EFFECTS OF NONINDIGENOUS PLANT SPECIES ON BIRD COMMUNITIES IN CENTRAL TEXAS PERIURBAN HABITATS

THESIS

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ABSTRACT

EFFECTS OF NONINDIGENOUS PLANT SPECIES ON BIRD COMMUNITIES IN CENTRAL TEXAS PERIURBAN HABITATS

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SUPERVISING PROFESSOR THOMAS R SIMPSON

Invasive, nonindigenous plants such as red tipped photinia (*Photinia seratofolia*), wax-leaf ligustrum (*Ligustrum japonicum*), heavenly bamboo (*Nandina domestica*), pyracantha (*Pyracantha coccinea*), Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*), Chinaberry tree (*Melia azedarach*) and Chinese tallow (*Triadica sebifera*) pose a significant threat to natural vegetative communities and by extension, to avian populations dependent upon native flora. In urban areas of central Texas, nonindigenous plants are widely used for landscaping purposes Consequently, many have naturalized and become invasive, spreading well beyond the manicured yard to infest the few forested green-spaces available to bird communities in this rapidly developing urban area Previous research indicates that nonindigenous plants do not provide native bird populations with necessary cover, forage (plant and insect), vertical profile, branch structure, predator escape, or nesting material This altered habitat is also viewed as encouraging use by nonindigenous bird species This research investigated the hypothesis that in Austin, Texas, sites invaded by nonindigenous woody plants species harbor a suite of birds lacking diversity and abundance when compared to areas unaffected by exotic woody vegetation The avian community was surveyed by point count on six study properties within and near Austin, Texas Point count sites were classified a-priori as unimpacted (< 5% canopy cover by nonindigenous species) or impacted (>5% canopy cover by nonindigenous species) Sixty-two species and 1742 individual bird detections were recorded during the 18 month study Avian species richness for impacted point count sites was 32 with 448 total detections, while species richness at unimpacted point count sites was 59 with 1294 total detections A two factor nonparametric multivariate analysis of variance (habitat x year) revealed significant differences between impact cover type (*P* = 0 0002), and year (*P* = 0 0002) There was also a significant cover x year interaction (*P* = 0 0156) These results identify differences between cover types and differences between study years to the extent that we can conclude that the presence of nonindigenous plant species has a significant influence on avian populations

CHAPTER I

INTRODUCTION

Many nonindigenous plants imported for landscaping and decorative planting purposes have become naturalized and invasive, competing with native flora for environmental resources Nonindigenous invasive plant species can reduce biodiversity, alter soil and hydrologic characteristics, interfere with natural succession, compete for pollinators, poison or repel native insects, displace rare plant species, serve as reservoirs of plant pathogens and replace complex communities with single species monocultures (Swearingen et al 2002) As a result, suitable habitat for native animal species becomes compromised. Where invasive plants have replaced native flora, many animal species have either coped with invasive exotics or disappeared (Mills et al 1989, Germaine et al 1998)

Substantial displacement of native flora by nonindigenous invasive plants occurs often in urban and suburban settings. Suburban areas rarely include the full complement of vertical strata found in natural forests and native species are often removed or replaced by nonindigenous ornamentals (Blair 1996, Melles et al 2003) Metropolitan and suburban areas are a mosaic of private residences, industrial complexes, infrastructure, various types of drainage systems, and pockets of undeveloped land creating an exceptionally fragmented environment Ecological characteristics of these areas include reduced levels of understory structure, snag and log prevalence, dead plant material, and top-level predators, and increased generalist and nonindigenous predators, avian parasites and diseases, and competition (Marzluff et al 2001, Marzluff and Ewing 2001) Habitat fragmentation intensifies the invasion of nonindigenous plant species producing altered habitats (Hobbs and Huenneke 1992, Hutchinson and Vankat 1997) Resulting in declines of local or regional avian populations (Friesen et al. 1995) Exotic, invasive plants out-compete native flora for space and resources leaving habitats dominated by nonindigenous flora as the alternative harbor for birds (Reichard et al. 2001) Biological invasions are ranked second to habitat loss as the leading cause of rare species endangerment in the United States, accounting for 49% of all threats to species and 57% of threats to rare plant species (Wilcove et al 1998) Subsequent habitat changes can lead to the decline and potential loss of wildlife species specifically dependent on native flora for survival Biological invasions have historically been detrimental to native flora and fauna In South Carolina biologists are concerned that the exotic fungus *Phytophthora ramorum*, which causes sudden oak death, will decimate deciduous forests and threaten resident avian communities similar to chestnut blight (Huckabee 2005)

Bird species are dependant on their floral environment for thermal cover, vertical structure, nesting sites, and food resources Increasing levels of invasive *Acacia cyclops* in tall mixed Fynbos assemblages within the Cape of Good Hope Nature Reserve in South Africa was correlated with the declining densities of nectarivorous bird populations, a result of the elimination of proteaceous and ericaceous shrubs, their natural food source (Fraser and Crowe 1990) Conversely, they reported an increase in insectivorous birds as the much shrubbier invading acacia provided greater insect resources The insectivorous birds noted were largely nonindigenous Endemic birds in New Zealand were left with inferior foraging habitat where introduced weeds replaced native vegetation (Williams and Karl 1996)

Native bird diversity and density were positively correlated with the volume of native vegetation but negatively correlated with the volume of nonindigenous vegetation in studies by Mills et al (1989) and Germainnne et al (1998) Native vegetative volume may be an accurate estimator of available food and other resources for native breeding birds (Germaine et al 1998) For example, native plants host various insects, a food source for many birds, while non-native plants are mostly devoid of insects. Even though nonindigenous plants may provide branch architecture suitable for nest sites and cover, birds may experience higher mortality rates due to nest predation (Robinson et al. 1995), nest parasitism, altered food supply, thermodynamics, cover or nesting material American Robins (*Turdus migratorius*) nesting in nonindigenous plants, amur honeysuckle (*Lonicera maackii*) and common buckthorn (*Rhamnus cathartica*), experienced higher nest predation than nests built in comparable native shrub and tree species (Schmidt and Whelan 1999). Predation was due to a combination of lower nest height, absence of sharp thorns on nonindigenous species, and perhaps a branch structure that facilitated predator movements and promoted competition with other nesting species

Japanese honeysuckle was identified as an invasive plant species potentially influencing bird species composition in two urban, forested wetlands on Staten Island, New York (Dowd 1991) Nonindigenous shrubs can reduce the nesting success of forest birds and may cause increased nest failure in urbanizing landscapes (Borgmann and Rodewald 2004). Early leaf emergence of the nonindigenous black locust (*Robinia pseudoacacia*) (indigenous to North America) acts as an ecological trap (Gates and Gysel 1978) in the Czech Republic negatively affecting nest success of the Blackcap (*Sylvia atricapilla*) (Remes 2003). Blackcap density in the locust grove was twice the density in native vegetation, but nest success in the locust grove was half that in native vegetation (Remes 2003) The exact mechanism decreasing nest success was unclear

Japanese honeysuckle, ligustrum species, heavenly bamboo, Chinaberry and Chinese tallow are common nonindigenous invasive woody plant species in Austin, Texas (Damude and Bender 1999) A variety of Ligustrum species were imported to North America in the 1950s from North Africa, Eurasia, Malaysia, and Australia for landscaping Specifically, wax-leaf ligustrum (Japanese Privet) invasion in the Austin, Texas, area has impacted native vegetation by out-competing native woody species such as wax mallow (*Malvaviscus arborea* var *drummondii*), Mexican buckeye (*Ungnadia speciosa*), American beautyberry (*Callicarpa americana*), small palmleaf thoroughwort (*Conoclinium greggii*), pecan (*Carya illinoensis*), and Texas ash (*Fraxinus texensis*) (Stone, S L 1997) Naturalized solid stands of privet, and clusters of Chinaberry and Chinese tallow trees thrive in moderately moist habitats in the Austin area Additionally, nandina is frequently an invading under-story plant and Japanese honeysuckle frequently occurs in fencerows and hedges

Invasive plant species are commonly thought to negatively effect populations of migratory songbirds, however, this theory has not been studied sufficiently at a fine scale In some cases invasive plants are thought to be beneficial Schmidt et al (2005) determined nesting success of the Veery (*Catharus fuscescens*) appreciably increased when located in exotic barberry (*Berberis thunbergii*) in comparison to nests in other vegetation or ground nests in years of increased rodent populations. However, the effects could have been transient.

Austin is within the central flyway migratory corridor with critical habitat for the Golden-cheeked Warbler (*Dendroica chrysoparia*) and the Black-capped Vireo (*Vireo atricapillus*) Many other neotropical migrant songbirds nest in this area or pass through during migration It is important to know the influence changing landscape has on birds that frequent or reside in the area to formulate management plans to protect, maintain and/or restore specific habitats The purpose of this study was to document and compare the effects non-native plants have on avian relative abundance, distribution, species composition and diversity in an increasingly urbanized area of central Texas

CHAPTER II

METHODS

Study Sites

This study was conducted on six separate properties within the city of Austin, Travis County, Texas (Fig 1) from March 2004 until August 2005 These six study locations were Bright Leaf State Natural Area (87 ha), The Barton Creek Greenbelt (323 ha), the Barton Creek Wilderness Park (404 ha), Blunn Creek Nature Preserve (16 ha) and two private tracts of land (total 100 hectares)

All properties are located in the Balcones Canyonlands subregion of the Edwards Plateau in the Dry Creek and Bull Creek watersheds Vegetative communities on these properties include oak-juniper woodlands, postoak grassland-savannas, mesic deciduous forests, stream bottom riparian forests, and low shrub Disturbed and edge areas in study locations included stands of native plant species, including honey mesquite (*Prosopis glandulosa*) and prickly pear (*Opuntia engelmanii*) and nonindigenous plant species such as red tipped photinia, wax-leaf ligustrum, heavenly bamboo, pyracantha, Japanese honeysuckle, Chinese privet, Chinaberry and Chinese tallow Each of these study properties are surrounded by extensive urban development.

The historically diverse avifauna in this area includes the federally endangered Golden-cheeked Warbler and the Black-capped Vireo. Individual point count locations, within each study property were established based on *a priori* vegetative analysis Vegetative parameters, including species composition, canopy cover, nonindigenous species presence and canopy composition, were measured using 100-m line intercepts at each of the point count sites (Bookhaut 1994). Two perpendicular, 50-m line transects were utilized at each point to determine the woody species present. Canopy cover was recorded along the transect lines at 10-m intervals using a densitometer. Brush density was quantified using a vegetation profile board with measurements taken at the four cardinal directions fifteen meters from the central axis of the intersecting transect lines (Bookhaut 1994, Nudds 1997). Point count sites with <5% percent non-native invasive plant species were designated unimpacted points (*n* = 5) and point count sites with >5% were designated impacted points (*n* = 8).

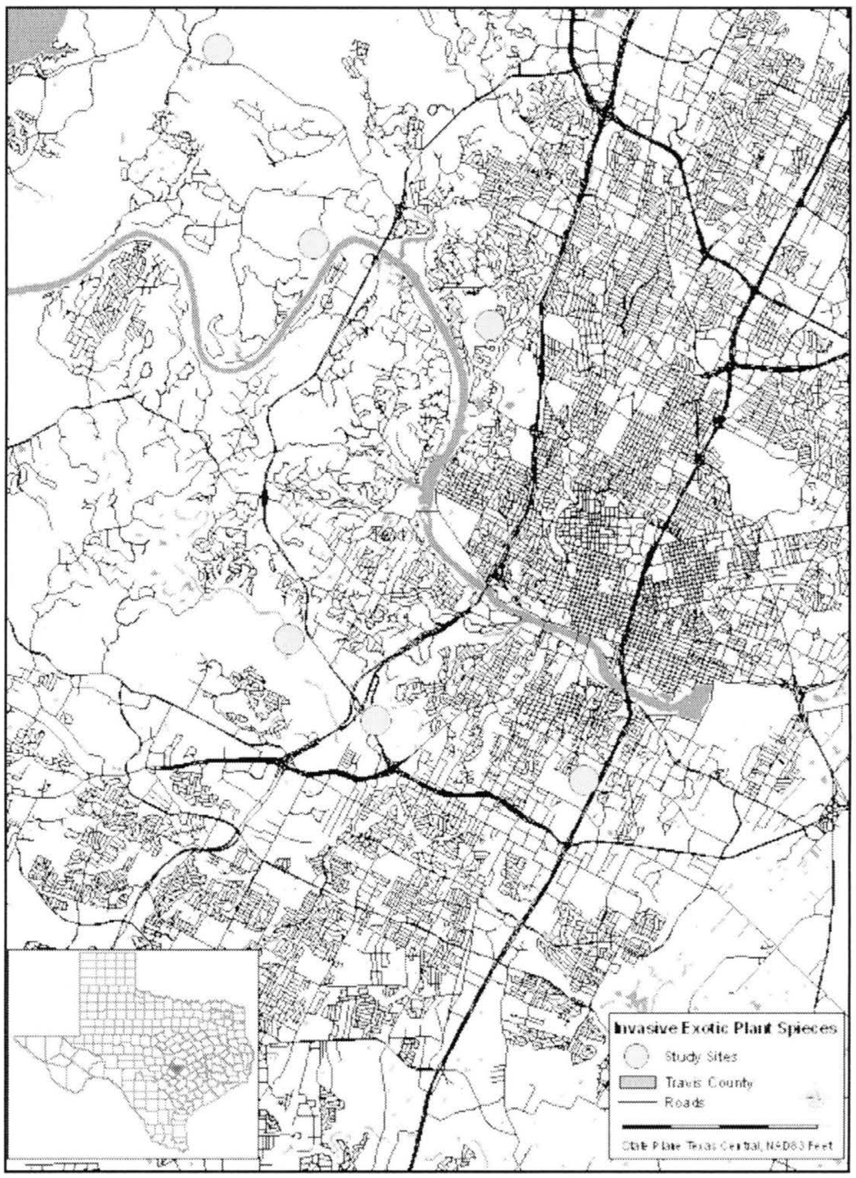


Figure 1. Location of the 6 survey properties in Travis County, Texas.

Bird Surveys

I conducted 199 fixed radius point count surveys (Hutto et al. 1986) on 13 points across the six study properties, to assess bird species richness, diversity, evenness, and relative abundance. Point count sites on each property were greater than 250-m apart Equipment required included binoculars (8x42), a hand held GPS unit, field guides, and a stop watch Each point count site was surveyed approximately once per month for 18 months between March 2004 and July 2005, thereby sampling during each season In an effort to maximize detection of various birds and reduce bias, dawn and dusk counts were conducted between 600h and 1100h or 1700h and 2000h (depending on wind, season and temperature) with start times for counts rotating from month to month The Barton Creek Greenbelt and the Barton Creek Wilderness Park were always completed in mornings and on weekdays with no alternation due to high human traffic of people later in the day or weekends Point count duration was 10 minutes, preceded by a 3 minute settling period (Scott and Ramsey 1981, Granholm 1983, Gates 1995) For the ten minute count period number of individuals of each bird species observed aurally or visually within the 100-m plot radius was recorded.

Data Analysis

Diversity and Evenness

Avian detections were summed for each species and categorized by season and habitat impact type Point count data were organized into three habitat categories, lightly impacted (0-24% invasive woody species, n = 8), moderately impacted (25-49% invasive woody species, n = 3) and heavily impacted (50-100% invasive woody species, n = 2) Likewise, all observations were temporally categorized into four seasons With this organization of raw data Brillouin's H Diversity Index and Smith and Wilson's index of evenness (E_{var}) were calculated (Krebs 2000) The Brillouin index (H) was used to evaluate species diversity among point count sites, while the Smith and Wilson's index of evenness estimated the equitability of individual observations among species within a point count site

Comparison of Impacted and Unimpacted Areas

I compared number of detections between years and seasons for impacted and unimpacted habitat types using a nonparametric multivariate analysis of variance (npMANOVA) technique based upon a multi-response permutation test (DISTLM, Legendre and Anderson 1999, Anderson 2001, McArdle and Anderson 2001) Because my data set contained a large amount of zeros, statistical transformation would not have been useful The use of permutations enabled us to derive the test statistics necessary from the raw data while avoiding the assumptions of normality (Anderson 2001).

The npMANOVA method of analysis partitions variation based upon any dissimilarity measure within a multi-factorial ANOVA design, and obtains *P*-values via permutation For this analysis, point count sites were categorized as either unimpacted (none to lightly impacted, 0-24% invasive woody species, n =8) or impacted (moderate to heavily impacted, 25-100% invasive woody species, n = 5), depending on abundance of invasive woody species. Detections were further categorized by year (2 levels) to evaluate differences between years during the study An npMANOVA allowed me to look for differences under the treatment factors: season x habitat x year Also, npMANOVA as implemented by DISTLM allowed for evaluation of an unbalanced, multifactorial ANOVA design using species abundance data Because counts of species within communities are non-normally distributed, parametric ANOVA assumptions could not be met. Thus I needed DISTLM to analyze these data

The npMANOVA also facilitated evaluation despite the uneven distribution (attributed to the high number of species with infrequent detections) within the data set and to address the multiple variables in the data. Additionally, an npMANOVA allowed the data to be analyzed with cover and time acting as categories and each of the different species detected as variables.

For all statistical tests $\alpha = 0$ 05

CHAPTER III

RESULTS

100-m line transect vegetation surveys indicated non-native, invasive woody species concentration to average 56 1 percent within each point count site designated as impacted Species dominant in the canopy cover of the impacted points were wax-leaf ligustrum, elm sp (*Ulmus sp.*), Ashe juniper (*Juniperus ashei*), greenbriar (*Smilax bona-nox*), and hackberry (*Celtis laevigata*) (Table 1).

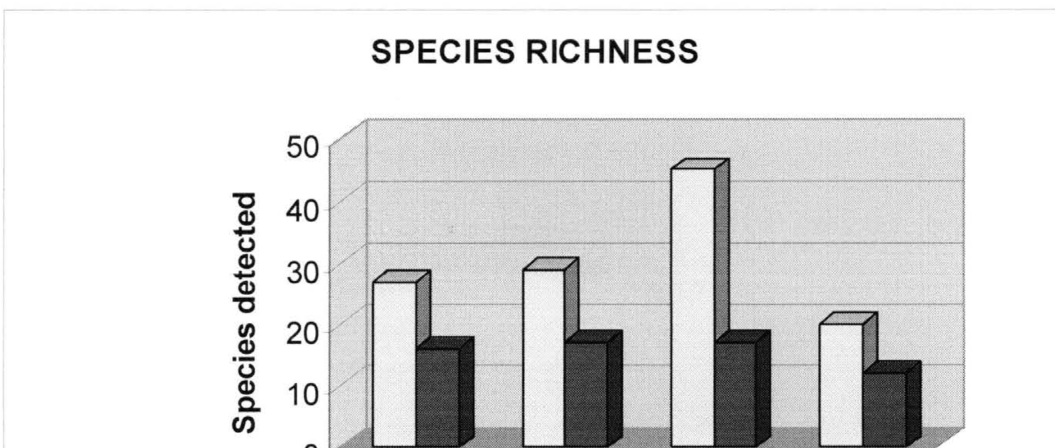
Similar vegetation surveys of the point count sites designated as unimpacted indicated on average, non-native, invasive woody species concentration of 1 73% The dominant canopy cover in the unimpacted points was Ashe juniper, Plateau live oak (*Quercus fusiformis*), elm, hackberry, and greenbriar (Table 1).

Point Count Site	Dominant Woody Vegetation	Total Percent Cover
UNIMPACTED		
Total invasives/strata	Ashe juniper	29 99
1.73%	Plateau Live oak	21 19
	Elm sp	20 45
	Hackberry	5 72
	Greenbrier	4 89
IMPACTED		
Total invasives/strata	Wax-leaf ligustrum	58 97
56 1%	Elm sp.	30 57
	Ashe juniper	30.17
	Greenbrier	21 63
	Hackberry	14.37

Table 1. Dominant woody vegetation for each stratum with total percent of invasive woody species per strata.

I visited each point count site between 14 and 18 times. Point count surveys averaged once per month in 2004 and in winter 2005 and increased to twice per month beginning in spring of 2005. The increased survey effort for spring and summer 2005 was to enhance detection of warblers and other migrating species. Sixty-two species and 1742 individual bird detections were recorded by combining all point count sites. Mean avian abundance per point count site, per visit was 8.7538 with a standard deviation of 5.22.

Avian species richness for the point count sites collectively designated as impacted by invasive, nonindigenous species (n = 5) was 32 with 448 total detections, while species richness for point count sites designated as unimpacted (n = 8) was 59 with 1294 total detections. Mean avian abundance per point count site was 10.4 per visit at impacted points with a standard deviation of 8.31; versus a mean of 8.29 at unimpacted point count sites with a standard deviation of 3.89 (Fig 2).



	Spring & Summer I	Fall & Winter I	Spring & Summer II	Fall & Winter II
□ Un-impacted	27	29	45	20
■ Impacted	16	17	17	12

Figure 2. Number of species observed by season & vegetation strata (unimpacted vs. impacted) in Travis County, Texas.

Thirty species were unique to the unimpacted stratum (Appendix B), including Canyon Wrens *(Catherpes mexicanus)*, Scarlet Tanagers *(Piranga olivacea)*, Golden-checked Warblers, Painted Buntings *(Passerina ciris)*, American Turkeys *(Meleagris gallopavo)*, and Tanager species *(Piranga sp.)* In contrast, only three species were unique to the impacted stratum, Eastern Meadowlarks *(Sturnella magna)* (with only one detection), Cedar Waxwings *(Bombycilla cedrorum)* and Western Kingbirds *(Tyrannus verticalis)* Nearly half of all species detected were absent from impacted point count sites (Fig 2)

Diversity and Evenness

Initial analysis using Brillouin's H Diversity Index to evaluate avian species diversity among point count sites and Smith and Wilson's index of evenness (E_{var}) to asses equitability of individual observations among species within each point count site indicated no differences between point count sites, seasons, or years (Table2) (data organized into three categories) Therefore, results and conclusions are based on the npMANOVA with data organized into two categories, impacted and unimpacted

Table 2. Diversity Indices.

	Light Impact	Moderate Impact	Heavy Impact
MEASURES OF HETEROGENEITY			
Simpson's Index	0 925	0 866	0.913
Reciprocal of Simpson's D (N2)	13 244	7 317	11 309
Shannon's H'	4 521	3 45	4 105
Number of Equally Common Species (N1)	22 96	10 93	17 2
Brillouin's H	4 39	3 251	3 934
MEASURES OF EVENNESS			
Carmargo E'	0 275	0 333	0.314
Simpson's E1/D	0 201	0 293	0 269
Modified NEE EQ	0 115	0 175	0 146
Smith & Wilson's EVAR	0 255	0 318	0 318

Comparison of Impacted and Unimpacted Areas

I used npMANOVA to explore differences in two different treatment factors (habitat x year) The npMANOVA results revealed significant differences between impact cover types (P = 0.04760), and year (P = 0 0002) There was also a significant cover x year interaction (P = 0 02180) The interaction among these two factors accounted for only a small portion of the variance in species diversity or abundance, indicating other factors influenced the analysis (Table 3) To accommodate the significant cover-time interaction detected, survey years were analyzed separately

Table 3. npMANOVA results from all tested interactions.

Sources	df	SS	MS	pseudo-*F*	*P*per[a]	Explained Var
Cover	1	0 93650	0 93650	1 53642	0 04760	0 0076
Time	1	2 36172	2.36172	3 87464	0 00020	0.0192
CxT	1	1 10971	1 10971	1 82060	0 02180	0 0090

n = 199 samples
Error = 195 118 8588 0 6095
Total = 198 123 2667
[a]*P*per = *P* value by unrestricted permutation

CHAPTER IV

DISCUSSION

The results of this analysis, specific to the Austin, Texas area indicates that presence of woody, nonindigenous, invasive plant species influences the suite of avian fauna present in the habitat. My study did not identify the degree to which nonindigenous vegetation influences avian diversity, the threshold at which percentage of nonindigenous vegetation becomes a significant negative influence, nor other factors influencing avian diversity and abundance

Collectively, the unimpacted point count sites had significantly higher species richness and abundance than those impacted by nonindigenous vegetation The large difference in number of point count detections at impacted and unimpacted point count sites indicates that vegetation influences avian abundance Presence of native plants and the natural vegetation structure they provide, very likely contributed to the high species richness and abundance observed in the unimpacted point count sites. The detection of 30 species unique to unimpacted point count sites seems to indicate avian preference for native flora

The npMANOVA identified differences between cover types and differences between years that could be attributed to the presence of nonindigenous vegetation and its influence on avian populations in a given habitat However, other factors may have influenced species richness and abundance, including observer ability, seasonal changes, habitat fragmentation, edge effects, and climactic changes could have also influenced the results of this study.

These results are consistent with other studies indicating the number of avian species declines with increasing urbanization (Williams and Karl 1996, Melles et al 2003, Borgmann and Rodewald 2004, Schmidt et al 2005) The Northern Cardinals *(Cardinalis cardinalis)*, Blue Jays *(Cyanocitta cristata)*, Carolina Wrens *(Thryothorus ludovicianus)* and Northern Mockingbirds *(Mimus polyglottos)* common in urban areas in my study are highly adapted to urban environments

This study supports the notion that nonindigenous woody vegetation is either lacking some environmental factor necessary for avian diversity, or presence of nonindigenous vegetation adds an element that is not conducive to avian diversity These elements may include altered thermal cover, vertical structure, nesting sites, or food resources In addition, nonindigenous vegetation might be responsible for increased nest predator success as was suggested by Robinson et al (1995)

Nonindigenous vegetation is most common in edge areas The argument can be made that decreased avian abundance is related to increased edge-related predation and disturbance and not necessarily to the vegetative substrate Borgmann and Rodewald (2004) found compelling evidence that the nest substrate itself, rather than the location within a site, was responsible for the increased predation and subsequent decreased nest success

CHAPTER V

MANAGEMENT IMPLICATIONS

The conservation of urban natural areas presents land managers with serious challenges. Often, these areas are highly fragmented, over-run with invasive nonindigenous species, and frequently lacking in key ecological processes (Grese 1999) They represent, however, habitat to species residing within urban areas

Species richness is a fundamental measure of community and regional diversity (Gotelli et al 2001). Therefore, in combination with the species richness and abundance results of the npMANOVA, my study identified nonindigenous woody plants as a contributing factor to the decline of avian diversity in the urban forest areas of central Texas My conclusions agree with the broad statement that increasing urbanization adjacent to natural areas and parks often results in simplified habitats and a community of birds with fewer species, dominated by abundant non-native species (Marzluff et al 2001). Based on the results of this study, it would seem prudent that when managing for optimum avian diversity and abundance, to take a course of action that would reduce the presence of nonindigenous woody vegetation from heavily infested areas.

The constant sale and use of these nonindigenous plant species for landscaping is a formidable problem The invasive and irruptive nature of these plants coupled with the constant seed source provided by exotics planted in surrounding neighborhoods serves only to compound the difficulty of implementing any action aimed at restoring native woody vegetation in urban, forested areas

This study provides baseline information for managers Ideally, efforts to reduce nonindigenous vegetation in these impacted areas would be undertaken immediately A follow up study to evaluate changes in avian species richness and abundance following the removal of nonindigenous vegetation would be appropriate In addition to the removal and control of the nonindigenous species in urban natural areas, efforts should be taken to increase implementation of sound management practices in the surrounding community that will enhance the value of these areas for birds (Melles et al 2003)

APPENDICES

Appendix A Comprehensive list of bird species observed on 13 study points by impact strata, in Travis County, Texas between March 2004 and August 2005

Scientific Name[a]	Common Name	Abbreviation	Unimpacted	Impacted
Unknown	Unknown		8	2
Accipiter striatus	Sharp-shinned Hawk	SSHA	1	0
Aix sponsa	Wood Duck	WODU	2	0
Aphelocoma californica	Western Scrub Jay	WESJ	3	0
Archilochus colubris	Ruby-throated Hummingbird	RTHU	4	1
Ardea herodias	Great Blue Heron	GBHE	1	0
Bombycilla cedrorum	Cedar Waxwing	CEWW	0	65
Buteo jamaicensis	Red-tailed Hawk	RTHA	16	4
Buteo lineatus	red shoulder hawk	RSHA	1	0
Butorides virescens	Green Heron	GRHE	3	0
Cardinalis cardinalis	Northern Cardinal	NOCA	273	80
Carduelis tristis	American Goldfinch	AMGO	10	2
Carpodacus mexicanus	House Finch	HOFI	20	3
Cathartes aura	Turkey Vulture	TUVU	6	2
Catharus guttatus	Hermit Thrush	HETH	1	0
Catherpes mexicanus	Canyon Wren	CNWR	21	0
Ceryle alcyon	Belted Kingfisher	BEKI	1	0
Chaetura pelagica	Chimney Swift	CHSW	3	0
Contopus virens	Eastern Wood Pewee	EAWP	2	0
Coragyps atratus	Black Vulture	BLVU	24	0
Corvus brachyrhynchos	American Crow	AMCR	9	1
Cyanocitta cristata	Blue Jay	BLJA	56	70
Dendroica chrysoparia	Golden-cheeked Warbler	GCWA	13	0
Dendroica coronata	Yellow-rumped Warbler	YRWA	10	9
Falco sparverius	American Kestrel	MAKE	1	1
Hirundo rustica	Barn Bwallow	BASW	4	0
Icterus galbula	Northtern Oriole	NOOR	1	0
Melanerpes aurifrons	Golden-fronted Woodpecker	GFWO	3	0
Melanerpes carolinus	Red-bellied Woodpecker	RBWO	10	6
Meleagris gallopavo	American Turkey	AMTU	3	0
Mimus polyglottos	Northern Mockingbird	NOMO	65	20
Mniotilta varia	Black and White Warbler	BWWA	1	0
Molothrus ater	Brown-headed Cowbird	BHCO	2	1
Nyctanassa violacea	Yellow-crowned Night heron	YCNH	1	0
Baeolophus atricristatus	Black-crested Titmouse	BCTI	72	15
Passerculus sandwichensis	Savannah Sparrow	SASP	1	6
Passerella iliaca	Fox Sparrow	FOSP	2	0
Passerina ciris	Painted Bunting	PABU	1	0
Passerina cyanea	Indigo Bunting	INBU	1	0
Picoides scalaris	Ladder-backed Woodpecker	LBWO	1	2
Piranga olivacea	Scarlet Tanager	SCTA	1	0
Piranga rubra	Summer Tanager	SUTA	4	0
Poecile carolinensis	Carolina Chickadee	CACH	99	17
Polioptila caerulea	Blue-gray Gnatcatcher	BGGN	27	0
Progne subis	Purple Martin	PUMA	5	0
Quiscalus quiscula	Common Grackle	COGR	14	2

Appendix A Comprehensive list of bird species observed on 13 study points by impact strata, in Travis County, Texas between March 2004 and August 2005

Scientific Name[a]	Common Name	Abbreviation	Unimpacted	Impacted
Regulus calendula	Ruby-crowned Kinglet	RCKI	42	5
Sayornis phoebe	Eastern Phoebe	EAPH	17	4
Spizella passerina	Chipping Sparrow	CHSP	7	0
Spizella pusilla	Field Sparrow	FISP	8	0
Sturnella sp	Meadowlark sp		0	1
Thryomanes bewickii	Bewick's Wren	BEWR	23	1
Thryothorus ludovicianus	Carolina Wren	CAWR	219	62
Turdus migratorius	American Robin	AMRO	27	19
Tyrannus verticalis	Western Kingbird	WEKI	0	2
Vermivora ruficapilla	Nashville Warbler	NAWA	7	3
Vireo flavifrons	Yellow-throated Vireo	YTVI	7	0
Vireo griseus	White-eyed Vireo	WEVI	103	12
Vireo olivaceus	Red-eyed Vireo	REVI	3	0
Zenaida asiatica	White-winged Dove	WWDO	5	13
Zenaida macroura	Mourning Dove	MODO	15	15
Zonotrichia albicollis	White-throated Sparrow	WTSP	4	2
			1294	448

[a] Scientific and common names follow The USF&W Bird Banding Lab codes (Klimkiewicz and Robbins, 1978)

Appendix B Species unique to the unimpacted and impacted point count sites shown separately

Species unique to the unimpacted strata	
Scientific Name	Common Name
Accipiter striatus	Sharp-shinned Hawk
Aix sponsa	Wood Duck
Aphelocoma californica	Western Scrub Jay
Ardea herodias	Great Blue Heron
Buteo lineatus	Red-shouldered Hawk
Butorides virescens	Green Heron
Catharus guttatus	Hermit Thrush
Catherpes mexicanus	Canyon Wren
Ceryle alcyon	Belted Kingfisher
Chaetura pelagica	Chimney Swift
Contopus virens	Eastern Wood Pewee
Coragyps atratus	Black Vulture
Dendroica chrysoparia	Golden-checked Warbler
Hirundo rustica	Barn Swallow
Icterus galbula	Northern Oriole
Melanerpes aurifrons	Golden-fronted Woodpecker
Meleagris gallopavo	American Turkey
Mniotilta varia	Black and White Warbler
Nyctanassa violacea	Yellow-crowned Night Heron
Passerella iliaca	Fox Sparrow
Passerina ciris	Painted Bunting
Passerina cyanea	Indigo Bunting
Piranga olivacea	Scarlet Tanager
Piranga rubra	Summer Tanager
Polioptila caerulea	Blue-grey Gnatcatcher
Progne subis	Purple Martin
Spizella passerina	Chipping Sparrow
Spizella pusilla	Field Sparrow
Vireo flavifrons	Yellow-throated Vireo
Vireo olivaceus	Red-eyed Vireo

Unique to the impacted point count sites	
Scientific Name	Common Name
Bombycilla cedrorum	Cedar Waxwing
Sturnella sp	Meadowlark sp
Tyrannus verticalis	Western Kingbird

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VITA

Arlene Kalmbach was born in Sunnyside Queens, New York on September 15, 1975 She is the oldest daughter of Thomas Nohilly, Irish immigrant and retired airline employee, and Rosemarie Nohilly, Spanish instructor and Brooklyn native of Puerto Rican decent Arlene graduated from Holy Trinity Diocesan High School in 1993 and received a minority scholarship and subsequent Bachelor of Science degree in Agriculture, from Truman State University – Kirksville, Missouri 1997

After graduation, she moved to Lexington, Kentucky and worked in the Thoroughbred racing industry throughout the US, UK and Australia In the spring of 2001, Arlene accepted a position at the College of Veterinary Medicine at Texas A&M University as the weekend emergency anesthetist One year later she transferred from the anesthesia department into the Zoological Medicine Department. In the summer of 2003 she entered the Graduate College of Texas State University-San Marcos, Texas as a graduate student in the Department of Biology. In the spring of 2004 she married Dr Michael Kalmbach, DVM In the winter of 2006 she accepted employment with the Texas Parks and Wildlife Department as the Program biologist for the Landowner Incentive Program and State Wildlife Grants Program

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