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Cover photo Scaled Quail (*Callipepla squamata*)
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BULLETIN OF THE

TEXAS ORNITHOLOGICAL SOCIETY

SPECIAL UPLAND GAME BIRD SECTION

LATE SUMMER DIETARY SURVEY OF SCALED QUAIL (CALLIPEPLA SQUAMATA)

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ABSTRACT.—This survey examines late summer dietary habits of a Scaled Quail (Callipepla squamata) population from Elephant Mountain Wildlife Management Area in Brewster County, Texas in 2002. Quail crop contents were quantified by frequency of occurrence and volumetric abundance. Results mirror summer and fall diet trends in the literature based on Scaled Quail populations in western Texas and southeastern New Mexico. Two age classes were examined (juvenile and adult) and between areas with and without spread dams. Newly documented genera included *Amsinckia*, *Iva*, and *Stellari*, while *Opuntia* was conspicuously absent. Food items of highest consumption based on volumetric abundance were *Acalypha ostryaefolia*, *Amsinckia intermedia*, *Mollugo verticulata*, *Verbena* sp., and insect orders Coleoptera, Isoptera, and Orthoptera.

Scaled Quail (*Callipepla squamata*) are indigenous southwestern game birds. Dietary studies conducted for this species have examined both crop and stomach contents throughout their range during various seasons but rarely in late summer. This study surveyed late summer dietary trends of Scaled Quail at the Elephant Mountain Wildlife Management Area (Elephant Mountain WMA) using a sample of 48 individuals classified as either juveniles or adults. Crop content analysis of Scaled Quail allow for a general selective comparison among age classes as well as augmenting the current catalog of their dietary items. Scaled Quail diet varies seasonally, primarily composed of seeds of shrubs, grasses, and forbs during fall and winter. By contrast, insects and green herbaceous material are consumed more heavily in late winter, spring, and summer (Kelso 1937, Wallmo 1956, Schemnitz 1994). Schemnitz (1994) suggested Scaled Quail may ingest greater amounts of insects than other quail species. Hunt and Best (2001) reported 40 plant and 35 invertebrate food items in 563 Scaled Quail crops from southeastern New Mexico during 1981–1988. Snakeweed (*Gutierrezia sarothrae*) was important in New Mexico (Campbell et al. 1973, Davis et al. 1975) but documented in only 5 of 324 Scaled Quail droppings assessed by microhistological analysis from northwest Texas even when abundant (Ault

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and Stormer 1983). Invertebrates are important to Scaled Quail chicks (Cain et al. 1982) and other quail species (Johnsgard 1973). Diets with $<$ 26% crude protein reduced growth of young and delayed first molt in captive birds (Cain et al. 1982).

Our objective was to survey late summer dietary trends of Scaled Quail in west Texas. We expected crop contents to contain significant amounts of invertebrates, especially among juvenile birds based on previously published seasonal dietary variation (Kelso 1937, Wallmo 1956, Schemnitz 1994). An additional factor for study was to investigate if the presence of spreader dams influenced dietary consumption. The effect spreader dams have on Scaled Quail remains under investigation, but quail from this modified habitat have shown a higher rank mean abundance of two helminth parasite species compared to unaltered habitat (Landgrebe et al. 2007). As this study was conducted outside the traditional timeframe in which hunter-acquired birds are collected during the fall-winter season, it provided a unique aspect of quail dietary consumption information (Campbell-Kissock et al. 1985).

METHODS

Texas Parks and Wildlife Department has managed the Elephant Mountain Wildlife Management Area (WMA) since 1985 (Texas Parks and Wildlife Department 1998). The most conspicuous feature of the area is Elephant Mountain (approximately 30°06'N and 103°30'W in Brewster County, TX) with separate major drainages on east and west mountain slopes. Chalk Valley, located to the east of the mountain, is a shallow drainage with a restricted watershed on the site and does not typically contain free water on a large scale (Lerich 2002). Spreader dams, constructed on this portion of the Elephant Mountain WMA circa 1950s, capture rainfall and subsequently provide for increased density and diversity of herbaceous vegetation. Major plant communities on the Chalk Valley vary from grama (*Bouteloua* spp.) and tobosa (*Pleuraphis* spp.) dominated grasslands to Chihuahuan Desert scrubland. Yewleaf willow (*Salix taxifolia*) and netleaf hackberry (*Celtis reticulata*) are restricted to areas around spreader dams in the lower drainage (Lerich 2002). Upland areas contain mesquite (*Prosopis glandulosa*) and redberry juniper (*Juniperus pinchotii*) (Lerich 2002). Calamity Creek, to the west of Elephant Mountain, contains portions of a relict gallery forest north of the area headquarters and runs through degraded Chihuahuan Desert grassland and mesquite-creosotebush (*Larrea tridentata*) dominated shrublands with little to no riparian vegetation to the south of headquarters (Lerich 2002). Average annual precipitation across the area from 1986 through 2001 was 363 mm, with the driest year recorded being 205 mm in 2001 (Lerich 2002).

We collected Scaled Quail by shotgun in August 2002 for a parasitological study (Landgrebe et al. 2007). Birds were taken from both the eastern and western sides of the area, thereby enabling a comparison of food habits between areas with and without spreader dams. Each bird was placed in individually labeled bags, quick-frozen in the field by dry ice and ethyl alcohol immersion, and stored in a freezer until necropsy (Landgrebe et al. 2007). Upon thawing, crop contents were removed, placed in individually marked plastic bags, refrozen, and sent to Sul Ross State University for examination. Crops were measured volumetrically and dissected in a petri dish. All contents were flushed, sorted, and identified to their separate dietary components using seed keys (Martin and Barkley 1973, Davis 1993) or insect identification (Whitaker 1988, Triplehorn and Johnson 2005).

We quantified crop contents by frequency according to occurrence and abundance through volumetric displacement in cm^3. Similarities in food consumption between juveniles and adults were compared by all food items recovered and by broad categories of food items using the Percentage Similarity or Renkonen index (P), which measures the amount of resource overlap among age classes. The index is calculated as the sum of the minimum value of the percentage of the food item from each age class times 100, and scores ranged from 0 (no similarity) to 100 (complete similarity).

RESULTS AND DISCUSSION

We sampled 48 quail, representing 22 juveniles and 26 adults. Dietary components fell in several large categories: grasses, forbs, woody plant seeds, and insects (Table 1).

Among juveniles and adults, grass dietary components included bristlegrass (*Setaria* sp.), panicum (*Panicum* sp.), and Johnsongrass (*Sorghum halapense*) in high, moderate, and low abundances relative to each other, respectively. Bristlegrass was documented at low abundances in summer diets of Scaled Quail in northwest Texas (Ault and Stormer 1983) and moderate to high abundances in Pecos

Table 1--Survey of late summer Scaled Quail diet items based on crop content frequency (*n* = 48 quail) and mean volumetric abundance (cm^3).

Scaled Quail Diet	Juveniles (*n* = 22)		Adults (*n* = 26)	
	Frequency	Abundance	Frequency	Abundance
Grasses				
Panicum capillare	3	0.263	6	0.074
Setaria spp.	13	1.02	14	0.636
Sorghum halapense			2	0.085
Forbs				
Acalypha ostryaefolia	3	0.66	7	0.509
Amaranthus sp.	1	0.005		
Amsinckia intermedia	13	0.691	14	0.485
Astragalus sp.	1	0.01	1	0.005
Euphorbia sp.	1	0.02		
Iva sp.	1	0.41	2	0.18
Mollugo verticulata	11	0.894	16	0.321
Stellaria media			1	0.01
Verbena sp.	3	0.31	4	0.838
Woody Plants				
Acacia sp.	3	2.92	4	0.11
Prosopis glandulosa	2	0.35	2	0.15
Insects				
Coleoptera: Curculionidae	3	0.365	5	0.138
Hemiptera: Pentatomidae			3	0.037
Hymenoptera: Formicidae	5	0.105		
Isoptera	2	0.045	1	0.005
Lepidoptera	1	0.45		
Orthoptera: Acrididae	2	0.605	6	0.406
Empty	0		2	

County, Texas (Howard 1981). Only panicum (Hunt and Best 2001) and bristlegrass (Davis et al. 1975) appeared within southeastern New Mexico populations. These differences may reflect seasonal and geographical availabilities rather than selected comsumption. In our study, only bristlegrass and panicum were consumed by both age classes.

Previously undocumented forbs included *Amsinckia*, *Iva*, and *Stellaria*. Scaled Quail forb selection included *Acalypha*, *Amaranthus*, *Astragalus*, *Euphorbia*, *Mollugo*, and *Verbena* in west Texas (Howard 1981) and southeastern New Mexico (Hunt and Best 2001) populations. Of these, only *Acalypha*, *Amsinckia*, *Mollugo*, and Verbena were present in a recurring frequency among both age classes. Forb consumption may increase during summer relative to increased abundance following summer precipitation.

Woody plants (including shrubs and trees) included mesquite (*Prosopsis*) and acacia (*Acacia* spp.). Both were present in noticable abundances because of the comparatively large size of fruits/seeds. Mesquite and *Acacia* spp. typically are consumed in relatively large amounts by Scaled Quail in summer and fall (Ault and Stormer 1983, Campbell-Kissock et al. 1985). Woody plants were consumed more by juveniles than adults, with adults presenting lower volumetric abundances than juveniles. Mesquite and white-thorn acacia (*A. constricta*) are both abundant across the landscape at Elephant Mountain WMA and likely provide an important year-round food source for Scaled Quail and other wildlife species.

Insect dietary components included Coleoptera (Curculionidae), Hemiptera (Pentatomidae), Hymenoptera (Formicidae), Isoptera, Lepidoptera (larval), and Orthoptera (Acrididae), all previously documented in Scaled Quail diet (Thomas 1957, Howard 1981, Campbell-Kissock et al. 1985). Insect ingestion typically peaks during summer, specifically shown by a high Curculionidae presence (Ault and Stormer 1983). Excepting Hemiptera (adult) and Lepidoptera (juvenile), both age classes consumed all insect orders, though in larger abundances by juveniles. This finding is as we predicted in that juvenile diets expressed greater insect consumption, likely to supplement growth toward maturation. Larger sample sizes of age categories would help provide greater resolution to this question.

Cacti were not detected in any of the 48 crops examined, though dozens of species exist at Elephant Mountain WMA, including numerous varieties of prickly pear and cholla (*Opuntia* spp.). Crop contents conspicuously lacked *Opuntia* seeds and fruit. Ault and Stormer (1983) showed heavy woodyroot prickly pear (*Opuntia macrorhiza*) fruit consumption during fall and winter. However, as noted by Ault and Stormer (1983), food selection by Scaled Quail may depend upon the location of food items in relation to where quail feed. The fruits of large prickly pear specimens, those most likely to provide a source of seeds or fruit for Scaled Quail, are often well protected by abundant spines and located out of reach for a primarily ground feeding quail. Many hundred hours observing Scaled Quail at Elephant Mountain WMA yielded only a single instance of off-the-ground feeding; an adult bird foraging ripe lotebush fruit (*Ziziphus obtusifolia*) in Chalk Valley (S. P. Lerich pers. obs.). The abundance of alternative food items, such as legume seeds and mast of other desert shrub species, likely precludes Scaled Quail from feeding on such difficult to reach items.

Dietary similarity comparison between age classes showed little overlap between juveniles and adults when compared by specific food items consumed as identified in the general food habitat analysis (Table 2). Examining food items by category (grasses, forbs, woody plant material, and insects) showed a greater degree of similarity between juveniles and adults, but not significantly. Adults consumed primarily forbs (58.8% to 35.8%) by volume; whereas, juveniles consumed a greater percentage of woody plant seeds (35.8% to 6.5%) and insects (17.2% to 14.7%) by volume. Insects were consumed in higher percent volumes by juveniles, which corresponded to Ault and Stormer (1983).

The impact of spreader dams on food item consumption was restricted to adults due to the low sample size of juveniles recovered per area. Adults collected from the eastern side of the area with spreader dams were only 53.3% similar to those collected from the western half of Elephant Mountain WMA (Table 2). Adults collected from the area with spreader dams consumed greater percent volumes of *Mollugo verticulata* and other forbs than adults collected from the area without spreader dams. By contrast, those birds collected from the western site consumed over double the percent volume of grasses.

Crop analysis of Scaled Quail collected during late summer allowed additional insight into quail diets at a point in their life cycle that is not well known. Unknown factors have led to Scaled Quail population declines across their range from 1966 through 1999 (Schemnitz 1994, Rollins 2000, Sauer et al. 2000). Many factors have been cited as possible mechanisms for Scaled Quail declines including predators (Rollins 2000), drought (Leopold 1924, Wallmo and Uzzell 1958, Saiwana 1990), hunting (Vorhies 1928, Ligon 1937), disease (Rollins 2000), overgrazing (Leopold, 1924), changing habitat conditions (Schemnitz 1994, Rollins 2000), or a combination of these factors. Drought, and the resulting poor habitat conditions frequently associated with it, is often cited by hunters, landowners, and land managers as the primary reason for population declines. Research on the effects of spreader dams has been mixed as to whether they benefit Scaled Quail populations by

Table 2—Percentage of dietary similarity (%) among age classes of *Callipepla squamata* and habitat modifications. Age classes include juveniles and adults, while habitat modifications compares spreader dams present or absent. Values are calculated by comparing all specific food items, with a broad category comparison of grasses, forbs, woody plant material, and insects presented in parentheses.

Age Class	Juveniles (n = 22)	Adults (n = 26)	Habitat
Juveniles	100 (100)		
Adults	60.3 (68.2)	100 (100)	53.3 (58.0)

increasing the density and diversity of herbaceous vegetation and invertebrate habitats across Brewster (Lerich 2002) and Pecos (Buntyn 2004) counties. Our study showed the presence of spreader dams might influence dietary consumption by Scaled Quail; however, dams increased parasitic load (Landgrebe et al. 2007). The role climate change has, or will have, on Scaled Quail populations is unknown at this time. A combination of factors cited above, including land use changes, are probable causes of scaled quail population declines. Further study into the impacts of land use changes and modifications will shed more light on this issue.

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DOVE DENSITY IN THE RIO GRANDE DELTA: 2007-2008

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ABSTRACT.—We used a grid sampling method to estimate Mourning Dove (*Zenaida macroura*) and White-winged Dove (*Z. asiatica*) densities in south Texas via distance sampling. We sampled over summers in 2007 and 2008 and calculated mean estimated density across years as well. Time (between years) did not affect density estimates for Mourning Doves but was significantly different for White-winged Doves. Species' distribution and a separate banding study suggest a possible reason for the difference between years in White-winged Dove density estimates.

Mourning Doves (*Zenaida macroura*) are one of the most ubiquitous bird species in the U.S. in both rural and urban areas (Dolton et al. 2008). Mourning Doves are distributed in three discreet populations (Kiel1959); the Western, Central, and Eastern Management Units (Kiel1961). Texas is located within the Central Management Unit. Mourning Doves breed throughout most of North America from southern Canada to northern Mexico and winter primarily in the southern U.S. south through Central America and Panama (Aldrich 1993) and are adapted to a wide range of habitat types (Otis et al. 2008). Mourning Doves in Texas have historically been considered cosmopolitan, occurring in all ecoregions of the state (Mirarchi and Baskett 1994). Population trend data strongly suggest Mourning Doves are declining (Baskett and Sayre 1993). White-winged Doves (*Z. asiatica*) have historically occurred throughout the southwestern U.S., inhabiting riparian habitats within predominantly arid regions (Small et al. 2006).

Prior to the early 20th Century, the breeding range of eastern White-winged Doves (*Z. a. asiatica*) was restricted to southern Texas from about Laredo in the west to Beeville in the east (Oberholser 1974); however, the majority of White-winged Doves inhabited the lower Rio Grande Valley (LRGV) (Cottam and Trefethen 1968), nesting predominantly in large colonies in riparian habitat along the terminal reach of the Rio Grande. Large tracts of riparian habitat were destroyed with the advent of mechanized agriculture in the 1920s and urban expansion in the 1950s (Purdy and Tomlinson1991). At some time during this period, a northward expansion of White-winged Doves in Texas began into areas with suitable, alternative nesting habitat (Small et al. 2006).

As migratory game birds, federal oversight for monitoring and managing populations of Mourning and White-winged Doves is delegated to state wildlife agencies (Gregory 1998, Bevill 2004, Eberly and Keating 2006). Trends for breeding populations of Mourning Doves are monitored by a national call-count survey (CCS). Coo-counts have been used to measure White-winged Dove population size in brushlands of the LRGV since 1949 (Uzzell in litt.; Cottam and Trefethen 1968). However, such counts have been found to be flawed because variances cannot be calculated, thus sources of error are unmeasurable (Rappole and Waggerman 1986, Berger and George 2004). Recently, Texas Parks and Wildlife Department (TPWD) implemented statewide dove surveys using distance sampling (Schwertner and Johnson 2006).

The objectives of our study were to 1) estimate chronological variation in Mourning and White-winged Dove densities and 2) estimate mean Mourning and White-winged Dove densities in a landscape matrix with a dispersion of agro-land and brush land in the Rio Grande delta.

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METHODS

Study Area.—We conducted our study in four Texas counties (Cameron, Hidalgo, Starr, and Willacy) forming the LRGV at the southernmost tip of Texas (Fig. 1). Within this area the Rio Grande River forms an extensive delta at its terminus with the Gulf of Mexico along the U.S./Mexico border (Dahm et al. 2005, Dykkesten 2009). Ecologically, the LRGV is part of the Tamaulipian Biotic Province and contains numerous biological communities (Blair 1950, Diamond et al. 1987, Jahrsdoerfer and Leslie 1988). The Tamaulipan brush community 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).

The advent of 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. Large-scale habitat conversion of the LRGV began as early as the 1920s with land use changing from ranching to field agriculture and urban or industrial development. By the end of 20th Century, an estimated 95% of the original native brushland 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 became

Figure 1. The lower Rio Grande Valley, Texas.

fragmented into isolated remnants of once-contiguous woodlands.

Survey Points Delineation.—We imported a 2001 National Land Cover Dataset map (Homer et al. 2007) of south Texas into geographic information system (GIS) software ArcGIS 9.2 (Environmental Systems Research Institute, Inc., Redlands, CA, USA). We then created a 10 points (east-west) by 13 points (north-south) sampling grid (130 points) (Buckland et al. 2001) such that the southern edge of the grid corresponded as closely as possible with the southern boundary of Texas. We used HawthsTools (Beyer 2004, Hawth's Analysis Tools for ArcGIS, http://www.spatialecology.com) extension to ArcGIS to move each point to the nearest road.

We created a single 5-km buffer around the sample grid, thus designating our effective sample area. We considered 5 km a reasonable distance based on our knowledge of White-winged Dove movements (Small et al. 2007, 2009). We then used Hawth's zonal statistics tool (Beyer 2004, Hawth's Analysis Tools for ArcGIS, http://www.spatialecology.com) to extract the proportion of each land cover category contained within the 5-km sample area. Fractions of proportions were rounded to the nearest integer. We also used GIS to create 300-m circular buffers around each survey point and repeated the land cover category extraction process for all buffer distances. The extracted proportions for each land cover type for the 5-km sample area and the 300-m point buffers for all points were compared using a goodness-of-fit contingency table (Zar 2009). This allowed us to evaluate whether the land cover composition of survey points was representative of the sample area.

Assumptions of Distance Sampling.—Point transect distance sampling requires that three primary assumptions be met to obtain unbiased density estimates (Buckland et al. 2001). These assumptions are: (1) objects on the point are detected with certainty (i.e., $g(0) = 1$); (2) objects are detected at their initial location; and (3) measurements of distances to objects are exact. We emphasized visually scanning each point upon approach and then scanning outward from the point. Consequently, individuals on the point did not go undetected. If a dove was observed on or near the point, but moved in response to the approach of the observer, the distance from the point to location of the dove prior to movement was recorded. All points were clearly marked and visible to the observer from a distance sufficient to determine the position of doves prior to movement in response to observer approach. Thus, assumption 1 was not violated.

We considered movements by doves prior to or during the observation period to be random with respect to the observer; thus, assumption 2 was considered met by recording the distance to doves at their point of initial detection (Turnock and Quinn 1991, Buckland and Turnock 1992, Buckland et al. 2001). We used a laser range finder to record distances to doves to the nearest meter and only doves visually detected were recorded, satisfying assumption 3.

Distance Sampling Protocol and Analysis.—We conducted distance sampling surveys from 19 June to 25 July 2007 and 15 May to 26 June 2008. These periods were of sufficient length to access all survey points at least once and to accrue adequate observations for analysis with minimal overlap. Surveys began about 15 min after official sunrise and ended no later than 2 h post-sunrise. Each point was visited for a 2-min period and distances to all Mourning and White-winged Doves observed were recorded to the nearest meter using a Bushnell™ Yardage Pro Legend laser range-finder (Bushnell, Inc., Overland Park, KS, USA) (Schwertner and Johnson 2005). For this study, only visual detections were used; auditory detections were not recorded.

We analyzed data in Program DISTANCE (Thomas et al. 2006, Distance 5.0. Release 5, version 2, Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/) with species (White-winged Dove and Mourning Dove) as a covariate at the stratum level for each year. We combined annual data for both species because Program DISTANCE uses detection models that are pooling robust. Initially, we ran 5 candidate models using all data (no truncation) and restricted to no more than 2 adjustment terms. We used the Akaike Information Criterion (AIC) to select the most parsimonious model for estimating population density (Burnham and Anderson 2003). We selected a likely truncation point using the most parsimonious model based on diagnostic output from Program DISTANCE. Once identified, data were analyzed again using various truncation points around the original choice until the data satisfactorily fit the probability of detection curve both visually and statistically (i.e., using the Komolgorov-Smirnov test *P*-value calculated by DISTANCE).

White-winged Dove Trapping.—We used trapping and banding data as supplementary information to buttress and verify the density trends derived for White-winged Doves by distance sampling. We trapped White-winged Doves at Estero Llano Grande State Park (26° 07.597 N, 97° 57.393 W) between 5 June and 25 July 2007 and 1 June and 5 August 2008 using standard wire funnel traps (92 × 60 × 23 cm) (Reeves et al. 1968) baited with a mixture of commercial chicken scratch, black oil sunflower seeds, sorghum, and commercial wild bird feed (Purina Corp, St. Louis, MO). We set 30 to 45 traps on 39 days in 2007 and 49 days in 2008. We banded all captured birds with U.S. Fish and Wildlife Service numbered, aluminum, butt-end leg bands and recorded all captures and recaptures. We assigned an age to all doves based on morphological characteristics and classified them as hatching year (HY) or after-hatching-year (AHY). The number of HY doves captured/day was calculated for each period of 7 (or approximately 7) trap-days and used as an indicator of productivity over time.

Unfortunately, no banding information was available for Mourning Doves.

A Priori Predictions.—Before conducting this study, we developed two primary predictions regarding density estimates in relation to temporal variation in sampling between years. For Mourning Doves we predicted temporal variation would have little effect on overall density because Mourning Doves are present in the area year-round as individuals immigrate and emigrate to and from the area during spring and into the breeding season. The majority of White-winged Doves leaves the LRGV and migrate south during winter and return in spring to establish nesting colonies in the region. We therefore predicted earlier sampling conducted during the second year would result in substantially lower density estimates because fewer young would have been incorporated into the population than later in the breeding season. We further predicted this disparity in the number of young would be reflected in the number of young trapped and banded across the breeding season.

All activities were conducted in accordance with Texas State University—San Marcos IACUC approval #06-05CC59736D, state permit #SPR-0890-234, and federal permit #06827.

RESULTS

Survey Points Delineation.—We found no difference between ratios of 2001 land cover classifications for 300-m point buffers with the 5-km buffer for 2007 (χ^2_{14} = 3.23, $P > 0.99$) or 2008 (χ^2_{14} =3.25, $P > 0.99$).

Distance Sampling.—For 2007, we surveyed 103 sample points (Fig. 2a). Of the surveyed points, 22 were surveyed 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). During 2008, 113 of the 130 points were accessible (Fig. 2b), and we surveyed all 113 points twice. We recorded 394 Mourning Doves during 288 observations (1.37 doves/observation) and 193 White-winged Doves during 120 observations (1.61 doves/observation).

For the 2007 data, the most parsimonious model selected by Program DISTANCE was a half-normal with a simple polynomial key function and no expansion terms (D = 0.04, P = 0.93) with data truncated at 150 m. For the 2008 data, the most parsimonious model selected by Program DISTANCE was a half-normal with no key function or expansion terms (D = 0.04, P = 0.67) with data truncated at 187 m.

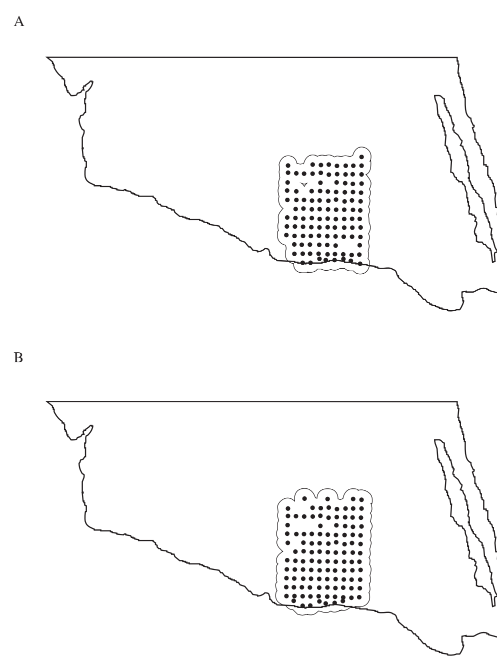

Figure 2. Survey points and 5-km survey area for 2007 (A) and 2008 (B).

Estimated mean White-winged Dove densities for the 2007 and 2008 sample periods were 0.72 (95% CI: 0.48-1.08) and 0.38 (95% CI: 0.27-0.53) doves/ha, respectively (Fig. 3). For Mourning Doves density estimates in 2007 and 2008 were 0.92 (95% CI: 0.69-1.23) and 0.88 (95% CI: 0.74-1.06) doves/ha, respectively (Fig. 3).

White-winged Dove Trapping.—We trapped 1,853 White-winged Doves on 39 trap days in 2007 of which 1,596 (86.1%) were HYs. Mean number of new HY doves trapped/day was 40.9 (range: 1-133, SE = 5.42). In 2008, we trapped 2,477 White-winged Doves on 49 trap days, including 2,304 HYs (93.0%). Mean number of new HY doves trapped/day was 56.1 (range: 1-122, SE = 3.86).

We calculated mean first capture HY White-winged Doves trapped/day for periods of 7 trap days. In 2007, there were two distinct peaks in first capture HYs trapped from 25 June to 4 July and 14 to 20 July (Fig. 4). In 2008, the mean number of first capture HYs was relatively consistent, averaging between 50 and 65 HYs trapped/day for each 7 trap/day period (Fig. 4).

DISCUSSION

Estimating the density or size of migratory bird populations is probably the most effective way to monitor annual population change. By monitoring annual fluctuations in populations through time, conservation biologists can objectively determine whether changes are part of a natural cycle or a stochastic event and respond more quickly with adaptive measures to curtail declines in the population.

Distance sampling is an effective method for estimating Mourning and White-winged Dove densities in Texas. Yet, as with any large-scale monitoring program which encompasses a large geographic area and uses numerous observers (who vary somewhat annually), logistical considerations is a priority. It is imperative that all participants conduct surveys within the constraints of structured a priori criteria, such as annual (specific dates) and daily time frames, to ensure the same population is being sampled.

White-winged and Mourning Dove surveys are conducted in spring in large part as a holdover of previous methodology which used calling doves

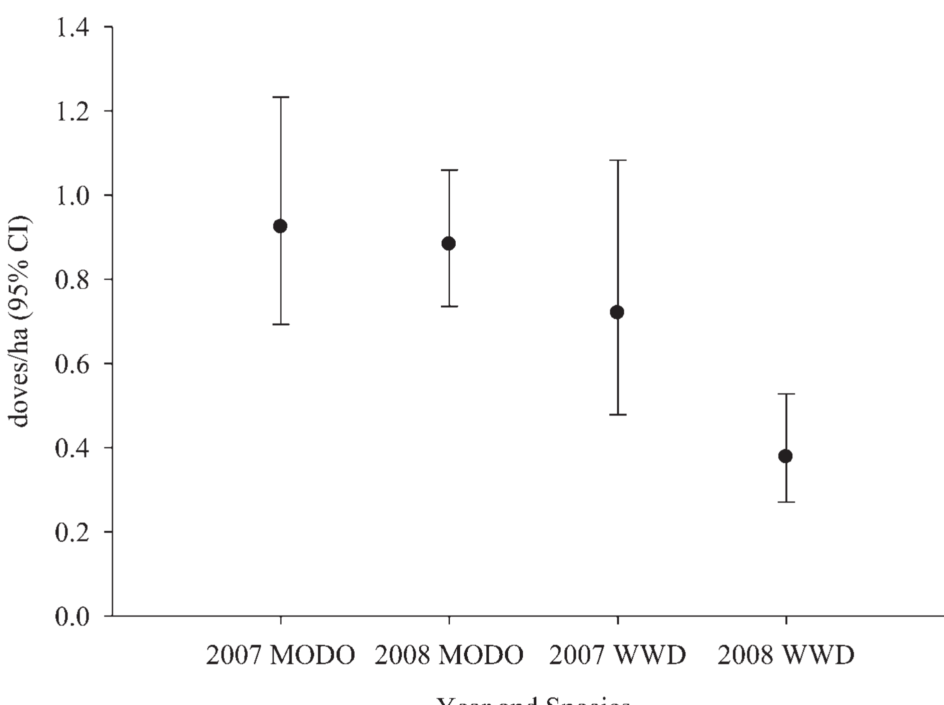

Figure 3. Density estimates and 95% CIs for Mourning (MODO) and White-winged (WWD) Doves by year.

A.

B.

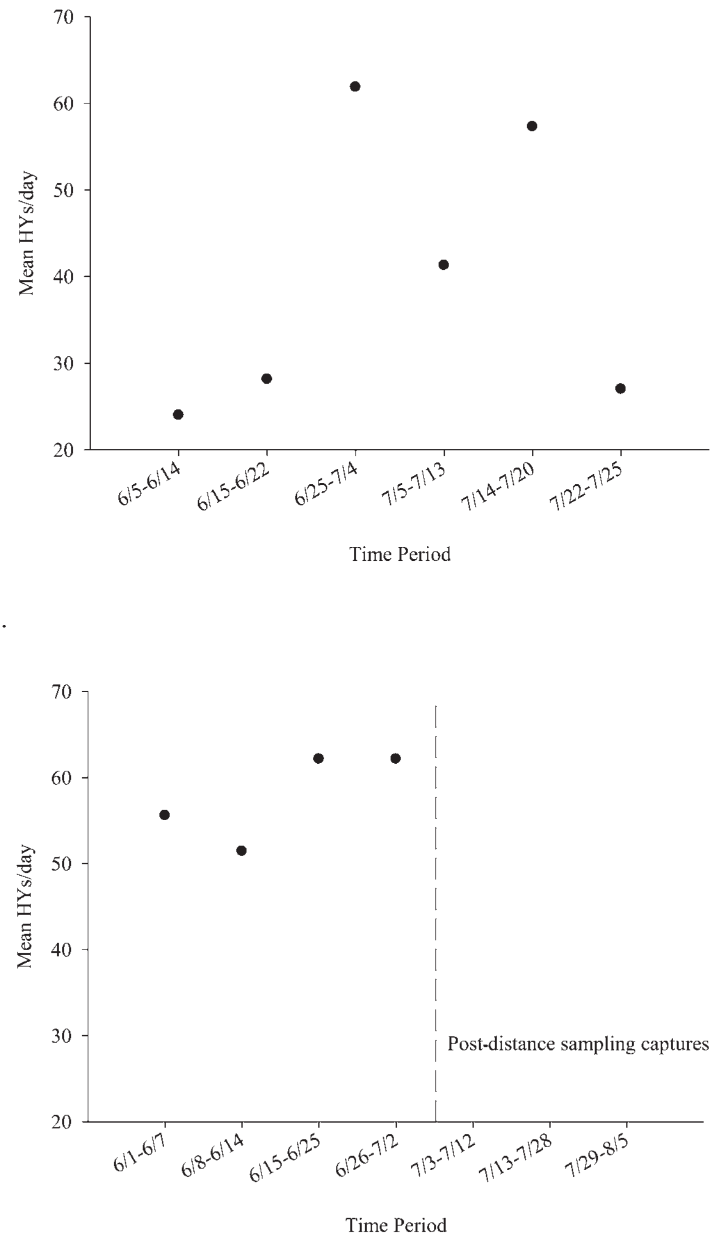

Figure 4. Mean captures-day of HY White-winged Doves for (A) 2007 and (B) 2008.

as an index of breeding pair density (Dolton 1993, Sepulveda et al. 2006). However, the call count methodology had inherent sources of bias (Sepulveda et al. 2006). Further, the reasoning for conducting White-winged Dove surveys in spring may not be valid, and the information obtained minimized, considering there is no monitoring of White-winged Dove productivity. The distance sampling methodology currently used by TPWD does not include auditory detections, thus, the need for spring counts is void. Further, some urban White-winged Doves in Texas became resident and substantially extended their breeding season prior to and beyond the current monitoring dates (Hayslette and Hayslette 1999). Consequently, many HY individuals are not included in the current sampling scheme used by TPWD.

Intraspecific density estimates did not differ significantly between years for either species. However, Mourning Dove density estimates were nearly identical for both years; whereas, White-winged Dove density estimates differed by nearly double between years. These results may, at first glance, seem inconsistent, however, given the differences in natural history of the two species, it is actually predictable.

Mourning Doves breed throughout the majority of North America and winter in the southern portion of their range (Dolton et al. 2008). Consequently, as Mourning Doves move north in spring from wintering areas, the population size remains relatively constant with local productivity mitigating for the loss of individuals migrating northward. While it is unlikely productivity would exactly match the exodus of a proportion of adults, some annual fluctuations in population size is expected. Overall, it is plausible that Mourning Dove densities in the LRGV would remain relatively constant throughout the breeding season.

The density of White-winged Doves in the LRGV would be expected to increase over the course of the breeding season. Although some individuals remain resident throughout the year, the majority of breeding White-winged Doves arrives and begins nesting in the LRGV in mid-spring (Cottam and Trefethen 1968). The population of adult White-winged Doves remains almost constant; however, productivity causes population size increases in an additive manner over the course of the breeding season.

Natural fluctuations in White-winged Dove density between years are not unexpected. However, the degree of change in density estimates we recorded for 2007 and 2008 (0.72 doves/ha and 0.38 doves/ha, respectively) seems excessively large. More likely, differences in the timing of the sampling period, which differed between years, are primarily responsible for the difference in White-winged Dove density estimates.

Distance sampling in 2007 (19 June to 25 July) encompassed the majority of the breeding season, including periods of peak productivity (Small et al. 2009). Consequently, as the population increased via recruitment, the effect, as evidenced by our trapping data (Fig. 4), was additive. Distance sampling in 2008 (15 May to 26 June) began very early in the White-winged Dove breeding season and ended prior to the peak of White-winged Dove production (interpreted from trapping data) in late July (Fig 4).

We have demonstrated the effect of sampling time on White-winged Dove density estimates and an apparent lack of effect on Mourning Doves. Substantial evidence from trapping data indicates the difference in density estimates is most likely attributable to productivity. Therefore, White-winged Dove population densities obtained by a set protocol effectively estimates potentially breeding adults. To obtain a more accurate estimate of individuals available for harvest during the hunting season, timing of sampling should be changed to the post-nesting, pre-hunt season period (about August), or some measure of productivity is needed in addition to the number of potentially breeding adults. Additionally, the remaining rural nesting habitat in south Texas is still occupied by White-winged Doves, but monitoring of these populations has been suspended by TPWD. Reinstatement of monitoring of this habitat with an annual production of about 200,000 White-winged Doves (Collins et al. 2010) is necessary for a more accurate estimate of the harvestable population.

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INFLUENCE OF INVASIVE TANGLEHEAD GRASS ON NORTHERN BOBWHITE NESTING AND HABITAT USE IN SOUTH TEXAS

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ABSTRACT.—Tanglehead grass (*Heteropogon contortus*; hereafter tanglehead) has historically occurred in small, isolated patches across south Texas. During the past 10–15 years, however, tanglehead has undergone a rapid expansion in south Texas similar to the spread of other introduced exotic grasses. Tanglehead can form extensive and exceptionally dense stands of grass that may result in reduced usable habitat space for the Northern Bobwhite (*Colinus virginianus*; hereafter bobwhite) in south Texas. Our objectives were to assess how the presence of vast and dense areas of tanglehead influenced nesting and general habitat use by bobwhites on south Texas rangelands. We monitored bobwhite nesting and general (off-nest) habitat use with radio telemetry during the 2008 and 2009 breeding seasons (April–September) at a private ranch in Duval County, Texas. We sampled bobwhite habitat at nest locations, random locations, and organism-centered locations. We analyzed habitat data at the macrohabitat (between habitat patches) and microhabitat (within habitat patches) scales for both nest site use and general (organism-centered) habitat use when bobwhites were off the nest. Nest sites had an average of 23.4% more tanglehead cover than random locations. Bobwhites nested in tanglehead but did not use tanglehead in greater proportion than available at the macrohabitat scale. In the organism-centered habitat use comparisons with random locations, bobwhites also did not significantly use or avoid tanglehead at the macrohabitat scale. However, when off-the-nest, bobwhites typically used patches of vegetation that had 38% less tanglehead cover compared to random locations. Our conclusions are that while bobwhites nest in patches of tanglehead at the macrohabitat and microhabitat scales, they tend to avoid areas with dense tanglehead cover at the microhabitat scale during the course of their other daily habitat use patterns. This avoidance of dense tanglehead patches for off-nest daily activities may be related to decreased plant diversity and presumably lack of available food.

The first description of tanglehead grass (*Heteropogon contortus*; hereafter tanglehead) in Texas occurred in 1885 (Reverchon 1886). During the 1950s, Val Lehmann reported tanglehead was present on the King Ranch but did not consider it a concern because of low abundance (Lehmann, unpublished report, Wildlife Production on the King Ranch, King Ranch Archives, Kingsville, Texas). Tanglehead is a native, warm-season, perennial bunchgrass found throughout south Texas, Arizona, New Mexico, Hawaii, Australia, and South Africa (USDA 2007). In south Texas, tanglehead has typically existed in small and widely distributed patches (Hatch et al. 1999). During the past decade however, tanglehead has become invasive and spread across several hundred thousand hectares of south Texas, primarily in Jim Hogg, Brooks, and parts of Kleberg counties (Tjelmeland 2011).

While unusual, native species of plants can undergo radical shifts in abundance and function like invasive exotic species (Simberloff 2011). Reduced cattle stocking rates and use of prescribed fire are possible reasons for the increase and spread of tanglehead (Orr and Paton 1997, Tjelmeland

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2011). Research from Australia showed shifting rainfall patterns from spring-early summer to late summer-early fall may also cause tanglehead to spread and ultimately dominate a landscape (Tothill 1966). Until our study no research had been conducted on how the recent widespread expansion of tanglehead in south Texas impacts Northern Bobwhite (*Colinus virginianus*; hereafter bobwhite) nesting and habitat use.

Bobwhites nest in a wide variety of vegetation. For example, row crops in the midwestern and southeastern United States and brush and prickly pear cactus (*Opuntia engalmannii*) in south Texas are used for nesting (Stoddard 1931, Hernández et al. 2007). The vast majority of circumstances, however, have indicated bobwhites use warm-season, perennial, native bunchgrasses for nesting (Hernández and Peterson 2007). For example, Lehmann (1984) documented 97% of bobwhite nests in south Texas occurred in native bluestems (*Andropogon* spp.), threeawns (*Aristida* spp.), and balsamscales (*Elyonurus* spp.). When native grasses are lacking, bobwhites will readily nest in exotic bunchgrasses such as buffelgrass (*Pennistum ciliare*) (Tjelmeland 2007).

Bobwhites construct nests in taller and denser vegetation than typically found at random locations in the same area (Rader et al. 2007). This relatively dense vegetation provides screening cover presumably concealing nests from predators. Lusk et al. (2006) found bobwhites used areas with > 40 cm vegetation height, $< 30\%$ bare ground exposure and $> 25\%$ shrub cover for nesting. Other habitat components influencing bobwhite nest-site use are herbaceous canopy cover (Townsend et al. 2001, Arredondo et al. 2007) and visual obstruction for nest concealment (Arredondo et al. 2007, Rader et al. 2007). Klimstra and Roseberry (1975) found 35% of bobwhite nests in Illinois were in large, dense patches of bunchgrasses. In other parts of bobwhite's geographic range including Oklahoma (Townsend et al. 2001) and south Texas (Tjelmeland 2007) nests also occurred in large, dense patches of bunchgrasses.

Landowners wishing to maximize bobwhite populations should focus on making all parts of a management unit usable by bobwhites (Guthery 1997). Bobwhite habitat in south Texas consists of well-interspersed cover types that include woody cover for loafing coverts, herbaceous cover, including forbs for food and native bunchgrasses for nesting, and bare ground for foraging (Kuvlesky et al. 2002b, Hernández and Peterson 2007). Throughout their range, bobwhites prefer diverse and patchy habitat to homogenous patches of vegetation. Roseberry and Sudkamp (1998) observed bobwhites in Illinois preferred patchy habitat with grass, brush, and crop fields in close proximity. At microhabitat and macrohabitat scales, Kuvlesky et al. (2002b) found bobwhites in south Texas used more diverse vegetation than randomly available. Kopp et al. (1998) identified brush cover, bare ground, and food-producing herbaceous cover as highly influential habitat factors in bobwhite habitat use.

The concept of bobwhites using diverse and patchy habitat for their daily needs is further supported by studies demonstrating avoidance of large patches of homogeneous vegetation. For example, Tjelmeland (2007) found bobwhites avoided large monocultures of buffelgrass for foraging primarily because of a lack of bare ground and food-producing plants. Stoddard (1931) observed that when broomsedge (*Andropogon* spp.) patches developed into large tracts of dense grass, the result was little to no bare ground and decreased species diversity, especially forbs. The lack of diverse food-producing plants and no bare ground made these stands poor overall quail habitat (Barnes et al. 1995). The same holds true for tall fescue (*Festuca arundinacea*) dominated landscapes. Barnes et al. (1995) found monocultures of tall fescue in Kentucky created poor quail habitat due to a lack of food and bare ground as well as low plant diversity.

Thus, based on the numerous studies of bobwhite nesting and general habitat use conducted over vast geographic areas of the midwestern and southeastern United States, we posed the following research hypotheses at the beginning of this study:

1. Bobwhites would use tanglehead for nesting because it provides tall, dense, vegetation with a large number of suitable nest clumps and standing dead vegetation for nest construction;
2. Bobwhites would avoid dense patches of tanglehead during the course of their other daily habitat use activities (i.e., when they were off the nest) due to a lack of plant diversity, bare ground, food-producing forbs and increased amounts of litter which makes foraging difficult; and

3. The presence of extensive (> 30% cover) tanglehead would result in habitat containing fewer forbs, deeper litter and overall denser vegetation that could potentially limit usable space for off-nest activities of bobwhites.

STUDY AREA

We conducted our study on La India Ranch in Duval County, Texas (E: 547357 N: 3023777). This ranch, in the South Texas Plains physiographic region, has primarily chaparral vegetation and open grasslands (Gould 1975). La India is ≈1,020 ha; the primary management priority is production of wild bobwhites for hunting.

Supplemental feed consisting of 60% milo and 40% corn is spread across the entire ranch year round. Water is provided systematically across the entire ranch via water drippers above small catchments in brush mottes. Vegetation is kept in early to mid-sucessional stages by strip disking and mechanical brush control. Prescribed burning is conducted during early spring (March–April) each year as weather conditions allow. Cattle were present on the ranch, but data on stocking rates were not disclosed.

Tanglehead is the dominant grass at La India; it covers approximately 48% (or ≈505 ha) of the entire ranch. Other dominant grasses on La India are buffelgrass, Pan-American balsam scale (*Elyonurus tripsacoides*), oldfield threeawn (*Aristida oligantha*), and seacoast bluestem (*Andropogon littoralis*). Common forbs are croton (*Croton capitatus*), western ragweed (*Ambrosia cumanensis*), horsemint (*Monarda citriodora*), Lindheimer tephrosia (*Tephrosia lindheimeri*), and various species of sunflower (*Helianthus* spp.). The woody plant community on La India consisted primarily of honey mesquite (*Prosopis glandulosa*), brasil (*Condalia hookeri*), and granjeno (*Celtis pallida*). Additional details about the study area are provided in Buelow (2009).

METHODS

Data Collection

Trapping and Radio Telemetry.—We captured bobwhites during 2008 and 2009 using standard funnel traps baited with milo (Stoddard 1931). Trapping began on 15 March and a constant trapping effort was implemented throughout the study to maintain a sample of at least 20 radio-marked bobwhite hens. During both years, we captured hens from March to mid-September during the breeding, nesting, and early covey stages of the annual cycle (Lehmann 1984). We aged (juvenile or adult), sexed, and banded all captured bobwhites (Kuvlesky et al. 2002b). We fitted bobwhites weighing 150 g or more with a 6-g necklace-style radio transmitter (American Wildlife Enterprises, Monticello, Florida, USA). We used a wooden restraining device to hold the bobwhite while a transmitter was fitted by the researcher (DeMaso and Peoples 1993). We flushed relocated radio-marked bobwhites to ensure that they were alive and assessed nesting. If a bird was discovered nesting, its position was checked from a short distance (5 m) away to avoid disturbance. Locations of nesting radio-marked bobwhites were recorded 3 times per week, and all other radio-marked bobwhites were relocated 2 times per week using a Yagi-style antenna and an R-1000 telemetry receiver (Communications Specialists, Inc., Orange, California, USA). We used these relocations to assess nest-site use by bobwhites throughout the study (Sands 2007, Buelow 2009). Telemetry data were collected during morning (700–1100 h) feeding, afternoon (> 1100–1500 h) loafing, and evening (> 1500–1900 h) feeding periods of the day (DeMaso 2008).

Relocations < 7 days after radio-marking were censured from the final data set to minimize potential bias for bait-site habitats (Sands 2007). Each time a bird was relocated, their position was recorded using a Garmin Geko 301 hand-held GPS unit accurate within 3 m. We later transferred these data into a Geographic Information System to establish a visual representation of habitat use and home range size (Tjelmeland 2007).

Vegetation Sampling.—Vegetation characteristics were sampled at an equal number of nest-site locations as well as general, off-nest or organism-centered and random locations. Random locations were established by traveling a random distance between 50 and 100 m away from nest-site or organism-centered locations along a randomly selected compass bearing. Random plot distances between 50 and 100 m were assumed far enough from nest or organism-centered locations so as to not impact bobwhite use of its actual location but close enough to be comparable to the used location. Hernández et al. (2003) and Lusk et al. (2006) employed similar methods for establishing random sites in relation to non-random ones for assessing bobwhite habitat use.

Each series of vegetation sampling encompassed 2 weeks of field time. Vegetation was sampled at a selected site no later than 3 days after relocation of a bobwhite. This avoided potential changes in vegetation structure between relocation time and sampling time. About half of locations for radio-marked bobwhites were randomly selected for the first week of vegetation sampling, and the other half of locations was used for the second week of sampling.

Estimates of plant canopy cover by species, bare ground, and bare ground exposure as described by Lusk et al. (2006) were collected with a 50 × 60 cm frame delineated into three sections (Lusk et al. (2006)). This frame simulates three 20 × 50 cm frames (Daubenmire 1959) placed side by side. We used a ruler to measure an average litter depth and height within the frame to the nearest centimeter. We counted the number woody plant and cati stems within a circular plot with a 2-m radius centered on the organism or a random location to estimate the average number of stems. We employed the point-centered quarter method to calculate an average distance between bunchgrass clumps. This plotless method of vegetation sampling has been shown to be more efficient and flexible than fixed plot methods (Cottam and Curtis 1956, Dix 1961).

We established a visual obstruction index using a GRS densitometer (Geographic Resource Solutions, Arcata, California, USA) to quantify screening cover at heights of 12, 25, and 50 cm. These heights represented the average height of a bobwhite (12 cm), a predator (25 cm) and overhead screening cover from aerial predators (50 cm). Modification was made to the densitometer by attaching height props and a periscope so data could be collected without lying on the ground. A 1-m tall, colored, 2.54-cm PVC pipe was placed in the center of a sampling point and supported by a 0.5 m long rebar hammered into the ground. We began at a distance of 0.5 m from the pole and tried to observe the pole through the periscope. We moved back at 0.5-m increments until the pole was completely obstructed, or we reached 3 m the maximum sampling distance. We repeated this method for each of the 3 heights at the 4 cardinal directions. This method was developed on the premise that traditional estimates of screening cover are observed from elevated angles and thus the actual amount of screening cover biologically significant to bobwhites is not accurately recorded. Collins and Becker (2001) developed a similar method using a staff and ball. We found this technique was more precise and faster than either the traditional cover pole and/or checkerboard methods (Buelow, unpublished data). This method also allowed us to look horizontally and level (as dictated by the levels in the densitometer) and observe visual obstruction from a "bobwhites eye view" of the vegetation.

Data Analysis

Habitat Variables.—Plant species were lumped into functional groupings for measuring floristic components of habitat (Lusk et al. (2006) and categories based on knowledge of plants identified as important for bobwhites during a review of the literature. Functional groupings were percent bare ground, percent litter, vegetation height, litter depth, percent bare ground exposure, percent tanglehead grass, percent brush, percent cactus, brush density (mesquite, brasil, hog plum (*Colubrina texensis*), catclaw acacia (*Acacia greggii*), blackbrush acacia (*Acacia rigidula*), and granjeno), cactus density (prickly pear cactus and tasajillo cactus (*Cylindropuntia leptocaulis*)), bunch grass density, visual obstruction at 3 established heights, native bunch grass (Pan American balsam scale, seacoast bluestem, Texas panicum (*Uruchloa texana*), silver bluestem (*Bothriochloa saccharoides*) and hooded windmill grass (*Chloris cucullata*)), exotic grass (buffelgrass, kleingrass (*Panicum coloratum*), bermuda grass (*Cynodon dactylon*) and old-field three-awn), primary forbs (sunflower, croton, partridge pea (*Chamaecrista fasciculata*), snout bean (*Rhynchosia senna*), ragweed, and Lindheimer tephrosia, and secondary forbs (which consisted of palafoxia (*Palafoxia* sp.), lantana (*Lantana urticoides*), round copper leaf (*Acalypha monostachya*), erect day flower (*Commelina erecta*), smartweed (*Polygonum hydropiperoides*), horsemint, old man's beard (*Clematis vitalba*), ground cherry (*Physalis* sp.), starflower (*Trientalis borealis*), prairie cone flower (*Ratibida columnifera*), and cowpen daisy (*Verbesina encelioides*)).

Statistical Analysis.—We examined macrohabitat use by quantifying the proportion of La India Ranch covered with tanglehead using GIS and subtracting that number from 1 to get the proportion of all other vegetation. We performed a chi-square contingency analysis (Brennan et al. 1987) to test whether tanglehead was used for nesting and general habitat use in proportion to its availability.

We examined microhabitat use by calculating both univariate and multivariate statistics using the STATISTICA (StatSoft, Tulsa, OK) software package. We used a Mann-Whitney *U* test for nonparametric data to calculate descriptive statistics and compare nest and organism-centered sites to random locations. Additionally, organism-centered microhabitat habitat use data were subdivided into 2 groups (habitat plots containing tanglehead and habitat plots without tanglehead) to examine how the presence of tanglehead influenced the composition and structure of habitat used by bobwhites. We used multivariate 2 group discriminant function analysis to build models of nesting and general habitat use with variables that explained the largest amount of variation between comparative groups (i.e., nest sites and random sites, organism-centered habitat use sites and random sites). Variables were selected for the discriminant function analysis using forward stepwise selection with a P value of ≤ 0.05 for entering or removing variables (DeMaso 2008). We calculated a Cohen's Kappa statistic to evaluate the significance of the classifications made with discriminant function analysis (Titus et al. 1984).

RESULTS

Trapping and Telemetry

Over two field seasons (March through September 2008 and 2009), we captured and banded 199 (92 females, 107 males: 152 juveniles, 47 adults) bobwhites and radiomarked 88 (78 females and 10 males). During 2008, we captured 112 (51 females, 61 males; 87 juveniles, 25 adults) bobwhites and radio-marked 51 birds (45 females and 6 males); 19 (37.2%) of these birds were depredated. Of 45 females radio-marked, 23 (51%) nested once and 17 (74%) renested. During the 2009 field season, we captured 87 (41 females, 46 males; 65 juveniles, 22 adults) bobwhites. We radio-marked 37 bobwhites (33 females and 4 males); 14 (38%) birds were depredated. Of 33 females radio-marked, 19 (57.5%) nested and 6 (31.6%) renested. Bobwhite productivity (Table 1) varied substantially between 2008 and 2009 due to a severe drought during the 2009-breeding season.

Nest Macrohabitat

Bobwhites used tanglehead grass and other vegetation for nesting in proportion to availability (Table 2). Bobwhites did not use tanglehead grass at a greater proportion than available for nesting at the macrohabitat scale.

Nest Microhabitat

Mann-Whitney *U*.—Nest sites had 9 habitat characteristics significantly different from random locations (Table 3). Nest sites had 1.9 cm greater litter depth, 5.6 cm taller vegetation height, 10.5% less bare ground, 13.7% fewer primary forbs and 25.9% lower species count than random locations. Nest sites also had a 1.4 cm less average distance to the nearest bunchgrass clump, which indicated denser vegetation cover than random locations. Visual height obstructions at nest points were 0.15 m less at 12 cm, 0.4 m less at 25 cm and 0.3 m less at 50 cm, respectively which indicated denser vegetation than at random locations. Tanglehead grass did not influence bobwhite nesting habitat use to any statistically significant extent. However, there was 23% more tanglehead grass cover at nest sites than at random locations and 63% of all nests we found, were in tanglehead grass.

Discriminant function analysis.—Litter depth, primary forbs and visual obstruction at 25 cm best described nest sites. Visual obstruction at 12 cm was highly correlated with visual obstruction at 25 cm; thus, visual obstruction at 12 cm was removed from the final analysis. Litter depth was greater at nest sites and primary forbs and visual obstruction were lower at nest sites compared to random locations (Fig. 1). This model (kappa = 0.43, $Z = 5.06$, $P < 0.001$) classified 71.2% of habitat plots into the correct group (nest or random).

Table 1. General characteristics of Northern Bobwhite nests on La India Ranch, Duval County, Texas, 2008 and 2009.

Year	Number of Nests	Nests used for egg laying	Percent Successful	Percent Unsuccessful[1]
2008	47	43	39.5	60.5
2009	26	19	21	79
Combined	73	62	33.9	66.1

[1] Includes depredated and abandoned nests.

Table 2. Chi-square contingency analysis of Northern bobwhite nest site use on La India Ranch, Duval County, Texas, 2008 and 2009.

Data type / Cover type	Proportion	Number of Observations: Observed	Expected	Chi-Square Value*
Nest				
Tanglehead	0.48	44	35	
Other	0.52	29	38	NS

*NS represents a non-significant value at $P > 0.05$.

Table 3. Descriptive statistics for nest sites and random locations on La India Ranch, Duval County, Texas, 2008 and 2009.

	Nest Site (n = 73)			Random Site (n = 73)			Mann-Whitney U
Variable	Mean	SE	Range	Mean	SE	Range	P-value*
Litter Depth (cm)	4.82	0.38	0-18.0	2.95	0.23	0-8.0	0.001
Vegetation Height (cm)	54.53	3.54	13-140.0	48.89	4.10	11-200.0	0.05
Percent Bare Ground	3.23	0.64	0-26.7	13.72	2.57	0-91.7	0.001
Percent Litter	22.69	2.47	0-100.0	23.47	2.68	0-91.7	—
Percent Bare Ground Exposure	1.00	0.33	0-13.3	0.73	0.24	0-10.0	—
Percent Tanglehead	49.56	4.44	0-100.0	37.94	3.96	0-100.0	—
Percent Primary Forbs	0.69	0.20	0-8.3	5.02	0.99	0-36.7	0.001
Percent Secondary Forbs	2.73	0.89	0-36.7	3.74	1.10	0-58.3	—
Percent Native Grasses	10.84	2.64	0-83.3	9.88	2.22	0-83.3	—
Percent Exotic Grasses	6.82	2.36	0-90.0	5.15	1.71	0-73.3	—
Percent Brush	1.05	0.64	0-38.3	0.27	0.20	0-13.3	—
Percent Cactus	0.08	0.06	0-3.3	0.02	0.02	0-1.6	—
Average number of woody stems in a 2-m radius circle	0.38	0.10	0-4.0	0.39	0.12	0-5.0	—
Average number of cacti stems in a 2-m radius circle	0.36	0.14	0-8.0	0.21	0.08	0-5.0	—
Species Count	2.89	0.27	1-10.0	3.64	0.30	1-10.0	0.04
Average distance to bunchgrass clumps (cm)	37.73	10.96	7.75-656.0	39.09	6.45	7.5-400.0	0.001
Visual Obstruction Index at 12-cm height (m)	0.63	0.06	0.5-1.63	0.78	0.05	0.5-3.0	0.001
Visual Obstruction Index at 25-cm height (m)	0.89	0.06	0.5-3.0	1.29	0.08	0.5-3.0	0.001
Visual Obstruction Index at 50-cm height (m)	2.23	0.09	0.63-3.0	2.50	0.07	0.625-3.0	0.01

*— represents a non significant value at $P > 0.05$.

Organism-Centered Macrohabitat

Bobwhites did not use tanglehead stands for feeding and/or brood rearing habitat disproportionately compared to other vegetation patches (Table 4). This suggests bobwhites used tanglehead in proportion to availability.

Organism-Centered Microhabitat

Mann-Whitney *U*.—Mann-Whitney *U* tests revealed bobwhites used areas with an average of 5.8% more bare ground, 5.71% more primary forbs, and 67.2% more brush compared to randomly selected areas. Bobwhites also used areas with

4.4% less exotic grass coverage that had 4% greater visual obstruction at 12 cm above the ground (Table 5). In general, the habitat structure bobwhites used was more open than habitat measured at random locations. Although tanglehead did not significantly impact bobwhite habitat use at the microhabitat scale, there was 39% less tanglehead coverage at organism-centered sites compared to randomly located sites.

Discriminant function analysis.—Percent bare ground, percent bare ground exposure, tanglehead gass, primary forbs, exotic grass and brush density best described daily habitat use by bobwhites (Fig. 2). There was more bare ground, bare ground exposure and primary forbs and greater brush density at organism-centered sites compared to random locations. There was less tanglehead grass and less exotic grass at organism-centered locations than random locations. The discriminant model (kappa = 0.31, Z = 4.44, P < 0.001) classified 65.5% of observations into the correct group (organism-centered or random).

Microhabitat Use Plots With and Without Tanglehead

Mann-Whitney *U*.—Eleven of 18 habitat variables were statistically different in tanglehead plots compared to plots without tanglehead (Table 6). Plots with tanglehead had 0.07 cm deeper litter, 10.7 cm taller vegetation, 16.4% less bare ground, and 5.6% more litter coverage compared to non-tanglehead locations. Areas with tanglehead also had 7.2% less primary forb coverage and 4.3% less secondary forb coverage, 7.4% less native grass

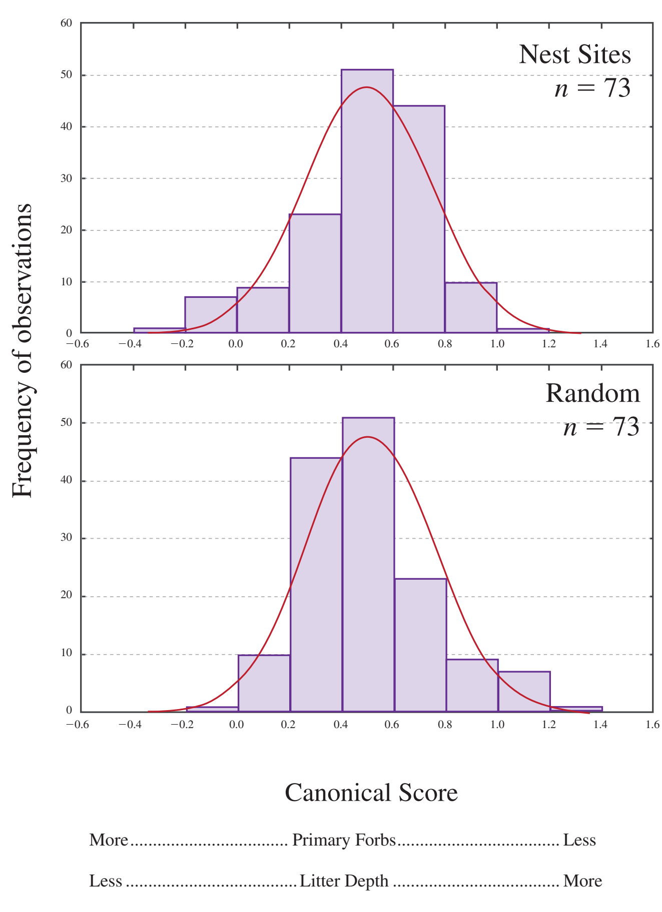


Figure 1. Discriminant function analysis of vegetation at Northern Bobwhite nest sites and random locations on La India Ranch, Duval County, Texas, 2008 and 2009.

Table 4. Chi-square contingency analysis of bobwhite habitat use on La India Ranch, Duval County, Texas, 2008 and 2009.

Data type / Cover type	Proportion	Number of Observations: Observed	Expected	Chi-Square Value*
Organism-centered				
Tanglehead	0.48	626	661	
Other	0.52	761	721	NS

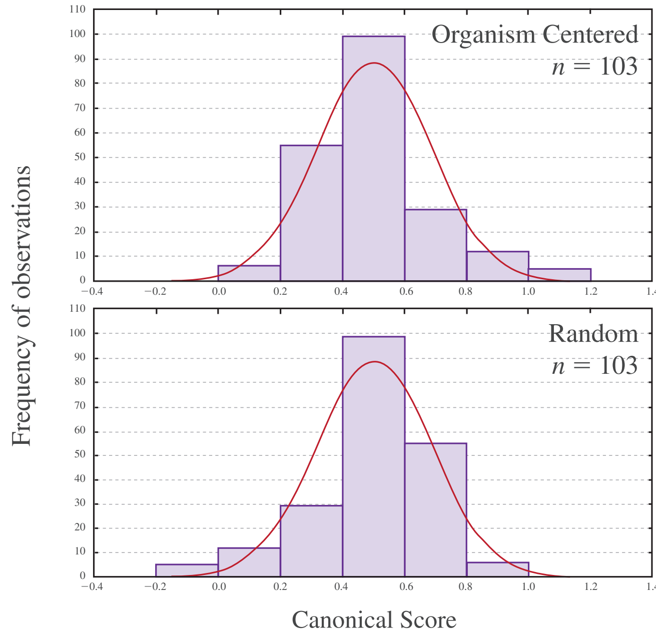
*NS represents a non-significant value at $P > 0.05$.

Table 5. Descriptive statistics of organism-centered and random locations on La India Ranch, Duval County, Texas, 2008 and 2009.

	Organism-Centered (n = 103)			Random Location (n = 103)			Mann-Whitney U P-value*
Variable	Mean	SE	Range	Mean	SE	Range	
Litter Depth (cm)	2.88	0.19	0-8.0	3.28	0.23	0-10.0	—
Vegetation height (cm)	33.93	2.17	10-120.0	36.54	1.93	10-95.0	—
Percent Bare Ground	23.59	2.37	0-88.3	17.76	2.47	0-93.3	0.0194
Percent Litter	27.28	2.35	0-86.7	24.96	2.27	0-90.0	—
Percent Bare Ground Exposure	2.83	1.15	0-85.0	0.72	0.56	0-56.7	—
Percent Tanglehead	24.20	2.84	0-96.7	33.51	3.45	0-100	—
Percent Primary Forbs	10.85	1.58	0-75.0	5.16	0.82	0-38.3	0.0466
Percent Secondary Forbs	3.50	0.82	0-46.7	3.78	0.72	0-31.7	—
Percent Native Grasses	3.98	1.23	0-71.7	5.27	1.59	0-83.3	—
Percent Exotic Grass	4.30	1.26	0-68.3	8.72	1.81	0-90.0	0.0148
Percent Brush	0.35	0.35	0-36.6	0.50	0.28	0-21.6	—
Percent Cactus	0.12	0.07	0-6.0	0.06	0.05	0-5.0	—
Average number of woody stems in a 2-m radius circle	0.67	0.13	0-7.0	0.22	0.07	0-4.0	0.0113
Average number of cacti stems in a 2-m radius circle	0.28	0.07	0-4.0	0.11	0.04	0-3.0	—
Species Count	2.15	0.13	0-6.0	2.16	0.12	1-6.0	—
Average distance to bunchgrass clumps (cm)	67.34	9.58	9.3-520.0	59.59	8.73	10.3-544.3	—
Visual Obstruction Index at 12-cm height (m)	0.81	0.03	0.5-2.5	0.77	0.04	0.5-2.25	0.0408
Visual Obstruction Index at 25-cm height (m)	1.58	0.07	0.5-3.0	1.44	0.08	0.5-3.0	—
Visual Obstruction Index at 50-cm height (m)	2.72	0.05	0.5-3.0	2.67	0.05	1.5-3.0	—

*— represents a non significant value at $P > 0.05$.

cover, 10.1% less exotic grass cover, and 10.9% fewer plant species. Bunchgrass clumps averaged 84.7 cm closer in tanglehead stands indicating thicker growth and increased bunchgrass density than what was present in non-tanglehead areas. Finally, visual height obstruction at 12 cm was reduced by 0.2 m and 0.5 m at 25 cm at tanglehead plots. Tanglehead plots had considerably denser grass coverage than non-tanglehead areas (Table 6).



More .... Percent Bare Ground .... Less

More .... Percent Bare Ground Exposure .... Less

Less .... Tanglehead .... More

More .... Primary Forbs .... Less

Less .... Exotic Grass .... More

More .... Brush Density .... Less

Figure 2. Discriminant function analysis of habitat characteristics at Northern Bobwhite organism-centered and random locations on La India Ranch, Duval County, Texas, 2008 and 2009.

DISCUSSION

Nesting Habitat

Our results supported the research hypothesis that bobwhites would use areas with tanglehead as nesting cover. Bobwhites on La India tended to nest in bunchgrasses (including tanglehead) with taller and denser structure than available at random locations. This represents a biologically important use of tanglehead for nesting habitat by bobwhites.

These results agree with past research conducted on bobwhite nesting ecology throughout their geographic range. Rosene (1969) and Stoddard (1931) documented bobwhites in the southeastern United States nesting in broomsedge areas with dense cover for nest concealment. Rosene (1969) observed bobwhites preferred grassland to dense brush or forest cover for nesting and would typically nest in standing dead vegetation from the previous growing season. Stoddard (1931) also found bobwhites typically nesting in bunchgrass communities that offered mobility to birds. In other words, bobwhites nested in areas with sufficient cover to conceal a nest, but such cover was not so dense as to impede movement.

Stoddard (1931) also observed 89% of all bobwhite nests occured in standing herbaceous vegetation from the previous year. Klimstra and Roseberry (1975) discovered over 35% of bobwhite nests in Illinois were in dense bunchgrass tracts with homogenous vegetation. Brennan (1999) reported bobwhites across their range consistently nest in standing herbaceous vegetation < 45 cm tall from the previous year. Additionally, in Oklahoma Townsend et al. (2001) documented more bobwhite

Table 6. Descriptive statistics for organism-centered habitat plots with tanglehead grass and plots without tanglehead grass on La India Ranch, Duval County, Texas, 2008 and 2009.

	Tanglehead Sites (n = 81)			No Tanglehead (n = 81)			Mann-Whitney U P-value*
Variable	Mean	SE	Range	Mean	SE	Range	
Litter depth (cm)	3.45	0.22	0-7.0	2.38	0.20	0-10.0	0.001
Vegetation height (cm)	38.34	2.60	7-120.0	27.58	1.67	0-64.0	0.005
Percent Bare Ground	15.24	2.46	0-93.3	31.64	2.94	0-88.3	0.001
Percent Litter	28.74	2.50	0-86.7	23.14	2.72	0-86.7	0.04
Percent Bare Ground Exposure	0.74	0.37	0-23.3	3.58	1.57	0-85.0	—
Percent Primary Forbs	5.51	1.13	0-46.7	12.67	1.83	0-75.0	0.001
Percent Secondary Forbs	1.74	0.53	0-28.3	6.06	1.12	0-46.7	0.001
Percent Native Grasses	2.14	1.04	0-66.7	9.54	2.24	0-83.3	0.001
Percent Exotic Grass	2.69	1.09	0-53.3	12.81	2.41	0-90.0	0.001
Percent Brush	0.57	0.36	0-21.7	0.06	0.06	0-5.0	—
Percent Cactus	0.09	0.05	0-3.3	0.15	0.09	0-6.0	—
Average number of woody stems in a 2-m radius circle	0.56	0.14	0-6.0	0.37	0.12	0-7.0	—
Average number of cacti stems in a 2-m radius circle	0.20	0.08	0-4.0	0.24	0.07	0-3.0	—
Species count	2.11	0.13	1-6.0	2.34	0.16	0-6.0	0.001
Average distance to bunchgrass clumps (cm)	27.12	1.56	9.3-113.3	111.78	14.42	12-544.3	0.001
Visual Obstruction Index at 12-cm height (m)	0.71	0.03	0.5-1.8	0.93	0.04	0.5-2.5	0.001
Visual Obstruction Index at 25-cm height (m)	1.35	0.08	0.5-3.0	1.87	0.08	0.5-3.0	0.001
Visual Obstruction Index at 50-cm height (m)	2.61	0.06	0.5-3.0	2.87	0.03	0.5-3.0	—

*— represents a non significant value at $P > 0.05$.

nests were associated with taller and denser grass cover than was available at random locations.

Bobwhites in south Texas also typically nest in native bunchgrasses (Hernández and Peterson 2007) but may nest in other vegetation if the desired structure is present. Sands (2007) and Tjelmeland (2007) documented bobwhites nesting in exotic bufflegrass, which also has a bunchgrass life form. In south Texas bobwhites used areas for nesting with greater visual obstruction, taller vegetation and less bare ground than found at random sites (Rader et al. 2007). Lusk et al. (2006) also documented that bobwhites used areas with taller nest-canopy heights and less bare ground than found at random locations.

Organism-Centered Habitat Use

When off-nests, bobwhites at La India used areas with more bare ground, more food-producing forbs, more woody vegetation, and less exotic grass cover than randomly available. The observation that organism-centered habitat plots had nearly 40% less tanglehead cover than random locations supports our hypothesis that bobwhites would tend to avoid dense patches of tanglehead during the course of their daily habitat use activities when off-nests. Northern Bobwhites consistently used areas with more complex habitat than found at random locations (Kuvlesky et al. 2002b). Our results suggest that while bobwhites tolerate tanglehead in the context of their general habitat use, they use habitat patches where tanglehead cover is significantly less than the average coverage (> 30% overall cover) across our study area. Past research in south Texas by Tjelmeland (2007) and Flanders et al. (2006) found off-nest bobwhites avoided exotic grass areas because of low species diversity, few forbs, and a lack of arthropod abundance for chick foraging. Sands et al. (2009) noted areas of exotic bufflegrass provided poor bobwhite habitat because of relatively low species diversity of food-producing forbs. Also, Kuvlesky et al. (2002a) observed rangelands encroached by invasive exotic grasses provided relatively poor bobwhite habitat compared to areas dominated by native bunchgrasses, forbs and woody shrubs. Because tanglehead creates uniform patches of habitat and usurps space for other species of plants, we would expect to see avoidance of these patches much like bobwhites have avoided bufflegrass as documented by these previous studies.

Stoddard (1931) found bobwhites preferred areas with brush and forb cover for foraging and areas with large amounts of bare ground and overhead screening cover for brood rearing. These areas with complex vegetation structure offer protection from the elements and aerial predators while offering ease of movement and food acquisition. Brennan (1999) concluded patchy mosaics of vegetation create the best bobwhite habitat across their range. Excessively dense vegetation patches, such as those dominated by tanglehead, buffelgrass, and broomsedge may become too dense and lack the species diversity sought by bobwhites for feeding and brood rearing cover.

In south Texas Kopp et al. (1998) found increased bare ground and brush density as well as canopy for screening cover were important habitat variables explaining bobwhite habitat use. Lehmann (1984) observed bobwhite broods needed adequate shade and fairly open habitat with bare ground for foraging. Hernández et al. (2007) also observed bobwhites use open and patchy habitat with increased bare ground and overhead screening cover for foraging and brood rearing. Tjelmeland (2007) found bobwhites avoided large tracts of bufflegrass presumably because these areas lacked bare ground and forbs that provided seed and arthropods for foraging (Flanders et al. 2006).

Microhabitat Use Plots With and Without Tanglehead

Habitat patches containing tanglehead tended to have fewer food-producing forbs, increased litter depth, less bare ground, lower species diversity and thicker vegetation growth than places without tanglehead. Thus, our hypothesis that tanglehead has the potential to limit usable space for off-nest activities was supported. Although bobwhites use habitat patches containing tanglehead during the course of their off-nest activities during the breeding season, tanglehead has the potential to limit important components of their habitat composition and structure. The result of extensive (> 30-50% of a pasture) tanglehead encroachment is that usable space for off-nest activities such as foraging and brood rearing for bobwhites may become limited. Therefore, management activities, such as prescribed fire followed by disking or cattle grazing, will almost certainly be required to keep tanglehead from limiting usable space for bobwhites where management to maintain their habitat is a priority (Tjelmeland 2011).

CONCLUSIONS

Tanglehead provides adequate nesting habitat for bobwhites in south Texas. However, bobwhites tend to use areas with substantially lower tanglehead cover when they are off-nest. Because of its invasive potential, managers should monitor and manage tanglehead stands to prevent its domination of rangeland pastures, if bobwhite management is a priority. Tanglehead can be managed using disturbance techniques such as disking, burning, cattle grazing, or combinations thereof. However, a management method for controlling the spread of tanglehead has not been identified.

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THE ROLE OF OPERATIVE TEMPERATURE IN PRICKLY PEAR USE BY NESTING NORTHERN BOBWHITE

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ABSTRACT.—High temperatures can negatively impact Northern Bobwhite (*Colinus virginianus*) populations by reducing reproductive effort or altering habitat use. In western Texas, Northern Bobwhite commonly nest in prickly pear cactus (*Opuntia* spp.) instead of their typical nesting substrate of bunchgrass habitat. We tested the hypothesis that bobwhites nest in prickly pear cactus because it offered a cooler microclimate than bunchgrass. Our objectives were to compare 1) operative temperature between bunchgrass and prickly pear habitat and 2) egg hatchability and clutch size between bobwhite nests located in either prickly pear or bunchgrass plants. We collected microclimate data at both habitat types during June–August 1997 and 1998 on four study areas in Shackelford County, Texas. We also monitored 218 radio- marked bobwhites during March–August 1997 and 1998 to locate nests and document clutch size and egg hatchability. Operative temperature was similar between prickly pear habitat ($\bar{\chi}$ = 39.7° C) and bunchgrass habitat ($\bar{\chi}$ = 40.1° C; $P > 0.05$). We also documented no difference in mean clutch size or egg hatchability between nests located in prickly pear (10.5 eggs, 93.2%, respectively) and bunchgrass habitat (11.9 eggs, 95.4 %, respectively; $P > 0.05$). Our findings do not support the hypothesis that bobwhites nest in prickly pear habitat because of cooler operative temperature. A more plausible explanation may be that prickly pear serves as a nest-predator deterrent.

High temperatures can have detrimental impacts on Northern Bobwhite (*Colinus virginianus*) populations (Guthery et al. 2005). These impacts can be expressed through direct effects such as lowered productivity or indirect effects mediated through reduction of thermally tolerable space. High ambient temperatures are known to reduce egg number and mass (Smith 1974), cease egg laying (Case 1972), shorten nesting-season length (Klimstra and Roseberrry 1975), and reduce breeding intensity (Guthery et al. 1988). Large (> 30%) reductions in thermally tolerable space of sufficient duration and intensity affected avian reproduction on southwestern rangelands (Land 1999, Guthery et al. 2001, 2005). These landscapes occasionally experience total collapse of thermally tolerable space during periods of acute heat (Guthery et al. 2001). In addition direct evidence exists that thermal stress is a regular occurrence in wild-ranging Northern Bobwhites during incubation (Guthery et al. 2005).

The selection of habitat based on thermal environment is important (Wolf et al. 1996). Avian breeding seasons have evolved to occur during periods most favorable for raising young (Murton and Prestwood 1977). High summer temperatures, however, can alter the length or duration of bobwhite breeding seasons. Guthery et al. (1988) documented a 2-month reduction in breeding-season length in the western Rio Grande Plains, which experiences higher temperatures and evaporation rates than the relatively more mesic and cooler eastern Rio Grande Plains.

Northern Bobwhites typically nest in bunchgrass habitat (Stoddard 1931, Lehmann 1984). Recently, however, prickly pear cactus (*Opuntia* spp.) has been reported as a common nesting substrate for Northern Bobwhite in western Texas (Carter et al. 2002,

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Hernández et al. 2003). Given the xeric environment of this region and the role high temperatures can have on habitat, we questioned whether bobwhites nest in prickly pear because it offered a cooler microclimate than bunchgrass habitat. Our objectives were to compare operative temperature between prickly pear and bunchgrass habitats and to compare clutch size and egg hatchability between nests located in either prickly pear or bunchgrass plants. We used operative temperature instead of ambient temperature for comparisons because operative temperature synthesizes microclimatic data into a single value capable of explaining thermoregulatory aspects of habitat use and selection (Goldstein 1984).

STUDY AREA

We collected data on 4 study areas (~ 500 ha each) in Shackelford County, Texas (32° 42' N, 99° 25' W). Shackelford County is located in the Rolling Plains of Texas (Gould 1975), which consists of gently rolling to moderately rough topography in northwestern Texas. Average annual precipitation ranges from 55–75 cm. Seasonal precipitation is lowest during summer when temperatures and evaporation rates are highest. Soils vary from coarse sands to redbed clays and shales (Gould 1975).

Original prairie vegetation included little bluestem (*Schizachyrium scoparium*), side-oats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), blue grama (*B. gracilis*), Canada wild rye (*Elymus canadensis*), and western wheatgrass (*Agropyron smithii*) (Correll and Johnston 1979). Buffalograss (*Buchloe dactyloides*), curly mesquite (*Hilaria belangeri*), and three-awns (*Aristida* spp.) tend to increase under grazing (Correll and Johnston 1979). Honey mesquite (*Prosopis glandulosa*) is the predominant woody plant with density increased over much of the region in the last 50 years (Guthery and Rollins 1997). Prickly pear is a codominant with mesquite over much of the region (Guthery and Rollins 1997).

METHODS

Operative Temperature

We collected microclimate data within prickly pear and bunchgrass habitat during peak nesting (June–August) of Northern Bobwhite during 1997 and 1998. We randomly selected 50 points within each habitat and sampled at approximately 8-day intervals during each month. We randomly selected new points for each 8-day sampling interval resulting in a total of 150 random points/nest habitat/month. At each point, we collected microclimate data (temperature, light intensity, and wind speed) during 1100–1500h CST. This time period was selected because it represented the hottest time of the day, and thus bobwhites would be at the greatest risk of thermal stress. We measured microclimate variables 7 cm above ground, which is the approximate height of an incubating hen. Air temperature (°C) was measured with a digital thermometer (Taylor, Forestry Suppliers, Jackson, Mississippi, USA). Light intensity was quantified using a light meter (Eptech, Forestry Suppliers, Jackson, Mississippi, USA), which was measured in lux and then converted to broad-spectrum solar irradiance as calculated by Forrester et al. (1998). Wind speed (m/s) was measured with a hand-held anemometer (Turbometer, Forestry Suppliers, Jackson, Mississippi, USA). These values were transformed into the operative environmental temperature using the model developed by Mahoney and King (1977). Following Forrester et al. (1998), we assumed a spherical shape for bobwhite (0.25 of surface area exposed to solar radiation; Campbell 1977), a characteristic dimension (body diameter) of $d = 0.05$ m (White 1995), absorbtivity of 0.78 (Calder and King 1974), and emissivity of 0.95.

Clutch Size and Egg Hatchability

We captured bobwhites using standard funnel traps during March–August 1997 and 1998. We sexed, aged, and banded all bobwhites and radio-marked bobwhites weighing > 150 g. We monitored radio-marked bobwhites 3 times/week throughout the study period. Once a nest site was located, we monitored it every other day from a distance of 20 m until hatch or nest loss. We then inspected nests to document nesting substrate, clutch size, and egg hatchability. We considered a nest depredated if ≥ 1 egg was removed or destroyed, and the adult did not return to incubate the remainder of the clutch (Burger et al. 1995). We considered a nest successful if ≥ 1 egg hatched from a nest. We classified nests as being located in bunchgrass or prickly pear habitat. We also recorded clutch size and egg hatachability. Egg hatchability was calculated as the proportion of eggs hatching from a clutch (Stoddard 1931).

Statistical Analyses

We used Friedman 2-way analysis of variance by ranks (Daniel 1987) to detect differences in operative temperature between habitats, months, and years. We considered results significant at $P < 0.05$. Because bobwhites avoid habitat with operative temperature > 39° C (Forrester et al. 1998), we used the operative temperature of 39° C as a landmark value to evaluate the microclimate within bunchgrass and prickly pear habitat. We used Kruskal-Wallis test (Daniel 1987) to compare clutch size and egg hatchability between nests located in bunchgrass or prickly pear habitat. We report results as mean ± standard deviation.

RESULTS

Operative Temperature

We documented a month × year interaction ($P = 0.001$); thus, we analyzed each field season separately by month. Operative temperature was significantly lower in prickly pear habitat (35.7 ± 3.1° C) than in bunchgrass habitat (36.4 ± 2.0° C) only during June 1997 ($P = 0.01$). Operative temperature in prickly pear habitat was consistently lower than bunchgrass habitat during July and August 1997; however, the difference was not significant (Table 1). Operative temperatures for both nest habitats increased with successive months. We documented operative temperatures above the 39° C landmark value only during August.

We documented no difference in operative temperatures between prickly pear and bunchgrass habitat in 1998. As was the case during 1997, operative temperature was consistently but not significantly lower in prickly pear habitat compared to bunchgrass habitat (Table 1). Operative temperature peaked during July for both habitat types. Operative temperatures were above the 39°C landmark value during June and July (Table 1).

Clutch size and Egg Hatchability

We located 81 nests (1997, $n = 27$ nests; 1998, $n = 54$ nests). Fourteen nests were successful in 1997 compared to 18 in 1998. No data were collected for 2 nests (both bunchgrass) in 1997 and 3 nests (1 bunchgrass and 2 prickly pear) in 1998. Thus, only 12 nests were used in analysis for 1997 and 15 nests for 1998. We documented no difference in clutch size or egg hatchability between nests located in either prickly pear or bunchgrass habitat (Table 2). Between years, however, clutch size was higher in 1997 (12.9 ± 3.6 eggs, $n = 12$ nests) than in 1998 (9.5 ± 2.6 eggs, $n = 15$ nests; $P = 0.009$). Egg hatchability did not differ between 1997 (90.6 ± 14.5 %, $n = 155$ eggs) and 1998 (97.9 ± 4.4, $n = 142$ eggs; $P = 0.15$).

DISCUSSION

In general, we detected no difference in operative temperature between bunchgrass and prickly pear habitat. Operative temperature, however, consistently was lower in prickly pear habitat. We do not know if the small difference (0.7° C) we observed in operative temperature between habitats is biologically meaningful. Active cooling (e.g., gular flutter) requires energy expenditure and gross energy intake decreases in bobwhites with increasing temperature (Case and Robel 1974). Thus, bobwhites may incur an energy deficit at high temperatures (> 35° C, the

Table 1. Operative temperature (° C) in prickly pear and bunchgrass habitat, Shackelford County, Texas, June–August 1997–1998.

Year	Prickly pear			Bunchgrass			
Month	*n*	Mean	*SD*	*n*	Mean	*SD*	*P*-value
1997							
June	100	35.7	1.9	100	36.4	2.0	0.02
July	150	37.8	3.3	150	38.4	3.5	0.08
August	150	40.6	1.7	150	40.8	3.3	0.10
1998							
June	100	42.0	1.6	100	42.2	1.7	0.20
July	150	43.6	1.7	150	43.9	1.6	0.13
August	150	38.5	2.2	150	38.6	2.1	0.57

Table 2. Clutch size and egg hatchability (%) of Northern Bobwhite nests located in either prickly pear or bunchgrass habitat, Shackelford County, Texas, May–August 1997–1998.

Year	Prickly pear			Bunchgrass			
Variable	*n*	Mean	*SD*	*n*	Mean	*SD*	*P*-value
1997							
Clutch size[a]	8	12.4	3.5	4	14.0	4.2	0.61
Egg hatchability (%)[b]	99	89.8	16.7	56	92.3	10.8	0.84
1998							
Clutch size	4	8.5	1.0	11	9.8	3.0	0.29
Egg hatchability (%)	34	96.5	7.0	108	98.5	3.4	0.64

[a]Sample size refers to number of nests
[b]Sample size refers to number of eggs

onset of gular flutter), particularly if this difference in operative temperature occurs over a prolonged period of time. Thermal stress appears to occur commonly in wild bobwhites during incubation (Guthery et al. 2005). In addition, maintenance metabolism (basal plus thermoregulatory) accounts for 40-60% of the total avian energy budget (Walsberg 1983, Weathers et al. 1984).

Johnson and Guthery (1988) reported a small mean difference (3.5° C) between operative temperatures inside and outside resting coverts. They speculated this small difference would be sufficient to reduce incident energy by 1,180 heating-degree min during a 6-h loafing period. (Note 1,180 heating-degree min is a calculation error. The correct amount is 1,260 heating-degree min/h]) [3.5° C × 6 h × 60 min/h]. In comparison, our observed greatest difference (0.7° C) would have resulted in a daily energy reduction of 840 heating-degree min during a 20-h incubation period (0.7° C ÷ 20 h × 60 min/h). However, this estimate assumes a difference of 0.7° C throughout the entire 20-h incubation period. We suspect that even in terms of energy expenditure over a period of time, the difference in operative temperature between nest habitats may be negligible.

We also detected no difference in clutch size or egg hatchability between bobwhite nests located in prickly pear or bunchgrass habitat. If prickly pear was providing a biologically meaningful cooler microclimate, one would expect these variables, particularly egg hatchability, to differ between habitat types. However, this was not the case. It is interesting to note that the 1998 field season was drier and summer temperatures were hotter than in 1997. Egg hatchability did not differ between years and was within the reported range (86–92%) for bobwhites (Stoddard 1931, Roseberry and Klimstra 1984). However, we observed lower clutch sizes in 1998 than 1997. This observation concurs with Case (1972) who documented bobwhite egg production decreased as temperatures increased.

A broader question to consider is what impact high operative temperatures had on bobwhites during the hottest periods of our study (August 1997 and June–July 1998). During these hot periods, bobwhites may have been in danger of hyperthermia given excessive operative temperatures (> 35° C). Non-incubating bobwhites may be able to minimize the effects of high operative temperatures by using resting coverts. Birds tend to select habitat features that minimize thermal stress when exposed to environments varying in temperature (Laudenslager and Hammel 1977, Mahoney and King 1977, DeJong 1979). Forrester et al. (1998) documented that bobwhites avoided habitat space-time with operative temperatures > 39° C during the hottest period (July-September) in south Texas. Further, Johnson and Guthery (1988) stated that in south Texas, bobwhite coveys tended to move further under canopies of loafing coverts as ambient temperature increased.

Although non-incubating bobwhites may be able to cope with high temperatures, incubating bobwhites may be more susceptible to hyperthermia. Nesting birds are reluctant to leave a nest, even during mid-day high temperatures (F. Hernández, pers. observ.). Hyperthermia may be a real threat to incubating bobwhites considering bobwhites were still nesting (19% of nests were active in

August 1997 and 54% nests in June-July 1998) during periods when operative temperatures were > 39° C. Guthery et al. (2005) documented 96% of incubating bobwhites exhibited bouts of gular fluttering and were in thermal stress about 10% of the time.

In summary, our data do not support the hypothesis that bobwhites are nesting in prickly pear because of a cooler microclimate. A more plausible explanation may be bobwhites are nesting in prickly pear cactus as a means of deterring nest predators. Hernandez et al. (2003, 2009) reported nest success was higher for nests located in prickly pear than those located in bunchgrass. We acknowledge other factors besides predator deterrence (e.g., limited bunchgrass) could explain the phenomenon of prickly pear use by nesting bobwhites. Land managers should consider the value of prickly pear as nesting cover for Northern Bobwhite when planning habitat management practices in western Texas.

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USE OF URBAN BIRD FEEDERS BY WHITE-WINGED DOVES AND GREAT-TAILED GRACKLES IN TEXAS

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ABSTRACT.— As White-winged Doves (*Zenaida asiatica*) and Great-tailed Grackles (*Quiscalus mexicanus*) expanded their range northward, these species have shown an increased affinity for urban areas, perhaps because of a constant supply of anthropogenic food sources. We compared use of bird feeders by both of these species to established avian species in urban central Texas. We used 15 feeding stations in San Marcos and 15 in San Antonio. We digitally recorded interaction events for half-hour intervals in summer 2009 and winter 2010. We used recordings to calculate total time spent by each species at each feeding station, count the number of aggressive interactions, and determine participants in each interaction. In summer, White-winged Doves and Great-tailed Grackles used feeding stations more than other avian species. In winter, there was little difference between feeding station use by White-winged Doves and Great-tailed Grackles; however, House Sparrows used feeding stations significantly more than both species. White-winged Doves were displaced by other species during summer but became more aggressive in winter, perhaps because food resources may have been limited more so in winter than summer. The results of our study are consistent with the possibility that maintenance of range expansion populations of White-winged Doves and Great-tailed Grackles has been facilitated by the ability of each species to use anthropogenic food sources.

Historically, the primary range of White-winged Doves (*Zenaida asiatica*) in Texas only extended as far north as the lower Rio Grande Valley (LRGV) with smaller populations in the Trans-Pecos region of Texas (Cottam and Trefethen 1968, George et al. 1994). However, since the 1950s range expansion has resulted in breeding populations as far north as Kansas (Cottam and Trefethen 1968, Moore 2001, Schwertner et al. 2002). This change in distribution has been attributed to loss and fragmentation of breeding habitat in the LRGV because of increased agricultural production, urbanization, industrialization, and weather events (severe freezes) that damaged citrus groves used as nesting sites (Cottam and Trefethen 1968, Curtis and Ripley 1975, Purdy and Tomlinson 1991, George et al. 1994, Hayslette et al. 1996, Brush and Cantu 1998).

Great-tailed Grackles (*Quiscalus mexicanus*) have undergone a similar range expansion within the United States. The original breeding range occurred only as far north as South Texas in the late 1800s; however, Great-tailed Grackles now breed in 20 states (Dinsmore and Dinsmore 1993, Wehtje 2003). Their expansion predated that of White-winged Doves by about 60 years with Great-tailed Grackles common in San Antonio, Texas by 1890 and Austin, Texas by 1902 (Attwater 1892, Schutze 1902). While habitat loss in the LRGV is likely the driving cause of Great-tailed Grackle expansion, the species may have expanded its range by taking advantage of increasing agricultural food resources (e.g., cattle feedlots) north of the LRGV (USDA-NASS 2000, Wehtje 2003).

Since expanding northward, both White-winged Doves and Great-tailed Grackles have shown an ability to successfully reproduce in urban areas (Small et al. 1989, West et al. 1993, Johnson and Peer 2001, Wehtje 2003). Urban areas may be

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facilitating expansion by providing a constant food source from various anthropogenic sources (Wehtje 2003).

Urban populations of nesting White-winged Doves also exhibit a reduction in migratory behavior, with a proportion of the population becoming year-round residents, likely taking advantage of a reliable food supply in the form of backyard feeders (George 1991, West et al. 1993, Hayslette and Hayslette 1999, Small et al. 2005). Great-tailed Grackles do not migrate and, since they are highly omnivorous (Johnson and Peer 2001), they may also take advantage of constant anthropogenic food sources such as refuse dumpsters and bird feeders. In a greater context, Moller (2009) found among European and North African bird species, those known to be "urban-adapted" tended to have larger geographic ranges than non-urban species; indirect evidence and inference the use of urban environments may facilitate range expansion.

Because White-winged Doves and Great-tailed Grackles are relatively recent colonizers of urban areas, we compared their utlization of anthropogenic food sources to exploitation by established urban species. A study of interactions between penned Mourning Doves (*Zenaida macroura*), a sympatric congener of White-winged Doves, and Eurasian Collared-Doves (*Streptopelia decaocto*), an invasive exotic species expanding across the United States, found both species exhibited aggression toward each other at feeders, but neither displaced the other (Poling and Hayslette 2006). Zenaida Doves (*Zenaida aurita*) in Barbados engaged in both territorial defense and communal feeding depending on food availability (Dolman et al. 1996, Lefebvre et al. 2006, Lefebvre et al. 2007). Because aggression is often heightened when food is reliable and clustered in a small area (Dubois and Giraldeau 2003), we surmised frequent bouts of aggression could be expected at feeders.

If exploitation of anthropogenic food sources has been a factor in maintaining range expansion populations of White-winged Doves and Great-tailed Grackles, then these two species should utilize "backyard bird feeders" extensively; perhaps, even more so than historically established urban species (e.g., House Sparrows, *Passer domesticus;* Northern Cardinals, *Cardinalis cardinalis*). Our objective was to compare the use of feeders by White-winged Doves and Great-tailed Grackles with other, established native species. We predicted that White-winged Doves and Great-tailed Grackles would use feeders more than the established resident species.

MATERIALS AND METHODS

Study Area.—We conducted our study at 30 locations in central Texas: 15 each in northeastern San Antonio and San Marcos. Live oak (*Quercus fusiformis*) and Ashe juniper (*Juniperus asheii*) woodlands primarily compose the natural vegetation surrounding these two cities, and these two species also comprise a substantial part of the vegetation within these cities. While San Antonio (including the smaller cities of Live Oak, Selma, Universal City, and Converse) is more urbanized than San Marcos, both contain neighborhoods of varying ages, commercial development, and city parks containing old growth and sapling trees, a woody understory, and short grasses. Rivers run through both cities. Every study site chosen had savannah-like habitat common to residential yards and parks and locations inhabited by White-winged Doves and Great-tailed Grackles. We attempted to select sites with vegetative and structural features as similar as possible.

Data Collection.—We located feeding stations in yards at residential homes, parks, or businesses at least 0.5 km apart to limit visitation of the same bird at more than one station within a day. Each feeding station (roughly simulating a commercial bird feeder) consisted of a metal tray (38.8 $\times$ 25.9 cm) filled with 2 cups (454 g) of commercial wild bird-seed mix (including millet, milo, sunflower seeds, and wheat). All trays were located on the ground, allowing access by all avian species (Losito et al. 1990) and reducing complications in defining presence of individual birds at a feeding station (see below). We placed trays near a tree at each site, but outside of the canopy to maximize visibility. We baited feeding stations on the day before observations began to allow birds time to discover the food source. We replenished feeding stations daily before an observation period.

We operated and observed 5 stations each week (1 tray per location), such that during our study of 6 weeks (3 weeks in each city), 6 sets of 5 stations were observed. We alternated baiting sites between San Marcos and San Antonio weekly to prevent habitation by birds to feeders. During each day of a given week, 5 sites (in either San Antonio or San Marcos) were tested for 5 consecutive days. Observation periods lasted for 30 min with the first period starting 30 min after sunrise each morning, followed by the other 4 periods later in the morning allowing for the observer to move between sites. The order for station testing was rotated temporally so no station was observed at the same time twice (e.g., a site observed at 0900 h on day one was observed at 0800 h on day two, and so on) within a given week.

After arriving at a site and feeding station, we allowed 15 min of settle time following placing food in each tray before beginning the 30 min observation period. Observations were made at a sufficient distance to avoid disruption of feeding while still allowing an adequate line of sight (about 4 m). When possible observations were made from a blind (car or house).

We conducted observations from 20 July to 22 August 2009 and from 25 January to 5 March 2010. We used a digital video camera (Sanyo Model Xacti HD, SANYO North America Corporation, San Diego, California) to record the 30-min observation periods and transferred all recordings to DVDs for later analysis. From these recordings we determined the amount of time (sec) each species spent at a feeding station. We defined presence at a feeder as a bird being physically on the feeder or within 1 m. We counted each instance of intraspecific and interspecific displacement during interactions (with displacement defined as an individual's position at a feeder being adversely affected as a result of the behavior or arrival of another individual) and noted the aggressor species and displaced species in each interaction.

Statistical Analysis.—Studies involving presence-absence of animals are generally predisposed to produce data sets containing large numbers of zeros, limiting the possible analysis. Consequently, if a species did not appear at a feeding station during the 5 observation periods, those zeros were designated null measurements and excluded from analyses because we could not determine with certainty whether the species was actually in the area. We included data from all stations where White-winged Doves or Great-tailed Grackles were present at least 1 day of the observation week, thus assuming the species was in the area but intermittently visited the feeding station. A multifactor ANOVA revealed no significant differences ($P > 0.1$) among the 30 locations, time of observation, or day of the week in overall time spent by birds (all species combined) at a feeding station. Therefore, there was no need to include these factors as grouping or blocking variables in subsequent analyses.

We used one-tailed paired *t*-tests to compare the time White-winged Doves spent at a feeding station with time spent by other species. To correct for the possibility of inflated Type I error (due to conducting a substantial number of significance tests), we used a Bonferroni-corrected alpha level when assessing the significance of *t*-tests. For another species to be used for comparison, there had to be at least 10 observation periods with both White-winged Doves and the other species present during an observation week. Preliminary assessments indicated this was a sufficient sample size to ensure normality of the response variable. We then repeated this analysis with Great-tailed Grackles as the focal species. These *t*-tests were performed for both summer and winter data separately. We also calculated percentage of 30 min observation periods that each species was present at a feeding station, so comparisons could be made between paired species, despite different numbers of observation periods where each species was present.

To get a clearer assessment of direct aggressive interaction, a count was taken of every instance an individual displaced another. We defined displacement as an individual moving from its location as a result of the action of another individual. The displacing species and displaced species were recorded. These counts were summed for each season. For each species in each season, the percentage of conspecific interactions was calculated out of total displacer events. For example, if a White-winged Dove exhibited aggressive behavior to another White-winged Dove in 192 out of 237 displacement events, it had a conspecific displacement percentage of 81%. An aggression ratio was also determined for each species in each season. The ratio was calculated by dividing the number of times a species was the displacer of a heterospecific individual by the number of times the species was displaced by a heterospecific individual. Therefore, a ratio > 1 indicated the species had a greater probability of being the aggressor, while a ratio < 1 indicated the species had a greater probability of being displaced.

RESULTS

In summer White-winged Doves spent significantly more time at feeding stations than Inca Doves, *Columbina inca*, ($t_1 = 3.53$, $P < 0.001$), Northern Cardinals ($t_1 = 4.16$, $P < 0.001$), Blue Jays, *Cyanocitta cristata*, ($t_1 = 3.84$, $P <$

0.001), and Brown-headed Cowbirds, *Molothrus ater*, (t_1 = 4.00, P = 0.001) (Table 1). Great-tailed grackles spent significantly more time at feeding stations than Northern Cardinals (t_1 = 2.88, P = 0.004) and Blue Jays (t_1 = 5.15, $P < 0.001$) but not more or less time than any of the other four species (Table 2).

In winter, White-winged Doves did not use feeding stations more often than other species (Table 3). House Sparrows actually used feeding stations significantly more than White-winged Doves (t_1 = -2.96, P = 0.001; Table 3). Great-tailed Grackles' use of feeding stations changed in winter as well, with no remarkable difference in time spent at feeding stations compared to other species. Again, House Sparrows also used feeding stations significantly more than Great-tailed Grackles (t_1 = −5.00, $P < 0.001$; Table 4).

In summer, most White-winged Dove displacement events involved conspecific individuals and the interspecific aggression ratio was < 1 (Table 5). This pattern was reversed in winter; White-winged Doves tended to be the aggressors (aggression ratio > 1) and most displacement events involved heterospecific individuals. In summer and winter, most Great-tailed Grackle displacement events involved conspecifics, but the interspecific aggression was also high (> 2) in both seasons (Table 5). The Great-tailed Grackle was one of the most aggressive species in summer and winter. The Northern Cardinal was the only other species with a similar level of aggression in both seasons (Table 5).

DISCUSSION

As populations of White-winged Doves and Great-tailed Grackles spread northward, the

Table 1. Percent time spent at feeding stations when White-winged Doves and other species were both present at feeding stations in San Marcos and San Antonio, Texas during summer 2009.

	White-winged Dove	Other Species	t_1	P^*	Species Present Most
Great-tailed Grackle	21.3	21.6	−0.05	0.48	No Difference
Mourning Dove	19.3	18.2	0.13	0.45	No Difference
Inca Dove	31.1	6.20	3.53	< 0.01	White-winged Dove
Northern Cardinal	22.4	6.41	4.16	< 0.01	White-winged Dove
Blue Jay	15.3	3.57	3.84	< 0.01	White-winged Dove
House Sparrow	17.9	18.7	−0.18	0.43	No Difference
House Finch	14.8	5.02	1.82	0.048	No Difference
Brown-headed Cowbird	23.9	1.72	4.00	< 0.01	White-winged Dove

* The Bonferroni adjustment was calculated by dividing $\alpha = 0.05$ by 8 comparisons performed, resulting in an adjusted $\alpha = 0.0063$

Table 2. Percent time spent at feeding stations when Great-tailed Grackles and other species were both present at the feeding stations in San Marcos and San Antonio, Texas during summer 2009.

	Great-tailed Grackle	Other Species	t_1	P^*	Species Present Most
Mourning Dove	29.4	13.3	2.25	0.021	No Difference
Inca Dove	7.41	12.1	−0.69	0.25	No Difference
Northern Cardinal	17.5	6.64	2.88	< 0.01	Great-tailed Grackle
Blue Jay	24.5	2.53	5.15	< 0.01	Great-tailed Grackle
House Sparrow	25.4	13.9	2.38	0.011	No Difference
Painted Bunting	21.3	5.24	2.64	0.014	No Difference

* The Bonferroni adjustment was calculated by dividing $\alpha = 0.05$ by 6 comparisons performed, resulting in an adjusted $\alpha = 00.071$.

Table 3. Percent time spent at feeding stations when White-winged Doves and other species were both present at the feeding stations in San Marcos and San Antonio, Texas during winter 2010.

	White-winged Dove	Other Species	t_1	P^*	Species Present Most
Great-tailed Grackle	15.7	10.8	0.97	0.17	No Difference
Mourning Dove	15.5	19.2	−0.51	0.31	No Difference
Inca Dove	18.0	6.9	1.90	0.041	No Difference
Northern Cardinal	15.8	5.9	2.18	0.020	No Difference
House Sparrow	13.0	21.0	−2.96	< 0.01	House Sparrow

* The Bonferroni adjustment was calculated by dividing $\alpha = 0.05$ by 5 comparisons performed, resulting in $\alpha = 0.01$.

Table 4. Percent time spent at feeding stations when Great-tailed Grackles and other species were both present at feeding stations in San Marcos and San Antonio, Texas during winter 2010.

	White-winged Doves	Other Species	t_1	P^*	Species Present Most
Mourning Dove	9.56	14.6	−0.65	0.26	No Difference
Inca Dove	9.65	6.81	0.62	0.27	No Difference
Northern Cardinal	4.76	4.26	0.21	0.42	No Difference
House Sparrow	6.58	20.5	−5.00	< 0.01	House Sparrow

* The Bonferroni adjustment was calculated by dividing $\alpha = 0.05$ by 4 comparisons performed, resulting in $\alpha = 0.0125$.

consistent food supply provided by bird feeders in urban areas may have performed an important function in survival, successful reproduction, and population growth. Even with other species present, White-winged Doves and Great-tailed Grackles typically spent more time at feeding stations than other species. House Sparrows also spent significant amounts of time at feeding stations. This species is one of the most "urban-adapted" of all bird species in North America. All three of these species feed in large flocks, which may allow them to dominate bird feeders; thus, limiting access to bird feeders by other species. However, competitive ability is just one of many factors that determine how well and quickly bird species can adapt to urban environments (Moller 2009).

Table 5. Percentage of conspecific displacements and interspecific aggression ratio calculated for species visiting feeding stations in San Marcos and San Antonio, Texas in summer and winter 2010.

	Sample Size (Displacement events)		Conspecific Displacements (%)		Interspecific Aggression Ratio	
Species	Summer	Winter	Summer	Winter	Summer	Winter
White-winged Dove	237	269	67.9	43.9	0.58	1.53
Great-tailed Grackle	305	141	73.8	62.4	3.48	2.41
Mourning Dove	21	34	23.8	23.5	3.20	0.70
Inca Dove	0	12	0	50.0	0	0.40
Northern Cardinal	58	30	5.17	23.3	2.12	2.56
Blue Jay	14	5	7.14	80.0	0.76	1.00
House Sparrow	37	20	67.6	65.0	0.11	0.04

While the relatively large-bodied Great-tailed Grackle was aggressive in both seasons, aggression of White-winged Doves toward heterospecifics varied by season. The species had a large number of conspecific interactions and a low heterospecific aggression ratio during summer. However, the ratio changed in winter and White-winged Doves became more aggressive. This may relate to an increased need for energy in winter because of larger body size and mass requiring greater nutrition. In previous studies, supplemental feeding has increased winter survivorship of other avian species (Brittingham and Temple 1988, 1992), providing an energy source when natural food abundance and availability has decreased. Non-migratory doves much farther north than the historical distribution must contend with established, native species to secure these limited food resources. Thus, non-migratory doves may be at a disadvantage in interactions for food and compensate with increased aggression. This may also be reflected by White-winged Doves and Great-tailed Grackles spending similar amounts of time at feeding stations as other species, while House Sparrows were present more often, perhaps because they do not migrate (Lowther and Cink 2006).

Our study suggests White-winged Doves and Great-tailed Grackles are capable of using urban food resources, possibly at the expense of other avian species. Only House Sparrows spent a comparable amount of time at feeding stations, and they also are an invasive species with a long history of spreading throughout North America. Further research is required to determine whether range expansions by White-winged Doves, Great-tailed Grackles, and House Sparrows are limiting food resources sufficiently to adversely affect native species.

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PREDATION OF A WHITE-WINGED DOVE NEST BY A FOX SQUIRREL

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Although a number of bird species are adapted to urban and suburban habitats, there is concern avian, mammalian (domestic and wild), and reptilian predators have also adapted to these environments, which may negatively affect nesting birds. Both fox squirrels (*Sciurus niger*) and White-winged Doves (*Zenaida asiatica*) inhabit urban habitats throughout South Texas. Herein, we report the first record of a fox squirrel depredating a White-winged Dove nest. The predation event was observed in Alice, Texas (27.741° N, 98.027° W) on 16 July 2010, while conducting nest surveys as part of a study to document White-winged Dove nestling development in Duval, Jim Wells, Kleberg, Live Oak, Nueces, and San Patricio counties in South Texas. At 0930 h, after we finished checking an active nest using a pole-mounted camera, a fox squirrel was sighted near the live oak tree (*Quercus virginiana*) with the nest. The squirrel climbed the tree and without hesitation went directly to the nest, which contained 2 White-winged Dove eggs. It picked up the first egg and sat on a nearby branch gnawing at the top of the egg. After opening the egg, the squirrel dropped the egg and it fell to the ground. The squirrel then picked up the remaining egg and moved farther away from the nest, gnawed at one end of the egg, and the squirrel then consumed the contents, which included a developing White-winged Dove embryo (Fig. 1). When the squirrel finished eating the contents of the egg, it dropped the shell to the ground and jumped to an adjacent tree where it stretched itself onto a branch.

Figure 1. Predation of a White-winged Dove egg by a fox squirrel. Photo by William Colson.

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While fox squirrels generally consume plant foods such as acorns, hackberries, and various seeds, including flowers and fungi (Reichard 1976, Korschgen 1981, Koprowski 1991), it is not uncommon for fox squirrels to consume insects and small animals (Korschgen 1981, Koprowski 1994). Prey items of fox squirrels have also included avian species including eggs. Small et. al. (2008) reported predation of a Northern Cardinal (*Cardinalis cardinalis*) by a fox squirrel in a dove funnel trap. Furthermore, Borell (1961) noted a fox squirrel attacking a nesting Mourning Dove (*Zenaida macroura*); the observer suggested the eggs were the primary goal of the squirrel.

The present report appears to be the first documented case of predation on White-winged Dove eggs by the fox squirrel. Blankinship (1966) stated that Great-tailed Grackles (*Quiscalus mexicanus*) are the primary predators of White-winged Dove eggs. The predation event described herein may indicate a previously undocumented source of nest predation, which may require further research to understand the interaction and impact of fox squirrels on nesting White-winged Doves and other urban and suburban avian species.

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FEATURE ARTICLES

TEXAS BIRD RECORDS COMMITTEE REPORT FOR 2010

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The Texas Bird Records Committee (hereafter "TBRC" or "committee") of the Texas Ornithological Society requests and reviews documentation on any record of a TBRC Review List species (see TBRC web page at http://texasbirds.org/tbrc/ or Lockwood 2008). Annual reports of the committee's activities have appeared in the Bulletin of the Texas Ornithological Society since 1984. For more information about the Texas Ornithological Society or the TBRC, please visit www.texasbirds.org. The committee reached a final decision on 87 records during 2010: 66 records of 39 species were accepted and 21 records of 18 species were not accepted, an acceptance rate of 75.9% for this report. There were 122 observers who submitted documentation (to the TBRC or to other entities) that was reviewed by the committee during 2010.

In 2010, the TBRC accepted the first state records of Bare-throated Tiger-Heron and Amazon Kingfisher. The A.O.U. Committee on Classification and Nomenclature "split" Whip-poor-will into Eastern Whip-poor-will and Mexican Whip-poor-will (Banks et al. 2010), both of which occur in the state. A species was removed from the state list, Wilson's Storm-Petrel, following a review of the material available to the Committee for the previously accepted lone state record. These actions bring the official Texas State List to 636 species in good standing. This total does not include the four species listed on the Presumptive Species List.

In addition to the review of previously undocumented species, any committee member may request a record of any species be reviewed. The committee requests written descriptions as well as photographs, video, and audio recordings if available. Information concerning a Review List species may be submitted to the committee secretary, Mark Lockwood, 402 E. Harriet Ave., Alpine, Texas 79830 (email: mark.lockwood@tpwd.state.tx.us). Guidelines for preparing rare bird documentation can be found in Dittmann and Lasley (1992) or at http://www.greglasley.net/document.html.

The records in this report are arranged taxonomically following the AOU Check-list of North American Birds (AOU 1998) through the 51st supplement (Banks et al. 2010). A number in parentheses after the species name represents the total number of accepted records in Texas for that species at the end of 2010. Species added to the Review List because of population declines in recent years do not have the total number of accepted records denoted as there are many documented records that are not subject to review (i.e., Brown Jay, Tamaulipas Crow, and Evening Grosbeak). All observers who submitted written documentation or photographs of accepted records are acknowledged by initials. If known, the initials of those who discovered a particular bird are in boldface but only if the discoverer(s) submitted supporting documentation. The TBRC file number of each accepted record will follow the observers' initials. If photographs or video recordings are on file with the TBRC, the Texas Photo Record File (TPRF) (Texas A&M University) number is also given. If an audio recording of the bird is on file with the TBRC, the Texas Bird Sounds Library (TBSL) (Sam Houston State University) number is also given. Specimen records are denoted with an asterisk (*) followed by the institution where the specimen is housed and the catalog number. The information in each account is usually based on the information provided in the original submitted documentation; however, in some cases this information has been supplemented

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Evening Grosbeaks have become an increasingly rare visitor to Texas which has lead to the species being added to the Review List. This male was found in the Chisos Mountains, Brewster County on 12 December 2009. Photograph by Mark W. Lockwood.

with a full range of dates the bird was present if that information was made available to the TBRC later. All locations in italics are counties.

TBRC Membership -- Members of the TBRC during 2010 who participated in decisions listed in this report were: Randy Pinkston, Chair, Keith Arnold, Academician, Mark Lockwood, Secretary, Eric Carpenter, Tim Fennell, Mary Gustafson, Jim Paton, Martin Reid, Willie Sekula, Byron Stone, and Ron Weeks. During 2010, Carpenter's and Sekula's second terms ended and therefore Byron Stone and Jim Paton were elected as voting members. The Secretary and Academician were re-elected.

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Providing a first state and United States record, this female Amazon Kingfisher was in Laredo, Webb County from 24 January-3 February 2010. Photograph by Robert Epstein.

Tingley, **MW -** Matt White, **NN -** Nick Nirschl, **PB -** Peter Barnes, **PF -** Paul Fagala, **PH -** Petra Hockey, **PS -** Paul Sunby, **PW -** Pam Wilson, **PZ -** Phil Zeigler, **RHi -** Ron Hillstrom, **RHo -** Rich Hoyer, **RK -** Rich Kostecke, **RM -** Rob Meade, **RN -** Rick Nirschl, **RO -** Robert Ohmart, **RPi -** Randy Pinkston, **RSn -** Rick Snider, **RSt -** Rex Stanford, **SA -** Stacy Armstrong, **SCo -** Scarlet Colley, **SD -** Stan DeOrsey, **SG –** Steve Glover, **SF -** Sue Foster, **SJ -** Suzanne Johnson, **TB -** Trey Barron, **TD -** Ted Drozdowski, **TeF -** Terry Ferguson, **TFe -** Tim Fennell, **TWi -** Tom Wimberely, **TWo -** Terry Woodward, **WH -** William Hill, **WS -** Willie Sekula, and **WSh -** Winnie Schrum.

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Additional Abbreviations—AOU = American Ornithologists' Union; NP = National Park; NWR = National Wildlife Refuge; SHS = State Historic Site; SNA = State Natural Area; SP = State Park; TBSL = Texas Bird Sounds Library (Sam Houston State University); TCWC = Texas Cooperative Wildlife Collection (Texas A&M University); WMA = Wildlife Management Area.

ACCEPTED RECORDS

Trumpeter Swan (*Cygnus buccinator*) (8). Two adults near Whiteface, *Cochran,* from 15 February-12 March 2010 (KM; 2010-23; TPRF 2803).

Eurasian Wigeon (*Anas penelope*) (53). An adult male at El Paso, *El Paso,* from 3 October 2009-16 February 2010 (**JSp**, JG; 2010-03; TPRF 2790). An adult male at Midlothian, *Ellis,* from 16-21 December 2009 (**TD**, SG, BT; 2009-107; TPRF 2787). An adult male at Thalia, *Foard,* from 16-20 February 2010 (**BSu**, HF; 2010-20; TPRF 2800). An adult male at El Dorado, *Schleicher,* on 27 March 2010 (**SJ**; 2010-27; TPRF 2807).

Masked Duck (*Nomonyx dominicus*) (86). Three from near Riviera, *Kleberg,* on 19 December 2007 (**ES**; 2010-45; TPRF 2819). A male at Santa Ana NWR, *Hidalgo,* on 30 August 2009 (**EC**; 2009-87; TPRF 2774). A male and female at Santa Ana NWR,

This Bare-throated Tiger-Heron at Bentsen State Park, Hidalgo County from 21 December 2009-20 January 2010 was a spectacular find represented the first record for the state and the United States. Photographs by Rick Nirschl.

Hidalgo, from 30 October-15 November 2009 (LT, JoM, LB; 2009-91; TPRF 2777). A male on the King Ranch, *Kenedy,* on 21 April 2010 (**DD**; 2010-34).

Great Shearwater (*Puffinus gravis*) (17). One off South Padre Island, *Cameron,* on 17 July 2010 (**MG**, **CBu**, **BMc**, **TF**, **RPi**, **LB**; 2010-48; TPRF 2821). One off Port Aransas, *Nueces,* on 31 July 2010 (**PS**; 2010-50; TPRF 2822).

Sooty Shearwater (*Puffinus griseus*) (16). One approximately 1 mile off the mouth of the San Bernard River, *Brazoria,* on 27 July 2010 (**TWo**; 2010-54; TPRF 2825).

Leach's Storm-Petrel (*Oceanodroma leucorhoa*) (29). One off South Padre Island, *Cameron,* on 17 July 2010 (**RPi**; 2010-57; TPRF 2826).

Red-billed Tropicbird (*Phaethon aethereus*) (12). One approximately 13 miles east of Port Aransas, *Nueces,* on 22 June 2010 (**JoM**, **CoM**; 2010-43).

Bare-throated Tiger-Heron (*Tigrisoma mexicanum*) (1). One at Bentsen-Rio Grande Valley State Park, *Hidalgo,* from 21 December 2009-20 January 2010 (**RN**, **RSn**, PS, JoM, RSt, BP, RPi, LB, JRa; 2009-106; TPRF 2786). This represents the first record for Texas and the United States.

Northern Goshawk (*Accipiter gentilis*) (24). An adult near Ingram, *Kerr,* on 3 December 2009 (**E&MH**; 2009-98; TPRF 2782). An immature bird at Lake Meredith, *Moore,* on 11 January 2010 (**TB**; 2010-05; TPRF 2792). An adult at Austin, *Travis,* on 26 February 2010 (**JaM**; 2010-29).

Roadside Hawk (*Buteo magnirostris*) (9). An adult at Weslaco, *Hidalgo,* from 24 January-6 February 2010 (**JL**, DD, JD, MS, MG; 2010-10; TPRF 2795). An immature bird at Falcon State Park, *Zapata/Starr,* from 5 February-11 March 2010 (RSt, WS, RO, MG, GO, AWo, CR; 2010-16; TPRF 2796).

Short-tailed Hawk (*Buteo brachyurus*) (37). A dark morph individual at Estero Llano Grande SP, *Hidalgo,* on 12 October 2009 (**MG**; 2009-94). A dark morph individual at Chihuahua Woods Preserve, *Hidalgo,* on 7 August 2010 (**MG**; 2010-51; TPRF 2823).

Northern Jacana (*Jacana spinosa*) (35). An adult at the Calliham unit of Choke Canyon State Park, *McMullen,* from 2 November 2009-16 April 2010 (JoM, LPa, WS, GS, CBu, RK, RPi, BCa, LB, KF, RSt, BN, LS, MK, JaM; 2009-90; TPRF 2776). A near adult plumaged bird at Santa Ana NWR,

Providing the second record for the state, this Northern Wheatear was near Beeville, Bee County from 30 December 2009-29 March 2010. Photograph by Matthew Matthiessen.

Hidalgo, from 4-7 April 2010 (**HH**, CH; 2010-26; TPRF 2806).

Purple Sandpiper (*Calidris maritima*) (21). One at Port Isabel, *Cameron,* from 25 February-10 June 2010 (**SCo**, RPi, WS, AWo, LeZ; 2010-22; TPRF 2802).

Ruff (*Philomachus pugnax*) (33). One at Anahuac NWR, *Chambers,* on 11 April 2010 (**DM**, **RHi**; 2010-38; TPRF 2814). One near Pattison, *Waller,* from 14-25 April 2010 (**MG**, AdW; 2010-37; TPRF 2813).

Red Phalarope (*Phalaropus fulicarius*) (36). One at Austin, *Travis,* from 17-22 October 2009 (**CW**, GL, TFe, RPi, EC, JW, TWi; 2009-86; TPRF 2773). An alternate plumage female at Padre Island National Seashore, *Kenedy,* on 4 June 2010 (**PZ**; 2010-44; TPRF 2818).

Black-legged Kittiwake (*Rissa tridactyla*) (82). A first-winter bird at Port Aransas, *Nueces,* on 3 April 2010 (**MR**; 2010-62; TPRF 2828).

Black-headed Gull (*Chroicocephalus ridibundus*) (27). An adult at Cooper Lake, *Hopkins,* on 7 November 2009 (**MW**; 2009-93; TPRF 2781).

Little Gull (*Hydrocoloeus minutus*) (59). An adult at White Rock Lake, *Dallas,* from 8 December 2009-5 March 2010 (**CR**, LHo; 2009-102; TPRF 2785).

Mew Gull (*Larus canus*) (35). A first-winter individual at McNary Reservoir, *Hudspeth,* on 1 November 2009 (**JPa**; 2009-89; TPRF 2775).

(Vega) Herring Gull (*Larus argentatus vegae*) (2). An adult at Houston, *Harris,* on 29 March 2006 (**MR**; 2010-53; TPRF 2824).

Great Black-backed Gull (*Larus marinus*) (45). A first-year bird at Boca Chica, *Cameron,* from 29 December 2009-6 March 2010 (**JOd**, BN, BMc, DV; 2010-04; TPRF 2791).

White-collared Swift (*Streptoprocne zonaris*) (5). An adult at Port O'Connor, *Calhoun,* on 9 September 2010 (**PH**; 2010-56).

Green Violetear (*Colibri thalassinus*) (68). One near Bowie, *Montague,* from 30 June-7 July 2010 (**BSt**, KH; 2010-46; TPRF 2820).

White-eared Hummingbird (*Hylocharis leucotis*) (32). Up to seven at the Davis Mountains Resort, *Jeff Davis,* from 12 May-17 September 2010 (ML, RPi, KB; 2010-42; TPRF 2817).

Costa's Hummingbird (*Calypte costae*) (31). An immature male at Terlingua, *Brewster,* from 6-13 October 2009 (**MF**; 2009-105). A female

Great Shearwater is a rarity in the western Gulf of Mexico and this individual was seen from the organized pelagic trip out of South Padre Island, Cameron County 17 July 2010. Photograph by Mary Gustafson.

at the Christmas Mountains, *Brewster,* from 29 October 2009-16 February 2010 (**KB**; 2009-99; TPRF 2783).

Amazon Kingfisher (*Chloroceryle amazona*) (1). A female at Laredo, *Webb,* from 24 January-3 February 2010 (**RE**, **AWo**, MH, AdW, TeF, SF, JoM, BP, RPi, BN, JRa, BR; 2010-09; TPRF 2794). This represents the first record for Texas and the United States.

Buff-breasted Flycatcher (*Empidonax fulvifrons*) (25). One at Wolf Den Canyon, Davis Mountains Preserve, *Jeff Davis,* from 16 April-29 May 2010 (**ML**; 2010-30; TPRF 2809). One at Tobe Canyon, Davis Mountains Preserve, *Jeff Davis,* on 11 September 2010 (**RK**; 2010-58; TPRF 2827).

Dusky-capped Flycatcher (*Myiarchus tuberculifer*) (51). Up to eight at No-Name Canyon, Davis Mountains Preserve, *Jeff Davis,* from 7 May-29 July 2010 (**ML**; 2010-35; TPRF 2811). Up to six in Tobe Canyon, Davis Mountains Preserve, *Jeff Davis,* from 8 May-31 July 2010 (**ML**, RPi; 2010-36; TPRF 2812). A pair near Pewee Spring, Davis Mountains Preserve, *Jeff Davis,* on 15 May 2010 (**ML**; 2010-39; TPRF 2815). One along the Limpia Chute Trail, Davis Mountains Preserve, *Jeff Davis,* on 15 May 2009 (**ML**; 2010-40; TPRF 2816). One in Fort Davis, *Jeff Davis,* on 16 May 2010 (**KB**; 2010-41). Dusky-capped Flycatcher was removed from the list of Review Species at the TBRC meeting in August 2010.

Fork-tailed Flycatcher (*Tyrannus savana*) (21). One at High Island, *Galveston,* from 24-25 April 2010 (PF, PB, JRy, AdW, IK, LPr; 2010-32; TPRF 2810).

Rose-throated Becard (*Pachyramphus aglaiae*) (45). A female or immature male at Bentsen-Rio Grande Valley SP, *Hidalgo,* on 30 October 2009 (**LT**; 2009-92; TPRF 2778). An immature male at Estero Llano Grande SP, *Hidalgo,* from 14 November 2009-1 May 2010 (**LoZ**, EB, JBo, PW; 2009-96; TPRF 2780). An immature male at Bentsen-Rio Grande Valley SP, *Hidalgo,* from 15 November 2009-19 February 2010 (**RHo**, MC, RPi, JoM, DS, BN, BSa, DH, EB, AWo; 2009-95; TPRF 2779). An adult male at Mission, *Hidalgo,* on 13 February 2010 (**DD**; 2010-17). A male at Salineno, *Starr,* on 3 April 2010 (**ChB**; 2010-31).

Brown Jay (*Cyanocorax morio*). Up to three at San Ygnacio, *Zapata,* from 22 January-17 April 2010 (MH, RM, MG, RPi, SA, KT, AWo; 2010-08;

This immature Northern Goshawk at Lake Meredith, Moore County on 11 January 2010 was one of very few individuals of this species photographed in Texas. Photograph by Trey Barron.

TPRF 2793). Two at Salineno, *Starr,* on 10 Jun 2010 (**HH**; 2010-49).

Tamaulipas Crow (*Corvus imparatus*). Up to two at Brownsville, *Cameron,* from 26 March-5 May 2010 (**SD**, **BiC**, MG, BZv, LZ; 2010-25; TPRF 2805).

Northern Wheatear (*Oenanthe oenanthe*) (2). One near Olmos, *Bee,* from 30 December 2009-29 March 2010 (MC, CH, RPi, JoM, AdW, BPi, BN, LB, LS, MM, JKa, AWo, BRi; 2010-02; TPRF 2789).

Varied Thrush (*Ixoreus naevius*) (38). A female at Independence Creek Preserve, *Terrell,* on 21 March 2010 (**LW**; 2010-24; TPRF 2804).

Aztec Thrush (*Ridgwayia pinicola*) (6). A male at Bentsen-Rio Grande Valley SP, *Hidalgo,* from 16-17 February 2010 (**D&BS**, NN, MG; 2010-18; TPRF 2798).

Crimson-collared Grosbeak (*Rhodothraupis celaeno*) (21). A female at Bentsen-Rio Grande Valley SP, *Hidalgo,* from 7-12 December 2009 (RSn; 2009-109; TPRF 2788). A male at McAllen, *Hidalgo,* from 3-19 February 2010 (LeH, RSt, MT, BPo, DJ, BiC; 2010-14; TPRF 2797).

Blue Bunting (*Cyanocompsa parellina*) (35). A male and female at Laguna Atascosa NWR, *Cameron,* from 12 February-14 March 2010 (MT, LHo, WSh; 2010-19; TPRF 2799).

Black-vented Oriole (*Icterus wagleri*) (6). An adult at South Padre Island, *Cameron,* from 10-11 April 2010 (**GT**, SCo, BMc, MG; 2010-28; TPRF 2808).

Evening Grosbeak (*Coccothraustes vespertinus*). A male at Boot Spring, Big Bend NP, *Brewster,* on 12 December 2009 (**ML**; 2009-100; TPRF 2784). A female near San Saba, *San Saba,* from 25 February-8 March 2010 (**CBe**; 2010-21; TPRF 2801).

NOT ACCEPTED

A number of factors may contribute to a record being denied acceptance. It is quite uncommon for a record to not be accepted because the bird was obviously misidentified. More commonly, a record is not accepted because the material submitted was incomplete, insufficient, superficial, or just too vague to properly document the reported occurrence while eliminating all other similar species. Also, written documentation or descriptions prepared entirely from memory weeks, months, or years after a sighting are seldom voted on favorably. It is important that the simple act of not accepting a particular record should by no means indicate that the TBRC or any of its members feel the record did not occur as reported. The non-acceptance of any record simply reflects the opinion of the TBRC that the documentation, as submitted, did not meet the rigorous standards appropriate for adding data to the formal historical record. The TBRC makes every effort to be as fair and objective as possible regarding each record. If the committee is unsure about any particular record, it prefers to err on the conservative side and not accept a good record rather than validate a bad one. All records, whether accepted or not, remain on file and can be re-submitted to the committee if additional substantive material is presented.

Yellow-billed Loon (*Gavia adamsii*). One at Canyon Lake, *Comal,* from 19-20 January 2010 (2010-07).

Wilson's Storm-Petrel (*Oceanites oceanicus*). Three off Port Aransas, *Nueces,* on 8 August 1979 (2010-52). The record was previously accepted under documentation included in TPRF 567. This is one of many records that were accepted prior to the current review practices of the TBRC. A current member of the Committee examined the photos and suggested a review of the record was warranted considering the current knowledge of storm-petrel status in the Gulf of Mexico.

Brown Booby (*Sula leucogaster*). Up to 16 at Boca Chica, *Cameron,* from 15-16 January 2010 (2010-06).

Northern Goshawk (*Accipiter gentilis*). One at Port O'Connor, *Calhoun,* from 28 December 2009-8 January 2010 (2010-15).

Roadside Hawk (*Buteo magnirostris*). One at Laredo, *Webb,* from 29-30 January 2010 (2010-13).

Black Noddy (*Anous minutus*). One at High Island, *Galveston,* on 25 April 2010 (2010-61).

Ruddy Ground-Dove (*Columbina talpacoti*). One near Sandia, *Jim Wells,* on 10 December 2009 (2009-101). One at Estero Llano Grande SP, *Hidalgo,* on 17 January 2010 (2010-11).

Northern Saw-whet Owl (*Aegolius acadicus*). One near Tehaha, *Shelby,* on 2 January 2010 (2010-12)

Mangrove Cuckoo (*Coccyzus minor*). One at Port O'Connor, *Calhoun,* on 5 July 2009 (2009-61).

Vaux's Swift (Chaetura vauxi). One at El Paso, *El Paso,* on 16 April 2009 (2009-33). Two at Port O'Connor, *Calhoun,* on 24 September 2009 (2009-85). One at El Paso, *El Paso,* on 10 October 2009 (2009-88).

Costa's Hummingbird (*Calypte costae*). One in El Paso, *El Paso,* from 6-21 October 2010 (2010-59).

Buff-breasted Flycatcher (*Empidonax fulvifrons*). One at the Madera Canyon Nature Trail, Davis Mountains Preserve, *Jeff Davis,* on 29 August 2009 (2009-75).

Rose-throated Becard (*Pachyramphus aglaiae*). One at Santa Ana NWR, *Hidalgo,* on 15 November 2009 (2009-103).

Yellow-green Vireo (*Vireo flavoviridis*). One at Resaca de la Palma SP, *Cameron,* on 15 November 2009 (2009-104).

Gray-crowned Yellowthroat (*Geothlypis poliocephala*). One at Laguna Atascosa NWR, *Cameron,* on 30 December 2009 (2009-109).

Bananaquit (*Coereba flaveola*). One near Waller, *Waller,* on 16 July 2010 (2010-47).

Crimson-collared Grosbeak (*Rhodothraupis celaeno*). One at Texas City, *Galveston,* on 23 April 2010 (2010-33).

Blue Bunting (*Cyanocompsa parellina*). One at Bentsen-Rio Grande Valley SP., *Hidalgo,* on 28 October 2009 (2009-97).

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COLONIAL WATERBIRD SURVEY

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ABSTRACT—Texas Parks and Wildlife Department (TPWD) staff and volunteers conducted ground and air surveys of inland colonial waterbird nest sites at 584 locations in Texas from 1973 through 2004. There was an average of 472,466 nesting pairs sighted per year at all colonies. Cattle Egret (*Bubulcus ibis*), Little Blue Heron (*Egretta caerulea*), Snowy Egret (*Egretta thula*) and Great Egret (Ardea alba) were the most abundant species. The Oaks and Prairie Bird Conservation Region (BCR 21) had the most colonies with 171 and 269,210 nesting pairs. The total for the average densities for each colony from ground surveys from 1981-1990 in eastern Texas was 300,421 breeding pairs compared to 282,925 pairs observed from the air in 2002-2003. These totals were greater than the 164,720 pairs reported in coastal bays by the Texas Colonial Waterbird Society in 2003. Ground surveys in the 1980's documented some of the largest nesting populations of Little Blue Herons in the United States, but aerial surveys from 2002-04 found only 50% of the previously reported birds with few in northern counties. This population either shifted location or declined in northern counties before the aerial surveys. Great Blue Heron (*Ardea herodias*) and Neotropic Cormorant (*Phalacrocorax brasilianus*) occurred in greater numbers inland than elsewhere in Texas. The combined ground and the air surveys over 31 years provided a good characterization of the density and distribution of colonial waterbirds nesting inland in Texas. We recommend future aerial surveys be conducted at least once per decade to continue to monitor the distribution and size of colonies of each species in eastern Texas where the bulk of nesting occurs.

INTRODUCTION

Texas Parks and Wildlife Department (TPWD) personnel have participated in the annual Texas colonial waterbird nesting survey since 1973. This survey is coordinated by the Texas Colonial Waterbird Society (TCWS). The TCWS is a scientific group dedicated to monitoring colonial waterbirds in Texas. It is made up of staff members of TPWD, U.S. Fish & Wildlife Service, The Nature Conservancy of Texas, Texas Audubon Society, Texas General Land Office, Coastal Bend Bays and Estuaries Program, Welder Wildlife Foundation, Texas A&M University, and Caesar Kleberg Research Institute. Participation of conservation groups has varied annually depending on the interest of their staff and available funding. The main emphasis of the TCWS is on coastal surveys of nesting colonial waterbirds and the major contribution of TPWD has been conducting inland surveys and coordinating statewide surveys. This report will describe the participation and results from the TPWD surveys with the TCWS, and volunteer data gathered at inland colonies.

Texas Parks and Wildlife Department's role with TCWS has varied over the decades. From 1973 through 1984 the main contribution of TPWD was to conduct aerial surveys of known colonies near the Coast (<80 km) that TCWS ground/boat crews could not access (Fig. 1). In 1985 TPWD took over the responsibility of data from the annual survey and publication of the annual report. Texas Parks and Wildlife Department Wildlife Division personnel assumed primary responsibility in 1986 for coastal aerial surveys, inland ground

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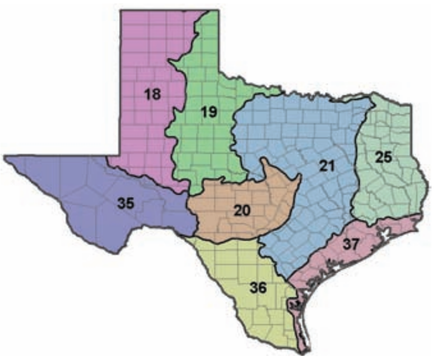

Figure 1. Bird Conservation Region Map of Texas

counts, data compilation, and report preparation through 1992. Afterwards, inland ground surveys were discontinued because of high labor demand and high variability of data between observers (Yantis 1990, Telfair 1993). Data compilation and report summary responsibility were transferred to cooperating agencies in 1993.

METHODS

All Texas colonial waterbird surveys were scheduled for the last week of May through the first week of June. A few were conducted at other times because of logistic issues.

Aerial Surveys.—Traditional annual coastal aerial surveys along the lower reaches of rivers from the Guadalupe to the Sabine were conducted by TPWD as part of the TCWS from 1973 until 1992. After 1992, annual aerial surveys were discontinued in favor of biennial surveys through 2004 primarily as a cost saving measure. These aerial colony surveys covered all known colonies from Victoria south to the San Antonio Bay along the Guadalupe River floodplain, from Green Lake to Freeport within 16 km of the bays, from Freeport to Richmond along the Brazos River floodplain, from Anahuac to Lake Livingston along the Trinity River floodplain, and coastal marshes of Chambers and Jefferson counties. Aerial surveys also covered a few colonies in the bays that were too difficult for boat crews to access. These areas near the coast were selected for surveying because they were the only sites TPWD traditionally received reports of colonies and aerial coverage was within the capability of our team to survey within one calendar day.

Fig. 2. Typical mixed species colonial waterbird site surveyed from airplane.

Texas Parks and Wildlife Department expanded its role in 2002 to conduct aerial surveys over inland colonies formally surveyed by ground crews east of Interstate 35 and as far inland as Dallas and Texarkana. The aerial survey protocol of surveying colonies at 2-year intervals was maintained, but different portions of East Texas were flown on alternate years. Thus, most of the historic inland colonial waterbird sites in eastern Texas were surveyed in 2002 (west side) and 2003 (east side). The west side was surveyed again in 2004, but low budgets did not allow the survey of the east side in 2005. This expanded aerial coverage required 3-flight days each year.

Aerial surveys were generally conducted with a high-winged single-engine Cessna aircraft with a pilot and two observers. Aerial surveys entailed flying from one previously recorded colony site to another by flying predominantly over wetlands. When flying between colony sites, we continually looked for new colonies by searching suitable habitat in our flight path or observing characteristic flight lines of birds leaving or returning from colonies. Keller et al. (1984) estimated the effective census strip width during aerial surveys for wading bird colonies was at least 1 km on either side of the airplane and this approximated our ability to detect colonies along the flight path of the survey.

Depending on colony size and number and diversity of birds present, 1 to 5 passes were typically made over each colony. One observer counted each species of white birds and one observer counted each species of non-white birds. Each adult observed was considered one nesting pair, which for most species closely approximated the number of nesting pairs (Erwin 1980). Multiple passes 100 m outside of the periphery of the colony were made to estimate population size from an altitude of approximately 100 m at a flight speed of about 80 knots. If observers needed to more accurately determine the total number of birds and ratio of each species within the colony, additional passes were made at an altitude of approximately 50 m along the edge of the colony. We attempted to not flush birds during these passes.

Data from aerial surveys of nesting adult pairs provided estimates of the number of nesting pairs. Nests containing young and empty nests of Great Blue Heron (*Ardea herodias*) and Neotropic Cormorant (*Phalacrocorax brasilianus*), which typically finished nesting before the survey, were counted to help make an estimate of nesting pairs. We considered our nesting estimates as conservative since species do not all peak at the same time each season and we likely missed some nesting activity (Ortego 1976, Portnoy 1977).

Ground Surveys.—Inland ground survey methodologies were quite variable and were adapted to the conditions at the colony. Over 100 staff and volunteers conducted these surveys. Inland colony sites varied from a few nests in a large tree (Great Blue Heron) at isolated sites to a large number of nests on woody vegetation in wetlands, or a large number of nests in dense woodlands in suburbs. Water depth and safety concerns at many sites did not always allow entry into colonies in wetlands. Thus, all nests were counted from convenient vantage points where possible. In situations where nests were not visible, each adult identified was considered to be one nesting pair. However, large colonies required sampling because all nests/adults were not visible in the diverse woody vegetation found at these large sites (Fig. 2). Numbers from samples were extrapolated to derive a total estimate. The preferred method of sampling was for the observer to select one or more representative portions of the colony and count all nests or adults for each species within the sampled area. The sample area was then measured by pacing. The size of the colony was determined by measuring it on aerial photographs or topo maps. The sample was then extrapolated at the appropriate multiplier to arrive at an estimate of total pairs by species.

Averaging data.—The average for each colony was determined by dividing the total nesting pairs surveyed by species and dividing it by the number of years surveyed. For species in which only occupation was known, this data was only used for history of the colony, but not the average. Data were sorted by county and Bird Conservation Region (Fig. 3).

Bay Island Surveys.—Texas Colonial Waterbird Society members surveyed virtually all nesting colonies in the bays annually. Most of these occurred on islands. Small colonies were generally surveyed from convenient vantage points on boats and a total count was attempted by using multiple positions of the boat. Larger colonies were typically surveyed on foot and similar to the small islands multiple vantage points were used to try to count all birds while creating minimal disturbance to nesters.

Figure 3. Dense nesting of multiple species at an inland forested wetland site in Texas.

Conducting transects or sample plots which have been commonly used on inland colonies were typically avoided because nesting birds on coastal islands were much more visible and observers wanted to minimize disturbance (Fig 4).

RESULTS

Texas Parks and Wildlife Department staff and volunteers surveyed 584 colonial waterbird nesting colonies from 1973 through 2004 at inland sites. The average for all colonies was 472,466 nesting pairs (Table 1). This nearly doubled the number of colonies and the estimate of nesting pairs of the original Texas survey from 1973-1980 (TCWS 1982). This is even more impressive when you consider the earlier survey included 130 colonies in bays and estuaries, which were mostly not covered by this summary.

Cattle Egret (*Bubulcus ibis*), Little Blue Heron (*Egretta caerulea*), Snowy Egret (*Egretta thula*) and Great Egret (*Ardea alba*) were the most abundant species during our study. The most common nester was the Great Blue Heron, which was found at 282 sites and was followed by the Cattle Egret at 212 sites, Little Blue Heron 163 sites, Great Egret 159 sites and Snowy Egret 135 sites. Inactive colony sites were somewhat common over the years. Many inactive sites resulted from the transitory nature of Great Blue Heron colonies and some wetland shrub communities being seasonally dry and exposed to mammalian predators.

The Oaks and Prairies BCR had the most colonies (171) and total nesting pairs (269,010). Colony density generally followed the rainfall gradient with fewer colonies to the west (TCWS 1982). However, density was greatest in wetlands in non-forested settings. Thus, the heavily forested West Gulf Coastal Plain BCR (#25 in Fig. 3) of East Texas had less suitable habitat for colonial waterbird nesters than the adjoining Oaks and Prairie BCR even though it had greater average annual rainfall and a greater surface area of lakes.

Hunt County had the largest number of nesting birds for a county with 39,086 largely due to high numbers of one species, Cattle Egret. This species represented 80% of the nesting birds. Species other

Figure 4. Diverse array of species are more visible at colonies on Texas bay islands because of the lower height of vegetation.

than Cattle Egret totaled 95,475 nesting pairs. The Gulf Coastal Prairie BCR (#37 in Fig. 3) had the most pairs with 43,211 followed by the Oaks and Prairies BCR with 31,129. Henderson County had the largest number for a county with 10,329 pairs. This was largely due to large numbers of Little Blue Herons and Snowy Egrets. Liberty County had the second most birds with 9,322 pairs with a good mixture of long legged waders. Jefferson County was third with 6,013 pairs of a diverse mix of species in the coastal marshes.

Density per season varied within colonies and river basins. Many variables contribute to density (McNicholl 1975, Erwin et al. 1981), but the most obvious one was water depth at colonies. Waterbirds in most inland colonies situate nests onto bushes or trees over water to avoid predation from mammals; whereas, most nests in coastal colonies were on the ground on islands. Islands with nests in the bays are usually too far from the mainland and too small to support mammal predators, and birds can safely nest on the ground. Whenever inland colonies did not have water under the nest sites, the birds generally did not build nests. Exceptions to this were upland egret colonies near suburbs (Parkes 2007).

During 6 years of aerial surveys near the coast from 1994 – 2004 (Table 2), we tracked the presence of water at nest colony sites in swamp settings. Years in which water occurred under $<50\%$ of nest trees were rated as dry years, and wet years had water under all nest sites. We located an average of 25 active colonies during wet years and 17 during dry years. This resulted in 70,233 nesting pairs during wet years and 34,887 nesting pairs in dry years. Sizeable dry year numbers of nesting birds were maintained by 8 colonies situated on reservoirs and lakes in the Brazos River watershed. These colony sites always had water under nest sites.

Population Trends. Surveys throughout the study were too sporadic to make many comparisons. Most inland colonies were only surveyed 4 of 10 years during the 1980s. The inland surveys on ground and by air covered a much larger area and indicated a much more dispersed breeding density with an unknown reliability of the percent of actual colonies present. We believe we surveyed the

Table 1. Average number of nesting pairs per colony visit by county, Bird Conservation Region (BCR), and total colonial waterbirds observed in Texas from 1973 through 2004. Gulls and Terns are not included in species totals..

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
Anderson	21	8	22,040		62	52	71	197	890	2,247			18,120			400	1	
Angelina	25	12	4,676		76	2	108	151	100	4			4,135			100		
Aransas	37	2	299															
Archer	21	3	56				56											
Armstrong	18	1	35											35				
Atascosa	21	1	225					75					150					
Atascosa	36	1	225					75					150					
Bandera	20	5	0															
Bastrop	21	1	7,573					8	5	60			7,500					
Baylor	19	8	691				86			130	1		465	7		2		
Bee	36	2	470		15								455					
Bell	21	2	373						8	15			350					
Bexar	36	5	2,074		28	4	3	55	33	24	2		1,842		83			
Blanco	20	1	0															
Bowie	25	3	711				14	1	1	5			690					
Brazoria	37	13	15,140		10	53	48	267	213	390	9		13,811	2	2	289		46
Brazos	21	4	8,070				10		20	40			8,000					
Brown	21	2	0															
Burleson	21	2	0															
Burnet	20	2	23				23											
Caldwell	21	1	401							1			400					
Calhoun	37	6	6,897		136	28	174	477	728	226	17		4,610	4	1	71	32	279
Callahan	21	2	14				14											
Camp	25	2	80				50	30										

Table 1. *(continued)*.

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
Cass	25	3	2,105			4	36	23	2	40			2,000					
Chambers	37	12	8,035		169	83	174	488	756	965	20		4,042	14		915	69	244
Cherokee	25	1	0															
Childress	19	1	8															
Clay	21	4	202		17		184	1										
Coke	21	1	0															
Coleman	19	6	16				23											
Collin	21	2	1,156	1	53	3	103	154	30	50			763					
Colorado	21	2	4,021		8	2		40	223	108			3,610	13				17
Comal	20	1	0															
Comanche	21	2	16				16											
Concho	19	5	4				4											
Dallas	21	10	8,786			1		647	225	2,064	1		5,821	21	1	4	1	
Deaf Smith	18	3	57				7							50				
Delta	21	3	118				68										43	
Denton	21	1	1,400					100	100	200			1,000					
Donley	19	3	9				5						3					
Eastland	21	2	15				15											
El Paso	35	2	140		10				30				100					
Ellis	21	3	21,598			1		86	89	4,572			16,826	15	8		1	
Erath	21	1	40				40											
Fannin	21	3	4,736				10	101		475			4,150					
Fayette	21	1	0															
Fort Bend	37	8	12,124		21	32	3	923	303	501	1		9,264	3		973	36	64

Table 1. *(continued)*.

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
Franklin	25	2	63		13		50											
Freestone	21	1	0															
Galveston	37	1	25															
Goliad	37	2	900			13	5	5	1	131			740					5
Gregg	25	4	7,129			98	39	79	51	310			6,548		1	3		
Grimes	21	2	323			5	1	3	8	5			300				1	
Hall	19	1	1															
Hamilton	21	1	0															
Hansford	18	2	34										10	22			2	
Hardeman	19	1	2															
Hardin	25	1	0															
Harris	37	10	6,827		178	22	60	476	650	224	22		4,597		34	167		50
Harrison	25	5	3,361				16	11		667			2,667					
Hartley	18	1	2				2											
Hemphill	19	7	131				124											
Henderson	21	18	32,975		265	34	33	967	2,592	6,393	29		22,646	15		1		
Hidalgo	36	1	49					5	26	3	5		10					
Hill	21	2	649				50		10	22			567					
Hood	21	1	13				13											
Hopkins	21	1	2,543				10			200			2,333					
Houston	25	1	61				1			15			45					
Hudspeth	35	3	?		x				x				x	x				
Hunt	21	6	39,086				105	8	1	3,777			35,195					
Irion	19	10	32				32											

Table 1. *(continued).*

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
Jack	21	4	51				51											
Jackson	37	2	3,580			10	1	20	11	196	1		3,341					
Jasper	25	7	3,602			20	21	2	19	560	18		2,950			12		
Jefferson	37	8	9,036		1,599	21	15	1,209	499	360	237	2	3,023	64		1,633		355
Johnson	21	2	28				28											
Kinney	36	1	0															
Kleberg	36	3	600		100												500	
Lamar	21	1	277				25			252								
Lamb	18	1	50										40	10				
Lampassas	20	1	6				6											
Lee	21	2	?															
Leon	21	2	3,680					50	30	100			3,500					
Liberty	37	30	23,009		152	130	171	1,430	1,156	2,621	47		13,687	10	12	3,466	22	105
Limestone	21	7	18,056		6		27	110	30	400			17,483					
Lipscomb	19	1	11				11											
Live Oak	21	1	3,750		200			50					3,500					
Liveoak	36	4	4,856		120			1,034	1				3,700					1
Llano	20	8	47				47											
Lubbock	18	1	120										100	20				
Madison	21	2	5,000										5,000					
Marion	25	5	416			23	120	273										
Mason	20	1	0															
Matagorda	37	13	13,938		129	10	65	616	2,020	815	109	1	8,237	17	23	287	29	219
McLennan	21	5	18,057					30	496	1,522			16,009					

Table 1. *(continued).*

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
McMullen	36	5	1,832		840	104		535	10	1	1		340					1
Milam	21	2	12,555					30	25	250			12,250					
Mills	21	1	0															
Montague	21	2	26				26											
Montgomery	25	6	904			12	25	11		31			825					
Moore	18	1	46										1	45				
Morris	25	3	20				2	18										
Nacogdoches	25	5	155			3			1	1			150					
Navarro	21	6	3,249				34						3,215					
Newton	25	8	1,257			11	58	367	22	97			615			7		80
Nolan	19	1	33				33											
Ochiltree	18	1	3				3											
Orange	37	5	8,434		249	14	1	845	4,123	83	604		2,040	140		82	41	198
Palo Pinto	21	9	158				158											
Panola	25	5	45				45											
Parker	21	2	22,797				17	205	175	3,100			19,300					
Parmer	18	2	44										14	30				
Polk	25	5	2,963			29	96	361	205	244			1,788	1	5	233		1
Potter	18	4	104				11							93				
Rains	21	1	200				200											
Randall	18	1	49				1		1				13	31		3		
Red River	25	1	0															
Refugio	37	4	306		10		8	61	10	3			213					1
Roberts	19	2	8				4											

Table 1. *(continued)*.

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
Robertson	21	2	2,500										2,500					
Rockwall	21	1	82		44		38											
Runnels	19	1	1				1											
Rusk	25	5	7,090			13	10			400			6,667					
Sabine	25	10	799		430	21	110	100					138					
San Augustine	25	4	1,504			8	6	3	7	28	2		1,450					
San Jacinto	25	4	10							10								
San Patricio	36	1	0															
San Saba	20	1	8				8											
Shackelford	21	3	57				57											
Shelby	25	7	484		150	27	146	161										
Sherman	18	1	10											10				
Smith	25	1	11				11											
Stephens	21	1	8				8											
Sterling	19	2	3				3											
Tarrant	21	5	3,819				26	127	6	667			2,990	3				
Throckmorton	21	2	12				12											
Tom Green	19	11	581				26	5	25	25			500					
Travis	21	4	10,216				45	15	6	150			10,000					
Trinity	25	12	2,686		175	11	81	470	10	46			1,883			8		2
Tyler	25	2	509					3		3			500		3			
Upshur	25	3	0															
Uvlade	36	1	0															
Val Verde	35	6	42				11											

Table 1. *(continued)*.

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
VanZandt	21	1	5			1	4											
Victoria	37	10	16,113		162	54	80	121	167	769	25		14,098	7	68	421		138
Walker	25	4	79				78	1										
Waller	37	2	3,426						15	125			3,175	9			100	2
Webb	36	1	39		7		2	3					12		3			
Wheeler	19	6	61				45							16				
Wichita	19	2	416				12	2	2	200			200					
Wilbarger	19	1	2				2											
Williamson	21	3	7,893					2	185	293			7,413					
Wise	21	2	0															
Wood	25	5	21,566		90	75	275	190	9	711			20,216					
Young	21	3	54				53	1										
Zapata	36	12	157															
Summary by BCR																		
Shortgrass Prairie BCR 18		8	554	0	0	0	24	0	1	0	0	0	178	346	0	3	2	0
Central Mixed-grass Prairie BCR 19		69	2,010	0	0	0	411	7	27	355	1	0	1,168	23	0	2	0	0
Edwards Plateau BCR 20		20	84	0	0	0	84	0	0	0	0	0	0	0	0	0	0	0

Table 1. *(continued)*.

County	BCR	Colonies	TOTAL	DCCO*	NECO	ANHI	GBHE	GREG	SNEG	LBHE	TRHE	REDE	CAEG	BCNH	YCNH	WHIB	WFIB	ROSP
Oaks and Prairies BCR 21		171	26,9010	1	655	99	1,608	3,007	5,154	26,963	30	0	230,891	67	60	405	47	17
West Gulf Coastal Plain BCR 25		136	62,286	0	934	357	1,398	2,255	427	3,172	20	0	53,267	1	9	363	0	83
Chihuahuan Desert BCR 35		11	182	0	10	0	11	0	30	0	0	0	100	0	0	0	0	0
Tamaulipan Brushlands BCR 36		43	10,251	0	1,110	108	5	1,707	70	28	8	0	6,509	0	35	0	500	2
Gulf Coastal Prairie BCR 37		126	128,089	2	2,815	470	805	6,938	10,652	7,409	1,092	3	84,878	270	140	8,304	329	1,706
TEXAS		584	472,466	3	5,524	1,034	4,346	13,914	16,361	37,927	1,151	3	376,991	707	244	9,077	878	1,808

* DCCO = Double-crested Cormorant (*Phalacrocorax auritus*), NECO = Neotropic Cormorant, ANHI = Anhinga, GBHE = Great Blue Heron, SNEG = Snowy Egret, LBHE = Little Blue Heron, TRHE = Tricolored Heron (*Egretta tricolor*), REDE = Reddish Egret (*Egretta rufescens*), CAEG = Cattle Egret, BCNH = Black-crowned Night-Heron (*Nycticorax nycticorax*), YCNH = Yellow-crowned Night Heron (*Nyctanassa violacea*), WHIB = White Ibis, WFIB = White-faced Ibis, ROSP = Roseate Spoonbill; 0 = no active nest present; X = species present; ? = unknown quantity
CAEG = Cattle Egret, BCNH = Black-crowned Night-Heron (*Nycticorax nycticorax*), YCNH = Yellow-crowned Night Heron (*Nyctanassa violacea*), WHIB = White Ibis, WFIB = White-faced Ibis, ROSP = Roseate Spoonbill.

Table 2. Number of colonial waterbird breeding pairs observed by species, by year and number of active colonies during wet and dry years during aerial surveys near the Texas Coast.

	wet	dry	wet	dry	wet	wet
Year	1994	1996	1998	2000	2002	2004
ACTIVE COLONIES	20	15	23	19	28	27
Neotropic Cormorant	225	284	3,410	290	954	873
Anhinga	398	46	107	28	94	203
Great Blue Heron	114	40	1,211	343	782	165
Great Egret	4,240	1,335	8,315	1,943	2,810	3,092
Snowy Egret	8,173	4,780	8,865	1,900	4,735	12,815
Little Blue Heron	12,355	2,900	4,075	834	5,855	6,106
Tricolored Heron	750	130	268	35	99	95
Reddish Egret	4	0	0	0	0	0
Cattle Egret	27,358	17,095	29,205	31,340	44,500	53,830
Black-crowned Night-Heron	0	0	45	0	4	70
Yellow-crowned Night-Heron	0	0	23	0	6	3
White Ibis	13,280	316	6,325	810	976	4,100
White-faced Ibis	0	2	0	0		0
Roseate Spoonbill	1,350	1,173	2,660	189	1,179	1,316
Laughing Gull	2,450	3,775	0	0	25	0
Least Tern					6	0
Forster's Tern					153	70
Black Skimmer	0	0	105	150	275	250
TOTAL	70,777	31,876	64,614	37,897	62,453	82,988

vast majority of colonies over wetlands in eastern Texas because most of our surveys occurred over floodplains, but we do not have an estimate of the number of unfound inland upland colonies.

Because of the large area we could cover and the greater visibility obtained from aircraft, we thought more colonies and nesting birds could be found by aerial surveys than previously reported on the ground. However, when you look at the different methodologies and time interval between surveys, there was not a remarkable difference in total numbers. The average density for all colonies from 1981-1990 was 300,421 breeding pairs versus 282,925 pairs observed from the air in 2002-2003 and 164,720 pairs on bay islands in 2003 (Table 3).

We observed twice as many Neotropic Cormorants during the inland aerial survey versus inland ground counts and on bay islands. These higher counts over inland ground survey were expected since most cormorants were dispersed nesters on snags on major reservoirs. These sites were difficult to access from the ground. We did not know at the time of the survey of the larger numbers of this species nesting inland because previous reports (Telfair and Morrison 1995) indicated this species was primarily a tidal marsh nesting species. The 3551 estimated breeding pairs in 2003 was similar to the 4334 reported in 1990 (Telfair and Morrison 1995). However, we showed 80% nested inland in 2003; whereas, Telfair and Morrison (1995) indicated 87% nested on the coast. We don't think this was a shift in nesting birds between the years because most birds from our survey were from locations that were not previously surveyed.

Ground crews reported twice as many Anhingas (*Anhinga anhinga*) during the 1980s than the aerial survey. These differences might be attributed to methodology with many Anhingas nesting within tree crowns rather than on top and not being visible from an airplane (Frederick and Siegel-Causey 2000). Low numbers within the bays were expected because this species prefers freshwater sites.

The most important areas for nesting Great Blue Herons are inland wetlands and reservoirs. The

Table 3. Comparison of averaged ground surveys for nesting colonial waterbirds from 1981-1990 to aerial surveys from 2002-2003 in eastern Texas, and to ground/boat surveys in Texas bays.

Year	INLAND 1981-1990	2002-2003	COASTAL 2003
Species	Ground	Airplane	Ground
Neotropic Cormorant	949	2,907	644
Anhinga	2,075	1,183	78
Great Blue Heron	1,381	7,219	1,185
Great Egret	6,709	10,411	3,824
Snowy Egret	6,250	8,557	4,162
Little Blue Heron	21,278	9,191	1,027
Reddish Egret	0	0	1,276
Tricolored Heron	416	234	5,147
Cattle Egret	255,637	238,206	10,381
Black-crowned Night Heron	149	102	699
Yellow-crowned Night Heron	38	28	3
White Ibis	5,037	3,752	18,470
White-faced Ibis	19	0	620
Roseate Spoonbill	483	1,135	2,454
Laughing Gull	0	25	83,701
Gull-billed Tern	0	0	1,292
Forster's Tern	0	113	1,102
Caspian Tern	0	0	1,341
Royal Tern (*Sterna maxima*)	0	65	22,342
Sandwich Tern (*Sterna sandvicensis*)	0	0	288
Least Tern	319	22	769
Black Skimmer	0	535	4,203
TOTAL	300,740	283,685	165,008

aerial survey reported 7,219 nesting pairs that were mostly located on snags dispersed over East Texas reservoirs. This was 5 times greater than what was found on inland ground and bay surveys.

Great Egrets and Snowy Egrets were twice as abundant inland than in the bays with aerial surveys reporting at least 30% more than ground surveys.

Average densities of Little Blue Herons were twice as high on inland ground counts during the 1980s than on aerial surveys. Bay surveys only found 10% of the state estimate during 2003. This species used to be abundant in counties near Dallas during the 1980's, but these populations have disappeared as area reservoirs have aged and the vicinity urbanized. There has been an increase in Little Blue Herons in the lower reaches of coastal rivers following this decline, but this increase is lower than former populations further north. Telfair (1993) showed Little Blue Heron populations declined at a rate of 3% per year from 1972-1990 using TCWS data. However, Texas breeding bird surveys from roads show Little Blue Heron populations are stable (Breeding Bird Survey Lab 2011).

As expected, almost all Tricolored Herons (*Egretta tricolor*) and Reddish Egrets (*Egretta rufescens*) were found nesting on bay islands.

Both inland ground and aerial surveys showed there were about 250,000 breeding pairs of Cattle Egrets. Bay colonies only support about 4% of this population. Even though the numbers between the 1980s and 2002-03 appear very similar, we were surprised to observe large expanses of pasture land in some counties without any Cattle Egrets.

This was particular evident in Ellis County which averaged 16,000 pairs during the 1980's and no presence during the aerial survey. Cattle Egrets nested on upland sites in this county until humans started removing upland colonies from near residences where they were creating disturbance and health issues (Telfair et al. 2000).

No survey methods estimate night-heron (*Nycticorax/Nyctanassa*) populations very well in Texas. These species tend to nest under shrubbery or tree canopies, only forage at night and are only exposed at colonies when flushed. Most surveyors in Texas try to avoid disturbing nesting birds, and thus, counts greatly underestimate populations of these species.

Ibises nest on bay islands in much greater density than elsewhere in Texas. Ground and aerial surveys had similar numbers but were only 1/3 of the numbers nesting on the bays. White Ibises (*Eudocimus albus*) primarily forage in brackish water habitats and nests in close proximity (TCWS 1982). In contrast, White-faced Ibises (*Plegadis chihi*) are primarily freshwater feeders and are frequently associated with rice fields. They are extremely difficult to survey since this species frequently nests by itself in tall marsh vegetation and are not visible to ground and aerial surveyors. Few were found during our survey.

The Roseate Spoonbill (*Platalea ajaja*) is a very colorful marsh bird that once was nearly extirpated from Texas (Allen 1942). There were twice as many on bay islands than inland colonies, and aerial surveys reported twice as many as inland ground surveys.

Gulls, terns and skimmers (*Laridae*) are species of the bays. These species are only marginally surveyed inland, except for the Least Tern (*Sterna antillarum*) which nests throughout Texas in small numbers.

DISCUSSION

The intent for the initiation of inland surveys was to compliment annual monitoring on the Gulf Coast to monitor population trends. After 17 years and considerable effort conducting ground surveys, TPWD (Yantis 1990) tested the variability of surveyors at the same colonies and determined there was a tremendous amount of variation in population estimates between observers at inland sites. This type of variation was typical for monitoring colonial waterbirds in very dense vegetation in wetlands (Portnoy 1977, Erwin 1980, 1985, 1990, Yantis 1990). It was decided in 1992 that conducting these inland surveys on an annual basis was not warranted when considering the natural variation which occurs between wet and dry cycles along with observer bias.

Even though there is a tremendous amount of variation among ground surveyors, these surveys did provide some useful information on the distribution of colonies and their relative sizes. Data for aerial flights 10 years later showed similarity in population estimates between aerial and ground surveys. Ground surveys of 1980s documented some of the largest nesting populations of Little Blue Herons in the United States (Ogden 1978). These populations either shifted their location or declined in northern counties before the flights of 2002-04. We gained a broader perspective on the magnitude of dispersed nesting on snags on major reservoirs where Great Blue Herons and Neotropic Cormorants occurred in numbers greater than elsewhere in Texas. The combined ground and air surveys over 31 years give a good characterization of the density and distribution of colonial waterbirds nesting in Texas. We recommend that aerial surveys be conducted in the future at least once per decade to continue to monitor the distribution and size of colonies of each species in eastern Texas where the bulk of nesting occurs.

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BIRD LIFE ON A 38-HECTARE PLOT IN BRAZOS COUNTY WITH COMPARISON TO PUBLICATIONS ON BIRD LIFE IN THE COUNTY

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ABSTRACT.—Over a one-year period, I conducted weekly avian surveys on a 38-ha plot in southern Brazos County. The land was typical of the rural and suburban post oak savannah of the area. The survey resulted in 84 species in six different categories. Results were compared to Davis (1940) resulting in 9 changes in status and 11 additions.

INTRODUCTION

Brazos County is in central Texas in the Post Oak Savannah ecoregion (Lockwood and Freeman 2004: xxvi). The earliest paper on bird life in Brazos County was Davis (1940). After this came Petrides and Davis (1951) and an unpublished 1954 checklist (Brazos Ornithological Society). In 1966 the Brazos Ornithological Society (B.O.S.) produced a checklist. Arnold (1973) compared species to Davis (1940). Since then the B.O.S (1977), the Rio Brazos Audubon Society (1985), the Center for Bioacoustics (Texas A&M University, 1995) and Bert Frenz (1998) have produced checklists. Because of rapid development and changes in habitat in Brazos County, I conducted this survey to compare my findings to previous studies and to note changes in the bird fauna. I also wanted to document permanent residents, summer residents, winter residents, and migrants, as well as annual abundance.

METHODS AND AREA DESCRIPTION

I conducted weekly surveys south of College Station from 21 January 2010 to 23 December 2010. The 38-ha tract (30° 32' 7" N, 96°18' 6" W) was approximately 520 m at its longest point and 200 m wide at its widest point (Fig. 1). I started at sunrise and finished in 30 to 50 min. I had a total of 47 count days. On each survey I walked the perimeter of the property, switching the side each week to balance out the time at different areas of the property. I counted birds using Nikon 8x40 binoculars.

Figure 1. Source: Google Earth. Satellite photo of the survey area in Brazos County, Texas. Darker trees are Ashe juniper. Lighter trees are post oaks. An apartment complex is in the upper right corner.

Goats periodically grazed different portions of the survey area for approximately two-week periods. The area was an open field with scattered trees including post oak (*Quercus stellata*) and Ashe juniper (*Juniperus ashei*), with an open grassy area, primarily bluestem (*Andropogon* spp.) and Bermuda grass (*Cynodon dactylon*), in the back, and yaupon (*Ilex vomitoria*), dewberry (*Rubus trivialis*), saw greenbriar (*Smilax bona-nox*), Virginia creeper (*Parthenocissus quinquefolia*) and poison ivy (*Toxicodendron radicans*) throughout the tract. Just across side fence lines were wooded areas and ponds. Overall, the area was typical of Brazos County post oak savannah habitat.

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RESULTS

Eighty-four species of birds were documented including 27 permanent, 10 summer residents, 25 winter residents, 12 migrants, and 10 flyovers (birds seen only flying over the property due to lack of habitat on the property.) Table 1 gives the results from the survey.

DISCUSSION

Several species known to be in the area were missed due to the time of day for conducting surveys I conducted the survey. Also, several species known to breed and migrate through the county were missed due to lack of proper habitat on the property, and also because I only saw what was on the property during

Table No. 1. List of bird species and occurrence in Brazos County, Texas in 2010.

	Days	Date seen		No. Per day		Total	Average
Species*	Seen	First	Last	Min.	Max.	Seen	per day
Snow Goose (*Chen caerulescens*)	1	2/23	-	100	100	100	-
Black-bellied Whistling Duck (*Dendrocygna autumnalis*)	1	5/20	-	1	1	1	-
Double-crested Cormorant (*Phalacrocoraz auritus*)	2	2/28	3/25	1	2	3	1.50
Great Blue Heron (*Ardea herodias*)	4	4/1	10/21	1	1	4	1.00
Little Blue Heron (*Egretta caerulea*)	1	7/8	-	1	1	1	-
Great Egret (*Ardea alba*)	2	4/22	5/6	1	1	2	1.00
Cattle Egret (*Bubulcus ibis*)	4	4/22	5/13	3	20	41	10.3
Turkey Vulture (*Cathartes aura*)	6	2/3	12/16	1	2	8	1.33
Black Vulture (*Coragyps atratus*)	2	6/3	12/16	1	1	3	1.50
Mississippi Kite (*Ictinia mississippiensis*)	3	7/22	8/13	1	2	4	1.33
Sharp-shinned Hawk (*Accipiter striatus*)	3	9/30	10/21	1	1	3	1.00
Cooper's Hawk (*Accipiter cooperii*)	2	10/14	11/11	1	1	2	1.00
Red-shouldered Hawk (*Buteo lineatus*)	6	2/9	12/16	1	2	7	1.17
Red-tailed Hawk (Buteo jamaicensis)	27	2/3	12/23	1	3	33	1.22
American Kestrel (*Falco sparverius*)	1	2/23	-	1	1	1	-
Killdeer (*Charadrius vociferous*)	21	3/3	12/16	1	12	49	2.33
Eurasian Collared-Dove (*Streptopelia decaocto*)	2	12/2	12/16	1	1	2	1.00
White-winged Dove (*Zenaida asiatica*)	15	2/9	12/16	1	15	62	4.13
Mourning Dove (*Zenaida macroura*)	43	1/21	12/16	1	15	131	3.05
Inca Dove (*Columbina inca*)	1	7/22	-	2	2	2	-
Yellow-billed Cuckoo (*Coccyzus americanus*)	11	5/6	8/20	1	3	20	1.82

Table 1. *(continued)*.

	Days	Date seen		No. Per day		Total	Average
	Seen	First	Last	Min.	Max.	seen	per day
Great Horned Owl (*Bulbo virginianus*)	3	6/3	10/7	1	1	3	1.00
Ruby-throated Hummingbird (*Archilochus colubris*)	5	6/3	9/30	1	1	5	1.00
Rufous Hummingbird (*Selasphorus rufus*)	2	9/23	9/30	1	1	2	1.00
Chimney Swift (*Chaetura pelagica*)	5	5/20	9/9	1	1	5	1.00
Belted Kingfisher (*Megaceryle alcyon*)	1	12/2	-	1	1	1	-
Red-bellied Woodpecker (*Melanerpes carolinus*)	18	2/23	11/18	1	3	23	1.28
Northern Flicker (*Colaptes auratus*)	8	2/3	12/9	1	2	13	1.63
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	3	2/17	10/14	1	1	4	1.33
Downy Woodpecker (*Picoides pubescens*)	31	1/21	12/23	1	4	49	1.58
Pileated Woodpecker (*Drycopus pileatus*)	2	3/3	5/6	1	1	2	1.00
Eastern Wood Pewee (*Contopus virens*)	3	4/29	5/20	1	1	3	1.00
Empidonax species	2	5/13	9/16	1	1	2	1.00
Eastern Phoebe (*Sayornis phoebe*)	11	1/21	12/23	1	3	16	1.45
Great-crested Flycatcher (*Myiarchus crinitus*)	1	4/1	-	1	1	1	-
Scissor-tailed Flycatcher (*Tyrannus forficatus*)	1	10/14	-	3	3	3	-
White-eyed Vireo (*Vireo griseus*)	14	3/25	7/8	1	6	26	1.86
Red-eyed Vireo (*Vireo olivaceus*)	1	4/22	-	1	1	1	-
Blue Jay (*Cyanocitta cristata*)	43	2/3	12/23	1	9	121	2.81
American Crow (*Corvus brachyrhynchos*)	29	1/28	12/23	1	5	60	2.07
No. Rough-winged Swallow (*Stelgidopteryx serripennis*)	1	9/30	-	1	1	1	-
Purple Martin (*Progne subis*)	8	5/6	7/29	1	3	11	138
Barn Swallow (*Hirundo rustica*)	16	4/1	9/30	1	7	32	2.00
Carolina Chickadee (*Poecile carolinensis*)	44	1/28	12/23	1	10	125	2.84
Tufted Titmouse (*Baeolophus bicolor*)	23	3/3	12/16	1	2	24	1.04
House Wren (*Troglodytes aedon*)	12	1/28	12/23	1	2	14	1.17
Bewick's Wren (*Thryomanes bewickii*)	1	12/9	-	1	1	1	-

Table 1. *(continued).*

	Days Seen	Date seen First	Date seen Last	No. Per day Min.	No. Per day Max.	Total seen	Average per day
Carolina Wren (*Thryothorus ludovicianus*)	44	1/28	12/23	1	10	121	2.75
Ruby-crowned kinglet (*Regulus calendula*)	17	1/2	12/23	1	10	44	2.59
Golden-crowned Kinglet (*Regulus satrapa*)	4	11/18	12/23	1	3	8	2.00
Blue-gray Gnatcatcher (*Polioptila caerulea*)	18	3/25	12/16	1	7	41	2.28
Eastern Bluebird (*Sialia sialis*)	7	5/27	12/23	1	7	22	3.14
Swainson's Thrush (*Catharus ustulatus*)	2	4/29	5/6	1	1	2	1.00
American Robin (*Turdus migratorius*)	9	1/21	12/16	1	151	288	32.0
Northern Mockingbird (*Mimus polyglottos*)	41	2/3	12/16	1	5	96	2.34
American Pipit (*Anthus rubescens*)	2	11/18	12/16	1	1	2	1.00
Cedar Waxwing (*Bombycilla cedrorum*)	10	1/28	12/23	10	225	561	56.1
European Starling (*Sturnus vulgaris*)	5	10/21	12/16	1	2	8	1.60
Orange-crowned Warbler (*Oreothlypis celata*)	5	1/21	12/16	1	2	7	1.40
Nashville Warbler (*Oreothlypis ruficapilla*)	3	4/7	4/22	1	1	3	1.00
Yellow Warbler (*Setophaga petechia*)	1	9/3	-	1	1	1	-
Yellow-rumped warbler (*Setophaga coronata*)	18	1/21	12/23	1	14	68	3.78
Black-throated Green Warbler (*Setophaga virens*)	1	3/25	-	1	1	1	-
Mourning Warbler (*Oporornis philadelphia*)	1	9/9	-	1	1	1	-
Common Yellowthroat (*Geothlypis trichas*)	3	4/22	5/13	1	1	3	1.00
Chipping Sparrow (*Spizella passerina*)	13	1/21	12/16	1	20	96	7.38
Field Sparrow (*Spizella pusilla*)	12	2/17	12/23	1	10	55	4.58
Swamp Sparrow (*Melospiza georgiana*)	2	3/10	9/9	1	1	2	1.00
Song Sparrow (*Melospiza melodia*)	2	3/10	12/23	1	1	2	1.00
Lincoln Sparrow (*Melospiza lincolnii*)	10	4/1	12/23	1	2	12	1.20
White-throated Sparrow *(Zonotrichia albicollis)*	7	2/3	12/16	1	5	11	1.57
White-crowned Sparrow (*Zonotrichia leucophyrus*)	2	4/1	12/2	1	1	2	1.00
Harris Sparrow (*Zonotrichia querula*)	1	11/18	-	2	2	2	-

Table 1. *(continued)*.

	Days	Date seen		No. Per day		Total	Average
	Seen	First	Last	Min.	Max.	seen	per day
Dark-eyed Juncos (*Junco hyemalis*)	1	1/28	-	1	1	1	-
Northern Cardinal (*Cardinalis cardinalis*)	47	1/21	12/23	2	30	525	11.2
Indigo Bunting (*Passerina cyanea*)	6	4/14	9/9	1	17	27	4.50
Painted Bunting (*Passerina ciris*)	15	4/29	8/20	1	5	47	3.13
Dickcissel (*Spiza americana*)			1	4/29	-	1	1
Common Grackle (*Quiscalus quiscula*)	12	1/21	9/16	1	20	61	5.08
Brown -headed Cowbird (*Molothrus ater*)	24	2/3	12/2	1	40	152	6.33
Baltimore Oriole *(Icterus galbula)*	1	5/6	-	1	1	1	
House Finch (*Carpodacus mexicanus*)	6	2/9	12/16	1	3	10	1.67
American Goldfinch (*Carduelis tristis*)	7	1/21	12/23	1	8	18	2.57
House Sparrow (*Passer domesticus*)	26	1/21	12/23	1	20	98	3.77

* Scientific names follow the AOU checklists and supplements.

that one day of the week. Adjacent properties with ponds could have been the reason for a number of flyover waterbirds recorded. Also, goats that grazed on the property had an unknown effect.

Changes in Status.—The survey revealed several changes in status from Davis (1940). These are: two residents to winter residents, one summer resident to resident, one summer resident to migrant, one winter resident to resident, and one summer resident to winter resident (Table 2). There are several reasons for status changes. One reason can be urbanization and destruction of habitat. But, urbanization can also create habitat for other species. For example, Davis (1940) considered the Great-tailed Grackle (*Quiscalus mexicanus*), a vagrant, but today it is a year-round resident. The American Robin (*Turdus migratorius*) and European Starling (*Sturnus vulgaris*) have become permanent residents due to urbanization. I did not see American Robins breeding in the study area, but Frenz (1998) recorded them as breeding in the county. Due to lack of habitat, species such as Northern Flicker (*Colaptes auratus*), American Kestrel (*Falco sparverius*), Common Yellowthroat (*Geothlypis trichas*), and Yellow Warbler (*Setophaga petechia*) cannot be found breeding in Brazos County. Blue-Gray Gnatcatchers (*Polioptila caerulea*) now have become permanent residents in Brazos County when they used to just breed here.

Additions.—New highway construction in the county may have resulted in three swallow species breeding in Brazos County, but I only recorded one, the Barn Swallow (*Hirundo rustica*). Another species not in Davis (1940) that I recorded was the White-winged Dove (*Zenaida asiatica*). The species was first reported in the county by Jack Kent in 1970, and became a common resident in the late 1990s. The Black-Bellied Whistling Duck (*Dendrocygna autumnalis*) was first reported breeding in the county in the 1970s by Dr. Mick Robinson (Cain and Arnold 1974) and is now a regular summer resident, which may be due to the numerous stock tanks that have been built in Brazos County. The Inca Dove (*Columbina inca*), first found breeding in Brazos County by Fitch (1948), is now another common resident. Chris Merkord (ebird April 8, 2001) first found the Eurasian Collared Dove (*Streptopelia decaocto*) in

Table 2. Additions and changes in status of species in Brazos County, Texas in relation to status in Davis (1940), Petrides and Davis (1951), Unpublished checklist (1954), Brazos Ornithological Society (1966), Rio Brazos Audubon Society (1985), and Frenz (1998). Status is represented by permanent resident (PR), summer resident (SR), winter resident (WR), vagrant (V) and migratory (M).

Species:	1940	1951	1954	1966	1985	1998
Black-bellied Whistling Duck	*	**	**	**	SR	PR
Mississippi Kite	*	**	**	V	M	SR
American Kestrel	PR	**	PR	WR	WR	WR
White-winged Dove	*	**	**	V	V	V
Eurasian Collared Dove	**	**	**	**	**	**
Inca Dove	*	**	SR	SR	SR	PR
Barn Swallow	*	**	M	M	SR	SR
Cliff Swallow (*Petrochelidon pyrrhonota*)	*	**	M	M	SR	SR
Belted Kingfisher	*	PR	PR	PR	PR	PR
Northern Flicker	PR	PR	PR	WR	WR	WR
Eastern Wood Pewee	SR	**	SR	SR	M	SR
Blue-Gray Gnatcatcher	SR	**	SR	M	WR	PR
American Robin	*	**	**	PR	PR	PR
European Starling	WR	**	WR	PR	PR	PR
Yellow Warbler	SR	**	**	M	SR	M
Orange-crowned warbler	*	M	M	WR	WR	WR
Common Yellowthroat	SR	**	SR	M	SR	WR
White-crowned Sparrow	*	**	**	WR	WR	WR
Harris Sparrow	*	**	WR	WR	WR	WR
House Finch	*	**	**	**	**	PR

*This species not present at time of publication.
** No change of status indicated presumed to be the same as Davis 1940.

Brazos County. The species has made an expansion all over Texas, and it remains unknown whether these birds came from escapees or are wild birds expanding in range. Either way, they have spread rapidly and are now a common bird in Brazos County. In 1936 Eleanor L. Scoates reported White-crowned Sparrow (*Zonotrichia leucophrys*) (B.A. Frenz, pers. comm.), which should have been included in Davis (1940) but was not found in the publication. K. L. Dixon first reported Harris Sparrow (*Zonotrichia querula*), in Brazos County in 1953 (K. A. Arnold pers. comm.). House Finches (Carpodacus mexicanus) are interesting because in Davis (1940) House Finches, were not mentioned, but Purple Finches (*Carpodacus purpureus*) were winter residents. Now, Purple Finches are rare and House Finches are a common resident. Another new breeding bird is the Mississippi Kite (*Ictinia mississippiensis*), which is becoming more common in Brazos County, even though I only recorded it as a post-breeding bird. Orange-crowned Warblers (*Vermivora celata*) were first reported in Brazos County between 1940 and 1951 and were considered migrants in Petrides and Davis (1951), but now they are common winter residents. Petrides and Davis (1951) first reported the Belted Kingfisher (*Megaceryle alcyon*) as a permanent resident in Brazos County.

CONCLUSION

Many changes, additions and losses of species in the birds of Brazos County have occurred over the last 70 years. I concentrated on those species which I recorded in my surveys. Since it was a limited area with limited habitat, I discussed just a few of the many changes that have occurred in Brazos County. Even with the limited area, I recorded a number of changes since Davis (1940), showing the importance of surveys through time to keep track of changes in bird life in any given area. It is also important to do surveys throughout all seasons of the year to get a true look at species and their occurrence.

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A SURVEY OF BREEDING BIRDS AT PEDERNALES FALLS STATE PARK

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ABSTRACT.—This paper summarizes a three-year survey (2008-2010) of breeding birds occurring along the Pedernales River at the same locations with 10 nest boxes. Permanent nest boxes were installed along the Pedernales River and tributary creeks within Pedernales Falls State Park (PFSP) boundaries, Blanco County, Texas in February 2008 in an attempt to lure breeding pairs of Prothonotary Warblers (*Protonotaria citrea*). All singing males and nest occurrences were recorded at each nest box station. In 2010 one nest box was used by a Tufted Titmouse (*Baeolophus bicolor*). The most locally abundant breeding bird within the study area was the Northern Cardinal (*Cardinalis cardinalis*). No Prothonotary Warblers were observed during the study. The author notes the possible impact feral pigs could have on Louisiana Waterthrush (*Seiurus motacilla*) nesting success within the park's boundaries. The Tobacco Creek site is noted as an unusually diverse habitat for many wildlife species within this state park.

In 2007 I sighted a single male Prothonotary Warbler (*Protonotavia citrea*) from bird blinds in Pedernales Falls State Park (PFSP), which is the initial reason for my study. This species is a rare to occasional spring migrant as far west as Junction, Texas (Helton 2004, Oberholser 1974).

A breeding bird survey in the vicinity of nest boxes was performed along with compilation of a comprehensive list of breeding, migrant, and accidental birds for PFSP.

STUDY AREA

Pedernales Falls State Park has approximately 3.4 km of the Pedernales River winding through its property with rows of bald cypress (*Taxodium distichum)* lining sections of the river. Five sites on or near the Pedernales River were selected for nest box placement, with three at the confluence of tributary creeks.

Site 1, Twin Falls **-** Nest box stations 1 and 2 (30° 18' 28" N, 98° 14' 53"W) were placed on metal poles near each of the two pools at the confluence of Bee and Regal creeks.

Site 2, Trammel Crossing **-** Nest box stations 3 (30° 18' 28.72" N, 98° 15' 0.04" W) and 4 (30° 18' 31.11" N, 98° 14' 48.50" W) are situated approximately 0.15 km southeast of Site 1, farther downstream on Twin Falls Creek (nest box 3), and at the creek's confluence with the Pedernales River (nest box 4). These two nest boxes were added because of the constant year round flow of water along the creek. Excellent viewing areas also made this a seemingly ideal location.

Site 3, Tobacco Creek **-** Nest box stations 5 (30° 17' 53.14" N, 98° 14' 15.21" W) and 6 (30° 17' 52.38" N, 98° 14' 9.65" W) are located at the confluence of Tobacco Creek with the Pedernales River. This site is just $<$ 1.6 km downstream of Twin Falls and Trammel Crossing. Nest box 5 is near a huge hillside seep upstream from Tobacco Creek that is lush in vegetation and wildlife. Nest box 6 is located downstream of Tobacco Creek on an island on the Pedernales River.

Site 4, Hackenberg Creek **-** Nest box stations 7 and 8 (30° 11' 35.23" N, 98° 8' 40.76" W) are upstream from Twin Falls by about 2 kms. This site lies at the confluence of Hackenberg Creek and the Pedernales River. Boxes were attached to bald cypress trees on each side of Hackenberg Creek.

Site 5, East Park Boundary **-** Nest box stations 9 (30° 17' 50.89" N, 98° 14' 3.07" W) and 10 (30° 17' 51.44" N, 98° 13' 53.45" W) are 0.8 km downstream from Tobacco Creek along the Pedernales River. Nest box 9 is mounted on a bald cypress tree along the

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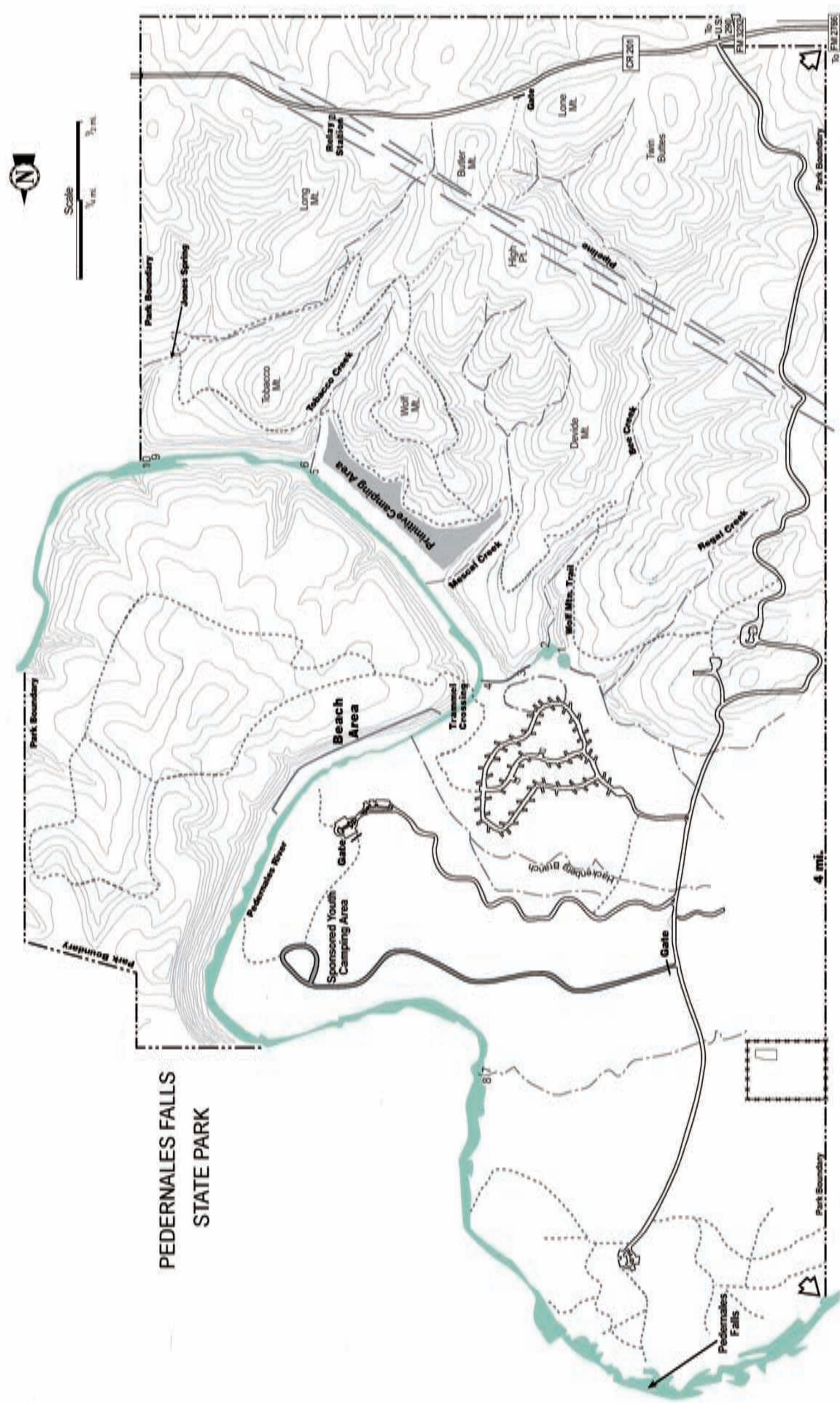

Figure 1. Site Map of Pedernales Falls State Park, Blanco County, Texas.

west edge of the river, and nest box 10 (downstream from 9) is on a cypress tree located on an island in the Pedernales River very near the park boundary line. Site 4 and Site 5, the most northern and southern sites are approximately 4 km apart. See Site Map above.

METHODS

Ten nest boxes constructed out of western red cedar with openings 3.69 cm wide by 5.08 cm tall were attached to posts or trees in February 2008. All boxes were assembled using galvanized decking screws for ease of service and replacement of damaged parts.

The monitoring period was early March through early July in 2008, 2009, and 2010. Surveys were conducted one time per week using the point count method (Hamel et al. 1996). Surveys began before sunrise and ended around 1200 h with start locations alternated weekly. Ten min. periods were used to record all birds heard and seen at each nest box station. At nest box stations 1 and 2, and 7 and 8 the proximity of the boxes allowed 10 ten minsurvey per each site. The longer distance between nesting boxes at the other three sites required individual 10 min surveys per station.

Natural nests found within each study site were monitored until fledging occurred. Male bird species recorded three or more times at each station during the survey period were considered breeding birds. To avoid recording migrant birds as breeders, species recorded during the peak spring migration period in May and not afterwards were exempted as breeding birds.

RESULTS

No Prothonotary Warblers were observed during the three-year period of study at any sites or on park property. The first year a nest box used by a bird species was 2010, the Tufted Titmouse (*Baeolophus bicolor*) at Site 2 - Trammel Crossing, nest box station 4.

Active bird nests found on study sites within the three-year-survey period include: Carolina Chickadee (*Poecile carolinensis*) natural cavity 2008, 2009; White-eyed Vireo (*Vireo griseus*) 2008; Black-chinned Hummingbird (*Archilochus alexandri*) 2010; Acadian Flycatcher (*Empidonax virescens*) 2009, 2010; Tufted Titmouse nest box four 2010; Louisiana Waterthrush (*Seiurus motacilla*) 2010; Northern Cardinal (*Cardinalis cardinalis*) 2009; Eastern Phoebe (*Sayornis phoebe*) 2009; and Blue Grosbeak (*Guiraca caerulea*) 2009. In 2009 Acadian Flycatchers used the exact same nest used the previous year; however, the second year it was not successful. In 2010 a Black-chinned Hummingbird successfully raised two young in the lower branches of a bald cypress tree overhanging the Pedernales River. In each of three years Louisiana Waterthrushes successfully raised young in at least one of three locations along the river – Trammel Crossing, Tobacco Creek and East Park Boundary.

Table 1 presents breeding bird species found at each nest box station. Cells bordered by parenthesis show a single territory found at more than one station. For example one Red-shouldered Hawk

Table 1. Breeding birds per year by nest box station at Pedernales Falls Stat Park, Blanco County, Texas during 2008-2010. Number observation per year is indicated per example for Broadwing Hawks 1/1/1.

	Next box station							
Species	1 & 2	3	4	5	6	7 & 8	9	10
Red-shouldered Hawk (*Buteo lineatus*)			(0/0/1	1/1/1	1/1/1)	1/1/1	(1/0/0	1/0/0)
Broadwing Hawk (*Buteo platyterus*)	1/1/1							
Wild Turkey (*Meleagrus gallopavo*)					1/1/0			
Killdeer (*Charadrius vociferus*)				(1/0/0	1/0/0)		(1/0/0	1/0/0)
Mourning Dove (*Zenaida macroura*)				(0/1/0	0/1/1)			
Yellow-billed Cuckoo (*Coccyzus americanus*)		0/1/1	0/0/1	(0/1/1	0/1/1)	1/0/1		
Black-chinned Hummingbird (*Archilochus alexandri*)	1/1/0	0/1/0	0/1/0	1/0/0	1/0/1		0/1/0	0/1/1
Green Kingfisher (*Chloroceryle americana*)	0/1/0				0/1/0	0/1/0	(1/1/0	1/1/0)
Ladder-backed Woodpecker (*Picoides scalaris*)			1/1/0	(1/1/1	0/0/1)	1/0/1		

Table 1. *(continued).*

	Next box station							
Species	1 & 2	3	4	5	6	7 & 8	9	10
Acadian Flycatcher (*Empidonax virescens*)	(0/1/0	0/1/1)		1/1/0	1/1/1	0/1/0	(0/0/1	0/1/1)
Least Flycatcher (*Empidonax minimus*)					0/0/1			
Eastern Pheobe (*Sayornis phoebe*)	(1/1/1	0/1/0)		(0/1/0	0/1/0)	0/1/0		
Great-crested Flycatcher (*Myiarchus crinitus*)					0/1/0			0/1/0
White-eyed Vireo (*Vireo griseus*)	1/2/1	1/2/1	1/1/0	2/2/1	2/2/1	2/2/1	1/1/1	1/1/0
Yellow-throated Vireo (*Vireo olivaceus*)	1/0/0		1/1/0	1/1/1	1/1/1	2/0/1	(1/1/0	1/1/0)
Red-eyed Vireo (*Vireo olivaceus*)	1/0/1	1/1/1	2/2/2	2/1/2	2/2/2	2/1/1	(1/1/1	1/1/1)
Common Raven (*Corvus corax*)					1/0/0			
Carolina Chickadee (*Poecile carolinensis*)	1/1/0	1/1/1	1/1/1	1/1/0	1/1/0	1/1/1	(1/1/1	1/1/1)
Tufted Titmouse (*Baeolophus bicolor*)	1/1/1	1/1/0	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	0/1/1
Canyon Wren (*Catherpes mexicanus*)			1/0/0	1/1/1	1/0/0	1/0/0	1/0/0	1/0/0
Carolina Wren (*Thryothorus ludovicianus*)	1/1/1	1/1/1	1/2/1	2/1/1	3/0/1	1/0/1	1/1/1	1/1/0
Blue-gray Gnatcatcher (*Polioptila caerulea*)	1/1/1	1/1/0	1/1/0	1/0/1	1/1/1	1/1/0	1/1/1	1/1/0
Northern Parula (*Parula americana*)				1/0/1	1/0/1	1/0/0		
Golden-cheeked Warbler (*Setophaga chrysoparia*)	2/1/1	1/1/1	1/1/0	1/0/0	1/1/1	2/1/0	1/1/0	1/1/0
Black & White Warbler (*Mniotilta varia*)	0/1/1	1/0/0	0/0/1	1/0/0	1/0/0	1/0/0		1/0/0
Louisiana Waterthrush (*Seiurus motacilla*)	(1/1/1	1/1/1	1/1/1)	(1/1/1	1/1/1)	0/1/0	(1/1/1	1/1/1)
Summer Tanager (*Piranga rubra*)	1/1/1	(1/1/1	1/1/1)	1/1/1	1/1/1	1/1/1	(1/1/1	1/2/1)
Rufous-crowned Sparrow (*Aimophila ruficeps*)	1/1/0							
Northern Cardinal (*Cardinalis cardinalis*)	2/2/1	(2/2/1	2/2/1)	3/2/2	2/2/0	2/2/1	(2/2/2	1/2/1)
Blue Grosbeak (*Guiraca caerulea*)			1/1/0	0/0/1	0/1/1		1/0/0	
Indigo Bunting (*Passerina cyannea*)		1/1/0	1/2/1	1/1/1	1/2/1	1/0/0	1/1/1	1/1/1
Painted Bunting (*Passerina amoena*)	1/0/0		1/1/0	1/1/0	1/1/0	1/1/1	1/1/1	1/1/1
Brown-headed Cowbird (*Molothrus ater*)	1/0/0				0/1/0	1/0/1	1/1/0	1/1/0
Site	1	2		3		4	5	

(*Buteo lineatus*) territory can be found at stations 4, 5, 6, 9 & 10 and a second territory at nest box stations 7 & 8. Table 2 summarizes total number of species at all 10 stations combined by year. Table 3 lists all bird sightings during the three years of the survey.

The most common breeding bird recorded across all three years was the Northern Cardinal followed by the Red-eyed Vireo (*Vireo olivaceus*), the White-eyed Vireo, and the Carolina Wren (*Thryothorus ludovicianus*). The Louisiana Waterthrush was a common breeder at all five sites. Three species of

Table 2. Total number breeding birds by species by year and average for three years at Pedernales Falls State Park.

Species	Year 2008	2009	2010	**Average**
Red-shouldered Hawk (*Buteo lineatus*)	2	2	2	2.00
Broadwing Hawk (*Buteo platyterus*)	1	0	0	0.33
Wild Turkey (*Meleagrus gallopavo*)	0	1	0	0.33
Killdeer (*Charadrius vociferous*)	2	0	0	0.66
Mourning Dove (*Zenaida macroura*)	0	1	1	0.66
Yellow-billed Cuckoo (*Coccyzus americanus*)	1	2	3	2.00
Black-chinned Hummingbird (*Archilochus alexandri*)	3	5	2	3.33
Green Kingfisher (*Chloroceryle americana*)	1	2	0	1.00
Ladder-backed Woodpecker (*Picoides scalaris*)	1	2	1	1.33
Acadian Flycatcher (*Empidonax virescens*)	2	5	3	3.33
Least Flycatcher (*Epidonax minimus*)	0	0	1	0.66
Eastern Pheobe (*Sayornis phoebe*)	1	3	1	1.7
Great-crested Flycatcher (*Myiarchus crinitus*)	2	0	0	0.7
White-eyed Vireo (*Vireo griseus*)	11	13	6	10.0
Yellow-throated Vireo (*Vireo flavifrons*)	7	5	3	5.0
Red-eyed Vireo (*Vireo olivaceus*)	12	9	11	10.7
Common Raven (*Corvus corax*)	1	0	0	0.3
Carolina Chickadee (*Poecile carolinensis*)	8	8	3	6.3
Tufted Titmouse (*Baeolophus bicolor*)	7	8	7	7.3
Canyon Wren (*Catherpes mexicanus*)	6	1	1	2.7
Carolina Wren (*Thryothorus ludovicianus*)	14	7	7	9.3
Blue-gray Gnatcatcher (*Polioptila caerulea*)	8	7	4	6.3
Northern Parula (*Parula americana*)	3	0	2	1.7
Golden-cheeked Warbler (*Setophaga chrysoparia*)	10	7	3	6.7
Black and White Warbler (*Mniotilta varia*)	5	1	2	2.7
Louisiana Waterthrush (*Seiurus motacilla*)	4	6	7	5.7
Summer Tanager (*Piranga rubra*)	8	8	6	7.3
Rufous-crowned Sparrow (*Aimophila ruficeps*)	1	1	0	0.7
Northern Cardinal (*Cardinalis cardinalis*)	16	16	7	13.0
Blue Grosbreak (*Guiraca caerulea*)	2	2	2	2.0
Indigo Bunting (*Passerina cyanea*)	7	8	5	6.7
Painted Bunting (*Passerina amoena*)	7	6	2	5.0
Brown-headed Cowbird (*Molothrus ater*)	4	3	0	2.3
Total # Breeding Birds	157	139	92	

warblers nested along the river in lesser numbers including the Golden-cheeked Warbler (*Dendroica chrysoparia*), Black and White Warbler (*Mniotilta varia*), and Northern Parula (*Parula americana*). Both the Acadian Flycatcher and Yellow-throated Vireo (*Vireo flavifrons*) were found breeding at all sites. Hawks inhabited the park; least two pairs of Red-shouldered Hawks one territory in the area between Boy Scout Camp and Pedernales Falls the other more southern territory bounded by Trammel Crossing and the east park boundary. At least one pair of Green Kingfishers (*Chloroceryle americana*) appeared were river residents in 2008 and 2009. Too few sightings occurred in 2010 for this species to be considered a breeder. Frequent rains creating murky and turbid water conditions

Table 3. List of bird species observed in Padernales Falls State Park in 2008, 2009, and 2010.

	Year		
Species	2008	2009	2010
Double-crested Cormorant (*Phalacrocorax auritus*)	X	X	
Great Blue Heron (*Ardea herodias*)	X	X	X
Great Egret (*Ardea alba*)		X	X
Green Heron (*Butorides virescens*)			X
Black Vulture (*Coragyps atratus*)	X	X	X
Turkey Vulture (*Cathartes aura*)	X	X	X
Mallard (*Anas platyrhynchos*)	X		
Blue-winged Teal (*Anas discors*)		X	
Osprey (*Pandion haliaetus*)		X	
Bald Eagle (*Haliaeetus leucocephalus*)		X	
Sharp-shinned Hawk (*Accipiter striatus*)	X	X	
Cooper's Hawk (*Accipiter cooperii*)	X		
Red-shouldered Hawk (*Buteo lineatus*)	X	X	X
Broadwing Hawk (*Buteo platyterus*)	X	X	X
Swainson's Hawk (*Buteo swainsoni*)			X
Red-tailed Hawk (*Buteo jamaicensis*)	X		
Crested Caracara (*Caracara plancus*)	X	X	X
American Kestrel (*Falco sparverius*)	X		X
Wild Turkey (*Meleagrus gallopavo*)	X	X	X
Northern Bobwhite (*Colinus virginianus*)	X	X	
Killdeer (*Charadrius vociferus*)	X	X	X
Solitary Sandpiper (*Tringa solitaria*)	X		
Spotted Sandpiper (*Actitis macularia*)	X	X	
White-winged Dove (*Zenaida asiatica*)		X	X
Mourning Dove (*Zenaida macroura*)	X	X	X
Inca Dove (*Columbina inca*)	X		X
Common Ground Dove (*Columbina passerina*)			X
Yellow-billed Cuckoo (*Coccyzus americanus*)	X	X	X
Greater Roadrunner (*Geococcyx californianus*)	X	X	X
Eastern Screech Owl (*Otus asio*)	X	X	X
Common Nighthawk (*Chordeiles minor*)	X	X	X
Chuck-wills Widow (*Caprimulgus carolinensis*)	X	X	X
Chimney Swift (*Chaetura pelagica*)	X	X	X
Ruby-throated Hummingbird (*Archilochus colubris*)		X	X
Black-chinned Hummingbird (*Archilochus alexandri*)	X	X	X
Rufous Hummingbird (*Selasphorus rufus*)	X		
Ringed Kingfisher (*Ceryle torquata*)	X		
Belted Kingfisher (*Ceryle alcyon*)	X	X	X
Green Kingfisher (*Chloroceryle americana*)	X	X	X
Golden-fronted Woodpecker (*Melanerpes orifrons*)			X
Yellow-bellied Sapsucker ((*Sphyrapicus varius*)	X	X	X
Ladder-backed Woodpecker (*Picoides scalaris*)	X	X	X
Northern Flicker (*Colaptes auratus*)	X		
Eastern Wood Pewee (*Contopus virens*)	X		

Table 3. *(continued).*

Species	Year 2008	2009	2010
Acadian Flycatcher (*Empidonax virescens*)	X	X	X
Alder Flycatcher (*Empidonax alnorum*)	X		
Least Flycatcher (*Empidonax minimus*)		X	X
Black Pheobe (*Sayornis nigricans*)		X	
Eastern Pheobe (*Sayornis phoebe*)	X	X	X
Vermilion Flycatcher (*Pyrocephalus rubinus*)			X
Ash-throated Flycatcher (*Myiarchus cinerascens*)	X	X	X
Great-crested Flycatcher (*Myiarchus crinitus*)	X	X	X
Western Kingbird (*Tyrannus verticalis*)		X	
Scissor-tailed Flycatcher (*Tyrannus forficatus*)			X
White-eyed Vireo (*Vireo griseus*)	X	X	X
Bell's Vireo (*Vireo bellii*)	X		
Yellow-throated Vireo (Vireo flavifrons)	X	X	X
Blue-headed Vireo (*Vireo solitarius*)	X		
Warbling Vireo (*Vireo gilvus*)	X	X	X
Red-eyed Vireo (*Vireo olivaceus*)	X	X	X
Western Scrub Jay (*Aphelocoma californica*)	X	X	X
Common Raven (*Corvus corax*)	X	X	X
Purple Martin (Progne subis)		X	
Cliff Swallow (*Petrochelidon pyrrhonota*)	X		
Barn Swallow (*Hirundo rustica*)		X	X
Carolina Chickadee (*Poecile carolinensis*)	X	X	X
Tufted Titmouse (*Baeolophus bicolor*)	X	X	X
Red-breasted Nuthatch (*Sitta canadensis*)	X		
Canyon Wren (*Catherpes mexicanus*)	X	X	X
Carolina Wren (*Thryothorus ludovicianus*)	X	X	X
Bewick's Wren (*Thryomanes bewickii*)	X	X	X
House Wren (*Troglodytes aedon*)	X		X
Winter Wren (*Troglodytes troglodytes*)	X		
Ruby-crowned Kinglet (*Regulus calendula*)	X	X	X
Blue-gray Gnatcatcher (*Polioptila caerulea*)	X	X	X
Eastern Bluebird (*Sialia sialis*)	X		X
Swainson's Thrush (*Catharus ustulatus*)	X		X
Hermit Thrush (*Catharus guttatus*)	X		
American Robin (*Turdus migratorius*)		X	
Gray Catbird (*Dumetella carolinensis*)		X	X
Northern Mockingbird (*Mimus polyglottos*)	X	X	X
Cedar Waxwing (*Bombycilla cedrorum*)	X	X	X
Orange-crowned Warbler (*Vermivora celata*)	X	X	X
Nashville Warbler (*Vermivora ruficapilla*)	X	X	X
Northern Parula (*Parula americana*)	X	X	X
Yellow Warbler (*Setophaga petechia*)		X	X
Yellow-rumped Warbler (*Setophaga coronata*)	X	X	X
Golden-cheeked Warbler (*Setophaga chrysoparia*)	X	X	X

Table 3. *(continued).*

Species	Year 2008	2009	2010
Black-throated Green Warbler (*Setophaga virens*)		X	
Black and White Warbler (*Mniotilta varia*)	X	X	X
American Redstart (*Setophaga ruticilla*)			X
Ovenbird (*Seiurus aurocapillus*)	X	X	
Louisiana Waterthrush (*Seiurus motacilla*)	X	X	X
Common Yellowthroat (*Geothlypis trichas*)	X	X	
Wilson's Warbler (*Wilsonia pusill*a)	X	X	
Canada Warbler (*Wilsonia canadensis*)		X	
Summer Tanager (*Piranga rubra*)	X	X	X
Spotted Towhee (*Pipilo maculatus*)	X	X	
Rufous-crowned Sparrow (*Aimophila ruficeps*)	X	X	X
Chipping Sparrow (*Spizella passerina*)	X	X	X
Clay-colored Sparrow (*Spizella pallida*)		X	
Field Sparrow (*Spizella pusilla*)	X	X	X
Vesper Sparrow (*Pooecetes gramineus*)	X	X	X
Lark Sparrow (*Chondestes grammacus*)	X	X	X
Savanna Sparrow (*Passerculus sandwichensis*)			X
Fox Sparrow (*Passerella iliaca*)		X	X
Song Sparrow (*Melospiza melodia*)	X	X	X
Lincoln's Sparrow (*Melospiza lincolnii*)	X	X	X
Swamp Sparrow (*Melospiza georigiana*)		X	X
White-throated Sparrow (*Zonotrichia albicollis*)	X	X	X
White-crowned Sparrow (*Zonotrichia leucophrys*)	X	X	X
Dark-eyed Junco (*Junco hyemalis*)	X	X	X
Northern Cardinal (*Cardinalis cardinalis*)	X	X	X
Blue Grosbeak (*Guiraca caerulea*)	X	X	X
Lazuli Bunting (*Passerina amoena*)		X	
Indigo Bunting (*Passerina cyanea*)	X	X	X
Painted Bunting (*Passeina ciris*)	X	X	X
Dickcissel (*Spiza americana*)		X	
Red-winged Blackbird (*Agelaius phoeniceus*)	X	X	X
Eastern Meadowlark (*Sturnella magna*)		X	X
Great-tailed Grackle (*Quiscalus mexicanus*)	X		
Brown-headed Cowbird (*Molothrus ater*)	X	X	X
Orchard Oriole (*Icterus spurius*)	X	X	
Baltimore Oriole (*Icterus galbula*)	X		
Purple Finch (*Carpodacus purpureus*)		X	
House Finch (*Carpodacus mexicanus*)	X	X	X
Pine Siskin (*Carduelis pinus*)	X	X	
Lesser Goldfinch (*Carduelis psaltria*)	X	X	X
American Goldfinch (*Carduelis tristis*)	X	X	X
House Sparrow (*Passer domesticus*)		X	X

may have affected kingfisher hunting success as well as this species ability to successfully breed along the river in 2010.

DISCUSSION

Site 1, Twin Falls—Nest box stations 1 & 2 - The two pools at the base of Twin Falls provide excellent bird habitat with a constant water source and large population of insects. The Eastern Phoebe has successfully nested in the sheer cliff bordering one of the pools. Green Kingfishers have also been recorded feeding at these pools. Unfortunately numerous times human park visitors have been observed swimming in the pools. As a result nest boxes 1 & 2 have been tampered with on many occasions over the study period.

Site 3, Tobacco Creek—Nest box stations 5 & 6—This area represents the most diverse habitat of all study sites with the largest number of breeding birds consistently recorded over the study. Tobacco Creek dries up by early May through the summer. The seep is a wide swath of the hillside upstream from the creek at station 5 remains saturated year-round. These wet conditions may be one reason the Acadian Flycatcher is common in the vicinity. In 2010 a Louisiana Waterthrush pair built a nest in the middle of the seep and successfully fledged young.

The Least Flycatcher (*Empidonax minimus*) recorded in 2010 was first heard at station 6 on 8 May. Subsequent sightings of a singing male were made on 5, 19, and 26 June, well past the normal migration window. This bird was out of the breeding range and did not attract a mate.

Red-shouldered hawks had an ample prey base of squirrels and snakes. I saw both carried away by hawks.

The Brown-headed Cowbird (*Molothrus ater*), a brood parasite, was evident at all sites, and was more numerous in some years than others. At Trammel Crossing I found one cowbird egg in a Blue Grosbeak nest in 2009. In 2010 cowbird occurrences were down from previous years.

The Louisiana Waterthrush, a ground nesting species, was common during my survey. This species builds nests in crevices, tree roots, on raised sites along banks of streams, or on cliffs and/or ravines over water (Cornell Lab of Ornithology). In two instances feral pig activity was observed occurring within several feet of waterthrush nest attempts. Further studies are suggested to evaluate the impact feral pig activity has on breeding success of the Louisiana Waterthrush in the park. To better protect the ecologically sensitive Twin Falls Site, I recommend a fence be installed on either side of the lookout to prevent human entry to the pools. Posting signs saying: "No Entry—Ecologically Sensitive Area" around the pools might also help deter individuals and groups from accessing and damaging this unique habitat.

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HABITAT USE BY GREAT-TAILED GRACKLES (QUISCALUS MEXICANUS) IN URBAN AND PERI-URBAN HABITATS OF SAN MARCOS, HAYS COUNTY, TEXAS

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ABSTRACT.—Great-tailed Grackles (*Quiscalus mexicanus*) are habitat generalists occupying a wide variety of environments except dense forests and prairies lacking nearby water sources. Golf courses, campuses, lawns, parks, and avenue rights-of-way are inhabited in urban and suburban areas. However, examination of seasonal use of habitats in urban environments is limited. We documented seasonal use of urban and peri-urban habitats in San Marcos, Hays County, Texas. We compared habitat use by program Presence to apply the best fit model explaining occupancy within habitats. Principal components analysis suggested differences in woody vegetation among study sites. The best fit model incorporated occupancy, colonization, and detection with habitat type and time of day as covariates. We found Great-tailed Grackles selected developed areas (85%) over open (60%) and wooded (27%) habitats based on occupancy modeling.

Great-tailed Grackles are habitat generalists occupying a wide variety of environments, except dense forests and prairies lacking nearby water sources (Selander and Giller 1961). They also inhabit human developments, such as golf courses, campuses, lawns, parks, and avenue rights-of-way (Johnson et al. 2000). Great-tailed Grackles are generally a resident species and only migratory at the northernmost edge of the range (Johnson and Peer 2001). Range expansion has followed irrigation and tree planting in grasslands and deserts where water is scarce (Dinsmore and Dinsmore 1993). Furthermore, new colonies are often established near natural and/or man-made marshes and other wetlands (Faanes and Norling 1981, Dinsmore and Dinsmore 1993). Significant increases in populations have occurred and may constitute the largest range expansion of any native bird species in the western United States (Marzluff et al. 1994).

Great-tailed Grackles often form large, mixed flocks near agricultural areas used for row-cropping and livestock grazing during the non-breeding season in Texas (Arnold and Folse 1977). Large roosts also occur in parking lots of large commercial retail developments (Johnson and Peer 2001). Great-tailed Grackles disperse over large areas in summer, but form large, dense flocks during winter over smaller areas with resident populations (Arnold and Folse 1977).

When present in large numbers, Great-tailed Grackles are often considered a nuisance species that benefits from human activity (Johnson and Peer 2001). Large roosts in unban habitats are undesirable because of noise and large quantities of excrement deposited nightly. Management of Great-tailed Grackle populations and roosts in urban areas has been ineffective and difficult because of proximity to humans (Johnson and Peer 2001).

There is a paucity of published information on Great-tailed Grackle natural history in urban habitats. An understanding of habitats occupied year-round and seasonally by Great-tailed Grackles will provide basic information for management plans and techniques to deter or attract Great-tailed Grackles to specific areas. We examined foraging behavior and habitat use by Great-tailed Grackles in an urban environment. Our objectives were to: 1) document seasonal habitat use in urban and peri-urban environs in the San Marcos area; 2) record behaviors observed in different habitat types; and 3) compare observed behaviors by habitat and season.

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METHODS

Study Area.—We studied habitat use by Great-tailed Grackles at 40 sites in San Marcos, Hays County, Texas (29° 52' N, 97° 56' W, Fig. 1) in 2009-2010. San Marcos is a mid-size city with a human population of 44,894, dense areas of commercial development, areas of less-dense residential developments and protected green space. It is located on the eastern boundary of the Balcones Escarpment with the Edwards Plateau ecoregion to the west and the Blackland Prairie ecoregion to the east (Gould et al. 1960). Our study area consisted of approximately 2,990 ha with 1,963.8 ha of developed land, 677.9 ha open land and 324.8 ha of woodland. Typical woody vegetation includes live oak (*Quercus fusiformis*), Texas oak (*Quercus buckleyi*), Texas persimmon (*Diospyros texana*), and Ashe juniper (*Juniperus ashei*). The climate is temperate with mean annual precipitation of 88 cm and an average daily temperature of 20°C.

All sites were located adjacent to public roads or in public green spaces and easily accessible with the exception of two accessible by foot only. Study sites reflected urban environmental patchiness with an intermixture of wooded, open, and developed areas. We used the 2001 National Land Cover Database (NLCD) from the United States (Homer et al. 2004) to designate habitat types. Habitat type databases were based on definitions from the Multi-Resolution Land Characteristics Consortium (1992). We used the 2001 NLCD because of high accuracy (over 70% for land cover, imperviousness and tree canopy) and usefulness in differentiating urban development from surrounding habitats (Homer et al. 2004). Nine land cover categories were present within the study area: developed (low, medium and high intensity), open space, deciduous forest, evergreen forest, mixed forest, shrub/scrub and grassland/herbaceous (Fig. 1). We combined similar land cover categories, resulting in three categories (developed, open, and wooded). We used ArcGIS v. 9.3 (Environmental Systems Research Institute, Redlands, CA) to randomly select 40 points in proportion to the area of the three land cover categories (14 in developed, 13 in open, and 13 in wooded). We recorded count data at each point eight times seasonally during a four-week period

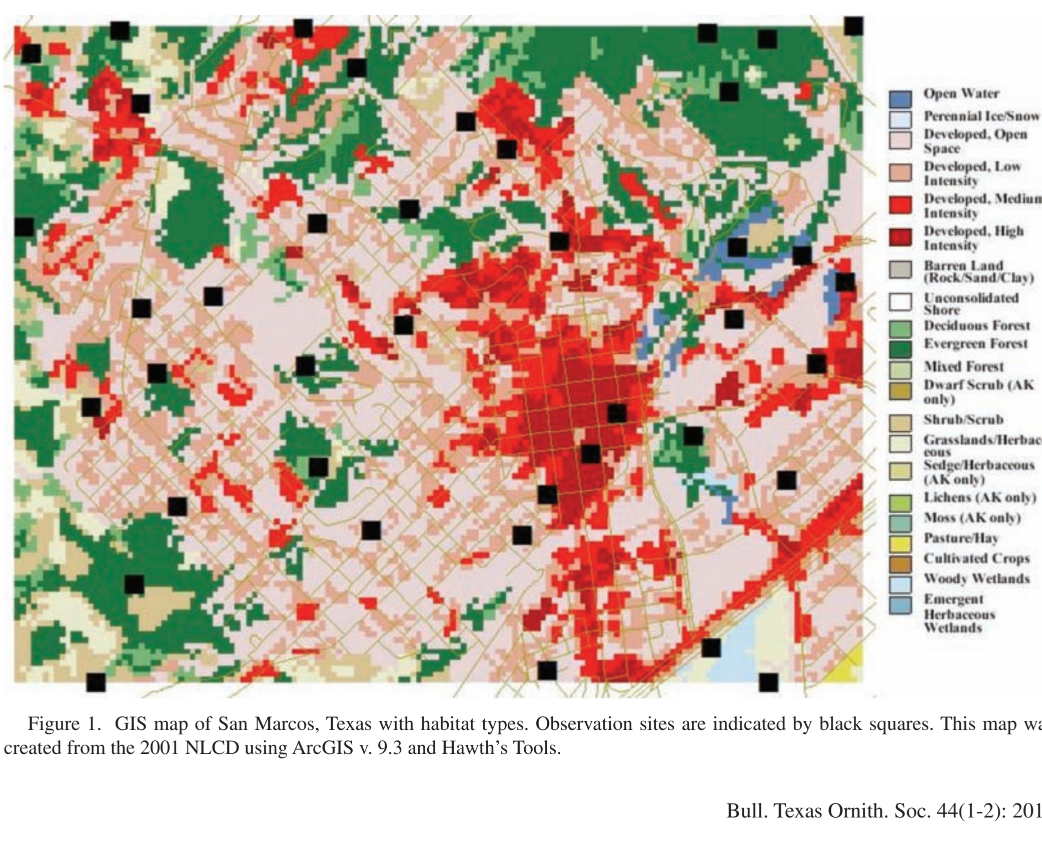

Figure 1. GIS map of San Marcos, Texas with habitat types. Observation sites are indicated by black squares. This map was created from the 2001 NLCD using ArcGIS v. 9.3 and Hawth's Tools.

with four counts in morning and four in evening. We conducted counts during 3 h after official sunrise and 3 h before official sunset. We divided point sites into three driving routes and reversed the sequence of counts along routes each time. We defined seasons traditionally; summer (21 June-21 September), fall (September 22-December 21), winter (22 December-21 March) and spring (22 March-21 June).

We used a 50-m fixed radius point count with points separated by a minimum of 250 m and an 8 min observation time at each point (Ralph et al. 1995). We recorded date, GPS coordinates, general weather conditions, time of day, habitat type, number of Great-tailed Grackles present and associated bird species and number present. We observed Great-tailed Grackles with 10x binoculars.

Statistical Analysis.—We used a 3-factor analysis of variance (ANOVA) to compare counts of Great-tailed Grackles by season, habitat, time of day, and interactions among these three variables. We used Tukey's Multiple Comparison of Means test as a post hoc analysis to determine specific differences in 2-way comparisons of season, habitat and time of day.

We used program PRESENCE v. 2.4 (United States Geological Service, Laurel, MD, 2006) to compare occupancy and detection of Great-tailed Grackles across seasons. We created a model that best explained trends of occupancy and detection and used Akaike Information Criterion (AIC) to determine the best model. The best fit model determined by program PRESENCE included occupancy, colonization, and detection with habitat as a site covariate and time of day as a sampling covariate applied to occupancy and detection, respectively. Some models were simple with no covariates and others included habitat type and time of day as covariates. We did not generate a reliable model with Program Presence using estimates of the original nine habitat types (Fig. 1). Therefore, we combined habitat types into three categories: developed, wooded, and open. Developed habitats consisted of low, medium and high intensity development. These included neighborhoods, apartment complexes, strip malls and large commercial buildings. Wooded habitats consisted of deciduous forest, evergreen forest and mixed forest. Neighborhoods with numerous large trees and large-size lots on the perimeter of San Marcos as well as green spaces were classified as wooded. Open habitats were areas designated as developed open space, shrub/scrub and grassland/herbaceous. Fields, pastures, parks and some neighborhoods with few trees constituted this category.

We measured and recorded vegetative data (canopy cover, distance to woody vegetation < 2-m height and > 2-m height and height of woody vegetation > 2-m) at each site. We measured canopy cover using a spherical convex densiometer and an Opti-Logic 400 LH Laser Rangefinder/Hypsometer (Opti-Logic Corporation, Tullahoma, TN) was used to measure distance to and height of woody vegetation. We used Excel (Microsoft Corporation, Redmond, Washington) to calculate mean distances and height of vegetative data and create a scatter plot of the loadings of the principal components. We used program R (R development core team 2005) to perform a principal components analysis (PCA) on vegetative data.

RESULTS

We counted 1,836 Great-tailed Grackles in a year (421 in spring, 341 in summer, 490 in fall, and 584 in winter; Table 1) at 40 point count sites within San Marcos. We recorded three other bird species, Red-wing Blackbird (*Agelaius phoeniceus*), European Starling (*Sturnus vulgaris*) and Common Grackle (*Quiscalus quiscalus*) associated with Great-tailed Grackles.

Table 1. Seasonal number of Great-tailed Grackles categorized habitat by type and time of day. Numbers were from 40 point count sites in San Marcos, Texas in 2009-2010.

	Season							
	Spring		Summer		Fall		Winter	
Habitat	AM	PM	AM	PM	AM	PM	AM	PM
Developed	109	105	94	86	168	245	67	176
Wooded	3	1	4	3	0	0	10	5
Open	88	113	69	86	11	68	39	286

Counts of Great-tailed Grackles differed by habitat type (F_2 = 20.7, P = 0.002; Table 2) and time of day (F_1 = 6.48, P = 0.04; Table 2); whereas, seasonal counts (F_3 = 1.05, P = 0.44; Table 2) and interactions did not differ (Table 2). Since there was no replication in our study, we could not examine third level interactions among season, habitat and time of day. The post hoc Tukey's Multiple Comparison of Means test indicated significant differences in number of Great-tailed Grackles at different habitat types with wooded habitat used significantly less (P = 0.002) than developed (P = 0.01) and open habitats (P = 0.26).

The best fit model (Table 3) determined by program PRESENCE determined habitat type and time of day were important with regard to occupancy and detection. Occupancy (Ψ) for developed habitats was 0.85, open habitats 0.60 and wooded habitats 0.27. Seasonal detection (P) was 0.48, 0.26, 0.19 and 0.28 for spring, summer, fall and winter, respectively.

Mean canopy cover was 32% (range = 0%-100%) for all sites. Mean distance to woody vegetation < 2 m in height was 19.3 m, while mean distance to woody vegetation > 2 m in height was 14.3 m. Mean height for vegetation > 2 m was 10.6 m. Principal component (PC) axes I and II explained 71% of variance in habitat among all sites Sites with strongest positive loadings for PC I had increased canopy cover. Sites with low loadings for PC I and PC II had low canopy cover and little woody vegetation < 2 m in height. Principal component II and PC III (distance to woody vegetation ≥ 2 m) accounted for only 42% of variance, while PC I and PC III accounted for 58% of variance. PC I accounted for the majority of total variance at 47%. Canopy cover, distance to vegetation < 2 m and distance to vegetation > 2 m

Table 2. Results of analysis of variance (ANOVA) comparing season, time of day, and habitat type of observed Great-tailed Grackles at 40 points in San Marcos, TX.

Factor	df	Sum Sq.	Mean Sq.	*F*	*P*
Season	3	5292	1764	1.0465	0.437734
Habitat	2	69643	34822	20.656	0.00204
Time	1	10923	10923	6.4793	0.043758
Season:Habitat	6	26809	4468	2.6505	0.130354
Season:Time	3	12674	4225	2.5061	0.155907
Habitat:Time	2	7834	3917	2.3237	0.178951
Residuals	6	10115	1686		

Table 3. Results of model selection from program PRESENCE. Results were based upon observations of Great-tailed Grackles at 40 points in San Marcos, Texas. Habitat type (Developed, Wooded, and Open) was a covariate of occupancy(Ψ) and time of day (morning or evening) was a covariate of detection (P).

Model	AIC	deltaAIC	AIC wgt	AICc	Model Likelihood	No. of Parameters	-2*Loglikelihood
psi(habitat),gamma(.),p(time)	1041.71	0	0.82	1041.85	1	9	1023.71
psi(habitat),gamma(.),p(.)	1045.38	3.67	0.1309	1045.49	0.1596	8	1029.38
psi(habitat),gamma(.),eps(.),p(time)	1047.85	6.14	0.0381	1048.02	0.0464	10	1027.85
psi(habitat),gamma(.),eps(.),p(.)	1051.57	9.86	0.0059	1051.71	0.0072	9	1033.57
psi(.),gamma(.),p(time)	1053.13	11.42	0.0027	1053.22	0.0033	7	1039.13
psi(.),gamma(.),eps(.),p(time)	1053.99	12.28	0.0018	1054.1	0.0022	8	1037.99
psi(.),gamma(.),p(.)	1056.83	15.12	0.0004	1056.9	0.0005	6	1044.83
psi(.), gam(.), eps(.), p(.)	1057.71	16	0.0003	1057.8	0.0003	7	1043.71

because they accounted for ~89% of total variation in our Principle Components Analysis.

DISCUSSION

Previous research on habitat use by Great-tailed Grackles has focused on basic life history and nuisance issues (Johnson and Peer 2001). Our research examined how Great-tailed Grackles used habitats within an urban environment. Great-tailed Grackle occupancy data showed preference for developed habitats in an urban setting in contrast to open and wooded habitats. Rappole et al. (1989) showed Great-tailed Grackle habitat use in urban environments changed seasonally with similar usage patterns between spring and summer and between fall and winter. When observations of Great-tailed Grackles in San Marcos were separated by habitat types the pattern becomes less clear. In spring and summer, developed and open habitats were used approximately equally. In fall, habitat use was skewed heavily towards developed habitat types. A contributing factor may be the availability of food source in the form of discarded food products at large sporting events such as football games (university and high school). The trend reversed during winter with habitat use skewed towards open habitats. Fewer large outdoor events occurred during winter, so Great-tailed Grackles foraged more in open habitats. Habitat type and time of day were the most significant factors in relation to number of Great-tailed Grackles in an area across all seasons.

The fluctuating seasonal nature of Great-tailed Grackle populations emerged in evening numbers but was not observed in morning numbers. This suggests individual Great-tailed Grackles may move between multiple roosts in evening more often than in the morning. This trend did not appear related to habitat type as Great-tailed Grackle numbers increased for developed and open habitats. The other possibility is we simply did not count some Great-tailed Grackles in morning or they left before we arrived at survey sites. Great-tailed Grackles typically leave in morning to forage and return to roosting sites in evening (Selander and Hauser 1965).

The best model from program PRESENCE included occupancy, colonization and detection as variables with covariates of habitat type and time of day. Extinction was dropped as a variable because estimates had high standard error, which indicated overall an increasing Great-tailed Grackle population. This model also supported habitat type and time of day as important factors explaining the presence or absence of Great-tailed Grackles in a given area. San Marcos is located close to large metropolitan areas, Austin and San Antonio, which also have large Great-tailed Grackle populations. The increase in the population in San Marcos could be the results of dispersal from metropolitan areas or smaller satellite roosts in smaller towns near San Marcos. Another possibility is the model simply did not capture the fluctuating nature of the Great-tailed Grackle population in San Marcos.

The principal components analysis reinforced selection of more open habitat types by Great-tailed Grackles. Our PCA results of canopy cover (PC I) and mean distance to woody vegetation < 2-m height (PC II) suggests Great-tailed Grackles favored open habitats because of the high negative loadings for both components. The data for mean distance to woody vegetation < 2-m height (PC II) and mean distance to woody vegetation > 2-m height (PC III) likewise shows Great-tailed Grackles favored open habitats because of the high negative loadings for both components.

We selected the 2001 NLCD for our analysis because it appeared to clearly distinguish between different habitats in urban areas. However, we found limitations to the database particularly with regard to developed habitats. The database indicated areas as developed with high levels of impervious cover. However, upon visiting the sites, we found areas classified as developed had large amounts of woody vegetation and open space. Future studies incorporating the 2001 NLCD should take these differences into account because the database has a coarse scale and fails to capture differences in vegetation.

Overall, Great-tailed Grackles selected developed habitats, used open habitats, while seldom using wooded habitats. Great-tailed Grackles are considered a nuisance species in urban environments (Johnson and Peer 2001). Management of Great-tailed Grackles should target developed habitats within urban regions. A management plan for the species should encourage large commercial developments to reduce the amount of trash targeted by Great-tailed Grackles as foraging resources. Future studies should also look at larger urban areas and compare how Great-tailed Grackles use urban areas and if usage patterns differ throughout a larger region.

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CASSIN'S SPARROWS NESTING ON THE SOUTHERN HIGH PLAINS OF TEXAS

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Abstract—We monitored 15 Cassin's Sparrow (*Peucaea cassini*) nests in two mesquite (*Prosopis* spp.) dominated grassland sites on the Southern High Plains of Texas during 2001. Mayfield daily survival rate was 0.942 ± 0.194 (30% nest success) and two unsuccessful nests were parasitized by Brown-headed Cowbirds (*Molothrus ater*). Although constrained by few nests in this study, we report a comparatively higher parasitism frequency (13%) and lower nest success than other regional (Texas) studies, but overall parasitism frequency in this study mirrors rates reported throughout the geographic range. The impacts of parasitism on Cassin's Sparrow populations remain unknown. Future studies focusing upon Cassin's Sparrows should incorporate direct comparisons of parasitism frequency and impacts as related to Cassin's Sparrow nest site selection and population trends.

Key Words: Cassin's Sparrow; *Peucaea cassinii; parasitism; B*rown-headed Cowbird; *Molothrus ater;* High Plains of Texas; mesquite-grasslands.

Cassin's Sparrows (*Peucaea cassinii*) frequently nest in native mixed-shrub grasslands (including Conservation Reserve Program (CRP) fields) in Arizona, New Mexico, Colorado, Nebraska, Oklahoma, Kansas and Texas (Berthelson and Smith 1995, Dunning et al. 1999, Ruth 2000, Thompson 2003). In the Southern High Plains of Texas, Cassin's Sparrows nest in mesquite (*Prosopis glandulosa*) grassland (Schnase 1984, Thompson 2003) as well as non-burned CRP pastures (Berthelson and Smith 1995, Oberheu et al. 1997, Thompson 2003), or CRP fields planted with native grass mixes with and without buffalo grass (*Buchlöe dactyloides*) (Thompson 2003), weeping lovegrass (*Eragrostis curvula*) (Oberheu et al. 1997, Thompson 2003) and Old World bluestem (*Bothriochlora ischaemum*), as well as blue grama (*Bouteloua gracillis*) mixes (Berthelson and Smith 1995). Contrasting with other endemic grassland birds, that often avoid habitats with woody plant cover, Cassin's Sparrows frequently use grassland habitats with significant woody plant cover (Dunning et al. 1999, Ruth 2000, Thompson 2003, Lynn 2006) and tend to reach greater nest densities in such habitats (see Thompson 2003). Although regional Breeding Bird Surveys do not detect enough Cassin's Sparrows to develop reliable trend estimates, most indicate general declines (Sauer et al. 2008). Information on Cassin's Sparrow breeding ecology is generally sparse (but see Borror 1971, Schnase 1984, Maurer et al. 1989, Schnase and Maxwell 1989, Schnase et al. 1991, Anderson and Conway 2000 for various dimensions of nesting biology and behavior).

Like most grassland bird species, Cassin's Sparrows are vulnerable to habitat loss, fragmentation, habitat degradation via overgrazing and other agricultural and range management practices, and may be susceptible to parasitism by Brown-headed Cowbirds (*Molothrus ater*; Dunning et al. 1999, Ruth 2000). Specific responses by Cassin's Sparrow populations to these perturbations are poorly understood but have demonstrated a tendency to avoid recently burned areas and occupy lightly grazed or non-grazed pastures (see Bock and Webb 1984, Bock and Bock 1999). Cassin's Sparrows are an uncommon Brown-headed Cowbird host (Friedmann 1931, Friedmann et al. 1977,

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Dunning et al. 1999), but a general lack of nesting data for this cryptic species may underestimate cowbird parasitism frequency. Although Cassin's Sparrows may be useful indicators of grassland health, their utility is contingent upon a sound understanding of its population biology (Vickery and Herkert 1999). We report here observations on Cassin's Sparrow breeding biology at two study sites in the Southern Great Plains of Texas.

STUDY AREA AND METHODS

From May-August 2001, we examined Cassin's Sparrow breeding biology in two mesquite grassland (*Prosopis glandulosa, Bouteloua* and *Panicum* spp.) study sites in Lubbock (Lubbock Lake Landmark [LLL]; 33° 35′32″ N, 101° 53′15″ W, 124 ha) and Lynn (Tahoka Lake Pasture [TLP]; 33° 14′52″ N, 101° 44′11″ W, 485 ha) counties, Texas. The LLL is a preserve currently undergoing restoration to native shortgrass prairie (approximately 100 ha). The TLP is approximately 250 ha of upland habitat adjacent to a saline lake. Both sites are relatively discrete mixed grassland patches (see Table 1), occuring within a larger matrix of rowcrop agriculture and some urban development. The Southern High Plains of Texas is characterized by hot summers averaging 25° C and often exceeding 31° C, with average precipitation of < 50 cm (NOAA 2003).

We located Cassin's Sparrow nests by flushing adults from nests, or using behavioral cues such as flight-song displays (see Anderson and Conway 2000), observing individuals flying short distances away, flushing close to observers, carrying nest material (sensu Thompson 2003) directly finding nests or identifying areas as appropriate habitat(s). Once such generalized areas were identified, we watched individuals sing and display, and then systematically searched those localized areas.

We marked each nest with numbered flagged stakes placed 3 m north of each nest and checked nests every 1-5 days until nest fate was determined. We considered nests successful if ≥ 1 young fledged (Mayfield 1975). Nests were considered unsuccessful if: eggs were absent prior to the estimated hatching date; obvious signs of predation or trampling (i.e., tracks, broken shells present,

Table 1. Means and Standard Errors (SE) of percent cover (%) and heights (cm) of vegetative types measured at Tahoka Lake Pasture and Lubbock Lake Landmark, May-August, 2001.

Vegetative type	Tahoka Lake (n = 50)[1] $\bar{x}$	SE	Lubbock Lake (n = 25) $\bar{x}$	SE
Cover				
Bare ground (%)	5.6	1.0	6.4	1.2
Grass (%)	17.1	1.4	22.7	3.1
Herbaceous (%)	23.9	1.9	52.8	3.5
Litter (%)	0.2	0.1	0.3	0.2
Shrub (%) (other)[2]	13.1	1.7	0.9	0.4
Mimosa biuncifera (%)	6.9	2.2	0.0	0.0
Opuntia spp. (%)	2.2	1.7	0.1	0.1
Prosopis spp. (%)	29.4	2.6	13.7	2.4
Yucca spp. (%)	3.0	0.5	3.2	0.8
Height				
Grass (cm)	28.1	1.8	34.8	2.6
Herbaceous (cm)	33.9	2.1	29.9	3.3
Shrub (cm) (other)[2]	35.7	3.2	18.3	8.2
Mimosa biuncifera (cm)	16.7	4.1	0.0	0.0
Opuntia spp. (cm)	3.1	1.2	8.0	0.8
Prosopis spp. (cm)	201.9	13.7	149.2	31.9
Yucca spp. (cm)	45.3	6.2	40.7	8.5

[1] n refers to the number of habitat plots established at each study site. We positioned four 50-m transects at 90° intervals. At 5-m intervals along each transect, we recorded vegetation type (e.g., woody, grass, forb, bare ground) and measured vegetation height (cm). Vegetation type data were converted to a percent value by summing the number of times each vegetation type was encountered along transects at each point, dividing by the total number of sample points (n = 40), and multiplying by 100.

[2] Shrub (other) refers to woody species other than *Mimosa biuncifera* and *Prosopis* spp..

crushed eggs, etc.) were visible; or nests contained a complete clutch 1 week beyond the estimated hatching date (abandoned).

We calculated nest success using a standard percent (i.e., number of successful clutches divided by the total number of clutches times 100) and a modified Mayfield estimate corrected for exposure (Mayfield 1975, Johnson 1979). We calculated days of exposure by terminating exposure with the midpoint between the last observed active and first observed inactive date for nests with known outcomes (Manolis et al. 2000). We used an estimated 20 day incubation and nestling period (Dunning et al. 1999, Thompson 2003). Calculations of 95% confidence intervals for Mayfield estimates followed Murphy et al. (1999). We present means and Standard Errors of vegetation type percent cover and height for each study site and Cassin's Sparrow nests at each study site.

RESULTS AND DISCUSSION

From May - August 2001, we monitored 15 Cassin's Sparrow nests (3 at LLL; 12 at TLP). Nests were discovered from 16 May to 21 June; 8 (53%) were discovered between 16 May – 31 May, and 7 (47%) between 1 June and 21 June. One nest discovered on 16 May had 2 nestlings. Given an 11-day incubation period (Dunning et al. 1999) and egg laying (1 per day) beginning 2-3 days after nests are already built (Schnase et al. 1991), earliest nest initiation dates for nests monitored during this study are estimated to be at least 2 weeks prior (i.e., ≈ 1 May). Clutches hatched as late as 6 July. Mean clutch size was 3.0 ± 0.2 (n = 15; range 1-4). Apparent nest success was 47% (7 of 15). Daily survival rate was 0.942 ± 0.194 with a modified Mayfield nest success estimate of 30% (95% Confidence Interval 20–46%). Most nest failures (7 of 8) occurred as a result of a single intense rain/hail storm on 30 May, when approximately 8 cm of hail was deposited during a single evening at TLP (WCC pers. observ.). No definitive predation events were recorded. One nest was abandoned.

Two nests (13%) were parasitized by Brown-headed Cowbirds; both at TLP. In both instances, an adult sparrow (gender unknown) was incubating and flushed from the nest. One nest discovered on 23 May (2 cowbird eggs; 2 Cassin's Sparrow eggs) was destroyed by hail. The second nest discovered on 21 June (1 cowbird egg; 1 Cassin's Sparrow egg) was abandoned by 6 July.

Cassin's Sparrow natural history remains poorly known (Bock and Scharf 1994, Dunning et al. 1999, Ruth 2000), as few studies have focused specifically upon them. Elusive, but locally abundant (given well timed precipitation; Dunning et al. 1999), Cassin's Sparrow nests are challenging to locate and populations are difficult to monitor accurately (Dunning et al. 1999). Within the context of larger, two-year projects examining grassland bird nesting ecology in CRP fields in the Southern High Plains of Texas, Thompson (2003) discovered 118 nests of several species, 28 (24%) were Cassin's Sparrow. Similarly, Berthelson and Smith (1995) monitored 218 nests of several species; 34 (16%) were Cassin's Sparrow nests. In both instances, all nests were in CRP fields or in grass-dominated study sites, as were six nests found in one CRP field in Lynn County, Texas (Oberheu et al. 1997). Schnase (1984) discovered 12 nests in mesquite dominated grasslands in Tom Green County, Texas, and is the only other study in the region that examined Cassin's Sparrow breeding ecology in non-CRP habitats.

Nest success was lower in this study (Mayfield estimate; 30 %) than found by Thompson (2003) (Mayfield estimate; 51%) or Berthelson and Smith (1995) (Mayfield estimate; 44%). Thompson (2003) reported all 12 nest failures were from predation; whereas, no causes of nest failure were reported in Berthleson and Smith (1995), and no nest success estimates were generated by Oberheu et al. (1997). No definitive nest predation occurred in this study.

Locally intense precipitation and hail events have long been documented as sources of adult bird and nest mortality (Hanford 1913, Lincoln 1931), but impacts of these events on birds are poorly known and rarely a focus of a specific bird study. Changnon and Changnon (1997) estimated that 7-8 hail days occur from June-August in our study counties, using combinations of 1948-1994 hail crop loss and National Weather Service data. Historical (1919-1994) hail database information from the Midwestern Regional Climate Center for Lubbock County shows 3.9 hail days occur per year (Steve Cobb, pers. comm.). Similarly, in Lynn County about 4 severe (≥ 1.9 cm) hail days occurred per year from 1988-2008 (Steve Cobb, pers. comm.). To our knowledge, the TLP record is the second documented nest failure due to weather in Cassin's Sparrow; the first was a nest record from the Cornell Laboratory of Ornithology Nest Record Program, which reported drowned nestlings in

1974 in Jim Wells County, Texas. Obviously, these hail day estimates represent a small fraction of the Cassin's Sparrow breeding season. However, nests may be susceptible to failure due to intense, but highly localized hail events if they occur throughout an entire breeding season.

Consistent with the lack of general natural history information for Cassin's Sparrows, their frequency as a Brown-headed Cowbird host and response(s) to parasitism remain poorly understood. Cassin's Sparrows are typically uncommon hosts (Friedmann 1931, Friedmann et al. 1977, Dunning et al. 1999). Using a total of 71 nest cards from 1889-1993 (obtained from both the Cornell Laboratory of Ornithology Nest Record Program 1954-1993 and the Western Foundation of Vertebrate Zoology, 1889-1970), only 2 (3%) Cassin's Sparrow nests were parasitized by cowbirds. In 1972, a nest with 1 cowbird egg and 4 Cassin's Sparrow eggs was reported in Jim Wells County, Texas on 23 May. In 1970, a nest with 1 cowbird egg and 4 Cassin's Sparrow eggs was discovered in Baca County, Colorado on 16 May. In the aforementioned studies within the Southern High Plains, neither Berthelson and Smith (1995) nor Oberheu et al. (1997) reported parasitism in their 40 combined nests. Thompson (2003) reported 1 parasitism in 28 (4%) Cassin's Sparrow nests and Schnase (1984) reported parasitism in 2 of 12 (17%) nests.

Parasitism impacts are more poorly documented than parasitism frequency. For example, Schnase (1984) documented 2 parasitized nests were abandoned, Thompson (2003) reported that 1 parasitized nest was abandoned, and 2 Cassin's Sparrows and 1 cowbird fledged from 1 nest in New Mexico (in Ruth 2000). The Jim Wells County, Texas nest appeared to be intact and empty approximately two weeks after discovery; whereas, the observer of the Baca County, Colorado nest pipped the cowbird egg 1 day after initial discovery, but no further information on nest success was reported. In this study, 1 nest was destroyed by hail, and 1 was abandoned. The abandoned nest, however likely did not have a complete clutch; it contained only 1 Cassin's Sparrow and 1 cowbird egg.

Few Cassin's Sparrow cogeners (except Bachman's Sparrows (*A. aestivalis*) have more than a few nests from which to draw inferences regarding either frequency or impacts of parasitism. Although Bachman's, Rufous-winged (*A. carpalis*), and Five-striped Sparrows (*A. quinquestriata*) have successfully fledged cowbird chicks (Collins 1999, Lowther et al. 1999, Dunning 2006, Reetz et al. 2008), these seem to be relatively uncommon occurrences. Rufous-crowned Sparrows (*A. ruficeps*) are an infrequent host (3 nest records), from which 1 cowbird nestling was reported (Collins 1999). How Cassin's Sparrows respond to parasitism remains poorly understood (see Dunning et al. 1999), and neither parasitized nest in this study had punctured eggs; a useful cue of host abandonment (Peer 2006). Nest abandonment may be a strategy by which Cassin's Sparrows react to cowbird eggs, as four nests reported here were abandoned. However, other reports of nest abandonment in cogeners may have been due to removal of cowbird eggs rather than the presence of the cowbird eggs directly (see Dunning 2006).

This study and Schnase (1984) were the only ones performed in mesquite dominated grasslands; all others in the region were performed in CRP fields and the 2 parasitism records in the Cornell Nest Cards were reported to be in yucca-sage grasslands. No study to date has monitored enough nests to ascertain true parasitism rates or impacts. Nevertheless, examining parasitism rates and impacts at landscape scales among different habitat types would be valuable. Future work should focus upon specifically addressing parasitism frequency and impacts on Cassin's Sparrows in structurally dissimilar habitats.

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SHORT COMMUNICATIONS

MORTALITY OF A BLACK-CHINNED HUMMINGBIRD FOLLOWING ENTANGELMENT IN A SPIDER WEB

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Owing to their small body size, hummingbirds are vulnerable to unusual sources of injury and mortality, including predation by invertebrates (McKenzie 1991). Dragonflies (*Odonata*) and praying mantids (*Mantodea*) have reportedly captured (Hildebrand 1949, Murray 1958) and killed (Butler 1949, Hofslund 1977) adult Ruby-throated Hummingbirds (*Archilochus colubria*). An adult Rufous Hummingbird (*Selasphorus rufus*) attacked by a hornet (*Vespula maculata*) was temporarily paralyzed, and yellow jackets (*V. arenaria*) were observed consuming nestlings (Grant 1959). However, the most common source of invertebrate-related mortality among hummingbirds is probably entanglement in spider webs, particularly those of orb-weavers (*Araneidae*) (McKenzie 1991). Species found entrapped in spider webs include Ruby-throated Hummingbird, Costa's Hummingbird (*Calypte costae*), and Anna's Hummingbird (*Calypte anna*) (Danforth 1921, Kirkham 1925, Woods 1934, Stott 1951, Hoyt 1960, McKenzie 1991). Here we report the death of a Black-chinned Hummingbird (*Archilochus alexandri*) following entanglement in a spider web.

On 16 April 2011, one of us (JM) found an adult female Black-chinned Hummingbird on the floor of an open warehouse, approximately 1 km E of the Sul Ross State University campus in Alpine (30° 21′ N; 103° 40′ W), Brewster County, Texas. Strands of spider web wrapped around the feet, bill, and wings effectively immobilized the hummingbird, which although alive when found, died about 10 min. later. We speculate the hummingbird tore free from the web after becoming entangled, but was unable to fly owing to the adhering strands and died of exhaustion. To our knowledge, this is the first report of a Black-chinned Hummingbird becoming entangled in a spider web (Johnsgard 1983, McKenzie 1991, Baltosser and Russell 2000).

It remains unclear how hummingbirds become entangled in spider webs, and actual entanglement events have apparently gone unobserved. Hummingbirds could become entangled when gleaning trapped insects from spider webs (Waide and Hailman 1977, Young 1971), foraging on young spiders (Wagner 1946), or gathering strands of webbing to use in nest construction (Johnsgard 1983). However, McKenzie (1991) suggested hummingbirds probably alert to webs when exploiting them for food and nest material, entanglement most likely occurs when birds inadvertently fly into webs while focused on nectar sources, or when pursued during territorial conflicts with conspecifics. Spider predation of trapped birds has not been reported, although an entangled Ruby-throated Hummingbird appeared to have been envenomated (McKenzie 1991). Entanglement in spider webs is probably more commonplace than the few available records suggest, and chance observations such as ours are important in documenting this poorly understood aspect of hummingbird life history.

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AERIAL BATHING BY BLACK-CHINNED HUMMINGBIRD

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On 18 June 2011 while watering an apricot tree (*Prunus armeniaca*) with a sprinkler attachment on a garden hose, I observed a Black-chinned Hummingbird (*Archilochus alexandri*) bathing while in flight. As the spray arched over the tree and descended to the ground the hummingbird flew into its path. The bird puffed up its breast and spread its tail while hovering in the water. After bathing for a few seconds, the hummingbird flew to a nearby branch and preened.

Occurrences of bathing by hummingbirds involved a standing position by splattering water onto the body while in small pools or utilizing water from an above source such as a waterfall or a sprinkler (Williamson 2001). Black-chinned Hummingbirds generally bath by splattering water from small pools, dipping into shallow water and fluttering in dew and foliage (Baltosser and Russell 2000) .

Bassett (1924) detailed a similar bathing behavior in Anna's Hummingbird (*Calypte anna*):

> "On 17 August, 1924, while watering my lawn in Alameda, California, I placed the sprinkler in position and had just turned on the water when an adult male Anna's Hummingbird flew into and poised in the dense spray. After glancing about for a moment he gradually assumed a vertical position and spreading his tail, then slowly settled to the ground, meanwhile drawing the tail back until it nearly reached the horizontal plane, when he actually 'sat' on the grass, the body erect and the tail spread out fanwise behind him. The wings continued to vibrate while in this position, but the strokes were much less frequent than when flying, being just sufficient to maintain a vertical balance. In a few seconds he began increasing the wing strokes and

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Aerial bathing by a Black-chinned Hummingbird.
Drawing by Robin Restall.

slowly ascended about a foot above the ground where he stayed a moment and then repeated the entire performance several times, after which he flew to a wire overhead"

Chavez and Moreno-Valdez (1999) observed Buff-bellied Hummingbirds (*Amazilia yucatanensis*) bathing under sprinklers by locating a low perch under the water spray. While bathing is a common maintenance behavior, documentation of aerial bathing by hummingbirds appears to be infrequent.

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FIRST SPECIMEN OF FLAME-COLORED TANAGER (PIRANGA BIDENTATA) FOR THE UNITED STATES

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The Flame-colored Tanager (*Piranga bidentata*), is distributed in Mexico from southern Chihuahua, Central Nuevo Leon and southern Tamaulipas extending south through Central America to Costa Rica and western Panama (American Ornithologists' Union. 1995, p. 579). This taxon is well represented from localities throughout Mexico, Central America and Panama in natural history collections . Here we report the first voucher specimen from the United States.

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Figure 1. TCWC No. 16153, first physical specimen of Flame-colored Tanager for the United States.

Confirmed Photographic Records from Texas

Piranga bidentata has been documented with seven photographic reports in Texas. Five of these are from Big Bend National Park and the Davis Mountains of West Texas. The other two records are from the Lower Rio Grande Valley. All photographic documentation of these seven records has been cataloged in the Texas Photo-Records File (TPRF) at the Texas Cooperative Wildlife Collections (TCWC) at Texas A&M University subsequent to vetting and species confirmation by the Texas Bird Records Committee.

Records from Trans-Pecos Region of West Texas

The species was formally documented in Texas in April, 1996, when two males were photographed at separate locations in Big Bend National Park, Brewster County (TPRF Nos., 1488, 1489). Since then, the species has been photographed two more times in the park [April 2002; June 2008; TPRF Nos. 2029 and 2587, respectively] and once in the Davis Mountains Resort in Jeff Davis County [October 2001; TPRF No. 2014].

Records from Lower Rio Grande Valley of Texas

In April 2002, a female Flame-colored Tanager was videotaped on South Padre Island, Cameron County (TPRF No. 2028) and in February 2005 in Pharr, Hidalgo County, a second-year male was photographed (TPRF No. 2301). See Lockwood 1998, 2003, 2004, 2006, and 2009 for details of these records.

The First United States Specimen of *Piranga bidentata*—TCWC 16,153.

On 5 March 2011, Gayle King, a realtor in McAllen, Texas, found an unfamiliar, freshly dead, brightly colored bird under a window when checking a model home at 4212 Wichita Avenue. She photographed the bird and placed the photo on Facebook. Marilyn LaManti, a friend of Ms. King, sent the photo to Tony Bennett, who immediately contacted Mary Gustafson, the senior author's subpermittee on state and federal salvage permits; she had the bird in her possession in less than a half-hour. The bird was immediately put in a freezer and soon thereafter transferred to Keith Arnold at the TCWC where it was prepared as a study skin and cataloged into the Bird Division collection. The tanager, an adult male, represents the first United States specimen and is the bright red northeastern Mexican subspecies, *P. b. sanguinolenta* (Fig. 1). Data for the specimen are: Texas, Hidalgo Co., McAllen, 4212 Wichita Ave.; 5 March 2011; weight 37g; male, testes 2 x 1 mm; skull ossification 100 per cent; moderate fat.

To assess the prevalence of voucher specimens for this species, we conducted a search of natural history museum holdings using the ORNIS data portal (www.ornisnet.org). We searched only for specimens with collection localities in the United States. The search returned one record from the University of Arizona Museum Natural History. The Arizona specimen (UAZ 14,814) actually consists of three photographs of an adult male Flame-colored Tanager, taken on 12 April 1985, the day after its initial discovery, in Cochise county, at the Lower South Fork of Cave Creek Canyon, Chiricahua Mountains. The photographs were taken by Robert Spahn of Webster, New York, and vetted by Tom Huels and Steven Russell. Thus, the Individual reported here (TCWC 16,153) represents the first physical specimen of this species collected in the United States.

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GOLDEN-CHEEKED WARBLER (*SETOPHAGA CHRYSOPARIA*) FEEDING ON CHILI PEQUIN IN WESTERN BASTROP COUNTY

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On 1-2 August 2011 I observed a Golden-cheeked Warbler (*Setophaga chrysoparia*) near Utley, Bastrop County foraging in dry scrub and repeatedly visiting a chili pequin pepper (*Capsicum annuum*) (Vines 1984). Golden-cheeked Warblers are very rare in Bastrop County and have only been noted during post-breeding dispersal in June and July usually as hatch-year birds. While this location is approximately 21.7 km from formerly occupied breeding habitat, there are only six records known from the county (Oberholser 1975) .

This behavior was documented using a remote wildlife camera (Bushnell). The photographs show an adult female consuming chili pequin (Fig. 1). A large plant is approximately 3 m from the water feature where the images were captured.

A literature search revealed no instances of Golden-cheeked Warbler feeding on vegetable matter (Ladd and Gass 1999). Pulich (1976) states in his seminal work on the species that "This bird is strictly insectivorous and, to the best of the author's knowledge, does not eat any form of vegetative matter." Chili pequins are native to northeast Mexico and southern Texas. The fruit (Fig. 2) is reported to be up to 40 times hotter than the familiar jalapeno, or about 110,000-14,000 units on the Scoville scale (Wikipedia 2011). While mammals shun the blistering fruits, some native birds use the plant as a food source.

Golden-cheeked Warblers typically leave their Hill Country breeding grounds by mid-July with small number still present through early August,

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Figure 1. Female Golden-cheeked Warbler with a chili pequin in its beak.

placing this individual in the latter portion of the migration period (Lockwood 2001). Central Texas was in the midst of a historic drought at the time of this observation and available water and insects were in short supply.

The observation provides a very rare, if not a first documented record of a Golden-cheeked Warbler feeding on vegetable matter

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Figure 2. Chili pequin (*Capsicum annuum*) plant.

COOPER'S HAWK NEST SITE CHARACTERISTICS IN THE PINEYWOODS REGION

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Early accounts describe the Cooper's Hawk (*Accipiter cooperi*) as a species in decline in much of North America during the early twentieth century (Bent 1937), particularly when in close proximity to humans (Eaton 1914). This decreasing population trend continued to be recognized later in the century in both Texas (Oberholser 1974) and Louisiana (Lowery 1974). Shooting and trapping during the first half of the 1900s, and pesticide use (especially DDT) after World War II are suggested as primary causes of the decline (Henny and Wight 1972, Bednarz et al. 1990). The Migratory Bird Treaty Act of 1972 and the ban on DDT during that same year, along with changes in human behaviors and attitudes have guided Cooper's Hawk populations toward recovery in areas negatively impacted (Bednarz et al. 1990, Johnsgard 1990). The overall North American population has increased substantially since the 1990s (Curtis et al. 2006), and the species is increasing as a breeder in parts of Texas, particularly in urban areas (Lockwood and Freeman 2004).

Cooper's Hawks nest in a variety of habitats in Texas including riparian woodlands, live oak mottes, pine-juniper-oak scrub, mixed pine-hardwood forest, and urban areas (Lockwood and Freeman 2004, Tweit 2007, RRS pers. obs.). The species is a scarce summer resident in the Pineywoods of eastern Texas (Wolf et al. 2001), and few confirmed breeding records are known from the region. Oberholser (1974) cited breeding records from Harrison County (eggs) and Upshur County (sight), but no dates are given. Texas Breeding Bird Atlas data provide one confirmed (Polk) and three probable (Angelina, two San Augustine) breeding records for counties within the Pineywoods during the 1987-1991 breeding seasons (Tweit 2007). The Northeast Texas Field Ornithologists' archives provided only a single report of breeding Cooper's Hawks from the northeastern Pineywoods (P. Barnes pers. comm.) in Harrison County (11-23 May 1996) where a female was observed by G. G. Luneau and others on a nest containing either eggs or very small young.

Archives of the Pineywoods Audubon Society contain three reports of Cooper's Hawk breeding activity (D. E. Wolf pers. comm.). The first was an observation in Nacogdoches County by C. D. Fisher of an adult and possible young birds heard nearby on 12 June 1974. The second report was a nesting pair near Garrison, Nacogdoches County during May 2004. A pair returned to the Garrison site in 2005, but no nest was found. The third sighting was from Angelina County where L. Debetaz located a nesting pair along a riparian nature trail in Lufkin on 28 March 2010. This pair nested successfully with one fledgling seen near the nest on 4 June 2010.

At the southern edge of the Pineywoods, an active Cooper's Hawk nest discovered at the Houston Arboretum and Nature Center (HANC), Harris County on 22 March 2008, fledged three young.

Here we describe the three most recently reported Cooper's Hawk nest sites (Table 1) and surrounding habitat (Table 2) for Garrison (31° 49′ 18.2″ N, 94° 31′ 24.3″ W), HANC (29° 45′ 53.9″ N, 95° 27′ 13.2″ W), and Lufkin (31° 18′ 58.5″ N, 94° 43′ 29.1″ W), for the Pineywoods. The HANC and Lufkin nests were located in large woodlots well within the city limits, providing additional evidence of expansion into urban areas (Lockwood and

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Table 1. Nest tree, nest height, and habitat measurements at three Cooper's Hawk nests in the Pineywoods region of eastern Texas.

Nest Tree/Habitat Variable	Nest A	Nest B	Nest C
Nest tree species	southern red oak[1]	loblolly pine[1]	loblolly pine[1]
Nest tree DBH[2] (cm)	70.5	34.0	34.0
Nest tree height (m)	20.1	22.5	23.0
Height of nest (m)	10.2	16.8	17.2
Forest canopy closure[3] (%)	32.0	91.8	90.5
Pine canopy BA[4] (m^2/ha)	0.0	8.5	14.0
Hardwood canopy BA (m^2/ha)	5.0	6.5	5.0
Pine mid-story BA (m^2/ha)	0.0	0.0	1.0
Hardwood mid-story BA (m^2/ha)	0.0	10.0	2.0

A Near the town of Garrison, Nacogdoches County.
B Houston Arboretum and Nature Center, Harris County.
C Azalea Trail, City of Lufkin, Angelina County.
[1] Southern red oak (*Quercus falcata*), loblolly pine (*Pinus taeda*).
[2] DBH = Diameter at Breast Height.
[3] Mean of four measurements at cardinal directions 15 m from the nest tree.
[4] BA = Basal Area.

Freeman 2004). The Garrison nest was located in a rural environment. The specific nest site was a large southern red oak (*Quercus falcata*) located near the edge of a pasture and only 77 m from a house.

Though confirmed reports of nesting in the Texas Pineywoods are scarce, Cooper's Hawks have been observed during the breeding season with some consistency and are probably more common as a breeder in the region than the few confirmed nesting observations suggest (Tweit 2007). The species' secretive behavior makes locating nests especially difficult in the heavily wooded Pineywoods.

Table 2. Percentage and number of hectares of each habitat type within a 1-km radius from each of three Cooper's Hawk nests in the Pineywoods region of eastern Texas.

Habitat Type	Nest A	Nest B	Nest C
Mature forest[1]	44.7 (140 ha)	52.9 (166 ha)	21.7 (68 ha)
Pine plantation[2]	17.6 (55 ha)	0.0 (0 ha)	0.0 (0 ha)
Mixed mature forest and pine plantation	11.0 (35 ha)	0.0 (0 ha)	0.0 (0 ha)
Clear-cut, pasture, field	25.3 (79 ha)	2.8 (9 ha)	3.5 (11 ha)
Urban with trees	0.0 (0 ha)	29.1 (91 ha)	43.5 (137 ha)
Structures and no trees[3]	0.6 (2 ha)	12.9 (41 ha)	31.1 (97 ha)
Surface water[4]	0.8 (3 ha)	2.3 (7 ha)	0.2 (1 ha)

A Near the town of Garrison, Nacogdoches County.
B Houston Arboretum and Nature Center, Harris County.
C Azalea Trail, City of Lufkin, Angelina County.
[1] Forest stands $\geq$ 50 years of age.
[2] Pine stands 10-30 years of age. Stands $<$ 10 years old were included with clear-cuts.
[3] Large buildings, parking lots, chicken houses, etc. (urban or rural).
[4] Lakes, ponds, and rivers (small streams not included).

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NESTING BY COMMON GROUND-DOVE AT FORT HOOD MILITARY RESERVATION

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The Common Ground-Dove (*Columbina passerina*) occurs across the southern United States and south through Mexico and Central America into northern South America to Ecuador and Brazil (American Ornithologists' Union 1998). The range in Texas covers approximately the southern third of the state including the coastal prairies, brush country, and southern Trans-Pecos (Lockwood and Freeman 2004). Outside of this region, Kostecke (2006) reported Common Ground-Doves occur

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Figure 1. Common Ground-Dove incubating on nest in Ashe Juniper at Fort Hood Military Reservation in Coryell County, Texas. Photograph by Gilbert Eckrich on 14 April, 2010.

regularly during the breeding season at Fort Hood Military Reservation in Coryell and Bell counties and suggested the species may breed there. Here, I report further on the occurrence of this dove at Fort Hood and document breeding.

Researchers regularly conduct point count surveys at Fort Hood to assess the relative abundance of the Golden-cheeked Warbler (*Setophaga chrysoparia*) and Black-capped Vireo (*Vireo atricapilla*) during the breeding season. From 1998 to 2005, researchers completed surveys in habitats of both endangered species and recorded detections of all avian species. Afterward, workers continued surveys annually following this protocol in the habitat of the warbler through 2011 but only completed them in vireo habitat in 2007. Over the 14-year period, Common Ground-Doves were detected in nine years (average of 2% of survey points range 0–9%) in habitat of the warbler. In habitat of the vireo, doves were detected each of nine years (8% average at survey points, range 3–18%).

On 12 April 2010, I discovered a Common Ground-Dove nest containing 2 eggs on Fort Hood in Coryell County approximately 1 km from the Bell County border. My attention was first attracted to the nest because an adult flushed and fluttered along the ground feigning injury in an apparent distraction display. The nest was 0.86 m above the ground in an Ashe Juniper (*Juniperus ashei*) resting against the main trunk and supported by two branches beneath it. On 12 and 14 April, I checked the nest and observed an incubating adult (Fig. 1). The nest was empty on 16 April, apparently depredated.

The frequency with which Common Ground-Doves were detected on point count surveys suggests the species occurs annually during the breeding season at Fort Hood but is not abundant. The species is known to occur in a variety early successional habitats as well as forest edges and habitats with trees that lack a closed canopy (Bowman 2002). This closely matches the habitat of the Black-capped Vireo at Fort Hood and likely explains why the dove was detected more frequently on surveys in the habitat this of species. Golden-cheeked Warblers at Fort Hood nest in oak/juniper forests both with and without a closed canopy. It is unclear whether detections of the dove on surveys in warbler habitat were near forest edges or in areas where the canopy was not continuous, but this seems likely.

The nest I observed was typical for the Common Ground-Dove. Most nests of the species are within 1 m of the ground and clutch size is predominately 2 eggs (Bowman 2002). Furthermore, the distraction display I observed has been previously described (Hailman 1989). The novel aspect of this nest was its location north of what has previously been considered the breeding range of the species in Texas. The Common Ground-Dove is known to breed in the state north to the southern edge of the Edward's Plateau east to the vicinity of San Antonio and several apparently territorial males have been noted at Balcones Canyonlands National Wildlife Refuge approximately 50 km south of Fort Hood (Lockwood 2001). The evidence I have presented here indicates it occurs and breeds farther north.

The content of this paper does not necessarily reflect the position or policy of the Government and no official endorsement should be inferred.

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THE BREEDING BIRDS OF URBAN SOUTH PADRE ISLAND

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I collected observational data on birds on Galveston Island, Galveston County (29° 18′ N, 94° 47′ W), Texas while walking a route along Sunset Drive to Palm Street (Fig. 1) from 0800 h to 1000 h. I documented birds by sight and sound. I also collected data on feeding of young or nest activities. I confirmed (confirmed if adult seen either feeding young, or sitting on/entering or nest) breeding a nesting or lack thereof.

After completion of the route each morning I compiled a list of species seen or heard and marked the location of species on a map of the route. I replicated the route six times from 13-28 June 2011. Weather conditions (rainfall, temperature and humidity) were assessed during observational periods.

I calculated a mean for the frequency of observations for each species with more than three observations to access the numerical abundance of each species.

I observed 16 species on my walks (n = 6). Only Great-tailed Grackles (*Quiscalus mexicanus*) and House Sparrows (*Passer domesticus*) were seen on every walk; whereas, the Buff-bellied Hummingbird (*Amazilia yucatanensis*) and Tropical Kingbird (*Tyrannus melancholicus*) were seen only once (Table 1).

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Figure 2. Outline in different colors are the 6 sections I divided the Galveston Island into for my walks. My northern limit was Sunset Drive, and my southern was Haas Street. I walked all the streets within and on the boundary lines.

The Great-tailed Grackle was the most common species observed followed by the House Sparrow. The least common species were those seen only one time, like the Buff-bellied Hummingbird (Table 2).

The most diverse count was on the Laguna Madre side of the island, where I documented 14 bird species.

The abundance of Eurasian Collared-Doves agreed with with my expectation (Rylander 2002), though Brush (2005) previously noted Eurasian-collared Doves were mostly found near grain elevators in the Lower Rio Grande Valley.

However, for some common species, I was interested in patterns related to their nesting habits. Great-tailed Grackles regularly nested in tops of palm trees among the bases of fronds, as well as having their more typical nesting in clumps of salt cedar (*Tamarix* sp.), particularly on the east side of the island. House Sparrows seemed to nest primarily under roof tiles, and Northern Mockingbird (*Mimus polyglottos*) nested in a low (1-m high) palm tree. I found three Great Kiskadee (*Pitangus sulphuratus*) nests, between telephone poles and their assorted parts.

For the uncommon island species, such as the Tropical Kingbird, Brown-crested Flycatcher (*Myiarchus tyrannulus*), and Brown-headed Cowbird (*Molothrus ater*), confirmed nesting remained elusive. Kingbirds were seen consistently in a pair at a small, grassy park, but I never saw

Table 1. Species seen, divided by those seen every time, sometimes, and once. For species seen occasionally, the number of times seen is shown.

Species Seen Every Walk	Species Seen	Species Seen Once
Rock Pigeon (*Columba livia*)	Mourning Dove (*Zenaida macroura*) 3x	Common Nighthawk (*Chordeiles minor*)
Eurasian Collared-Dove (*Streptopilia decaoto*)	Yellow-billed Cuckoo (*Coccyzus americanus*) 2x	Buff-bellied Hummingbird (*Amazilia yucatanensis*)
Inca Dove (*Columbina inca*)	Brown-crested Flycatcher (*Myiarchus tyrannulus*) 2x	Tropical Kingbird (*Tyrannus melancholicus*)
Northern Mockingbird (*Mimus Polyglottos*)	Great Kiskadee (*Pitangus sulphuratus*) 3x	Brown-headed Cowbird (*Molothrus ater*)
Great-tailed Grackle (*Quiscalus mexicanus*)	Barn Swallow (*Hirundo rustica*) 3x	Belted Kingfisher (*Megaceryle alcon*)
House Sparrow (*Passer domesticus*)		

Table 2. Species of bird and their corresponding mean number of individuals/walk, along with nesting confirmation.

Species Name	Means	Confirmed Nesting
Rock Pigeon	15.8	No
Eurasian Collared-Dove	12.2	Yes
Mourning Dove	0.8	No
Inca Dove	7.5	Yes
Yellow-billed Cuckoo	0.3	No
Common Nighthawk	0.5	No
Buff-bellied Hummingbird	0.2	No
Belted Kingfisher	0.2	No
Brown-crested Flychatcher	0.5	No
Tropical Kingbird	0.3	No
Great Kiskadee	1.5	Yes
Barn Swallow	2.5	No
Northern Mockingbird	5.3	Yes
Great-tailed Grackle	35.3	Yes
Brown-headed Cowbird	0.2	No
House Sparrow	27.2	Yes

them go to a nest. Brown-crested Flycatchers were a similar story, except I didn't see the birds again in the same area, perhaps because of the fragmentation of wooded habitats on that side of the island and their range covered many smaller woodlots.

The female Belted Kingfisher (*Megaceryle alcyon*), an undocumented species in the Lower Rio Grande Valley (Lockwood and Freeman 2005) in summer, inhabited the Laguna Madre side of the island on the corner of a building abutting the water. I only saw this bird once and could not determine breeding status, or whether it was a vagrant over summer.

The habitat on the Laguna Madre side of the island had more patches of woodlands than the Gulf of Mexico side, where most undeveloped lots consist of herbaceous plants and grasses. I noted that the Valley Land Fund's plot on West Sheepshead Street and the small woodlot by the South Padre Island Convention Center were excellent places for migrants in spring and fall, but they were almost entirely devoid of birds in summer. I only saw a Eurasian Collared-Dove at Sheepshead, and I found most Great-tailed Grackles at the Convention Center woodlot, along with a solitary Cattle Egret (*Bubulcus ibis*).

Eurasian Collared-Doves and Inca Doves (*Columbina inca*) were more abundant on the gulf side of the island, perhaps due to more grassy, low-growing plants in yards and road side of-the-road. Scattered bird seed along a fence, caused a feeding frenzy of Rock Pigeons (*Columba livia*) and Eurasian Collared-Doves.

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