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Article

The Influence of Different Cover Types on American Robin Nest Success in Organic Agroecosystems

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Abstract: There are many opportunities for biodiversity conservation in organic farm systems. Successful and sustainable conservation efforts in organic systems, however, need to measure appropriate outcomes. In particular, data are needed on the breeding success of associated wildlife species. We measured nesting success of the American Robin (*Turdus migratorius*) in woodlands embedded within eight organic farms in eastern Nebraska. We modeled daily nest survival rate to identify land use and land cover patterns that optimize conservation of birds in organic farm systems. The percentage of a crop in the fields adjacent to linear woodlands best predicted daily survival rate. Daily survival rate was lower in fields adjacent to wheat and greater in woodlands adjacent to soybean fields, though the latter may be a weak effect. There was no evidence that reducing the area allocated to organic crop production would improve daily survival rate but rather an evidence of a patch-matrix interaction. These results suggest that, if suitable nesting sites exist, organic farmers can complement local conservation efforts without losing working farmland.

Keywords: associated biodiversity; conservation; land sharing; patch-matrix; soybean; wildlife; wheat

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1. Introduction

Given the limited progress made toward achieving biodiversity conservation targets via protected areas [1], sustainable solutions are needed that consider opportunities beyond their borders. However, as a disproportionate amount of ecology and conservation research is conducted in protected areas [2], new data are needed to improve conservation targets and management action outside of protected areas, including in agroecosystems. These data are necessary as conservation outcomes based on research in protected areas may not be transferable to managed landscapes beyond. These data, from managed and novel ecosystems, will improve the ability of land managers and conservation practitioners to optimize the investment of limited conservation resources across land use types.

Of managed ecosystems globally, agricultural landscapes are attributed with driving the greatest land use and land cover change [3], but are also among the managed ecosystems with the most extensive base of research focused on identifying sustainable solutions to this change. Central to the discussion on conservation of biodiversity in agroecosystems is the debate between land sharing and land sparing as the best means to ensure conservation of biodiversity in the future, with evidence emerging that supports each argument as well as the spectrum of practices between [3–5]. Under land sparing, conservation efforts are separate from crop production while land sharing works to combine biodiversity conservation and agronomic production on the same land. Within this discussion, organic farming has been a frequent research focus. Organic farming is frequently identified as land sharing, with organic croplands and pasture managed concurrently for both biodiversity and food production. However, many organic farms also spare land from production via required field buffers or set-aside land, albeit at a smaller scale than protected areas.

Comparisons between organic and non-organic farm systems have demonstrated greater species richness and abundance on organic farmland when compared to non-organic farmland [6,7], though it can vary by taxa [8]. In birds, research has regularly demonstrated that organic farming increases richness, abundance, and use during breeding [9], winter [10], and migration [11]. In organic systems, nest density has been shown to be greater than in non-organic systems [12,13]. However, if organic farmers are going to contribute to biodiversity conservation efforts, conservation practitioners require measures of habitat quality beyond richness, abundance, and density [14] to more accurately quantify the conservation value of different land use and land cover patterns associated with organic farming, regardless of being identified as land spared or land shared. In particular, data are needed to identify what applied farm management practices contribute to increased nesting success in organic farm systems. Nesting success provides important demographic data not available when only occupancy or abundance is considered. Nesting success can provide data on recruitment of young and evidence of source or sink dynamics.

Broadly, agroecosystems have been shown to provide important nesting habitat [15,16]. While the results for breeding success in organic farm systems compared to non-organic systems are mixed [13,17,18], perhaps the more pressing question for organic farmers is how organic farm management practices influence nesting success within organic systems. Indeed, at this time, particularly for organic farmers, it may be more important to focus on how to optimize the contribution of organic farming to conservation rather than further comparisons between organic and non-organic agroecosystems [19]. In particular, data are needed as to what land use and land cover types managed by organic famers improve nesting success, including both non-crop (e.g., buffer strips [20]) and crop (e.g., crop types [21]) types. Data on the value of cropland habitat are particularly necessary, as cropland is an aspect of wildlife conservation research often generalized or oversimplified. Specific predictions related to crop type and intensity of cropping practice are lost when cropland is lumped together in analysis as general category of "row crop". Given that these croplands compose the largest percent of the land cover in many regions, including the Great Plains of North America [22,23], and that croplands provide economic gain to individual farmers, better data are need to understand the role of specific crops relative to the role of non-crop habitat patches embedded in working organic farmland.

Indeed, consideration of patch-matrix interactions may be central to conservation in agroecosystems and the discussion of scale in the land sharing/land sparing literature. There is increasing evidence that the surrounding landscape shape and structure is a significant modifier of habitat use [24,25], but current research evaluating the role of surrounding landscape has largely been limited to the effects of either high or low quality habitat (e.g., crop or non-crop) in an either-or-context. In reality, habitats surrounding patches fall along a continuum of high to low suitability and consequently nesting success should be evaluated with consideration to the availability of the entire suite of possible land use and land cover types.

The agroecosystem of the central Great Plains of North America transitioned from tall and mixed grass prairie to a limited number of agricultural land use practices, in particular high intensity crop production [22,23]. As an alternate farming system to these intensive practices, land dedicated to organic crop and livestock production is increasing locally [26] and globally [27]. Organic farms in the Great Plains region involve row crop and small grain production and livestock grazing. Land use associated with organic farms in the region include high and low intensity crops, pasture, and non-crop natural areas [28]. Common crops in the region include corn (*Zea mays*), soybean (*Glycine max*), wheat (*Triticum aestivum*), and alfalfa (*Medicago sativa*). Other crops are grown but not in significant quantities. We followed Meehan *et al.* [29] in classifying corn and soybean as high intensity crops requiring a higher level of management intensity. We classified wheat and alfalfa, plants more similar to perennial grasses and forbs, as low intensity crop types. Those farms with livestock devote a significant portion to pasture. Non-crop land cover includes riparian buffers, windbreaks of various tree and shrub species, fruit trees, grass strips adjacent to fields and grassland patches spared from crop production [28].

In this project, we examined the nesting success of a common farmland bird of the central United States. Because of their broad presence in agroecosystems [30,31] and evidence that they respond positively to organic farm management [9], American Robins (*Turdus migratorius*) serve as an ideal first species to evaluate nesting success within organic systems in North America. American Robins in the Great Plains nest in shelterbelts, fencerows, and riparian areas adjacent to or embedded within crop fields [31] and forage, on average, 25 meters into crop fields from woody edges [32]. The cropland matrix that a patch is embedded within may influence distance traveled and time necessary to support young. Thus we would predict that patches embedded within a higher quality matrix of low intensity crops would require less time foraging and less travel to obtain sufficient resources. The abundance of American Robins was demonstrated to be greater on organic farm systems than comparable non-organic systems in the same region as this study, including many of the same farms [9]. Clutch sizes are between three and five eggs with one to three broods per year. Nests are incubated for 12–14 days with fledging occurring near 13 days [30]. Building on field sampling on collaborating organic farms, we modeled daily nest survival rate [33–35] of the American Robin and evaluated what land use and land cover patterns associated with organic management hinder or enhance the breeding success of American Robins nesting in organic farm systems. Importantly, in this effort, we did not seek to compare organic to other farming methods (e.g., conventional) or other land cover types (e.g., fragmented forests). Rather, we identified organic farming practices that optimize the contribution of organic farming to local biodiversity conservation efforts.

2. Experimental Section

In 2010 and 2011, we monitored American Robin (*Turdus migratorius*) nests on eight organic farms in six counties of southeast Nebraska, USA. To locate nests, we systematically searched linear woody cover on participating farms twice a week during the breeding season (May-August). We checked active nests (those with eggs or young) at three or four day intervals after they were located [36]. Nest age was estimated by dates of transition. At each check, we documented the number of eggs and/or young, age of nest, and current nest fate. At the end of the nesting season, we estimated the percent coverage of each land use and land cover (Table 1) within 50 meters of each nest, a distance beyond the average observed foraging distance [32]; visually estimating, in the field, percent cover while standing at each nest site. In order to associate daily survival rate to organic farm management we selected model parameters associated with local land use and land cover patterns (Table 1) by reviewing published literature from American Robin and both woodland and agroecosystem biodiversity conservation [20,37–40].

Table 1. Descriptive summary (Minimum, Mean, Maximum) of estimated percent land use and land cover types measured within 50m of American Robins nests on organic farms in Nebraska in 2007 and 2008.

Covariate	Description	Min.	Mean	Max.
Bare Soil	Bare soil in unplanted or early season crop fields	0	8.3	85
Corn	Crop fields planted in corn	0	11.7	80
Soybean	Crop fields planted in soybean	0	7.9	80
Wheat	Crop fields planted in wheat	0	1.7	35
Alfalfa	Crop fields planted in alfalfa	0	1.5	35
Linear Grass	Linear grasslands adjacent to crop fields, patches, roadways	0	18.6	70
Non-linear Grass	Grassland patches; includes set-asides and pasture	0	24.3	90
Linear Wood	Linear woodslands adjacent to crop fields, patches, roadways; includes windbreaks, riparian areas, and hedgerows	0	21.0	80
Non-linear Wood	Woodland patches	0	1.7	40
Road	Paved and dirt roads	0	2.7	30

We used Program Mark [41] to estimate daily survival rate and to test *a priori* model combinations (Table 2) of the available land use and land cover patterns. We checked model parameters for multicollinearity. We tested a global model, individual models, and models organized by non-crop (e.g., linear and non-linear grasslands) and crop (e.g., high-intensity corn and soybean) land use and land cover types. We included wheat in multiple crop combinations due to its value as an alternative cash crop and classification as a lower-intensity crop. A model set that included nesting date was tested. We compared models using Akaike's information criterion model selection for small sample size (AICc). Models were ranked and compared by delta AIC. We sorted competing models according to their Akaike weight. The top models (ΔAICc < 2) were averaged to estimate daily survival rate [42]. We estimated period survival rate using the Delta method [43].

Table 2. Akaike's Information Criterion (AICc), Delta AIC (ΔAICc, difference in AIC from minimum in each model set), model weight for daily nest survival rate of American Robins nesting on organic farms in Nebraska in 2007 and 2008.

Model	k	AICc	ΔAICc	weight
Wheat + Soybean	3	342.92	0.00	0.37
Wheat	2	344.47	1.54	0.17
Soybean	2	346.28	3.35	0.07
Wheat + Alfalfa	3	346.47	3.55	0.06
Wheat + Corn	3	346.48	3.55	0.06
All crops	5	346.78	3.85	0.05
Corn + Soybean	3	347.56	4.63	0.04
Null	1	347.67	4.75	0.03
Road	2	348.88	5.96	0.02
Bare Soil	2	348.90	5.98	0.02
Linear wood	2	349.18	6.25	0.02
Non-linear Wood	2	349.50	6.57	0.01
Corn	2	349.55	6.63	0.01
Non-linear Grass	2	349.64	6.71	0.01
Linear Grass	2	349.66	6.74	0.01
Alfalfa	2	349.67	6.74	0.01
Linear Wood + Non-linear Wood	3	351.12	8.19	0.01
Linear Grass + Non-linear Grass	3	351.65	8.73	0.00
Global	11	354.47	11.55	0.00
All non-crop	5	355.13	12.20	0.00

3. Results and Discussion

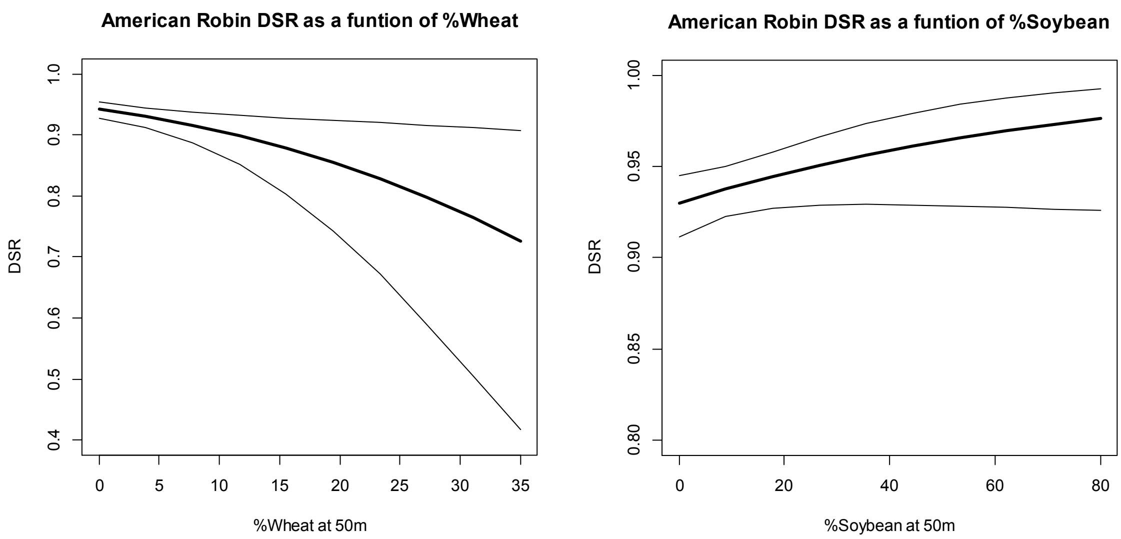
3.2. Model Results

A total of 119 nests were found during the two years of sampling, 56 in 2010 and 63 in 2011. Of these nests, 31 percent successfully fledged young. The top six models (ΔAICc < 4) of American Robin daily survival rate all included important crops to organic farmers in the region (Table 2). Nesting date was not included in top models. Daily survival rate was estimated at 0.93 ± 0.007. Nesting period survival rate was estimated at 0.15 ± 0.03. Daily survival rate was lower with a greater percentage of the local landscape as wheat and greater when nests were embedded in soybeans, though the latter may be a weak effect, with a 95% confidence interval that includes zero (Table 3, Figure 1). There was no evidence for an effect, positive or negative, of non-crop land cover, including presence of woody cover or grasslands.

Table 3. Beta estimates, standard error (SE) and 95% confidence limits from top model on daily survival rate of American Robins on organic farms in Nebraska in 2007 and 2008. Covariates are percent wheat and percent soybean within 50 m.

	Estimate	SE	95% CI	
Intercept	2.67	0.14	2.41	2.94
Wheat	-0.05	0.02	-0.09	-0.01
Soybean	0.01	0.01	0.00	0.03

Figure 1. Estimated daily nest survival rate (DSR) for American Robins nesting on organic farms in Nebraska in 2007 and 2008 as a function of percent wheat and percent soybean within 50 m of the nest.



3.2. Discussion

Conservation of biodiversity requires efforts outside of protected areas. Organic farming provides a wildlife-friendly agricultural landscape that can complement regional conservation efforts, including increasing bird abundance and richness [7,9]. Yet, to optimize the contribution of organic farming to species conservation, farming practices need to contribute to the breeding success of farmland bird species. In this project, we identified land use practices that organic farmers can adopt to enhance the contribution of their land to the improvement of nesting success of a farmland bird.

Our results present a clear example of patch-matrix interaction [44]. In particular, these data suggest that the choice of crop in the matrix may be as important as the non-crop habitat patch to daily nest survival rate of American Robins. In particular while a non-crop patch for nesting sites, in this case trees and shrubs, is necessary, we observed a decline in American Robin daily survival rate as a function of percent wheat in surrounding fields. In contrast, we see a weak effect of percent soybean, with an increase in daily survival rate as a function of the percent of land planted in soybean. Surprisingly, we did not see an effect of non-crop cover including no evidence that linear non-crop grassy areas [20] or woody cover [45] limited or enhanced nest success of the American Robin.

Different crop and field types may provide different benefits to birds at different times of the year [34]. Thus, the vegetation structure associated with these two crops may explain the observed patterns of daily survival rate. Both crops changed in percent ground cover and vertical structure over the sampling period. Early in the season (May–June), soybean fields are bare while wheat is rapidly growing in densely planted rows. Later in the year (July–August), wheat has been harvested, leaving short stubble in the fields. Soybean plants emerge through the growing season, reaching peak growth in late summer after most nests have fledged.

Because of the lack of vegetation, there may be greater foraging opportunities in soybean fields adjacent to nests, thus limiting the time that the adult birds have to spend away from the nest and not incubating or feeding young. Largely bare organic soybean fields would provide easy access to the high protein invertebrate populations preferred by breeding American Robins [46]. In contrast, the vegetation cover in wheat fields is denser throughout the year, perhaps limiting foraging opportunities. Even post-harvest, the stubble cover may increase foraging effort to such a point that robins may avoid wheat fields. The lack of response to grasslands may reflect the value of organic cropland providing greater foraging opportunities. The increased necessary foraging effort may also explain the lack of response to grass cover. Further work is needed monitoring adult and post-fledging movements [47] in organic systems to assess where American Robins and other species forage throughout the nesting season and how this may be associated with crop management.

Nest predation is an important source of nest failure [48,49]. It is possible that the linear woodlands in which many nests are embedded serve as corridors and edges for nest predators [40] while the agricultural matrix may limit the activity of the predator community [39]. For example, predation of Field Sparrow (*Spizella pusilla*) nests in North Carolina was lower when a greater percentage of the landscape was dedicated to agricultural production [39], though individual crops were not identified. In our study sties, wheat may provide cover and thus recruit predators, decreasing daily survival rate. Predator movement to nests embedded in soybean fields may be reduced as a result of being isolated by the bare soil associated with this crop during the early months of the growing season. American Robins will aggressively defend the nest [30]. Given evidence of reduced predation rates as an outcome of the presence of adult birds [50], it may be that time adult birds spend foraging away from the nest reduces nest defense. In addition to direct mortality, there is evidence of sub-lethal effects of predators, for example, reduced feeding rates at the nest [51] and in increased likelihood of predation following exposure to a predator even if the initial contact does not result in a nest failure [52].

4. Conclusions

In conclusion, these data move the discussion about conservation in organic agroecosystems beyond comparisons of organic to conventional to ways that organic farmers can optimize their contribution to biodiversity conservation. In particular, how crop selection may affect American Robin daily nest survival rate, provides an example lacking the perceived conflict between agricultural and conservation [5]. These data contribute to the land sparing/land sharing discussion; providing an example where farm-scale land sparing, in this case woodland patches, is complemented by land sharing in the adjacent crop matrix. Further data are needed for other farmland birds in North America, including both shrubland and grassland species [28,53], particularly those populations in decline in regions where organic farming is practiced at a sufficiently large scale to contribute to species conservation.

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Conflict of Interest

The authors declare no conflict of interest.

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