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The effects of land sparing and wildlife-friendly practices on grassland bird abundance within organic farmlands

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ABSTRACT

Biodiversity is often greater in organic farm systems than non-organic. However, variation in land use within organic systems limits absolute statements about its value for species conservation. Thus, a need is evident to better understand what practices associated with organic farming benefit conservation. We modeled abundance, within organic systems, of six grassland birds of conservation concern as an outcome of applied wildlife-friendly and land sparing practices at multiple spatial scales. We used a Poisson-binomial model to estimate the relative effect of abundance drivers while accounting for detectability. At the field scale, species response to vegetation structure was mixed. At a local scale, Dickcissels were more abundant at points with greater percentage of alfalfa and soybean. Three species were less abundant at points with a greater percent of local woodland and there was no significant response to local linear grass. Grasshopper Sparrows were more abundant at points with more local block grassland. At a landscape scale, Western Meadowlarks and Ring-necked Pheasants were more abundant at points with a greater percent of grassland in the landscape. Results highlight the importance of a multiscale approach and demonstrate that effective management of species should consider costs and benefits of wildlife-friendly and land sparing practices.

1. Introduction

A variety of solutions have been suggested to identify a balance between biodiversity conservation and food production (Green et al., 2005; Fischer et al., 2008; Phalan et al., 2011). Among these, organic farming has been shown to benefit biodiversity, with richness and abundance of a variety of organisms greater on organic than non-organic farms (Hole et al., 2005). Organic farming, however, is a broad management system that can incorporate many applied practices that may or may not benefit biodiversity. The variation in organic systems reflects a focus in organic standards on actions prohibited rather than practices implemented (Shennan, 2008), different certification standards that generally lack clear guidelines in regards to biodiversity conservation, and individual farm systems that reflect a regions agroecology. The applied practices fall along a gradient between two conservation philosophies: land sparing in which land for conservation is held separate from crop production and wildlife-friendly farming that integrates biodiversity conservation with agronomic production goals (Fischer et al., 2008). The variety of wildlife-friendly (e.g., crop diversity and field buffers) and land sparing (e.g., set-asides) practices currently applied within temperate organic farms ultimately limits the accuracy of broad statements describing organic farming as beneficial to biodiversity. Furthermore, the varied success of applied agri-environment schemes (Kleijn et al., 2006) and proposition that organic agriculture can mediate the tradeoffs between food production and conservation in agricultural areas where low intensity farm systems are economically viable (Gabriel et al., 2009) suggest data are needed for accurate predictions about the outcomes for biodiversity from the increasingly widespread adoption of organic farming.

In our study region, the Central Great Plains of North America, wildlife-friendly farming practices available to organic farmers include diverse crop rotations with high and low intensity crops, increased heterogeneity, and linear grasslands, woodlands, and shrubs embedded within the farm in gradients of varied sizes, shapes, and extents. Land sparing practices (i.e., larger contiguous patches of protected or set-aside habitats (Phalan et al., 2011)), included managed pasture and set-aside lands primarily composed of grassland, though riparian woodlands are also important landscape elements.

Grassland birds are among the species in greatest conservation need in North American agricultural landscapes (Askins et al., 2007; Sauer et al., 2008). While most grassland species are not yet formally threatened or endangered, current population trends

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Table 1
Description, classification, and summary statistics for mirco, local, and landscape variables from organic farms in Nebraska surveyed 2007–2009.

Scale/parameter	Land sparing or wildlife-friendly	Mean	SD
Microhabitat			
Bare soil	–	55.3	36.4
Total vegetation cover	–	40.3	30.9
Vegetation height	–	36.8	25.3
Veg. density	–	1.3	1.7
Local			
Linear woodland	Wildlife-friendly	2.9	8.2
Block woodland	Land sparing	3.9	14.5
Linear grassland	Wildlife-friendly	5.0	10.6
Block grassland	Land sparing	25.1	38.0
Shannon diversity index (SHDI)	Wildlife-friendly	0.8	0.4
Alfalfa	Wildlife-friendly	7.7	24.2
Corn	Land sparing	9.0	23.4
Small grain	Wildlife-friendly	11.3	26.9
Soybean	Land sparing	6.5	20.5
Landscape			
Grassland	Land sparing	28.0	16.4
Woodland	Land sparing	5.1	5.2
Shannon diversity index (SHDI)	Wildlife-friendly	1.7	0.2

warrant conservation concern. To address how practices associated with organic farming can compliment current conservation efforts we focused on the response of individual species of conservation need or recreation value rather than diversity metrics (e.g., species richness). While consideration of diversity metrics to evaluate conservation in agroecosystems has proved fruitful (e.g., Beecher et al., 2002), a need is evident (Phalan et al., 2011) to move the discussion about the tradeoffs of food production and conservation beyond aggregate measures of diversity and towards predictions of the response of individual species, in this case grassland birds. In turn, these data on individual species can be aggregated in setting targets and evaluating tradeoffs for multi-species conservation plans.

We focus on testing hypotheses derived from the gradients of land use and heterogeneity associated with organic farming at multiple spatial scales. Though theory regarding what practices, at what scale, and in what location a land use is considered wildlife-friendly or land sparing is still evolving (Fischer et al., 2008; Norris, 2008; Meehan et al., 2010; Phalan et al., 2011), in light of current dialogue, we classified model parameters in the framework of this active discussion. We identify land uses as wildlife-friendly or land sparing in the context of agroecosystems in the central Great Plains of the United Sates, an agroecoregion dominated by high-intensity row crop farm systems (Henebry et al., 2005). More specifically, we tested whether North American grassland birds were more abundant at points in organic farms associated with practices described as wildlife-friendly (e.g., narrow linear grasslands or tree buffers, heterogeneity, or low-intensity crops (Perlut et al., 2006; Mendenhall et al., 2011; Pickett and Siriwardena, 2011)) or as land sparing practices (e.g., contiguous blocks of non-crop habitat (Fischer et al., 2008; Phalan et al., 2011)). We measured availability of selected wildlife-friendly and land sparing practices (Table 1) within the farm and as part of the larger landscape around the organic farm. While we focused on the Great Plains, inference drawn from temperate North American prairies may provide applied conservation suggestions for other temperate grassland regions that have or are in the process of increasing agricultural output or considering organic farming as part of local conservation efforts.

2. Methods

2.1. Study region

The central Great Plains of North America historically transitioned from tallgrass prairie in the east to mixed and short grass farther west (Samson et al., 1998; Askins et al., 2007). However, land use and land cover of the region has undergone dramatic change in the last 200 years (Ellis and Ramankutty, 2008). Today, a limited number of agricultural land uses; in particular, conventional and genetically modified corn and soybean (Henebry et al., 2005) dominates the study area. As an alternate farming system, land dedicated to organic crop and livestock production is increasing. The total acreage of land managed under organic practices in the region, however, remains relatively small compared to other farm management systems (USDA, 2009).

2.2. Field sampling

We sampled 285 points embedded within 19 certified organic farms in the central Great Plains. We identified farm sites by soliciting participation from the organic farming community and by using criteria of current organic certification, row crops as part of the operation, and farm size ≥65.8 ha, large enough for sixteen sampling points. We located survey points on each farm by digitizing the farm perimeter and randomly selecting up to 16 points >200 m apart within each farm using HawthsTools extension (Beyer, 2004) for ArcMap (ESRI Redlands, CA). Trained field ornithologists visited each point four times between 14 May and 10 July during two of three years between 2007, 2008 and 2009. We applied unbounded point counts to maximize detections. While not as accurate for density estimates as other methods (e.g., fixed radius counts), in addition to maximizing detections, unbounded counts reduce bias with regard to bird-distance estimation, over-estimation at the perimeter of a count circle, and birds dispersing in response to the observer (Bani et al., 2006). In addition, while past analysis techniques were more limited by variations in detectability, we applied process–observation models (Royle and Dorazio, 2008) to more accurately account for variation in detectability caused by observer bias and reduced detectability due to wind (Quinn et al., 2011). Thus, by employing process–observation models we take advantage of the increased the number of observations in the data set, a valuable outcome when sampling low-density populations with low probability of detection. All counts were 5 min in duration and conducted within four hours of sunrise. We recorded average wind speed for ten seconds prior to each count using a Kestrel® 1000 Pocket Wind Meter (Boothwyn, PA). We did not conduct counts during times of high winds or heavy rain that limited visibility and we varied order and time of counts to limit bias.

Table 2
Estimates of microhabitat/field measures within 20 × 50 cm quadrat from the posterior distribution of N-mixture models of abundance of grassland birds. Mean parameter estimates and 95% credible intervals (CI) shown. Abundance estimates shown on the log scale. Credible intervals not overlapping zero (significant effect) highlighted in bold.

Species	Number of detections	Bare soil			Total vegetation cover			Vegetation height			Vegetation density		
		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Dickcissel (DICK)	5604	0.01	−0.05	0.07	0.04	−0.04	0.12	**0.18**	**0.09**	**0.30**	−0.02	−0.09	0.06
Grasshopper Sparrow (GRSP)	954	−0.12	−0.26	0.03	−0.19	−0.43	0.04	**0.37**	**0.07**	**0.70**	**−0.51**	**−0.90**	**−0.20**
Western Meadowlark (WEME)	2696	−0.04	−0.13	0.03	0.04	−0.06	0.14	**0.21**	**0.08**	**0.40**	**−0.25**	**−0.40**	**−0.10**
Vesper Sparrow (VESP)	264	0.08	−0.12	0.29	**0.32**	**0.04**	**0.60**	0.12	−0.22	0.46	**−0.45**	**−0.90**	**−0.10**
Ring-neck Pheasant (RNPH)	1117	−0.07	−0.17	0.03	0.01	−0.12	0.15	0.02	−0.13	0.18	−0.09	−0.25	0.05
Horned Lark (HOLA)	1284	0.11	−0.03	0.26	−0.07	−0.25	0.11	−0.01	−0.23	0.21	−0.17	−0.45	0.07

2.3. Study species

We recorded 104 species during three years of sampling. Of these species, grassland birds in the region that are of national and regional conservation concern include the grassland obligate species Western Meadowlark (*Sturnella neglecta*), Dickcissel (*Spiza americana*), Grasshopper Sparrow (*Ammodramus savannarum*), Vesper Sparrow (*Pooecetes gramineus*), Bobolink (*Dolichonyx oryzivorus*), Upland Sandpiper (*Bartramia longicauda*), and Horned Lark (*Eremophila alpestris*); and facultative species of recreation and economic value (Ring-neck Pheasant (*Phasianus colchicus*) and Northern Bobwhite (*Colinus virginianus*)). The nine grassland species described above combined for 34% of observations. Six of these species (Table 2) had sufficient detections for model convergence.

2.4. Data analysis

We selected model parameters (Table 1) by reviewing published literature from both grassland and agroecosystem biodiversity conservation (e.g., Beecher et al., 2002; Benton et al., 2003; Hole et al., 2005; Askins et al., 2007) and protocols for avian sampling in the region (Peitz et al., 2008). We sampled relevant microhabitat measures (Table 1) immediately adjacent to each point-count location and at three random points distributed 50 m from the count location. At these four points, we visually estimated foliar cover and ground cover in 20 × 50 cm quadrat frame using modified Daubenmire cover classes and vertical obstruction with a Robel Pole placed in the center of each quadrat (Robel et al., 1970). We used the mean of the four quadrats associated with a point for analysis. At the local scale, we followed established regional protocols (Peitz et al., 2008, e.g., 50 m buffer) to sample habitat extents adjacent to the point. Each year we categorized, at the sampling point, the surrounding land use and land cover pattern (Table 1), including percent of crop fields and non-crop habitat within 50 m from the center of each point. At the landscape scale, we quantified percent land use in the matrix around each farm of conventional arable cropland, managed grasslands, and forest cover at 5000 m (Table 1), a distance identified as a mid-point in similar regional multiscale habitat assessments (e.g., Thogmartin and Knutson, 2007), using ArcGIS, v9.3 (ESRI Redlands, CA) and Fragstats v3.3 (McGarigal et al., 2002) with image data compiled by the US Fish and Wildlife Service, Grand Island, NE.

We used hierarchical Poisson-binomial N-mixture models (Royle, 2004; Clark, 2005; Royle and Dorazio, 2008) in a Bayesian framework to predict the relationship between estimated bird abundance and relevant habitat variables. N-mixture models use spatial and temporal replication to estimate abundance and to account for the varied and imperfect detection probability of a species. By accounting for varied detection probability, model estimated abundances are more accurate than using the maximum or average number of detections across multiple counts (Rota et al., 2011). We included microhabitat, local, and landscape metrics described above (Table 1) as variables influencing estimated abundance. We checked model parameters for multicolinearity. We applied hierarchical modeling with landscape as a random effect to account for effects of spatial-autocorrelation and pseudoreplication that may result from analysis of multiple points within multiple sites. Bayesian analysis was used to take advantage of its ease of application in hierarchical models. Observer and wind speed were included as detection covariates.

We assigned non-informative priors with normal distributions (mean = 0, SD = 1000) to parameters and intercepts (McCarthy, 2007; Kery, 2010). Bayesian analysis was run with WinBugs (Lunn et al., 2000) through the R2WinBugs package (Sturtz et al., 2005) for program R v. 2.12.0 (R Development Core Team, 2010) using three Markov Chain Monte Carlo (MCMC) simulation chains with 250,000 iterations, discarding the first 100,000 iterations as a burn-in and thinning chains by 50:1. We checked results for autocorrelation and for convergence with Gelman and Rubin's convergence diagnostic (Gelman and Rubin, 1992; Brooks and Gelman, 1997). Given the limitations of the Deviance Information Criterion (DIC) as a model selection criterion for hierarchical models (Celeux et al., 2006), we present here the result of full models, accepting the loss of precision, (Bolker et al., 2008), with inference based on 95% Bayesian credible intervals not overlapping zero.

3. Results

Of the six species with converging models, only the Western Meadowlark showed associations at three scales (microhabitat/field, local, and landscape) and with both wildlife-friendly and land sparing practices. Four of the remaining species showed habitat associations at two of three scales, and a mixture of land sparing or wildlife-friendly practices. The measured effect of observer or wind speed on detection probability was not significant.

At the microhabitat/field scale the Dickcissel, Western Meadowlark, and Grasshopper Sparrow were more abundant at points with greater vegetation height (Table 2, Fig. 1a). Vesper Sparrow, Western Meadowlark, and Grasshopper Sparrow were less abundant at points with greater vegetation density (Table 2, Fig. 1b). Vesper Sparrows were more abundant at points with greater total ground cover (Table 2).

The response to local and landscape scale wildlife-friendly practices was mixed. Western Meadowlarks, Horned Larks, and Dickcissels were less abundant at points with more local linear woodland (Table 3, Fig. 1c). There was no significant response by any species to local linear grassland (Table 3). There were no observed differences in abundance in response to local or landscape heterogeneity (Tables 3 and 5). Dickcissels were more abundant at points with more alfalfa planted locally (Table 4, Fig. 1d).

Response to land sparing also varied. Grasshopper Sparrows were more abundant and Horned Larks less abundant at points with more local block grassland (Table 3, Fig. 1d). Western Meadowlark and Dickcissel were less abundant at points with more local block woodland (Table 3). Grasshopper Sparrow and Vesper

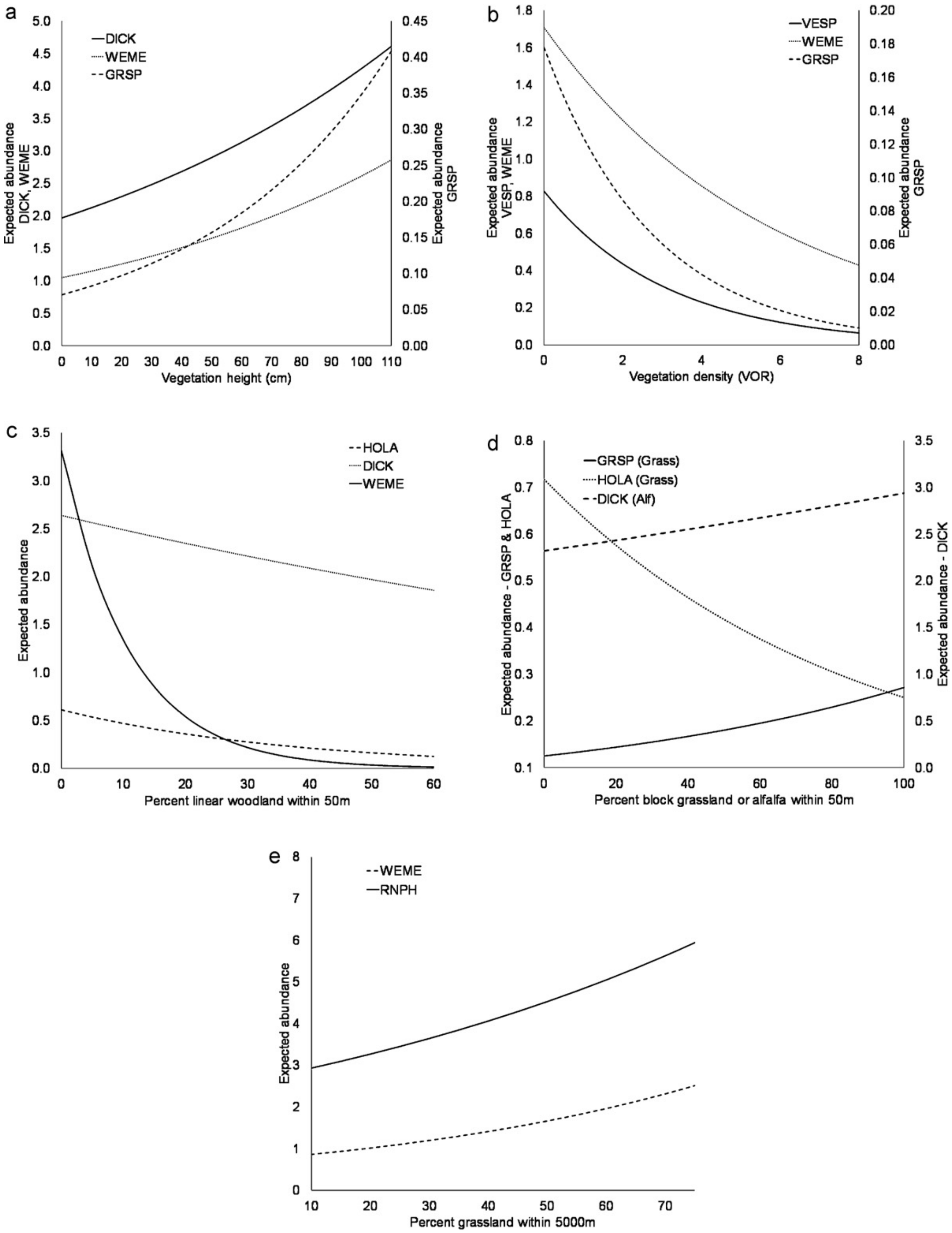

Fig. 1. Predicted relationship from N-mixture models between avian abundance and (a) vegetation height, (b) vegetation density, (c) percent linear woodland within 50 m, (d) percent block grassland or alfalfa within 50 m, (e) percent grassland within 5000 m. Only significant relationships (C.I. do not overlap zero) are shown. Credible intervals excluded for clarity, but measures of precision are reported in Tables 2–5. See Table 2 for species abbreviations.

Sparrows were less abundant at points with greater corn locally (Table 4), while Dickcissels were more abundant at points with more soybean planted locally (Table 4). Western Meadowlarks and Ring-necked Pheasants were more abundant in areas with a greater percent of grassland at the landscape scale (Table 5, Fig. 1e). Horned Larks were less abundant at points embedded in landscapes with a greater percentage of woodland cover.

4. Discussion

Adoption of organic management does benefit biodiversity (Hole et al., 2005) and more specifically bird abundance and richness (Beecher et al., 2002). Yet, to optimize the contribution of organic farming to local species conservation efforts, adopted practices need to address the individual local and landscape

Table 3
Estimates of local (within 50 m) non-crop measures from the posterior distribution of N-mixture models of abundance of grassland birds. Mean parameter estimates and 95% credible intervals (CI) shown. Abundance estimates shown on the log scale. Credible intervals not overlapping zero (significant effect) highlighted in bold.

Species	Linear woodland			Block wood			Linear grassland			Block grassland			Local SHDI		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Dickcissel	**−0.11**	**−0.17**	**−0.05**	**−0.21**	**−0.30**	**−0.13**	−0.01	−0.07	0.05	−0.01	−0.08	0.06	−0.03	−0.09	0.03
Grasshopper Sparrow	−0.14	−0.31	0.02	−0.08	−0.27	0.10	−0.02	−0.22	0.18	**0.39**	**0.22**	**0.57**	−0.20	−0.20	0.03
Western Meadowlark	**−0.17**	**−0.26**	**−0.09**	**−0.19**	**−0.32**	**−0.07**	0.02	−0.07	0.11	−0.02	−0.12	0.07	−0.07	−0.16	0.02
Vesper Sparrow	−0.07	−0.29	0.14	0.09	−0.19	0.36	−0.14	−0.34	0.06	−0.22	−0.50	0.06	0.00	−0.24	0.24
Ring-neck Pheasant	−0.08	−0.19	0.03	0.02	−0.10	0.14	−0.03	−0.14	0.07	−0.04	−0.16	0.09	0.00	−0.11	0.11
Horned Lark	**−0.51**	**−0.74**	**−0.30**	−0.26	−0.59	0.02	−0.06	−0.20	0.07	**−0.45**	**−0.69**	**−0.22**	−0.06	−0.19	0.08

Table 4
Estimates of local (within 50 m) arable crop measures from the posterior distribution of N-mixture models of abundance of grassland birds. Mean parameter estimates and 95% credible intervals (CI) shown. Abundance estimates shown on the log scale. Credible intervals not overlapping zero (significant effect) highlighted in bold.

Species	Alfalfa			Corn			Small grain			Soybean		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Dickcissel	**0.09**	**0.04**	**0.15**	0.01	−0.06	0.07	0.03	−0.03	0.10	**0.08**	**0.03**	**0.13**
Grasshopper Sparrow	0.10	−0.08	0.27	**−0.29**	**−0.60**	**−0.01**	−0.15	−0.41	0.10	−0.12	−0.36	0.09
Western Meadowlark	−0.07	−0.15	0.00	−0.11	−0.22	0.00	0.00	−0.10	0.09	0.03	−0.05	0.11
Vesper Sparrow	−0.08	−0.28	0.11	**−0.23**	**−0.46**	**−0.01**	−0.04	−0.26	0.18	−0.11	−0.28	0.05
Ring-neck Pheasant	0.01	−0.09	0.11	0.00	−0.12	0.12	0.04	−0.07	0.16	0.01	−0.09	0.12
Horned Lark	−0.13	−0.29	0.02	0.03	−0.09	0.14	−0.07	−0.22	0.07	0.02	−0.08	0.13

habitat requirements of local species of conservation concern. Our results demonstrate the challenge of grassland bird conservation in organic agroecosystems where the majority of arable land is in row crop production. The estimated abundance of grassland species was predicted by a mix of wildlife-friendly and land sparing practices at field, local, and landscape scales. These results convey the importance of understanding of the response of individual species to specific agricultural management practices, in particular the limitation of some perceived wildlife-friendly practices in temperate ecosystems, the importance of a landscape context in agroecosystem conservation, and the necessity of sparing land from cultivation.

Wildlife-friendly farming practices that have demonstrated benefits to both species conservation and agricultural sustainability include narrow grass buffers, low-intensity crops, and woody cover (e.g., Jobin et al., 2004; Wilson et al., 2009; Batáry et al., 2010; Wretenberg et al., 2010; Mendenhall et al., 2011). Yet, our results suggest a more limited value of these practices for efforts to conserve North American grassland birds in temperate organic farm systems. In particular, given the known habitat association of the target species (King and Savidge, 1995; Helzer and Jelinski, 1999; Murphy, 2003; Poole, 2005; Herkert, 2009), the limited role of both linear and block grassland at the local level was unexpected.

Results do suggest that the strong negative effect of local encroachment of woody vegetation observed here and documented broadly (Kelsey et al., 2006; Askins et al., 2007) is an important conservation barrier in Great Plains agroecosystems. Woody cover may be masking or limiting the potential benefits of small grasslands (e.g., Walk et al., 2010) common in organic agroecosystems and supported by the Conservation Reserve Program and other agri-environmental schemes. The Dickcissel's greater abundance at points with alfalfa and soybean suggests a benefit to lower intensity cropland acres. However, caution is necessary as harvested and cultivated croplands, particularly hayed crops such as alfalfa, can create population sinks (Perlut et al., 2006) and a false measure of success of an agri-environmental schemes.

Despite demonstrated benefits of heterogeneity for other species (e.g., Pickett and Siriwardena, 2011) we were unable to elucidate an influence of heterogeneity in the region. Given the recent interest in the benefits and limitations of heterogeneity (Fahrig et al., 2011), a need for further research related to heterogeneity across species, regions, and landscape types is evident. In particular, better data are needed to evaluate if functional heterogeneity (Fahrig et al., 2011) is more relevant then coarse or general measures of heterogeneity as applied here. For example, heterogeneity within grassland patch types has been demonstrated to benefit grassland-associated species (Toombs et al., 2010), but how heterogeneity of the larger landscapes interacts with grassland patches is less well understood.

In the study region, set-aside land and pastures are the most commonly available contiguous grasslands spared from cultivation. Contiguous blocks of local grassland within farms benefited only the Grasshopper Sparrow. Larger grassland areas spared from cultivation measured as part of the larger landscape scale benefited Western Meadowlark and Ring-necked Pheasant populations. These results are consistent with work (e.g., Bakker et al., 2008) suggesting that conservation efforts for grassland species are most effective in conjunction with larger protected grasslands,

Table 5
Estimates of landscape (within 5000 m) measures from the posterior distribution of N-mixture models of abundance of grassland birds. Mean parameter estimates and 95% credible intervals (CI) shown. Abundance estimates shown on the log scale. Credible intervals not overlapping zero (significant effect) highlighted in bold.

Species	Grassland			Woodland			Landscape SHDI		
	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Dickcissel	0.04	−0.16	0.24	0.04	−0.19	0.27	0.02	−0.20	0.24
Grasshopper sparrow	0.51	−0.08	1.15	0.21	−0.46	0.87	0.19	−0.50	0.88
Western meadowlark	**0.53**	**0.01**	**1.06**	−0.50	−1.10	0.10	0.22	−0.35	0.79
Vesper sparrow	−0.60	−1.24	0.01	0.32	−0.35	1.02	0.32	−0.32	0.93
Ring-neck pheasant	**0.35**	**0.08**	**0.64**	−0.26	−0.58	0.05	−0.01	−0.31	0.29
horned lark	−0.51	−1.16	0.11	**−0.83**	**−1.68**	**−0.04**	0.26	−0.47	0.97

essentially land sparing. These larger grasslands may also buffer species from the negative effects of linear and contiguous woodlands. These results provide further evidence of interactions between local and landscape management, in particular consideration of how the larger landscape can moderate local conservation practices and the relative value of organic farming in different matrix types (Winqvist et al., 2012). For example, the lack of response by Western Meadowlarks to organic management (Beecher et al., 2002) may reflect a moderating effect of the larger landscape that lacks grassland above a threshold.

Given the response to non-crop habitat across scales, it may be simple to conclude that it is larger non-crop habitat blocks, associated with land sparing practices, that are contributing to species conservation associated with organic farming. However, further research and discussion is necessary to identify at what scale, both grain and extent, does a practice considered as wildlife-friendly shift to land sparing and how does this vary for different regions, ecosystem types, and species (Phalan et al., 2011). For example, while considered here as land spared because of the contiguous nature of the habitat type and steep tradeoff with corn production, blocks of pasture withheld from crop production could be classified as wildlife-friendly at a longer temporal scale if the pasture was returned to cropland as part of a long-term rotation. In addition, there is a strong role of region and economics in the classification of a practice as wildlife-friendly or land sparing. As above, pasture may be considered wildlife-friendly in a region in which the economic return for grazing was closer to the value of high value commodity crops. Such a reclassification would temper the conclusions made here of the limited value of wildlife-friendly practices. In contrast, other practices are easier to classify as they clearly improve the profitability of a farm (e.g., windbreaks or linear woodlands (Mize et al., 2008)) despite land taken out of production. On balance though, given the loss of historical grassland and that protected areas are such a small portion of the landscape, a deeper understanding of how land uses associated directly with farm management systems benefit conservation efforts and how observed patterns compare to patterns established for protected areas (e.g., Bakker et al., 2008; Ribic et al., 2009) is essential.

Conservation practitioners need to apply limited funds for the greatest return. Thus, identification of species benefited or limited by either land sparing or wildlife-friendly practices is of immediate value. These data, under the above classification, suggest limited value of wildlife-friendly practices associated with organic farming for North American grassland birds. The strong negative effect of linear woodlands within 50 m and the non-significant effects of linear grasslands and low-intensity crops are clear. As discussed above, alfalfa, a low intensity crop can create an ecological trap. In contrast, the value of land sparing was evident by varied across scales, with the Grasshopper Sparrow benefiting from local blocks of grassland while Western Meadowlark and Ring-necked Pheasant appear to require a larger quantity of set-aside grassland habitat. In addition, a key attribute of the land sparing method of conservation is intensification of land not spared. The negative response of Grasshopper Sparrow and Vesper Sparrow to corn, a high intensity crop, complicates management that focuses on the patch or local while ignoring the matrix around a farm.

Local and field drivers, largely the decisions of individual farmers or landowners, are constrained within the context of farm programs and market limitations (Johnson et al., 2011) and the moderating effect of the larger landscape (Winqvist et al., 2012). Consideration of the micro and local level data suggests actions for individuals interested in improving habitat, including management of vegetation density and height. Limiting the extent of woody vegetation in the landscape, particularly near contiguous block grasslands or pastures, would likely improve the habitat for many grassland species. Working with farmers and private landowners to implement a range of practices will be essential if farmland is going to aid in biodiversity conservation efforts.

The response to blocks of grassland and grassland at larger scales (i.e., 5000 m) indicate the necessity of investing resources in land sparing practices to conserve those species that need larger tracks of suitable grassland habitat. However, landscape-scale management decisions are often beyond the scope of an individual farmer or landowner. Cross-property agreements, meta-population conservation, and other means of working across property lines may be necessary to address the need for larger scale grasslands.

5. Conclusion

The loss of remaining contiguous grasslands and rapid homogenization and intensification of farmland suggests that threats to grassland species in the Great Plains are not fading. Given that conservation focused on protected areas alone (the extreme end of the land sparing approach) has not proven as successful as hoped (Rosenzwig, 2003; Askins et al., 2007; Mora and Sale, 2011), recognizing the response of birds to the spectrum of practices available in agroecosystems is a needed first step towards a shared vision between crop production and biodiversity conservation (Quinn, 2012). If in the Great Plains, organic farm systems are to have a role in grassland bird conservation, clearly larger extents of grassland are needed. Thus while organic agriculture can fill a valuable conservation role in some low intensity agroecosystems (Gabriel et al., 2009) the farming practices need to include suitable wildlife-friendly or land spring practices that complement local conservation efforts. In addition, further research needs include evaluation of nesting success in North American agroecosystems, particularly in light of the observed limited population viability of grassland species in even large contiguous patches (With et al., 2008). Research of the ecosystem services provided by agrobiodiversity (Jackson et al., 2007; Wenny et al., 2011) and other associated species would serve as a pragmatic starting point for identifying common objectives between species conservation and farming sustainability.

Given the spatial breadth of current farming systems and the loss of historical grassland in the Great Plains and other temperate grassland ecosystems, conservation action in working farmland is necessary. Organic farming is one means by which combined objectives of conservation and food production can be achieved (Hole et al., 2005). However, given the uncertainty of the benefits of some agri-environmental programs (Kleijn et al., 2006), looking within one management system provides valuable data to increase the likelihood that applied practices will benefit the target species of conservation need. Ultimately, while organic farming broadly does benefit biodiversity, farmer adoption of elements along the land sparing-wildlife-friendly gradient at multiple spatial scales will drive the benefits for individual species.

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