# AVIAN HABITAT AFFINITY IN THE LOST PINES REGION OF TEXAS

THESIS

Presented to the Graduate Council of

Texas State University — San Marcos

in Partial Fulfillment of

the Requirements

For the Degree

Master of SCIENCE

By

Clayton J. White, B.S.

San Marcos, Texas

December 2003

## ACKNOWLEDGMENTS

This thesis was only completed through the generous contributions of many people. I would like to first thank my graduate committee (Dr. Thomas R. Simpson, Dr. Richard Manning and Dr. Floyd Weckerly) for the knowledge, patience, support, and critical reviews of my thesis. My advisor, Dr. Simpson, I especially thank for the research opportunity and constant advice through the entire process.

I thank the Texas Forest Service (Rich Gray and Karen Allender) for the internship opportunity and the funding provided through that internship. Karen Allender I especially thank for the wonderful maps so diligently made for this thesis and for keeping me on track while conducting my field work. I also greatly appreciate the Capital Area Boy Scouts of America for allowing me access to the Griffith League Ranch for this project.

I think all the graduate students from the Biology Department who contributed vast amounts of free fieldwork. Shane Kieffer has been my right arm for the duration of this fieldwork and to him I will forever be in debt. Sue Morris, Stephanie Shelton, Adam Ferguson, Deena Francis, and Shawn Gray shared in on the joys of the redundant vegetation sampling. Minnette Mar, thanks for all the guidance and attempts to teach me something about plants.

But to my wife, Melissa, I express the most appreciation of all. Thank you for the constant love, support and motivation you have generously provided over the last two years.

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

## ABSTRACT

AVIAN HABITAT AFFINITY IN

THE LOST PINES REGION OF TEXAS

by

CLAYTON J. WHITE, B.S.

Texas State University — San Marcos

December 2003

SUPERVISING PROFESOR: THOMAS R. SIMPSON

Avian diversity has been used by many in the past as an indicator of habitat quality due to the relative ease of detecting birds. Even within habitats and seasons, primary components of the habitat that are most associated with avian diversity have been identified. Combining the habitat health and primary components of the habitat approaches will allow an investigator to identify not only the higher quality habitats, but also the factors that are most influential on the diversity in those habitats. The Lost Pines region of Texas is a well known area in central Texas. However, little scientific knowledge is known about the area. I investigated four identified habitat types located on Griffith League Ranch within the Lost Pines, Grassland habitats, Oak/Cedar habitats, Pine habitats and Pond habitats. Within each habitat, point counts were preformed in all seasons to identify the avian community present in the 100 m fixed radius sample area. 3,487 detections of 75 avian species were recorded from 300 point counts, indicating a relatively low abundance and low species richness for the area. Primary components of the vegetation were measured to identify associations of avian diversity with habitats. These measures included: percent canopy cover and density of each woody species, horizontal obscurity at 0.5 m height increments, herbaceous vegetation cover, and duff depth. Results from the ANOVA and orthogonal contrasts identified Oak/Cedar, Pine and Pond habitats as similar and most diverse, but different from Grassland habitats in three of four seasons. Fall had no difference in diversity values among the four habitat types. All possible subsets regression preformed on each season was used to identify components most associated with avian diversity. Diversity in winter had a positive correlation with yaupon and post oak canopy cover and an inverse correlation with duff depth. Diversity in spring had a positive correlation with yaupon and pine canopy cover and an inverse correlation with horizontal obscurity 0.0 to 0.5 m above ground level. Diversity in summer had a positive correlation with post oak canopy cover. Diversity in fall had a positive correlation with yaupon and eastern red cedar canopy cover and an inverse correlation with horizontal obscurity 0.0 to 0.5 m above ground and post oak canopy cover. The diversity of habitat components associated with avian diversity among seasons corresponds with original thoughts of diverse habitats supporting more diverse avian communities.

# CHAPTER 1

# INTRODUCTION

Avian diversity and habitat association has been investigated by many workers (MacArthur and MacArthur 1961, MacArthur 1964, Rice et al. 1983, McCollin 1998). Rice et al. (1983) found that avian communities can be used as an indicator of habitat type, while Todt (1989) showed that avian diversity corresponds to differences observed in the habitat. Diversity may also be used as an indicator of habitat quality. High quality habitat is assumed to support a more diverse avian community which could include both specialists and generalists (Gabbe et al. 2002). This could also indicate that low species richness or the absence of common bird species may indicate poor habitat quality. Among terrestrial vertebrate groups, birds are the most numerous and easiest to detect making them the logical choice for the evaluation of habitat quality.

Single species or specific group studies focusing on habitat selection and habitat attributes are also common, (Bertin 1977, Conner and Adkisson 1977, Martinez and Jaksic 1996, Ritter and Savidge 1999). McClelland and McClelland (1999) reported that Pileated Woodpeckers (*Dryocopus pileatus*) indicate a healthy old growth forest. Single species studies are useful, but somewhat limited in overall conclusions that can be drawn for an avian community. While these studies are necessary, especially when dealing with endangered species, community based approaches must be used to conduct sound ecosystem management. A community based approach would consider all species present within the community, and any potential interactions among those species.

**Avian Habitat Use**

Habitat use by avifauna varies among species, seasons, and possibly broad-scale location. Use of habitat is a well studied field with many proposed hypotheses on how and why birds choose one or more habitat types. Boulinier et al. (2001) suggests that landscape structure may influence forest bird communities at regional scales through its effects on the total number of species and also on the temporal rates of change in community composition. Reduction of nest predation pressure (Sieving and Wilson 1998), foliage profile characteristics (MacArthur and MacArthur 1961), latitude (Tramer 1969), heterogeneity and patchiness (Franzreb and Ohmart 1978), edge density (Howell et al. 2000), plant species (Tomoff 1974), guild structure (Rice et al. 1983), interaction and competition avoidance, microclimate modification, and vegetation structure (McCollin 1998) all have been suggested as possible factors influencing habitat use. Not only do these factors vary among species, but also among other taxonomic groupings and seasonal groups (breeders, winter residents, permanent residents) as well. Flather and Sauer (1996) reported Neotropical migrants show a more sensitive response than temperate migrants or permanent residents to changes in landscape structure and utilize large contiguous habitats with continuous canopy cover. Permanent residents in the same study showed less affinity with landscape structure while temperate migrants were correlated with habitat diversity and edge attributes rather than with the amount, size, and dispersion of forest habitats.

Prior to any understanding of potential relationships between avian communities and habitat, thorough descriptions of all possible factors influencing that relationship must be investigated. Vegetation is the major component of most terrestrial habitats and quantifying measurements of vegetation are useful in identifying any relationship between avian diversity and habitat. Vegetation does not account for other influential factors (avoidance of nest predation, guild structure, competition avoidance) that may also affect avian diversity associations with habitat types. In addition to vegetation, avian communities must be surveyed to estimate current populations. This data may also be used to establish trends and evaluate progress following application of management techniques.

The Lost Pines is a well known part of Texas, but little research has been conducted that quantify the plant and animal communities associated with the region (Taber and Fleenor 2003). Many scientists propose that this isolated pocket of pines is a remnant of a greater forest that once covered the eastern half of the state. Correll (1966) described the Lost Pines as a fractured, western peninsula that currently is a distant island or archipelago of pine. Tabor and Fleenor (2003) proposed that the pines possibly arose independently of the pines to the east but offered no support for this hypothesis. Pollen analysis has suggested that loblolly pines have been in the area for nearly twenty thousand years (Bryant 1977) and no significant change or expansion of the Lost Pines has occurred during the last sixteen thousand years (Larson et al. 1972). Regardless of origin, habitat fragmentation from recent urban sprawl has made its impact on the land and will continue to do so over time. The best chance for conservation of the Lost Pines is its strong hold for the endangered Houston Toad (*Bufo houstonensis*). Research on the larger unfragmented areas of forest is necessary in order to identify habitats that support the greatest diversity and the factors within those habitats that are most critical. In addition to conservations efforts, baseline plant and animal populations will establish a starting point for analyzing the effects of forest fragmentation in the Lost Pines Region.

Population decline among Neotropical migrants is a well documented occurrence (Robbins et al. 1989). With this current trend, identification of diverse habitats and key habitat components must be found within the Lost Pines for proper management of bird populations. Among the problems contributing to the decline are habitat fragmentation, urban sprawl, loss of old growth forest, loss of large scale contiguous forest, nest parasitism and others. Habitat fragmentation coupled with Brown-headed Cowbird (*Molothrus ater*) nest parasitism may multiply the detrimental effects on declining populations. Fragments of habitat create more edge, which is utilized by the cowbirds, and offer more hosts to parasitize (Robinson et al. 1995). Other combinations of causes likely are having similar affects. With modern progress (urbanization, forest fragmentation) and declining bird populations, application of sound ecosystem management practices must focus on habitat types and factors that are most influential across all seasons for the avian communities present.

Like many studies dealing with habitat use, components of the habitat that best describe avian diversity may be site specific. Factors influencing a species may not differ greatly by site but factors affecting diversity could and probably do vary by site. This potential variation may be explained by vegetation, guild structure and microclimate differences found within each habitat.

## Research Objectives

In this paper I will present findings which 1) establish a baseline inventory of the avian community found on Griffith League Ranch, 2) establish a vegetation profile of the plant community including canopy coverage, vertical structure, woody species density, herbaceous plant coverage, and duff depths, 3) identify habitats of higher diversity by season and 4) identify primary vegetative components that are associated with avian community diversity by season.

# CHAPTER 2

# MATERIALS AND METHODS

## Study Site

The Griffith League Ranch (hereafter GLR) occupies 1,961 ha of the Lost Pines Region of south central Texas (Fig.1). GLR lies in an isolated loblolly pine (*Pinus taeda*) forest geographically separated from the Piney Woods region of east Texas by approximately 160 km. GLR is approximately thirteen km northeast of Bastrop, Texas in Bastrop County.

Forested areas (1,728 ha) of GLR are a mix of loblolly pine, post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*) and eastern red cedar (*Juniperus virginianus*). Cleared pasture lands (233 ha) consisting of costal Bermuda (*Cynodon dactylon*) and Bahia grass (*Paspalum notatum*) formerly were grazed by livestock. Within the forested areas, the understory includes American beautyberry (*Callicarpa americana*), yaupon (*Ilex vomitoria*) and farkleberry (*Vaccinium arboreum*). Herbaceous vegetation under the forest canopy is sparse, but does include Texas bull-nettle (*Cnidoscolus texanus*), panic grasses (*Dicanthelium spp,*) and flowering spurge (*Euphorbia corolata*).

Rolling hills of sandy soils make up the topography of GLR. Demona loamy fine sand, Patilo and Silstid loamy fine sand of the sand range site cover more than 90% of GLR (USDA Soil Conservation Service 1979). Elevations range from 137 m to 198 m with Alum Creek on the eastern edge of the ranch and Piney Creek and Spicer Creek drainages to the west and southwest, respectively. Nineteen known ponds exist on the ranch varying in size from less than 0.5 ha to just under 1.5 ha, eleven of which hold water permanently (Koepp 2001).

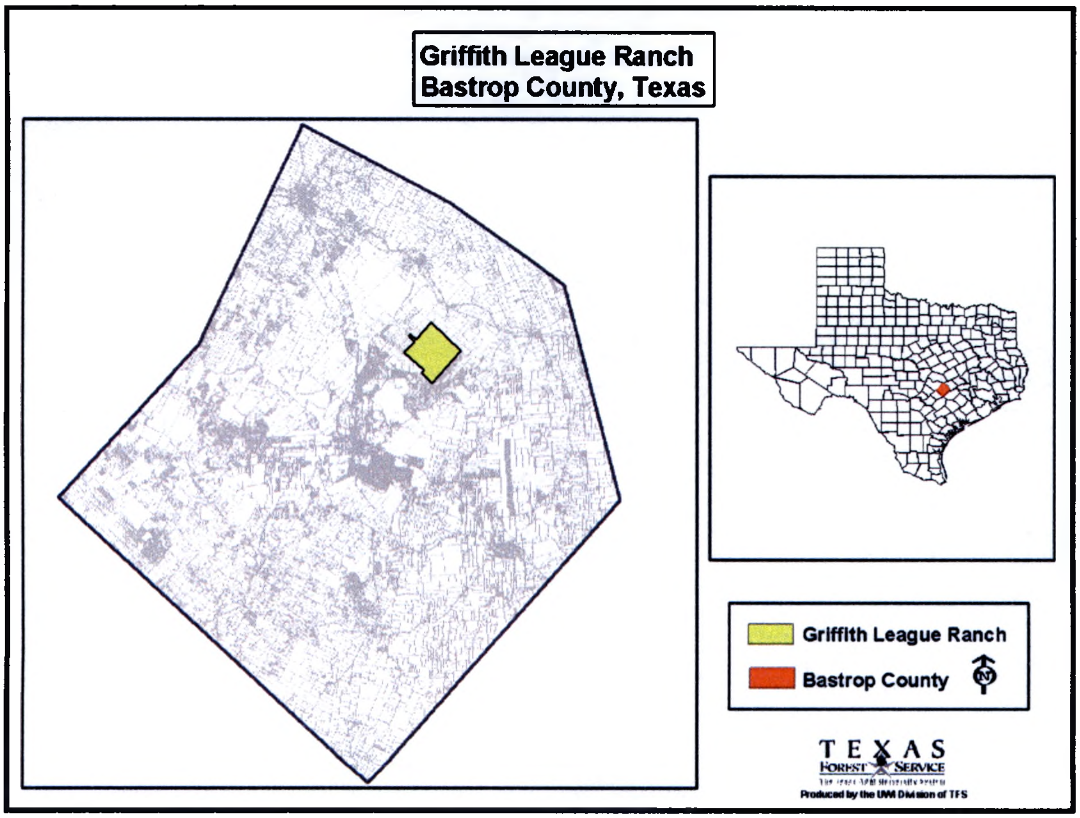



Figure 1. Location of Griffith League Ranch within Bastrop County, Texas (1,728 ha).

**Habitats Associated with Griffith League Ranch**

Delineation of habitats was determined by the use of digital orthophoto quarter quadrangles (DOQQ). Points within selected habitat types were selected and ground truthed to verify habitat type identification. At each point one t-post was driven into the ground to serve as a center point of that habitat. Twenty-five points within four habitat types were chosen and measured to quantify habitat type assignments (Fig. 2). Habitat types were grasslands with reduced woody species canopy cover, oak/cedar habitats with greatest amounts of post and blackjack oaks and eastern red cedar, pine habitats with a dominant overstory of loblolly pine, and pond habitats containing a permanent pond within a 100 m radius of the point center (Fig. 2). Points were treated as independent samples and spaced > 250 m apart to prevent violation of independence by overlapping points.

**Sampling Methods**

*Avian Surveys* — Point counts were used to identify avifaunal communities at each point within habitat types. Point counts are used to monitor trends of bird populations over time, but are also useful in bird-habitat relationship studies (Dettmers et al. 1999) and less time consuming than line-transect surveys (Robel et al. 2000). Detection of birds varies among species (Mayfield 1981, Lynch 1995), seasons (Best 1981, Best and Peterson 1985), habitat types (Reynolds et al. 1980, Schiek 1997), and time of day (Fuller and Langslow 1984, Gates 1995).

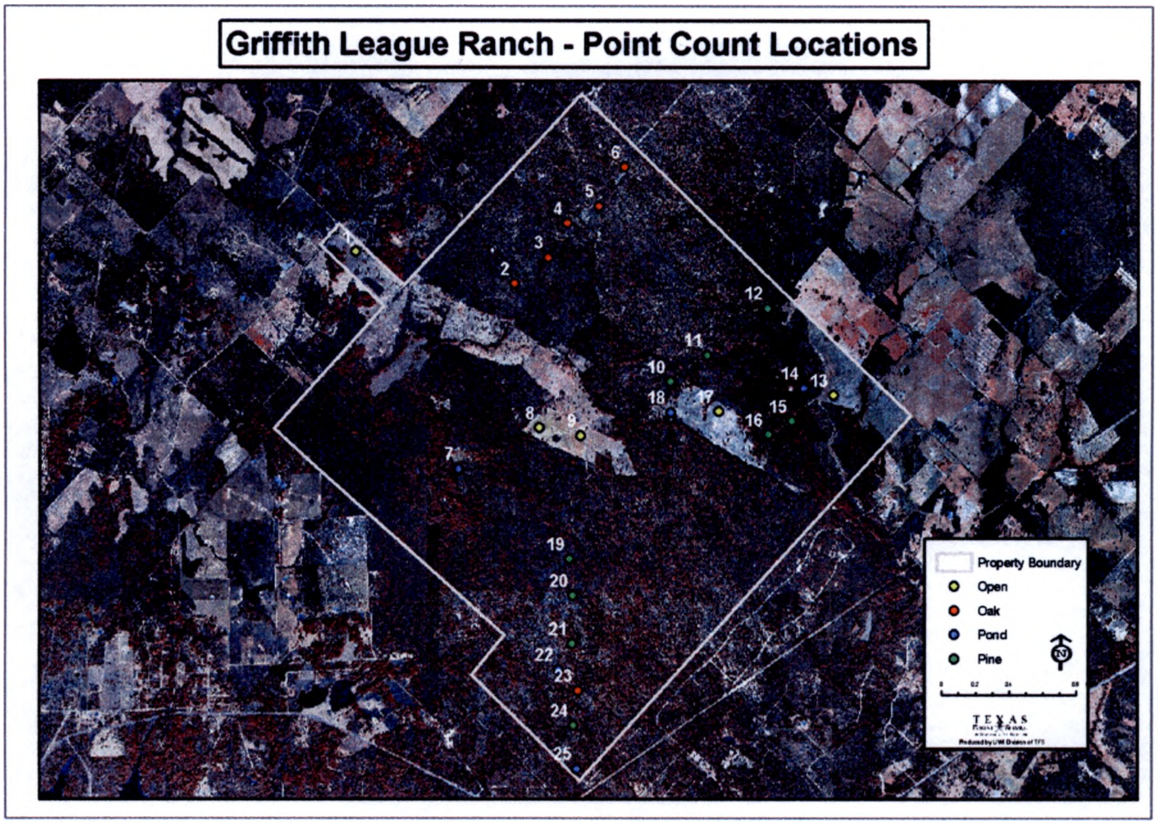



Figure 2. Point count locations in the four habitat types surveyed on Griffith League Ranch, Bastrop County, Texas.

To reduce potential bias from samples, each point count site was surveyed three times in each season, starting in the summer of 2002, with sampling occurring in four assigned habitat types. Calendar dates were used to estimate seasonal changes (Winter, Dec. 22 — Mar. 20; Spring, Mar. 21 — Jun. 20; Summer, Jun. 21 — Sept. 22; Fall Sept. 23 — Dec. 22)Dettmers et al. (1999) reported that sampling twice is sufficient with little to no improvement on the third sample. However, when studying bird-habitat associations, more counts may be necessary (Petit et al. 1995, Thompson and Schwalbach 1995). Point counts lasted for ten minutes (Ralph et al. 1993, Brooks et al. 2001) and all birds counted were confined within a 100 m radius of the point count site center. All point counts were conducted from 6:00 am to 9:00 am (Lynch 1995) with the earliest count occurring no more than thirty minutes before sunrise.

In addition to point counts, mist netting results and incidental observations were recorded to supplement a list of birds recorded on GLR. These observations were not used in the statistical analysis of point count data. Mist netting was conducted under authority of Texas State University IACUC permit (N2E772) as well as a federal bird marking and salvage permit (22280-P).

*Vegetation Sampling* — To understand avian diversity-habitat associations, vegetation variables were measured at each point count site. Percent canopy cover of each tree species sampled, density of trees sampled, duff depth (decaying leaves and branches), vertical obscurity and herbaceous vegetation cover were measured to identify potential associations between avian diversity and habitats. Many of the variables measured at each point count site were discarded prior to analysis of the data due to an infrequency of measurements among sites. These variables included uncommon woody species present in small amounts at only a few locations. Woody vegetation variables were measured only one time assuming that no change among seasons within a year would occur while all other variables (herbaceous and structure composition) were measured each season.

Line-intercepts method was used to measure the canopy cover of each woody species. Three 100 m transects separated 120 degrees were stretched from center point to perimeter of the point count circle. Woody vegetation crossing the tape was recorded by site. Line-intercept data was summed by species to yield a percent canopy cover for each species observed. In addition to line-intercepts, woody stems/ha were measured for each species using a 10 X 10 m quadrat. Three quadrat measurements were taken within each point count site to determine the density of each woody species. This technique also measured the number of standing dead trees/ha. Woody species/ha were calculated from the pooled quadrat samples measured at each point count site. Both line-intercept and woody stems/ha were measured only once per site.

Horizontal visual obscurity below 2.5 m was measured using a vegetation profile board (VPB) (Nudds 1977). Five VPB measures were taken at all points in each season. Canopy cover of woody structure was measured using a spherical densiometer (model A) (Lemmon 1957). Five readings using the densiometer were recorded per point in each season. Means by point count sites were calculated for VPB and canopy cover measures for each season.

Daubenmire frames (25 cm X 100 cm) were used in quantifying the herbaceous vegetation at each site (Daubenmire 1959). Ten frame samples were used at each point count site to determine herbaceous vegetation composition by season. Each plant was identified and then classified as grass, forb or sedge. Plants again were classified into groups of native and introduced herbaceous vegetation. Total percent cover by point for each season was then determined for each of the five classifications.

Duff measures were recorded within each Daubenmire frame sample. Ten duff measures were averaged and used to assess duff depth by point each season.

Canopy coverage, woody species density, VPB, herbaceous vegetation coverage and duff measures are only representative of point count sites and may not adequately describe the entire ranch on a broader scale.

**Statistical Methods and Diversity Indices**

Habitat assignments delineated through DOQQ's and ground truthing were verified using the percent canopy cover measures of the common woody species in a Principal Component Analysis using the covariance matrix (S-Plus). Principal component loadings were then graphed on a biplot to examine the predetermined habitat assignments. The biplot is a graphical representation of the first two component scores in relation to the data set with the arrows representing the loadings of the two components.

Avian diversity was calculated using the observations from three point counts performed at each point count site, within each season. This resulted in 100 diversity values for the 25 point count sites. Diversity for habitats within each season was then determined by taking the mean of diversity values for points in their respective habitat types. Avian diversity was measured using Brillouin's Index (H') (Exeter Software 2000). This index is more appropriate because the total number of species within the point count area is unknown (Krebs 1989).

This conservative index is prone to underestimate the diversity however, with sample sizes often exceeding thirty observations the potential bias is reduced (Zar 1996).

A single factor Analysis of Variance (ANOVA) was performed on the diversity indices to evaluate possible differences among habitats within seasons. Contrasts (3, -1,-1,-1) were performed on the seasons showing differences among habitats to identify those differences (S-Plus).

A fully factorial ANOVA with three fixed factors was used to identify differences among seasons, habitats and half meter height increments for VBP measures. Line-Intercept data was summed by species to yield a percent canopy cover for each species observed.

To identify possible factors that influence avian diversity all possible subsets regression was used (Montgomery et al. 2001). Data transformation (ln(1+value)) and variable reduction procedures preceded the multiple linear regression analysis. Variables that contained more that five zero values were first excluded from the data set leaving only the variables with ample observations. Correlation matrices of all independent variables that may be related were then constructed to reduce variable multicollinearity in the model. The remaining variables were examined choosing the best three to five variables to use in the complete model. All possible subsets multiple linear regression (MLR) was then used to identify the best model from all possible combinations of the selected variables. Selection of the best model was based on a combination of lowest Mallow's Cp, highest $r^2$ value and lowest residual standard error

(Montgomery et al. 2001). Mallow's Cp is a measure of bias within each subset model, assuming that the complete model has no bias. The p value represents the results from an ANOVA test on the selected model.

# CHAPTER 3

# RESULTS

## Habitat Identification

Habitat classification based on visual interpretation of DOQQ and ground truthing first produced five habitat types (grassland, oak, cedar, pine, and pond) with five point count sites in each habitat. Principal Component Analysis (PCA) was selected to verify habitat classification of the 25 point count sites. Principal Component I explained 60.4% of the variation among variables and Principal component II explained 20.9% of the variation. Pine was highly correlated (0.81) with Principal Component I while both post oak and eastern red cedar were moderately correlated with Component II (0.61, 0.54 respectively).

From the principal component loadings (Table 1) and biplot (Fig. 3) five grassland habitats (point count sites 1, 8, 9, 13, 17), six oak/cedar habitats (2, 3, 4, 5, 6, 23), and nine pine habitats (10, 11, 12, 15, 16, 19, 20, 21, 24) were identified (Fig. 2), reducing the prior habitat designations to three habitat types. PCA designations for pond habitats were disregarded based on the previous designation of permanent water, which was not a variable considered in this analysis. Pond habitats, the fourth designated habitat, occurred in both grassland (18) and oak/cedar (22) habitats one time each and pine habitats (7, 14, 25) three times. For component I (Fig. 3), points occurring on the right side of the biplot are dominated by higher amounts of pine. For component II, points occurring on the top portion of the biplot are dominated by higher amounts of oak and cedar.

Table 1. Principal component loadings of yaupon, eastern red cedar, loblolly pine, blackjack oak and post oak canopy coverage of PC I and II for 25 point count sites on Griffith League Ranch, Bastrop Co. Texas.

| | Principal Component I | Principal Component II |
|---|---|---|
| Yaupon | 0.4623 | -0.3413 |
| Cedar | 0.1794 | 0.5418 |
| Pine | 0.8060 | -0.1879 |
| Blackjack | 0.0350 | 0.4213 |
| Post | 0.3213 | 0.6114 |

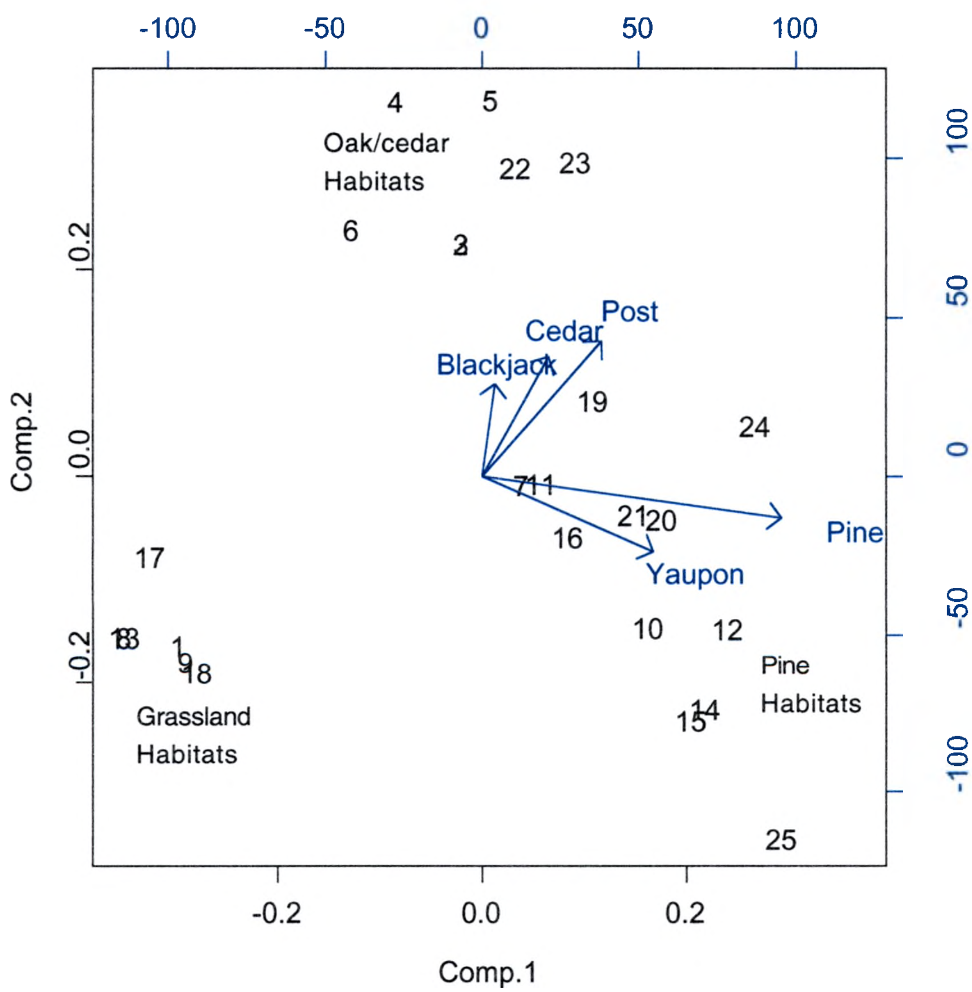



Figure 3. Biplot of Principal Components I and II from canopy coverage measures from line intercept data for 25 point count sites showing similarities among sites and habitat designation on Griffith League Ranch, Bastrop County, Texas. Pond point count sites are mixed within other habitats of similar canopy cover measures.

**Avian Diversity**

3,487 detections of 75 avian species were recorded from 300 point counts on the Griffith League Ranch (Appendix1). Mist netting and incidental observations increased the total number of species to 110. One hundred hours of mist netting accounted for five of the species not detected in point counts.

Fall had the highest number of observations with 1,156 and the fewest number of species at 39. Summer had the fewest observations with 749 and spring had the highest number of species recorded totaling 74 (Table 2).
Fall also had the lowest mean diversity (H'= 2.02), while spring had the highest mean diversity (H'= 2.43) (Appendix 2). Pond habitats for combined seasons had the highest mean diversity (H'= 2.59) and open habitats had the lowest mean diversity (H'= 1.64). ANOVA and contrast results showed diversity by habitat within each season to be fairly consistent yielding similar results for winter, spring and summer. For each of these three seasons the ANOVA resulted in a significant difference ($p < 0.001$) and the contrast identified pond habitats, oak habitats and pine habitats as similar groups. Grassland habitats were dissimilar from all others in winter, spring and summer. Fall diversity values had no significant differences among habitats (Table 3).

Table 2 Mean number of observations, number of species and mean Brillouin's Index (H') of diversity for birds counted on the Griffith League Ranch from 300 point counts by season and habitat type

| | Habitat type | n | Mean Number of Observations | Number of Species | Mean H' |
|---|---|---|---|---|---|
| Winter | | | | | |
| | Grassland | 5 | 17.4 | 17 | 1.43 |
| | Pond | 5 | 49.0 | 30 | 2.77 |
| | Oak/Cedar | 6 | 31.2 | 23 | 2.67 |
| | Pine | 9 | 26.3 | 25 | 2.41 |
| Spring | | | | | |
| | Grassland | 5 | 12.2 | 18 | 1.44 |
| | Pond | 5 | 41.2 | 30 | 2.76 |
| | Oak/Cedar | 6 | 37.2 | 22 | 2.64 |
| | Pine | 9 | 37.2 | 28 | 2.63 |
| Summer | Grassland | 5 | 17.0 | 16 | 1.63 |
| | Pond | 5 | 39.2 | 29 | 2.42 |
| | Oak/Cedar | 6 | 29.7 | 18 | 2.63 |
| | Pine | 9 | 32.2 | 24 | 2.46 |
| Fall | Grassland | 5 | 26.2 | 20 | 1.81 |
| | Pond | 5 | 40.8 | 19 | 2.48 |
| | Oak/Cedar | 6 | 81.5 | 16 | 1.84 |
| | Pine | 9 | 37.9 | 18 | 1.99 |

Table 3 ANOVA results comparing Brillouin's Index of diversity values for grassland, oak/cedar, pond and pine habitats within seasons

| Source | $df_{numerator}$ | $df_{denominator}$ | F | p |
|---|---|---|---|---|
| Winter | 3 | 21 | 12.32 | $< 0.001$ |
| Spring | 3 | 21 | 10.23 | $< 0.001$ |
| Summer | 3 | 21 | 13.74 | $< 0.001$ |
| Fall | 3 | 21 | 1.59 | $> 0.5$ |

**Vegetation Inventory**

Thirty woody vegetation species were identified among the 25 point count sites. The dominant trees across the property were loblolly pine (40% canopy cover), post oak (25%), yaupon (18%), eastern red cedar (15%) and blackjack oak (10%) (Appendix 3). Measurements of woody stem density suggest yaupon to be the most dense (2,620 individuals/ha) followed by post oak (547/ha), eastern red cedar (446/ha) and loblolly pine (435/ha).

The herbaceous vegetation inventory identified 21 species of winter plants, 45 species of spring plants, 40 species of summer plants and 30 species of fall plants (Appendix 4). Grasses were the dominant herbaceous plants comprising 60% to 80% of the overall herbaceous vegetation when viewed by season (Table 4). Dominant grasses in the open areas included Bahia grass and costal Bermuda grass, both introduced species. Within the forested areas, panic grasses (*Dichanthelium spp.*) were more common. Sedges were present and identified as a third group which covered less than 1% of the point count sites in each season. Pooled seasonal data revealed 70% of the identified herbaceous cover to be introduced and 30% native. Mean duff depth for pooled points and seasons was 44.5 mm.

Table 4 Percent herbaceous cover including forbs and grasses of 25 point count sites measured using Daubenmire frames for Griffith League Ranch, Bastrop Co. Texas

| | Winter | Spring | Summer | Fall |
|---|---|---|---|---|
| Forb Cover | 4.7 | 4.5 | 5.0 | 2.5 |
| Grass Cover | 10.2 | 6.9 | 16.8 | 13.9 |
| Total herb cover | 14.9 | 11.7 | 22.4 | 16.5 |

VPB measures had a grand mean of 57.83% horizontal obscurity with means for GLR reported in Table 5. No interaction was found among the main effects (p >0.05) and habitat was the only main effect to show a significant difference.

Table 5 Mean Vegetation Profile Board measures of horizontal obscurity for five half meter height increments by habitat type within seasons for 25 points on Griffith League Ranch, Bastrop Co, Texas.

| | Habitat | VPB1 (2-2.5 m) | VPB2 (1.5-2 m) | VPB3 (1-1.5 m) | VPB4 (0.5-1m) | VPB5 (0-0.5m) |
|---|---|---|---|---|---|---|
| Winter | | | | | | |
| | Grassland | 20.0 | 20.0 | 20.0 | 20.8 | 41.6 |
| | Oak/Cedar | 60.7 | 58.0 | 60.0 | 53.3 | 58.0 |
| | Pond | 66.8 | 64.6 | 67.4 | 77.6 | 75.6 |
| | Pine | 72.0 | 74.7 | 74.7 | 73.8 | 72.9 |
| Spring | | | | | | |
| | Grassland | 20.0 | 20.0 | 23.2 | 24.8 | 62.4 |
| | Oak/Cedar | 72.7 | 67.3 | 62.0 | 55.3 | 59.3 |
| | Pond | 65.6 | 65.6 | 64.8 | 64.8 | 71.2 |
| | Pine | 71.1 | 68.0 | 76.9 | 71.6 | 77.3 |
| Summer | | | | | | |
| | Grassland | 23.2 | 22.4 | 22.4 | 29.6 | 68.0 |
| | Oak/Cedar | 82.7 | 69.3 | 69.3 | 56.0 | 66.0 |
| | Pond | 72.8 | 68.0 | 64.8 | 60.0 | 73.6 |
| | Pine | 72.9 | 66.7 | 74.7 | 62.2 | 70.2 |
| Fall | | | | | | |
| | Grassland | 20.0 | 20.0 | 20.8 | 28.0 | 48.8 |
| | Oak/Cedar | 72.0 | 68.0 | 63.3 | 51.3 | 50.7 |
| | Pond | 69.8 | 69.0 | 66.0 | 63.4 | 73.0 |
| | Pine | 72.9 | 70.7 | 72.4 | 66.7 | 68.4 |

**Factors Influencing Diversity**

Factors affecting diversity within seasons varied greatly when compared across all habitats. Multiple linear regression (MLR) models each season showed diversity correlated with one to four variables. All candidate variables for the MLR regression models are in Appendix 5. The MLR model for winter was represented by a Mallow's Cp of 4.579, $r^2$=0.61 and $p$ <0.001. For the winter model, positive correlations were found between diversity and both yaupon and post oak canopy covers. An inverse correlation existed with duff depth.

H' = 2.651 + 0.203 (yaupon canopy cover)

+ 0.233 (post oak canopy cover)

– 0.402 (duff depth)

The MLR model for spring had a Mallow's Cp of 4.904, $r^2$ = 0.646 and $p < 0.001$. Like the winter model, the spring model shows a positive correlation between diversity and yaupon canopy cover. A positive correlation with pine canopy coverage is also present in the spring. The spring model also had an inverse correlation with horizontal obscurity measures from 0.0 – 0.5 m.

H' = 2.995 + 0.176 (yaupon canopy cover)

+ 0.274 (pine canopy cover)

– 1.273 (VPB 0.0 – 0.5 m height increment)

The model for summer was represented by a Mallow's Cp of 1.7, $r^2$ = 0.699 and $p < 0.001$. This model was the simplest with only one factor needed to describe diversity, post oak canopy cover with which a positive correlation was found.

H' = 1.629 + 0.258 (post oak canopy cover)

The MLR model for fall was represented by a Mallow's Cp of 8.244, $r^2 = 0.323$ and $p = 0.086$. Of the four seasons, fall had the lowest desirable selection criteria (Cp, $r^2$, p). This model shows a positive correlation between diversity and both yaupon and eastern red cedar canopy cover. Inverse correlations were shown with vertical obscurity measures at 0.0 – 0.5 m and post oak canopy cover.

H' = 3.538 + 0.512 (yaupon canopy cover)

+ 0.481 (eastern red cedar canopy cover)

– 1.340 (VPB 0.0 – 0.5 m height increment)

– 0.702 (post oak canopy)

## CHAPTER 4

## DISCUSSION

### Avian Diversity

I documented the presence of 110 species of birds representing fifteen orders on the Griffith League Ranch. Order Passeriformes, as expected, dominated the total number of species detected with 62 detections through point counts, incidental observation and mist netting. Other orders with modest representations include both Orders Ciconiiformes and Piciformes, each with eight species. Two members of the Order Ciconiiformes, White Ibis (*Eudocimus albus*) and White-faced Ibis (*Plegadis chihi*), were unexpected birds for GLR due to the lack of suitable habitat. The White-faced Ibis is currently listed as Threatened by the State of Texas.

Most species observed were expected, however, some common birds never were found or were present in low numbers. One such group was ducks. Freeman (1996) notes 23 possible species for the area; only five species were recorded on GLR. Also missing were Eastern Screech Owl (*Megascops asio*), Ruby-throated Hummingbird (*Archilochus colubris*), Dickcissel (*Spiza americana*), Red-winged Blackbird (*Ageliaus phoeniceus*) and Pine Siskin (*Carduelis pinus*). The only species of woodpecker (Piciformes) not observed that could potentially occur on GLR was the Redheaded Woodpecker (*Melanerpes erthrocephalus*). With an abundance of snags (75/ha) on GLR this diversity of woodpeckers was expected, since woodpeckers show a positive correlation with snag abundance (Lohr et al. 2002, Showalter and Whitmore 2002). While the species richness for GLR is moderate at best, no introduced birds were observed.

Diversity values did not vary significantly among seasons but were different among habitat types within three of the four seasons. Because diversity values did not change across seasons, avian community variation may best explain the differences seen among seasons, habitat use, and factors influencing avian diversity.

Birds common during all seasons (permanent residents) through point count detections were Red-shouldered Hawk (*Buteo lineatus*), Red-bellied Woodpecker (*Melanerpes carolinus*), Tufted-titmouse (*Baeolophus bicolor*), Carolina Wren (*Thryothorus ludovicianus*), Pine Warbler (*Dendroica pinus*), and Northern Cardinal (*Cardinalis cardinalis*). Winter birds common to GLR were Ruby-crowned Kinglet (*Regulus calendula*), American Robin (*Turdus migratorius*), Cedar Waxwing (*Bombycilla cedrorum*), Yellow-rumped Warbler (*Dendroica* coronata), American Goldfinch (*Carduelis psaltria*) and Chipping Sparrow (*Spizella passerine*). Birds common in the summer season were Yellow-billed Cuckoo (*Coccyzus americanus*), White-eyed Vireo (*Vireo griseus*), Summer Tanager (*Piranga flava*) and Painted Bunting (*Passerina ciris*).

Winter and summer had a similar number of species, 49 and 51 respectively. Twenty-six species were present both seasons and can be classified as permanent residents. Spring observations totaled 74 species, the most of any season. Twenty-six species were seen only in the spring season, seventeen of these were migrants. Fall had the fewest number of species, 39, with thirteen percent of the avian community being sparrows of the Family Emberizidae. The low number of species in the fall may be a reflection of the point count method as birds did not appear to vocalize as often or as late into the morning when compared to the spring or summer. Fall did have the highest number of observations but they commonly were visual detections of large groups of American Robins and Cedar Waxwings.

From the results of the ANOVA and contrasts comparing habitats within season, winter had similar diversity values for oak/cedar habitats, pond habitats and pine habitats. Grassland habitats were less diverse and dissimilar from the other habitat types. Eastern Phoebe (*Sayornis phoebe*), Vesper Sparrow (*Poecetes gramineus*) and Lincoln Sparrow (*Melospiza lincolnii*) were common in winter grassland habitats. Mallard (*Anas platyrhynchos*), Ring-necked Duck (*Aythya collaris*) and Purple Gallinule (*Porphyrio* martinica) were found in pond habitats. Oak/cedar habitats and Pine habitats were similar in avian composition.

Spring had similar results as winter for diversity among habitats. Mourning Dove (*Zenaida* macroura), Scissor-tailed Flycatcher (*Tyrannus forficatus*) and Northern Mockingbird (*Mimus polyglottos*) were commonly found in grassland habitats during the spring. All spring migrants, excluding the Common Snipe (*Gallinago gallinago*) and Northern Harrier (*Ciris cyaneus*), were found in the three other habitat types but appeared more common (13 of 17) in the pond habitats.

Summer also had habitat diversities similar to winter and spring. Summer breeders were commonly found in the three similar habitat types, but the late summer migrant, Blue-gray Gnatcatcher (*Polioptila caerulea*), was most common in the oak/cedar habitat. This may contribute to the slightly higher, though not significant, diversity value found in the oak/cedar habitat.

Fall had the fewest number of species and no difference in diversity among habitat types. The avian communities differed with sparrows common in the grasslands while both kinglets, American Robins and Carolina Chickadees (*Parus bicolor*) were common in the other habitats.

**Vegetation Inventory**

The USDA Soil Conservation Service, SCS (1979) lists an historical, stable plant community most like that of a post oak savannah habitat with a mix of perennial grasses and deciduous oaks. Little bluestem (*Schizachyrium scoparium*), indiangrass (Sorghastrum nutans), brownseed paspalum (*Paspalum plicatulum*) and switchgrass (*Panicum virgatum*) should be the dominant grass species and post oak, blackjack oak, elm (*Ulmus sp.*), hackberry (*Celtis sp.*) and yaupon are listed as the dominant trees. Interestingly, loblolly pine and eastern red cedar are not part of the historical plant community according to the SCS but pollen records from nearby bogs document their presence in the region for the last twenty-thousand years (Bryant 1977) and should be included in any description of the vegetation.

Current vegetation conditions for GLR yield different results with the absence of almost all dominant native grasses. In the northern corner of GLR little bluestem appears to be holding strong, however brownseed paspalum and switchgrass are rare and Indiangrass was never observed on GLR. Increased forest canopy, grazing history of the property, and introduction of non-native grasses are possible explanations for the reduction in these native grasses.

Dominant trees have increased from their historical proportion and contributed to the lack of herbaceous vegetation by shading and excess deposits of duff. Post oak and blackjack oak were the dominant woody species and have continued to increase along with other tree species. Hackberry was not a common tree on the property, nor were elm species except in the riparian habitats. One tree species quickly becoming abundant in some parts of GLR is honey mesquite (*Prosopus glandulosa*). Chinaberry (*Melia azedarach*) also is becoming abundant in some areas, but this tree was not noted at any of the 25 point count sites. Fire suppression and grazing are the most likely causes for the change in woody vegetation composition (Smeins and Diamond 1984).

VPB measures suggest that grassland habitats consistently have lower percent horizontal obscurity in four or five height levels for the grassland habitat. All other habitats are similar. This shows possible correlations with avian diversity and should influence habitat use.

According to measures of herbaceous vegetation using Daubenmire frames 70% of the herbaceous plant cover is composed of introduced species. The majority of this is attributed to the cleared pastures of Bahia grass and costal

Bermuda found across the property. Habitat restoration of the grasslands as well as the woodlands must be considered and are further discussed in the Management Implications section.

**Factors Influencing Diversity**

Avian communities may vary greatly among seasons at a given location (Rice et al. 1980). If those communities vary, factors that best describe avian communities also may vary from season to season. Rotenberry et al. (1979) found this variation of factors among seasons, but also found that some factors were common in multiple seasons. Factors of the habitat that best describe the association found between avian diversity and habitats for my study are similar to that of Rotenberry et al., except post oak showed both positive and inverse correlations to bird diversity among seasons. Also as previously noted, there were similar results from ANOVA of VPB measures and avian diversity. Both tests showed no difference among seasons, but were different among habitats. Vertical structure has been reported in other studies as a factor relating to avian diversity (MacArthur and MacArthur 1961, MacArthur 1964, Recher 1969). These factors associated with avian diversity are simply the first step in understanding how diversity relates to habitat components. How and why birds use these components were not investigated in this study but possible explanations are offered.

*Winter* — American Robins and Cedar Waxwings, both known frugivores, were abundant in the winter. Fruit produced by yaupon in the fall that persists throughout much of the winter probably account for much of the positive correlation found between yaupon and avian diversity. Wintering sparrows were most common in grassland habitats where the least amount of duff was recorded. The Vesper Sparrow was common in grasslands and relies mostly on grass and forb seeds in winter months (Rosenberg et al. 1991). The reduction in duff and increase in herbaceous vegetation, mostly grasses, can account for the inverse correlation found between duff depth and avian diversity. Foraging ecology of wintering warbler species may be one of many possible explanations for the positive correlation found between post oak and diversity.

*Spring* — Horizontal obscurity at the 0.0 — 0.5 m height increment was found to have an inverse relationship with diversity. The inverse relationship is likely due to the positive correlations found with other woody components. In areas of high yaupon and pine canopy cover, very little herbaceous vegetation was found due to the shading and duff deposits. Yaupon and pine canopy covers both show a positive correlation with avian diversity and may provide birds with structure and thermal cover not present in deciduous hardwoods early in the season. MacArthur and MacArthur (1961) found that foliage height density, a measure of vertical woody structure, best explained bird occurrence. Results from my spring regression model concur with that report.

*Summer* —Post oak was the only factor chosen to describe diversity in summer. While post oak was the dominant tree in the soil types found on GLR historically (USDA Soil Conservation Service 1979), this species has greatly increased in abundance since then. Regardless of the increase, diversity continues to show a positive correlation with post oak canopy cover likely due to structure and foraging opportunities provided by this component.

*Fall* — The regression model for fall had a rather low $r^2$, but does report some potentially useful findings. Evergreen trees, yaupon and eastern red cedar, had a positive correlation with diversity. These species may provide cover and food for many species as they migrate though in the fall. Eastern red cedar and yaupon both fruit at this time of year and provide wintering frugivores structure, cover and food. Horizontal obscurity at 0.0 — 0.5 m had an inverse correlation with avian diversity and again may be related to the presences of woody structure shading out herbaceous vegetation that contribute to the horizontal cover at this height level. Post oak had an unexpected inverse correlation with avian diversity.

**Management Implications**

The common assumption that a diverse habitat will provide a more diverse avian community is supported by this study. By comparing those components of the habitat, I found that great variation of components associated with avian diversity takes place among seasons (e.g., inverse correlation with post oak in fall, positive correlation in the spring). Four factors show a positive correlation with avian diversity (loblolly pine, eastern red cedar, yaupon and post oak) and three factors show an inverse correlation with avian diversity (duff depth, VPB 0.0 — 0.5 m and post oak). When comparing measured factors in all seasons, yaupon appears to be one of the most important habitat components explaining diversity. Yaupon may be a primary food source for many of the avian species found on GLR. Vertical obscurity at the 0.0 — 0.5 m height increment also appears to be an important factor in associated with avian diversity. The inverse correlation may appear as an anomaly but is best explained by the presence of dense woody structure in the forested areas and possibly introduced grasses dominating the grassland habitats. Grassland habitats were characterized by having a reduced avian diversity, reduced woody vegetation canopy, and increased herbaceous vegetation coverage. The opposite is true for the other three habitat types. Post oak shows both positive and inverse correlations and was chosen as a factor that explains avian diversity in three seasons. Differences in avian communities from season to season likely attribute to this change in use and should be a focus in habitat management. The woody components of a habitat provide nesting structure, cover, and food for birds and have been shown to be an important component in habitat use (Rice et al. 1983). When comparing the four MLR models for each season, 87.5% of the time tree species are factors explaining a positive correlation with avian diversity. Only once was an inverse correlation found with trees. That correlation was with post oak in the fall when avian diversity values were equal among habitats.

Each of the four habitat types varied in woody canopy cover and water availability. By seasons avian diversity did not vary, but in three of four seasons oak/cedar, pine and pond habitats had a higher diversity with no difference among the three. This similarity in diversity among wooded habitats suggests that the oak/cedar, pine and pond habitats can be treated as a single habitat type. Habitat types can then be reduced to grasslands and forest. Grassland habitats have a lower diversity, but contribute to the overall avian diversity found on GLR because some species were observed only in the grassland habitat. These sites are important to GLR and should be managed to preserve that diversity. The forested habitats were more diverse and contained a greater abundance of migratory species.

Grassland habitats were dominated by introduced grasses like costal Bermuda and Bahia grass and lacked the native dominant grasses that are part of the historical community. Restoration efforts which could include burning, disking, mowing, chemical herbicide application and reseeding could be implemented to promote a more diverse vegetation and avian community. Bobwhite Quail (*Colinus virginianus*) were not observed on the ranch and were part of the historical avian community. Current habitat condition and imported red fire ants are the likely causes for the absence of this species. Habitat management over the next decade could allow reintroduction of this species.

Forest habitats show a greater diversity of birds, but would not be described as high quality based on low species diversity and richness. Ample vertical structure may better explain the higher diversity found in the forested habitats. Forested habitats are dense with closed canopies, and lack herbaceous vegetation needed to produce seeds and support invertebrate populations within the forest. This may drive many species to nest in edge habitats where both forest structure and herbaceous vegetation occur. This site selection can then increase the risk of predation and nest parasitism by cowbirds.

Thinning of the forest and prescribed fire are two primary management strategies needed to better the forest habitat quality. Timber harvest of pine followed by cool season prescribed burning to remove slash and duff buildup could benefit both landowner and avian communities.

# APPENDICES

Appendix 1: Species List of Birds detected from June 2002 to May 2003 for Griffith League Ranch. Names in accordance with AOU and changes made through Banks et al. (2003).

| Scientific Name | Common Name | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| ORDER ANSERIFORMES | | | | | |
| *Dendrocygna autumnalis* | Black-bellied Whistling Duck | | X | | |
| *Aix sponsa* | Wood Duck | | X | | |
| *Anas strepera* | Gadwall | | X | | |
| *Anas platyrhynchos* | Mallard | X | | | |
| *Aythya collaris* | Ringed-neck Duck | X | | | |
| ORDER GALLIFORMES | | | | | |
| *Melagris gallopavo* | Wild Turkey | X | X | X | |
| ORDER PELECANIFORMES | | | | | |
| *Phalacrocax auritus* | Double-crested Cormorant | | X | | |
| *Anhinga anhinga* | Anhinga | | X | | |
| ORDER CICONIIFORMES | | | | | |
| *Ardea herodias* | Great Blue Heron | | X | X | |
| *Ardea alba* | Great Egret | | X | | |
| *Egretta caerulea* | Little Blue Heron | | X | | |
| *Bubulcus ibis* | Cattle Egret | | X | X | |
| *Butorides virescens* | Green Heron | | X | X | |
| *Eudocimus albus* | White Ibis | | | X | |
| *Plegadis chihi* | White-faced Ibis | | X | | |
| *Coragyps atratus* | Black Vulture | X | | X | |
| *Carthartes aura* | Turkey Vulture | X | X | X | X |

Appendix 1 cont.

| Scientific Name | Common Name | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| ORDER FALCONIFORMES | | | | | |
| *Cirus cyaneus* | Northern Harrier | | X | | |
| *Accipiter striatus* | Sharp-shinned Hawk | | X | X | |
| *Pandion haliaetus* | Osprey | | X | | |
| *Buteo lineatus* | Red-shouldered Hawk | X | X | X | X |
| *Buteo platypterus* | Broad-winged Hawk | | | X | |
| *Buteo jamaicensis* | Red-tailed Hawk | | X | X | X |
| *Caracara cheriway* | Crested Caracara | | | | X |
| *Falco spaverius* | American Kestrel | | | X | X |
| ORDER GRUIIFORMES | | | | | |
| *Porphyrio martinica* | Purple Gallinule | X | | | |
| *Grus canadensis* | Sandhill Crane | X | | | |
| ORDER CHARDRIIFORMES | | | | | |
| *Charadrius vociferus* | Killdeer | X | | | |
| *Gallinago gallinago* | Common Snipe | | X | | |
| ORDER COLUMBIFORMES | | | | | |
| *Zenaida macroura* | Mourning Dove | X | X | X | X |
| *Columbina inca* | Inca Dove | | | X | |
| *Columbina passerina* | Common Ground Dove | X | X | X | |
| ORDER CUCULIFORMES | | | | | |
| *Coccyzus americanus* | Yellow-billed Cuckoo | | X | X | |
| *Geococcyx californianus* | Greater Roadrunner | | X | X | |

Appendix 1 cont.

| Scientific Name | Common Name | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| ORDER STRIGIFORMES | | | | | |
| *Bufo virginianus* | Great Horned Owl | | | | X |
| *Strix varia* | Barred Owl | X | X | X | X |
| ORDER CAPRIMULGIFORMES | | | | | |
| *Capromulgus carolinensis* | Chuck-will's-widow | | X | | |
| *Capromulgus vociferus* | Whip-poor-will | | | X | |
| ORDER APODIFORMES | | | | | |
| *Archilochus alexandri* | Black-chinned Hummingbird | | X | X | |
| ORDER CORACIIFORMES | | | | | |
| *Ceryle alcyon* | Belted Kingfisher | | | X | X |
| ORDER PICIFORMES | | | | | |
| *Melanerpes aurifrons* | Golden-fronted Woodpecker | X | X | X | |
| *Melanerpes carolinus* | Red-bellied Woodpecker | X | X | X | X |
| *Sphyrapicus varius* | Yellow-bellied Sapsucker | X | | | |
| *Picodes scalaris* | Ladder-backed Woodpecker | | X | | |
| *Picodes pubescens* | Downy Woodpecker | X | X | X | X |
| *Picodes villosus* | Hairy Woodpecker | | X | X | |
| *Dryocopus pileatus* | Pileated Woodpecker | X | X | X | X |
| *Colaptes auratus* | Northern Flicker | X | | | |

Appendix 1 cont.

| Scientific Name | Common Name | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| ORDER PASSERIFORMES | | | | | |
| FAMILY TYRANNIDAE | | | | | |
| *Contopus cooperi* | Olive-sided Flycatcher | | X | X | X |
| *Empidonax virescens* | Acadian Flycatcher | | X | | |
| *Empidnax minimus* | Least Flycatcher | | X | | |
| *Empidnas sp.* | Empidnax sp. | | X | X | |
| *Sayornis phoebe* | Eastern Phoebe | X | | X | X |
| *Myiarchus crinitus* | Great-crested Flycatcher | | X | X | |
| *Tryannus forficatus* | Scissor-tailed Flycatcher | | X | X | X |
| FAMILY LANIIDAE | | | | | |
| *Lanius ludovicianus* | Loggerhead Shrike | | X | | |
| FAMILY VERIONIDAE | | | | | |
| *Vireo olivaceous* | Red-eyed Vireo | X | X | X | |
| *Vireo bellii* | Bell's Vireo | | | X | |
| *Vireo griseus* | White-eyed Vireo | X | X | X | |
| *Vireo solitarius* | Blue-headed Vireo | | X | | |
| FAMILY CORVIDAE | | | | | |
| *Cyanocitta cristata* | Blue Jay | X | X | X | X |
| *Corvus brachyrhychos* | American Crow | X | X | X | X |
| FAMILY HIRUNDINIDAE | | | | | |
| *Progne subis* | Purple Martin | X | X | | |
| *Hirundo rustica* | Barn Swallow | | X | X | |

Appendix 1 cont.

| Scientific Name | Common Name | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| FAMILY PARIDAE | | | | | |
| *Baeolophus bicolor* | Tufted Titmouse | X | X | X | X |
| *Poecile carolinensis* | Carolina Chickadee | X | X | X | X |
| FAMILY TROGLODYTIDAE | | | | | |
| *Thryothorus ludovicianus* | Carolina Wren | X | X | X | X |
| *Thryomanes bewickii* | Bewick's Wren | X | | | |
| *Troglodytes aedon* | House Wren | | X | | |
| *Troglodytes troglodytes* | Winter Wren | X | | | |
| FAMILY REGULIDAE | | | | | |
| *Regulus satrapa* | Golden-crowned Kinglet | X | | | X |
| *Regulus calendula* | Ruby-crowned Kinglet | X | X | | X |
| FAMILY SYLVIIDAE | | | | | |
| *Polioptila caerulea* | Blue-gray Gnatcatcher | | X | X | |
| FAMILY TURDIDAE | | | | | |
| *Sialia sialis* | Eastern Bluebird | X | X | | |
| *Turdus migratorius* | American Robin | X | | | X |
| *Hylocichla mustelina* | Wood Thrush | | X | | |
| *Catharus guttatus* | Hermit Thrush | X | | | X |
| FAMILY MIMIDAE | | | | | |
| *Mimus polyglottos* | Northern Mockingbird | X | X | X | X |
| FAMILY BOMBYCILLIDAE | | | | | |
| *Bombycilla cedrorum* | Cedar Waxwing | X | X | | X |

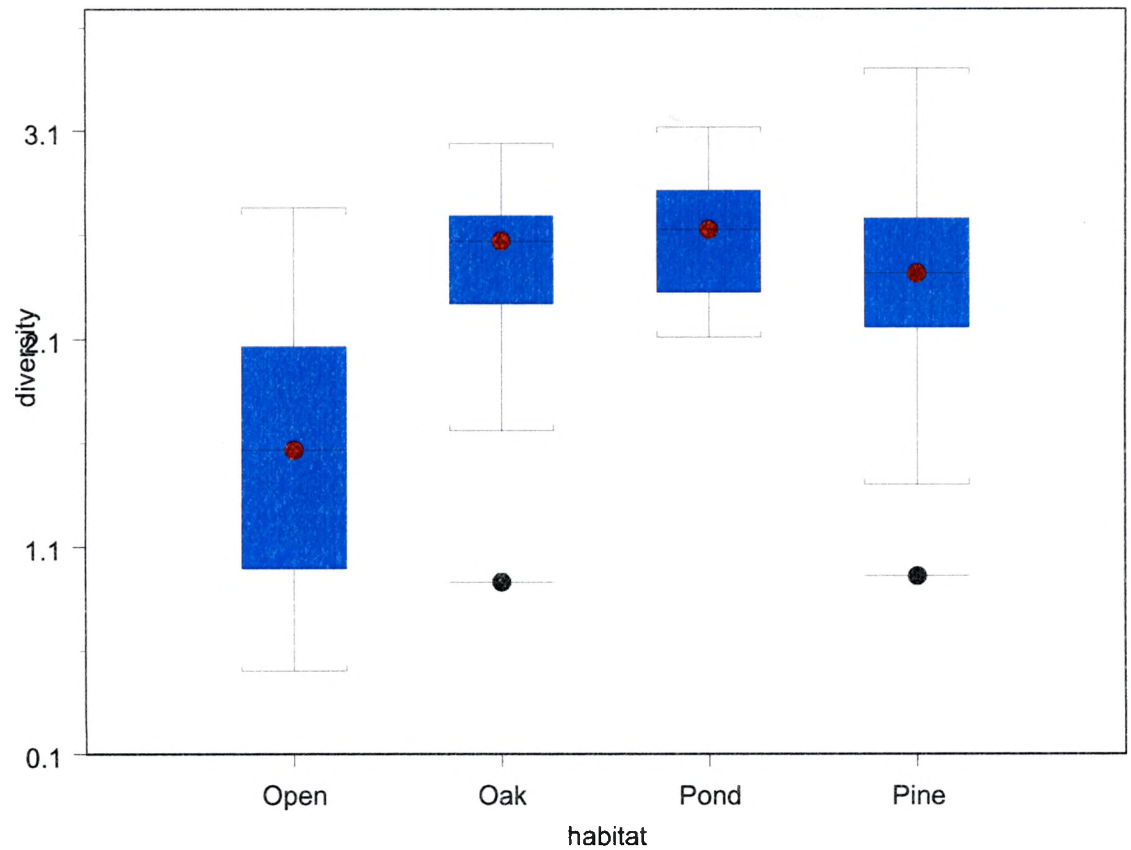
Appendix 1 cont.

| Scientific Name | Common Name | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| FAMILY PARULIDAE | | | | | |
| *Vermivora chrysoptera* | Golden-winged Warbler | | | | X |
| *Vermivora ruficapilla* | Nashville Warbler | | X | X | |
| *Parula americana* | Northern Parula | X | X | X | |
| *Dendroica petechia* | Yellow Warbler | | | | X |
| *Dendroica magnolia* | Magnolia Warbler | | X | | |
| *Dendroica coronata* | Yellow-rumped Warbler | X | X | X | X |
| *Dendroica pinus* | Pine Warbler | X | X | X | X |
| *Mniotilta varia* | Black-and-White Warbler | X | X | X | |
| *Seiurus motacilla* | Louisiana Waterthrush | X | | | |
| *Geothlypis trichas* | Common Yellowthroat | | X | | |
| *Icteria virens* | Yellow-breasted Chat | | X | | |
| FAMILY THRAUPIDAE | | | | | |
| *Piranga flava* | Summer Tanager | | X | X | |

Appendix 1 cont.

| Scientific Name | Common Name | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| FAMILY EMBERIZIDAE | | | | | |
| *Spizella pusilla* | Field Sparrow | | | | X |
| *Spizella passerina* | Chipping Sparrow | X | | | X |
| *Poecetes gramineus* | Vesper Sparrow | X | | | X |
| *Passerculus sandwichensis* | Savannah Sparrow | | | | X |
| *Chondestes grammacus* | Lark Sparrow | | X | | |
| *Passerian iliaca* | Fox Sparrow | | | | X |
| *Melospiza melodia* | Song Sparrow | X | | | |
| *Melospiza lincolnii* | Lincoln Sparrow | X | X | | |
| *Zonotrichia albicollis* | White-throated Sparrow | | X | | |
| *Junco hyemalis* | Dark-eyed Junco | X | | | |
| FAMILY CARDINALIDAE | | | | | |
| *Cardinalis cardinalis* | Northern Cardinal | X | X | X | X |
| *Passerina ciris* | Painted Bunting | | X | X | |
| FAMILY ICTERIDAE | | | | | |
| *Sturnella sp* | Meadowlark sp. | | | | X |
| *Quiscalus quiscula* | Common Grackle | | | | X |
| *Quiscalus mexicanus* | Great-tailed Grackle | | X | | |
| *Molothrus ater* | Brown-headed Cowbird | X | X | X | |
| *Icterus galbula* | Baltimore Oriole | | X | | |
| FAMILY FRINGILLIDAE | | | | | |
| *Carpodacus mexicanus* | House Finch | | X | | |
| *Carduelis psaltria* | American Goldfinch | X | X | | X |

Appendix 2. Box plot summaries, pooled across seasons, of avian diversity values (H ) from point counts within four habitats found on Griffith League Ranch, Bastrop County, Texas.



Appendix 3. Percent canopy cover of five dominant woody plant species (*Ilex vomitoria*, *Juniperus virginiana, Pinus taeda*, *Quercus marilandica* and *Q. stellata*) recorded using line intercept measures taken from 25 points on Griffith League Ranch, Bastrop County, Texas.

| | *Ilex vomitoria* | *Juniperus virginiana* | *Pinus taeda* | *Quercus marilandica* | *Quercus stellata* |
|---|---|---|---|---|---|
| Site 1 | 0.0 | 1.9 | 9.1 | 0.0 | 0.0 |
| Site 2 | 4.9 | 27.1 | 42.8 | 41.3 | 17.4 |
| Site 3 | 1.2 | 28.2 | 25.1 | 25.9 | 39.0 |
| Site 4 | 5.5 | 19.8 | 34.3 | 17.3 | 57.7 |
| Site 5 | 17.1 | 32.9 | 10.7 | 26.4 | 64.1 |
| Site6 | 11.2 | 23.8 | 13.2 | 9.5 | 38.5 |
| Site 7 | 17.2 | 18.5 | 47.6 | 7.6 | 23.4 |
| Site 8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Site 9 | 0.0 | 0.0 | 11.0 | 0.0 | 0.0 |
| Site 10 | 18.2 | 16.5 | 73.1 | 3.9 | 16.6 |
| Site 11 | 14.4 | 6.4 | 52.9 | 15.9 | 28.6 |
| Site 12 | 43.8 | 13.4 | 67.3 | 3.8 | 31.7 |
| Site 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Site 14 | 43.4 | 7.8 | 67.3 | 3.8 | 25.3 |
| Site 15 | 53.3 | 19.9 | 59.8 | 2.9 | 16.8 |
| Site 16 | 17.4 | 3.0 | 57.2 | 15.5 | 27.6 |
| Site 17 | 1.3 | 0.8 | 1.3 | 9.2 | 5.1 |
| Site 18 | 2.9 | 0.2 | 11.3 | 0.0 | 0.0 |
| Site 19 | 14.1 | 16.2 | 58.1 | 14.0 | 34.2 |
| Site 20 | 24.9 | 13.3 | 66.6 | 12.5 | 30.1 |
| Site 21 | 22.9 | 9.6 | 77.1 | 2.4 | 30.2 |
| Site 22 | 15.2 | 44.8 | 35.8 | 8.6 | 38.2 |
| Site 23 | 30.2 | 39.0 | 34.2 | 10.2 | 50.8 |
| Site 24 | 38.9 | 34.1 | 68.3 | 6.7 | 36.8 |
| Site 25 | 59.8 | 6.9 | 73.9 | 2.2 | 20.3 |

Appendix 4. Herbaceous plants recorded at 25 sites using quadrat sampling techniques on Griffith League Ranch, Bastrop County, Texas. Comments refer to Native (N), Introduced (I), Forb (F), Grass (G), Sedge (S), Annual (A) and Perennial (P).
Appendix 4a. Summer herbaceous plants

| Scientific Name | Common Name | Family | Comments | | |
|---|---|---|---|---|---|
| *Froelichia floridana* | Field snakecotton | Amaranthaceae | N | F | A |
| *Ambrosia psilostachya* | Western ragweed | Asteraceae | N | F | P |
| *Bidens frondosa* | Beggar-tick | Asteraceae | N | F | A |
| *Chrysopsis pilosa* | Soft golden aster | Asteraceae | N | F | A |
| *Eupatorium compositifolium* | Dogfennel | Asteraceae | N | F | P |
| *Gaillardia pulchella* | Indian blanket | Asteraceae | N | F | A |
| *Symphyotricum subulatum* | Wirewood | Asteraceae | N | F | A |
| *Vernonia texana* | Texas ironweed | Asteraceae | N | F | P |
| *Polypremum procumbens* | Juniper-leaf | Buddlejaceae | N | F | A |
| *Lechea mucronata* | Hairy pinweed | Cistaceae | N | F | P |
| *Commelina erecta* | Erect day flower | Commelinaceae | N | F | P |
| *Carex* sp. | Caric sedge | Cyperaceae | N | S | P |
| *Isolepis* sp. | Bulrush | Cyperaceae | N | S | A |
| *Scleria triglomerata* | Whip-grass | Cyperaceae | N | S | P |
| *Stylisma pickeringii* | Big-pod bonamia | Convolvulaceae | N | F | P |
| *Cnidoscolus texanus* | Texas bull nettle | Euphorbiaceae | N | F | P |
| *Croton capitatus* | Woolly croton | Euphorbiaceae | N | F | A |
| *Croton glandulosus* | Tropic croton | Euphorbiaceae | N | F | A |
| *Euphorbia corollata* | Flowering spurge | Euphorbiaceae | N | F | A |
| *Euphorbia* sp. | Spurge sp. | Euphorbiaceae | ? | F | ? |
| *Senna* sp. | Senna sp. | Fabaceae | ? | F | ? |
| *Centrosema virginianum* | Butterfly-pea | Fabaceae | N | F | P |
| *Chamaecrista fasciculata* | Partridge-pea | Fabaceae | N | F | A |
| *Galactia canescens* | Hoary milk-pea | Fabaceae | N | F | P |
| *Galactia regularis* | Downy milk-pea | Fabaceae | N | F | P |
| *Galactia* sp. | Milk-pea sp. | Fabaceae | N | F | P |
| *Galactia volubilus* | Downy milk-pea | Fabaceae | N | F | P |
| *Lespedeza repens* | Creeping bush-clover | Fabaceae | N | F | P |

Appendix 4a cont.

| Scientific Name | Common Name | Family | Comments | | |
| --- | --- | --- | --- | --- | --- |
| *Cenchrus spinifex* | Common sandbur | Poaceae | N | G | P |
| *Cynodon dactylon* | Bermuda grass | Poaceae | I | G | P |
| *Dichanthelium* sp. | Panic grass | Poaceae | N | G | P |
| *Digitaria cognata* | Crabgrass | Poaceae | N | G | P |
| *Eragrostis secundiflora* | Red love grass | Poaceae | N | G | P |
| *Panicum acuminatum* | Woolly rosette grass | Poaceae | N | G | P |
| *Paspalum setaceum* | Thin paspalum | Poaceae | N | G | P |
| *Paspalum notatum* | Bahiagrass | Poaceae | I | G | P |
| *Schizachyrium scoparium* | Little bluestem | Poaceae | N | G | P |
| *Diodia teres* | Buttonweed | Rubiaceae | N | F | A |
| *Galium pilosum* | Hairy bedstraw | Rubiaceae | N | F | P |
| *Parietaria pensylvanica* | Pennsylvania pellitory | Urticaceae | N | F | A |

Appendix 4b. Fall herbaceous plants.

| Scientific Name | Common Name | Family | Comments | | |
|---|---|---|---|---|---|
| *Ambrosia psilostachya* | Western ragweed | Asteraceae | N | F | P |
| *Andropogon ternarius* | Split-beard bluestem | Poaceae | N | G | P |
| *Aristida purpurea* | Purple three-awn | Poaceae | N | G | P |
| *Callirhoe involucrata* | Winecup | Malavaceae | N | F | P |
| *Carex planostachys* | Cedar caric sedge | Cyperaceae | N | S | P |
| *Carex* sp. | Caric sp. | Cyperaceae | N | S | P |
| *Cenchrus spinifex* | Common sandbur | Poaceae | N | G | P |
| *Chamaecrista fasciculata* | Partridge-pea | Fabaceae | N | F | A |
| *Chrysopsis pilosa* | Soft golden aster | Asteraceae | N | F | A |
| *Cnidoscolus texanus* | Texas bull nettle | Euphorbiaceae | N | F | P |
| *Commelina erecta* | Erect day flower | Commelinaceae | N | F | P |
| *Croton capitatus* | Woolly croton | Euphorbiaceae | N | F | A |
| *Cynodon dactylon* | Bermuda grass | Poaceae | I | G | P |
| *Dichanthelium* sp. | Panic grass | Poaceae | N | G | P |
| *Eupatorium compositifolium* | Dogfennel | Asteraceae | N | F | P |
| *Euphorbia bombensis* | Ingalls euphorbia | Euphorbiaceae | N | F | A |
| *Froelichia floridana* | Field snakecotton | Amaranthaceae | N | F | A |
| *Galactia* sp. | Milk-pea sp. | Fabaceae | N | F | P |
| *Galium pilosum* | Hairy bedstraw | Rubiaceae | N | F | P |
| *Oxalis* sp. | Woodsorrel | Oxalidaceae | N | F | P |
| *Panicum* sp. | Panic grass | Poaceae | N | G | P |
| *Paspalum notatum* | Bahia grass | Poaceae | I | G | P |
| *Polypremum procumbens* | Juniper-leaf | Buddlejaceae | N | F | A |
| *Schizachyrium scoparium* | Little bluestem | Poaceae | N | G | P |
| *Selaginella arenicola* | Riddell's spike-moss | Selaginellaceae | N | F | P |
| *Sida rhombifolia* | Arrow-leaf sida | Malvaceae | I | F | A |
| *Taraxacum officinale* | Common dandelion | Asteraceae | I | F | P |
| *Tradescantia sp.* | Spiderwort | Commelinaceae | N | F | P |
| *Triplasis purpurea* | Purple sand grass | Poaceae | N | G | A |
| *Vicia sativa* | Common vetch | Fabaceae | I | F | A |

Appendix 4c. Winter herbaceous plants.

| Scientific Name | Common Name | Family | Comments | | |
|---|---|---|---|---|---|
| *Ambrosia psilostachya* | Western ragweed | Asteraceae | N | F | A |
| *Evax* sp. | Rabbit's tobacco | Asteraceae | N | F | A |
| *Krigia occidentalis* | Western dwarf dandelion | Asteraceae | N | F | A |
| *Polypremum procumbens* | Juniper-leaf | Buddlejaceae | N | F | A |
| *Cerastium* sp. | Chickweed | Caryophyllaceae | ? | F | A |
| *Commelina erecta* | Erect day flower | Commelinaceae | N | F | P |
| *Carex planostachys* | Cedar caric sedge | Cyperaceae | N | S | P |
| *Carex* sp. | Caric sp. | Cyperaceae | N | S | P |
| *Baptisia bracteata* | Plains wild indigo | Fabaceae | N | F | P |
| *Vicia sativa* | Common vetch | Fabaceae | I | F | A |
| *Callirhoe involucrata* | Winecup | Malvaceae | N | F | P |
| *Mollugo verticillata* | Carpet weed | Molluginaceae | I | F | A |
| *Oxalis* sp. | Woodsorrel | Oxalidaceae | N | F | P |
| *Aristida purpurea* | Purple three-awn | Poaceae | N | G | P |
| *Cenchrus spinifex* | Common sandbur | Poaceae | N | G | P |
| *Cynodon dactylon* | Bermuda grass | Poaceae | I | G | P |
| *Dichanthelium* sp. | Panic grass | Poaceae | N | G | P |
| *Paspalum notatum* | Bahiagrass | Poaceae | I | G | P |
| *Schizachyrium scoparium* | Little bluestem | Poaceae | N | G | P |
| *Vulpia bromoides* | Sixweeks grass | Poaceae | I | G | A |
| *Galium pilosum* | Hairy bedstraw | Rubiaceae | N | F | P |

Appendix 4d. Spring herbaceous plants.

| Scientific Name | Common Name | Family | Comments | | |
|---|---|---|---|---|---|
| *Froelichia floridana* | Field snakecotton | Amaranthaceae | N | F | A |
| *Aristolochia erecta* | Swanflower | Aristolochiaceae | N | F | P |
| *Asclepias tuberosa* | Butterfly-weed | Asclepiadaceae | N | F | P |
| *Ambrosia psilostachya* | Western ragweed | Asteraceae | N | F | A |
| *Aphanostephus skirrobasis* | Arkansas lazy daisy | Asteraceae | N | F | A |
| *Bidens frondosa* | Beggar-tick | Asteraceae | N | F | A |
| *Chrysopsis pilosa* | Soft golden aster | Asteraceae | N | F | A |
| *Coreopsis* sp. | Coreopsis | Asteraceae | N | F | A |
| *Evax* sp. | Rabbit's tobacco | Asteraceae | N | F | A |
| *Psuedognaphalium obtusifolium* | Fragrant cudweed | Asteraceae | N | F | A |
| *Heterotheca subaxillaris* | Camphorweed | Asteraceae | N | F | A |
| *Parthenium hysterophorus* | False ragweed | Asteraceae | N | F | A |
| *Rudbeckia hirta* | Black-eyed-susan | Asteraceae | N | F | P |
| *Polypremum procumbens* | Juniper-leaf | Buddlejaceae | N | F | A |
| *Paronychia drummondii* | Drummond's nailwort | Caryophyllaceae | N | F | A |
| *Chenopodium ambrosioides* | Lamb's quarters | Chenopodiaceae | I | F | A |
| *Commelina erecta* | Erect day flower | Commelinaceae | N | ? | P |
| *Stylisma pickeringii* | Big-pod bonamia | Cornaceae | N | F | P |
| *Carex* sp. | Caric sedge | Cyperaceae | N | S | P |
| *Fimbrlstylis* sp. | Fimbristylis | Cyperaceae | ? | S | ? |
| *Cnidoscolus texanus* | Texas bull nettle | Euphorbiaceae | N | F | P |
| *Croton capitatus* | Woolly croton | Euphorbiaceae | N | F | A |
| *Euphorbia bombensis* | Ingalls euphorbia | Euphorbiaceae | N | F | A |
| *Euphorbia* sp. | Spurge sp. | Euphorbiaceae | N | F | A |
| *Tragia* sp. | Noseburn | Euphorbiaceae | N | F | P |
| *Chamaecrista fasciculata* | Partridge-pea | Fabaceae | N | F | A |
| *Galactia sp.* | Milk-pea sp. | Fabaceae | N | F | P |
| *Galactia volubilis* | Downy milk-pea | Fabaceae | N | F | P |
| *Pediomelum sp.* | Scurf-pea | Fabaceae | N | F | P |
| *Selaginella arenicola* | Riddell's selaginella | Selaginellaceae | N | F | P |
| *Monarda punctata* | Spotted beebalm | Lamiaceae | N | F | A |

Appendix 4d cont.

| Scientific Name | Common Name | Family | Comments |
|---|---|---|---|
| *Oenothera laciniata* | Cut-leaf evening-primrose | Onagraceae | N F P |
| *Plantago aristata* | Bottlebrush plantain | Plantaginaceae | N F A |
| *Bromus catharticus* | Rescue grass | Poaceae | I G A |
| *Chasmanthium sessiliflorum* | Narrow-leaf wood-oats | Poaceae | N G P |
| *Cynodon dactylon* | Bermuda grass | Poaceae | I G P |
| *Dichanthelium* sp. | Panic grass | Poaceae | N G P |
| *Digitaria cognata* | Crabgrass | Poaceae | N G P |
| *Eragrostis secundiflora* | Red love grass | Poaceae | N G P |
| *Paspalum notatum* | Bahiagrass | Poaceae | I G P |
| *Phalaris* sp. | Canary grass | Poaceae | I G A |
| *Schizachyrium scoparium* | Little bluestem | Poaceae | N G P |
| *Vulpia bromoides* | Six-weeks grass | Poaceae | I G A |
| *Rumex hastatulus* | Heart-winged sorrel | Polygonaceae | N F A |
| *Galium pilosum* | Hairy bedstraw | Rubiaceae | N F P |

Appendix 5. Candidate variables used in Multiple Linear Regression models constructed to identify important components of the habitats found on Griffith League Ranch, Bastrop County, Texas.

| Variable | Description |
|---|---|
| Duff | Measure of dead leaf matter |
| Canopy | Measure of horizontal cover by tree species |
| VPB 1 | Vertical obscurity at 2.0 - 2.5 m above ground |
| VPB 2 | Vertical obscurity at 1.5 - 2.0 m above ground |
| VPB 3 | Vertical obscurity at 1.0 - 1.5 m above ground |
| VPB 4 | Vertical obscurity at 0.5 - 1.0 m above ground |
| VPB 5 | Vertical obscurity at 0.0 - 0.5 m above ground |
| Pine/ha | Number of loblolly pines per hector |
| Cedar/ha | Number of eastern red cedar per hector |
| Post Oak/ha | Number of post oak per hector |
| BJ Oak/ha | Number of blackjack oak per hector |
| Yaupon/ha | Number of yaupon per hector |
| Yaupon canopy cover | Percent canopy cover of yaupon |
| Cedar canopy cover | Percent canopy cover of eastern red cedar |
| Pine canopy cover | Percent canopy cover of loblolly pine |
| BJ Oak canopy cover | Percent canopy cover of blackjack oak |
| P Oak canopy cover | Percent canopy cover of post oak |
| Forb Cover | Percent cover of all forbs |
| Grass Cover | Percent cover of all grasses |
| Sedge Cover | Percent cover of all sedges |
| Total herb cover | Percent cover of all herbaceous vegetation |
| Introduced herb cover | Percent cover of all introduced vegetation |
| Native plant cover | Percent cover of all native vegetation |
| Perennial cover | Percent cover of all perennials |
| Annual cover | Percent cover of all annuals |

## LITERATURE CITED

BANKS, RICHARD C., CARLA CICERO, JON L. DUNN, ANDREW W. KRATTER, PAMELA C. RASMUSSEN, J. V. REMSEN, JR., JAMES D. RISING, AND DOUGLAS F. STOTZ. 2003. Forty-fourth supplement to the American Ornithologists Union Check-list of North American Birds. Auk 120(3):923-931.

BERTIN R. I. 1977. Breeding habits of the Wood Thrush and Veery. Condor 79:303-311.

BEST, L. B. 1981. Seasonal changes in detection of individual bird species. Studies in Avian Biology 6:252-261.

BEST L. B. AND K. L. PETERSEN. 1985. Seasonal changes in detectability of sage and Brewer s sparrow. Condor 87:556-558.

BOULINIER, THIERRY, JAMES D. NICHOLS, JAMES E. HINES, JOHN R. SAUER, CURTIS H. FLATHER, AND KENNETH H POLLOCK. 2001. Higher temporal variability of forest breeding bird communities in fragmented landscapes. Proceedings of the National Academy of Sciences (USA) 95 (13) 7497-7501.

BROOKS, MARSHALL A., BRENNA C. HARRIGAN, KAREN M. JOHNSON, DAVID E. LOWE, JUSTEN P. LOWERY, JOEL W. MCGLOTHLIN, MICHELLE M. SASSO, SARAH A. SMITH, AND DANIEL A. CRISTOL. 2001. Revisit schedule does not affect result of point counts. Journal of Field Ornithology 72(3):404-411.

BRYANT V. M. JR. 1977. A 16,000 year old pollen record of vegetational change in central Texas. Palynology I:43-156.

CONNER, R. N. AND C. S. ADKISSON. 1977. Principal Component Analysis of woodpecker nesting habitat. Wilson Bulletin 89:122-129.

CORRELL, D. S. 1966. Pinaceae. In C. L. Lundell, Floral of Texas I. Renner: Texas Research Foundation.

DAUBENMIRE, R. F. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

DETTERMERS, RANDY, DAVID A. BUEHLER, JOHN G. BARTLETT, AND NATHAN A. KLAUS. 1999. Influence of point count length and repeated visits on habitat model performance. Journal of Wildlife Management 63(3):815-823.

FLATHER, C. H. AND J. R. SAUER. 1996. Using landscape ecology to test hypotheses about large-scale abundance patterns in migratory bird. Ecology 77(1):28-35.

FRANZREB, K. E. AND R. D. OHMART. 1978. The effects of timber harvesting on breeding birds in mixed coniferous forest. Condor 80:431-441.

FREEMAN, BRUSH. 1996. Birds of Bastrop and Buescher State Parks, including Lake Bastrop: A Field Checklist. Natural Resource Program, Texas Parks and Wildlife, Austin, Texas. 16 pp.

FULLER, R. J. AND D. R. LANGSLOW. 1984. Estimating numbers of birds by point counts: how long should counts last? Bird Study 31:195-202.

GABBE, AARON, P., SCOTT K. ROBINSON, AND JEFFERY D. BROWN. 2002. Tree-species preference of foraging insectivorous birds: Implications for floodplain restoration. Conservation Biology 16(2):462-470.

GATES, J. E. 1995. Point count modifications and breeding bird abundances in central Appalachian forests. Pages 135-144 in C. J. Ralph, J. R. Sauer, and S. Droege. Monitoring Bird Populations by Point Counts. U.S. Forest Service General Technical Report PSW-GTR-149.

HOWELL, CHRISTINE A., STEVEN C. LATTA, THERESE M. DONOVAN, PAUL A. PORNELUZI, GEOFFREY R. PARKS, AND JOHN FAABORG. 2000. Landscape effects mediate breeding bird abundance in Midwestern forests. Landscape Ecology 15(6):547-562.

KOEPP, PHILIP W. 2001. Environmental assessment/habitat conservation plan for an endangered species section 10(a) (1) (B) permit for incidental take of the Houston toad on Griffith League Ranch in Bastrop County, Texas.

KREBS, C. J. 2000. Ecological Methodology software.

LARSON, D. A., V. M. BRYANT, AND T. PATTY. 1972. Pollen analysis of a central Texas bog. American Midland Naturalist 88:358-367

LEMMONS, P. E. 1957. A new instrument for measuring forest overstory density. Journal of Forestry 55:667-669.

LOHR, STEVEN M., SIDNEY A. GAUTHREAUX, AND JOHN C. KILGO. 2002. Importance of coarse woody debris to avian communities in loblolly pine forests. Conservation-Biology.16(3):767-777.

LYNCH, JAMES F. 1995. Effects of point count duration, time of day, and aural stimuli on detectability of migratory and resident birds species in Quintana Roo, Mexico. Pages 1-6 in C. J. Ralph, J. R. Sauer, and S. Droege. Monitoring Bird Populations by Point Counts. U.S. Forest Service General Technical Report PSW-GTR-149.

MACARTHUR R. H. 1964. Environmental factors affecting bird species diversity. American Naturalist 98:387-396.

MACARTHUR R. H. AND J. W. MACARTHUR. 1961. On bird species diversity. Ecology 42:594-598.

MARTINEZ, DAVID R. AND FABIAN M. JAKSIC. 1996. Habitat, relative abundance, and diet of roufous-legged owls (*Strix rufipes* King) in temperate forest remnants of southern Chile. Ecoscience 3(3):259-263.

MAYFIELD H. F. 1981. Problems in estimating population size through counts of singing males. Studies in Avian Biology 6:200-224.

MCCLELLAND, RILEY B. AND PATRICIA T. MCCLELLAND. 1999. Pileated woodpecker nest and roost trees in Montana: links with old-growth and forest health . Wildlife Society Bulletin 27(3):846-857.

MCCOLLIN, DUNCAN. 1998. Forest edge habitat selection in birds: a functional approach. Ecography 21(3):247-260.

MONTGOMERY, DOUGLAS C., ELIZABETH A PECK, AND G. GEOFFREY VINING. 2001. Introduction to Linear Regression Analysis. John Wiley and Sons Inc. New York. pp. 641.

NUDDS, T. D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin 5:113-117.

PETIT, D. R., L. J. PETIT, V. A. SAAB, AND T. E. MARTIN. 1995. Fixed radius point counts in forests: factors influencing effectiveness and efficiency. Pages 49-56 in C. J. Ralph, J. R. Sauer, and S. Droege. Monitoring Bird Populations by Point Counts. U.S. Forest Service General Technical Report PSW-GTR-149.

RALPH C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, AND D. F. DESANTE. 1993. Handbook of Field Methods for Monitoring Landbirds. US Forest Service General Technical Report PSW-GTR-144.

RECHER, H. F. 1969. Species diversity and habitat diversity in Australia and North America. American Naturalist 103:75-80.

REYNOLDS, R. T., J. M. SCOTT, AND R. A. NUSSBAUM. 1980. A variable circular-plot method for estimating bird numbers. Condor 82:309-313.

RICE, JAKE, B. W. ANDERSON, AND R. D. OHMART. 1980. Seasonal habitat selection by birds in the lower Colorado River valley. Ecology 61:1402-1411.

RICE, JAKE, ROBERT D. OHMART, AND ANDERSON W. BERTIN. 1983. Habitat selection attributes of an avian community: a discriminant analysis investigation. Ecological Monographs 53(3):263-290.

RITTER, MICHAEL W. AND JULIE A. SAVIDGE. 1999. A predictive model of wetland habitat use on Guam by endangered Mariana Common Moorhens. Condor 101(2):282-287.

ROBEL, ROBERT J., SHANE J. ANTHOLZ, KENNETH E. KEMP, AND CHAD B. RUNCO. 2000. Assessment of avian populations in Kansas tallgrass prairie landscape: Two survey methods compared. Transactions of the Kansas Academy of Science 103(3-4):139-149.

ROBINS, C. S., J. R. SAUER, R. GREENBERG, AND S. DROEGE. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Science (USA) 86:7658-7662.

ROBINSON, S. K., F. R. THOMPSON, T. M. DONOVAN, D. R. WHITEHEAD, AND J. FAABORG. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science. 267(5206).

ROSENBERG, K. V., R. D. OHMART, W. C. HUNTER, AND B. W. ANDERSON. 1991. Birds of the lower Colorado River valley. University of Arizona Press.

ROTENBERRY, J. T., R. E. FITZNER, AND W. H. RICKARD. 1979. Seasonal variation in avian community structure: differences in mechanisms regulating diversity. Auk 96:499-505.

S-PLUS 2001. Version 6.1 for Windows. Statistical software.

SCHIEK, J. 1997. Biased detection of bird vocalizations affects comparisons of bird abundance among forested habitats. Condor 99:179-190.

SMEINS, FRED E. AND DAVID D. DIAMOND. 1984. Grasslands and savannahs of east central Texas: Ecology, preservation status and management problems. In D. L. Kulhavy and R. C. Conner. Wilderness and Natural areas in the Eastern United States: A Management Concern. Stephen F. Austin University. Nacogdoches.

SIEVING, KATHRYN E. AND MARY F. WILSON. 1998. Nest predation and avian species diversity in northwester forest understory. Ecology 79(7):2391-2402.

SHOWALTER, CHRISTOPHER R. AND ROBERT C. WHITMORE. 2002. The effect of gypsy moth defoliation on cavity-nesting bird communities. Forest Science 48(2)273-281.

TABOR, STEPHEN W. AND SCOTT B. FLEENOR. 2003. Insects of the Texas Lost Pines. p 283. Texas A&M University Press, College Station.

THOMPSON, F. R. AND SCHWALBACH. 1995. Analysis of sample size, count time, and plot size from an avian point count survey on Hoosier National Forest, Indiana. Pages 45-48 in C. J. Ralph, J. R. Sauer, and S. Droege. Monitoring Bird Populations by Point Counts. U.S. Forest Service General Technical Report PSW-GTR-149.

TODT, D. 1989. Birds in the Ohio River Valley: Possible indicators of environmental quality. Ohio Journal of Science 89(5):192-195.

TOMOFF, C. S. 1974. Avian species diversity in desert scrub. Ecology 55:396-403.

TRAMER, E. J. 1969. Bird species diversity: component of Shannon s formula. Ecology 50:927-929.

USDA Soil Conservation Service. 1979. Soil Survey of Bastrop County. United States Department of Agriculture in cooperation with the Texas Agriculture Experiment Station. U. S. Government Printing Office.

ZAR, J. H. 1996. BIostatistical Analysis. Prentice Hall, Upper Saddle River, New Jersey. 662 pp.

## VITA

Clayton J. White was born on the 7th of April, 1979, in Lubbock, Texas to Darold and Frances White. Clayton is the oldest of three, with a brother and sister four and ten years younger in age, respectively. In 2001, he married Melissa deSteiguer of Lake Jackson, Texas. Clayton graduated from Frenship High School in 1997 and Angelo State University (ASU) in 2001 with a Bachelor of Science degree in Biology. While enrolled at ASU Clayton was active in the Angelo State Natural History Collection preserving more than three hundred specimens. In January of 2002, he entered the Graduate College at Texas State University in San Marcos, Texas, as a full time graduate student working on a Master of Science degree in Wildlife Ecology. While attending Texas State, Clayton taught biology labs which include Modern Biology II, General Ecology, Wildlife Management Techniques and Vertebrate Natural History. Clayton was also a member of the student chapter of the Texas State University Wildlife Society and Texas Society of Mammalogists.

Permanent Address: 1712 NCR 1450
Lubbock, Texas 79416

This thesis was typed by Clayton J. White.