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Management and Conservation Article

Dove Habitat Association Based on Remotely Sensed Land Cover Types in South Texas

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ABSTRACT We tested whether presence of white-winged doves (*Zenaida asiatica*) and mourning doves (*Z. macroura*) in South Texas, USA, was associated with any of the land cover types recorded in the 2001 National Land Classification Database. We used the point-transect method to conduct presence–absence surveys for both species at 236 points encompassing 744 observations. Within predefined land cover types surrounding each survey point, we used Geographic Information Systems to determine the proportions of each land cover type present. We used randomization tests to compare proportions of land cover types present at points with and without doves. We used Program DISTANCE to estimate dove densities at survey points and to test whether certain land cover types were associated with greater dove densities. Our results indicated white-winged dove occurrence in South Texas was positively associated with urban land and cropland, whereas mourning dove occurrence was positively associated with cropland. For land cover types found to be associated with dove presence, estimated density for each dove species increased as the proportion of associated land cover type increased. These results can assist wildlife biologists in the development of a more efficient and targeted protocol for censusing doves. In addition, our methods can be applied to other species across several geographic areas and landscape scales.

KEY WORDS distance sampling, doves, Geographic Information Systems (GIS), land cover, Lower Rio Grande Valley, Texas.

Mourning (*Zenaida macroura*) and white-winged (*Zenaida asiatica*) doves are hunted in Texas, USA, for recreation and food (Baskett and Sayre 1993, George 2004). Because mourning and white-winged doves are migratory game birds, they are subject to federal oversight (Gregory 1998, Bevill 2004). Responsibility for monitoring and managing populations of these species is delegated to state wildlife agencies, which are tasked with developing accurate and efficient methods for monitoring populations of these 2 species (Eberly and Keating 2006). Mourning doves are monitored as part of the national mourning dove call-count survey (CCS), used to determine breeding population trends. The CCS involves federal and state wildlife agencies conducting annual roadside call-counts and counts of doves seen on established survey routes. In Texas, the Texas Parks and Wildlife Department (TPWD) conducts the CCS. Breeding population numbers, based on these call-counts, are the primary basis for setting hunting seasons and bag limits on doves.

White-winged doves in Texas have traditionally been monitored using coo-counts conducted only in the Lower Rio Grande Valley (LRGV) of extreme South Texas (Berger and George 2004). Coo-counts have been used to measure white-winged dove population size in brushlands of the LRGV since 1949 (Uzzell 1949, Cottam and Trefethen 1968). However, such counts are flawed because variances cannot be calculated; thus, sources of error are unmeasurable (Rappole and Waggerman 1986). Recently, TPWD redesigned and implemented white-winged dove surveys statewide using distance sampling because of questionable results and unsatisfactory reviews of sampling methodology (Schwertner and Johnson 2006). Recent research suggested that distance sampling of randomly placed point counts in urban areas yielded reliable density estimates and this protocol was instituted as the primary sampling method for white-winged doves in Texas (Schwertner and Johnson 2006).

Development of an efficient method for identifying and qualitatively categorizing dove habitats will allow survey resource expenditures to be scaled to density. An association between land cover types and mourning dove and white-winged dove densities would allow field biologists to more efficiently dispense finite resources while maximizing return per effort. Consequently, our objectives were to 1) determine which, if any, land cover categories from an existing Geographic Information Systems (GIS)–linked database are associated with presence or absence of white-winged and mourning doves in the LRGV; 2) quantify habitat affiliations of these 2 dove species in the LRGV; and 3) determine mean dove densities as a function of degree of habitat association and, thus, estimate overall population size.

STUDY AREA

We conducted our study in the LRGV of Texas. Within this area the Rio Grande River formed an extensive delta at its terminus with the Gulf of Mexico along the United States–Mexico border (Dahm et al. 2005, Dykkesten 2009). The LRGV was comprised of 4 counties (Cameron, Hidalgo, Starr, and Willacy) located at the southernmost

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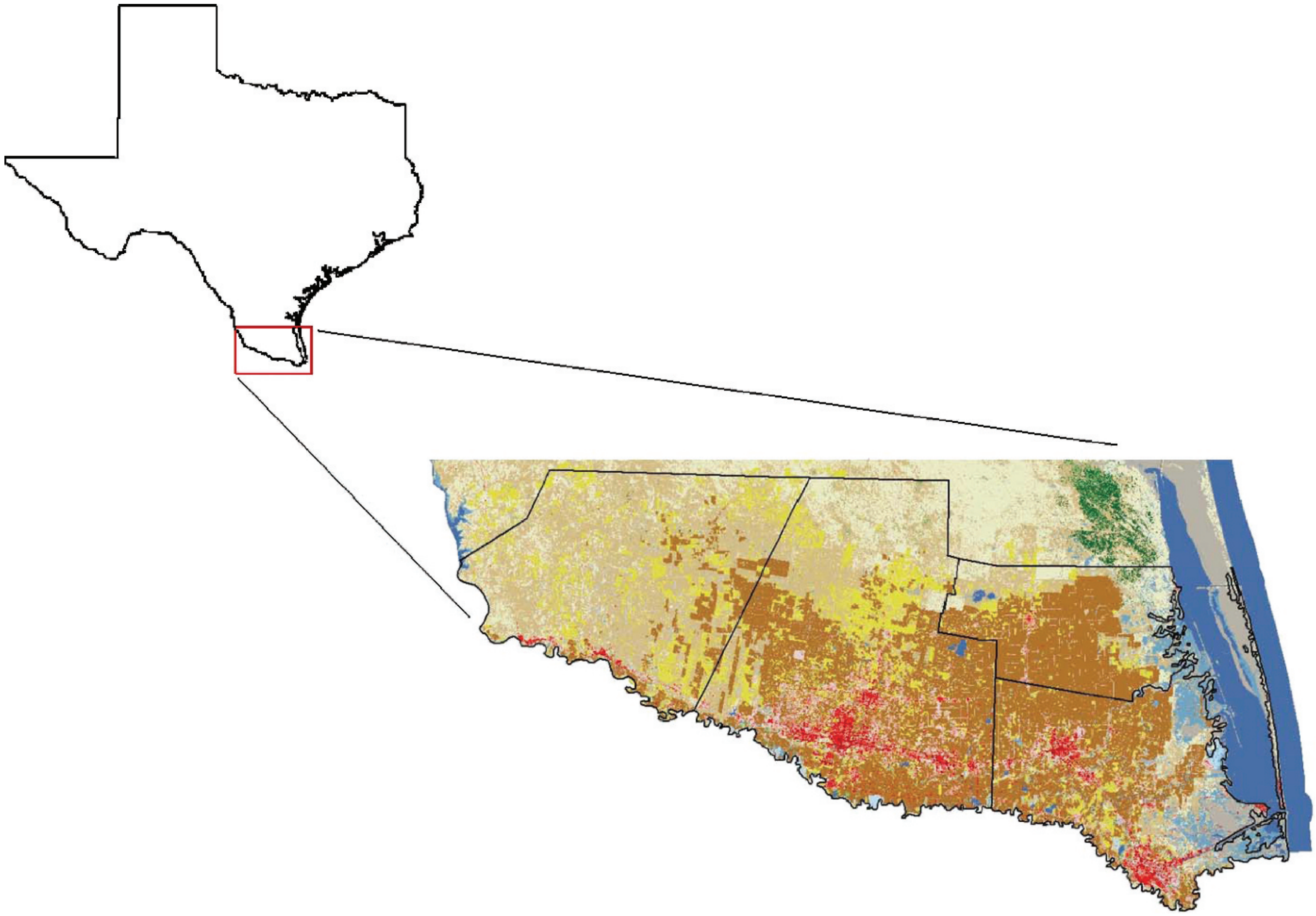

Figure 1. Study area in the Lower Rio Grande Valley, Texas, USA, where we collected white-winged and mourning dove occurrence data during 2007 and 2008. The 2001 National Land Cover Database categories are displayed with different colors representing different land cover categories (e.g., red represents urban, brown represents cropland).

tip of Texas (Fig. 1). Ecologically, the LRGV was part of the Tamaulipian Biotic Province and contained numerous biological communities (Blair 1950, Diamond et al. 1987, Jahrsdoerfer and Leslie 1988). The Tamaulipan brush community of the LRGV was not only among the most biologically diverse regions in the United States, it was also arguably among the most threatened (Mathis and Mastioff 2004, TPWD 2005).

Urban and agricultural development during the 20th century 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 was destroyed or converted to other uses (Rappole and Waggerman 1986, Jahrsdoerfer and Leslie 1988, Hayslette et al. 1996). Dove habitat in the LRGV became fragmented into isolated remnants of once-contiguous woodlands.

METHODS

We used GIS software ArcGIS v9.2 and the generate regular points feature in Hawth's tools extension (Hawth's analysis tools for ArcGIS, Edmonton, Canada) to produce a 10×13 matrix of 130 census points spaced at about 3,200-m intervals. We moved all points to the nearest road to ensure maximum accessibility. In 2007 we evenly distributed points in a structured random grid mainly in Hidalgo County with points extending into southern Willacy and eastern Cameron counties (Fig. 2A, B). In 2008 we used the same points from 2007 and an additional 158 points (Fig. 2B). We placed 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 longitudinal coverage of habitat types in the LRGV. We selectively placed all new points approximately 1,600 m apart on accessible roads.

Dove Sampling

We conducted point-transect surveys, beginning with the southernmost point on the grid, from 19 May through 25 July 2007 and 15 May through 3 July 2008. These survey periods corresponded to the breeding season and followed current TPWD methodology (Schwertner and Johnson 2006). We did not conduct surveys during inclement weather. Point-transect surveys began 10 minutes after official sunrise and continued no later than 2 hours after

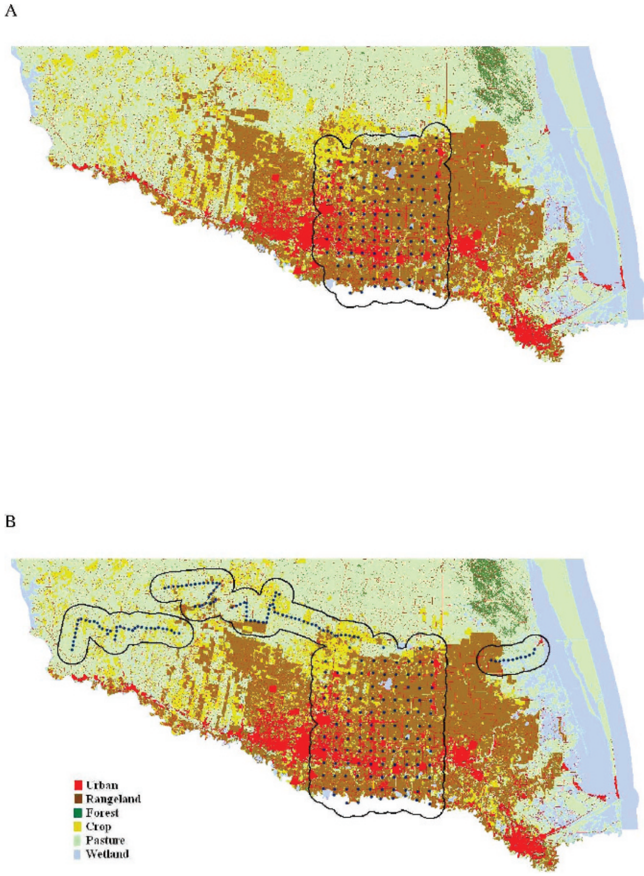

Figure 2. Points where we surveyed white-winged and mourning doves, including the 5-km effective sample area delimited around each point for (A) 2007, and (B) 2008 in the Lower Rio Grande Valley of Texas, USA.

official sunrise. Each point was surveyed for 2 minutes by a stationary observer. This procedure satisfied the assumption of Program DISTANCE (see Estimation of Dove Densities below) that each point is an assumed snapshot in time; hence, our 2-minute survey period allowed us sufficient time to record the number of doves present at each point but was short enough to minimize the chance of duplicate counting of doves leaving and reentering the sampling area (Buckland et al. 1993). We recorded presence or absence of a white-winged dove or mourning dove at each point during the 2-minute survey and distances to doves (Buckland et al. 1993). We used only visual observations to eliminate possible bias associated with auditory counts and avoid error in estimating distances to an auditory signal (Simons et al. 2007). We determined distances to doves to the nearest meter using a laser range-finder (Bushnell Yardage Pro Legend; Bushnell, Inc., Overland Park, KS). We recognized clusters when recording distances to doves (Buckland et al. 2001). We considered doves clustered (i.e., not independent) when observed in a flock either flying or in the same tree. We recorded doves foraging on the ground or perched far apart on artificial structures (e.g., telephone or power lines) as individual observations (independent), given that in these situations presence of a dove was likely not due to other doves (i.e., there was no true flock formation). In addition, we assumed the immediate area around each

Table 1. National Land Cover Dataset (NLCD) reclassification into 6 relevant categories for our study of white-winged and mourning doves in the Lower Rio Grande Valley, Texas, USA, during 2007 and 2008.

NLCD classification	Reclassification
Open water	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

survey point could potentially contain doves, such that no points had a probability of occupancy of zero.

In 2007, after we completed one survey, we initiated a second survey but terminated it after we surveyed about half of the points because the primary breeding season was near its end. In 2008 we conducted sampling as in 2007, except after completion of the southern grid we surveyed the additional 158 northern transect points. We sampled both the southern grid and northern transect twice to increase accuracy and reduce bias (Buckland et al. 1993, Hostetler and Main 2001).

Land Cover Delineation

We imported land-cover classification maps of the LGRV from the 2001 National Land Cover Dataset (NLCD) into ArcGIS 9.2 to quantify land cover proportions. We then reclassified the 15 land cover classes represented in the LGRV into 6 grouped categories or cover types (urban, rangeland, pasture, cropland, wetland, and forest) to quantify landscape composition (Table 1). We based reclassification into these categories on similarities among the 15 land cover classes. 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. Although doves may differentiate between these urban land-cover types, it is evident from NLCD 2001 maps that the urban land-cover types were not independent geographically and were interspersed. By reducing the number of land cover classes, we made the data set more manageable. With fewer variables to test, we also decreased the chance of committing a Type I error. In addition, reclassification made land cover classes more biologically relevant (e.g., it is unlikely doves can differentiate between intensity of development to any degree of ecological relevance).

We created circular buffers of 300-m radii around each sample point to quantify land cover composition at each point. We then extracted pixel counts from each buffer area using Hawth's tools thematic raster summary add-in for ArcGIS. We excluded cells with a NODATA value from analysis. We then converted pixel counts into percentage of land cover type per survey point within the buffer. We used a goodness-of-fit chi-square test to determine whether mean landscapes in the 300-m buffer were proportionally representative of the entire area (most of the LRGV) we studied. The sampling area consisted of a 5-km buffer around the cumulative set of survey points (hereafter, the effective sample area) and was based on home range studies conducted in Texas (Small et al. 2007, 2009; Fig. 2A, B).

Randomization Test Protocol

We used a randomization test to compare land cover types at points where we observed doves to points where we observed no doves (Veech 2006). We did this because requisite assumptions for parametric analysis of normally distributed and homoscedastic data were not met because observations at each survey point were low, with most point surveys consisting of zero or one observation. The randomization test consisted of computing mean proportions of land-cover classification types at points with doves and comparing them to mean proportions of land-cover classification types at points without doves.

We used the statistical package Program R (R version 2.8, <http://www.r-project.org/>, accessed 2 Dec 2008) to randomly draw, without replacement, sets of 58 points (no. of points with white-winged doves) from the pool of 171 points without white-winged doves. We then calculated the mean proportion of each land cover type in each set of 58 points. We performed 10,000 iterations to generate a test or null distribution of means for each of the 6 land cover categories. For each land cover type, we then compared the mean proportion for points with doves (observed means) to distributions of mean proportions for points without doves. If a value fell within 5% of either end of the distribution, we deemed it significant ($P \leq 0.05$). We considered the effect significantly small or large depending on which tail of the distribution contained the observed mean (Veech 2006).

We also applied the randomization test to compare points with and without mourning doves. However, mourning doves were present at more points than they were absent. Consequently, we created a distribution for comparison by drawing 10,000 random iterations of 75 points (the no. 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 evaluation of significance was the same as with white-winged doves.

Estimation of Dove Densities

We grouped survey points by percentage of urban and cropland cover types and graphically compared these groupings to the species' probability of occurrence (calculated by dividing the no. of points with observations of doves in a given percentage category by the total no. of points included in that category; Fig. 3). Where a punctuated break occurred in each graph, we divided points into 2 groups (strata; Fig. 3). We then used Program DISTANCE 5.0 v. 2 (Buckland et al. 2001) to determine density estimates within each strata and then compared

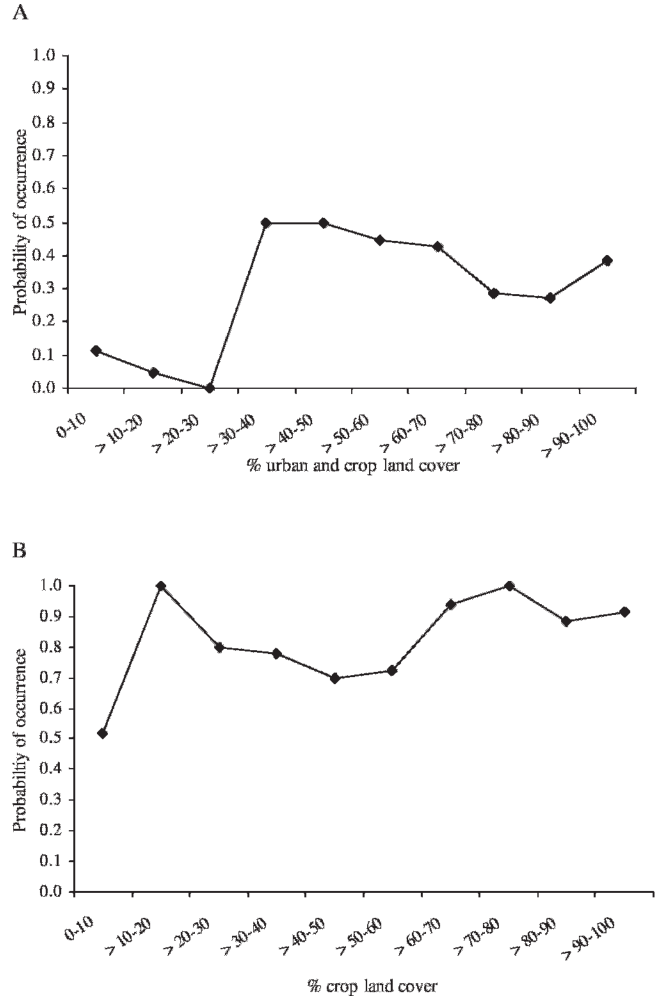

Figure 3. Probability of occurrence of (A) white-winged doves based on percentage of urban and crop habitat types, and (B) mourning doves based on percentage of crop habitat type in the Lower Rio Grande Valley, Texas, USA, during 2007 and 2008.

estimates. We pooled both years of data into one model without using year as a covariate. A preliminary examination revealed that the year covariate did not improve model fit. In addition, one observer performed all surveys, thus negating the need for an observer covariate. We also used the poststratify by point option in DISTANCE 5.0 v. 2, so the fitted model would recognize some points were surveyed more than once and, thus, treat them accordingly. We tested 5 models that included half-normal with cosine and simple polynomial expansion series and hazard-rate with cosine, hermite polynomial, and simple polynomial expansions series, a priori. We restricted all models to $\leq$2 adjustment terms and enforced strict monotonicity (Buckland et al. 1993). For each candidate model we right-truncated data at a distance where detection probability fell below 10% following standard distance sampling methods (Buckland et al. 2001). Program DISTANCE indicated the most parsimonious model based on Akaike's Information Criterion. We created maximum likelihood histograms fitted with probability of detection curves plotted against distance of the selected model with Program DISTANCE and tested

Table 2. Relationships of white-winged dove presence–absence to land cover type in the Lower Rio Grande Valley, Texas, USA, during 2007 and 2008. Values shown are mean percentage of the land cover type in landscapes with and without doves. We obtained *P*-values from the randomization test.

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

Table 3. Relationships of mourning dove presence–absence to land cover type in the Lower Rio Grande Valley, Texas, USA, during 2007 and 2008. Values shown are mean percentage of the land cover type in landscapes with and without doves. We obtained *P*-values from the randomization test.

Parameter	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

them for fit using a Kolmogorov–Smirnov test. We calculated density estimates and 95% confidence intervals from this model for each dove species in strata representing survey points with either a high or low percentage of urban and cropland.

Lastly, to estimate overall population size of each species in the LRGV, we multiplied estimated densities by the effective land area (5-km buffer around sample points) sampled by points in each of the 2 strata. The points in the 2 strata were interspersed slightly in a small area of overlap. Thus, we divided the area of overlap based on the relative size of each stratum, to avoid double-counting in the area of overlap. In this way, we obtained the area of each stratum, absent of any overlap with other strata.

RESULTS

Based on the randomization test, landscapes with white-winged doves had significantly greater mean percentages (about twice as much) urban, forest, and crop cover and significantly lower percentages (about half as much) range and pasture cover than landscapes without doves (Table 2). Landscapes with mourning doves had a significantly greater mean percentage (more than twice as much) of cropland cover and significantly lower percentage (about half as much) of range cover than landscapes without doves (Table 3). Other cover types (urban, forest, wetland, and pasture) were not significantly different between landscapes with and without mourning doves. Thus, white-winged doves had a stronger association with urban and forest cover types than mourning doves. Rangeland was equally associated with both species whereas wetland was not significantly associated with presence of either species.

In 2007 we surveyed 103 of 130 sample points; 27 points were inaccessible. Prior to termination of the breeding season, we surveyed 22 of these points twice. We 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 had no observations of white-winged doves in 2007. During 2008 we surveyed 236 of 288 sample points; 52 points were inaccessible. Therefore, we surveyed all 236 points twice. We 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 had no observation of mourning doves and 171 points lacked observations of white-winged doves in 2008.

For white-winged doves, probability of occurrence was low in landscapes with <25% combined urban and cropland cover (Fig. 3A). Therefore, we placed all points with ≥25% combination of urban and cropland cover in stratum 1 (132 points) and remaining points in stratum 2 (103 points). The probability of mourning dove occurrence was low in landscapes with <15% cropland cover (Fig. 3B). Therefore, we placed all points with ≥15% cropland cover in stratum 1 (117 points) and the rest in stratum 2 (119 points).

The most parsimonious model selected by Program DISTANCE for white-winged dove data was a hazard rate with a hermite polynomial key function and one adjustment term (K–S test; $D = 0.03$, $P = 0.97$) with data truncated at 179 m, and for mourning doves the same model was selected (K–S test; $D = 0.02$, $P = 0.92$) with a truncation distance of 161 m.

Estimated mean white-winged dove densities/100 ha for stratum 1 and 2 were 55 (95% CI = 38–82) and 5 (95% CI = 2–11), respectively. Mourning dove density estimates/100 ha for stratum 1 and 2 were 62 (95% CI = 51–76) and 25 (95% CI = 19–33), respectively.

Percent 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 (5-km point buffers) were similar for sets of sample points in both years ($\chi^2_5 = 3.33$, $P = 0.65$ and $\chi^2_5 = 1.13$, $P = 0.95$ for 2007 and 2008, respectively). Thus, 300-m point buffers were representative of the effective sample area, which allowed us to use estimated densities and land area of each strata to extrapolate estimates of total population size for both species in the effective sample area. For white-winged doves the area sampled with <25% combination of urban and crop coverage (stratum 2 in the distance sampling model) included about 165,000 ha, and the estimated population was about 8,500. The area sampled with ≥25% combination of urban and cropland cover types (stratum 1) included about 283,000 ha, and the estimated population was about 155,500. Total estimated white-winged dove population in the effective sample area was about 164,000. For mourning doves, the area sampled with <15% cropland cover (stratum 2) included about 220,000 ha, and the estimated population was about 55,000. The sampled area with ≥15% crop coverage (stratum 1) included about 228,000 ha, and the estimated population was about 141,000. Total estimated mourning dove population in the effective sample area was about 196,000.

DISCUSSION

We used an existing GIS land-cover database to qualify and quantify habitat affiliation with white-winged and mourning doves. We derived estimates of white-winged and mourning dove densities using distance sampling and the land cover database and converted these to estimates of population size in the LRGV of Texas. Our surveys for doves used roads, as do many avian surveys that traverse long transects with regular sample or stopping points for timed observation periods. Such surveys may be susceptible to considerable road bias or mis-estimation of densities if the surveyed bird species is either attracted to or avoids roads. Road density in the 300-m buffer areas around sample points was 0.25 km/ha and 0.06 km/ha in the effective sample area. Despite this difference, we do not believe road bias appreciably affected our estimates of population size of either dove species in the effective sample areas. Road surveys in open habitats may increase the number of species observed but do not generally affect abundance estimates (Dieni and Scherr 2004). In addition, 47% of all observations were of doves in flight, and direction of flights was random with respect to the observer (and subsequently roads). Thus, white-winged doves and mourning doves probably have neither a strong attraction to nor avoidance of roads.

White-winged doves and mourning doves are definitely associated with certain land cover types over others. We demonstrated the potential use of a national GIS-linked land-cover database in developing and targeting survey efforts intended to monitor dove populations (Ma et al. 2001). The National Land Cover Dataset is a 15-class land-cover classification system 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 in categorization systems of the 1992 and 2001 NLCD versions led us to reclassify certain land cover classifications into 6 broader, yet relevant, related categories. Reclassification into these 6 categories made the data set more manageable and decreased the chance of a Type I error.

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, our randomization test indicated that mourning doves were associated with cropland and avoided the rangeland habitat type. Mourning doves appear to select crop habitat types over other habitat types; however, monitoring of mourning dove populations should probably be conducted across all habitat types to account for the species' large niche breadth.

Not surprisingly, our results show an association between white-winged dove presence and habitat types classified as urban, forest, and crop. However, we quantified for the first time the strength of association between this species, various land cover types, and prevalence of each land cover type. Associations between land cover types and presence of white-winged doves will allow wildlife biologists to focus monitoring of populations in landscapes where white-winged doves are more likely to occur, which will reduce time spent unnecessarily monitoring areas where dove species are unlikely to inhabit or occur in low numbers. All habitats should be surveyed for presence or absence of dove species, but a greater effort should be focused on landscapes having land cover types associated with presence of dove species. However, estimated densities (calculated from habitat types with a high degree of association to doves) should not be applied equally across all habitat types, because this would produce a gross overestimation of the population.

MANAGEMENT IMPLICATIONS

Populations of white-winged and mourning doves can be monitored within large areas by survey efforts focused on land cover types with which doves are most likely to associate. Such surveys require less time and money than surveys of cover types not known to be well-associated with doves. Moreover, surveys based on distance sampling are easy to conduct for these visually apparent dove species. The ongoing conversion by TPWD from using coo-counts to distance sampling is a positive step in upgrading sampling methods for white-winged doves. We recommend that TPWD focus their monitoring efforts on survey routes that traverse landscapes with substantial amounts of urban, cropland, and rangeland cover. In a wider context, we hope our study motivates other state wildlife agencies to monitor game birds and other avifauna by selectively surveying areas where species of interest are most likely to occur.

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