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Disturbance and Landscape Effects on Avian Nests in Agricultural Conservation Buffers

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ABSTRACT We studied the effects of periodic disturbance (prescribed burning and light disking) and landscape composition on nest density and success for grassland birds in agricultural conservation buffers in southeastern United States agroecosystems. During the 2007–2009 breeding seasons, we located 387 nests in buffers of a northeast Mississippi agroecosystem. Dickcissel (*Spiza americana*) and red-winged blackbird (*Agelaius phoeniceus*) were the most common nesting species. Time since disturbance influenced nest densities of dickcissels and red-winged blackbirds; densities were lesser during the first growing season post-disturbance but increased during the second growing season post-burn. Nest densities for both species were least in buffers adjacent to woodland. Inclusion of disturbance did not improve models of dickcissel and red-winged blackbird nest survival, suggesting that disturbance influenced nesting density, but not nesting outcomes. Amount of grassland surrounding dickcissel nests was positively associated with nest survival, but confidence intervals included zero indicating effects were not strong. Although distance to nearest crop or developed edge were included in competing models of red-winged blackbird nest survival, their effects were negligible. Agricultural conservation buffers will best serve breeding grassland bird populations if they are established in areas with minimal woodland cover, maximize total grassland in the landscape, and are maintained with prescribed burning. These results will help characterize the contribution of agricultural conservation buffers in agroecosystems of the southeastern United States. © 2013 The Wildlife Society.

KEY WORDS conservation buffers, disturbance, grassland birds, landscape composition, nest density, nest survival.

Habitat loss associated with agricultural conversion and intensification is the greatest threat to declining bird populations, particularly grassland birds (Green et al. 2005). Since the advent of industrialized agriculture, up to 99.9% of natural grassland ecosystems have been lost in some regions of North America (Samson and Knopf 1994). Grassland birds using these habitats may be at risk of increased nest predation and parasitism, increased interspecific competition, reduced abundance and diversity of insect prey, fewer breeding areas, and reduced pairing success (Winter and Faaborg 1999).

Conservation strategies for restoring bird populations in agricultural landscapes emphasize creation and maintenance of structurally and floristically diverse grasslands that support local and regional breeding grassland bird populations (Murphy 2003). Agricultural conservation buffer practices can add critical grassland components back into agricultural landscapes, thereby increasing the proportion of the landscape in natural communities while minimally influencing crop production systems (Lovell and Sullivan 2006). The United States Department of Agriculture's Conservation

Reserve Program (CRP) Conservation Practice 33 (CP33; Habitat Buffers for Upland Birds) was designed to provide grassland habitat for upland birds in working landscapes. Buffers enrolled in CP33 are 9.1–36.5 m wide and comprised of a mixture of native warm-season grasses and associated forbs planted along agricultural crop field margins, often adjacent to other crop field edge habitats like fencerows and drainage ditches (Smeding and Joenje 1999). Fields with CP33 buffers have been reported to support greater abundances of northern bobwhite (*Colinus virginianus*), dickcissel (*Spiza americana*), and field sparrow (*Spizella pusilla*) compared to fields without CP33 buffers (Smith et al. 2005; Evans et al. 2013*a*, *b*). Moreover, nest survival estimates reported for dickcissels and red-winged blackbirds (*Agelaius phoeniceus*) nesting in agricultural conservation buffers are within the range reported for native prairie and semi-natural grasslands (Conover et al. 2011*a*, *b*).

Planted grass communities, such as CP33 buffers, change through ecological succession so must be actively managed to retain early-successional attributes (McCoy et al. 2001, Burger et al. 2005). Indeed, lack of management in existing grasslands has exacerbated declines of grassland bird populations (Churchwell et al. 2008). In the absence of disturbance, herbaceous plantings succeed to shrubby and, ultimately, forested communities (Millenbah et al. 1996). Additionally, as planted grasslands mature, litter accumu-

lates, availability of bare ground declines, forb density diminishes, and habitat quality for many early-successional grassland birds declines (McCoy et al. 2001, Greenfield et al. 2003). In the southeastern United States, periodic disturbance, such as prescribed burning or light disking, enhances structural diversity, reduces vegetation density, and prevents woody plant encroachment, thereby maintaining habitat for grassland birds. Furthermore, development of a conservation plan of operation that defines a mid-contract management regime and schedule is required for all CRP contracts enrolled in CP33 (United States Department of Agriculture Farm Service Agency 2004).

Reproductive performance of grassland birds in CP33 buffers may be influenced by type of and time since disturbance, as well as the landscape context in which buffers occur (e.g., adjacent habitat or surrounding land cover). Conservation buffers likely provide the greatest benefits in landscapes where grasslands are most scarce or where buffers increase area of grassland above critical threshold levels (Batáry et al. 2010; Evans et al. 2013a, b). Buffers will provide conservation benefits for grassland birds if they are source habitats or if reproductive success exceeds that accrued in other available habitats (Smith et al. 2005).

Most research on conservation buffers has been conducted in agricultural systems of the midwestern United States, whereas little information exists from agricultural systems in the southeastern United States. Also, most previous work has focused on narrow strips along fencerows, waterways, and terraces with little investigation of wider buffers created specifically as grassland bird habitat (Clark and Reeder 2005). Although the influence of early-successional plantings on birds has been studied (Conover et al. 2011b), the effects of periodic disturbance on breeding grassland birds has not been evaluated. Thus, our goal was to determine how periodic disturbance and landscape composition influence nest density and success of breeding grassland birds in agricultural conservation buffers created specifically for avian habitat in agroecosystems of the southeastern United States. Results from this study will assist land managers with designing conservation practice enrollments and management regimes to optimize producers' wildlife conservation goals while minimally affecting crop production.

STUDY AREA

We conducted our research on a 2,104-ha, privately owned farm in northeast Mississippi (USA) that included a 587-ha cattle operation and 486 ha in rowcrop production. In spring 2005, 79 ha that met cropping history requirements for continuous CRP were enrolled in CP33. Buffers of 18.2 m or 36.5 m in width were established around the entire margin of 14 crop fields and planted with a mixture of native warm-season grasses (big bluestem [*Andropogon gerardii*]; little bluestem [*Schizachyrium scoparium*]; indiangrass [*Sorghastrum nutans*]), and forbs (partridge pea [*Chamaecrista fasciculata*]; black-eyed susan [*Rudbeckia hirta*]; Maximillian sunflower [*Helianthus maximiliani*]).

METHODS

We randomly assigned each crop field enrolled in CP33 to 1 of 3 disturbance regimes: 1) light disking in the fall (Sep–Oct), 2) prescribed burning in the spring (Mar–Apr), and 3) no management (control; Fig. 1). Planted crops included corn, soybean, sorghum, or Bermuda grass established for cattle forage. The area included 51 conservation buffers (field edges); we randomly assigned 19 to prescribed burning, 17 to light disking, and 15 as controls. Within disk and burn treatments, we randomly chose 1 buffer per field for disturbance the first year, and then 1 adjacent buffer was disturbed in subsequent years. To continually provide cover for wildlife throughout the year, only 1 buffer per field was disturbed each year. Data collected during the 2007 growing season provided pre-disturbance information. We documented vegetation and avian responses to disturbance during the first (2008 and 2009) and second (2009 only) growing seasons post-disturbance.

During the 2007–2009 breeding seasons (May–early Aug), we systematically searched buffers every 2 weeks (6 times during each breeding season) to locate nests. We monitored located nests every 3 days to determine nest fate, taking irregular, inconsistent paths leading to nests to minimize disturbance and prevent predators from easily locating them.
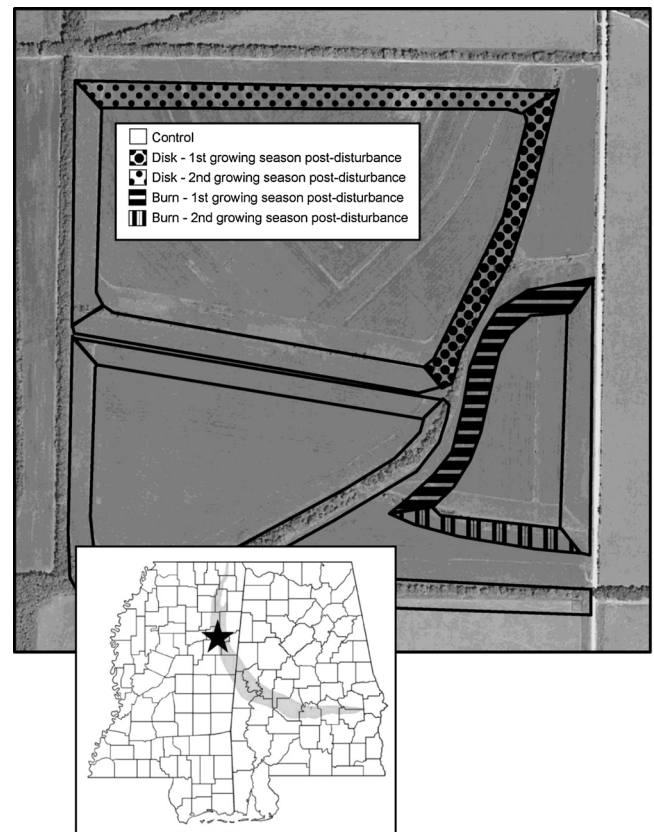

Figure 1. Experimental design for spring burning and fall light disking treatments. Undisturbed buffers are merely outlined. Shaded area on inset map describes historical range of Blackland Prairie in Mississippi and Alabama (USA). Star indicates general location of the grassland bird study area, 2007–2009.

A nest was considered successful if it fledged at least 1 chick, whereas a nest was considered unsuccessful if it was depredated or abandoned prior to hatching or fledging.

After fledging or failure, we revisited each nest to collect site-specific characteristics. We estimated mean percent ground coverage within a 0.25-m^2 area at cardinal points around a nest (i.e., north, south, east, and west). We estimated mean height of surrounding vegetation using visual obstruction measurements at the cardinal points around a nest (Robel et al. 1970). We recorded nest height and the plant species in which the nest was built.

To quantify landscape composition, we created a geographic information system (GIS) land cover of the study area using ArcGIS (Environmental Systems Research Institute, Inc., Redlands, CA). Based on photo interpretation of 2007 color infrared aerial imagery at 1.5-m^2 resolution acquired from the 2007 National Agricultural Imagery Program (United States Department of Agriculture, Natural Resource Conservation Service 2011), as well as on-site land cover verification, we classified land cover as 1 of 4 types: cropland, grassland, developed area (e.g., residential areas, roads), or woodland. The minimum mapping unit of digitized polygons was 5 m. We imported nest coordinates into ArcGIS and categorized each by species and fate. Within ArcGIS, we measured distance from each nest to the nearest cropland, grassland, developed area, and woodland in meters. We also estimated proportion of the landscape made up of cropland, grassland, developed area, and woodland within a 50-m radius around each nest. We used a 50-m radius because an area of this size would adequately cover breeding territories of the most common breeding birds using buffers (red-winged blackbirds, Yasukawa and Searcy 1995; dickcissel, Temple 2002).

We calculated observed nest density (number of nests detected per ha in each buffer) for 2007–2009. We categorized buffers as first growing season since burning or disking, second growing season since burning or disking, or control. We also independently calculated observed nest density in buffers for each year of this study based on type of non-crop edge adjacent to each buffer. We only used control fields for this portion of the analysis to avoid confounding landscape context with disturbance. Although we did not correct for heterogeneous nest detection probabilities, major differences in nest detection probabilities are unlikely because buffers were relatively narrow ($\leq$36.5 m), and we detected fewer nests in buffers with less vegetation (recently disturbed) where detectability would likely have been greater. We conducted a chi-square test to determine if differences in nest density occurred among buffers based on disturbance and type of non-crop edge using $\alpha = 0.05$.

We estimated nest success using maximum likelihood approaches to model daily survival rates (DSR) of nests in Program MARK (White and Burnham 1999). We selected model parameters in a sequential fashion that reflected processes affecting nest success following the recommendations of Dinsmore et al. (2002). We retained the best model or competing models at each stage of the analytical process (difference in second-order Akaike's Information Criterion

[ΔAIC_c] $\leq$ 2) and included them in the next stage. This process consisted of modeling DSR in 4 stages: 1) temporal effect (year and breeding season as a constant, linear, or quadratic time trend), 2) disturbance effect (type of disturbance and time since last disturbance event), 3) landscape effect (distance to nearest cropland, grassland, developed area, and woodland and amount of these areas within a 50-m radius around a nest), and 4) site-specific effects (vegetation height, percent ground coverage, and nest height).

At each stage of the modeling process, we constructed a candidate set of models that articulated a biological hypothesis based on relevant literature and ecological theory. We first considered the temporal scale to account for stochastic environmental variation (e.g., rainfall, temperature), within year phenological changes (e.g., vegetation), and seasonal anthropogenic activities (e.g., agricultural activities) that occur at a broad geographic scale and would be common across all treatments and replicates (Block and Brennan 1993). Second, we carried over the competing models that added type of and time since disturbance. Third, we evaluated models including different landscape variables (including variables carried over from the time and disturbance steps) assuming that large-scale spatial variation (i.e., landscape variables) constrains processes at smaller spatial scales (Fisher and Davis 2010). The fourth and final step was to evaluate microhabitat characteristics. To account for model selection uncertainty, we used Program MARK to calculate weighted averages for model parameters (and associate unconditional 95% CIs) across all candidate models in the last stage ($\Delta AIC_c \leq 2$) to account for uncertainty in the model selection process.

RESULTS

During 2007–2009, we located 387 active nests in the CP33 buffers. Nesting species included dickcissel (132 nests), red-winged blackbird (226 nests), indigo bunting (*Passerina cyanea*; 8 nests), mourning dove (*Zenaida macroura*; 14 nests), field sparrow (5 nests), grasshopper sparrow (*Ammodramus savannarum*; 1 nest), and northern bobwhite (1 nest). However, because small sample sizes would have limited our ability to compare multiple covariates in our analyses (Dinsmore et al. 2002), we estimated nest density and success only for dickcissel and red-winged blackbird. Of 132 dickcissel nests, we located 33 in 2007, 39 in 2008, and 60 in 2009. Of 226 red-winged blackbird nests, we located 46 in 2007, 98 in 2008, and 82 in 2009. Confirmed causes of nest failure included depredation, such as by snakes (e.g., southern black racer [*Coluber constrictor priapus*]), mammals, birds, and fire ants (*Solenopis* spp.), and nest abandonment.

Nest Density

Dickcissel nest densities in CP33 buffers during 2007 differed from expected among disturbance categories with no nests found in soon to be disked buffers ($\chi^2_{0.05,2} = 9.26$, $P = 0.01$). In 2008, we found fewer dickcissel nests in buffers during the first growing season after burning (0.27 nests/ha; Table 1) and no nests in buffers in the first

Table 1. Observed nest density (number of nests detected per buffer ha) of dickcissels and red-winged blackbirds in CP33 buffers with different disturbance histories in northeast Mississippi, USA, 2007–2009. N = number of conservation buffers.

Treatment	N	Dickcissel nest density (SE)	Red-winged blackbird nest density (SE)
2007			
Control	41	0.38 (0.10)	0.32 (0.12)
Pre-burn growing season	5	0.82 (0.29)	2.13 (1.01)
Pre-disk growing season	5	0.00 (0.00)	1.52 (1.03)
2008			
Control	41	0.53 (0.14)	1.04 (0.35)
First growing season post-burn	5	0.27 (0.27)	2.39 (1.84)
First growing season post-disk	5	0.00 (0.00)	0.00 (0.00)
2009			
Control	31	0.77 (0.22)	1.06 (0.37)
First growing season post-burn	5	1.05 (0.47)	1.69 (1.05)
First growing season post-disk	5	0.00 (0.00)	0.00 (0.00)
Second growing season post-burn	5	0.75 (0.46)	0.92 (0.59)
Second growing season post-disk	5	0.21 (0.21)	0.21 (0.21)

growing season after disking (0.0 nests/ha; Table 1) compared to 0.53 nests/ha in undisturbed control buffers ($\chi^2_{0.05,2} = 7.35$, $P = 0.03$). In 2009, we encountered the most dickcissel nests in buffers that were in the second growing season post-burning (1.05 nests/ha; Table 1) and few or no nests in disked buffers (0.21 nests/ha first season post-disking, 0.00 nests/ha second season post-disking; $\chi^2_{0.05,4} = 14.10$, $P < 0.01$; Table 1).

Red-winged blackbird nest density also differed from expected among disturbance categories ($\chi^2_{0.05,2} = 19.49$, $P < 0.01$), but in contrast to dickcissels, we found nests on all treatments in 2007 prior to initiating disturbance (Table 1). Similar to dickcissels, we encountered few or no red-winged blackbird nests in disked buffers in both 2008 ($\chi^2_{0.05,2} = 18.22$, $P < 0.01$; 0.00 nests/ha first season post-disk; Table 1) and 2009 (0.21 nests/ha first season post-disking, 0.00 nests/ha second season post-disking; $\chi^2_{0.05,4} = 20.18$, $P < 0.01$; Table 1).

Dickcissel nest densities in CP33 buffers during 2007 did not differ from expected regardless of type of non-crop edge ($\chi^2_{0.05,3} = 3.70$, $P = 0.30$; Table 2). We found few dickcissel nests in buffers bordered by woody vegetation in 2008 ($\chi^2_{0.05,3} = 25.75$, $P < 0.01$) and 2009 ($\chi^2_{0.05,3} = 50.57$, $P < 0.01$), and greater densities in buffers bordered by crop or grass (Table 2). Red-winged blackbird nests

differed from expected among edge types in all 3 years (2007: $\chi^2_{0.05,3} = 49.03$, $P < 0.01$; 2008: $\chi^2_{0.05,3} = 81.52$, $P < 0.01$; 2009: $\chi^2_{0.05,3} = 64.29$, $P < 0.01$). We consistently encountered fewer blackbird nests in buffers bordered by woody vegetation and more nests in buffers bordered by crops or urban land uses (Table 2).

Nest Success
Disturbance variables did not improve models of dickcissel nest survival to an extent that warranted inclusion in the best approximating models (2.41 AIC_c units below the best approximating model in the second sequential stage). Furthermore, confidence intervals for disturbance effects included zero (burn, $\beta = 0.13$, SE $= 0.10$, $\pm 95\%$ CI $= -0.07$ to 0.33; disk, $\beta = -0.10$, SE $= 0.15$, $\pm 95\%$ CI $= -0.39$ to 0.18).

Four competing models best described dickcissel nest survival in CP33 buffers (Table 3). We averaged these models to generate estimates of dickcissel nest success. The averaged model included a constant (.) year effect ($\beta = 2.85$, SE $= 0.35$, $\pm 95\%$ CI $= 2.16$ to 3.53), a negative linear time trend within breeding season ($\beta = -0.03$, SE $= 0.01$, $\pm 95\%$ CI $= -0.043$ to -0.015), terms indicating interaction effects between distance to nearest developed area and amount of cropland around a nest ($\beta = -0.04$, SE $= 887.51$,

Table 2. Observed nest density (number of nests detected per buffer ha) of dickcissels and red-winged blackbirds in CP33 buffers bordered by different habitats on the non-crop side in northeast Mississippi, USA, 2007–2009. N = number of conservation buffers.

Treatment	N	Dickcissel nest density (SE)	Red-winged blackbird nest density (SE)
2007			
Crop	2	0.14 (0.14)	1.23 (1.23)
Grassland	11	0.50 (0.23)	0.39 (0.29)
Developed	12	0.57 (0.19)	1.67 (0.57)
Woodland	26	0.27 (0.12)	0.18 (0.13)
2008			
Crop	1	2.46	6.41
Grassland	11	1.13 (0.39)	1.46 (0.51)
Developed	8	0.64 (0.20)	2.44 (1.39)
Woodland	21	0.07 (0.04)	0.03 (0.03)
2009			
Crop	1	3.94	3.45
Grassland	8	1.77 (0.55)	0.90 (0.59)
Developed	6	0.44 (0.20)	3.04 (1.38)
Woodland	16	0.19 (0.12)	0.25 (0.22)

Table 3. Summary of model selection results for dickcissel and red-winged blackbird nest survival in CP33 buffers in northeast Mississippi, USA, 2007–2009, including second-order Akaike's Information Criterion (AIC_c), model weight (w_i), number of parameters (K), and model deviance.

Model[a]	AIC_c	ΔAIC_c[b]	w_i	K	Deviance
Dickcissel					
$S_{year(.)+season(linear)+crop \times near\_developed+nesthgt}$	495.74	0.00	0.39	5	485.69
$S_{year(.)+season(linear)+near\_wood+nesthgt}$	496.80	1.06	0.23	4	488.77
$S_{year(.)+season(linear)+crop+nesthgt}$	497.21	1.47	0.19	4	489.18
$S_{year(.)+season(linear)+grass+nesthgt}$	497.22	1.48	0.19	4	489.19
Red-winged blackbird					
$S_{year(.)+season(quadratic)+near\_crop+veghgt \times cover}$	789.70	0.00	0.10	6	777.66
$S_{year(.)+season(linear)+near\_crop+veghgt \times cover}$	789.78	0.08	0.10	6	777.74
$S_{year(.)+season(quadratic)+near\_crop}$	789.94	0.24	0.09	3	783.93
$S_{year(.)+season(linear)+near\_crop}$	790.00	0.30	0.09	3	783.99
$S_{year(.)+season(quadratic)+near\_developed}$	790.81	1.11	0.06	3	784.80
$S_{year(.)+season(linear)+veghgt \times cover}$	790.87	1.17	0.06	5	780.85
$S_{year(.)+season(linear)+near\_developed}$	790.89	1.19	0.06	3	784.88
$S_{year(.)+season(quadratic)+near\_developed+veghgt \times cover}$	791.04	1.34	0.05	6	779.00
$S_{year(.)+season(quadratic)+veghgt \times cover}$	791.05	1.35	0.05	5	781.03
$S_{year(.)+season(linear)+near\_crop+nesthgt}$	791.07	1.37	0.05	4	783.05
$S_{year(.)+season(linear)+near\_crop+veghgt}$	791.08	1.38	0.05	4	783.07
$S_{year(.)+season(linear)+near\_developed+veghgt \times cover}$	791.09	1.39	0.05	6	779.06
$S_{year(.)+season(quadratic)+near\_crop+veghgt}$	791.09	1.39	0.05	4	783.08
$S_{year(.)+season(quadratic)+near\_crop+nesthgt}$	791.17	1.47	0.05	4	783.15
$S_{year(.)+season(linear)+near\_crop+veghgt \times cover \times nesthgt}$	791.28	1.58	0.05	7	777.24
$S_{year(.)+season(quadratic)+near\_crop+veghgt \times cover \times nesthgt}$	791.33	1.63	0.05	7	777.28

[a] Nest survival (S) covariates include constant year effect (.), linear season effect (linear), quadratic season effect (quadratic), percentage of land cover within 50-m radius around nest classified as cropland (crop), percentage of land cover within 50-m radius around nest classified as grassland (grass), distance from nest to nearest developed edge (near_developed), distance from nest to nearest cropland edge (near_crop), distance from nest to nearest woodland edge (near_wood), mean percent ground coverage within a 0.25-m^2 area at cardinal points around nest (cover), mean height of vegetation surrounding nest (veghgt), and nest height (nesthgt).

[b] Only competing models with a $\Delta AIC_c \leq 2$ are listed.

±95% CI = −1730.69 to 1730.61), a positive effect of distance to nearest woodland ($\beta = 0.0004$, SE = 0.0003, ±95% CI = −0.0003 to 0.001), a positive effect of amount of grassland surrounding a nest ($\beta = 0.11$, SE = 0.11, ±95% CI = −0.11 to 0.32), and a positive effect associated with nest height ($\beta = 1.98$, SE = 0.62, ±95% CI = 0.76 to 3.20). Based on the averaged model and a 24-day nesting period (i.e., egg laying to fledging), nests initiated 1 May had an estimated success rate of 44.8% (±95% CI = 28.0 to 60.1%; Fig. 2). This rate declined to 1.38% (±95% CI = 0.14 to 6.5%) by 30 June. Peak initiation dates for dickcissel nests (i.e., start of egg-laying) occurred in mid-May (11–20 May). During the peak nesting period, dickcissel nest survival averaged 29.7 ± 0.98%.

Inclusion of disturbance in red-winged blackbird nest survival (S) models did not substantively improve information content; adding disturbance parameters to the top 2 competing temporal models ($S_{year(.)+season(linear)}$ and $S_{year(.)+season(quadratic)}$) increased AIC_c values by 3.03 and 3.21 units, respectively. Furthermore, confidence intervals for effects of disturbance on a logit scale included zero ($S_{year(.)+season(linear)+burn}$, $\beta = -0.06$, SE = 0.07, ±95% CI = −0.194 to 0.065; $S_{year(.)+season(linear)+disk}$, $\beta = 0.03$, SE = 0.11, ±95% CI = −0.179 to 0.237; $S_{year(.)+season(quadratic)+burn}$, $\beta = -0.06$, SE = 0.07, ±95% CI = −0.19 to 0.07; $S_{year(.)+season(quadratic)+disk}$, $\beta = 0.03$, SE = 0.11, ±95% CI = −0.180 to 0.234).

Model selection revealed 16 competing models of red-winged blackbird nest survival in the final sequential modeling stage (Table 3). Neither the season-only models ($S_{year(.)+season(linear)}$, $\Delta AIC_c = 2.09$; $S_{year(.)+season(quadratic)}$, $\Delta AIC_c = 2.22$) nor the null model ($S_{(.)}$, $\Delta AIC_c = 11.92$) were included in the candidate set. This indicates that the models that were included had substantial support and were not spurious. We averaged these models to generate a single nest survival model for red-winged blackbirds. The averaged model included a constant year effect ($\beta = 3.40$, SE = 0.31, ±95% CI = 2.780 to 3.99), a negative quadratic time trend
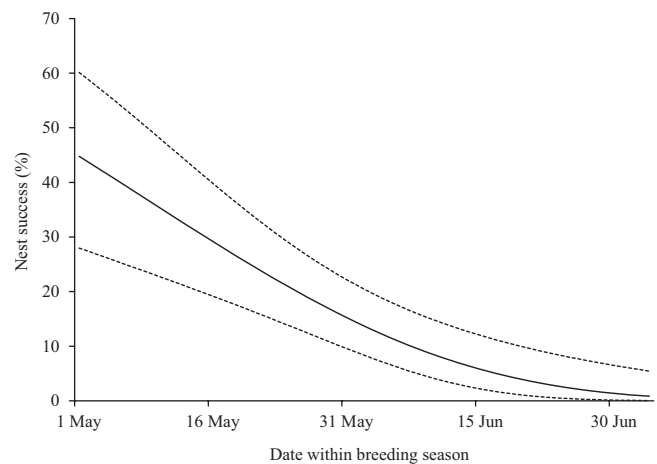

Figure 2. Dickcissel nest success (–) and 95% confidence intervals (- -) in Conservation Reserve Program CP33 buffers in northeast Mississippi, USA, as a function of nest initiation date, 2007–2009. We calculated nest success based on a 24-day nesting period (i.e., egg laying to fledging).

within the breeding season ($\beta = -7.36E-5$, SE = 7.76 E−5, ±95% CI = −0.0002 to 7.78E−5), a negative linear time trend within the breeding season ($\beta = -0.01$, SE = 0.01, ±95% CI = −0.02 to 0.01), distance to nearest developed edge ($\beta = 0.0002$, SE = 0.0003, ±95% CI = −0.0004 to 0.001), distance to nearest crop edge ($\beta = -0.0001$, SE = 0.001, ±95% CI = −0.003 to 0.001), vegetation height ($\beta = -0.02$, SE = 0.02, ±95% CI = −0.05 to 0.02), percent ground coverage ($\beta = -0.003$, SE = 0.05, ±95% CI = −0.01 to 0.09), nest height ($\beta = 0.05$, SE = 0.11, ±95% CI = −0.16 to 0.25), an interaction effect between vegetation height and percent ground coverage ($\beta = 0.02$, SE = 0.02, ±95% CI = −0.03 to 0.06), and an interaction effect between vegetation height, percent ground coverage, and nest height ($\beta = 0.002$, SE = 0.004, ±95% CI = −0.006 to 0.01). Based on the averaged model and a 25-day nesting period, nests initiated 1 May had an estimated success rate of 35.1% (±95% CI = 23.8 to 49.6%), which declined to 8.77% (±95% CI = 2.8 to 14.1%) by 10 July (Fig. 3). Peak initiation dates for red-winged blackbird nests occurred during late June (21–30 Jun), during which blackbird nest survival averaged 12.9 ± 0.42%.

DISCUSSION

Nest Density
In general, dickcissels and red-winged blackbirds had greater nest densities in CP33 buffers that were burned or undisturbed than in disked buffers. This is likely attributable to the time to recovery of the grass stand. Warmer soil temperatures and greater availability of soil nutrients following burning allows vegetation to recover from disturbance more quickly than vegetation in disked buffers (Harper et al. 2007). Also, disking disrupts grass root structures, setting succession back to an earlier seral stage than burning (Jones et al. 2007). In our buffers, plant

Figure 3. Red-winged blackbird nest success (–) and 95% confidence intervals (- -) in Conservation Reserve Program CP33 buffers in northeast Mississippi, USA, as a function of nest initiation date, 2007–2009. Nest success calculated based on a 25-day nesting period (i.e., egg laying to fledging).

communities recovered more slowly in disked buffers (Dollar 2011). For dickcissels, negative effects of disking were possibly a result of pre-disturbance patterns because nest density was zero the summer before implementing treatments. However, this was not the case for blackbirds, and yet we found few or no nests after disking. In addition, other taxa (plants, fire ants, butterflies) responded most strongly to disking and, similar to nest density, these effects persisted at least 2 years post-disking (Dollar 2011, Hale et al. 2011, Dollar et al. 2012).

In 2008 and 2009, dickcissel nest density was lowest in buffers bordered by woodland habitat. Similarly, red-winged blackbird nest densities were least in woodland-bordered buffers during all 3 years of this study. Because woodland edges are often associated with increased nest predation and parasitism, these grassland species may have avoided nesting in buffers proximate to woodland. In southwest Missouri, for instance, dickcissel nest predation by mid-sized mammals (e.g., American badgers [*Taxidea taxus*], striped skunk [*Mephitis mephitis*]) and nest parasitism by brown-headed cowbirds was greatest within 50 m of a woodland edge (Winter et al. 2000). Clotfelter (1998) found that blackbird nests farther from woody vegetation would be less likely to be parasitized by brown-headed cowbirds. Also, nest parasitism by the brown-headed cowbird was greatest within 50 m of woody edges in Kansas compared to nests that were 100 m or more from the edge (Jensen and Finck 2004).

Nest Success
During the peak of the dickcissel breeding season, estimated nest success in buffers was 29.7%. Several other studies have reported nest success estimates for this species, ranging from 15% to 31% (e.g., McCoy et al. 1999, Churchwell et al. 2008, Frey et al. 2008, Burhans et al. 2010). Assuming nest success and brood size were constant, fecundity was equal among all age classes, and the offspring-sex ratio was 50:50, dickcissels would require a nest success of at least 35% in a given habitat for it to be considered a source (McCoy 1996, McCoy et al. 1999). Therefore, CP33 buffers in this study may not support source populations of dickcissels. If, however, buffers provide habitat for dickcissels that would have nested in lower-quality habitat or not at all, then CP33 buffers can still provide an important conservation service for this species in intensively farmed landscapes (McCoy et al. 1999).

Although disturbance did not improve dickcissel nest survival models, other studies have found that it can affect nest success of this and other grassland bird species. In Maryland, for instance, 35.3% of grassland bird nests in burned sites were depredated as opposed to 13.3% in unburned sites (Almario et al. 2009). These negative effects, however, are often restricted to the time period immediately following a burn. Once vegetation has recovered from disturbance, grassland birds will quickly recolonize. Churchwell et al. (2008) found 89–94% of dickcissel nests were depredated in current-year burn patches as opposed to 76–78% in 1-year or 2-year post-burn patches. Furthermore, dickcissel nest success in current-year burn patches was 29%,
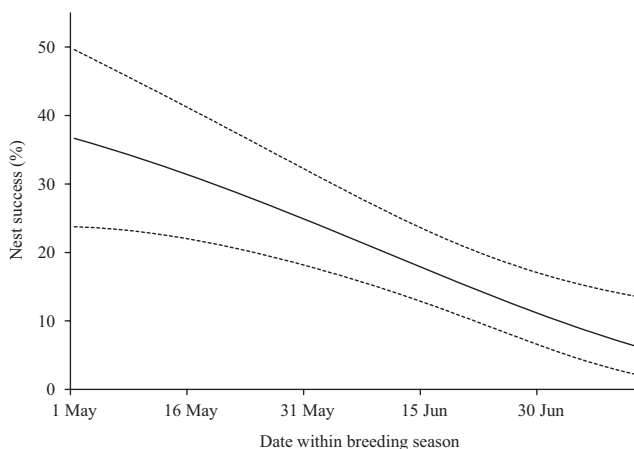
whereas nest success in 1-year and 2-year post-burn patches was 41% (Churchwell et al. 2008). Results from these 2 studies, however, reflect grassland bird nest success in large marsh and grassland habitats, respectively, whereas our results were based on linear patches of grassland in an agricultural matrix. Alternatively, disturbance may not have improved nest success models simply because we had so few nests in disked buffers (see nest density results).

Consistent with other published studies, the averaged model of dickcissel nest survival contained positive relations with proportion of grassland surrounding a nest and increasing distance from woody cover (e.g., Winter and Faaborg 1999, Winter et al. 2000, Jensen and Finck 2004). However, the coefficient for distance from woody cover was very small and confidence intervals for these parameters included zero, so these effects were not strong in our study.

During this study, red-winged blackbird nest success decreased during the breeding season. At the peak of their breeding season, this species had an estimated nest success of 12.9% in CP33 buffers. Conover et al. (2011b) estimated red-winged blackbird nest success was 8.6% ($\pm$95% CI $= 2.3$–19.8%) in early-successional CRP fields in Coahoma County, Mississippi. Because of low nest success, CP33 buffers likely provide sink habitat for red-winged blackbirds.

Disturbance did not improve models of red-winged blackbird nest survival; however, immediately following a burn, buffers tend to have short, sparse grass cover, few forbs, and sparse litter, decreasing the adequacy of habitat for red-winged blackbirds, and other grassland birds (Madden et al. 1999). Furthermore, nests that are built in such areas may be at greater risk of nest predation (Almario et al. 2009). Alternatively, disturbance may not have improved nest success models simply because we had so few nests in disked buffers (see nest density results).

MANAGEMENT IMPLICATIONS

To support populations of dickcissels and potentially other grassland bird species in agricultural conservation buffers, such as those enrolled in CP33, we recommend management of early-successional herbaceous buffers with prescribed burning. Although nest survival did not vary in relation to disturbance, dickcissel nest densities were greater in burned buffers compared to those that were disked. Grassland bird nest success can be further increased if total grassland habitat is maximized by increasing buffer area and establishing buffers in areas with other grassland cover. Agricultural conservation buffers implemented as a component of a comprehensive conservation management system may provide breeding habitat, increase total grassland in the landscape, and provide connectivity, thereby contributing to overall avian conservation objectives in agricultural landscapes. Disking, however, can be a beneficial disturbance method in landscapes that do not permit safe burns because it encourages biomass decomposition, exposes bare ground, increases nutrient availability, and provides habitat for other life requisites (e.g., foraging and brood habitat; Harper et al. 2007).

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