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SHORT-TERM RESPONSES OF BREEDING BIRDS OF GRASSLAND AND EARLY SUCCESSIONAL HABITAT TO TIMING OF HAYING IN NORTHWESTERN ARKANSAS

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Abstract. In 2003, we evaluated nest survival and density of the Dickcissel (*Spiza americana*), Eastern Meadowlark (*Sturnella magna*), Field Sparrow (*Spizella pusilla*), and Red-winged Blackbird (*Agelaius phoeniceus*) in four unhayed, two early-hayed (26–31 May) and three late-hayed (17–25 June) fields in northwestern Arkansas. Rope dragging and observations revealed 89 nests. Daily nest-survival rates (SE) prior to haying ranged from 0.94 (0.03) to 0.97 (0.02). Early haying affected both nest-survival rates and bird densities negatively, whereas late haying had minimal effects. Fifteen nests in hayed portions of early-hayed fields were destroyed, whereas only 2 of 52 nests were affected by late haying. Density was at least 0.98 birds ha^{-1} higher in unhayed than in early-hayed fields and 1.03 birds ha^{-1} higher in late-hayed than in early-hayed fields. In northwestern Arkansas, postponing haying until mid- to late June would allow time for nestlings to fledge, would have little effect on bird densities, and would affect hay nutrition and regrowth minimally.

Key words: Agelaius phoeniceus, *density, Dickcissel, Eastern Meadowlark, Field Sparrow, haying, grassland birds, nest survival, Red-winged Blackbird,* Spiza americana, Spizella pusilla, Sturnella magna.

Respuestas de Corto Plazo de las Aves que Anidan en Pastizales y en Estadios Sucesionales Tempranos al Momento de Cosecha en el Noroeste de Arkansas

Resumen. En 2003, evaluamos la supervivencia de los nidos y las densidades de *Spiza americana*, *Sturnella magna*, *Spizella pusilla* y A*gelaius phoeniceus* en cuatro pastizales no cosechados, en dos cosechados tempranamente (26–31 de mayo) y en tres cosechados tardíamente (17–25 de junio) en el noroeste de Arkansas. Fueron encontrados 89 nidos utilizando el método de arrastre de cuerda y observaciones. Las tasas de supervivencia de los nidos (TS) correspondientes al periodo que antecedió a la cosecha de pasto variaron desde 0.94 (0.03) a 0.97 (0.02). La cosecha de pasto temprana afectó negativamente a la supervivencia de nidos y a la densidad, mientras que la cosecha tardía tuvo efectos mínimos. Quince nidos fueron destruidos en las partes cosechadas de los campos con cosecha temprana, mientras que sólo 2 de los 52 nidos fueron afectados por la cosecha de pasto tardía. La densidad en los campos no cosechados fue por lo menos 0.98 individuos ha^{-1} mayor que en los capos con cosecha temprana y en los campos con cosecha tardía fue 1.03 individuos ha^{-1} mayor que en los campos con cosecha temprana. Posponer la cosecha de pasto hasta mitades o fines de junio en el noroeste de Arkansas, permitiría que los polluelos tuviesen tiempo suficiente para salir del nido, no tendría un gran efecto sobre la densidad de aves y afectaría de forma mínima la nutrición y el crecimiento del pasto.

In North America tallgrass prairie has been reduced to less than 4% of its area at the time of European settlement (Samson and Knopf 1994). These losses have been accompanied by substantial reductions continent-wide in numbers and distributions of bird species that breed in this habitat, especially since the mid-1970s (Peterjohn and Sauer 1999, Vickery and Herkert 2001). Much of the tallgrass prairie has been converted from native, warm-season grasses to non-native, cool-season grasses for cattle grazing and haying (Barnes et al. 1995, Washburn et al. 2000). This trend has been mirrored in northwestern Arkansas, which formerly contained large tracts of tallgrass prairie interspersed within a matrix of oak–hickory forest (Küchler 1964, James and Neal 1986). Of the >100 000 ha of tallgrass prairie in northwestern Arkansas before European settlement, only about 40 ha remain (T. Witsell, Arkansas Natural Heritage Commission, pers. comm.). Therefore, pastures and hayfields are essentially the only breeding habitats remaining for obligate grassland birds.

In northwestern Arkansas and at similar latitudes hayfields dominated by cool-season grasses have a long growing season so are often hayed two or more times a year. These fields are typically first hayed after grasses produce seeds in mid-May, which coincides with breeding of grassland birds. In fields dominated by cool-season grasses, vegetation is often cut to a height of <5 cm during mid- to late spring (Capel 1992, Giuliano and Daves 2002). Direct mortality from grass-cutting machinery is inevitable if the field is hayed while nestlings are too young to fledge (Broyer 2003). Therefore, timing of haying can be crucial to the reproductive success of birds nesting in hayfields. Also, depending on the timing of haying, adults may or may not renest. Hayfields may become ecological traps for grassland birds because after haying the quality of nesting habitats greatly diminished (Donovan and Thompson 2001). Consequently, these fields

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may become population sinks (Pulliam 1988) if effects of spring haying on reproductive success are severe enough.

The adverse effects of spring haying on breeding grassland birds can be reduced effectively by delaying haying until later in the breeding season. Previous studies recommending that haying be delayed until after grassland birds fledge took place at more northerly latitudes, as in Nova Scotia (Nocera et al. 2005), Vermont and New York (Perlut et al. 2006), and Pennsylvania (Giuliano and Daves 2002). Recommendations on timing of spring haying in grasslands in Arkansas and at similar latitudes may well differ from those developed farther north because the growing season starts earlier and lasts longer (James and Neal 1986). Because birds of grassland and early successional habitats are a high conservation priority for many public and private agencies (e.g., Partners in Flight; Pashley et al. 2000), it is crucial to develop land-management guidelines that are geographically and ecologically relevant. Consequently, our objective was to evaluate short-term responses of birds of grassland and early successional habitats to timing of haying in northwestern Arkansas.

METHODS

STUDY AREA

We estimated nest survival and breeding density of grassland birds in two early-hayed fields (26–31 May), four late-hayed fields (17–26 June), and three unhayed fields (range of field sizes 6–33 ha; mean 18 ha) in Benton and Washington counties in northwestern Arkansas during 2003 (Fig. 1). Before haying the vegetational structure and composition of all fields studied were similar. Fields were dominated by tall fescue (*Schedonorus phoenix*) interspersed with Bermuda grass (*Cynodon dactylon*), Johnson grass (*Sorghum halepense*), and forbs such as clover (*Trifolium* spp.) and Chinese lespedeza (*Lespedeza cuneata*) (Luscier 2004). We used nest-survival estimates from a pilot study in two fields (WU8 and WU9; Fig. 1) during 2002 to calculate the minimum number or size of fields necessary for an effect of treatment to be detected with 90% confidence (Thompson 2002) and to estimate the length of transects necessary to obtain density estimates with a coefficient of variation of no more than 20% for each field (Buckland et al. 2001).

NEST DETECTION, MEASUREMENT, AND SURVIVAL

Two teams of three observers dragged a rope to flush birds and locate their nests (Higgins et al. 1969, Nesbit 1996). At each nest, we recorded date, time, species, presence and number of eggs and/or nestlings, and habitat variables (Table 1). Each visit lasted no more than 5 min to minimize disruption to the nesting birds (Martin and Geupel 1993). We monitored nests every 3 or 4 days after initial detection.

We used the program MARK (White and Burnham 1999) to estimate nest survival for the Eastern Meadowlark (*Sturnella magna*) alone and for the Dickcissel (*Spiza americana*), Field Sparrow (*Spizella pusilla*), and Red-winged Blackbird (*Agelaius phoeniceus*) pooled together. We did not have a sample of nests large enough to estimate nest survival for each species individually. We pooled the species on the basis of nesting ecology; Eastern Meadowlarks nest directly on the ground (species group 1), whereas the other species nest in vegetation above ground (species group 2; James and Neal 1986). In the hayed fields haying destroyed all nests except for two in unhayed corners. Therefore, we modeled nest survival only before haying (this was the entire 82 days for unhayed fields) to provide baseline estimates for comparison. Candidate models of nest survival incorporated habitat variables, time effects, and species-group effects (Table 2). To avoid overfitting models, we reduced our 82 days of nest monitoring to six 10-day sampling intervals followed by two 11-day sampling intervals. Therefore, instead of estimating 82 separate daily nest-survival rates in the global model, we estimated 8 separate daily nest-survival rates for each of the six 10-day and two 11-day intervals, i.e., the daily rates were the same for each day within each interval but differed from interval to interval. Because of sparsity of data, 10 days was the shortest interval we could fit that produced a reasonable model.

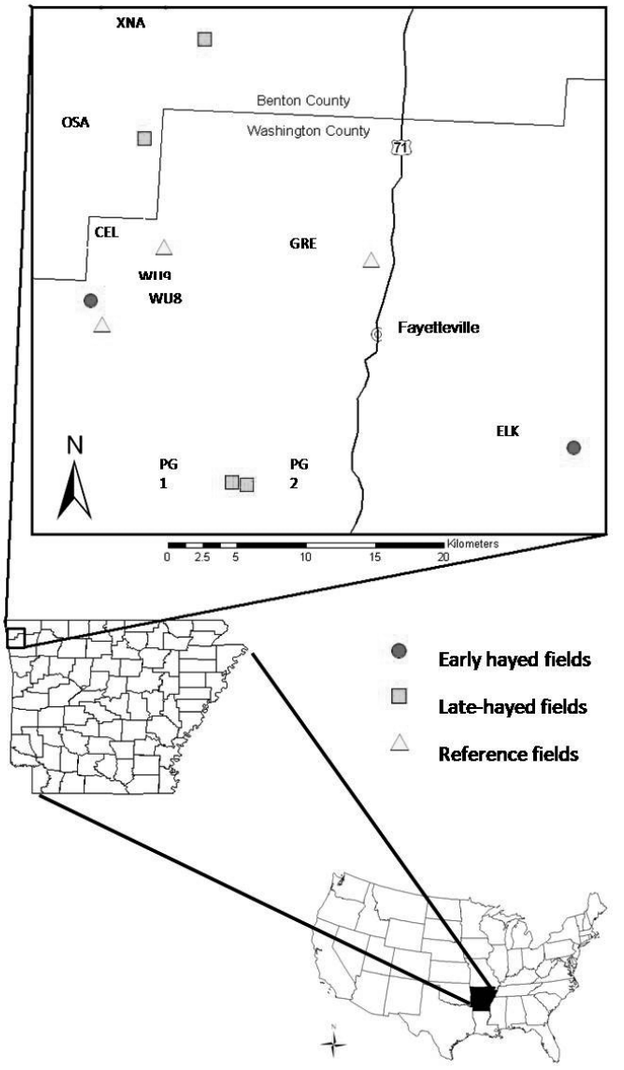


FIGURE 1. Locations of early-hayed (26–31 May), late-hayed (17–26 June), and unhayed fields studied for short-term responses of birds of grassland and early successional habitat to timing of haying in Benton and Washington counties, Arkansas, during 2003. Sites were in the Wedington Unit of Ozark National Forest (WU8 [22 ha] and WU9 [25 ha]), on Cellar Ridge on the property of the University of Arkansas Agricultural Experiment Station (CEL [6 ha]), on property of the northwestern Arkansas Regional Airport (XNA [33 ha]), in Prairie Grove (PG1 [21 ha] and PG2 [18 ha]), in Elkins (ELK [12 ha]), in Osage (OSA [14 ha]), and on Gregg Avenue in Fayetteville (GRE [10 ha]).

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TABLE 1. Descriptions and mnemonics used in model notation (see Table 2) of habitat variables measured at each nest and at points 50 m apart along transects at each study site in northwestern Arkansas during 2003.

Mnemonic	Variable	Description and methods
Perimeter	Perimeter-to-area ratio of hayfields	Perimeter-to-area ratio of fields; we used ArcMap to plot perimeters.
Edge	Distance from nests to nearest edge	Measured distance (km) from nests to nearest edge in the field with laser-rangefinders after nest completion.
Stage	Nesting stage	Stage at nest's initial detection (1 = nest built, no eggs; 2 = incubating; Dinsmore et al. 2002).
Grass	Percent ground cover of grass	Percent ground cover of grass; quantified with the GIS software eCognition (Definiens Imaging, 2000–2003) to analyze digital photographs taken at initial nest detection of ~2-m^2 area centered around each nest (Luscier et al. 2006).
Medium	Medium (mid-height) vegetational cover	Vertical structure (0.3–1 m high) of vegetation; number of 35 10-cm^2 squares obscured ≥50% on a profile board 2 m tall by 0.5 m wide read from 5 m north of each nest at time of initial nest detection (Nudds 1977).

We used Akaike's information criterion corrected for small sample size (AIC_c; Burnham and Anderson 2002) to rank our candidate models for nest survival. We calculated ratios of Akaike weights (w_i) for each model relative to the top model to assess its level of support, given the data. We used the program MARK (White and Burnham 1999) to compute model-averaged estimates across all nest-survival models.

BREEDING BIRD DENSITY

We used line-transect sampling (Buckland et al. 2001) to estimate bird densities during three periods: (1) before early haying (18–23 May), (2) after early haying but before late haying (12–15 June), and (3) after late haying (7–14 July). We used a Bushnell laser rangefinder Yardage Pro 500s or Yardage Pro 400s to estimate perpendicular distances to birds (Ransom and Pinchak 2003) detected along a randomly placed, systematic arrangement of four to six transects (lengths 185–531 m) spaced 150 m apart in each field. We did not survey birds on days with rain or heavy wind because such weather may have affected bird detectability adversely (Martin et al. 1997). Before surveys started, we estimated the length of transects necessary to obtain density estimates with a coefficient of variation of 20% for each study site (Buckland et al. 2001); therefore, each study site required a different number of surveys (range 1–4) during each count period for density estimates to achieve this level of precision.

We used the program DISTANCE 5.0 (Thomas et al. 2005) to estimate site-specific bird densities with a detection function in which all fields were pooled. We did not average bird-detection models because DISTANCE 5.0 does not allow model averaging when data are stratified and/or when its "multiple covariate distance sampling" (MCDS) option is used. We used PROC MIXED in SAS 9.1.3 (SAS Institute 2004, Littell et al. 1998) to fit repeated-measures models to assess possible effects of haying on bird densities; these models included a covariance structure that accounted for the temporal autocorrelation among counts (Table 3). We used AIC_c to select the covariance structure that best fitted the data and then we used this structure in our candidate set of mixed models (Wolfinger 1996). We used the LSMEANS function in SAS to calculate 95% confidence intervals around differences between density estimates, with the family-wise confidence level adjusted for the number of comparisons. We evaluated the biological importance of these differences by comparing their 95% confidence limits (Gerard et al. 1998) with historical records of densities from James and Neal (1986). Differences with lower limits greater than 0.56 birds ha^{-1} or upper limits less than –0.56 birds ha^{-1} were

TABLE 2. Notation and description of nest-survival models in a candidate set for estimating survival rates of nests of birds of grassland and early successional habitat over an 82-day period in northwestern Arkansas during 2003. Habitat variables and notations are described in Table 1. These models apply only to nest-survival rates prior to haying in hayed fields but to the entire study period for unhayed fields.

Model notation	Model description
S	Constant daily survival (single estimate) before haying in all fields
$S_{\text{10-day SR}}$	Daily survival rates vary among 10-day periods
$S_{\text{10-day SR}-T}$	Daily survival rates change linearly among 10-day periods (Dinsmore et al. 2002, Ainley and Schlatter 1972)
$S_{\text{10-day SR}-TT}$	Daily survival rates follow a quadratic trend among 10-day periods throughout the nesting season
S_{species}	Constant daily survival rates of species groups differ (i.e., Eastern Meadowlark versus other 3 species [Dickcissel, Field Sparrow, and Red-winged Blackbird] pooled)
$S_{\text{10-day SR}-T\times\text{species}}$	Daily survival rates change linearly among 10-day periods throughout the nesting season by species group
S_{stage}	Daily survival rates depend upon stage (1 = nest building/egg laying; 2 = incubating) of the nest at detection
S_{edge}	Effect of distance to nearest edge of the field on daily survival rates
$S_{\text{perimeter}}$	Effect of perimeter-to-area ratio of the field on daily survival rates
S_{medium}	Effect of vertical vegetation density (0.3–1.0 m) on daily survival rates
$S_{\text{species + grass + medium}}$	Daily survival rates differ by species group and by percentage ground cover of grass and shrub
$S_{\text{stage + medium}}$	Effect of nest stage and vertical vegetation density on daily survival rates
$S_{\text{edge + medium}}$	Effect of distance to nearest edge of the field and vertical density of vegetation on daily survival rates

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TABLE 3. Notation and description of a candidate set of models for evaluating spatial and temporal patterns in density estimates (from program DISTANCE) of four species of grassland and early successional habitat in northwestern Arkansas during 2003. Models include treatment effects (TRT) of unhayed ($n = 3$), early-hayed ($n = 2$), and late-hayed fields ($n = 4$), time effects (Time) during count 1 (18–23 May), 2 (12–15 June), or 3 (7–14 July), and effects of distance (km) of fields to nearest residence.

Model notation	Model description
$\hat{D}_{(\mathrm{TRT + Time + TRT \times Time + Residence})}$	Density estimates differ among the different treated fields (TRT), among the 3 survey periods (Time), the interaction of TRT and Time, and are affected by distance (km) to nearest residence
$\hat{D}_{(\mathrm{TRT + Time + Residence})}$	Density estimates differ among treatments (TRT), among the 3 survey periods (Time), and are affected by distance (km) to nearest residence
$\hat{D}_{(\mathrm{TRT + Residence})}$	Density estimates differ among treatments (TRT) and are affected by distance (km) to nearest residence
$\hat{D}_{(\mathrm{Time + Residence})}$	Density estimates differ among the 3 survey periods and are affected by distance (km) to nearest residence
$\hat{D}_{(\mathrm{TRT})}$	Density estimates differ among treatments (TRT)
$\hat{D}_{(\mathrm{Time})}$	Density estimates differ among the 3 survey periods
$\hat{D}_{(\mathrm{Residence})}$	Density estimates are affected by distance (km) to nearest residence

considered biologically important; differences were considered biologically unimportant if their confidence limits were between –0.56 and 0.56 birds ha^{-1}. Differences with confidence intervals containing both biologically important and unimportant values were deemed inconclusive.

RESULTS

All fields combined, we located 89 nests (20 in unhayed, 18 in early-hayed, and 51 in late-hayed fields) of the Dickcissel, Red-winged Blackbird, Eastern Meadowlark, and Field Sparrow between 22 April and 25 June 2003. All Eastern Meadowlark nests and one Dickcissel nest were on the ground. All other nests (31 Dickcissel, 30 Red-winged Blackbird, and 14 Field Sparrow nests) were in vegetation ≥15 cm off the ground.

Eleven of the 13 candidate models estimating nest survival before haying in hayed fields and during the entire study period in unhayed fields were reasonably supported (i.e., evidence ratios less than 32) by the data so could not be discounted (Table 4). The model-averaged logistic-regression equation (SE of coefficients in parentheses) of these 11 models was

$$\underset{(0.68)}{\mathrm{logit}(\hat{S}_i) = 3.59} \underset{(0.34)}{- 0.19T} \underset{(0.065)}{+ 0.003TT} \underset{(0.05)}{+ 1.16(\mathrm{species})} \underset{(0.13)}{- 0.16T \times \mathrm{species}} \underset{(0.22)}{+ 0.11(\mathrm{stage})}$$

$$\underset{(0.20)}{- 0.06(\mathrm{edge})} \underset{(0.23)}{+ 0.22(\mathrm{perimeter})} \underset{(0.12)}{- 0.18(\mathrm{medium}),}$$

where T indicates that daily survival rates changed linearly among the 10-day intervals and TT indicates a quadratic trend of daily survival rates among the 10-day intervals. Ten-day estimates of nest-survival rate (SE) ranged from 0.95 (0.04) to 0.97 (0.02) for the Eastern Meadowlark alone and 0.94 (0.03) to 0.97 (0.01) for the Dickcissel, Red-winged Blackbird, and Field Sparrow combined before haying in hayed fields and over the entire study in unhayed fields.

Haying had a strong negative effect on nest-survival rates of the Eastern Meadowlark and of the Dickcissel, Red-winged Blackbird, and Field Sparrow combined. Fifteen of the 18 (83%)

TABLE 4. Ranking of models, ordered from best to worst fitting, relating nest survival rates of birds of grassland and early successional habitat (Eastern Meadowlark alone and Dickcissel, Red-winged Blackbird, and Field Sparrow combined) to temporal patterns and habitat variables prior to haying in hayed and unhayed fields in northwestern Arkansas, May–July 2003. See Table 2 for model descriptions.

Model	–2 log(L)	No. of parameters	Δ_i[a]	Akaike weight (w_i)	Evidence ratio (w_1/w_i)
S	175.28	1	0.00	0.19	1.00
$S_{\mathrm{10daySR - T}}$	173.50	2	0.23	0.17	1.12
$S_{\mathrm{perimeter}}$	174.25	2	0.98	0.12	1.58
S_{medium}	174.56	2	1.29	0.10	1.90
S_{stage}	174.99	2	1.73	0.08	2.38
S_{species}	175.12	2	1.85	0.07	2.71
S_{edge}	175.24	2	1.97	0.07	2.71
$S_{\mathrm{10daySR - TT}}$	173.50	3	2.25	0.06	3.17
$S_{\mathrm{10daySR - T \times species}}$	173.53	3	2.28	0.06	3.17
$S_{\mathrm{stage + medium}}$	174.37	3	3.12	0.04	4.75
$S_{\mathrm{edge + medium}}$	174.43	3	3.18	0.04	4.75
S_{10daySR}	168.31	8	7.27	<0.01	37.94
$S_{\mathrm{species + grass + medium}}$	196.12	4	26.90	<0.01	>1000.00

[a]Minimum $\mathrm{AIC}_c = 177.29$.

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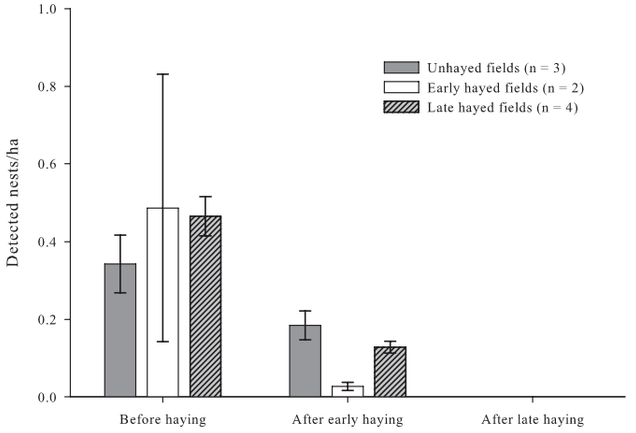


FIGURE 2. Number of nests of birds of grassland and early successional habitat per hectare (1 SE) detected in fields studied before haying (22 April–25 May), after early haying (26 May–16 June), and after late haying (17 June–13 July) in northwestern Arkansas during 2003.

nests detected in early-hayed fields were destroyed by haying. The two nests that were not destroyed were in unhayed corners of the fields, so the nest-survival rate was 0 for nests in the hayed portions. In both of these corner nests the eggs hatched before haying. Nestlings remained in each of these nests after haying but none survived to fledge. Conversely, just 2 of the 52 (4%) nests detected in late-hayed fields were destroyed by haying.

The effect of early haying on the number of nests initiated by birds in our hayfields was also negative. We only detected one nest (0.03 nests ha^{-1}) initiated in early-hayed fields during the 39 days after the early haying, whereas we detected seven nests (0.18 nests ha^{-1}) in unhayed fields and 11 nests (0.13 nests ha^{-1}) in late-hayed fields during the same period (Fig. 2). No nests were detected in any field after late haying.

We detected 22 species of birds, but the number of detections was insufficient for species-specific detectabilities and densities to be estimated. Therefore, we pooled distance data from the four most commonly detected species with similar singing behaviors (Dickcissel, Eastern Meadowlark, Red-winged Blackbird, and Field Sparrow) and estimated densities of this subset during each count period. The best-fitting detectability model for each count period included the hazard-rate cosine detection-key function, meaning detectability remained constant within a short distance of transects and dropped off steadily thereafter (Buckland et al. 2001). Estimates of detectability (SE) based on this model decreased through the season: 0.29 (0.02) in count period 1, 0.23 (0.01) in count period 2, and 0.18 (0.02) in count period 3. Density estimates (SE) among the three treatments ranged from 0.73 (0.27) to 4.09 (1.31) birds ha^{-1} across all count periods.

The only reasonably supported model with bird density as the response variable incorporated effects of haying (TRT) and distance (km) to nearest residence ($\hat{D}_{(\mathrm{TRT + Residence})}$; Table 5). Density of the four species from the best-fitting model at the minimum (0.01 km), mean (0.21 km), and maximum (1.61 km) distances to nearest residence was higher in both unhayed and late-hayed fields than in early-hayed fields (Fig. 3). The differences in bird density between unhayed and late-hayed fields with 1.6 km from nearest residence were trivially small (Fig. 3). Other 95% confidence intervals around differences included both biologically important and unimportant values, so results were inconclusive.

DISCUSSION

Haying fields early in the birds' breeding season (26–31 May) was detrimental to nest survival and resulted in decreased densities of birds of grassland and early successional habitat in fields of northwestern Arkansas, whereas the effects of haying late (17–26 June) were trivial. These results are similar to those of studies in Iowa (Frawley and Best 1991), New York (Bollinger 1995), Saskatchewan (Dale et al. 1997), and Pennsylvania (Giuliano and Daves 2002). Swengel and Swengel (2001) also reported a trivial effect of late haying on the Dickcissel's reproductive success in nearby southwestern Missouri during late June/early July.

We found that haying affected nest survival and subsequent nest-initiation rates among birds of grassland and early successional habitats in early hayed fields severely, but magnitude of its effects on density may have been more variable by species. For instance, Dickcissels, Field Sparrows, and Red-winged Blackbirds typically nest and feed in vegetation that is a few centimeters to 1 m high. When this vegetation is removed, these species often leave hayed fields in search of more suitable habitat (James and Neal 1986). Fledglings that remain in hayed fields are more susceptible to predation because of lack of cover (Suedkamp Wells et al. 2007). Conversely, Eastern Meadowlarks typically nest and feed on the ground (James and Neal 1986). Fields with vegetation hayed to <5 cm still provide nesting and feeding cover adequate for this species, so haying may have had less of a negative effect

TABLE 5. Ranking of models, ordered from best to worst fitting, relating estimates of density of pooled species (Eastern Meadowlark, Dickcissel, Red-winged Blackbird, and Field Sparrow) to timing of haying in northwestern Arkansas, May–July 2003. See Table 3 for model descriptions.

Model	$-2\log(L)$	No. of parameters	Δ_i[a]	Akaike weight (w_i)	Evidence ratio (w_1/w_i)
$\hat{D}_{(\mathrm{TRT + Residence})}$	51.7	8	0.0	0.94	1.00
$\hat{D}_{(\mathrm{TRT + Time + Residence})}$	47.1	11	6.4	0.04	23.50
$\hat{D}_{(\mathrm{TRT})}$	64.9	7	8.6	0.01	94.00
$\hat{D}_{(\mathrm{Time})}$	70.6	7	14.3	<0.01	>1000.00
$\hat{D}_{(\mathrm{Residence})}$	76.8	5	16.4	<0.01	>1000.00
$\hat{D}_{(\mathrm{Time + Residence})}$	70.5	8	18.8	<0.01	>1000.00
$\hat{D}_{(\mathrm{TRT + Time + TRT \times Time + Residence})}$	41.6	20	115.3	<0.01	>1000.00

[a]Minimum $AIC_c = 80.3$.

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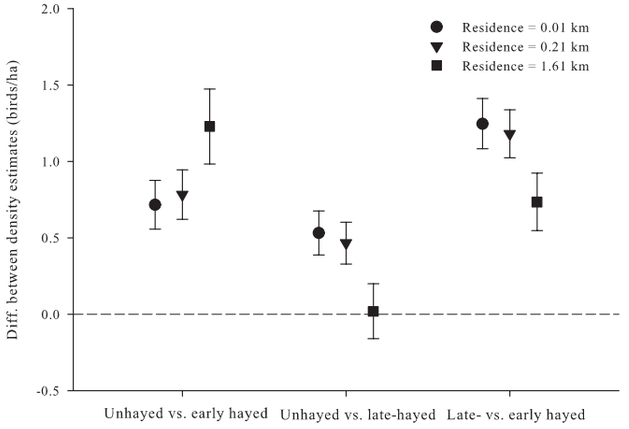


FIGURE 3. Differences (95% confidence intervals) between estimates of the density of the Eastern Meadowlark, Dickcissel, Red-winged Blackbird, and Field Sparrow combined in unhayed versus early-hayed fields, unhayed versus late-hayed fields, and early-hayed versus late-hayed fields for minimum, mean, and maximum distances (km) to nearest residence in northwestern Arkansas during 2003.

on densities of the meadowlark than on those of the Dickcissel, Field Sparrow, and Red-winged Blackbird.

Proximity of hayfields to human residences may intensify the effects of early haying on bird densities. Our results indicated more pronounced effects of early haying on bird densities in fields closer to residences. These fields may have had more domestic cats (Crooks and Soulé 1999) and provided less escape cover for birds after haying.

Our study demonstrated that in northwestern Arkansas a delay of haying until mid- to late June should provide sufficient time for most birds of grassland and early successional habitats to fledge young. Such a delay would postpone haying by about 2–3 weeks from current initiation dates, a delay similar to that recommended from studies in Nova Scotia (Nocera et al. 2005) and Saskatchewan (Dale et al. 1997), even though haying was initiated later at these more northerly locations. From the economic standpoint of farmers in northwestern Arkansas, haying could be delayed 2–3 weeks with minimal effects on the nutritional quality of hay (Nocera et al. 2005) or the minimum time required for adequate regrowth of vegetation for additional haying under the current harvest schedule (R. Odegard, U.S. Forest Service, pers. comm.).

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