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Uncommon/Rare Avian Species Decline and Extirpation in Nested Assemblages of Northeastern Illinois Wetlands

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UNCOMMON/RARE AVIAN SPECIES DECLINE AND EXTIRPATION IN NESTED ASSEMBLAGES OF NORTHEASTERN ILLINOIS WETLANDS

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Introduction

Environmental changes can drive avian communities to nestedness, potentially at the cost of some species extirpation. Nestedness is a measure of order, or organization in a system, where the ratio of less to more species is the same regardless of the area.[1] An example follows of an originally undisturbed prairie ecosystem with high avian species richness. Due to human development, sections of the large prairies are dissected or fragmented, leading to an edge effect on the area. Consequently, these smaller areas of prairie have lower species richness. The more disconnected the smaller areas are from the large prairies, the lower the species richness will be. This pattern of species composition is nestedness in a grassland community of birds. Only the most abundant species would be found in the furthest units. The rarest of birds would be found in the large prairie, and would be the first to disappear as the smaller units grew smaller and further away in distance from the large prairie.

Research has shown that habitat fragmentation will result in a loss of species richness, resulting in nestedness. The species-area relationship in a fragmented natural habitat compared to that of an unfragmented habitat shows a quick loss in avian species.[2]

One study tests for nestedness among 27 assemblages. The study revealed that among the 27 assemblages observed, the more strongly nested assemblages were driven and dominated by extinction. Extinction is something conservationists strive to operate against.[3]

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[1] David Wright, "On the Meaning and Measurement of Nestedness of Species Assemblages," *Oecologia* 92, (1992): 416.

[2] Douglas Bolger, Allison Alberts, Michael Soulet, "Occurrence Patterns of Bird Species in Habitat Fragments: Sampling, Extinction, and Nested Species Subsets," *American Society of Naturalists* 137, no. 2 (1991): 155-156, accessed November 14, 2011, http://www.jstor.org/stable/2462110.

[3] Wright, "On the Meaning and Measurement," 425-427.

Nested patterns offer valuable information for biological conservation. Human developments and expansion result in a highly fragmented landscape. This is true for northeastern Illinois and can be clearly seen on aerial photos. Nested patterns result in loss the rarest of species first, based on size and distance from reference areas. However, even when large preserves are near and provide suitable habitat, extinction rates in the fragments will be greater than the colonization rates into the smaller fragments. This results in faunal relaxation.[4]

Baisa found that avian assemblages are highly nested in palustrine emergent wetlands in northeastern Illinois. He measured nestedness by constructing a binary matrix of species presence and absence across sites. Nestedness was also quantified using the Mann-Whitney U-test in his study.[5]

Species richness can be altered, and species abundances can change in changing habitats over time. For example, species present in the Chicago region are more than likely different now than during the Pleistocene. The environment dictated the habitat suitable or not suitable for a given species. Or, a wetland with fluctuating water levels can alter avian community composition.[6]

Changes in resource availability can alter species abundance in a community. This simple concept can be exhibited in a number of ways. For example, a dramatic increase in acorn production in a deciduous forest will greatly increase rodent numbers the following growing

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[4] Bruce Patterson, "The Principle of Nested Subsets and Its Implications for Biological Conservation," *Conservation Biology*, 1, no. 4 (1987): 331-332, accessed November 14, 2001, http://www.jstor.org/stable/2386017.

[5] Richard Baisa, "Nested Subset Patterns and Avian Distribution in Emergent Wetlands," Master's Thesis, Governors State University, 2001.

[6] Henry Murkin, Elaine Murkin, John Ball, "Avian Habitat Selection and Prairie Wetland Dynamics: A 10-Year Experiment," *Ecological Applications*, 7, no. 4 (1997): 1145, accessed May 13, 2011, http://www.jstor.org/stable/2641203.

season. The increase in rodents takes a toll on some songbird species in the form of nest predation. On the other hand, during seasons of low rodent numbers, accipiters may target more songbirds that year due to the low abundance of rodents.[7] The avian populations are affected by predatory forces dictated by availability of resources.

Another factor that can affect species richness in a system is climate change. This variable brings us into the concept of macroecology, and understanding that much of the research that is available to us, is limited by small temporal scales. In other words, we have limited data from a limited period in time. The recognition of the fact, coupled with larger-scale data interpretation, will allow us to better understand and predict species responses to a variety of variable over time.[8]

Grassland fragmentation by means of shrub encroachment is another example of a force that could manipulate avian community structure. As shrub encroachment increases in a grassland, so do the avian species that are successful shrub/woodland species and open-habitat generalists, while grassland species decline in abundance.[9]

Greenhouse gases can be another factor contributing to changing environments and hence to the biotic communities that are a part of a given region. Specifically with avian populations, changes in greenhouse gases can be a challenge for successful reproduction. Four factors that

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[7] Kenneth Schmidt, Richard Ostfeld, "Songbird Populations in Fluctuating Environments: Predator Responses to Pulsed Resources," *Ecology,* 84, no. 2 (2003): 406-407, accessed May 13, 2011, http://www.jstor.org/stable/3107896.

[8] Jonathan Fisher, Kenneth Frank, William Leggett, "Dynamic Macroecology on Ecological Time-Scales," *Global Ecology and Biogeography,* 19, (2010): 14-15.

[9] Bryan Coppedge, David Engle, Ronald Masters, Mark Gregory, "Avian Response to Landscape Change in Fragmented Southern Great Plains Grasslands," *Ecological Applications*, 11, no. 1 (2001): 57, accessed May 13, 2011, http://www.jstor.org/stable/3061054.

are most important for successful reproduction in these populations are availability of food, suitability of the habitat, predation/parasitism, and the ability to fend off disease. These important factors can be affected in a potentially negative way due to the changes in greenhouse gases. Greenhouse gases can trigger warmer environments, which may alter time of flowering in plants, or change timing of insect emergence.[10] That said, avian populations could be indirectly affected by the increase in the greenhouse gases.

Habitat restoration efforts can also influence avian diversity and richness in an area. Bird surveys were conducted from 1999 – 2001 in the Eagle Lake Wetland Complex in Iowa. Surveys took place in grasslands and wetlands that had undergone habitat restoration practices. Results of the study show that of 54 species observed, 20 species showed changes in abundance. Sixteen species showed an increase in numbers, and four species showed a decrease in numbers.[11] These results can be used to aid land managers in decisions regarding habitat enhancement/restoration for a given species.

Transformation of land for agricultural use alters avian communities. Even the type of farming can have differing results on changes in the community. A study done in Saskatchewan looked at avian species richness and abundance in wetlands found amongst land designated for agricultural use. The four treatments were conventional farms, conservation farms with minimal tillage, organic farms, and farms that had undergone some restoration back to its original form.

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[10] Diane Larson, "Potential Effects of Anthropogenic Greenhouse Gases on Avian Habitats and Populations in the Northern Great Plains," *American Midland Naturalist*, 131, no. 2 (1994): 330, accessed May 13, 2011, http://www.jstor.org/stable/2426259.

[11] Robert Fletcher Jr, Rolf Koford, "Changes in Breeding Bird Populations with Habitat Restoration in Northern Iowa," *American Midland Naturalist*, 150, no. 1 (2003): 87-90, accessed July 18, 2011, http://www.jstor.org/stable/3566595.

The author found that of 79 species, 6 were more abundant on organic farms and restored farms.[12]

Anthropogenic influence (usually in the form of a disturbance) can accelerate changes in the environment. In one study, avian population numbers from the North American Breeding Bird Survey were examined over a 35 year period in the contiguous United States and southern Canada. Results showed that abundances in common species reached an equilibrium associated with patterns of colonization and extirpation. Changes in the avian community structure were correlated with the changes leading to the equilibrium. Nine species in this study were responsible for the community changes by becoming the dominant colonizers of habitats that changed due to human influence. These nine species (only one of which can be labeled exotic/invasive) benefited from human presence by exploiting four factors. One factor is introduction/invasion, where a species is introduced to an environment and grows in numbers to a certain abundance and possibly invades neighboring habitat. Using human-influenced habitat is another factor, meaning the species is a human commensalist, or a habitat generalist. Another factor is management activities, where the results of these activities positively influence target species being managed, if the species is considered common. The final factor is the ability of avian species to use abandoned agricultural fields undergoing forest regeneration as suitable habitat. The author concluded that these four factors together were responsible for recent changes in avian community structure, and were driven by human impact.[13] Perhaps

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[12] Dave Shutler, Adele Mullie, Robert Clark, "Bird Communities of Prairie Uplands and Wetlands in Relation to Farming Practices in Saskatchewan," *Conservation Biology*, 14, no. 5 (2000): 1445, accessed July 18, 2001, http://www.jstor.org/stable/2641797.

[13] Frank LaSorte, William Boecklen, "Temporal Turnover of Common Species in Avian Assemblages in North America," *Journal of Biogeography*, 32 (2005): 1156-1159.

anthropogenic influence on an environment drives avian species richness to nestedness in a community.

Presence/absence data is useful (as was used in the Nestedness Temperature Calculator)[14], but species abundance data provides more understanding. Species abundances can be time consuming to apprehend, and therefore, shortcuts to estimate species abundances have been used. Species abundances were estimated from presence-absence point-count data, along with occupancy models to give reasonable results pertaining to the area and associated abundances, in a study done by Royle.[15] Even the hollow-curved, graphical result we typically find when plotting species abundances is under scrutiny and does not tell the entire story. Models are being looked at to better explain the abundances of species based on known factors, such as environmental gradients.[16]

The abundance spectrum is an approach that will allow species-specific changes in a system to be observed. Species in this approach are ranked in a fixed system. This allows for consistency in viewing the results of varying wetlands for a species. For example, in the rank-abundance approach, the most abundant species is not always the same species; therefore, the rank-abundance approach is incomplete in its representation of changes in species numbers (Mac Nally 2007).[17] The abundance spectrum fixes that issue, and we can identify changes to a specific species. An abundance spectrum will be created by ordering species in each wetland

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[14] . The Nestedness Temperature Calculator, AICS Research Inc., University Park, NM and The Field Museum, Chicago, IL.

[15] J. Andrew Royle, James Nichols, "Estimating Abundance from Repeated Presence-Absence Data or Point Counts," *Ecology*, 84, no. 3 (2003): 777-778, accessed November 14, 2011, http://www.jstor.org/stable/3107871.

[16] B.J. McGill, "Species Abundance Distributions: Moving Beyond Single Prediction Theories to Integration within an Ecological Framework," *Ecology Letters,* 10, no.10 (2007): 995-1015.

[17] Ralph MacNally, "Use of the Abundance Spectrum and Relative-Abundance Distributions to Analyze Assemblage Change in Massively Altered Landscapes," *The American Naturalist*, 170, no. 3 (2007): 319, accessed July 17, 2013, http://www.jstor.org/stable/10.1086/519859.

from most abundant to least abundant, then plotting them against abundance rank, with the most abundant species having a rank of 1. The ranking of species abundances are derived from existing habitats with as few disturbances as possible. The most pristine wetlands, in this study, will be used to simulate pre-disturbance species abundances, and will be used to assign abundance ranks to species. When comparing abundances to measure effects of fragmentation, we want to compare the observed numbers to those numbers measured during pre-fragmentation. Unfortunately, we don't usually have abundance numbers from pre-European settlement in our region.[18]

The measure of change in species abundance from a pristine habitat to a habitat fragmented and disturbed by anthropogenic effects is referred to as incoherence. So, the abundance spectrum will measure incoherence. In Mac Nally's study, remnants of decreasing size were high in incoherence. However, the results were surprising. In the most pristine (or reference) areas, a species of bird (*Lichenostomus penicillatus)* was the 57th most abundant bird in the community. That same species was one of the top four abundant species in all of the remnant areas of the study. This suggests the community is not nested. One explanation could be that although *L. penicillatus* may be less abundant in a pristine environment than other species, perhaps it responds better to anthropogenic disturbance than the other species. If the community were nested, we would expect to see the rarest birds in the pristine environment disappear first, as disturbances increased in fragmented habitats.[19]

The goal of this project was to sample the wetlands as Baisa had done in his study. By doing so, we will have 2 sampling events, approximately 10 years apart. Nestedness of the

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[18] MacNally, "Use of the Abundance Spectrum," 320-321.
[19] Ibid., 323-326.

wetland communities will be checked, and data compared to that of Baisa. Emergent wetlands in northeastern Illinois were found by Baisa to contain highly nested avian assemblages. [20]

Methods

Study site – The study site includes 39 wetlands that are located within the Palos Forest Preserve system in Cook County, IL (41° N between 87° and 88° W). This approximately 11,000 ha system has over 200 wetlands. The 39 wetlands surveyed were emergent wetlands whose vegetation types were mostly graminoids and cattail (*Typhalatifolia*). The upland plant communities of these wetlands consisted of oak woods (*Quercus* spp.) The National Wetland Inventory, ground truthing, and digital ortho quads were used to locate these wetlands in 2001. To locate the wetlands in this study, I used wetland data from Baisa's 2001 project, and matched up wetland size and type on the U.S. Fish and Wildlife Service's National Wetlands Inventory website (http://www.fws.gov/wetlands). Recreational activities such as fishing, mountain biking, and hiking occur in this large, suburban surrounded preserve.

Sampling - During June/July of 2012, I sampled 39 wetlands between sunrise and 1000 h. I did not sample when precipitation was more than a light drizzle. I used the point count method to sample the wetlands. To determine the number of points per wetland, the wetland perimeter was measured. Point counts occurred at site arrival, and at 100 m intervals around the perimeter. In instances where the wetland perimeter was less than 200 m, two point counts occurred at opposite ends of the wetland, as well as a point count for the site arrival. Upon reaching a point, I waited one minute before surveying an additional three minutes. At each point, I counted birds by vision or call. I also played a recording of calls at each point from the King Rail (*Rallus*

[20] Baisa, "Nested Subset Patterns," 7-9.

elegans), Virginia Rail (*Rallus limicola*), and Sora (*Porzana carolina*), to try to get a call back, as these species are not seen as often, but can provide call backs.

Data Analysis – A binary matrix was created to quantify nestedness, where one indicates species presence, and zero indicates species absence. A Monte Carlo simulation was used to check the probability that a system may be randomly reproduced. The system temperature was checked by utilizing the Nestedness Temperature Calculator. This provided information on how far the sample deviated from nestedness. The temperature ranges from 0° to 100°, where 0° is cool and the most nested the sample can be. Further, as the temperature increases, the less nested the sample becomes.[21]

Species abundances were then standardized and ordered based on relative abundances. This provided information, or incoherence, on comparing the abundances amongst spectra. Incoherence is the distance from a set of data to its reference data.[22]

Results

I obtained a *p*-value of 1.6×10^{-20}, by using presence-absence data in the Nestedness Temperature Calculator (1995). Based on the findings, the null hypothesis will be rejected; H_0 = data is not nested. I will accept the alternative hypothesis, where H_1= data is nested.

The 39 wetlands sampled had a total of 32 different species. To compare, Baisa (Baisa, R. 2001) had 44 wetlands with 45 different species. In the control (wetland #59), the Red-winged Blackbird (*Agelaius phoeniceus*) was the most abundant, as was the case in 11 of the 39

[21]W. Atmar,B.D.Patterson, "The Measure of Order and Disorder in the Distribution of Species in Fragmented Habitat," *Oecologia*, 96, (1993): 373-382.

[22] MacNally, "Use of the Abundance Specturm," 323.

wetlands. However, in 14 of 39 wetlands, the American Robin (*Turdus migratorius*) was the most abundant (Figure 1).

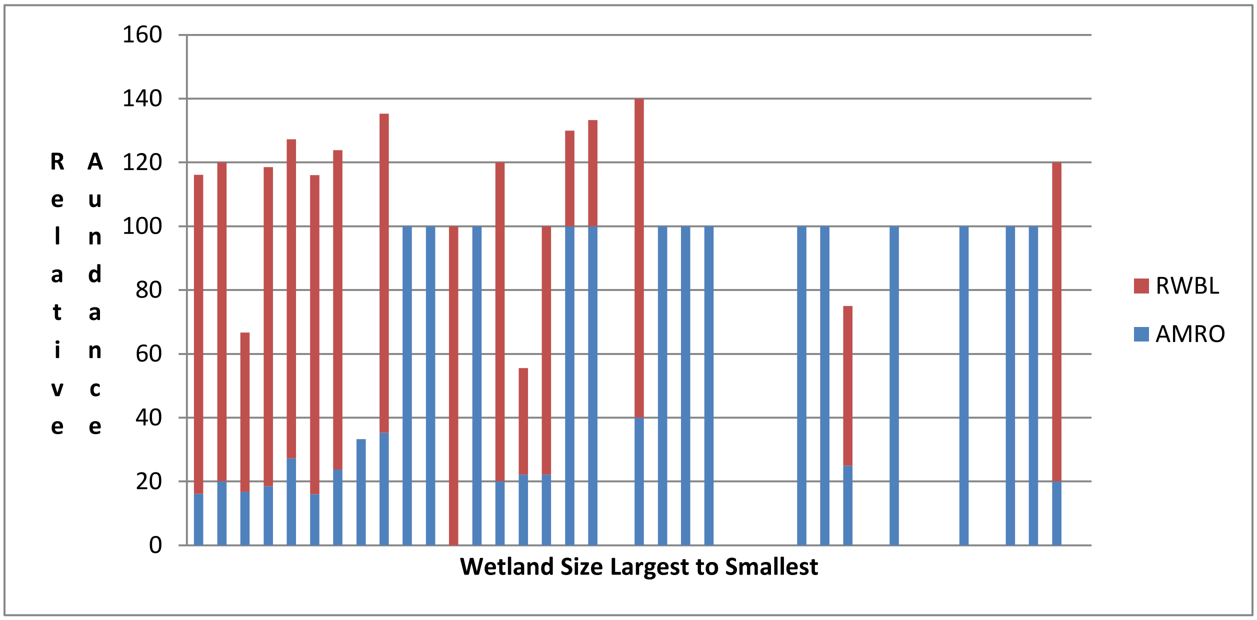

Figure 1. Relative abundances shown with decreasing wetland size. Trend can be seen where AMRO replaces RWBL as dominant species. Observed outlier in small wetland.

This change in dominant species is not expected in a nested system. However, the overall data does suggest a nested system.

Using the Nestedness Temperature Calculator, the temperature of the system is 12.85 degrees, indicating a nested system. The temperatures in the calculator range from 0 to 100 degrees, where the lower the temperature, the more nested the sample. Probability was given from the Nestedness Temperature Calculator by way of a Monte Carlo simulation, to show that the data was randomly generated, resulting with p=1.6 x 10^{-20}.

Figure 2 shows species relative abundances for the reference wetland and an obvious outlier (wetland #191), which is very similar to the control, yet much smaller. In fact, it is the second smallest wetland sampled (Figure 2).

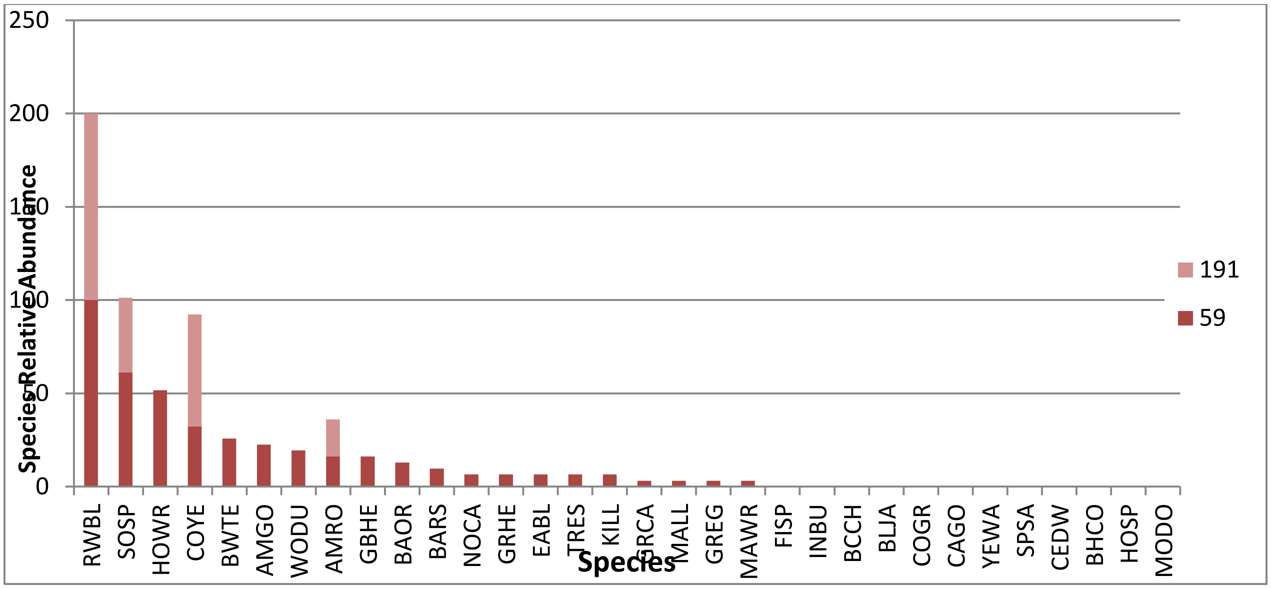

Figure 2. Relative abundances shown for control wetland (59) and similar small wetland (191).

Only 4 species were found at #191, and they were 4 of the more abundant species at the control wetland #59.

Incoherence, or the distance for a data set relative to its reference data, is graphed and shown below (Figure 3).

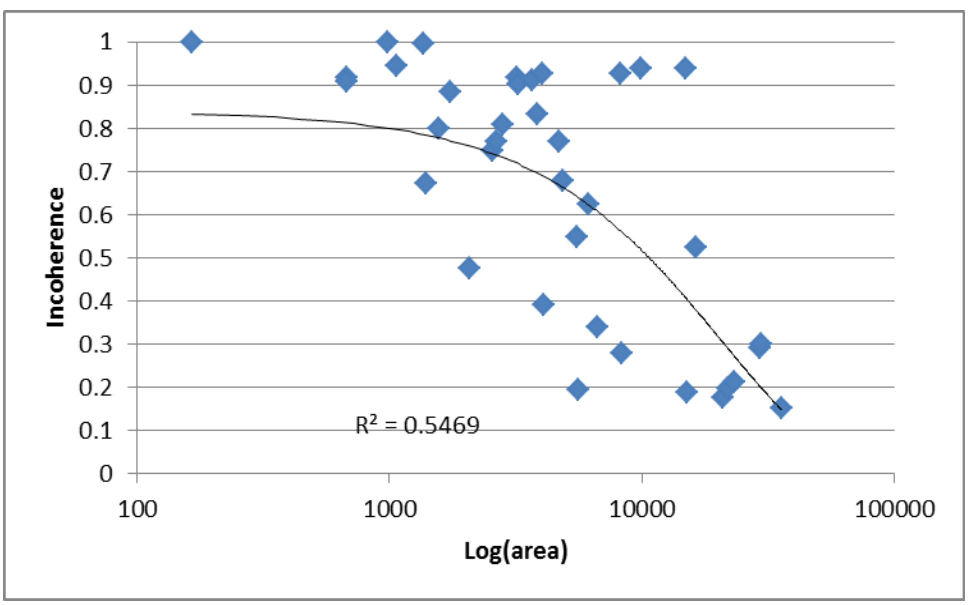

Figure 3. Incoherence values decrease as log(area) is increased.

Discussion

Avian assemblages of northeastern Illinois' wetlands are significantly nested, as indicated by the *p*-value of 1.6 x 10^{-20}. This value was obtained from the Nestedness Calculator, and is a Monte Carlo derived probability, showing that the matrix was not random.

Temperature (T) of the system in this study is 12.85, and was derived from the Nestedness Calculator. Baisa calculated Temperature for four different matrices of differing hierarchal breeding statuses. For the matrices, he used four possible bird breeding states including confirmed breeding, probable breeding, possible breeding, and observed species. Matrix one included all four states. Matrix two contained possible, probable, and confirmed. Matrix three included probable and confirmed, and matrix four had confirmed state only. Baisa's results show a range of temperatures among the matrices, where T=4.9 – 10.5, and has an average of T=9 for wetlands with birds of all different breeding statuses. The slight increase in T could indicate the system moving away from a nested system, but more likely just a function of the given season/time of the data sampling. To support the latter, I found that one of the smallest wetlands (#191) resembles that of the reference wetland by sharing its most abundant species. This could alter the system temperature by a slight increase, but could also suggest something unique about this wetland (favorable vegetation, lack of competition).[23]

When looking at species relative abundance vs. wetland size, we see a change in the most dominant species recorded. Red-winged Blackbirds (*Agelaius phoeniceus*) dominate wetlands of larger sizes, where the American Robin (*Turdus migratorius*) is the most abundant in the smaller

[23] Baisa, "Nested Subset Patterns," 7-9.

wetlands recorded. This change is observed around the wetland area size of 4500 m^2. One explanation as to why, could be that as the wetland area decreases, the likelihood of avian species that are not normally associated with wetland habitat, to become the most frequently observed species in the wetland increases (Figure 1). In the study done by Baisa, the Red-winged Blackbird (*Agelaius phoeniceus*) is the most abundant species, however, the American Robin (*Turdus migratorius*) is seldom recorded.[24] Perhaps a decade of hydrological changes and/or shrub encroachment of wetland areas have led to the increase of non-traditional wetland species. In addition, the sampling year of 2012 was a dry year in regards to precipitation. June through August of 2012 received only 6.6 inches of rain, where 12 inches is average. The spring months also had below normal precipitation values.[25] The low precipitation values also led to reduced water levels in the field. Dry cattail marshes were likely one reason I did not receive call backs from the species where calls were played.

When looking at incoherence values, we see a trend of reduced values as we move further from the reference data. The further from the reference data, the greater the incoherence, as size decreases and distance increases. This would suggest a nested system.

To conclude, nested systems are neither favorable nor non-favorable. Rather, a system that is found to be nested can drive management operations and decisions for preservation of specific habitat types, sizes, and species. Further, it is imperative that larger sized units are maintained and preserved in a nested system, due to the fact that the larger the area is, the more

[24] Baisa, “Nested Subset Patterns,” 9-12.
[25] National Weather Service, accessed August 1, 2016 http://forecast.weather.gov/product.php?site=LOT&product=RTP&issuedby=LOT.

species are likely to be present. This is the case for the Palos Morainal wetland system based on this study, as well as the study done by Baisa.

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