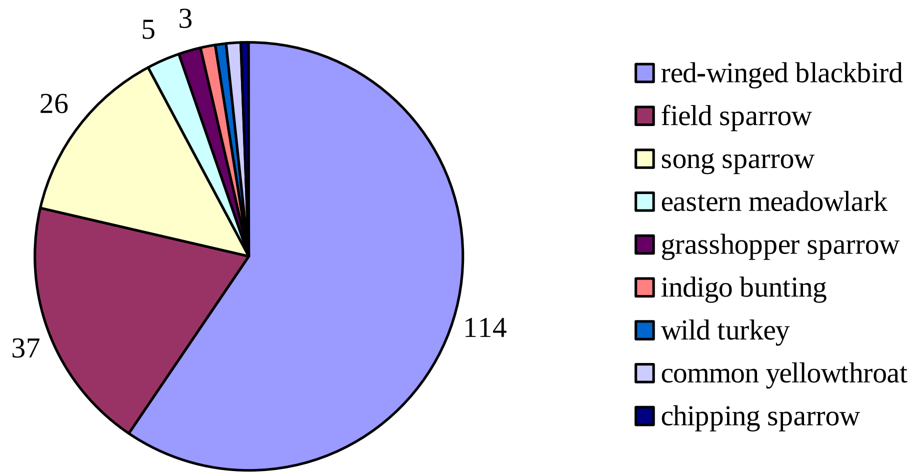

Fig. 4.1: Number of nests located on 16 Conservation Reserve Enhancement Program fields that were matched with 16 hayfields in south-central Pennsylvania, 2001 – 2004.

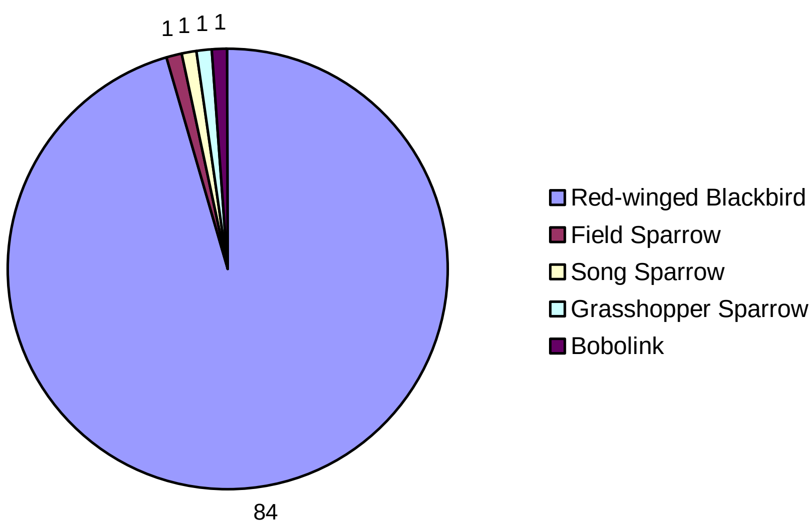

Fig. 4.2: Number of nests located on 16 hayfields in south-central Pennsylvania, 2001 – 2004.

Table 4.3: Mann-Whitney test of 16 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. This may be in part because of the greater age and field size of CRP fields 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 whether using singing male density or nest abundance but both were uncommon. Bobolinks had the highest density on an individual field, but we only located one nest on our CREP fields and one on a hayfield. Red-winged blackbirds were the most common species overall. Field sparrows and song sparrows were the next most common though their respective rank changed depending on whether the measurement tool was density or nest abundance. Nest success was similar to that found in other studies, though nest success was on the lower end of the range for most species. Forbs and woody vegetation were the most important nesting substrates for aboveground nesting species, cool and warm-season grasses were used occasionally. Multi-flora rose, while an exotic, is commonly used as a nest substrate or as a cover for ground nests (e.g., wild turkeys). The amount of woody cover within the field also separated the nesting bird community with red-winged blackbird nest abundance decreasing and wild turkey, indigo bunting, field sparrow and grasshopper sparrow nest abundance increasing with increasing woody cover. There was no clear response to warm and cool-season grass cover though more species were positively associated with increasing warm-season grass cover than cool-season grass cover. Song sparrows showed the strongest negative reaction to cool-season grass cover and red-winged blackbirds showed a positive relationship to grass cover but more for cool-season grass than warm-season grass. While many species had higher nest success in dense clumps of tall vegetation, fields need to be maintained with a mixture of cover types including patches of bare ground to attract the most species. Larger fields should be selected whenever possible because wild turkeys, common yellowthroats, grasshopper sparrows, song sparrows, bobolinks and red-winged blackbirds showed a positive relationship with increasing field size. Within the landscape wild turkey, indigo bunting, field sparrow and grasshopper sparrow nest abundance increased with increasing diversity of cover types surrounding the field. This may be an indication that species are using a larger area than simply the field. Forest cover at the larger scale and local field edge were important factors in many species models but there was a very mixed response by species. Field sparrows consistently increased with increasing forest edge and song sparrows declined. Even the response to perennial herbaceous cover was mixed, with grasshopper sparrow and bobolink density decreasing and eastern meadowlark and red-winged blackbird density increasing with increasing perennial herbaceous cover and core areas surrounding the field.

For managers it is important to understand that presently grassland specialists are not as common as in the Midwest and will probably never be because they are on the edge of their ranges, but they still used CREP fields and were as successful as those found in the Midwest. Grassland specialists showed little regard for forest edge density or percent cover of forest, which indicates that they will use fields in the fragmented forest landscape of Pennsylvania. No field or landscape variables were positively associated with all species in both density and nest abundance. This indicates a need to continue to have a mixture of field and landscape composition for the greatest diversity of species. However, there were indications that CREP fields should be selected and managed to maintain fields that are not dense homogeneous stands of either grass or forbs. Fields should be more open with dense patches (especially of forbs) that indicates a decrease in the seeding rate of clover so that even initially fields are more heterogeneous. Larger fields should be selected over smaller fields, this includes signing up fields that adjoin one another to increase the overall field size. Within the landscape, fields with a diversity of cover types and higher forest edge density are important to many of the edge species that used the fields.

Further research

The difference between the results of density and nest abundance indicates that there is not a perfect correlation and nest data, when possible, is probably a better measurement tool of field productivity. 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 shown that, as hayfields age they become more attractive to many grassland specialists and monitoring should be continued to see if this occurs on CREP fields. 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 tools such as mowing have shown a different response by species. Population studies (e.g., Balent and Norment 2003) should be conducted to determine if CREP fields provide source populations 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.

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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

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 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

	EDGE05	EDGE10	EDGE20	EDGE50	CADHAY05	CADHAY10	CADHAY20	CADHAY50
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	RWBL	2	1	1				
Schuylkill	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	DICK	1						1
House 02	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 Chick 02	FISP	4		3				1
Robinson Chick	FISP	1						1
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 Medium	EAME	2		2				
	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	MALL	1	1					
Medium								
	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)