Expanding Bioacoustic Surveys Across Farm Sites to Test for Relationships with Agricultural Landscape Pattern

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Introduction

Agricultural landscape structure was shown to be significantly correlated with acoustic measures of songbird diversity in research conducted at several Iowa State University Research and Demonstration Farms (ISRFs) during the summer of 2018. These results demonstrate the efficacy of bioacoustic surveys in agricultural landscapes. However, the sample size was limited to only 12 study sites. During the summer of 2019, the total number of bioacoustic recorders were increased to 31 study sites, which were located on several ISRFs and on privately owned farms.

Prior to bioacoustic surveys, measuring biodiversity in relation to agricultural landscape structure has relied on labor-intensive and costly fieldwork to acquire data. Bioacoustic surveys linked with vegetation characteristics derived from satellite imagery offer the potential to increase the scale of biodiversity monitoring by greatly reducing field costs. Bioacoustic surveys are increasingly being used to characterize wildlife populations, yielding results as good or better than traditional approaches for estimating species presence. Here, results of the bioacoustic surveys along with preliminary assessment of landscape characteristics are presented. These results will be used in future research to evaluate the relationship between fine scale agricultural landscape pattern, management practices, and the avian species richness (number of species identified) on Iowa farms. Characterizing vegetation in agricultural landscapes as habitat for wildlife has been a key area of investigation for many decades. The variability in both crop and non-crop vegetation types has been hypothesized to be important predictors of biodiversity in agricultural landscapes.

Materials and Methods

Study sites were located at four ISRFs and 21 privately owned farms across Iowa totaling 31 bioacoustic survey locations. Site selection was guided by opportunity and by *a priori* analysis of variation in the percent composition of non-crop vegetation within a 1-km radius around the site. Acoustic recordings were collected with an AudioMoth (v1.0), a small and lightweight recorder developed to enable acoustic monitoring at low-cost. The unit was programmed to record for one minute, every 10 minutes, 24 hours/day from early June through July 2019. On review of recorded samples, it was found the time period between June 19-26, 2019, was consistently captured across bioacoustic survey locations. Recordings occurring from approximate time of sunrise to two hours after sunrise were reviewed using Raven Pro 1.5 software allowing for focused listening and spectrogram review. Avian biodiversity was quantified by identifying the total number of unique bird species calls with duration longer than one second in acoustic recordings; a measure of songbird richness.

Agricultural landscape pattern was characterized using a vegetation index and local measures of spatial autocorrelation. It is expected homogenous landscapes with monocultural vegetation patterns will support low biodiversity. The Normalized Difference Vegetation Index (NDVI) is a widely used

image remote sensing measure of vegetation productivity and has been correlated with various vegetation applications such as primary productivity estimation and crop yields. Local variation in NDVI could indicate increased heterogeneity of agricultural landscapes. PlanetScope satellite imagery with surface reflectance correction was obtained for each bioacoustic sample location. The Near Infrared and red spectral bands were used to compute NDVI. Next, a 3 x 3 m pixel neighborhood was used to calculate Local Moran's I. Moran's I is a measure of spatial autocorrelation resulting in a convenient index indicating either positive or negative spatial autocorrelation. Measures approaching the value of 1 indicate nearby values are similar, therefore, values approaching -1 indicate dissimilarity. The mean value of local Moran's I was calculated within a 1 km circle radius at each site.

Results and Discussion

Approximately 3,100 one-minute audio recordings were analyzed for songbird species. The most common species identified were the Ring-necked Pheasant, Red-winged Blackbird, American Robin, Dickcissel, and the Western Meadowlark. In total, 51 species were identified. On the ISRFs, there were 34 species identified.

The mean Local Moran's I value for each site indicated a high degree of spatial autocorrelation of NDVI values. All values were above 0.7 indicating largely homogenous landscapes when considering the landscape at the 1-km scale. A weak, negative statistical relationship was observed between the mean Local Moran's I of NDVI value and songbird richness. Using songbird richness as the response variable in a generalized linear model shows the predictor is significant at the 1 percent level and has an adjusted R square value of 0.13. These results are expected as all bioacoustic recording locations were on farms managed for high yields. The mean Local Moran's I of NDVI values could have higher predictive power with a better adapted vegetation index for agricultural landscapes. There are a variety of vegetation indices proposed for use in agricultural landscapes that were not tested. The differentiation between variability in both crop and non-crop vegetation also could produce different results. Although there is a strong degree of similar management approaches to row-crop agriculture, there may be more variability in farmer's approaches to management of non-crop vegetation and thus stronger biodiversity responses, especially with birds.

In Figure 1, the number of songbirds identified at each site (including four of the ISRFs) is shown in Plot A. Plot B shows the relationship between number of songbirds by the degree of landscape heterogeneity.

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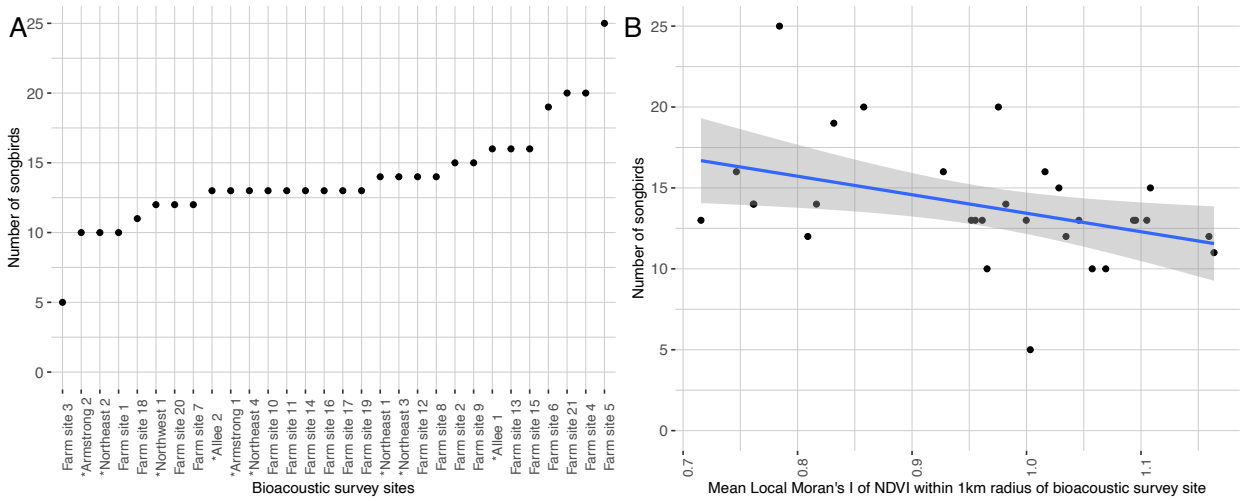

Figure 1. The number of songbirds identified at each site are presented in plot A. Private property sites are simply listed as "Farm site 1", and so on, to avoid using the name of the land owner. Iowa State University Research and Demonstration Farms have an asterisk placed in front of the name. In plot B, the mean Local Moran's I of NDVI was used to measure the degree of landscape heterogeneity and regressed against songbird richness at each site. The weak statistical relationship (significant at the 1% level) indicates local variation in the landscapes as measured has an effect on the number of songbirds identified through bioacoustic survey. Refinement of the landscape characterization may be needed to detect a stronger signal.