

BASELINE SURVEY AND CHECKLIST OF THE BIRDS OF
SAN MARCOS SPRINGS, HAYS COUNTY, TEXAS,
AND SURROUNDING VICINITY

THESIS

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In Partial Fulfillment of
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For the Degree

Master of SCIENCE

By

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DEDICATION

To my Mom, Mildred Elizabeth Hansen,
for teaching me to believe that I could do
anything that I set my mind to do.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	VI
TABLE OF CONTENTS	VII
LIST OF TABLES	X
LIST OF FIGURES	XIII
ABSTRACT	XV
CHAPTER I.....	1
INTRODUCTION.....	1
San Marcos Springs.....	1
Aquarena Center.....	2
Objectives.....	2
CHAPTER II	3
MATERIALS AND METHODS	3
Study Site	3
Description of Stations	6
Point Counts	10
Species Richness, Abundance and Diversity	11
CHAPTER III.....	14

RESULTS.....	14
Species Richness	14
Abundance.....	15
Relative Abundance	15
Annual Residents.....	19
Summer Residents.....	20
Winter Residents	21
Migratory Species	22
Introduced Species	23
Species of Management Concern or Rare and Declining	24
Diversity and Evenness	25
Bird Checklist.....	27
CHAPTER IV.....	28
DISCUSSION	28
Species Richness	28
Abundance.....	28
Annual Residents.....	29
Summer Residents.....	30
Winter Residents	31
Migratory Species	34
Introduced Species	35

Species of Management Concern or Rare and Declining	36
Diversity and Evenness	37
CHAPTER V	40
CONCLUSION	40
APPENDIX I	41
SITE DESCRIPTIONS AND PHOTOGRAPHS	41
APPENDIX II	81
AVIAN SPECIES OBSERVED DURING BASELINE SURVEY	81
APPENDIX III	86
SEASONAL DISTRIBUTION OF BIRDS DURING BASELINE SURVEY	86
APPENDIX IV	91
RELATIVE ABUNDANCE OF AVIAN SPECIES OBSERVED DURING BASELINE SURVEY	91
APPENDIX V	94
CHECKLIST OF BIRDS – SAN MARCOS SPRINGS AND VICINITY	94
LITERATURE CITED	96

LIST OF TABLES

Table 1. G.P.S. readings for each point count station.	4
Table 2. Mean Distance (MD = mean point to plant distance) and Total Density (TD) of woody vegetation at each point count station.	10
Table 3. Species richness and individual observations of bird species from point counts across stations in each study year of the 2-year baseline bird survey.....	15
Table 4. Total number and relative abundance of the ten most abundant bird species observed in year one.....	16
Table 5. Total number and relative abundance of the ten most abundant bird species observed in year two.	18
Table 6. Actual (%) and transformed (p') percentage of individual observations of bird species with the status of annual resident (year-round) from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 50.90 and 46.17).....	19
Table 7. Actual (%) and transformed (p') percentage of individual observations of bird species with the status of summer resident from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 17.41 and 20.25).....	20

Table 8. Actual (%) and transformed (p') percentage of individual observations of bird species with the status of winter resident from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 29.09 and 32.16).....	21
Table 9. Actual (%) and transformed (p') percentage of individual observations of migratory bird species from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 3.86 and 3.24).....	22
Table 10. Actual (%) and transformed (p') percentage of individual observations of introduced bird species from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 9.99 and 13.36).....	23
Table 11. Actual (%) and transformed (p') percentage of individual observations of bird species listed as species of management concern or rare and declining from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 6.55 and 6.91).....	24
Table 12. Brillouin diversity (H) and evenness (J) in each year across stations.....	25
Table 13. Brillouin diversity (H) and evenness (J) in each year across seasons.....	26
Table 14. Relative Cover and Relative Density of Woody Vegetation at Station #1	41
Table 15. Relative Cover and Relative Density of Woody Vegetation at Station #2	46
Table 16. Relative Cover and Relative Density of Woody Vegetation at Station #3.	51
Table 17. Relative Cover and Relative Density of Woody Vegetation at Station #4	56

Table 18. Relative Cover and Relative Density of Woody Vegetation at Station #5	61
Table 19. Relative Cover and Relative Density of Woody Vegetation at Station #6.	66
Table 20. Relative Cover and Relative Density of Woody Vegetation at Station #7	71
Table 21. Relative Cover and Relative Density of Woody Vegetation at Station #8	76

LIST OF FIGURES

Figure 1. Location of point count stations within the boundaries of the Aquarena	
Center, labeled 1 through 8.	5
Figure 2. Ten most abundant bird species observed during the first year of the study.	
(RA = 0.0310), Pied-billed Grebe (<i>Podilymbus podiceps</i>) (RA = 0.0304),	
and Carolina Chickadee (<i>Poecile carolinensis</i>) (RA = 0.0273).....	16
Figure 3. Ten most abundant avian species observed during the second year of the	
study.	18
Figure 4. Station #1 Facing North.....	42
Figure 5. Station #1 Facing South.....	43
Figure 6. Station #1 Facing East	44
Figure 7. Station #1 Facing West.....	45
Figure 8. Station #2 Facing North.....	47
Figure 9. Station #2 Facing South.....	48
Figure 10. Station #2 Facing East	49
Figure 11. Station #2 Facing West.....	50
Figure 12. Station #3 Facing North.....	52
Figure 13. Station #3 Facing South.....	53
Figure 14. Station #3 Facing East	54
Figure 15. Station #3 Facing West.....	55

Figure 16. Station #4 Facing North.....	57
Figure 17. Station #4 Facing South.....	58
Figure 18. Station #4 Facing East	59
Figure 19. Station #4 Facing West	60
Figure 20. Station #5 Facing North.....	62
Figure 21. Station #5 Facing South.....	63
Figure 22. Station #5 Facing East	64
Figure 23. Station #5 Facing West.....	65
Figure 24. Station #6 Facing North.....	67
Figure 25. Station #6 Facing South.....	68
Figure 26. Station #6 Facing East	69
Figure 27. Station #6 Facing West.....	70
Figure 28. Station #6 Facing West.....	72
Figure 29. Station #7 Facing South.....	73
Figure 30. Station #7 Facing East	74
Figure 31. Station #7 Facing West.....	75
Figure 32. Station #8 Facing North.....	77
Figure 33. Station #8 Facing South.....	78
Figure 34. Station #8 Facing East	79
Figure 35. Station #8 Facing West.....	80

ABSTRACT

BASELINE SURVEY AND CHECKLIST OF THE BIRDS OF SAN MARCOS SPRINGS, HAYS COUNTY, TEXAS, AND SURROUNDING VICINITY

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A baseline survey of bird species at the Aquarena Center, Southwest Texas State University (SWT), Hays County, Texas, was conducted from summer 1999 through spring 2001. From a total of 11,151 individual observations, 103 bird species were recorded in 320 point counts from eight stations. Species richness, relative abundance, and diversity of the bird species were calculated from the data for each study year. The most abundant bird species for year one and two was the American Coot (*Fulica americana*) (respectively $RA = 0.1341$, $RA = 0.1421$). The Brillouin index of diversity (H) was used to calculate the diversity for each year and season. Station #2, near a new wildlife-viewing boardwalk, in year one and two had the highest diversity (respectively $H = 1.29$, $H = 1.37$). The summer of year one had the highest diversity ($H = 1.37$), and the spring of year two had the highest diversity ($H = 1.40$). These data and previous data from many contributors were used to compile a bird checklist for the site. The purpose of this study was to provide baseline information that will be a useful tool for evaluating future habitat conservation efforts.

CHAPTER I

INTRODUCTION

Wetlands are transition zones between dry uplands and open water environments, often with a rich flora and fauna. Skartvedt (2000) recognized that wetlands and riparian ecosystems play a role in arid and semiarid areas in the Southwestern United States as some of the most productive and biologically important terrestrial ecosystems. They perform many ecological roles including the recharging of groundwater supplies, preventing flood damage, and serve as a vitally important resource to hundreds of bird species (Gill 1994). Bird species use wetlands as important habitat for breeding, nesting, and rearing young, as well as sources of drinking water, food, and shelter. Wetlands are recognized as one of the most imperiled habitats because of anthropogenic disturbances (Skartvedt 2000). That recognition plus the ecological importance of wetlands provides the incentive for their protection and restoration.

San Marcos Springs

The San Marcos Springs, located within the boundaries of the Aquarena Center, San Marcos, Hays County, Texas, with a constant water temperature ranging from 21.1°C to 22.5°C (Groeger et al. 1997) and dependable flow, supports a diverse community of organisms with a high degree of endemism (United States Fish and Wildlife Service, hereafter USFWS, 1995a). The USFWS (1995a) lists five species in the Upper San Marcos River (area above the confluence with the Blanco River) as endangered or

threatened: the San Marcos gambusia (*Gambusia georgei*), the fountain darter (*Etheostoma fonticola*), the Texas blind salamander (*Typhlomolge rathbuni*), Texas wild rice (*Zizania texana*), and the San Marcos salamander (*Eurycea nana*). Human development has altered the wetlands surrounding the ecologically sensitive San Marcos Springs.

Aquarena Center

The Aquarena Center functions as a conservation and environmental education facility under the direction of Southwest Texas State University (hereafter SWT). The SWT Wetlands Project, initiated by the SWT Biology Department, began restoration of the wetlands at the Aquarena Center to a more natural state through removal of exotics and revegetation with natives. The future of the Aquarena Center also includes a joint venture with the Texas Parks and Wildlife Department (hereafter TPWD) known as the Texas Rivers Center (TPWD 2001), which will focus on education, policy, research and tourism as it relates to aquifers, springs and rivers. The plans for the Texas Rivers Center include showcasing an environmentally sensitive facility design, educational and entertaining exhibits, and a restored native wildlife habitat (TPWD 2001).

Objectives

The objectives of this study are to 1) provide a two-year baseline survey that will include species richness, abundance, diversity and evenness of the avian community inhabiting the Aquarena Center from which comparisons can be drawn following any restoration efforts and 2) produce a checklist for the birds of the San Marcos Springs and surrounding vicinity.

CHAPTER II

MATERIALS AND METHODS

Study Site

This study was conducted at the Aquarena Center. The property lies within the Balcones Fault zone that separates two ecological regions, the Edwards Plateau to the west and the Blackland Prairie to the east.

The Edwards Plateau consists of plateau uplands and ruggedly dissected limestone hills. The Edwards Plateau soils on the west slope above the Aquarena Center's Spring Lake are Eckrant and Rock outcrop complex, which consists of shallow, extremely stony clay and exposed, indurated limestone. Eckrant soils are moderately alkaline, noncalcareous, well drained, and prone to rapid surface runoff. These soils are mainly used as rangeland and provide habitat for openland wildlife such as quail, dove, rabbit, and small birds. The soils immediately surrounding Spring Lake and adjoining Sink Creek Slough are Oakalla soils that are frequently flooded. Oakalla soils are clay loam that are moderately alkaline, calcareous, well drained, with moderate permeability and slow runoff. These soils are often used as pastureland and rangeland and provide fair habitat for wildlife (United States Department of Agriculture, hereafter USDA, 1984).

The Blackland Prairie consists of rolling prairies and broad river bottoms. The Blackland Prairie soils east of Spring Lake are Tinn Clay that frequently flood. Tinn Clay soils are moderately alkaline, calcareous, and somewhat poorly drained, with very

slow permeability and surface runoff. This clay is well suited for grasslands and provides good wildlife habitat for species that inhabit the areas along creeks (USDA 1984).

Sink Creek Slough and the San Marcos Springs flow within the boundaries of the study site. The source of the San Marcos Springs is the San Antonio segment of the Edwards Aquifer. The San Marcos Springs consists of six major orifices with a mean historical flow of 4.5 m³/sec and are the second largest spring group in Texas (Ogden et al. 1986). A dam below the confluence of Sink Creek Slough and the San Marcos River forms Spring Lake, a small (7.9 ha) reservoir.

Eight point count stations were systematically selected from an aerial photograph (Figure 1) to maximize coverage of the sites wetlands. All stations were 200m apart as suggested by Gutzwiller (1991).

A GPS (Global Positioning System) reading was recorded for each of the eight stations (Table 1) using a Magellan ProMark X CPTM GPS Unit v.4.03 with Magellan multipath resistant antenna. Each reading was then overlaid on the map of the Aquarena Center (Figure 1) with Geographic Information System (GIS) software ArcView.

Table 1. G.P.S. readings for each point count station.

Station	° N Latitude	° W Longitude
#1	29.89047	97.93310
#2	29.89146	97.93059
#3	29.89193	97.92864
#4	29.89401	97.92765
#5	29.89594	97.92667
#6	29.89047	97.93310
#7	29.89272	97.93249
#8	29.89364	97.93033

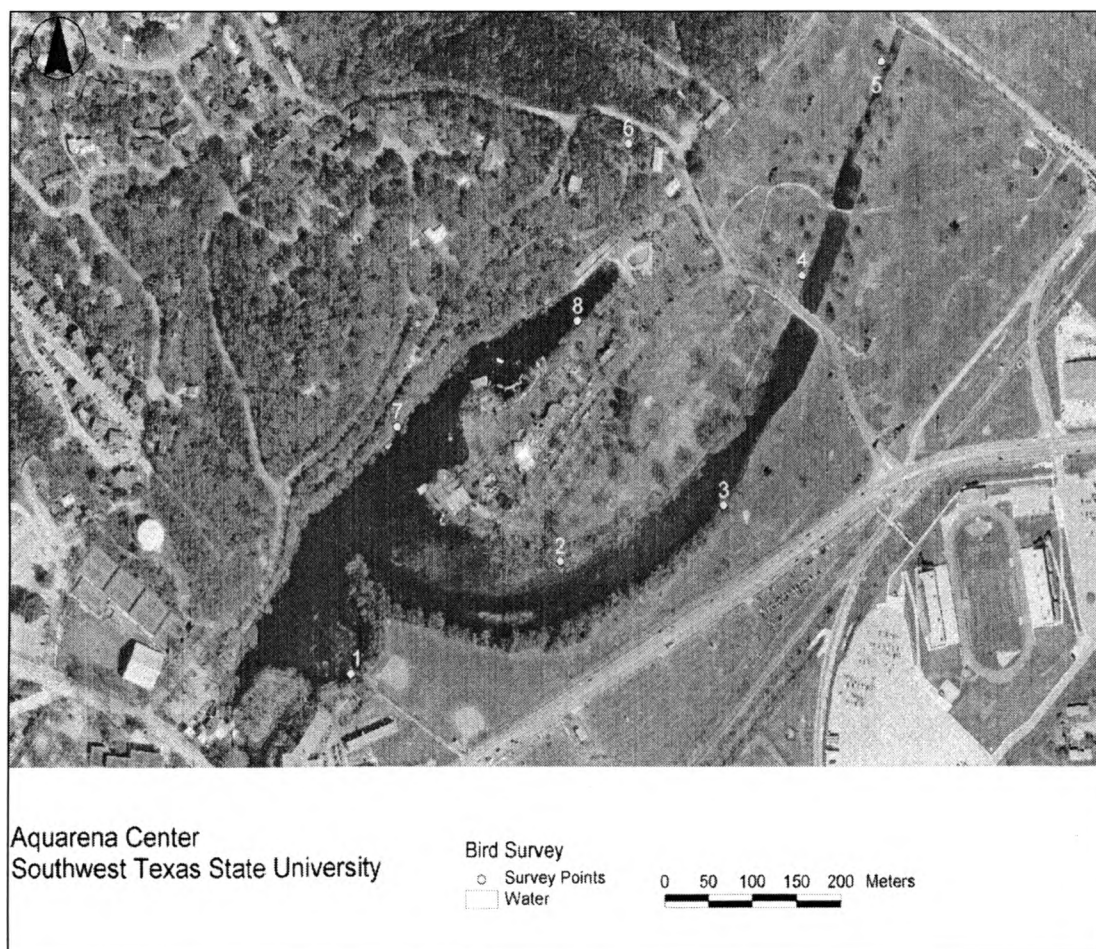


Figure 1. Location of point count stations within the boundaries of the Aquarena Center, labeled 1 through 8.

Photographs of the north, south, east and west quadrant of each station were taken in the summer 2000 and winter 2001 (Appendix I, Figure 4 through Figure 35). The point-quarter method was used to describe the density of woody vegetation at each station. The same method was used in a vegetation study at the Aquarena Center (J. Mittelhauser, Pers. Comm.) and data from that study was used to describe the woody vegetation at Station #1 and Station #3 of this study. A 100-meter line transect was set

near each of the eight point count stations. Each line transect ran 5 m parallel to the nearest body of water. The exception was station #6 where the transect ran 5 m parallel to the dirt road. Eleven points, 10 m apart, were marked with flags along each 100 m line transect. Each of these points along the line transect represents the center of four compass directions (N, S, E, W). These compass directions divide the point into quarters. The distance (m) was measured and recorded from the center point in each quarter to the nearest woody vegetation located within that quarter. A total of four woody plants were identified and the diameter at breast height (DBH) of each was measured. The relative cover (RC), relative density (RD) (Appendix I, Table 14 through Table 21), mean distance (MD) from point to plant and total density (TD) (Table 2) for the woody vegetation at each station were calculated (Brower et al. 1999). Plants were identified using Correll and Johnston (1970).

Description of Stations

Station #1 is riparian habitat located in the southeast section of the cove of Spring Lake near a metal drainpipe. A large portion of the habitat associated with this station consists of the cove of Spring Lake. A thin section of riparian woodlands run along the shoreline. The east and southeast portion includes a baseball field, and an apartment complex. The dominant terrestrial woody vegetation along the shoreline with a relative cover > 0.10 (Appendix I, Table 14) consists of Live Oak (*Quercus fusiformis*) (RC = 0.4772, RD = 0.131), Wax-leaf Ligustrum (*Ligustrum lucidum*) (RC = 0.1697, RD = 0.221), and Chinaberry-Tree (*Melia azedarach*) (RC = 0.1313, RD = 0.272). The spatial distribution of the woody vegetation was found to be MD = 3.45 m and TD = 0.0720 Individuals/m² (Table 2). Islands of aquatic vegetation, including Water-Hyacinth

(*Eichornia crassipes*) occur in the cove. The aquatic exotic plant, Elephant Ear (*Colocasia esculenta*) dominates the shoreline.

Station #2 is riparian habitat located on the north shore of Sink Creek Slough near the confluence with Spring Lake. This station occurs near a wetland boardwalk. Most of the habitat associated with this station consists of the Sink Creek Slough. The remaining is riparian woodland along the shoreline with a paved parking lot to the north. The dominant terrestrial woody vegetation with a relative cover > 0.10 (Appendix I, Table 15) consists of Black Willow (*Salix nigra*) (RC = 0.5036, RD 0.322), Boxelder (*Acer negundo*) (RC = 0.2745, RD = 0.366), and Eastern Cottonwood (*Populus deltoids*) (RC = 0.1900, RD = 0.202). The spatial distribution of the woody vegetation was found to be MD = 4.14 m and TD = 0.0264 Individuals/m² (Table 2). Common Cat-tail (*Typha latifolia*) and Elephant Ear (*C. esculenta*) dominates the shoreline.

Station #3 is riparian habitat located on the southeast shore of Sink Creek Slough. A small portion of the site consists of riparian woodlands along the shoreline of the slough. A large portion of the terrestrial site is a mowed grass lawn of the SWT golf course. The dominant terrestrial woody vegetation with a relative cover > 0.10 (Appendix I, Table 16) consists of Pecan (*Carya illinoensis*) (RC = 0.6334, RD = 0.132), Common Chaste-tree (*Vitex agnus-castus*) (RC = 0.1188, RD = 0.334), and Texas Sugarberry (*Celtis laevigata*) (RC = 0.1154, RD = 0.131). The spatial distribution of the woody vegetation was found to be MD = 4.10 m and TD = 0.0208 Individuals/m² (Table 2). Elephant Ear (*Colocasia esculenta*) dominates the shoreline. An island of Water-Hyacinth (*Eichornia crassipes*) was present in the slough.

Station #4 is an altered riparian habitat located on the northwest shore of the Sink Creek Slough labeled by SWT Biology Department as Pond #1. A large portion of this station consists of mowed grass lawn of the SWT golf course. The dominant terrestrial woody vegetation with a relative cover > 0.10 (Appendix I, Table 17) was Bald Cypress (*Taxodium distichum*) (RC = 0.8876, RD = 0.102). The spatial distribution of the woody vegetation was found to be MD = 17.90 m and TD = 0.0030 Individuals/m² (Table 2). The vegetation is mowed near the shoreline of the Sink Creek Slough.

Station #5 is in a partially altered riparian habitat located on the northwest shore of the Sink Creek Slough labeled by SWT Biology Department as Pond #2. A large portion of this site consists of the mowed grass lawn of the SWT golf course and a smaller portion is riparian woodlands along the shoreline of Sink Creek. The dominant terrestrial woody vegetation with a relative cover > 0.10 (Appendix I, Table 18) consists of Bald Cypress (*T. distichum*) (RC = 0.5654, RD = 0.258), Black Willow (*S. nigra*) (RC = 0.1882, RD = 0.070), and Pecan (*C. illinoensis*) (RC = 0.1618, RD = 0.287). The spatial distribution of the woody vegetation was found to be MD = 23.23 m and TD = 0.0012 Individuals/m² (Table 2).

Station #6 is a hillside woodland/edge habitat bisected by an unpaved road that runs behind a historical building, formerly known as the Aquarena Inn, at the headwaters of the San Marcos River. There are a few other SWT buildings nearby, but most of the habitat associated with this site consists of oak woodland with a small portion of open grassland. The dominant terrestrial woody vegetation with a relative cover > 0.10 (Appendix I, Table 19) consists of Cedar Elm (*Ulmus crassifolia*) (RC = 0.2891, RD = 0.267), Honey Mesquite (*Prosopis glandulosa*) (RC = 0.1833, RD = 0.118), and Live

Oak (*Q. fusiformis*) (RC = 0.1699, RD = 0.010). The spatial distribution of woody vegetation was found to be MD = 2.13 m and TD = 0.1761 Individuals/m² (Table 2). Vegetation in the open grassland area consists of a variety of grasses and Texas Prickly Pear (*Opuntia lindheimeri*).

Station #7 is riparian habitat located on the northwest side of Spring Lake. A portion of this site, on the opposite shore, consists of Texas Parks and Wildlife Department offices and the mowed grass lawn of the Aquarena Center. The rest consists of a hillside of oak woodlands. The dominant terrestrial woody vegetation with a relative cover > 0.10 (Appendix I, Table 20) consists of Anacua (*Ehretia anacua*) (RC = 0.5209, RD = 0.480), Texas Red Oak (*Q. texana*) (RC = 0.2284, RD = 0.065), and Pecan (*C. illinoensis*) (RC = 0.0643, RD = 0.010). The spatial distribution of the woody vegetation was found to be MD = 1.60 m and TD = 0.3663 Individuals/m² (Table 2). Elephant Ear (*Colocasia esculenta*) dominates the northwest shoreline.

Station #8 is an altered riparian habitat located on the southeast side of the headwaters of the San Marcos River. A small portion of this site consists of a riparian hillside. Buildings and park-like grounds of the Aquarena Center make up most of this site. The dominant terrestrial woody vegetation with a relative cover > 0.10 (Appendix I, Table 21) consists of Bald Cypress (*T. distichum*) (RC = 0.4205, RD = 0.140), Pecan (*C. illinoensis*) (RC = 0.2669, RD = 0.278), and Sycamore (*Platanus occidentalis*) (RC = 0.1444, RD = 0.294). The spatial distribution of the woody vegetation was found to be MD = 10.60 m and TD = 0.0046 Individuals/m² (Table 2). Trumpet-honeysuckle (*Campsis radicans*) grows along a large portion of the southeast shoreline.

Table 2. Mean Distance (MD = mean point to plant distance) and Total Density (TD) of woody vegetation at each point count station.

Station	MD	TD
	(m)	(Individuals/m ²)
#1	3.45	0.0720
#2	4.14	0.0264
#3	4.10	0.0208
#4	17.90	0.0030
#5	23.23	0.0012
#6	2.13	0.1761
#7	1.60	0.3663
#8	10.60	0.0046

Point Counts

The unlimited-radius point count method was used for this study. The point count method is the most widely used quantitative method for surveying birds (Ralph et al. 1995), and a single observer can visit many points within the morning hours (Bibby et al. 1993). The unlimited-radius point count method can be used when dense vegetation makes it difficult to measure the distance to each bird (Bibby et al. 1993), and it is also a useful tool for measuring species richness (Wunderle 1994). The point count method requires that an observer stand at a fixed point for a designated period of time and record all birds detected by sight and sound. Many variations exist in the exact protocol for point counts (Bibby et al. 1993; Ralph et al. 1993; Wunderle 1994; Hamel et al. 1996). I followed the protocol outlined by Bibby et al. (1993) and Ralph et al. (1993).

Each point count was conducted for a total of 6 minutes (recorded in two 3-minute segments) with the first 3 minutes of data separated to allow for comparison with

the North American Breeding Bird Survey (Bibby et al. 1993). All counts for this study took place during the morning hours between 6 a.m. and 10 a.m. Central Standard Time. Visits to point locations in this study occurred in alternating order with one visit beginning at site #1, proceeding through site #8, the next beginning at site #8, and proceeding through site #1. Weather conditions were taken into account and counts were not conducted during a rain or when winds made bird vocalizations difficult to hear. Point counts for each station were conducted once every two to three weeks in year one (summer 1999 through spring 2000) and year two (summer 2000 through spring 2001). Taxonomy follow the American Ornithologists' Union (1998, 2000).

Species Richness, Abundance and Diversity

The species richness, relative abundance, and diversity of the bird species were calculated from the point count data for each study year.

Species richness is simply the number of species in a habitat. Birds observed between point counts and those that flew over the station during a count were recorded and included in the site list, but not included in the calculations. Behavior notes were also kept.

Relative abundance (RA) is a measure of the proportional representation of a species in a community. The percentage of annual residents, summer residents, winter residents, migratory and introduced (Kutac & Caran 1994; Travis Audubon Society 1994; Lockwood 2001) bird species (Appendix II) were calculated from the individual observations for each study year. The percentage of bird species that occur on the USFWS (1995b) List of Non-game Birds of Management Concern and listed in the Texas Parks and Wildlife Department's Rare and Declining Birds of Texas (Shackelford &

Lockwood 2000) were also calculated from individual observations for each study year. Significance of differences between the mean percentage of each study year were determined using the Two-Sample *t* Test (Brower et al. 1998). Zar (1999) recommends that the percentages, known to form a binomial distribution, be transformed to its arcsine, so that the data will have a nearly normal distribution. Therefore the following equation was used for this transformation:

$$p' = \arcsine (X+3/4 / n+3/4)^{1/2}$$

The mean of the transformed percentages for each of the above percentage calculations for each station for each year of the study were then compared using the Two-Sample *t* Test (Brower et al. 1998, Zar & Brower 1997).

Diversity and evenness were calculated for each year and compared across all stations and all seasons. Diversity is the measure of the variety of species in the community that takes into account the relative abundance of each species. Evenness is often calculated with diversity to express the observed diversity as a proportion of the maximum possible diversity (Zar 1999). The Brillouin Index of Diversity is the recommended diversity measurement method when data are not considered random (Zar 1999). Since data for this study were taken nonrandomly from the population, diversity and evenness of the bird species were measured with the Brillouin Index of Diversity (*H*) and Brillouin-based evenness measure (*J*). The index is expressed as:

$$H = \frac{\log(n!) - \sum_{i=1}^k \log(f_i!)}{n}$$

$$J = \frac{H}{H_{\max}}$$

Where n is the sample size and f is the number of observations in category i .

CHAPTER III

RESULTS

Species Richness

A total of 11,151 individual observations of 103 (does not include incidentals or flyovers) bird species (includes one genus for hummingbirds) were recorded in 320 point counts from eight stations during the 2-year baseline bird survey (Table 3, Appendix II). All hummingbirds were pooled by their common genus, *Archilochus*, for abundance and diversity calculations because during this study it was often difficult to decipher between the Black-chinned Hummingbird and the Ruby-throated Hummingbird on the wing. In year one, 5,830 individual observations of 82 bird species were recorded and in year two, 5,319 individual observations of 95 bird species were recorded (Table 3). A visual display of the number of individual observations and month each bird species was observed are shown in Appendix III. Station #1 had the highest species richness (N=49) in year one and station #5 and #6 had the lowest (N=37). Station #2 had the highest species richness (N=54) in year two and station #4 had the lowest (N=37).

Table 3. Species richness and individual observations of bird species from point counts across stations in each study year of the 2-year baseline bird survey.

Station	Species Richness		Individual Observations	
	Year		Year	
	<u>One</u>	<u>Two</u>	<u>One</u>	<u>Two</u>
#1	49	42	998	775
#2	47	54	492	461
#3	39	46	872	362
#4	40	37	399	365
#5	37	46	474	1224
#6	37	50	342	400
#7	41	50	1628	1123
#8	46	46	625	609
Pooled	82	95	5830	5319

Abundance

Relative Abundance

The relative abundance (RA) for all bird species observed in year one and two of the study is shown in Appendix IV. The most abundant species observed in the study was the American Coot (*Fulica americana*). The ten most abundant bird species for the first year (Table 4, Figure 2) were: American Coot (*F. americana*) (RA = 0.1341), Ring-necked Duck (*Aythya collaris*) (RA = 0.1103), Great-tailed Grackle (*Quiscalus mexicanus*) (RA = 0.0866), American Wigeon (*Anas americana*) (RA = 0.0852), Gadwall (*Anas strepera*) (RA = 0.0827), Purple Martin (*Progne subis*) (RA = 0.0377), Mourning Dove (*Zenaida macroura*) (RA = 0.0370), Red-winged Blackbird (*Agelaius phoeniceus*)

Table 4. Total number and relative abundance of the ten most abundant bird species observed in year one.

Species	Total Individuals	Relative Abundance
American Coot	782	0.1341
Ring-necked Duck	643	0.1103
Great-tailed Grackle	505	0.0866
American Wigeon	497	0.0852
Gadwall	482	0.0827
Purple Martin	220	0.0377
Mourning Dove	216	0.0370
Red-winged Blackbird	181	0.0310
Pied-billed Grebe	177	0.0304
Carolina Chickadee	159	0.0273

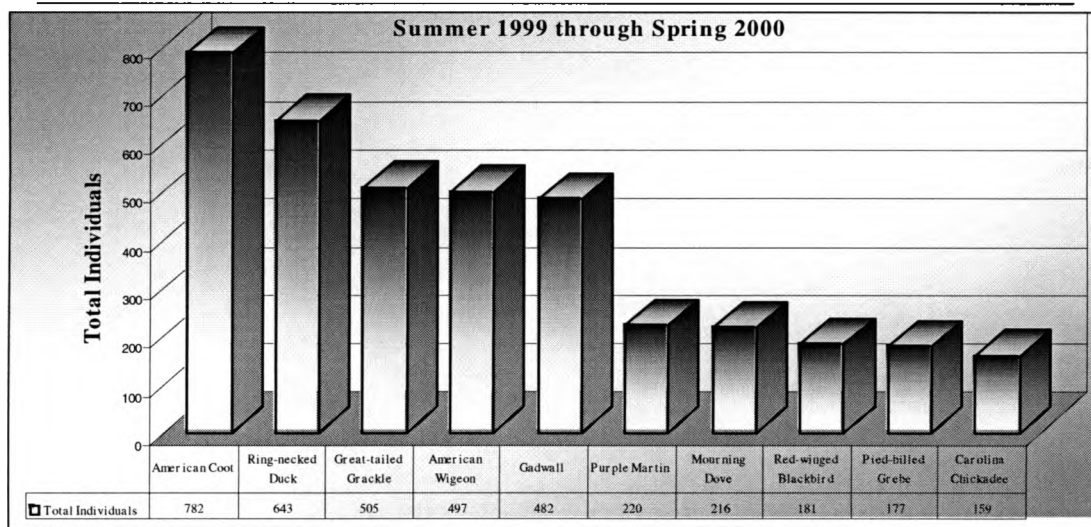


Figure 2. Ten most abundant bird species observed during the first year of the study.

(RA = 0.0310), Pied-billed Grebe (*Podilymbus podiceps*) (RA = 0.0304), and Carolina Chickadee (*Poecile carolinensis*) (RA = 0.0273).

The ten most abundant bird species for year two (Table 5, Figure 3) were:

American Coot (*F. americana*) (RA = 0.1421), Cedar Waxwing (*Bombycilla cedrorum*) (RA = 0.0976), White-winged Dove (*Zenaida asiatica*) (RA = 0.0899), Great-tailed Grackle (*Q. mexicanus*) (RA = 0.0624), American Wigeon (*Anas americana*) (RA = 0.0525), Purple Martin (*Progne subis*) (RA = 0.0414), Gadwall (*Anas strepera*) (RA = 0.0382), Mourning Dove (*Zenaida macroura*) (RA = 0.0359), Ring-necked Duck (*Aythya collaris*) (RA = 0.0344), and Pied-billed Grebe (*Podilymbus podiceps*) (RA = 0.0320).

Table 5. Total number and relative abundance of the ten most abundant bird species observed in year two.

Species	Total Individuals	Relative Abundance
American Coot	756	0.1421
Cedar Waxwing	519	0.0976
White-winged Dove	478	0.0899
Great-tailed Grackle	332	0.0624
American Wigeon	279	0.0525
Purple Martin	220	0.0414
Gadwall	203	0.0382
Mourning Dove	191	0.0359
Ring-necked Duck	183	0.0344
Pied-billed Grebe	170	0.0320

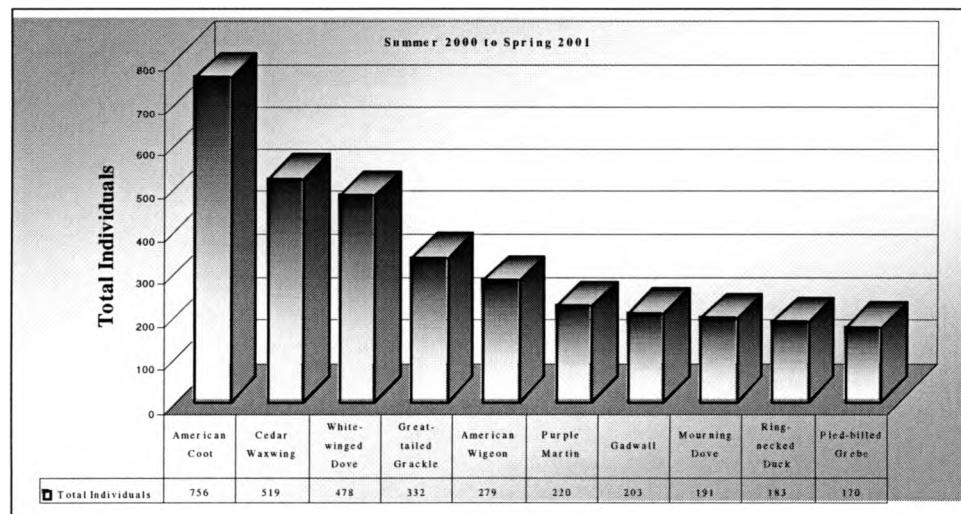


Figure 3. Ten most abundant avian species observed during the second year of the study.

Annual Residents

In year one, 2,981 individual observations of 34 annual resident bird species were recorded, and in year two, 2,739 individual observations of 36 annual resident bird species (Appendix II). The individual observations and percentages of annual residents recorded at each station per year are listed in Table 6. Station #6 had the highest percentage of annual residents (81.58%) in year one and station #7 had the lowest (30.34%) (Table 6). Station #4 had the highest percentage of annual residents (66.85%) in year two and station #7 again had the lowest (41.76%) (Table 6). The mean percentages for the two years were not significantly different ($P(t_{\alpha(2), 14} \geq |1.04|) > 0.20$).

Table 6. Actual (%) and transformed (p') percentage of individual observations of bird species with the status of annual resident (year-round) from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 50.90 and 46.17).

Stations	<i>Annual Residents</i>					
	Year One			Year Two		
	<u>Observations</u>	<u>%</u>	<u>p'</u>	<u>Observations</u>	<u>%</u>	<u>p'</u>
#1	454	45.49	42.41	479	61.81	51.82
#2	245	49.80	44.88	213	46.20	42.83
#3	474	54.36	47.50	162	44.75	41.99
#4	320	80.20	63.54	244	66.85	54.83
#5	385	81.22	64.29	684	55.88	48.38
#6	279	81.58	64.53	216	54.00	47.29
#7	494	30.34	33.43	469	41.76	40.26
#8	330	52.80	46.60	272	44.66	41.94

Summer Residents

In year one, 560 individual observations of 17 summer resident bird species were recorded, and in year two, 622 individual observations of 22 summer resident bird species were recorded (Appendix II). The individual observations and percentages of summer residents recorded at each station per year are listed in Table 7. Station #6 had the highest percentage of summer residents (13.74%) in year one and station #5 had the lowest (4.22%) (Table 7). Station #6 again had the highest percentage of summer residents (19.25%) in year two and station #4 had the lowest (6.58%) (Table 7). The mean percentages for the two years were not significantly different ($P(t_{\alpha(2), 14} \geq (1.48) > 0.10$).

Table 7. Actual (%) and transformed (p') percentage of individual observations of bird species with the status of summer resident from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 17.41 and 20.25).

Stations	<i>Summer Residents</i>					
	Year One			Year Two		
	<u>Observations</u>	<u>%</u>	<u>p'</u>	<u>Observations</u>	<u>%</u>	<u>p'</u>
#1	121	12.12	20.40	77	9.94	18.41
#2	57	11.59	19.95	68	14.75	22.63
#3	38	4.36	12.10	48	13.26	21.42
#4	31	7.77	16.27	24	6.58	14.96
#5	20	4.22	11.96	88	7.19	15.58
#6	47	13.74	21.83	77	19.25	26.07
#7	196	12.04	20.32	168	14.96	22.77
#8	50	8.00	16.48	72	11.82	20.15

Winter Residents

In year one, 2,024 individual observations of 20 winter resident bird species were recorded, and in year two, 1,633 individual observations of 26 winter resident bird species were recorded (Appendix II). The individual observations and percentages of winter residents recorded at each station per year are listed in Table 8. Station #7 had the highest percentage of winter residents (55.84%) in year one and station #6 had the lowest (2.63%) (Table 8). Station #3 had the highest percentage of winter residents (39.78%) in year two and station #4 had the lowest (13.97%) (Table 8). The mean percentages for the two years were not significantly different ($P(t_{\alpha(2), 14} \geq |0.58|) > 0.50$).

Table 8. Actual (%) and transformed (p') percentage of individual observations of bird species with the status of winter resident from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 29.09 and 32.16).

Stations	<i>Winter Residents</i>					
	Year One			Year Two		
	<u>Observations</u>	<u>%</u>	<u>p'</u>	<u>Observations</u>	<u>%</u>	<u>p'</u>
#1	405	40.58	39.58	198	25.55	30.38
#2	180	36.59	37.23	131	28.42	32.24
#3	352	40.37	39.45	144	39.78	39.11
#4	36	9.02	17.56	51	13.97	22.01
#5	64	13.50	21.61	444	36.27	37.04
#6	9	2.63	9.52	102	25.50	30.36
#7	909	55.84	48.35	429	38.20	38.18
#8	69	11.04	19.45	134	22.00	28.00

Migratory Species

In year one, 27 individual observations of six migratory bird species were recorded, and in year two, 14 individual observations of five migratory bird species were recorded (Appendix II). The individual observations and percentages of migratory species recorded at each station per year are listed in Table 9. Station #8 had the highest percentage of migratory bird species (1.28%) in year one and station #6 had the lowest with no migratory bird species recorded (Table 9). Station #2 had the highest percentage of migratory bird species (1.08%) in year two and no migratory bird species were recorded at stations #1 or #8 (Table 9). The mean percentages for the two years were not significantly different ($P(t_{\alpha(2), 14} \geq (|0.78|) > 0.20)$).

Table 9. Actual (%) and transformed (p') percentage of individual observations of migratory bird species from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 3.86 and 3.24).

Stations	<i>Migratory</i>					
	Year One			Year Two		
	<u>Observations</u>	<u>%</u>	<u>p'</u>	<u>Observations</u>	<u>%</u>	<u>p'</u>
#1	8	0.80	5.25	0	0.00	1.26
#2	1	0.20	3.03	5	1.08	6.19
#3	3	0.34	3.57	1	0.28	3.53
#4	2	0.50	4.42	2	0.55	4.62
#5	1	0.21	3.08	1	0.08	1.92
#6	0	0.00	1.90	1	0.25	3.36
#7	4	0.25	2.97	4	0.36	3.58
#8	8	1.28	6.64	0	0.00	1.42

Introduced Species

In year one, 238 individual observations of four introduced bird species were recorded, and in year two, 311 individual observations of five introduced bird species were recorded (Appendix II). The individual observations and percentages of introduced species recorded at each station per year are listed in Table 10. Station #8 had the highest percentage of introduced species (26.88%) in year one and station #3 had the lowest (0.57%) (Table 10). Station #8 again had the highest percentage of introduced species (21.51%) in year two and station #5 had the lowest (0.57%) (Table 10). The mean percentages for the two years were not significantly different ($P(t_{\alpha(2), 14} \geq (|0.80|) > 0.20)$).

Table 10. Actual (%) and transformed (p') percentage of individual observations of introduced bird species from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 9.99 and 13.36).

Stations	<i>Introduced</i>					
	Year One			Year Two		
	<u>Observations</u>	<u>%</u>	<u>p'</u>	<u>Observations</u>	<u>%</u>	<u>p'</u>
#1	10	1.00	5.85	21	2.71	9.55
#2	9	1.83	7.93	44	9.54	18.06
#3	5	0.57	4.50	7	1.93	8.20
#4	10	2.51	9.27	44	12.05	20.38
#5	4	0.84	5.51	7	0.57	4.45
#6	7	2.05	8.43	4	1.00	6.00
#7	25	1.54	7.17	53	4.72	12.59
#8	168	26.88	31.25	131	21.51	27.66

Species of Management Concern or Rare and Declining

In year one, 64 individual observations of seven bird species of management concern (USFWS 1995b) or rare and declining (Shackelford & Lockwood 2000) were recorded, and in year two, 68 individual observations of ten bird species were recorded (Appendix II). The individual observations and percentages of species of management concern or rare and declining recorded at each station per year are listed in Table 11. Station #6 had the highest percentage of species of management concern or rare and declining for both years one and two (respectively 9.65% and 4.75%) and station #7 had the lowest percentage for both years (respectively 0.06% and 0.27%) (Table 11). The mean percentages for the two years were not significantly different ($P(t_{\alpha(2), 14} \geq (|0.17|) > 0.50)$).

Table 11. Actual (%) and transformed (p') percentage of individual observations of bird species listed as species of management concern or rare and declining from point count data across stations in each study year. The mean of the transformed percentages per station was used to compare years (respectively 6.55 and 6.91).

Stations	<i>Species of Management Concern or Rare and Declining</i>					
	Year One			Year Two		
	<u>Observations</u>	<u>%</u>	<u>p'</u>	<u>Observations</u>	<u>%</u>	<u>p'</u>
#1	3	0.30	3.33	4	0.52	4.31
#2	6	1.22	6.53	10	2.17	8.62
#3	3	0.34	3.57	4	1.10	6.30
#4	3	0.75	5.27	4	1.10	6.28
#5	9	1.90	8.08	12	0.98	5.77
#6	33	9.65	18.18	19	4.75	12.70
#7	1	0.06	1.66	3	0.27	3.14
#8	6	0.96	5.79	12	1.97	8.19

Diversity and Evenness

The diversity of bird species (Table 12) across all stations in year one and two of the study was not significantly different (Respectively $H = 1.15$, $H = 1.16$, $(P(t_{\alpha(2), 14} \geq (|0.15|) > 0.50)$). In year one and two, station #2 had the highest diversity (respectively $H = 1.29$, $H = 1.37$). Station #7 had the lowest diversity ($H = 0.98$) in year one and station #5 had the lowest diversity ($H = 0.91$) in year two.

The evenness of bird species across all stations in year one and two of the study was also not significantly different (respectively $J = 0.72$, $J = 0.71$, $(P(t_{\alpha(2), 14} \geq (|0.03|) > 0.50)$). Station #6 had the highest evenness ($J = 0.82$) in year one and station #2 had the highest evenness ($J = 0.81$) in year two (Table 12). Station #7 had the lowest evenness ($J = 0.61$) in year one and station #5 had the lowest evenness ($J = 0.55$) in year two (Table 12).

Table 12. Brillouin diversity (H) and evenness (J) in each year across stations.

Stations	H		J	
	Year		Year	
	One	Two	One	Two
#1	1.17	1.05	0.70	0.66
#2	1.29	1.37	0.79	0.81
#3	1.10	1.23	0.70	0.79
#4	1.07	1.11	0.66	0.71
#5	1.08	0.91	0.69	0.55
#6	1.23	1.28	0.82	0.80
#7	0.98	1.06	0.61	0.63
#8	1.24	1.23	0.75	0.76
Mean	1.15	1.16	0.72	0.71

The diversity of bird species (Table 13) across all seasons in year one and two of the study was not significantly different (respectively $H = 1.30$, $H = 1.31$, $(P(t_{\alpha(2),6} \geq (|0.23|) > 0.50))$. The season with the highest diversity in year one was summer ($H = 1.37$), closely followed by spring ($H = 1.36$) (Table 13). The season with the highest diversity in the second year was spring ($H = 1.40$) (Table 13). The season with the lowest diversity in both the first and second year was winter (respectively $H = 1.16$, $H = 1.19$) (Table 13).

The evenness of bird species (Table 13) across all seasons in year one and two of the study was also not significantly different (respectively $J = 0.77$, $J = 0.76$, $(P(t_{\alpha(2),6} \geq (|0.31|) > 0.50))$. The season with the highest evenness was both summer and fall ($J = 0.81$) for year one (Table 13). The season with the highest evenness for year two was summer ($J = 0.80$) (Table 13). The season with the lowest evenness for year one was winter ($J = 0.68$) and the lowest evenness for year two was also winter ($J = 0.68$) (Table 13).

Table 13. Brillouin diversity (H) and evenness (J) in each year across seasons

Season	H		J	
	Year		Year	
	<u>One</u>	<u>Two</u>	<u>One</u>	<u>Two</u>
Summer	1.37	1.34	0.81	0.80
Fall	1.29	1.31	0.81	0.77
Winter	1.16	1.19	0.68	0.68
Spring	1.36	1.40	0.77	0.77
Mean	1.30	1.31	0.77	0.76

Bird Checklist

These data, along with previous data from many contributors from the San Marcos area, were used to compile a bird checklist for the site, *Birds of San Marcos Springs and Surrounding Vicinity* (Appendix V). This checklist contains a total of 135 bird species grouped by family observed at the site as of June 2001.

CHAPTER IV

DISCUSSION

Species Richness

The point count stations with high total densities of woody vegetation generally had a higher species richness. The point count stations with low total densities of woody vegetation generally had a lower species richness. The stations with low woody vegetation densities had mostly park-like habitat with mowed grass lawns, tall trees, and very little underbrush. Morrison et al. (1994) found a low number of species on a site at the Sweetwater Regional Park, San Diego County, California, that had a higher percent of Bermuda grass, pampas grass, and mule fat, plants characteristic of open, dry, and disturbed areas, and few animals used bulrush. The site with the highest species richness observed by Morrison et al. (1994) was apparently due to a high willow cover and relatively low amount of open disturbed areas.

Abundance

The most abundant bird species observed during the study was a member of the family Rallidae, the American Coot. Lockwood (2001) describes status of the American Coot as a common winter resident and rare summer visitor to the Edwards Plateau. Kutac & Caran (1994) also describe the status of the American Coot as an abundant spring, fall and winter resident and an uncommon summer resident in perennial waterways in Central Texas. In the perennial waters of Spring Lake, the American Coot

was observed during every month of the 2-year survey. Throughout the summers of 1999 and 2000, there was at least one American Coot on Spring Lake. Their numbers increased to over one hundred in the winter of 2000 and 2001. No evidence of breeding, such as the presence of young, was observed. Weller & Weller (2000) state that American Coots often form interspecies feeding associations with American Wigeons and Gadwalls and are often harassed by these species when surfacing after diving for deep-water vegetation. Incongruously, Sibley (2001) states that American Coots are very aggressive and will steal food from dabbling ducks, such as American Wigeons and Gadwalls. The Gadwall and American Wigeon were both listed in the top ten most abundant bird species for both years of this study. American Coots were only observed chasing conspecifics, with a higher rate of this activity in the spring of both study years. This behavior may have been migrating restlessness or *zugunruhe* (Gill 1994).

Annual Residents

Almost one fourth of the birds observed during this study were annual residents. These birds are generally nonmigratory.

The Great-tailed Grackle was the third most abundant bird species in year one and the fourth most abundant bird species in year two, and they were frequently observed near Stations #4 and #5, which probably accounts for the high percentage of annual resident species observations at these two stations. Stations #4 and #5 had the lowest total density of vegetation and the highest mean distance of the eight stations. These sites have large expanses of mowed lawn and Kaufman (1996) describes these birds as common species on suburban lawns and other many types of open or semi-open country, striding about in search of insects.

Evidence of breeding was observed in many of these species during this study. Wood Ducks were observed in family groups. Begging behavior of young toward adults was observed in Red-shouldered Hawks, Carolina Wrens, Bewick's Wrens, Northern Mockingbirds, Northern Cardinals and Great-tailed Grackles. On 8 September 1999, a young European Starling was observed begging an adult male Northern Cardinal, and when the cardinal flew away the starling quickly followed.

The American Robin was placed in this category even though Lockwood (2001) states that its status is a common to abundant migrant and winter resident, and uncommon and local breeding species in urban settings within the Edwards Plateau. Kutac & Caran (1994) states that the American Robin is an abundant spring, fall and winter resident and uncommon summer resident in Central Texas. The Travis Audubon Society Checklist (1994) lists the American Robin as a species that nests regularly in the area and the area that they cover is a 60-mile radius centered in Austin, Texas that includes Hays County. During this study, the American Robin was only observed during the winter months and there was no evidence of breeding.

Summer Residents

Summer resident bird species arrive in the area during the spring and raise young into the summer months. The highest percentage of summer residents was observed at station #6, an oak woodland with a small portion of grassland on the hillside. That station also had a high total density of woody vegetation

Four summer resident species were from the wading bird family Ardeidae: the Snowy Egret, the Little Blue Heron, the Green Heron and the Yellow-crowned Night-

Heron. The only young wading birds that were observed were Green Herons and Yellow-crowned Night-Herons. Nests were not located.

The other summer residents observed in this study come from a group of birds known as the Nearctic/Neotropical Migrants. These birds travel between wintering tropical grounds in South and Central America and northern temperate zones where they nest in North America, and there is concern about population declines of these bird species due to loss of habitat in both their wintering and nesting grounds (Gill 1994). Twenty-one species of Nearctic/Neotropical migrant bird species (Appendix II) that could potentially breed in Central Texas (Travis Audubon Society 1994) were observed in this study. The Western Kingbird, Eastern Kingbird, Scissor-tailed Flycatcher and Purple Martin were all observed in this study interacting with young conspecifics, therefore, there was evidence of breeding. Chimney Swifts, Black-chinned Hummingbirds, Great Crested Flycatchers, White-eyed Vireos, Summer Tanagers, and Painted Buntings were observed regularly throughout the summer, so it was assumed that they also were breeding in the area.

Winter Residents

In year two of the study, six more winter resident species were observed than in year one. The largest number of wintering species observed came from the family Anatidae and subfamily Anatinae or true ducks (Sibley 2001). A total of 12 species of wintering true ducks were observed during this study. Station #7 had the highest percentage of winter residents during the first year due to the presence of wintering waterfowl on Spring Lake. True ducks are categorized as dabbling ducks (surface feeding ducks) or as bay ducks or pochards (diving ducks) (Kaufman 1996).

The dabbling ducks observed on Spring Lake and the Sink Creek Slough were Gadwalls, American Wigeons, Mallards, Blue-winged Teal, Cinnamon Teal, Northern Shovelers, Northern Pintails, and Green-winged Teal. As mentioned earlier, the Gadwalls and American Wigeons were listed in the top ten most abundant species list for both year one and two of the study. The Gadwall was the fifth most abundant species in year one of the study and the seventh most abundant in the year two. The American Wigeon was the fourth most abundant species in year one of the study and the fifth most abundant species in year two. Mallards were rarely observed. Blue-winged Teal were only observed during the early spring of both years. Cinnamon Teal were only observed in the early spring in year one of the study. Green-winged Teal were only observed during the late summer in year one of the study. Northern Pintails were incidental and rarely observed. Northern Shovelers were only observed once in the Sink Creek Slough in the winter of year two. Dabbling ducks feed by dabbling at the water's surface or up ending with tail up and head submerged searching for mostly vegetation (Kaufman 1996). Shovelers, teals, and pintails prefer shallow lakes where they forage for seeds (Kaufman 1996) and the clear, deep waters of Spring Lake may account for their low numbers. Gadwalls and American Wigeons eat mostly aquatic plants and fewer seeds compared with other dabbling ducks (Kaufman 1996). Gadwalls will sometimes dive for food and American Wigeons often associate with diving ducks and steal their food when they come to the surface (Kaufman 1996, Weller & Weller 2000).

The bay ducks or pochards (diving ducks) observed on Spring Lake and the Sink Creek Slough in this study were Canvasbacks, Redheads, Ring-necked Ducks, and Lesser Scaup. Canvasbacks were rarely seen during the first winter of the study, only one

observation was recorded, but in the second year of the study, six were observed in one day. The Canvasback's (*Aythya valisineria*) favored food is wild celery (*Vallisneria Americana*) (Stutzenbaker 1999), an aquatic plant found in Spring Lake. An increase of this plant in Spring Lake may attract more of these ducks to the area. Redheads were observed in the winter of the first year but not in the winter of the second year. Redheads winter on freshwater inland lakes. That first winter in the study experienced many days without rainfall and Spring Lake may have been the one of a few large freshwater bodies available in the area. During that same winter, the number of observations of Ring-necked Ducks was tremendously high (291 observations recorded on 23 January 2000). Spring Lake may be an important habitat for wintering waterfowl, especially during drought years.

Although many populations of waterfowl in North America have increased since the North American Waterfowl Management Plan, a conservation program in the Great Lakes, the Lesser Scaup numbers have continued to decline since the 1970's and reasons are not well known (Sibley 2001). Lesser Scaup were only observed once in the Sink Creek Slough. Their diet includes mollusks and Kaufman (1996) notes that these birds may feed heavily on the introduced zebra mussel (*Dreissena polymorpha*) in the Great Lakes. With the possible future introduction of the invasive zebra mussel into Texas water systems, this bird species may possibly play a key role in the control of this mussel.

A Sora, a member of the family Rallidae, was observed at the study site but not during the point count. The Sora was observed from September 2000 through October 2000 foraging in the wetland habitat immediately southeast of station #2. Lockwood

(2001) describes the status of the Sora in the Edwards Plateau as an occasional migrant and rare winter visitor throughout the region.

Migratory Species

There were six migratory bird species in year one and five in year two. Two migratory species observed were in the family Ardeidae, the American Bittern and the Tricolored Heron. The American Bittern was observed in November 2000 near the point count station #4 in the middle of the golf course. The bird was standing near the edge of Sink Creek Slough in a short, mowed lawn with its bill pointing straight up in the air. Kaufman (1996) describes this behavior in bitterns that when they are alarmed they will freeze with their neck stretched up and bill pointed skyward, their pattern of vertical stripes provides camouflage in a background of tall marsh grasses. Short, mowed lawns do not provide much camouflage for a bittern trying to hide from an approaching human. The Tricolored Herons were only observed during the late summer in the first year of the study. The high percentage of migratory species observed at station #8 in the altered riparian habitat of the Aquarena Center in year one was probably due to the presence of the Tricolored Herons along the shoreline.

One migratory species in the family Anatidae was observed, the Canada Goose. Canada Geese are known to be migratory in this region, but are rarely observed. The goose observed in this study may have been introduced to Spring Lake because it did not display normal migratory behavior, and was observed only from 30 June 1999 to 20 February 2000.

Other migratory species observed include birds from the family Accipitridae, Mississippi Kites and Swainson's Hawks; from the family Gruidae, Sandhill Cranes;

from the family Scolopacidae, Spotted Sandpipers and Pectoral Sandpipers; and from the family Emberizidae, Clay-colored Sparrows and Field Sparrows. Many of these species were recorded as flyovers and not directly associated with the study site.

The wetland habitat of station #2 had the highest percentage of migratory species in year two, probably due to the large amount of migrating Nearctic/Neotropical migrants during the fall 2000. Many migratory bird species were observed outside the point counts in the wetland habitat near station #2. These included Nearctic/Neotropical bird species from the family Mimidae, Gray Catbirds; the family Parulidae, Nashville Warblers, Yellow Warblers, Magnolia Warbler, Black and White Warbler, Prothonotary Warbler, Mourning Warbler and Wilson's Warbler; and from the family Icteridae, Baltimore Orioles. A fallout (Gill 2000) of migratory songbirds occurred in the fall 2000 at the study site. There were hundreds of migratory warblers foraging on the willows in the wetlands near station #2.

Introduced Species

Introduced species, also called exotic species (Gill 1994), observed during this study, were from four families. The Mute Swans and domestic ducks are both from the family Anatidae; the Rock Dove from the family Columbidae; the European Starlings from the family Sturnidae; and the House Sparrows from the family Passeridae.

Introduced species can negatively compete with native species (Sibley 2001). Mute Swans have been introduced throughout the world. They are aggressive toward other species and may out compete other species for food (Sibley 2001). The European Starling is one of the most abundant bird species in North America and is a threat to cavity-nesting native bird populations (Sibley 2001). The House Sparrow is a threat to

Eastern Bluebirds and Purple Martins by taking over their nest sites (Sibley 2001). Gill (1994) states that a redistribution of birds able to coexist with human societies, such as Rock Doves, European Starlings, and House Sparrows, is underway and these species show prospects of widespread success. Station #8, the location with the buildings and park-like grounds of the Aquarena Center, had the highest percentage of introduced bird species in both years of the study.

Species of Management Concern or Rare and Declining

The oak woodland/edge habitat at station #6 had the highest percentage of species of management concern or rare and declining in year one and two, and this location also had a high total density of woody vegetation.

The purpose of the *Non-game Birds of Management Concern - The 1995 List* by the USFWS was to identify migratory nongame bird species that are considered to be of concern because of population declines that are documented or apparent; have populations that are small or restricted; or are dependent on restricted or vulnerable habitats. Bird species on this list that were observed in this study include; from the family Ardeidae, American Bittern; from the family Accipitridae, Northern Harrier and Red-shouldered Hawk; from the family Cuculidae, Yellow-billed Cuckoo; from the family Picidae, Northern Flicker; from the family Laniidae, Loggerhead Shrike; from the family Troglodytidae, Bewick's Wren; from the family Emberizidae, Field Sparrow; from the family Cardinalidae, Painted Bunting; and from the family Icteridae, Eastern Meadowlark.

Shackelford and Lockwood (2000) designed the Rare and Declining Birds of Texas: Conservation Needed booklet to direct attention to species that have not had a

conservation focus. This booklet lists bird species by habitat type and Hays County falls within the boundaries of the Edwards Plateau (“Texas Hill Country”). The Painted Bunting observed in this study occurs in the habitat Shackelford and Lockwood (2000) describe as shrub-scrub with associated grassy areas. The Scissor-tailed Flycatcher observed in this study occurs in grasslands and oak savannahs, and the Black-chinned Hummingbird and Yellow-billed Cuckoo observed in this study occur in hardwood-dominated woodlands (Shackelford & Lockwood 2000). These habitats are important areas to enhance and maintain at the Aquarena Center.

Diversity and Evenness

The highest diversity of avian species for both years was at the wetland station #2. The woody plants at that station with the greatest relative coverage were Black Willow, Boxelder, and Eastern Cottonwood. Foraging observations of Morrison et al. (1994) confirmed the reliance of many avian species on willow and willow-cottonwood vegetation and avoidance of exotic vegetation in a California riparian floodplain. Willows and cottonwoods are important avian foraging plants to preserve in the wetlands at the Aquarena Center.

Station #7 had the lowest diversity of avian species in year one. This was probably not related to the vegetation, because the woody vegetation at that station had the highest total density overall, but due to the high numbers of waterbirds in Spring Lake during that first winter. Station #5 had the lowest diversity in year two, which was probably due to the fact that station #5 had the lowest total density of woody vegetation overall.

Station #6 had the highest evenness for both years and this may have been due to the diversity of habitat at the station. Station #6 was an edge habitat mix of oak woodlands and grasslands with a variety plant species and a variety bird species typically found in the Edwards Plateau.

Station #7 had the lowest evenness for year one and that was probably due to the large number of waterfowl at that location. Station #5 had the lowest evenness for year two and that may have been due to the large number of Cedar Waxwings that visited the location that winter. The Cedar Waxwing was the second most abundant bird species during that second year.

Spring and summer had the highest avian diversity for both years. This is probably due to the high number of Nearctic/Neotropical migrants that either pass through or breed at this location. The Aquarena Center may be important breeding habitat for a number of summer breeders, as well as for the large number of annual avian residents that inhabit the site.

The season with the lowest diversity for both years was the winter and that was probably due to the large number of waterfowl that make up the most of the winter avian residents.

Evenness was the highest for the bird species during the summer and fall of year one and the summer of year two. This was probably due to the variety of bird species that breed at this location in the summer or migrate through the area in the fall.

Evenness of avian species was the lowest during the winter for both years and that was probably due to the large amount of wintering waterfowl.

Spring Lake appears to be an important habitat for wintering waterfowl in the Central Texas area especially during times of drought, and the surrounding riparian habitat appears to be important habitat for many land birds, both for breeding and wintering grounds.

CHAPTER V

CONCLUSION

Monitoring the composition and diversity of avian communities provides both a useful means of evaluating habitat conservation efforts and determining the conservation needs of specific habitats (Leonard 1994; Ntiamoa-baidu et al. 2000). The results of this study will be useful tools for future comparisons, especially following any restoration efforts at the Aquarena Center.

The checklist of the birds is also a useful tool for ecotourists, especially bird watchers, visiting the Aquarena Center. The author would like to continue updating the checklist of bird species at the site, so current contact information for the author is included in the publication.

APPENDIX I

SITE DESCRIPTIONS AND PHOTOGRAPHS

Table 14. Relative Cover and Relative Density of Woody Vegetation at Station #1

Species	Relative Cover	Relative Density
Live Oak (<i>Quercus fusiformis</i>)	0.4772	0.131
Wax-leaf Ligustrum (<i>Ligustrum lucidum</i>)	0.1697	0.221
Chinaberry-Tree (<i>Melia azedarach</i>)	0.1312	0.272
Cedar Elm (<i>Ulmus crassifolia</i>)	0.0898	0.036
Pecan (<i>Carya illinoensis</i>)	0.0430	0.037
Boxelder (<i>Acer negundo</i>)	0.0345	0.037
Possum-haw (<i>Ilex decidua</i>)	0.0337	0.180
Anacua (<i>Ehretia anacua</i>)	0.0135	0.055
Chinese Tallow Tree (<i>Sapium sebiferum</i>)	0.0046	0.009
Mexican Buckeye (<i>Ugnadia speciosa</i>)	0.0017	0.017
Rough-leaf Dogwood (<i>Cornus drummondii</i>)	0.0012	0.003



Figure 4. Station #1 Facing North



Figure 5. Station #1 Facing South.

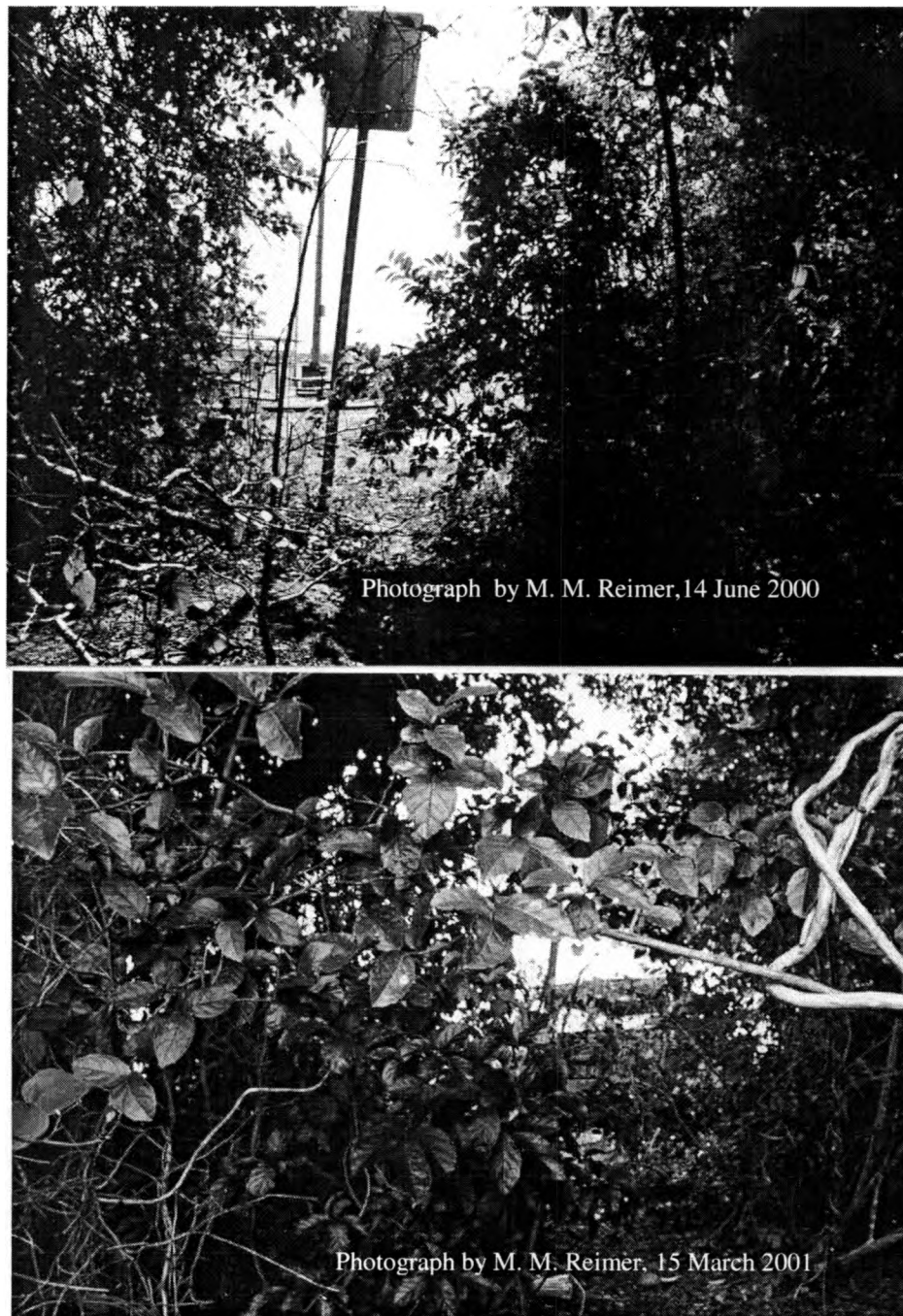


Figure 6. Station #1 Facing East



Figure 7. Station #1 Facing West

Table 15. Relative Cover and Relative Density of Woody Vegetation at Station #2

Species	Relative Cover	Relative Density
Black Willow (<i>Salix nigra</i>)	0.5036	0.322
Boxelder (<i>Acer negundo</i>)	0.2745	0.366
Eastern Cottonwood (<i>Populus deltoides</i>)	0.1900	0.202
Sycamore (<i>Platanus occidentalis</i>)	0.0159	0.018
Mexican Ash (<i>Fraxinus berlandieriana</i>)	0.0133	0.021
Texas Ash (<i>Fraxinus texensis</i>)	0.0016	0.025
Sandbar Willow (<i>Salix interior</i>)	0.0005	0.026
Common Elder-berry (<i>Sambucus Canadensis</i>)	0.0005	0.019



Figure 8. Station #2 Facing North

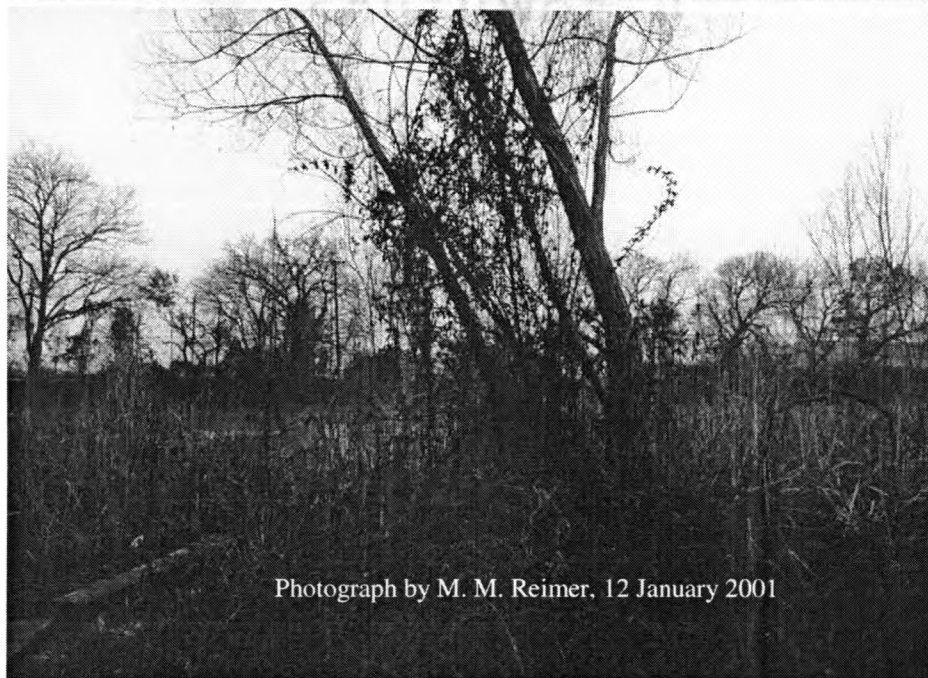


Figure 9. Station #2 Facing South



Figure 10. Station #2 Facing East

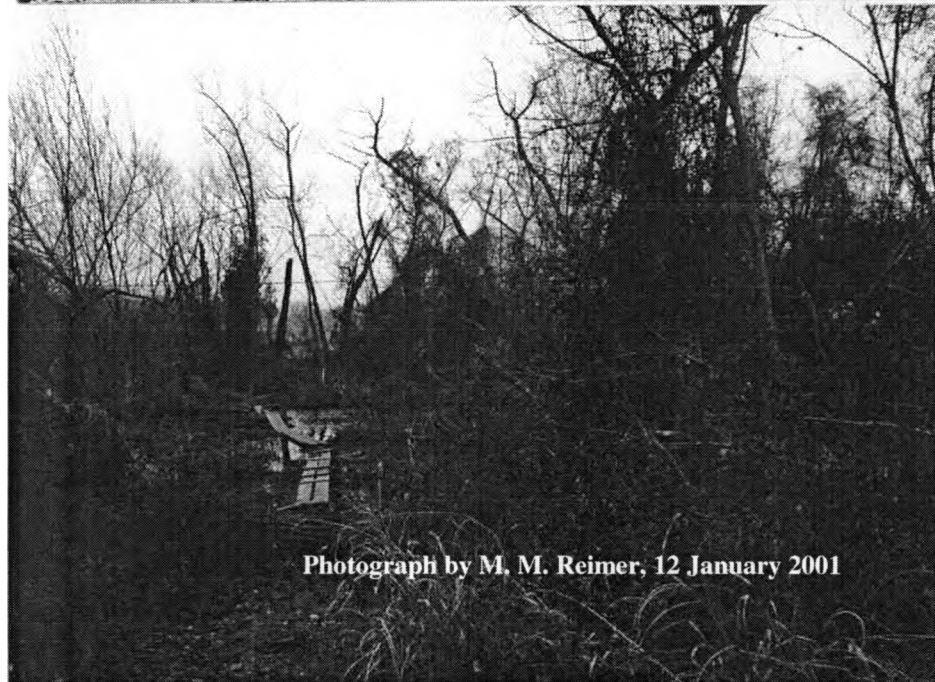


Figure 11. Station #2 Facing West

Table 16. Relative Cover and Relative Density of Woody Vegetation at Station #3.

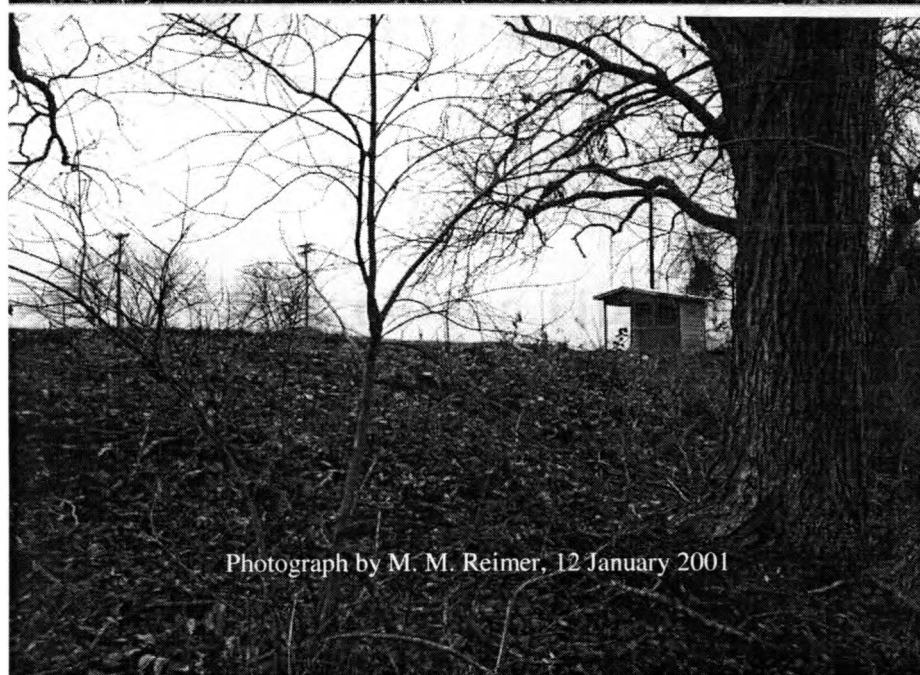
Species	Relative Cover	Relative Density
Pecan (<i>Carya illinoensis</i>)	0.6334	0.132
Common Chaste-tree (<i>Vitex agnus-castus</i>)	0.1188	0.334
Texas Sugarberry (<i>Celtis laevigata</i>)	0.1154	0.131
White Mulberry (<i>Morus alba</i>)	0.0486	0.022
Rough-leaf Dogwood (<i>Cornus drummondii</i>)	0.0268	0.129
Ironwood (<i>Bumelia lanuginosa</i>)	0.0208	0.012
Yaupon (<i>Ilex vomitoria</i>)	0.0179	0.059
Bur Oak (<i>Quercus macrocarpa</i>)	0.0061	0.126
Common Buttonbush (<i>Cephalanthus occidentalis</i>)	0.0061	0.017
Wax-leaf Ligustrum (<i>Ligustrum lucidum</i>)	0.0055	0.022
Anacua (<i>Ehretia anacua</i>)	0.0007	0.015



Figure 12. Station #3 Facing North

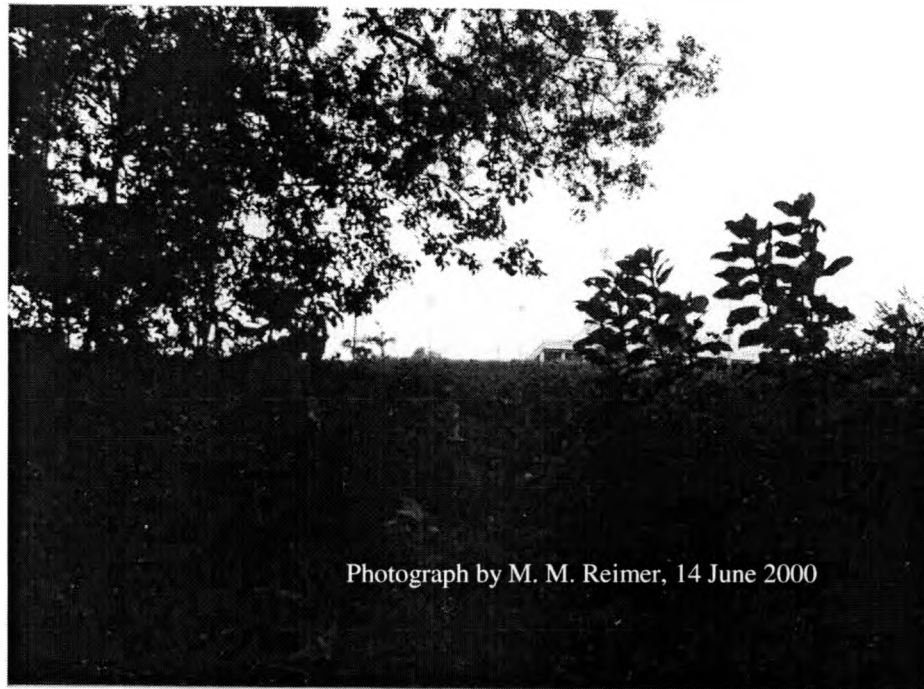


Photograph by M. M. Reimer, 14 June 2000



Photograph by M. M. Reimer, 12 January 2001

Figure 13. Station #3 Facing South



Photograph by M. M. Reimer, 14 June 2000



Photograph by M. M. Reimer, 15 March 2001

Figure 14. Station #3 Facing East

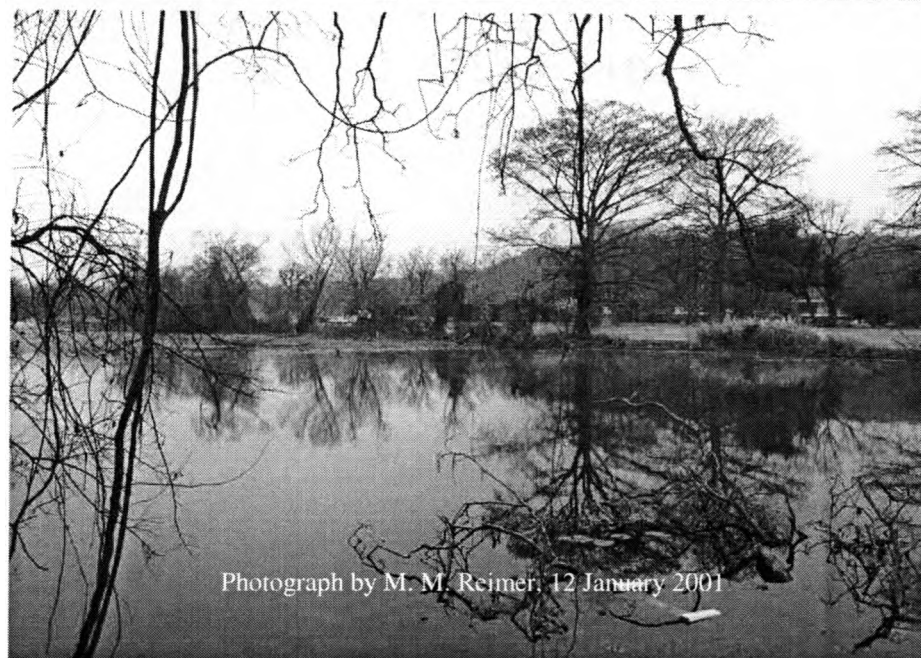
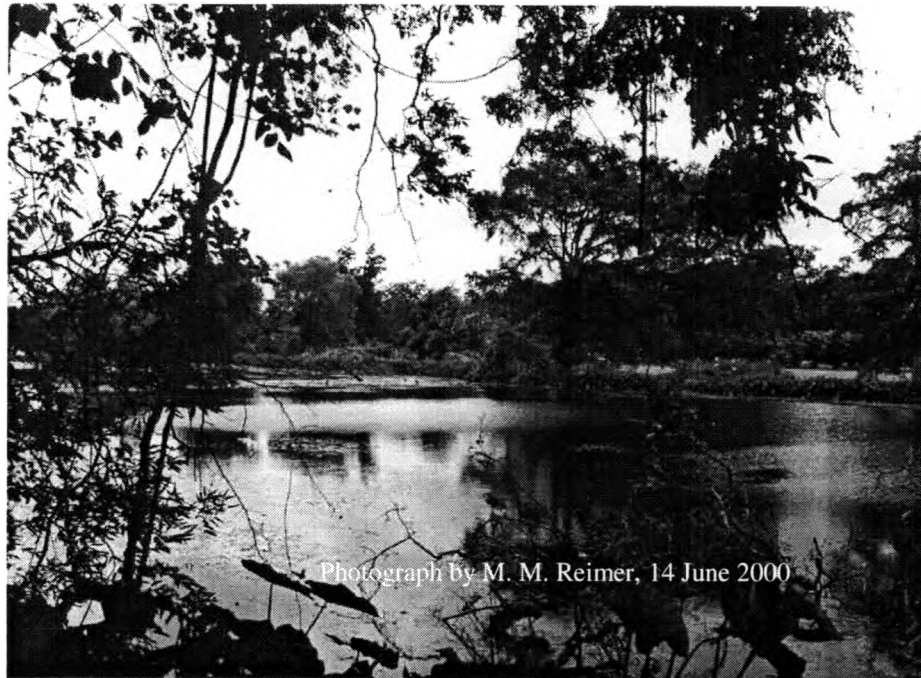


Figure 15. Station #3 Facing West

Table 17. Relative Cover and Relative Density of Woody Vegetation at Station #4

Species	Relative Cover	Relative Density
Bald Cypress (<i>Taxodium distichum</i>)	0.8876	0.102
Eastern Cottonwood (<i>Populus deltoides</i>)	0.0549	0.637
Black Willow (<i>Salix nigra</i>)	0.0299	0.033
Pecan (<i>Carya illinoensis</i>)	0.0272	0.035
<i>Sesbania</i> sp.	0.0003	0.192

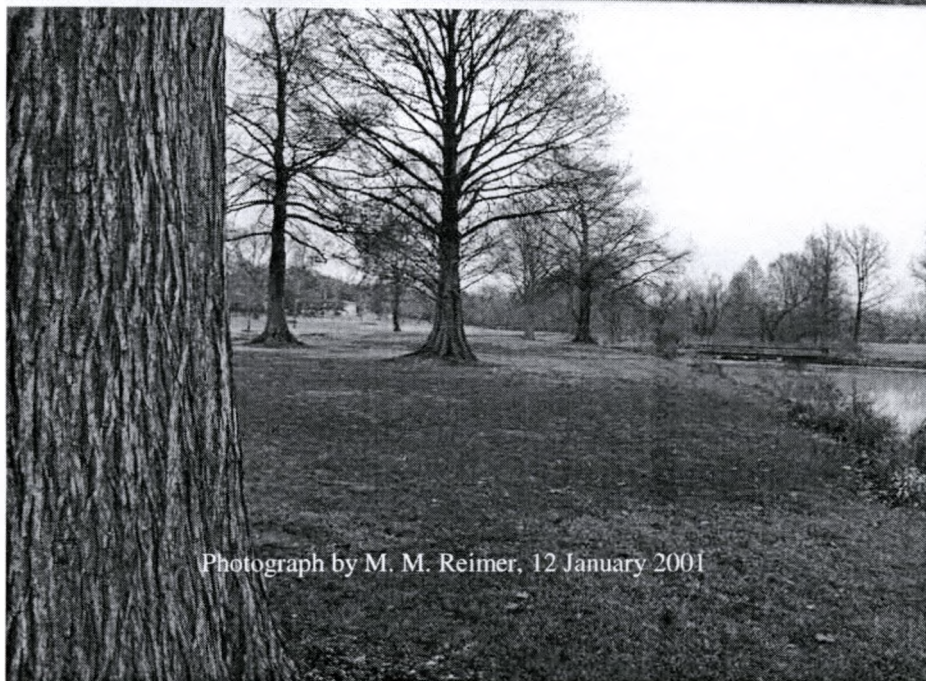
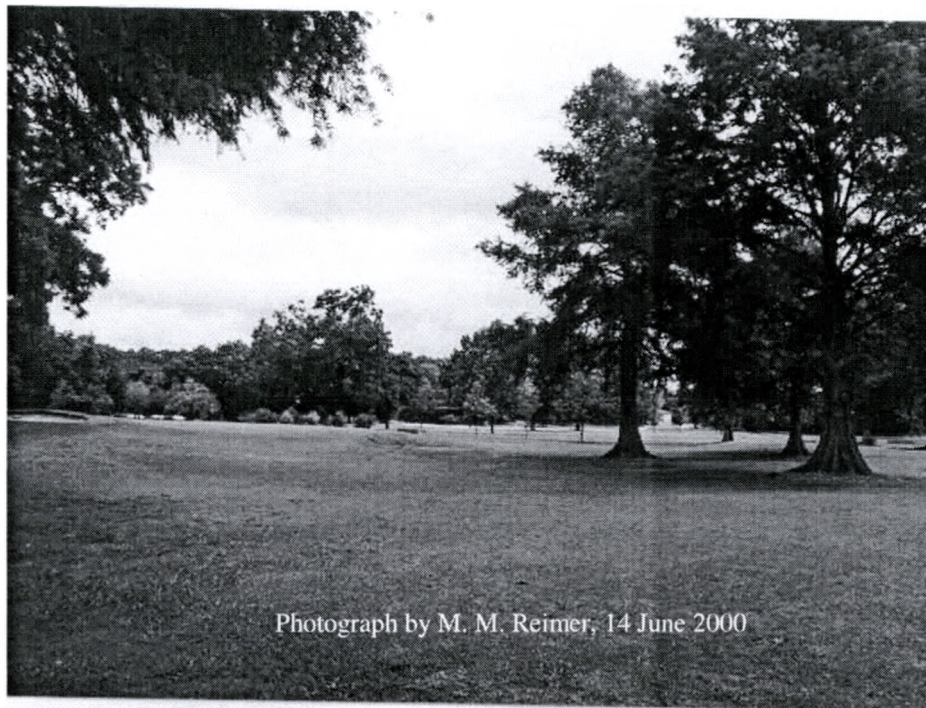


Figure 16. Station #4 Facing North



Figure 17. Station #4 Facing South

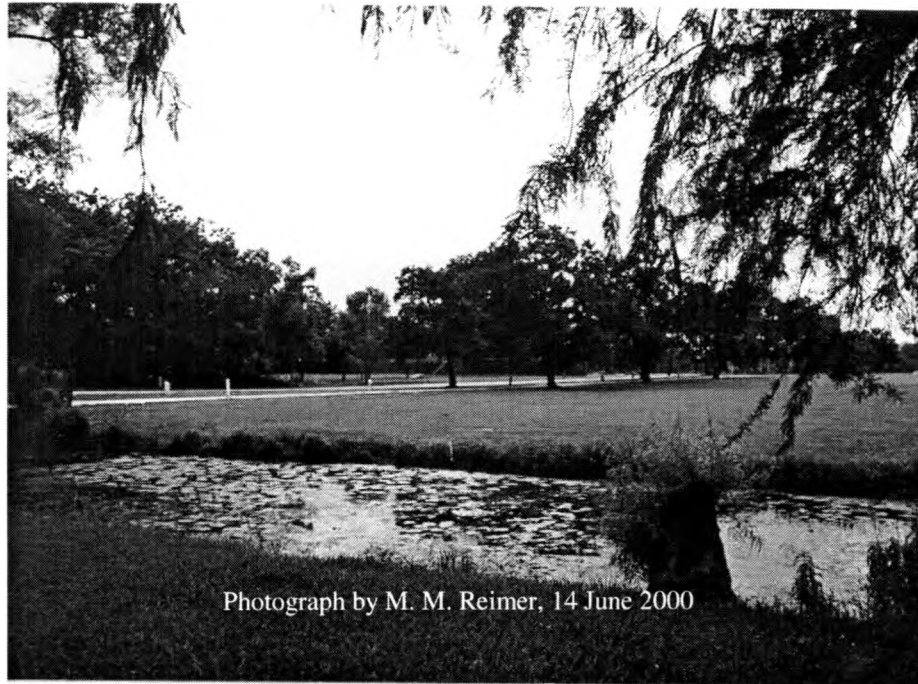


Figure 18. Station #4 Facing East

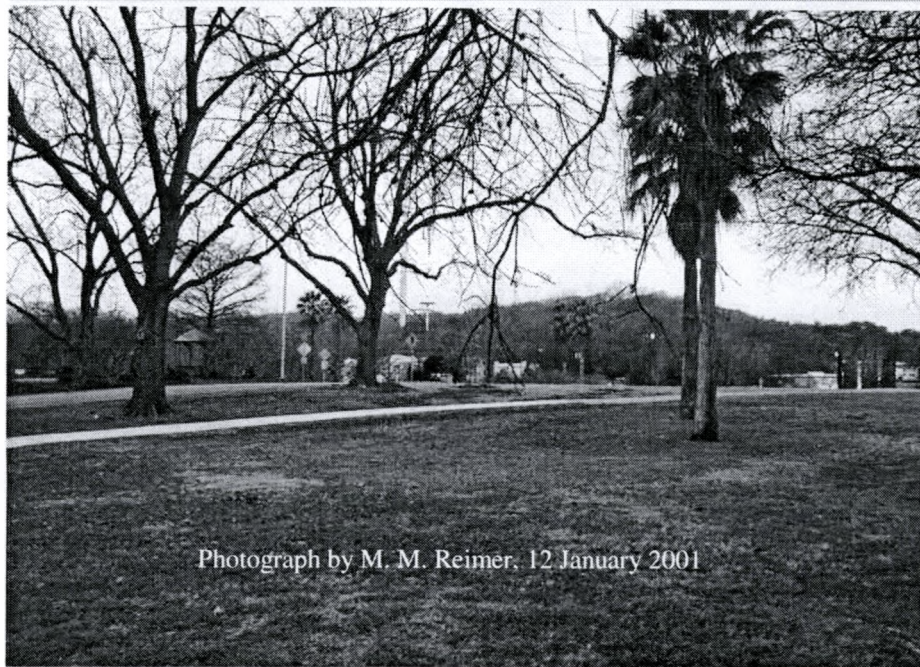


Figure 19. Station #4 Facing West

Table 18. Relative Cover and Relative Density of Woody Vegetation at Station #5

Species	Relative Cover	Relative Density
Bald Cypress (<i>Taxodium distichum</i>)	0.5654	0.258
Black Willow (<i>Salix nigra</i>)	0.1882	0.070
Pecan (<i>Carya illinoensis</i>)	0.1618	0.287
Eastern Cottonwood (<i>Populus deltoides</i>)	0.0625	0.272
Sweet-gum (<i>Liquidambar styraciflua</i>)	0.0143	0.052
Common Elder-berry (<i>Sambucus Canadensis</i>)	0.0035	0.032
Chinese Tallow Tree (<i>Sapium sebiferum</i>)	0.0034	0.015
Texas Sugarberry (<i>Celtis laevigata</i>)	0.0007	0.014

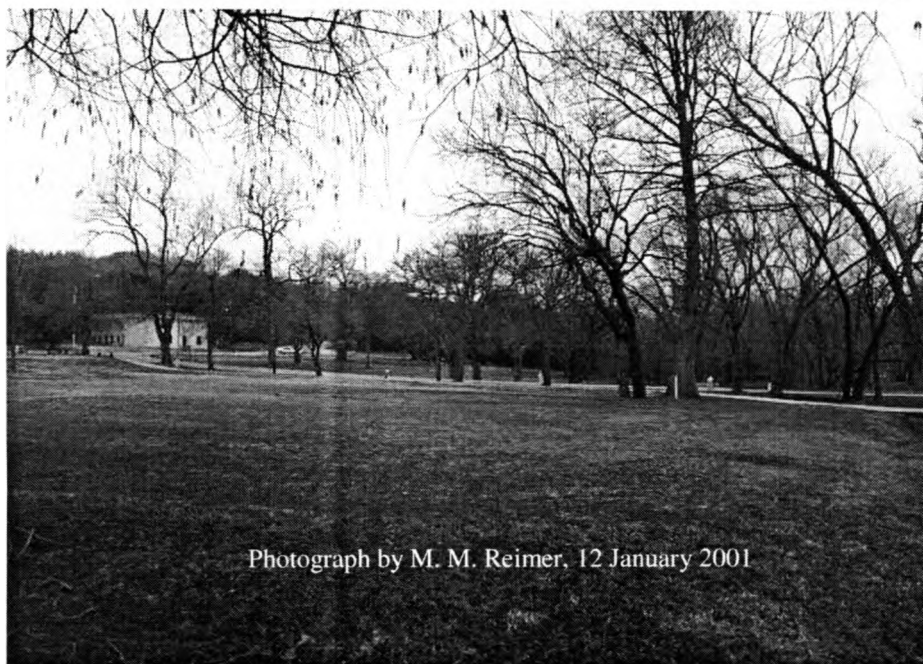


Figure 20. Station #5 Facing North

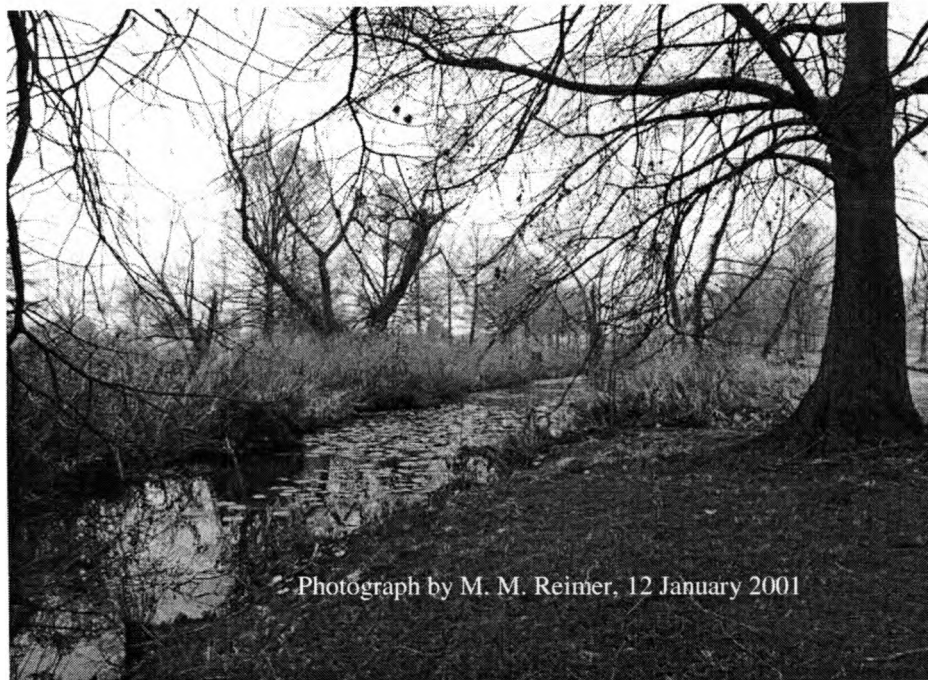
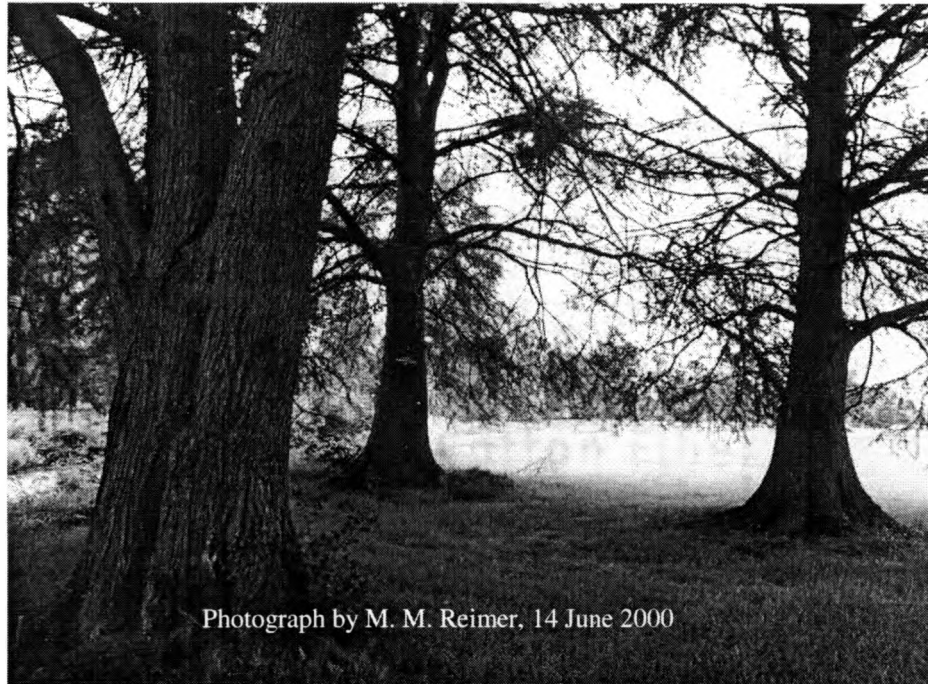


Figure 21. Station #5 Facing South



Figure 22. Station #5 Facing East

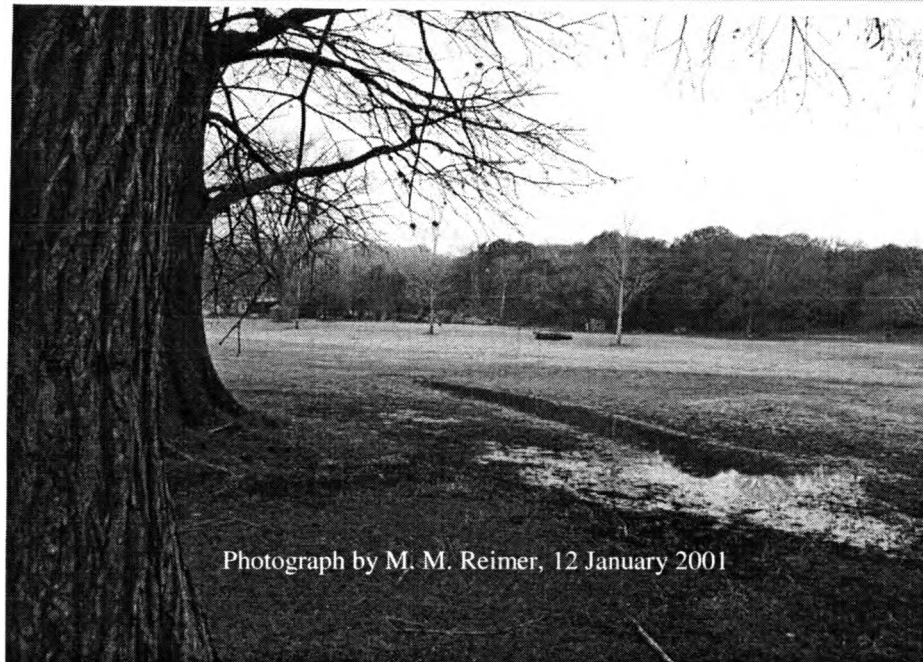
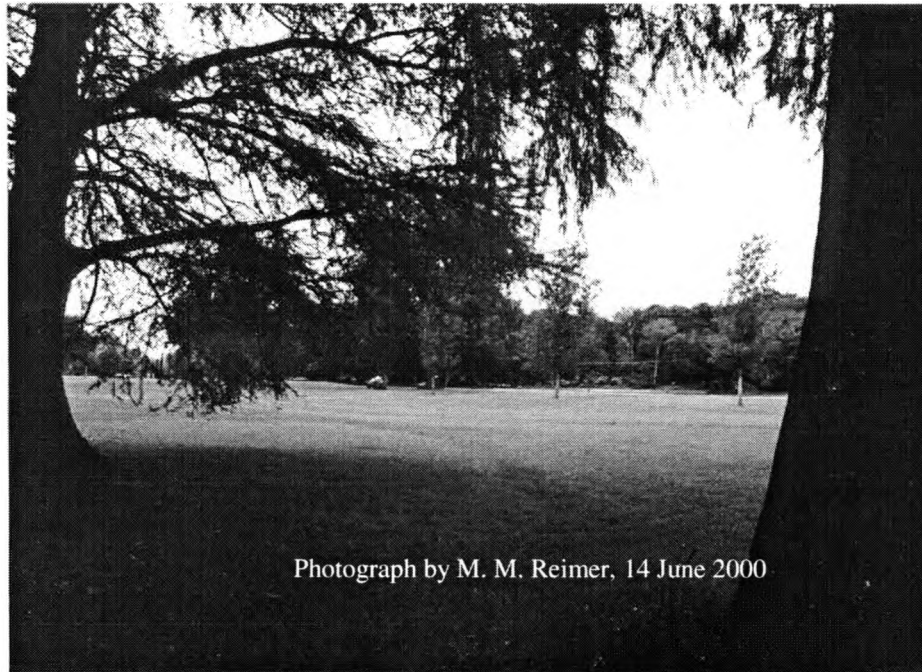


Figure 23. Station #5 Facing West

Table 19. Relative Cover and Relative Density of Woody Vegetation at Station #6.

Species	Relative Cover	Relative Density
Cedar Elm (<i>Ulmus crassifolia</i>)	0.2891	0.267
Honey Mesquite (<i>Prosopis glandulosa</i>)	0.1833	0.118
Live Oak (<i>Quercus fusiformis</i>)	0.1699	0.010
Mexican Juniper (<i>Juniperus ashei</i>)	0.0811	0.042
Texas Persimmon (<i>Diospyros texana</i>)	0.0572	0.198
Texas Mountain Laurel (<i>Sophora secundiflora</i>)	0.0570	0.078
Texas Prickly Pear (<i>Opuntia lindheimeri</i>)	0.0501	0.029
Oreja de Ratón (<i>Bernardia myricaefolia</i>)	0.0361	0.072
Lotebush (<i>Ziziphus obtusifolia</i>)	0.0198	0.013
Anacua (<i>Ehretia anacua</i>)	0.0188	0.019
Granjeno (<i>Celtis pallida</i>)	0.0161	0.047
Guayacán (<i>Porlieria angustifolia</i>)	0.0114	0.015
Buckeye (<i>Aesculus pavia</i>)	0.0039	0.026
Brasil (<i>Condalia hookeri</i>)	0.0033	0.020
Common Bee-brush (<i>Aloysia gratissima</i>)	0.0025	0.037
Encinilla (<i>Croton fruticulosus</i>)	0.0003	0.010

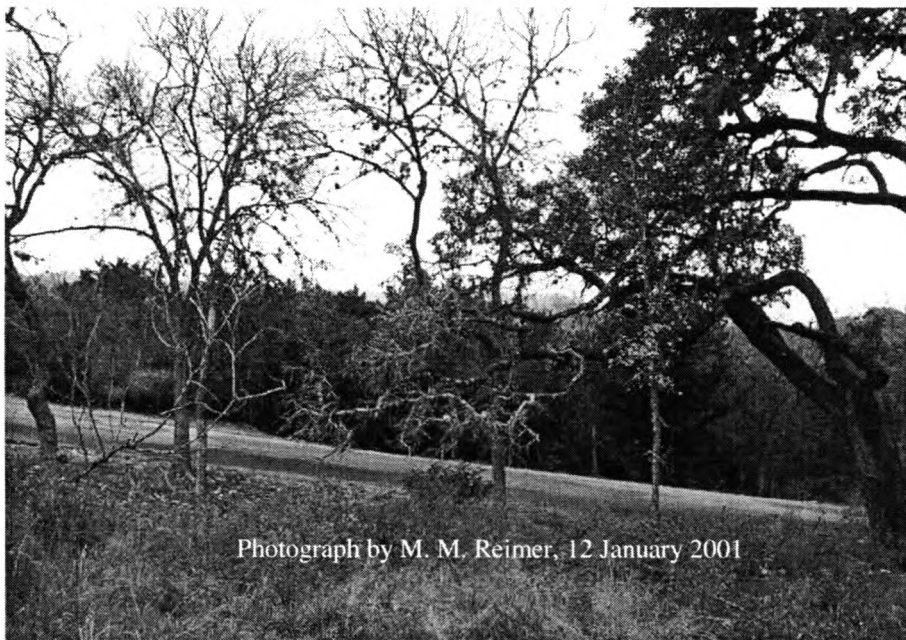


Figure 24. Station #6 Facing North



Figure 25. Station #6 Facing South

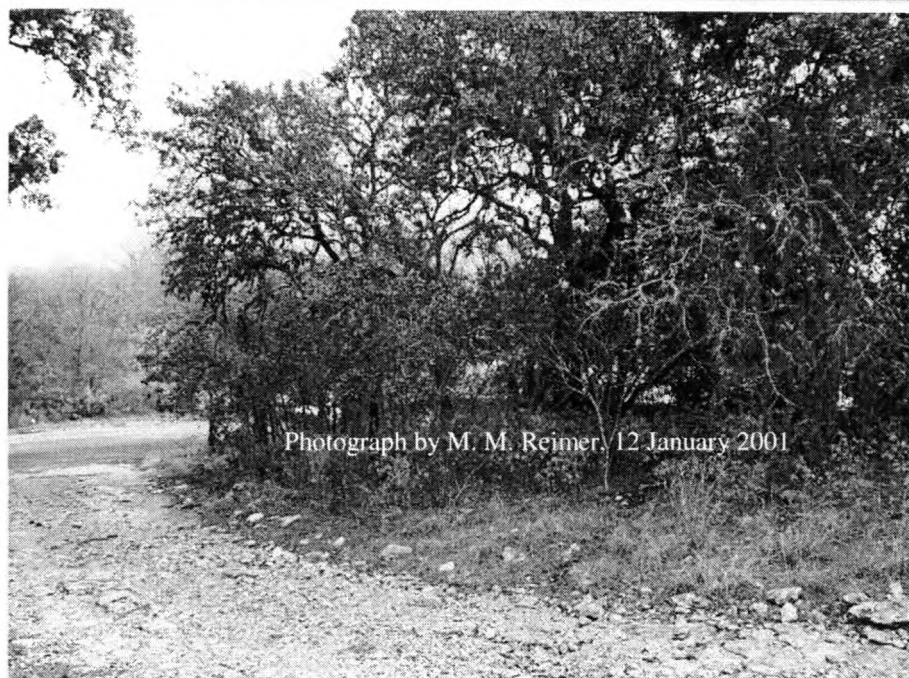


Figure 26. Station #6 Facing East



Figure 27. Station #6 Facing West

Table 20. Relative Cover and Relative Density of Woody Vegetation at Station #7

Species	Relative Cover	Relative Density
<i>Anacua (Ehretia anacua)</i>	0.5209	0.480
Texas Red Oak (<i>Quercus texana</i>)	0.2284	0.065
Pecan (<i>Carya illinoensis</i>)	0.0643	0.010
Mexican Plum (<i>Prunus mexicana</i>)	0.0513	0.118
Mexican Buckeye (<i>Ungnadia speciosa</i>)	0.0433	0.089
Wax-leaf Ligustrum (<i>Ligustrum lucidum</i>)	0.0405	0.106
Shumard Red Oak (<i>Quercus shumardii</i>)	0.0371	0.023
Texas Sugarberry (<i>Celtis laevigata</i>)	0.0088	0.034
Buckeye (<i>Aesculus pavia</i>)	0.0029	0.044
Bur Oak (<i>Quercus macrocarpa</i>)	0.0025	0.030



Figure 28. Station #6 Facing West

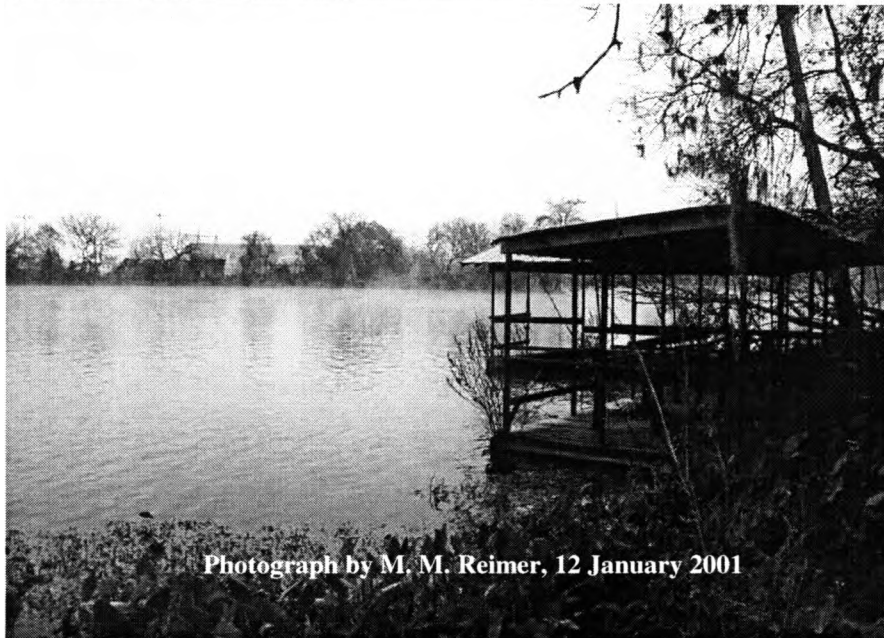
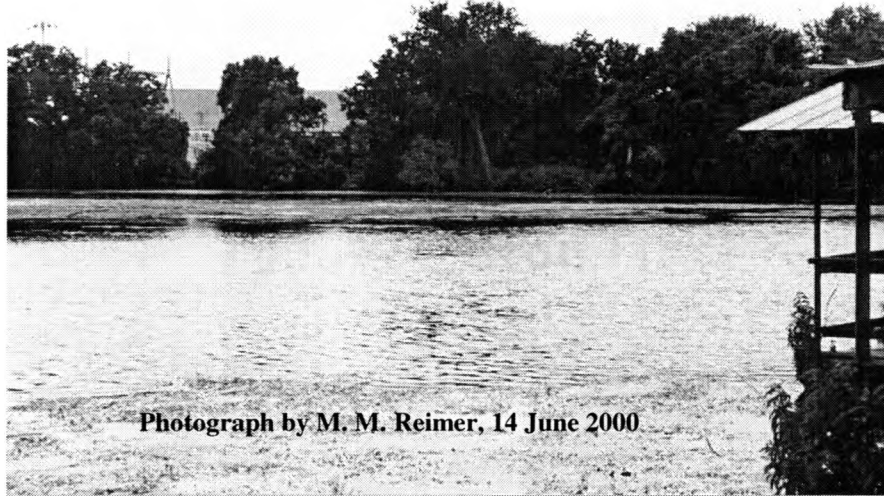


Figure 29. Station #7 Facing South

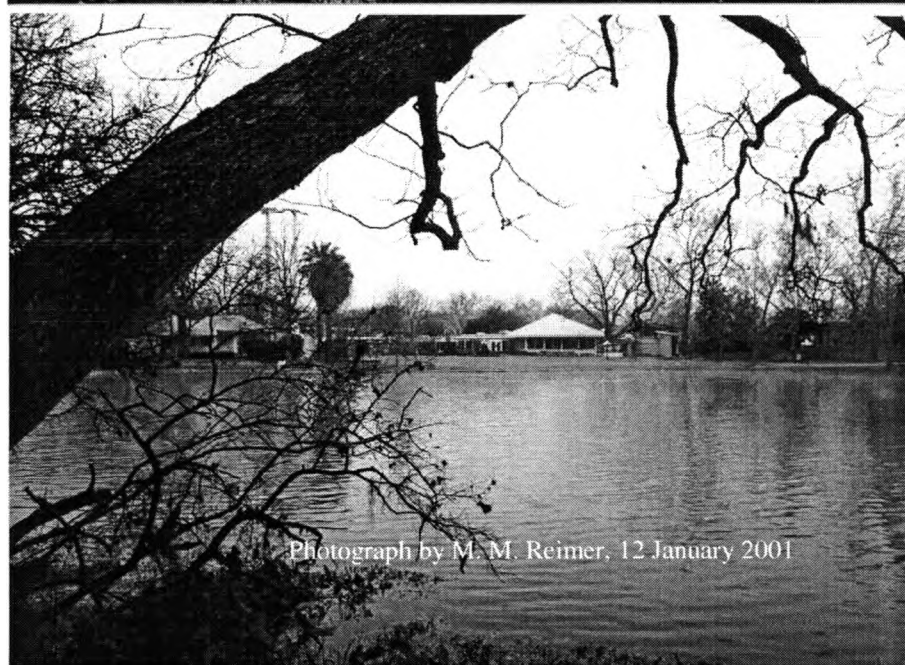
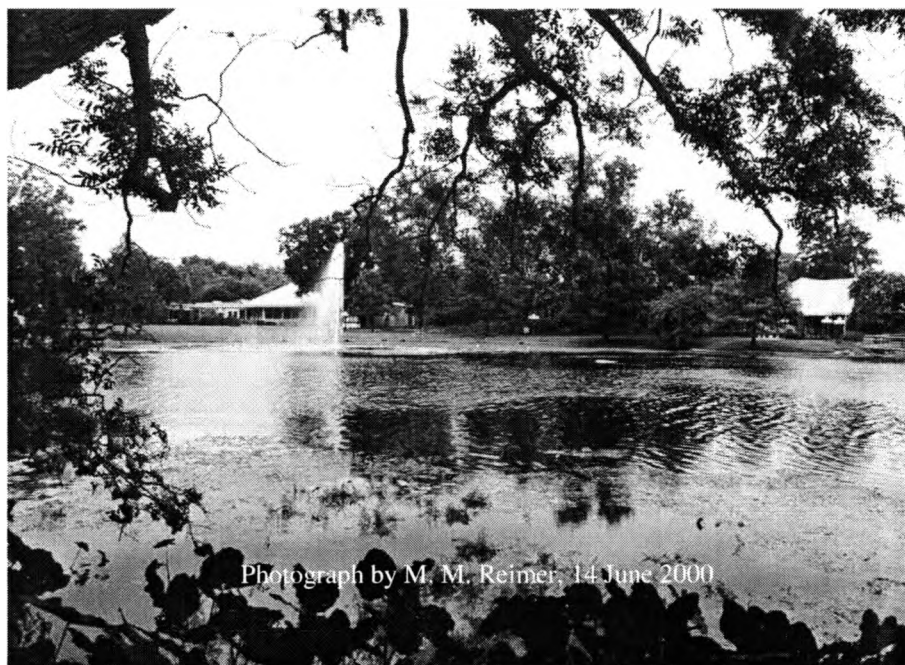


Figure 30. Station #7 Facing East



Figure 31. Station #7 Facing West

Table 21. Relative Cover and Relative Density of Woody Vegetation at Station #8

Species	Relative Cover	Relative Density
Bald Cypress (<i>Taxodium distichum</i>)	0.4205	0.140
Pecan (<i>Carya illinoensis</i>)	0.2669	0.278
Sycamore (<i>Platanus occidentalis</i>)	0.1444	0.294
Texas Sugarberry (<i>Celtis laevigata</i>)	0.0718	0.115
Southern Magnolia (<i>Magnolia grandiflora</i>)	0.0564	0.024
Mexican Buckeye (<i>Ungnadia speciosa</i>)	0.0223	0.027
Mexican Plum (<i>Prunus mexicana</i>)	0.0142	0.043
Crape-myrtle (<i>Lagerstroemia indica</i>)	0.0014	0.028
Wax-leaf Ligustrum (<i>Ligustrum lucidum</i>)	0.0012	0.032
White Mulberry (<i>Morus alba</i>)	0.0010	0.020

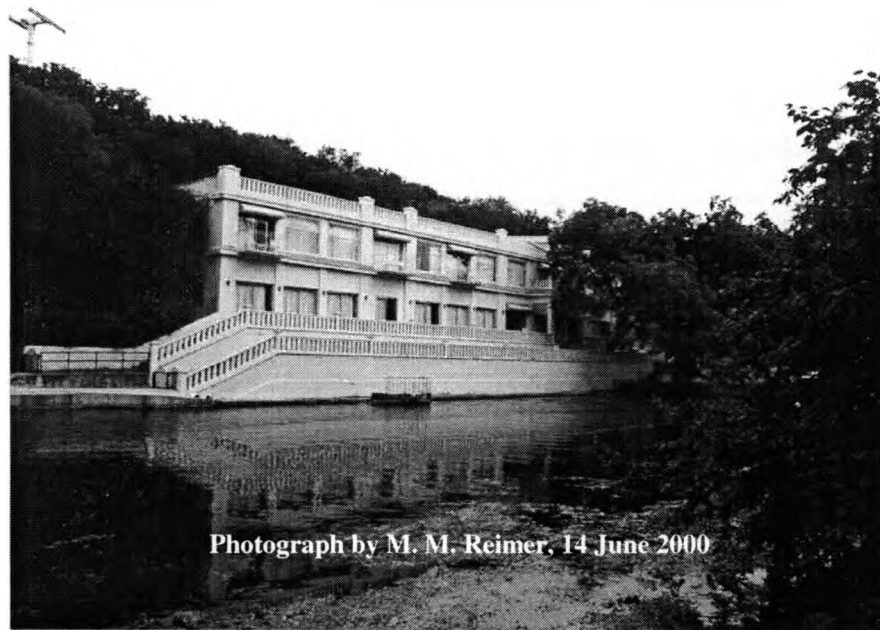


Figure 32. Station #8 Facing North

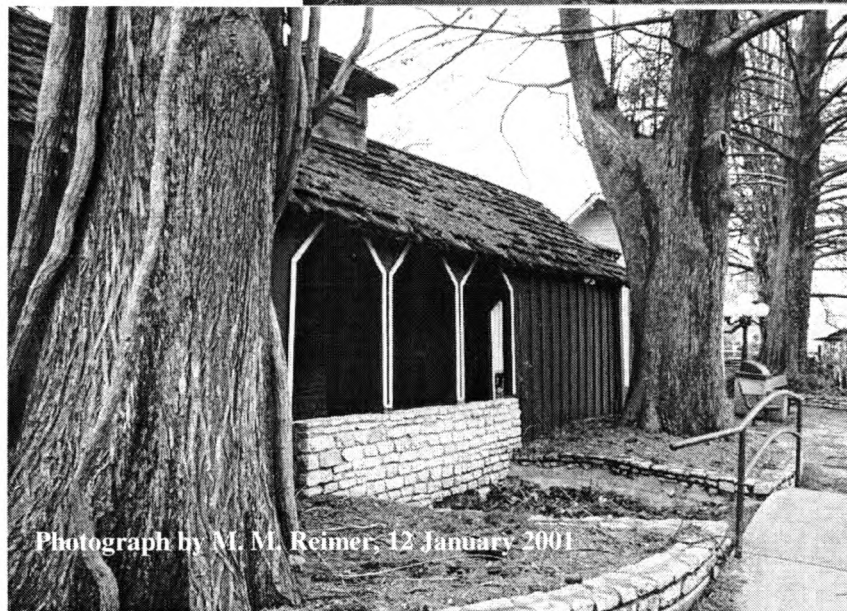
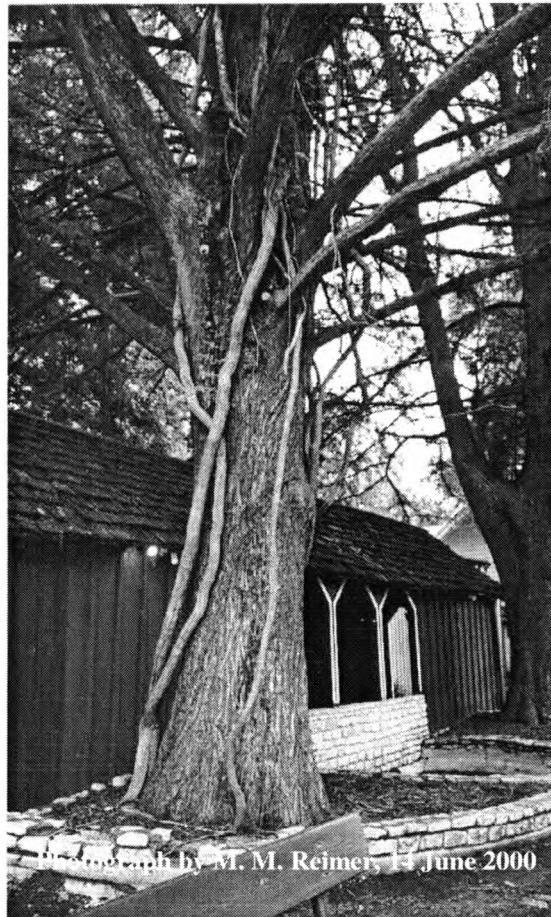


Figure 33. Station #8 Facing South

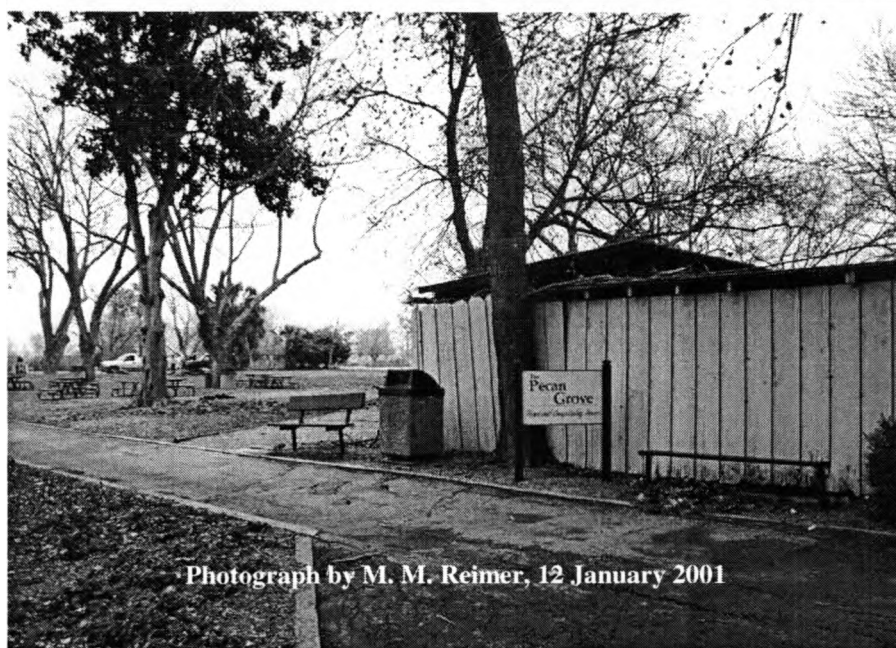
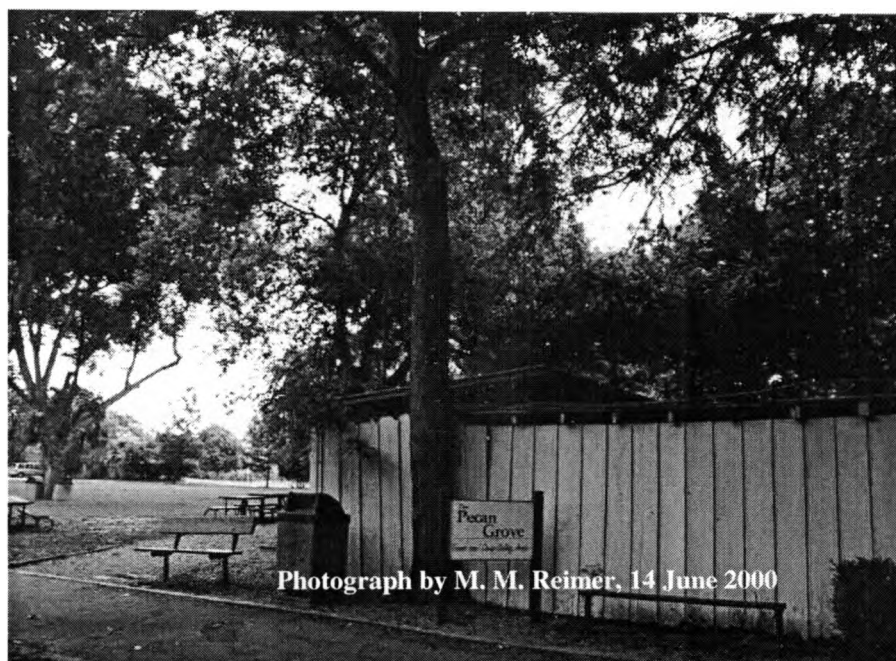


Figure 34. Station #8 Facing East

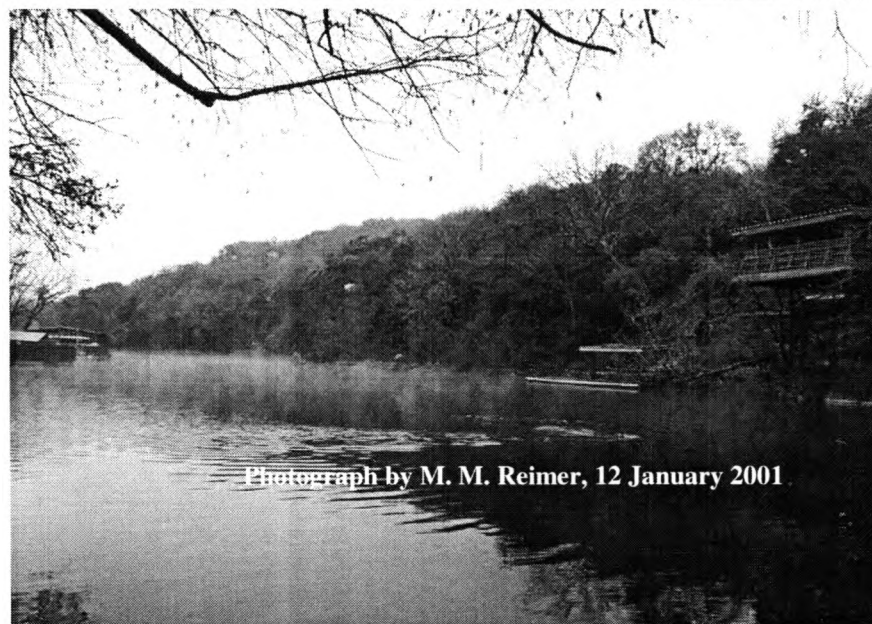
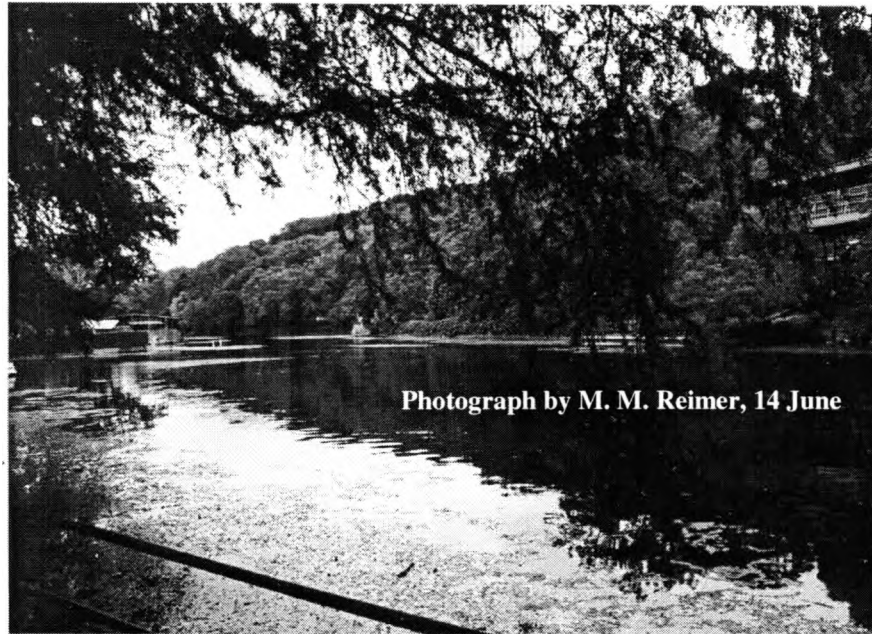


Figure 35. Station #8 Facing West

APPENDIX II

AVIAN SPECIES OBSERVED DURING BASELINE SURVEY

Total species = 127 - Includes flyovers, incidentals and two genera (103 species observed in point count study)

Status

- AR** - Annual Resident (Year-round)
SR - Summer Resident (* Nearctic/Neotropical Migrant)
WR - Winter Resident
M - Migrant (* Nearctic/Neotropical Migrant)
I - Introduced

- 1** Species on the 1995 List, Non-game Birds of Management Concern, Office of Migratory Bird Management, United States Fish and Wildlife Service
2 Species listed in Rare and Declining Birds of Texas: Conservation Needed by C E. Shackelford and M.W Lockwood 2000 Texas Parks and Wildlife Department
***** Flyover
****** Incidental, observed at site but not during point count

		Station								
		Status	#1	#2	#3	#4	#5	#6	#7	#8
PODICIPEDIFORMES										
Podicipedidae										
Pied-billed Grebe	<i>Podilymbus podiceps</i>	WR	X	X	X	X			X	X
PELECANIFORMES										
Phalacrocoracidae										
Double-crested Cormorant	<i>Phalacrocorax auritus</i>	WR	X	X	X				X	X
CICONIIFORMES										
Ardeidae										
American Bittern ¹	<i>Botaurus lentiginosus</i>	M			X					
Great Blue Heron	<i>Ardea herodias</i>	AR	X	X	X	X		X	X	X
Great Egret	<i>Ardea alba</i>	AR	X		X	X			X	
Snowy Egret	<i>Egretta thula</i>	SR	X					X	X	X
Little Blue Heron	<i>Egretta caerulea</i>	SR							X	
Tricolored Heron	<i>Egretta tricolor</i>	M	X						X	X
Green Heron	<i>Butorides virescens</i>	SR	X	X	X	X	X		X	X
Yellow-crowned Night-Heron	<i>Nyctanassa violacea</i>	SR	X		X	X			X	
Cathartidae										
Black Vulture	<i>Coragyps atratus</i>	AR	X	X	X	X	X	X	X	X
Turkey Vulture	<i>Cathartes aura</i>	AR	X	X	X	X	X	X	X	X
ANSERIFORMES										
Anatidae										
Anserinae										
Canada Goose	<i>Branta canadensis</i>	M							X	X
Mute Swan	<i>Cygnus olor</i>	I	X	X	X	X			X	X
Anatinae										

			Station								
			Status	#1	#2	#3	#4	#5	#6	#7	#8
Wood Duck	<i>Aix sponsa</i>	AR	X	X	X					X	X
Gadwall	<i>Anas strepera</i>	WR	X	X	X	X	X			X	X
American Wigeon	<i>Anas americana</i>	WR	X	X						X	X
Mallard	<i>Anas platyrhynchos</i>	WR	X							X	X
Domestic Duck	<i>Anas sp</i>	I	X							X	X
Blue-winged Teal	<i>Anas discors</i>	WR	X		X					X	
Cinnamon Teal	<i>Anas cyanoptera</i>	WR	X								
Northern Shoveler	<i>Anas clypeata</i>	WR			X						
Northern Pintail**	<i>Anas acuta</i>	WR									
Green-winged Teal	<i>Anas crecca</i>	WR	X								
Canvasback	<i>Aythya valisineria</i>	WR	X							X	X
Redhead	<i>Aythya americana</i>	WR			X					X	
Ring-necked Duck	<i>Aythya collaris</i>	WR	X	X	X	X				X	X
Lesser Scaup	<i>Aythya affinis</i>	WR			X	X					
FALCONIFORMES											
Accipitridae											
Pandioninae											
Osprey	<i>Pandion haliaetus</i>	WR	X	X					X	X	
Accipitrinae											
Mississippi Kite*	<i>Ictinia mississippiensis</i>	M*			X						X
Northern Harrier **, 1	<i>Circus cyaneus</i>	WR									
Red-shouldered Hawk ¹	<i>Buteo lineatus</i>	AR	X	X	X	X	X			X	X
Swainson's Hawk*	<i>Buteo swainsoni</i>	M*							X		
Red-tailed Hawk*	<i>Buteo jamaicensis</i>	AR							X	X	X
Falconidae											
Caracarinae											
Crested Caracara*	<i>Caracara cherway</i>	AR							X		
Falconinae											
American Kestrel**	<i>Falco sparverius</i>	WR									
GRUIFORMES											
Rallidae											
Sora**	<i>Porzana carolina</i>	WR									
American Coot	<i>Fulica americana</i>	AR	X	X	X	X	X			X	X
Gruidae											
Gruinae											
Sandhill Crane*, **	<i>Grus canadensis</i>	M									
CHARADRIIFORMES											
Charadriidae											
Charadriinae											
Killdeer	<i>Charadrius vociferus</i>	AR	X	X	X	X	X	X	X	X	X
Scolopacidae											
Scolopacinae											
Spotted Sandpiper	<i>Actitis macularia</i>	M								X	
Pectoral Sandpiper**	<i>Calidris melanotos</i>	M									
Common Snipe**	<i>Gallinago gallinago</i>	WR									
Laridae											
Larinae											
Ring-billed Gull*	<i>Larus delawarensis</i>	WR				X					
COLUMBIFORMES											
Columbidae											
Rock Dove	<i>Columba livia</i>	I		X	X	X					X
White-winged Dove	<i>Zenaida asiatica</i>	AR	X	X	X	X	X	X	X	X	X
Mourning Dove	<i>Zenaida macroura</i>	AR	X	X	X	X	X	X	X	X	X
Inca Dove	<i>Columbina inca</i>	AR	X	X		X	X	X			X

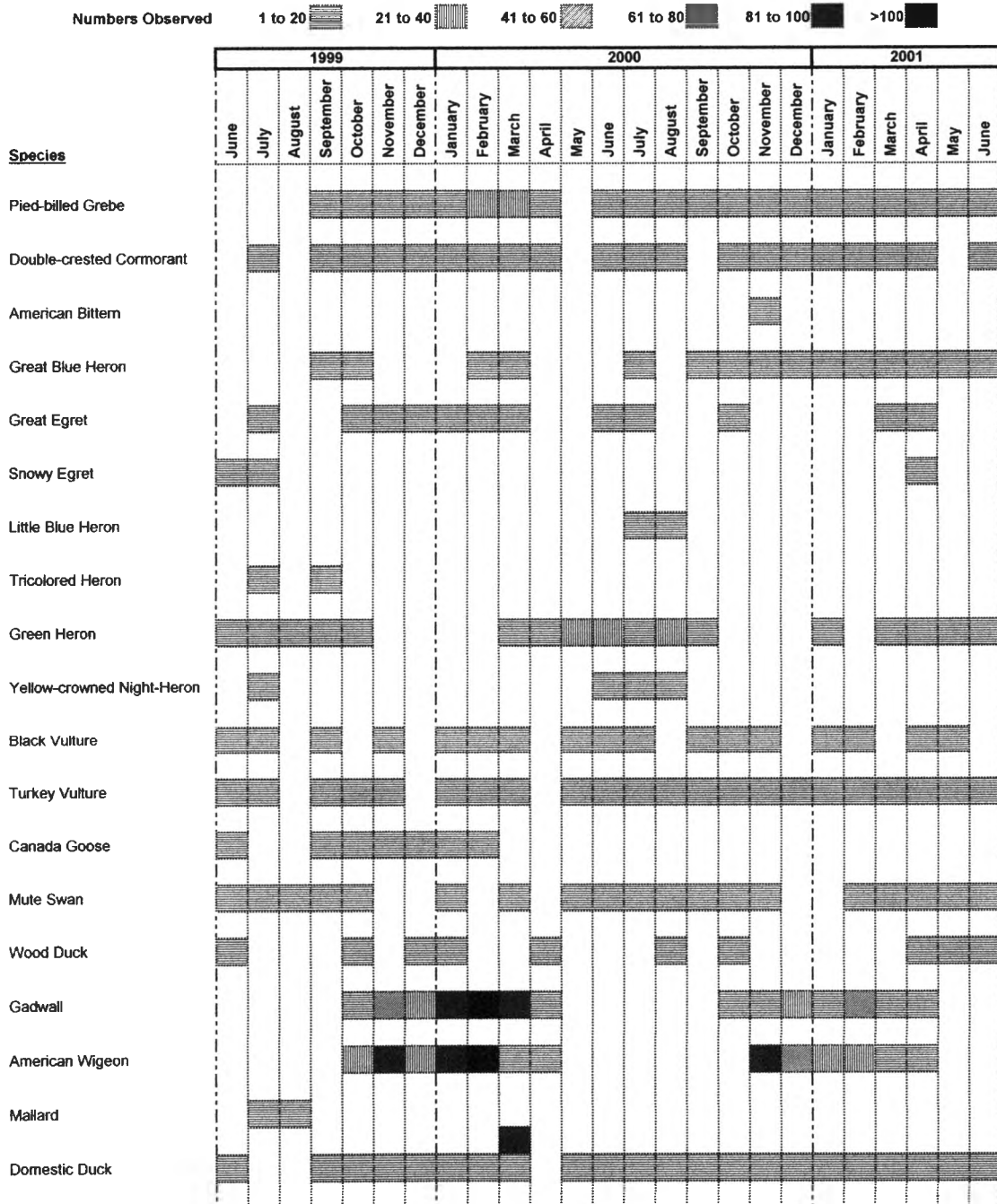
			Station								
			Status	#1	#2	#3	#4	#5	#6	#7	#8
CUCULIFORMES											
Cuculidae											
	Coccyzinae										
	Yellow-billed Cuckoo ^{1,2}	<i>Coccyzus americanus</i>	SR*	X	X	X	X	X	X	X	
	Neomorphinae										
	Greater Roadrunner	<i>Geococcyx californianus</i>	AR							X	
STRIGIFORMES											
Strigidae											
	Great Horned Owl	<i>Bubo virginianus</i>	AR							X	
CAPRIMULGIFORMES											
Caprimulgidae											
	Chordeilinae										
	Common Nighthawk**	<i>Chordeiles minor</i>	SR*								
APODIFORMES											
Apodidae											
	Chaeturinae										
	Chimney Swift	<i>Chaetura pelagica</i>	SR*	X	X	X	X		X	X	X
Trochilidae											
	Hummingbird species			X		X	X		X	X	X
	Trochilinae										
	Ruby-throated Hummingbird**	<i>Archilochus colubris</i>	SR*								
	Black-chinned Hummingbird ²	<i>Archilochus alexandri</i>	SR*		X	X			X		X
CORACIIFORMES											
Alcedinidae											
	Cerylinae										
	Belted Kingfisher	<i>Ceryle alcyon</i>	AR	X	X	X	X	X		X	X
	Green Kingfisher	<i>Chloroceryle americana</i>	AR	X						X	
PICIFORMES											
Picidae											
	Picinae										
	Golden-fronted Woodpecker	<i>Melanerpes aurifrons</i>	AR		X	X	X	X	X		X
	Red-bellied Woodpecker	<i>Melanerpes carolinus</i>	AR	X	X	X	X	X	X	X	X
	Ladder-backed Woodpecker	<i>Picoides scalaris</i>	AR	X	X	X	X	X	X	X	X
	Downy Woodpecker	<i>Picoides pubescens</i>	AR	X	X	X	X	X	X	X	X
	Northern Flicker ¹	<i>Colaptes auratus</i>	WR	X	X		X	X	X	X	X
PASSERIFORMES											
Tyrannidae											
	Fluvicolinae										
	<i>Empidonax</i> sp**	<i>Empidonax</i> sp									
	Eastern Phoebe	<i>Sayornis phoebe</i>	AR	X	X	X	X	X		X	X
	Tyranninae										
	Great Crested Flycatcher	<i>Myiarchus crinitus</i>	SR*		X		X				X
	Western Kingbird	<i>Tyrannus verticalis</i>	SR*	X	X	X	X	X	X	X	X
	Eastern Kingbird	<i>Tyrannus tyrannus</i>	SR*	X	X	X	X	X	X		
	Scissor-tailed Flycatcher	<i>Tyrannus forficatus</i>	SR*		X	X	X	X	X		
Laniidae											
	Loggerhead Shrike ¹	<i>Lanius ludovicianus</i>	AR	X	X	X	X	X	X		
Vireonidae											
	White-eyed Vireo	<i>Vireo griseus</i>	SR*	X	X				X	X	X
	Red-eyed Vireo	<i>Vireo olivaceus</i>	SR*	X					X		
Corvidae											
	Blue Jay	<i>Cyanocitta cristata</i>	AR	X	X	X	X	X	X	X	X
	American Crow	<i>Corvus brachyrhynchos</i>	AR			X		X	X	X	
Hirundinidae											

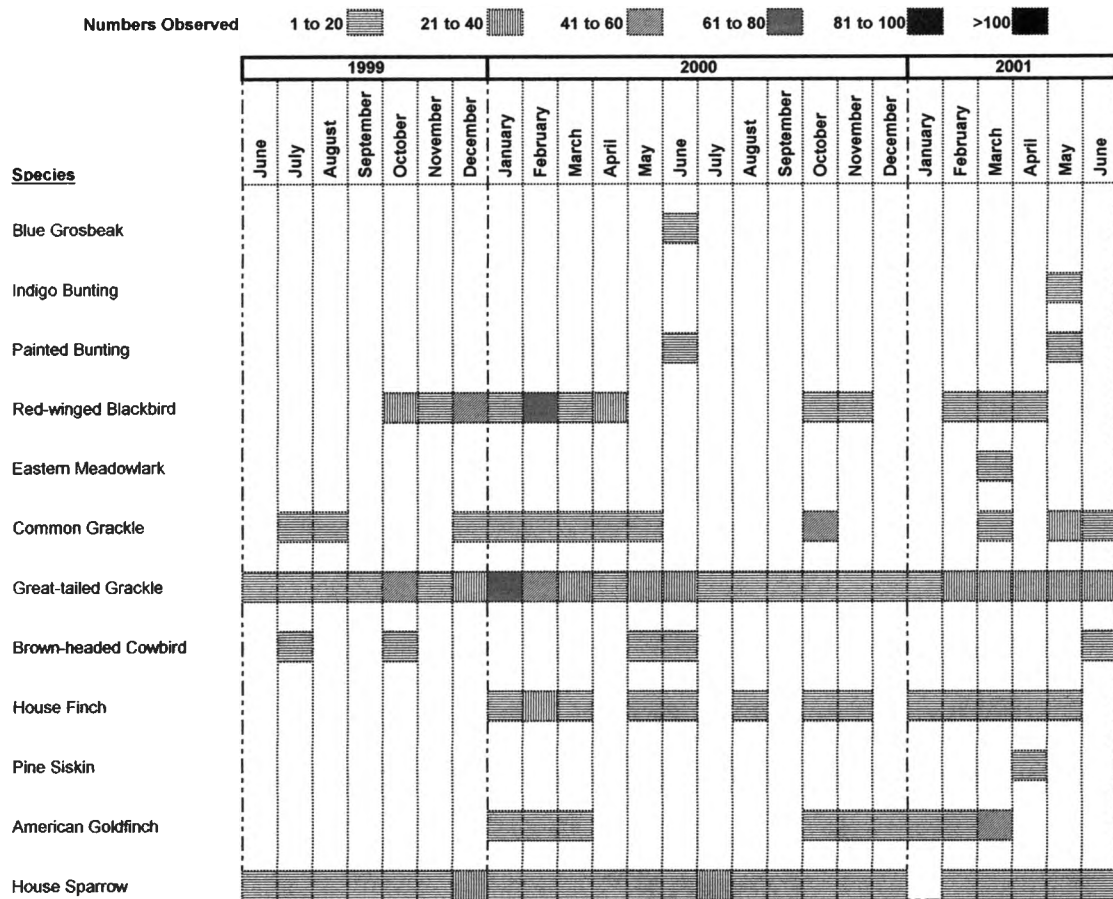
		Status	Station								
			#1	#2	#3	#4	#5	#6	#7	#8	
Hirundininae											
Purple Martin	<i>Progne subis</i>	SR*	X	X	X	X	X	X	X	X	
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	SR*					X				
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>	SR*	X	X	X				X	X	
Barn Swallow	<i>Hirundo rustica</i>	SR*	X	X	X	X	X	X	X	X	
Paridae											
Carolina Chickadee	<i>Poecile carolinensis</i>	AR	X	X	X	X	X	X	X	X	
Tufted Titmouse	<i>Baeolophus bicolor</i>	AR	X	X	X	X	X	X	X	X	
Troglodytidae											
Carolina Wren	<i>Thryothorus ludovicianus</i>	AR	X	X	X	X	X	X	X	X	
Bewick's Wren ^{1, 2}	<i>Thryomanes bewickii</i>	AR	X	X			X	X		X	
House Wren	<i>Troglodytes aedon</i>	WR	X					X			
Winter Wren**	<i>Troglodytes troglodytes</i>	WR									
Marsh Wren	<i>Cistothorus palustris</i>	WR		X							
Regulidae											
Ruby-crowned Kinglet	<i>Regulus calendula</i>	WR	X	X	X	X	X	X	X	X	
Sylviidae											
Poliophtilinae											
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>	AR				X		X			
Turdidae											
American Robin	<i>Turdus migratorius</i>	AR	X				X	X			
Mimidae											
Gray Catbird**	<i>Dumetella carolinensis</i>	M									
Northern Mockingbird	<i>Mimus polyglottos</i>	AR	X	X	X	X	X	X	X	X	
Sturnidae											
European Starling	<i>Sturnus vulgaris</i>	I	X	X	X	X	X	X	X	X	
Motacillidae											
American Pipet	<i>Anthus rubescens</i>	WR			X		X				
Bombycillidae											
Cedar Waxwing	<i>Bombycilla cedrorum</i>	WR	X	X	X		X	X		X	
Parulidae											
Orange-crowned Warbler	<i>Vermivora celata</i>	WR	X	X		X	X		X	X	
Nashville Warbler	<i>Vermivora ruficapilla</i>	M		X							
Northern Parula	<i>Parula americana</i>	SR*						X			
Yellow Warbler	<i>Dendroica petechia</i>	M	X	X		X	X		X	X	
Magnolia Warbler	<i>Dendroica magnolia</i>	M		X							
Yellow-rumped Warbler	<i>Dendroica coronata</i>	WR	X	X	X	X	X	X		X	
Black-and-white Warbler**	<i>Mniotilta varia</i>	M									
Prothonotary Warbler**	<i>Protonotaria citrea</i>	M									
Mourning Warbler**	<i>Oporornis philadelphia</i>	M									
Common Yellowthroat	<i>Geothlypis trichas</i>	WR		X		X	X				
Wilson's Warbler	<i>Wilsonia pusilla</i>	M					X				
Yellow-breasted Chat**	<i>Icteria virens</i>	SR*									
Thraupidae											
Summer Tanager	<i>Piranga rubra</i>	SR*		X	X		X	X		X	
Emberizidae											
Spotted Towhee	<i>Pipilo maculatus</i>	WR						X	X		
Clay-colored Sparrow	<i>Spizella pallida</i>	M			X						
Field Sparrow ¹	<i>Spizella pusilla</i>	M				X		X			
Song Sparrow	<i>Melospiza melodia</i>	WR		X				X		X	
Lincoln's Sparrow	<i>Melospiza lincolni</i>	WR		X		X	X	X		X	
White-throated Sparrow	<i>Zonotrichia albicollis</i>	WR						X			
White-crowned Sparrow**	<i>Zonotrichia leucophrys</i>	WR									
Cardinalidae											

		Station								
		Status	#1	#2	#3	#4	#5	#6	#7	#8
Northern Cardinal	<i>Cardinalis cardinalis</i>	AR	X	X	X	X	X	X	X	X
Blue Grosbeak	<i>Guiraca caerulea</i>	SR*								X
Indigo Bunting	<i>Passerina cyanea</i>	SR*						X		
Painted Bunting ^{1, 2}	<i>Passerina ciris</i>	SR*					X	X	X	
Icteridae										
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	AR	X	X	X	X	X			X
Eastern Meadowlark ¹	<i>Sturnella magna</i>	AR					X			
Common Grackle	<i>Quiscalus quiscula</i>	AR	X	X	X	X	X	X	X	X
Great-tailed Grackle	<i>Quiscalus mexicanus</i>	AR	X	X	X	X	X	X	X	X
Brown-headed Cowbird	<i>Molothrus ater</i>	AR	X		X	X		X		X
Baltimore Oriole**	<i>Icterus galbula</i>	M								
Fringillidae										
Carduelinae										
House Finch	<i>Carpodacus mexicanus</i>	AR	X	X	X	X	X	X	X	X
Pine Siskin	<i>Carduelis pinus</i>	WR					X	X		
American Goldfinch	<i>Carduelis tristis</i>	WR	X	X	X	X	X	X	X	X
Passeridae										
House Sparrow	<i>Passer domesticus</i>	I	X	X	X	X	X	X	X	X

APPENDIX III

SEASONAL DISTRIBUTION OF BIRDS DURING BASELINE SURVEY





APPENDIX IV

RELATIVE ABUNDANCE OF AVIAN SPECIES OBSERVED DURING

BASELINE SURVEY

Relative abundance of bird species (including one genus) observed in year one (species richness = 82) and year two (species richness = 95) of the study. The total number of individuals detected during the counts for each year is listed in parentheses.

(Year One = Summer 1999 through Spring 2000)

(Year Two = Summer 2000 through Spring 2001)

Species	Year			
	One		Two	
Pied-billed Grebe (<i>Podilymbus podiceps</i>)	0.0304	(177)	0.0320	(170)
Double-crested Cormorant (<i>Phalacrocorax auritus</i>)	0.0060	(35)	0.0083	(44)
American Bittern (<i>Botaurus lentiginosus</i>)	0.0000		0.0002	(1)
* Great Blue Heron (<i>Ardea herodias</i>)	0.0019	(11)	0.0039	(21)
Great Egret (<i>Ardea alba</i>)	0.0024	(14)	0.0013	(7)
Snowy Egret (<i>Egretta thula</i>)	0.0014	(8)	0.0002	(1)
Little Blue Heron (<i>Egretta caerulea</i>)	0.0000		0.0004	(2)
Tricolored Heron (<i>Egretta tricolor</i>)	0.0005	(3)	0.0000	
Green Heron (<i>Butorides virescens</i>)	0.0269	(157)	0.0243	(129)
Yellow-crowned Night-Heron (<i>Nyctanassa violacea</i>)	0.0003	(2)	0.0009	(5)
Black Vulture (<i>Coragyps atratus</i>)	0.0110	(64)	0.0079	(42)
Turkey Vulture (<i>Cathartes aura</i>)	0.0058	(34)	0.0073	(39)
Canada Goose (<i>Branta canadensis</i>)	0.0015	(9)	0.0000	
Mute Swan (<i>Cygnus olor</i>)	0.0027	(16)	0.0070	(37)
Wood Duck (<i>Aix sponsa</i>)	0.0019	(11)	0.0036	(19)
Gadwall (<i>Anas strepera</i>)	0.0827	(482)	0.0382	(203)
American Wigeon (<i>Anas americana</i>)	0.0852	(497)	0.0525	(279)
Mallard (<i>Anas platyrhynchos</i>)	0.0007	(4)	0.0000	
Domestic Duck (<i>Anas</i> sp.)	0.0075	(44)	0.0094	(50)
Blue-winged Teal (<i>Anas discors</i>)	0.0024	(14)	0.0030	(16)
Cinnamon Teal (<i>Anas cyanoptera</i>)	0.0002	(1)	0.0000	
Northern Shoveler (<i>Anas clypeata</i>)	0.0000		0.0004	(2)
Green-winged Teal (<i>Anas crecca</i>)	0.0000		0.0002	(1)

Species	Year			
	One		Two	
Canvasback (<i>Aythya valisineria</i>)	0.0002	(1)	0.0023	(12)
Redhead (<i>Aythya americana</i>)	0.0024	(14)	0.0000	
Ring-necked Duck (<i>Aythya collaris</i>)	0.1103	(643)	0.0344	(183)
Lesser Scaup (<i>Aythya affinis</i>)	0.0000		0.0009	(5)
Osprey (<i>Pandion haliaetus</i>)	0.0000		0.0008	(4)
Red-shouldered Hawk (<i>Buteo lineatus</i>)	0.0012	(7)	0.0013	(7)
American Coot (<i>Fulica americana</i>)	0.1341	(782)	0.1421	(756)
Killdeer (<i>Charadrius vociferus</i>)	0.0045	(26)	0.0058	(31)
Spotted Sandpiper (<i>Actitis macularia</i>)	0.0000		0.0008	(4)
Rock Dove (<i>Columba livia</i>)	0.0000		0.0041	(22)
White-winged Dove (<i>Zenaida asiatica</i>)	0.0214	(125)	0.0899	(478)
Mourning Dove (<i>Zenaida macroura</i>)	0.0370	(216)	0.0359	(191)
Inca Dove (<i>Columbina inca</i>)	0.0015	(9)	0.0008	(4)
Yellow-billed Cuckoo (<i>Coccyzus americanus</i>)	0.0009	(5)	0.0015	(8)
Greater Roadrunner (<i>Geococcyx californianus</i>)	0.0002	(1)	0.0000	
Great Horned Owl (<i>Bubo virginianus</i>)	0.0000		0.0002	(1)
Chimney Swift (<i>Chaetura pelagica</i>)	0.0022	(13)	0.0079	(42)
Hummingbird species	0.0012	(7)	0.0045	(24)
Belted Kingfisher (<i>Ceryle alcyon</i>)	0.0027	(16)	0.0024	(13)
Green Kingfisher (<i>Chloroceryle americana</i>)	0.0003	(2)	0.0002	(1)
Golden-fronted Woodpecker (<i>Melanerpes aurifrons</i>)	0.0024	(14)	0.0009	(5)
Red-bellied Woodpecker (<i>Melanerpes carolinus</i>)	0.0046	(27)	0.0030	(16)
Ladder-backed Woodpecker (<i>Picoides scalaris</i>)	0.0034	(20)	0.0030	(16)
Downy Woodpecker (<i>Picoides pubescens</i>)	0.0015	(9)	0.0015	(8)
Northern Flicker (<i>Colaptes auratus</i>)	0.0012	(7)	0.0004	(2)
Eastern Phoebe (<i>Sayornis phoebe</i>)	0.0027	(16)	0.0034	(18)
Great Crested Flycatcher (<i>Myiarchus crinitus</i>)	0.0002	(1)	0.0006	(3)
Western Kingbird (<i>Tyrannus verticalis</i>)	0.0021	(12)	0.0056	(30)
Eastern Kingbird (<i>Tyrannus tyrannus</i>)	0.0039	(23)	0.0045	(24)
Scissor-tailed Flycatcher (<i>Tyrannus forficatus</i>)	0.0021	(12)	0.0006	(3)
Loggerhead Shrike (<i>Lanius ludovicianus</i>)	0.0005	(3)	0.0019	(10)
White-eyed Vireo (<i>Vireo griseus</i>)	0.0051	(30)	0.0034	(18)
Red-eyed Vireo (<i>Vireo olivaceus</i>)	0.0002	(1)	0.0004	(2)
Blue Jay (<i>Cyanocitta cristata</i>)	0.0132	(77)	0.0073	(39)
American Crow (<i>Corvus brachyrhynchos</i>)	0.0000		0.0011	(6)
Purple Martin (<i>Progne subis</i>)	0.0377	(220)	0.0414	(220)
Northern Rough-winged Swallow (<i>Stelgidopteryx serripennis</i>)	0.0000		0.0103	(55)
Cliff Swallow (<i>Petrochelidon pyrrhonota</i>)	0.0034	(20)	0.0009	(5)
Barn Swallow (<i>Hirundo rustica</i>)	0.0072	(42)	0.0066	(35)
Carolina Chickadee (<i>Poecile carolinensis</i>)	0.0273	(159)	0.0102	(54)
Tufted Titmouse (<i>Baeolophus bicolor</i>)	0.0125	(73)	0.0070	(37)

Species	Year			
	One		Two	
Carolina Wren (<i>Thryothorus ludovicianus</i>)	0.0261	(152)	0.0203	(108)
Bewick's Wren (<i>Thryomanes bewickii</i>)	0.0058	(34)	0.0015	(8)
House Wren (<i>Troglodytes aedon</i>)	0.0002	(1)	0.0002	(1)
Marsh Wren (<i>Cistothorus palustris</i>)	0.0002	(1)	0.0002	(1)
Ruby-crowned Kinglet (<i>Regulus calendula</i>)	0.0017	(10)	0.0055	(29)
Blue-gray Gnatcatcher (<i>Poliophtila caerulea</i>)	0.0003	(2)	0.0017	(9)
American Robin (<i>Turdus migratorius</i>)	0.0002	(1)	0.0141	(75)
Northern Mockingbird (<i>Mimus polyglottos</i>)	0.0211	(123)	0.0274	(146)
European Starling (<i>Sturnus vulgaris</i>)	0.0057	(33)	0.0098	(52)
American Pipet (<i>Anthus rubescens</i>)	0.0000		0.0032	(17)
Cedar Waxwing (<i>Bombycilla cedrorum</i>)	0.0077	(45)	0.0976	(519)
Orange-crowned Warbler (<i>Vermivora celata</i>)	0.0007	(4)	0.0015	(8)
Nashville Warbler (<i>Vermivora ruficapilla</i>)	0.0000		0.0008	(4)
Northern Parula (<i>Parula americana</i>)	0.0000		0.0002	(1)
Yellow Warbler (<i>Dendroica petechia</i>)	0.0017	(10)	0.0008	(4)
Magnolia Warbler (<i>Dendroica magnolia</i>)	0.0002	(1)	0.0000	
Yellow-rumped Warbler (<i>Dendroica coronata</i>)	0.0077	(45)	0.0053	(28)
Common Yellowthroat (<i>Geothlypis trichas</i>)	0.0007	(4)	0.0009	(5)
Wilson's Warbler (<i>Wilsonia pusilla</i>)	0.0002	(1)	0.0000	
Summer Tanager (<i>Piranga rubra</i>)	0.0010	(6)	0.0009	(5)
Spotted Towhee (<i>Pipilo maculatus</i>)	0.0000		0.0006	(3)
Clay-colored Sparrow (<i>Spizella pallida</i>)	0.0005	(3)	0.0000	
Field Sparrow (<i>Spizella pusilla</i>)	0.0000		0.0002	(1)
Song Sparrow (<i>Melospiza melodia</i>)	0.0000		0.0006	(3)
Lincoln's Sparrow (<i>Melospiza lincolnii</i>)	0.0009	(5)	0.0006	(3)
White-throated Sparrow (<i>Zonotrichia albicollis</i>)	0.0000		0.0006	(3)
Northern Cardinal (<i>Cardinalis cardinalis</i>)	0.0228	(133)	0.0156	(83)
Blue Grosbeak (<i>Guiraca caerulea</i>)	0.0000		0.0002	(1)
Indigo Bunting (<i>Passerina cyanea</i>)	0.0000		0.0006	(3)
Painted Bunting (<i>Passerina ciris</i>)	0.0002	(1)	0.0011	(6)
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	0.0310	(181)	0.0083	(44)
Eastern Meadowlark (<i>Sturnella magna</i>)	0.0000		0.0002	(1)
Common Grackle (<i>Quiscalus quiscula</i>)	0.0118	(69)	0.0171	(91)
Great-tailed Grackle (<i>Quiscalus mexicanus</i>)	0.0866	(505)	0.0624	(332)
Brown-headed Cowbird (<i>Molothrus ater</i>)	0.0022	(13)	0.0004	(2)
House Finch (<i>Carpodacus mexicanus</i>)	0.0089	(52)	0.0039	(21)
Pine Siskin (<i>Carduelis pinus</i>)	0.0000		0.0008	(4)
American Goldfinch (<i>Carduelis tristis</i>)	0.0058	(34)	0.0165	(88)
House Sparrow (<i>Passer domesticus</i>)	0.0249	(145)	0.0282	(150)
Total	1.0000	5830	1.0000	5319

	Spring	Summer	Fall	Winter
Paridae				
Carolina Chickadee (AR)	C	C	C	C
Tufted Titmouse (AR)	C	C	C	C
Troglodytidae				
Carolina Wren (AR)	A	A	A	A
Bewick's Wren (AR)	C	C	C	C
House Wren (WR)	R	R	U	
Winter Wren (WR)	R	R	U	
Marsh Wren (WR)	R	R	U	
Regulidae				
Ruby-crowned Kinglet (WR)	U	U	C	
Sylviidae				
Blue-gray Gnatcatcher (AR)	U	U	U	R
Turdidae				
Eastern Bluebird (AR)	U	U	U	U
American Robin (AR)	R	R	R	U
Mimidae				
Gray Catbird (M)	U	U		
Northern Mockingbird (AR)	A	A	A	A
Sturnidae				
European Starling (AR)	A	A	A	A
Motacillidae				
American Pipit (WR)	U	R	R	
Bombycillidae				
Cedar Waxwing (WR)	U	R	U	
Parulidae				
Orange-crowned Warbler (WR)	U	U	U	
Nashville Warbler (M)	U	U		
Northern Parula (SR)	U	U	U	
Yellow Warbler (M)	U	U		
Magnolia Warbler (M)	U	U		
Yellow-rumped Warbler (WR)	U	U	C	
Black-and-white Warbler (M)	R	R		
Prothonotary Warbler (M)	R	R		
Mourning Warbler (M)	R	R		
Common Yellowthroat (WR)	U	U	U	
Wilson's Warbler (M)	U	U		
Yellow-breasted Chat (SR)	U	U	U	

Contributors:

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	Spring	Summer	Fall	Winter
Thraupidae				
Summer Tanager (SR)	U	C	U	
Emberizidae				
Spotted Towhee (WR)	U	R	U	
Chipping Sparrow (WR)	R	R	R	U
Clay-colored Sparrow (M)	R	R	R	
Field Sparrow (WR)	R	R	R	U
Song Sparrow (WR)	R	R	R	U
Lincoln's Sparrow (WR)	U	R	U	
White-throated Sparrow (WR)	U	U	U	
White-crowned Sparrow (WR)	U	U	U	
Dark-eyed Junco (WR)	R	R	R	
Cardinalidae				
Northern Cardinal (AR)	A	A	A	A
Blue Grosbeak (SR)	U	R	R	
Indigo Bunting (SR)	U	R	R	
Painted Bunting (SR)	U	C	R	
Icteridae				
Red-winged Blackbird (AR)	C	C	A	A
Eastern Meadowlark (AR)	U	U	U	U
Common Grackle (AR)	C	C	C	C
Great-tailed Grackle (AR)	A	A	A	A
Brown-headed Cowbird (AR)	U	U	U	U
Baltimore Oriole (M)	R	R	U	
Fringillidae				
House Finch (AR)	C	C	C	C
Pine Siskin (WR)	U	R	U	
American Goldfinch (WR)	U	U	C	
Passeridae				
House Sparrow (I)	A	A	A	A

For new bird species
please Contact Marsha May Reimer at
<marsha_reimer@tpwd.state.tx.us>
or at (512) 282-6714

Bird Reports:

San Marcos Area - (512) 396-BIRD (2473)

Austin Area - (512) 926-8751

Statewide - (713) 369-9673

Report an injured bird: (512) 472-WILD (9453)

Bird Web Sites:

<http://www.centuryinter.net/birding>

<http://tqjunior.advanced.org/6235/>

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Birds of The San Marcos Springs and Surrounding Vicinity

Southwest Texas State
University
Aquarena Center
San Marcos, TX 78666

Compiled by:
Marsha May Reimer

June 2001

CHECKLIST OF BIRDS – SAN MARCOS SPRINGS AND VICINITY

APPENDIX V

Bird Checklist

Date: _____

Time of Day: _____

Weather Conditions: _____

A = Abundant (very likely seen)
C = Common (likely to be seen)
U = Uncommon (sometimes seen)
R = Rare (rarely seen)

(AR) = Annual Resident (year-round)
(SR) = Summer Resident (late spring through early fall)
(WR) = Winter Resident (late fall through early spring)
(M) = Migrant (spring or fall)
(I) = Introduced

	Spring	Summer	Fall	Winter
Podicipedidae				
Pied-billed Grebe (WR)	A	U	C	A
Least Grebe (WR)	R	R	U	U
Phalacrocoracidae				
Neotropic Cormorant (SR)	U	U	R	R
Double-crested Cormorant (WR)	A	U	C	A
Ardidae				
American Bittern (M)			R	
Great Blue Heron (AR)	A	C	A	A
Great Egret (AR)	U	U	U	U
Snowy Egret (SR)	R	U	R	
Little Blue Heron (SR)	R	U	R	
Tricolored Heron (M)	R	U	C	
Green Heron (SR)	C	A	C	R
Yellow-crowned Night-Heron (SR)	U	U	U	
Cathartidae				
Black Vulture (AR)	A	A	A	A
Turkey Vulture (AR)	A	A	A	A

	Spring	Summer	Fall	Winter
Anatidae				
Canada Goose *				
Black-bellied Whistling-Duck (AR)	U	U	U	R
Mute Swan (I)	A	A	A	A
Wood Duck (AR)	C	C	C	C
Gadwall (WR)	C	C	A	
American Wigeon (WR)	C	C	A	
Mallard (WR)	U	U	U	C
Domestic Duck (I)	C	C	C	C
Blue-winged Teal (WR)	C	C	U	
Cinnamon Teal (WR)	R	R	U	
Northern Shoveler (WR)	R	R	U	
Northern Pintail (WR)	R	R	U	
Green-winged Teal (WR)	U	U	U	
Canvasback (WR)	R	R	U	
Redhead (WR)	U	U	C	
Ring-necked Duck (WR)	C	C	A	
Greater Scaup (WR)	R	R	R	
Lesser Scaup (WR)	C	C	A	
Accipitridae				
Osprey (WR)	U	U	U	
Mississippi Kite (M)	U	R	U	
Northern Harrier (WR)	R	R	U	
Red-shouldered Hawk (AR)	C	C	C	
Swainson's Hawk (M)	C	R	C	
Red-tailed Hawk (AR)	C	U	C	C
Falconidae				
Crested Caracara (AR)	R	R	R	R
American Kestrel (WR)	U	U	U	
Rallidae				
Sora (WR)	R	R	R	
American Coot (AR)	A	C	A	A
Gruidae				
Sandhill Crane (M)	U	U	U	
Charadriidae				
Killdeer (AR)	C	C	C	C
Scolopacidae				
Greater Yellowlegs (WR)	U	R	U	U
Spotted Sandpiper (M)	U	U	U	U
Least Sandpiper (WR)	U	R	U	U
Pectoral Sandpiper (M)	U	R	U	R
Common Snipe (WR)	U	U	U	
Laridae				
Ring-billed Gull (WR)	U	R	U	U

*Observed from June 1999 to February 2000

	Spring	Summer	Fall	Winter
Columbidae				
Rock Dove (AR)	C	C	C	C
White-winged Dove (AR)	C	C	C	C
Mourning Dove (AR)	A	A	A	A
Inca Dove (AR)	C	C	C	C
Cuculidae				
Yellow-billed Cuckoo (SR)	U	C	R	
Greater Roadrunner (AR)	U	U	U	U
Strigidae				
Great Horned Owl (AR)	U	U	U	U
Caprimulgidae				
Common Nighthawk (SR)	U	C	U	R
Apodidae				
Chimney Swift (SR)	U	U	R	
Trochilidae				
Ruby-throated Hummingbird (SR)	U	U	U	
Black-chinned Hummingbird (SR)	C	C	U	
Alcedinidae				
Ringed Kingfisher			R	
Belted Kingfisher (AR)	C	C	C	C
Green Kingfisher (AR)	U	U	U	U
Picidae				
Golden-fronted Woodpecker (AR)	U	U	U	U
Red-bellied Woodpecker (AR)	C	C	C	C
Ladder-backed Woodpecker (AR)	C	C	C	C
Downy Woodpecker (AR)	U	U	U	U
Northern Flicker (WR)	R		C	C
Tyrannidae				
Eastern Phoebe (AR)	C	R	C	C
Great Crested Flycatcher (SR)	R	U	R	
Western Kingbird (SR)	U	C	U	
Eastern Kingbird (SR)	C	C	C	
Scissor-tailed Flycatcher (SR)	C	C	C	R
Laniidae				
Loggerhead Shrike (AR)	U	R	U	U
Vireonidae				
White-eyed Vireo (SR)	C	C	R	
Red-eyed Vireo (SR)	U	U	R	
Corvidae				
Blue Jay (AR)	A	A	A	A
American Crow (AR)	U	U	U	U
Hirundinidae				
Purple Martin (SR)	C	A	U	R
Northern Rough-winged Swallow (SR)	U	U	U	R
Cliff Swallow (SR)	R	C	R	R
Barn Swallow (SR)	C	A	U	R

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VITA

Marsha May Reimer was born in Chicago, Illinois, as Marsha Elizabeth May, on August 12, 1952, the daughter of Clifton Thomas May and Mildred Elizabeth Hansen. She received her Associate of Applied Science degree in Animal Health from Parkland Community College, Champaign, Illinois, in May 1980. She moved to Austin, Texas, in 1981, where she worked for 8 years as a veterinary technician for the Austin Area Animal Emergency Clinic, Austin, Texas. She continues to hold a certification as a Registered Veterinary Technician for the State of Texas since 1981. She accepted a position at Austin Community College, Austin, Texas, in 1989 as the Head Biology Laboratory Assistant at the Northridge Campus, where she was employed full-time until August 1996. She received her Associate of Science degree in Mathematics from Austin Community College in May 1996. She accepted a seasonal position as a Life Scientist III for Colorado State University, Center for Ecological Management of Military Lands, Fort Collins, Colorado, as a crew leader for the Land Condition Trend Analysis Program at Fort Huachuca, Sierra Vista, Arizona, from August 1996 through November 1996. She attended Texas A&M University from January 1997 to August 1998, where she received her Bachelor of Science degree in Wildlife Science. She entered the Aquatic Biology graduate program at SWT in September 1998. During her graduate years, she worked as an instructional assistant for Ornithology, Botany, and Biology labs. She presented a poster of preliminary results of her research at the Waterbird Society Meeting held in Plymouth, Massachusetts, in 2000. She presented preliminary results of her research at the 104th Annual Meeting of the Texas Academy of Science held in San Marcos, Texas, in 2001 and at the Southwestern Association of Naturalists 48th Annual Meeting held in Hays, Kansas, in 2001. She co-authored two publications, *Birder's Directory of Texas: Birding Clubs, Licensed Bird Banders, & Reporting Bird Sightings*, 2nd and 3rd editions, with Cliff Shackelford and Shelly Scroggs for Partners in Flight and the Texas Parks and Wildlife Department (TPWD). She coordinates bird counts for SELAH, Bamberger Ranch, Johnson City, Texas, three times a year since the winter of 2001. She conducted Black-capped Vireo surveys for SELAH and City of Austin, Parks and Recreation Department, Texas, in the summer 2000. She currently is full-time employed as an

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