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Field-level spatial factors, associated edges, and dickcissel nesting ecology on reclaimed lands in Texas

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Abstract

Surface-mined land reclamation creates grass and shrub lands that provide important wildlife habitat, particularly for disturbance-dependent birds. Declines in disturbance-dependent birds have been observed for 30 years, emphasizing the importance of proper reclamation strategies. Understanding the influence of spatial factors on nesting ecology of avian populations can improve restoration strategies on reclaimed mines. We evaluated the influence of spatial factors on nest site selection, nest success, and nest parasitism of dickcissels (*Spiza americana*) on two sites reclaimed as wildlife habitat on the Big Brown Mine, Freestone County, Texas, in 2002–2003. We found 119 nests, 14 of which were parasitized by the brown-headed cowbird (*Molothrus ater*). Dickcissels were more likely to select nest sites farther from riparian areas and closer to brush-encroached areas. Nest success was not clearly explained by one or few variables. Parasitism was more likely to occur near riparian areas and roads. For these reasons, we suggest the establishment of larger wildlife habitat blocks, which would provide more field-interior habitat for dickcissels and similar species.
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1. Introduction

Reclamation following surface mining of coal creates large, contiguous tracts of grasslands (Brothers, 1990) that are important areas for disturbance-dependent birds (Allaire, 1978; Ingold, 2002). Because the grassland bird assemblage has declined more than any other avian group during the last 30 years (Peterjohn and Sauer, 1999), grassland habitat created during the reclamation process could be critical to these species. Increased nest predation, brood or nest parasitism by brown-headed cowbirds, and habitat loss and fragmentation contributed to these declines (Johnson and Temple, 1990). This loss of habitat could be countered by two conservation programs (DeVault et al., 2002). The first, the conservation reserve program, has the potential to convert cropland into suitable grassland habitat (Best et al., 1997), but only on a relatively short timescale. Although there are 12.5 million hectares currently enrolled in the program, contracts on 84% of this land will expire by 2010 (U.S. Department of Agriculture, 2004). The second conservation effort (DeVault et al., 2002) involves millions of hectares of reclaimed surface-mined land that create suitable habitat for disturbance-dependent birds (Wray et al., 1982; Bajema et al., 2001; Ingold, 2002). Due to the size, time-span, and contiguity involved with surface mining and reclamation, enormous opportunities for grassland bird conservation exist in these areas.

The dickcissel, a neotropical migrant of conservation concern (Hunter et al., 2001), is a grassland bird which has suffered a population decline during at least the last 30 years due to habitat loss, increased nest predation and parasitism (i.e., by brown-headed cowbirds), and control as a pest (i.e., lethally controlled as an agricultural pest on its wintering range in Central and South America (Basili and Temple, 1998; Temple, 2002)). Indeed, reclaimed surface-mined lands provide important breeding habitat for dickcissels in the United States (Cantle, 1978; DeVault et al., 2002; Scott et al., 2002), which emphasizes the importance of reclamation efforts.

Habitat edges influence nest-site preferences, nest success, and brood parasitism of birds (Jensen and Finck, 2004). For example, grassland birds typically avoid nesting near wooded edges (Johnson and Temple, 1986; Winter et al., 2000), and

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nest predation and parasitism rates are usually highest in highly fragmented habitats as well as near habitat edges (Paton, 1994), where variation in predation and parasitism rates are likely due to habitat affinities of nest predators and brood parasites, such as the brown-headed cowbird. The reclamation process often results in a land-use mosaic (Brothers, 1990) with agricultural and wooded edges and creates habitat for wildlife at large scales (Brenner, 1973). Understanding the influence of spatial features (e.g., gradual vs. abrupt edges) on avian nesting ecology could help to provide specific habitat prescriptions for targeted species such as dickcissels.

In a grassland habitat, breeding birds may avoid abrupt edges (i.e., wooded edges) but may not avoid gradual edges (i.e., agricultural edges) (Jensen and Finck, 2004), which are common components of North American grasslands (Sampson and Knopf, 1994). This study investigated edge effects on the nesting ecology of a neotropical migratory avian species of concern. Specifically we evaluated the influence of gradual and abrupt edges, on (1) nest-site selection, (2) nest success, and (3) nest parasitism of dickcissels on reclaimed surface-mined lands created as wildlife habitat on the Big Brown Mine in Freestone County, Texas.

2. Methods

2.1. Study area

Our study was conducted on the Big Brown Mine (5800 ha) owned and operated by TXU Energy in Freestone County, 16 km east of Fairfield, TX. The mine was within the northern post-oak savannah vegetation region of Texas wedged between the pineywoods on the east, blackland prairies on the west, and coastal prairies and marshes on the south (Gould, 1975). Topography was gently rolling to hilly. Historically, this region was characterized by post-oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) in the overstory, and climax grasses (e.g., little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*)) in the understory (Gould, 1975). Since 1971, TXU Energy has reclaimed surface-mined lands to create a variety of habitats (e.g., wildlife habitat, riparian areas, hayfields, grazed pastures, timber plantations, and wetlands) all of which began as early successional grasslands.

We evaluated the nesting ecology of dickcissels on two study areas designated as wildlife habitat areas (i.e., no mowing or grazing allowed; site 1 = 52 ha; site 2 = 64 ha) managed by TXU Energy and reclaimed in 1993. Vegetation in these areas was characterized by various young oaks, willow baccharis (*Baccharis salicina*), chickasaw plum (*Prunus augustafolia*), and grasses such as bushy bluestem (*Andropogon glomeratus*), Wilmann's lovegrass (*Eragrostis superba*), switchgrass, coastal bermudagrass (*Cynodon dactylon*), and clover (*Trifolium* spp.).

2.2. Nest monitoring

Dickcissel nests were located and monitored from April to July 2002 and 2003 using guidelines suggested by Martin and Geupel (1993). Eight systematically placed plots (50 m × 200 m) in each area were searched once weekly. In 2003, less-intensive systematic searches were performed over entire study areas every 2–3 days in addition to the nest search plots. Once a nest was found, its location was marked with a global positioning system waypoint, and subsequently revisited every 2–3 days thereafter to monitor success (Martin and Geupel, 1993). We determined and categorized nest fate as successful (fledge $\geq$ 1), or failed (depredated or abandoned). Additionally, nests were also categorized as parasitized given the presence of $\geq$1 brown-headed cowbird egg.

2.3. Spatial data acquisition

Several abrupt- and gradual-edged field-level spatial features were common to both study sites, and included gradual edges: (1) agricultural fields (i.e., fields used for cattle grazing or hay production; primarily a monoculture of bermudagrass), (2) newly reclaimed areas (i.e., land reclaimed within the past 2 years and planted with wheat (*Triticum* spp.) as a fast cover), (3) brush-encroached areas within the study sites, and (4) younger wildlife areas (i.e., adjacent fields that were reclaimed as wildlife habitat like the study sites but were absent of woody encroachment due to age); abrupt edges: (1) roads, (2) forested riparian areas (i.e., bottomland forest), (3) young woodlands (i.e., included fields that were reclaimed as forest or pine tree plantations that contained trees $\geq$5 m in height), and (4) bare soil (areas that have not yet been planted following mining operations). In addition we included permanent water sources in the analyses because of biological importance (e.g., influence on establishment of vegetation, predator movements, etc.). These features were digitized from a 1-m resolution digital orthophoto quadrangle taken in October 2002 with ArcView 3.3 (ESRI Institute, Redlands, CA, USA). Proximity of nests from features was calculated in ArcView using the extension spatial analyst.

Nest-site selection, nest success, and nest parasitism were evaluated using binary logistic regression. Nest-site selection (0 = unoccupied random point, 1 = nest site) was determined by comparing the distance to features from actual nests and randomly generated points within unoccupied locations. Although random points were generated throughout each site, we avoided the placement of random points within a 10-m buffer of an actual nest point (i.e., case-control study design; Hosmer and Lemeshow, 2000; North and Reynolds, 1996). Similarly, nest success (0 = failed, 1 = successful) and nest parasitism (0 = not parasitized, 1 = parasitized) were modeled by comparing distances to spatial features between failed and successful nests, and parasitized and non-parasitized nests, respectively. For the parasitism model, only nests that were observed within the timeframe of known cowbird parasitism activity were used (i.e., 27 May–25 June for this study; Budnik et al., 2002).

In each analysis, predictor variables were based on the proximity of nests from spatial features (i.e., distance from roads, water, agricultural fields, riparian area, and newly reclaimed areas, bare soil, and young woodlands, young wildlife areas) in which the distances were treated as continuous variables. Site and year were entered as categorical variables. Highly correlated variables ($r^2 \geq 0.70$; Pearson-product moment correlation) were identified prior to model building, and in which case one of the pair of predictors was eliminated for analysis. Models were evaluated using an information-theoretic approach via Akaike's Information Criterion (AIC; Burnham and Anderson, 2002). Additionally, the importance of model parameters was evaluated by summing the AIC weights (ω) of each subset in which the parameter appears (Burnham and Anderson, 2002). Logistic regression analyses were performed with Statistica 6 (StatSoft, Inc., Tulsa, Oklahoma).

3. Results

We found and collected data on 119 nests ($n = 25$, 2002; $n = 94$, 2003). These nests were compared to 119 randomly generated points. The predictors based on distance from young wildlife areas, distance from newly reclaimed areas, and distances from young woodlands were eliminated due to multicollinearity issues. Based on the global model, five subsets were generated that were within two AIC units of each other (Table 1), suggesting each model was a competing or plausible model (Burnham and Anderson, 2002). Distance from riparian zones, distance from bare soil, distance from brush-encroached areas, and the categorical variable "site" were the most prominent variables in predicting nest-site selection, appearing in each competing model or subset (Table 2).

We modeled nest success using data from 71 failed and 48 successful nests (total $n = 119$). Distance from newly reclaimed areas, young wildlife areas and young woodlands were eliminated from analysis due to collinearity. The remaining variables were used for both parasitism and nest success modeling. Six subsets were generated from the global success model that were within two AIC units and were considered competing models (Table 1). Year, distance from agricultural fields, and distance from roads appeared in the most subsets, but distance from water, brush-encroached areas, riparian areas, and the categorical variable "site" appeared in many subsets as well (Table 2).

Brood parasitism was relatively infrequent in this study. A total of 111 nests were monitored during known cowbird parasitism activity, with 14 nests being parasitized. Twelve competing models were generated from the global nest parasitism model (Table 1). Distance from riparian zones and roads were the most prominent variables in explaining the incidence of nest parasitism, but distance from agricultural fields and site also appeared in several of the competing models (Table 2).

4. Discussion

Four variables appeared in all competing nest-site selection models (i.e., they had equivalent AIC weight sums; Table 2). Nest sites were likely to be closer to brush-encroached areas. This may be explained by habitat affinities of dickcissels for heterogeneous vegetation structure, such as shrub density (Dixon, 2004) or woody nest substrates (Overmire, 1962), rather than by edge effects. Nest-site selection was also likely to occur far-

Table 1
Global model and competing subsets for nest-site selection, nest success, and nest parasitism of dickcissels on reclaimed lands in Texas, 2002–2003

Subsets	Predictors	AIC diagnostics						Correctly predicted
		K	$-2\log$	AIC	AICc	ΔAICc	ωi	data (%)
Nest-site selection models								
1	BRUSH + RIP + BARE + SITE	5	231.78	241.78	242.04	0.00	0.36	76.9
2	BRUSH + RIP + BARE + SITE + AG	6	231.27	243.27	243.63	1.60	0.33	77.3
Global	BRUSH + RIP + BARE + SITE + ROAD + AG + WATER	8	228.33	244.33	244.96	2.92	0.31	76.1
Nest success models								
1	YEAR + AG + ROAD + RIP + SITE + WATER + BRUSH	8	137.34	153.34	154.65	0.00	0.17	73.9
2	YEAR + AG + ROAD	4	146.34	154.34	154.69	0.04	0.17	69.7
3	YEAR + WATER	3	148.65	154.65	154.86	0.21	0.17	59.7
4	YEAR + AG + ROAD + SITE + BRUSH + RIP + WATER + BARE	9	135.61	153.61	155.26	0.61	0.16	73.1
5	YEAR + AG + ROAD + SITE + BRUSH + RIP	7	140.40	154.40	155.41	0.76	0.16	73.1
Global	YEAR + AG + ROAD + SITE + BRUSH + RIP + WATER + BARE	9	135.61	153.61	155.26	0.61	0.16	73.1
Nest parasitism models								
1	RIP + ROAD	3	63.20	69.20	69.42	0.00	0.12	89.1
2	AG + BARE + SITE	4	61.69	69.69	69.87	0.46	0.12	89.1
3	RIP + ROAD + SITE	4	62.20	70.20	70.38	0.97	0.11	89.9
4	AG + BRUSH + SITE	4	62.42	70.42	70.60	1.19	0.11	89.9
5	RIP + AG + BARE + SITE	5	60.66	70.66	70.94	1.52	0.11	89.1
6	AG + WATER + BARE + SITE	5	60.69	70.69	70.97	1.55	0.11	89.9
7	ROAD + RIP + AG	4	62.91	70.91	71.09	1.68	0.11	89.9
8	ROAD + RIP + BRUSH	4	63.08	71.08	71.26	1.85	0.11	89.9
9	ROAD + RIP + YEAR	4	63.13	71.13	71.31	1.90	0.11	89.1
Global	AG + ROAD + YEAR + SITE + RIP + WATER + BRUSH + BARE	9	137.01	155.01	155.86	86.44		89.1

BRUSH, RIP, BARE and AG correspond to the variables, distance (meters) from brush-encroached areas, distance from riparian areas, distance from bare ground, and distance from agricultural fields, respectively.

Table 2
Variable importance and means (distance in meters) of variables from each model

Nest-site selection		Mean ± S.E.	
Variable	$\sum\omega$ in plausible subsets	Unoccupied random	Nest
Distance from brush encroached	0.69	425.06 ± 20.69	204.73 ± 15.45
Distance from riparian zone	0.69	277.55 ± 14.24	278.03 ± 15.29
Distance from bare soil	0.69	346.92 ± 18.45	365.96 ± 16.33
Site	0.69	N/A	N/A
Distance from ag field	0.33	306.09 ± 12.11	283.84 ± 13.38

Nest success		Mean ± S.E.	
Variable	$\sum\omega$ in plausible subsets	Failed	Successful
Year	0.84	N/A	N/A
Distance from agricultural field	0.67	277.85 ± 18.13	292.7 ± 19.69
Distance from roads	0.67	276.35 ± 19.36	241.65 ± 25.52
Distance from brush encroached	0.50	187.93 ± 18.12	229.58 ± 27.23
Distance from riparian zone	0.50	279.39 ± 20.11	276.02 ± 23.74
Site	0.50	N/A	N/A
Distance from water	0.50	212.63 ± 11.31	181.59 ± 12.14
Distance from bare soil	0.16	383.92 ± 21.28	339.40 ± 25.21

Nest parasitism		Mean ± S.E.	
Variable	$\sum\omega$ in plausible subsets	Unparasitized	Parasitized
Distance from riparian zone	0.66	299.34 ± 15.58	118.21 ± 35.36
Distance from roads	0.55	276.78 ± 16.86	154.18 ± 20.73
Site	0.56	N/A	N/A
Distance from ag field	0.55	297.16 ± 14.30	183.97 ± 25.96
Distance from bare soil	0.33	365.56 ± 17.58	368.95 ± 44.82
Distance from brush encroached	0.22	189.30 ± 13.71	320.44 ± 77.31
Distance from water	0.11	198.42 ± 9.00	212.79 ± 24.42
Year	0.11	N/A	N/A

Variable importance was expressed as the sum of weights (ω) from each competing subset in which variables appear.

ther from areas of substantial bare ground (i.e., newly reclaimed areas), perhaps due to lack of aforementioned structure. Dickcissels were likely to select sites farther from forested riparian areas. Lower nest densities of dickcissels have occurred near wooded edges (Hughes et al., 1999; O'Leary and Nyberg, 2000; Jensen and Finck, 2004) and mesopredator activities were highest in wooded edges in remnant tallgrass prairie (Winter et al., 2000). Although mean distance to riparian areas was similar between unoccupied random locations and nest locations, the variable is only important when included with the other three variables (distance to bare ground, and distance to brush-encroached areas, and site). Lastly, the categorical variable "site" also appeared in all subsets suggesting nest-site selection factors differed between sites (i.e., spatial variation; Chase, 2002). Again, these four variables explaining nest-site selection were only important when all are included in the model together (i.e., the combination of the four variables better explained nest-site selection than three, two, or one of the four variables).

Year was the most prominent variable in all subsets explaining nest success. Nest success can fluctuate yearly and, although anecdotal, more predators or physical signs of predation were observed during the 2003 breeding season. For example, extensive areas were damaged by feral hogs (*Sus scrofa*), including damage to or predation of nests. Also, several coyotes (*Canis latrans*) were observed on site during daylight. These instances did not occur during 2002. Additionally, nests further from agricultural fields and closer to roads were more likely to be successful (Tables 1 and 2). Nest parasitism model subsets suggest that parasitism was also likely to occur near agricultural fields, which may explain the appearance of the variable in nest success subsets.

Lastly, distance to riparian areas and roads appeared in most subsets that explained nest parasitism (Tables 1 and 2). Brown-headed cowbirds have an affinity for elevated perches, from which they can scan for potential hosts (Gates and Gysel, 1978). Other spatial features lacked elevated perches, which may explain their weaker contribution to nest parasitism models. Roads contained transmission and fence lines, while the riparian areas contained tall trees (relative to the study sites), which may explain the higher incidence of parasitism near these spatial features. Agricultural edges, which appeared in many of the competing subsets (Table 1), included fence lines (i.e., elevated perch) and cowbird food sources (i.e., grains and seeds). Lastly, the categorical variable "site" also appeared in many subsets. Our results support the hypothesis that cowbird parasitism is skewed toward woodland edges in grasslands (Mayfield, 1965; Johnson and Temple, 1990; Winter et al., 2000; Budnik et al., 2002; Jensen and Finck, 2004).

The focus of this research was on dickcissel ecology; however, many of the trends and habitat requirements associated with dickcissels are relevant to other grassland or shrubland birds (disturbance-dependent birds). For example, anticipating brown-headed cowbird affinities toward certain types of edges, structures, or reclamation strategies could help to improve reclamation plans with regards many disturbance-dependent birds. In addition, reclamation for a particular target species should incorporate appropriate edges according to habitat requirements and life history traits.

4.1. Management implications

Although this study would have benefited from more replicates and sites, we offer the following management recommendations. We suggest the establishment of larger blocks of areas created for wildlife (i.e., structurally heterogeneous with native bunchgrasses, brush, and young trees) on reclaimed lands, which would provide more habitats for breeding dickcissels and other similar species. Reclamation specialists should consider continental-wide trends like cowbird affinities for elevated perches or range-wide trends like lower dickcissel nest densities near wooded edges.

Given the large temporal and spatial scales at which reclamation occurs, it provides unique opportunities for the conservation and creation of habitat for longer intervals than what CRP Programs usually provide. With over 2.3 million ha permitted for surface mining in the United States (Office of Surface Mining 2002) in the near future, the conservation implications are large scale and long-term. Therefore, we suggest more attention and research should be invested in the surface-mining reclamation process and habitat management.

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