MOURNING DOVE AND WHITE-WINGED DOVE HABITAT ASSOCIATION BASED ON REMOTELY SENSED LAND COVER TYPES IN THE LOWER RIO GRANDE VALLEY, TEXAS

THESIS

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by

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ABSTRACT

Mourning Dove and White-winged Dove Habitat Association

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I compared presence or absence of White-winged Doves (*Zenaida asiatica*) and Mourning Doves (*Z. macroura*) in south Texas to the 2001 National Land Classification Database (NLCD) categories. My objective was to determine which, if any, categories from the NLCD classification scheme could be used to predict each species occurrence. My study was conducted between 15 May and 15 August in 2007 and 2008. I used point-transect methodology to conduct presence/absence surveys for both species at 236 points encompassing 744 observations. Land classification categories were quantified using geographic information systems (GIS). Each point and its associated 300-m buffer were projected on NLCD maps. I then used GIS to determine proportions of each land classification type within the area of each buffer. Randomization tests were used to compare proportions of land cover types present at points with and without doves. I used program DISTANCE to determine if land cover types associated with dove presence had higher estimated densities than those not associated with doves. My results indicated that White-winged Dove occurrence in south Texas was positively associated with land cover categorized as urban and cropland, while Mourning Dove occurrence was positively associated with crop land cover type. In land cover types found to be associated with dove presence, the estimated density for each dove species increased as proportion of associated land cover increased.

CHAPTER I

INTRODUCTION

The Rio Grande River originates in the Rocky Mountains in southwestern Colorado and traverses more than 2,830 km across Colorado, New Mexico and Texas before forming an extensive delta at its terminus with the Gulf of Mexico along the U.S./Mexico border (Dahm et al. 2005, Dykkesten, 2009). This final reach of the Rio Grande is in an area generally referred to as the Lower Rio Grande Valley (LRGV). The LRGV is comprised of four Texas counties (Cameron, Hidalgo, Starr, and Willacy) located at the southernmost tip of Texas (Fig. 1).

Ecologically, the LRGV is part of the Tamaulipian Biotic Province (Blair 1950, Diamond et al. 1987, Jahrsdoefer and Leslie 1989). Numerous biological communities have evolved within this delta region and collectively comprise the Tamaulipan brushland. These communities are among the most species diverse in North America north of Mexico and are composed of unique assemblages of flora and fauna. The Tamaulipan brush community of the LRGV is not only among the most biologically diverse regions in the United States, it is also arguably among the most threatened (Mathis and Mastioff 2004, TPWD 2005).

The Tamaulipan brushland along the lower Rio Grande is comprised of 11 distinct biotic district types all with distinct characteristics (Blair 1950, Diamond et al. 1987).

These biotic districts are limited in distribution and, north of Mexico, unique to the LRGV. Also, many floral and faunal taxa occur in the region in greater numbers than in any similar region in North America because of the LRGV's location between tropical and temperate latitudes and its unique physiographic characteristics (Cottam and Trefethen 1968, Waggerman and Sorola 1977, Haughey 1986, George et al. 1994).

In the LRGV, birds are of special interest to birding enthusiasts. Of the 634 species of birds found in Texas, 517 species inhabit the LRGV (Dauphin and Dauphin 2008). This is more species of birds than found in any other ecological area in Texas and most other states. Close proximity to Mexico, extreme southern location, and unique habitats, are among the factors which contribute to the avian diversity of the LRGV (Dauphin and Dauphin 2008). The presence of so many unique species of birds has made bird watching the primary economic factor in the huge eco-tourism industry in the LRGV (Dauphin and Dauphin 2008). Also, of great economic value to the LRGV are migratory game birds such as the eastern White-winged Dove (*Zenaida asiatica*) and Mourning Dove (*Z. macroura*). White-winged and Mourning Doves are medium-sized columbids that are sympatric in Texas (George 2004, Silvy and Rollins 2004). Mourning Doves are distinguishable from White-winged Doves by their smaller body size, long, pointed tail, and lack of a white wing patch (Sanderson 1977, George 2004). White-winged Doves exhibit a squared, white-tipped tail while perching, and are the only North American dove with a conspicuous white wing patch or epaulet (George et al. 1994).

White-winged Doves inhabit brushlands and woodlands or desert scrub with cacti, as well as agricultural and urban areas throughout their range (Linex et al. 2004). Migratory populations breed and nest in semi-tropical, thorny woodlands in the states of

Tamaulipas, Coahuila, Nuevo Leon, and Veracruz in Mexico and in the LRGV and Trans-Pecos regions of Texas (Cottam and Trefethen 1968, Swanson and Rappole 1992, Schacht et al. 1995). They have also, in the past, nested extensively in citrus orchards in the LRGV, accounting in some years for 50-90% of all nesting activity (Cottam and Trefethen 1968, George et al. 1994, Small et al. 2005). North of the LRGV in Texas, nesting colonies and individuals in urban areas also rely on shade and ornamental trees as nest sites, utilize bird feeders and bird baths, and make feeding flights into nearby agricultural fields (Mills et al. 1989).

In the early 1900s, White-winged Dove breeding populations increased as irrigation and grain farming brought new sources of food and water to their historic range (Purdy and Tomlinson 1991). As agricultural and urban development encroached into and eliminated the customary native brush nesting areas, a large proportion of populations shifted to nesting in citrus orchards. However, after severe freezes in the 1950s and 1960s damaged trees, citrus orchards that served as major nest sites for White-winged Doves became unusable and the population declined; however, after 5-8 years, branches on the damaged trees regrew sufficiently to provide cover and nesting platforms and the population rebounded (Cottam and Trefethen 1968, Swanson and Rappole 1992, Schacht et al. 1995, Rappole et al. 2007, Small 2007).

White-winged Dove populations have fluctuated throughout much of their range in response to changing environmental conditions relating to their nesting and feeding. Likewise, population increases or decreases have often been linked to availability of agricultural grain crops. Since the 1960s, the overriding trend amid these fluctuations has been a steady decline in eastern and western White-winged Dove populations on their traditional breeding grounds in Texas and increased White-winged Dove populations in urban areas (Blankenship 1966, Brown 1989, George et al. 1994, Small and Waggerman 1999).

Mourning Doves and White-winged Doves in Texas have undergone dynamic changes in abundance and distribution in recent years (Baskett and Sayre 1993, Small et al. 2007). Mourning Doves have declined in numbers, resulting in increased concern about the species long-term viability (Baskett and Sayre 1993). Historically, White-winged Doves inhabited brush and riparian habitats of the LRGV, as far north as Bee County, Texas (Cottam and Trefethen 1968, Oberholser 1974, George et al. 1994, Small et al. 2005). White-winged Doves have undergone a dramatic northward range expansion with new populations becoming urban obligate in nesting and partially resident instead of migratory, probably as a result of associated land use practices (Rogers 1998, Small and Waggerman 1999, Pruett et al. 2002, Schwertner et al. 2006).

Urban and agricultural development during the 20th Century has decimated the Tamaulipan brushland (on both sides of the Rio Grande) and its associated flora and fauna. Beginning in the 1920s, large scale habitat conversion of the LRGV began as land use changed from ranching to field agriculture, urban, and industrial development. By the end of 20th Century, an estimated 95% of the original native brush had been destroyed or converted to other uses (Rappole and Waggerman 1986, Jahrsdoefer and Leslie 1988, Hayslette et al. 1996). Dove habitat in the LRGV has become fragmented into isolated remnants of once-contiguous woodlands. For example, of the original 16,194 ha of native Sabal palms lining the Rio Grande, only 16 ha remain. Greater than 90% of the riparian vegetation along the U.S. side of the Rio Grande has been cleared, and the corresponding habitat on the Mexican side is being removed at an accelerated rate (Hayslette et al. 1996, Brush 2005, Small et al. 2005). The LRGV's flood plain forests are no longer shaped by annual flood waters because flood control structures on the Rio Grande have eliminated the annual flood-pulse cycle (Small 2007, Small et al. 2009). The remaining forest is gradually evolving into dryer, less diverse woodland (Jahrsdoerfer and Leslie 1988, Twedt and Best 2004). Perhaps most threatening to native land cover in the LRGV is the continuing human population increase and concurrent urban expansion, which intensifies conversion and fragmentation of the remaining limited native habitat (Jahrsdoerfer and Leslie 1988, Roberson 2004).

Scattered patches of native vegetation in a matrix of cleared land present problems for doves and other species. In particular, increased energetic costs and risk of detection by predators as they search for food, water, and cover adversely affect populations (Schwertner et al. 2002). Habitat alteration reduced the quality of nesting sites and food resources (Kiel and Harris 1956, Cottam and Trefethen 1968). Loss of large amounts of Tamaulipan brushland has been linked to population declines of White-winged Doves and poses a potential threat to Mourning Doves (Keeler et al. 1977, George et al. 1994, Waggerman et al. 1994).

Estimates of population decline are based on "coo-counts". Coo-counts have been used to measure the White-winged Dove population size in brushlands of the LRGV since 1949 (Uzzell 1949, Cottam and Trefethen 1968). Counts are based on experiments comparing number of coos/ha with number of nests counted on sample sites. However, such counts have been found to "contain serious, essentially immeasurable sources of error" (Rappole and Waggerman 1986).

Mourning Doves and White-winged Doves are hunted in Texas for recreation and food (George 2004). Dove hunting is an important form of outdoor recreation; about 460,000 dove hunters spend 3.6 million hunt-days afield each year. The $438 typically spent per capita to harvest dove species amounts to one-third of the money spent annually by the average Texas hunter (Bevill 2004). Nationally, annual harvest of doves exceeds that of all other species of game birds in the U.S. (Silvy and Rollins 2004).

Dove hunting seasons in Texas are based on a three-zone latitudinal system (north, central, and south) with different opening days for the season and an additional special White-winged Dove hunting season in early September in part of the south zone (Texas Parks and Wildlife Department Outdoor Annual 2008-2009). Because Mourning and White-winged Doves are migratory game birds, they are subject to federal oversight (Gregory 1998, Bevill 2004). Consequently, responsibility for monitoring and managing populations of these species is delegated to state agencies (Eberly and Keating 2006). Traditionally, White-winged Dove monitoring was conducted using inefficient methods and relegated to the LRGV (Berger and George 2004). Range expansion of White-winged Doves into northern, urban areas created a need to expand the survey effort statewide (Schwertner and Johnson 2006). Unsatisfactory reviews of sampling methodology led TPWD to redesign and implement White-winged Dove surveys statewide. Recent research suggested that randomly placed point counts in urban areas using DISTANCE (Research Unit for Wildlife Population Assessment, St. Andrews, Scotland) methodology yielded reliable estimates of density, so DISTANCE sampling was adopted as the primary sampling method for White-winged and Mourning Doves (Schwertner and Johnson 2006). Also, because White-winged Doves in much of Texas are restricted to urban areas, TPWD developed an intensive dove census and monitoring program of urban areas using DISTANCE sampling and large-scale leg-banding (Sepulveda et al. 2006). The objective of this program is to gather large quantities of data to monitor dove populations and develop an adaptive management plan for doves (Schwertner per. comm.). Monitoring these species is extremely laborious and time intensive requiring a concentrated annual effort (Schwertner and Johnson 2006, Small 2007).

Progressively more management practices are shifting to those based on mapping and relating species occurrence to potential habitat (Rice et al. 2008). Effective management of wildlife species is contingent on a preliminary understanding of the natural history of species and habitat needs (Hutto et al. 1992). Habitat modeling using land cover classes as key attributes can be used to indicate habitat preference by species. Habitat modeling is dependent on the quality and accuracy of the land cover map in use. The National Land Cover Dataset (NLCD) is a 15-class land cover classification scheme mapped consistently over the United States using unsupervised clustering and geographic information systems (GIS) modeling (Homer et al. 2007). Spatial resolution of these data is 30 by 30-m pixels.

Remote sensing techniques are useful because land cover and land use data across large areas can be obtained from a distance. Satellite imagery, combined with GIS and accuracy assessments, provide an effective approach to mapping species occurrence in complex habitats, a particularly useful approach for generalist species with large home ranges (Rice et al. 2008). The NLCD is easy to access and widely available, but its large-scale (national) nature is an impediment in maintaining up-to-date information. The

NLCD 2001 version was created by partitioning the U.S. into mapping zones. A total of 66 mapping zones were delineated within the conterminous U.S. based on ecoregion and geographical characteristics, edge matching features, and the size requirement of Landsat mosaics (Homer et al. 2004). I used the most recent NLCD available, which was the 2001 version. Prior to the 2001 NLCD the latest version was the 1992 NLCD.

Development of an efficient method for identifying and qualitatively categorizing dove habitats will allow survey resource expenditures to be scaled to habitat quality. An association between land cover and Mourning Dove and White-winged Dove densities would allow field biologists to more efficiently dispense finite resources while maximizing return per effort. Consequently, the objectives of this study were 1) to determine which, if any, land cover categories from an existing dataset indicate the presence or absence of White-winged and Mourning Doves in the LRGV, 2) to quantify habitat affiliations of these two dove species in the LRGV, 3) to determine dove densities as a function of degree of habitat association and subsequent population size, and 4) to delimit the northern extent to which White-winged Doves use native habitat for breeding and become urban obligate.

CHAPTER II

METHODS

Survey Point Delineation

I used GIS software ArcGIS v9.2 (ESRI 2007) and the generate regular points feature in Hawth's tools extension (Beyer 2004) for ArcGIS to generate a 10 x 13 matrix of 130 census points spaced at about 3,200-m intervals. This follows the current sampling methodology of the TPWD. All points were moved to the nearest road to maximize accessibility. In 2007, points were evenly distributed in a structured random grid mainly in Hidalgo County with points extending into southern Willacy and eastern Cameron counties (Fig. 2). In 2008, the same points from 2007 and an additional 158 points were used (Fig. 2). I placed the new points north of the 2007 sampling grid linearly east to west using the create points function in ArcGIS; points extended further into Willacy County, included Cameron County, spanned Starr County and included southern Kennedy County. These new points provided a more comprehensive coverage of habitat types in the LRGV. All new points were selectively placed <1,600 m apart on accessible roads.

Avian Sampling

I conducted point-transect surveys in the LRGV from 19 May through 25 July 2007 and 15 May through 3 July 2008 during the breeding season following the TPWD methodology (Schwertner and Johnson 2006). Some points were inaccessible and excluded from survey analyses. Points were not surveyed during inclement weather. Similar to TPWD, point-transect surveys began 10 min after official sunrise and continued no later than 2 h after official sunrise. Each point was surveyed for 2-min by a stationary observer. An assumption of program DISTANCE is that each point is surveyed as a theoretical "snapshot" in time; hence, my 2-min survey period allowed me to record doves present at each point and was still short enough to minimize the chance of duplicate counting of doves leaving and re-entering the sampling area (Buckland et al. 1993). Presence or absence of a White-winged Dove or Mourning Dove at each point during the 2-min survey was recorded and distances to doves sighted were recorded on a standardized data sheet (Appendix A) (Buckland et al. 1993). Only visual observations were used to eliminate possible bias associated with auditory counts and avoid error in estimating distances to an auditory signal (Simons et al. 2007). Distances to doves were determined to the nearest meter using a laser range-finder (Bushnell Yardage Pro Legend, Bushnell, Inc., Overland Park, KS, USA). Doves were considered to be clustered when observed in the same tree or flying in flocks. Doves on the ground or perched on artificial structures were recorded as individual observations.

In 2007, sampling began at the southernmost points and progressed to the northernmost points. Upon completion, a second sampling effort was initiated and one-half the points were surveyed prior to termination of the sampling period. In 2008, sampling was conducted as in 2007 except after completion of the southern point grid, the additional northern points were surveyed. Sampling northern points began in the east and progressed west. As soon as all points (southern grid and northern transect) had been sampled, all points were sampled a second time to increase accuracy and reduce bias (Buckland et al. 1993, Hostetler and Main 2001).

Data Analysis

Land Cover Delineation

I imported land cover classification maps of the LGRV from the 2001 NLCD into ArcGIS 9.2 to quantify land cover proportions. Image data were downloaded into ArcMap as a raster data file. Raster data are displayed as discrete picture elements (pixels); it is a cellular data structure composed of rows and columns with groups of cells representing landscape features. Values in each cell represent values of the feature.

I reclassified the 15 land cover classes represented in the LGRV into six, grouped categories (urban, rangeland, pasture, cropland, wetland, and forest) to quantify landscape structure (Fig. 5). Reclassification into these categories was based on the similarity of the habitat characteristics being grouped. For example, the reclassified category "urban" encompassed the 2001 NLCD classes for high intensity developed, medium intensity developed, low intensity developed, and developed open space. I reduced the number of land cover classes to make the dataset more manageable. There was high variability between land use types when specific rather than general categories were used; with a smaller number of variables to test, I decreased the chance of committing a Type I error. Also, reclassification was used to make land cover classes more biologically relevant (e.g., it is unlikely doves can differentiate between intensity of development to any degree of ecological relevance). Reclassification also increased resolution among land cover types doves might prefer.

I created circular buffers of 300-m, 500-m, and 700-m radii around each sample point to determine the scale of habitat use (Fig. 3). The 300-m buffer was initially chosen for comparison because it encompassed all observations of dove species. The 500-m and 700-m buffers were also chosen for comparison because the habitat scale being used by doves was unverified. Pixel counts were then extracted from each respective buffer zone around each point using Hawth's tools thematic raster summary add-in for ArcGIS (Beyer 2004). Cells given a NODATA value were excluded from analysis. The NODATA values were present in cells where no spatial information was available; these were mainly along the U.S./Mexico border. Pixel counts were then converted into percentage of land cover type per survey point at a given buffer distance. I used a 3 by 6 goodness-of-fit contingency table to determine if buffers of differing radii contained similar proportions of land cover types. I also used a goodness-of-fit Chi-square test to determine if the mean landscapes in the 300-m buffer were proportionally representative of the area sampled. The sampling area consisted of a 5-km buffer zone around the cumulative set of survey points and was based on home range studies conducted in Texas (Small et al. 2009, Fig. 4a & b).

Randomization Test Protocol

The requisite assumptions for parametric analysis of normally distributed and homoscedastic data were not met because observations at each survey point were low, with the majority of point surveys consisting of zero or one observation. Consequently, to compare land cover types at points where doves were observed to points where no doves were observed, I used a randomization test (Veech 2006). The randomization test consists of computing mean proportions of land cover classification types at points with doves and comparing it to mean proportions of land cover classification types at points without doves. For White-winged Doves, fewer points had doves present than had doves absent.

I used the statistical package Program R (R Development Core Team 2008) to randomly draw without replacement sets of 58 points (the number of points with White-winged Doves) from the pool of points without White-winged Doves (171). The mean of this sample was stored in a matrix. This protocol was repeated with replacement for 10,000 iterations. The means from the 10,000 iterations for each of the six land cover categories were used as six test distributions where White-winged Doves were absent. I then evaluated each mean land cover type proportion for points with doves to the distributions of mean proportions for points without doves. If a value fell within 5% of either end of the distribution, it was deemed to have a significant effect ($P \leq 0.05$). Where significance occurred, the effect was considered significantly small or significantly large depending on which tail of the distribution the sample mean occurred.

This process was also used to evaluate Mourning Dove presence and absence. However, Mourning Doves were present at more points than they were absent. Consequently, the distribution used for comparison was created by drawing 10,000 random iterations of 75 points (the number of points without Mourning Doves) from the pool of points with Mourning Doves present (161). Comparisons of mean proportions of land cover types and subsequent significance of effect were evaluated similar to White-winged Doves.

Distance Sampling Protocol

Data were analyzed using program DISTANCE 5.0 v. 2 (Buckland et al. 2001). Program DISTANCE was used to model the probability of detection at various distances and to evaluate slopes of selected fitted functions in building candidate models from which I selected the most parsimonious (Buckland et al. 1993). I used half-normal and hazard-rate detection function models with cosine, hermite polynomial, and simple polynomial expansions series for density estimation and allowed no more than two adjustment terms (Buckland et al. 2001:156). Before model selection in DISTANCE, I fitted a plausible model to data and right truncated data at a distance where detection probability fell below 10% following standard distance sampling methods (Buckland et al. 2001:151). Program DISTANCE indicated the most parsimonious model based on Akaike Information Criterion (AIC) (Buckland et al. 2001). Maximum likelihood histograms fitted with probability of detection curves plotted against distance were created by Program DISTANCE and tested for fit using a Kolmogorov-Smirnov test. I selected the best model (with an appropriate truncation point) by visual inspection of histograms, model fit, and coefficients of variation. From this model, density estimates and 95% confidence intervals were calculated.

For each point visited, density estimates were combined with land cover data. The land cover classification(s) found to significantly influence each species were used to sort data. White-winged Dove data were sorted in ascending order by percentage of the combined urban and crop land categories, while Mourning Dove data were sorted by percentage of crop land category. I then grouped data by percentage of significant land cover type(s) (0-10%, > 10-20%, > 20-30%, etc.) and graphically compared these groupings to a calculated probability of occurrence by dove species (probability of occurrence was calculated by dividing the number of points with observations of doves in a given percentage category by the total number of points included in that category). Where a punctuated break occurred in each graph, data were divided into two groups (strata) (Fig. 8). Data were analyzed in Program DISTANCE to determine if the two strata density estimates differed significantly.

The estimated densities were then combined with the effective sample area to estimate population size. This was done for both species by calculating the area sampled by points placed in each stratum independently. The sample areas calculated independently contained some overlap. To account for this the two areas were summed and the percentage for each stratum calculated. I then calculated the effective sample area for all points combined. I then applied the percentages for each stratum to the effective sample area to determine the two areas sample strata.

CHAPTER III

RESULTS

Survey Point Delineation

Proportions of habitat categories did not differ by radius distance around survey points when comparing the 300, 500, and 700-m radii (2007; $\chi^2_{15} = 5.7431$, $P = 0.98$ and 2008; $\chi^2_{15} = 4.51$, $P > 0.99$). Consequently, I selected the 300-m buffer zone because it was the smallest and no dove observations were made at distances > 300-m. The proportion of each land cover category within the summed 300-m point buffers and the proportion of each land cover category in the effective sample area were similar for both years ($\chi^2_5 = 3.33$, $P = 0.65$ and $\chi^2_5 = 1.13$, $P = 0.95$ for 2007 and 2008, respectively; Tables 2 & 3). Thus, 300-m point buffers were representative of the sampling area.

Data Analysis

Randomization Analysis

Based on the randomization test, points with White-winged Doves present versus points without observations of White-winged Doves occurred in significantly greater proportions in urban, forest, and crop habitat types ($P < 0.001$, $P < 0.001$, $P = 0.002$, respectively; Table 4 & Fig. 6a). Points without White-winged Dove observations had significantly greater proportions of range and pasture habitat types ($P < 0.001$ and $P = 0.001$, respectively) than points with White-winged Doves present (Table 4 & Fig. 6a).

Points with Mourning Doves present had significantly greater proportions of crop land cover ($P < 0.001$) (Table 5, Fig. 6b). Range habitat type occurred in significantly greater proportions where Mourning Doves were absent ($P < 0.001$). Habitats classified as urban, forest, wetland, and pasture were not significantly associated with the presence or absence of Mourning Doves. I did not make inferences from the results for wetland and forest habitat types for either species independently (Tables 4 & 5; Fig. 6a, b) because they represented a very small proportion of the overall land cover types.

When comparing mean habitat usage by species, White-winged Doves had a stronger association with urban and forest classified habitat types than Mourning Doves. Mourning Doves had a stronger association to crop, wetland, and pasture habitat types than White-winged Doves. Rangeland classified habitat types were equally associated with both species (Fig. 7).

Distance Sampling Analysis

For White-winged Doves, probability of occurrence was low prior to the category > 20-30% combination of urban and crop coverage; after reaching > 20-30% combination of urban and crop coverage, probability of occurrence greatly increased. So the mid-point (25%) was considered the natural break between land cover with a low probability of dove occurrence and land cover with an elevated probability of occurrence. All points with ≥ 25% combination of urban and crop land cover were placed in stratum one while the remaining points were placed in stratum two.

For Mourning Doves the probability of occurrence was low prior to the category > 10-20% crop land cover, after reaching > 10-20% crop land cover the probability of occurrence greatly increased. So the mid-point (15%) was considered the natural break between land cover with a low probability of dove occurrence and land cover with an elevated probability of occurrence. All points with ≥ 15% crop land cover were placed in stratum one while the rest were placed in stratum two.

In 2007, I surveyed 103 of the 130 sample points; 27 points were inaccessible. Prior to termination of the sampling season, 22 of these points were surveyed twice. I recorded 153 Mourning Doves during 118 observations (1.30 doves/observation) and 184 White-winged Doves during 84 observations (2.19 doves/observation). Also 60 points lacked observations of Mourning Doves and 91 points were without observations of White-winged Doves in 2007. During 2008, I surveyed 236 of the 288 sample points; 52 points were inaccessible; therefore, I surveyed all 236 points twice. I recorded 553 Mourning Doves during 229 observations (2.41 doves/observation) and 203 White-winged Doves during 59 observations (3.44 doves/observation). Also 75 points were without observation of Mourning Doves and 171 points lacked observation of White-winged Doves in 2008.

I pooled DISTANCE sampling data across years for both species and analyzed each species independently. When data were sorted into strata by percentage urban and crop land cover for White-winged Doves, stratum two (all point buffer areas with < 25% combination of urban and crop coverage) included 103 buffers and stratum one (all point buffer areas with ≥ 25% combination of urban and crop coverage) included 132 buffers. For White-winged Dove data, the most parsimonious model selected by program DISTANCE was a hazard rate with a hermite polynomial key function and one adjustment term ($D = 0.03$, $P = 0.97$) with data truncated at 179 m.

When data were sorted into strata by crop land cover for Mourning Doves, stratum two (all point buffer areas with < 15% crop coverage) included 119 buffers and stratum one (all point buffer areas with ≥ 15% crop coverage) included 117 buffers. For Mourning Doves, the most parsimonious model selected by program DISTANCE was a hazard rate with a hermite polynomial key and one adjustment term ($D = 0.02$, $P = 0.92$) with data truncated at 161 m.

Estimated mean White-winged Dove densities for stratum 1 and 2 were 0.55 (95% CI: 0.38 to 0.82) and 0.05 (95% CI: 0.02 to 0.11) doves/ha, respectively. Mourning Doves density estimates for stratum 1 and 2 were 0.62 (95% CI: 0.51 to 0.76) and 0.25 (95% CI: 0.19 to 0.33) doves/ha, respectively.

White-winged Dove probability of occurrence as a function of percentage of urban and crop land cover, probability was low (< 0.11 probability of occurrence) until urban and crop land cover reached or exceeded the 20.1-30% range of the total point buffer area. When urban and crop land cover composition exceeded 30% total point buffer area coverage, White-winged Dove probability of occurrence increased to > 0.50 (Fig. 8a).

When comparing Mourning Dove probability of occurrence as a function of percentage crop land cover, the probability was moderate (< 0.52 probability of occurrence) until land cover reached or exceeded the > 10-20% range of the total point buffer area. When crop land cover composition exceeded 20% total point buffer area coverage, Mourning Dove probability of occurrence increased to > 0.70 (Fig. 8b).

For White-winged Doves the area sampled with < 25% combination of urban and crop coverage included about 165,000 ha, and the estimated population was about 7,400.

The area sampled with ≥ 25% combination of urban and crop land cover types the included about 283,000 ha, and the estimated population was about 150,000. The total estimated White-winged Dove population over the area I sampled was about 157,000.

For Mourning Doves, the area sampled with < 15% crop land cover included about 220,000 ha, and the estimated population was about 55,000. The sampled area with ≥ 15% crop coverage included about 228,000 ha, and the estimated population was about 139,000. The total estimated Mourning Dove population in the area I sampled was about 194,000. I was unable to locate recent Mourning or White-winged Dove population size estimates from the LRGV for comparison.

CHAPTER IV

DISCUSSION

An improved understanding of species interactions with their environment, particularly land use and land cover, is critical to evaluating anthropogenically induced ecosystem change and accruing information needed to mitigate potential future impacts and protect ecosystem health (Homer et al. 2007, Rice et al. 2008). With the range expansion of White-winged Doves, probably induced by loss of native nesting habitat, determining species occurrence and associating it to habitat types allows the modeling of predictive distribution maps. General land cover information is essential for many environmental, land management, and modeling applications, such as landscape diversity, fragmentation, and fractal dimension of patches, and can be effectively analyzed when combined with GIS (Ma et al. 2001). Accuracy of habitat modeling is dependent on the quality of the land cover map used. The National Land Cover Dataset is a 15-class land cover classification scheme mapped consistently over the United States (Homer et al. 2007). The large-scale nature of the NLCD makes it difficult to maintain contemporary information; the last revision was in 2001, which updated and modified the previous 1992 land cover classification scheme. Differences occurring in the categorization scheme of the 1992 and 2001 NLCD versions led me to reclassify land cover classifications into six broader, yet relevant, related categories. Reclassification into these six categories made the dataset more manageable. With a decreased number of land cover types for comparison, there is decreased chance of a Type I error. Also reclassification made the land cover classes more biologically relevant and increased the resolution among the land cover types to which doves might associate or respond. Having six broad categories makes my system amenable to reclassification for many existing land cover datasets. Thus, I have provided a robust system that can be used to reclassify other, existing land cover datasets.

I determined that landscapes where White-winged Doves occurred were composed of significantly greater amounts of urban, forest, and crop habitat types versus points where White-winged Doves were absent. This is consistent with White-winged Dove history in Texas. In the early 1900s, White-winged Dove breeding populations increased as irrigation and grain farming provided new food and water resources in the LRGV. Increased grain production in the LRGV and subsequent use by White-winged Doves as a food source make agriculture a substantial habitat type. As agricultural and urban development began to eliminate traditional native brush nesting areas, doves shifted to nesting in citrus orchards and began occupying urban areas (Blankenship 1966, Brown 1989, George et al. 1994). Urban areas generally offer greater canopy cover, as compared to areas developed for agriculture and readily available anthropogenic food sources (Kropp 2002, Silvy 2004). In much of Texas, White-winged Doves rely on residential shade and ornamental trees as nest sites (Kropp 2002).

My comparison of land cover types to dove species occurrence was based on use in relation to availability. While wetland habitat types did not appear to be significantly associated with the presence or absence of White-winged or Mourning Doves this did not necessarily indicate any form of avoidance of this habitat type. Wetland habitat types occurred in limited proportions in relation to other habitat types in the LRGV. Also, the NLCD did not include the Rio Grande in any land cover category. With limited sampling in wetland habitats, the randomization test was inconclusive for this land cover type. Also, the rangeland habitat type occurred in a large proportion of the area sampled in the LRGV making it significant in the randomization test, but rangeland occurred in a significantly greater proportion of the sample areas where White-winged and Mourning Doves were absent than areas where these species were present.

Mourning Doves are among the most abundant and widespread terrestrial birds endemic to North America. Breeding populations of Mourning Doves occur in parts of southern Canada, all of the lower 48 states, and into temperate Mexico. As a habitat generalist, Mourning Doves occur in habitats which vary widely and include both rural and urban landscapes. Previous studies have shown Mourning Doves select open habitats and avoid only extensively forested areas and wetlands (Drobney et al. 1998, Emiley and Dewey 2007). However, my randomization test indicated that Mourning Doves showed a preference for crops and avoided rangeland habitat types. Other habitat types in the LRGV were neither preferred nor avoided.

My results show an association exists between White-winged Dove presence and habitat types classified as urban, forest and crop. I also demonstrated that estimated White-winged Dove density increased 10-fold when a combination of crop and urban land cover comprised $\geq 25\%$ coverage at point buffer areas. Also, the probability of occurrence of White-winged Doves in these habitat types increased greatly (from about 0.05 with $< 25\%$ cover to 0.40 with $\geq 25\%$ cover). These associations between land cover types and presence of White-winged Doves will allow wildlife biologists to focus monitoring of populations in areas where White-winged Doves are more likely to occur. This will reduce time spent unnecessarily monitoring areas where dove species are likely to occur in low numbers or be absent. All habitats should be surveyed for the presence or absence of dove species, but more efforts should be focused on area associated with the presence of dove species. The estimated densities from areas with a high association to dove presence should not be applied equally across all habitat types; this would produce a gross overestimate of the population.

Mourning Doves exhibited a significant association with habitats classified as crop land cover. In areas where percentage crop land cover at point buffers comprised ≥ 15% of the total area, estimated density doubled from < 25 doves/100 ha to > 62 doves/100 ha. The probability of occurrence for Mourning Doves was high when land cover consisted of < 15% crop (> 0.52), but when land cover composed of ≥ 15% crop, the mean probability of occurrence increased substantially to 0.86. Mourning Doves appear to favor crop habitat types over other habitat types; however, Mourning Dove population monitoring should probably be conducted across all habitat types to account for the species large niche breadth.

My population estimates for White-winged and Mourning Doves were 158,000 and 194,000, respectively. Population estimates only represent the effective area sampled, about 448,000 ha. These estimates exclude major metropolitan areas, such as McAllen, Harlingen, and Brownsville, which contain large White-winged Dove numbers but were not within my effective sample area.

CHAPTER V

MANAGEMENT IMPLICATIONS

This study demonstrated that large areas can be comprehensively sampled with reduced resource expenditure and increased efficiency. Also, the methods used in this study are applicable to other species (Veech 2006) provided the biology of the species of interest and geographic scale used are given appropriate attention.

Current dove census efforts in the LRGV by the TPWD include distance sampling of 200-350 points distributed solely in areas classified as residential in the 1992 NLCD (S. Benn pers. comm.). I systematically surveyed about 230 points across a large portion of the LGRV and accrued enough observations to estimate density using DISTANCE sampling (M. Small unpublished data). Sampling fewer, more judiciously chosen points, allows a net savings in time expended to conduct the sampling, provided personnel resources remain constant. Alternatively, personnel resources can be reduced while still sampling across the same time period, providing a net savings in personnel. Also, sampling the entirety of the LGRV rather than sampling only urban classifications increases the validity of the census.

While sampling across the LGRV, I was able to approximate a northern boundary of non-urban nesting White-winged Doves. Above Highway 186 very few White-winged Doves were observed, below this boundary, White-winged doves are considered brush nesting because they still utilize native brush tracts for nesting. North of Highway 186, White-winged Doves predominantly shifted to nesting in urban areas.

The conversion by the TPWD from using systematic coo-counts to DISTANCE sampling is a positive step in upgrading sampling methods. Coo-count survey locations were not randomly distributed, thus precluding making valid inferences from these data and the ability to assess precision of estimates (Wildlife Management Institute 2005). By using DISTANCE sampling, a single, probabilistic method can be applied statewide. However, this methodology needs to be documented and critically reviewed so any potential sources of bias can be identified, tested, and appropriate adjustments implemented. Additionally, as this study demonstrates, areas in which methodological efficiency might be improved can be identified.

Table 1. National Land Cover Dataset reclassification into six relevant categories.

NLCD Classification	Reclassification
Open Water	Wetland
Perennial Ice/Snow	Wetland
Woody Wetland	Wetland
Herbaceous Wetland	Wetland
Developed, Open Space	Urban
Developed, Low Intensity	Urban
Developed, Medium Intensity	Urban
Developed, High Intensity	Urban
Deciduous Forest	Forest
Evergreen Forest	Forest
Mixed Forest	Forest
Barren Land	Rangeland
Scrub/Shrub	Rangeland
Grassland/Herbaceous	Rangeland
Pasture/Hay	Pasture
Cultivated Crop	Crop

Table 2. Comparisons of land cover type proportions present in 300-m buffers to total sampling area in the Lower Rio Grande Valley for 2007.

Class Type	300-m Buffer	Sampling Area
Wetland	1.71	2.36
Urban	21.67	18.40
Forest	0.56	0.41
Range	5.92	9.79
Crop	61.59	56.90
Pasture	8.55	12.14

Table 3. Comparisons of land cover type proportions present in 300-m buffers to total sampling area in the Lower Rio Grande Valley for 2008.

Class Type	300-m Buffer	Sampling Area
Wetland	3.31	3.15
Urban	15.59	12.34
Forest	0.28	0.37
Range	32.48	34.20
Crop	33.84	35.91
Pasture	14.51	14.03

Table 4. Relationship of White-winged Dove presence/absence to land cover type in the Lower Rio Grande Valley, Texas.

	Urban	Forest	Range	Pasture	Crop	Wetland
Mean without doves	11.93	0.18	39.43	17.41	29.78	4.03
Mean with doves	26.02	0.54	15.31	8.98	41.38	2.76
P-value	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.700
Effect	Significantly Large	Significantly Large	Significantly Small	Significantly Small	Significantly Large	Non-significant

Table 5. Relationship of Mourning Dove presence/absence to land cover type in the Lower Rio Grande Valley, Texas.

	Urban	Forest	Range	Pasture	Crop	Wetland
Mean with doves	14.94	0.27	24.02	14.14	41.23	3.57
Mean without doves	16.51	0.28	50.51	15.26	15.12	2.33
P-value	0.152	0.490	< 0.001	0.277	< 0.001	0.061
Effect	Non-significant	Non-significant	Significantly Small	Non-significant	Significantly Large	Non-significant

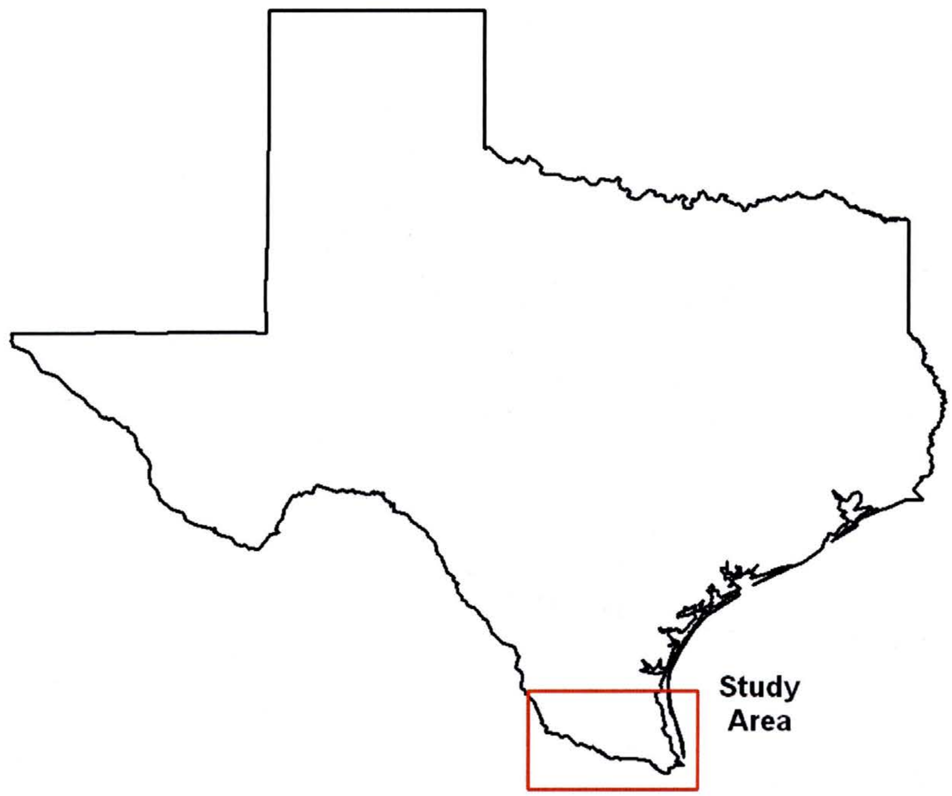
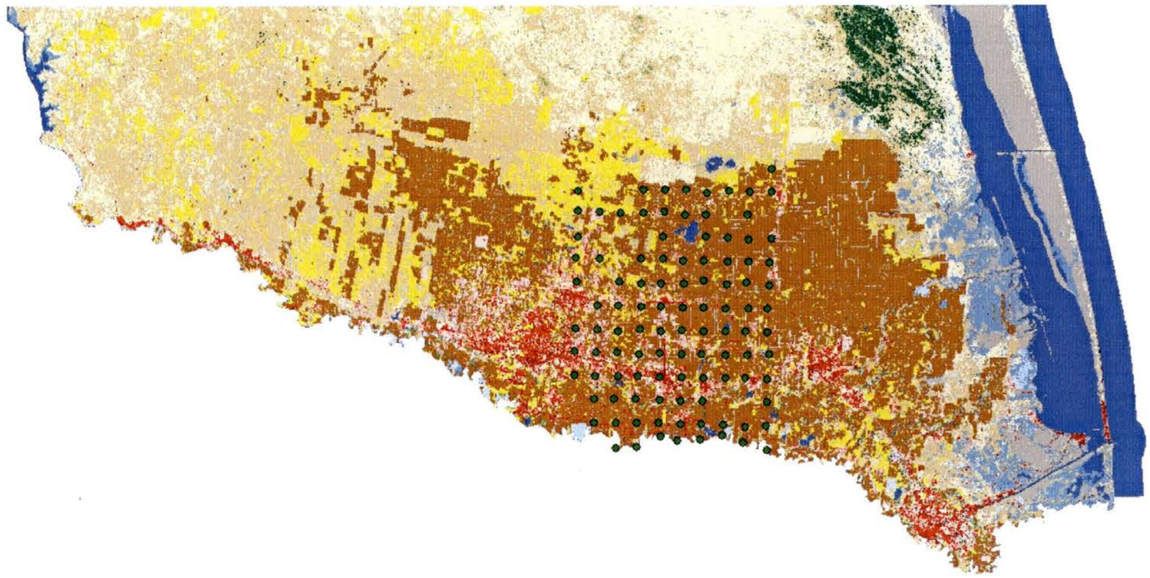
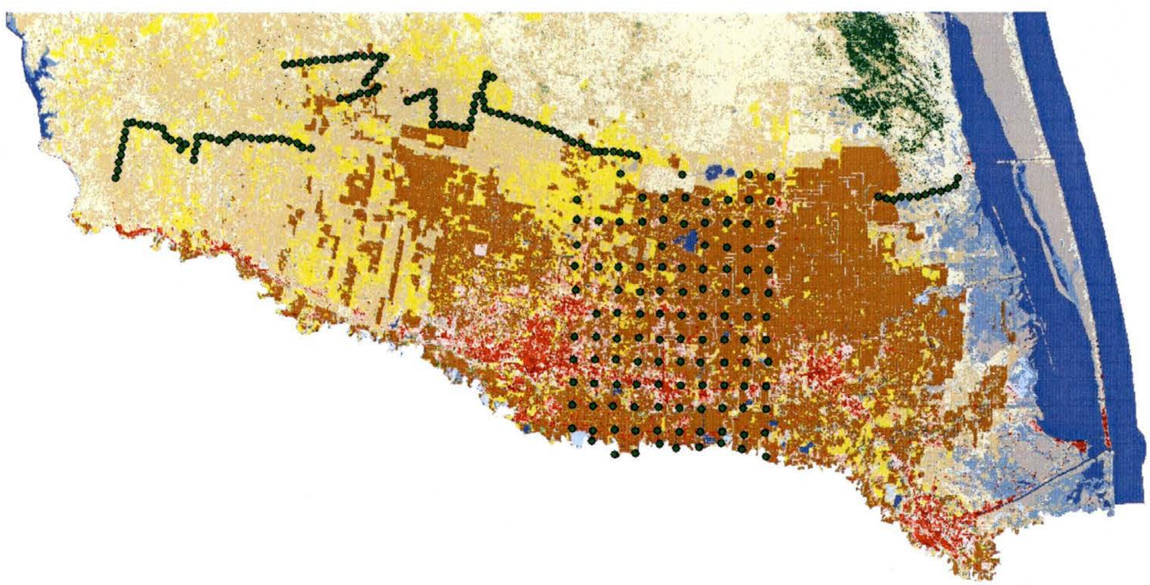


Figure 1. Study area in the Lower Rio Grande Valley.



(a)



(b)

Figure 2. Survey points accessed during (a) 2007 and (b) 2008.

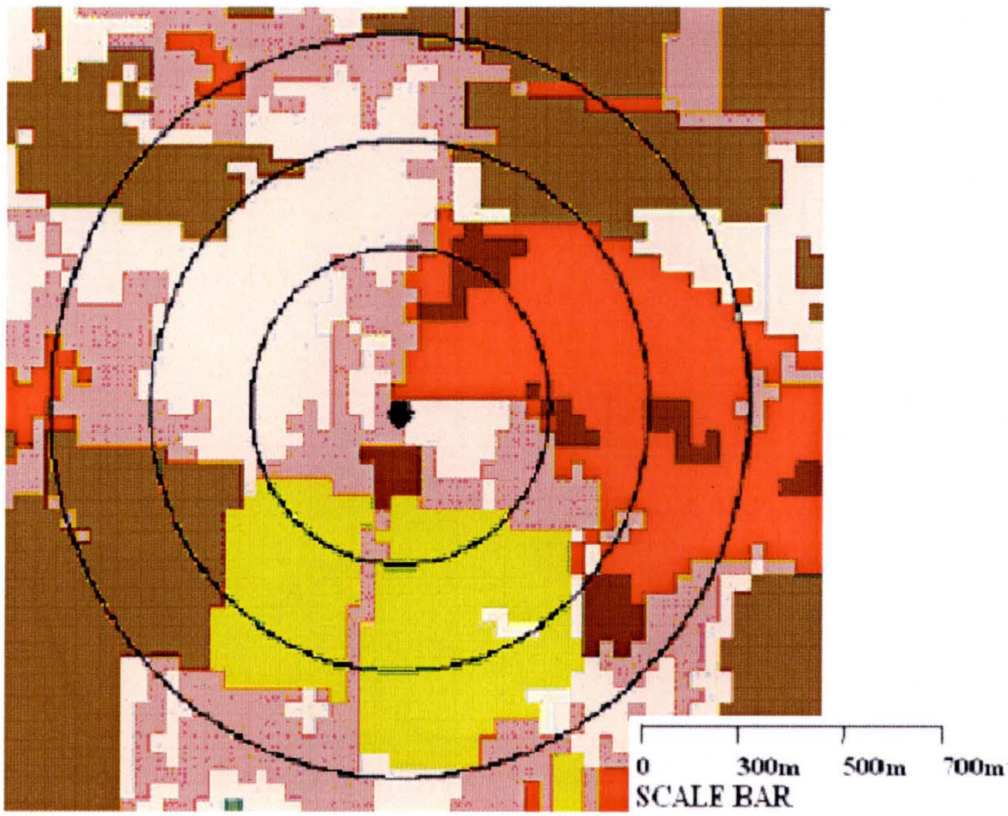
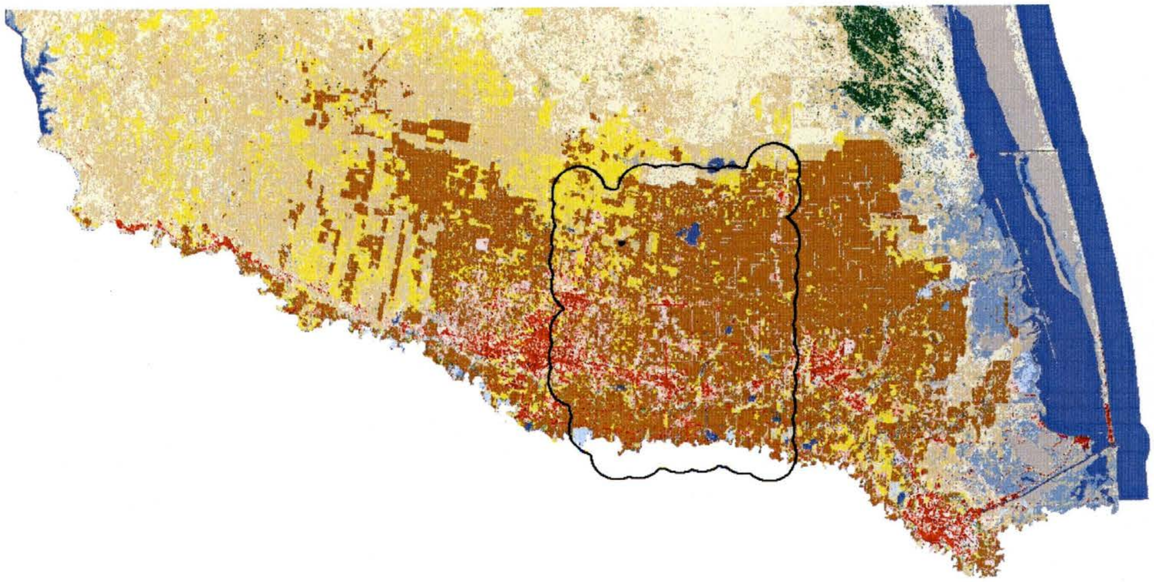
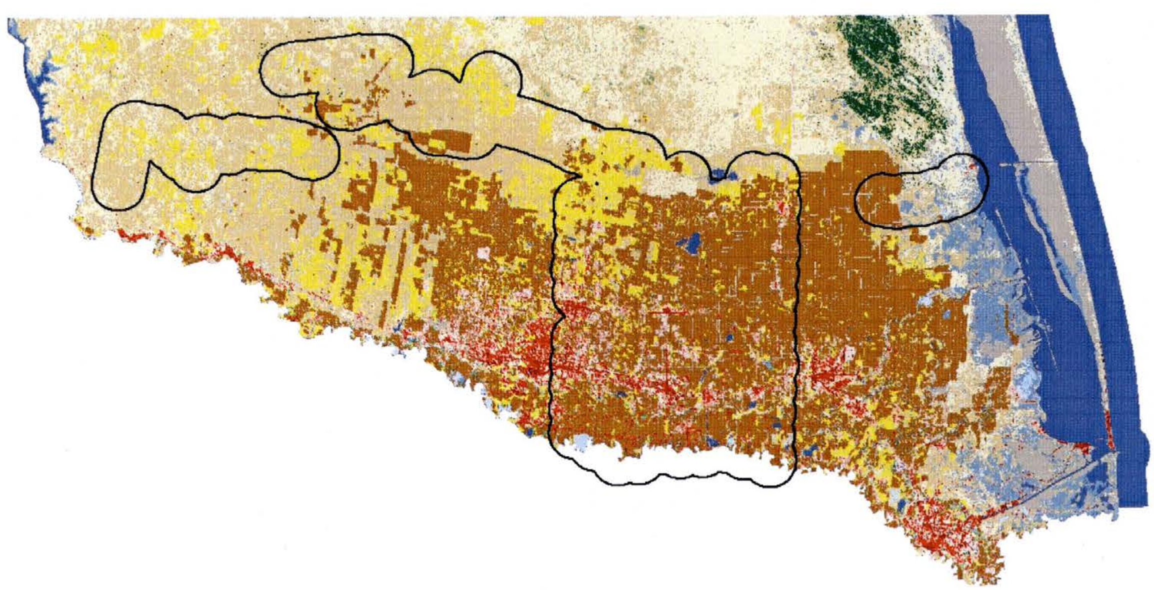


Figure 3. Example point overlaid on land cover projection with 300-m, 500-m, and 700-m buffers.



(a)



(b)

Figure 4. Study area in (a) 2007 and (b) 2008.

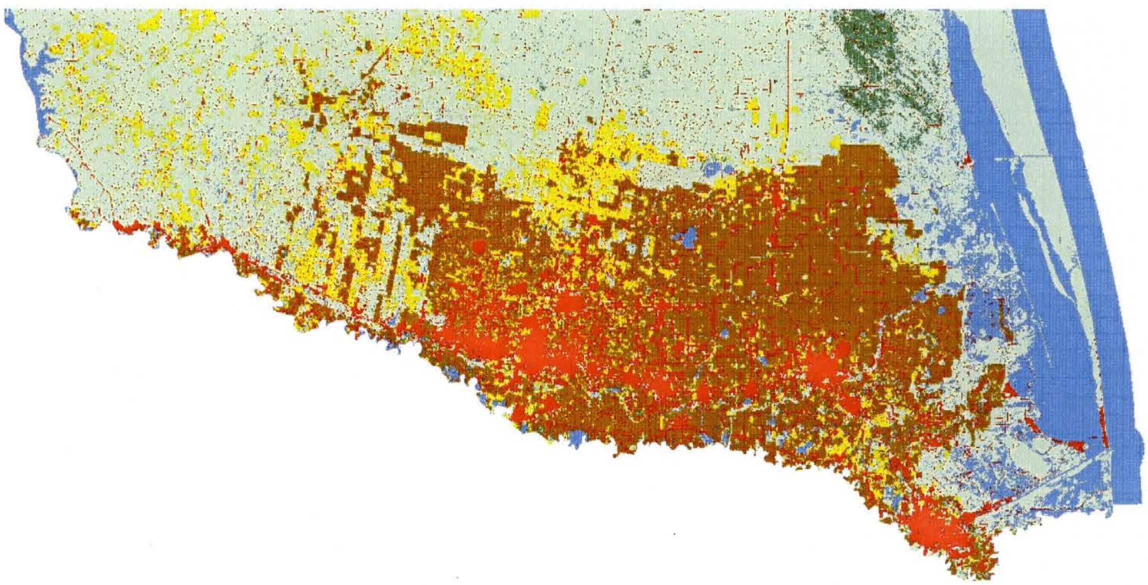
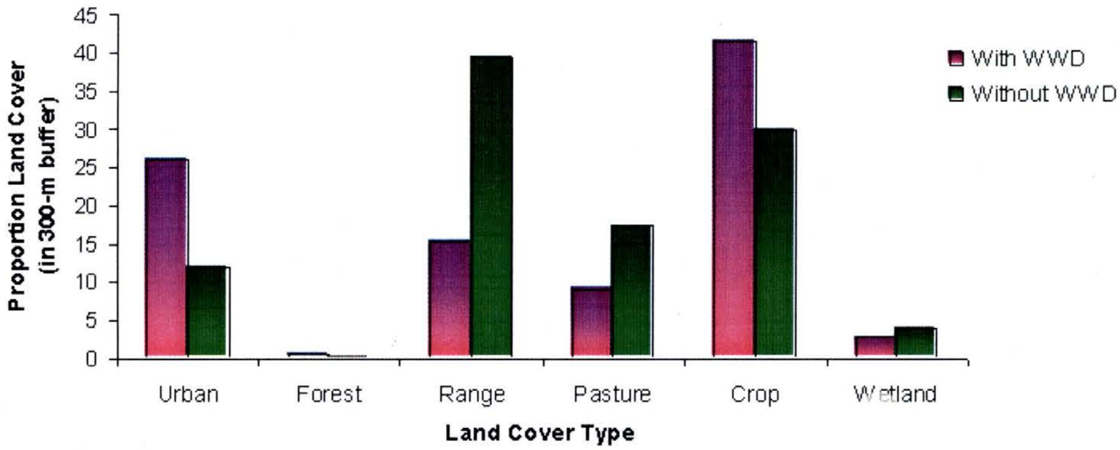
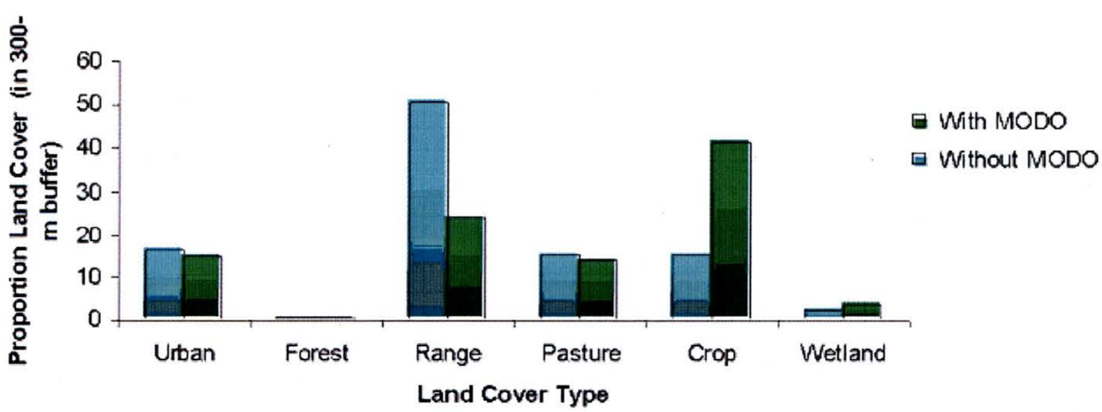


Figure 5. Reclassified land cover map.



(a)



(b)

Figure 6. Relationship of presence/absence for (a) White-winged Dove and (b) Mourning Dove to land cover types in the Lower Rio Grande Valley, Texas.

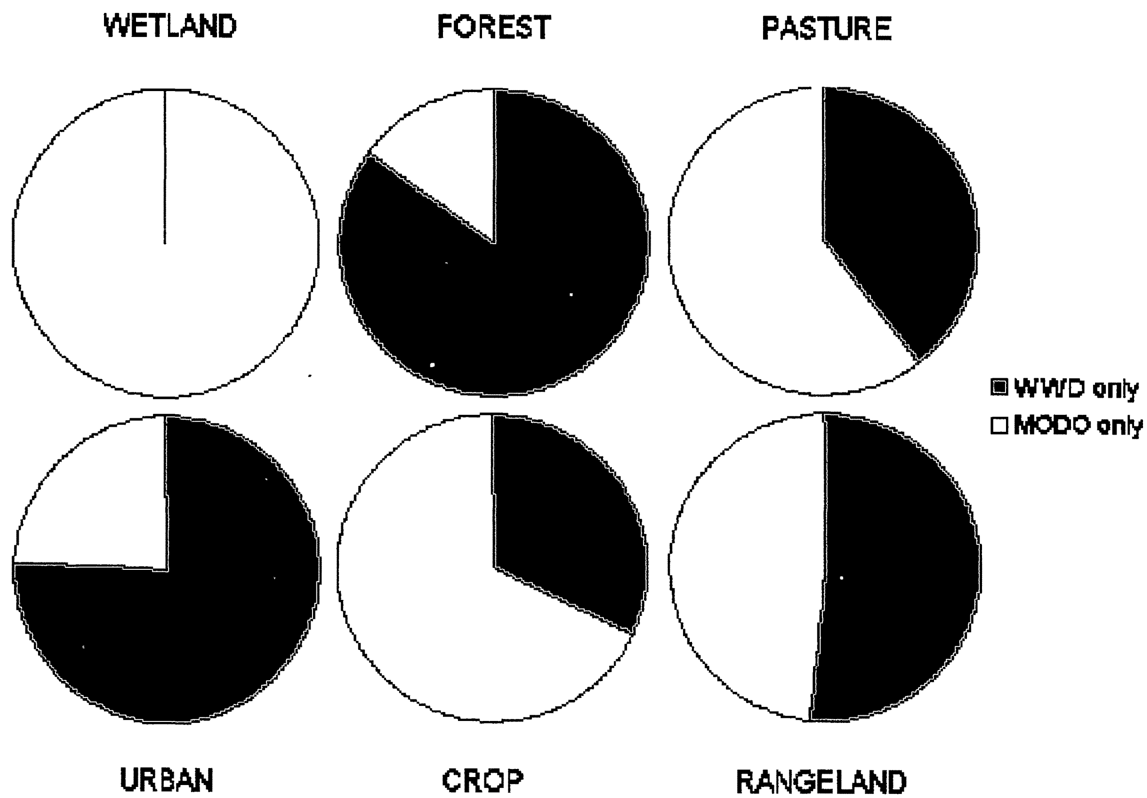
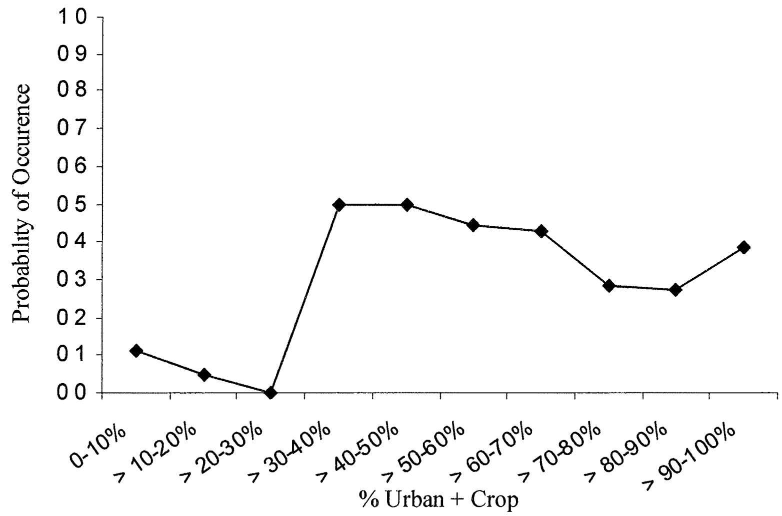
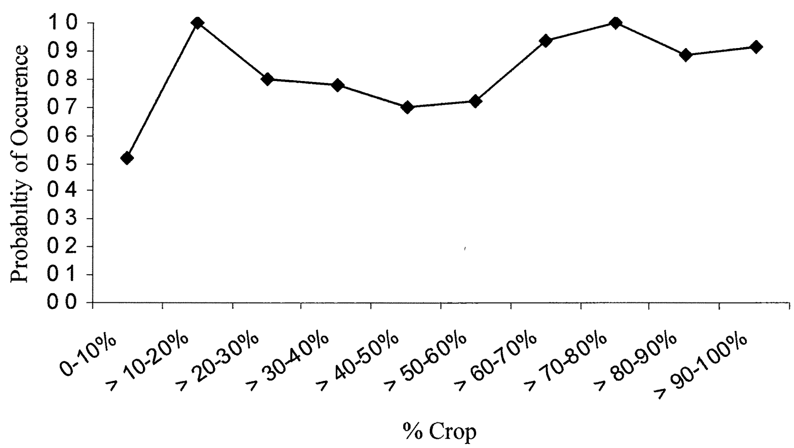


Figure 7. Comparison of habitat types used by White-winged Doves (WWD) and Mourning Doves (MODO) in the Lower Rio Grande Valley, Texas.



(a)



(b)

Figure 8. Probability of occurrence of (a) White-winged Doves based on percentage of urban and crop habitat types and (b) Mourning Doves based on percentage of crop habitat type in the Lower Rio Grande Valley, Texas.

APPENDIX A

Distance Sampling Data Sheet

City	Sample Period	Date	Point ID	Time	Yards/ Meters	Observation / Bird ID	Distance	Species	Activity Code
LRGV									
LRGV									
LRGV									
LRGV									
LRGV									
LRGV									
LRGV									
LRGV									
LRGV									
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