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Prairie strips as a mechanism to promote land sharing by birds in industrial agricultural landscapes

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ABSTRACT

Reserving large patches of perennial vegetation has been shown to facilitate biodiversity conservation in industrial agricultural landscapes, but high demand for agricultural products challenges their establishment. Responding to this situation, in 2007, we experimentally integrated diverse native perennial vegetation (i.e., prairie) within annual row crops as a part of the Science-based Trials of Rowcrops Integrated with Prairie Strips (STRIPS) project in Iowa, USA. Four treatments were applied to small (0.47–3.19 ha) watersheds and included: 100% row crops (0% prairie) farmed on a soybean (*Glycine max*)—maize (*Zea mays*) rotation, and three treatments with prairie strips comprising 10% or 20% of the watershed area with the remaining area in row crops. This study evaluated bird response to these treatments between 2007 and 2012. We observed a total of 52 species using the experimental sites across six years of study, with 16 species comprising 99% of the observations. Bird abundance, species richness, and diversity positively responded to prairie within row-crop fields: we specifically recorded 1.53–2.88 times more birds, 1.53–2.13 times more bird species, and 1.40-1.98 times greater diversity in treatments with prairie compared to the 0% prairie control. Several generalist species – Eastern kingbird (*Tyrannus tyrannus*), American robin (*Turdus migratorius*), and common yellowthroat (*Geothlypis trichas*) – were statistically more abundant in treatments with prairie, and song sparrow (*Melospiza melodia*) were more abundant in one specific prairie treatment, whereas no species was statistically more abundant in the 0% prairie control. We found few differences between 10% and 20% prairie treatments, but recorded increases in bird abundance, richness, and diversity from 2007 to post-establishment years. This experiment suggests that incorporating prairie strips into annual row crops has the potential to increase agricultural land sharing by birds.

1. Introduction

While producing phenomenal crop yields for human benefit, extensive industrial agriculture is also associated with substantial environmental degradation (Foley et al., 2005; Robertson and Swinton, 2005), including profound impacts on native biodiversity (Sala et al., 2000; Tscharntke et al., 2005). Taxa dependent on low-intensity agricultural and grassland habitats have experienced particularly precipitous declines, including birds (Herkert et al., 2003; Murphy, 2003; Voříšek et al., 2010). Population declines for farmland and grassland birds in both Europe and North America are strongly connected to the intensity of agricultural land use (Donald et al., 2001; Murphy, 2003).

Reserving or setting aside whole fields is a proven mechanism for reducing agricultural intensity and fostering biodiversity in well-developed agricultural regions (Ryan et al., 1998; Van Buskirk and Willi, 2004), but can be socially, economically, and politically challenging. For example, high crop prices place pressure on farmers to farm both more intensively and more land, which negatively influences enrollment in the USDA Conservation Reserve Program (Lark et al., 2015), the principal mechanism for land set asides in the US (McGranahan et al., 2013). Research suggests farmers and farm landowners in the Midwestern US may be more amenable to land-sharing strategies – those that address conservation goals within agricultural production fields (Fischer et al., 2008) – targeted to achieve multiple benefits (Atwell et al., 2009; Arbuckle, 2013; Arbuckle et al., 2015). Targeted perennial practices, which strategically interject small amounts of perennial cover into annual row-crop fields, are expected to achieve substantial environmental gains while only removing a small

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amount of land from crop production (Berry et al., 2003; Schulte et al., 2006; Walter et al., 2007). While often developed to meet traditional soil and water goals, targeted practices could be constructed to also support biodiversity (Tscharntke et al., 2005; Fischer et al., 2006; Asbjornsen et al., 2013), and specifically bird populations (Van Buskirk and Willi, 2004; Clark and Reeder, 2007; Hiron et al., 2013; Bright et al., 2015). Many bird species respond positively to the presence of small patches of perennial vegetation such as grassed waterways (Bryan and Best, 1991, 1994), field borders (Marshall and Moonen, 2002; Conover et al., 2009), and riparian buffers (Henningsen and Best, 2005; Berges et al., 2010) in or adjacent to annual row-crop fields. In the Midwestern US, Best et al. (1995) found greater bird species richness in linear perennial habitats embedded in agricultural landscapes (e.g., farmstead shelterbelts, grassed waterways) compared to other agricultural habitat types.

A remaining question is whether the biodiversity and other benefits provided by targeted land-sharing approaches could be amplified by incorporating diverse native plant communities rather than non-native monocultures, such as the exotic cool-season brome (*Bromus* spp.) or fescue (*Festuca* spp.) grasses typically used in the US. Previous research across plant, spider, insect, and bird taxa documents higher species richness associated with diverse, native communities (Van Buskirk and Willi 2004). Reconstructed native prairie communities are expected to perform especially well in the Midwestern US (Liebman et al., 2013), given that prairie was the predominant vegetation in the region for several millennia leading up to Euro-American settlement in the 1800s and it is well-adapted to the region's environmental conditions.

As part of the Science-based Trials of Row crops Integrated with Prairie Strips (STRIPS; www.prairiestrips.org) project, we sought to understand the biodiversity and other impacts of integrating small strips of diverse, native grassland vegetation – prairie strips – into row-crop agricultural fields. Using prairie in a farmland conservation practice is novel in the US, where exotic brome (*Bromus* spp.) or fescue (*Festuca* spp.) grasses are more typically used. The project includes an experiment conducted at Neal Smith National Wildlife Refuge (hereafter, Neal Smith NWR or "the refuge") in central Iowa, USA, in which strips of prairie plant species were strategically sowed within small agricultural watersheds (0.47–3.19 ha) farmed on a soybean (*Glycine max*)—maize (*Zea mays*) rotation. We previously established that prairie strips are a cost-effective agricultural conservation option for the region (Tyndall et al., 2013).

In this study, we specifically assessed the response of bird abundance, richness, and diversity to this targeted land-sharing approach; other components of the STRIPS project address impacts on plant and insect biodiversity (Hirsh et al., 2013; Cox et al., 2014), soil and water (Zhou et al., 2010; Helmers et al., 2012; Pérez-Suárez et al., 2014; Zhou et al., 2014), and heat-trapping gases (Iqbal et al., 2015). We hypothesized that the bird community and populations would respond positively to (1) treatments with prairie compared to those entirely in row-crop production, (2) treatments with a greater percentage of prairie, and (3) time following prairie establishment. We expected the responses of individual bird species to be variable with treatment, amount of prairie, and time. More specifically, we expected greater abundance of species preferring open conditions (e.g., killdeer, *Charadrius vociferous*; vesper sparrow, *Pooecetes gramineus*) in the treatment without prairie and greater abundance of grassland generalist species (e.g., red-winged blackbird, *Agelaius phoeniceus*; common yellowthroat, *Geothlypis trichas*) in treatments with prairie. We did not expect grassland interior species (e.g., bobolink, *Dolichonyx oryzivorus*; Henslow's sparrow, *Ammodramus henslowii*) to be present within our treatments.

2. Materials and methods

2.1. Study area

Neal Smith NWR where the STRIPS experiment is located is situated on steeply rolling, well-drained terrain formed by the erosion of glacial deposits (Prior, 1991). Historically, this region was covered by tallgrass prairie interspersed with oak savannas and riparian forests, but is now dominated by cropland and pasture. The climate is humid continental, with an average annual temperature of 10 degrees Celsius, and annual precipitation amounting to 88 cm on average (NOAA NWS, 2015). Most of the land was farmed before the refuge was established in 1991, but the majority has since been restored to native plant communities. The STRIPS experiment is located on portions of the refuge that have not yet been restored and are currently in row-crop production.

Experimental units for this project included 12 small watersheds (hereafter referred to as "sites") ranging in size from 0.47 to 3.19 ha with boundaries determined topographically (Table 1); slopes ranged 6.1–10.5%. Treatments consisted of varying amounts (i.e., 0%, 10%, 20%) and positions (i.e., all at the footslope, multiple strips on the contour) of prairie. The four treatments included sites with: (1) the entire area planted to row crops (0% prairie); (2) 10% of the area planted to prairie at the footslope, and the remaining 90% in row crops; (3) 10% of the area planted to prairie in multiple strips on the contour, and the remaining 90% in row crops; and (4) 20% of the area planted to prairie in multiple strips on the contour, with the remaining 80% in row crops. The 0% prairie was the control because it is representative of standard agricultural

Table 1
Distribution of treatments among blocks, number of surveys, and site size for the STRIPS experiment at Neal Smith National Wildlife Refuge. The remaining percentage of the experimental sites is in annual row crop production, either soybean (odd years) or maize (even years).

Block	Treatment	Area (ha)	Number of surveys					
			2007	2008	2009	2010	2011	2012
Basswood	0% prairie (control)	0.81	7	11	10	21	19	10
Basswood	10% prairie bottom	0.55	8	12	10	21	22	10
Basswood	10% prairie strips	0.56	8	12	10	21	22	10
Basswood	10% prairie strips	1.31	8	12	10	21	20	10
Basswood	20% prairie strips	0.57	8	12	10	21	21	9
Basswood	20% prairie strips	0.61	8	12	10	21	21	10
Interim	0% prairie (control)	0.61	8	12	10	19	22	10
Interim	10% prairie bottom	3.24	8	12	10	19	22	10
Interim	10% prairie strips	3.10	8	12	10	19	22	10
Orbweaver	0% prairie (control)	1.24	8	12	8	19	23	10
Orbweaver	10% prairie bottom	1.25	8	12	10	20	23	10
Orbweaver	20% prairie strips	2.51	8	12	8	20	24	10