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BIOTIC INTERACTIONS IN ORGANIC FARM SYSTEMS

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Abstract: Fire, drought, and grazing were primary ecological drivers of the historical Great Plains' prairie ecosystem. The suppression of fire, a shift in grazing and cropping systems, and the introduction of windbreaks and other woody vegetation altered the landscape. The abundance, vertical diversity, and composition of woody species have noticeably increased. A subsequent shift has been documented in relative abundance of bird species in the state, with shrubland and edge species filling the ecological niche created with the conversion of many cropland acres to woodland. Shrubland and edge birds may fill an important functional role in agroecosystems.

Organic farms frequently have greater habitat heterogeneity then other farm types. Agroforesty is an important component of this habitat diversity. To quantify the effect of woody land-use and land-cover on biodiversity and to assess the functionality of avian species as predators in organic farm systems, avian and insect diversity were sampled on 23 organic farms in eastern Nebraska and Kansas in 2007 and 2008.

Species response to the presence and arrangement of woodland cover on farms is of great interest. An N-mixture model was used to estimate abundance and detectability of farmland bird species. Results from these analyses will be used to assess the functional role of birds and explore relationships between insect and bird communities to determine whether woodland edge bird species have the potential to effectively suppress crop pests on organic farms.

Key Words: Birds, Community, Woody Land Cover

INTRODUCTION

Biodiversity and associated ecosystem services are threatened locally and globally, a threat recognized internationally as a critical environmental issue (MA 2005). The maintenance of biodiversity is necessary to maintain resilient ecosystems and the continued provisioning of ecosystem services (Bengtsson et al. 2003). Successful conservation strategies will need to consider the whole landscape including the matrix around protected areas (Fahrig 2001, Murphy 2003). Agriculture is the dominant matrix of many landscapes (Schulte et al. 2006).

Agriculture is frequently faulted for habitat loss and resulting species decline (Main et al. 1999, Perrings et al. 2006). Agricultural practices today affect 70% of all threatened bird species (IUCN 2000). Improving the quality of the agricultural matrix may increase species survival rate and reduce the size of the patch needed to maintain a population (Fahrig 2001). The matrix can serve as a source of food and other resources; and as a wildlife corridor facilitating dispersal among populations, essential for metapopulation persistence and the conservation of regional diversity (Matson et al. 1997).

Enhancing the quality of the matrix requires increased heterogeneity at the field and farm scale. Many agroforestry practices increase heterogeneity in a farm system. The presence of woody cover in the landscape increases local bird species richness (Pierce et al. 2001, Perkins et al. 2003) but the response of individual guilds and species vary (Pierce et al. 2001, Perkins et al. 2003). Richness (Pierce et al. 2001) and diversity (USFWS 1981) of woodland birds increased with increased presence of shelterbelts. Many woodland edge species respond positively to windbreaks (Johnson and Beck 1988, Pierce et al. 2001, Perkins et al. 2003), but many grassland birds avoid woody vegetation (Knopf 1994, Grant et al. 2004, Brennan and Kuvlesky 2005). Planning in relation to available woody and grassland habitats, landscape context, and species of interest is necessary to accommodate conservation needs of both woody and grassland species, and pest insect suppression in agroecosystems (Henningsen and Best, 2005).

Linear and non-linear woodlands are two categories of woody land cover types in agroecosystems. These woody landscape features can enhance beneficial interactions between crops and species. The presence of these two woody land cover types may have a strong influence on species abundance. Our objective in this paper is to examine the habitat relationships between farmland birds and woody landscape features at a local scale.

METHODS

Birds, insects, crop and non-crop vegetation were sampled at 358 points across twenty-three organic farms (Fig. 1) in eastern Nebraska and Kansas in 2007 and 2008. Surveys were conducted May 15-July 15 to assess richness, diversity and relative abundance across the different farm management types. Birds were surveyed during the first four hours after sunrise on two consecutive mornings. Counts were 5 minutes in duration and all birds heard or seen were recorded by species. Two observers conducted bird surveys at each point each morning, though at different times. Each point was sampled four times over a 48-hour period. The order and time of day in which point counts on each transect were conducted was varied to minimize these as confounding factors. Sticky traps (11.5 by 14 cm) were placed at each point to sample insect richness and diversity. Traps remained out for 48-hours and were collected after the final bird survey. Insects were transported to the lab and indentified to functional groups using dissecting microscopes as needed. Surrounding land use and pertinent landscape variables including adjacent non-crop habitat was categorized in the field using modified Daubenmire classes (PC-LETM 2008).

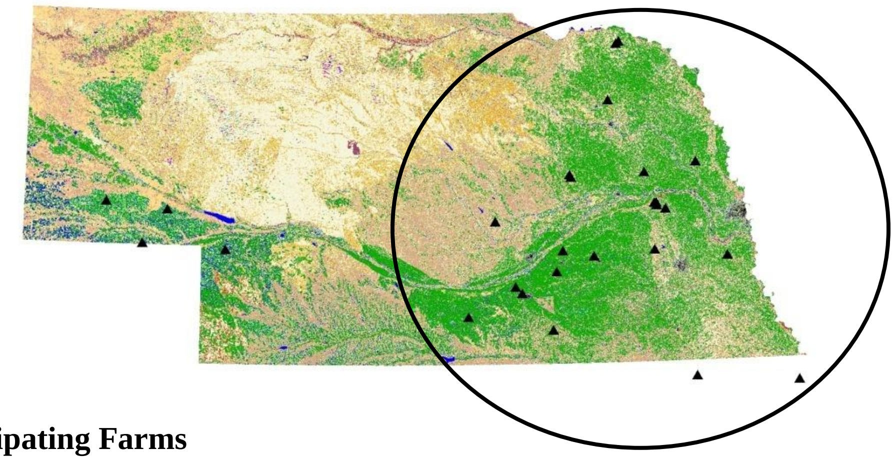

Figure 1. Participating Farms

We hypothesize that two types of woody land cover, linear (LWOOD) and non-linear (WOOD), would best predict the abundance of the Red-bellied Woodpecker *Melanerpes carolinus* (RBWO) and Orchard Oriole *Icterus spurius* (OROR), based on their habitat preferences. Both species move between woody vegetation and cropland for food and cover. A better understanding of what land cover types these species use would improve management goals. We include wind (WIND) as covariate of detectability. Ecological models are often flawed as a consequence of imperfect detection of individuals, reducing the value of management decisions based on the data. Using spatial and temporal replication, N-mixture models allow for an estimate of abundance, modeled as a random effect, from simple point-counts as well as accommodate for the probability of detection for each species despite imperfect detection (Royle 2004). This analysis technique allows for the development of clear and interpretable data to enable effective management.

Land use and land cover types can be included as covariates (X_i) influencing abundance (mu_i)(Eq 1.). Probability of detection (p_{it}) (Eq 2.) may vary other covariates (D_i) including date, wind speed, and observer (Royle 2004).

$$\text{Eq.1 } \log(mu_i) = b_0+b_1X1+b_2X2+b_3X3+b_4X4+b_5X5$$
$$\text{Eq. 2 logit } (p_{it})\ a_0+a_1D+a_2D$$

The best possible parameters were estimated using the optim function in the software package R (R Development). Likelihood models were fit under the negative binomial distribution. This distribution has been favored in previous N-mixture model efforts (Kery et al. 2005). Models were tested using Akaike's information criterion (AIC) model selection. Models were ranked and compared by delta AIC (Burnham and Anderson 1998). The best model was used to extract the estimated abundance and occurrence probability for the target species.

RESULTS

Ninety-six species of breeding birds were observed in the surveys. Individual farm richness ranged between 25 and 60 species. The top five models for Red-bellied Woodpecker and Orchard Oriole are presented in Tables 1 and 2. The top models had a weight greater then 0.58, two times better then the next model. The best model for each species was used to construct abundance and occurrence parameters (Table 3) and model the relationship between species abundance and land cover type (Figs. 2,3).

RBWO Models	K	AIC	delta AIC	weight
Wood+Wind	5	761.3973	0.0000	0.5923
Wood+Lwood+Wind	6	763.2505	-1.8532	0.2345
Wind	4	764.5606	-3.1633	0.1218
Lwood+Wind	5	766.2885	-4.8912	0.0513
Wood	4	811.4912	-50.0939	0.0000

Table 1. Top RBWO Models

OROR Models	K	AIC	delta AIC	weight
Lwood+Wind	5	809.3092	0.0000	0.5817
Wood+Lwood+Wind	6	810.6886	-1.3794	0.2918
Lwood	4	813.6950	-4.3858	0.0649
Wood+Lwood	5	815.0176	-5.7084	0.0335
Wind	4	816.2527	-6.9435	0.0181

Table 2. Top OROR Models

Species/Model	Abundance Parameters				Detection Parameters	
RBWO	b0	alpha	Lwood	Wood	a0	Wind
Wood+Wind	0.1368	2.7890	NA	0.2046	-2.0090	-1.1543
OROR						
Lwood+Wind	0.7556	0.5820	0.2983	NA	-2.4255	-0.2295

Table 3. Estimated Abundance and Occurrence Probability

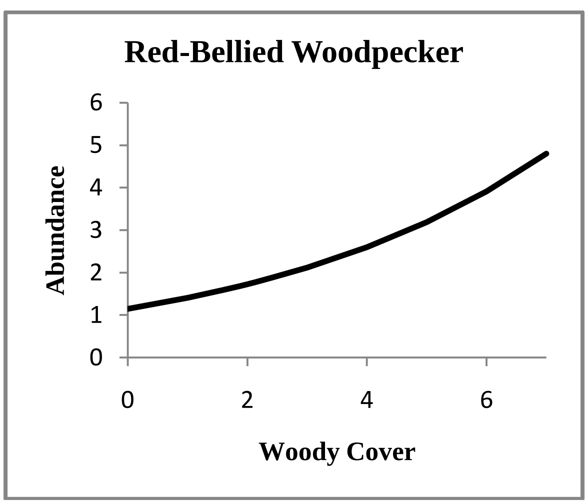

Figure 2

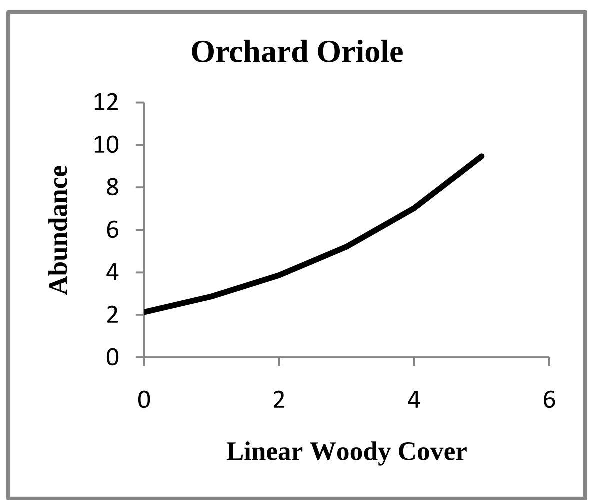

Figure 3

DISCUSSION

Woody landscape features are an important component of farmland sustainability. Their value in enhancing species diversity has been demonstrated (Pierce et al. 2001, Perkins et al. 2003). The optimal shape and arrangement of woody land cover for various species, however, remains unidentified. We have shown that different species using agroecosystems respond to different woody land cover shapes. The greatest difficulty for land managers is optimizing multiple goals. Different species provide multiple benefits to farm systems including biological control and aesthetic value. While food production is an essential component of farm management, farmland also has an essential role in protecting species and enhancing ecosystem services. Balancing multiple outputs from farm systems remains an elusive goal. The different responses of the two species presented here further complicates farm management goals but also demonstrates potential to focus management to conserve or enhance a species or guild if desired.

As ecological and economic parameters of agriculture shift, assessing and monitoring this dynamic landscape is essential to ensuring maintenance of natural and economic capital. The results of this research will be integrated into the Healthy Farm Index (Quinn et al. 2009). The Healthy Farm Index assesses biological, environmental, and socio-economic parameters' on working farm systems to guide to long-term sustainability. Recognizing the response of birds to land-cover variables is a first step in developing an effective means to optimize multiple goals. Birds have the potential to provide farmers an easy to use and accurate measure to monitor the health of their agroecosystem, encouraging the adoption of beneficial and sustainable farm practices.

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