AVIAN BREEDING ECOLOGY IN SOYBEAN FIELDS: DOES NO-TILL PROVIDE ANY BENEFITS?

BY

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THESIS

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ABSTRACT

Approximately 71% of land cover in the Midwest is in agriculture production, with row crops being the most prevalent. Most row crops have replaced grasslands, resulting in declines of their constituent bird communities. Previous research has shown that tillage regimes can affect the suitability of row crop fields as wildlife habitat. Originally created as a soil conservation measure, use of no-till agriculture is increasing in areas of intensive row crop production. Nonetheless, it is not yet clear whether this practice benefits wildlife compared to conventional tillage methods and whether bird production in row crop fields can contribute to regional bird populations. I compared the nesting success and avian communities in tilled and no-till soybean fields. I found significantly higher densities of birds in no-till fields than tilled fields but no differences in avian communities. Of the 114 nests found, 99 were in no-till soybean fields with only 15 nests in tilled fields. Nest densities were significantly greater in no-till fields than tilled fields. The most common nesting species were American Robins (*Turdus migratorius*), Mourning Doves (*Zenaida macroura*), and Vesper Sparrows (*Pooecetes gramineus*). Overall nest success estimated from daily survival rates was 18.2%. Predation was the main cause of nest failure, but 25.6% of all failures were caused by farm machinery. Variation in nest success was primarily explained by nest stage and date, and success did not differ between no-till and tilled fields. In summary, birds prefer no-till fields to tilled fields for nesting, but nest success did not differ between tilled and no-till fields. While the nesting success of birds is low in row crops, the large amount of acreage in row crops dictates that we understand its contribution to the population of certain species.

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GENERAL INTRODUCTION

Bird Use of Agricultural Areas

Approximately 50 bird species have been observed using agricultural fields in the Midwest during the breeding season - most for foraging and only 8 for nesting (Best et al., 1995). Bird communities in agricultural fields are similar to those of grasslands, but the number of nesting species is much greater in grasslands (Best et al., 1995). Nonetheless, most grassland bird species occur rarely in agricultural fields, have relatively small abundances compared to less disturbed habitats, and are not using agricultural fields exclusively (Best et al., 1995). Vegetation cover and height (crops or weeds) appear to determine the number and diversity of birds in these fields. These vegetation characteristics vary with season, crop type, and most importantly for the purposes of this study, tillage practices, thereby impacting bird diversity and abundance (Flickinger and Pendleton, 1994). Despite some benefits of certain farming practices, global agricultural intensification has decreased available habitat for birds (Tilman et al., 2001), and increased bird densities in certain field types may not reflect that these sites are of high quality (Van Horne, 1983; Vickery et al., 1992).

Bird Nesting in Till and No-till Fields

Although agricultural fields are limited in their ability to provide bird habitat relative to restored grasslands, no-till cropping practices may be comparably favorable to traditional cropping practices. No-till practices are most commonly implemented with soybeans. Approximately 70 million acres were planted to soybeans in the United States in 2007 (CTIC, 2010), 25% of which were planted under a no-tillage regime. Fifty percent of the soybeans planted in Illinois are under a no-till regime (CTIC, 2010). If no-till soybean fields contribute habitat for reproduction, this practice may help mitigate the long-term decline of grassland birds in North America (Herkert, 1991).

Because tillage practices play a role in affecting vegetation structure of fields and therefore bird communities, and because I am trying to address questions specifically about nesting success, an explicit comparison of nesting success in no-till and tilled fields must be made. Birds have been found nesting in greater densities in no-till fields versus tilled fields in the Prairie Potholes (Lokemoen and Beiser, 1997). Nevertheless, cropping systems of the Great Plains are different from those of the Midwest. An explicit comparison of no-till and tilled fields of Iowa was conducted by Basore et al. (1986). They found that the number of nesting species and nests found in various types of agricultural fields differed, with greater species diversity and nest density in no-till fields. Four times as many nesting species and five times as many nests were found in no-tilled fields compared to tilled fields. Still, debate remains as to whether the nest success in no-till fields is enough to sustain viable bird populations (Rodenhouse and Best, 1983; Basore et al., 1986; Best, 1986).

Documenting the nesting success of birds in fields under different tillage regimes is the first hurdle in understanding the effects of different types of agricultural fields to breeding birds, but it is necessary that we also understand the factors leading to either poor or high nesting success. Several factors could directly impact nest density and success in agricultural fields, including vegetation structure (Wray and Whitmore, 1979) and anthropogenic disturbance (Rodenhouse and Best, 1983). Nests found in fields with more residue are generally more successful owing to better concealment and protection from predators (Basore et al., 1986). Despite differences in vegetation structure and the amount of anthropogenic disturbance, nest success rates are similar between Conservation Reserve Program (CRP, 18.0%) and cropland habitats (14.0%), with success in CRP fields being slightly higher (Koford, 1999; Lokemoen and Beiser, 1997). Therefore investigating nesting success in crops still deserves attention, especially as cropping practices continue to change (Johnson et al., 2011).

Anthropogenic disturbance, through tillage and planting activity, could potentially truncate the amount of time needed for birds to nest successfully, resulting in these agricultural fields being ecological traps for birds (Best, 1986). Fields with residue are attractive to certain bird species, causing them to choose these sites for nests. If farmers enter fields to conduct a tillage practice or apply herbicides, nests could be destroyed by mechanical disturbance. Depending on when this disturbance occurs during the breeding season, birds may not be able to produce another clutch after nest loss. Consequently, these fields could be ecological traps, particularly if no-till fields attract birds away from more suitable areas.

Study Significance

Midwest landscapes are dominated by agriculture. In the Midwest and globally, intensive agriculture has adversely impacted bird populations. The effects of alternative agricultural practices on birds are therefore an important conservation issue. The implications of alternative agricultural practices for birds are potentially promising, but fundamental questions remain. The main questions I will address include differences in avian communities, nest density, and nest success between no-till and tilled soybean fields. I will also address the overall suitability of soybean fields for bird nesting and production. My research will contribute to the pressing need to understand how birds are using working landscapes and how current farming practices provide benefits.

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INTRODUCTION

Declines in the diversity and abundance of wildlife have followed intensification of agriculture and homogenization of habitat (Askins, 1993; Peterjohn and Sauer, 1999; Benton et al., 2003). While these effects have been observed in South America (Schrag et al., 2009) and Europe (Donald et al., 2001), declines of birds in the Midwestern United States have been dramatic due to intensive row cropping (Wooley et al., 1985; Warner and Havera, 1989; Warner, 1994). Notwithstanding, alternative cropping practices, such as no-till practices, in the Midwest and other regions may have less negative effects on bird populations and communities relative to more intense tillage practices (i.e. conventional tillage).

Whereas the primary driver for no-till practices is soil and water conservation and associated economic benefits (Van Ouwerkerk, 1985; Cannell and Hawes, 1994), a secondary benefit may be for bird habitat. Bird surveys in Europe have shown that broad scale changes in farming practices (i.e. enrollment areas for a targeted management practice such as crop stubble) can increase farmland bird populations (Doxa et al., 2010; Baker et al., 2012). One agricultural practice that may benefit birds is no-till management. No-till fields generally have greater abundance, species richness, and nesting densities of birds than tilled fields, (Castrale, 1985; Walk et al., 2010a; Basore et al., 1986). No-till management likely increases food resources and cover within row crop fields (Castrale, 1985), making them more attractive to birds (Flickinger and Pendleton, 1994). While nest densities are greater in no-till fields, they are relatively low compared to nearby grassland habitat (Basore et al., 1986), and nest failure due to farm machinery could result in no-till fields being ecological traps (Best, 1986).

No-till has experienced a steady increase across the United States since the 1980s, with increases in use estimated at 1.5% per year since 2005 (USDA-ERS, 2010). Over the last several decades, no-till management of soybeans has increased dramatically due to the development of *RoundUp Ready* crop varieties (CTIC, 2010). Up to 50% of soybeans in Illinois are planted under no-till, with even higher proportions in other Midwestern states (CTIC, 2010). Despite continued increase of no-till and over 245 million acres of row crops in the United States, there is only one study in the past 25 years that has investigated the role of corn and soybean no-till fields in the nest density and success of birds (Basore et al., 1986). At the same time no-till has increased, agriculture practices have become "cleaner," resulting in agricultural areas becoming less appealing for birds (Warner, 2005).

Furthermore, the landscape composition of Midwestern states such as Illinois has become increasingly simplified (Warner, 1990). The landscape context of fields also affects bird abundance and diversity in row crops (Best et al., 2001) but has not been examined as a factor in nest density or success. Therefore understanding how birds are impacted by not just no-till, but row crops in general as they are the predominant land cover in the Midwest is a pressing research need (Johnson et al., 2011). In order to develop sound conservation strategies we must also understand how nesting success of birds in row crop fields compares to other habitats in the region.

I compared bird communities, nest density, and nesting success of birds in tilled and no-till soybean fields. Despite significant changes in agricultural practices over the last 25 years (cropping intensity, herbicide applications, etc.), I still expected that no-till fields would have higher diversity, density, and nesting success than tilled fields. I also compared the nest success results with reported nesting success of birds in grasslands embedded within landscapes dominated by row crops and discuss broadly how soybean fields, particularly no-till fields, may contribute to bird conservation in agricultural landscapes.

METHODS

Study Area

I conducted my field work in soybean fields located in two counties of East-Central Illinois, McLean and Champaign, from 2011-2012 (Figure 1). Both areas are dominated by corn (*Zea mays*) and soybean (*Glycine max*) I selected 12 sites each year, 6 no-till sites and 6 tilled sites, for a total of 24 sites over the course of the study. Average site size for no-till fields was 20.9 ha (SD 7.5 ha, range 9.2-32.0 ha) and 18.0 ha (SD 5.6 ha, range 14.0-32.0 ha) for tilled fields. Land cover in both areas contained over 85% cultivated land, with less than 5% land cover consisting of forest, wetlands, and grasslands combined (USDA NASS, 2012). In order to address questions related to landscape composition and their effects on nesting activity, 3 no-till and 3 tilled sites were selected in each "landscape" each year; McLean County was considered a "grassland" landscape and Champaign County was considered an "intensive agriculture" landscape. Study sites in McLean County contained more topography, fencerows, wood lots, and restored grassland by means of State Acres for Wildlife Enhancement (SAFE), a specific type of Conservation Reserve Program enrollment, than Champaign County.

Tillage Practices

Soybeans were planted into corn stubble each year regardless of tillage practice. "Tilled sites" were generally under conservation tillage practices meaning a minimum of 30% residue from the previous crop year was left on the soil surface at the time of planting. Fields were tilled with chisel plows in fall, spring, or both. Tilled fields were often leveled with a cultipacker to smooth the soil surface, but the degree in which this practice was applied varied according to farmer preferences. "No-till" sites received no tillage activity, and soybeans were directly drilled into the soil surface between rows of standing corn stubble. Row width of sites varied between 8 cm to 30 cm. Planting occurred May 10th - June 10th in 2011, and May 5th - May 25th in 2012. The only field activity observed after planting were applications of a non-selective herbicide, glyphosate.

Avian Communities and Density

I surveyed bird densities on all sites by traversing fixed-width line transects (Buckland et al. 2001). Transects were created in ArcMap (ArcMap for Windows, version 10.0; ESRI, Redlands, California) and overlaid on aerial photos of the site. The number and length of transects per site was based on the size and shape of the field. The range in the number of transects per site was 1-3, while the length of transects varied from 250 - 700 m. I counted birds that were seen or heard perched within 50 m of transect lines. I estimated the perpendicular distance to the transect for each bird. Surveys were conducted between sunrise and approximately 1000 h when songbirds are most active. Six surveys were conducted at each site between May 10th and July 10th during both 2011 and 2012.

Locating and Monitoring Nests

I systematically searched for nests from mid-April to mid-July. Two to four observers walked approximately 10 m apart parallel to crop rows until the field was completely traversed. No-till fields were searched on a weekly basis and tilled fields on a bi-weekly basis, but nest searching effort was accounted for in order to adequately estimate nest densities. Nests were most often located by flushing incubating females or by observing birds that were carrying nesting material or food for nestlings. Nests of all species were monitored and marked with utility flags placed a minimum of 10 m from the nest. Locations were marked using a GPS (Garmin eTrex). Nest contents were checked every 1-4 days until they failed or fledged at least one chick. I classified nests as failed or successful by incorporating nest site characteristics such as nest disturbance, fledgling presence, nestling age at the previous visit, and evidence of farming practices (tire tracks, vegetation disturbance). Brown-headed cowbirds (*Molothrus ater*), a passerine that parasitizes nests by laying their eggs in a host nest, parasitized nests in my study area. Because I was interested in whether a nest could escape predation and farming induced failure, a nest that only fledged a cowbird was considered successful.

Statistical Analyses

Program Distance 6.0 v 2.0 (Thomas et al., 2010) was used to estimate bird densities for each treatment (no-till and tilled). Few detections per species were recorded, so I combined all species to determine detection probabilities and densities. Density estimates for no-till and tilled sites were compared and considered significantly different if the 95% confidence intervals of bird density for no-till and till did not overlap. The following key functions and series expansions were examined: uniform cosine, uniform simple polynomial, half-normal cosine, half normal hermite polynomial, and hazard-rate cosine. The best fit model for both no-till and tilled bird densities was uniform simple polynomial. I compared the presence/absence of the 10 most common bird species in my sites via principal components analysis (PCA; NCSS, 2007 Release, Kaysville, Utah) to summarize factors that best explained variation in bird community composition between no-till and tilled sites. The PCA factor scores were then analyzed with a two-sample Hotellings t^2 test (NCSS, 2007 Release, Kaysville, Utah) to formally test differences between species presence/absence of no-till and tilled sites.

Nest densities were adjusted for search effort because nest searching effort was not equal within and between years. To account for the amount of search effort applied in each field over the course of the season, I calculated the average density of nests per 100 ha walked based on the number of times a field was searched each season. A balanced, two-way ANOVA was used to compare nest densities between treatment and year and to investigate the interaction between treatment and year. The majority of nests were found early in their nesting cycle (i.e. laying and incubation stages), so I felt confident that I was finding a high percentage of nests once they were initiated. I also assumed equal nest detectability between no-till and tilled sites. I used Fischer's Exact Test to test the difference between nesting phenology of no-till and tilled fields. Specifically I tested whether nests were more likely to be initiated by the time soybean planting occurred in tilled vs. no-tilled fields (i.e. before or after May 31st, the date by which nearly all sites were planted). Nest initiation dates were estimated with similar methods to that of Cox et al. (2012) except for nests that were found after hatching; nests were randomly assigned an age between the minimum age possible based on incubation length plus the number of days the nest was monitored and the mean nest cycle length.

Apparent nest survival generally overestimates nest success, and not all nests were found during the same stage. Therefore I estimated daily survival rates (DSR) by using the logistic-exposure method in SAS PROC GENMOD (SAS for Windows, version 9.3; SAS Institute, Cary, North Carolina; Shaffer, 2004). An information theoretic approach was used to explore the importance of factors that may affect overall nest survival in soybeans, including temporal effects: nest stage (incubation, nestling), date (Julian), quadratic effect of date ($date^2$; Grant et al., 2005), and year, and habitat related effects: landscape, and distance to edge. *A priori* combinations of these effects were modeled based on biological questions, (e.g. differences in survival between years could be further affected by the nest location in terms of landscape). Distance to edge was measured in ArcMap and included the closest linear distance to a change in cover type, including a change in crop type. The main investigation of differences in survival between no-till and tilled sites entailed modeling treatment as a covariate. Quadratic effect of day of year better described nest survival than a linear term, so the quadratic effect was retained for all subsequent models.

I conducted an analysis of nest survival to examine factors that affect overall nest survival in soybeans. Because of low sample sizes for most species, I combined all species for the overall nest survival analysis. I also conducted an analysis for each source of nest loss (predation/abandonment, farming). This approach allowed me to examine factors affecting a specific type of nest loss. I established twelve candidate models for the overall survival analysis, including a constant-survival model, and models with combinations of possible sources of variation of nesting success (Table 1a). Treatment was excluded from analyses examining specific failure types because too few nests were found in tilled fields to run the analysis. I calculated daily failure rates (the inverse of daily survival) for analyses of specific failure types. I ranked candidate models using Akaike's information criterion adjusted for small sample sizes (AICc) and model weights (w_i; Burnham and Anderson, 2002). I present DSR estimates as a model-averaged estimate by using observed mean values for continuous variables and proportional values for categorical variables (Shaffer and Thompson, 2007).

RESULTS

Avian Communities and Density

There was no difference in the avian community between no-till and tilled fields (P= 0.16; Table 2), but bird densities were greater in no-till fields (2.3 birds/ha no-till, 95% CI 1.8 – 3.0, n = 12) than tilled fields (1.1 birds/ha tilled, 95% CI 0.7 – 1.5, n = 12). The most common species occupying soybeans were American Robin (*Turdus migratorius*), Common Grackle (*Quiscalus quiscula*), Red-winged Blackbird (*Agelaius phoeniceus*), and Vesper Sparrow (*Pooecetes gramineus*).

Nest Density

Two hundred and sixteen ha of tilled and 209 ha of no-till soybeans were searched for bird nests. To provide some context of search effort, an individual searcher walked approximately 3,200 km searching for nests over the course of the study. I found and monitored 114 nests (n = 60, 2011; n = 54, 2012). Nest densities, based on search effort, were higher in no-till soybean fields (4.5 nests/100 ha ± 0.58, n = 12) than tilled (1.6 nests/100ha ± 0.58, n = 12; P ≤ 0.01; Figure 2). There was an interaction between treatment and year (P = 0.04); The difference in nest density between no-till and tilled fields was approximately five-times lower in 2012 than 2011.

The most common nesting species overall were American Robin (n = 35), Vesper Sparrow (n = 27), and Mourning Dove (*Zenaida macroura*) (n = 22). Twelve species nested in no-till versus six species in tilled fields (Table 3). American Robins were the most common nesting species in both no-till and tilled fields. In no-till fields, Mourning Doves were the third most common nesting species, but no nests of this species were found in tilled fields. Horned

Larks (*Eremophila alpestris*) were only found nesting in tilled fields, while Mourning Doves, Brown Thrashers (*Toxostoma rufum*), Eastern Meadowlarks (*Sturnella magna*), Field Sparrows (*Spizella pusilla*), Upland Sandpipers (*Bartramia longicauda*), and Ring-necked Pheasants (*Phasianus colchicus*) were only found in no-till fields. A greater percentage of nests in no-tilled fields (68.7%, 68/99) were found before May 31st (the date by which nearly all fields had been planted) compared to tilled fields (33.3%, 5/15; P = 0.01; Figure 3).

Sixty-three nests (n = 6 tilled, n = 57 no-till) were found in the grassland landscape and 51 nests (n = 9 tilled, n = 42 no-till) in the intensive agriculture landscape. Brown Thrasher, Eastern Meadowlark, Field Sparrow, and Upland Sandpiper were only found nesting in the grassland landscape, while Dickcissel (*Spiza americana*) and Ring-necked Pheasant were only found nesting in the intensive agriculture landscape.

Nest Survival

Of the 114 nests monitored (1,177 exposure days), 28 (24.6%) fledged at least one chick. Of the 86 nests that failed, 65.1% (n = 56) were due to predation, 24.4% (n = 21) to farm machinery, and 10.5% (n = 9) to abandonment. All nests that failed due to farm machinery failed when farmers were planting. Nests were 6.6 times more likely to fail due to predation than farming practices.

The best predictor of overall nest survival was nest stage (Table 1a). Despite stage receiving the most statistical support, the 95% confidence intervals of the model-averaged parameter estimates for stage both overlapped zero. Therefore inferring biological meaning from this result is difficult. Little support was found for differences in survival between no-till and tilled fields. The DSR for tilled fields was 0.91 (95% CI 0.85 - 0.95) and 0.93 for no-till fields

(95% CI 0.91- 0.94). Date^2 was also a highly supported predictor of nest survival; survival increased slightly throughout the nesting season (Figure 4a). Little evidence was found for the effects of landscape, year, or distance to edge on daily survival. The DSR estimate, model averaged across all models, was 0.93 (95% CI: 0.91 - 0.94). Using a nesting length of 23.5 days (the average for species in this study), the estimated overall nest success rate was 18.2%. As a result of there being little support for differences between no-till and tilled fields, I combined all nests for further investigation of factors associated with failure due to predation (Table 1b) and farm machinery (Table 1c).

For nests that failed due to predation, nest stage was again the most supported predictor of nest survival, but the 95% confidence interval of the model-averaged parameter estimates for stage both overlapped zero. Constant survival was also highly supported. Distance to edge and year were not well supported predictors of nest survival but were more supported than the effect of landscape or date^2. In contrast, the models for the analysis of nests that failed due to farming practices indicated strong effects of date^2 (Figure 4b), year, and landscape.

DISCUSSION

Despite greater bird densities in no-till fields, I found no differences in avian communities between tilled and no-till fields. Similar to the only other study of nest success in soybean fields (Basore et al., 1986), very few nests were found in tilled fields relative to no-till fields. No difference in nest survival between no-till and tilled fields was detected.

Nest Survival

The candidate models for nest survival revealed few strong predictors of nest survival. Low support for the top models (w_i of all top models was less than 0.50) is likely related to the pooling of species in the survival analysis. Combining species was needed in order to statistically explore predictors of nest success, but species in this study differed in terms of life history traits (i.e. length of incubation and nestling stages varied between species). Despite stage being the most supported predictor of nest success, it is likely not biologically significant given the initial pooling of species. $Date^2$ was relatively well supported for the analysis of nest loss due to farming, which can be explained by all farming failure occurring during the narrow window of time in which planting occurs. Additionally, constant survival was relatively well supported for both the overall survival and predation/abandonment analysis, suggesting that daily nest survival in soybeans did not vary between no-till and tilled sites, the landscape in which sites were located, or by distance to edge. Constant survival may also suggest that daily nest survival is random. Alternatively, significant or consistent predictors of nest success may not have been measured in our study or were obscured by different pressures of predator species (Benson et al., 2010).

Predation and farming practices were the leading causes of nest failure, respectively. While the additional tillage activity associated with tilled fields might be expected to result in greater nest failure due to farming, tillage activity was performed before initial nesting activity. Therefore birds nesting in tilled fields were not exposed to additional mechanical disturbance. No-till practices involve less mechanical disturbance, causing the presence of early-season cover in the form of crop residue and weeds which attract birds to a site. While 66.7% of nests in tilled fields were initiated after May 31st, eliminating the likelihood that farming practices would destroy the nest, the majority of nests in no-till were initiated before planting (Figure 3). Therefore the presence of cover in no-till fields before planting could result in reduced nest success in no-till fields, creating the potential for an ecological trap (Best, 1986).

Although birds nesting in no-till fields could experience reduced success because of planting, nest survival in soybeans follows the same survival patterns of other studies of nesting success in agricultural landscapes of Illinois and the Midwest (Robinson et al., 1995; Brawn and Robinson, 1996), that being nest survival is very low and driven by nest predation. Because agricultural landscapes are often composed of row crops and small grasslands, I compared the nest survival estimates to those of grasslands embedded in agriculture in Illinois and Iowa. The nest survival estimate for all nests in soybeans was 18.2%, which is within the range (5.4-38.0%) of several other studies in agricultural landscapes (Table 4). Although some nests are lost to farm machinery in my study, predation is likely driving nest survival patterns. The deployment of cameras in the study area identified coyotes (*Canis latrans*) and thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) as nest predators (Table A.1). These species have also been documented depredating nests in grasslands (Renfrew and Ribic, 2003), and it is likely that predators in my sites also depredated nests in nearby grasslands.

While only 18.4% (21/114) of nests were lost to farm machinery, if soybean planting could be delayed until early June, undisturbed vegetation would remain available earlier in the nesting season, coinciding with the time period that birds appear to be nesting in soybean fields most frequently. Delayed planting may also increase the survival of a first brood, allowing birds with active nests sufficient time to complete their nesting cycle. In Illinois, soybean yields have been found to decrease by 0.5 bushels per acre for every day soybean planting is delayed in early June (Emerson, 2012). On average, nests that were destroyed by planting required 11.4 additional days to complete their nesting cycle; all nests that were destroyed would have finished their nesting cycle by June 1st. A similar strategy of delaying certain farming practices while providing monetary incentives increased nest success of grassland birds in Northeastern U.S. haylands (Perlut et al., 2011). Alternatively, earlier planting would not only increase nest failure, but decrease the amount of time available for birds to nest in early season cover.

Nest and avian densities

Greater nest densities were found in no-till fields than tilled fields (Figure 2). Interestingly, the uncorrected density of nests reported by Basore et al. (1986) and this study are very similar (4.0 vs 7.6 nests/100 ha in tilled fields and 36.0 vs. 41.7 nests/100 ha in no-till fields). This difference was diminished in 2012, illustrated by the interaction between nest year and treatment. This interaction likely relates to the extreme drought experienced in 2012. No-till fields can become highly compacted during extreme drought, limiting invertebrate availability (Schrader and Lingnau, 1997). Therefore, if we assume that bird use of row crops is related to increased food resources, the relative benefit of no-till to birds during drought may be lessened. The drought also affected species composition of nesting birds. Whereas in 2011 American

Robins were the most common species, Vesper Sparrows were the most common in 2012. Food and nest resource limitations during drought, particularly earthworms and mud for nest building in the case of American Robins, could be causing the observed difference.

Bird densities were greater in no-till compared with tilled fields, a result that is consistent with other studies (Castrale, 1985; Walk et al., 2010a). Unlike previous studies, avian communities did not differ between no-till and tilled fields. The presence of habitat patches near row crops can affect the species composition of birds utilizing agricultural fields (Best et al., 2001). Increased homogeneity through loss of natural habitat patches in the landscape surrounding my sites could further simplify bird communities compared to previous studies. For example, Upland Sandpipers were only detected in the grassland landscape in which more heterogeneous cover surrounded sites. Differences in landscape composition likely explain why certain species, such as Upland Sandpiper, were only found nesting in the grassland landscape. Further research is necessary to understand whether more heterogeneous landscapes translate to more birds utilizing row crops for nesting.

Conservation Implications

Row crops will continue to dominate landscapes in the Midwest and in many areas around the world. Therefore it is important to understand what farming practices could potentially benefit birds in terms of increased nesting opportunities. While no-till is not a substitute for natural habitat, it provides more benefits to birds than tilled fields. Although nest survival is low, other habitats in Illinois also have high nest predation rates. If you apply the raw nest densities found in this study and extrapolate them to the amount of soybean acreage in Illinois, approximately 750,000 nests may be in no-till fields per year compared to 139,000 in tilled fields per year. If all soybean acreage in Illinois was tilled, many fewer nests (~279,000) may be found in soybeans. To provide additional context, approximately 1.13 million hectares of grassland, including working grasslands such as hay and pasture, exist in Illinois. Nest densities must be at least two times greater in grasslands in order to exceed the number of potential nests in no-till soybeans. Although a low percentage of nests in soybeans are successful, the prevalence of no-till row crops as compared to other natural habitats suggests that for some species specializing in arable lands (i.e. Vesper Sparrows), a large percentage of young are being produced in row crop fields. The sheer acreage of no-till row crops dictates that for certain species of conservation concern in the Midwest (ex. Dickcissel, Upland Sandpiper), we must understand both positive and negative effects of tillage practices and account for these effects when developing management plans for birds in agricultural landscapes.

SUMMARY

Given the large extent of agricultural lands in the Midwest and North America, understanding how farming practices affect breeding birds should be an important aspect of future management. No-till practices have been shown to increase avian diversity and nest density (Castrale, 1985; Walk et al., 2010a, Basore et al., 1986), but agricultural landscapes have changed dramatically since the publication of these studies. My research shows the benefits of no-till in terms of increased bird and nest density. Higher densities of birds were found in no-till compared to tilled fields, but no differences in avian community composition were found. In general, I found few strong predictors of nest survival, suggesting that nest survival in soybeans is either highly random, or that consistent predictors of nest success were not measured in my study or were obscured by different pressures of predator species (Benson et al., 2010). Predation was the leading cause of nest failure. Farming practices, namely planting, was the primary cause of mortality early in the nesting season. Based on daily survival rates, overall nest success was 18.2%.

Despite low nest survival, the extensive acreage of no-till dictates the need to understand how certain species, especially those of conservation need or that are agricultural specialists, are using row crop fields as breeding habitat in the Midwest. Understanding how no-till fields and row crops in general are contributing or adding to declines of regional bird populations remains a critical research need (Johnson et al., 2011) in addition to how wildlife-friendly farming practices can be integrated with working lands (Fischer et al., 2008). I have shown that no-till does provide benefits to breeding birds relative to tilled fields, but these benefits are contingent on the future direction of farming practices in terms of the presence of no-till on the landscape, its juxtaposition with natural habitat, and the timing of crop planting

TABLES AND FIGURES

Table 1. Ranking of models for (a) nest survival of all nests, (b) analysis for nests that failed due to predation and abandonment, and (c) nest analysis for nests that failed due to farming in East-Central Illinois, 2011-2012. Predictors included nest stage, the quadratic effect of date ($date^2$), treatment (no-till or till), distance to edge (linear distance measured to closest change in cover type), year, and landscape (grassland or intensive agriculture).

(a)

Model	-2logL	K	ΔAIC_c	w_i
Stage	455.6	2	0.00	0.440
$Date^2$	455.9	3	2.33	0.137
Constant survival	460.7	1	3.14	0.092
Treatment * $Date^2$	452.9	5	3.39	0.081
Distance to edge	459.8	2	4.27	0.052
Year + $Date^2$	455.9	4	4.34	0.050
Treatment	460.4	2	4.81	0.040
Year	460.7	2	5.13	0.034
Landscape	460.7	2	5.13	0.034
Year+ $Date^2$+Landscape	455.7	5	6.13	0.020
Distance to Edge+Landscape	459.8	3	6.20	0.020

(b)

Model	-2logL	K	ΔAIC_c	w_i
Stage	381.7	2	0.00	0.390
Constant survival	386.1	1	2.33	0.121
Distance to edge	384.3	2	2.55	0.109
Year	384.5	2	2.79	0.096
Distance to Edge+Landscape	382.6	3	2.90	0.092
$Date^2$	383.1	3	3.44	0.070
Landscape	385.7	2	3.95	0.054
Year+ $Date^2$	381.8	4	4.11	0.050
Year+ $Date^2$+ Landscape	381.7	5	6.03	0.019

(c)

Model	-2logL	K	ΔAIC_c	w_i
$Date^2$	144.4	3	0.00	0.443
Year+ $Date^2$	142.6	4	0.21	0.399
Year+ $Date^2$+ Landscape	142.5	5	2.07	0.158

Table 2. Ten most common species observed in fixed-width line transect surveys, presented in % of sites occupied in East-Central Illinois, 2011-2012. Birds that were heard or seen perched within 50 m of the transect were counted, and the perpendicular estimate to each bird was estimated in order to conduct distance analysis.

	% of sites Occupied	
	No-till	Till
American Robin (*Turdus migratorious*)	92	92
Common Grackle (*Quiscalus quiscula*)	100	75
Red-Winged Blackbird (*Agelaius phoeniceus*)	100	75
Vesper Sparrow (*Pooecetes gramineus*)	100	75
Brown-headed Cowbird (*Molothrus ater*)	83	83
Killdeer (*Charadrius vociferus*)	75	75
Horned Lark (*Eremophilia alpestris*)	42	75
Eastern Meadowlark (*Sturnella magna*)	58	42
Dickcissel (*Spiza americana*)	42	50
Mourning Dove (*Zenaida macroura*)	50	0

Table 3. Species composition of all nests found in (a) no-till and (b) tilled soybean fields in East-Central Illinois, 2011-2012. Number of successful nests includes any nest that fledged ≥1 chick.

(a)

Species	# of Nests Found	# of Successful Nests
American Robin (*Turdus migratorius*)	31	7
Vesper Sparrow (*Pooecetes gramineus*)	26	8
Mourning Dove (*Zenaida macroura*)	22	8
Red-winged Blackbird (*Agelaius phoeniceus*)	7	0
Killdeer (*Charadrius vociferus*)	4	2
Brown Thrasher (*Toxostoma rufum*)	4	0
Eastern Meadowlark (*Sturnella magna*)	2	0
Dickcissel (*Spiza americana*)	1	0
Ring-necked Pheasant (*Phasianus colchicus*)	1	0
Upland Sandpiper (*Bartramia longicauda*)	1	0
Field Sparrow (*Spizella pusilla*)	1	0
Totals	100	25

(b)

Species	# of Nests Found	# of Successful Nests
American Robin (*Turdus migratorius*)	4	2
Vesper Sparrow (*Pooecetes gramineus*)	1	0
Red-winged Blackbird (*Agelaius phoeniceus*)	4	0
Killdeer (*Charadrius vociferus*)	2	1
Horned Lark (*Eremophila alpestris*)	2	0
Dickcissel (*Spiza americana*)	1	0
Totals	14	3

Table 4. Nest survival estimates from other nesting studies in agricultural landscapes of Iowa and Illinois. Filter strips were defined as narrow, linear strips of grassland and shrub habitat along waterways. Grasslands were defined as larger, more contiguous patches of habitat.

State	Site Type	Species	Survival Estimate (Range)	Author
Iowa	Filter Strips	All Species	8.6-34.8%	Davros 2005
Iowa	Filter Strips	Red-Winged Blackbirds Dickcissels Common Yellowthroats Song Sparrows	9.6-15.6% 11.3% 5.4-24.7% 7.5-28.4%	Henningsen and Best 2005
Illinois	Filter Strips	Red-winged Blackbirds American Robin	8.0% 6.0%	Kammin 2003
Illinois	Grasslands	Dickcissels Meadowlarks	28.0-32.0% 29.0-38.0%	Walk et al. 2010b

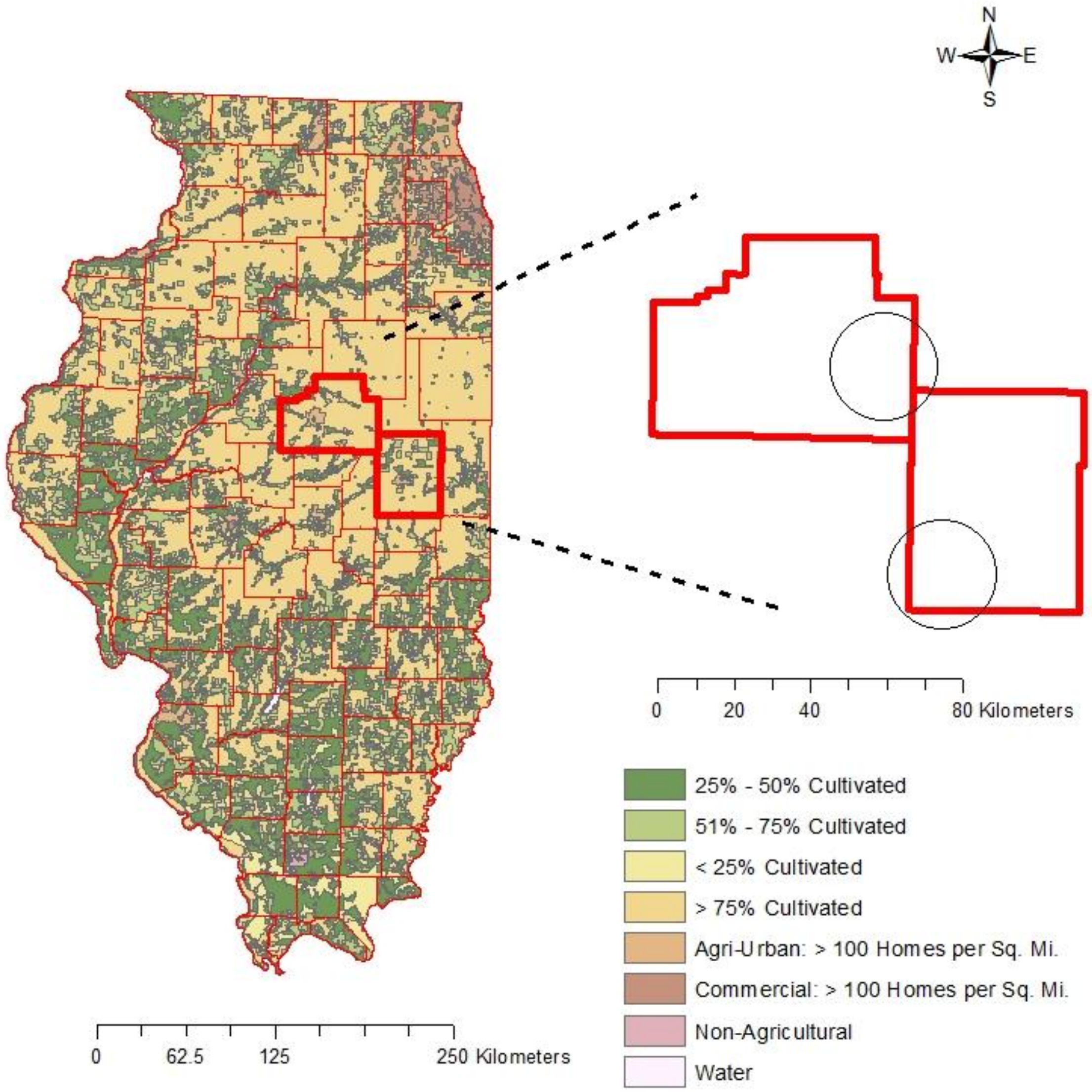


Figure 1. Land cover map of Illinois, including counties where study sites were located (McLean and Champaign) during the summers of 2011 and 2012. Circles indicate the general area where sites (no-till and till) were located in each county.

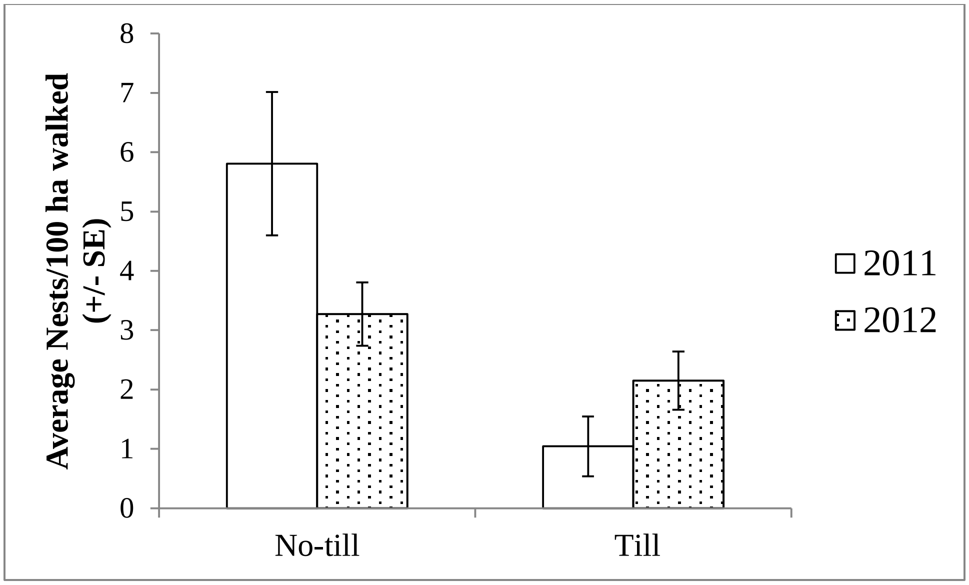


Figure 2. Average nest density (± SE) averaged across sites and based on search effort per site in no-till and tilled fields of East-Central Illinois, 2011-2012.

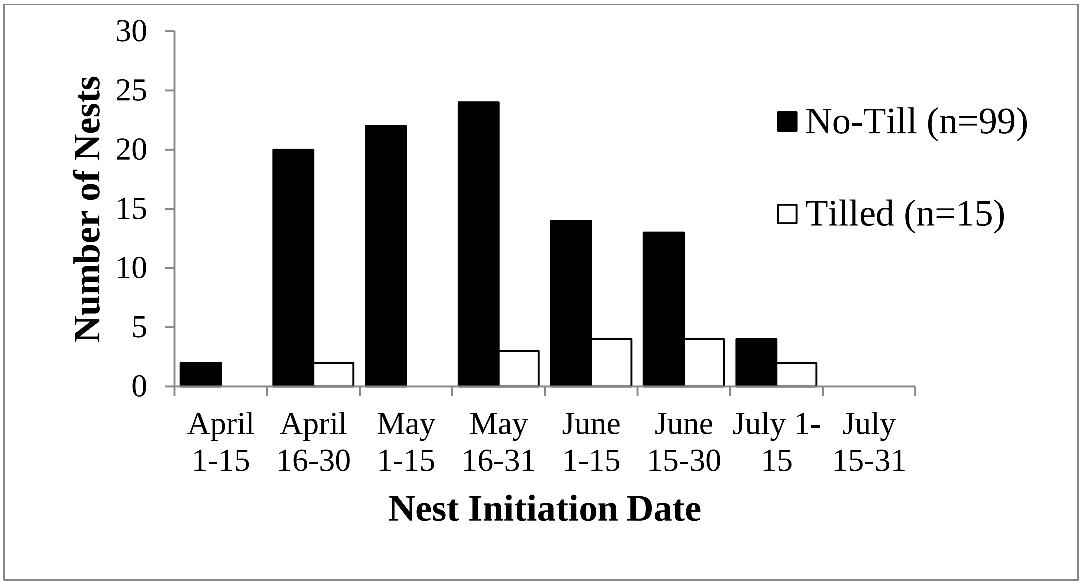
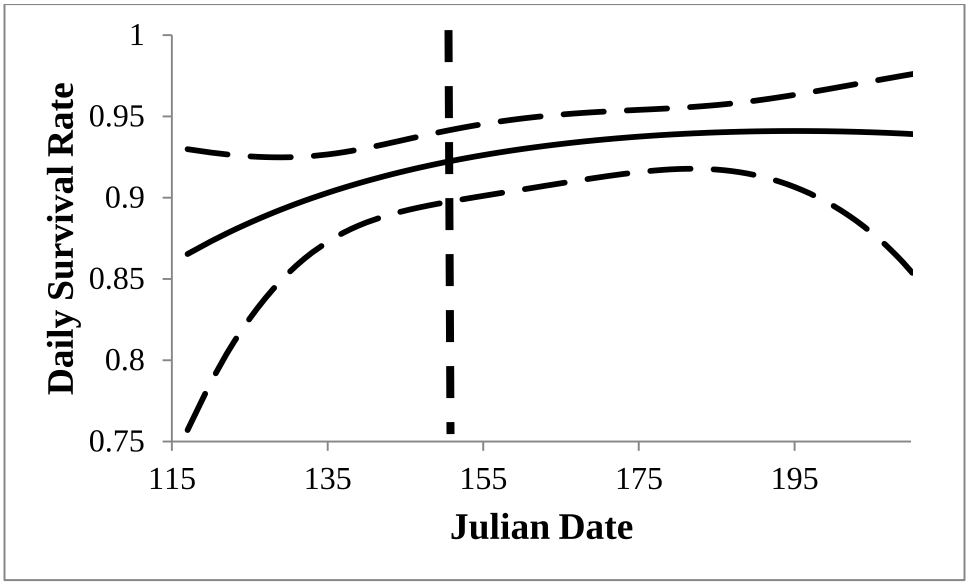


Figure 3. Number of nests initiated in relation to bi-monthly time periods in the nesting season for no-till and tilled sites in East-Central Illinois, 2011-2012.

(a)



(b)

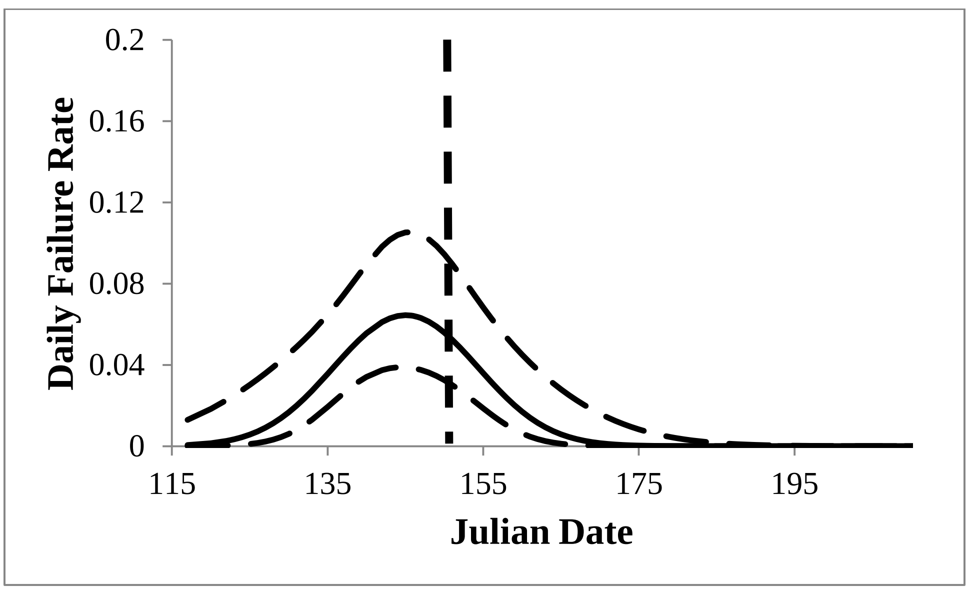


Figure 4. Daily survival rates across the breeding season of all nests (a), and daily failure rates of nests that failed due to farming (b), based on predicted values for models of the quadratic effect of date (±95% CI) in East-Central Illinois, 2011-2012. Dashed lines indicate May 31st, the date by which nearly all sites were planted.

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APPENDIX A: Camera Results

Table A.1 Predation events of bird nests recorded on camera in soybean fields of East-Central Illinois, 2011-2012. Time-lapse video cameras were placed opportunistically on nests throughout the nesting season. Recording systems included a security camera, DVR, and deep-cycle marine battery. All cameras were placed on nests in no-till fields. Cameras were placed a minimum 0.5 m from the nest and were supported by either corn stubble or a wooden dowel, and a container holding the battery and DVR was placed a minimum 15 m from the nest. A total of 15 nests had cameras at the nest site, but only 7 recorded predation events.

Year	Landscape	Species	Stage	Predator
2011	Grassland	Vesper Sparrow	Nestling	Coyote
2011	Intensive Ag	American Robin	Incubation	Coyote
2011	Intensive Ag	American Robin	Incubation	Thirteen-Lined Ground Squirrel
2011	Intensive Ag	Red-winged Blackbird	Nestling	Thirteen-Lined Ground Squirrel
2011	Intensive Ag	Mourning Dove	Incubation	Coyote
2011	Intensive Ag	Mourning Dove	Nestling	Coyote
2012	Intensive Ag	American Robin	Nestling	Coyote

APPENDIX B: Nest Productivity Measures

Table B.1 Productivity measures for all species of birds found nesting in soybean fields of East-Central Illinois, 2011-2012 (±SE (sample size)). Measures included clutch size of the host species, number of Brown-headed Cowbird (BHCO) eggs, brood size of the host species, number of BHCO nestlings, number of host species fledged, and number of BHCOs fledged. The parasitism rate only included nests that are known to be parasitized by Brown-headed Cowbirds: Vesper Sparrow (27), Red-winged Blackbird (11), Dickcissel (2), Eastern Meadowlark (2), Horned Lark (2), and Field Sparrow (1).

Species	Clutch Size (Host)	BHCO Eggs	Brood Size (Host)	# of BHCO Nestlings	Fledged (host)	Fledged (BHCO)
American Robin	3.3 ± 0.1 (32)	0	3.1 ± 0.3 (11)	0	2.5 ± 0.4 (8)	0
*Vesper Sparrow	2.8 ± 0.2 (26)	2.2 ± 0.3 (15)	2.1 ± 0.3 (13)	1.8 ± 0.3 (10)	1.2 ± 0.2 (5)	1.3 ± 0.2 (7)
Mourning Dove	2 ± 0 (22)	0	1.9 ± 0.1 (15)	0	1.8 ± 0.2 (8)	0
Red-winged Blackbird	3.3 ± 0.2 (10)	1 ± 0 (1)	2.8 ± 0.2 (4)	1 ± 0 (1)	0	0
Killdeer	3.5 ± 0.3 (6)	0	4 ± 0 (3)	0	4 ± 0 (3)	0
Brown Thrasher	3.8 ± 0.2 (4)	0	2 ± 0 (1)	0	0	0
Dickcissel	4 ± 0 (2)	2 ± 0 (1)	N/A	0	0	0
Eastern Meadowlark	3.5 ± 0.4 (2)	4 ± 0 (1)	4 ± 0 (1)	0	0	0
Horned Lark	5 ± 0 (1)	4 ± 0.7 (2)	0	0	0	0
Field Sparrow	N/A	0	0	0	0	0
Upland Sandpiper	4 ± 0 (1)	0	0	0	0	0
Ring-necked Pheasant	10 ± 0 (1)	0	0	0	0	0

Parasitism Rate: 20/45 nests (44%)

*Vesper Sparrow clutch size in this study was lower than other studies, possibly due to Brown-headed Cowbirds ejecting host eggs before the nest was found. The parasitism rate of Vesper Sparrow nests was 55.6% (15/27).