NESTING NICHE PARTITIONING BY WHITE-WINGED AND MOURNING DOVES WITH OBSERVATIONS OF OTHER SYMPATRIC COLUMBIDS

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NESTING NICHE PARTITIONING BY WHITE-WINGED AND MOURNING DOVES WITH OBSERVATIONS OF OTHER SYMPATRIC COLUMBIDS

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ABSTRACT

NESTING NICHE PARTITIONING BY WHITE-WINGED AND MOURNING DOVES WITH OBSERVATIONS OF OTHER SYMPATRIC COLUMBIDS

by

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White-winged (*Zenaida asiatica*), Mourning (*Z. macroura*), White-tipped (*Leptotila verreauxi*), Inca (*Columbina inca*), and Common Ground (*Columbina passerina*) doves commonly nest in the same environment in South Texas, and White-winged, Mourning, and Inca Doves nest in the same environment in central Texas. Differences in nesting behavior and dimensional aspects of the nesting substrate chosen by these sympatric dove species have not been thoroughly studied. My study provides comprehensive analyses of active nests for these doves in two distinct study sites: Estero Llano Grande State Park in the Lower Rio Grande Valley (LRGV) and the City of San Marcos in central Texas. I hypothesize that discernible and substantial differences exist in nest location and habitat

among these species. Doves nested in distinct habitats in Estero Llano Grande State Park. There was a significant difference in nest height in Estero Llano Grande State Park between White-winged and Mourning Doves. There were no differences in nesting characteristics for doves in San Marcos. White-winged and Mourning Doves may be partitioning space for nesting in Estero Llano Grande State Park because both species have historically nested together in that area as opposed to the more recent expansion of White-winged Doves into central Texas.

CHAPTER I

INTRODUCTION

Studies of niche partitioning in doves have addressed food habits and foraging activities (Rivera-Milãn 1993, 1996, 2001; Wolf et al. 2002; Sol et al. 2005; Hayslette 2006) and vocal activities (de Kort et al. 2002; Kopij 2003) in dove species. Nesting behaviors and partitioning of space among dove species (Columbidiae) using similar resources have not been thoroughly researched (Cunningham 1997). A multitude of factors ranging from risk of predation to interspecific competition for available resources may influence nesting habitat selection by dove species. Nesting preferences are difficult to determine and may also vary by habitat.

Five species of native doves breed and nest in Estero Llano Grande State Park in south Texas: White-winged (*Zenaida asiatica*), Mourning (*Z. macroura*), White-tipped (*Leptotila verreauxi*), Inca (*Columbina inca*), and Common Ground (*Columbina passerina*) Doves. Three species, White-winged, Mourning and Inca Doves, breed and nest at San Marcos in central Texas.

Highest nest densities and nesting success of White-winged Doves historically occurred in dense, mixed woodlands dominated by Texas ebony (*Ebenopsis ebano*) in Tamaulipas Mexico and the Lower Rio Grande Valley (LRGV) of Texas (Cottam and Trefethen 1968; Schwertner et al. 2002). Recently, White-winged Doves have expanded their range from the LRGV northward and eastward in Texas to urban environments (Glass et al. 2002; Schwertner et al. 2002).

Mourning Doves nest in a wide array of ecological types throughout North America. A precise description of breeding habitat is difficult because of the broad adaptability of this species. Generally Mourning Doves avoid dense woods or extensive forest and select more open woodlands and edges between forest and prairie biomes for nesting (Tomlinson et al. 1994). Mourning Doves use a variety of coniferous and deciduous trees, shrubs, vines, man-made structures, and the ground for nesting. Heavy use is made of honey mesquite (*Prosopis glandulosa*) and ground nesting in central North America (Eng 1986; Sayre and Silvy 1993; Mirarchi and Baskett 1994).

White-tipped Doves in south Texas and northern Mexico historically occupied native riparian vegetation along the Rio Grande. Native vegetation in these areas is characterized by Texas ebony, cedar elm (*Ulmus crassifolia*), sugar hackberry (*Celtis laevigata*), honey mesquite, retama (*Parkinsonia aculeata*), granjeno (*Celtis padilla*), and huisache (*Acacia farnesiana*) (Boydstun and DeYoung 1988). In south Texas, available data suggest White-tipped Dove nests are typically located in the interior of native brush in areas with dense vines (Boydstun 1982; Hayslette 1996).

Inca doves nest in a wide variety of trees and shrubs, most often in the immediate vicinity of dwellings. They also nest in palm fronds and hanging fern baskets (Dickey and van Rossem 1938), on vines and utility poles (Oberholser 1974), and on houses, pipe posts and dead trees (Simmons 1925; Muller 1992).

In Texas, Common Ground-Doves nest most frequently in prickly pear (*Opuntia* spp.), blackbush (*Coleogyne* spp.), and granjeno (Passmore 1981; Bowman 2002). In the southwestern U.S., they nest in honey mesquite thickets, cottonwood (*Populus* spp.), and willow (*Salix* spp.) trees. They usually nest within 1 m of the ground and rarely > 3 m

above ground although they have been recorded nesting as high as 6-8 m (Russell and Monson 1998).

The objective of my study was to test for nest resource partitioning in habitat by sympatric doves using several factors or dimensions (Hutchinsonian Type III Niche, Hutchinson 1957) related to active nests. My hypotheses were:

H_o Different dove species use different habitats for nesting.

H_1 Different dove species do not use different habitats for nesting.

Data obtained by my research will benefit management of multiple dove species using a common area. These data will also provide insight into how these species use and share space, particularly with respect to nesting resources,

CHAPTER II

MATERIALS AND METHODS

Study Areas

Estero Llano Grande State Park.---Estero Llano Grande State Park, Hidalgo County (26°07'31.06"N, 97°51'11.35"W) is located at the southern tip of Texas in the lower Rio Grande Valley, Texas (LRGV). Estero Llano Grande State Park is characterized by its diverse avifauna and is a member of the World Birding Center (WBC 2010). This region of Texas near the terminus of the Rio Grande has a particularly diverse floral and faunal composition (Blair 1950) because of tropical, subtropical, coastal, and temperate influences (Jahrsdoerfer and Leslie 1988). Estero Llano Grande State Park is a restored wetland (WBC 2010) with four distinct and unique terrestrial habitat types. These include grassland with mixed shrubs (Grassland), upland mesquite scrub (Mesquite Scrub), mixed native hardwood (Native Hardwood), and exotic/ornamental woodland (Exotic Woodland). Distinct habitats within the park provided me opportunities to observe nest site selection by dove species within the historical and current distributions of these species.

San Marcos, Texas.---The City of San Marcos, Hays County (29°53'33.37"N, 97°55'42.88"W) is located in central Texas. San Marcos in contrast to Estero Llano Grande State Park had fewer distinct habitat types. However, a comparative study of nest resource partitioning between sympatric columbids in historic native habitat and a much more urban area was of interest because White-winged, Mourning, and Inca Doves are

sympatric nesters in San Marcos. There is particular interest in nesting patterns of White-winged Doves and the reported area of range expansion primarily into urban areas during the past 40 years from the LRGV into central, north, and east Texas (Cottam and Trefethen 1968; George et al. 1994; Waggerman 1998).

Data Collection

Estero Llano Grande State Park.---I conducted weekly nest searches in Estero Llano Grande State Park in four distinct habitat types (native hardwood, mesquite scrub, grassland, and exotic woodland) from mid-May through mid-August 2009. The native hardwoods habitat consisted mostly of anacua (*Ehretia anacua*), Texas ebony, and coma (*Bumelia celastrina*). The mesquite scrub habitat consisted mainly of honey mesquite, prickly pear, huisache, and granjeno. The grassland habitat had limited nesting sites except for scattered retama and honey mesquite. The exotic woodland habitat consisted of diverse nonindigenous species of fruit trees and shrubs and a limited abundance of native species, such as live oak (*Quercus virginiana*) and Texas ebony.

Data were recorded for each active nest located. For purposes of this study, an active nest is defined as nests with an adult dove either incubating eggs or caring for fledglings. For grassland and mesquite scrub habitats, a random plot sub-sample was surveyed because these two habitats were the largest and consequently could not be surveyed in entirety in a single day. All survey areas were plotted using global positioning systems (GPS,Garmin eTrex 20, Olathe, KS) and mapped using geographic information system (GIS, ArcGIS, Version 9.2, ESRI, Redlands, CA).

San Marcos.---From mid-May through mid-August 2010 weekly searches were conducted in four separate urban areas following the same protocol described above for

Estero Llano Grande State Park. The areas were comprised of the San Marcos Cemetery, the San Marcos Baptist Academy, Aquarena Springs/Texas State University Golf Course, and a portion of the Texas State University Campus. The San Marcos Baptist Academy is a coeducational Christian boarding and day school. Aquarena Springs is a nature center for conservation education that was formerly an amusement park. Each of these search areas contained mostly native species of vegetation, such as live oak, Texas oak (*Quercus texana*), Ashe juniper (*Juniperus ashei*), and cedar elm (*Ulmus crassifolia*) for trees higher than 2.5 m in height. All survey areas were plotted using GPS and mapped using GIS.

Survey Methods

For each plot, I examined every woody tree species > 2.5 m in height or large *Opuntia* spp. of cacti for active nests. I used colored survey tape to mark the location of each active nest and recorded GPS coordinates for the nest to ensure relocation. I used a mirror on an extendable pole to identify nest contents for trees higher than 2.5 m.

Nest Measurements

Nest tree species was determined and location data were recorded no later than two days following initial discovery. Nest and tree height was determined using a Nikon Forestry 550 hypsometer (Nikon, Inc., Tokyo, Japan). From these data, nest height as a percent of tree height was calculated. Basal circumference of nest trees (or substrate) was measured using a 100-m tape measure.

Mean maximum substrate width (i.e., canopy width) was determined by averaging widths taken from cardinal directions. Nest orientation was recorded in degrees away from North with a standard compass. Distance of the nest from the tree's geometric

center was taken using a laser measurer (Stanley™ TLM 200, New Britain, CT).

Statistical Analysis

Only species with a minimum of 25 nests were included in analysis. Consequently, I present only descriptive statistics for White-tipped and Inca Doves from Estero Llano Grande State Park and Inca and Common Ground-Doves in San Marcos (White-tipped Doves do not occur in San Marcos). In addition, Common Ground-Doves were excluded from analysis (descriptive statistics are provided) for Estero Llano Grande State Park because their nesting substrate had almost no variation.

I ran *t*-tests comparing nest height as a percent of tree height between Mourning and White-winged Dove nests for each study site. I decided *a priori* that if the *t*-test was not significant, then nest height and tree height measurements could be combined for both species and a regression calculated to determine if nest height was affected (i.e., related) by tree height. Should the *t*-test indicate a difference then regressions would be run individually for each species. Additionally, based on *a priori* consideration I determined that if a regression indicated a relationship was not present then both tree height and nest height could be included in additional analysis, however, should the regressions show that there was a relationship present between these two variables, then only one of the variables (nest height) would be included in additional analysis.

I then used a single factor multivariate analysis of variance (MANOVA) for each research location to determine if there was a significant difference among variables between species. If the MANOVA indicated a significant difference for a location then individual analysis of variance was conducted for each response variable to determine which variable(s) account for the variation indicated by the MANOVA.

Niche breadth was also calculated based on species of available nesting substrate. Niche breadth is defined as the degree of similarity between the frequency distribution of resources used by members of a population and the frequency distribution of resources available to them (Feinsinger et al. 1981). In my study I applied niche breadth to the availability of nesting trees in the search areas. An available nesting tree was defined as any woody species of vegetation taller than two and a half meters. Niche breadth was calculated using Program NICHE version 7.0 (Exeter Software, Setauket, NY, Krebs 1999).

CHAPTER III

RESULTS

Estero Llano Grande State Park.---From mid-May through mid-August 2009, I found 103 dove nests: 37 White-winged Dove, 25 Mourning Dove, 34 Ground Dove, 5 White-tipped Dove, and 2 Inca Dove at Estero Llano Grande State Park.

White-winged Dove nests were only found in exotic woodland and native hardwood habitats. Nests occurred in Texas ebony (35%, $n = 13$), anacua (14%, $n = 5$), live oak (22%, $n = 8$), Rio Grande ash (*Fraxinum berlandieriana*, [8%, $n = 3$]), avocado (*Persea* spp., [11%, $n = 4$]), and orchid (*Bauhinea variegate*, [5%, $n = 2$]) trees. The remaining nests ($n = 2$) were found in loquat (*Eriobotrya japonica*) and Mexican olive (*Cordia boissieri*). Mourning Dove nests were found only in exotic woodland, native hardwood, and mesquite scrub habitats. Sixty-eight percent of Mourning Dove nests were either in Texas ebony (28%, $n = 7$), or live oak (40%, $n = 10$) trees. The remaining nests were in prickly pear (12%, $n = 3$), honey mesquite (8%, $n = 2$), royal poinciana (*Delonix regia*, [8%, $n = 2$]) and coma (*Bumelia celastrina*, [4%, $n = 1$]) trees.

The result of the *t*-test of nest height as a percent of tree height for White-winged versus Mourning Doves was significant ($t_{60} = 2.44$, $P = 0.02$). Regression for White-winged and Mourning Dove nest height and tree height were significant ($r^2 = 0.32$, $F_{1,35} = 18.32$, $P < 0.01$ and ($r^2 = 0.73$, $F_{1,23} = 65.83$, $P < 0.01$, respectively). Multivariate analysis of variance for White-winged versus Mourning Doves nests in the Estero Llano

Grande State Park differed significantly (*Pillai* = 0.23, df = 56, $P < 0.01$; Table 1). Individual ANOVAs for each response variable showed only nest height differed significantly between the two species (F_{56}= 12.90, $P < 0.01$; Table 2). White-winged Doves had a Hurlbert's Standardized Niche Breadth of 0.03 (95% CI = -0.019-0.078). Mourning Doves had a Hurlbert's Standardized Niche Breadth of 0.07 (95% CI = 0.003-0.127).

All Ground Dove nests occurred exclusively in the mesquite scrub habitat. Ninety-four percent of Ground Doves nests (*n* = 32) were in prickly pear cactus with the remainder (*n* = 2) in honey mesquite. Nest heights ranged in height from 0.33 m to 1.74 m in prickly pear ($\bar{x}$ = 0.91) and from 0.87 m to 2.6 m in honey mesquite ($\bar{x}$ = 1.45). All White-tipped Dove nests (*n* = 5) were located in native hardwoods habitat with the exception of one in exotic woodland habitat. Nests occurred in anacua (*n* = 2), live oak (*n* = 1), Texas ebony (*n* = 1), and brasil (*Condalia hookeri*, [*n* = 1]). Nest height ranged from 2.2 m to 5.2 m ($\bar{x}$ = 3.83) among all tree species. Nest tree height ranged from 6 m to 11.4 m among all tree species ($\bar{x}$ = 7.8). The two Inca dove nests were located in the exotic woodland habitat. One nest was in a live oak tree with the other in Texas ebony tree.

San Marcos.---I found 49 White-winged Dove nests, 35 Mourning Dove nests, and 3 Inca Dove nests in San Marcos from mid-May through mid-August 2010.

White-winged Dove nests were only found at the San Marcos Baptist Academy and Texas State University Campus survey sites. Eighty-eight percent of White-winged Dove nests at the San Marcos Baptist Academy and Texas State University Campus survey sites occurred in Texas oak (10%, *n* = 5), cedar elm (41%, *n* = 20), or live oak

(37%, *n* = 18) trees. The remaining White-winged Dove nests were found in retama (2%, *n* = 1), Wright acacia (*Acacia wrightii*, [2%, *n* = 1]), bur oak (*Quercus macrocarpa*, [2%, *n* = 1]), Texas persimmon (*Diospyros texana*, [2%, *n* = 1]) and ornamental ficus (*Ficus* spp. [4%, *n* = 2]) trees. Mourning Dove nests were found in all four-survey areas in San Marcos. Mourning Dove nests occurred in a variety of tree species, however, eighty-three percent were in Texas oak (8.6%, *n* = 3), cedar elm (28.6%, *n* = 10), or live oak (45.7%, *n* = 16) trees. The remaining Mourning Dove nests were found in ashe juniper (*Juniperus ashei*, [2.9%, *n* = 1]), pecan (*Carya illinoinensis*, [2.9%, *n* = 1]), evergreen sumac (Rhus virens, [2.9%, n = 1]) Texas persimmon (n = 1, 2.9%) and *Photinia* spp. (n = 2, 5.7%) trees. All three Inca Dove nests found at the Aquarena Springs survey site were in Texas mountain laurel (*Sophora secundiflora*).

The result of the *t*-test of nest height as a percent of tree height for White-winged and Mourning Dove was not significant ($t_{82} = 1.23$, $P = 0.26$). The regression for the combined White-winged and Mourning Dove height data was significant ($r^2 = 0.45$, $F_{1,82} = 68.93$, $P < 0.01$). Multivariate Analysis of Variance for White-winged Doves and Mourning Doves in San Marcos was not significant ($Pillai_{78} = 0.07$, $P = 0.35$; Table 1). Individual ANOVAs performed on each response variable showed nest height was significant ($F_{78} = 5.47$, $P = 0.02$; Table 3). White winged Doves had a Hurlbert's Standardized Niche Breadth of 0.56 (95% CI = 0.21-0.92). Mourning Doves had a Hurlbert's Standardized Niche Breadth of 0.63 (95% CI = 0.32-0.94).

CHAPTER IV

DISCUSSION

Selection of suitable nest sites is a key component of the breeding cycle in many avian taxa (Lindell 1996) with nest site selection influencing avian natural history (Brightsmith 2005). Traits like selection for plant community, community structural configuration, habitat selection at the landscape level or microhabitat, tree height, tree species, clutch size, nestling period, probability of renesting, nest initiation date, foraging requirements within habitats and rate of nest predation all correlate with nesting niche (Lack 1968; Martin 1995). Species that nest in limiting microhabitats can have the availability of nesting sites regulate the productivity of populations (Duffy 1983; Newton 1995; Robinson et al. 2000; Brightsmith 2005). It would seem that a species' choice of nest site could directly influence where it lives and with which species it coexists (Brightsmith 2005). Hence, investigation and explanation of patterns of nest-site use are central to understanding the population ecology and evolution of species, including how nest-site use affects a species' interactions with coexisting species. Despite the importance of nesting niche in avian evolution and ecology, evolutionary changes in nesting niche and the ecological forces favoring such changes have received relatively little study where evolutionary and ecologically sympatric species inhabit a community.

Coexistence of ecologically equivalent species is unlikely; mechanisms that allow for coexistence include habitat or niche partitioning, use of resources during different

times (i.e., temporal partitioning), and/or differential use of food (Schoener 1974; Anderson et al. 2002). Habitat partitioning between ecologically equivalent avian species is often evaluated using metrics such as nest site selection. For example, Martin and Martin (2001) examined the effect of Orange-crowned Warbler (*Vermivoracelata*) removal on Virginia's Warbler (*V. virginiae*) nest site selection and the effect of Virginia's Warbler removal on Orange-crowned Warbler nest site selection. The responses were asymmetric; Orange-crowned Warblers did not shift nest sites in response to Virginia's Warbler removal, but Virginia's Warblers shifted nest sites in response to the removal of Orange-crowned Warblers (Martin and Martin 2001). These authors noted that a greater understanding of habitat partitioning is important, particularly regarding the potential ecological consequences of coexistence between ecologically similar species.

Temporal partitioning of resources may also allow for coexistence of ecologically similar species. For example, differences in nesting phenologies by cavity nesters may decrease interspecific interactions and facilitate coexistence. Ingold (1989) studied the nesting phenologies of three co-occurring cavity nesters in Ohio. He found that Red-headed Woodpeckers (*Melanerpes erythrocephalus*) likely experienced little competition from European Starlings (*Sturnus vulgaris*) because of large differences in nesting phenologies; whereas, Red-bellied Woodpeckers (*M. carolinus*) had a higher frequency of interactions with European Starlings due to similarities in nesting phenologies of the two species.

Partitioning of nesting space between White-winged and Mourning Doves in San Marcos was not distinct. San Marcos is not within the historic range of White-winged Doves. The recent range expansion of White-winged Doves could explain why the

specialization we see in Estero Llano Grande State Park is not seen in the San Marcos area (Small et al. 2006). Data indicate that White-winged Doves may be encroaching on Mourning Dove nesting habitat.

My study suggests that Mourning Doves prefer nesting habitat with multiple tree species from which to select. In addition to tree species diversity, tree height also influenced nest site selection for White-winged and Mourning Doves. Low sample size of Inca Dove nests found was due to their longer breeding cycle. In Texas Inca Dove pairs breed from late February to late December (Oberholster 1974). Also, Inca Doves will nest on man-made structures. White-tipped Doves also had a small sample size due to the fact that the majority of their range is in Mexico, Central and South America (Howell and Webb 1995). White-tipped Doves are not found as far North as San Marcos, Texas.

APPENDIX

Table 1. Multivariate analysis of variance results of nest characteristics between White-winged Doves and Mourning Doves for both Estero Llano Grande State Park and San Marcos, Texas.

Study Site	*Pillai*'s Trace	den DF	*P*
Estero Llano Grande	0.231	56	0.01
San Marcos	0.067	78	0.35

Table 2. Individual analysis of variance results for each nest characteristic for White-winged Doves and Mourning Doves in Estero Llano Grande State Park during summer 2009.

Nest Characteristics	Sum of Squares	Mean Square	den DF	F	*P*
Basal Diameter(m)	0.065	0.065	55	0.867	0.355
Mean Canopy Width(m)	2.710	2.710	55	0.115	0.736
Nest Orientation	1.730	1.730	55	1.592	0.212
Distance from Center of Tree (m)	0.004	0.004	55	0.001	0.975
Nest Height (m)	50.053	50.053	55	12.895	0.001

Table 3. Individual analysis of variance results for each nest characteristic for White-winged Doves and Mourning Doves in San Marcos.

Nest Characteristics	Sum of Squares	Mean Square	den DF	F	*P*
Basal Diameter(m)	0.052	0.052	55	0.705	0.404
Mean Canopy Width(m)	27.030	27.034	55	1.705	0.195
Nest Orientation	0.067	0.067	55	0.052	0.821
Distance from Center of Tree (m)	6.593	6.593	55	1.763	0.188
Nest Height (m)	11.896	11.896	55	5.468	0.022

Table 4. Hurlbert's Standardized Niche Breadth for both White-winged and Mourning Doves in Estero Llano Grande State Park.

Dove Species	Hurlbert's Standardized Niche Breadth	95% CI
White-winged	0.029	-0.019, 0.078
Mourning	0.065	0.003, 0.127

Table 5. Hurlbert's Standardized Niche Breadth for both White-winged and Mourning Doves in San Marcos.

Dove Species	Hurlbert's Standardized Niche Breadth	95% CI
White-winged	0.559	0.496, 0.620
Mourning	0.630	0.586, 0.685

Table 6. The values of all nest parameters for White-winged Dove nests in San Marcos during summer 2010.

Nest ID	Basal Diameter	Mean Canopy Width (m)	Nest Orientation	Distance from center of tree (m)	Nest Height (m)
WW/BP1	0.35	10.31	2	2.15	4.21
WW/BP2	0.59	11.74	2	4.61	3.55
WW/BP3	0.49	10.32	1	1.91	5.49
WW/BP4	0.27	6.08	2	1.55	3.47
WW/BP5	0.37	7.63	4	0.10	6.00
WW/BP8	0.30	6.70	3	0.92	3.99
WW/BIO1	0.46	8.11	3	3.61	4.65
WW/BIO2	0.71	12.46	3	5.68	3.54
WW/BIO3	0.28	7.95	3	4.17	5.40
WW/BIO6	0.53	12.66	2	6.23	5.00
WW/BIO7	0.56	10.95	2	4.99	6.80
WW/BIO8	0.69	13.42	4	4.24	7.00
WW/BIO9	0.23	5.33	1	0.92	3.00
WW/BIO10	0.28	4.56	2	0.94	2.78
WW/BIO12	0.27	8.25	3	2.82	3.01
WW/BIO18	0.21	3.91	1	1.36	3.20
WW/BIO19	0.18	6.28	1	1.41	3.00
WW/BIO21	0.50	12.22	4	4.50	5.07
WW/BIO22	0.21	4.37	3	0.59	3.60
WW/BIO24	0.64	16.09	1	5.99	4.01
WW/BIO25	1.10	10.16	2	2.65	7.00
WW/BIO26	0.37	8.04	4	4.26	7.54
WW/BIO27	0.07	2.18	1	0.48	2.15
WW/BIO28	0.56	9.09	3	4.09	5.70
WW/BIO30	0.99	13.88	4	5.45	5.80
WW/BIO31	0.66	17.09	2	6.45	4.62
WW/BIO32	0.24	5.95	4	1.11	3.60
WW/BIO33	0.28	7.12	1	2.59	4.00
WW/BIO34	0.70	16.17	4	7.06	8.20
WW/BIO37	0.40	12.76	3	6.92	6.94
WW/BIO38	0.52	13.44	3	3.52	3.22

Table 6. Continued.

Nest ID	Basal Diameter (m)	Mean Canopy Width (m)	Nest Orientation	Distance from center of tree (m)	Nest Height (m)
WW/BIO41	0.18	5.32	3	2.13	5.20
WW/BIO42	0.27	5.72	3	2.19	2.83
WW/BIO43	0.54	11.38	3	2.19	5.60
WW/BIO45	0.29	11.72	3	3.21	6.80
WW/BIO48	0.28	7.08	3	2.27	5.40
WW/BIO49	0.40	12.61	3	2.21	4.87
WW/BIO50	0.27	4.70	3	1.25	2.35
WW/BIO51	0.53	13.80	4	5.21	7.12
WW/BIO53	0.50	12.62	2	4.65	4.20
WW/BIO54	0.20	4.31	2	0.68	4.08
WW/BIO55	0.21	4.42	1	1.36	3.59
WW/BIO57	0.27	6.24	1	1.88	4.22
WW/BIO58	1.23	14.55	1	6.45	6.27
WW/BIO65	0.57	12.90	1	5.02	5.22
WW/BIO67	0.36	9.17	1	2.27	4.26
WW/BIO69	1.11	8.90	2	3.03	7.60
WW/BIO75	0.82	14.50	2	3.75	6.80
WW/BIO77	0.18	5.11	3	1.10	4.07

Table 7. The values of all nest parameters for Mourning Dove nests in San Marcos during summer 2010.

Nest ID	Basal Diameter (m)	Mean Canopy Width (m)	Nest Orientation	Distance from center of tree (m)	Nest Height (m)
MD/AQ1	0.94	10.67	4.00	2.52	3.36
MD/AQ2	0.72	19.00	1.00	6.08	5.84
MD/BP7	0.61	9.45	2.00	3.56	2.91
MD/BIO4	0.22	3.16	2.00	1.30	2.71
MD/BIO11	0.21	5.66	3.00	1.16	2.97
MD/BIO13	0.36	10.84	4.00	3.51	4.23
MD/BIO14	0.36	10.84	2.00	2.71	2.22
MD/BIO15	0.24	5.62	4.00	1.07	5.23
MD/BIO16	0.24	6.03	4.00	1.54	3.00
MD/BIO17	0.18	4.06	2.00	1.03	2.62
MD/BIO20	0.17	4.56	2.00	1.09	4.88
MD/BIO23	0.25	3.45	1.00	1.58	2.00
MD/BIO29	0.18	5.64	1.00	1.41	2.00
MD/BIO36	0.36	10.18	1.00	2.85	4.86
MD/BIO39	0.51	12.00	2.00	3.46	6.46
MD/BIO40	0.17	5.45	3.00	1.39	3.70
MD/BIO44	1.32	13.81	4.00	5.80	4.95
MD/BIO46	0.18	4.28	4.00	0.81	2.32
MD/BIO47	0.20	7.00	2.00	2.21	3.13
MD/BIO52	0.50	12.62	1.00	4.02	4.41
MD/BIO56	1.13	14.45	2.00	5.72	5.62
MD/BIO62	0.22	3.08	1.00	1.55	1.85
MD/BIO64	0.26	7.13	1.00	0.81	5.04
MD/BIO63	0.61	16.37	3.00	6.64	5.85
MD/BIO70	0.20	4.55	4.00	1.57	3.84
MD/BIO71	0.24	5.62	1.00	1.07	5.23
MD/BIO66	0.70	13.96	1.00	6.43	6.35
MD/BIO72	0.21	5.27	1.00	0.49	4.09
MD/BIO73	0.27	5.39	4.00	0.76	2.83
MD/BIO74	0.77	14.76	2.00	6.15	5.10
MD/BIO76	0.21	5.97	1.00	0.64	4.67
MD/BIO78	0.28	6.24	4.00	1.42	2.78
MD/CM1	0.42	8.21	1.00	2.38	4.33
MD/CM3	0.31	6.82	4.00	4.37	4.65
MD/CM4	0.35	6.35	4.00	1.12	5.84

Table 8. The values for all nest parameters for White-winged Dove nests in Estero Llano Grande State Park.

Nest ID	Basal Diameter (m)	Mean Canopy Width (m)	Nest Orientation	Distance from center of tree (m)	Nest Height (m)
WW/EN1	0.78	16.12	1.00	8.65	6.80
WW/EN3	0.21	4.75	4.00	3.50	5.00
WW/EN4	0.50	8.30	4.00	2.41	6.44
WW/EN6	0.43	9.03	2.00	3.78	6.00
WW/EN7	0.27	6.14	1.00	4.31	5.20
WW/EN8	0.36	8.57	2.00	1.51	6.40
WW/EN9	0.86	18.66	3.00	7.53	7.00
WW/EN10	0.86	18.66	3.00	7.89	8.40
WW/EN11	0.86	18.66	4.00	5.77	9.25
WW/EN12	0.50	12.99	1.00	4.06	7.60
WW/EN15	0.58	12.96	3.00	4.32	4.00
WW/EN16	1.22	14.44	2.00	4.94	8.20
WW/EN18	0.96	22.22	2.00	4.13	4.40
WW/EN19	0.29	5.52	1.00	4.09	2.60
WW/EN20	0.49	6.32	3.00	2.85	4.80
WW/EN21	0.46	10.93	1.00	1.23	6.60
WW/EN23	0.90	16.08	4.00	6.98	5.00
WW/EN24	0.85	8.55	3.00	3.68	7.80
WW/EN25	0.76	7.05	2.00	4.69	6.60
WW/EN26	0.62	12.45	4.00	5.00	8.40
WW/EN27	0.50	12.99	2.00	2.00	7.80
WW/EN28	0.60	7.11	4.00	2.83	6.60
WW/EN29	0.50	8.10	3.00	1.83	9.40
WW/EN33	0.33	6.35	1.00	3.08	7.18
WW/EN34	1.18	6.27	2.00	1.27	8.40
WW/EN38	0.86	18.36	3.00	5.58	8.60
WW/EN39	0.91	11.52	4.00	5.50	8.80
WW/EN43	0.62	12.76	3.00	3.25	8.60
WW/EN48	0.63	4.52	1.00	4.11	9.20
WW/EN49	0.82	9.59	1.00	3.35	5.80
WW/EN28A	0.60	7.11	4.00	2.83	6.60
WW/EN50	0.69	11.43	4.00	4.80	5.20
WW/EN51	1.14	21.91	2.00	3.28	9.00
WW/HN4	0.21	4.54	2.00	2.72	2.20
WW/HN6	0.24	4.70	2.00	0.71	3.41
WW/IN5	0.16	5.74	1.00	1.99	5.80
WW/HN17	0.27	6.73	2.00	2.23	4.87

Table 9. The values of all nest parameters for Mourning Dove nests in Estero Llano State Park.

Nest ID	Basal Diameter (m)	Mean Canopy Width (m)	Nest Orientation	Distance from center of tree (m)	Nest Height (m)
MD/EN2	0.17	4.96	3.00	2.28	3.70
MD/EN5	0.92	6.54	2.00	2.69	5.60
MD/EN14	0.62	14.06	2.00	5.22	6.80
MD/EN17	0.62	12.45	3.00	5.87	5.20
MD/EN22	0.46	9.04	3.00	4.97	5.80
MD/EN30	0.48	8.67	4.00	0.98	3.43
MD/EN31	0.61	12.14	3.00	4.58	7.00
MD/EN32	0.91	11.52	2.00	3.74	6.00
MD/EN14A	0.62	14.06	2.00	5.22	6.80
MD/EN35	0.46	9.04	4.00	5.57	8.00
MD/EN36	0.39	7.30	3.00	3.39	5.40
MD/EN37	0.82	13.18	3.00	4.21	7.17
MD/EN40	1.07	18.65	2.00	6.85	5.20
MD/EN41	0.87	18.17	1.00	8.36	4.60
MD/EN42	0.91	11.52	4.00	4.04	6.40
MD/EN44	0.45	8.28	1.00	5.14	5.20
MD/EN45	0.48	14.31	2.00	4.30	5.20
MD/EN46	0.65	12.74	2.00	5.18	5.20
MD/EN47	0.64	14.74	3.00	6.11	6.00
MD/EN30A	0.48	8.67	4.00	0.98	3.43
MD/MN2	0.27	8.97	3.00	0.97	1.47
MD/MN5	0.21	2.50	3.00	0.97	1.17
MD/MN16	0.31	2.88	4.00	0.05	0.80
MD/MN24	0.19	2.88	4.00	1.92	1.06
MD/MN34	0.30	11.08	3.00	2.41	2.41

Table 10. The number of available nesting trees within the study sites in Estero Llano Grande State Park.

Vegetation Species	Available Trees
Anacua *(Ehretia anacua*)	272
Texas Ebony (*Pithecellobium ebano*)	328
Live Oak (*Quercus virginiana*)	64
Retama (*Parkinsonia aculeate*)	113
Prickly Pear (*Opuntia engelmannii var. lindheimeri*)	829
Honey Mesquite (*Prosopis glandulosa*)	999
Huisache (*Acacia farnesiana*)	197
Lote Bush (*Ziziphus obtusifolia*)	35
Granjeno (*Celtis pallida*)	270
Guajillo (*Acacia berlandieri*)	23
Loquat (*Eriobotrya japonica*)	23
Brasil (*Condalia hookeri*)	108
Avocado (*Persea spp.*)	25
Orchid Tree (*Bauhinea Variegata*)	15
Coma (*Bumelia celastrina*)	310
Mexican Olive (*Cordia boissieri*)	39
China Berry (*Melia azedarach*)	3
Royal Poinciana (*Delonix regia*)	4
Cedar Elm (*Ulmus crassifolia*)	1
Rio Grande Ash (*Fraxinum berlandieriana*)	1
Tenaza (*Havardia pallens*)	12
Tepaguaje (*Leucaena pulverulenta*)	4
Privet *(Ligustrum spp.)*	9
Lime Prickly Ash (*Zanthoxylum fagara*)	18
Coyotillo (*Karwinskia humboldtiana*)	3
Sugarberry (*Ceitis laevigata*)	20
Texas Persimmon (*Diospyros texana*)	43
Guayacan (*Guaiacum angustifolium*)	10
Sabal spp.	21
Mexican Amyris (*Amyris madrensis*)	32
Blackbrush Acacia (*Acacia rigidula*)	15
Texas Mimosa (*Acacia greggii*)	3
Texas Paloverde (*Cercidium texanum*)	1
Crucillo (*Randia rhagocarpa*)	9
Elbow Bush (*Forestiera angustifolia*)	14
Musa spp.	50
Ashe Juniper (*Juniperus ashei*)	1
Eastern Red Cedar (*Juniperus virginiana*)	1
Brazilian Pepper Tree (*Schinus terebinthifolius*)	1

Table 10. Continued.

Vegetation Species	Available Trees
Ficus (*Ficus benjamina*)	1
White Mulberry (*Morus alba*)	2
Taxus spp.	2
Mangifera spp.	3
Aralia spp.	1
Citrus spp.	25
Norfolk Island Pine (*Araucaria heterophy*)	7
Albizia spp.	8
Pecan (*Carya illinoinensis*)	6
Ficus religiosa	4

Table 11. The number of available nesting trees within the study sites in San Marcos.

Vegetation Species	Available Trees
Live Oak (Quercus virginiana)	443
Texas Oak (Quercus texana)	51
Ashe Juniper (Juniperus ashei)	152
Cedar Elm (Ulmus crassifolia)	188
Pecan (Carya illinoinensis)	55
Ornamental Ficus	15
Photinia spp.	10
Wright Acacia (Acacia wrightii)	8
Retama (Parkinsonia aculeate)	6
Evergreen Sumac (Rhus virens)	7
Texas Persimmon (Diospyros texana)	9
Lacey Oak (Quercus laceyi)	2
Bur Oak (Quercus macrocarpa)	3
Bald Cypress (Taxodium distichum)	23
Texas Sumac (Rhus lanceolata)	2
Western Soapberry (Sapindus drummondii)	4
Honey Mesquite (Prosopis glandulosa)	6
Post Oak (Quercus stellata)	3
Blackjack Oak (Quercus marilandica)	2

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