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EFFECTS OF WIND TURBINES ON UPLAND NESTING BIRDS IN CONSERVATION RESERVE PROGRAM GRASSLANDS

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ABSTRACT.—Grassland passerines were surveyed during summer 1995 on the Buffalo Ridge Wind Resource Area in southwestern Minnesota to determine the relative influence of wind turbines on overall densities of upland nesting birds in Conservation Reserve Program (CRP) grasslands. Birds were surveyed along 40 m fixed width transects that were placed along wind turbine strings within three CRP fields and in three CRP fields without turbines. Conservation Reserve Program grasslands without turbines and areas located 180 m from turbines supported higher densities (261.0–312.5 males/100 ha) of grassland birds than areas within 80 m of turbines (58.2–128.0 males/100 ha). Human disturbance, turbine noise, and physical movements of turbines during operation may have distrurbed nesting birds. We recommend that wind turbines be placed within cropland habitats that support lower densities of grassland passerines than those found in CRP grasslands. *Received 9 Sept. 1997, accepted 5 Oct. 1998.*

Technological advances that have reduced the cost of electricity generated from windplants have enabled the wind-power industry to expand from California into the eastern United States and Canada (Nelson and Curry 1995). Wind power has received strong public support as an alternative energy source despite the potential threats that the presence of wind turbines may pose to avian species. Recent research has indicated that raptor mortality from collisions with wind turbines varies greatly from no mortality (Higgins et al. 1996; Usgaard et al., in press) to substantial mortality (Orloff and Flannery 1992). In addition to direct mortality from collisions, research also has indicated that waterfowl, wading bird, and raptor densities near turbines were lower compared to densities in similar habitats away from turbines (Winkelman 1990; Pedersen and Poulsen 1991; Usgaard et al., in press). The influence of wind turbines on grassland nesting passerine species has not been previously measured.

Recent construction of the first windplant facility in the midwestern United States provided a unique opportunity to study the effects of wind turbines on grassland nesting passerines. Several midwestern grassland passerine species have declined in abundance (Johnson and Schwartz 1993) in response to agricultural tillage, grazing, and invasive woody species that have destroyed or degraded most of the remaining grasslands (Kantrud 1981, Castrale 1985). Although Conservation Reserve Program (CRP; Young and Osborn 1990) grasslands provide habitat for grassland nesting birds (Johnson and Schwartz 1993, Igl and Johnson 1995, Johnson and Igl 1995, King and Savidge 1995, Millenbah et al. 1996), the potential impact of wind turbines in CRP fields could negate those benefits. The objective of this study was to determine whether density of upland nesting passerines in CRP grasslands was influenced by the presence of wind turbines. We hypothesized that bird density in CRP grasslands would not differ in relation to distance from wind turbines.

STUDY AREA AND METHODS

Study area.—The Buffalo Ridge Wind Resource Area (WRA) in southwestern Minnesota is located along a 100 km segment of the Bemis Moraine near Lake Benton, Minnesota. Elevation is 546–610 m. Wind turbines cover 32 km^2 of the 293 km^2 Buffalo Ridge WRA. Additional lands within the Buffalo Ridge WRA have been leased as future wind-turbine development sites. The windplant contains 73 operational wind turbines that are arranged in 10 turbine strings, with 3–20 turbines/string. Turbines are 91–183 m apart within strings. Turbines (model KVS-33; KENETECH Windpower, Inc.), which operate at wind speeds of 14–104 km/h, consist of a 33 m diameter rotor mounted on a 37 m tubular tower.

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Upland grassland bird nesting habitat within the Buffalo Ridge WRA consisted primarily of CRP grasslands, mostly planted with a mixture of smooth brome (*Bromus inermis*) and alfalfa (*Medicago sativa*) or switchgrass (*Panicum virgatum*). Habitats surrounding CRP grasslands were agricultural lands dominated by corn (*Zea mays*) and soybeans (*Glycine max*) with smaller areas of haylands, pasturelands, and scattered woodlands near farmsteads and in ravines.

Methods.—Bird survey transects were placed along wind-turbine strings within three CRP fields and in three CRP fields without turbines (i.e., control; Leddy 1996). We selected CRP fields that were 7–8 years of age to minimize effects of field age on diversity and density of avain species (Millenbah et al. 1996). Visual obstruction readings (Robel et al. 1970, Higgins and Barker 1982) did not differ between CRP grasslands with and without turbines, indicating that vegetation structure in experimental and control fields was similar (Leddy 1996). Transects were surveyed weekly in random order from 15 May to 1 July 1995. Multiple surveys of a single transect were averaged into one bird density to avoid pseudoreplication (Hurlbert 1984). Six 40-m fixed width transects (Wakeley 1987) paralleling each turbine string were used per field. One transect ran directly underneath turbine strings. Two additional transects on each side of the turbine string paralleled the string at distances of 40 and 80 m; the sixth transect was placed 180 m from the turbine string. Transects varied in length according to field size and were placed at least 30 m from field borders and wetlands to minimize bias associated with edges (Arnold and Higgins 1986, Reese and Ratti 1988). One transect was established at a random location in each of the three control CRP fields without turbines.

Inconsistencies among surveys attributable to periodic bird inactivity (Skirvin 1981, Verner and Ritter 1986) were minimized by conducting surveys from sunrise to 10:00 CST. We recorded all birds seen or heard while walking transects at 1.0–1.5 km/h (Mikol 1980, Wakeley 1987); only perched and/or singing males were used in statistical analyses. Flushed birds seen leaving transects were counted (Burnham et al. 1980), whereas birds seen entering transects or flying overhead were not counted. Surveys were not conducted during heavy rain or high winds (≥20 km/h; Ralph et al. 1993). Birds were surveyed in CRP fields with turbines when turbines were operational and non-operational because turbines began operating during surveys when wind speeds reached 14–20 km/h. We compared surveys that were conducted during operational and non-operational periods to determine whether noise produced during turbine operation biased surveys.

An index of total breeding bird density was calculated by dividing the number of perched and/or singing males by transect area. Percent species composition was calculated by dividing the number of perched and/or singing males of a particular species by the total number of males. Species richness was defined as the number of species (Koford et al. 1994).

Analysis of covariance (SAS 1989) was used to determine whether bird density across transects was related to noise produced during wind turbine operation. We used turbine operational status (i.e., running versus idle) to determine whether the slope of bird densities differed. Analysis of variance (ANOVA; SAS 1989) was used to determine whether bird density in CRP grasslands without turbines differed from that in CRP grasslands containing turbines. An ANOVA also was used to determine whether bird density was related to distance from wind turbines. A Least Significant Difference Multiple Comparisons test was used to determine where differences in bird density occurred among transects.

RESULTS

Ten upland grassland bird species occurred in CRP grasslands with and without turbines (Table 1). Bobolinks (*Dolichonyx oryzivorus*), Red-winged Blackbirds (*Agelaius phoeniceus*), and Savannah Sparrows (*Passerculus sandwichensis*) comprised 74.5% of the birds in CRP grasslands with turbines (Table 1). Bobolinks, Sedge Wrens (*Cistothorus platensis*), and Savannah Sparrows comprised 80.0% of the individuals in CRP fields without turbines (Table 1).

Mean bird densities from surveys conducted while wind turbines were operational ($\bar{x}$ = 4.7 ± 0.88 SE) and non-operational ($\bar{x}$ = 5.4 ± 0.94 SE) were pooled because slopes of bird densities among transects did not differ (F = 0.39, 1,30 df, $P > 0.05$). Total bird density was lower in CRP grasslands containing turbines than in CRP grasslands without turbines (F = 17.36, 6,14 df, P = 0.001; Table 2). Bird density was lower (F = 12.37, 1,10 df, P = 0.006) in the 0 and 40 m transects compared to density in transects 80 m or more from turbines (Table 2). Bird density also was lower (F = 13.10, 1,10 df, P = 0.001) in transects within 80 m of the turbines compared to 180 m from turbines (Table 2). Bird density 180 m from turbines did not differ (F = 0.10, 1,10 df, $P > 0.05$) from that in CRP grasslands without turbines (Table 2). A linear relationship existed (r^2 = 0.746, n = 18, $P < 0.001$) between bird density and transect distance from turbines (Fig. 1).

DISCUSSION

Conservation Reserve Program grasslands without turbines and areas located 180 m from turbines supported mean densities of grassland birds that were four times higher than those

TABLE 1. Number (*n*) and percent (%) composition of breeding grassland birds in Conservation Reserve Program grasslands with and without turbines at the Buffalo Ridge Wind Resource Area, Minnesota, May–July 1995.

Species	Turbines		No turbines	
	n	%	*n*	%
Bobolink (*Dolichonyx oryzivorus*)	139	36.6	48	32.0
Red-winged Blackbird (*Agelaius phoeniceus*)	85	22.4	7	4.7
Savannah Sparrow (*Passerculus sandwichensis*)	59	15.5	33	22.0
Common Yellowthroat (*Geothlypis trichas*)	36	9.5	7	4.7
Dickcissel (*Spiza americana*)	22	5.8	2	1.3
Le Conte's Sparrow (*Ammodramus leconteii*)	10	2.6		
Brown-headed Cowbird (*Molothrus ater*)	9	2.4	6	4.0
Western Meadowlark (*Strunella neglecta*)	5	1.3	1	0.7
Grasshopper Sparrow (*Ammodramus savannarum*)	4	1.1	4	2.7
Sedge Wren (*Cistothorus platensis*)	1	0.3	39	26.0
Clay-colored Sparrow (*Spizella pallida*)			1	0.7
Unknown	9	2.3	2	1.3
Total species	10		10	

in grasslands nearer to turbines. Three of four species that composed at least 74.5% of the bird community composition (Bobolink, Savannah Sparrow, Sedge Wrens) in CRP fields with and without turbines are area-sensitive species (Herkert 1994a, b; Swanson 1996) that require large tracts of tall, dense vegetation for nesting (Wiens 1969, Herkert 1994a). Minor differences in overall bird species richness and composition were likely related to subtle structural differences in grassland stand types. Leddy and coworkers (in press) found that Clay-colored Sparrows (*Spizella pallida*) and Sedge Wrens using CRP grasslands on the Buffalo Ridge WRA preferred dense stands of switchgrass while Dickcissels (*Spiza americana*) and Bobolinks usually used stands of smooth brome and alfalfa.

TABLE 2. Species richness and mean density of upland grassland birds/100 ha at varying distances from wind turbines in Conservation Reserve Program grasslands at the Buffalo Ridge Wind Resource Area, Minnesota, May–July 1995.

Transect	*n*	Breeding males		
		Species richness	Mean density[a]	SE
0 m	3	6	58.2 A	26.3
40 m	6	8	66.0 A	17.1
80 m	6	7	128.0 B	19.6
180 m	3	9	261.0 C	12.0
CRP Control	3	10	312.5 C	15.7

[a] Means denoted by the same letter do not differ ($P \leq 0.05$).

Little evidence has been found linking avian mortality to collisions with wind turbines on the Buffalo Ridge WRA (Higgins et al. 1996). Although wind turbines may not directly cause mortality, the presence of wind turbines may indirectly affect local grassland bird populations by decreasing the area of grassland habitat available to breeding birds. Comparison of bird density and species richness among transects indicated that bird use of grasslands 180 m from turbines was similar to that in CRP fields without turbines (Table 2). Although research in the Netherlands also

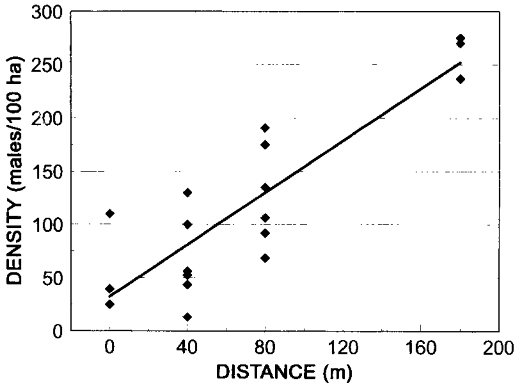

FIG. 1. Linear relationship (Density = 32.30 + 1.22 × Distance; r^2 = 0.746) between breeding bird density (males/100 ha) and distance (0–180 m) from wind turbines in Conservation Reserve Program grasslands at the Buffalo Ridge Wind Resource Area in southwestern Minnesota, May–July 1995.

has indicated that the presence of turbines has prevented waterfowl and wading bird species from using otherwise suitable habitat (Winkelman 1990, Pedersen and Poulsen 1991), mechanisms inhibiting birds from exploiting grasslands near turbines have not yet been identified. In addition to human disturbance and noise, the physical movements of the turbines when they are operating may have disturbed nesting birds. Maintenance trails between turbines that are driven daily may have further decreased the availiability of grassland habitat adjacent to turbines.

Construction of windplants within midwestern grassland habitats may soon become an additional source of habitat degradation as demands for wind generated power increase. Current grazing and tillage practices on many privately owned lands that are less conducive to grassland bird production increase the importance of remaining grasslands to prairie nesting birds (Johnson and Schwartz 1993; Johnson and Igl 1995; Leddy et al., in press). Until additional research is conducted, we recommend that wind turbines be placed within cropland habitats that support lower densities of grassland passerines than those found in CRP grasslands (Leddy et al., in press). We also recommend that additional research be conducted in other geographic regions where wind generated power is currently used to further assess possible effects of wind turbines on avian habitats.

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