# Method Development for Testing Relationships Between Bioacoustics and Agricultural Landscape Pattern

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## Introduction

A correlation between soundscapes and landscapes has been proposed, but there are few studies that have attempted to test this, especially in agricultural systems. The use of passive acoustic monitoring has the potential to scale up biodiversity monitoring across landscapes and potentially derive the necessary information to confirm patterns and processes driven by vegetation dynamics. In order to accomplish this task efficiently, rich data available through acoustic monitoring can be abstracted to a meaningful index and then used to select recordings most likely to contain songs and calls of farmland birds.

Characterizing vegetation in agricultural landscapes as habitat for wildlife has been a key area of investigation for many decades. Non-crop vegetation on farmland is a key landscape element of interest because it can represent a minor proportion of the landscape not directly managed for crop production. Here, bioacoustic energy is evaluated using an index value, and is compared with the Iowa farmland mosaic, including crops and non-crop vegetation, and other landscape characteristics. The Iowa State University Research and Demonstration Farms are used as bioacoustic monitoring sample sites, and landscape vegetation characteristics are analyzed using high resolution, satellite remote sensing analysis.

## Materials and Methods

Sample sites were located at four ISU Research and Demonstration Farms and at a grassland preserve site operated by The Nature Conservancy. Twelve bioacoustic monitors were installed at the sites with variation in non-crop vegetation characteristics, ranging from narrow, linear field margins to sites adjacent to a Conservation Reserve Program (CRP) set-aside field. The bioacoustic monitors were programed to record for one minute, every 10 minutes, 24 hours/day, ranging from one to two weeks in July and August 2018. A bioacoustic index was calculated for each one-minute sample to derive the total area under the time-frequency curve on the spectrogram within each frequency band from 2,000 to 8,000 Hz. Biological sounds are often within this frequency range. Samples were ranked based on the bioacoustic index score, and then listened to while inspecting the spectrogram. Unique sounds were extracted and placed into a final list. These were evaluated individually for bird species identification.

Non-crop vegetation characteristics were analyzed using a time-series of PlanetScope satellite imagery over the course of the growing season. PlanetScope imagery has four spectral bands (blue, green, red, near infrared), is three-meter spatial resolution, and revisits each site every five days. Each location contained at least four, but usually six repeat images with zero cloud cover between June and September of 2018. The images were downloaded as a surface reflectance product, were mosaicked, and then combined as a full band stack with each imagery date. This resulted in stacked images with up to 24 separate bands. Vegetation training sites were developed using a combination of ground truth sample points collected during the summer of 2018, USDA NAIP 2017 imagery, and Google's imagery web service. A support vector machine classification was used to classify each site into eight land cover classes (monotypic grass, mixed grass, bare soil, corn, soybean, infrastructure, wooded, water). Non-crop land cover was aggregated and then characterized within a one km radius for the proportion of each type within the total area along with total crop area, and by landscape heterogeneity, measured as Shannon's Diversity Index.

## Results and Discussion

To date, avian species richness has been analyzed using the computer assisted sampling approach with a bioacoustic index to identify the sound samples with the most accumulated biological sound energy. From these, species were identified by calls and songs. The total proportion of crop and non-crop vegetation, and the Shannon's Diversity Index (SHDI) within a one km radius from the sample site, was calculated using the land cover classification data (Table 1). Shannon's Diversity with a higher score indicates a higher proportion of different land cover types than sites with lower scores. An analysis of variance indicated land cover patterns at each site are statistically different from one another. Further analysis will investigate the impact of scale using hierarchical models to nest the size of the landscape unit of analysis from 100 m to 3 km. This current research was intended to prototype for a larger sampling operation during the summer of 2019, where the number of sampled landscapes will be increased. More sample sites should increase the statistical significance of results and provide an indication of the feasibility of using bioacoustic monitoring to predict differences in land cover patterns in agricultural landscapes.

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**Table 1. A comparison of land cover pattern and avian species richness at Iowa sample sites.[1]**

| Site[2] | Non-crop[3] (%) | Crop[4] (%) | SHDI[5] | Avian species richness[6] |
|---|---|---|---|---|
| Broken Kettle Grassland | 0.76 | 0.23 | 1.52 | 10 |
| McNay | 0.58 | 0.39 | 1.47 | 8 |
| Armstrong 2 | 0.33 | 0.63 | 1.53 | 6 |
| Armstrong 3 | 0.32 | 0.64 | 1.51 | 4 |
| Armstrong 1 | 0.32 | 0.65 | 1.49 | 6 |
| Allee 4 | 0.20 | 0.77 | 1.29 | 3 |
| Allee 1 | 0.16 | 0.80 | 1.26 | 7 |
| Allee 3 | 0.15 | 0.81 | 1.24 | 1 |
| Allee 2 | 0.15 | 0.82 | 1.21 | 4 |
| Northeast 1 | 0.11 | 0.87 | 0.64 | 12 |
| Northeast 2 | 0.09 | 0.89 | 1.46 | 8 |

[1]Observations are sorted by proportion of non-crop vegetation in a 1 km radius from sample site.
[2]McNay = ISU McNay Research Farm, Chariton, IA; Armstrong = ISU Armstrong Research Farm, Lewis, IA; Allee = ISU Allee Research Farm, Newell, IA; Northeast = ISU Northeast Research Farm, Nashua, IA.
[3]Non-crop refers to all non-crop vegetation and includes fields, margins, and vegetation around infrustructure.
[4]Crop vegetation includes all row-crop agriculture, which is mostly corn and soybean.
[5]Shannon's Diversity Index (SHDI) indicates a level of proportional difference in land cover patterns with higher values indicating more variation in land cover pattern.
[6]Avian species richness includes all bird species detections using a bioacoustic monitoring approach.