BENEFITS OF THE STATE ACRES FOR WILDLIFE ENHANCEMENT PRACTICE FOR BIRD POPULATIONS IN KANSAS

by

ALAINA D. THOMAS

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Dr. Brett K. Sandercock

Abstract

Grassland birds have experienced population declines worldwide from habitat degradation caused by conversion to agriculture and recent intensification of land use, including increased use of fertilizer, fossil fuels, and irrigation. The U.S. Department of Agriculture, Conservation Reserve Program (CRP) includes initiatives targeting wildlife enhancement to mitigate ongoing declines in grassland bird populations. The newest CRP practice, State Acres for Wildlife Enhancement (SAFE), was designed to restore vital habitats for high priority wildlife species throughout the United States. Our objective was to assess the potential benefits of SAFE for upland gamebirds and grassland songbirds in Kansas. We monitored lands enrolled in SAFE to estimate bird density based on *field scale* and *landscape scale* characteristics. Our study was conducted in three ecoregions: Smoky Hills (4 counties), Flint Hills (3 counties), and the High Plains (3 counties). We surveyed 121 SAFE fields and 49 CRP fields from 2012 – 2013. Northern Bobwhite density was negatively associated with percent litter within survey fields. Ring-necked Pheasant density differed among ecoregions, and was positively associated with percent bare ground in the High Plains, but negatively associated with field age in the Smoky Hills. Mourning Dove density differed among ecoregions, and was negatively associated with percent forb in the High Plains, and positively associated with percent grassland in the Smoky Hills. In the Flint Hills, Mourning Doves were negatively associated with CRP fields and large fields. Brown-headed Cowbirds were positively associated with percent forbs. Amount of CRP surrounding survey locations was positively associated with bird density through the entire range for Grasshopper Sparrows, Dickcissels, and Lark Buntings, and in the High Plains for Western Meadowlarks. Percent woodland had negative effects on Western Meadowlarks in the Smoky Hills, whereas percent cropland had negative effects on Eastern

Meadowlarks statewide. CRP positively affected abundance of four of our species, whereas percent cropland and woodland negatively affected others. Thus, the amount of set-aside lands enrolled in SAFE could be important for grassland bird populations. SAFE and CRP supported equal numbers of Northern Bobwhites and Ring-necked Pheasants, suggesting SAFE provides benefits for target species of upland gamebirds.

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Dedication

I dedicate my thesis to my mom because she has always been extremely supportive of my education and interests. Without her, I would not be where I am today.

Benefits of the State Acres for Wildlife Enhancement practice for bird populations in Kansas

INTRODUCTION

Grasslands worldwide have declined in much of their historic range due to agricultural production of food crops, with temperate grasslands suffering the greatest losses of any biome (White et al. 2000, Hoekstra et al. 2005). Tallgrass prairie and mixed-grass prairie in North America have declined by 97% and 64%, respectively, since 1830 (Samson et al. 1998). The state of Kansas has experienced an 82% decline in tallgrass prairie from a historic area of 69,000 km^2 in 1830 to 12,000 km^2 in 1994 (Samson and Knopf 1994, White et al. 2000). Early conversion of grassland to cropland resulted in past loss of habitat. In recent years, intensification of agricultural production, including mechanical harvest of crops, increased use of pesticides, and increased biofuel production have contributed to ongoing habitat losses for many grassland bird species, which have declined more than any other avian guild over a 45-year period (Table 1; Matson et al. 1997, Vickery and Herkert 2001, Sauer et al. 2014). Because of ongoing habitat loss and degradation, it is important to determine the role that agricultural grasslands may play in current conservation of sensitive species.

With 97% of Kansas lands under private ownership, partnerships are essential for conservation of grassland bird populations. The federal Food and Security Act of 1985 (also known as the Farm Bill) established the Conservation Reserve Program (CRP) as a voluntary program by which erodible croplands could be taken out of production and planted to permanent cover (Gray and Teels 2006). Several years since its inception, the conservation title of the Farm Bill has been modified to include different practices that emphasize the conservation of habitat for wildlife species (Burger 2006). The Farm Bill or the Food, Conservation and Energy Act of 2008 introduced a new continuous Conservation Reserve Program initiative called State Acres for Wildlife Enhancement (SAFE) or Conservation Practice 38 (CP38). The purpose of the SAFE program is to set aside marginal lands for wildlife species that are in serious need of conservation (USDA 2008 Fact Sheet). Each state has developed a set of target bird species for which the SAFE program is intended to benefit. The key species of interest for Kansas were outlined in the Kansas Comprehensive Wildlife Conservation Plan (Wasson 2005), and include three species of upland game birds: Northern Bobwhites (*Colinus virginianus*), Ring-necked Pheasants (*Phasianus colchicus*), and Greater Prairie-Chickens (*Tympanuchus cupido*). Ring-necked Pheasants are an introduced species but have economic value as an important gamebird in the state. Kansas currently has ~ 1.4 million acres (5,780 km^2) enrolled in some form of Conservation Reserve Program, with 231,424 acres (930 km^2) scheduled to expire during 2014—2018 (USDA, FSA Monthly CRP Acreage Report). A total of 67,500 acres (273 km^2) were enrolled in the SAFE program or about 5% of the total CRP enrollments in Kansas (USDA, FSA Monthly Summary Report August 2014). Recently, high commodity prices have led to major losses of lands once enrolled in CRP easements (Rashford et al. 2010, Stuart and Gillon 2013).

SAFE is a relatively new program and its effectiveness for wildlife has not been previously evaluated in Kansas. We had two key questions we wanted to address for the project:

1. What should the optimal seeding type and landscape composition be for SAFE fields to benefit grassland birds?

2. How large should SAFE fields be to benefit grassland birds?

To answer the first question we wanted to examine field structure and vegetation cover classes as a proxy for understanding the optimum seeding type and determine landscape composition based on the surround proportion of land cover types around our survey fields. Now that grasslands have been historically converted to croplands and current agricultural practices are intensifying; bird use of agricultural lands has increased (Askins et al. 2007). Grasshopper Sparrows (*Ammodramus savannarum*) were in steep decline in the Great Plains before development of CRP. Breeding Bird Survey routes in areas with > 3.8% CRP enrollment reported a greater abundance of Grasshopper Sparrows than areas with low CRP enrollment (Herkert 1998). Moreover, two comparative studies revealed that grassland songbirds that use the widespread set-aside program tend to benefit the most, while other species that do not use CRP are still experiencing declines in population numbers (Veech 2006, Herkert 2009). Grassland bird diversity and abundance was greater in CRP enrolled fields when compared to publicly managed grasslands in Minnesota (Cunningham 2005). Mourning Doves (*Zenaida macroura*) have been shown to prefer open areas within CRP fields and benefit from tall vegetation and bare ground when placing their nests (Hughes et al. 2000). Hughes found that nest survival of Mourning Doves was influenced by the characteristics of vegetation structure but not by edge characteristics. It is important to understand how native plantings within SAFE practices affect habitat for birds. Conservation buffers under the Conservation Practice 33 (CP33) initiative within CRP have had a positive impact on some grassland bird species due to greater abundance of food plants and more complex vegetation structure for nesting (Burger et al. 2010). CP33 fields are similar to the SAFE fields because they are designated as habitat buffers for upland birds. In some counties in Kansas, the seed mix is the same for plantings in both SAFE and CP33 fields (FSA Seed Mixture).

CRP fields must be maintained properly throughout their lifespan to be suitable habitat for different grassland bird species. Grassland bird diversity may decline with floristic and structural diversity of maturing CRP fields (Negus et al. 2010). For upland gamebirds, field age can have a negative effect on mobility, which in turn affects foraging rates (Doxon and Carroll 2010). Doxon and Carroll found that older, denser fields ~ 6-7 years of age may reduce invertebrate diversity and hinder upland gamebird chick movements. Some CRP and SAFE fields may be surrounded or near to forest patches. While there may be increased diversity of bird species in fields that border a forest area, there may also be a negative impact on sensitive species that do better in larger, contiguous grasslands not bordered by forested areas (Reino et al. 2008). However, some avian species require a variety of habitat types for successful nesting, brood rearing, and foraging areas. Target species for the SAFE practice, especially Northern Bobwhite, are more adapted to fragmented landscapes that provide for different life stages and will make use of a variety of habitat configurations within their extensive range (Guthery 1999). Ring-necked Pheasants have been shown to select habitat that contains up to 32% grass, which can be developed through CRP enrollments and various spatial compositions of CRP and grasslands (Haroldson et al. 2006). We compared SAFE vs. other CRP fields because previous studies have shown that species richness is similar between CRP and crop fields, but avian and nest densities are much greater in CRP fields (Best et al. 1997). Nest survival is also higher in CRP fields than in crop fields (Berthelsen and Smith 1995).

To understand how field size influences grassland birds, we used the area of our survey fields in distance models. Area sensitivity is an important concept for conservation planning. Area sensitivity is thought to occur among bird species that are more sensitive to edge surrounding their habitats and are less likely to be present in smaller habitat patches (Robbins

1979). Most temperate-breeding birds, including grassland species, are sensitive to the size and arrangement of habitats (Bayard and Elphick 2009, Shake et al. 2012). A study of fragmented grasslands in Maine by Vickery (1994) showed field sizes would need to be roughly 100—200 ha in size to accommodate a suite of area-sensitive grassland birds. Larger CRP fields have a positive effect on certain grassland birds, but small grasslands in the SAFE designation or fragmented patches of grasslands may not have enough area to meet habitat size requirements (Johnson and Igl 2001, Davis 2004). Nevertheless, spatial variability in habitat suitability of some grassland birds suggest regional assessments of area sensitivity are warranted (Vickery et al. 1994, Vickery 2000).

We had several *a priori* predictions for our models of avian abundance. We predicted that abundance would differ based on field scale characteristics, such as percent cover of grass, forb, litter, and bare ground. We also predicted that abundance would differ based on the amount of obstruction caused by vegetation within the survey field as estimated by a visual obstruction reading (Robel 1970). We predicted that abundance would differ based on several field attributes such as field age determined by year of planting, field size and enrollment type (SAFE or CRP), We also predicted that surrounding habitat within a 300 m buffer would influence avian density because most of our detections were within 300 m of our survey point location.

We hypothesized that older fields would become more dense with vegetation as they matured and avian density would decline after ~ 4 years since establishment (Millenbah et al. 1996). We hypothesized that field size would be important for avian abundance based on previous studies showing area sensitivity for some of our target species of grassland birds (Johnson and Igl 2001, Davis 2004, Vickery et al. 1994, Vickery 2000). We hypothesized that there would be a greater percentage of forb coverage in the SAFE fields because the forb mix is added at fist planting and SAFE fields are younger (0-4 yrs) and would still have forbs in the vegetation. As fields age, grasses begin to dominate, so the fields with forbs added initially will have greater forbs present (Schwartz and Whitson 1987). The intent of adding forbs is to attract more upland game birds to the area. Forbs were not initially included in the seed mixtures used for CRP fields planted before 2000, but are currently added to most of the seed mixtures. Composition of seed mixtures within the counties where we conducted surveys did not vary, according the Farm Service Agency seed mixtures, but soil type and precipitation would be expected to have an effect on germination and growth rates of grasses and forbs in each region. We hypothesized there would be a difference in bird abundance based on field type (SAFE or CRP); with SAFE fields having greater density of Northern Bobwhite and Ring-necked Pheasant because forbs were more readily available as food plants for these species (Burger et al. 2010).

We also hypothesized that the habitats surrounding SAFE fields would influence avian abundance, so we investigated the influence of percent land cover types in a surrounding 300 m buffer around each point location. We used 300 m as the limit of our detection range and an area that was ~0.28 km^2 (28.3 ha).

STUDY AREA

Our study sites were located in three ecoregions throughout western, northcentral, and eastern Kansas during 2012 and 2013 (Fig. 1). The ecoregions of Kansas have been classified based on a framework proposed by Omernik (1995) that considers geology, soil, climate, and dominant biota of an area. The High Plains ecoregion consisted of short-grass prairie and included Gray, Kearney, and Haskell counties. The High Plains was characterized by sandstone and siltstone, sandy soils, and large areas of irrigated agriculture that include winter wheat, corn, sorghum, and beets (EPA.gov, 2014). The Smoky Hills ecoregion consisted of mixed-grass prairie and included Smith, Osborne, Russell, and Barton counties. The Smoky Hills had rolling hills, chalky limestone, sandstone and shale, and forests along the riparian areas. The primary crop was winter wheat with grassland interspersed throughout agricultural areas (EPA.gov, 2014). The Flint Hills ecoregion was dominated by large and relatively intact tallgrass prairie and included Chase, Lyon, and Morris counties. The Flint Hills consisted of rolling hills underlain with limestone, as well as cherty, clay and shale. The dominant land use in this area was cattle grazing on large contiguous grasslands managed with prescribed fire. Cropland in the Flint Hills was limited to river bottoms and other low lying areas (EPA.gov, 2014). Kansas had a precipitation gradient ranging from an average of about 48.6 cm in the High Plains, 68.4 cm in the Smoky Hills, and 91.0 cm in the Flint Hills (NOAA.gov, 2014).

SAFE Field Characteristics

The SAFE designation within CRP is a practice whereby landowners can enroll land continuously. Field sizes for this enrollment type tend to be small as they are intended to provide patchy landscapes for Northern Bobwhites and Ring-necked Pheasants. Landowners can enroll up to 20% of a field (e.g. 5 acres of a 25 acre field), and the maximum acreage per field is 80 acres (USDA.gov). SAFE seed mixtures in all three ecoregions had similar composition, containing several native species of warm-season grasses, such as Big Bluestem (*Anthropogon gerardi*), Little Bluestem (*Schizachyrium scoparium*), Sideoats Grama (*Bouteloua curtipendula*), and Switchgrass (*Panicum virgatum*), but they can also contain, Western Wheatgrass (*Agropyron smithii*), and Buffalo Grass (*Buchloe dactyloides*). Seed mixtures also contained several forb species, most containing Illinois Bundleflower (*Desmanthus illinoensis*), and either perennial Maximilian Sunflower (*Helianthus maximiliani)* or Annual Sunflower (*H. annuus*). Seed mixtures can also contain Alfalfa (*Medicago sativa*), Purple Prairie Clover (*Dalea purpurea*), Indian Blanket (*Gaillardia pulchella*), Upright Prairie Coneflower (*Ratibida columnifera)*, and any other type of forb that may be suitable for the program.

CRP Field Characteristics

We surveyed birds at point-count stations in eight different types of CRP enrollments (Table 2). CP2 was designated for the establishment of native warm season grasses, such as Blue Grama, Little Bluestem, Sideoats Grama, Switchgrass, and Western Wheatgrass. CP4D was intended to provide wildlife habitat by providing cover types for upland habitat management. CP10 was vegetative cover that was already established to grass, which can be used as erosion control and to provide wildlife habitat. CP16A was designated as a shelterbelt establishment to protect plants from wind damage, and reduce soil erosion from wind. CP21 were filter strips providing a field border to reduce erosion and protect water quality. CP25 provided habitat for rare and declining wildlife species of concern. CP25 in most counties required ten native forbs in addition to the grass mixtures. CP33 were field buffers designed for upland game birds. The CP33 mixtures were also similar to the SAFE mixtures and in some cases were the same exact mixture. CP42 provided pollinator habitat with an emphasis on forbs that bloom during the April to October time period. CP42 seed mixes may not contain >25% grasses but they must be native species. CRP seed mixtures not designated under the SAFE category contained some of the same forbs that are in the SAFE mixes and are used to interseed fields at their mid-contract management time periods. Seed mixtures were tailored for the specific needs of the CRP designation.

METHODS

Bird Surveys

We surveyed bird populations at 69 points in fields enrolled in the SAFE practice and 29 points in fields enrolled in other types of Conservation Reserve Program (as delineated by the USDA Farm Service Agency) from 21 May to 15 July 2012 (Table 3). We surveyed bird population in 53 different points in fields enrolled in the SAFE practice and 20 different points in fields enrolled in other types of Conservation Reserve Program (as delineated by the Farm Service Agency) from 26 May to 3 July 2013 (Table 3). Each field had one point count location regardless of field size to standardize survey effort.

We visited 6-9 sites per day beginning at sunrise and ending no later than 10:00 CST. Each point-count site was visited 3 times during each summer field season. Surveys were conducted on days when wind speeds were low (<25 km/h), with little to no precipitation (<1 cm). We recorded starting time, temperature, and cloud cover. We accounted for potential temporal variation by visiting each point in a different order with each subsequent visit. Point-count surveys were conducted by two different observers each year, and we controlled for possible observer effects by visiting each point sequentially, and by alternating observers on consecutive visits during the field season. Upon arriving at the point, we waited two minutes to allow birds to acclimate to our presence. Surveys lasted ten minutes and we recorded every bird seen or heard. We used the American Ornithologist's Union 4-letter coding for each bird species and recorded sex of each bird, as well as number of birds per group if more than one. We also noted whether birds were seen, heard, or detected flying over the field. We noted whether birds were inside or outside the survey field and what type of habitat in which they were located. Field types included, grass, crop, wood, or other habitats such as, near house or on power line.

Point-count circles had variable distances for a radius and we measured distance to individuals that were sighted using laser rangefinders (accuracy ±1 m, Bushnell Yardage Pro Sport 450).

Multi-Scale Habitat Evaluation

We collected seven vegetation measurements at two different sampling plots at every SAFE and CRP fields where our point-count stations for bird surveys were located. One vegetation measurement was taken at the exact point used for bird surveys and a second measurement was taken at a random bearing, but 25 m away within the study field. We selected this distance to minimize the chance of getting a random bearing outside of the study fields, which was problematic for small or oddly shaped fields. We used a 20 x 50 cm sampling frame to estimate percent cover of grass, forbs, shrub, litter, bare ground and litter depth (Daubenmire 1959). We measured visual obstruction (VOR) of the vegetative cover with a Robel pole at 4 m away from the pole at a height of 1 m in each of the four cardinal directions (Robel et al. 1970).

Fields enrolled in the SAFE practice vary in size and are often interspersed in a larger landscape consisting of crop fields, other Conservation Reserve Program enrollments, woodland, grassland, and urban areas. To understand how the spatial landscape surrounding our point count locations affected density of grassland songbird and upland gamebirds, we used ArcGIS software and placed a 300 m buffer around each point count location over the extent of our survey (ESRI 2011, ArcGIS Desktop: Release 10.0, Redlands, CA: Environmental Systems Research Institute). We selected a 300 m buffer as the maximum detection distance for most of our species, with the exception of Ring-necked Pheasants, which were detected up to 400 m (Irvin et al. 2013). Using an updated version of a database of Kansas land cover patterns from the Kansas Data Access and Support Center (KLCP 2008), and shape files for SAFE and CRP fields provided by Farm Service Agency offices, we classified land cover types in and around our point-count locations. We overlaid the existing GIS layer for CRP fields onto the land cover layer for Kansas, and then used the merge tool to make a land cover map that included the existing CRP as well as all the other land cover types. Within each 300 m buffer, we calculated the amount of CRP, cropland, grassland, woodland, water, and urban habitats. Each buffer had a total area of 28.3 ha (69.9 ac), and the amount of each land use type was divided by the total for each buffer to determine a proportion for each land use type (Fig. 2). We used the proportions of land use type around each point as covariates for bird abundance.

Study Species

We selected nine key bird species for analysis based on their conservation status in the Kansas Comprehensive Wildlife Conservation Plan and because we had an adequate number of detections in each of the three ecoregions. We analyzed count data for Northern Bobwhite, Ring-necked Pheasant, Mourning Dove, Eastern Meadowlark *(Sturnella magna*), Western Meadowlark (*S. neglecta*), Brown-headed Cowbird, Lark Bunting (*Calamospiza melanocorys*), Grasshopper Sparrow, and Dickcissel. Most of these grassland birds have undergone significant population declines both nationwide and locally over the past 44 years (Sauer et al. 2014). Declines have been upwards of -4.2% per year nationwide and -2.4% per year in Kansas across our nine study species (Table 1).

Statistical Analysis

We used Program R to conduct all analyses (R Core Team 2013). We used Kruskal-Wallis tests to compare whether percent forb, percent grass, percent litter, percent bare ground, VOR and field size differed between SAFE and CRP fields. We also tested landscape scale attributes around the 300 m buffer, such as woodland, cropland, grassland and CRP between the three ecoregions. We grouped the data by ecoregion and compared the field scale and field attributes by field type. We grouped the data across all surveys, and compared the landscape scale attributes across ecoregions.

We estimated density and evaluated the effects of CRP treatments and habitat covariates using the hierarchical distance sampling model available in function *distsamp* in package unmarked. (Fiske and Chandler 2011; 2014). We were interested in modeling detection and abundance covariates for the nine species of interest at each of our point count locations. We evaluated one covariate for detection and several covariates for abundance. The abundance covariates we selected were based on *a priori* hypotheses of field characteristics and surrounding field metrics that we predicted would be important drivers of bird abundance.

We used the Akaike's Information Criterion (AIC) to determine the most parsimonious model (Burnham and Anderson 1998). We selected the top models based on ΔAIC and associated model weights. Models with the lowest ΔAIC values were considered to be the most parsimonious and indicated the best fit. We used a constant model for detection and abundance (or intercept-only), and compared the null model against models with covariates for detection and abundance. We tested the effects of start time on detection because we expected bird activity to peak at sunrise and decline by mid to late morning. We attempted to visit each point location at different times on subsequent visits, but due to logistical constraints some points were visited at similar times during each survey because of their location on our routes. We did not model observer, wind speed, or precipitation because we controlled for these factors with our study design.

For effects on abundance, we considered 12 different covariates that were predicted to be important for each of our species. Covariates included four *landscape scale* characteristics;

percent CRP, percent grassland, percent woodland, and percent cropland within the 300 m buffer surrounding our fields, and five *field scale* characteristics; percent grass cover, percent forb cover, percent litter cover, percent bare ground, and visual obstruction reading (VOR). We also tested four *field attributes* of field age, field size, and practice type (SAFE or CRP). We collapsed all CRP field types into one category because of the small number of fields we had for each enrollment type (Table 2). We then used SAFE and CRP and SAFE categories for further analysis.

We included one *regional* covariate in our model set. We used a model containing effects of ecoregion on abundance with separate estimates for our three ecoregions, High Plains Flint Hills, or Smoky Hills. We tested each species with all ecoregions in the initial evaluation and if ecoregion was considered the top model, we evaluated the model to determine which ecoregion had the smallest density estimate. The ecoregion with the smallest density estimate was removed and we then ran the models for only the two remaining ecoregions. In some cases, ecoregion was the top model no matter how the data were analyzed, so for these species we conducted separate analyses for each ecoregion. Ring-necked Pheasants, Mourning Doves, Western Meadowlarks, and Lark Buntings were four species that were analyzed separately for each ecoregion. Due to range restrictions, ecoregion was not included as a variable for Lark Bunting because they did not occur throughout all ecoregions of Kansas.

We fit the model functions using the half-normal, hazard, exponential or uniform function, depending on which function was the top-rated model. We also tested a constant model for detection and abundance. We selected distance bins, as required for the function *distsamp* for each species based on a preliminary inspection of the histogram of detection frequencies. We used 20-30 m bins and most of our species were right truncated at 250-300 m, except for Brown-headed Cowbirds, which were truncated at 150 m. One of the assumptions for distance sampling is that objects at the line or point are detected with certainty, but the probability of detection decreases with increasing distance from the point (Buckland et al. 2001). Our initial histograms revealed a pattern in which locations closest the point center had a low frequency of detections, creating a donut pattern, which is common in point count surveys (Fig. 3; Buckland et al. 2001). We accounted for the effects of movement away from the point-count station by applying left truncation during analysis. We applied left truncation at 5% of detections for all species, and then used the best fit function for each of our detection and abundance models to find the model with the best explanatory variables. To test the goodness of fit for our top ranked model, we ran 5,000 simulations of a parametric bootstrap in Program R and used the Freeman-Tukey fit statistic (Cox et al. 2014). Based on a $p > 0.05$, we would fail to reject the null hypothesis that the fitted model is a good fit.

Initial density estimates were based on clusters of detections without regard to number of birds per group, so each cluster was considered one detection. We calculated true density based on density estimates from our abundance models, and then multiplied them by the average cluster or group size for each species. Average cluster sizes for eight of our bird species in all three ecoregions were > 1 with the highest averaging 1.3 birds per cluster. Brown-headed Cowbirds were social and had larger cluster sizes on average ranging from1-2.4 birds per cluster. We used the delta method to estimate the variance of the true density estimates (Powell 2007):

$$var(G) = \sum_{i=1}^{n} var(x) \left[\frac{\partial f}{\partial X_1} \right]^2$$

Where *var*(*x*) is the variance of each parameter (*x*) and $\left[\frac{\partial f}{\partial X_1}\right]^2$ is the partial derivative of *G*, with respect to each parameter. Our calculation of density was given by:

$$d = c \times i$$

Where *d* = density, *c* = mean density of clusters, and *i* = mean number of individuals per cluster. From the delta method, the variance of density was calculated as:

$$var(d) = var(c)[i]^2 + var(i)[c]^2$$

Where *var*(c) is the variance of the density estimate of clusters, var(*i*) is the variance of the birds per cluster and *c* and *i* are defined above. Last, we took the square root of *var*(*d*) to obtain the new standard error of our true density estimate. The 95% CI were then estimated as mean density ± 1.96 SE.

Species Richness

We calculated overall species richness across all three ecoregions by field type (SAFE and CRP) using closed population models in Program Mark (White 1999). We considered each season a closed population without emigration or immigration of species into the area. We created encounter histories for all species seen or heard during each of the three point-count survey visits.

RESULTS

Field Scale Characteristics

In our two-year study, we surveyed a total of 122 SAFE fields and 49 CRP fields across the three ecoregions. We did not find a difference in the proportion of grass or forb between SAFE vs. other CRP for fields in the Smoky Hills and Flint Hills region. Proportion of grass within the field did not differ by field type in the Smoky Hills (chi-squared approximation to Kruskal-Wallis test, $\chi^2_1 = 3.18$, $p = 0.07$), or Flint Hills ($\chi^2_1 = 0.21$, $p = 0.64$), nor did proportion of forb differ by field type in the Smoky Hills ($\chi^2_1 = 2.63$, $p = 0.10$), or Flint Hills ($\chi^2_1 = 0.46$, $p = 0.50$). Thus, SAFE and CRP fields were similar in proportion of grass and forb amounts for these regions. CRP fields had greater proportion of grass cover ($\chi^2_1 = 7.68$, $p = 0.01$) and a lower proportion of forb cover ($\chi^2_1 = 9.60$, $p < 0.00$) than SAFE fields in the High Plains ecoregion (Fig. 4). Proportion of litter was different between SAFE and CRP fields in the Smoky Hills ($\chi^2_1 = 2.18$, $p = 0.01$), with SAFE having greater proportion of litter (Fig. 5). Litter did not differ by field type in the Flint Hills ($\chi^2_1 = 0.15$, $p = 0.70$), or High Plains ($\chi^2_1 = 0.3.21$, $p = 0.08$). Proportion of bare ground did not differ between field types in any of the ecoregions; Flint Hills ($\chi^2_1 = 0.10$, $p = 0.74$), Smoky Hills ($\chi^2_1 = 0.33$, $p = 0.56$), or High Plains ($\chi^2_1 = 0.04$, $p = 0.83$). VOR was greater in CRP fields in the High Plains ecoregion ($\chi^2_1 = 6.49$, $p = 0.01$), but there was no difference between fields in the Flint Hills ($\chi^2_1 = 0.28$, $p = 0.59$) or the Smoky Hills ($\chi^2_1 = 0.09$, $p = 0.76$).

Field Attribute Characteristics

We found differences in field size based on field type across the Smoky Hills and the High Plains ecoregions (Fig. 6). CRP fields were larger than SAFE in the Smoky Hills ($\chi^2_1 = 5.66$, $p = 0.02$), and in the High Plains ($\chi^{2\,=}_1$ 6.34, $p = 0.01$). CRP fields tended to be larger in the Flint Hills ecoregion but field size was not statistically different ($\chi^2_1 = 2.34$, $p = 0.13$). However, field size was not included in the top models of abundance for any species but it did have some support for two of our study species, Western Meadowlarks in the High Plains and Mourning Doves in the Flint Hills.

Landscape Scale Characteristics

We found differences in landscape characteristics surrounding the survey fields across ecoregion. Proportion of woodland ($\chi^2_2 = 67.28$, $p < 0.01$) and proportion of grassland ($\chi^2_2 = 99.08$, $p < 0.01$) in the 300 m buffers was greater in the Flint Hills compared to the Smoky Hills or High Plains. Proportion of cropland was greatest in the High Plains ($\chi^2_2 = 56.12$, $p < 0.01$), when compared to the Smoky Hills or Flint Hills. Proportion of CRP did not differ among the three ecoregions ($\chi^2_2 = 1.78$, $p = 0.41$).

Distance Models

We ran models with effects of start time on detection, which was calculated as time since sunrise. Start time for detection was the top model for three of our species; Northern Bobwhites in all of their range, and Mourning Doves and Ring-necked Pheasants in the Smoky Hills (Tables 4-5). Start time negatively affected all three of the species when it was in the top model for detection. However, start time had a positive effect on detection for Mourning Doves in the Flint Hills (Table 5). A constant model for detection was best fit for all other species.

In the Flint Hills, SAFE fields were surrounded by wooded areas, some crops, and large rangelands. In the Smoky Hills, SAFE fields were surrounded by wooded areas and crops, and in the western High Plains, SAFE fields were mostly surrounded by agricultural fields. Several species showed effects of land cover surrounding the point on abundance. Density of four grassland bird species increased with percent CRP in the 300 m buffer area (Fig. 7). Amount of

CRP in the surrounding matrix around the point was the top model for abundance of four species, Grasshopper Sparrow, Dickcissel, Mourning Dove in the High Plains ecoregion, and Lark Bunting in the High Plains ecoregion. Other land cover types surrounding the fields that influenced abundance were percent woodland, percent cropland, and percent grassland. Western Meadowlarks in the Smoky Hills region were negatively associated with percent woodland, whereas Eastern Meadowlarks statewide were negatively associated with percent cropland in the surrounding 300 m area around the point-count location. Mourning Doves in the Smoky Hills were positively associated with percent grassland in the surrounding matrix.

Other field characteristics, such as percent forb, percent bare ground, and percent litter were included in the top models for several bird species. Forb cover at the field scale was a top model for Mourning Doves, but only in part of their range. Densities of Mourning Doves were negatively associated with forb presence in the High Plains (Fig. 8). Mourning Doves in the Smoky Hills showed a positive association with percent forb cover in the field, but forb coverage was not in the top model for doves in this part of their range. Brown-headed Cowbirds were positively associated with percent forb cover. Percent forb was not a covariate in the top models of any other species, but Ring-necked Pheasants, and Lark Buntings were positively associated with percent forb in the fields, whereas Northern Bobwhites, Grasshopper Sparrows, and Dickcissels all were negatively associated with percent forb in the field. Percent grass within the field was not highly ranked as a top model in any of our model sets. However, we estimated density of birds by percent grass within the field and found that Northern Bobwhites, Brown-headed Cowbirds, and Dickcissels were positively associated with amount of grass in the field. Ring-necked Pheasants, Lark Buntings, and Grasshopper Sparrows were negatively associated with percent grass (Fig. 9).

Northern Bobwhites had a negative relationship with percent litter within the field, decreasing in density as percent litter increased. Ring-necked Pheasants in the High Plains were negatively associated with increased percentage of bare ground. However, pheasants were also influenced by percent grass in the matrix, percent crop in the matrix, and percent litter within the field.

Field age was important for only one species in one of three ecoregions. Densities of Ring-necked Pheasants in the Smoky Hills decreased with increasing field age. Field type was significant for Mourning Doves in the Flint Hills, and their densities decreased in fields that were within the CRP designation.

We expected that field size would have some effect on bird density, but it was not highly supported as a factor in any of our models. The effect of field size received some support for Western Meadowlarks in the High Plains and Mourning Doves in the Flint Hills (w_i = 0.2). Four bird species had negative relationships between abundance and field size: Northern Bobwhites statewide, Ring-necked Pheasants in the High Plains, Mourning Doves in the High Plains, and Brown-headed Cowbirds statewide. In contrast, Ring-necked Pheasants in the Smoky Hills, Mourning Doves in the Smoky Hills, Western Meadowlarks in the High Plains Eastern Meadowlarks statewide, Lark Buntings in the High Plains, Grasshopper Sparrows statewide, and Dickcissels statewide all had positive trends between density and field size. Estimated density of Western Meadowlarks in the Smoky Hills remained stable with regard to field size (Fig. 10). Density decreased as field size increased for Mourning Doves in the Flint Hills, but the density estimates had large standard errors (results not shown).

Density Estimates

Density estimates were based on a constant model for detection and field type for abundance (Table 6). For both Northern Bobwhites and Ring-necked Pheasants, densities were similar but tended to be greater in SAFE than CRP fields. In the Flint Hills, SAFE fields supported 4.0 birds/km^2 of Northern Bobwhites compared to CRP fields, which supported 1.7 birds/km^2. Ring-necked Pheasants in the Smoky Hills had greater densities in SAFE fields with 2.8 birds/km^2 than in other CRP fields with 2.2 birds/km^2. In the Smoky Hills, Ring-necked Pheasant densities were similar in both field types (2.3-2.4 birds/km^2).

In contrast to upland gamebirds, the densities for most songbird species were greater in CRP fields than in SAFE fields. CRP fields had greater densities for Western Meadowlarks, Eastern Meadowlarks, Lark Buntings, Grasshopper Sparrows, and Dickcissels. With greater host abundance, Brown-headed Cowbirds had greater densities in CRP fields in all three ecoregions from the High Plains, Smoky Hills, and Flint Hills, 3.2 birds per km^2, 20.2 birds per km^2, and 22.1 birds per km^2, respectively when compared with SAFE, 1.7 birds per km^2, 11.3 birds per km, and 17.3 birds per km^2, respectively.

Species richness

Species richness for the High Plains SAFE fields was 40.22 ($\pm$ 1.05), 95% CI [40.00, 47.22] species and was higher than the CRP fields at 31.04 (± 0.91), 95% CI [31.00, 36.29] species. The High Plains had the lowest species richness of all three ecoregions. The Smoky Hills had the highest species richness. SAFE fields in the Smoky Hills had 82.69 ($\pm$ 1.26), 95% CI [82.06, 89.44] species, and the CRP fields had 71.92 (± 1.16), 95% CI [71.04, 78.18] species. In the Flint Hills SAFE fields had 66.36 ($\pm$2.20), 95% CI [64.50, 75.13] species and CRP fields had 48.59 (± 1.80), 95% CI [47.27, 56.39] species (Fig. 11). SAFE fields had greater species richness than CRP fields in all three ecoregions.

DISCUSSION

We surveyed birds in SAFE and CRP fields across three ecoregions, and investigated the effects of landscape scale and field scale characteristics on density of grassland birds. Our results showed that the surrounding landscape and field scale characteristics were important determinants of abundance for several grassland bird species within our study. We did not test for any specific covariates at the regional scale; however, we did test for ecoregion effects for each of our bird species. Grasshopper Sparrows were the only species with similar densities across all three ecoregions. All other species had either similar density across a combination of two ecoregions or were tested across each ecoregion separately (Tables 5-6). At a regional scale, ecoregion was an important factor determining how birds were affected by other characteristics at the landscape and field scales. Species occurrence in some ecoregions was indicative of the range of that species. Lark Buntings did not occur in the Flint Hills or Smoky Hills, Dickcissels were uncommon in the High Plains, and Western Meadowlarks and Eastern Meadowlarks showed little overlap between the eastern and western portions of Kansas. Because most of our study species were tested across ecoregions that were surveyed within the same year or across ecoregions separately, ecoregion cannot be explained by annual variation. Grasshopper Sparrows are the only species where annual variation might be playing a role in some of our estimates, however logistical constraints prevented us from surveying all three ecoregions across both years.

We observed that some species were influenced by characteristics in the surrounding landscape, and not just at the local field scale. Important landscape scale characteristics included proportion of CRP, cropland, grassland, and woodland in the 300 m buffer surrounding each site, and were supported in top models for eight of our species in at least part of their range. The songbird species in our study were positively associated with proportion of CRP and proportion of grassland, but negatively associated with percent cropland and woodland, which is consistent with past studies that have found different landscape scale characteristics important for the maintenance of diverse bird populations (Ribic and Sample 2001, Bakker et al. 2002). Species richness in our study was greater in the Smoky Hills than in the High Plains or Flint Hills and was greater in SAFE fields across all three ecoregions. Richness was greater in the Smoky Hills which could be due to the landscape scale composition around the survey fields, with the Smoky Hills having a high amount of woodland and grassland. While the proportion of woodland and grassland were greater in the Flint Hills, the Smoky Hills exits in the center of Kansas, where many eastern and western species overlap which could be contributing to greater species richness.

Important field scale characteristics included percent forb, percent litter, and percent bare ground. Mourning Doves in the High Plains had a negative association with the amount of forbs within the field. Because doves forage and nest on the ground, they may be associated with fields that have more open areas with less vegetative cover in which to forage and nest (Hughes et al. 2000). Proportion of forb cover was greater and proportion of grass cover was lower in SAFE fields in the High Plains. SAFE fields should have more forb coverage and less grass coverage because of the design of the enrollment type to provide habitat for upland gamebirds, as well as the young age of the fields, which would provide early successional opportunities for forb growth (Dickson and Busby 2009). CRP fields in the High Plains had higher VOR, which was achieved by greater proportion of grass in those same fields.

For Northern Bobwhites, more litter within a field resulted in lower densities. As litter increases, fields become unsuitable for Northern Bobwhite brood-rearing (Doxon and Carroll

2010), although changes in field structure can impact different life-cycle stages. While young SAFE fields with low amounts of litter provide beneficial brood rearing habitat, and mid-contract management on older SAFE fields could re-create this habitat, low cover associated with shorter vegetation and less visual obstruction might not provide appropriate nesting habitat (Taylor et al. 1999). Older SAFE fields with more protective vegetation could provide the required habitat during nesting for some species, emphasizing the importance of a mixture of field ages within the matrix of CRP (Greenfield et al. 2002). A study in eastern South Dakota found that pheasants were more abundant in older CRP fields (10-13 yrs of age) consisting of cool-season grasses (Eggebo et al. 2003). In our study, Ring-necked Pheasants in the Smoky Hills were negatively associated with field age with CRP plantings of warm-season grasses. In the High Plains, Ring-necked Pheasants were negatively associated with percent bare ground. These results indicate that Ring-necked Pheasants may be responding to different field characteristics, and field age and structure within the field effects species differently throughout their Kansas range.

CRP fields were larger than SAFE fields in Kansas. Although field size was not supported by any of our top models for abundance, it did receive some weight for Western Meadowlarks in the High Plains and Mourning Doves in the Flint Hills. Western Meadowlark density increased with increasing field size, but Mourning Dove density decreased with increasing field size. We did observe greater densities of birds in CRP fields than SAFE fields, suggesting that field size is playing a role in bird numbers. However, we expected that more species would be affected by field size, especially those with area sensitivity (Davis 2004, Winter et al. 2006, Bayard and Elphick 2009, Shake et al. 2012).

We found that Mourning Doves were influenced by landscape scale characteristics in one part of their Kansas range, but in another part of their range, field scale characteristics were the indicator of abundance. For most of our other species, either landscape or field scale characteristics played a role in abundance, but not both. Our work joins previous studies that have found landscape and field scale characteristics play a role in the density of grassland birds in varying ways, where some species are only influenced by landscape or field scale characteristics, and others are influenced by both (Ribic and Sample 2001, Bakker et al. 2002, Filloy and Bellocq 2007, Riffell et al. 2008, Blank 2013). A study conducted on set-aside lands within organic farmlands, found Western Meadowlark abundance was negatively associated with percent linear woodland at a local scale, but positively associated with percent linear grassland in buffer strips at a landscape scale (Quinn et al. 2012). Quinn et al. (2012) also found that Grasshopper Sparrows were more abundant when percent of set-aside program in block grasslands at a local scale was greater, while Dickcissels were less abundant.

Densities of Northern Bobwhites and Ring-necked Pheasants did not differ between CRP and SAFE fields, suggesting that the relatively new SAFE practice is as effective as other CRP conservation practices for game birds in Kansas. For all other birds in our analyses, we found that density estimates were greater for CRP fields when compared to SAFE fields, including Brown-headed Cowbirds as a brood-parasite. Given that overall songbird densities were greater in CRP fields, Brown-headed Cowbird densities may be tracking areas of greater host abundance. We did not investigate nesting density or success in SAFE or CRP fields, but Brown-headed Cowbird density could be an indirect indicator of nest success and abundance (Jensen and Cully 2005). However, Brown-headed Cowbirds in our study were also negatively associated with field size, indicating that they are present in high numbers in small CRP fields and were less dense in larger CRP fields. Brown-headed Cowbird nest parasitism results in lower nest success and increases with landscape fragmentation (Robinson et al. 1995).

SAFE fields may be as beneficial for Northern Bobwhites and Ring-necked Pheasants as other CRP enrollments. SAFE fields also have lower densities of Brown-headed Cowbirds, which could be beneficial for grassland songbird nesting success. However, SAFE fields may not be providing the proper habitat composition and area requirements that grassland bird species require for successful breeding. The densities derived from our distance sampling models were not productivity of our study species, so our results might not be indicative of bird nesting success in small, fragmented SAFE fields. One study suggests that while bird densities might be high in CRP fields, nest success remained low (With et al. 2008). Thus, SAFE and CRP fields could be acting as sinks for various bird populations (Hughes, et al. 1999, Conover et al. 2011).

CONSERVATION IMPLICATIONS

State Acres for Wildlife Enhancement is one of the newest Conservation Reserve enrollment types created by the Food, Conservation and Energy Act of 2008 for the benefit of upland gamebirds and other sensitive bird species in Kansas. Our findings suggest that the practice is supporting comparable numbers of Northern Bobwhites and Ring-necked Pheasants as other CRP enrollment types. Young SAFE fields, devoid of dense litter, are potentially providing brood rearing habitat for Northern Bobwhites and Ring-necked Pheasants, while the older fields in the practice may be suitable for nesting habitat for Northern Bobwhites (Taylor et al. 1999, Greenfield et al. 2002, Doxon et al. 2010). Ring-necked Pheasants responded positively to younger fields in the Smoky Hills and a decrease in percent bare ground in the High Plains. A balance of older, dense fields for nest sites, younger, litter-free fields for brood-rearing, and fields that are maintained at a 5-6 year interval via mid-contract management techniques, would benefit both Northern Bobwhites and Ring-necked Pheasants (Matthews et al. 2012). To conserve other grassland songbirds, the landscape composition around SAFE fields might play a role. An increase in CRP has a positive effect on several species, so continuation of the program and increased enrollment could benefit bird numbers throughout Kansas. Privately managed grasslands are maintained by landowners, thus providing habitat with various vegetative structure, field age, and field sizes. Private lands have been shown to have greater bird diversity and abundance when compared to public lands in Minnesota, suggesting that Kansas has the same potential with continued and increased enrollment in private set-aside practices (Cunningham 2005). Kansas currently has 273 km^2 of lands enrolled in the SAFE practice. We estimated that for 1 km^2 of land, ~6 Northern Bobwhites were supported and ~5 Ring-necked Pheasants were supported. If SAFE enrollments were in optimum areas for both Northern Bobwhites and Ring-necked Pheasants, the program would support an estimated 1,638 Northern Bobwhites and 1,365 Ring-necked Pheasants statewide across all SAFE enrollments in Kansas.

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Table 1. Breeding Bird Survey trends (% change per year) for the 44-year period of 1968—2012 and the 11-year period from 2002—2012 for nine bird species at a national level and within the state of Kansas.

Species	United States						
		1968-2012		2002-2012			
	N	Trend	(95% CI)	Trend	(95% CI)	R.A.	Decline
Northern Bobwhite	1971	-4.20	(4.5, -3.95)	-4.06	(-4.72, -3.40)	28.0	Y
Ring-necked Pheasant	1587	-0.65	(-1.15, -0.17)	0.69	(-0.60, 2.16)	24.6	Y
Mourning Dove	3618	-0.57	(-0.70, -0.44)	-0.67	(-0.94, -0.40)	38.4	Y
Eastern Meadowlark	2320	-3.41	(-13.05,-3.10)	-3.13	(-3.59,-1.96)	29.0	Y**
Western Meadowlark	1683	-1.31	(-1.54, -1.03)	-1.17	(-1.56, -0.75)	120.3	Y
Brown-headed Cowbird	3563	-0.30	(-0.50, -0.20)	0.70	(0.30, 1.20)	17.0	Y
Lark Bunting	468	-3.48	(-5.29, -2.04)	-0.63	(-4.63, 3.28)	368.7	Y
Grasshopper Sparrow	1967	-2.82	(-3.46,-2.32)	-1.49	(-2.82, -0.12)	9.4	Y
Dickcissel	1284	-0.55	(-1.05, -0.12)	1.10	(0.015, 2.10)	33.5	Y
	Kansas						
		1968-2012		2002-2012			
Species	N	Trend	(95% CI)	Trend	(95% CI)	R.A.	Decline
Northern Bobwhite	65	-1.72	(-2.35, -1.14)	0.75	(-1.05, 2.62)	54.3	Y
Ring-necked Pheasant	59	-0.04	(-1.45, 1.08)	-0.59	(-3.07, 1.93)	161.8	*
Mourning Dove	65	-0.50	(-1.02, -0.05)	0.28	(-1.11, 1.72)	103.9	Y
Eastern Meadowlark	61	-2.42	(-3.02,-1.83)	-1.56	(-3.21, 0.21)	49.7	Y
Western Meadowlark	58	-1.19	(-1.95, -0.51)	-2.45	(-3.96, -1.06)	262.4	Y
Brown-headed Cowbird	65	-0.44	(-1.03, 0.12)	0.49	(-1.34, 2.41)	45.9	*
Lark Bunting	31	-9.26	(-3.87, -1.01)	-12.86	(-21.92, -4.09)	299.6	Y
Grasshopper Sparrow	64	-2.30	(-3.87, -1.01	-4.69	(-7.50,-1.91)	46.6	Y**
Dickcissel	65	-0.73	(-1.46, -0.04)	-2.48	(-4.44, -0.86)	181.9	Y

**Data with deficiency, *Unreliable based on CI, N = Sample size of BBS routes, CI = Credible Interval, R.A. = relative abundance

Table 2. Number of fields surveyed for SAFE (CP38) and each of the other eight CRP enrollment types. Total CRP is the total number of all CRP field types combined.

Ecoregion	**SAFE**	**Total CRP**	Field type: CP2	CP4D	CP10	CP16A	CP21	CP25	CP33	CP42
Flint	**19**	**5**	3	0	1	0	1	0	0	0
Smoky	**50**	**24**	6	2	1	1	0	8	5	1
West	**53**	**20**	12	0	0	0	0	8	0	0
Total	**122**	**49**	21	2	2	1	1	16	5	1

Table 3**.** Field size, % grass, % forb, % bare ground, % litter, % detritus (standing dead vegetation), and VOR (visual obstruction reading in decimeters (dm)) by field type in each ecoregion.

Ecoregion Year	Field Type	No. of sites	Field Size (ha)			% grass	% forb	%bare	% litter	% detritus	VOR (dm)	
			x̄	SE	Range	x̄	x̄	x̄	x̄	x̄	x̄	SE
Flint Hills	SAFE	19	1.37	0.5	0.28-2.02	36.50	12.15	13.24	21.31	3.66	1.79	0.19
2012	CRP	5	5.2	4.33	0.49-10.38	40.90	8.15	13.60	22.70	3.02	1.97	0.22
Smoky Hills	SAFE	50	1.82	1.51	0.11-8.41	37.60	7.40	8.00	28.30	5.60	1.60	0.09
2012	CRP	24	6.08	9.15	0.26-42.46	45.15	4.13	6.16	22.53	9.12	1.60	0.13
High Plains	SAFE	53	3.79	3.5	0.32-21.76	9.30	12.90	17.80	41.14	18.40	0.6	0.05
2013	CRP	20	25.09	29.21	1.99-77.35	15.00	5.42	19.30	34.40	24.30	0.9	0.07

Table 4. Model selection results for detection and abundance of five species within three ecoregions. n = number of detections.

Model Set						
Northern Bobwhite (n = 208) Ecoregions = Flint, Smoky						
Detection	**Abundance**	**K**	**AIC**	**Δ AIC**	w_i	p
Sunrise	Litter (hazard)	5	652.6	0.0	0.8	0.5
Sunrise	Constant (hazard)	4	654.9	2.3	0.2	
Eastern Meadowlark (n = 95) Ecoregions = Flint, Smoky						
Detection	**Abundance**	**K**	**AIC**	**Δ AIC**	w_i	p
Constant	Percent Crop (half-normal)	3	524.4	0.0	1.0	0.5
Constant	Percent CRP (half-normal)	3	533.8	9.4	0.0	
Constant	Practice Type (half-normal)	3	537.7	13.3	0.0	
Brown-headed Cowbird (n = 159) Ecoregions = Flint, Smoky						
Detection	**Abundance**	**K**	**AIC**	**Δ AIC**	w_i	p
Constant	Forb in field (half-normal)	3	693.5	0.0	0.4	0.5
Constant	Litter in field (half-normal)	3	697.1	3.5	0.1	
Constant	Field Age (half-normal)	3	697.3	3.7	0.1	
Constant	Constant (half-normal)	2	697.3	3.8	0.1	
Grasshopper Sparrow (n = 334) Ecoregions = Flint, Smoky, High Plains						
Detection	**Abundance**	**K**	**AIC**	**Δ AIC**	w_i	p
Constant	Percent CRP (hazard)	4	2036.5	0.0	1.0	0.6
Constant	Field Size (hazard)	4	2070.5	34.0	0.0	
Constant	Field Age (hazard)	4	2102.9	66.4	0.0	
Dickcissel (n = 534) Ecoregions = Flint, Smoky						
Detection	**Abundance**	**K**	**AIC**	**Δ AIC**	w_i	p
Constant	Percent CRP (half-normal)	3	2363.3	0.0	1.0	0.1
Constant	Litter in field (half-normal)	3	2385.9	22.7	0.0	
Constant	Field Size (half-normal)	3	2388.4	25.1	0.0	
Constant	Percent Crop (half-normal)	3	2400.7	37.4	0.0	

K = number of parameters, AIC = Akaike's information criterion, Δ AIC = difference in Akaike's information criterion, w_i = model weight, p = GOF Freeman-Tukey fit statistic.

Table 5. Model selection results for several species across three ecoregions. n = number of detections. Percent grass = percent grass in surrounding 300 m area. Grass in field = % grass in vegetation survey plots within field.

High Plains Model Set						
Ring-necked Pheasant (n = 189)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Constant	Bare Ground in field (uniform)	2	926.8	0.0	0.2	0.6
Constant	Percent Grass (uniform)	2	927.5	0.6	0.1	
Constant	Percent Crop (uniform)	2	927.9	1.0	0.1	
Constant	Litter in field (uniform)	2	928.1	1.2	0.1	
Constant	Constant (uniform)	1	928.5	1.7	0.1	
Mourning Dove (n = 224)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Constant	Forb in field (hazard)	4	1195.9	0.0	0.4	0.5
Constant	Field age (hazard)	4	1198.0	2.0	0.1	
Constant	Practice Type (hazard)	4	1198.8	2.8	0.1	
Constant	Field size (hazard)	4	1199.0	3.1	0.1	
Western Meadowlark (n = 628)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Constant	Percent CRP (hazard)	4	2977.2	0.0	0.4	0.4
Constant	Field Size (hazard)	4	2979.0	1.8	0.2	
Constant	Percent Crop (hazard)	4	2979.4	2.3	0.1	
Constant	VOR (hazard)	4	2981.0	3.9	0.1	
Lark Bunting (n = 150)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Constant	Percent CRP (hazard)	4	873.1	0.0	0.7	0.4
Constant	Percent Crop (hazard)	4	875.3	2.2	0.2	
Constant	Litter in field (hazard)	4	880.2	7.1	0.0	
Constant	Field size (hazard)	4	885.2	12.1	0.0	

K = number of parameters, AIC = Akaike's information criterion, Δ AIC = difference in Akaike's information criterion, w_i = model weight, p = GOF Freeman-Tukey fit statistic.

Table 5 (continued).

Detection	Abundance	K	AIC	ΔAIC	w_i	$p \leq$
Smoky Hills Model Set						
Ring-necked Pheasant (n = 230)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Sunrise	Field Age (half-normal)	4	586.3	0.0	1.0	0.4
Sunrise	Constant (half-normal)	3	593.0	6.7	0.0	
Mourning Dove (n = 292)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Sunrise	Percent Grass (half-norm)	4	1213.8	0.0	1.0	0.4
Sunrise	Constant (half-normal)	3	1223.7	9.9	0.0	
Western Meadowlark (n = 315)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Constant	Percent Wood (hazard)	4	1295.1	0.0	1.0	0.5
Constant	Percent Grass (hazard)	4	1315.0	19.9	0.0	
Constant	VOR (hazard)	4	1315.7	20.6	0.0	
Constant	Percent Crop (hazard)	4	1330.2	35.1	0.0	
Flint Hills Model Set						
Mourning Dove (n = 50)						
Detection	**Abundance**	**K**	**AIC**	**ΔAIC**	w_i	$p \leq$
Constant	Practice Type (half-normal)	3	181.6	0.0	0.2	0.5
Constant	Field Size (half-normal)	3	181.8	0.2	0.2	
Sunrise	Constant (half-normal)	3	182.5	1.0	0.1	
Constant	Percent Crop (half-normal)	3	183.1	1.5	0.1	

K = number of parameters, AIC = Akaike's information criterion, Δ AIC = difference in Akaike's information criterion, w_i = model weight, p = GOF Freeman-Tukey fit statistic.

Table 6. Density estimates of birds per km^2 across three ecoregions by SAFE and CRP enrollments. Estimates include standard error and 95% confidence intervals. Model = constant for detection, field type for abundance. Tested separately for each species and ecoregion.

Species	Ecoregion	Density Estimates	
		SAFE	CRP
Northern Bobwhite	High	---	---
	Smoky	2.1 (±0.8, CI 0.5, 3.8)	2.4 (±0.6, CI 1.5, 4.0)
	Flint	4.0 (±1.7, CI 0.6, 7.4)	1.7 (±1.3, CI 0.40, 7.8)
Ring-necked Pheasant	High	2.3 (±0.4, CI 1.6, 3.0)	2.4 (±0.7, CI 1.1, 3.7)
	Smoky	2.8 (±1.5, CI -0.1, 5.7)	2.2 (±0.8, CI 0.7, 3.8)
	Flint		
Mourning Dove	High	4.9 (±2.5, CI -0.1, 9.9)	6.5 (±2.9, CI 0.9, 12.1)
	Smoky	9.8 (±6.8, CI -3.5, 23.1)	10.0 (± 3.9, CI 2.4, 17.6)
	Flint	4.1(±2.0, CI 0.3, 8.1)	1.6 (±1.3, CI 0.4, 7.6)
Western Meadowlark	High	52.4 (±20.8, CI 11.6, 93.2)	52.8 (± 5.6, CI 43.0, 65.0)
	Smoky	12.3 (±5.1, CI 2.3, 22.3)	13.9 (±5.6, CI 3.0, 24.8)
	Flint	---	---
Eastern Meadowlark	High	---	---
	Smoky	2.1 (±0.7, CI 0.6, 3.5)	2.8 (±1.0, CI 1.4, 5.5)
	Flint	1.3 (±0.7, CI 0.5, 3.4)	11.3 (±4.6, CI 5.1, 24.9)
Brown-headed Cowbird	High	1.6 (±0.9, CI -0.3, 3.4)	2.8 (±1.3, CI 1.2, 6.9)
	Smoky	11.9 (±9.0, CI -5.7, 29.5)	20.8 (± 14.5, CI -7.6, 49.2)
	Flint	17.1 (±10.9, CI -4.3, 38.5)	23.9 (±18.8, CI -13.0, 60.8)
Lark Bunting	High	27.0 (±7.9, CI 11.4, 42.5)	38.9 (±15.7, CI 8.1, 69.6)
	Smoky	---	---
	Flint	---	---
Grasshopper Sparrow	High	15.8 (±3.2 CI 9.4, 22.1)	45.0 (±11.3, CI 22.9, 67.2)
	Smoky	24.2 (±4.5, CI 17.7, 35.8)	42.8 (±12.8, CI 17.6, 67.9)
	Flint	4.5(±3.1, CI 1.2, 17.3)	28.2 (±16.6, CI 8.9, 89.2)
Dickcissel	High	8.1 (±1.9, CI 5.1, 12.8)	9.7 (±3.0, CI 3.8, 15.7)
	Smoky	62.7 (±21.3, CI 20.9, 104.5)	70.3 (± 18.7, CI 33.5, 107.0)
	Flint	24.6 (±9.7, CI 5.6, 43.6)	110 (±24.8, CI 71.5, 171.6)

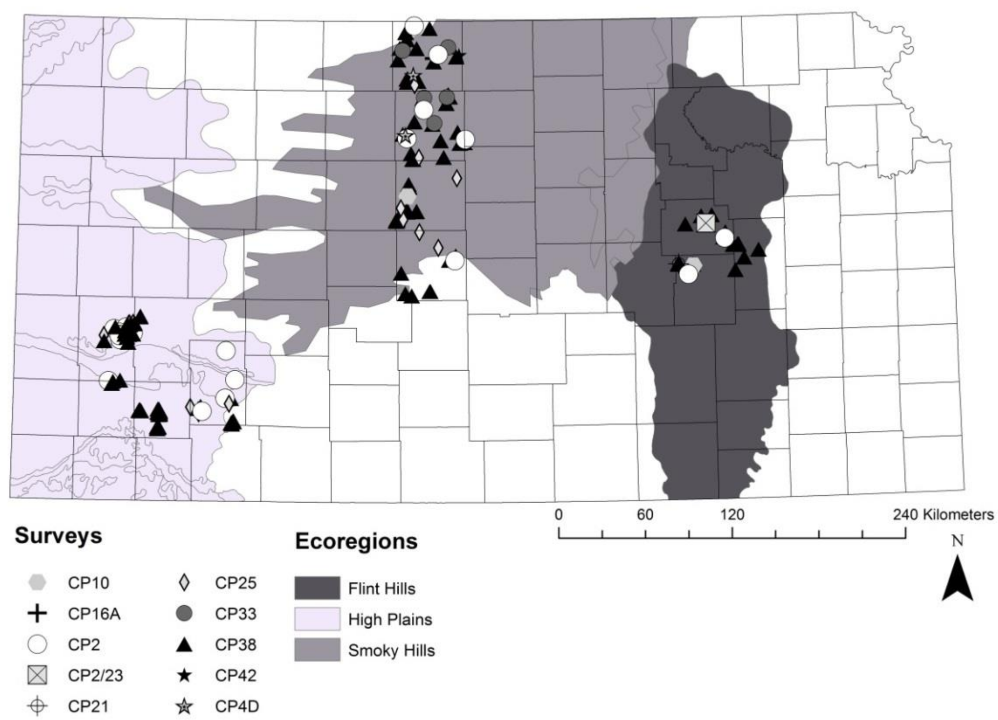

Figure 1. Map of Kansas with the three ecoregions and point-count locations for the field surveys of birds, 2012—2013..

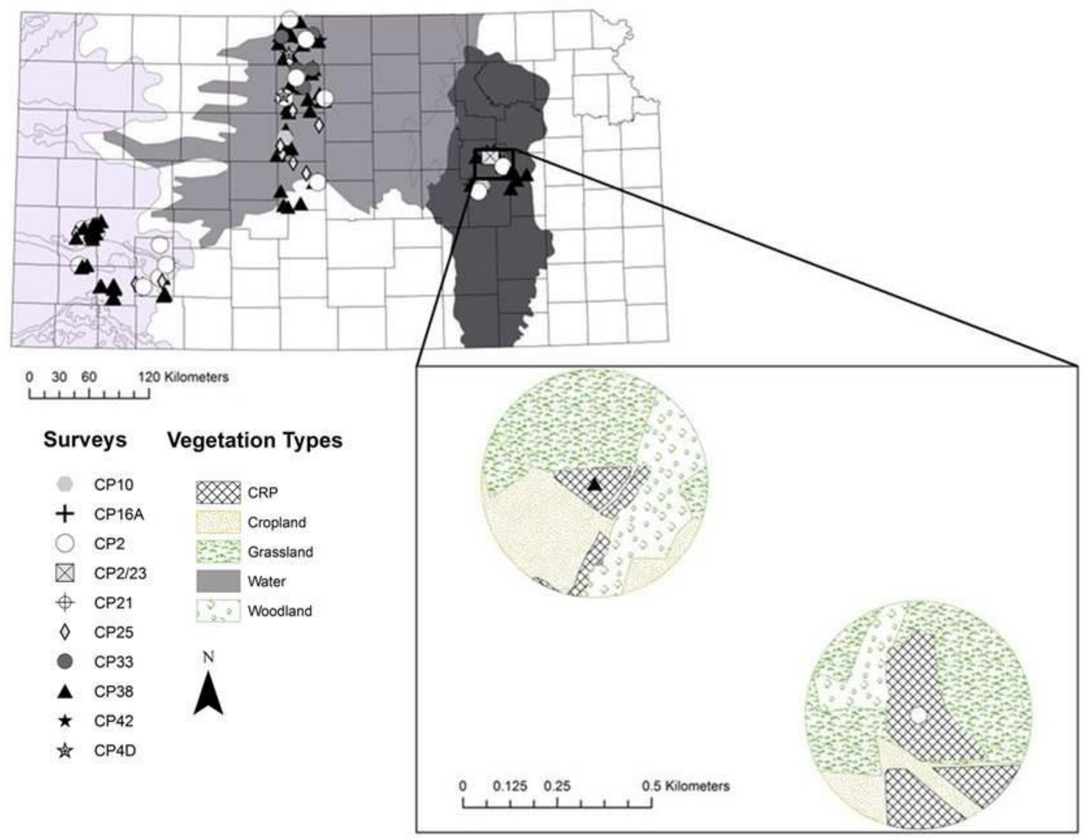

Figure 2. Land cover analysis and two examples of 300 m buffers intersected with the land use types. The percent CRP, cropland, grassland, water, and woodland were calculated within each buffer and used in the analysis in with function *distsamp*.

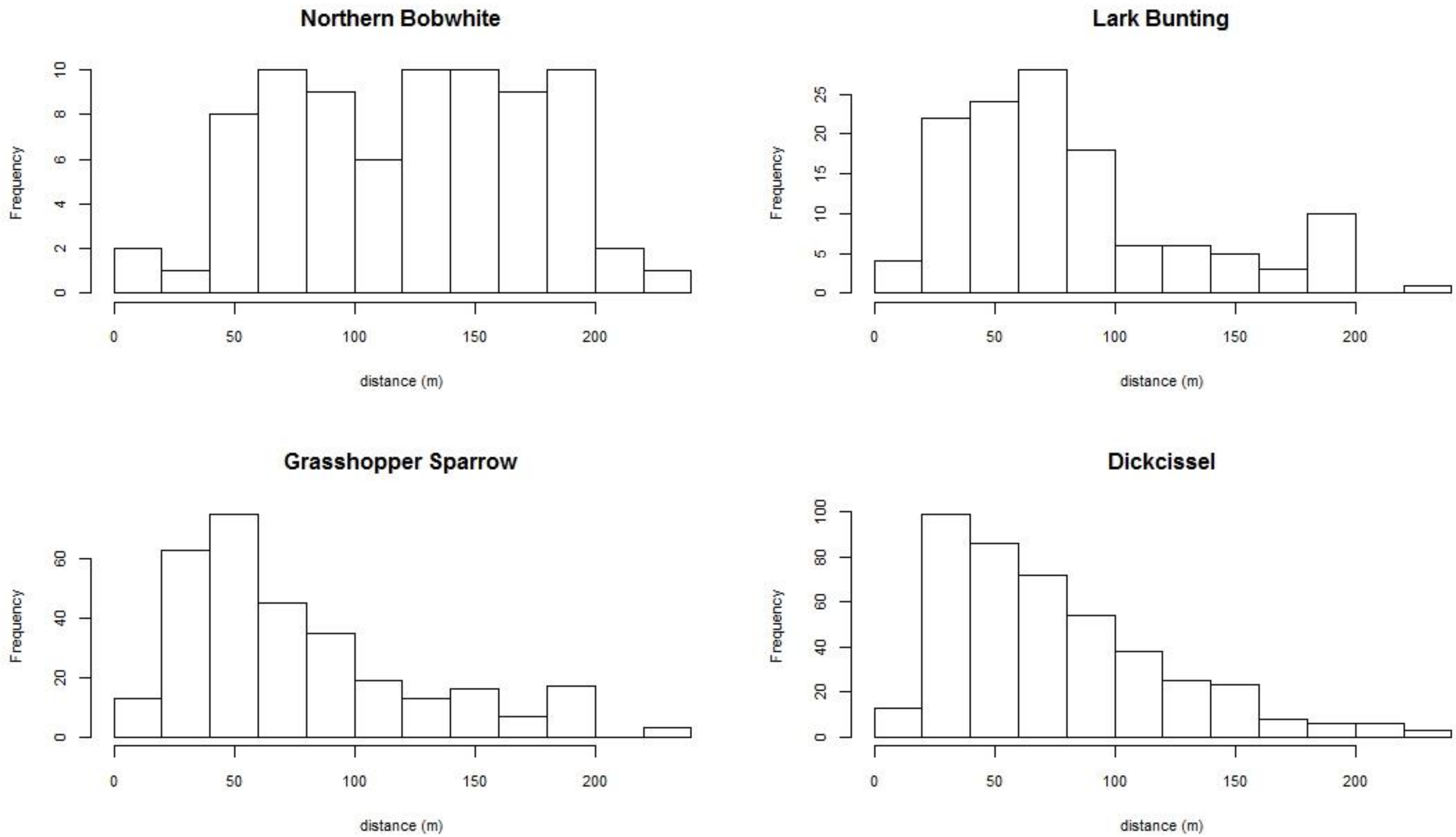

Figure 3. Examples of histograms showing frequency of detections for four bird species by distance from the point-count station. The drop in detections at a distance of zero is a “donut effect” where displacement of birds occurred at or near the center of the point-count circle.

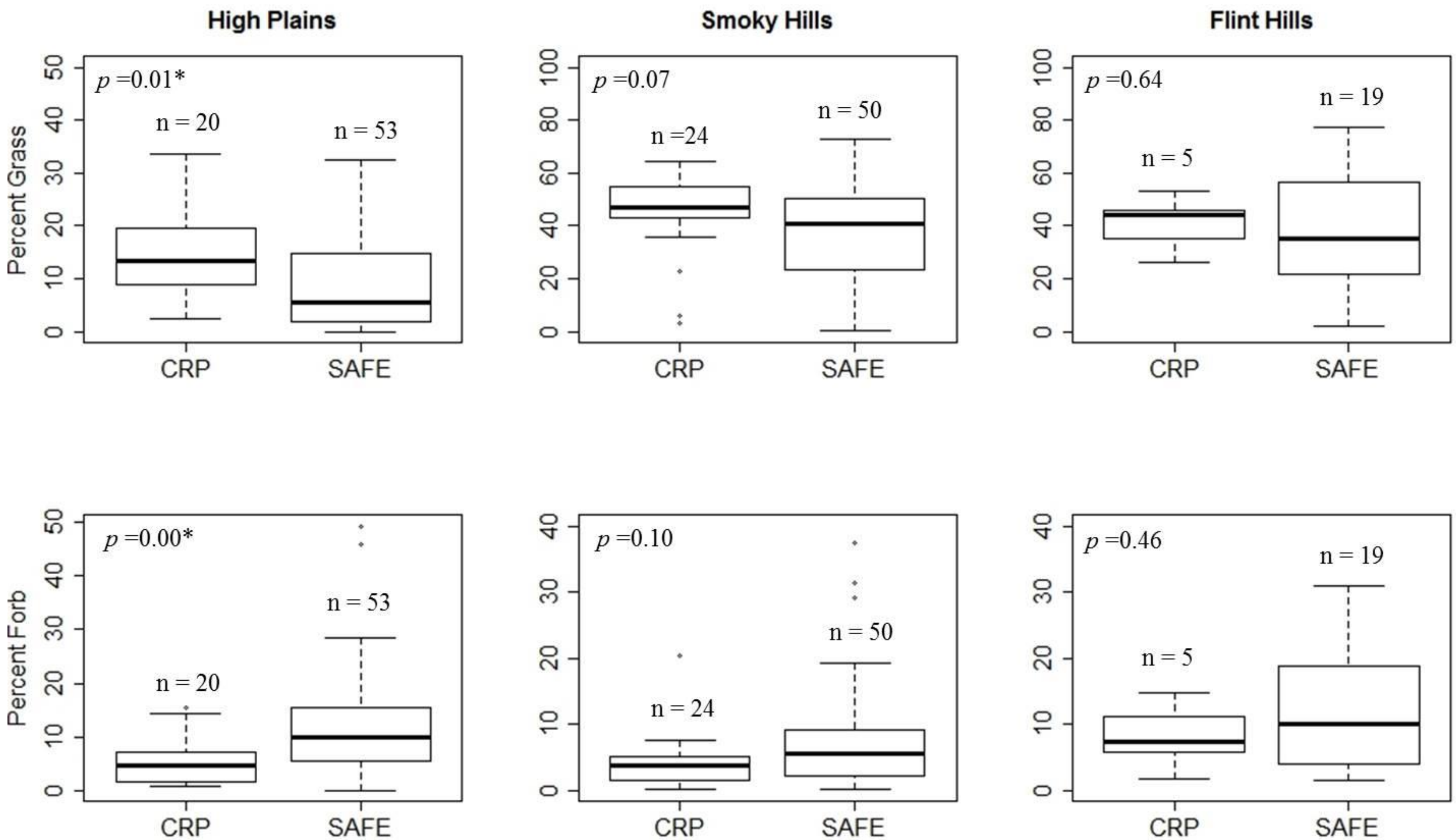

Figure 4. Field characteristics of SAFE and CRP fields surveyed for birds in three ecoregions of Kansas, 2012—2013.

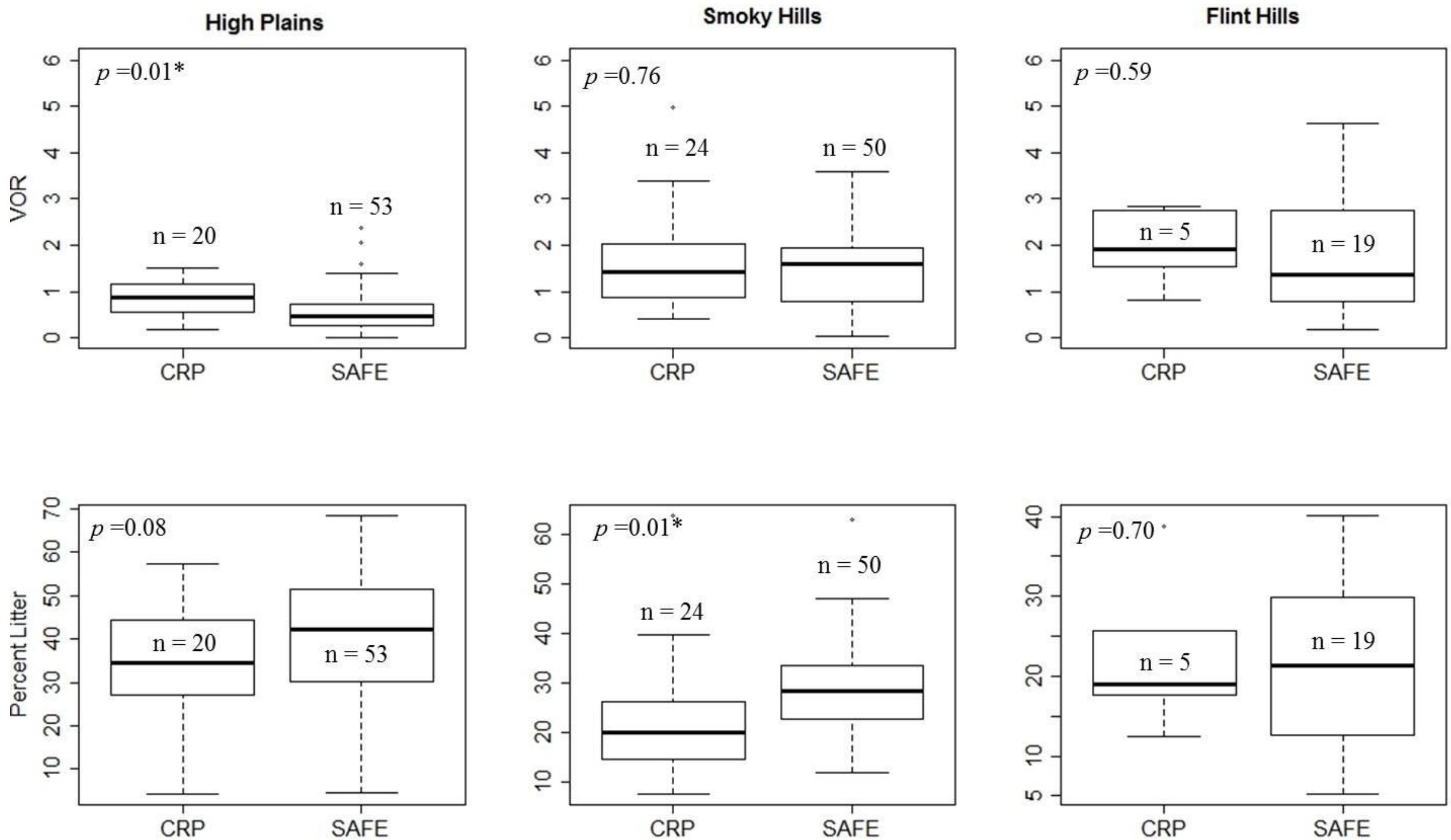

Figure 5. Field characteristics of SAFE and CRP fields surveyed for birds in three ecoregions of Kansas, 2012—2013.

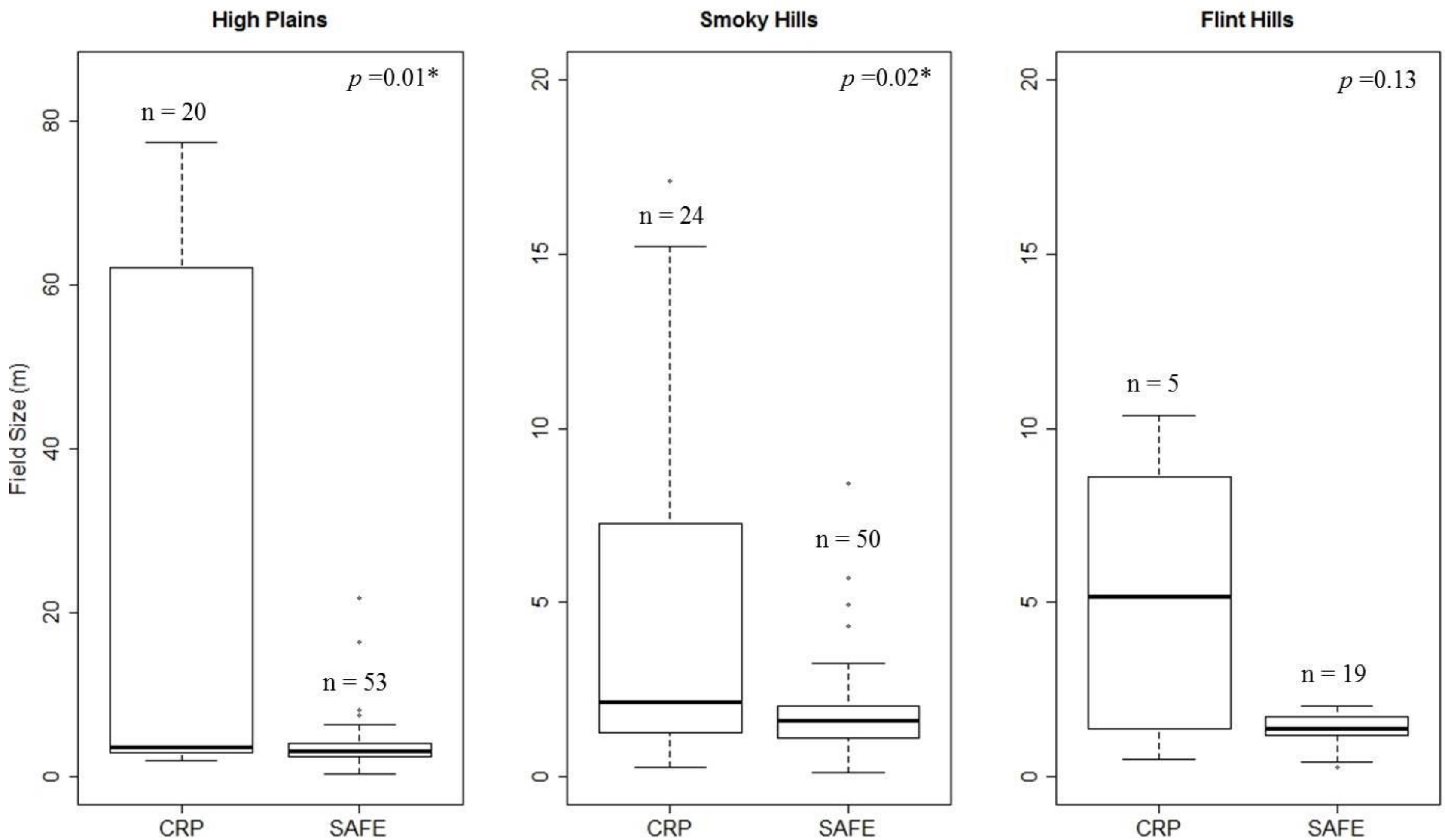

Figure 6. Field sizes of SAFE and CRP fields in three ecoregions of Kansas, 2012—2013.

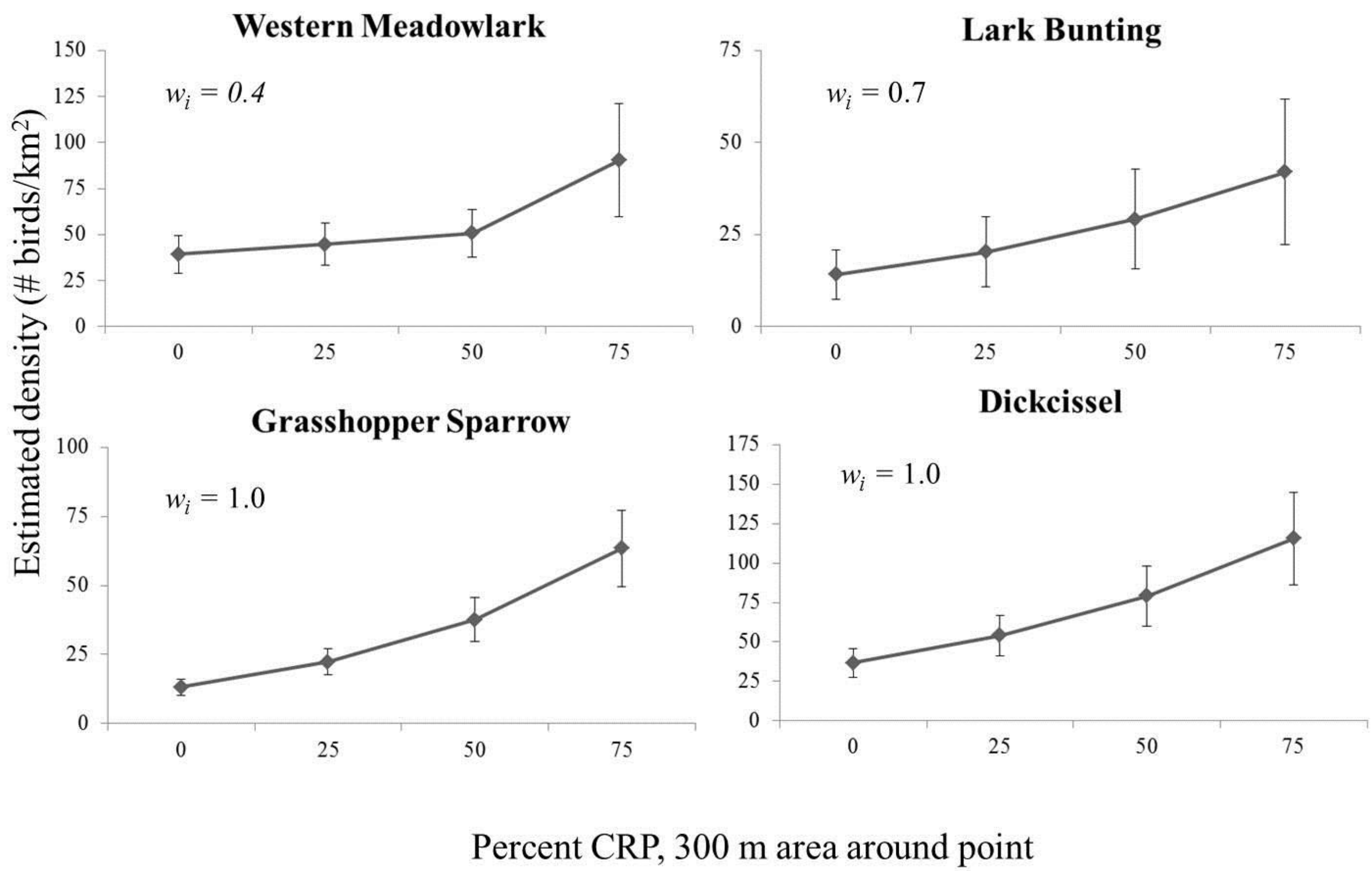

Figure 7. Estimated density of birds per km^2 (± SE) by percent CRP within the 300 m area surrounding the point, including surveyed fields and surrounding buffer. Percent CRP = 0, 25%, 50%, and 75%. Model structure was constant for detection, percent CRP for abundance.

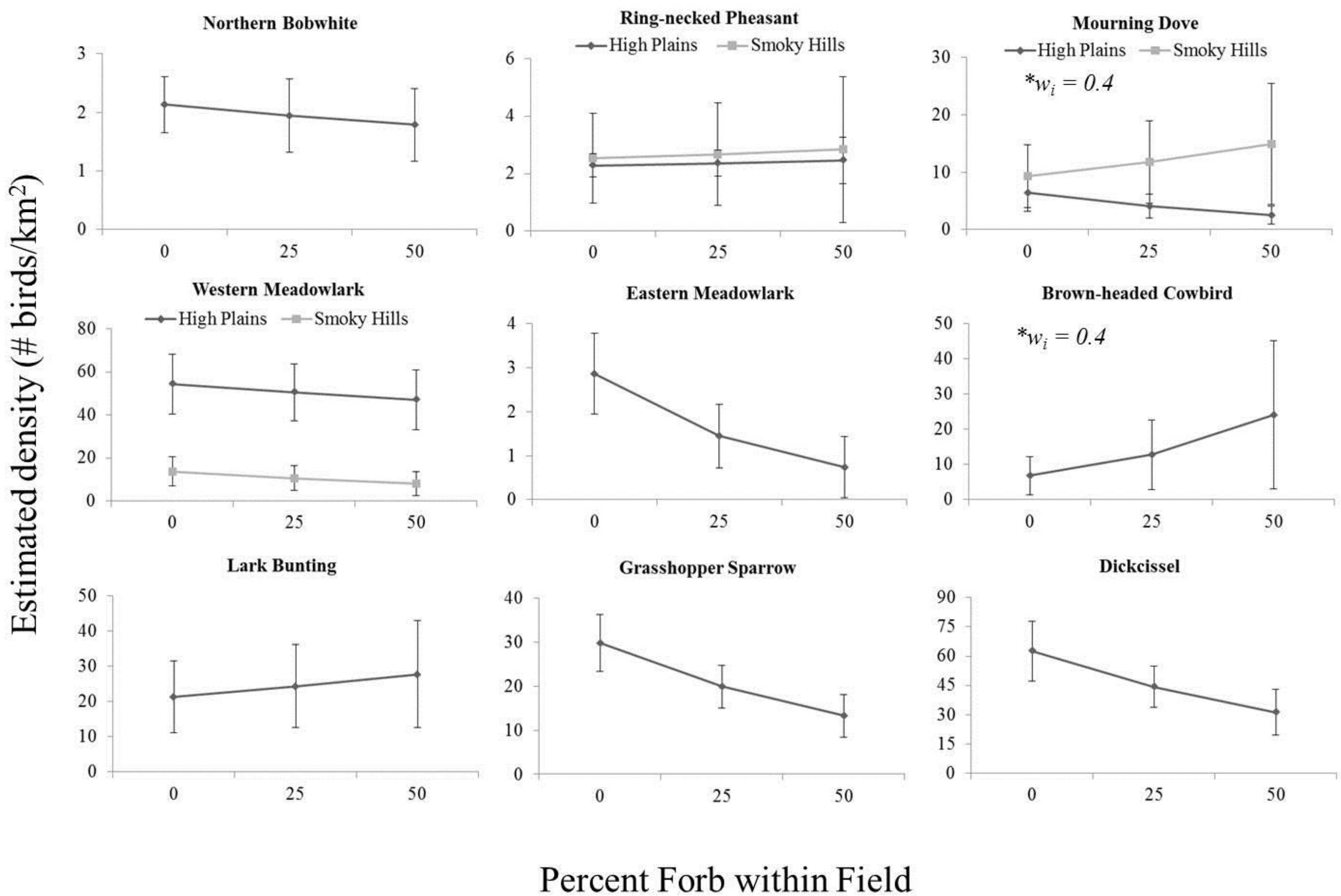

Figure 8. Estimated density of birds per km^2 (± SE) by percent forb at the field scale for nine study species. Percent forb = 0, 25%, and 50%, where 50% corresponds with our maximum percentage. *Top model for Mourning Doves in the High Plains and Brown-headed Cowbirds across their range. Model structure was constant for detection, percent forb for abundance.

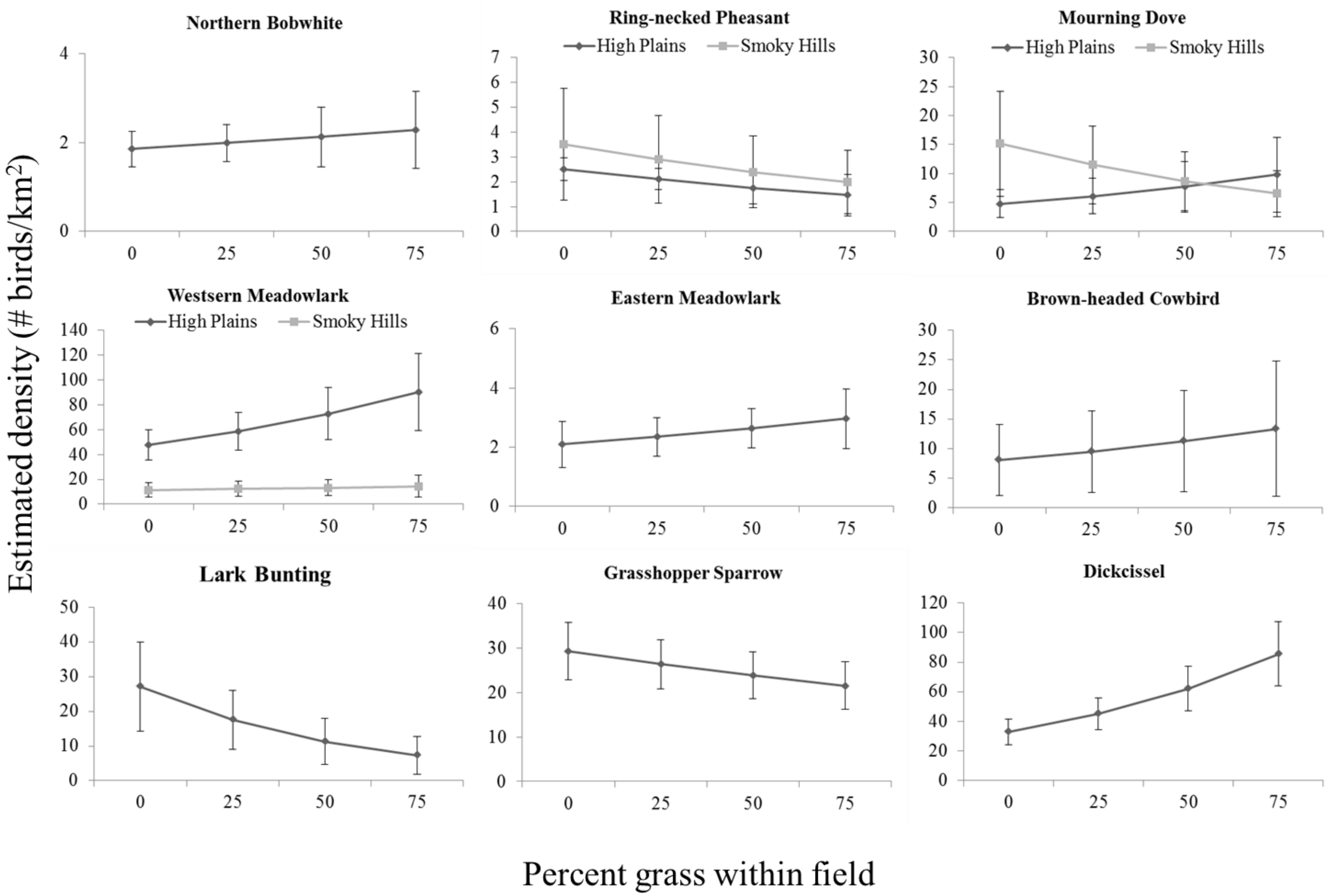

Figure 9. Estimated density of birds per km^2 (± SE) by percent grass at the field scale for nine study species. Percent grass = 0, 25%, 50%, and 75%, where 75% corresponds with our maximum percentage. Model structure was constant for detection, percent grass for abundance. Percent grass in the field held no weight for any of the bird species.

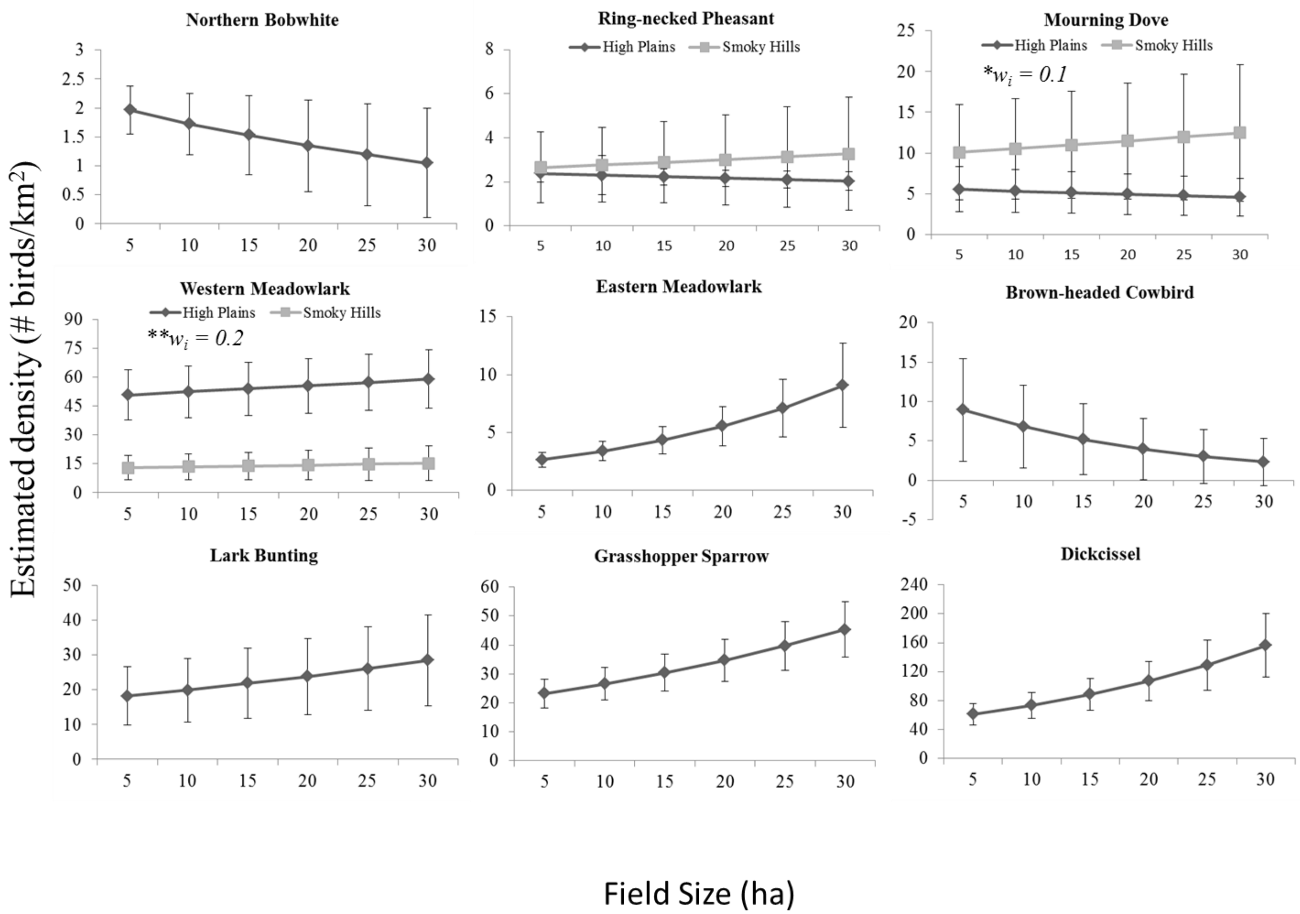

Figure 10. Estimated density of birds per km^2 (± SE) by field size (ha) for nine study species. Model structure was constant for detection, field size for abundance. *Field size had some weight ($w_i = 0.10$) for Mourning Doves in the High Plains. **Field size had some weight ($w_i = 0.20$) for Western Meadowlarks in the High Plains. Field size received little to no weight ($w_i < 0.01$) for any of the other seven study species depicted.

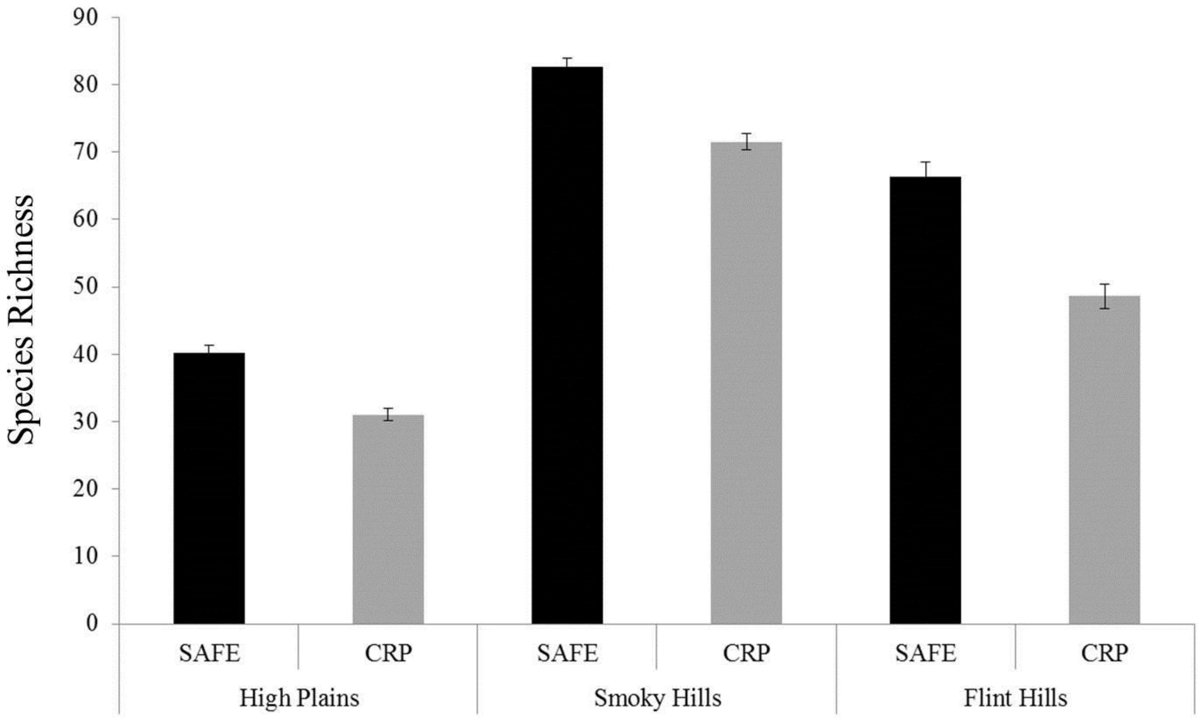

Figure 11. Species richness for each of the three ecoregions surveyed during the 2012 and 2013 survey periods. Flint Hills SAFE = 66.36 (±2.20), 95% CI [64.50, 75.13], CRP = 48.59 (± 1.80), 95% CI [47.27, 56.39], Smoky Hills SAFE 82.69 (± 1.26), 95% CI [82.06, 89.44], CRP = 71.92 (± 1.16), 95% CI [71.04, 78.18], and High Plains SAFE = 40.22 (± 1.05), 95% CI [40.00, 47.22], CRP = 31.04 (± 0.91), 95% CI [31.00, 36.29].

Appendix A - Nest Records

We located and recorded 17 nests from May to 15 July 2012, and eight nests from 26 May to 3 July 2013 (Table A.1). We opportunistically located nests while walking to and from bird survey point-count locations or vegetation survey locations. Upon finding a nest, we recorded date, species, number of host eggs, number of cowbird eggs, number of host young, and number of cowbird young and in what field type the nest was located. We were not able to determine the fate of the nests due to logistical constraints with nest monitoring.

Table A-1. Nests located during survey period 2012—2013. Nest contents were recorded at discovery. BHCO= Brown-headed Cowbird eggs and young were noted if present. Nests were noted as being in SAFE, CRP or other field type.

			Nest Contents				Field Type		
Ecoregion	Species	Date	Host Eggs	BHCO Eggs	Host Young	BHCO young	SAFE	CRP	Other
High Plains	Lark Bunting	5/28/2013	5	0	0	0	X		
High Plains	Lark Bunting	5/28/2013	5	0	0	0	X		
High Plains	Western Meadowlark	6/28/2013	0	0	4	0	X		
High Plains	Mourning Dove	7/2/2013	2	0	0	0	X		
High Plains	Mourning Dove	7/2/2013	2	0	0	0		X	
High Plains	Lark Bunting	6/12/2013	0	0	4	0	X		
High Plains	Horned Lark	6/25/2013	4	0	0	0		X	
High Plains	Mourning Dove	5/28/2013	2	0	0	0	X		
Smoky Hills	Mourning Dove	5/27/2012	2	0	0	0	X		
Smoky Hills	Mourning Dove	5/27/2012	0	0	2	0	X		
Smoky Hills	Mourning Dove	5/29/2012	1	0	0	0	X		
Smoky Hills	Grasshopper Sparrow	5/29/2012	5	0	0	0		X	
Smoky Hills	Western Meadowlark	5/30/2012	5	0	0	0		X	
Smoky Hills	Dickcissel	5/31/2012	2	3	0	0	X		
Smoky Hills	Western Meadowlark	5/31/2012	5	0	0	0	X		
Smoky Hills	Northern Bobwhite	5/31/2012	0	0	2	0	X		
Smoky Hills	Western Meadowlark	6/4/2012	0	0	4	0		X	
Smoky Hills	Dickcissel	6/22/2012	3	1	0	0	X		
Smoky Hills	Field Sparrow	6/28/2012	0	0	1	1	X		
Flint Hills	Wild Turkey	6/8/2012	0	0	1	0	X		
Flint Hills	Lark Sparrow	6/9/2012	0	0	5	0	X		
Flint Hills	Lark Sparrow	6/9/2012	0	0	5	0		X	
Flint Hills	Lark Sparrow	7/1/2012	3	2	0	0	X		
Flint Hills	Common Nighthawk	7/7/2012	1	0	0	0			Crop
Flint Hills	Mourning Dove	7/10/2012	2	0	0	0	X		