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Converting exotic forages to native warm-season grass can increase avian productivity in beef production systems

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ABSTRACT

Grasslands are among the most imperiled ecosystems in the world, and establishment of exotic forage grasses and management for uniform utilization may have contributed to population declines of many obligate grassland bird species in North America. Native warm-season grasses (NWSG) are increasingly promoted as viable alternatives to exotic forages currently in production such as bermudagrass (*Cynodon dactylon*) and tall fescue (*Schedonorus arundinaceus*), but structure of native bunchgrasses also may offer nesting habitat for birds such as the dickcissel (*Spiza americana*). Establishing NWSG pastures may thereby create an opportunity for land-sharing, where agriculture incorporates biodiversity-friendly practices. We investigated dickcissel responses to NWSG and grazing at the Prairie Research Unit in Monroe Co., Mississippi (USA), where we established a gradient of management intensity among four treatments in small, operational-scale pastures (6.4–10.5 ha). Treatments included grazed exotic forages, two grazed NWSG treatments including Indian grass (*Sorghastrum nutans*) monoculture and grazed mixed NWSG polyculture of Indian grass, little bluestem (*Schizachyrium scoparium*), and big bluestem (*Andropogon gerardii*), and a non-grazed NWSG polyculture treatment. We applied a multi-state capture-recapture model in a Bayesian framework to estimate dickcissel nest density and productivity while accounting for nest stage-specific variation in survival and detection. Nest density and productivity were consistently greater in non-grazed NWSG than grazed exotic pasture, whereas productivity in grazed NWSG treatments was intermediate but declined between years. We also found that variation in survival and density did not always correspond with estimated productivity, and thus solely relying on either parameter may be misleading when making inferences on habitat quality. These results suggest a positive response to NWSG among dickcissels in this system, but grazing may reduce nest site abundance, and consequently productivity. Native warm-season forages may be a viable land-sharing alternative by increasing productivity of tall structure specialists such as dickcissels compared with exotic grass pastures currently in production, but grazing should be managed to ensure abundance of tall vegetation structure for nest sites.

1. Introduction

Conservation of biodiversity in agricultural landscapes often operates along a dichotomy of land-sparing and land-sharing (e.g., Phalan et al., 2011; Pimentel et al., 1992). Land-sharing proposes incorporating biodiversity-friendly practices with agriculture, whereas land-sparing advocates maximizing production on current agricultural lands while setting aside natural areas. This land-sparing/land-sharing debate has extended to temperate grasslands (e.g., Brown and McDonald, 1995; Egan and Mortensen, 2012; Hodgson et al., 2010; Wright et al., 2012), which are among the most imperiled ecosystems in the world (Hoekstra et al., 2005) and where livestock production is a widespread form of land-use (Asner et al., 2004). In North America, management for uniform vegetation structure and composition in pastures and rangelands is common and can be detrimental to native biodiversity by limiting opportunities for species that favor different levels of vegetation structure and composition (Askins et al., 2007; Fuhlendorf et al.,

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2012; Toombs and Roberts, 2009). Although land-sparing efforts such as the Conservation Reserve Program (CRP) have been successful in providing habitat for multiple grassland bird species (Askins et al., 2007; Vickery and Herkert, 2001), landowner participation may be sensitive to market factors. For example, demand for biofuels may prompt widespread conversion of CRP enrollments to corn and soybean production (Wright and Wimberly, 2013). Given the projected growth in global human populations through 2050 (UN DESA, 2015) and increased demand for meat in the developing world (Steinfeld et al., 2006), novel land-sharing approaches to pasture and rangeland management may be needed to alleviate stressors on biodiversity while also supporting food production (Askins et al., 2007).

In the Southeastern United States, monocultures of exotic forages such as bermudagrass (*Cynodon dactylon*) and tall fescue (*Schedonorus arundinaceus*) are established across millions of hectares (Barnes et al., 2013) and can be managed with high stocking rates and large inputs of nitrogen fertilizer (Burns et al., 1984; Phillips and Coleman, 1995). Obligate grassland bird populations in North America have exhibited precipitous declines (Sauer and Link, 2011), and the structural and compositional homogeneity often created by contemporary grazing systems can reduce reproductive success of birds such as dickcissels (*Spiza americana*; Davis et al., 2016; With et al., 2008 With et al., 2008). Native warm-season grasses (NWSG) are increasingly promoted as a sustainable alternative to exotic forages because of their lower input requirements and drought tolerance (Harper et al., 2007), but NWSG also may create suitable nesting habitat for grassland birds (Giuliano and Daves, 2002; Harper et al., 2015; Hughes et al., 1999). In addition to the greater height and structural complexity of native bunchgrasses, these forages generally are not grazed as heavily as exotic grass pasture (Chamberlain et al., 2012; Harper et al., 2015; Mousel et al., 2003), and thus may retain structure for cover and nesting. Grazed NWSG therefore may be a land-sharing alternative to exotic forages and set aside programs, offering benefits for wildlife while also permitting beef production.

In this study we investigate use of native and exotic grass pastures by nesting passerines in Mississippi. We also surveyed non-grazed NWSG to evaluate effects of grazing on avian habitat quality and to include a land-sparing comparison. We focused on dickcissels because they are obligate grassland birds and tall structure specialists (Temple, 2002) and therefore are useful for examining effects of stand-type and grazing for species with similar preferences for tall structure (e.g., Henslow's sparrow [*Ammodramus henslowii*]; Winter, 1999; Zimmerman, 1988). Conservation implications also are relevant for this Neotropical migrant because their populations have declined in Mississippi (Sauer et al., 2014) and abundance of tall structure is likely limited in pastures and rangeland currently managed for uniform utilization of forage (Fuhlendorf et al., 2012).

Avian habitat quality is commonly assessed through nest searching and monitoring to estimate nest survival rates (indices of individual fitness), but studies may overlook relationships at the population level without also measuring density (Johnson, 2007). For example, members of a territorial species may exclude conspecifics from areas with high quality resources (ideal despotic distribution; Fretwell, 1972), thereby increasing per capita reproductive success but reducing productivity per hectare due to low nest density. Previous grassland bird studies typically evaluated nest densities using relative or apparent indices (e.g., Churchwell et al., 2008; Conover et al., 2011b; Hatchett et al., 2013). However, as with other survey methods, nest detectability is rarely 100%, so apparent indices may confound variation in true abundance with variation in detectability (Royle and Dorazio, 2008). An important advance in nest density estimation was proposed by Péron et al. (2014), who used a capture-recapture model to estimate waterfowl nest density while accounting for variation in nest survival and detectability. Here, we extend their approach to our study by using a multi-state capture-recapture model to account for nest stage-specific variability in survival and detectability. In addition, we use the nest density model to estimate the number of successful nests and compare productivity (fledglings ha^{-1}) among treatments. Because our model incorporates a detection process, these productivity estimates include both nests observed to have fledged nestlings as well as successful but unobserved nesting attempts. We hypothesized that breeding dickcissels respond to pasture stand type through abundance of suitable nest sites, predicting greater nest density and productivity in NWSG relative to exotic grass pastures, whereas grazing may reduce nest site abundance for this tall structure specialist.

2. Methods

2.1. Study area

We conducted our study at Mississippi State University's Prairie Research Unit (PRU) in Monroe Co., Mississippi, USA (lat 33°47′N, long 88°38′W) during May–July, 2011–2012. The PRU is located in the Black Belt Prairie region, one of the southern extensions of Great Plains grasslands known as the Blackland Prairies. Since the 19th century, native prairies in the Black Belt have been extensively reduced due to degradation and conversion to agriculture (Barone, 2005). The landscape context of our experimental units was mostly exotic pastures and row-crop fields, interspersed with woodland corridors and blocks. Total growing season precipitation (April–October) was 712 mm and 808 mm in 2011 and 2012, respectively, and mean daily maximum temperature in July was similar between years (2011: 33.7 °C; 2012: 33.4 °C; NCDC, 2016).

We conducted nest searches in 12 pastures (range = 6.4–10.5 ha) at the PRU. Pastures were assigned one of four treatments, and each treatment was replicated three times. One treatment consisted of a grazed non-native grass mix of bermudagrass and tall fescue (hereafter grazed mixed exotic pasture, or GMEP). The remaining treatments were native grass stands established in 2008. Native grass treatments included grazed Indian grass monoculture (*Sorghastrum nutans*; hereafter, grazed Indian grass native pasture, or GINP), grazed NWSG polyculture of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and Indian grass (hereafter, grazed mixed native pasture, or GMNP), and a non-grazed mixed native pasture treatment (NMNP). As an operation-scale study with pasture sizes within the range of beef production operations typically found in Mississippi and the Southeast (USDA NASS, 2014), each pasture was managed using conventional practices recommended for each treatment (H. Boland, personal communication). Management included prescribed fire for native treatments (grazed and non-grazed) in spring during each study year, and grazed treatments (native and exotic) were stocked continuously with fall-born steers from mid-May until September at 2.7 head ha^{-1}. Following results from soil tests, fertilizer was applied to exotic grass pastures at twice the rate as native grass treatments (67.3 kg ha^{-1} vs. 33.6 kg ha^{-1}). Other management actions were required to mitigate changes in stand condition, including application of 2,4-D herbicide to all pastures (grazed and non-grazed) in June 2012 to control excessive forb cover. Additionally, although total growing season precipitation (April–October) was somewhat greater in 2012 (808 mm) than in 2011 (712 mm), precipitation before July was less in 2012 (194 mm) than 2011 (368 mm; NCDC, 2016), and as a result stocking rates in grazed treatments (native and exotic) were uniformly reduced by one third in July 2012. Additional details on pasture establishment and management are reported by Monroe (2014). Treatment