Survey of Avian Population, Distribution, and Diversity In a Variety of Habitats at UNDERC

Lynne DeFilippo

Department of Biological Sciences

University of Notre Dame Environmental Research Center

Advisor: Dr. Karen Francl

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Abstract

This study identified the diversity and abundance of species in the Wisconsin / Michigan region and examined the presence of species in different habitats representing an ecological variety of environments located on the UNDERC property. Bird species and density counts were evaluated among six habitats, which included river crossings, lakes, bogs with open water, fens without open water, upland hardwood forest, and bottomland mixed forest. These areas were analyzed both independently and in comparison to one another to examine species richness, density, and distribution. A total of 63 species were observed, with an average of 11.5 species per site and an average bird species diversity of 2.045. Sites with the presence of water exhibited increased species richness, number of individuals, and bird species density. Although previous studies have indicated the correlation between vegetative complexity and structure of the avian community, a relationship between bird diversity and vegetative complexity was only observed in the bottomland mixed and open water wetland habitats.

Introduction

Birds are commonly utilized as indicators of ecosystem integrity. Population levels and breeding success are monitored at many different geographical scales to assess environmental change and to determine future conservation. Various factors contribute to the extensive usage of birds as bio-indicators (Furness et al. 1993; Carignan and Villard, 2002). Identification of birds is relatively straight-forward, allowing those without significant scientific training to contribute to surveys and field research. Also, birds have proven popular study subjects throughout history. Thus, many lengthy time series of data collections exist such as the Christmas Bird Count (Butcher et al., 1990), and Breeding Bird Census (Link and Sauer, 1998), as well as a large body of behavioral and ecological research. The availability of established study methods for censusing and monitoring performance and their relative ease of application in the field contribute to the attractiveness of birds as bio-indicators.

Many components of the environment affect the distribution of bird species. The general habitat greatly influences the presence or absence of a particular species through the restriction of nesting and breeding areas, nutrition, temperature, natural resources, etc. Food, water, space, and cover are four essential components required of a habitat (U.S. Fish and Wildlife Service, 2002). A species' diet depends on availability and abundance of biotic and abiotic resources to satisfy nutritional requirements. Water is also critical for diet, feeding, and other activities. Space is critical for breeding, nesting, and the location of resources. And finally, sufficient cover is required for protection from predators and shelter for nesting and from the natural elements (U.S. Fish and Wildlife Service, 2002).

Within a certain habitat, regarding cover, vegetation structure, plant species composition, succession, and vegetation layering also contribute to the distribution of birds. Specifically, the vertical complexity of forest vegetation has been shown to significantly affect breeding bird diversity (MacArthur and MacArthur, 1961). The diversity of vegetation heights and the density of foliage have been demonstrated to directly relate to bird species diversity in many habitats (Wilson, 1974; Slater 1995; Patterson 2002).

Quantitative long-term studies of avian populations and distribution have not been performed on University of Notre Dame Environmental Research Center (UNDERC) property. UNDERC is a 7500-acre research facility in northern Wisconsin and the upper peninsula of Michigan. All available bird data is anecdotal or undocumented. This research, to the best of available knowledge, is the first effort to accurately characterize the avian population at UNDERC and will hopefully serve as baseline information for future studies.

Materials and Methods

Six individual habitats were selected to represent a variety of habitat types present on the UNDERC property. These six specific habitats include bottomland mixed forest, upland hardwood forest, wetlands with open water, wetlands without open water, lakes, and river crossings. Four sites from each habitat were chosen as survey locations, resulting in a total of 24 sites distributed throughout the property (Figure 1). The locations for each site were determined after assessment of the Notre Dame property and identification of the most similar habitat types dispersed throughout the area. The chosen sites of the six distinct habitats were at least 60-m apart to guarantee that overlap of the point count areas did not occur. Characteristics of each site are described in Table 1. The bottomland mixed forest was dominated by moist ground and mixed conifer and deciduous forest, while the upland forest consisted primarily of open deciduous forest with visibly less ground cover. Bogs or fens with open water were characterized by dense vegetation and conifer trees, while bogs or fens without open water contained very moist, sphagnum covered soil with many shrubs and grasses. Lakes and river crossings were typically surrounded by mature mixed forests.

Each of the sites was surveyed daily during a period of 4 to 5 consecutive days, depending on weather conditions, to allow 4 total surveys per site from 2 June through 17 July 2003. Surveys were conducted once each day, either from sunrise to 4 hours after sunrise or from 4 hours before sunset until sunset. Morning and evening counts were alternated between sites each day. This procedure yielded a total of 96 bird surveys: 16 for each habitat, and 4 surveys for each individual site.

The surveys were conducted according to a standard point count method which has been utilized in extensive geographic coverage of bird studies in the Great Lakes region (Howe et al., 1997). Point counts involved an observer remaining at one location and recording all the birds seen or heard at a fixed or unlimited distance. At the time of surveying, one random survey point within each site location was established through the use of a random number table. It was ensured that each point was situated at least 30-m within the specific habitat. Twenty minute censuses were performed and birds seen or heard within a 30-m radius were documented. The species were written in the order of observation and the number of individuals for each species was also recorded. A tape recorder was also utilized during each survey to record the particular calls, which were later analyzed and identified to species with the assistance of the Peterson Multimedia Guide to North American Birds (1995).

Birds were not surveyed in extreme weather, when wind or rain interfered with the audibility of bird calls, when fog or rain impaired visibility, or when cold weather limited bird activity. Materials required for each census included a map of the property with identified sites, flagging tape, notebook, pencil, watch, tape recorder, Peterson's Field Guide to Birds of Eastern and Central North America (Peterson, 2002) and binoculars.

The bird species diversity at each site was calculated using the Shannon-Weiner index of diversity (MacArthur and MacArthur, 1961):

$$H = -\sum p_i (\ln p_i)$$

Where p_i is the proportion of individuals which belong to the i^{th} species. This index provides a quantitative measure of the diversity of species in the total population at a particular site.

At each particular habitat site, the vertical stratification of vegetation within the 30-m radius was also recorded. The structure of vegetation was analyzed through range-pole surveys at 30 random points within each site (Francl and Schnell, 2000). The range-pole was divided into 11 half meter increments, extending from 0.0 to 5.5 meters, as well as an interval for vegetation above 5.5-m. Intervals where vegetation crossed the range-pole were recorded. The number of hits on the range pole were averaged for each site. Using this data, total vegetation volume was calculated (Mills et al., 1991) through the following formula:

$$TVV = h / 10v$$

where h is the number of increments for which vegetation hit the range pole, and v represents the total number of intervals on the range pole. In this particular study, $v = 12$. This procedure for measuring and determining total vegetation volume provides an accurate method of estimating vegetation structure and may be useful in the quantitative description and comparison of plant communities (Francl and Schnell, 2000).

To directly assess the relation between vegetative complexity and bird diversity, scatter plots comparing the total vegetation volume to bird species diversity at each site were plotted using Microsoft Excel (Microsoft Corporation, 2002) and correlation analysis was performed through Systat 10.0 (SPSS, INC., 2000. Analysis was completed for both the entire set of 24 sites, as well as independently by habitat. Pearson's correlation tests were also performed to determine the significance of these results (SPSS, INC., 2000).

Statistical analyses comparing habitats with an abundance of water (i.e., lakes, river crossings, and wetlands with open water) and forested habitats (i.e., bottomland mixed, upland hardwood, and wetlands without open water) were also completed. Analysis of variance was performed (in Systat) to determine any significant differences between variables in the two types of habitats.

Results

A total of 707 birds, composed of 63 species were observed during the course of this study (Appendix 1). The most common species seen was the common grackle, followed by the cedar waxwing (Table 2). On the basis of distribution of species, the American robin was present at the greatest number of sites (15), followed by the song sparrow (14), and the yellow-bellied sapsucker (13; Table 3).

The average number of individuals per survey varied from 2.25 to 14.25, with an average of 7.6. Species richness per site ranged from 4 to 21 with an average of 11.5 species across sites. Bird species diversity ranged from 1.255 to 2.933, with an average of 2.045 (Table 4). Total vegetation volume varied from 0.017 to 0.048. The average vegetation volume across sites was 0.030 (Table 4).

Correlation analysis of total vegetation volume versus bird species diversity generally revealed no relationship between the two variables (Table 5). However, the bottomland mixed hardwood ($r = 0.994$, $p = 0.006$) and open water wetland habitats ($r = 0.975$, $p = 0.025$) did reveal a significant correlation (Table 5). Scatter plots comparing total vegetation volume and bird species diversity illustrate a linear correlation in the bottomland mixed hardwood ($R^2 = 0.9889$) and open water wetland sites ($R^2 = 0.9512$; Figure 2).

The average number of individuals, species richness, and total vegetation volume were found to differ significantly between habitats including the presence of water versus habitats lacking a body of water (Figure 3). These variables were shown to be significantly greater in habitats with the presence and abundance of water. Bird species diversity, while not significant, also showed an increase in habitats with the presence of water (Figure 3).

Discussion

Vegetative complexity has been shown to be strongly correlated with the structure of avian communities. Vertical vegetation structure and complexity increase foraging surfaces for insectivorous species, while also creating a wider variety of fruit and seed resources. Complex vegetation also aids in protection from predators. The relationship between bird species diversity and vertical vegetation structure has previously been demonstrated to be positively associated (MacArthur and MacArthur 1961, Wilson 1974).

In seeming contrast to the MacArthurs' earlier results, this relationship was not found during the study. Analysis of the combined habitats reveals no significant correlation of bird species diversity and total vegetation volume throughout the surveyed sites. However, previous research on the relationship between bird species diversity and vegetation structure has been concentrated on one particular type of homogenous habitat. MacArthur and MacArthur determined that, "In deciduous forests, bird species diversity can be predicted in terms of the height profile of foliage," (MacArthur and MacArthur 1961). Their research included only forested areas, and did not consider other habitat varieties.

In analysis of forested areas alone (i.e., upland hardwood and bottomland mixed forest), a positive correlation is only evident in the bottomland mixed hardwood areas. It is feasible that this relationship was not identified in the upland hardwood habitat due to a greater diversity of sites. Two of the upland hardwood stands were very open maple and birch stands, while the two remaining sites resembled bottomland areas with dense ground cover and mixed forest (Table 1). The findings may have been more correlated if sites with more similar understory and canopy were analyzed.

In further evaluation of separate habitats, a positive correlation is also apparent between vertical complexity and bird species diversity in wetland habitats with the presence of open water (Figure 2). Bird species diversity was demonstrated to increase as the vegetation becomes more complex.

The lack of a positive correlation between total vegetation volume and bird species diversity could be the result of survey techniques. In especially dense areas of vegetation, individuals may have evaded observation and avian populations may not have been fully accounted for due to the presence of vegetative cover. Also, an increase in the replicates of surveys at each site and a greater number of sites per habitat may have yielded more statistically significant results.

Regarding vegetation, thirty random points per site may not have accurately represented the total vegetation present at each site. It may be necessary to alter techniques when measuring vegetation heights in different habitats. Also, there were no established guidelines to determine where to measure vegetation near water. At many of the sites with the presence of water, a distinct area of low vegetation exists immediately adjacent to the water, surrounded by a mature forest. As previous studies have demonstrated, many bird species seem to prefer more complex vegetation (Wilson, 1974; Slater, 1995). Therefore, it is unclear the proximity to water where measures of vegetation should have been taken to determine the most correct amount of total vegetation volume for the habitat.

The presence and abundance of water has been shown to exhibit a direct effect upon the avian population (Croonquist, 1991). Birds require water, not only as a critical component of nutrition, but also as an essential medium for other activities. Bodies of water provide aquatic food sources, protection from predators, and areas for courting and preening. The presence of water also increases the diversity and abundance of tree species resulting in a greater variety of nutritional resources and vegetation structure (U.S. Fish and Wildlife Service, 2002).

The average number of individuals, species richness, and total vegetation volume were found to be significantly greater in habitats with the presence of water versus habitats lacking a body of water. Bird species diversity, while not necessarily significant, was also seen to be greater in habitats containing open water. Therefore, as indicated by these results, the number of individuals, species richness, and diversity increase as total vegetation volume also increases, in correspondence with prior studies (Rotenberry et al., 1979).

In the course of this study, four species of concern in the states of Michigan and Wisconsin were observed. Three of these species, the broad-winged hawk, northern harrier, and bald eagle belong to the family Accipitridae, while the osprey composes the monotypic family Pandionidae. A single bald eagle and one northern harrier, along with six broad-winged hawks and three osprey were observed. Broad-winged hawk populations are currently stable in the area, but populations are threatened due to shoreline development resulting in the loss of colony nesting sites. Destruction of marsh habitats as a result of human activity has placed northern harriers under special concern in the state of Michigan. Bald eagles were included in the Endangered Species Act in 1973, and continue to be a rare species despite increasing populations in Michigan and Wisconsin. It is believed that two pairs of eagles currently reside on the property. The osprey population is continuing to increase due to human assistance in the form of artificial nesting platforms along bodies of water. However, heavy use of pesticides in its winter habitat is a major threat to the species (Michigan DNR, 2003).

This study has provided background data on the avian species and diversity found on the UNDERC property. This study can serve as initial research on the bird population and should be useful in the establishment of future studies on the UNDERC property. Similar studies must be carried out in the near future to obtain a more accurate representation of the distribution and abundance of species. Future research should include habitat sites utilized during this study, but should also consist of new survey sites representing similar habitats in order to gain a more complete survey of the property. Vegetation measurements should also be taken and analyzed to determine if a positive correlation does exist between vegetation complexity and bird species diversity. And finally, future avian surveys should continue to record the presence of threatened or endangered species and will therefore be able to provide suggestions for the protection of these populations.

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Table 1. Characteristics of study areas.

	Site	Dominant Vegetation
1	Bottomland Mixed 1	Mixed forest, moist ground, sphagnum, bracken fern, and dense herbaceous ground cover
2	Bottomland Mixed 2	Mixed forest, moist ground, sphagnum, bracken fern, and dense herbaceous ground cover
3	Bottomland Mixed 3	Open mixed forest, herbaceous and woody ground cover, conifer & maple saplings
4	Bottomland Mixed 4	Mixed forest, dense herbaceous ground cover
5	Upland Hardwood 1	Very open sugar maple stand, dense & tall canopy cover, minimal ground cover
6	Upland Hardwood 2	Primarily sugar maple, conifer saplings, dense ground cover
7	Upland Hardwood 3	Open sugar maple and birch stand, dense & tall canopy, minimal ground cover
8	Upland Hardwood 4	Primarily aspen & maple, conifer saplings, dense bracken fern
9	Wetland w/ open water 1	Sphagnum moss, many shrubs, few conifers
10	Wetland w/ open water 2	Sphagnum moss, shrubs, bracken fern, conifer saplings
11	Wetland w/ open water 3	Dense vegetation, sphagnum moss, conifers, herbaceous ground cover
12	Wetland w/ open water 4	Sphagnum moss, many shrubs, few conifers
13	Wetland w/o open water 1	Sphagnum moss, many shrubs & grasses, few conifers
14	Wetland w/o open water 2	Dense shrub & grass ground cover
15	Wetland w/o open water 3	Dense shrub & grass ground cover
16	Wetland w/o open water 4	Primarily conifer forest, moist ground, sphagnum moss, dense ground cover
17	Lake 1 (Plum / Inkpot)	Mature mixed deciduous & conifer forest
18	Lake 2 (Bergner)	Primarily balsalm & red pine forest, moist ground, herbaceous ground cover
19	Lake 3 (Morris)	Tall grass & shrubs, few deciduous trees
20	Lake 4 (Kickapoo)	Tall grass & shrubs, conifer forest
21	River Crossing 1 (Tenderfoot)	Mature mixed deciduous & conifer forest, dense & tall canopy
22	River Crossing 2 (Tenderfoot)	Deciduous & conifer trees, many shrubs, dense vegetation
23	River Crossing 3 (Tenderfoot)	Deciduous & conifer trees, many shrubs, dense vegetation
24	River Crossing 4 (Brown)	Young deciduous & conifer forest, dense herbaceous cover & shrubs

Table 2. Ten Most Common Species Observed

	Species	Total No. of Individuals Observed	Total No. of Sites Where Present
1	Common Grackle	70	10
2	Cedar Waxwing	59	10
3	Black-capped Chickadee	36	12
4	Goose	35	1
5	Song Sparrow	35	14
6	Hermit Thrush	33	11
7	Ovenbird	27	10
8	White-throated Sparrow	27	10
9	Red-eyed Vireo	26	11
10	American Robin	25	15

Table 3. Distribution of Species

	Species	Total No. of Sites Where Present	Total No. of Individuals Observed
1	American Robin	15	25
2	Song Sparrow	14	35
3	Yellow-bellied Sapsucker	13	19
4	Black-capped Chickadee	12	36
5	Blue Jay	12	24
6	White-Breasted Nuthatch	12	21
7	Hermit Thrush	11	33
8	Red-eyed Vireo	11	26
9	Common Grackle	10	70
10	Cedar Waxwing	10	59
11	Ovenbird	10	27
12	White-throated Sparrow	10	27

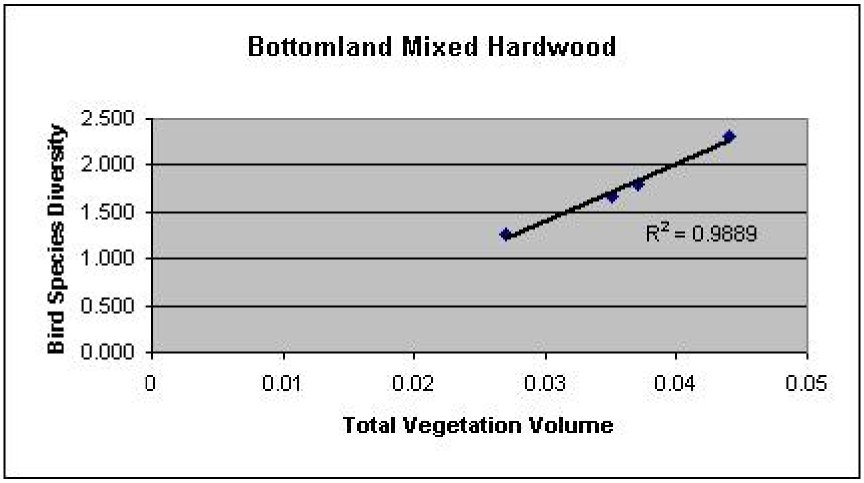
Table 4. Collected data at each survey site.

Site		Average Number of Individuals	Species Richness	Bird Species Diversity	Total Vegetation Volume
1	Bottomland Mixed 1	2.25	6	1.667	0.035
2	Bottomland Mixed 2	4.25	11	2.307	0.044
3	Bottomland Mixed 3	2.67	4	1.255	0.027
4	Bottomland Mixed 4	3.67	7	1.799	0.037
5	Upland Hardwood 1	5.25	10	2.017	0.017
6	Upland Hardwood 2	5.5	9	2.014	0.030
7	Upland Hardwood 3	4.67	6	1.540	0.017
8	Upland Hardwood 4	5.5	8	1.821	0.036
9	Wetland w/ open water 1	8.25	14	2.163	0.032
10	Wetland w/ open water 2	3	7	1.820	0.026
11	Wetland w/ open water 3	7.25	13	2.394	0.033
12	Wetland w/ open water 4	5	8	1.760	0.025
13	Wetland w/o open water 1	4.25	10	2.166	0.013
14	Wetland w/o open water 2	4	7	1.804	0.019
15	Wetland w/o open water 3	12.67	16	2.381	0.017
16	Wetland w/o open water 4	8	11	2.255	0.027
17	Lake 1 (Plum / Inkpot)	13.25	17	2.417	0.044
18	Lake 2 (Bergner)	4.5	5	1.274	0.032
19	Lake 3 (Morris)	10.75	17	2.568	0.033
20	Lake 4 (Kickapoo)	10.75	14	2.142	0.021
21	River Crossing 1 (Tenderfoot)	18	19	2.078	0.048
22	River Crossing 2 (Tenderfoot)	10	21	2.933	0.042
23	River Crossing 3 (Tenderfoot)	15	21	2.536	0.030
24	River Crossing 4 (Brown)	14.25	15	1.977	0.041

Table 5. Correlation ("r") and p values for habitats and total vegetation volume.

Habitat	Pearson Correlation	p value
All Habitats	0.173	0.493
Bottomland Mixed Hardwood	0.994	0.006
Upland Hardwood	0.255	0.745
Wetland w/ Open Water	0.975	0.025
Wetland w/o Open Water	0.064	0.936
Lake	0.234	0.766
River Crossing	-0.330	0.670

Figure 2. Regression scatter plots of total bird species diversity vs. vegetation volume.



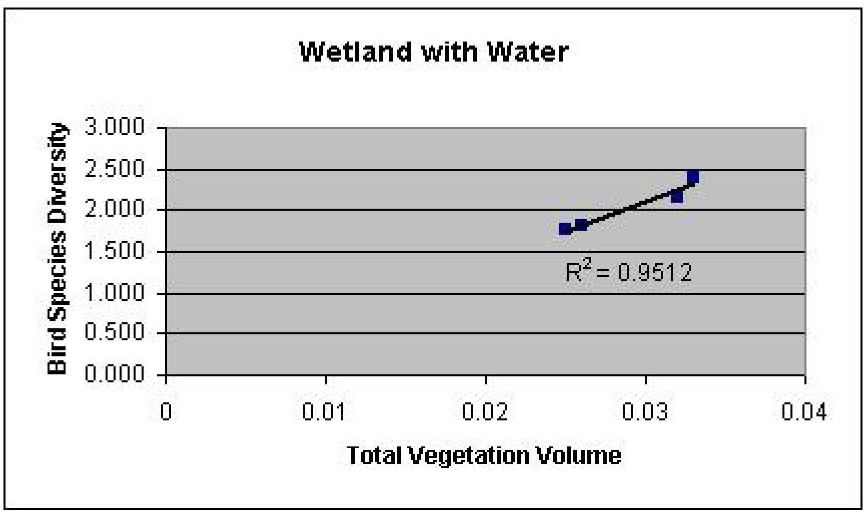
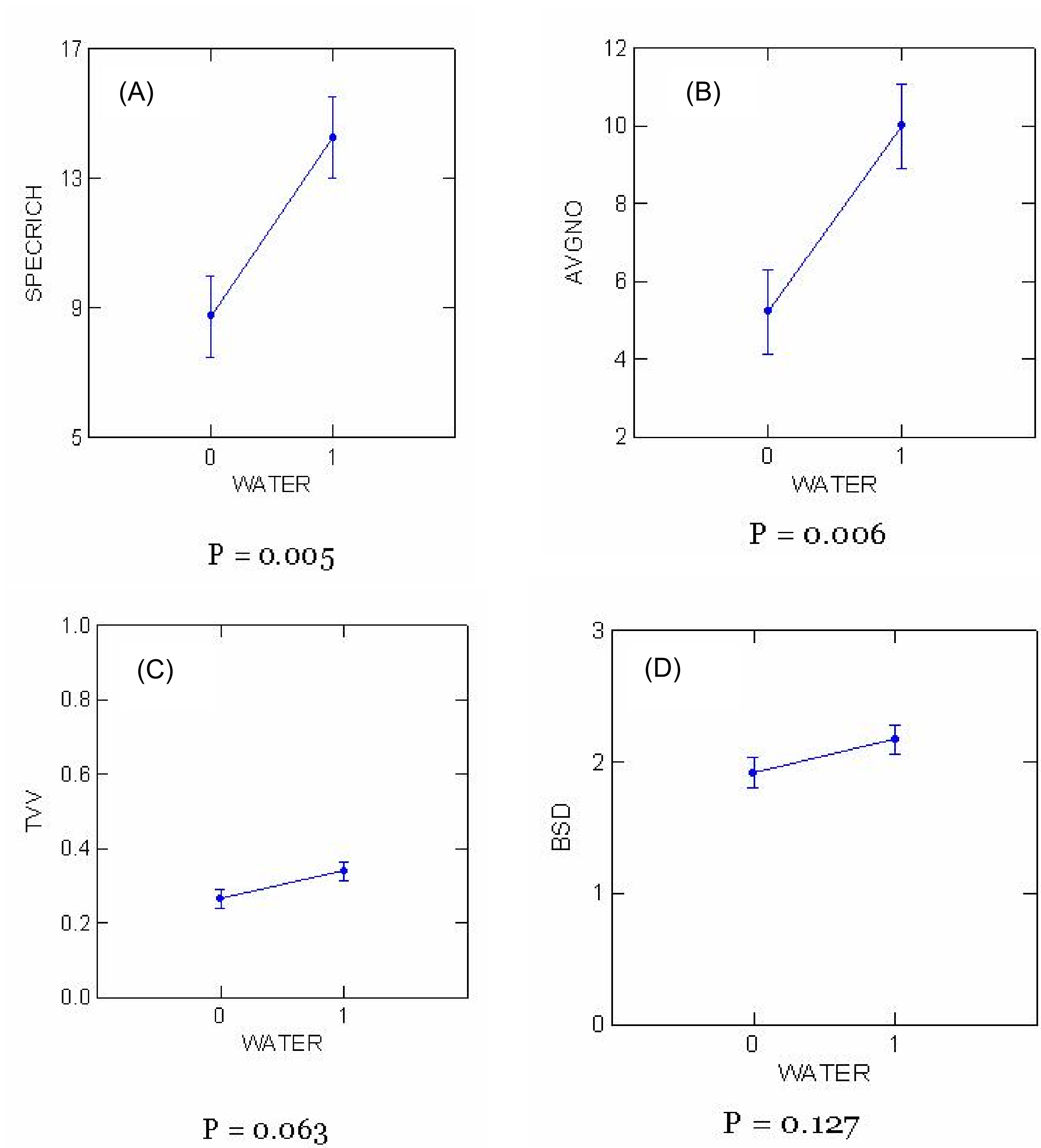


Figure 3. ANOVA results between sites without open water (0) and sites with the presence of water (1) comparing species richness (A), average number of individuals (B), total vegetation volume (C), and bird species diversity (D).



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