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SONGBIRD ABUNDANCE IN GRASSLANDS AT A SUBURBAN INTERFACE ON THE COLORADO HIGH PLAINS

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Abstract. We counted nesting songbirds for three summers on 62 200-meter-diameter plots on City of Boulder, Colorado, Open Space grasslands. Habitats included upland mixed-grass prairie and lowlands with tallgrass prairie and irrigated hayfields. Plots were located either at habitat edges adjacent to suburban developments or at least 200 meters interior to such edges. Grassland-nesting songbirds collectively were nearly twice as abundant on interior as on edge plots. Species significantly more abundant on interior plots, independent of habitat type, included Vesper Sparrow (*Pooecetes gramineus*), Savannah Sparrow (*Passerculus sandwichensis*), Grasshopper Sparrow (*Ammodramus savannarum*), Bobolink (*Dolichonyx oryzivorus*), and Western Meadowlark (*Sturnella neglecta*). By contrast, combined counts of five suburban species—American Robin (*Turdus migratorius*), European Starling (*Sturnus vulgaris*), Common Grackle (*Quiscalus quiscula*), House Finch (*Carpodacus mexicanus*), and House Sparrow (*Passer domesticus*)—were nearly five times greater on edge than on interior plots. If it is a goal to conserve native grassland birds on the western Great Plains, we conclude that grassland open-space systems in this region should be designed to reduce edges with suburban development. More research is needed to determine what causes edge effects, which might include increased nest predation, human interference with the nesting process, and increased competition with suburban species.

LA ABUNDANCIA DE AVES PASERIFORMES EN PASTIZALES EN UN LÍMITE SUBURBANO EN LA LLANURA ALTA DE COLORADO

Sinopsis. Contamos aves paseriformes durante tres veranos en 62 parcelas de 200 metros de diámetro en los pastizales Terreno Escampado de la Ciudad de Boulder, Colorado. Los hábitats incluyeron pradera alta de hierba mixta y tierra baja con pradera de hierba alta y campos regados de heno. Las parcelas se ubicaron ya sea en los límites de hábitats adyacentes a urbanizaciones de suburbios o a por los menos 200 metros al interior de esos límites. Las aves paseriformes fueron colectivamente casi dos veces más abundantes en las parcelas interiores que en aquéllas de los límites. Las especies significativamente más abundantes en las parcelas interiores, independientemente del tipo de hábitat, incluyeron el Gorrión Coliblanco (*Pooecetes gramineus*), el Gorrión Sabanero (*Passerculus sandwichensis*), el Gorrión Chapulín (*Ammodramus savannarum*), el Tordo Arrocero (*Dolichonyx oryzivorus*) y el Pradero Occidental (*Sturnella neglecta*). En cambio, las cifras combinadas de cinco especies suburbanas—el Zorzal Petirrojo (*Turdus migratorius*), el Estornino Europeo (*Sturnus vulgaris*), el Zanate Común (*Quiscalus quiscula*), el Fringílido Mexicano (*Carpodacus mexicanus*) y el Gorrión Doméstico (*Passer domesticus*)—fueron casi cinco veces mayores en las parcelas de los límites que en las parcelas interiores. Si es una prioridad conservar las aves nativas de pastizal en el oeste de la Gran Llanura, concluimos que los sistemas de terreno escampado para pastizales en esta región deben ser diseñados para reducir los límites de la urbanización de suburbios. Se necesitan más investigaciones para determinar lo que causa los efectos de los límites, que puede incluir una aumentada depredación de los nidos, la intervención humana en el proceso de nidaje y una mayor competencia con especies suburbanas.

Key Words: Colorado; edge effects; grassland birds; habitat fragmentation; prairie.

U.S. Fish and Wildlife Service Breeding Bird Surveys (now conducted by the Biological Resources Division of the U.S. Geological Survey) indicate widespread and substantial declines of grassland birds in North America since the mid-1960s (Peterjohn and Sauer 1993, Herkert 1995). Likely causes include habitat losses due to agricultural conversion and spreading urbanization (Knopf 1994). An additional factor may be that remaining patches of suitable habitat are too small and isolated to support viable populations of many species. Such landscape effects were evident in prairie remnants in Illinois and Maine, where various grassland birds were absent or scarce in relatively small prairies embedded in woodlands and croplands (Herkert 1994, Vickery et al. 1994).

Conserving and restoring grasslands and their bird populations on the western Great Plains also must take into account potential landscape effects. These grasslands, however, usually are not fragmented into discreet and isolated units like their prairie counterparts in the Midwest or Northeast. Rather, a background matrix of grasslands is variously interspersed with row crops, woodlots, and spreading urban fronts. Are western grassland bird populations affected by these landscape intrusions? Are the abundance and variety of endemic birds reduced in grasslands adjacent to human-created environments?

One rapidly urbanizing section of the western Great Plains lies at the eastern face of the Rocky Mountains in Colorado, from Fort Collins in the north to Pueblo in the south—the so-called Front Range Corridor (Alexander 1980, FitzSimmons 1985, Matthews 1992). Habitats being replaced by spreading suburbs for the most part are shortgrass, mixed-grass, and occasional tallgrass prairies used primarily for livestock grazing and haying, with some irrigated row crops. The city of Boulder is one community in the Front Range Corridor that has a well-established Open Space program, designed to create a buffer against urban sprawl and to conserve endemic grassland flora and fauna (City of Boulder Open Space Department 1995, Zaslowsky 1995). More than 10,000 ha presently are included, making it the largest per-capita municipally owned open-space system in the United States (J. Crain, pers. comm.).

Most parcels of Boulder Open Space do not exist as isolated patches surrounded by suburban areas but rather as part of a belt of largely undeveloped land enclosing the city around its northern, eastern, and southern perimeters. Our objective in the present study was to test for edge effects (Harris 1988, Paton 1994) on bird abundance in open-space grasslands adjacent to this suburban front. We quantified relative abundances of birds in open-space grasslands and hayfields, comparing data from plots at habitat edges with those from plots located more to the interior of the protected lands. Our goal was to provide information on possible edge effects that might be useful to individuals and organizations planning similar open-space systems along the Front Range Corridor.

STUDY AREA

Boulder Open Space habitats include narrow riparian corridors along streams, tallgrass prairies and agricultural hayfields in adjacent lowland floodplains, and mixed grasslands on upland slopes and benches (Moir 1969, Santanachote 1992, Bock et al. 1995). Tallgrass stands include grasses typical of the true prairie to the east: big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*). Boulder tallgrass stands are ungrazed in summer, but most are grazed by cattle in fall and winter.

Agricultural hayfields near Boulder support mixtures of alfalfa (*Medicago sativa*), sedges (*Carex* spp.), and various non-native pasture grasses, including smooth brome (*Bromus inermis*), meadow fescue (*Festuca pratensis*), orchard-grass (*Dactylis glomerata*), and timothy (*Phleum pratense*). Hayfields are flood-irrigated in spring and early summer, mowed in July, and sometimes grazed by cattle in fall and winter.

Upland habitats support diverse mixtures of short and midheight grasses, both native and introduced, along with a large variety of broad-leaved herbs. Yucca (*Yucca glauca*) and prickly-pear cactus (*Opuntia* spp.) are common in some areas. Dominant grasses include blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), buffalograss (*Buchloë dactyloides*), needle grasses (*Stipa* spp.), and two exotics, Japanese brome (*Bromus japonicus*) and cheatgrass (*B. tectorum*). All upland sites have a history of livestock grazing, although some areas have been ungrazed for the past several years.

METHODS

Upland mixed grasslands supported very different avifaunas than lowland prairies and hayfields. Therefore, it was essential that our study plots include a mixture of both types of habitats, in both suburban edge and interior landscape settings. In the fall of 1993 we established 62 circular 200-m-diam plots on Boulder Open Space grasslands; 30 of the plots were in lowland hayfields and tallgrass prairies and 32 in upland mixed-grass prairies. Among the 32 upland plots, 22 were a minimum of 200 m from the nearest suburban edge and were designated interior plots, and 10 were directly adjacent to suburban housing developments. The 30 lowland plots were divided evenly between interior and suburban edge situations.

It is not clear how far apart bird count plots should be to be considered statistically independent (Verner 1985). Our plots were widely scattered over the 10,000 ha of open space, and no pair of plots was closer than 200 m. Each plot was marked with a single center stake, from which we conducted fixed-distance point counts between mid-May and mid-July in 1994, 1995, and 1996. During each count we recorded the number of birds we saw or heard over a 10-min period within 100 m of the plot center point. We made four counts per plot in 1994 and three counts per plot in 1995 and 1996.

As an index of relative abundance, we computed the average number of each species recorded per point count per plot, weighting each year's data equally to compute a single value for each species on each plot.

Interior versus edge plots were not evenly divided among lowland versus upland habitats because there has been more suburban development in lowland areas near Boulder. Furthermore, some birds were strongly associated with one or the other of the two habitat types. This made it possible to confuse landscape and habitat effects. For example, Lark Sparrows (*Chondestes grammacus*) were strongly associated with upland sites; because fewer upland than lowland plots were at suburban edges, this could have resulted in an impression that Lark Sparrows were avoiding grasslands in suburban landscape settings. Conversely, actual avoidance of edges could lead to the impression that Lark Sparrows were selecting uplands over lowlands. To control for the possibility of confusing landscape with habitat effects, we analyzed count data using two-way analysis of variance (ANOVA), with plot habitat (upland vs. lowland) and plot setting (interior vs. edge) as independent variables. By this method, resulting pairs of F-values for each species would reveal significant ($P < 0.05$) landscape effects independent of habitat, and vice versa.

Based on their likely nest locations, we identified three groups of songbirds using the 62 plots: 8 grass-

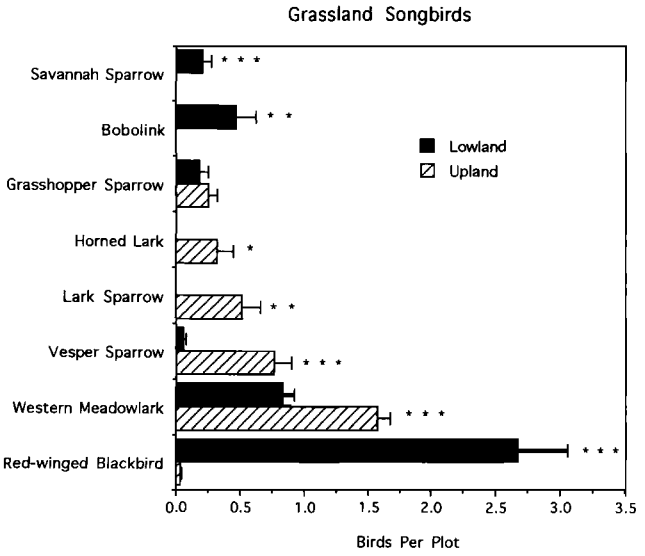

FIGURE 1. Numbers of grassland-nesting songbirds (means + SE) counted per 100-m fixed-distance point count on 32 upland and 30 lowland grassland plots that are part of Boulder, Colorado, Open Space. Each plot was counted four times in summer 1994 and three times in summers 1995 and 1996. (* Significant difference between habitats independent of plot landscape setting, two-way ANOVA, $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.)

land species, 5 suburban species, and 17 other species. We made no systematic effort to locate nests, but incidental to point counts we did find nests of the eight grassland-nesting species. The five suburban species were all common in suburban environments in and near Boulder. The third group of 17 species did not nest in grasslands, nor were they specifically associated with suburban environments; nesting habitats for this group included cliffs and anthropogenic structures for swallows (*Hirundo* spp.) and riparian woodlands and shrublands for most of the remaining species.

RESULTS

Grassland-nesting Species

Eight grassland-nesting species accounted for 46% of the songbird sightings on the 62 plots. Among these, Savannah Sparrows (*Passerculus sandwichensis*), Bobolinks (*Dolichonyx oryzivorus*), and Red-winged Blackbirds (*Agelaius phoeniceus*) were significantly more abundant on lowland than on upland plots, independent of plot proximity to suburban developments (Fig. 1). Horned Larks (*Eremophila alpestris*), Lark Sparrows, Vesper Sparrows (*Pooecetes gramineus*), and Western Meadowlarks (*Sturnella neglecta*) were more common in uplands, whereas Grasshopper Sparrows (*Ammodramus savannarum*) did not differ significantly between habitat types.

Among these same eight grassland-nesting species, all but Lark Sparrow, Horned Lark, and Red-winged Blackbird were significantly more abundant on interior plots not adjacent to suburbia, independent of plot habitat type (Fig. 2). We counted Lark Sparrows and Horned Larks much more frequently on interior plots, but their very high interplot variances resulted in a lack of statistical significance. Only Red-winged Blackbirds seemed unaffected by proximity to suburban edges. Combined counts of all eight grassland-nesting songbirds were 1.9 times higher on interior plots ($\bar{X} = 4.87$, SE = 0.29) than on edge plots ($\bar{X} = 2.52$, SE = 0.40), and this difference was highly significant, independent of habitat type (two-way ANOVA, $F = 33.27$, $P < 0.0001$, df = 1, 58).

Suburban Species

Five species nesting commonly in suburban habitats accounted for 30% of songbird sightings on our grassland plots. American Robins (*Turdus migratorius*), European Starlings (*Sturnus vulgaris*), and Common Grackles (*Quiscalus quiscula*) were more common in lowlands (Fig. 3), whereas House Sparrows (*Passer domesticus*) were more common in upland situations, and House Finches (*Carpodacus mexicanus*) did not differ between habitat types. Each of the five species was significantly more abundant on edge plots adjacent to suburban developments, independent of grassland habitat (Fig. 4). Combined counts of these five species were 4.9 times higher on edge plots ($\bar{X} = 4.72$, SE = 0.43) than on

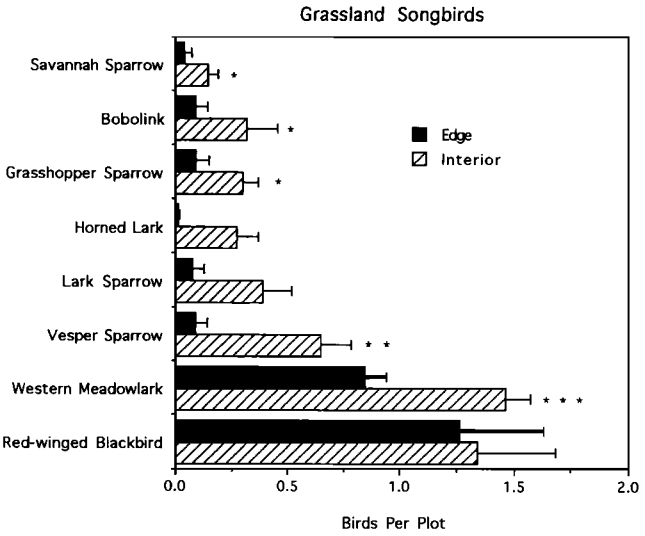

FIGURE 2. Numbers of grassland-nesting songbirds counted on 25 edge plots adjacent to suburban developments and 37 interior plots more than 200 m from suburban environments. (* Significant difference between landscape settings independent of plot habitat, two-way ANOVA, $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.)

interior plots ($\bar{X} = 0.97$, SE = 0.26), and this difference was highly significant, independent of habitat type (two-way ANOVA, $F = 67.70$, $P < 0.0001$, df = 1, 58).

Other Songbirds

Seventeen other songbird species accounted for 24% of our sightings on the 62 plots. None of these species nested in grasslands nor exclusively in suburban habitats. Most common among these were Cliff Swallows (*Hirundo pyrrhonota*), Barn Swallows (*H. rustica*), and Black-billed Magpies (*Pica pica*), with much smaller numbers of various riparian and shrubland species such as Western Kingbirds (*Tyrannus verticalis*), Spotted Towhees (*Pipilo maculatus*), Bullock's Orioles (*Icterus bullockii*), and American Goldfinches (*Carduelis tristis*). Col-

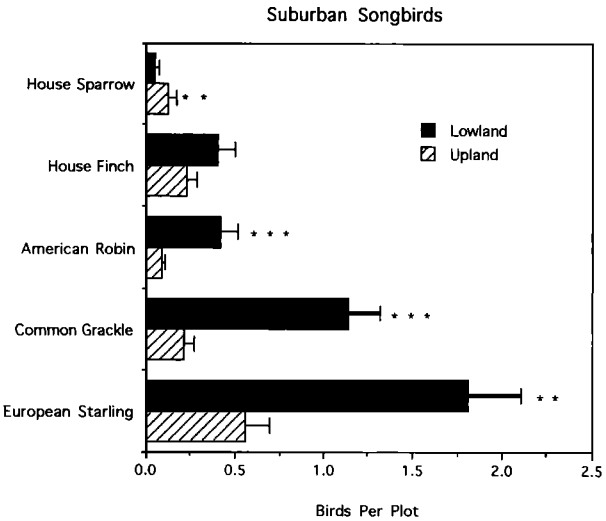

FIGURE 3. Numbers of suburban songbirds counted on 32 upland and 30 lowland grassland plots that are part of Boulder, Colorado, Open Space. (** Significant difference between habitats independent of plot landscape setting, two-way ANOVA, $P < 0.01$; *** $P < 0.001$.)

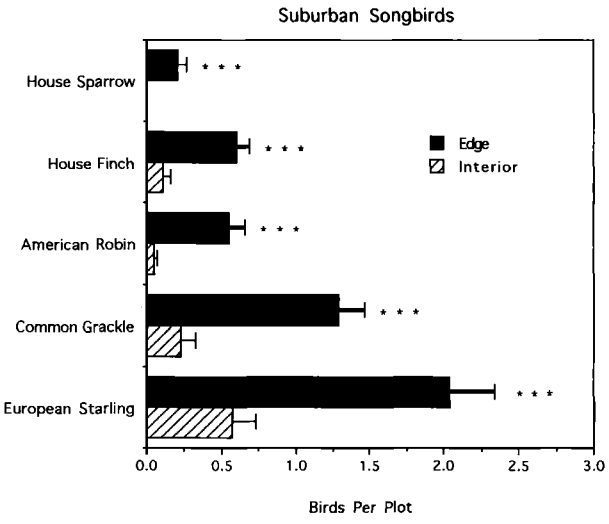

FIGURE 4. Numbers of suburban songbirds counted on 25 edge plots adjacent to suburban developments and 37 interior plots more than 200 m from suburban environments. (*** Significant difference between landscape settings independent of plot habitat, two-way ANOVA, $P < 0.001$.)

lectively, counts of these 17 species did not differ significantly between edge plots ($\bar{X} = 2.16$, SE = 0.28) and interior plots ($\bar{X} = 1.87$, SE = 0.25), independent of habitat type (two-way ANOVA, $F = 0.24$, $P = 0.63$, $df = 1, 58$).

DISCUSSION

Most of the grassland bird species in our study area avoided suburban edges, despite the fact that the grassland habitats of the edge plots did not differ from those of interior plots. Edge effects and the overall impacts of urbanization have been demonstrated primarily for woodland and forest birds in previous studies (Paton 1994, Blair 1996), but our results suggest they exist for grassland birds as well.

Overall abundance of grassland-nesting songbirds was nearly twice as high on interior plots as on plots adjacent to suburban environments. Five of the eight grassland species—Vesper Sparrow, Savannah Sparrow, Grasshopper Sparrow, Bobolink, and Western Meadowlark—were significantly less common in edge situations, and all five have been declining on a continental scale according to Breeding Bird Survey data (Knopf 1994, Herkert 1995). Some of these species have been found to be area sensitive in other prairie grasslands; examples include Savannah Sparrow, Grasshopper Sparrow, and Bobolink in Illinois (Herkert 1994) and Vesper Sparrow, Savannah Sparrow, Grasshopper Sparrow, and Bobolink in Maine (Vickery et al. 1994).

Our results strongly suggest that to enhance conservation of grassland-nesting birds, grassland open-space systems on the western Great Plains should be designed to reduce edges with suburban developments. More research is necessary, however, to determine why these edge effects occur.

Suburban songbirds foraged but did not nest on open-space grasslands adjacent to suburban developments. It is possible that resource competition with these suburban species resulted in reduced numbers of grassland birds at habitat edges. The fact that only grassland nesters and not the other grassland foragers were scarce in edge situations, however, suggests that nest predation (Martin 1993) and/or human nest interference (Knight and Gutzwiller 1995) were more likely factors. We observed very few Brown-headed Cowbirds (*Molothrus ater*) on Boulder Open Space grasslands, so nest parasitism seems unlikely to be involved. The logical next step in our research will be to compare reproductive success of grassland birds nesting in suburban edge versus interior situations, and to attempt to determine the possible causes of nesting failure in the different landscape settings.

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