

## EASTERN MEADOWLARKS NESTING IN RANGELANDS AND CONSERVATION RESERVE PROGRAM FIELDS IN KANSAS

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**Abstract.**—Eastern Meadowlark (*Sturnella magna*) nesting habitat was studied to make management recommendations for fields enrolled in a federal land retirement program. We compared available microhabitat, nest-site selection, and nest success on rangelands and Conservation Reserve Program (CRP) fields in eastern Kansas. Daily nest survival rates and numbers fledged per female did not differ significantly between land-use types, but the power of these tests was low. Predation was the primary source of nest failure throughout incubation, hatching, and nestling stages; abandonment, trampling, inviability, and unknown causes also were important during incubation. Mowing CRP fields was a source of nest failure and also induced adults to abandon some fields. CRP fields had a significantly higher percent, depth, and density of litter cover; a taller herbaceous canopy; less herbaceous cover; and more standing dead cover than rangelands. Differences in habitat structure indicate that CRP has increased the diversity of available nesting habitats. Eastern Meadowlarks selected nest sites with significantly greater litter cover, higher proportion of grass, more uncompacted litter, and more structural homogeneity than available on random plots. Delay of mowing and prescribed burning are recommended to enhance and maintain habitat suitability for nesting Eastern Meadowlarks in CRP fields.

### **STURNELLA MAGNA ANIDANDO EN EXTENSIONES DE TIERRA Y TERRENOS DEL PROGRAMA DE RESERVAS DE CONSERVACIÓN EN KANSAS**

**Sinopsis.**—Se estudió el habitat de anidamiento de *Sturnella magna* para producir recomendaciones de manejo para terrenos enlistados en un programa federal de retraer tierras. Se compararon el éxito de los nidos, el microhabitat disponible y la selección de lugar para anidar en las extensiones de tierra y en terrenos del Programa de Reservas de Conservación (PRC) en el este de Kansas. Ni las tasas diarias de supervivencia de nido ni el número de volantones por hembra variaron significativamente entre terrenos de uso diferente, pero la potencia de la prueba estadística fue baja. La depredación fue la causa principal de la mortalidad en nidos durante las etapas de incubación, eclosión y de crecimiento en el nido, pero el abandono, el pisoteo, la infertilidad, y otras causas desconocidas también fueron importantes durante la incubación. Desyerbar los campos del PRC causó mortandad de nidos

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y también indujo al abandono de los predios. Los terrenos del PRC tuvieron mayores porcentaje, profundidad y densidad de cubierta de materiales, un mayor dosel herbáceo, menos cubierta herbácea y más cubierta erecta muerta que las extensiones de tierra. Las diferencias en la estructura de hábitat indican que el PRC ha aumentado la diversidad de hábitats de anidamiento. Los individuos de *Sturnella magna* seleccionaron lugares de anidaje con una cubierta de materiales significativamente mayor, mayor proporción de hierbas, materiales poco compactos y mayor homogeneidad estructural que los disponibles en parcelas fortuitas. Se recomienda retrasar el corte de césped y de quema prescrita para estimular y mantener la adecuación de hábitat para el anidaje de *Sturnella magna* en los predios del PRC.

The Conservation Reserve Program (CRP) of the 1985 Food Security Act converted >14.3 million ha of highly erodible cropland in the United States to a variety of permanent cover types for 10 yr. In Kansas, >1.1 million ha were enrolled in CRP with >90% planted in native grasses (U.S. Department of Agriculture 1993). The CRP was intended to accommodate wildlife and agricultural concerns and may provide quality habitat for grassland bird populations.

Quality of CRP habitat has been evaluated by comparing passerine densities in CRP versus cropland (Johnson and Schwartz 1993) and by applying Habitat Suitability Index (HSI) models (Hays et al. 1989). Although these studies use practical methodologies for regional scales, the assumption that density or HSI alone reflect habitat quality may not be valid (Van Horne 1983, Vickery et al. 1992). Several studies have used productivity as an indicator of CRP habitat quality for game species (e.g., Berthelsen et al. 1990, Kantrud 1993). Given high use of CRP by passerines (Johnson and Schwartz 1993), reproductive success of non-game species also needs to be investigated.

We assessed the quality of habitat in CRP fields by comparing the reproductive ecology of Eastern Meadowlarks (*Sturnella magna*) in CRP fields and grazed, native grass rangelands. These habitats had similar plant species composition, but haying and grazing were not permitted in CRP. Our objectives were to: (1) compare Eastern Meadowlark nest success in CRP and rangeland habitats, (2) identify causes of nest failure, (3) compare nest-site microhabitat selection between CRP fields and rangelands, and (4) examine the importance of microhabitat to nest success.

#### METHODS

Our study was conducted 10 km north of Emporia in Lyon County, Kansas (38°30'N, 96°20'W). Topography was gently rolling with elevations ranging from 323–466 m. Winter wheat, row crops, rangeland, and hayfields were primary land uses. Climate was continental averaging 0 C in winter and 25 C in summer, with a 6-mo growing season. Annual precipitation ranged from 63–114 cm with 73% falling from April through September (U.S. Department of Agriculture, Soil Conservation Service 1981).

To minimize variability associated with different CRP practices, we examined conversion to native grass because it promoted vegetation with which Eastern Meadowlarks evolved and was the most common practice in Kansas (U.S. Department of Agriculture 1993). We used three CRP fields in 1990 and added one field in 1991. Field size ranged from 18–24

ha. Mowing, without removal of cut material, was conducted in mid-June 1990 and in previous years to control noxious weeds. One field was mowed only in selected strips, and mowing was completed in late August. Only one of the four CRP fields was mowed in mid-June of 1991.

We used five rangeland sites in 1990. Stocking rates were  $\leq 1.63$  animal unit months (AUM)/ha (cow/calf) and field size was 14–63 ha. Range sites had a history of spring burning, but were not burned in 1990. We used four range sites in 1991, but only one 1990 site was reused. This field was not burned in 1991 and was stocked with cows and calves at 0.54 AUM/ha. Three replacement range sites (178–259 ha) were burned in April 1991 and stocked with steers at 1.85–3.09 AUM/ha.

CRP fields were planted in 1988 or 1989 with a mix of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), sideoatgrass (*Bouteloua curtipendula*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). Cool-season grasses (*Bromus* spp.) also were common. The most common forbs were western ragweed (*Ambrosia psilostachya*) and mare's tail (*Conyza canadensis*) in 1990 and lettuce (*Lactuca* spp.) and sweetclover (*Melilotus* spp.) in 1991. The above native grass species, tall dropseed (*Sporobolus asper*), and Kentucky bluegrass (*Poa pratensis*) were also characteristic of rangelands. Clumping of native grasses, which occurred in CRP fields, was prevented in rangelands by grazing and burning. The most common forbs in rangeland were western ragweed and Baldwin's ironweed (*Vernonia baldwinii*).

*Nest success.*—We captured female Eastern Meadowlarks with mist nets and by night-lighting (Drewien et al. 1967) in April–June 1990 and 1991. We placed mist nets in areas of meadowlark activity and near nests. We moved nets within each field to avoid concentrating the sample in one area. We night-lighted by walking through fields and dragging a rope to flush meadowlarks. We determined sex on the basis of plumage, bill color, and body size (Kemmerer 1981).

We fitted females with 2.5-g transmitters ( $\leq 3\%$  body mass), each attached to the back with an elastic wing-loop harness. We obtained daily locations by circling with a hand-held antenna system to within 30–40 m of the radio-tagged bird. We found nests by flushing females that had the same location for  $\geq 2$  d. When we could not estimate incubation stage from the female's location record, we floated eggs to estimate hatch date (Westerskov 1950). We also used any nests of unmarked birds that we found.

When a radio-tagged female was off the nest, we checked the site to confirm nest status. We examined nests of unmarked birds about every third day. To prevent human-induced premature fledging, we did not visit nests between the seventh and 12th day posthatch (Brown 1988). On the 13th day posthatch, we determined if the attempt was successful ( $\geq 1$  nestling fledged; Nice 1957) by finding feather sheaths at the bottom of the nest (Roseberry and Klimstra 1970). Successful nests were also characterized by an enlarged nest bowl and the presence of fecal sacs. We considered nests unsuccessful if feather sheaths were few or absent, or there

were signs of nest destruction. We placed nest losses into five categories: (1) depredated, (2) abandoned, (3) trampled, (4) inviable, and (5) unknown. Nests of radio-tagged birds composed 70% of the sample, so for these nests the date of nest failure was known.

We estimated daily nest survival and failure rates using the Mayfield (1961) method as adapted by Heisey and Fuller (1985). Because of small sample size, we estimated daily survival rates for 1990 over the entire nesting period. For 1991, we estimated daily survival for incubation (1–12 d), hatching (13–14 d) and nestling (15–24 d) periods. We treated complete clutches of inviable eggs as surviving until the twelfth day of incubation and thereafter deleted them from analyses. We delimited seasons (early, middle, and late) by grouping first, second, and subsequent nesting attempts. We used a *z*-test for comparison of daily survival and failure rates (Johnson 1979) and adjusted overall nest success rates for non-normal bias (Heisey and Fuller 1985). We tested power for non-significant ( $P > 0.05$ ) results as in White and Garrott (1990:28–35) using an effect size equal to observed differences.

*Microhabitat.*—We measured microhabitat characteristics at nests when nestlings fledged or 24 d after initiation of incubation if the attempt was unsuccessful. In 1990, we measured random plots within the nest field (1/ha) during 1-wk sampling periods in June and July. On the basis of subsample variation in the 1990 data, we sampled 20 random plots/field/mo in 1991 and measured random plots on the same date as nests (e.g., if four nests in one field were due to fledge within a month, we measured five random plots per nest). To determine potential nest-site selection over a larger area, we sampled vegetation at four plots 5 m from nests in the cardinal directions.

We visually estimated herbaceous canopy cover, proportion of grass, standing dead cover, and litter cover to the nearest 5% within a 75 × 75-cm quadrat (Hays et al. 1981). We measured herbaceous canopy height to the nearest cm and litter depth in four cardinal directions 20 cm from the quadrat center. In 1991, we ranked litter density (1–5, 5 = densest) on the basis of gap size among litter materials and the difficulty of inserting a metal ruler to the soil surface. We also ranked litter type (1 = predominantly fine materials [ $<3$  mm diameter], 5 = predominantly coarse materials [ $>10$  mm diameter]) in 1991. We recorded 24 visual obstruction readings at each plot (Robel et al. 1970). We estimated microhabitat heterogeneity using the covariance of the 24 readings for each plot (Wiens 1974). We measured distance from nests to an edge (fence-line, cover type change, road, or pond).

Some microhabitat variables were not normally distributed or violated assumptions of homogeneous variances. We still used ANOVA for univariate analyses because the *F*-test is robust to these violations (Cochran 1947, Pearson 1931) and results could be interpreted as a comparison of actual means. Calculated probability levels are not exact however (Cochran 1947). We assessed potential violations of sphericity for blocked (subplot) data by comparing computed *F*-values to an *F*-distribution with 1 df.

In 1990, radio-tagged females nested in different rangeland sites each month. Therefore, we used a factorial split-plot ANOVA with land use  $\times$  month (June and July) as whole-plot factors and location (random plots, nest sites, and plots surrounding the nest) as the subplot factor. For 1991 data, we analyzed microhabitat characteristics in a split-plot, repeated measures ANOVA with land use as the whole-plot factor, fields as experimental units, location as the subplot factor, and season as the repeated measure. We used a *t*-test to separate means when a single factor *F*-test was significant ( $P < 0.05$ ). If an interaction was present ( $P < 0.1$ ), we used a *t*-test to compare means within levels of interacting factors. We followed Milliken and Johnson's (1984:377–407) recommendations for split-plot designs with missing data.

We compared microhabitats of successful and unsuccessful nests in 1991 using a split-plot design with treatments as the whole plot factor, fields as the experimental unit, and success as the subplot factor. We included only season  $\times$  field combinations for which both successful and unsuccessful nests were found and pooled characteristics over time periods. We used a similar analysis for distance to edge, but included all nests. We excluded trampled nests and inviable clutches from these analyses. We used DESIGN (Dallal 1988) to test power for consistent trends that yielded nonsignificant ( $P > 0.05$ ) results.

#### RESULTS

*Nest success and mortality factors.*—Daily nest survival rates tended to be lower in CRP fields in 1990 (CRP:  $0.93 \pm 0.022$  [SE],  $n = 10$  nests; rangeland:  $0.95 \pm 0.022$ ,  $n = 11$  nests) and for all nesting periods in 1991 (Fig. 1), but the trend was not significant, perhaps as a result of low power (1990:  $z = 0.48$ ,  $P = 0.63$ , power = 0.07; 1991:  $z = 0.40$ – $0.78$ ,  $P = 0.44$ – $0.69$ , power = 0.06– $0.13$ ). Overall nest success rates in 1990 were 16.5% in CRP and 24.6% in rangelands; 1991 success rates were 9.6% in CRP and 19.8% in rangelands. Daily nest success of radio-tagged birds ( $0.93 \pm 0.011$ ,  $n = 49$  nests) was not different ( $z = 0.72$ ,  $P = 0.47$ ) from unmarked birds ( $0.91 \pm 0.022$ ,  $n = 22$  nests). Daily nest survival rates were higher ( $z = 2.49$ ,  $P = 0.013$ ) for late versus early nests in rangelands in 1991. We were unable to detect a difference ( $F = 0.95$ ,  $P = 0.37$ ) in nestlings fledged per radio-tagged female between CRP fields ( $1.92 \pm 0.30$ ,  $n = 12$  females) and rangeland sites ( $0.71 \pm 0.28$ ,  $n = 11$  females), again perhaps as a result of low power (0.08).

There were more ( $z = 2.26$ ,  $P = 0.024$ ) nest failures due to inviability in CRP than rangelands, but no difference ( $P > 0.1$ , power = 0.05– $0.14$ ) among other mortality factors between land uses in 1991 (Fig. 2). Daily predation rates were higher (CRP:  $z = 2.11$ ,  $P = 0.035$ ; rangeland:  $z = 2.10$ ,  $P = 0.036$ ) during hatching (overall CRP: 37.3%; rangeland: 25.5%) than during incubation (CRP: 24.4%; rangeland: 15.5%). In 1990, mowing caused the loss of three nests in two CRP fields. A female remained to re-nest in the field that was spot mowed, but complete mowing of the other field caused abandonment by three radio-tagged females. Similarly,

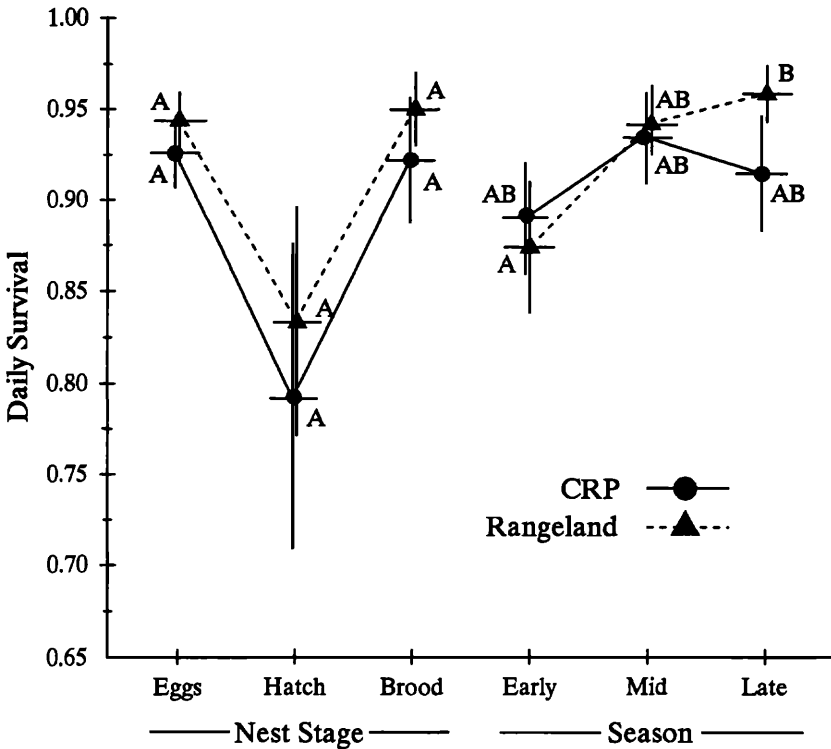


FIGURE 1. Daily nest survival rates ( $\bar{x} \pm SE$ ) of Eastern Meadowlarks in Conservation Reserve Program fields and rangelands in 1991. Eggs = 1–12 d, Hatch = 13–14 d, Brood = 15–24 d, Early = incubation initiated <21 May, Mid = initiated 21 May–14 Jun., Late = initiated >14 Jun. Means with the same letter are not different ( $P > 0.1$ , z-test) between land uses or among nest stages and seasons.

a female with four-day-old fledglings abandoned a CRP field when it was mowed completely on 12 Jun. 1991.

*Microhabitat.*—Nine nest sites and 204 random plots were measured in five rangelands, and seven nest sites and 190 random plots in three CRP fields in 1990. Herbaceous cover was greater in rangelands than in CRP ( $F_{1,5.77} = 12.3, P = 0.014$ ) and decreased from June to July ( $F_{1,5.87} = 64.1, P < 0.001$ ) in both land use types. Available standing dead cover was greater in CRP than in rangelands ( $t = 3.14, df = 13.48, P = 0.007$ ) and was lower at nest sites than random plots in CRP ( $t = 4.48, df = 11, P < 0.001$ ).

In 1991, 44 nests and 215 random plots were measured on four rangeland sites, and 30 nests and 160 random plots were measured on four CRP fields. At least one nest was found in each rangeland site for each seasonal period, but in CRP, one field was represented by one early-season nest and another field had nests for the first two seasons only.

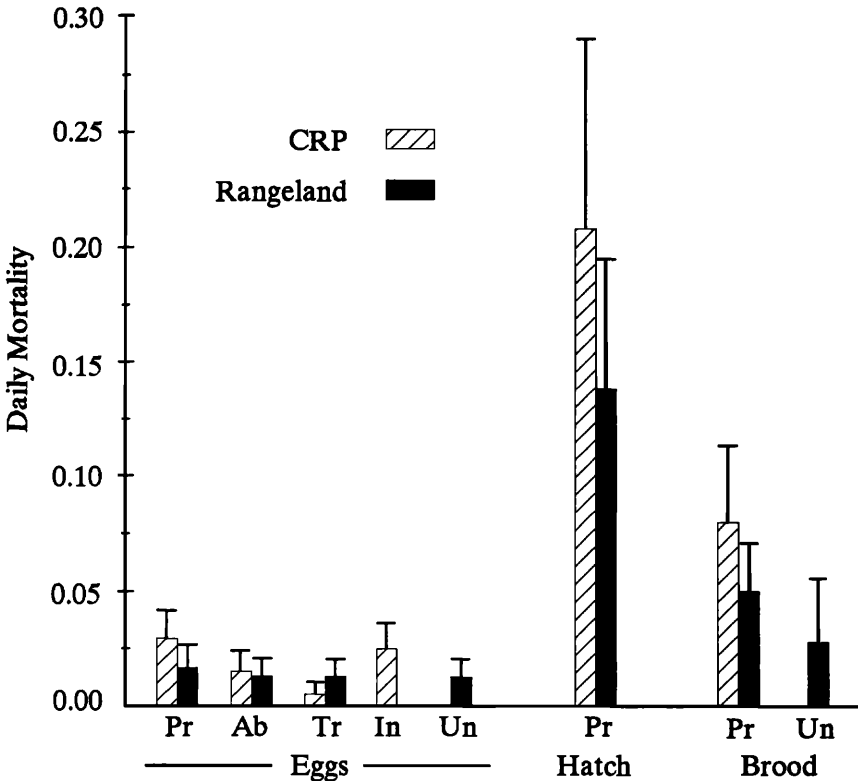


FIGURE 2. Daily failure (mortality) rates ( $\bar{x} \pm SE$ ) for Eastern Meadowlark nests in Conservation Reserve Program fields (CRP) and rangelands in 1991. Eggs = 1–12 d, Hatch = 13–14 d, Brood = 15–24 d, Pr = predation, Ab = abandonment, Tr = trampling, In = inviable clutch, Un = unknown.

TABLE 1. Microhabitat characteristics of Conservation Reserve Program fields (CRP) and rangelands for Eastern Meadowlarks through three seasons in Lyon County, Kansas, 1991, for variables without land use  $\times$  season interactions ( $P > 0.1$ ).

Land use or season <sup>a</sup>	Herbaceous height (cm)		% litter cover		Litter depth (cm)		Litter type (1–5)		CV visual obstruction	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Rangeland	32.4A <sup>b</sup>	2.43	—	—	—	—	2.4A	0.31	41.8A	2.97
CRP	42.1B*	2.52	—	—	—	—	2.3A	0.33	47.6A	3.15
Early	36.2A	1.84	67A	6.1	2.5A*	0.25	2.8A	0.24	43.4A	2.34
Mid	39.2B*	1.90	59A	6.4	2.3A**	0.29	2.2B**	0.25	45.1A	2.45
Late	36.5AB	1.98	64A	6.9	3.6B	0.35	2.1B**	0.27	45.6A	2.60

<sup>a</sup> Early = <21 May; Mid = 21 May–14 June; Late = >14 June.

<sup>b</sup> Means followed by the same letter are not different (*t*-test), \* $P < 0.05$ , \*\* $P < 0.01$ .

Microhabitat structure of CRP differed from rangelands for seven of 10 variables. The only consistent difference over locations and through seasons was taller herbaceous canopy in CRP versus rangelands (Table 1). Land use  $\times$  season interactions indicated differences in vegetation structure development between CRP and rangeland. In CRP, herbaceous cover and the proportion of grass decreased through the season in contrast to the increase in rangeland (Table 2). Random plots in CRP had more litter and standing dead cover than in rangelands (Table 3).

Microhabitat at nest sites did not differ between CRP and rangelands ( $P > 0.09$ ), except for canopy height and litter density, which differed over all locations. In both land use types, vegetation structure was most homogeneous at nest plots and litter was finer at plots surrounding nests than at random plots (Table 4). Plots 5 m from nests were more like nest sites than random plots for all variables associated with litter. In rangelands, meadowlarks selected nest sites with greater litter cover and depth than was available at random plots (Table 3). In CRP, selection for a greater proportion of grass and less dense litter was evident.

The only vegetation characteristics that may have differentiated successful from unsuccessful nests were higher proportion of grass ( $P = 0.092$ , power = 0.22) and greater standing dead cover ( $P = 0.095$ , power = 0.28). Successful nests were not farther from edge than unsuccessful nests ( $P = 0.92$ , power = 0.14).

#### DISCUSSION

We were unable to detect differences in Eastern Meadowlark reproductive success between CRP and rangelands, despite differences in overall habitat structure. Unfortunately, low nest success resulted in few nest days for determination of daily success, high variance, and low test power for all factors associated with nest survival and numbers fledged per nest. Small differences in daily survival rates result in large differences in overall nest success, which may be biologically significant. Our data suggest lower nest survival rates but higher reproductive output per female in CRP fields. Much larger sample sizes (100–200 nests) would be needed to determine (power = 0.8) if these apparent differences really exist and the degree to which they may be compensatory.

Nest success rates were lower (<25%) than previously reported for Eastern Meadowlarks (e.g., 33% in Illinois [Lanyon 1957], 30% for monogamous females and 52% for polygynous females in Ontario [Knapton 1988]). In the preceding studies, it was assumed that all nests were found, and nest success calculated directly may have over-estimated success (Mayfield 1961). Radio-tagging birds did not appear to affect nest success in our study, but could have affected the propensity to re-nest (Rotella et al. 1993), thereby lowering the number of late-season nests. Because the life expectancy of Eastern Meadowlarks is not known, the impact of low nest success on the population cannot be evaluated. Eastern Meadowlarks were persistent re-nesters in our study, which would lessen the impact of low nest success on the population.



TABLE 2. Microhabitat characteristics with land use  $\times$  season interaction ( $P < 0.1$ ) for Eastern Meadowlarks in Conservation Reserve Program fields (CRP) and rangelands through three seasons in Lyon County, Kansas, 1991.

Season <sup>a</sup>	% herbaceous cover		% grass cover		% standing dead cover		Litter density (1-5) <sup>b</sup>		Visual obstruction (dm)	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
<b>Rangeland</b>										
Early	73a <sup>c</sup>	3.5	60aA	7.7	5aA	2.1	1.6abA	0.14	1.8aA	0.31
Mid	87b*A	3.5	66abA	7.7	1aA	2.1	1.3aA	0.14	2.1aA	0.31
Late	83b*A	3.5	68b*A	7.7	4aA	2.1	1.7b*A	0.14	2.0aA	0.31
<b>CRP</b>										
Early	64aA	3.5	76aA	7.7	5aA	2.2	2.8aB**	0.14	2.3aA	0.31
Mid	48b*B**	4.2	62b**A	8.0	27b**B**	2.4	3.1b*B**	0.16	2.8b*A	0.32
Late	47b*B**	5.1	60b*A	8.3	4aA	3.4	2.7aB**	0.18	3.1b**B*	0.34

<sup>a</sup> Early = <21 May; Mid = 21 May-14 June; Late = >14 June.

<sup>b</sup> 1 = least dense; 5 = most dense.

<sup>c</sup> Means with the same lower case letter are not different among seasons within land-use types (*t*-test). Means with the same upper case letter are not different between land-use types within seasons (*t*-test), \* $P < 0.05$ , \*\* $P < 0.001$ .

TABLE 3. Microhabitat characteristics with land use  $\times$  location interaction ( $P < 0.1$ ) at random plots, Eastern Meadowlark nest sites, and plots 5 m from nests in Conservation Reserve Program fields (CRP) and rangelands in Lyon County, Kansas, 1991.

Location	% grass cover		% standing dead cover		% litter cover		Litter depth (cm)		Litter density (1-5) <sup>a</sup>	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
<b>Rangeland</b>										
Random	67aA <sup>b</sup>	8.1	2aA	1.5	36aA	9.0	1.5aA	0.28	1.7aA	0.15
Nest	67aA	8.1	5aA	1.5	78b**A	9.0	3.1b**A	0.28	1.5aA	0.15
5-m	59aA	8.1	3aA	1.5	59c*A	9.0	2.9b**A	0.28	1.4aA	0.15
<b>CRP</b>										
Random	54aA	8.4	10abB*	2.4	66aB*	10.2	3.4aB*	0.47	3.4aB**	0.17
Nest	82b**A	8.4	10aA	2.1	77aA	10.2	2.7aA	0.47	2.3b**B*	0.17
5-m	62aA	8.4	14b*B*	2.4	66aA	10.2	3.1aA	0.47	3.0c*B**	0.17

<sup>a</sup> 1 = least dense; 5 = most dense.

<sup>b</sup> Means followed by the same lower case letter are not different among locations within land-use types (*t*-test). Means followed by the same upper case letter are not different between land-use types within locations (*t*-test), \* $P < 0.05$ , \*\* $P < 0.001$ .

TABLE 4. Microhabitat characteristics without land use  $\times$  location interaction ( $P > 0.1$ ) in Conservation Reserve Program fields and rangelands at random plots, Eastern Meadowlark nest sites, and plots 5 m from nests in Lyon County, Kansas, 1991.

Location	% herbaceous cover		Herbaceous height (cm)		Litter type (1-5) <sup>a</sup>		Visual obstruction (dm)		CV visual obstruction	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Random	67A <sup>b</sup>	2.3	37.8A	2.01	2.7A	0.26	2.5A	0.28	47.0A	2.46
Nest	69A	2.3	37.8A	2.01	2.3AB	0.26	2.3A	0.28	39.4B*	2.46
5-m	65A	2.3	36.2A	2.01	2.0B*	0.26	2.3A	0.28	47.7A	2.46

<sup>a</sup> 1 = most materials <3 mm diam.; 5 = most materials >10 mm diam.

<sup>b</sup> Means followed by the same letter are not different ( $t$ -test), \* $P < 0.01$ .

Roseberry and Klimstra (1970) attributed an 18% nest success rate for Eastern Meadowlarks in a re-seeded, ungrazed pasture in Illinois to high predator densities. Predation rates of 53% (CRP) and 42% (rangeland) are high, but similar to those found for other ground-nesting species in grassland ecosystems (Martin 1993, Miller and Knight 1993). Most likely, a variety of potential predators, (e.g., bullsnake [*Pituophis melanoleucus*], Common Grackle [*Quiscalus quiscula*], Corvids, opossum [*Didelphis virginiana*], badger [*Taxidea taxus*], striped skunk [*Mephitis mephitis*], raccoon [*Procyon lotor*], coyote [*Canis latrans*]) lead to high predation rates (Miller and Knight 1993). Other causes of nest failure were as important as predation during incubation, indicating that the sum of many factors was responsible for the low success rates we observed. We often found nests with less than the full clutch taken, especially in rangelands, suggesting disturbance by small predators and Brown-headed Cowbirds (*Molothrus ater*), which may have increased abandonment rates. Meadowlarks also have been shown to remove eggs from nests, which could indicate possible interference competition (Picman 1992).

Brown (1988) and Roseberry and Klimstra (1970) did not find differences in vegetation between successful and unsuccessful Eastern Meadowlark nest sites, whereas we found an indication of more grass and standing dead cover at successful nests. Lanyon (1957) hypothesized that an observed increase in nest success through the season was the result of an increase in vegetative cover. The increase in nest success in rangeland corresponds to an increase in herbaceous cover, but we did not find more herbaceous cover at successful versus unsuccessful nests.

Characteristics important at nest sites could be ascertained when management affected habitat structure. Annual grazing and burning reduced litter in rangelands resulting in nest-site selection for more litter cover. Greater litter cover in CRP was a positive factor, but high litter density as a result of the lack of removal of mowed material may have lowered nest-site quality. Lack of disturbance in CRP (e.g., fire, grazing) was also likely to have perpetuated forbs, which provided little ground cover and resulted in nest-site selection for a higher proportion of grass. Risser et al.

(1981) found higher Eastern Meadowlark densities on moderately grazed versus ungrazed grasslands, possibly reflecting their co-evolution with grazers and a need for periodic habitat perturbation. Grazing can have negative impacts, however, such as nest trampling and possible attraction of Brown-headed Cowbirds (Friedmann 1929, Rothstein et al. 1987) leading to increased brood parasitism rates (Granfors 1992).

Differences in habitat structure between CRP fields and rangelands indicate an increase in the diversity of habitats available for nesting Eastern Meadowlarks and other ground-nesting birds. An increase in breeding habitat diversity mitigates adverse effects of stress in other habitats (Ruggiero et al. 1988) and could provide a variety of microsites which may vary in quality within and between seasons depending on the relative number and types of predators. The similarity of meadowlark nest-site structure between land uses reflects the meadowlark's ability to find suitable nest sites in spite of overall differences in habitat structure. CRP provided nesting habitat for meadowlarks, but quality was not consistent through the season.

#### MANAGEMENT IMPLICATIONS

Whereas constraints of forage production and grazing may limit rangeland management options, CRP fields can be managed for grassland-nesting birds. Rotenberry and Wiens (1980) found that Eastern Meadowlark densities were correlated with whole-field characteristics equivalent to nest-site characteristics selected in our study (e.g., grass cover, litter cover and depth, and structural homogeneity). Thus, microhabitat selection at nest-sites appears to be similar to macrohabitat selection.

Mowing and burning are often recommended for controlling noxious plants in CRP. Mowing causes undesirable litter build up and, dependent on seasonality and extent, may cause abandonment of fields and direct failure of nests. Frawley and Best (1991) found no reduction in Western Meadowlark (*Sturnella neglecta*) densities when part of a breeding territory was mowed. Similarly, females did not abandon fields in our study when only portions of the field were mowed. Therefore, we recommend spot mowing to control noxious plants. Mowing should be conducted as late as possible (after 15 July) to avoid destruction of nests.

Grazing is an alternative to mowing, and it would decrease litter build-up (Risser et al. 1981), but increase the probability of trampling and attracting cowbirds (Friedmann 1929, Granfors 1992, Rothstein et al. 1987). When conducted at the proper time of year, prescribed burning can reduce litter and increase the proportion and vigor of native grasses, while decreasing the proportion of cool-season grasses and forbs (Wright and Bailey 1982). Periodic burns may increase invertebrate populations (Risser et al. 1981) and increased vegetation cover can lead to increased nest success for ground-nesting grassland species (Johnson and Temple 1990). Annual burning could increase soil erosion (Wright and Bailey 1982) and conflict with other conservation objectives of CRP. Thus, we recommend burning in spring before significant green-up every 3–4 yr

to approximate natural fire frequency (Risser et al. 1981, Wright and Bailey 1982), but specific prescriptions will depend on litter build-up, grass vigor, and local plant populations. This practice may temporarily reduce early-season habitat quality in the year of burning, but increased grass cover and some reduction of litter should enhance quality later in the season and in subsequent years.

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#### LITERATURE CITED

- BERTHELSEN, P. S., L. M. SMITH, AND R. R. GEORGE. 1990. Ring-necked pheasant nesting ecology and production on CRP lands in the Texas Southern High Plains. *Trans. N. Am. Wildl. Nat. Resour. Conf.* 55:46–56.
- BROWN, S. L. 1988. The maintenance and consequences of polygyny in eastern meadowlark (*Sturnella magna*). Ph.D. thesis, Purdue Univ., West Lafayette, Indiana.
- COCHRAN, W. G. 1947. Some consequences when the assumptions for the analysis of variance are not satisfied. *Biometrics* 3:22–38.
- DALLAL, G. E. 1988. DESIGN: a supplementary module for SYSTAT and SYSGRAPH. SYSTAT, Inc. Evanston, Illinois. 23 pp.
- DREWIEN, R. C., H. M. REEVES, P. F. SPRINGER, AND T. L. KUCK. 1967. Back-pack unit for capturing waterfowl and upland game by night-lighting. *J. Wildl. Manage.* 3:778–783.
- FRAWLEY, B. J., AND L. B. BEST. 1991. Effects of mowing on breeding bird abundance and species composition in alfalfa fields. *Wildl. Soc. Bull.* 19:135–142.
- FRIEDMANN, H. 1929. The cowbirds: a study in the biology of social parasitism. Charles C. Thomas Publ., Springfield, Illinois. 421 pp.
- GRANFORS, D. A. 1992. The impact of the Conservation Reserve Program on eastern meadowlark production and validation of the eastern meadowlark habitat suitability index model. M.Sc. thesis, Texas Tech Univ., Lubbock, Texas.
- HAYS, R. L., C. SUMMERS, AND W. SEITZ. 1981. Estimating wildlife habitat variables. U.S. Fish and Wildl. Serv., Biol. Serv. Prog. FWS/OBS-81/47. Washington, D. C.
- , R. P. WEBB, AND A. H. FARMER. 1989. Effects of the Conservation Reserve Program on wildlife habitat: results of the 1988 monitoring. *Trans. N. Am. Wildl. Nat. Resour. Conf.* 54:365–376.
- HEISEY, D. M., AND T. K. FULLER. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. *J. Wildl. Manage.* 49:668–674.
- JOHNSON, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. *Auk* 96:651–661.
- , AND M. D. SCHWARTZ. 1993. The Conservation Reserve Program and grassland birds. *Conserv. Biol.* 7:934–937.
- JOHNSON, R. G., AND S. A. TEMPLE. 1990. Nest predation and brood parasitism of tallgrass prairie birds. *J. Wildl. Manage.* 54:106–111.
- KANTRUD, H. A. 1993. Duck nest success on Conservation Reserve Program land in the Prairie Pothole region. *J. Soil Water Conserv.* 48:238–242.
- KEMMERER, M. R. 1981. Physiological condition and sex determination of eastern meadowlarks in north central Oklahoma. M.Sc. thesis, Oklahoma State Univ., Stillwater, Oklahoma.
- KNAPTON, R. W. 1988. Nesting success is higher for polygynously mated females than for monogamously mated females in the Eastern Meadowlark. *Auk* 105:325–329.

- LANYON, W. E. 1957. The comparative biology of the meadowlarks (*Sturnella*) in Wisconsin. Pub. Nuttall Ornithol. Club 1, Cambridge, Massachusetts. 67 pp.
- MARTIN, T. E. 1993. Nest predation among vegetation layers and habitat types: revising the dogmas. *Am. Nat.* 141:897-913.
- MAYFIELD, H. 1961. Nesting success calculated from exposure. *Wilson Bull.* 73:255-261.
- MILLER, C. K., AND R. L. KNIGHT. 1993. Does predator assemblage affect reproductive success in songbirds? *Condor* 95:712-715.
- MILLIKEN, G. A., AND D. E. JOHNSON. 1984. Analysis of messy data. Van Nostrand Reinhold Co., New York, New York. 473 pp.
- NICE, M. M. 1957. Nesting success in altricial birds. *Auk* 74:305-321.
- PEARSON, E. S. 1931. The analysis of variance in cases of non-normal variation. *Biometrika* 23:114-133.
- PICMAN, J. 1992. Egg destruction by Eastern Meadowlarks. *Wilson Bull.* 104:520-525.
- RISSE, P. G., E. C. BIRNEY, H. D. BLOCKER, S. W. MAY, W. J. PARTON, AND J. A. WIENS. 1981. The true prairie ecosystem. U.S./IBP Synthesis Ser. 16. Hutchinson Ross Publ. Co. Stroudsburg, Pennsylvania. 556 pp.
- ROBEL, R. J., J. N. BRIGGS, A. D. DAYTON, AND L. C. HULBERT. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. *J. Range Manage.* 23:295-297.
- ROSEBERRY, J. L., AND W. D. KLIMSTRA. 1970. The nesting ecology and reproductive performance of the Eastern Meadowlark. *Wilson Bull.* 82:243-267.
- ROTELLA, J. J., D. W. HOWERTER, T. P. SANKOWSKI, AND J. H. DEVRIES. 1993. Nesting effort by wild mallards with 3 types of radio transmitters. *J. Wildl. Manage.* 57:690-695.
- ROTENBERRY, J. T., AND J. A. WIENS. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. *Ecology* 61:1228-1250.
- ROTHSTEIN, S. I., J. VERNER, E. STEVENS, AND L. V. RITTER. 1987. Behavioral differences among sex and age classes of the Brown-headed Cowbird and their relation to the efficacy of a control program. *Wilson Bull.* 99:322-337.
- RUGGIERO, L. F., R. S. HOLTHAUSEN, B. G. MARCOT, K. B. AUBRY, J. W. THOMAS, AND E. C. MESLOW. 1988. Ecological dependency: the concept and its implications for research and management. *Trans. N. Am. Wildl. Nat. Resour. Conf.* 53:115-126.
- U.S. DEPARTMENT OF AGRICULTURE. 1993. Agricultural statistics 1992. U.S. Govt. Printing Off., Washington, D.C. 517 pp.
- U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE. 1981. Soil survey of Lyon County, Kansas. U.S. Govt. Printing Off., Washington, D.C. 1981-293-883/95. 96 pp.
- VAN HORNE, B. 1983. Density as a misleading indicator of habitat quality. *J. Wildl. Manage.* 47:893-901.
- VICKERY, P. D., M. L. HUNTER, JR., AND J. V. WELLS. 1992. Is density an indicator of breeding success? *Auk* 109:706-710.
- WESTERSKOV, K. 1950. Methods for determining the age of game bird eggs. *J. Wildl. Manage.* 14:56-57.
- WHITE, G. C., AND R. A. GARROTT. 1990. Analysis of wildlife radio-tracking data. Academic Press, Inc. San Diego, California. 383 pp.
- WIENS, J. A. 1974. Habitat heterogeneity and avian community structure in North American grasslands. *Am. Midl. Nat.* 91:195-213.
- WRIGHT, H. A., AND A. W. BAILEY. 1982. Fire ecology, United States and southern Canada. John Wiley and Sons, New York, New York. 501 pp.

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