

EFFECTS OF PATCH SIZE AND MATRIX TYPE ON BIRD ASSEMBLAGES
WITHIN CENTRAL FLORIDA CYPRESS DOMES

by

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A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Department of Biology
in the College of Arts and Sciences
at the University of Central Florida
Orlando, Florida

Spring Term
2006

ABSTRACT

The numerous studies on the effects of patch size on bird assemblages have produced varied results. I studied the effects of patch size and surrounding matrix on bird assemblages within central Florida cypress domes. My null hypothesis was that bird assemblages within cypress domes are unaffected by dome size or development in the matrix around the dome. My alternative hypothesis was that differences in bird assemblages are correlated with size and the degree of development within the matrix. I classified a pool of over a thousand domes according to three size categories and four matrix types. Three representatives for each combination of size and matrix were spot mapped for birds from May through August 2005. I examined the relationship of species richness and bird guilds to patch size and surrounding matrix. I also measured a series of potential covariates for each dome to account for variation among the three size-matrix representatives for each combination. Richness and abundance counts were divided by the number of listening points to standardize the data by effort.

I found that the standardized species richness of bird assemblages significantly increased with the patch size of cypress domes; however, matrix and the interaction effect of size and matrix on overall standardized species richness were not significant. Significant covariates included percent of the buffer undeveloped, percent herbaceous cover, and the number of listening points per unit area. A linear regression tested for significant effects of log area and matrix on standardized species richness. Matrix was not significant, but log area did have a significant effect on standardized species richness.

The MANOVA tests for guild richness data indicated no significant effects of dome size, matrix, or their interaction effect on diet, foraging, or location guilds. There were no significant

main or interaction effects on any individual guilds in the ANOVA output. Individual backward linear regressions done on each guild indicated that matrix did not have significant effects on any guild, but log area had significant effects on ground foragers, lower-canopy foragers, omnivores, herbivores, and edge species.

I then investigated the effects of size and matrix on standardized guild abundance. Dome size and matrix significantly effected diet guild abundance, but the size-matrix interaction did not. Dome size significantly affected insectivores, omnivores, and carnivores. Matrix had a significant effect on omnivores, herbivores, and carnivores. The size and matrix interaction had a significant effect on carnivores. Dome size and matrix significantly affected foraging guild abundance, but the size-matrix interaction did not. Dome size significantly affected ground, lower- and upper-canopy foragers. Matrix had a significant effect on ground, water, and upper-canopy foragers. The size and matrix interaction was not significant for any foraging guild. Dome size and matrix significantly effected location guild abundance, but the size-matrix interaction did not. Dome size significantly affected edge and interior species. Matrix had a significant effect on edge and interior species. The size and matrix interaction was not significant for any location guild.

The relationship between species richness and habitat area is well-documented, and the results of this study were consistent with the expectation of higher species richness in larger areas. If maintaining high species richness is the sole goal of conservationists, then large habitat fragments would be preferable regardless of surrounding matrix. Nevertheless, species richness alone is not informative of the potential effects of patch size and matrix on the composition of an

avian assemblage. Guild analysis gives insight into community structure and should be considered in addition to simple measures of species richness.

Patch size and matrix type significantly affected a number of guilds, and several factors could contribute to the observed differences in guilds across patch size categories and matrix types. Different habitats are available to birds in domes of each size class and matrix type. The potential for diverse foraging opportunities increases as domes increase in size and change in relation to their surrounding matrix. A more detailed analysis is needed to determine how differences in vegetation of domes and surrounding matrix affect guilds, members of which may use habitats both within domes and the matrix.

Cypress domes in the central Florida area face severe alteration or destruction due to rapid development. Long-term research that focuses on domes before and after development is needed to understand how changes in the matrix or size of the domes affect all resident flora and fauna. A variety of taxa and biogeochemical processes should be researched. Domes are naturally highly variable in size, shape, and structure, and development changes all of these characteristics. Conservation biologists and managers urgently need to determine how development affects cypress domes and what can be done to maintain their characteristic biodiversity.

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LIST OF ACRONYMS/ ABBREVIATIONS

ANHI	anhinga	<i>Anhinga anhinga</i>
BACS	Bachman's sparrow	<i>Aimophila aestivalis</i>
BLVU	black vulture	<i>Coragyps atratus</i>
BGGN	blue-gray gnatcatcher	<i>Poliophtila caerulea</i>
BLJA	blue jay	<i>Cyanocitta cristata</i>
BTGR	boat-tailed grackle	<i>Quiscalus major</i>
BHNU	brown-headed nuthatch	<i>Sitta pusilla</i>
BRTH	brown thrasher	<i>Toxostoma rufum</i>
CARW	Carolina wren	<i>Thryothorus ludovicianus</i>
CAEG	cattle egret	<i>Bubulcus ibis</i>
CEDW	cedar waxwing	<i>Bombycilla cedrorum</i>
CONI	common nighthawk	<i>Chordeiles minor</i>
COYE	common yellowthroat	<i>Geothlypis trichas</i>
DOWO	downy woodpecker	<i>Picoides pubescens</i>
EAME	eastern meadowlark	<i>Sturnella magna</i>
EATO	eastern towhee	<i>Pipilo erythrophthalmus</i>
ECDO	Eurasian collard dove	<i>Streptopelia chinensis</i>
FICR	fish crow	<i>Corvus ossifragus</i>
GBHE	great blue heron	<i>Ardea herodias</i>
GCFL	great-crested flycatcher	<i>Myiarchus crinitus</i>
GREG	great egret	<i>Ardea alba</i>
GRHE	green heron	<i>Butorides virescens</i>
KILL	killdeer	<i>Charadrius vociferus</i>
LBHE	little blue heron	<i>Egretta caerulea</i>
MALL	mallard	<i>Anas platyrhynchos</i>
MODU	mottled duck	<i>Anas fulvigula</i>
MODO	mourning dove	<i>Zenaida macroura</i>
NOBO	northern bobwhite	<i>Colinus virginianus</i>
NOCA	northern cardinal	<i>Cardinalis cardinalis</i>
NOFL	northern flicker	<i>Colaptes auratus</i>
NOMO	northern mockingbird	<i>Mimus polyglottos</i>
NOPA	northern parula	<i>Parula americana</i>
PIWO	pileated woodpecker	<i>Dryocopus pileatus</i>
PIWA	pine warbler	<i>Dendroica pinus</i>
PUMA	purple martin	<i>Progne subis</i>
RBWO	red-bellied woodpecker	<i>Melanerpes carolinus</i>
RSHA	red-shouldered hawk	<i>Buteo lineatus</i>
RTHA	red-tailed hawk	<i>Buteo jamaicensis</i>
RWBL	red-winged blackbird	<i>Agelaius phoeniceus</i>
ROOS	domestic chicken	<i>Gallus domesticus</i>

SACR	sandhill crane	<i>Grus canadensis</i>
SNEG	snowy egret	<i>Egretta thula</i>
TUTI	tufted titmouse	<i>Baeolophus bicolor</i>
WEVI	white-eyed vireo	<i>Vireo griseus</i>
WHIB	white ibis	<i>Eudocimus albus</i>
WITU	wild turkey	<i>Meleagris gallopavo</i>
YBCU	yellow-billed cuckoo	<i>Coccyzus americanus</i>
YTWA	yellow-throated warbler	<i>Dendroica dominica</i>

CHAPTER ONE: INTRODUCTION

In today's world, scientific and technological advances are made with amazing speed. Sometimes the consequences of progress are unpredictable, and scientists must undertake the difficult task of reconciling the needs of the natural world with the demands of a rapidly developing society. Many cities are quickly growing and expanding into their surrounding natural lands. The intricate interplay of flora and fauna becomes further complicated when anthropogenic forces begin to encroach upon natural areas. The consequences of "urbanization" are complex. One result of urbanization is habitat fragmentation, or the reduction of a large tract of land into several smaller patches. Natural processes such as fire and windfall can cause habitat fragmentation, but human activities such as urbanization and agriculture are the major causes today (Andren 1994). Some habitats are naturally patchy, such as isolated wetlands, and in those cases the surrounding matrix may change radically as landscapes are modified by urbanization.

The landscape resulting from urbanization cannot be classified simply as either urban or rural. There are a variety of land uses that may each have a different degree of similarity to the predevelopment habitat; moreover, the perceived similarity varies by species. A land-use gradient occurs, and the result is often patches of natural or semi-natural habitat surrounded by various degrees of development. For example, a business district or office park with manicured lawns full of exotic vegetation would look very different from the area's original state. A park or recreational area may be closer to natural conditions than the business district or office park, and an actively managed preserve may be more similar to predevelopment conditions.

Urban gradient analysis can be used to examine the complex effects of a fragmented, patchy landscape on species richness and composition (Blair 1996). Typically several study areas with different degrees of development are surveyed, and the results can be analyzed as samples of a continuum of land development. Past studies that investigated a gradient of land types have described a few general trends. Factors of anthropogenic disturbance, such as human population density, soil compaction, road density, and air and soil pollution decrease when moving away from the urban core, and there is a simultaneous loss in natural habitat that becomes more evident when moving closer to the urban core (Blair 1996, Germaine et al. 1998, McKinney 2002).

Birds are typically easy to detect and are often surveyed to compare habitats across a land-use gradient. Several generalities are rather consistently supported in bird assemblage studies. For example, bird species richness increases as landscape or patch size increases (Donnelly and Marzluff 2004). Results within bird assemblages have also been consistent with the intermediate disturbance hypothesis in that species richness is at its highest at intermediate levels of disturbance (Connell 1978; Chalfoun et al. 2001, McKinney 2002). However, increased diversity does not mean that all of the species present are predevelopment species. Exurban developments allow non-native and human-commensal species to flourish, possibly to the detriment of other native species (Noss 1983, Maestas et al. 2003). Therefore, conservation biologists generally do not consider high species richness or diversity, unless restricted to native or narrow endemic taxa, a defensible conservation goal at any spatial scale smaller than global.

In urban areas, where levels of development are at their peak, species richness is generally lower, and the presence of non-native species is more prominent than in rural habitats. Urban bird assemblages in North America and Europe are dominated by a few species that can

quickly colonize and reproduce in artificial habitats (Beissinger and Osborne 1982). Therefore, while bird species richness may be lower in both predevelopment and urban areas than in areas of intermediate disturbance, bird assemblage composition is typically different in each case. Three components of habitat fragmentation—loss of original habitat, reduced patch size, and increased isolation of patches—all contribute to the decline of biodiversity seen in the original habitat (Andren 1994).

It is not surprising that habitat fragments function differently from the original larger tract of land. The small pieces of land left behind are discontinuous patches with a higher proportion of exposed habitat at the perimeter, or edge habitat, than there would have been in the original tract. Severely fragmented habitats are virtually all edge because the entire area within the patch is close to an edge (Temple and Cary 1988). The environmental conditions at the edge of a patch differ from the interior. Treefall rate, temperature, wind, and light penetration are higher at the edge of fragments, and the humidity is lower (Harrison and Bruna 1999, Noss et al. 2005). The fragmented habitat resulting from urbanization does not hinder the reproduction and survival of all species, but it is well-documented that increased edge habitat is harmful for many bird species.

Watson et al. (2004) found that over 68% of forest-dependent species were edge-sensitive in coastal forests of Madagascar. Interior-edge birds in 46 tracts in Connecticut were equally represented in large and small tracts, but forest-interior species were most common in large forests (Askins et al. 1987). The research of Whitcomb et al. (1981) in eastern deciduous forests shows that only large forest tracts contain the majority of the regional species pool and neotropical migrant forest-interior birds. Neotropical migrants are poorly adapted for survival in small forest fragments. Open cup nests used by most neotropical migrants have low

reproductive success in small forest tracts due to frequent nest predation and parasitism by edge-associated species (Askins et al. 1990). Evidence of a negative edge effect on nesting success has also been observed in cavity-nesting species (Deng and Gao 2005).

Higher predation rates near patch edges lead to lower fledgling success, and edges show higher activity of small mammals and brown-headed cowbirds than in patch interiors (Gates and Gysel 1978). A recent meta-analysis of sixty-four experiments confirmed the results of numerous past reviews and showed increased nest predation at habitat edges (Bataary and Baldi 2004). Nest predation and brood parasitism have been shown to increase as prairie fragment sizes decrease for grassland species such as the grasshopper sparrow, Henslow's sparrow, eastern meadowlark, and dickcissel, presumably due to the increased edge to area ratio (Herkert et al. 2003). Predation rates on ovenbirds and Kentucky warblers and parasitism levels of wood thrushes and hooded warblers in fragmented forests are so high that the habitat patches become population sinks (Robinson et al. 1995).

A landscape mosaic contains habitat patches embedded in a matrix, and a species' presence in one particular patch may not just reflect patch size and isolation but also its relation to the neighboring habitat (Andren 1994). Numerous studies on edge effect are testimony to the importance of considering what happens when two different habitats meet. Brown and Curtain (2001) introduced the concept of the "semi-natural matrix", defined by areas of species' use outside of conservation areas that are important because they provide habitat, act as buffers, and provide connectivity between conservation areas (Groves 2003). Brown's semi-natural matrix illustrates the importance of considering the quality of habitat surrounding natural areas. For example, birds inhabiting a natural area may also use the surrounding matrix and vice versa. A highly-disturbed matrix can promote colonization by nonnative, invasive plants and predators,

which makes it difficult for some native species, especially avian species, to persist (McKinney 2002).

Nonnative species flourish in disturbed environments, which can lead to problems when solely taking measures of species richness when studying bird assemblages. Species richness does not provide insight into whether birds are predominantly native or exotic or how they are using a habitat. Thus species richness is not a complete indicator of whether bird assemblages in natural areas are similar to those found in near-natural or degraded areas.

Guild analyses can supplement species richness. Guild analysis reveals niche separation and functional relationships within and between communities and how habitat change affects community dynamics (Graaf et al. 1985). For example, insectivore birds switched from canopy foliage gleaners and bark drillers in a forested area to a predominance of ground gleaners in an urban area; variables, such as vegetative composition and continuity in the strata correlated with guild presence between different habitats (Beissinger and Osbourne 1982). Guild analysis can also be used to rank areas for conservation because guilds differ in sensitivity to habitat change (Bishop and Myers 2004). For example, O'Connell et al. (1998) developed a bird community index (BCI) to score sites based on relative proportions of specialists and generalists, and then compared scores across multiple sites to assess the biotic integrity of different areas. Two ways to analyze guild data are to use calculations involving guild richness and guild abundance. Guild abundance uses the number of individuals representing each guild to determine how a site is being used. Guild richness is a measure of how many species are present in a guild to determine which guilds are most prominent at a site.

Florida is home to an interesting assortment of flora and fauna, but one habitat unique to it is cypress domes. The characteristic shape of cypress domes comes from the apparent

arrangement of taller trees in the center of a bowl-shaped depression that lowers to shorter trees on either side (Mitsch 1984). Cypress domes vary in shape, and although they appear dome-like from a distance, they can be open in the center. The bowl-shaped depressions expose the shallow water table, and cypress-dominated wetlands are located throughout poorly drained pine flatwoods and plantations in northern and central Florida (Ewel 1990). Cypress domes in the greater Orlando metropolitan area, an area in central Florida known for its rapid growth and expansion (The Metropolitan Center for Regional Studies 2005), provide an excellent opportunity to examine the effects of the matrix on bird use of an embedded habitat. Development and fragmentation within the matrix could potentially cause floral and faunal changes within cypress domes. Even if cypress domes are intact in terms of vegetation, the lands surrounding them are often developed and fragmented to some degree. The landscape matrix surrounding cypress domes varies, and variation in edge effects can be expected.

I surveyed bird assemblages in central Florida cypress domes surrounded by a gradient of undeveloped and developed land to investigate how anthropogenic change in the matrix may be influencing species composition. Surveying bird assemblages and habitat variables within cypress domes alone may not provide a complete understanding of why the assemblage is structured as it is. The habitat surrounding the cypress dome must also be considered. New housing communities and subdivisions arise constantly along the outskirts of Orlando, hence urbanization is a reality with which the species using cypress domes in central Florida must contend. My null hypothesis was that bird assemblages within cypress domes are unaffected by dome size or development in the matrix around the dome. My alternative hypothesis was that differences in bird assemblages are correlated with size and degree of development within the matrix.

CHAPTER TWO: METHODS

I used ArcGIS 9 to assemble a pool of cypress domes as potential study sites in the central Florida area and downloaded data layers from the St. Johns River Water Management District (<http://sjr.state.fl.us/>). Aerial photographs selected from this website were taken in 2004 (Figure 1a). Domes (N = 36) within a 15-km radius of my residence in the east Orlando area were included within the pool of wetlands (for example, Figure 1b). This distance was long enough to ensure that a large number of domes would be included in the pool but short enough so that several domes could be surveyed in one morning. The area enclosed within the circle also included a variety of habitat such as residential areas, business districts, agricultural areas, and undeveloped areas like Hal Scott Regional Preserve and Park and the south Alafaya branch of the Orlando Utilities Commission. I exported the areas of all the domes from GIS into an Excel document and then created several histograms. I used the breaks in the data to determine size classes: small (1- 6999 m²), medium (7000 – 26,999 m²), and large (27,000 – 1,375,000 m²).

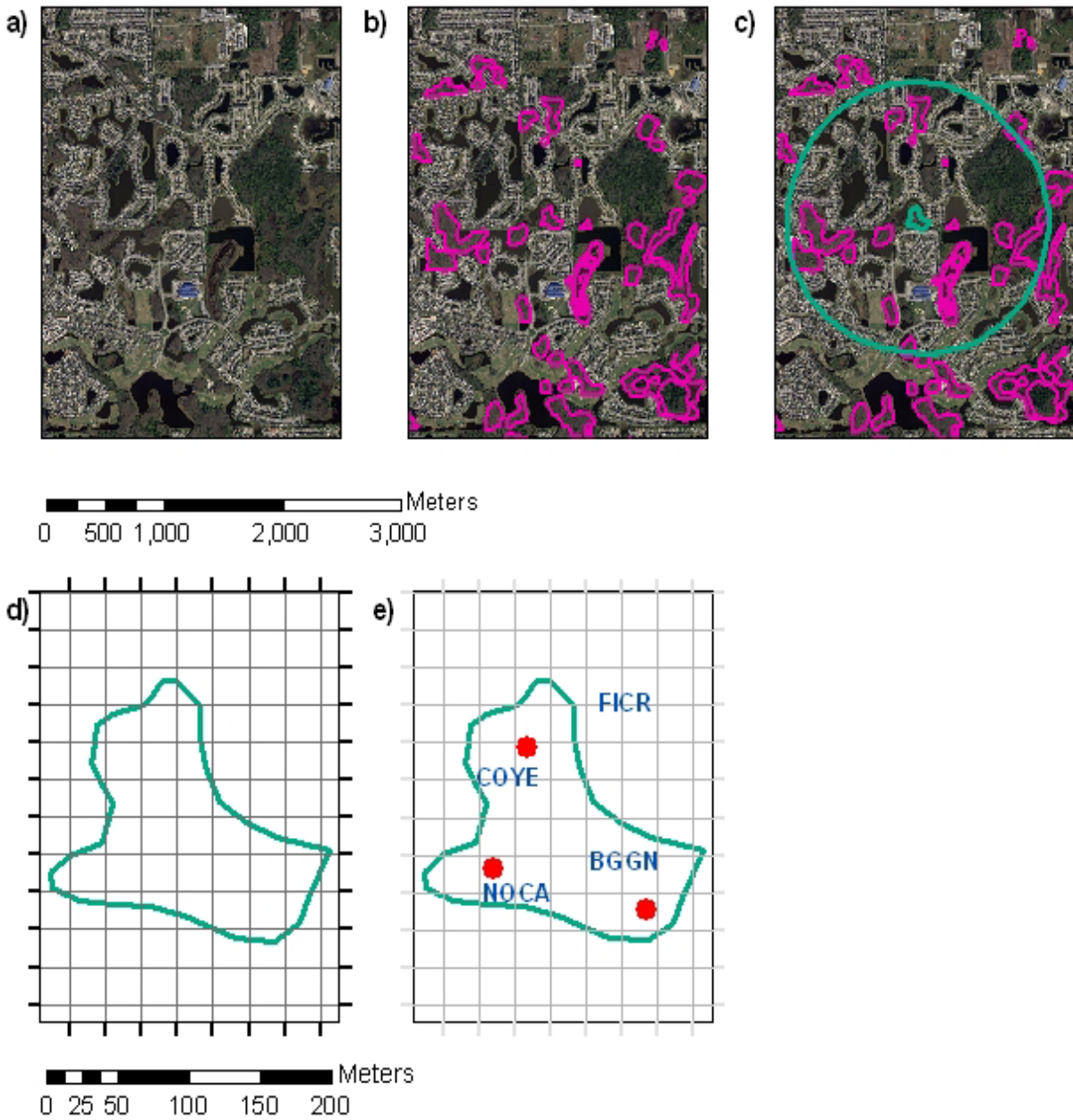
I drew a 1-km buffer around each dome (Figure 1c) and examined land-use included within the buffer to determine the matrix for each dome. The four matrix types are flatwoods, pasture, low-density residential, and high-density residential. I classified domes as being in a flatwoods matrix when the majority of the buffer was hammock or flatwoods. The buffers of pasture domes were dominated by lands that have been cleared for grazing, and the buffers of low-density residential domes have some housing intermixed with undeveloped areas. I classified domes as high-density residential when the majority of the buffer was highly-developed (i.e. housing, shopping centers, high-traffic roadways). Low-density residential areas had approximately one dwelling per two acres, and high-density residential buffers had more

than one dwelling per two acres. The buffers sometimes contained more than one matrix type, so I estimated what percentage of the buffer belonged to each matrix type. I then classified the dome according the dominant matrix, defined as $\geq 60\%$ of the buffer.

Once the size and matrix were determined for each dome, I randomly selected three representatives for each combination of size and matrix. I compared aerial photographs from 1999 located at www.terraserver.com to the 2004 aerial photographs to see how much the buffer had changed over a five year period. If the buffer was dominated by different matrices in 1999 and 2004, then a replacement dome was randomly selected. Once all the domes were chosen, the dome owners were determined using the interactive Orange County INFOMAP (<http://www.orangecountyfl.net/cms/default.htm>). I mailed letters to addresses found at <http://www.ocpafl.org/>, Orange County's property appraiser's web site, and followed up with telephone calls. Replacement domes that fulfilled the criteria were selected randomly on an individual basis if permission to access a dome was denied.

Once permission for visitation of the necessary thirty-six domes was secured (Table 1), I used ArcGIS 9 to create survey data sheets. I overlaid a 25 x 25 m grid on the domes and printed the outline on a sheet of paper to use for data collection (Figure 1d). I visited each dome to map and flag listening points and save listening point locations in a handheld GPS unit. I placed listening points 100 meters apart. I conducted spot mapping of birds seen or heard four times between May 8th and August 31st of 2005 from half an hour before sunrise until four hours after sunrise. I allowed a two-minute settling period before data collection at each point (Gibbons et al. 1996). Spot mapping at each point was done for one five-minute interval. I recorded bird movements unless they happened in reaction to the observer, and I noted observations of

individual birds using both domes and adjacent habitat (Figure 1e). I recorded birds seen or heard up to 50 m from the wetland's edge.



a) aerial photograph of the Waterford Lakes area in eastern Orlando, b) cypress domes seen in the aerial photograph, c) 1-km buffer around selected cypress dome, d) 25-m x 25-m grid overlaid on selected dome, e) example of a grid marked from a bird survey; red dots indicate listening points and four-letter banding codes are used to denote bird species present

Figure 1: Site Selection and Data Collection

Table 1: List of study sites, by category

		Size				
		<i>Small</i>	<i>Medium</i>	<i>Large</i>		
Matrix		OUC 1	Hal Scott 1	OUC 2	3	
		OOCEA	Morgran	OUC 3		
	Flatwoods	Anonymous 2-1	Anonymous 2-2	Anonymous 2-3		9
		B. Schlusemeyer 1-1	International Corp. Park	B. Schlusemeyer 2-1	9	
		Anonymous 1-1	B. Schlusemeyer 1-2	B. Schlusemeyer 2-2		
	Pasture	Anonymous 1-2	B. Schlusemeyer 1-3	Anonymous 1-3		
		Wedgfield 41	G. W. Smith	Hal Scott 3	9	
		Lockheed	Wedgfield 44	Bad Dogg Driving Range		
	Low-Density	Wedgfield 45	Hal Scott 2	Lake Kehoe HOA		
		Regency Park	R/C World of Florida	Legacy Land Corp.	9	
		Pine Harbour	Centex Homes	Cypress Springs HOA		
	High-Density	Rio Pinar Golf Course	Eastwood HOA 1	Eastwood HOA 2		
		4	12	12	12	36

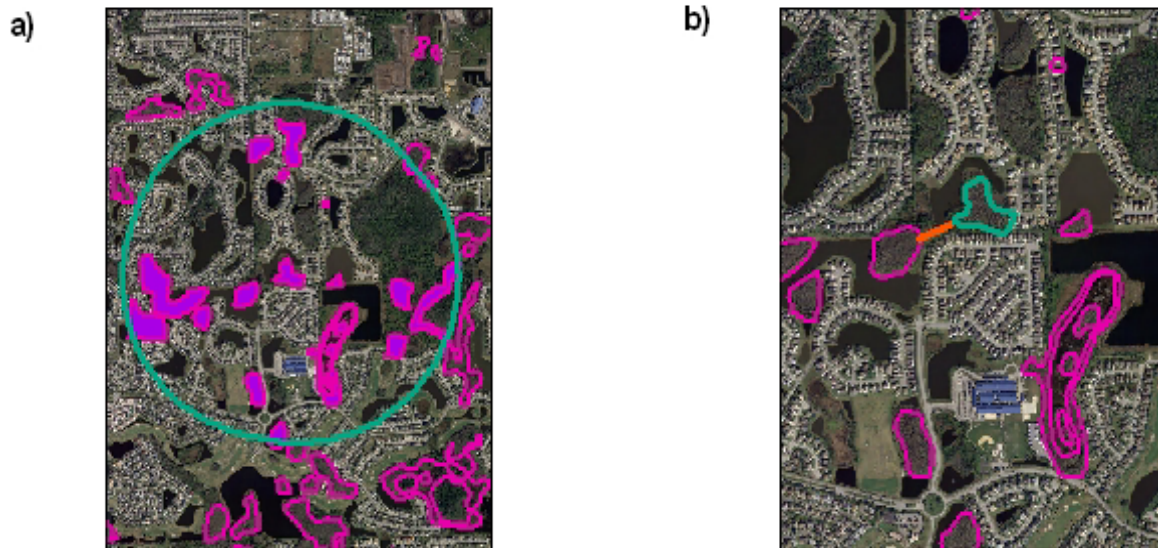
Overall Presence/Absence Analyses

I analyzed the effects of patch size and matrix type on bird assemblages using SPSS 11.5 for Windows (2002). Presence/ Absence data were recorded for each species at each site, and analyzed in aggregate by five different methods: three focused on species richness, and two other methods focused on the pattern of presence/absence data among domes. In addition, presence/absence data were also analyzed per guild (see Guild Analyses below).

Species Richness Regression and ANCOVA. Data were compiled to determine the species richness of each site, and then divided by the number of listening points for each dome to

correct for sampling effort. Area was also log transformed to normalize the data. Analysis of covariance (ANCOVA) was conducted to test the effects of size class and matrix type on standardized species richness, while also accounting for the effects of various covariates. The covariates differ among natural ecosystems that are not necessarily independent, identical experiment units. Covariates included variables collected from GIS (edge-to-area ratio, distance to nearest dome, distance to nearest retention pond, and total area of cypress domes within 1 km buffer; Figures 2a and 2b) and data collected on site. I estimated average water depth at a location determined during the first visit to each dome. Canopy cover was recorded with a vertically-oriented digital camera equipped with a 180°-degree fish-eye lens and analyzed with Gap Light Analyzer (GLA; http://www.rem.sfu.ca/forestry/downloads/gap_light_analyzer.htm), version 2.0 according to guidelines established by Simon Fraser University (1999). I visually estimated percent herbaceous and percent shrub cover and used the property appraiser's web site to determine the time since development and the percent of the buffer left undeveloped. I created a Pearson correlation matrix to determine whether it was necessary to include all covariates in the study before conducting the ANCOVA, and then tested the effect of each covariate on standardized species richness to determine if any of the covariates could account for observed patterns separately from the main independent variables, patch size and matrix type.

In addition to ANCOVA, standardized species richness was regressed against $\log(\text{area})$ and matrix type in a backward multiple regression. This test used actual area instead of size classes and permitted non-significant factors to be excluded.



a) the clip tool was used to select any part of a cypress dome that fell within the 1-km buffer around the selected site, b) the measure tool was used to determine the distance to the nearest cypress dome and the distance to the nearest retention pond

Figure 2: Using GIS for covariate measurements

Species Co-Occurrence and Nestedness. I analyzed presence-absence patterns for significant spatial structure using species co-occurrence analysis in EcoSim version 7.0 (<http://garyentsminger.com/ecosim.htm>) Species co-occurrence analysis generates multiple random communities in a Monte Carlo simulation and compares the expected data (null model) to the observed data. I ran the simulation using mainly default settings (fixed rows, user-defined columns, sequential swap algorithm) and with 5000 randomizations. The user defined columns weighted sites according to size by assigning the appropriate size classes to each site. Standardized effect size was compared to the random distribution, and significance was tested with $\alpha = 0.05$. I also used the Nestedness Temperature Calculator Program (NTCP; <http://aics-research.com/nestedness/tempcalc.html>) to test for assemblage nestedness across sites, following

Patterson and Atmar (2000). NTCP calculates the degree of nestedness across species and sites by calculating the matrix “temperature.” If matrix temperature is low (approaching 0°), then placement of species is hierarchical (i.e. a core list of species exists at all sites, and other species are added successively at other sites). However, if matrix temperature is high (approaching 100°), then placement of species is random (Patterson and Atmar 2000).

Guild Analyses

Presence/ absence data were also used to test for the effects of patch size and matrix type on guild richness. Guild richness data were determined by summing the number of species present in each guild. Guild abundance data were found by adding the number of individual birds found in each guild and by taking into account territory delineations to avoid multiple counts for individual birds. Territory delineation revealed the number of individuals of each species at each site. I compared all four data sheets for each site to see if an individual was consistently found in one location. I also noted if two birds of the same species were counter-singing to determine territory boundaries. If there was overlap in a bird’s location during several sampling periods, then I concluded there was one bird located in a territory. Birds with distinct territories were only counted once for guild abundance data even if they appeared several times in the same location.

I assigned birds to the following guilds: diet (insectivore, granivore, omnivore, herbivore, carnivore), foraging space (air, ground, water, lower-canopy, upper-canopy), and location in relation to the dome (edge, interior). I used *The Sibley Field Guide to Birds of Eastern North America* (Sibley 2003) to determine residential status and “Foraging guilds of North American Birds” (Graaf et al. 1985) for feeding and foraging status (Table 2). Graaf et al. (1985) assigned each avian species in North America to a guild according to major food type, location, and

foraging technique used year round. I applied a foraging guild classification for bird species either during the breeding season or year round for my guild analyses.

Guild richness and guild abundance data were analyzed using MANOVAs in SPSS 11.5 for Windows (2002). I used full-factorial general linear models because every possible combination of the two predictor variables (dome area and matrix type) was used (Quinn and Keough 2002). Guild richness was standardized by dividing the number of species present in a guild by the number of listening points in each dome, and guild abundance was standardized by dividing the number of individual birds present in a guild by the number of listening points in each dome. The MANOVAs revealed any significant effects of the categorical variables patch size and matrix types on standardized guild richness and standardized guild abundance. In addition, the effects of the log(area) and matrix on standardized guild richness were tested using backwards multiple linear regression on each guild.

I also analyzed guild richness in EcoSim. EcoSim can also be used to provide null models for guild structure, and significance was tested with $\alpha = 0.05$. For guild analysis the program requires that each guild be analyzed separately, so I conducted individual analyses for location, diet, and foraging substrate.

CHAPTER THREE: RESULTS

Overall Presence/Absence Analyses

Data collected for species richness are summarized in Table 2. The number of times a species was recorded in each matrix type is summed in the central and far right columns. The correlation matrix showed that no covariates warranted exclusion because there was not significant overlap in the information contained by any variable. Significant negative relationships existed between distance to the nearest cypress dome and total area of domes within the buffer ($r = -0.325$), edge to area ratio and percent shrub cover and ($r = -0.358$), and edge to area ratio and sampling effort per unit area ($r = -0.555$). A significant positive relationship existed between undeveloped percent of the buffer and distance to the nearest retention pond ($r = 0.650$; Table 4).

The ANCOVA showed that size class of a cypress dome significantly affected overall bird species richness ($p = 0.006$) but matrix alone and the interaction of dome size and matrix did not significantly influence overall bird species richness ($p = 0.192$ and $p = 0.633$). Significant covariates included percent of the buffer left undeveloped ($p = 0.026$), percent herbaceous cover ($p = 0.002$), and the number of listening points per unit area ($p = 0.013$; Table 3). Consistent with the ANCOVA results, multiple linear regression revealed that matrix was not significant and was removed during the backwards linear regression ($p = 0.725$), but $\log(\text{area})$ did have a significant effect on standardized species richness ($p = 0.007$).

Table 2: Presence/ Absence data from the thirty-six selected sites

	Flatwoods			Total number of sites		Pasture			Total number of sites
	Small	Medium	Large			Small	Medium	Large	
CARW	x	x	x	8	CARW	x	x	x	8
EATO	x	x	x	8	DOWO	x	x	x	6
NOCA	x	x	x	7	COYE	x	x	x	6
NOBO	x	x	x	7	NOCA	x	x	x	5
DOWO	x	x	x	6	BGGN	-	x	x	5
BGGN	x	x	x	5	PIWO	x	x	x	5
RBWO	x	x	x	5	TUTI	-	x	x	4
COYE	-	x	x	4	WEVI	-	x	x	4
TUTI	-	x	-	4	RSHA	-	-	x	3
PIWO	x	-	x	3	GCFL	-	x	x	3
MODO	-	x	x	2	RBWO	-	-	x	2
WEVI	-	x	x	2	EATO	x	-	x	2
WITU	-	x	x	2	NOPA	-	x	x	2
BACS	-	x	x	2	BAVU	-	x	x	2
BTGR	x	-	-	1	WITU	-	-	x	2
BLJA	-	-	x	1	EAME	x	-	x	2
FICR	-	x	-	1	NOBO	-	x	-	1
RSHA	-	-	x	1	FICR	-	x	-	1
GCFL	x	-	-	1	PIWA	-	-	x	1
NOPA	x	-	-	1	CAEG	-	x	-	1
BAVU	-	x	-	1	YBCU	-	x	-	1
PIWA	-	-	x	1					
EAME	-	x	-	1					
CAEG	-	-	x	1					
SACR	-	-	x	1					
BHNU	-	-	x	1					
CONI	-	-	x	1					
PUMA	-	-	x	1					
RTHA	-	x	-	1					

Table 2: Presence/ Absence data from the thirty-six selected sites.

	Low-Density Residential			Total number of sites		High-Density Residential			Total number of sites
	Small	Medium	Large			Small	Medium	Large	
CARW	x	x	x	8	BGGN	x	x	x	7
NOMO	x	x	x	6	NOMO	x	x	x	7
RBWO	x	x	x	5	CARW	x	x	x	6
MODO	x	x	x	5	NOCA	x	x	x	6
BTGR	x	x	x	5	DOWO	x	x	x	6
NOCA	x	x	x	4	BLJA	x	x	x	6
COYE	-	x	x	4	RBWO	x	x	x	5
BGGN	x	x	x	4	BTGR	-	x	x	5
TUTI	x	x	x	3	FICR	x	x	x	5
EATO	-	x	x	3	TUTI	-	x	x	4
DOWO	x	x	x	3	PIWO	x	x	x	3
BLJA	x	x	x	3	MODO	-	x	x	3
RSHA	x	-	x	2	RSHA	-	x	x	3
ROOS	-	x	-	2	GCFL	-	x	x	3
NOBO	-	x	x	2	NOPA	-	x	x	3
FICR	-	-	x	2	ECDO	-	x	x	3
WHIB	-	-	x	1	GBHE	-	x	x	3
SACR	-	-	x	1	RWBL	-	x	-	2
RWBL	x	-	-	1	ANHI	-	x	x	2
PIWA	-	x	-	1	COYE	-	x	-	1
NOPA	-	-	x	1	BAVU	-	-	x	1
GCFL	-	x	-	1	PIWA	-	-	-	1
CEWA	-	-	x	1	GREG	-	-	x	1
BRTH	x	-	-	1	GRHE	-	-	x	1
					KILL	-	-	x	1
					LBHE	-	-	x	1
					MALL	x	-	-	1
					MODU	-	-	x	1
					NOFL	x	-	-	1
					SNEG	-	-	x	1

Table 3: Correlation matrix of ANCOVA covariates

EFF_AREA	WAT_DEP	PER_SHR	PER_HERB	CAN_COVE	PER_UNDE	EDGE_ARE	DOME_IN	DIST_DOME	DIST_RET
0.190	0.157	0.047	-0.087	-0.054	0.650	-0.154	0.008	-0.191	1.000
0.266	0.361	0.784	0.614	0.753	0.000	0.371	0.964	0.264	Pearson Correlation
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
-0.261	-0.305	-0.230	0.208	0.026	-0.173	0.296	-0.325	1.000	36.000
0.125	0.070	0.176	0.224	0.879	0.312	0.080	0.053	.	Pearson Correlation
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
-0.049	0.072	-0.111	-0.026	0.176	0.235	-0.108	1.000	-0.325	0.008
0.778	0.678	0.520	0.878	0.303	0.168	0.530	.	0.053	0.964
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
-0.555	-0.141	-0.358	0.178	-0.246	-0.011	1.000	-0.108	0.296	36.000
0.000	0.413	0.032	0.300	0.148	0.951	.	0.530	0.080	Pearson Correlation
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
0.208	0.187	-0.004	-0.221	-0.213	1.000	-0.011	0.235	-0.173	0.650
0.223	0.274	0.981	0.195	0.212	.	0.951	0.168	0.312	0.000
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
-0.252	-0.083	-0.066	-0.018	1.000	-0.213	-0.246	0.176	0.026	36.000
0.138	0.629	0.703	0.916	.	0.212	0.148	0.303	0.879	Pearson Correlation
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
-0.082	-0.266	-0.040	1.000	-0.018	-0.221	0.178	-0.026	0.208	0.087
0.635	0.117	0.815	.	0.916	0.195	0.300	0.878	0.224	0.614
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
0.223	0.198	1.000	-0.040	-0.066	-0.004	-0.358	-0.111	-0.230	0.047
0.190	0.246	.	0.815	0.703	0.981	0.032	0.520	0.176	0.784
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
0.202	1.000	0.198	-0.266	-0.083	0.187	-0.141	0.072	-0.305	0.157
0.238	.	0.246	0.117	0.629	0.274	0.413	0.678	0.070	0.361
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Sig. (2-tailed)
1.000	0.202	0.223	-0.082	-0.252	0.208	-0.555	-0.049	-0.261	0.190
.	0.238	0.190	0.635	0.138	0.223	0.000	0.778	0.125	0.266
36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	Pearson Correlation
									Sig. (2-tailed)
									N

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed)

Table 4: SPSS output for standardized species richness ANCOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	111.851	22	5.084	3.698	0.009
Intercept	0.718	1	0.718	0.522	0.483
log(area)	4.056	1	4.056	2.95	0.11
Distance to nearest retention pond	4.032	1	4.032	2.933	0.111
Distance to nearest cypress domes	0.438	1	0.438	0.318	0.582
Area of cypress domes within the buffer	0.368	1	0.368	0.268	0.614
Edge: Area	4.292	1	4.292	3.122	0.101
Percent of the buffer left undeveloped	8.662	1	8.662	6.3	0.026
Canopy cover	0.379	1	0.379	0.275	0.609
Percent herbaceous cover	21.836	1	21.836	15.882	0.002
Percent shrub cover	2.514	1	2.514	1.829	0.199
Water depth	4.01E-04	1	4.01E-04	0	0.987
Effort: Area	11.311	1	11.311	8.227	0.013
Size	20.916	2	10.458	7.606	0.006
Matrix	7.53	3	2.51	1.826	0.192
Size * Matrix	6.036	6	1.006	0.732	0.633
Error	17.873	13	1.375	-	-
Total	632.273	36	-	-	-
Corrected Total	129.724	35	-	-	-

a) R Squared = .862 (Adjusted R Squared = .629)

Table 5: SPSS output for standardized species richness backward linear regression

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model	-	B	Std. Error	Beta	-	-
1	(Constant)	11.634	2.808	-	4.143	0
	LOG_AREA	-1.873	0.666	-0.439	-2.812	0.008
	MATRIX	-9.41E-02	0.265	-0.055	-0.355	0.725
2	(Constant)	11.416	2.705	-	4.22	0
	LOG_AREA	-1.877	0.657	-0.44	-2.856	0.007

a Dependent Variable: SPEC_EFF

Species co-occurrence analysis in EcoSim revealed no significant overall spatial structure in the presence/ absence data ($p = 0.950$). The same was true for guilds: residential/ migrant status ($p = 0.85900$), edge versus interior species ($p = 0.20280$), diet ($p = 0.20280$), and foraging substrate ($p = 0.20280$). Guilds all were not significantly structured relative to randomized presence/ absences matrices.

The nestedness temperature calculator recorded a matrix temperature of 15.49° (Figure 7). 15.49° is a relatively high temperature and indicates that pattern among cypress domes was random; there is little nestedness across species and sites, indicating relatively low commonality in species presence/ absence structure among cypress domes.

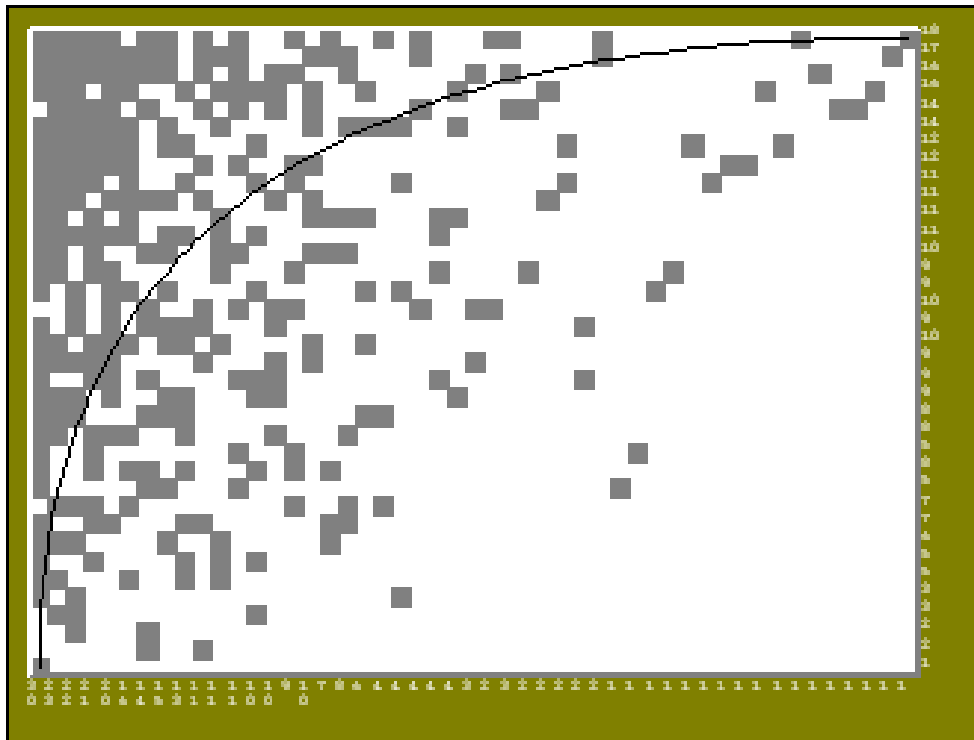


Figure 3: Output from the Nestedness Temperature Calculator Program. The maximally packed matrix made using the presence/ absence data is shown along with the system temperature (15.49°). The graph and the system temperature are used to determine the degree of nestedness across species and sites. The blocks are fairly loose and scattered and the matrix temperature is high, which means that the sites are not nested.

Guild Richness

The first three MANOVA tests investigated the effects of size class, matrix type, and their interaction effect on standardized diet, foraging, and location guild richness data. The last three MANOVA tests investigated the effects of size class, matrix type, and their interaction effect on standardized diet, foraging, and location guild abundance data. The MANOVA multivariate tests on guild richness data (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) indicated no significant effects of dome size, matrix, or their interaction effects on diet, foraging, or location guilds. One of the four tests (Roy's Largest Root, $p = 0.020$) was significant for the interaction effect of dome size and matrix on diet guilds ($p =$

0.027) and foraging guilds ($p = 0.020$; Table 6). There were no significant main or interaction effects on any individual guilds in the ANOVA outputs (Table 7).

Table 6: Multivariate test results for guild richness data

Effect		Diet Guild		Foraging Guild		Location Guild	
		F	Sig.	F	Sig.	F	Sig.
SIZE	Pillai's Trace	1.046	0.424	0.970	0.483	0.166	0.954
	Wilks' Lambda	1.038	0.431	0.956	0.495	0.160	0.958
	Hotelling's Trace	1.026	0.441	0.938	0.511	0.153	0.961
	Roy's Largest Root	1.819	0.153	1.627	0.196	0.205	0.816
MATRIX	Pillai's Trace	0.844	0.627	1.145	0.336	1.342	0.257
	Wilks' Lambda	0.846	0.624	1.087	0.389	1.304	0.274
	Hotelling's Trace	0.845	0.626	1.021	0.448	1.264	0.293
	Roy's Largest Root	2.340	0.076	1.940	0.128	1.968	0.146
SIZE * MATRIX	Pillai's Trace	0.989	0.492	1.154	0.288	1.016	0.450
	Wilks' Lambda	0.968	0.524	1.102	0.356	1.006	0.459
	Hotelling's Trace	0.930	0.575	1.030	0.440	0.994	0.470
	Roy's Largest Root	2.934	0.027	3.144	0.020	1.677	0.170

Table 7: Univariate test results for guild richness data

Diet Guilds				Foraging Guilds				Location Guilds			
Source	Dependent Variable	F	Sig.	Source	Dependent Variable	F	Sig.	Source	Dependent Variable	F	Sig.
SIZE	insectivore	0.012	0.988	SIZE	air	0.779	0.470	SIZE	edge	0.154	0.858
	granivore	1.162	0.330		ground	1.700	0.204		interior	0.196	0.823
	omnivore	0.820	0.452		water	1.461	0.252	MATRIX	edge	1.234	0.319
	herbivore	1.372	0.273		l-canopy	1.418	0.262		interior	1.804	0.173
	carnivore	2.789	0.081		u-canopy	0.821	0.452	SIZE * MATRIX	edge	1.002	0.447
MATRIX	insectivore	1.326	0.289	MATRIX	air	1.480	0.245	MATRIX	interior	1.465	0.232
	granivore	1.005	0.407		ground	0.625	0.606				
	omnivore	1.782	0.178		water	1.611	0.213				
	herbivore	0.607	0.617		l-canopy	1.081	0.376				
	carnivore	0.373	0.773		u-canopy	0.882	0.464				
SIZE * MATRIX	insectivore	0.806	0.575	SIZE * MATRIX	air	0.509	0.796				
	granivore	1.174	0.353		ground	1.223	0.329				
	omnivore	0.874	0.528		water	1.117	0.382				
	herbivore	1.535	0.210		l-canopy	0.758	0.610				
	carnivore	1.625	0.184		u-canopy	1.263	0.311				

Individual backward linear regressions were done on each guild to test how log(area) and matrix type affected standardized guild richness. Matrix did not have significant effects on any

guild. Log(area) had significant effects on ground foragers ($p = 0.043$), lower-canopy foragers ($p = 0.021$), omnivores ($p \leq 0.001$), herbivores ($p = 0.024$), and edge species ($p = 0.006$; Table 8).

Table 8: Linear regression results for guild richness

Guild	Area	Matrix	p	r^2
Foragers				
air	not significant	not significant	N/A	N/A
ground	significant	not significant	0.043	0.115
water	not significant	not significant	N/A	N/A
lower-canopy	significant	not significant	0.021	0.146
upper-canopy	not significant	not significant	N/A	N/A
Diet				
insectivore	not significant	not significant	N/A	N/A
granivore	not significant	not significant	N/A	N/A
omnivore	significant	not significant	≤ 0.001	0.308
herbivore	significant	not significant	0.024	0.141
carnivore	not significant	not significant	N/A	N/A
Location				
edge	significant	not significant	0.006	0.199
interior	not significant	not significant	N/A	N/A

Guild Abundance

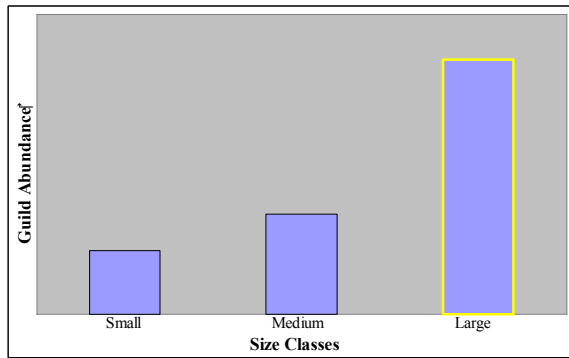
All four MANOVA multivariate tests on diet guild abundance data indicated significant effects of both dome size and matrix alone on diet guilds, but three of the four multivariate tests were not significant for the size-matrix interaction (Table 9). Dome size significantly affected insectivores, omnivores, and carnivores. Matrix had a significant effect on omnivores, herbivores, and carnivores. The size and matrix interaction had a significant effect on carnivores (Table 10; Figure 4 a-f).

Table 9: Multivariate test results for guild abundance data

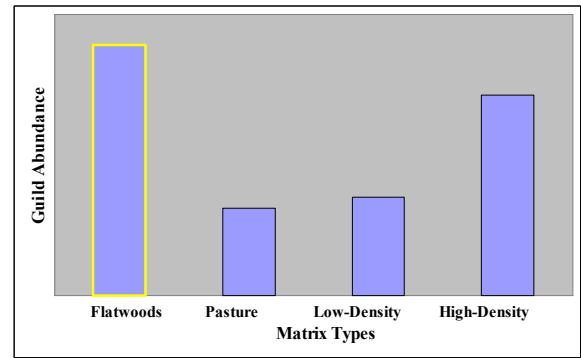
Effect		Diet Guild		Foraging Guild		Location Guild	
		F	Sig.	F	Sig.	F	Sig.
SIZE	Pillai's Trace	2.294	0.030	1.782	0.094	4.307	0.005
	Wilks' Lambda	2.652	0.014	2.168	0.041	5.165	0.002
	Hotelling's Trace	2.996	0.007	2.544	0.019	6.000	0.001
	Roy's Largest Root	6.075	0.001	5.498	0.002	12.988	0.000
MATRIX	Pillai's Trace	2.905	0.001	2.056	0.024	2.652	0.027
	Wilks' Lambda	3.413	0.000	2.165	0.019	2.589	0.030
	Hotelling's Trace	3.855	0.000	2.171	0.019	2.522	0.035
	Roy's Largest Root	10.576	0.000	4.114	0.009	3.789	0.023
SIZE * MATRIX	Pillai's Trace	1.099	0.350	0.778	0.785	0.686	0.756
	Wilks' Lambda	1.180	0.275	0.726	0.837	0.659	0.780
	Hotelling's Trace	1.261	0.200	0.677	0.887	0.632	0.804
	Roy's Largest Root	5.849	0.001	2.142	0.085	0.815	0.569

Table 10: Univariate test results for guild abundance data

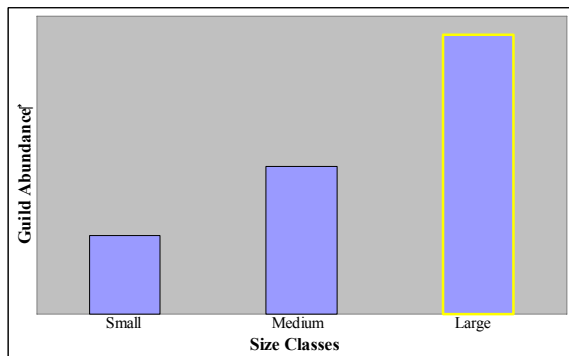
Diet Guilds				Foraging Guilds				Location Guilds			
Source	Dependent Variable	F	Sig.	Source	Dependent Variable	F	Sig.	Source	Dependent Variable	F	Sig.
SIZE	insectivore	11.743	0.000	SIZE	air	1.535	0.236	SIZE	edge	8.561	0.002
	granivore	1.904	0.171		ground	4.633	0.020		interior	12.741	0.000
	omnivore	9.571	0.001		water	2.156	0.138	MATRIX	edge	3.680	0.026
	herbivore	1.239	0.308		l-canopy	7.802	0.002		interior	3.251	0.039
	carnivore	8.833	0.001		u-canopy	14.543	0.000	SIZE *	edge	0.710	0.645
MATRIX	insectivore	2.367	0.096	MATRIX	air	1.380	0.273	MATRIX	interior	0.566	0.753
	granivore	2.854	0.058		ground	4.297	0.015				
	omnivore	4.868	0.009		water	6.621	0.002				
	herbivore	4.387	0.013		l-canopy	0.539	0.660				
	carnivore	5.479	0.005		u-canopy	3.048	0.048				
SIZE * MATRIX	insectivore	0.344	0.907	SIZE * MATRIX	air	1.077	0.404				
	granivore	0.369	0.891		ground	0.601	0.727				
	omnivore	0.447	0.840		water	1.199	0.340				
	herbivore	0.276	0.943		l-canopy	0.312	0.925				
	carnivore	3.399	0.014		u-canopy	0.599	0.729				



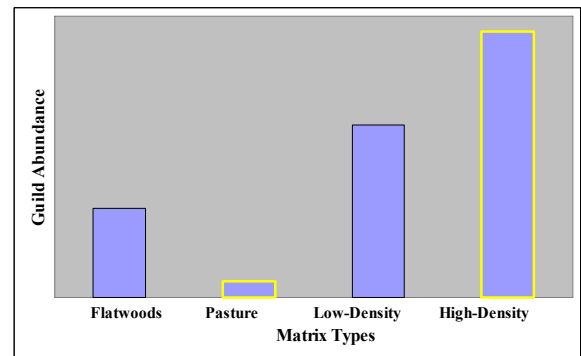
a) insectivores



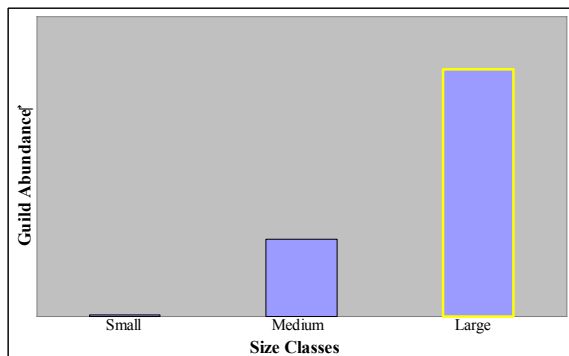
d) omnivores



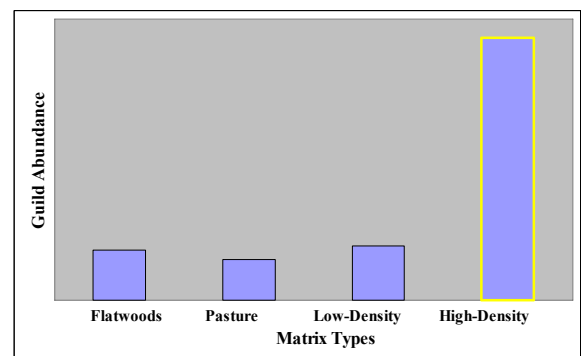
b) omnivores



e) herbivores



c) carnivores

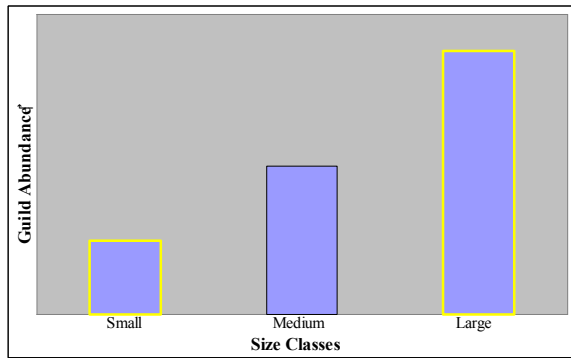


f) carnivores

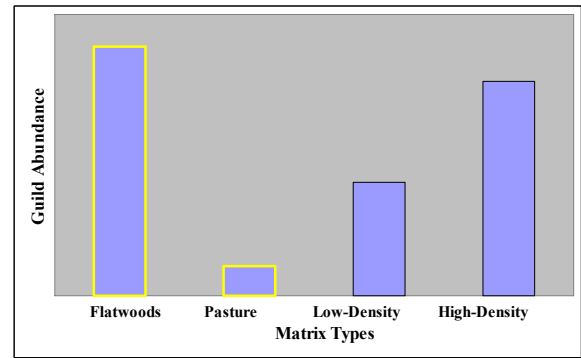
Figure 4: ANOVA results for guild abundance data; diet guilds significantly affected by dome size and matrix. Bar(s) outlined in yellow are significantly different from the others; as determined by post hoc Tukey's HSD tests ($p \leq 0.05$).

a) insectivores were significantly ($p \leq 0.001$) more rich with dome size; b) omnivores were significantly ($p = 0.001$) more rich with dome size; c) carnivores were significantly ($p = 0.001$) more rich with dome size; d) omnivores were significantly ($p = 0.009$) more rich in domes with a flatwoods matrix; e) herbivores were significantly ($p = 0.013$) more rich within high-density matrix; and f) carnivores were significantly ($p = 0.005$) more rich within high-density matrix

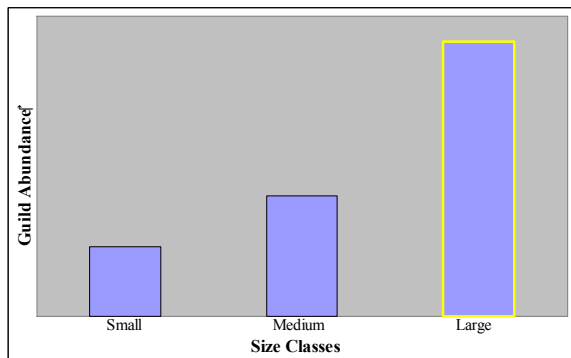
The MANOVA multivariate tests for foraging guild abundance data indicated significant effects of both dome size and matrix alone on foraging guild abundance, but three of the four multivariate tests were not significant for the size-matrix interaction (Table 9). Dome size significantly affected ground, lower- and upper-canopy foragers. Matrix had a significant effect on ground, water, and upper-canopy foragers. The size and matrix interaction was not significant for any foraging guild (Table 10; Figure 5s a-f).



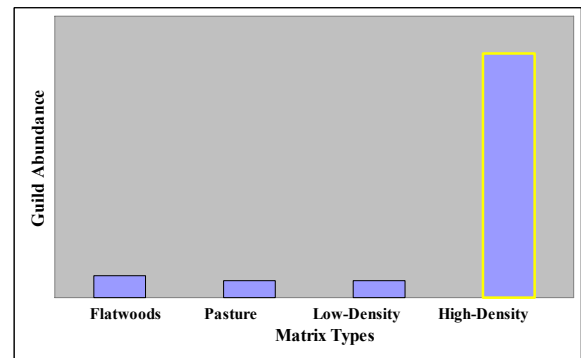
a) ground foragers



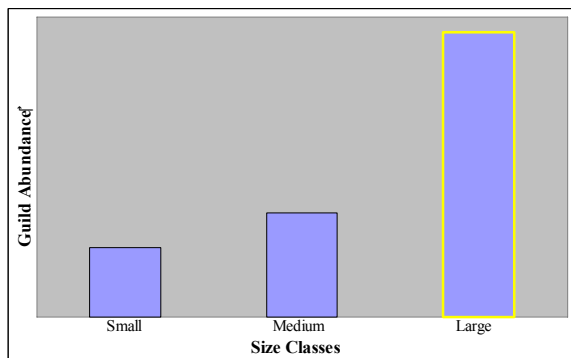
d) ground foragers



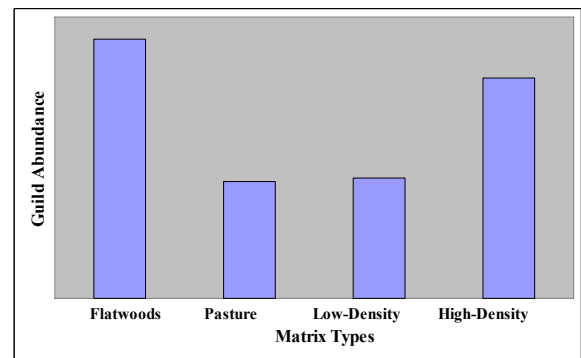
b) lower-canopy foragers



e) water foragers



c) upper-canopy foragers

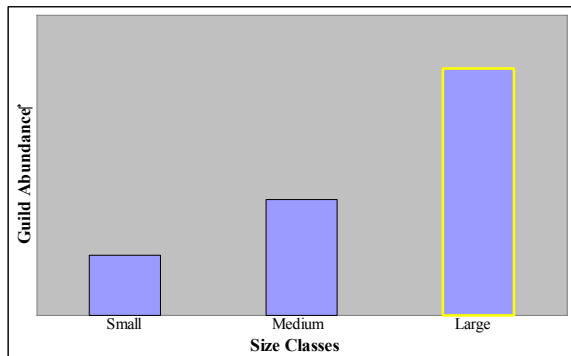


f) upper-canopy foragers

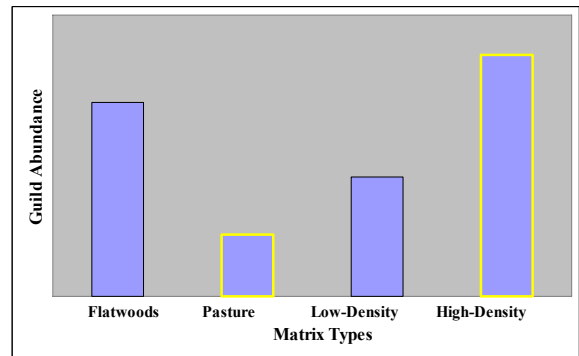
Figure 5: ANOVA results for guild abundance data; foraging guilds significantly affected by dome size and matrix. Bar(s) outlined in yellow are significantly different from the others; as determined by post hoc Tukey's HSD tests ($p \leq 0.05$).

a) ground foragers were significantly ($p = 0.020$) more rich with dome size; b) lower-canopy foragers were significantly ($p = 0.002$) more rich with dome size; c) upper-canopy foragers were significantly ($p \leq 0.001$) more rich with dome size; d) ground foragers were significantly ($p = 0.015$) more rich in domes with a flatwoods matrix; e) water foragers were significantly ($p = 0.002$) more rich with high-density matrix; and f) upper-canopy foragers were significantly ($p = 0.048$) different across matrix types

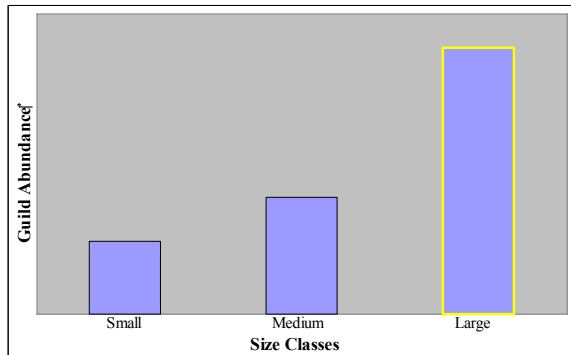
All four MANOVA multivariate tests on location guild abundance data indicated significant effects of both dome size and matrix alone on location guilds, but all four multivariate tests were not significant for the size-matrix interaction (Table 9). Dome size significantly affected edge and interior species. Matrix had a significant effect on edge and interior species. The size and matrix interaction was not significant for any location guild (Table 10; Figures 6 a-d).



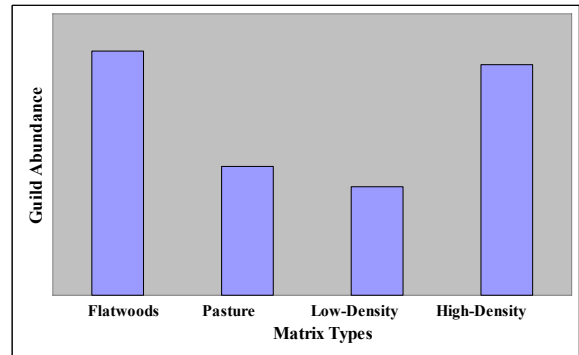
a) edge



c) edge



b) interior



d) interior

Figure 6: ANOVA results for guild abundance data; location guilds significantly affected by dome size and matrix. Bar(s) outlined in yellow are significantly different from the others; as determined by post hoc Tukey's HSD tests ($p \leq 0.05$).

a) edge species were significantly ($p = 0.002$) more rich with dome size; b) interior species were significantly ($p \leq 0.001$) more rich with dome size; c) edge species were significantly ($p = 0.026$) more rich within a high-density matrix; d) interior species were significantly ($p = 0.039$) different across matrix types

CHAPTER FOUR: DISCUSSION

Overall Presence/Absence Analyses

Patch size was shown to have a significant effect on the standardized species richness of birds in cypress domes, but the influence of surrounding matrix and the interaction effect of size and matrix were not significant for all species combined. Historically, studies that found a correlation between species richness and site area explained that larger areas had higher species richness because they had more room to accommodate bird territories and more resources to support a variety of birds (MacArthur and Wilson 1967; Askins et al. 1986; Temple and Cary 1988, Andren 1994, Saab 1999; Kurosawa and Askins 2003; Uezu et al. 2005). The current trend is to investigate variables other than size that may influence species richness, such as the nature of the surrounding matrix and habitat structure.

Measures of habitat quality (i.e., plant species richness, floristic composition, vegetation structure) and landscape characteristics (i.e., degree of isolation; reserve size, shape, area) have been used to predict patterns of species richness, but no single factor fully explains species richness (Gillespie and Walter 2001). For example, Fraser and Stutchbury (2004) found the relationship between regional forest cover and patch size could be used to determine if scarlet tanagers would inhabit a patch. Tanagers will inhabit small patches as long as there is a high degree of forest cover. In landscapes with low forest cover, they inhabit only large patches (Fraser and Stutchbury 2004). Interspecific competition has also been credited with causing species to be absent from patches large enough to meet their territory requirements or causing an increase in population density in smaller patches (Moller 1987). I found that neither matrix type nor any of the habitat variables measured significantly affected standardized species richness, so

differences in species richness were solely a function of the size of cypress domes. The use of standardized species richness in the analyses reinforces the fact that domes size is significant. Each species count has been divided by the number of listening points which ensures that increased species richness is a result of higher species richness and not increased sampling effort in larger domes.

MacArthur and Wilson's (1967) theory of island biogeography investigates the effects of dispersal and colonization as well as the effects of area on species richness. The tenets of island biogeography are often applied to habitats that are naturally patchy and disconnected, such as cypress domes. Many studies have confirmed that larger islands have more species (Moller 1987; Bennett et al. 2004; Radford et al. 2005). My results support the conclusion that larger domes are more species-rich. One criticism of applying MacArthur and Wilson's island biogeography theory to habitats in a terrestrial landscape is that habitat patches are embedded in a heterogeneous matrix whereas for real islands the matrix is homogenous (Saab 1999). Saab (1999) implies that a heterogeneous matrix would affect species richness, but the results of my study indicate that varied matrix types did not influence overall species richness.

The species-area relationship is one of the fundamental principles of ecology (Lawton 1999). According to the species-area relationship, $S = CA^z$ where S is the number of species, A is the area of an island, and C and z are constants that depend on the ecosystem (MacArthur and Wilson 1967). The species-area relationship has been confirmed across a wide range of taxonomic groups, biogeographic regions, and spatial scales (Storch et al. 2005). Many studies have investigated why the relationship holds true and if other variables have a strong relationship with species richness and area. Numerous and varied contemporary studies investigate more specific aspects of the species-area relationship. Examples of such studies include research on

the relationship of plant biomass and the seasonal pulsing of production to bird species richness (Hawkins 2004); the relationship of energy, species, and area (Storch et al. 2005); how the species-area relationship can be used to determine size requirements for conservation areas (Gillespie and Walter 2001); and how a metapopulation model can be used to predict species-area relationships (Matter et al. 2002). Several studies found that the relationship of forest cover and species richness were significantly positive (Trzcinski et al. 1999; Bennett et al. 2004; Fraser and Stutchbury 2004; Radford et al. 2005).

The data from this study support the species-area relationship in that larger cypress domes have more species of birds, but more research is needed to explain why this relationship is seen. The type of matrix surrounding domes did not affect species richness significantly. Future studies on avian assemblages within cypress domes should focus on the mechanisms producing area effects and the influence of habitat variables within cypress domes, as well as matrix effects on particular species and guilds. Structural and functional connectivity of patches should also be considered for future research as shorter inter-patch distances have been shown to promote species maintenance for Atlantic forest bird species in Brazil (Uezu et al. 2005)

Results of this study indicate that future research should put more effort into studying wetland characteristics. The vegetative and hydrological analyses in this study were minimal because I was attempting to study bird use of both matrix and the wetland itself. Hydrological data should be taken more frequently, and more work should be done on vegetative stratification within and along the perimeter of domes. My field work began later in the breeding season than planned due to difficulty selecting sites with landowner permission for access. Data collection in future studies should begin earlier in the breeding season, and if time allows, the listening points

should be closer together. The survey changes would ensure more complete sampling of the species present in each dome.

The nested subset hypothesis states that nested assemblages occur when species-poor patches contain a subset of species found in species-rich patches (Fischer and Lindenmayer 2002). Nested communities are not random subsets of species but rather highly non-random groups of species. Results of the nestedness temperature calculator indicate that bird assemblages in smaller domes were not nested subsets of species found in large domes. Species placement in cypress domes is random with respect to nestedness. There is no core group of generalists found in every dome because placement of species from one dome to the next is random. The differences in assemblages found between domes could reflect the various and unique biogeochemical, floral, and faunal conditions of each dome. Different generalist may be attracted to open, well-maintained domes, and a whole different set of generalist species may be attracted to the domes that are dominated by vines and have an overabundance of subcanopy and shrub species.

Species co-occurrence analysis showed no significant difference between the presence/absence data collected in this study and the 5000 null models generated randomly. It is not unusual for real communities to be no more structured spatially than randomly generated communities. One study showed through a series of mathematical calculations that the distributions of birds on a string of islands in a large reservoir were distributed randomly, but even with random distribution it was still possible to predict the average number of species on an island and the variation of species richness from one island to the next (Coleman et al. 1982). In other words, species richness can be predicted, but there is no pattern or way to predict which

species will be present. The species- area relationship holds true in that there are more species in larger islands, but there is no prediction for which species will be present.

The composition of bird assemblages has been shown to differ according to matrix. For example, a patch embedded in an agriculture matrix supported a different assemblage from a patch with a natural matrix in southeastern Idaho (Saab 1999). Similarly, a study in central California found that patches surrounded by the same matrix were more similar in composition and abundance than patches surrounded by a different matrix (Sisk et al. 1997). In my study, birds such as eastern towhee and northern bobwhite were common in pine flatwoods but were not present in residential or pasture habitats. Northern mockingbirds, on the other hand, were found in the open habitat provided by pastures and residential areas, but less often in pine flatwoods. If bird assemblages had varied according to matrix, a significant matrix effect should have been observed, and this would have also affected the NTCP and the species co-occurrence analyses. If species recorded were restricted to species seen or heard only within a dome, then the results would change because the data would not include species found in the different, nearby habitats of the matrix.

Guild Data

Species richness indicates how many species are present in an area but says nothing about the characteristics of the species present. It does not lend insight into how a habitat is being used, and many questions are left unanswered. Are the species observed predominately native? Are they edge sensitive? Are they lower-canopy or upper-canopy foragers? Guild analysis is useful for investigating differences in assemblages across sites because it makes it possible to find correlations between the strength of guild presence and changes in habitat. A single species does not provide much information about a habitat, but intra-guild richness and the identity of

guilds does. When intra-guild richness is high, habitat suitability for all members of that guild is high (Bishop and Myers 2004).

None of the observed guilds was significantly different in membership from the randomized guild simulations generated by EcoSim. For example, the observed distribution of edge and interior species across sites was not significantly different from the randomly generated models. EcoSim cannot determine how each guild component is affected by the independent variables. In other words, EcoSim cannot show which guild component, such as insectivores, granivores, omnivores, herbivores, and carnivores of the diet guild, are significantly influenced in relation to one another, but the backwards regression can do so. First, the MANOVA was run to see if anything was significant at all before finding individual effects.

The MANOVA multivariate tests on guild richness data indicate that dome size, matrix, and their interaction had no significant effects on diet, foraging, or location guild richness. The MANOVA results would lead one to believe that guild richness is in no way influenced by size and matrix. However, when area is used as a continuous variable and transformed, as it was used in the linear regression, size significantly affects ground and lower-canopy foragers, omnivores and herbivores, and edge species. The linear regression results may inspire more confidence because actual size measurements are used, and the size data have not been collapsed into categories. Therefore, diet, foraging, and location guild richness are all affected by the area of cypress domes.

Results were different for the MANOVA analysis of guild abundance data. Size and matrix had significant effects on diet, foraging, and location guild abundance. The size and matrix interaction had no significant effects. Size affected insectivores, omnivores, and carnivores; ground, lower- and upper-canopy foragers; and edge and interior species. Matrix

influenced omnivores, herbivores, and carnivores; ground, water, and upper-canopy foragers; edge and interior species. Overall, the MANOVA results indicated that the number of species in a guild is not affected by size and matrix, but the numbers of individuals in a guild are significantly effected by size and matrix.

One study of birds in cypress domes found that, in smaller domes, territory size restricts species occurrence, and the species that do inhabit small domes tend to be residents, edge species, granivores, or omnivores (O'Meara 1984). The diversity of guilds that are attracted to larger domes could be explained by larger domes having greater habitat diversity than smaller domes. Vegetative differences provide different substrates for foraging and more dietary variety. Larger domes can accommodate more and larger territories for edge and interior species significantly influenced by size. Larger domes can also provide more variety in terms of foraging substrate and diet, which might explain why so many foraging and diet guilds were influenced by size.

Matrix effects on guild abundance could also be explained in terms of habitat variability. Flatwoods, pasture, and residential areas each provide unique habitat and foraging opportunities that appeal to different guilds. Guilds significantly affected by matrix types were mainly defined by diet. Pasture provides open foraging in low vegetation, flatwoods offers cover and low shrubs, and residential areas provide disturbed habitat that is open with patchily distributed vegetation and some food subsidies (e.g. feeders, pet food, garbage).

Regardless of whether dome size is the main variable that influences bird assemblages, the results of this study indicate that it is important. Large cypress domes need to be maintained in order to preserve habitat suitable for a variety of guilds and a large number of species. It becomes harder to find large cypress domes as the human population of central Florida grows.

Domes are commonly fragmented and converted into several smaller domes, divided by roadways, surrounded by housing communities, or whittled down to one smaller wetland. There is an immediate need for more research on how development influences all elements of biodiversity in cypress domes. Size and matrix are unlikely to be the only variables that influence bird assemblages, which is emphasized by the fact that several covariates had a significant effect on standardized species richness.

Humans have altered between thirty-three and fifty percent of the earth's land surface, and the human enterprises responsible for land surface changes also affect major biogeochemical cycles (Vitousek et al. 1997). Some species are common to most deciduous forested wetlands, but bird density, species richness, and guild structure are all affected by vegetative structure and hydrology (Swift et al. 1984). It would be worthwhile to investigate how development affects the hydrology of cypress domes. Retention ponds are often located in close proximity to cypress domes, or cypress domes are used as retention ponds and are left to contain an unnaturally large amount of water due to runoff from surrounding impermeable surfaces.

Also, the perimeters of many residential domes are a mix of heavy vines and shrubs. Watson et al. (2004) found that the structure of vegetation at the edge of forest may be an important indicator of edge sensitivity for forest-dependent species, and it is possible that this is true for forested wetland species. Research is needed on how unnatural vegetative growth may affect resident fauna and how herbaceous and shrub layers of residential domes compare to that of domes that abut natural lands maintained by prescribed burning. Further examination of the vegetation and hydrology of Florida cypress domes is needed to determine how they influence local fauna. In addition, a better understanding of how vegetation and hydrology are impacted by development is essential for cypress wetland conservation.

APPENDIX A: GUILD ASSIGNMENTS FOR SPECIES RECORDED

Table 11: Guild assignment for species recorded

	Foraging Space					Location within Dome		Diet				
	Air	Ground	Water	Lower-canopy	Upper-canopy	Edge	Interior	Insectivore	Granivore	Omnivore	Herbivore	Carnivore
ANHI	-	-	X	-	-	X	-	-	-	-	-	X
BACS	-	X	-	-	-	X	-	-	-	X	-	-
BAVU	-	X	-	-	-	X	-	-	-	-	-	X
BGGN	-	-	-	-	X	-	X	X	-	-	-	-
BHNU	-	-	-	-	X	-	X	X	X	-	-	-
BLJA	-	X	-	-	-	X	-	-	-	X	-	-
BRTH	-	X	-	X	-	X	-	-	-	X	-	-
BTGR	-	X	-	-	-	X	-	-	-	X	-	-
CAEG	-	X	-	-	-	X	-	X	-	-	-	-
CARW	-	-	-	X	-	X	X	X	-	-	-	-
CEWA	X	-	-	-	X	X	-	X	-	-	X	-
CONI	X	-	-	-	-	X	-	X	-	-	-	-
COYE	-	-	-	X	-	X	-	X	-	-	-	-
DOWO	-	-	-	-	X	-	X	X	-	-	-	-
EAME	-	X	-	-	-	X	-	-	-	X	-	-
EATO	-	X	-	-	-	X	-	-	-	X	-	-
ECDO	-	X	-	-	-	X	-	-	X	-	-	-
FICR	-	-	X	-	-	X	-	-	-	X	-	-
GBHE	-	-	X	-	-	X	X	-	-	-	-	X
GCFL	X	-	-	-	-	-	X	X	-	-	-	-
GREG	-	-	X	-	-	X	-	-	-	-	-	X
GRHE	-	-	X	-	-	X	-	-	-	-	-	X
KILL	-	-	X	-	-	X	-	X	-	-	-	-
LBHE	-	-	X	-	-	X	-	-	-	-	-	X
MALL	-	X	X	-	-	X	-	-	X	-	X	-
MODO	-	X	-	-	-	X	-	-	X	-	-	-
MODU	-	-	X	-	-	X	-	-	-	X	-	-
NOBO	-	X	-	-	-	X	-	-	-	X	-	-
NOCA	-	X	-	-	-	X	X	-	-	X	-	-
NOFL	-	X	-	X	-	X	-	-	-	X	-	-
NOMO	-	-	-	X	-	X	-	-	-	-	X	-
NOPA	-	-	-	-	X	-	X	X	-	-	-	-
PIWA	-	-	-	-	X	-	X	-	-	X	-	-
PIWO	-	-	-	X	X	-	X	X	-	X	-	-
PUMA	X	-	-	-	-	X	-	X	-	-	-	-
RBWO	-	-	-	-	X	-	X	X	-	-	-	-
ROOS	-	X	-	-	-	X	-	-	X	-	-	-
RSHA	-	X	-	-	-	X	-	-	-	-	-	X
RTHA	-	X	-	-	-	X	-	-	-	-	-	X
RWBL	-	X	-	-	-	X	-	-	X	-	-	-
SACR	-	X	X	-	-	X	-	-	-	X	-	-
SNEG	-	-	X	-	-	X	-	-	-	-	-	X
TUTI	-	-	-	X	-	-	X	-	-	X	-	-
WEVI	-	-	-	X	-	-	X	-	-	X	-	-
WHIB	-	-	X	-	-	X	-	-	-	-	-	X
WITU	-	X	-	-	-	X	-	-	-	-	X	-
YBCU	-	-	-	X	-	-	X	X	-	-	-	-

APPENDIX B: THESIS AND DISSERTATION APPROVAL PAGE

UNIVERSITY OF CENTRAL FLORIDA
THESIS APPROVAL

The members of the Committee approve the thesis of Julia Erica Noran entitled *Effects of Patch Size and Matrix Type on Bird Assemblages within Central Florida Cypress Domes, March 27, 2006*.

Reed F. Noss, Chair

David Jenkins
Committee Member

I. Jack Stout
Committee Member

It is recommended that this thesis be used in partial fulfillment of the requirements for the degree of Master of Science from the Department of Biology in the College of Arts and Sciences.

David W. Borst, Chair

Kathyn L. Seidel, Dean

Patricia J. Bishop
Vice Provost and Dean of Graduate Studies

The committee, the college, and the University of Central Florida are not liable for any use of the materials presented in this study.

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