What variables affect bird communities in restored wetlands in Western Montana?

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University of Notre Dame BIOS 35503-Practicum in Field Biology
UNDERC West 2011
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ABSTRACT: In the past two decades, thousands of hectares of wetlands have been restored to land in the United States. Recent work has shown that flora and fauna, including bird communities, return to "natural" levels after a few years. Various studies have also correlated wetland bird diversity and abundance to certain environmental factors. This study examined 29 wetlands composing four wetland complexes in western Montana. I tested what environmental variables (dissolved oxygen, pH, depth, temperature, nitrogen, vegetation, area, wind speed) had significant correlations with the most commonly seen bird species (yellow-headed blackbird, red-winged blackbird, common yellowthroat, American coot, mallard, vesper sparrow, killdeer, marsh wren). Vegetation and depth were the most commonly correlated variables for these species, each having 22 and 5 occurrences respectively. A cluster analysis followed by a discriminate function analysis yielded significant interactions between several prominent bird communities. My results indicate a complex wetland ecosystem that needs to be well understood in order to implement the most ecologically sound strategy for restoring Montana wetlands.

INTRODUCTION: In the past two decades, thousands of hectares of wetlands have been restored to land in the United States (Dahl 1990). In Montana, an overall goal of "no net loss of wetlands" was established to restore the approximate third of its wetland base that was lost due to inappropriate farming techniques, filling, and draining. The Montana Department of Environmental Quality in conjunction with the Montana Wetland Council is achieving this goal of "no net loss" by restoring wetland areas, providing funding for wetland research, and raising awareness. One of the overarching goals of this initiative is to provide and protect habitat for wetland wildlife.

Birds are extremely reliant on local vegetation for many aspects of their ecology, especially for food and nesting. Rather than discriminate between species, many birds' association with wetland vegetation is based upon structure or cover, e.g. the yellow-headed blackbird and bulrush (VanRees-Siewert and Dinsmore 1996). Wetland vegetation, being such a crucial element to bird success, must be given particular care, both in planning and development, when restoring a wetland. In most restored wetlands, birds have been shown to recolonize within a few years of completion (Brown and Smith 1998). This recolonization is also correlated with a prior resurgence of the wetland vegetation, with both communities returning to "unaltered status" after some time (VanRees-Siewert and Dinsmore 1996).

Many features other than vegetation have been linked to bird diversity and abundance. For example, Colwell and Taft (2000) found that birds correlated significantly with the depth of the wetland being studied. In a 1996 study, Schafer considered many landscape level effects such as vegetation, water depth, pH, and temperature when considering wetland bird nesting success. In addition, wetland area has been shown to have significant effects on wetland bird communities (Naugle et al., 1999). These landscape level effects have rarely been studied in restored wetlands, and could have implications for future wetland bird communities.

The objectives of this paper are to evaluate wetland bird species diversity and overall wetland bird abundance, and relate them to observed local environmental characteristics in order to gain a better understanding of how birds are utilizing and adapting to the restored wetlands of Montana.

MATERIALS AND METHODS:

Study Sites

This experiment examined what attributes of a wetland could significantly affect bird diversity and abundance. The study sites were restored wetlands that formed wetland complexes in wildlife management areas including the Ninepipes Wildlife Refuge, Herak, Sandsmark, and Piedalue Waterfowl Protection Areas. The four complexes ranged from 3 acres to 2,062 acres in total area and contained anywhere from 1 to 12 (mean: 7.5) wetlands.

Bird Surveys

A random number of wetlands in a complex were surveyed once to determine the number of individuals of each species present. Surveys were conducted between 20 and 29 July, between the approximate hours of 0530 and 0900. Surveys were not taken in the rain. A standard operating procedure for each site was established to ensure completeness and homogeneity in data collection. Before entering the wetland, the date, time, site, wind speed, and air temperature were collected. A timer was then started and a ten-minute point count began. Next, after entering the wetland, birds visible on the water's face were recorded from a vantage point such as a ridge or overlook. For those birds (such as mallards) that exhibit sexual dimorphism or have clearly distinct male and female calls, sex was noted as well as age (fledgling/juvenile). Calling birds were noted, with males being counted as two as they were assumed to have a mate in the area. Finally, flyovers were counted as any bird that flew over the wetland within the ten minutes of the count.

Vegetation Surveys

The percent cover of the surrounding vegetation was estimated visually, with plants covering >5% included in the count. Plants were separated by commonly occurring wetland species (bullrush, cattail, etc.) and grasses.

Water Samples

Water samples were taken at five points along the edge of the wetland and at the middle. At the same time, Dissolved Oxygen and temperature (via an HIS DO meter), pH, and depth were taken at each point. The samples were brought back to the lab and assessed for nitrogen content. Since nitrogen was not assessed on the same day as it was collected, samples were placed in a refrigerator so the nitrogen would not degrade until the measurements were taken.

Statistical Analysis

Firstly, a perimeter-to-area ratio was calculated from the transect length and total area of the wetland. Then, birds were ranked based on total number of times seen, and a cutoff for running statistical analyses was established (over 8 individuals). For instance, the most commonly seen bird, the yellow-headed blackbird, was included for statistical analysis because a total of 176 individuals were seen at over half the sites and was included. The ruddy duck, however, was only seen at one site for a total of two individuals and was cut out of the statistical testing. Next, nine multiple backwards stepwise regressions each analyzed independent environmental variables (DO, depth, temperature, pH, area, perimeter, nitrogen, and percent cover) against different dependent variables (total species and the most commonly seen bird species). A Principle Components Analysis was run on both the environmental data (DO etc.) and the bird species data to establish similarities. A hierarchal cluster analysis then grouped both the bird and environmental data into the most similar clusters. This cluster analysis was tested numerous times in order to achieve the “best” clustering. After the cluster analysis was completed, a discriminate analysis determined which variables were most important to wetland bird communities.

RESULTS: The initial backward stepwise regressions between the environmental variables at each site and the individual bird species yielded and average of 4.1 factors per dependent variable (see Table 1, Graph 1). Mallard ducks (R-squared= .719) had the most correlations with the environmental data with 9, being significantly positively correlated with deep depth (*p=.004*) and strongly negatively correlated with average nitrogen (*p=.003*), air temperature (*p=.005*), and sedge cover (*p=.007*). Red-winged black birds had the least amount of correlations, being only significantly positively correlated with area (*p=.005*). Yellow headed blackbirds were the most sighted species (175 sightings) and the common yellowthroat was the least seen bird (8sightings) (Graph 2). The first Principle Components Analysis produced six different groupings, each with unique site-level environmental characteristics (Table 2). The second PCA yielded four groupings, each with unique bird species similarities (Table 3). In this analysis, it was discovered that the american coot, the killdeer, and the marsh wren were negatively associated with their PCA groupings. Therefore, when a cluster analysis was run to group the bird species data by site based upon the results of the PCA, different clusters were obtained than when the negatively associated birds were excluded. For example, the initial clustering yielded three clusters, while the final clustering yielded six. Thus, highly insignificant results were obtained for the Discriminate Function Analysis when the initial clusters (three) were used: Wilks's Lambda (F= .938, df=70, 50, *p=.602*), Pillai's Trace (F= .915, df=70, 70, *p=.644*), and Lawley-Hotelling Trace (F= .922, df=70, 42, *p=.624*). When the clusters from the final cluster analysis (without the negatively correlated species, Cluster 1) were used for the Discriminate Function Analysis, the results were much closer to statistical significance: Wilks's Lambda (F= .150, df=30, 74, *p=.082*), Pillai's Trace (F= 1.401, df=30, 110, *p=.095*), and Lawley-Hotelling Trace (F= .2.782, df=3, 82, *p=.071*).

DISCUSSION: My first hypothesis, that depth and vegetation would have correlations with the most bird species, is supported by the data that I compiled. When the backwards stepwise regression results were analyzed, vegetation had, by far, the most species correlations. This makes sense because as Van Rees-Siewert and Dinsmore (1996) had found, vegetation is one of the most important factors for bird ecology. This correlation also makes sense in terms of my data. Yellow-headed blackbirds were the most sighted bird in my study at 175 sighting and in her study of this species Schafer (1996) reported that they are highly associated with sturdy wetland plants. My second hypothesis, that the environment would not be the only factor that came into play when grouping sites, was also supported. This was discovered after a great deal of statistical analysis. Firstly, a principal components analysis was run on the bird species data coming up with four groupings. Of these four groupings, three had negatively associated bird species. After this PCA, I ran the first cluster analysis in order to group my 29 sites based on the results obtained from the bird species PCA. A discriminate function analysis then tested the significance of these groupings and found them to be highly insignificant ($p>0.60$). This meant that there were other interactions affecting these groupings besides the environment. These interactions were found to be the negatively associated bird species. When the cluster analysis/discriminate function analysis combination was run again without these species, the results were much closer to statistical significance ($p>0.01$).

Biologically, these interactions make sense and the first conclusion I can come to deals with competition. Species that are negatively associated with each other on such local scales are usually competing with each other for resources. Unfortunately, I cannot, with the data I have, determine what those resources are. However, looking into the species involved may provide an insight into this question. Of the three groupings that have an interacting pair, only one makes biological sense. The grouping of the American coot and the marsh wren had such a correlation, I believe, due to competition for habitat. Both utilize the same areas of wetlands for breeding and for nesting, and competition is likely. The other interactions involve seemingly unrelated species, and I would need more data in order to analyze them accurately.

The results of my multiple backwards-stepwise regressions also yielded some interesting results. Firstly, it showed that my most common species (the yellow-headed blackbird) was significantly correlated to bulrush, cattail, and foxtail. This finding is well supported in the literature. However, in her study of yellow-headed blackbirds Schafer (1996) asserted that red-winged blackbirds occupy the same habitats and the two species are closely related. This prompted me to examine the regression results, in the hopes of see similarities between the two species at my study sites. In my study, yellow-headed blackbirds and red-winged blackbirds shared no environmental similarities. The only possible way to explain this based upon my data is to look at the number of sightings of each and relate them to each site. Red-winged blackbirds were found at seven total sites, and six of those sites contained yellow-headed blackbirds. After then examining the sighting data, I found that yellow-headed blackbirds outnumbered red-winged blackbirds at every site. Indeed, the total number of red-winged blackbirds sighted (23) was extremely less than the number of yellow-headed blackbirds (175). Thus, I can hypothesize that yellow-headed blackbirds were outcompeting red-winged blackbirds for resources due to sheer number.

Every scientific experiment can be improved upon and mine is no different. Firstly, and most importantly, sample size must be increased. The number of study sites I had was too little in order to make a solid assessment of Western Montana restored wetlands. For example, the Ninepipes Wildlife Refuge (one of my wetland complex areas) alone holds over 800 wetlands in the form of marshes, ponds, reservoirs, glacial potholes, and manmade structures. I would like to be able to sample more of these wetlands in order to better assess my questions. The way in which I sampled could also be improved. For instance, no measure of vegetation cover by area was taken. This is an important measure to examine for many bird species are significantly related to the amount of vegetation available, not just its species. This measurement may also be related to total bird abundance and diversity. Also, it would be interesting to compare known restored wetland sites to natural sites in the area to see if significant differences occur. Restored wetland succession studies could also yield interesting data that could match bird community succession over time. Finally, since this area of Montana is an important habitat for migrating waterfowl, studies examining migratory routes and wetland selection by these birds could further aid conservationists and local agencies.

The results of this experiment can help to paint a better picture of how bird communities are utilizing these restored wetlands. It also helps us to understand the importance of being able to cater to the needs of particular bird species. As we have seen, different bird species have different ecological needs. Therefore, when farmers, government agencies, or even engineers seek to restore or reclaim damaged wetlands, these needs must be taken into account. Even more important is that the needs of all the wetland birds (not just a select few) be catered to. Natural and restored wetlands, in order to become indistinguishable, must have thriving communities of every species that can colonize there. So-called “boutique” wetlands that are specifically geared towards popular species have no place in nature and can negatively affect species unable to live in them. If anything, this study has shown the intricacies and immense complexions that define wetlands, how little humans know about them, and how crucial it is that we study them more.

ACKNOWLEDGEMENTS: I would like to thank, first and foremost, my mentor Dr. Page Klug, whose experience and mentorship made this project possible. I would also like to thank UNDERC's Director Dr. Gary Belovsky, whose guidance and understanding of this ecosystem helped me with numerous aspects of my research. I also extend my sincerest thanks to our TA Rebecca Flynn, whose day-to-day help made my research go smoothly. Finally, I would like to thank the entire UNDERC West class of 2011, who all, at one point or another, helped me to complete this project.

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Table 1: Outlining the results of the nine individual backstepping regressions that relate bird communities to individual site environments.

	AVG pH	AVG NITROGEN	AVG DO	AVG TEMP	DEEP DEPTH	BULLRUSH	CATTAIL	SEDGE	FOXTAIL	GRASSES	AREA	WIND SPEED	AIR TEMP
SPECIES	■								■			■	
YHBB						■	■		■				
AMCO	■				■	■					■		
RWBB											■		
COYT	■			■									
KLDR							■		■				■
MSWR					■	■	■		■				■
MALL		■		■	■	■	■	■	■	■			■
VESP		■				■	■	■	■	■			

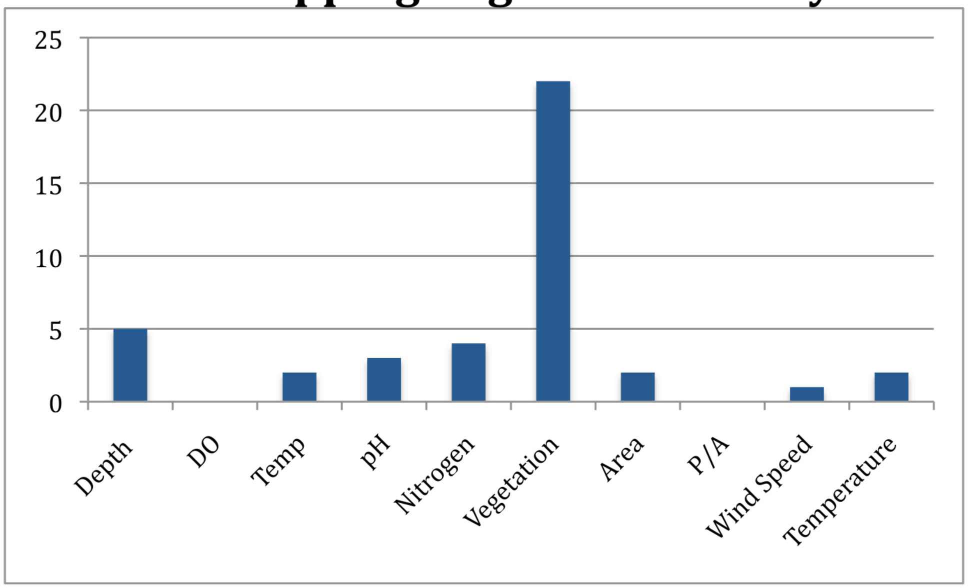
Principal Component	Species
1	RWBB
2	***AMCO***, VESP
3	YHBB, ***KLDR***
4	AMCO, ***MSWR***

Table2: Results of the Principle Components Analysis for Bird Species

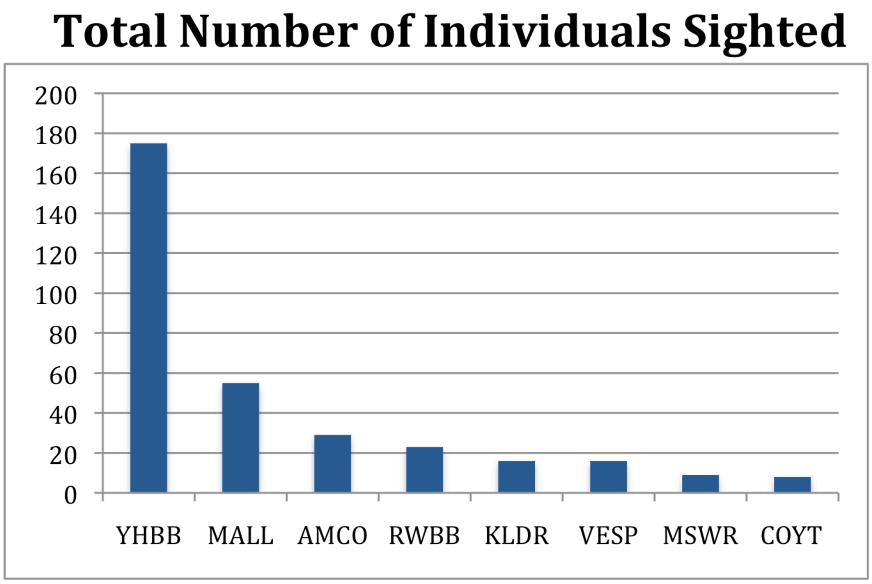
Principle Component	Environmental Variable
1	GRASS, pH, NITROGEN, DEEP DEPTH, BULRUSH
2	DO, WIND SPEED, AIR TEMPERATURE
3	TEMPERATURE, AREA, PERIMETER-TO-AREA RATIO
4	CATTAIL, SEDGE
5	DEEP DEPTH
6	FOXTAIL

Table 3: Results of the Principle Components Analysis for Environmental Variables

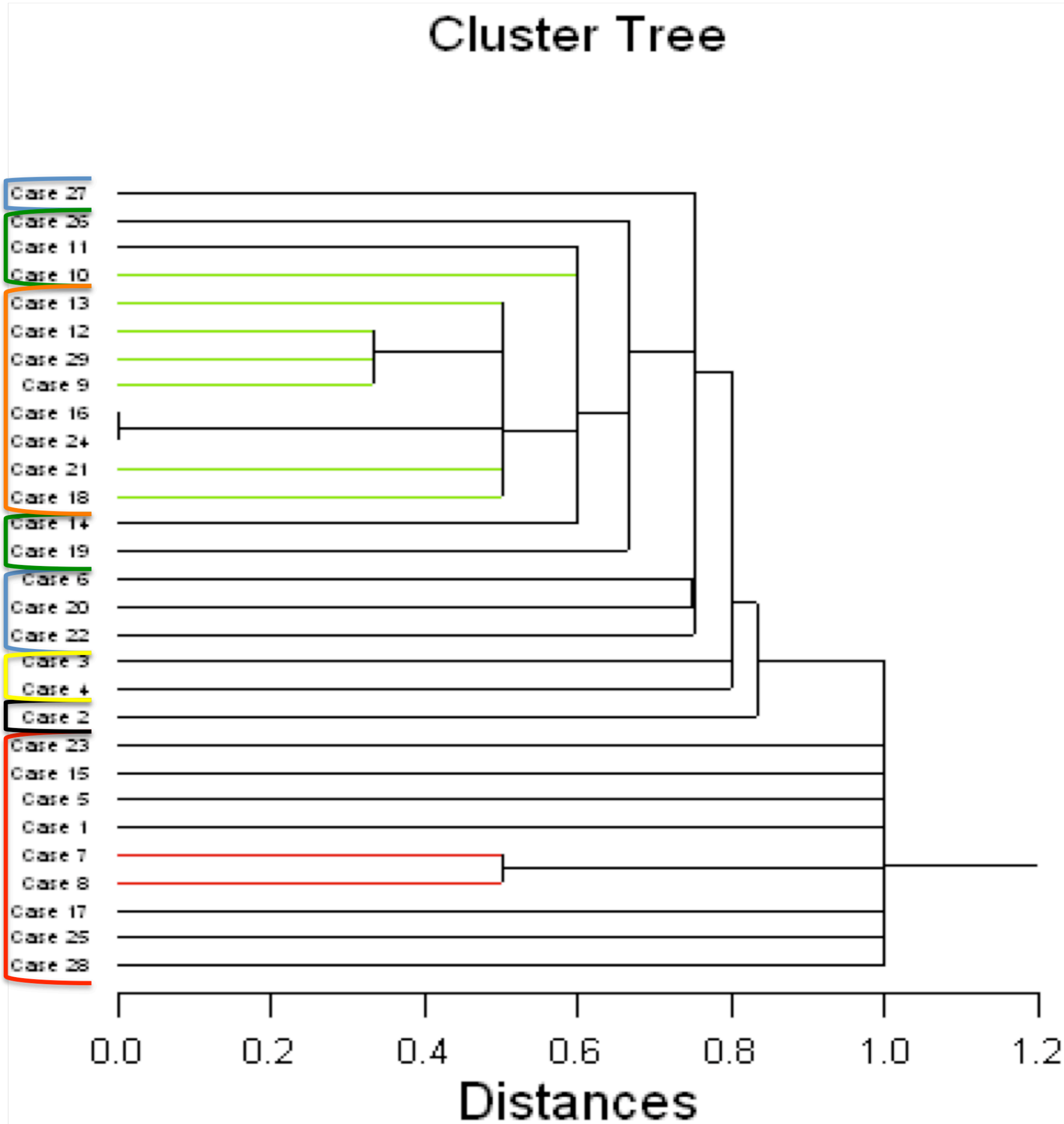
Environmental Variable Occurrence via Backstepping Regresssion Analysis



Graph 1: Showing Vegetation as the most commonly associated variable (22) and Deep Depth as the second most associated variable (4).



Graph 2: Showing Yellow-Headed Blackbirds as the most numerous bird sighted (175) and the Common Yellowthroat as the least numerous bird sighted (8).



Cluster 1: Cluster Tree used for Discriminate Analysis denoting 6 groupings in different colored brackets.