EFFECTS OF OKLAHOMA CROSS TIMBERS RIPARIAN VEGETATION COMPOSITION ON AVIAN COMMUNITY DYNAMICS

By

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PREFACE

This study is a descriptive analysis of the avian communities in riparian vegetation throughout an entire year. It was designed to suggest possible alternatives for consideration in the management of the quality of riparian habitat. The project included an investigation of optimum width range of vegetation belts and how the vegetation structure relates to the bird community. The importance of the size and structure of the riparian habitat to woodland dependent bird species of the Cross Timbers region of Oklahoma was emphasized.

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CHAPTER I

INTRODUCTION

Riparian vegetation is ecotonal and physiographically distinct, particularly in central Oklahoma. It furnishes a major habitat for obligate forest dwelling wildlife. This habitat is essential for some wildlife communities as forestry, agricultural and developmental activities continue to encroach on the critical riparian systems of the south central states (Best et el. 1979, Conine et al. 1979). This habitat has become increasingly restricted and isolated. The size, length, and width of these vegetated strips is decreasing. Their value as corridors for wildlife travel diminishes, while the need for them increases (MacClintock et al. 1977, Robbins 1979, Brinson et al. 1981). The importance and uniqueness of riparian ecosystems has been recognized by researchers in many fields (Clark 1979, Odum 1979).

Because bird populations act as monitors of natural diversity in biological communities (Plunkett 1979), birds in riparian habitats have been studied by many researchers. Yet, there is a need for information on those bird species that winter in these habitats, as well as for ecological tolerance studies of the breeding and migratory birds (Samson 1979). According to Tubbs (1980) some factors to consider include minimum width of the vegetation, tree density, species diversity, and vegetation structure. The size of a habitat can be directly related to its ecological value for specific bird species and for overall species richness (Forman et al. 1976, Galli et al. 1976, Brinson et al. 1981). Stauffer and Best (1980) noted a direct relationship between bird species richness and the width of wooded riparian habitats in Illinois. However, there is no concensus on the minimum width necessary to support wildlife populations (Brinson et al. 1981). Many studies have concluded that the habitat size along with the diversity and quality of that habitat affects the suitability criteria for certain bird species and the attributes needed to maintain biotic diversity (Karr and Roth 1971, Johnson 1975, Willson and Carothers 1979). Accordingly, Oklahoma Cross Timbers riparian vegetation appears more mature in the wider belts so the size and vegetative structure cannot act as independent variables in these habitats.

A survey conducted by the Oklahoma Chapters of The Wildlife Society and the American Fisheries Society (1982) indicated that a large majority of Oklahomans felt that riparian habitat should be conserved by state statute. They concluded that the public supports proper management of Oklahoma's riparian habitats, but there is a need for more comprehensive data to assist in resource management decisions. This study was designed to suggest possible guidelines for riparian habitat quality management to land managers. The objectives of the project were (1) to determine the relationship between width of the riparian belt and bird community structure through an entire year; (2) to determine the importance of size and structure of the riparian habitat to the woodland dependent bird species in the Cross Timbers region of Oklahoma: (3) to determine the width of vegetation belts where an increase in bird species diversity or richness might become minimal (i.e. an optimum width range).

CHAPTER II

STUDY AREA DESCRIPTION

Ten study sites, located in the Cross Timbers Region of the Prairie Parklands (Bailey 1976), were established on Oklahoma State University lands west of Stillwater. They were chosen as representatives of homogeneous woody vegetation belts along intermittent streams that appeared distinct from the adjacent habitat types. Additional selection criteria included: 1) no isolated wooded stands nearby; 2) a continuous length of vegetative strip of similar width at least 60 m long to accommodate two bird census belt transects placed perpendicular to the stream channel; and 3) similar topography.

Each of the areas consisted of different plant community organizations and relative distributions of dominant species. Since the structure and physiognomy of vegetation has important influences on the associated bird communities, extensive vegetation measurements were taken. Generally, the narrower strips were characterized by shrubby woody vegetation of a lower successional stage than the wider strips. The wider strips contained large deciduous trees with little or no woody understory. Individual habitat descriptive statistics for the areas are listed in Appendix A.

CHAPTER III

METHODS AND MATERIALS

Bird Community Census Techniques

At each study site, two census transect lines were established parallel to each other and perpendicular to the stream channel (Burnham et al. 1980). They were situated as far apart as possible, yet still within the designated study site (Anderson et al. 1979). The lengths of the transect lines varied according to the width of the vegetative strip. The census route was marked with forester's flagging. The census area contained a 10 m belt on each side of the transect line (Mikol 1980).

In order to reduce observation bias, censusing was done on clear mornings between 0600 hrs and 0900 hrs when wind speed was less than 25 mph (Anderson and Ohmart 1977a, Conner and Dickson 1980). I recorded any bird heard or seen within the 20 m belt. I censused the areas from 5 June 1981 through 10 June 1982. All bird species recorded are listed in Appendix B.

Bird Community Data Analysis

Census results for the entire year were divided into seasonal groups according to the equinox dates. Since the average number of visits per location was greater in both the spring and summer seasons compared to the fall and winter seasons, community results for the fall and winter were combined.

I assigned each species a feeding guild designation and placed locally nesting species in nesting guilds. These guild separations followed Willson (1974). Feeding guilds were described by food habits, foraging strata, and foraging behavior. Nesting guild characteristics were nest site preference, number of broods per season, and number of eggs per clutch. The coding format and specific categories are in Appendix C.

Summarization parameters of the bird communities for comparisons among locations within seasons and between seasons within locations include:

1) bird species diversity (BSD);

2) bird species evenness (BSE);

3) bird species richness (BSR);

4) feeding guild richness (GFR);

5) nesting guild richness (GNR);

6) number of typical grassland species;

7) number of typical woodland species;

8) number of associated food habit species; and

9) number of associated nest site preference species.

Computations for bird species diversity and evenness were done using an IBM computer with the Statistical Analysis System procedures (SAS Institute 1979).

Bird species diversity was calculated using Shannon and Weavers' (1949) index:

$$H' = p_i \log_e p_i$$

which includes species richness and evenness values in the calculation.

An estimate of the evenness of the distribution of the individuals among the species was extracted. Bird species richness, the number of species occurring in the sample, and richness value of the guilds were recorded by location and season. Relative frequencies for the associated species groups were calculated to investigate the representation of the various characteristic species among the locations throughout the year.

Vegetation Sampling

I measured the width of the vegetation strips of the study areas in four places then averaged them for an overall width estimate. With an increase in width there was an observable trend in successional maturity. In order to measure this structural quality in a quantitative description of the study areas, I followed the sampling design of Cottam and Curtis (1956) using the parameters and methods similar to those of James and Shugart (1970).

I superimposed a numbered grid on the aerial photograph of a study area. Using a random number table, I chose three of the grids to represent the three 10 m^2 plots for vegetation measurements. Within each plot, two 4 m^2 subplots were consistently placed in the northeast and southwest corners of the plot.

In the field, metered clothesline was stretched to outline the plot boundaries, and a Baltimore "reach stick" (Forbes 1955) was used to measure the diameter at breast height (DBH) of trees at least 1 inch in diameter as well as the height of woody stems taller than 18 inches. All trees in the plot were identified and classified by species and DBH class. All woody stems taller than 18 inches and less than 1 inch DBH in the subplots were identified by species and tallied. Ground cover and canopy cover estimates were made using an ocular cardboard tube to site the presence or absence of vegetation at ten 1 m intervals on the west and south plot boundaries, respectively. These values were recorded as percent cover.

Habitat Analysis

Relative and absolute values of tree density, dominance, and frequency were calculated by species and by DBH classes for each of the plots. Tree species diversity, richness, and DBH richness values were calculated for each location. I also calculated an importance value for each species at each location by summing the relative values of density, dominance and frequency.

Density and frequency values for the species of woody stems in each subplot was calculated, then I assigned shrub richness figures and average percent cover values for each location. Tree and shrubby stem species names are listed in Appendix D.

Statistical Analysis

All statistical procedures were produced by the SAS Institute, Inc. (1982). Initially, the habitat and bird data were analyzed in a balanced format for each study location. This made it possible to produce univariate descriptive statistics and a correlation matrix with correlation coefficients that described the comparisons between all measured variables. The matrix was used for an exploration into the relationships between the independent variables (habitat) and the dependent variables (birds) through a stepwise regression procedure. This procedure produced a set of models for the categorical variables by using the best fit independent variables that account for the greatest increase in the R^2 value, the square of the multiple correlation coefficient. For entry into the model, a habitat variable must have a significance level of at least 0.5.

Further exploratory analysis included a multivariate principal component analysis for four sets of variables, i.e., habitat, birds, trees, and shrubs.

The correlation matrix of all habitat values across the ten study locations (10 x 46 matrix) was used to generate three principal component factors. Each of these were sets of linearly correlated habitat values that retained as much of the information in the original vegetation measurements as possible. Once plotted, the principal components show possible groupings of the study locations into associations based on habitat analogy. Similarly, the bird community, tree data, and shrub data variables were separately analyzed and plotted across locations. Next, the factor scores were produced to reduce the complexity of the principal component analysis variables and to allow a concise consideration of the actual weighted loadings of the variables. Relationships among the variables making up a principal component factor can help explain the arrangement of similarity between locations (Bhattacharyga 1981).

In order to describe variation between bird community variables and associations of locations, locations, seasons, and their distributive interactions, the balanced format data were used in several analysis of variance models. The discrete variables of bird diversity, richness, and evenness were analyzed over all seasons and within seasons. Fall and winter data were merged to increase the total number of observations. Duncan's multiple range tests were used to separate the means of the main effects for significant differences.

The feeding and nesting guilds were tested for homogeneity of distribution across the study locations. A chi-square test produced frequency tables of each descriptive component of the guild for differences between the associations of locations.

CHAPTER IV

RESULTS

Through the year, 61 species of birds were catalogued from all the study areas. Most of these (51) were year-round or breeding season residents. Only three species of migrants were detected. Seven species of winter transients occurred in the areas. The relative distributions of individuals among these species were summarized over the entire year into bird species diversity (BSD), bird species evenness (BSE), bird species richness (BSR), and guild richness values for each location.

Correlations

The widths of the vegetative strips were highly significantly correlated with six tree variables and one bird variable. There was a positive correlation with the density and richness of trees with DBH of 4 to 6 inches, the richness of trees with a DBH greater than six inches, the richness of tree DBH classes, tree dominance, and canopy cover. A negative correlation existed with bird species evenness values in the fall. There was no apparent relationship between bird diversity or richness and width or area.

Bird variables were highly significantly correlated with several habitat variables (Table 1). Bird species diversity was highly negatively correlated with shrub variables. Feeding guild richness was positively correlated with tree density while BSE was negatively correlated. These habitat variables enhanced the final grouping of location associations based on all vegetative parameters.

Location Associations

Principal component analysis separated the locations according to all the habitat descriptive statistics. Three components were used for this separation as well as for an analysis based on just the highly significantly correlated vegetation variables. The plots of the first two components of both analyses were similar. The factor loadings in the components differed slightly, but the factor pattern showed Factor 1 as being influenced by large, mature tree variables (Table 2). The highest contributors to Factor 2 are small tree or shrub variables. Factor 3 was composed primarily of shrub variables and ground cover. The third factor helps in relative grouping within the four major associations (Table 3). Together, the three Factors can compare the vegetation characteristics of the ten study locations.

The principal component analysis of just the tree variables resulted in the large tree variables comprising the first factor, but the locations were plotted with greater separation, making it difficult to find a grouping pattern. The plots of shrub variables were not as separated, yet there was still no clear pattern. Similarly, the plots of bird variables separated the locations on all three principal axes. The best explanation of similarity between study areas was provided by the principal component analysis of all vegetation variables.

The graph of the principal component analysis of all the habitat variables groups the locations in three dimensions (Fig. 1). Those locations at the higher values of the Factor 1 axis are similarly composed of the larger more mature tree variables such as higher tree dominance, canopy cover, and richness and density of trees with a DBH of 4 to 6 inches. Other variables characterize these areas such as greater width of vegetative strip, richness of tree DBH classes, and tree density. Those locations on the upper scale of the Factor 2 axis have a greater richness and diversity of tree species. These trees are mainly smaller, since density, and richness of trees with a DBH of 1 to 3 inches contribute highly to this factor. Also, these areas have a high density of shrubby woody species. Gradations between the first two factors are fulfilled by the variables contributing the greatest portion to the third factor. The locations at the higher reaches of the Factor 3 axis have low shrub richness and diversity values but a great amount of ground cover. The trees at these locations are of a small DBH and are fairly dense with a high number of species. The locations were grouped into their respective associations accordingly.

Association I contains two locations, Popsickle Cottonwood (PC) and Ditch Fence (DF). These locations have the narrowest widths. This Association was low on the axes of the first two factors but had high values of Factor 3; it is characterized by low shrub richness and diversity and much ground cover (Fig. 1). The trees are small and dense. Five locations are in Association II, East Arm (EA), Deer Dike (DD), Stable Road (SR), Frog Green (FG), and Lichen Bottom (LB). These locations are generally low on the Factor 3 axis. Their values range from middle to high for Factors 1 and 2. This Association has larger more mature trees with a greater richness and diversity of species than Association I. Still, the density and richness of trees with a DBH of 1 to 3 inches characterized this Association. The location, Homestead

Pond (HP) represents Association III. This location was very dissimilar from any of the others. It ranks very high on the Factor 3 axis; this location has many small dense trees and a great amount of ground cover. However, there are also a great numbers of mature trees of many species atthis location, so it shows a high value for Factor 1. Association III has the lowest value on the Factor 2 axis. The fourth Association is made up of two locations, Killdeer (KD) and Hydraulic North (HN), which are two of the wider vegetated strips. This Association has the greatest tree dominance, canopy cover, and richness and density of large trees.

Bird Species Distributions

The relative numbers of species and individuals at each location through the year may be separated according to their preferred habitat. Typical grassland species such as field sparrow, meadowlark, and dickcissel were found to assume a greater percentage of the total species composition in the narrower, less mature vegetation strips (Fig. 2). The percentages of those species considered to be more forest dependent (Robbins 1979) such as the yellow-throated warbler, red-headed woodpecker, Eastern wood pewee, red-eyed vireo, and hermit thrush, fluctuated, showing no general trends. A list of species recorded at each location is in Appendix E.

Bird species diversity values were highest in Association I of the study locations (Table 4). Association II locations ranged from 2.178 to 2.660 and had a lower mean (2.453) than the absolute values for Associations III and IV. Diversity seemed to remain consistently higher in the narrow less mature locations and in the wider more mature areas than in the middle range widths that are not at strictly early or late stages of successional growth. Evenness values ranged from 0.769 to 0.861 (Table 4). Locations in Association I have the highest evenness values.

Bird species richness values varied within Associations, but not greatly between Association means (Table 4). Two locations, Stable Road and Hydraulic North, shared the highest number of species observed through the year. Frog Green and Lichen Bottom, both in Association II, had the lowest richness values.

Bird Species Variations

Bird species diversity, evenness, and richness values were used as dependent variables in three analysis of variance tests. The means of BSD and BSR were significantly different ($P < 0.05$) between seasons but not between locations for two of the three models processed (Table 5). Diversity varied between all seasons. Richness means from spring and summer values were significantly different from those of the combined winter and fall values.

Evenness was not different between seasons but was highly significant between locations for the model. The locations Ditch Fence, Deer Dike, and East Arm were significantly different from Hydraulic North, Stable Road, Killdeer, and Lichen Bottom. Popsickle Cottonwood was different from Killdeer and Lichen Bottom, while Homestead Pond differed only from Lichen Bottom. Two locations, Hydraulic North and Stable Road, were different from East Arm, Deer Dike, and Ditch Fence. Killdeer differed from Popsickle Cottonwood, East Arm, Deer Dike, and Ditch Fence. Similarly, Lichen Bottom differed from these areas as well as Homestead Pond. Evenness means for Frog Green were not significantly different from any of the other locations.

In the model testing the effects of Associations and locations, evenness was the only significant variable. Evenness was significantly different between Associations. Association I was different from II and IV. Association II was different from all other Associations. Association III was different from only Association II. Association IV differed from I and II. In addition, evenness means were significantly different between locations. The locations Ditch Fence and Deer Dike were different from Hydraulic North, Stable Road, Killdeer, and Lichen Bottom. East Arm and Popsickle Cottonwood were different from Deer Dike and Ditch Fence. Killdeer and Lichen Bottom were different from Deer Dike, Ditch Fence, East Arm and Popsickle Cottonwood. Finally, East Arm and Popsickle Cottonwood were not significantly different from any of the locations.

In the model testing the effects of Associations, location, seasons, and their interactions, diversity indices were significant in the location-season interaction. Diversity was different between the spring, summer, and combined fall and winter seasons. Also, Popsickle Cottonwood and Deer Dike were different from Lichen Bottom. There were no other significant differences between locations for bird species diversity. However, evenness differed between locations. Three locations, Ditch Fence, Deer Dike, and East Arm, were significantly different from Hydraulic North, Stable Road, Killdeer, and Lichen Bottom. The locations, Popsickle Cottonwood, Homestead Pond and Frog Green, were significantly different from Killdeer and Lichen Bottom. Hydraulic North and Stable Road were different from Ditch Fence, Deer Dike, East Arm, Killdeer, and Lichen Bottom. Lastly, Killdeer and

Lichen Bottom were different from Ditch Fence, Deer Dike, East Arm, Popsickle Cottonwood, and Homestead Pond.

Guild Distributions

Feeding guild richness values ranged from 12 to 20. The greatest number of different feeding guilds was at Stable Road (Table 6). Only the foraging strata component of the feeding guild assignments was significantly different among location Associations in a chi-square analysis (Table 7). In Association I, herbaceous level foragers showed a much higher frequency value from the expected chi-square value. Twenty-five species were represented. Upper canopy foragers were lower than expected; only six species were represented. In Associations II and III, herbaceous foragers were lower than expected. Association III had a greater value of tree trunk foragers. Association IV had a high level of species feeding in the upper canopy, with 28 representatives.

Two components of the nesting guild assignments were significantly different among locations, nest site preference and the number of broods per season. Nest site preferences in herbaceous, shrub, canopy, and the other catagories had high values for Association I (Table 8). The herbaceous, shrub, and other categories had more species than expected, while the canopy group had fewer. Association II also had lower than expected frequencies for herbaceous and other nest site preferences. Species in Association III were canopy layer, and secondary cavity users. Association IV also had a high frequency of secondary cavity users. Shrub nesters were fewer than expected.

Chi-square values for the number of broods per season were particularly high in Association I (Table 9). Within the Association, species producing two broods per season showed the highest frequency value. The same group of species had a lower than expected value in Association II. But the highest frequency was with the single brood species. Association III had a high level of species with two broods per season. The highest frequency in Association IV also was from the two broods per season category, but this value was lower than expected. Lists of the guilds found at each location are in Appendices F and G.

Stepwise Regression

Regression models for the four bird variables representing the year round measurements, bird diversity overall (BDO), evenness overall (EO), bird richness overall (BRO) and feeding guild richness overall (GFRO), produced high R^2 values. A list of all the variable name abbreviations used in the models is in Appendix H. Appendix I lists all the dependent variables and their models.

The best model for bird diversity uses six independent variables to obtain an R^2 value of 0.99 (Table 10). The first variable entered, shrub diversity, contributes the most to the R^2 value. Seven independent variables were used to get the best model for evenness. Tree density was the first variable entered, but it was soon replaced by tree diversity. Bird richness may be predicted with 99% confidence by using a six variable model. Density of trees with a DBH of 4 to 6 inches was the best variable for the beginning model in the stepwise procedure. In the final model, tree density is the only variable which has a probability level greater than 0.05. Tree density was the first variable entered in the model for feeding guild richness and it had a predictive accuracy of 52%. All the habitat variables in this model were highly significant ($P<.05$).

Avian Seasonal Dynamics

The relative distributions of bird species and individuals were also summarized within the different seasons. For most of the analyses, fall and winter data were compiled together.

Correlations

Highly significantly correlated bird variables reviewed from the spring collections were diversity and evenness (Table 11). Diversity was negatively correlated with shrub species diversity and richness. Evenness was negatively correlated with density of trees with DBH greater than 6 inches and with richness of trees with DBH of 4 to 6 inches. Tree density was positively correlated with bird evenness.

Bird species evenness was the only summer bird variable significantly correlated with habitat measurements (Table 12). All the correlations were negative and consisted entirely of tree variables.

In the fall, there were positive correlations of tree richness with bird diversity and richness. Evenness was negatively correlated with canopy cover, width and area of vegetative strip (Table 13).

Bird Species Distributions

Bird species diversity had no regular trend between seasons within locations (Fig. 3). Six of the areas had the highest diversity in the spring; Stable Road and Lichen Bottom had high diversities in the summer, while Frog Green and Hydraulic North had high diversities in the fall and winter seasons. Both locations in Association I had a decrease in diversity through the year.

Bird species evenness values were high in the spring, then followed a trend of decrease in the summer and increase in the fall and winter, except for two locations, Ditch Fence and Killdeer (Fig. 4). Spring values ranged from 0.802 to 0.916. Summer values ranged from 0.723 to 0.934. The combined fall and winter values ranged from 0.645 to 0.948.

Bird species richness values followed a trend of decrease through the year at all locations except Stable Road, Frog Green and Lichen Bottom (Fig. 5). These three areas had an increase in the number of species in the summer. The patterns for species richness are not similar to those of species diversity.

Variations

Analysis of variance was conducted for each of the three seasonal groups using Associations and locations as classes. The only significant differences were between locations (Table 14). Bird species diversity in the spring was significantly different between locations. Deer Dike was different from Frog Green and Lichen Bottom. Six locations, Killdeer, Ditch Fence, East Arm, Popsickle Cottonwood, Homestead Pond and Hydraulic North, were different from Lichen Bottom. Frog Green was different from Deer Dike and Lichen Bottom was different from Deer Dike, Killdeer, Ditch Fence, East Arm, Popsickle Cottonwood, Homestead Pond, and Hydraulic North. Stable Road was not significantly different from any other location.

Bird species richness in the spring was also significantly different between locations. Six locations, Ditch Fence, East Arm, Hydraulic North, Homestead Pond, Popsickle Cottonwood, and Stable Road were different from Lichen Bottom. Deer Dike and Killdeer were not different from Frog Green and Lichen Bottom. Frog Green was different from Deer Dike and Killdeer. Lichen Bottom was also different from Deer Dike and Killdeer as well as Ditch Fence, East Arm, and Hydraulic North.

Bird species evenness in the summer was significantly different between locations. Ditch Fence was different from East Arm, Stable Road, Hydraulic North, and Killdeer; these four locations were each different from Ditch Fence. There were no other significant differences. Evenness also showed significant differences between locations in the fall and winter combined seasons. Deer Dike, East Arm, and Ditch Fence were different from Killdeer and Lichen Bottom, just as these two were different from Deer Dike, East Arm and Ditch Fence. There were no other significant differences.

Guild Distributions

There were greater numbers of feeding guilds in the spring and summer at the various locations than in the fall and winter (Table 15). Richness values ranged from 7 to 13 in the spring, 6 to 14 in the summer, 2 to 7 in the fall and 4 to 12 in the winter. There was no observable trend in richness values between Associations. Nesting guild richness values were summarized for all seasons. Fall and winter values represent the numbers of those guild members present at these locations even in the non-breeding season (Table 16). Values ranged from 7 to 13 in the spring and from 4 to 14 in the summer. A list of the guilds present at each location by location groups and by seasonal groups is in Appendices I and J.

Stepwise Regression

Regression models were produced for the bird variables diversity, evenness, richness, feeding guild richness and nesting guild richness, in all seasonal groups. Bird diversity and evenness models for spring, summer, and fall and winter combinations were made. Two bird species richness models, spring and summer, were made. Feeding guild richness models for spring, summer, fall and winter were produced. Nesting guild richness was predicted by two models, spring and summer, for the breeding season. All these bird variable models are listed in Appendix G.

CHAPTER V

DISCUSSION

Bird and Habitat Relationships Over All Seasons

The Associations as Gradients

The study locations were grouped into the Associations as a successional gradient of shrub-ground cover amounts to small tree-shrub abundance to more mature tree characteristics. In addition, the width of the vegetative strips was significantly correlated with the Associations. Mature tree characteristics (tree dominance, canopy cover, richness of DBH classes, richness and density of trees 4-6 inch DBH, and richness of trees greater than 6 inch DBH) occur in the wider locations. Locations in Associations II, III and IV are wider, yet they include various average widths of the locations. Therefore, a specific definitive width for an optimum width range for bird species diversity is possible only with a simultaneous consideration of the vegetative structure. Trends of the bird communities along this vegetational gradient can determine an optimum width range.

Bird Diversity Measurements in the Associations

The components of the bird diversity measurements corresponded to particular vegetation variables. There was a significant negative correlation of shrub diversity and richness with bird species diversity, over all seasons. Those locations characterized by high shrub diversity and richness have narrower widths of vegetation. Yet the two locations with the narrowest widths supported a high bird species diversity and evenness. Bird diversity decreased in Association II then increased in Association III. Grassland bird species, such as field sparrow, meadowlark and dickcissel contributed greatly to the diversity measurements in the narrowest width locations, Association I. These species are abundant in the surrounding habitat of grazing lands. The riparian habitat is a noncritical habitat type for these species. More stenoecious species, such as Eastern bluebird, black and white warbler, and summer tanager, comprised the bird diversity measurements in Associations II and III. These bird species are usually more dependent on their required habitat and are easily susceptible to disturbance compared to grassland species (Wiens 1974, Balda 1975, Brewer and Swander 1977, Heller 1978, Anderson 1979).

Bird species of the midwidth locations in Association II were more typically woodland species. These woodland species, such as red-headed woodpecker, red-eyed vireo, Eastern wood pewee, and barred owl, are more dependent on the wooded riparian habitats in Associations II, III, and IV. But the greater numbers and diversity of species are in the widest tracts of Associations III and IV, except for the location, Stable Road, of Association II. Stable Road had outstandingly high diversity, evenness, and richness figures compared to all other locations (Table 4). According to the vegetation analysis, it was grouped in Association II, and it has a medium average width, 76m. Two possible explanations for this difference may be the topography of the location and the proximity to a perennial source of water. The creek at this location flows at the bottom of a steep sided ravine. This depression can trap humidity and help maintain a more stable temperature as well as provide added protection from wind. Karr (1982) found that in the tropics, such a slight depression contained more birds in the dry season because of higher humidity. In the winter, the reduced wind chill and temperature fluctuations may attract a greater number of bird species simply for shelter. Also, this location is within a quarter mile of Lake Carl Blackwell, a year-round source of water, which may add another dimension to a structurally practical habitat, as other researchers have noted (MacArthur 1964, Carothers and Johnson 1974).

The other locations in Association II supported low and medium values of bird diversity, yet harbor many forest dependent birds. If a manager's objective were to maximize bird species diversity, according to this analysis he or she should maintain narrow, early growth vegetative strips along streams or extremely wide, mature stands. This could result in a reduction of habitat for many bird species whose value is not weighted in the diversity index.

Species diversity as a sole goal of management has been criticized by many researchers (Hurlbert 1971, Peet 1974, Back 1982). Efforts have been made to find alternative measures (James and Rathbun 1981) and to promote a consideration of other factors in the makeup of species in a community. Samson and Knopf (1982) distinguished within-habitat diversity from between-habitat diversity and revealed the species composition dynamics of two communities and the importance of including a broader scope by looking at between-habitat diversity. The types of species making up similar diversity indexes may be totally different in two communities along a habitat-size gradient. Also, in a regional association some habitat may have a low diversity of species, yet contribute substantially to the between-habitat diversity of that region. And there may be a danger in managing to increase a low within-habitat diversity by decreasing between-habitat diversity. This could result in an exclusion of species dependent on particular habitat characteristics, such as contiguous area or width of vegetative strips. In managing for a stable bird community, species abundances in different seasons and in guild distributions must be considered along with a single diversity index of a habitat.

Guild Distributions in the Associations

Both feeding and nesting guilds showed significant trends along the vegetational gradient of the Associations. The richness of feeding guilds was positively correlated with tree density, which is highest in Association II, III, and IV. Only the foraging strata component of the feeding guild assignments was significant in a Chi-square analysis. Not surprisingly, Association I had a high number of herbaceous level feeding species and a low number of upper canopy feeders. In contrast, Association II supported a low number of herbaceous foragers. These wider tracts with denser, more mature trees had the greatest proportion of both midcanopy and upper canopy feeding species. Similarly, Association III had a low number of herbaceous feeders and a high number of tree trunk foragers and midcanopy feeders. The wider tracts of mature trees with high tree dominance and low density of shrubs supported a high number of upper canopy gleanors, as well as a greater number of tree trunk foragers. Similar uniformity of bird population structures after a certain degree of vegetative parameters are met, were found by Bond (1957).

Two of the three components comprising the nesting guild assignments were significant in the chi-square analysis, nest site preference and the number of broods per season. In Association I, there was a high number of species preferring to nest at herbaceous, shrub, and canopy levels. Most of the species in this Association are typical grassland birds that may be considered prolific. This Association contained a high number of species attempting two broods per season and of all the Associations, it supported the greatest number of species nesting three times per season. In contrast, Association II harbors bird species which are more dependent on this habitat and possibly more sensitive to disturbance. Of all the locations, the midwidths supported the greatest number of species that nest in shrubs, in the canopy, and on the ground, as well as the greatest number of primary cavity excavators and secondary cavity nesters. In addition, this Association had the highest number of species producing only one or two broods per season. In particular, the high frequency of single brood per season species (80) was much higher than expected from a homogeneous distribution (Table 9).

The wider tracts of Associations III and IV still support similar species of nest preference as in Association II. Association III had the highest number of secondary cavity nesters from what was expected in a homogeneous distribution (Table 8). Association IV had more secondary cavity nesting species but at a proportion lower than the calculated expectations. Shrub, canopy and primary cavity excavators were all present in these Associations but not in as high frequencies as Association II. Very high frequencies of one and two broods per season species were still accomodated in Associations III and IV. No species with three broods per season occurred in Association III. The wider, mature tracts still support some of the species found in the midwidths, though not as many. Wider tracts still contain the capacity to shelter some sensitive species producing only one or two broods per season. The greatest variety of nest sites must be available beginning in the midwidths of Association II. For bird species producing few broods, and nesting on the ground, such as chuck-will's widow and Louisiana waterthrush, only Association II contains the most preferred habitats. The midwidths are characterized by denser, more mature trees and a higher shrub richness than the narrower tracts. At the same time, Association II has lower tree dominance and a more diversified diameter of trees than the wider, largest tracts. For bird species susceptible to disturbance, the optimum width range would be that of the averages in Association II, 38-98 meters.

Bird and Habitat Relationships Between Seasons

The measurements of bird species diversity and richness followed similar general trends of increase and decrease from spring to summer. In the spring, winter residents may be present while summer residents are arriving, resulting in a greater number of species. However, in the fall-winter season, bird species richness decreased while the diversity increased from the summer at five locations, East Arm, Frog Green, Lichen Bottom, Homestead Pond, and Hydraulic North. This reflects a more even distribution of individuals among the species detected at these locations of Associations II, III, and IV. Measured evenness values were highest at this season in all these locations except Frog Green, which was higher than in the spring but not summer. A greater evenness of distribution may be accounted for in the fall-winter season by a more rigorous environment and unpredictable food resources (Tramer 1969, Kricher 1972). These factors will vary in different habitat structures and can restrict certain species yet support many individuals of a single species. Permanent, year-round residents will occupy the available habitat more evenly, while winter visitors usually are in large populations and require special features of a habitat (Anderson and Ohmart 1977b). The fall-winter season showed reduced diversity values compared to the breeding season at all locations except Frog Green and Hydraulic North (Fig. 4). Most likely this is due to a lack of territoriality and the great mobility of migrants in the fall (Heller 1978).

Guild richness values were highest in the spring and decreased slightly in the summer, similar to species richness values. Again, this may be a result of spring being a time of transition for most species. Feeding guild richness is probably attuned to the timing of plant and insect recrudescence. Nesting guild richness values were highest in Association II in the summer. It is possible that the midwidth ranges are most supportive of a high variety of nesting species in the summer.

In the fall-winter season, the guild richness values were low. Riparian habitat in this area of Oklahoma shelters few types of nesting species over the winter (Table 16). Feeding guild numbers were lowest for all the locations except Hydraulic North (Table 15). This location accommodated the highest richness of feeding guilds in the fall-winter season and was the only location with an increased bird species diversity value for this season. Hydraulic North is the location with the greatest tree dominance, more mature trees of fewer species richness and a high diversity and richness of shrubs. This combination may be the ultimate habitat structure for fall and winter food and shelter for the greatest variety of bird species.

Conclusions

The composition of bird communities can reflect habitat quality. Bird species diversity is a commonly measured indicator. This index is best generated for use in relative comparisons of riparian tracts. Bird species diversity was predicted in the regression models using certain habitat variables. It may be more desirable for land use managers to measure the vegetation of the habitat and rely on such models for an estimate of the bird diversity. Particularly since regression models for seasonal diversities were produced, one could manage the habitat for a more critical season. According to the results of this study, however, a manager should not consider within-habitat diversity alone, especially since easily recognizable habitat characteristics can suggest management guidelines.

Riparian habitat is physiographically distinct from adjacent habitats and so can contribute greatly to regional diversity. A manager should broaden the scope of a management plan to consider not only a project site but the area surrounding that habitat and the contribution it makes to the diversity of the region. Diversity within riparian habitat is influenced by the vegetation characteristics. The types of bird species making up that diversity may be a function of discernable features of the habitat, according to this study. The width of the riparian strip along with the overall maturity of the stand can be estimated so that the possible composition of the bird communities may be generalized. For rare bird species or those more sensitive to disturbance, specific requirements must be maintained. Topography, such as ravines, should be noted, as well as the proximity of a year round source of water. These features can allow a habitat to accomodate a greater number of species and types of feeding guilds. An optimum width range for bird diversity including woodland dependent species and those species susceptible to disturbance, would be from 38 to 98 meters of many species of dense trees with a DBH of 1 to 3 inches and a high shrub density. For high bird species diversity, many feeding guilds, and woodland dependent species, particularly in the fall and winter seasons, mature trees of many species with a diverse understory of many DBH sizes in a strip at least 78 meters wide should be supportive. With the use of these guidelines, the value of riparian habitat to bird communities and consequently, many wildlife species, will not be lost.

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Table 1. Highly correlated ($P < 0.05$) bird and habitat variables

Bird variable	Habitat variable	R^2
Bird species diversity	Shrub species diversity	-0.77
Bird species diversity	Shrub richness	-0.76
Feeding guild richness	Tree density	0.65
Bird species evenness	Tree density	-0.63

Table 2. Factor scores for principal components of habitat variables.

Variable	Factor 1 Mature tree characters	Factor 2 Small tree characters	Factor 3 Shrub and ground
Tree dominance	0.92	-0.23	0.08
Canopy cover	0.90	0.12	-0.31
Richness trees with DBH > 6 in	0.89	-0.35	0.07
Richness of tree DBH classes	0.86	-0.37	-0.04
Width	0.82	-0.18	0.16
Density trees with DBH 4-6 in	0.80	0.07	0.17
Tree density	0.77	0.51	0.34
Shrub diversity	0.77	0.28	-0.51
Area	0.77	-0.34	0.00
Density trees with DBH > 6 in	0.70	0.14	-0.14
Density trees with DBH 1-3 in	0.51	0.72	0.43
Richness trees with DBH 1-3 in	0.51	0.71	0.45
Tree diversity	-0.46	0.73	-0.02
Shrub richness	0.45	0.42	-0.66
Shrub density	-0.14	0.82	0.03
Tree richness	-0.12	0.87	-0.17
Ground cover	-0.07	-0.25	0.62

Table 3. Principal component analysis assignment of study locations into similar Associations.

Association	Locations
I	Popsickle Cottonwood (PC) Ditch Fence (DF)
II	East Arm (EA) Deer Dike (DD) Stable Road (SR) Frog Green (FG) Lichen Bottom (LB)
III	Homestead Pond (HP)
IV	Killdeer (KD) Hydraulic North (HN)

Table 4. Bird species diversity, evenness, richness over all seasons

Association	Location	Diversity	Evenness	Richness
I	Popsickle Cottonwood	0.690	0.847	24
	Ditch Fence	0.698	0.861	21
II	East Arm	0.579	0.861	20
	Deer Dike	0.494	0.819	22
	Stable Road	0.660	0.719	30
	Frog Green	0.178	0.769	17
	Lichen Bottom	0.355	0.831	17
III	Homestead Pond	0.544	0.823	22
IV	Killdeer	0.542	0.823	25
	Hydraulic North	0.642	0.777	30

Table 5. Analysis of variance significant ($P < 0.05$) independent variables

	Dependent variables		
Classes	BSD	BSR	BSE
Location, Season	Season	Season	Location
Association, Location	-	-	Association Location
Association, Location, Season	Season Location X Season	Season Location X Season	Location

Table 6. Feeding guild richness over all seasons.

Association	Location	Feeding Guild Richness
I	Popsickle Cottonwood	13
	Ditch Fence	14
II	East Arm	12
	Deer Dike	14
	Stable Road	20
	Frog Green	15
	Lichen Bottom	14
III	Homestead Pond	14
IV	Killdeer	17
	Hydraulic North	16

Table 7. Feeding Guild-foraging strata component; values of Frequency Expected and Chi-square Test (P= 0.002).

Foraging strata	Association			
	I	II	III	IV
Ground				
freq.	15.0	32.0	5.0	15.0
expt.	13.7	32.0	5.3	16.0
chi2.	0.1	0	0	0.1
Herbaceous				
freq.	25.0	20.0	2.0	14.0
expt.	12.5	29.1	4.9	14.6
chi2.	12.6	2.9	1.7	0
Midcanopy				
freq.	24.0	72.0	12.0	27.0
expt.	27.6	64.5	10.7	32.2
chi2.	0.5	0.9	0.1	0.8
Upper Canopy				
freq.	6.0	36.0	6.0	28.0
expt.	15.5	36.3	6.0	36.1
chi2.				
Trunk				
freq.	6.0	18.0	5.0	6.0
expt.	7.1	16.7	2.8.	8.4
chi2.	0.2	0.1	1.8	0.7
Air				
freq.	1.0	2.0	0	0.7
expt.	0.6	1.4	0.2	0.7
chi2.	0.2	0.2	0.2	0.7

Table 8. Nesting Guild - nest site preference component; values of Frequency, Expected, and Chi-square Test (P = 0.007).

Nest Site Preference	Association I	II	III	IV
Ground				
freq.	8.0	17.0	2.0	6.0
expt.	6.7	15.3	3.1	7.9
chi2.	0.3	0.2	0.4	0.4
Herbaceous				
freq.	8.0	4.0	2.0	5.0
expt.	3.8	8.8	1.8	4.5
chi2.	4.5	2.6	0	0.1
Shrub				
freq.	31.0	41.0	7.0	29.0
expt.	21.8	50.2	10.3	25.7
chi2.	3.9	1.7	1.0	0.4
Canopy				
freq.	5.0	33.0	8.0	1.4
expt.	12.1	27.9	5.7	14.3
chi2.	4.2	0.9	0.9	0
1° Cavity				
freq.	9.0	31.0	6.0	16.0
expt.	12.5	28.8	5.9	14.8
chi2.	1.0	0.2	0	0.1
2° Cavity				
freq.	8.0	40.0	9.0	13.0
expt.	14.1	32.5	6.7	16.7
chi2.	2.7	1.7	0.8	0.8
Other				
freq.	3.0	0	0	2.0
expt.	1.0	2.3	0.5	1.2
chi2.	3.9	2.3	0.5	0.6

Table 9. Nesting Guild - number broods/season component; values of Frequency, Expected, and Chi-square Test (P = 0.0002).

		Number Broods/Season		
Association	Value	1	2	3
I	freq.	13.0	52.0	7.0
	expt.	30.1	38.7	3.2
	chi2.	9.7	4.6	4.4
II	freq.	82.0	80.0	4.0
	expt.	69.3	89.3	7.4
	chi2.	2.3	1.0	1.6
III	freq.	16.0	18.0	0
	expt.	14.2	18.3	1.5
	chi2.	0.2	0	1.5
IV	freq.	38.0	42.0	5.0
	expt.	35.5	45.7	3.8
	chi2.	0.2	0.3	0.4

Table 10. Maximum R-square improvement regression models for bird variables over all seasons.

Dependent variable	R^2	Independent variables	Prob > F
Bird diversity over all seasons	0.99	Area	0.0046
		Shrub species diversity	0.0001
		Density trees > 6 in.	0.0002
		Shrub density	0.0069
		Tree species richness	0.0007
		Richness trees 4-6 in.	0.0012
Bird evenness over all seasons	0.99	Tree species diversity	0.0063
		Density trees 1-6 in.	0.0047
		Density trees > 6 in.	0.0277
		Ground cover	0.0336
		Richness trees 1-3 in.	0.0050
		Richness trees 4-6 in.	0.0114
		Richness trees > 6 in.	0.0129
Bird richness over all seasons	0.99	Tree species diversity	0.0145
		Shrub species diversity	0.0020
		Tree density	0.2939
		Density trees 4-6 in.	0.0080
		Tree species richness	0.0082
		Richness trees 4-6 in.	0.0221
Feeding guild richness over all seasons	0.99	Area	0.0366
		Shrub density	0.0025
		Ground cover	0.0019
		Tree species richness	0.0057
		Richness trees 4-6 in.	0.0037
		Shrub richness	0.0051

Table 11. Highly correlated ($P < 0.05$) spring bird and habitat variables.

Bird variable	Habitat variable	R^2
Bird species diversity	Shrub species diversity	-0.66
Bird species diversity	Shrub richness	-0.67
Bird species evenness	Density trees DBH > 6 in.	-0.64
Bird species evenness	Tree density	0.65
Bird species evenness	Richness trees DBH > 6 in.	-0.66

Table 12. Highly correlated ($P < 0.05$) summer bird and habitat variables .

Bird variable	Habitat variable	R^2
Bird species evenness	Density trees DBH 4-6 in.	-0.69
Bird species evenness	Tree density	-0.69
Bird species evenness	Richness trees DBH 4-6 in.	-0.68
Bird species evenness	Tree dominance	-0.68
Bird species evenness	Canopy cover	-0.71

Table 13. Highly correlated ($P < 0.05$) fall bird and habitat variables.

Bird variable	Habitat variable	R^2
Bird species diversity	Tree richness	0.68
Bird species richness	Tree richness	0.70
Bird species evenness	Canopy cover	-0.66
Bird species evenness	Width	-0.74
Bird species evenness	Area	-0.82

Table 14. Analysis of variance significant sources of variation within seasons.

Source of variation	BSD			BSR			BSE		
	SP	SU	FW	SP	SU	FW	SP	SU	FW
Association	-	-	-	-	-	-	-	-	-
Location	*	-	-	*	-	-	-	*	*
Association X Location	-	-	-	-	-	-	-	-	-

*Indicates significance $P < 0.05$.

Table 15. Feeding guild richness values within seasons.

Location	Spring	Summer	Fall	Winter
Deer Dike	12	11	2	7
Ditch Fence	11	9	7	4
East Arm	12	6	6	5
Frog Green	7	10	6	7
Hydraulic North	11	9	4	12
Homestead Pond	10	6	3	6
Killdeer	13	14	4	4
Lichen Bottom	8	9	7	5
Popsickle Cottonwood	8	11	4	8
Stable Road	10	12	7	10

Table 16. Nesting guild richness values within seasons.

Location	Spring	Summer	Fall	Winter
Deer Dike	12	9	2	7
Ditch Fence	10	8	5	3
East Arm	9	4	6	5
Frog Green	7	8	5	7
Hydraulic North	11	12	4	10
Homestead Pond	10	10	3	6
Killdeer	13	12	5	4
Lichen Bottom	8	9	6	5
Popsickle Cottonwood	12	11	5	7
Stable Road	11	14	7	8

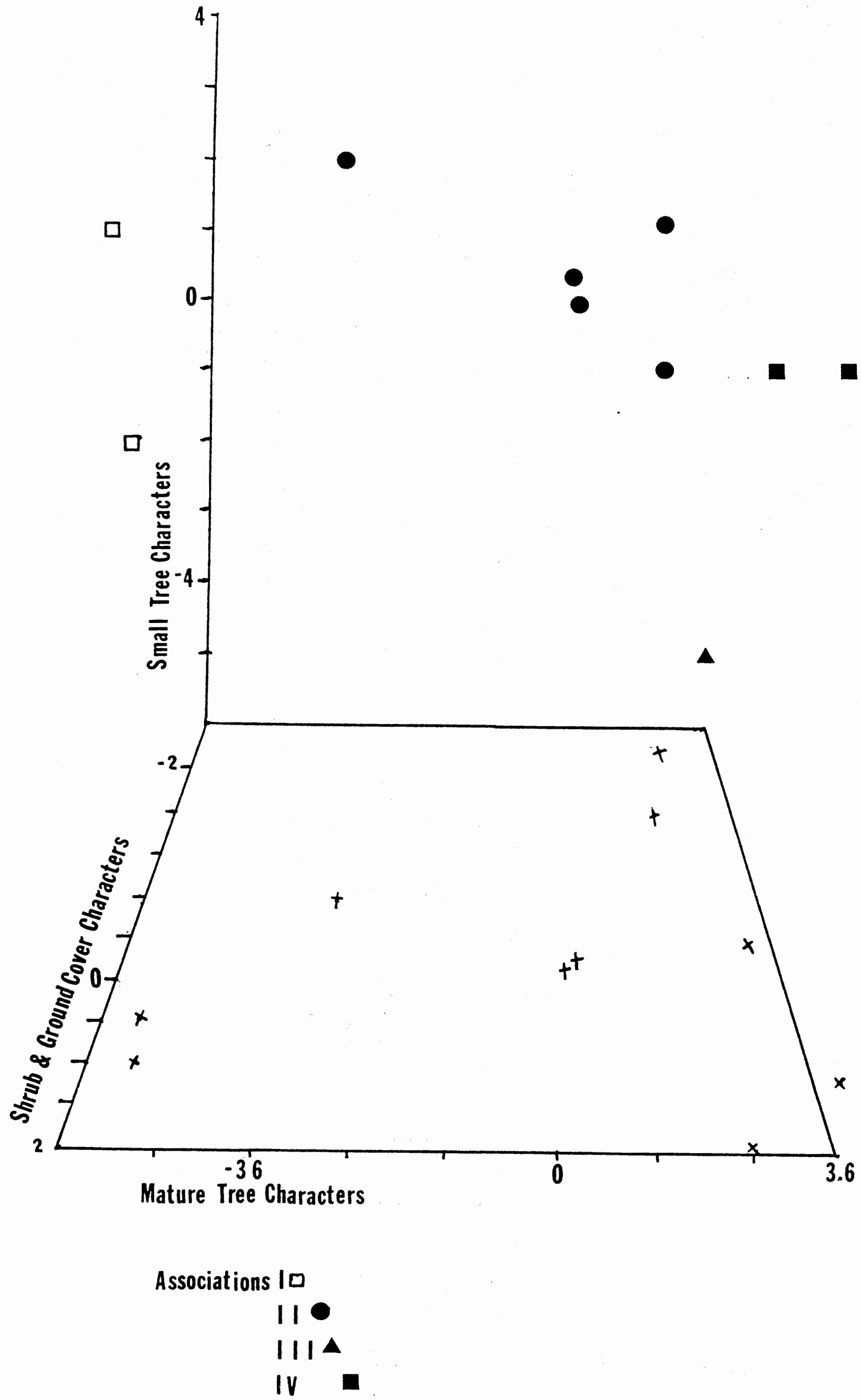

Fig. 1. Principal component grouping of locations into Associations.

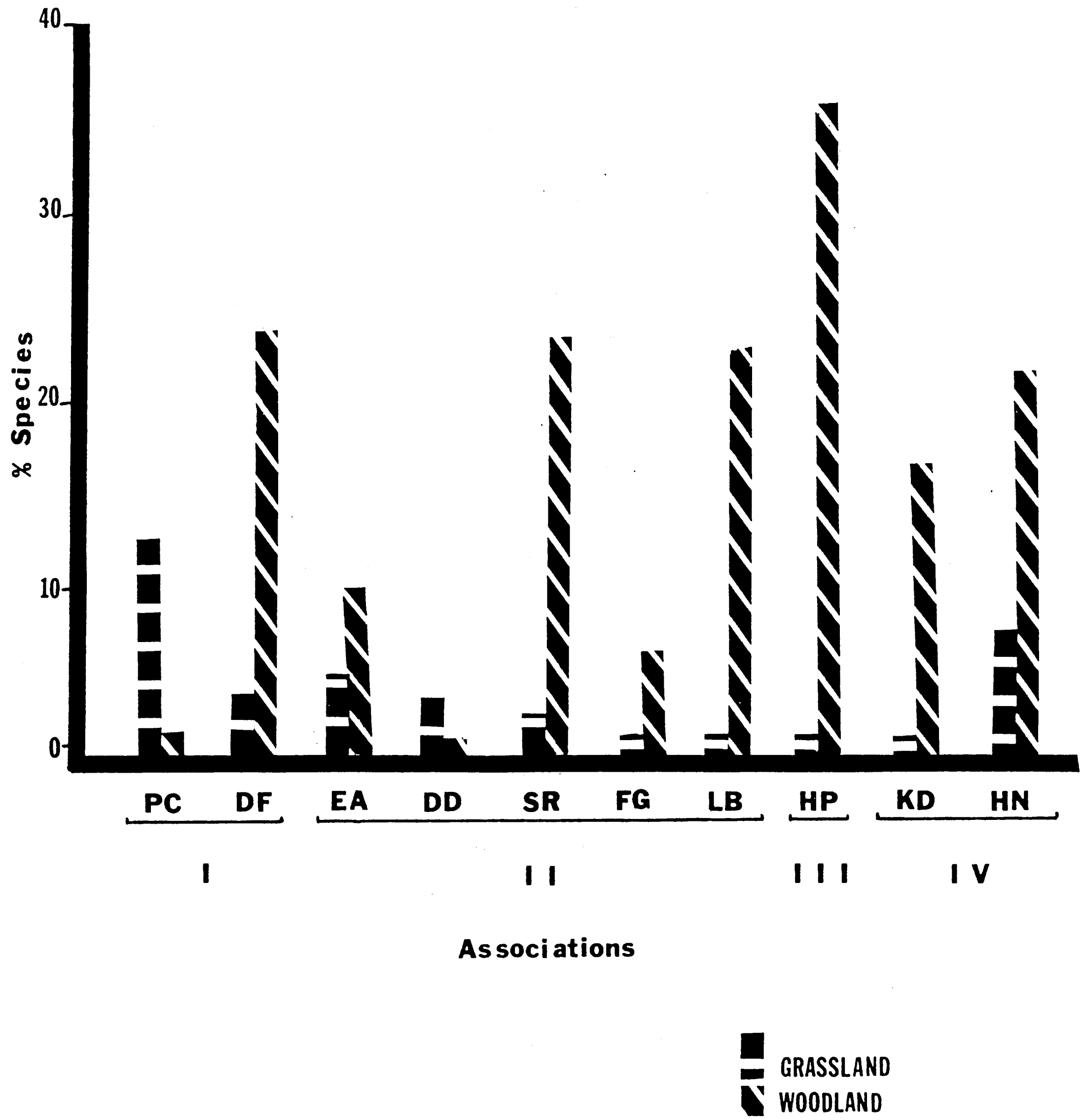

Fig. 2. Percents of grassland and woodland bird species, excluding edge species, at each location.

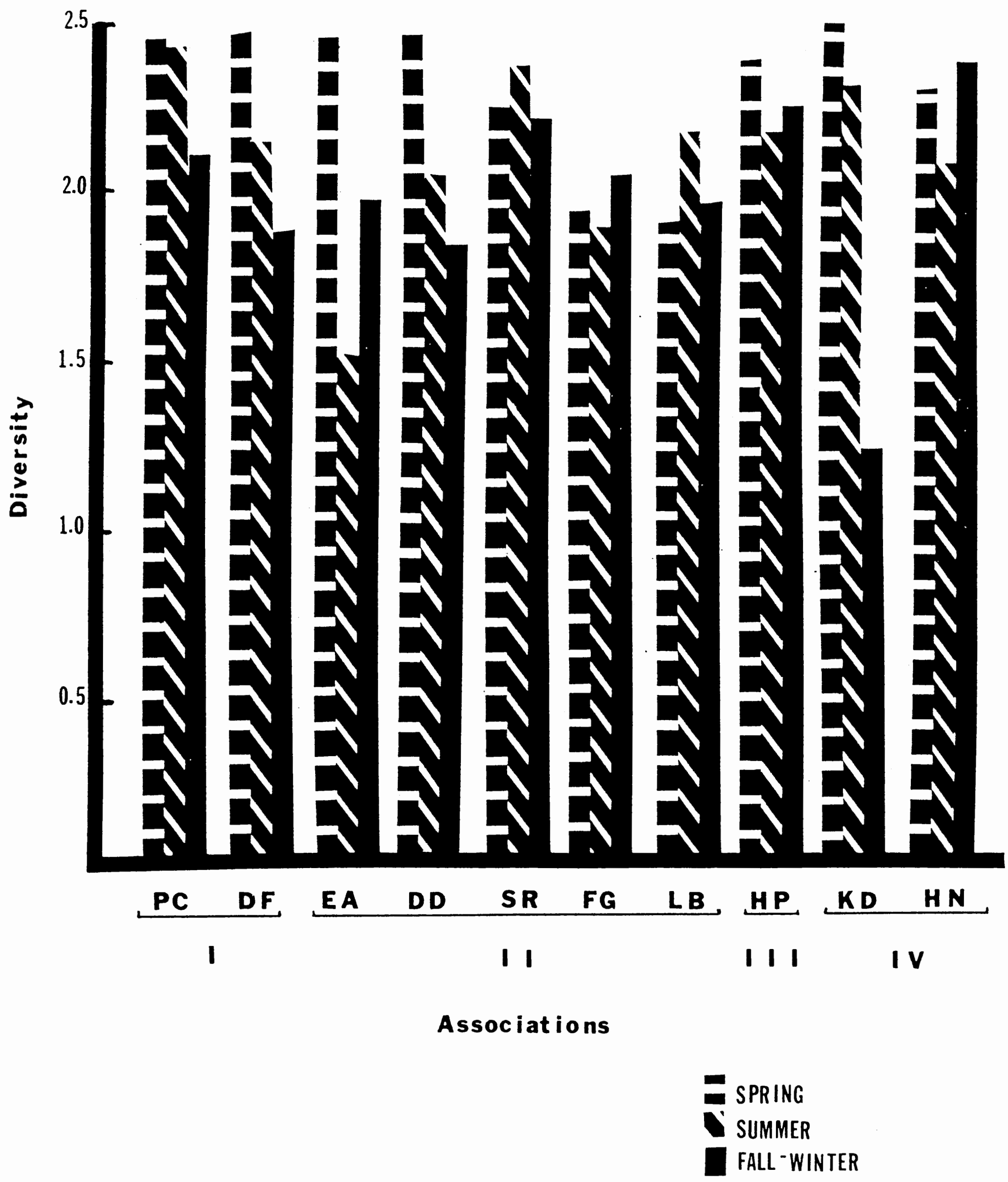

Fig. 3. Bird species diversity in spring, summer, and fall-winter at each location.

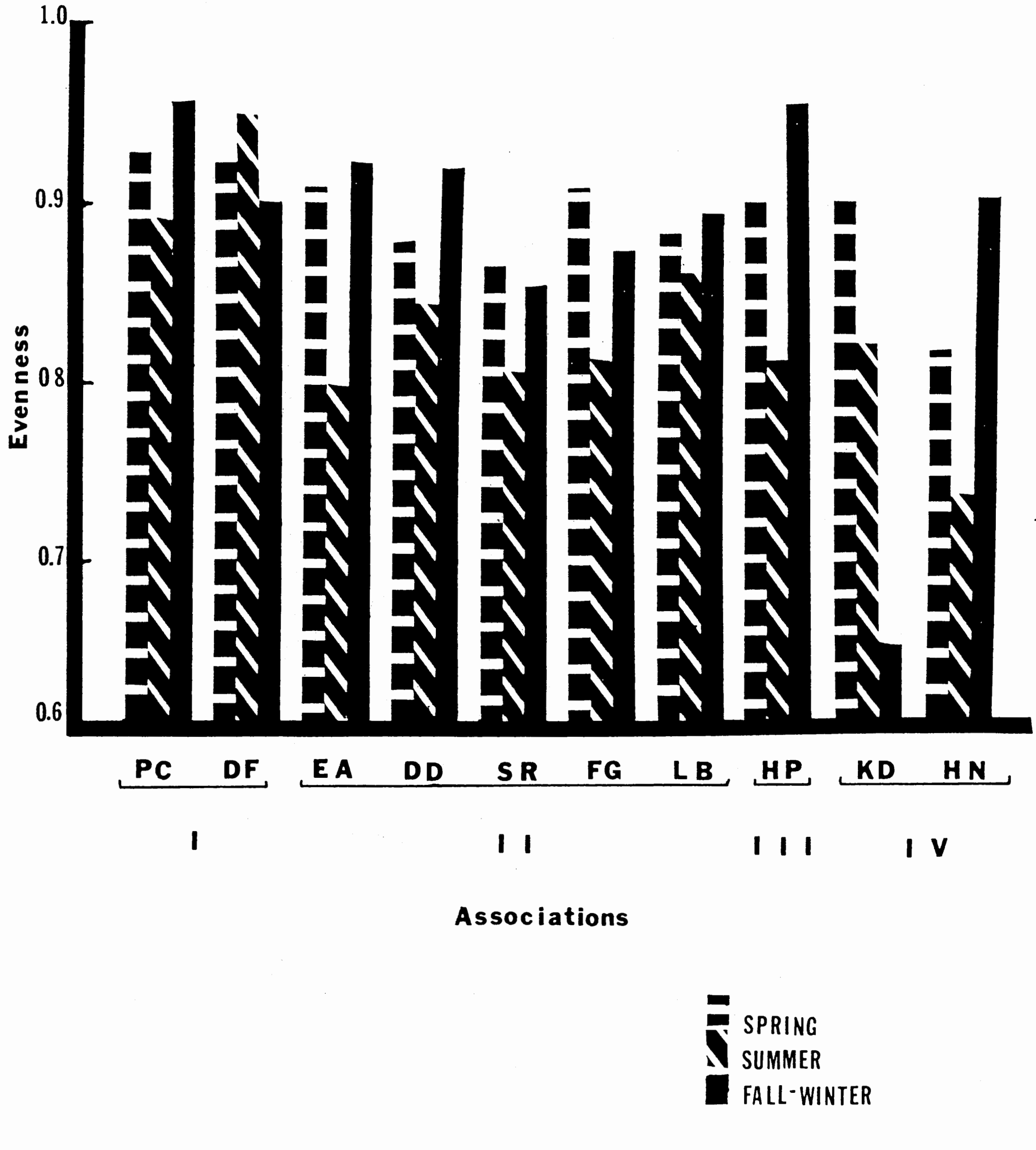

Fig. 4. Bird species evenness in spring, summer, and fall-winter at each location.

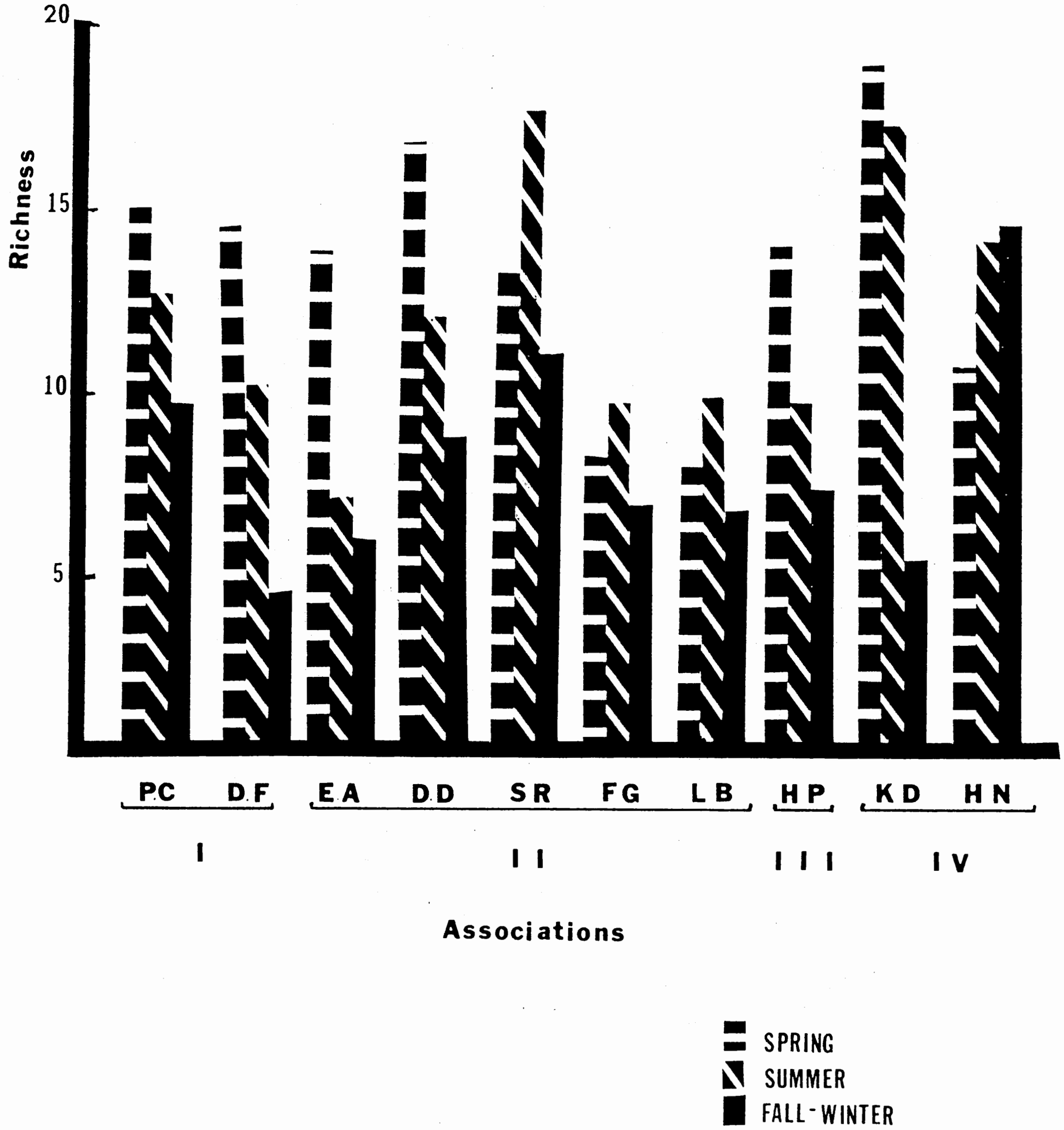

Fig. 5. Bird species richness in spring, summer, and fall-winter at each location.

APPENDIXES

APPENDIX A

HABITAT DESCRIPTIVE STATISTICS

Location: Deer Dike (DD)

Legal description: T19N; R1E; Sec. 20; S.E. 1/4

Width of vegetation (m): 98 Ground cover (%): 40

Length of area (m): 75 Canopy cover (%): 100

Diversity of tree species: 1.795 Richness of tree species: 8

Diversity of shrub species: 1.041 Richness of shrub species: 6

Species	Density	Dominance	Importance value
A. Trees			
AE	202.34	17.0510	33.1658
BJ	40.47	4.4696	9.2593
CP	80.94	16.0020	21.2112
HB	242.81	18.8712	30.2550
PT	768.90	152.9049	112.9538
RB	202.34	4.2488	22.7308
RD	238.28	3.4763	26.4363
SN	202.34	45.3030	43.9363
B. Shrubs			
AE	87.50	0.4772	-
CB	43.75	0.23861	-
CP	12.50	0.0682	-
PT	6.25	0.0341	-
RB	43.75	0.2386	-
RD	418.75	2.2839	-

Location: Ditch Fence (DF)

Legal description: T18N; R1E; Sec. 6; S.E. 1/4

Width of vegetation (m): 35 Ground cover (%): 86.7

Length of area (m): 68 Canopy cover (%): 16.7

Diversity of tree species: 1.939 Richness of tree species: 10

Diversity of shrub species: 0.352 Richness of shrub species: 5

Species	Density	Dominance	Importance value
A. Trees			
AE	161.87	5.9594	32.6547
BJ	242.81	9.1599	42.6307
HB	80.94	1.8761	14.7513
MP	80.94	7.1731	22.3163
PT	40.47	1.3795	11.3394
RD	364.22	6.2363	46.5622
RM	40.47	0.4970	11.0785
RY	40.47	0.4970	10.0785
SN	404.69	12.9140	65.4667
WL	40.47	24.3350	44.1205
B. Shrubs			
AE	43.75	0.2386	-
BG	6.25	0.0341	-
BJ	6.25	0.0341	-
RB	6.25	0.0341	-
RD	725.00	3.9542	-

Location: East Arm (EA)

Legal description: T19N; R1E; Sec. 29; N.E. 1/4

Width of vegetation (m): 38 | Ground cover (%): 73.3

Length of area (m): 63 | Canopy cover (%): 86.7

Diversity of tree species: 2.084 | Richness of tree species: 12

Diversity of shrub species: 1.249 | Richness of shrub species: 7

Species	Density	Dominance	Importance value
A. Trees			
AE	364.22	15.8690	38.8721
BG	40.47	1.380	8.2426
BJ	40.47	9.3250	11.6892
CP	40.47	1.380	8.2426
HB	323.75	18.0990	37.4245
JP	40.47	0.4970	7.8596
MP	80.94	9.3810	14.0940
PT	323.75	157.5970	87.5636
RB	283.28	9.6580	21.0132
RD	40.47	1.380	8.2426
RM	40.47	2.7040	8.8170
SN	80.94	3.201	16.6764
B. Shrubs			
AE	25.00	0.1363	-
CB	125.00	0.6817	-
CP	6.25	0.0341	-
JP	56.25	0.3068	-
RD	356.25	1.9430	-
RL	25.00	0.1363	-
SP	12.50	0.0682	-

Location: Frog Green (FG)

Legal description: T19N; R1E; Sec. 29; N.W. 1/4

Width of vegetation (m): 56

Ground cover (%): 66.7

Length of area (m): 63

Canopy cover (%): 100

Diversity of tree species: 1.766

Richness of tree species: 10

Diversity of shrub species: 1.690

Richness of shrub species: 10

Species	Density	Dominance	Importance value
A. Trees			
AE	200.34	147.2780	54.7504
BL	445.15	62.8502	44.1823
CP	40.47	4.4696	8.5334
GA	121.41	96.8417	39.5732
HB	121.41	34.1567	24.6553
JP	40.47	0.4966	7.5879
RB	121.41	7.6700	12.4696
RD	1133.12	14.7889	59.7285
SE	80.94	10.7050	11.6046
SN	242.81	40.9438	36.9148
B. Shrubs			
AE	18.75	0.1022	-
BL	6.25	0.0341	-
CB	168.75	0.9204	-
GA	18.75	0.1022	-
HB	6.25	0.0341	-
JP	68.75	0.3749	-
PT	6.25	0.3409	-
RB	18.75	0.1022	-
RD	193.75	1.0567	-
SE	43.75	0.2386	-

Location: Hydraulic North (HN)

Legal description: T19N; R1E; Sec. 10; N.W. 1/4

Width of vegetation (m): 78

Ground cover (%): 73.4

Length of area (m): 62

Canopy cover (%): 100

Diversity of tree species: 1.623

Richness of tree species: 8

Diversity of shrub species: 1.207

Richness of shrub species: 5

Species	Density	Dominance	Importance value
A. Trees			
AE	1173.59	253.6644	101.0894
BL	40.47	0.4966	6.6780
HB	1052.18	75.5971	59.3614
PT	80.94	64.5611	21.6107
RB	80.94	0.9932	13.3461
RD	1052.18	22.1825	47.7533
RM	242.81	27.7004	23.1905
SN	283.28	14.9538	26.9905
B. Shrubs			
AE	37.50	0.2045	-
BL	31.25	0.1704	-
CB	162.50	0.8863	-
HB	25.00	0.1363	-
RD	268.75	1.4658	-

Location: Homestead Pond (HP)

Legal description: T19N; R1E; Sec. 20; S.W. 1/4

Width of vegetation (m): 116

Ground cover (%): 96.7

Length of area (m): 75

Canopy cover (%): 100

Diversity of tree species: 1.211

Richness of tree species: 6

Diversity of shrub species: 0.977

Richness of shrub species: 5

Species	Density	Dominance	Importance value
A. Trees			
AE	687.97	172.2181	97.0324
GA	80.94	120.6244	33.1850
HB	687.97	335.1105	122.8186
JP	40.47	0.4970	11.6686
RD	40.47	0.4970	11.6686
SN	80.94	0.7600	23.6168
B. Shrubs			
AE	162.50	0.8863	-
CB	31.25	0.1704	-
CP	12.50	0.0682	-
HB	18.75	0.1022	-
JP	6.25	0.0341	-

Location: Killdeer (KD)

Legal description: T19N; R1E; Sec. 10; N.W. 1/4

Width of vegetation (m): 141 Ground cover (%): 100

Length of area (m): 63 Canopy cover (%): 100

Diversity of tree species: 1.960 Richness of tree species: 10

Diversity of shrub species: 1.519 Richness of shrub species: 8

Species	Density	Dominance	Importance value
A. Trees			
AE	809.37	151.198	70.8713
BG	40.47	9.325	8.8941
HB	647.50	234.851	83.0010
JP	202.34	7.34	18.9746
PI	161.87	2.87	11.0515
PT	40.47	0.497	7.1287
RB	121.41	1.49	9.6262
RD	607.03	9.215	24.9641
RM	202.34	32.502	24.0061
SN	687.97	50.8212	41.4624
B. Shrubs			
AE	68.75	0.03497	-
BG	6.25	0.0341	-
CB	50.00	0.2727	-
HB	25.00	0.1363	-
PI	18.75	0.1022	-
PT	6.25	0.0341	-
RB	181.25	0.9885	-
RD	243.75	1.3294	-

Location: Lichen Bottom (LB)

Legal description: T19N; R1E; Sec. 29; N.W. 1/4

Width of vegetation (m): 79 Ground cover (%): 60

Length of area (m): 88 Canopy cover (%): 100

Diversity of tree species: 1.619 Richness of tree species: 8

Diversity of shrub species: 1.739 Richness of shrub species: 9

Species	Density	Dominance	Importance value
A. Trees			
BG	40.47	1.3795	8.8104
BJ	80.94	24.3897	24.3702
GA	526.09	126.0872	29.4923
HB	1211.41	2.3727	20.0004
MP	80.94	3.2004	17.7586
PT	607.03	156.2157	103.8931
RB	80.94	1.8761	17.3454
SN	80.94	4.9662	18.3096
B. Shrubs			
BG	6.25	0.0341	-
CB	106.25	0.5795	-
GA	25.00	0.1363	-
HB	18.75	0.1022	-
JP	131.25	0.7158	-
RB	43.75	0.2386	-
RD	106.25	0.5795	-
SE	6.25	0.0341	-
SS	6.25	0.0341	-

Location: Popsickle Cottonwood (PC)

Legal description: T18N; R1E; Sec. 5; S.W. 1/4

Width of vegetation (m): 25 Ground cover (%): 93

Length of area (m): 88 Canopy cover (%): 0

Diversity of tree species: 1.834 Richness of tree species: 7

Diversity of shrub species: 0.293 Richness of shrub species: 4

Species	Density	Dominance	Importance value
A. Trees			
BJ	121.41	15.6160	77.7858
GA	40.47	1.3795	24.5129
HB	40.47	0.4966	23.2246
MP	40.47	6.6768	32.2424
PT	80.94	7.1734	42.9670
SN	40.47	2.7038	26.4452
WL	40.47	34.4878	72.8221
B. Shrubs			
HB	6.25	0.0341	-
MP	6.25	0.0341	-
RB	6.25	0.0341	-
RD	293.75	1.6021	-

Location: Stable Road (SR)

Legal description: T19N; R1E; Sec. 17; S.W. 1/4

Width of vegetation (m): 76 Ground cover (%): 80

Length of area (m): 75 Canopy cover (%): 90

Diversity of tree species: 1.543 Richness of tree species: 10

Diversity of shrub species: 0.958 Richness of shrub species: 8

Species	Density	Dominance	Importance value
A. Trees			
BG	40.47	0.4966	8.6649
BJ	121.41	28.4179	27.068
CP	40.47	6.6768	10.4444
GA	40.47	29.1905	16.9267
HB	202.34	29.8526	24.5248
MP	40.47	1.3795	8.9191
PT	364.22	161.6236	76.5331
RB	121.41	3.2556	19.8230
RD	40.47	0.4966	8.6649
SN	1173.59	85.9158	98.4415
B. Shrubs			
BJ	31.25	0.1704	-
CB	31.25	0.1704	-
CP	18.75	0.1022	-
HB	18.75	0.1022	-
PT	25.00	0.1363	-
RB	50.00	0.2927	-
RD	606.25	3.3066	-
SS	6.25	010341	-

APPENDIX B

BIRD SPECIES CODES, NAMES, AND

GUILD ASSOCIATIONS

Code	Common name	Scientific name	Feeding guild	Nesting guild
BA	Barred Owl	*Strix varia*	515	611
BC	Brown Creeper	*Certhia familiaris*	243	-
BE	Bewick's Wren	*Thryomanes bewickii*	232	622
B6	Blue-gray Gnatcatcher	*Polioptila caerulea*	242	421
BJ	Blue Jay	*Cyanocitta cristata*	332	422
BQ	Northern Bobwhite	*Colinus virginianus*	321	113
BS	Barn Swallow	*Hirundo rustica*	265	722
BT	Brown Thrasher	*Toxostoma rufum*	311	321
BW	Black-and-white Warbler	*Miniotilta varia*	243	111
CB	Brown-headed Cowbird	*Molothrus ater*	322	332
CD	Carolina Chickadee	*Parus carolinensis*	253	622
CK	Yellow-billed Cuckoo	*Coccyzus americanus*	232	321
CN	Northern Cardinal	*Pyrrhuloxia cardinalis*	132	321
CR	American Crow	*Corvus brachyrhnchos*	311	412
CW	Chuck-will's Widow	*Caprimulgus carolinensis*	265	111
DC	Dickcissel	*Spiza americana*	322	221
DW	Downy Woodpecker	*Picoides pubescens*	234	511
EB	Eastern Bluebird	*Sialia sialis*	225	621
EK	Eastern Kingbird	*Tyrannus tyrannus*	325	311
FB	Eastern Phoebe	*Sayornis phoebe*	242	722
FS	Field Sparrow	*Spizella pusilla*	322	122
GK	Common Grackle	*Quiscalus quiscula*	322	311
GF	American Goldfinch	*Spinus tristis*	122	312
GH	Great Horned Owl	*Bubo virginianus*	515	611
GR	Great Crested Flycatcher	*Myiarchus crinitus*	242	612
HB	Ruby-throated Hummingbird	*Archilochus colubris*	422	321
HT	Hermit Thrush	*Catharus guttatus*	332	-
HW	Hairy Woodpecker	*Picoides villasus*	254	411
IB	Indigo Bunting	*Passerina cyanea*	332	321
JC	Dark-eyed Junco	*Junco hyemalis*	111	-
LK	Lark Sparrow	*Chondestes grammacus*	122	121
LS	Le Conte's Sparrow	*Passerherbulus caudacutus*	122	-

Code	Common name	Scientific name	Feeding guild	Nesting guild
LW	Louisiana Waterthrush	Seiurus motacilla	211	112
MB	Northern Mockingbird	Mimus polyglottos	311	321
MD	Mourning Dove	Zenaidura macroura	311	331
ML	Meadowlark	Sternella spp.	311	221
MW	Yellow-rumped Warbler	Dendroica cormata	142	-
NO	Northern Oriole	Icterus galbula	232	412
NW	Nashville Warbler	Vermivora ruficapilla	132	-
PB	Painted Bunting	Passerina ciris	332	331
PI	Pileated Woodpecker	Dryocopus pileatus	353	511
PW	Eastern Wood-Pewee	Cohtopus virens	242	411
RB	American Robin	Turdus migratorius	211	321
RH	Red-headed Woodpecker	Melanerpes erthrocephalus	343	522
RT	Red-tailed Hawk	Buteo jamaicensis	515	411
RU	Rufous-sided Towhee	Pipilo erythrophthalmus	311	-
RV	Red-eyed Vireo	Vireo olivaceus	242	311
RW	Red-bellied Woodpecker	Centurus carolinus	333	521
SM	Summer Tanager	Piranga rubra	242	411
SS	Song Sparrow	Melospiza melodia	322	-
ST	Scissor-tailed Flycatcher	Muscivora forficata	265	322
SW	Swainson's Thrush	Catharus ustulatus	132	-
TT	Tufted Titmouse	Parus bicolor	243	612
TW	Tennessee Warbler	Vermivora peregrina	242	-
WK	Western Kingbird	Tyrannus verticalis	242	311
WN	White-breasted Nuthatch	Sitta carolinensis	253	612
WS	White-crowned Sparrow	Zonotrichia leuophrys	122	
WV	White-eyed Vireo	Vireo griseus	242	311
YE	Yellow Warbler	Dendroica petechia	242	311
YF	Nothern Flicker	Colaptes auratus	211	512
YW	Yellow-throated Warbler	Dendroica dominica	242	411
UI	Unidentified			

APPENDIX C

GUILD DEFINITION

A. Feeding Guild

Food habits	Foraging strata	Foraging behavior
1. Fruit eater	1. Ground	1. Ground gleanor
2. Insectivore	2. Herbaceous	2. Foliage gleanor
3. Omnivore	3. Shrub-midcanopy	3. Bark gleanor
4. Nectar feeder	4. Upper canopy	4. Bark driller
5. Carnivore	5. Trunk	5. Sally
	6. Air	

B. Nesting Guild

Nest site preference	Number broods/season	Number eggs/clutch
1. Ground	1. One	1. 2-4
2. Herbaceous	2. Two	2. 5-8
3. Shrub-midcanopy	3. Three	3. Many
4. Upper canopy		
5. Primary cavity excavator		
6. Secondary cavity user		
7. Other		

APPENDIX D

VEGETATION SPECIES CODES

A. Tree Species Codes

Code	Common name	Scientific name
AE	American Elm	*Ulmus americana*
BG	Chittamwood	*Bumelia lanuginosa*
BJ	Blackjack Oak	*Quercus marilandica*
BL	Black Locust	*Robina pseudoacacia*
CP	Chinquapin Oak	*Quercus muelhenbergii*
GA	Green Ash	*Fraxinus pennsylvanica*
HB	Hackberry	*Celtus occidentalis*
JP	Eastern Red Cedar	*Juniperus virginiana*
MP	Mexican Plum	*Prunus mexicana*
PI	Poison Ivy	*Rhus radicaus*
PT	Post Oak	*Quercus stellata*
RB	Redbud	*Cercis canadensis*
RD	Roughleaf Dogwood	*Cornus drummondii*
RM	Red Mulberry	*Morus rubra*
RY	Rusty Blackhaw	*Viburnum rufidulum*
SE	Slippery Elm	*Ulmus rubra*
WL	Black Willow	*Salix nigra*
SN	Snag	

B. Shrub Species Codes

CB	Buckbrush	*Symphoricarpos orbiculatus*
SP	Sand Plum	*Prunus angustifolia*
SS	Smooth Sumac	*Rhus glabra*

APPENDIX E

BIRD SPECIES COUNTED, DIVERSITY, EVENNESS

FOR STUDY LOCATIONS

COMBINED FOR ENTIRE YEAR

Location	Species	Diversity	Evenness
Deer Dike	BJ CR TT RB BG BE BW CR CD GH CK MW CN SW DW WK FS HW LW RT MD RW	2.494	0.819
Ditch Fence	CD MB CN ML FS TT JC YF RW EB TW HB BJ IB CB DW CK MD DC PB FB	2.689	0.861
East Arm	BJ HT DW RB TT BQ BW CD CK CN CR FS RU YE IB RW NW SS WK EK	2.579	0.861
Frog Green	RW WK BJ BQ CD TT YF BW CN GF CK EB MD DW IB HB	2.718	0.769

Location	Species	Diversity	Evenness
Hydraulic North	CD BQ CN CK RW MD B6 RV BJ WV BW FB CB PB DW PW GK CR MW EB TT FS RH HT WK JC RB ML RT	2.642	0.777
Homestead Pond	BJ RH RW BC BW BQ CD RT CK DW CN GH GF GR TT SW CR WN PI YW RB SM	2.544	0.823
Killdeer	CR RV YF TT B6 WK BJ RB CD BQ CK FB CN GF GK RH PW TW RW DW BW EK CB HB RT	2.542	0.823

Location	Species	Diversity	Evenness
Lichen Bottom	BC DW	2.355	0.831
	BQ GK		
	BA RW		
	BG TT		
	BJ GF		
	CN YF		
	BW CR		
	CD MB		
	CK		
Popsickle Cottonwood	GF DC	2.690	0.847
	MB HB		
	RB MD		
	BT BJ		
	CB FB		
	CP GK		
	CN WS		
	DW YF		
	FS IB		
	LK RW		
	WK ST		
	CK SS		
Stable Road	CD IB	2.660	0.790
	CR MD		
	DW ST		
	BW BC		
	TT JC		
	YF LS		
	BE CB		
	BJ MW		
	BW BQ		
	FS BT		
	NR CW		
	RW GH		
	BG RB		
	CK YW		
	CN RE		

APPENDIX F

DISTRIBUTION OF FEEDING GUILD MEMBERS

Location	Guilds (no. represented if > 1)
DD	142, 253, 234, 211, 254, 332, 332, 333, 243(2), 242(2), 232(2), 515(2), 311(4)
DF	111, 132, 232, 243, 225, 234, 253, 333, 422, 242(2), 322(3), 332(3), 311(3)
EA	234, 253, 232, 333, 325, 132(2), 311(2), 322(2), 242(2), 332(3), 243(4),
FG	122, 111, 211, 232, 225, 234, 242, 321, 311, 333, 332(2), 243(2)
HN	132, 142, 111, 253, 234, 232, 225, 333, 343, 321, 515, 243(2), 322(3), 332(3), 311(5), 242(6)
KD	132, 122, 211, 253, 232, 234, 332, 333, 321, 343, 325, 422, 515, 311(2), 322(2), 243(2), 242(6)
LB	132, 122, 242, 253, 234, 232, 221, 311(2), 243(3)
HP	122, 232, 234, 332, 333, 353, 343, 321, 253(2), 132(2), 311(2), 515(2), 243(3), 242(3)
PC	132, 253, 234, 232, 211, 265, 333, 422, 242(2), 332(2), 122(3), 311(4), 322(5)
SR	111, 122, 132, 142, 234, 253, 211, 321, 333, 515, 265(2), 332(2), 322(2), 242(3), 232(3), 243(3), 311(5)

APPENDIX G

VARIABLE ABBREVIATIONS

A. Bird Variables

BSD	bird species diversity
BSR	bird species richness
BSE	bird species evenness
BDO	bird diversity over all seasons
BDF	bird diversity fall
BDSP	bird diversity spring
BDSU	bird diversity summer
BDW	bird diversity winter
BDA	bird diversity fall and winter combined
EO	evenness over all seasons
EF	evenness fall
ESP	evenness spring
ESU	evenness summer
EW	evenness winter
EA	evenness fall and winter combined
BRO	bird richness over all seasons
BRF	bird richness fall
BRSP	bird richness spring
BRSU	bird richness summer
BRW	bird richness winter
GFRO	feeding guild richness over all seasons
GFRF	feeding guild richness fall
GFRSP	feeding guild richness spring
GFRSU	feeding guild richness summer
GFRW	feeding guild richness winter
GNRSP	nesting guild richness spring
GNRSU	nesting guild richness summer

B. Habitat Variables

TRD	tree species diversity
SHD	shrub species diversity
TRDEN	tree density
TDBHOD	density of trees with DBH 1-3 in.
TDBHFD	density of trees with DBH 4-6 in.
TDBHSD	density of trees with DBH over 6 in.
SHDEN	shrub density
TRDOM	tree dominance
GRC	ground cover
CAC	canopy cover
TRRO	tree species richness
TRRDO	tree DBH richness
TRDBHO	richness of trees with DBH 1-3 in.
TRDBHF	richness of trees with DBH 4-6 in.
TRDBHS	richness of trees with DBH over 6 in.
SHR	shrub richness
W	width of vegetative strip
A	area of location

APPENDIX H

INDEPENDENT VARIABLES ENTERED IN STEPWISE

REGRESSION MODEL WITH IMPROVED

MAXIMUM R-SQUARE VALUES

Dependent variables	Number of variables in model						
	1	2	3	4	5	6	7
BDO	SHD 0.60	SHD TDBHSD 0.81	SHD TRDEN TDBHSD 0.87	SHD TDBHSD TRRO TRDBHF 0.96	W SHD TDBHSD TRRO TRDBHF 0.98	A SHD TDBHSD SHDEN TRRO TRDBHF 0.99	
BDSP	SHR 0.46	TRD SHR 0.60	W TRD SHD 0.92	A TRD SHD TRDOM 0.97	W A TRD SHD TRDOM 0.98	W A TRD SHD TRDOM 0.99	
BDSU	TRRO 0.21	SHDEN TRRO 0.45	SHDEN GRC TRRO 0.69	SHDEN GRC TRRO SHR 0.78	SHDEN GRC TRRO TRDBHS SHR 0.96	TDBHFD SHDEN GRC TRRO TRDBHS SHR 0.99	
BDA	W 0.24	A TRD 0.78	A TRD TRDBHF 0.92	A TRD TRDBHF SHR 0.94	A TRD CAC TRRDO SHR 0.97	A TRD TDBHFD CAC TRRDO SHR 0.98	A TRD TRDOM GRC CAC TRDBHF SHR 0.99
EO	TRDEN 0.41	TRD TRDBHOD 0.59	TRD TDBHOD TRDBHO 0.80	TRD TDBHOD TDBHFD TRDBHO 0.89	TRD TDBHOD TDBHFD TRDBHO TRDBHS 0.96	TRD TDBHOD TDBHFD TDBHSO TRDBHO TRDBHS 0.97	TRD TDBHOD TDBHSD GRC TRDBHF TRDBHF TRDBHS 0.99

Dependent variables	Number of variables in model						
	1	2	3	4	5	6	7
ESP	TDBHFD 0.51	W TDBHFD 0.72	W TDBHFD TRDBHS 0.85	W TDBHFD SHDEN TRDBHS 0.94	W TDBHFD SHDEN TRDBHS SHR 0.97	W A TDBHFD SHDEN TRDBHS SHR 0.99	
ESU	CAC 0.51	A TRDOM 0.60	A TRDOM TRDBHF 0.92	A TRDEN TRDOM TRDBHF 0.94	W TRDEN TRDOM TRRDO TRDBHF 0.98	W TRDEN SHDEN TRDOM TRRDO TRDBHF 0.99	
EA	TRDBHO 0.36	W TRD 0.68	W TRD GRC 0.76	W TRD GRC SHR 0.90	W TRD SHDEN GRC SHR 0.94	TRD SHDEN GRC CAC TRRO SHR 0.99	
BRO	TDBHFD 0.25	SHD TDBHFD 0.67	SHD TDBHFD TRRO 0.78	TRD SHD TDBHFD TRRO 0.89	TRD SHD TDBHFD TRRO TRDBHF 0.98	TRD SHD TRDEN TDBHFD TRRO TRDBHF 0.99	
BRSP	SHR 0.43	W SHR 0.68	W TRRO SHR 0.91	W TRD TRRO SHR 0.93	W CAC TRRO TRDBHF SHR 0.96	W SHD TDBHFD SHDEN TRRO SHR 0.98	W TRD SHD TDBHFD TRRO SHR 0.99

Dependent variables	Number of variables in model						
	1	2	3	4	5	6	7
BRSU	TDBHFD 0.30	TDBHFD GRC 0.54	TDBHFD SHDEN GRC 0.69	TRDEN TDBHFD SHDEN GRC 0.82	TRDEN TDBHFD SHDEN GRC TRDBHF 0.85	TRDEN TDBHFD TDBHSD SHDEN CAC TRDBHF 0.96	W TRDEN TDBHFD TDBHSD SHDEN CAC TRDBHF 0.99
GFRO	TRDEN 0.52	TRDEN GRC 0.58	TRD TRDEN SHDEN 0.67	TRD TDBHFD SHDEN GRC 0.83	TDBHFD SHDEN GRC TRRO SHR 0.95	A SHDEN GRC TRRO TRDBHF SHR 0.99	
GFRF	TRRO 0.33	TRDBHF SHR 0.60	TDBHSD SHDEN TRDBHF 0.88	TDBHSD SHDEN TRDBHF SHR 0.92	TDBHSD SHDEN TRRO TRDBHF SHR 0.96	TRD TDBHSD SHDEN TRDOM TRDBHF SHR 0.99	
GFRSP	TRDBHO 0.21	TDBHOD TRDBHO 0.64	TDBHOD TDBHSD TRDBHO 0.73	SHD TDBHOD TDBHSD TRDBHO 0.91	SHD TDBHOD TDBHFD TDBHSD TRDBHO 0.95	SHD TDBHOD TDBHFD TDBHSD SHDEN TRDBHO 0.98	SHD TDBHOD TDBHSD SHDEN CAC TRDBHO TRDBHF 0.99
GFRW	TDBHFD 0.21	W TDBHFD 0.60	W TRD TDBHFD 0.82	A TRD TDBHFD TDBHSD 0.95	A TRD TDBHFD TDBHSD TRRO 0.96	A TRD TDBHFD TDBHSD CAC TRRO 0.98	A TRD TDBHFD TDBHSD CAC TRRO TRDBHO 0.99

Dependent variables	Number of variables in model						
	1	2	3	4	5	6	7
GNRSP	SHR 0.28	SHD TDBHFD 0.71	TRD SHD TDBHFD 0.80	W TRD SHD TDBHFD 0.94	W SHD TRDEN TDBHFD TRDBHO 0.97	W A SHD TRDEN TDBHFD TRDBHO 0.99	
GNRSU	TDBHFD 0.28	TDBHFD TRDBHF 0.51	TDBHFD TDBHSD TRDBHF 0.67	TRD TDBHFD TDBHSD TREBHF 0.77	TRD TDBHFD TDBHSD SHDEN TRDBHF 0.88	TDBHFD TDBHSD SHDEN TRRDO TRDBHO TRDBHF 0.99	

APPENDIX I

FEEDING AND NESTING GUILD DISTRIBUTION

WITHIN SEASONS

Location	Season	Guilds (no. representatives if > 1)
DD	SP	242(2), 232(2), 132(2), 311(2), 332, 243, 253, 234, 211, 515, 142
	SU	253, 232, 132, 311, 234, 243, 332, 322, 254, 515, 333
	FA	332, 243
	WI	332, 253, 234, 211, 243, 132, 333
DF	SP	332(2), 322(2), 311(2), 353, 322, 132, 242, 322, 243, 225, 422
	SU	322(2), 132, 242, 333, 353, 232, 234, 311, 332
	FA	253, 132, 322, 111, 333, 242, 332
	WI	211, 332, 322, 111
EA	SP	132(2), 311(2), 322(2), 243(2), 332, 321, 253, 232, 234, 242
	SU	332, 232, 132, 311, 234, 242, 332, 322, 254, 515, 333
	FA	332(2), 243, 234, 211, 132, 333
	WI	332, 353, 234, 325, 243
FG	SP	243(2), 321, 253, 132, 122, 234, 332
	SU	253, 232, 132, 225, 311, 243, 234, 422, 333, 242
	FA	332, 321, 353, 243, 211, 111
	WI	332, 253, 132, 234, 243, 333, 211
HN	SP	242(2), 243(2), 322(2), 311(2), 332, 253, 132, 234, 142, 321, 232
	SU	242(6), 253, 132, 234, 343, 333, 243, 322, 332
	FA	353, 132, 333, 515
	WI	311(2), 253, 211, 332, 234, 225, 322, 332, 111, 333, 243

Location	Season	Guilds (no. representatives if > 1)
HP	SP	242(2), 253(2), 132(2), 242(2), 332, 232, 122, 234, 515, 333
	SU	253, 232, 132, 311, 253, 211
	FA	332, 333, 132
	WI	243(2), 321, 253, 132, 211, 515
KD	SP	242(5), 322(2), 332, 253, 232, 132, 311, 333, 211, 321, 122, 343, 243
	SU	243(2), 242(2), 322, 253, 232, 132, 333, 321, 234, 325, 422, 211, 343, 515
	FA	211(2), 311, 132, 333
	WI	132, 211, 243, 333
LB	SP	515, 242, 332, 132, 321, 253, 234, 243
	SU	243(2), 311(2), 253, 232, 234, 322, 333, 132, 211
	FA	243, 321, 332, 253, 234, 122, 211
	WI	243(2), 234, 232, 253, 122
PC	SP	311(2), 322(4), 122(2), 211(2), 242(2), 253, 132, 234
	SU	322(4), 253, 232, 132, 234, 122, 422, 311, 332, 333, 265
	FA	122, 311, 211, 232
	WI	322, 332, 253, 132, 234, 122, 311, 211
SR	SP	232(2), 243(2), 322(2), 332, 253, 311, 333, 132, 234, 142
	SU	311(3), 242(2), 332(2), 265(2), 253, 232, 132, 321, 234, 515, 211, 243
	FA	253, 311, 234, 242, 243, 211, 332
	WI	243(2), 111(2), 332, 253, 132, 311, 122, 333, 211

Nesting Guild Distribution

Location	Season	Guilds (no. representatives if > 1)
DD	SP	622(2), 321(2), 421, 422, 111, 511, 122, 112, 331, 412, 611, 311
	SU	321(2), 411(2), 622, 412, 511, 612, 422, 122, 521
DF	SP	321(5), 221(2), 422, 332, 332, 622, 321, 722, 122, 612, 621
	SU	321(2), 331(2), 221, 722, 122, 521, 622, 511
EA	SP	321(2), 422, 113, 111, 622, 412, 511, 122, 612, 311
	SU	321(3), 412, 511, 311
FG	SP	321(2), 113, 111, 622, 312, 612, 511
	SU	321(3), 622, 621, 331, 612, 511, 512, 311
HN	SP	321(2), 311(2), 421, 422, 111, 332, 622, 511, 612, 113, 331
	SU	333, 421, 622, 321, 511, 522, 521, 612, 332, 722, 331, 411
HP	SP	321(2), 612(3), 422, 111, 622, 312, 411, 511, 611, 521
	SU	321(2), 411(2), 622, 412, 511, 221, 522, 521, 612, 422
KD	SP	321(2), 311(3), 421, 422, 622, 412, 411, 521, 512, 113, 722, 312, 522, 612
	SU	321(3), 411(2), 311(3), 111, 332, 622, 521, 612, 113, 511, 221, 522
LB	SP	611, 421, 422, 321, 113, 622, 511, 612
	SU	321(3), 111, 622, 511, 311, 521, 612, 412, 512
PC	SP	321(2), 221(2), 311(2), 332, 622, 511, 122, 121, 722, 331, 512
	SU	321(4), 622, 221, 511, 122, 312, 331, 332, 311, 521, 322

Location	Season	Guilds (no. representatives if > 1)
<u>SR</u>	SP	622(2), 412(2), 422, 111, 122, 512, 612, 332, 321, 511
	SU	321(4), 421, 422, 622, 331, 332, 113, 412, 111, 511, 511, 611, 221, 612, 411

APPENDIX J

GUILD RICHNESS VALUES

Seasonal Feeding and Nesting Guild Richness Values at Locations

	Winter feeding	Spring feeding	Summer feeding	Fall feeding	Overall feeding	Spring nesting	Summer nesting
DD	7	12	11	2	14	12	9
DF	4	11	9	7	14	10	8
EA	5	12	6	6	12	9	4
FG	7	7	10	6	15	7	8
HN	12	11	9	4	16	11	12
HP	6	10	6	3	14	10	10
KD	4	13	14	4	17	13	12
LB	5	8	9	7	14	8	9
PC	8	8	11	4	13	12	11
SR	10	10	12	7	20	11	14

VITA 2

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