EFFECTS OF RECREATIONAL ACTIVITY ON THE AVIAN COMMUNITY OF GREEN SPACES WITHIN SUNSET VALLEY, TEXAS

THESIS

Presented to the Graduate Council of
Texas State University–San Marcos
in Partial Fulfillment of
the Requirements

for the Degree

Master of SCIENCE

by

Mary N. Tibbets, M.S.

San Marcos, Texas
December 2009

ACKNOWLEDGEMENTS

I would like to thank Dr. Thomas R. Simpson for his guidance and assistance on this project and for initially giving me the opportunity to conduct this study. I would also like to thank Dr. Timothy H. Bonner for his guidance and seemingly endless supply of patience regarding the statistics for this research. I would also like to thank Dr. M. Clay Green for his support and input on this project. I would never have been able to complete this study without the intellectual and emotional support of the other graduate students in my department. There are too many to name here, but I would especially like to thank Amber Jonker, Leska Sieber, Melissa Duran, and Patti Vallela.

This project would not have been possible without the support and participation of the City of Sunset Valley, Texas. I would especially like to thank Carolyn Meredith for her assistance in getting the project off the ground.

Finally, none of this would have been possible without the support and guidance of my family. I would like to thank my mom and dad, Marcia and Michael Tibbets, for supporting me throughout my entire academic career and offering their love and encouragement through the good times and the bad. I would also like to thank Peter McKeigue for so selflessly offering me his support, love, and patience throughout the course of this study.

TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ABSTRACT

EFFECTS OF RECREATIONAL ACTIVITY ON THE AVIAN COMMUNITY

OF GREEN SPACES WITHIN SUNSET VALLEY, TEXAS

by

Mary N. Tibbets, B.S.

Texas State University–San Marcos

December 2009

SUPERVISING PROFESSOR: THOMAS R. SIMPSON

The spread of urban and suburban habitats into what were once rural and undeveloped lands has left urban green spaces as refuges for wildlife populations in otherwise inhospitable environments. As human populations grow, so does the use of these green spaces for recreational activities. This study examined the effects of human recreational activities within green spaces on bird populations in Sunset Valley, Texas, an urban/suburban habitat southwest of Austin, Texas. Thirty fixed-radius point count stations were placed on walking trails throughout the city. Each point was visited five times during each of four seasons. I recorded birds seen or heard at each point count station, their distance from the center of the point, the number of recreationists passing through the point count site, and decibel levels at the point for a five minute duration.

Vegetation information was taken at each point before and after leaf drop using a vegetation profile board and a densiometer. I used a principal component analysis (PCA) to describe habitat characteristics at each site and a canonical correspondence analysis (CCA) to assess relationships between bird species, habitat, season, area of the study site, and recreational activities. I also conducted univariate tests to determine the relationship between urban bird guilds and different habitat and anthropogenic variables. The full model of the CCA explained 44.7% of the observed variation within bird abundances with the pure effects of habitat explaining 26.1 percent of the variation ($p = 0.002$) and season explaining 2.4 percent ($p = 0.002$) of the variation. Pure effects of area (0.9%; $p = 0.18$) and anthropogenic disturbances (4.9%; $p = 0.11$) were not significant. Univariate parameters significant in the stepwise procedure were mean canopy cover (17%; $p = 0.002$), mean vertical vegetation cover (6%; $p = 0.002$), area (5%; $p = 0.002$), high decibel level (5%; $p = 0.002$), and percent Ashe juniper cover (2%; $p = 0.05$). My results indicate that vegetational characteristics are the main factor influencing bird populations in urban/suburban habitats, followed by the mean maximum decibel level at each point. My results also suggest that bird species that are already stressed under urban/suburban environments may be excluded from areas where decibel levels are too high.

CHAPTER 1

INTRODUCTION

Expansion of urban and suburban centers across the United States and its impact on wildlife habitats and ecosystems is a growing concern for biologists and conservationists. Urban and suburban sprawl is replacing rural and natural landscapes (Reale and Blaire 2005). Such development leads to habitat fragmentation, leaving scattered parks and urban "green spaces" as the last remnants of natural habitat for wildlife. Urbanization has led to an increasing network of roadways (National Research Council 1997) that exacerbates the problems of habitat fragmentation and anthropogenic disturbance. Of particular concern are many songbird populations which are declining nationwide (Ambuel and Temple 1982, Wilcove 1985). With increasing numbers of people participating in outdoor recreational activities (USDA 2008), impact of recreational activities on bird populations and other wildlife is a growing concern. When green spaces in urban environments are of a sufficient size and quality, some birds find them to be suitable habitat where otherwise they would find none (Park and Lee 2000, Mortberg and Wallentinus 2000). However, such green spaces also attract human recreationists, presenting a potential conflict of interests for managers (Taylor and Knight 2003). In these cases, park and green space managers must reconcile the needs of wildlife with the needs of recreationists. Habitat structure is a primary factor affecting bird diversity (Emlen 1974, Mills et al. 1989). Anthropogenic disturbances have also been implicated (Beale and Monaghan 2004) with some avian species exhibiting avoidance behaviors in areas where non-consumptive human activities occur (Miller et al. 1998). Furthermore, non-consumptive anthropogenic disturbance affects reproductive success (Giese 1996, Miller et al. 1998), nest predation rates (Miller et al. 1998), foraging time, and capture success rates (Burger and Gochfiel 1998, Leseberg et al. 2000). Even when behavioral effects of human disturbance are not readily observed, unseen physiological impacts may affect a species' fitness (Beale and Monaghan 2004). Beale and Monaghan (2004) indicated that the number of humans present and their distance from birds in an area affect the level of impact seen within bird communities, with larger groups of people at a closer distance causing more impact than smaller groups of people at a greater distance. Miller et al. (1998) observed that bird community composition along recreational trails in Boulder County, Colorado, was significantly affected in both woodland and grassland ecosystems by human recreational activities. Manner of approach towards birds may also determine level of impact. Fernandez-Juricic et al. (2005) showed a greater impact when some Argentine species of grassland birds are approached tangentially rather than directly.

Research examining impact of different recreational activities on wildlife populations is scarce. Taylor and Knight (2003) found no significant difference in effect on wild ungulate populations due to hiking and mountain biking. However, the impact of human recreational activity on bird diversity seems to be amplified by the presence of dogs in park settings (Banks and Bryant 2007) and when humans stray off recreation trails (Taylor and Knight 2003).

Research on the effects of anthropogenic noise on songbird behavior is more abundant. Intraspecific communication in songbirds is largely dependent on vocal communication (Slabbekoorn and Ripmeester 2008). Success of these vocal communications is greatly influenced by the signal-to-noise ratio (SNR) and the detection threshold of the receiver (Patricelli and Blickley 2006). If the SNR falls below the receiver's detection threshold, the communication attempt fails. One possible response to elevated ambient noise levels is the Lombard effect (Lombard 1911) in which the sender of the signal increases the amplitude of the signal so that it falls above the detection threshold of the receiver. Brumm and Todt (2002) found that male nightingales can control the amplitude of their songs based on the level of ambient noise. However, such an increase in amplitude is not without costs, with one study showing that a 16-dB increase in starling (*Sturnus vulgaris*) song caused a 16 percent increase in the rate of oxygen consumption (Oberweger and Goller 2001). Brumm (2004) found that in an environment with ambient noise levels ranging from 40 to 60 dB, nightingales (*Luscinia megarhynchos*) increased the amplitude of their song from 77 dB(A) to 91 dB(A) depending on the level of ambient noise. A major cause of increasing ambient noise levels in many habitats is an increase in automobile traffic on nearby roadways (Forman and Alexander 1998, Forman et al. 2002, Brumm 2004, Patricelli and Blickley 2006, Slabbekoorn and Ripmeester 2008). Slabbekoorn and Ripmeester (2008) suggest that even with all other necessary habitat requirements met for a given species, an increased ambient noise level may results in habitat being unsuitable.

The objective of this study is to evaluate the influence of human recreational activities, high decibel levels, vegetation characteristics, area, and season upon avian community and population parameters within the green space of Sunset Valley, Texas. The results of this study will describe the available habitat in Sunset Valley green space, describe the abundance of different bird species and urban bird guilds, and will assess the association between urban bird guilds and habitat and season. The results will also assess the significant of human recreational activity and anthropogenic noise levels on guild abundances. The information this study provides will not only grant a better understanding of the use of green space in Sunset Valley by different urban bird guilds, but will also provide information to improve guidelines for future green space development.

CHAPTER 2

METHODS

Study Site – Sunset Valley, Travis County, Texas (30°13′ N, 97°48′ W), is situated at the boundary between the Edwards Plateau and the Blackland Prairie ecological regions of Texas (Texas Parks and Wildlife Department 2008). The city is a suburb approximately 8 km southwest of the center of Austin, Texas. Sunset Valley city limits enclose 3.6 km^2, of which 0.8 km^2 is designated green space. The remaining area is composed of single family housing, multi-family housing, commercial areas, and government buildings. Incorporated as a city in 1954, Sunset Valley was initially a residential area. Since then commercial development has increased, allowing the construction of a sixty-acre shopping complex in 1990. Sunset Valley has since been surrounded by Austin along all sides.

Green spaces in Sunset Valley support a variety of habitat types. The majority of green space is dominated by juniper-elm (*Juniperus ashei-Ulmus crassifolia)* woodlands. Other areas are composed of woodlands dominated by hackberry (*Celtis laevigata*), or mesquite (*Prosopis glandulosa*) and a few grassland habitats. An intermittent stream in the northernmost area connects Sunset Valley green spaces with Austin's Barton Creek greenbelt. Paved and unpaved recreational trails pass through the green space, with paved trails closest to the commercial and residential areas. Unpaved trails are more abundant and are found in more remote areas of green space throughout the city.

Sampling Methodology – I conducted fixed radius point counts (Hutto et al. 1986) of birds during four seasons from June 2008 to March 2009. For the purposes of this study, autumn was defined as September to November, winter from December to February, spring from March to May, and summer from June to August. Thirty randomly placed points were established on recreational trails within the city limits (Figure 1). At each point, I surveyed birds within a 75 m radius. Points were spaced at a minimum of 150 m apart. Point counts lasted for five minutes each with a one minute settling period prior to starting. I conducted point counts from dawn until five hours after dawn. Birds were identified by sight or sound and the distance to each individual was recorded using either range finding binoculars or by estimating the distance to the identifying sound (Ransom and Pinchak 2003). Flyovers were not counted unless the bird was determined to be actively using the area. In the case of such flyovers, distance was recorded to the position where the bird was first spotted or heard. Each point was visited five times per season.

I divided the points into three groups (Area 1 = 20 points, Area 2 = 4 points, Area 3 = 6 points) based on existing divisions within the study area to account for possible area effect. This controls for the influence of any variables unique to an area that are not already specifically described by the study.

I recorded decibel levels for the duration of each point count using a sound level meter (Extech, Waltham, MA) calibrated in accordance with American National Standards Institute (ANSI) and International Electronics Commission (IEC) Type II standards. Highest and lowest decibel levels were recorded at each site. Human activity (number of humans, type of activity (i.e., walking, jogging), and the presence of dogs on

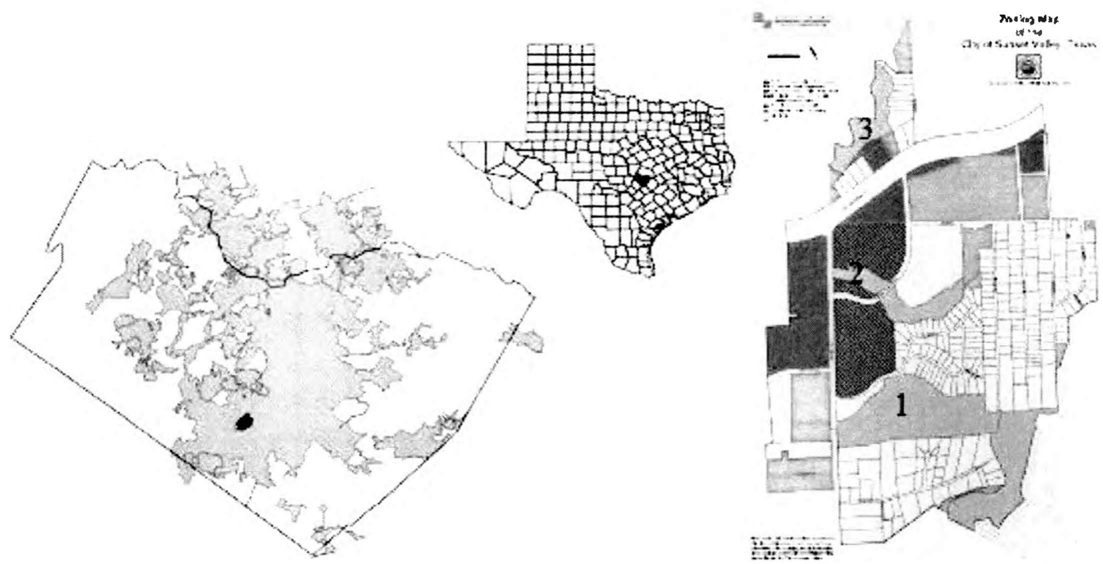

Figure 1. Location map of Sunset Valley, Texas with green space indicated.

or off-leash) passing through each point count site were also recorded. I also recorded vegetation data before and after leaf drop in August 2008 and December 2009. At each point I positioned two 50 m line intercepts perpendicular to green space trails. Along each transect, I recorded percent cover of woody species. At 25 m and 50 m, I recorded vertical vegetative cover with a vegetation profile board (VPB) (Nudds 1977), and canopy cover over two meters with a densiometer (Geographic Resource Solutions, Arcata, CA).

Statistical Methodology – I z-scored and analyzed the habitat information and human recreational activity data by site (Krebs 1999) using a principal components analysis (PCA; Canoco 4.5) to describe the habitat at each site. Vegetation profile board scores were averaged per board and then averaged again per point per season to obtain a single representative number. Densiometer scores were similarly averaged by point for each season. The PCA loadings were plotted to show habitat and human recreational activities characteristic of each site.

Using available life history information (Cornell Lab of Ornithology 2009, Peterson 2002, Sibley 2000), I divided observed bird species into three guilds based on their relationship to anthropogenic disturbance (Table 1). Guild divisions were based on the guidelines provided by Johnston (2001), but guild names were changed to better reflect their response to urban and suburban development (Hunter 2002). Those bird species Johnston (2001) labeled "full synanthropes" I classified as "urban adapted". Similarly, Johnston's term of "casual synanthropes" was replaced with Hunter's term "urban tolerant", and Johnston's "tangential synanthropes" are called "urban intolerant". I calculated the raw abundance for each of these guilds for each of the three areas in the study site and Renkonen indices (Krebs 1999) were used to assess similarities. Diversity and evenness were calculated for each area for the entire year using the Shannon-Weiner Index and the Smith and Wilson's index, respectively.

I used a canonical correspondence analysis (CCA; Canoco 4.5) to assess relationships between bird species, habitat, season, area, and recreational activities. I also conducted variance partitioning (Borcard et al. 1992), running a series of partial CCA's for each of the variables of interest and using the remaining three variables as covariates. Monte Carlo tests (499 permutations) were used to determine the significance ($\alpha = 0.05$) of each variable.

I also used univariate analyses to further explore the relationships between the abundance of the three urban bird guilds and variables of interest. Regression analyses (R version 2.7.2) were conducted for each urban guild to examine their relationship with high decibel levels, mean VPB reading, mean densiometer reading, percent Ashe juniper cover, and mean number of walkers. All simple linear regressions suffered from violations of the assumptions of homoscedasticity and linearity. The data were log transformed, but the violations were never truly rectified. I conducted analysis of variance (ANOVA; R version 2.7.2) to determine significant variation in bird abundances between seasons and between the three different areas of the study site.

Table 1. Total bird species abundances by area from June 2008 to March 2009.

Species	Area 1	Area 2	Area 3
Urban Adapted Species			
Barn Swallow	116	31	0
Common Grackle	176	7	3
European Starling	12	1	0
Great-tailed Grackle	226	12	9
House Finch	103	9	31
House Sparrow	16	1	1
Ladderback Woodpecker	10	2	4
Rock Dove	1	0	0
White-eyed Vireo	81	5	69
Urban Tolerant Species			
American Crow	7	1	0
American Goldfinch	4	0	8
American Robin	2	0	0
Bewick's Wren	11	1	2
Black Vulture	6	3	0
Blue Jay	250	63	32
Cedar Waxwing	2	3	0
Carolina Chickadee	44	20	26
Carolina Wren	0	0	16
Common Nighthawk	2	1	1
Eastern Phoebe	2	4	2
Killdeer	5	0	2
Mourning Dove	30	2	6
Northern Cardinal	276	51	92
Northern Flicker	0	1	0
Northern Mockingbird	188	47	13
Purple Martin	3	0	0
Red-tailed Hawk	6	3	0
Red-shouldered Hawk	5	2	0
Ruby-crowned Kinglet	43	1	4
Scissor-tailed Flycatcher	11	1	0
Tufted Titmouse	24	11	29
Turkey Vulture	1	0	0
Western Kingbird	20	9	1
White-winged Dove	91	14	8
Urban Intolerant Species			
Black and White Warbler	0	1	1
Canyon Wren	0	0	18
Golden-fronted Woodpecker	4	0	2
Nashville Warbler	12	5	6
Yellow-crowned Kinglet	0	0	2
Yellow-rumped Warbler	12	1	0
Unknown Species			
Unknown Bird	10	2	0
Unknown Sparrow	8	1	0
Unknown Hummingbird	4	0	2
Total N	1952	346	426

CHAPTER 3

RESULTS

Ashe juniper was the most prevalent woody species in Area 1 (27% ± 26) and Area 2 (85% ±18) (Table 2). Cedar elm was also prevalent in Area 1 (24% ±24) and Area 3 (41% ±35). Area 2 was dominated by cedar elm (35% ±40), live oak (24% ±22) and Ashe juniper (23% ±26). Area 3 had the highest mean vertical cover indicated by VPB readings (1.79 ±0.51), closely followed by Area 1 (1.70 ±0.65). Area 2 had less vertical vegetative cover (1.51 ±0.30). Area 3 had the highest level of canopy cover (1.0 ±0.00), followed by Area 2 (0.75 ±0.32) and Area 3 (0.56 ±0.35). The highest mean decibel level was in Area 2 (60.39 ±4.41) (Table 3), followed closely by Area 1 (60.07 ±6.67). Area 3 had the lowest mean decibel level (56.87 ±2.67). Area 2 was the least heavily trafficked by recreationists with only one biker, two walkers and one dog on-leash recorded throughout the duration of the study for a mean 0.5 recreationists recorded per point. Area 3 was the most heavily trafficked area with a total of 58 recreationists recorded throughout the duration of the study for a mean 2.4 recreationists recorded per point. Bikers were the most abundant type of recreationists (64%), followed by walkers (18%). Area 1 had the highest number of recreationalists recorded with a total of 162 throughout the duration of the study for a mean 2 recreationalists per point. Walkers were the most abundant type of recreationalists (49%), followed by dogs off-leash (20%).

Table 2. Mean vegetation parameters across areas ± standard deviation. Plant cover by species reported in percent.

Variable	Area 1	Area 2	Area 3
VPB AVG	1.70 (±0.65)	1.51 (±0.30)	1.79 (±0.51)
Dens Avg	0.56 (±0.35)	0.75 (±0.32)	1.00 (±0.00)
A. gregii	0.01 (±0.01)	--	--
B. trifoliate	< 0.01	<0.01	< 0.01
C. hookeri	< 0.01	--	0.02 (±0.02)
C. illinoensis	--	--	0.01 (±0.03)
C. laevigata	0.05 (±0.13)	--	--
C. reticulata	0.01 (±0.02)	--	--
Diospyros texanum	0.02 (±0.03)	--	--
E. anacua	< 0.01	<0.01	0.01 (±0.01)
F. pubescens	< 0.01	0.03 (±0.06)	< 0.01
F. texensis	0.01 (±0.03)	--	--
I. vomitoria	--	--	0.01 (±0.01)
J. ashei	0.27 (±0.26)	0.23 (±0.26)	0.85 (±0.18)
J. microcarpa	< 0.01	0.02 (±0.04)	--
L. frutescens	< 0.01	--	--
L. ligustrum	< 0.01	--	< 0.01
M. azedarach	0.01 (±0.02)	0.01 (±0.01)	--
N. domestica	--	0.01 (±0.01)	< 0.01
O. leptocaulis	< 0.01	--	< 0.01
P. aculeate	< 0.01	--	--
P. glandulosa	0.05 (±0.08)	0.01 (±0.02)	--
Q. fusiformis	0.08 (±0.14)	0.24 (±0.22)	--
Q. laceyi	< 0.01	--	0.01 (±0.01)
Q. marilandica	< 0.01	--	--
Q. muhlenbergii	< 0.01	--	0.02 (±0.04)
Q. stellata	< 0.01	--	--
Q. texanum	< 0.01	--	0.02 (±0.02)
U. americana	--	--	0.01 (±0.02)
U. crassifolia	0.24 (±0.24)	0.35 (±0.40)	0.41 (±0.35)

Table 3. Anthropogenic disturbance recorded in each area. Occurrence of recreational activities recorded for each area with total N of recreationists. Mean recreationists observed per point for each area. Mean high decibel level ± standard deviation.

Variable	Area 1	Area 2	Area 3
Walkers	80	2	11
Joggers	18	0	3
Bikers	12	1	37
Dogs On-Leash	19	1	2
Dogs Off-Leash	33	0	5
Total N	162	4	58
Mean Walkers	1	0.24	0.46
Mean Joggers	0.23	0	0.13
Mean Bikers	0.15	0.12	1.54
Mean Dogs On-Leash	0.24	0.12	0.08
Mean Dogs Off-Leash	0.41	0	0.21
Mean High Decibels	60.07 ±6.67	60.39 ±4.41	56.87 ±2.67

Principal Component Analysis – Principal component axes I and II explained 21.3 percent of the variation in habitat and human recreational activity data at the 30 points over a year. Axis I explained 12.4 percent of the variation and described a species composition and anthropogenic disturbance gradient. Strongest positive loadings for PCA I were percent Ashe juniper cover (0.8083), mean densiometer reading (0.6824), and percent yaupon holly (*Ilex vomitoria*) cover (0.6025). Strongest negative loadings were high decibel levels (-0.5289), mean number of dogs on leash (-0.4495), and percent cover of Texas ash (*Fraxinus texensis*) (-0.4443). Axis II explained 8.9 percent of the variation and described a species composition gradient. Strongest positive loadings for PCA II were percent cover of purple sage (*Leucophyllum frutescens*) (0.5576), percent cover of post oak (*Quercus stellata*) (0.5576), and percent cover of Texas ash (0.5193). Strongest negative loadings for PCA II were percent cover cedar elm (-0.5907) and percent cover of nandina (*Nandina domestica*) (-0.5054). Area 1 was negatively associated with PCA axis I, Area 2 was negatively associated with PCA axis II, and Area 3 was positively associated with PCA axis I (Figure 2).

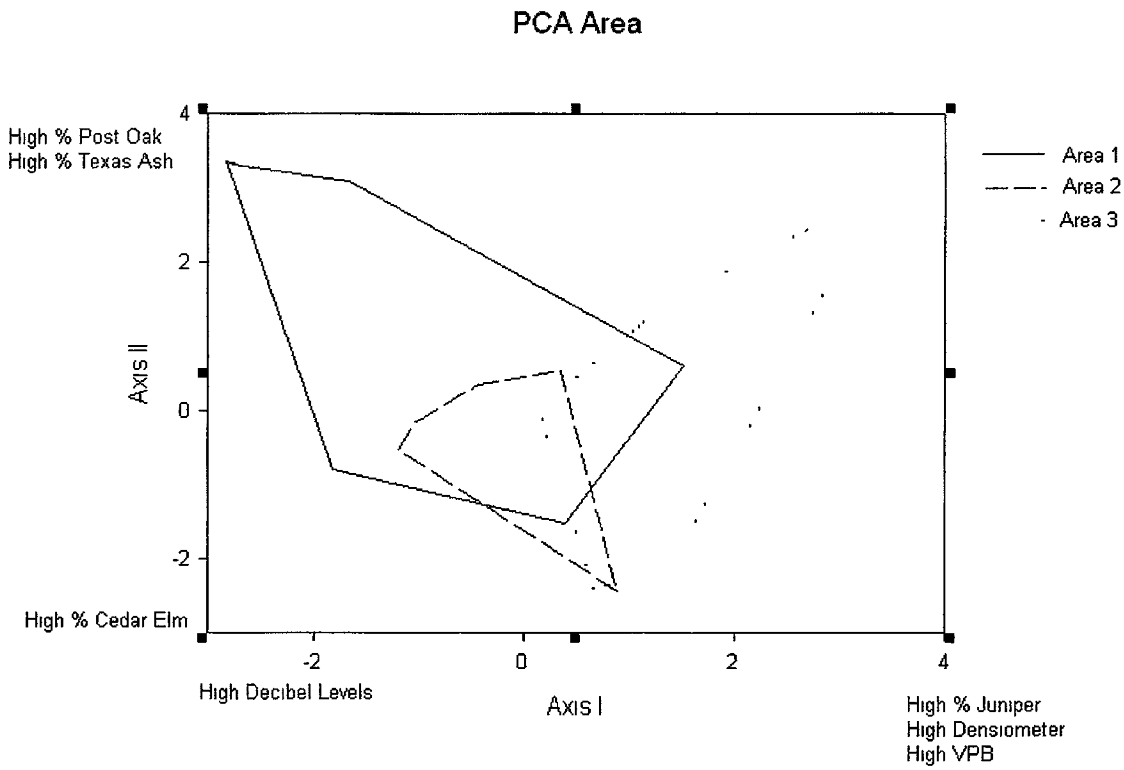

Figure 2. Principal component ordination plots for measured environmental variables per point with areas highlighted separately.

Avian Abundance, Diversity, and Evenness – Over the course of 600 fixed radius point counts, 2724 individual birds from 40 species and three unidentified species were recorded across three areas. These accounted for approximately 42% of species historically recorded in Sunset Valley as well as three species not previously recorded (C. Meredith pers. comm.). However, according to bird lists compiled by the Travis

Audubon Society, the species identified during this study represent only 12% of all species that have been identified within Austin city limits (Travis Audubon Society pers. comm.). The most abundant species were northern cardinal (*Cardinalis cardinalis*) (15.4%), blue jay (*Cyanocitta cristata*) (12.7%), northern mockingbird (*Mimus polyglottus*) (9.1%), great-tailed grackle (*Quiscalus mexicanus*) (9.1%), and Carolina wren (*Thryothorus ludovicianus*) (7.8%). Urban tolerant birds were the most abundant in all three areas, followed by urban adapted bird abundances and urban intolerant bird abundances (Table 4). Renkonen analysis shows total abundances in Area 1 and Area 2 were 72.7% similar to one another. Areas 1 and 2 were 54.7% similar to Area 3. Area 1 had a Shannon-Weiner H diversity of 4.0 and a Smith and Wilson evenness index of 0.2. Area 2 had a Shannon-Weiner H diversity of 3.9 and a Smith and Wilson evenness index of 0.3. Area 3 had a Shannon-Weiner H diversity of 3.6 and a Smith and Wilson evenness index of 0.3.

Canonical Correspondence Analysis – Habitat, anthropogenic disturbance (including decibel levels), area, and season explained 44.7 percent of the variability in the avian species abundances. Pure effects of habitat explained 26.1 percent of the variation ($P = 0.002$) while season explained 2.4 percent ($P = 0.002$) of the variation. Pure effects of area (0.9%; $P = 0.18$) and anthropogenic disturbances (4.9%; $P = 0.11$) were not significant. Univariate parameters significant in the stepwise procedure were mean canopy cover (17%; $P = 0.002$), mean vertical vegetation cover (6%; $P = 0.002$), area (5%; $P = 0.002$), high decibel level (5%; $P = 0.002$), and percent Ashe juniper cover (2%; $P = 0.05$). Physical parameters strongly associated with CCA axis I were mean

Table 4. Relative abundance of urban guilds, diversity, and evenness by area.

Variable	Area 1	Area 2	Area 3
Urban Adapted Abundance	32.5%	17.3%	10.1%
Urban Tolerant Abundance	57.5%	76.9%	64.6%
Urban Intolerant Abundance	1.6%	2.0%	6.1%
Shannon-Weiner Diversity Index	4.032	3.872	3.619
Smith and Wilson Evenness	0.22	0.321	0.295

densiometer reading (-0.7840), percent *J. ashei* cover (-0.6983), high decibel levels (0.5773), and mean VPB readings (-0.5452). Physical parameters strongly associated with CCA axis II were percent chinaberry (*Melia azedarach*) cover (0.2951), mean VPB readings (-0.2777), percent live oak (*Quercus fusiformis*) cover (0.2643), and percent Lacey oak (*Quercus laceyi*) cover (0.2039). Two species from the urban intolerant guild, black-and-white warblers (*Mniotilta varia*) and golden-crowned kinglets (*Regulus satrapa*), and one species from the urban tolerant guild, cedar waxwings (*Bombycilla cedrorum*), were most closely associated with lower decibel levels as well as higher mean densiometer readings and higher percent Ashe juniper cover (Figure 3). Urban adapted birds were positively associated with CCA axis I and urban intolerant birds were negatively associated with CCA axis I (Figure 4). Urban tolerant birds showed no strong associations with either axis. The urban adapted guild, except for house finches (*Carpodacus mexicanus*), were associated with high decibel levels, higher amounts of human recreational activities, and lower mean densiometer readings. Canyon wrens (*Catherpes mexicanus*) and yellow-rumped warblers (*Dendroica coronata*) were outliers from the urban intolerant guild, with canyon wrens more strongly associated with high

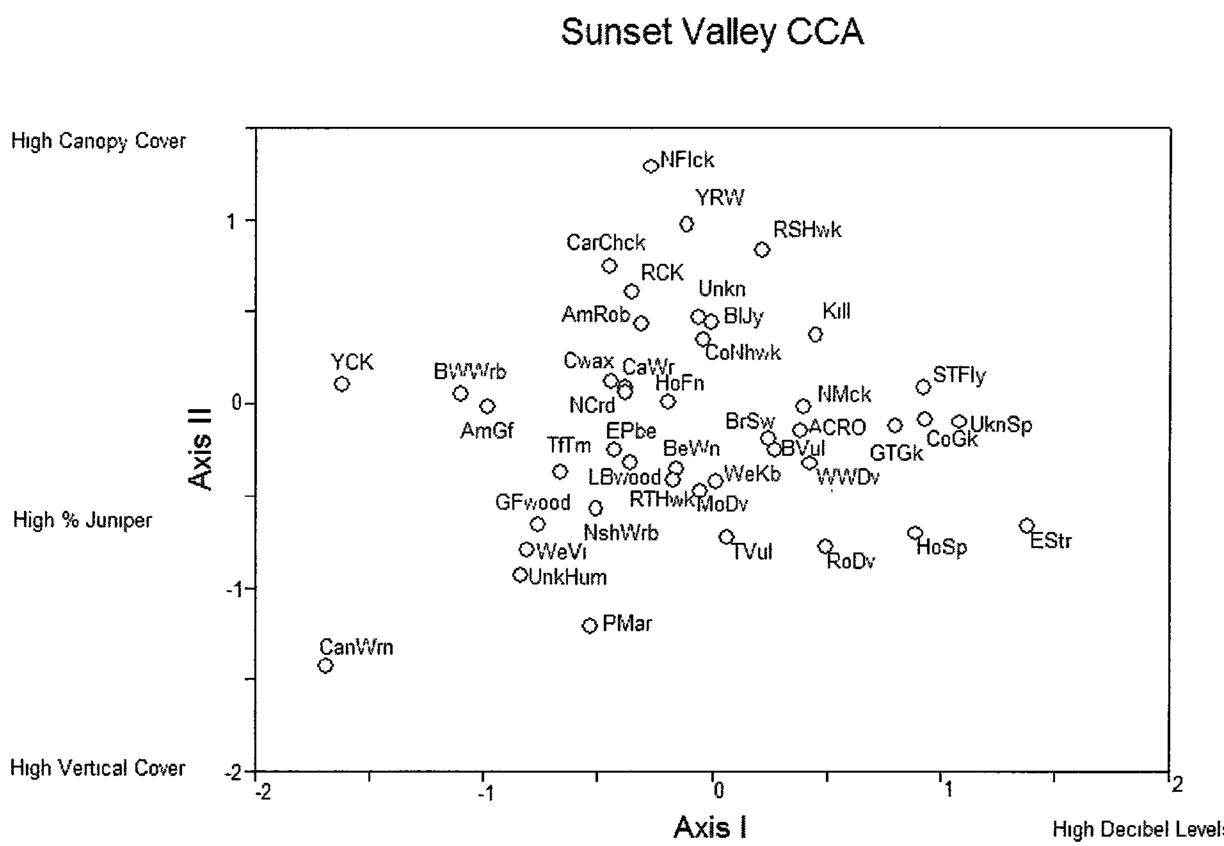

Figure 3. Canonical correspondence ordination plot for bird species with environmental variables.

vertical vegetative cover and lower decibel levels and with yellow-rumped warblers being more strongly associated with higher canopy cover but less vertical cover than the rest of the guild. Purple martins (*Progne subis*) were the only outlier for the urban tolerant birds, showing a stronger association with high vertical cover than the rest of the guild.

Univariate Analyses –Though many of the simple linear regressions were found to be significant, the r^2 values of the regressions were quite low with the highest r^2

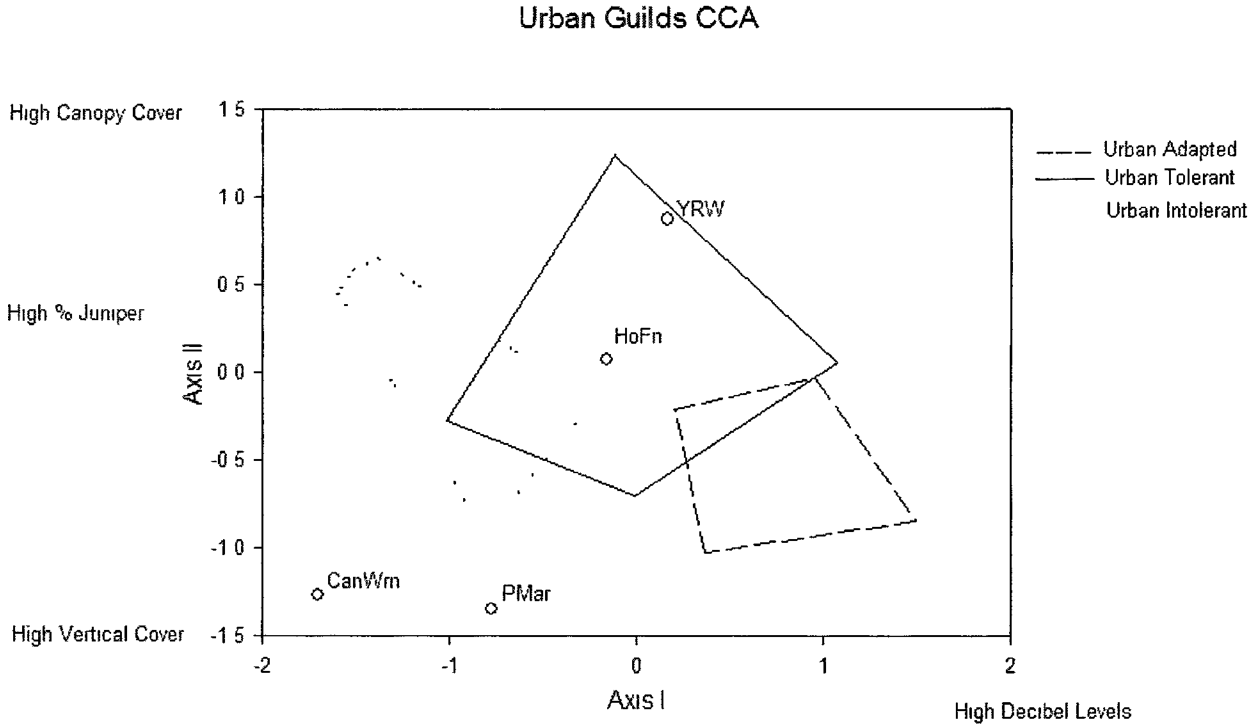

Figure 4. Canonical correspondence ordination plot for urban bird guilds.

value of 0.31 coming from the relationship between urban adapted birds and canopy cover (Table 5). Though the regressions indicated that there could be a significant cause and effect relationship between bird guilds and single environmental variables, the low r^2 values caused us to throw these results out.

Abundances among the three urban bird guilds varied by season and area. The results of ANOVA analysis indicate that bird abundances differed between seasons for urban adapted ($P < 0.001$, df=3, F=6.8) and urban tolerant ($P < 0.001$, df=3, F=34.9) guilds, with the highest abundances in the summer and spring and the lowest in the autumn and winter. Abundances of urban intolerant birds also varied between the seasons ($P < 0.001$, df=3, F=10.5) with the highest abundances in the spring, followed by the summer, then autumn, and finally winter. Urban adapted bird abundances varied significantly between the three areas ($P < 0.001$, df=2, F=13.1) with the mean abundance higher in Area 1 than in Area 2 or 3. Urban intolerant abundances also varied significantly between the areas ($P = 0.02$, df=2. F=4.0), with the mean abundance higher in Area 3 than in Area 1 or 2. Urban tolerant bird abundances did not vary significantly between areas.

Table 5. Results of simple linear regression analysis for each urban bird guild and the environmental variable being examined.

Environmental Variable	Urban Adapted		Urban Tolerant		Urban Intolerant	
	p-value	r^2	p-value	r^2	p-value	r^2
High Decibel Level	0.004	0.15	0.008	0.06	0.041	0.03
Mean Vertical Cover	0.001	0.19	0.002	0.08	0.001	0.19
Mean Canopy Cover	< 0.001	0.31	0.007	0.06	0.02	0.05
Ashe Juniper Cover	0.001	0.19	0.349	0.007	0.023	0.05

CHAPTER 4

DISCUSSION

Effects of Vegetation – Vegetation characteristics were the most influential variable in determining bird abundances and diversity along walking trails in Sunset Valley, TX with the pure effects of habitat explaining the highest percent of the variation observed in the CCA model. These results are consistent with the findings of Emlen (1974) and Mills et al. (1989) that, in general, bird abundances and diversity are more affected by vegetation characteristics than by anthropogenic disturbance. Urban tolerant and intolerant birds were more strongly associated with more natural, less manicured habitats with denser vegetation whereas urban adapted birds were more abundant in more open, less structurally complex habitat types. Taylor and Knight (2003) found that wildlife in areas with denser vegetative cover do not flush as readily in response to anthropogenic disturbances as wildlife in areas with sparser cover. Species more sensitive to human disturbance such as urban intolerant birds may be better able to persist in areas where suitable vegetative cover is available. However, vegetative cover does not necessarily make a significant difference on the impact of human presence on some species of birds (Fernandez-Juricic et al. 2005), suggesting that the protective benefits of vegetative cover are species specific and not a panacea for disturbance issues.

Effects of Decibel Levels – Recreational activities did not strongly influence abundance of bird species; however, high decibel levels did explain a significant portion of community variation. Urban adapted birds were more abundant where ambient noise levels were high, whereas urban tolerant and urban intolerant birds were not associated with such areas. High decibel levels were largely attributable to nearby roadways within and outside of the city limits as well as air traffic passing overhead. Saturation of the study site in such ambient noise might have overshadowed any effects from recreational activities, making them harder if not impossible to detect. Bird species sensitive to higher levels of ambient noise were possibly excluded from areas where the habitat was otherwise suitable (Slabbekoorn and Ripmeester 2008), making it impossible to separate the effects of disturbance from recreational activities on sensitive species. Even urban tolerant species were excluded from areas with higher ambient noise levels which were often also areas of greatest recreational activity due to their proximity to commercial and residential structures.

Effects of Seasonality – Seasonality also played a significant role in the variation of bird abundances. The highest level of bird abundance occurred in spring and summer months, a predictable finding since birds are generally most active and migrants are passing through Central Texas during these months. However, the amount of variation between seasons appears extreme. When temperatures drop, birds spend more time foraging to meet their energy requirements, spending less time singing (Garson and Hunter 1979, Strain and Mumme 1988). Because birds located in an environment with higher levels of ambient noise must expend more energy to increase the amplitude of their calls to be heard (Oberweger and Goller 2001), birds in urban environments might be more inclined to forage and less inclined to sing in the winter than their more rural counterparts, making them harder to detect. This might also indicate that bird species already struggling to subsist in an urban environment were excluded from an area by the extra energy requirements necessary to survive in an environment with elevated ambient noise levels. This suggests that in winter when resources are scarce, birds might be more susceptible to negative effects of disturbance from human recreational activities than at other times of the year, with studies suggesting that flight from human recreationists negatively affects energy consumption by wildlife (Taylor and Knight 2003).

Effects of Recreational Activities – Human recreational activities other than noise were not associated with bird occurrence or abundance. This could be due to a relatively low level of human traffic on most of the surveyed trails as well as the small group sizes of recreationists. Human recreationists have been shown to be perceived as threats by birds, with the degree of threat dependent upon the size of the human group as well as their distance from the birds (Beale and Monaghan 2004). Human recreational groups recorded during this study averaged less than three people per occurrence. According to research done by Beale and Monaghan (2004), the threat level perceived by birds, depending on their distance from the trail, was likely small. The presence of dogs can increase the perceived threat level (Banks and Bryant 2007), but on average people were walking with two dogs or less. However, dogs off leash were almost as common as dogs on leash and were the only type of off-trail disturbance consistently observed. As off-trail activities have been shown to increase disturbance (Taylor and Knight 2003) and dogs have been shown to compound the effects of disturbance caused by people (Banks and Bryant 2007), this is a matter of concern in areas where bird populations are already potentially under stress from elevated noise levels. Bikers were most abundant in Area 3, where abundances of urban intolerant bird species were higher, but they were still not indicated as having a significant effect on the bird population. Again, this could be due to their relatively low mean group sizes as well as the fact that mountain bikers may not cause as much disturbance to wildlife as they do not have a human form (Taylor and Knight 2003) and may not recognized as being human by wildlife.

Results of Simple Linear Regressions – The weak r^2 values from the linear regressions indicate that there is not a strong cause and effect relationship between environmental variables and observed bird abundances, despite the strong associations the results of the CCA indicate. However, the univariate simple linear regressions fail to take into account more than one environmental variable, excluding all other covariables that the CCA encompasses. To truly get a clear picture of how one environmental variable affects an urban bird guild from a regression analysis, all the other environmental variables must be held constant. Given the limitations of this study, holding all variables except for the one being examined constant is an impossibility. The results of CCA analysis and the ANOVA indicate that seasonality has an effect on bird abundances. Because the majority of birds sing during only certain times of the year (Catchpole and Slater 1995), the relationship between an environmental variable and bird abundances might vary between seasons. Because the regressions conducted were for data from across all seasons, stronger relationships from certain seasons may have been drowned out. Another weakness of the simple linear regressions is that bird species were pooled into guilds and the effects of a single environmental variable on those guilds were examined over the course of the year. Examining species pooled together in a guild can drown strong relationships between an environmental variable and a single species. Unfortunately, not enough data points were available for the majority of environmental variables to be examined on a species-by-species basis. Until such a study can be undertaken, the conclusions drawn in this discussion are based upon the associations seen in the CCA, which coincide with the majority of the literature on this topic.

Sunset Valley Green Space – Since this study was conducted solely on walking trails, it is difficult to partition the effect of edge habitat from human recreational activities occurring on the trails (Miller et al. 1998). For example, urban tolerant species were the most abundant guild in all three areas of this study, but many of these urban tolerant species also favor edge habitats. Due to area constraints, each point in the study was 75 meters in radius, which has been shown to be the approximate "area of effect" from recreational trails in similar habitats and situations (Miller et al. 1998). Most of the green space within Sunset Valley falls within 75 meters of a nearby walking trail or area of residential or commercial activity. Therefore, it is safe to assume that my study results apply to the majority of green space in the study.

During the course of this study, 40 different bird species were positively identified. The city of Sunset Valley has a known bird list of 95 different bird species (C. Meredith pers. comm.), meaning that this study captured approximately 42% of all known bird species. On the other hand, the city of Austin has a bird list of 324 common and uncommon bird species (Travis Audubon Society pers. comm.), meaning that this study only accounted for 12% of known bird species in Austin. Austin has a wide variety of green spaces of varying habitat types throughout the city. It is unlikely that the green space in Sunset Valley would ever be able to be as diverse as the city of Austin due to lack of area, but to attract more bird species to Sunset Valley, they would need a greater variety of habitat types than what is currently present.

CHAPTER 5

MANAGEMENT IMPLICATIONS

As the degree of urbanization increases in an area, so does the loss of vegetative and avian diversity (Chace and Walsh 2006). Some species of birds are favored while others are excluded. Urban park and green space managers are faced with the dilemma of balancing the needs of wildlife with the needs of human recreationists. My results suggest that to mitigate the impact of urbanization on urban green space, managers should maintain more areas of dense vegetation to provide habitat and cover for sensitive bird species. Green space should be placed as far away from major automotive thoroughfares as possible to reduce ambient noise levels. Other sources of elevated ambient noise should also be limited to reduce stress levels on sensitive wildlife.

To reduce adding stressors to urban habitats, trails within green space should be placed judiciously to limit the impact of edge effects as well as habitat fragmentation and disturbance by recreationists. The type of recreational activity does not appear to matter as long as the number of recreationists and group sizes remain relatively small. Any sort of automated recreation should be banned as this would increase ambient noise levels, increasing disturbance to wildlife.

APPENDIX A

Appendix A. Comprehensive list of bird species observed in Sunset Valley, Texas green space between June 2008 and March 2009.

Scientific Name	Common Name	Abbreviation	Area 1	Area 2	Area 3
	Hummingbird sp.	UnknoHum	X		X
Baeolophus bicolor	tufted titmouse	TfTm	X	X	X
Bombycilla cedrorum	cedar waxwing	Cwax	X	X	
Buteo jamaicensis	red-tailed hawk	RTHwk	X	X	
Buteo lineatus	red-shouldered hawk	RSHwk	X	X	
Cardinalis cardinalis	Northern cardinal	NCrd	X	X	X
Carduelis tristis	American goldfinch	AmGf	X		X
Caprodacus mexicanus	house finch	HoFn	X	X	X
Cathartes aura	turkey vulture	TVul	X		
Catherpes mexicanus	canyon wren	CanWrn			X
Coragyps atratus	black vulture	BVul	X	X	
Cyanocitta cristata	blue jay	BlJy	X	X	X
Dendroica coronata	yellow-rumped warbler	YRW	X	X	
Hirundo rustica	barn swallow	BrSw	X	X	
Melanerpes aurifrons	golden-fronted woodpecker	GFwood	X		X
Mimus polyglottus	northern mockingbird	NMck	X	X	X
Picoides scalaris	ladderback woodpecker	LBwood	X	X	X
Poecile carolinensis	Carolina chickadee	CarChck	X	X	X
Progne subis	purple martin	PMar	X		
Quiscalis mexicanus	great-tailed grackle	GTGk	X	X	X
Quiscalis quiscula	common grackle	CoGk	X	X	X
Regulus calendula	ruby-crowned kinglet	RCK	X	X	X
Sayornis phoebe	eastern phoebe	EPbe	X	X	X
Thyromanes bewickii	Bewick's wren	BeWn	X	X	X
Thyrothorus ludovicianus	Carolina wren	CaWr	X	X	X
Turdus migratorius	American robin	AmRob	X		
Zenaida asiatica	white-winged dove	WWDv	X	X	X
Zenaida macroura	mourning dove	MoDv	X	X	X

Appendix A – Continued. Comprehensive list of bird species observed in Sunset Valley, Texas green space between June 2008 and March 2009.

Species Name	Common Name	Abbreviation	Area 1	Area 2	Area 3
	sparrow sp	UknSp	X	X	
Regulus satrapa	golden-crowned kinglet	YCK			X
Vermivorva ruficapilla	Nashville warbler	NshWrb	X	X	X
Vireo griseus	white-eyed vireo	WeVi	X	X	X
Colaptes auratus	northern flicker	NFlck		X	
Corvus brachyrhynchos	American crow	AmCro	X	X	X
Passer domesticus	house sparrow	HoSp	X	X	X
Sturnus vulgaris	European starling	EStr	X	X	
Charadrius vociferous	killdeer	Kill	X		
Chordeilis minor	common nighthawk	CoNhwk	X	X	X
Mniotilta varia	black-and-white warbler	BWWrb		X	X
Tyrannus forficatus	scissor-tailed flycatcher	STFly	X	X	
Tyrannus verticalis	western kingbird	WeKb	X	X	X
Columba livia	rock dove	RoDv	X		
	bird sp.	UknSp	X	X	

APPENDIX B

Appendix B. Number of observations per bird species per season made within the green space of Sunset Valley, Texas.

Species	Summer	Autumn	Winter	Spring
UnknoHum	6	0	0	0
TfTm	10	6	5	43
Cwax	0	0	0	5
RTHwk	7	0	0	2
RSHwk	0	4	3	0
NCrd	129	60	54	176
AmGf	0	0	6	6
HoFn	36	39	18	51
TVul	0	0	0	1
CanWrn	7	1	0	10
BVul	7	1	1	0
BlJy	104	153	48	41
YRW	0	0	13	0
BrSw	86	4	0	57
GFwood	4	0	0	2
NMck	123	70	4	51
LBwood	11	1	2	2
CarChck	5	27	45	14
PMar	0	0	0	3
GTGk	109	72	25	41
CoGk	83	58	23	22
RCK	0	2	26	20
EPbe	0	0	2	6
BeWn	5	1	0	8
CaWr	117	32	37	26
AmRob	2	0	0	0
WWDv	65	14	6	28
MoDv	27	2	0	9
UknSp	0	0	5	4
YCK	0	0	2	0
NshWrb	0	0	0	23
WeVi	80	1	6	68
NFlck	0	0	1	0

Appendix B – Continued. Number of observations per bird species per season made within the green space of Sunset Valley, Texas.

Species	Summer	Autumn	Winter	Spring
AmCro	0	3	2	3
HoSp	10	1	7	0
EStr	6	0	4	3
Kill	0	4	0	1
CoNhwk	3	1	0	0
BWWrb	0	0	2	0
STFly	0	3	0	9
WeKb	20	0	0	10
RoDv	0	0	1	0
UnknSp	10	0	1	1

APPENDIX C

Appendix C. Principal Component Analysis loadings for vegetation and anthropogenic variables.

Variable	Axis 1	Axis 2	Axis 3	Axis 4
Dogs (off-leash)	-0.2051	-0.0545	-0.1003	-0.0429
Dogs (on-leash)	-0.4495	0.1104	-0.05	0.1653
Joggers	-0.3459	-0.1913	-0.0425	0.3434
Walkers	-0.4024	-0.0605	-0.0461	0.2219
High Decibels	-0.5289	-0.0351	-0.1027	0.44
VPB AVG	0.3218	0.2135	0.1847	-0.4995
Dens AVG	0.6824	0.0548	-0.0472	-0.3219
A. gregii	0.1726	0.1513	0.3147	-0.4606
B. trifoliate	0.214	0.2725	0.4633	-0.2214
C. hookeri	0.3785	0.1245	0.197	0.0718
C. illinoensis	0.2124	-0.3955	-0.4019	0.0522
C. laevigata	-0.0002	-0.0359	0.0733	-0.0303
C. reticulata	0.1354	-0.2238	-0.1417	-0.1467
Diospyros texanum	-0.2572	0.2666	0.0597	-0.4443
E. anacua	0.2951	-0.1851	-0.1306	-0.1715
F. pubescens	0.0133	0.1508	-0.1275	-0.0376
F. texensis	-0.4443	0.5193	-0.3922	-0.2753
I. vomitoria	0.6025	0.2195	-0.2189	0.405
J. Ashei	0.8083	0.218	-0.0393	0.0257
J. microcarp	0.023	-0.3272	-0.1811	-0.2672
L. frutescens	0.1578	-0.3016	-0.2707	-0.0167
L. ligustrum	0.2494	-0.0281	0.1638	-0.3681
M. azedarach	0.1938	-0.5054	-0.3111	-0.2754
N. domestica	-0.1332	-0.1296	0.5954	0.1408
O. leptocaulis	-0.1679	-0.1453	0.5786	0.1324
P. aculeate	-0.1902	-0.0419	0.7019	-0.0083
P. glandulosa	-0.152	0.1865	-0.1265	-0.1664
Q. fusiformis	0.5135	0.3906	-0.0087	0.1643
Q. laceyi	0.0269	0.1505	0.289	-0.3705
Q. marilandica	0.1663	-0.4018	-0.3943	0.0866
Q. muhlenbergii	-0.3861	0.5576	-0.4388	-0.3261
Q. stellata	0.4782	0.4666	-0.0961	0.4704
Q. texanum	-0.3861	0.5576	-0.4388	-0.3261
U. americana	0.5439	0.4636	-0.0967	0.4927
U. crassifolia	0.3291	-0.5907	-0.1741	-0.3641
Season	0.0146	-0.002	0.0043	-0.0466

APPENDIX D

Appendix D. Canonical Correspondence Analysis loadings for avian species observed in Sunset Valley, Texas green space.

Species	Axis 1	Axis 2	Axis 3	Axis 4
ACRO	0.3808	-0.1451	-0.2208	0.5137
AmGf	-0.8816	-0.1694	0.6825	0.1112
AmRob	-0.3143	0.4593	-0.3046	-1.948
BrSw	0.2621	-0.2571	-0.7326	0.2831
BeWn	-0.1144	-0.3759	-0.4338	0.167
BWWarb	-1.0289	0.3326	0.5604	0.5141
BVul	0.2225	-0.2701	-0.5984	0.1956
BlJy	0.0092	0.4833	-0.2134	-0.0371
CanWr	-1.7035	-1.2666	1.6866	1.5161
Cwax	-0.5289	0.2501	0.1142	-0.2383
CarChick	-0.3827	0.7131	0.495	0.18
CaWr	-0.382	0.0899	0.0718	-0.069
CoGk	0.9187	-0.1107	0.2997	0.0358
CoNhwk	-0.0608	0.3509	0.4641	-0.9482
EPbe	-0.5345	-0.4085	-0.1929	-0.3704
Estr	1.4143	-0.7997	0.7938	-0.6073
GFWood	-0.8116	-0.6091	0.0873	-0.6468
GTGk	0.7714	-0.1358	0.3129	0.055
HoFn	-0.1562	0.0751	0.0709	0.0403
HoSp	1.0197	-0.7157	0.6607	-0.6845
UnKnHum	-0.6766	-0.6108	0.56	0.3692
Kill	0.267	0.5349	-0.3205	0.5082
LBWood	-0.3046	-0.2044	-0.1056	-0.1669
MoDv	-0.069	-0.6168	-0.4097	0.1465
NshWrb	-0.6299	-0.6274	-0.3713	-0.0744
NCrd	-0.3813	0.0848	-0.0224	-0.1208
NFlc k	-0.1114	1.1679	-0.0207	-0.3476
NMck	0.3716	-0.0219	-0.1223	0.0738
Pmar	-0.7743	-1.3495	-0.3705	1.5046
RTHwk	-0.1702	-0.3864	-0.702	-0.3819
RSHwk	0.1866	0.8873	-0.252	0.3689
RoDov	0.4298	-0.9463	-0.3613	-0.6449
RCK	-0.2572	0.5536	0.0806	0.4388
STFly	1.0139	0.0589	-0.3551	0.6663

Appendix D – Continued. Canonical Correspondence Analysis loadings for avian species observed in Sunset Valley, Texas green space.

Species	Axis 1	Axis 2	Axis 3	Axis 4
TfTm	-0.7237	-0.3486	0.214	-0.4743
TVul	0.0192	-0.6393	-0.4957	-0.8983
UnKnown	-0.0213	0.3674	-0.7265	-0.0939
UnKnSp	1.1791	-0.2903	0.3245	0.0736
WeKb	-0.0057	-0.4264	-0.2104	-1.024
WeVi	-0.8484	-0.7792	0.1758	0.2821
YCK	-1.5107	0.4741	0.6623	1.0553
YRW	0.1669	0.8708	0.6088	-0.1706

LITERATURE CITED

Ambul, B. and S. A. Temple. 1982. Songbird populations in southern Wisconsin forests: 1954 and 1979. Journal of Field Ornithology 53:149–158.

Banks, P. B. and J. V. Bryant. 2007. Four legged friend or foe? Dog walking displaces native birds from natural areas. Biology Letters 3:611–613.

Beale, C. M. and P. Monaghan. 2004. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41:335–343.

Blair, R. B. 1999. Birds and butterflies along an urban gradient: surrogate taxa for assessing biodiversity? Ecological Applications 9:164–170.

Borcard, D., P. Legendre, and P. Drapeau. 1992. Partialling out the spatial component of ecological variation. Ecology 73:1045–1055.

Brumm, H. and D. Todt. 2002. Noise-dependent song amplitude regulation in a territorial songbird. Animal Behaviour 63:891–897.

Burger, J. and M. Gochfiel. 1998. Effects of ecotourists on bird behaviour at Loxahatchee National Wildlife Refuge, Florida. Environmental Conservation 25:13–21.

Catchpole, C. K. and P. J. B. Slater. 1995. Bird song: biological themes and variations. Cambridge University Press, Cambridge, United Kingdom.

Chace, J. F. and J. J. Walsh. 2006. Urban effects on native avifauna: a review. Landscape and Urban Planning 74:46–69.

Cornell Lab of Ornithology. 2009. All About Birds. <http://www.allaboutbirds.org/>. Accessed 2 Aug 2009.

Emlen, J. T. 1974. An urban bird community in Tucson, Arizona: derivation, structure, regulation. Condor 76:184–197.

Fernandez-Juricic, E., M. P. Venier, D. Renison, and D. T. Blumstein. Sensitivity of wildlife to spatial patterns of recreationist behavior: A critical assessment of minimum approaching distances and buffer areas for grassland birds. Biological Conservation 125:225–235.

Forman, R. T. T. and L. E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207–231.

Forman, R. T. T., B. Reineking, and A. M. Herperger. 2002. Road traffic and nearby grassland bird patterns in a suburbanizing landscape. Environmental Management 29:782–800.

Garson, P. J. and M. L. Hunter. 1979. Effects of temperature and time of year on the singing of wrens *Troglodytes trogolodytes* and great tits *Parus major*. Ibis 121:481–487.

Giese, M. 1996. Effects of human activity on Adelie penguin *Pygoscelis adeliae* breeding success. Biological Conservation 75:157–164.

Hunter, A. L. 2002. Comparison of avian communities within traditional and wildscaped residential neighborhoods in San Antonio, Texas. Thesis, Texas State University, San Marcos, USA.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. The Auk 103:593–602.

Johnston, R. F. 2001. Synanthropic birds of North America. Pages 49–66 *in* J.M. Marzluff, R. Bowman, R. Donnelly, editors. Avian Ecology and Conservation in an Urbanizing World. Kluwer Academic Publishers.

Krebs, C. J. 1999. Ecological methodology. Second Edition. Addison Wesley Longman, New York, pp. 1-496.

Leseberg, A., P. A. R. Hockey, and D. Lowenthal. 2000. Human disturbance and the chick-rearing ability of African black oystercatchers (*Haematopus moquini*): a geographical perspective. Biological Conservation 96:379–385.

Lombard, E. 1911. Le signe de l'elevation de la voix. Annales des maladies de l'oreille et du larynx 37:101–119.

Miller, S. G., R. L. Knight and C. K. Miller. 1998. Influence of recreational trails on breeding bird communities. Ecological Applications 8:162–169.

Mills, G. S., J. B. Dunning Jr. and J. M. Bates. 1989. Effects of urbanization on breeding bird community structure in southwestern desert habitats. Condor 91:416–428.

Mortberg, U. and H. G. Wallentinus. 2000. Red-listed forest bird species in an urban environment – assessment of green space corridors. Landscape and Urban Planning 50:215–226.

National Research Council. 1997. Toward a sustainable future: addressing the long-term effects of motor vehicle transportation on climate and ecology. National Academy Press, Washington, DC.

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

Oberweger, K. and F. Goeller. 2001. The metabolic costs of birdsong production. Journal of Experimental Biology 204:3379–3388.

Park, C. R. and W. S. Lee. 2000. Relationship between species composition and area in breeding birds in urban woods of Seoul, Korea. Landscape and Urban Planning 51:29–36.

Patricelli, G. L. and J. L. Blickley. 2006. Avian communication in urban noise: causes and consequences of vocal adjustment. The Auk 123:639–649.

Peterson, R. T. 2000. Birds of Eastern and Central North America. Fifth Edition. Houghton Mifflin Company, New York, pp. 1-427.

Ransom, D. and W. E. Pinchak. 2003.Assessing accuracy of a laser rangefinder in estimating grassland bird density. Wildlife Society Bulletin 31:406–463.

Reale, J. A. and R. B. Blair. 2005. Nesting success and life-history attributes of bird communities along an urbanization gradient. Urban Habitats 3:1–24.

Sibley, D. A. 2000. The Sibley Guide to Birds. Alfred A. Knopf, New York, pp. 1-543.
Slabbekoorn, H. and E. A. P. Ripmeester. 2008. Birdsong and anthropogenic noise: implications and applications for conservation. Molecular Ecology 17:72–83.

Strain, J. G., and R. L. Mumme. 1988. Effects of food supplementation, song playback, and temperature on vocal territorial behavior of Carolina wrens. The Auk 105:11–16.

Taylor, A. R. and R. L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. Ecological Applications 13:951–963.

Texas Parks and Wildlife Department. 2008. Texas partners in flight: Texas ecoregions. http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/. Accessed 17 September 2009.

Thompson, F. R. and M. J. Schwalbach. 1995. Analysis of sample size, counting time, and plot size from an avian point count survey on Hoosier National Forest, Indiana. USDA Forest Service. Pages 45–48 *in* Ralph, C. John; Sauer, John R.; Droege, Sam, technical editors. 1995. Monitoring bird populations by point counts. Gen. Tech. Rep. PSW-GTR-149. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

United States Department of Agriculture. 2008. Outdoor recreation increasing among American adults, survey shows. http://www.srs.fs.usda.gov/news/341. Accessed 15 October 2008.

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of the migratory songbird. Ecology 6:1211–1214.

VITA

Mary Norris Tibbets was born in Houston, Texas to Michael and Marcia Tibbets on June 2, 1983. Since a very early age, when asked what she wanted to do when she grew up, Mary would reply, "Save the world." As she grew older, this idea became more refined. She attended Knox College in Galesburg, Illinois, graduating with a B.A. in Conservation Biology with a minor in Anthropology and Sociology in the summer of 2006. During her time at Knox, Mary had the opportunity to study abroad, attending a semester at the University of Dar es Salaam in Tanzania and conducting field research in Tarangire National Park. After graduating from Knox, Mary worked for six months as a wetlands scientist for a civil engineering company in Chicago, Illinois. She then returned to her home state of Texas and enrolled in the Wildlife Ecology Program at Texas State University–San Marcos to pursue a Master of Science degree. While at Texas State she worked as an instructional assistant for Organismal Biology and General Science labs.

Permanent Address: 854 Bandera St.

San Marcos, Tx 78666

This thesis was typed by Mary N. Tibbets.