Area Sensitivity of Grassland Sparrows Overwintering in a South Carolina Forested Landscape

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Abstract - We assessed area sensitivity of overwintering *Peucaea aestivalis* (Bachman's Sparrow), *Ammodramus savannarum* (Grasshopper Sparrow), and *A. henslowii* (Henslow's Sparrow) within utility rights-of-way (ROWs) at the US Department of Energy's Savannah River Site (SRS) in South Carolina. We compared sparrow abundance among 4 ROW-width classes (25–44.9 m, 45–64.9 m, 65–84.9 m, and ≥85 m) and used landform index (LFI; a measure of topography and environmental exposure) as a covariate in our analyses to assess potential effects of abiotic characteristics. Total number of sparrows flushed/ha, Grasshopper Sparrows flushed/ha, and Henslow's Sparrows flushed/ha were positively related to ROW-width class. Total number of sparrows flushed/ha and Bachman's Sparrows flushed/ha were negatively related to LFI, indicating a positive relationship with site exposure. Utility ROWs in the Southeast provide wintering habitat for grassland sparrows, especially on exposed elevated plateaus within wide ROWs.

Introduction

Grassland-bird populations are declining more rapidly than any other North American avian guild (Herkert 1995, Peterjohn and Sauer 1999, Sauer et al. 2008, Vickery and Herkert 2001), and habitat fragmentation has been suggested as an important factor in these declines (Askins 1993, Herkert et al. 2002, Winter and Faaborg 1999). Smaller grassland-patch sizes can reduce density or productivity of some grassland-bird species, although these effects vary regionally and among species (Donovan et al. 1997, Ribic et al. 2009). Most efforts investigating area sensitivity and edge effects have focused on breeding grassland birds and have included the determination of minimum-area requirements for many species (Askins 1993, Davis 2004, Walk and Warner 1999). However, area effects on grassland birds in their wintering sites have received little attention.

Differences in suitability of grassland patches of various sizes may be due in part to variability in the abiotic environmental conditions that affect grassland habitats. Thus, patch area actually may be a loose surrogate for various abiotic environmental conditions, such as exposure (e.g., to solar radiation, wind, and precipitation). Furthermore, grassland-bird density, diversity, and productivity are strongly linked to vegetative composition (Carrie et al. 2002, Herkert 1994, Johnson and Igl 2001, Winter et al. 2005), and vegetative composition and structure are dependent on a host of abiotic environmental factors such as topography and environmental

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exposure (Chen et al. 1992, 1995; Knapp et al. 1993, Martin 2001, Yahner 1988). Topography and exposure can be quantified by a single metric, the landform index (LFI), which is the mean of a series of measurements of percent slope across the horizon (McNab 1992). Because LFI is affected by both forest structure and slope, it reflects the relative openness (i.e., exposure) of a site. Lower angle-measurements indicate more exposed sites, and a negative response to LFI would represent a positive response to exposure. We hypothesized that grassland birds may be associated with LFI as well as an index of patch area.

The intensification of agriculture and land development in the southeastern US, coupled with cessation of frequent natural disturbance regimes such as fire, have greatly fragmented grassland and savanna habitats (Askins 1993, Hunter 1990). Rights-of-way (ROWs) are common features of the landscape and are kept in an early successional state over long time-periods through regular disturbances including mowing, herbicide use, and burning. ROWs provide an opportunity to assess the effects of abiotic traits such as topography and exposure in an unbiased fashion due to the manner in which they bisect the landscape. Whereas the original positions of fields may have been selected due to topographic considerations, ROWs allow for essentially random transects through grassland habitat irrespective of topography. ROWs and other such habitats present novel opportunities for surrogate grassland-habitat research and management because they support early successional avifauna including overwintering grassland birds (Anderson et al. 1977, Champlin 2007).

The 3 grassland sparrow species of conservation concern most commonly encountered at the Savannah River Site (SRS) in western South Carolina are *Peucaea aestivalis* (Lichtenstein) (Bachman's Sparrow), *Ammodramus savannarum* (Gmelin) (Grasshopper Sparrow), and *A. henslowii* (Audubon) (Henslow's Sparrow). All 3 species winter in grasslands of *Pinus* (pine) savannas in the southeastern US. Of these 3 species, only the Bachman's Sparrow occurs regularly in SRS pine forests (Champlin 2007), presumably due to the poorly developed grass-forb layer of these forests (Imm and McLeod 2005). However, all 3 species occur in ROWs at SRS (Champlin 2007). We took advantage of the properties of ROWs to investigate whether grassland-sparrow density, as indexed by the number flushed/ha of strip transect, may be a function of habitat area and the relative exposure of ROW grasslands to abiotic influences, as reflected in the LFI, during winter on the predominantly forested landscape of the SRS in western South Carolina.

Study Area

The SRS is an 80,267-ha US Department of Energy National Environmental Research Park in the Upper Coastal Plain and Sandhills physiographic provinces of western South Carolina (Fig. 1). At the time of our study, 85% of the SRS was forested, with ~2700 ha of ROWs embedded in ~56,000 ha of pine-dominated forest and ~18,000 ha of forested bottomland and wetland. Pine forests were primarily *Pinus taeda* L. (Loblolly Pine) and *Pinus palustris* Miller (Longleaf Pine) managed on 50- to 120-year rotations, depending on species and site-specific land-use objectives. Wetlands ranged in size from a few to nearly 100 ha and included more than

200 Carolina bays, many of the largest of which were grass-dominated (Imm and McLeod 2005).

Rights-of-way at the SRS were dominated by xeric tall-grass prairie-like grasslands on well-drained, sandy ultisol and quartzisamment soils with predominantly moderate relief but also bisected topographically low, flat settings such as river bottoms that supported wetland shrubs and hardwood species growing in entisol soils

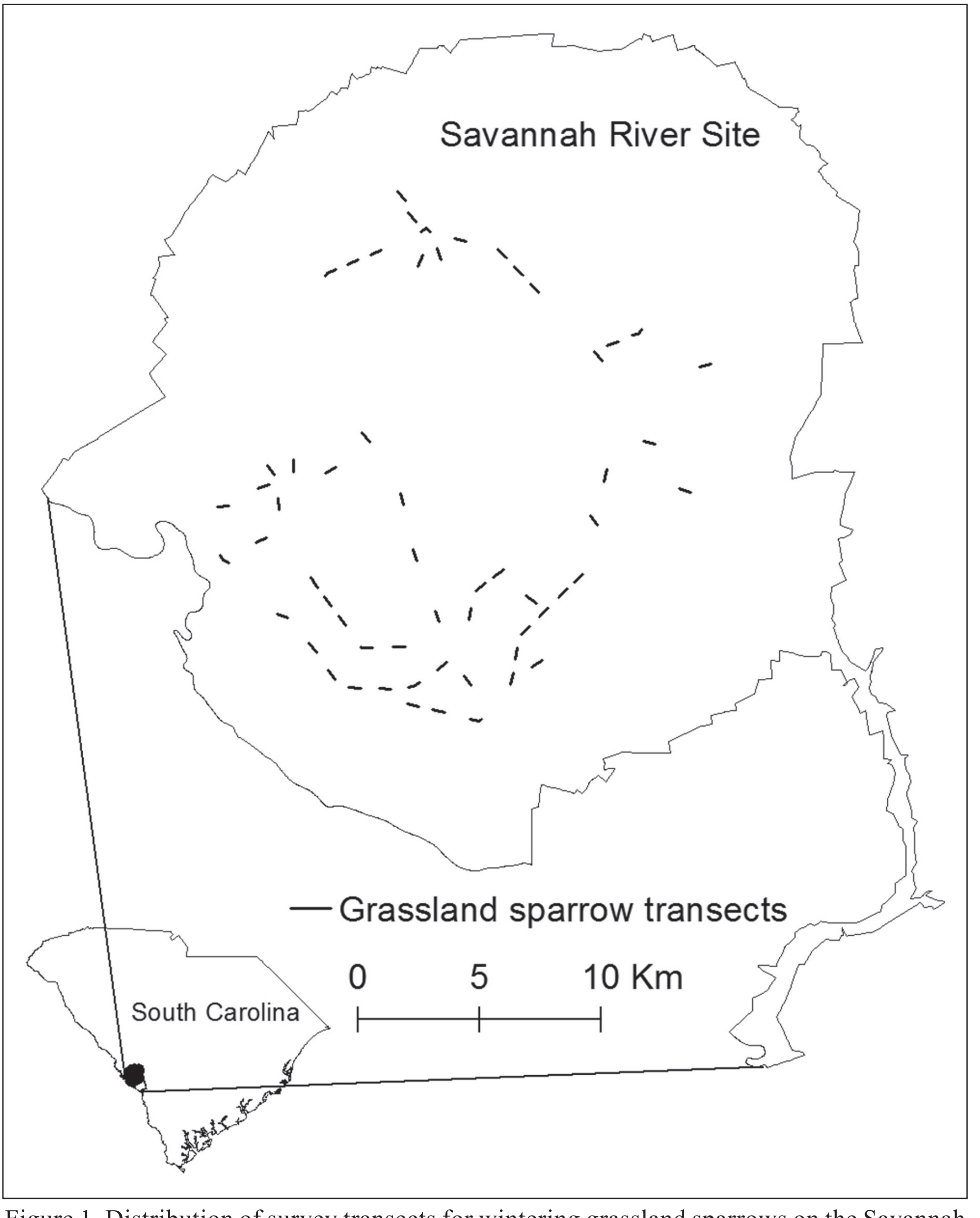

Figure 1. Distribution of survey transects for wintering grassland sparrows on the Savannah River Site, SC, 2003–2006.

with high clay content (Imm and McLeod 2005). While most ROWs at the SRS were predominantly grassland, gradients existed from dense sapling and shrub cover to scattered sites of nearly bare sand. Soils at our research sites had not undergone major human perturbation for ~30–50 years. Vegetation management in ROWs was conducted in an ad-hoc manner and included a combination of intermittent mowing, selective treatment of woody vegetation with herbicide, and prescribed burning. Herbicide use occurred at ~3-year intervals, and burning occurred whenever adjacent forest compartments were burned, typically at 3–5-year intervals, although prescribed fires were infrequent during this study due to a severe drought.

Methods

We surveyed grassland sparrows on sixty 500-m long transects positioned at least 500 m apart (Igl and Ballard 1999) within grassland-dominated portions of utility ROWs (Fig. 1). We recorded all avian species, but we focus here only on Bachman's, Grasshopper, and Henslow's sparrows. Single observers traversed ROWs linearly while flushing birds from a 10-m-wide swath using two 5-m long, telescopic, fiberglass fishing poles. After walking 500 m, the observer shifted laterally 90° from the direction of travel for a distance of no more than 25 m and walked a parallel transect back to the initial starting point. Thus each transect surveyed 1 ha (1000 m long x 10 m wide). Experienced observers trained in sparrow identification walked transects at a pace of ~5 km/hr, only counting birds flushed from within the reach of the poles and taking a conservative approach in the potential recounting of previously flushed birds. Observers identified birds to species by their size, coloration, flight characteristics, and tail length. Surveyors followed any unknown birds until identification could be confirmed either visually or via capture for a concurrent banding study.

We surveyed 30 transects once during winter (25 Dec–31 March of 2002–2003), 30 different transects once during the winter of 2003–2004, and all 60 of these transects 3 times each during the winters of 2004–2005 and 2005–2006. During winters with multiple surveys per transect, we used data from the second survey round (the round in the core of the winter season), unless a transect was mowed or burned after the first survey of any year, in which case we used count data from the first survey. We made no adjustments to survey results for detection probability due to the narrow nature of flush transects (10 m) and the proximity of the 3 focal species to observers when flushed (often <5 m); we assumed equal detection probability for all individuals and transects.

We used ROW width as an index to habitat area. We defined ROW width as the mean of 5 measurements taken perpendicular to the ROW centerline approximately every 100 m along each surveyed ROW. We measured distance between the 2 tree boles closest to the centerline of the ROW. ROWs ranged in width from 24 m to 102 m. We assigned ROW width to 4 classes: ≤44.9 m (n = 32), 45–64.9 m (n = 14), 65–84.9 m (n = 6), and ≥85 m (n = 8). Our focal species are known to be affected by time since burn (Cox and Jones 2009, Korosy et al. 2013), but each of our ROWs bisected or abutted multiple forest stands, each with a different burn history. Our transects therefore represented the full range of conditions available in SRS ROWs with regard to vegetation management and burn histories, and these histories were not confounded with ROW width.

We measured LFI at 5 points spaced approximately every 100 m along each surveyed ROW and located random distances from the ROW centerline. We measured percent slope to the lowest point of sky visible through the surrounding forest on either side of each point in a direction perpendicular to the transect orientation. We took the mean of these 10 measurements as the LFI for each transect. This procedure is an alteration of the typical LFI measurement, which is made at a single point and measured at 8 equal increments around the compass (McNab 1992).

We used a mixed model (Sokal and Rohlf 1995) analysis of covariance (SAS 2004) at $\alpha = 0.05$ to compare the number of the 3 focal species flushed/ha, both individually and combined, among width classes, and to evaluate the degree to which LFI explained variation in abundance. We considered width class as a fixed effect, LFI as a covariate, and year as a repeated measure on each transect nested within each width class. Adjustments to estimates of the width class to account for effects of LFI did not change results for any analysis, so we report unadjusted estimates.

Results

We detected 199 grassland sparrows, including 108 Bachman's, 44 Grasshopper, and 47 Henslow's Sparrows during the first 2 years and during the second round of surveys of the last 2 years of the study. No interaction between width class and LFI was present. Total number of sparrows flushed/ha, number of Grasshopper Sparrows flushed/ha, and number of Henslow's Sparrow flushed/ha responded positively to width class (Table 1, Fig. 2). Total number of sparrows flushed/ha and the number of Bachman's Sparrow flushed/ha were negatively correlated with LFI (Table 1).

Discussion

The number of grassland sparrows flushed/ha was greater in wider and more open ROWs than in narrower, less-exposed ROWs at the SRS. Although previous

Table 1. Effects of width class and landform index (LFI) on number of grassland sparrows flushed/ha within utility rights-of-way at the Savannah River Site, SC, 2002–2006 (negative response to LFI represents a positive response to exposure; $P < 0.05$).

Species/group	Effect	Estimate	SE	*F*	df	*P*
Total sparrows	Width class			14.0	3, 49	<0.001
	LFI	-11.05	5.22	4.5	1, 124	0.036
Bachman's Sparrow	Width class			1.7	3, 49	0.185
	LFI	-8.51	3.70	5.3	1, 124	0.023
Grasshopper Sparrow	Width class			4.9	3, 49	0.005
	LFI	-1.43	2.23	0.4	1, 124	0.521
Henslow's Sparrow	Width class			9.2	3, 49	<0.001
	LFI	-1.06	1.93	0.3	1, 124	0.586

studies related habitat occupancy to habitat-patch area and juxtaposition to forest or edge (Herkert 1994, Vickery et al. 1994, Winter and Faaborg 1999), the mechanisms underlying these relationships are poorly understood. Positive relationships between sparrows, ROW width, and exposure might indicate that larger habitat-patches have an inherently greater likelihood of encompassing a wider array of abiotic environmental attributes responsible for greater habitat complexity.

Even though our study was conducted within a relatively narrow range of size classes compared to other studies, we were still able to detect trends in area sensitivity both within and among species. The ratio of our smallest to largest ROW width was 1:4 (24 m:102 m). Ratios of smallest to largest patch size studied reported in other research on breeding birds include 1:34 (Winter and Faaborg 1999), 1:250 (Riffell et al. 2001), 1:644 (Davis et al. 2006), and 1:1347 (Vickery et al. 1994). Thus, although ROW width is only an index to patch area, it appears that wintering grassland birds may be sensitive to area (or abiotic factors related to area) within a narrow range at the lower end of the area spectrum.

Hostility of environmental edge has been commonly suggested as an explanation for edge avoidance and accompanying area sensitivity in breeding birds, with the effect most acute within 50 m of the surrounding matrix (Burger et al. 1994,

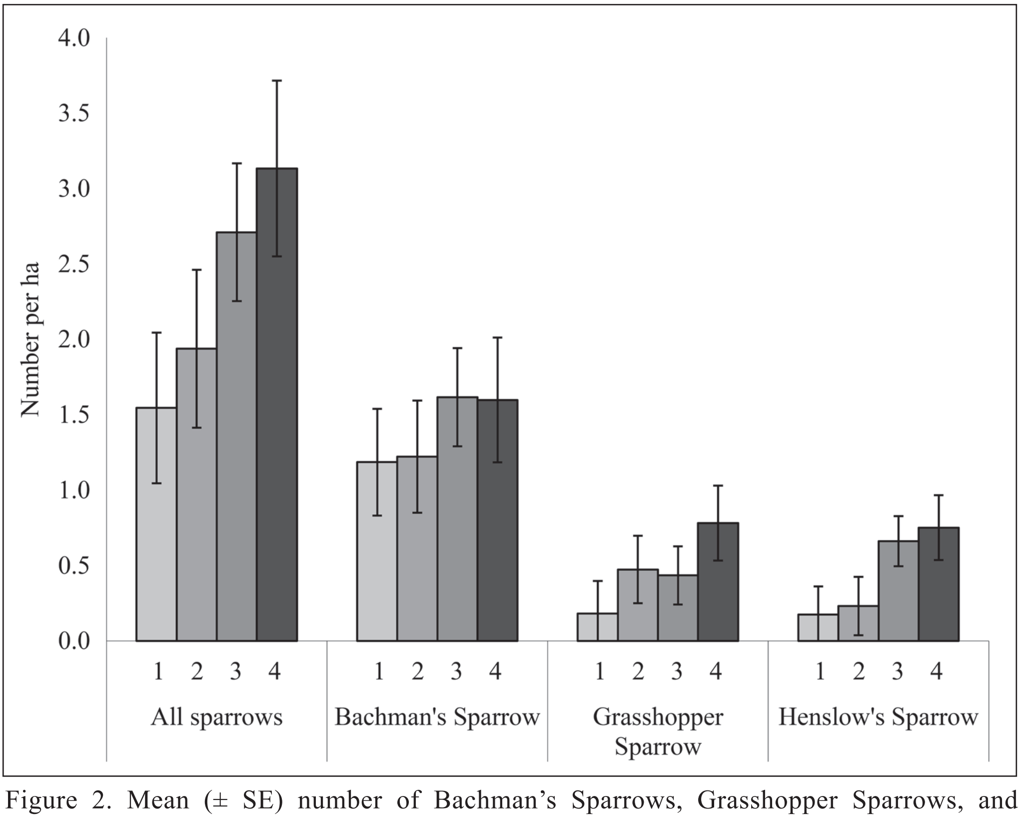

Figure 2. Mean (± SE) number of Bachman's Sparrows, Grasshopper Sparrows, and Henslow's Sparrows flushed/ha in 4 utility right-of-way width classes (1 = 25–44.9 m; 2 = 45–64.9 m; 3 = 65–84.9 m; and 4 = ≥85 m) at the Savannah River Site, SC during the winters of 2003–2006.

Johnson and Temple 1986, Winter et al. 2000). We observed no indication of actual avoidance of edges; we regularly detected all 3 grassland sparrow species at the forest edge (P.J. Champlin, pers. observ.). In addition, concurrent monitoring of 116 radio-tagged Henslow's Sparrows on our research sites revealed that this focal species frequently used portions of ROWs within 10 m of edges and that overall mortality was low (~3%; Champlin 2007; P.J. Champlin, unpubl. data). Thus, predator-driven edge avoidance (Lima and Valone 1991, Pulliam and Mills 1977) seems an unlikely explanation for the apparent area sensitivity we found in ROWs at SRS. We believe differences in vegetation composition and structure among size classes were responsible for the presence of birds in relation to edge (Champlin 2007), but our sampling was not designed to address this effect directly. Whether such differences exist and if so, whether they are attributable to fire effects or other management activities, remains unclear.

Although it is important to assess the grassland-bird response to habitat-patch size, it is perhaps of greater management utility to understand the habitat conditions associated with patch size. Likewise it is important to understand whether and how management may promote large-patch conditions within management units of limited size. In addition, landscape-scale factors appear to play an important role in determining grassland-sparrow distribution and abundance (Dunning et al. 1995, Taillie et al. 2015). Future research should endeavor to clarify the interactions between habitat-management activities in ROWs and the effects of ROW-patch size and exposure on grassland vegetation and, in turn, on grassland-sparrow habitat quality. Our ROW width classes were not correlated with LFI, indicating that other factors may influence environmental exposure in grasslands. In Louisiana, Carrie et al. (2002) found Henslow's Sparrows most frequently on dry, well-drained sandy soils similar to what occured on exposed elevated sites at SRS. Large grassland-patches on elevated plateaus with soft forest edges (limited height and density of adjacent canopy) may represent important opportunities for the conservation of wintering grassland birds in the South Atlantic Coastal Plain.

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