FINAL REPORT

HORNED LIZARD LICENSE PLATE FUNDS PROGRAM

IMPACT OF EXOTIC INVASIVE PLANTS AND CURRENT LAND USE PRACTICES ON WINTERING AVIAN COMMUNITY STRUCTURE IN TEXAS COASTAL PRAIRIE

TPWD-SFASU CONTRACT NUMBER 189691

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October 31, 2010

Period Covered: September 1, 2008 – August 31, 2010

Abstract

Grassland dependent birds have been reported to be the most imperiled assemblage of migratory birds in North America. Although many migratory grassland passerines complete their annual life cycle within the United States, investigations into wintering ecology of these species are scarce, but important, particularly in ecoregions where habitat suitability and quality is considered to be compromised, such as the Texas coastal prairie. During 2008 – 2010, we investigated wintering grassland bird ecology as related to coastal prairie composition and management practices on the mid-upper Texas coast. To quantify grassland bird diversity, composition, and density among management regimes, 249 transect surveys were performed on 28 different study site pastures deployed among seven different management regimes from 28 October 2008 – 7 April 2009 and 17 November 2009 – 17 March 2010. Habitat structure, native and exotic plant composition and food availability was quantified using 596 vegetation sampling points and 513 seed traps deployed throughout the study period. A total of 74 bird species (48 species in 2008 –2009 and 60 species in 2009 – 2010) were recorded during surveys, and individual species densities estimates were calculated for eight species in 2008 – 2009 and for five species in 2009 – 2010. Bird species composition and densities varied between sampling periods (i.e., late fall – early winter or mid winter – early spring) and among management regimes, but were similar between years. Savannah Sparrow (*Passerculus sandwichensis*) and Eastern Meadowlark (*Sturnella magna*) densities and abundance were ubiquitous among study sites. However, Le Conte's Sparrow (*Ammodramus leconteii*) and Sedge Wren (*Cistothorus platensis*) reached their highest densities in habitats with greater vertical vegetation density, whereas the pipits (American Pipit [*Anthus rubescens*] and Sprague's Pipit [*Anthus spragueii*]) and Killdeer (*Charadrius vociferous*) reached greater densities in habitats with little or no

vertical vegetation structure. Eastern Meadowlark, Sprague's Pipit, Sedge Wren, Savannah Sparrow and Le Conte's Sparrow were the most abundant birds among all study sites.

Introduction

The original boundaries of the coastal prairie region comprised ca. 3.8 million ha extending from south-central Louisiana to south Texas along the northwestern Gulf of Mexico (Sims and Risser 2000). The southernmost tallgrass prairie in the United States, the coastal prairie ecoregion now only exists in a disjunct network of isolated patches in various stages of condition and size. Estimates from 10 – 20 years ago estimated that < 1% of the coastal prairie remained in relatively pristine condition (Diamond and Smeins 1984, Smeins et al. 1991, Arey et al. 1998). Continued degradation, alteration, and destruction have likely reduced the extent and integrity of remaining fragments. Coastal prairie preservation, conservation, management, and restoration are high conservation priorities for natural resource agencies and conservation interests in both Texas and Louisiana. Additionally, the inland coastal prairies are considered to be "imperiled"; one of the most endangered in North America and a Tier I, High Priority Ecoregion in the 2005 – 2010 Texas Comprehensive Wildlife Conservation Strategy (TPWD 2005).

The additive or cumulative impacts of alterations in historical disturbance regimes (i.e., fire, grazing, and flooding), land use (i.e., urbanization and agriculture), fragmentation, and patch size reduction, have all contributed to coastal prairie degradation. However, beyond the direct impacts of such perturbations on coastal prairie integrity, it has been hypothesized that alterations in natural disturbance regimes and associated anthropogenic pressures have also contributed directly to exotic species establishment, naturalization, and proliferation (Bruce et al. 1997, Barrilleaux and Grace 2000). For example, development of monotypic Chinese tallow (*Triadica sebiferum*) woodlands in degraded prairies, pastures, and abandoned agricultural fields, dramatically alters the physiognomic structure and ecosystem function of former prairie ecosystems (Conway et al. 1999). Moreover, widespread intentional native prairie conversion into exotic grass pastures (i.e., Australian bluestem (*Bothriochloa bladhii* subsp. *bladhii*), King Ranch bluestem (*B. ischaemum* var. *songarica*), bermudagrass (*Cynodon dactylon*), old-world bluestems (*Dichanthium* spp.), bahiagrass (*Paspalum notatum*), vasey-grass (*P. urvillei*), and Johnson grass (*Sorghum halepense*)), has also dramatically altered prairie species composition and function, by typically forming extensive monospecific stands. Such invasion and subsequent establishment is a result of (or contributor to) changes in natural disturbance regimes, alterations in invertebrate assemblage structure, and declines in overall habitat quality and availability for grassland birds (Brennan and Kuvlesky 2005).

Grassland birds are considered to be one of the most imperiled group of birds in North America, where Breeding Bird Survey (BBS) data indicate that many grassland bird species have been experiencing long term, dramatic, population declines for the last 30 years, at rates greater than any other ecological avian guild (Samson and Knopf 1994, Sauer et al. 1999, Samson et al. 2004). These declines are hypothesized to be the result of a combination of outright loss, degradation, and decreasing patch size of breeding and wintering grassland habitats (Samson and Knopf 1994, Johnson and Igl 2001). To date, most research on grassland bird ecology has focused upon breeding season events (i.e., nest success, productivity, habitat use, etc.) as related to habitat patch size, grazing, prescribed fire, and Conservation Reserve Program (CRP) fields (e.g., Berthelson and Smith 1995, Best et al. 1997, Deslisle and Savidge 1997, Johnson and Igl 2001). Recently, Vickery and Herkert (2001) called attention to (1) the large information gaps existing in wintering ecology of grassland birds, as their responses to grazing, prescribed fire, exotic invasive species, and patch size during winter are poorly known (see Gryzbowski 1976, 1982, 1983, Igl and Ballard 1999, Brennan and Kuvlesky 2005, Baldwin et al. 2007), and (2) the possibility that population declines are a result of grassland habitat management issues during winter within the United States. As opposed to Neotropical migrant landbirds (NTMs), which generally winter outside the continental U.S., many grassland birds are temperate migrants, whereby land management practices within the U.S. impact these birds throughout the annual cycle. Moreover, Texas coastal prairie is considered to be very important for wintering grassland birds (Igl and Ballard 1999). Because so few studies exist (see Vickery and Herkert 2001) examining the impacts of current land-use practices, patch size, habitat composition and structure, particularly as related to exotic invasive plants, there are few discrete examples of how temperate migrant wintering grassland bird declines are related to (1) events during winter or (2) Texas coastal prairie habitat quality.

Texas coastal prairie provides habitat for many wintering grassland birds (Igl and Ballard 1999), many of which are identified as species of concern (TPWD 2005) such as, Grasshopper Sparrow (*Ammodramus savannarum*), Henslow's Sparrow (*Ammodramus henslowii*), LeConte's Sparrow, and Sedge Wren (TPWD 2005). Beyond the aforementioned impacts of degradation and fragmentation, fire suppression and/or alterations in fire timing, frequency, and intensity can also adversely impact species (i.e., plant and animal) whose existence is predicated by fire (Baldwin et al. 2007), as well as increasing the likelihood of exotic invasive species invasion (Barrilleaux and Grace 2000). Moreover, overgrazing, native prairie conversion, and other alterations in sustainable grazing systems have reduced some former grassland systems to scrub-shrub areas, with limited grass production (Fuhlendorf and Engle 2001). Furthermore, overgrazing has been hypothesized to increase the probability of successful exotic invasive plant establishment (Fuhlendorf et al. 2002). Some have hypothesized that grassland bird declines have occurred when rangeland conditions and management practices have improved and become more sophisticated, whereby rangeland management techniques currently may be insufficient to maintain biological diversity (Fuhlendorf and Engle 2001). Despite recent work examining wintering grassland bird responses to prescribed fire (Baldwin et al. 2007), few studies have specifically examined how grassland birds use habitats dominated by exotic invasive species in grassland ecosystems. As such, to evaluate the impacts of winter habitat(s) on grassland bird declines, it is critical to simultaneously quantify wintering grassland bird abundance, species composition, and density as related to coastal prairie patch size, grazing and fire regimes, and native/exotic invasive plant composition within grasslands.

Objectives

The primary objectives of this study as related to grassland bird density and abundance are to:

1. Describe and quantify coastal prairie plant species composition and seed production.
2. Quantify wintering grassland bird presence, abundance, density, and species composition in Texas coastal prairies.
3. Relate coastal prairie habitat features (i.e., plant species, vegetative structure, patch size) and management practices (i.e., grazing, burning, etc.) with wintering bird presence, abundance, and density.

The objectives of this study as related to grassland bird capture and handling are to amplify and enhance meeting the research objectives outlined above:

1. Verify identification of species detected during distance sampling procedures (see above Objective 2).

2. Evaluate body condition of focal species (i.e., Savannah Sparrow, LeConte's Sparrow, Sedge Wren) as related to habitat using blood metabolite levels associated with fluctuations of fat reserves to elaborate upon Objective 2 and 3 above.
3. Determine broad scale movements and cohesion (connectivity) among populations of migratory grassland birds wintering in Texas coastal prairie using stable isotope signatures present in recently molted primary feathers.

Justification for primary objectives

This research, to our knowledge, is unique in several ways. First, there are few studies examining abundance, densities, or habitat use/associations of wintering birds in Texas coastal prairie (see Gryzbowski 1976, 1982, 1983, Igl and Ballard 1999) and only one (Baldwin et al. 2007) in the mid-upper Texas coast. As such, this research was conducted in an ecoregion of high concern for which few data currently exist in the published literature. As most wintering grassland birds are granivorous (Pulliam and Brand 1975), seed production is critical for overwintering survival and subsequent breeding success (*sensu* waterfowl winter-breeding season relationships). Therefore, if vegetative structure (as influenced by species, grazing, and fire) is provided by seed producing plants that are not valuable food sources during winter, such habitats (hypothesized to be dominated by tame pasture species or other exotic invasive species) may allow bird occupancy, but at lower densities (i.e., possibly exist as winter sinks). Conversely, if vegetative structure (as influenced by species, grazing, and fire) is provided by seed producing plants that are valuable food sources during winter, such habitats (hypothesized to be dominated by native coastal prairie species) should allow not only bird occupancy, but birds should exist at higher densities. As such, we can directly link wintering grassland bird occupancy, abundance, and density to plant species composition, structure, management regimes, and estimated seed production. Third, to our knowledge, no one has attempted to develop (1) seed production estimates, (2) seed prediction models, nor (3) GBUD in coastal prairie ecosystems in Texas. As such, we expect that through our bird surveys and vegetative analyses, we can begin to model/estimate wintering grassland bird abundance/density using patch size, plant species composition/structure, and seed yield models. The end product of this research is intended to be useful, easily quantifiable habitat measures that can be used to estimate habitat quality and predict grassland bird occupancy and abundance and directly influence current and future management of coastal prairies in Texas.

Justification for bird handling portion of this research

Capture and Handling:

At the simplest level, using mist nets to capture birds on established study sites for this research project will serve to corroborate bird species presence as determined via the field bird surveys executed using distance sampling.

Blood Sampling Portion:

Small quantities of blood can be drawn from birds with little impact on the individual (Stangel 1986). Physiological status can be quantified from measurements of blood metabolites which are associated with an individual's body condition and diet. Plasma triglycerides (Mueller and Dabbert 2002), free fatty acids, glycerol, uric acid (Jenni-Eiermann and Jenni 1998) and plasma corticosterone (Marra and Holberton 1998) can all be generated from live birds to assess bird body condition and physiological stress. These directly measure body condition and serve as superior alternatives to measures of body condition such as fat scoring, normalized body mass (Haramis et al. 1986), and morphological measures of size such as wing cord, primary, and tarsus length, which can be subjective and/or do not account for individual variation in size. By directly measuring these metrics, body condition can be estimated for focal species during winter. Again, as there are concerns regarding the impacts of exotic invasive plant invasion in coastal prairie habitats, we can directly assess body condition of species among study areas so as to more precisely address the magnitude of impacts of future conversion of these habitats. In short, we assume that native, remnant coastal prairie habitats will harbor focal species in better condition than other, poorer quality habitats. Such information can be useful for future conservation and restoration of these habitats, and directly evaluate the assertion that coastal prairie habitats dominated by exotic invasive plants provide poor wintering grassland bird habitats.

Feather Sampling Portion:

Research addressing questions about breeding locations and cohesion among bird populations during winter will provide information for range-wide conservation plans of grassland birds wintering in Texas coastal prairie. Previous research used feather samples collected during winter and/or migration to estimate breeding location and migratory connectivity in migratory birds by analyzing ^{2}H and ^{34}S fractions (Hobson and Wassenaar 1997, Kelly et al. 2002; 2005, Rubenstein and Hobson 2004, Hobson 2005). Migratory connectivity is the degree to which individuals of breeding populations winter together (Hobson 2005). When connectivity data generated through isotope analyses are combined with identified breeding locations and known capture locations during winter, we anticipate being able to more specifically address concerns regarding habitat during winter for these grassland birds.

METHODS

Study Area

This study was executed on the mid-upper Texas coast between 29 October 2008 – 7 April 2009 and 17 November 2009 – 17 March 2010. The extent of the study area was approximately 1 km from the inter-coastal waterway, north to southern Fort Bend County, west to southeastern Goliad County, and east to eastern Galveston County (Figure 1), which approximately falls within the southern extent of the historical tallgrass prairie ecoregion (Steinauer and Collins 1996) and the eco-type classified as emergent coastal wetlands (NOAA 2006). Within Texas, < 1% of the historic tallgrass prairie remains and prairie remnants in the study area exist as fragments (Figure 1) in a matrix of agricultural and urban development. Common vegetation of the region area consists of grasses such as little bluestem (*Schizachyrium scoparium*), gulf cordgrass (*Spartina spartinae*), bushy bluestem (*Andropogon glomeratus*) and brownseed paspalum (*Paspalum plicatulum*), forbs such as western ragweed (*Ambrosia psilostachya*), wooly croton (*Croton capitatus*), Virginia pepperweed (*Lepidium virgincium*) and snow on the prairie (*Euphorbia bicolor*), shrubs and semi-woody plants such as eastern baccharis (*Baccharis halimifolia*) and sawtooth blackberry (*Rubus argutus*). Prairies within this region vary from sites with little or no alteration in native flora to sites dominated by exotic plants. Common exotic invasive plants of the region consist of deep-rooted sedge (*Cyperus entrerianus*), gordo bluestem (*Dichanthium aristatum*), rattlebox (*Sesbania punicea*), Chinese tallow (*Triadica sebiferum*) and McCartney rose (*Rosa bracteata*). Management consists of parcels remaining idle for several years, mowing for hay, livestock grazing and/or burning for shrub control or to increase productivity (Anderson et al. 1970) and nutritional value for cattle (Pieper 2005; J. Laing *personal communication*).

Study Site Selection and Experimental Design

We selected 23 study site pastures on eight different private or publicly owned properties in 2008 – 2009 and 19 study site pastures on six different properties in 2009 – 2010 (Figure 1). Study site pastures were deployed among 7 treatments encompassing both common regional management practices and a range of floristic conditions (Table 1). Several study site pastures were grazed either just prior to, or during, both field seasons of this research. Within these grazed study sites, they were separated further based upon the timing of most recent prescribed burn. As such, there were replicates of each grazing-burning treatment combination: GB0 (burned after the growing season directly prior to the initiation of this study), GB1 (burned exactly one growing season prior to the initiation of this study), and GB2 (burned exactly two growing seasons prior to the initiation of this study). There were also replicates of the fourth treatment (UBG), which were study site pastures that had been neither burned nor grazed at least one growing season prior to the initiation of this study. Additionally, there were replicates of the fifth (NPM) and sixth (NP) treatments, which were native, coastal prairie study site pastures that had either been mowed (NPM) or not mowed (NP) after the growing season prior to the initiation of this study. Finally, there were replicates of the seventh treatment (FD), which are study site pastures containing substantial alterations in floral composition and dominance from native coastal prairie remnants, and were typically dominated by exotic invasive species such as deep-rooted sedge. If study site pastures occurred on the same property, individual pastures used for this study were separated > 500 m.

Bird Survey Transect Deployment

Within each study site pasture, a single 500 m transect was randomly deployed by defining the possible area to be surveyed in ArcView 9.3 (ESRI, Redlands CA) and selecting two random points within the polygon that defined the starting point and direction. Transects were placed a minimum of 50 m from study site pasture borders by minimal adjustment of the starting point and/or the direction if random points were near edges. Transects were at least 500 m, although final deployment and length were contingent upon size and shape of study site pastures. At NP and NPM study sites, transects were deployed so half was in each treatment.

Bird Surveys

Surveys were conducted using variable width transect surveys and distance sampling techniques (Buckland et al. 2001, Diefenbach et al. 2003), as these techniques are more robust than other point-sampling or fixed-width transect sampling techniques (Norvell et al. 2003, Buckland 2006). Surveys were conducted during two discrete temporal windows: early (28 October – 2 January) and late (17 January – 7 April). Each transect was surveyed 3 – 4 times during each sampling window, depending upon weather and logistical constraints, but consecutive surveys performed on an individual transect were separated by ≥ 10 days. Surveys were initiated when ambient light allowed reliable visual bird identification and were terminated 3 h after sunrise. Prior to each survey, air temperature (°C) and wind speed (m/sec) were recorded using a pocket weather meter (Kestrel 3000, Boothwyn PA). Ambient noise was also noted. Transect starting point, end point, and bearing were determined using a hand held GPS unit (Garmin eTrex Legend HCx) and a compass. Survey starting and ending times were recorded for each survey. All surveys were conducted by the same observer at a maximum pace of 1.5 km/hr, maintained by using the GPS and a stop watch. Every bird detected was identified to species (and sex when possible) using visual and/or vocal cues. Perpendicular distance (m) from the transect for each bird was ocularly estimated or measured using a laser range finder (Nikon Laser 1200). For each bird detected during surveys, detection cue type (i.e., visual, audible, or both) was recorded. If birds occurred in groups, total number of individuals within each group was recorded, as was the number of individuals by species.

Vegetation Surveys

Vegetation surveys were conducted by establishing 4 – 5, 100 m transects on each study site pasture. Vegetation sampling transects were positioned 100 m apart perpendicular to each bird survey transect, where the mid-point of the vegetation transect intersected the bird survey transect. Three sampling points were established on each vegetation transect: one at the intersection of the vegetation and bird survey transects, one 50 m to the left, and one 50 m to the right of the bird survey transect.

Vegetative structure was measured twice; once during the early sampling period (28 October – 2 January) and once during the late sampling period (17 January – 7 April). Horizontal structure was quantified by centering a 0.25 m^2 plot on each point and estimating the proportion (%) of cover for grass and forbs, differentiated into alive, dead, native, and exotic. Height (cm) of the tallest stalk for each group was measured. Litter depth at points was characterized by measuring the depth of dead and toppled vegetation to the nearest cm at the four corners of the frame. Horizontal cover and stature of woody vegetation was estimated by centering a 20 m diameter circular plot on each point. Vertical vegetation density was quantified by placing a Robel pole at the point and obtaining four visual obstruction readings (VOR; Robel et al. 1970) from directions separated by 90°.

Seed Rain Surveys

Seed rain within study site pastures was quantified using circular seed traps (total n = 513) installed at sampling points established during vegetation surveys in each pasture. Seed traps were constructed from a 10 cm diameter Nalgene powder funnel with a mesh bag fitted to the stem opening. Mesh bags were constructed from mosquito netting folded over and heat sealed at the seams so one edge was open and then attached to the funnel stem using rubber bands. Seed traps were deployed at points using an 8 cm long, 4 cm diameter PVC pipe driven into the ground, where the wide opening of the funnel remained 6 cm above the soil surface. When emptied, the used mesh bag was exchanged and placed into a plastic bag along with plant debris, soil, and seeds sitting in the funnel by pushing the material through the stem and brushing off the inner and outer surface with a clean cotton swab. Bags were labeled with collection date and sampling point identification, and air dried prior to sorting and identification.

Bird Capture and Handling

Grassland bird capture efforts were dispersed among sites, and were executed opportunistically throughout both the early and late sampling periods. Birds were captured using ≤ 5 mist nets, where all captured birds were identified to species, and aged and sexed (when possible) using molt limits, skull pneumatization and plumage dimorphism (if present), using Pyle (1997). All birds were banded using USFWS aluminum leg bands, and the following morphological characteristics were measured on each captured bird: total body mass (g), wing cord length (cm), tail length (cm), tarsus length (cm), culmen length (cm) and culmen width (cm). Once all morphological features were measured, two flight feathers were removed (Clark 2001) and stored in a labeled paper envelope (Smith et al. 2003). Blood samples were removed within 5 – 10 min of capture to ensure representative plasma metabolite levels (Jenni-Eiermann and Jenni 1998, Guglielmo et al. 2002). A 150 μl blood sample was removed from each individual using brachial veinopuncture, where blood was collected into a heparin coated (to prevent clotting) micro test tube and placed on ice. Tubes were centrifuged in the field for approximately 15 – 20 min until plasma and red blood cell constituents were clearly separated. Plasma was removed using a micropipette and placed in individually marked cryovials and frozen at -80º C (Mueller and Dabbert 2002). Red blood cells were placed into 10 ml of lysis buffer.

DATA ANALYSIS

Bird Species Diversity, Composition, and Density

Bird community structure was quantified by calculating species richness and species composition among sites and treatments. Density estimates were calculated for the most common species (> 30 detections, within sampling periods) using program Distance (Thomas et al. 2006). Global detection curve models were fit to species specific detection distance data to develop species specific detection probability curves (Buckland et al. 2001). For species in which most detections occurred in groups, detection probability models were fit for "clusters"; using size biased regression to calculate mean cluster size when regression slopes between cluster size (ln) and detection probability was significant ($\alpha \leq 0.15$). Species specific densities were calculated for each sampling period and management treatment. Density estimates resulting from different detection probability models were compared using AICc values, where (lower) AICc values indicated better model fit among the population of models. Differences in species specific densities were examined between years and periods (early [28 October – 2 January] and late [17 January – 7 April]) and among transects using repeated measures analysis of variance (ANOVA; PROC MIXED; SAS Institute 2002), repeated among transects with a compound symmetric covariance structure.

Vegetative structure and composition

Vegetative structure was quantified for each study site pasture and each treatment during each sampling period. At each vegetation point, means of the four visual obstruction readings (Robel) and litter depth measurements were calculated. To obtain an obstruction and litter depth value for each site/transect, all points within a site were averaged for each period and the mean and standard deviation of site values were calculated for each management type. For percent cover measurements, if a category was absent, a zero was recorded and included in the calculations. For measurements where height was to be recorded and the category was absent, the associated cell was left blank, so as not to include a zero in the analysis when no data were recorded. Linear regression models (PROC REG: SAS Institute 2002) were used to determine habitat variables most predictive of species specific bird densities. A set of *a priori* candidate models was developed that included biologically relevant combinations of the following habitat variables: surrounding vegetation (percent composition of native grass, deep rooted sedge, McCartney rose, cordgrass, forbs, shrubs, and bare ground), visual obstruction readings, and litter depth. Correlated variables were not permitted in the same models ($P > 0.05$). Akaike's

Information Criterion corrected for small sample size (AIC_c) was used to rank the model(s). Models were considered plausible if $\Delta AICc < 2$ (Burnham and Anderson 2002).

Seed Rain

For this final report seed biomass estimates were calculated from study site pastures in each management regime to obtain pooled seed biomass estimates, independent of individual species. Biomass was measured to the nearest 0.0001 g (0.1 mg). These values were summed for each point/seed trap to obtain seed biomass, and extrapolated to a biomass/m^2, by multiplying by 127.2. The scaling factor of 127.2 is appropriate, as each 10 cm diameter funnels sampled 0.00786 m^2.

Bird Capture and Condition Indices

We used captured birds to determine if condition of birds varied among management regimes. A measure of body size was derived using principal component analysis (PCA) to determine the first principle component corresponding to the measurements (e.g., wing cord length, tail length, tarsus length, culmen length, and culmen width) explaining the majority of the variability in size (PROC PRINCOMP; SAS Institute 2002). To derive an index of body condition, the residuals of a regression of body mass on the first principle component scores was used similar to Amat et al. (2001). Finally, an ANOVA (PROC MIXED; SAS Institute 2002) was used to test for differences in body condition among management regimes for species with sufficient sample sizes ($n > 30$) of captured birds.

RESULTS

Bird Species Richness and Composition

A total of 74 species were detected on 249 surveys conducted during the 2008 – 2009 and 2009 – 2010 study seasons (Table 2). A total of 48 species were detected on 134 surveys during 2008 – 2009 (Table 3) and a total of 60 species were detected in 2009 – 2010 (Table 4). Total species richness was greatest in GB0 (richness = 38), and least in NP (richness = 20; Table 5). Obligate grassland bird richness was greatest in sites that had been grazed and burned at least one year prior to the initiation of this study (i.e., GB1; Table 5). Facultative grassland bird richness was greatest in sites that had been grazed and burned during the growing season of the same year as the initiation of this study (i.e., GB0; Table 5).

Detectability and Density Estimates

Eight species (Killdeer, American Pipit, Sprague's Pipit, Sedge Wren, Le Conte's Sparrow, Savannah Sparrow, Swamp Sparrow [*Melospiza georgiana*], and Eastern Meadowlark) were observed frequently enough to develop detection probability functions and estimate densities in 2008 – 2009 and five species (Sprague's Pipit, Sedge Wren, Le Conte's Sparrow, Savannah Sparrow, and Eastern Meadowlark) in 2009 – 2010. Detection probability functions and density estimates were calculated using 249 surveys, where the outermost 5% of all detection distances were removed (Thomas et al. 2006). Detection probability curves for Sprague's Pipit, Sedge Wren, Le Conte's Sparrow, Savannah Sparrow, Swamp Sparrow, and Eastern Meadowlark were best modeled with the hazard-rate key function with no series expansion. American Pipits and Killdeer were typically detected in groups, so detection probability models were fit to observation "clusters". Both Killdeer and American Pipit detection probabilities were best modeled with the hazard-rate key function.

During the first year of this study, density estimates (birds/ha) for Savannah Sparrow and Sedge Wrens were quantified using 677 and 754 detections, respectively. These two species were the most frequently encountered species during the first year of this research. Density estimates for the remaining 6 species (Eastern Meadowlark, American Pipit, Killdeer, Le Conte's Sparrow, Sprague's Pipit and Swamp Sparrow) had successively fewer detections (295, 251, 175, 109, 78, 50), respectively. During the winter of 2009 – 2010 (i.e., second year of this study), Savannah Sparrows (814 detections) and Eastern Meadowlarks (441 detections) were the most frequently encountered species, both of which were detected more frequently during the second year of this study. In addition to Savannah Sparrows and Eastern Meadowlarks, Sprague's Pipits (125 detections) were detected more frequently in 2009 – 2010. However, Le Conte's Sparrows (66 detections) and Sedge Wrens (154 detections) were detected less frequently in the second year of this study.

Savannah Sparrows (Figure 2) and Eastern Meadowlark (Figure 3) densities tended to be ubiquitous among management regimes. Sedge Wren (Figure 4) and Le Conte's Sparrow (Figure 5) densities were greatest in management regimes with greater vertical vegetation density (i.e., GB2, UGB, and NP). Swamp Sparrow densities were only estimated for the first year of this study (< 30 detections in second year of study) and reached highest densities in pastures that were neither burned nor grazed (UGB; Figure 6). Sprague's Pipit (Figure 7), American Pipit (Figure 8), and Killdeer (Figure 9) densities were quite low among management regimes, but tended to occur at comparatively greater densities in recently burned, mowed, and/or grazed study site pastures. Density estimates for Killdeer and American Pipits were only calculated for the first year of study due to < 30 detections in the second year.

Due to few detections for Killdeer, Swamp Sparrows, and American Pipits in the second year of this study, these species were excluded from any subsequent analyses. Eastern Meadowlarks densities varied ($P < 0.05$) among management regimes (Table 6), where Eastern Meadowlark densities were greater in GB2 and NPM compared to other management regimes (Figure 10). No interactions, period, or year effects were detected ($P > 0.05$) for Eastern Meadowlarks (Table 6). Le Conte's Sparrow densities varied ($P < 0.05$) among management regimes (Table 6), where densities were greatest in plots with greater vertical vegetation density (e.g., NP and UGB; Figure 11). Moreover, Le Conte's Sparrow densities varied ($P < 0.05$) among periods (Table 6), where densities declined during the late sampling period (Figure 12). Finally, a management regime * period interaction occurred ($P < 0.05$) for Le Conte's Sparrows (Figure 13), but, no other effects were significant ($P > 0.05$) (Table 6). No management * period * year, management * period, management * year, nor period * year interactions were detected ($P > 0.05$) for Savannah Sparrows, whose densities were similar ($P > 0.05$) among management regimes, periods, and years (Table 6). Similar to Le Conte's Sparrows, Sedge Wren densities varied ($P < 0.05$) among management regimes (Table 6), where Sedge Wren densities were greatest in management regimes with greater vertical vegetation density (e.g., NP, UGB, and GB2; Figure 14). No management * period * year, management * period, nor management * period interactions ($P > 0.05$) occurred, nor did period or year ($P > 0.05$) influence Sedge Wren densities (Table 6). However, Sedge Wren densities were related ($P < 0.05$) to the interaction between period and year (Table 6; Figure 15). Sprague's Pipit densities varied ($P < 0.05$) among management regimes (Table 6), reaching greatest densities in regimes with little or no vertical vegetation structure (e.g., NPM, GB0, and GB1; Figure 16). No management * period * year, management * period, management * period, nor period * year interactions ($P > 0.05$) occurred, nor did period and year ($P > 0.05$) influence Sprague's Pipit densities (Table 6).

Vegetative structure and composition

A total of 596 vegetation points were sampled during the two field seasons (Table 7). Vegetative structure of the study sites (by management regimes) generally corresponded well with the visual interpretation of the density estimates (see previous section). To more clearly delineate relationships among habitat variables and focal species densities, linear regression models were developed for Eastern Meadowlark, Le Conte's Sparrow, Sedge Wren, Savannah Sparrow, and Sprague's Pipit biologically relevant combinations of habitat variables. Correlated variables were not entered into the same model, and as most habitat variables were correlated, only 18 candidate models could be developed for each focal species.

Among the population of 18 models developed using linear regression to predict Eastern Meadowlark density, there was no top model (i.e., not sufficient evidence to reject the intercept as a plausible model; Table 8). The lack of any habitat-meadowlark density relationship emphasizes their ubiquitousness among management regimes in this study. Among the population of 18 models developed using linear regression to predict Le Conte's Sparrow density, the best model ($AIC_w = 0.670$) contained vertical vegetation density (i.e., Robel Pole; Table 9). The second-best model ($\Delta AIC_c = 1.45$, $AIC_w = 0.330$) was the additive model of % forbs and vertical vegetation density (Table 9). Le Conte's Sparrow densities increased in study sites with greater vertical vegetation density and a greater percent composition of forbs.

Among the population of 18 models developed using linear regression to predict Savannah Sparrow density, the best model ($AIC_w = 0.360$) was the additive model of % deep rooted sedge and litter depth (Table 10). The second-best model ($\Delta AIC_c = 0.630$, $AIC_w = 0.260$) was the single variable model containing % deep rooted sedge (Table 10). Savannah Sparrow densities increased as percent composition of deep rooted sedge also increased and decreased as litter depth increased.

Among the population of 18 models developed using linear regression to predict Sedge Wren density, the best model ($AIC_w = 0.500$) was the additive model of % deep rooted sedge and litter depth (Table 11). The second-best model ($\Delta AIC_c = 1.17$, $AIC_w = 0.280$) was the single variable model containing litter depth, while the third best (plausible) model ($\Delta AIC_c = 1.58$, $AIC_w = 0.230$) was the additive model of % native grass and litter depth (Table 11). In contrast to Savannah Sparrows, Sedge Wren densities increased as percent composition of deep rooted sedge decreased and litter depth and percentage of native grasses increased.

Among the population of 18 models developed using linear regression to predict Sprague's Pipit density, the best model ($AIC_w = 0.560$) was the single variable model containing vertical vegetation density (i.e., Robel; Table 12). The second-best model ($\Delta AIC_c = 0.890$, $AIC_w = 0.360$) was additive model of vertical vegetation density and % forbs (Table 12). From the top models, Sprague's Pipits densities increased as vertical vegetation density decreased and percentage of forbs increased.

Seed Rain

Preliminary analysis of biomass of seed available per 1 m^2 in each management type indicates seed biomass was similar among management regimes ($F = 2.03$; 4, 174; $P = 0.054$).

In general, seed biomass tended to be greatest in pastures with the GB2 management regimes and lowest in GB0 management regimes (Table 13). Further analyses project seed production and estimates will be performed.

Bird Handling

Preliminary analyses of body condition as estimated by blood metabolite levels have been performed, but no analyses have been conducted. Similarly, the stable isotope work has not begun. Overall, 266 individual birds were banded comprising 16 species (Table 14). During the first field season, 21 mist-netting sessions were performed, where 154 individual birds were captured. Three species (Sedge Wren, Savannah Sparrow, and LeConte's Sparrows) accounted for 66% (n = 102) of all captures. During the second field season, 10 mist-netting sessions were performed, where 112 individual birds were captured and again three species (Sedge Wren, Savannah Sparrow, and LeConte's Sparrows) accounted for > 87% (n = 98) of all captures. Analysis of body condition as estimated by morphological measurements indicate that condition for Savannah Sparrows ($F_{5,\,95} = 3.35$; $P = 0.008$) and Sedge Wren's ($F_{5,\,36} = 5.39$; $P = 0.001$) varied among management regimes. Savannah Sparrows were in better condition in UGB and NP management regimes and Sedge Wren's were in better condition in disturbed sites. Le Conte's Sparrows were in similar ($F_{5,\,38} = 2.30$; $P = 0.064$) condition among management regimes.

Discussion

During the last quarter-century, grassland birds have shown greater and more consistent continental population declines than any other avian group in North America (Knopf 1994, Peterjohn and Sauer 1999). Although most studies implicate loss, fragmentation, and degradation of grassland habitats on the breeding grounds as the primary mechanism driving recent declines, several studies have argued that some grassland bird populations are limited by events affecting survival during the non-breeding season (Fretwell 1972, Knopf 1994, Igl and Ballard 1999, and Peterjohn and Sauer 1999, Woodin et al. 2010). However, few studies have explored types of habitats migratory birds use during the non-breeding season (Herkert and Knopf 1998), making the relative contribution of changes in habitat used during winter difficult to assess. Similar to previous studies (Gryzbowski 1983, Igl and Ballard 1999), we found grassland bird species during the non-breeding season occupying habitats that are structurally similar to habitats occupied on the breeding grounds. For example, selection of low stature vegetation by Sprague's Pipits was evident during the wintering season, where highest densities were observed in recently burned and grazed prairies (GB0 and GB1) and mowed native prairies (NPM) and is consistent with selection patterns during the breeding season (Dechant et al. 1998a). Furthermore, selection of prairies with high vertical vegetation densities (GB2, UGB, and NP) by Le Conte's Sparrow and Sedge Wren was similar to selection patterns observed during the breeding season (Dechant et al 1998b, Dechant et al. 1998c).

Because many grassland species of concern (e.g., Sedge Wren, Sprague's Pipit, and Le Conte's Sparrow; U. S. Fish and Wildlife Service, 2008) utilize different habitats (e.g., low stature grasslands that were grazed/burned or mowed selected by Sprague's Pipit, high vertical density selected by Sedge Wrens and Le Conte's Sparrow, and increased litter depth by Sedge Wrens), maintaining a mosaic of habitats with varying vegetation density is necessary to provide sufficient food and cover for wintering grassland birds. Historically, bison (*Bison bison*) and fire maintained a disturbance regime that maintained a mosaic of successionally distinct plant communities that helped fulfill the habitat requirements of grassland bird communities (Brennan and Kuvlesky 2005). However, in many grasslands throughout the U.S., natural fire regimes have been suppressed, cattle have replaced native bison, and non-native species have been introduced, often resulting in a monoculture of grassland characteristics (e.g., height, species, etc.; Woodin et al. 2010). In order to restore native grasslands, many management practices have been utilized including prescribe fire, renovation of historical hydrological regimes, controlling exotic invasive plant species, mowing, and rotational grazing.

Prescribed fire is commonly used to manage habitat conditions (i.e., maintain habitats in suitable condition) for birds in some grassland types (Van't Hul et al. 1997, Madden et al. 1999, Tucker and Robinson 2003,) particularly in the southeastern United States. However, responses of vegetation following fire can be influenced by factors such as rainfall, soil type, and season of burning. From this study, it appears that grassland bird densities are impacted more by vegetative structure rather than management regime, although management regime does influence the vegetative structure. Baldwin et al. (2007) suggests that a mosaic of coastal prairie in 2 – 3 year burn rotation provides suitable habitat for overwintering birds. These intensive management practices may provide suitable habitat for most grassland bird species observed in this study (e.g., Eastern Meadowlark, Le Conte's Sparrow, Sedge Wren, Sprague's Pipit, and Savannah Sparrow), however, several species of concern (e.g., Grasshopper Sparrow and Henslow's Sparrow) were only detected in ungrazed/unburned prairies and native prairies.

These species appear to be more habitat specialist in the winter which can further complicate implementation of management practices. Therefore, management plans need to include 1) prairies that are in 2 – 3 year burn rotation, 2) prairies that remain ungrazed and unburned for > 3 year but are comprised of native vegetation, and 3) maintaining and establishing native prairies that are floristically diverse and maintained through mowing rather than fire. Maintaining a diverse array of habitats can provide sufficient wintering grounds for grassland birds, however, it is unknown if the amount of current prairie habitat is sufficient to support current populations without forcing individuals into sub-optimum habitat.

Within coastal Texas prairies, controlling exotic invasive plant species is a primary management goal. Previous studies in south Texas found that species richness (i.e., diversity) of birds was greater in native grasslands than in exotic grasses (Woodin et al. 2010). In this study, disturbed sites (i.e., those that contain exotic invasive plant species) had similar bird diversity as most managed prairies, however, the diversity of obligate and facultative grassland bird species was lower than in other management regimes. For example, disturbed sites were typically occupied by more cosmopolitan species (e.g., Eastern Meadowlark, and Savannah Sparrow) that have less rigorous habitat requirements, while obligate grassland bird species such as Sedge Wrens had higher densities in grasslands with fewer exotic invasive plants species. Furthermore, higher densities of birds observed in disturbed sites could be a result of poor seed crop in native prairies during 2010 that potentially forced birds to take advantage of whatever food was available (i.e., seeds from exotic species). In addition to reducing floristic diversity and impacting food availability (Flanders et al. 2006), exotic invasive plant species may alter flow of energy and nutrients in the soil (Christian and Wilson 1999), fire regimes (Brooks et al. 2004), and rates of litter accumulation and decomposition (Olge and Reiners 2003), resulting in dramatic alterations to prairie functions. Because of this, prairies may become functionally smaller, reducing functional grassland habitats available to over-wintering birds. Due to the continual decline in prairie habitat throughout coastal Texas it remains important to not only manage for vegetation structure but also control exotic invasive species.

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Figure 1. Locations and labels of coastal prairie study areas used to examine wintering grassland bird ecology on the mid to upper Texas coast. Locations of study areas are indicated by triangles and number of sites on each are in parenthesis after property labels. Number of sites at each study area was consistent between years; however, Brazoria National Wildlife Refuge and El Papalote Ranch were not used in winter 2009 – 2010. Remnant pastures, grassland, hay and emergent wetlands/meadows patches appear in green (NOAA 2006).

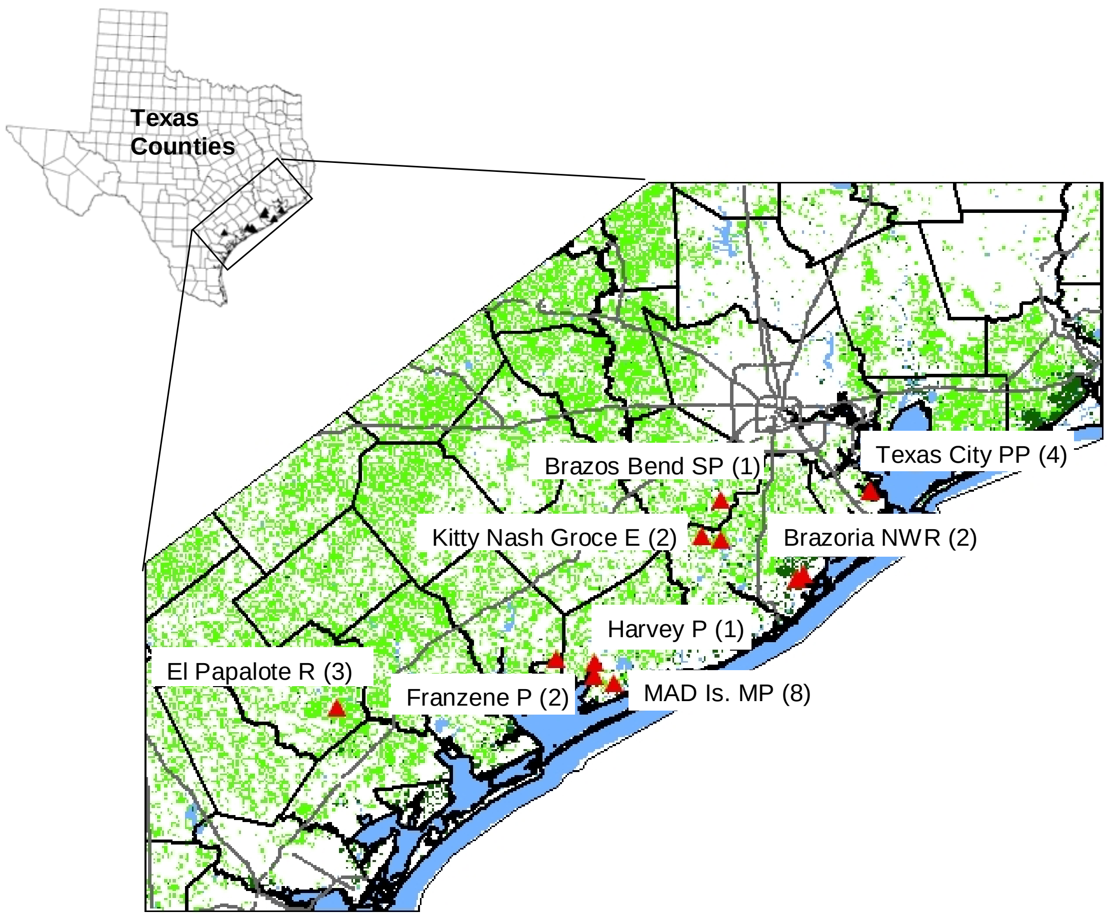


Figure 2. Density estimates (number/ha) of Savannah Sparrow (*Passerculus sandwichensis*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during (A) winter 2008 – 2009, (B) winter 2009 – 2010, and (C) both years combined.

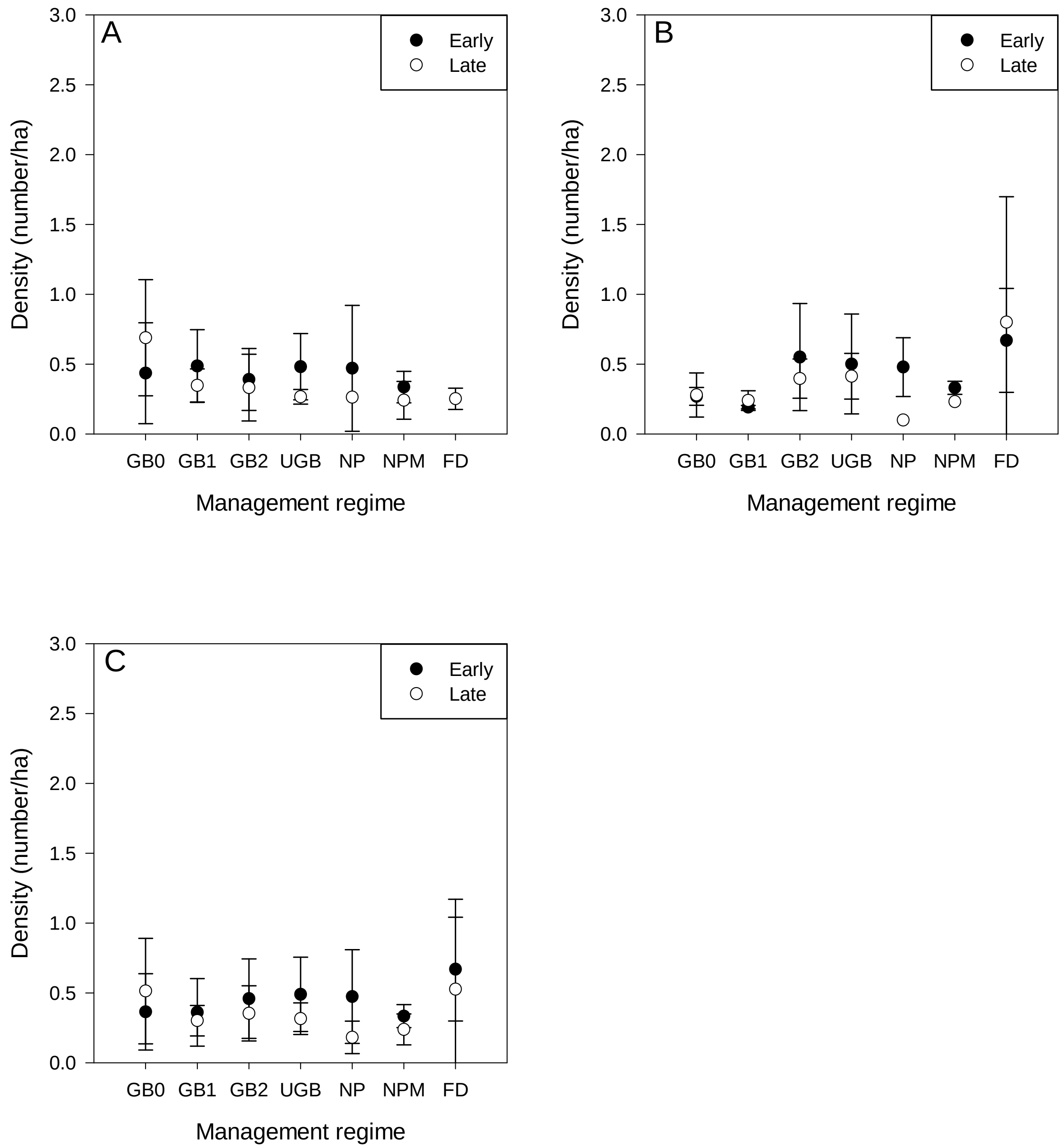


Figure 3. Density estimates (number/ha) of Eastern Meadowlarks (*Sturnella magna*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during (A) winter 2008 – 2009, (B) winter 2009 – 2010, and (C) both years combined. (See Table 1 for management regime descriptions).

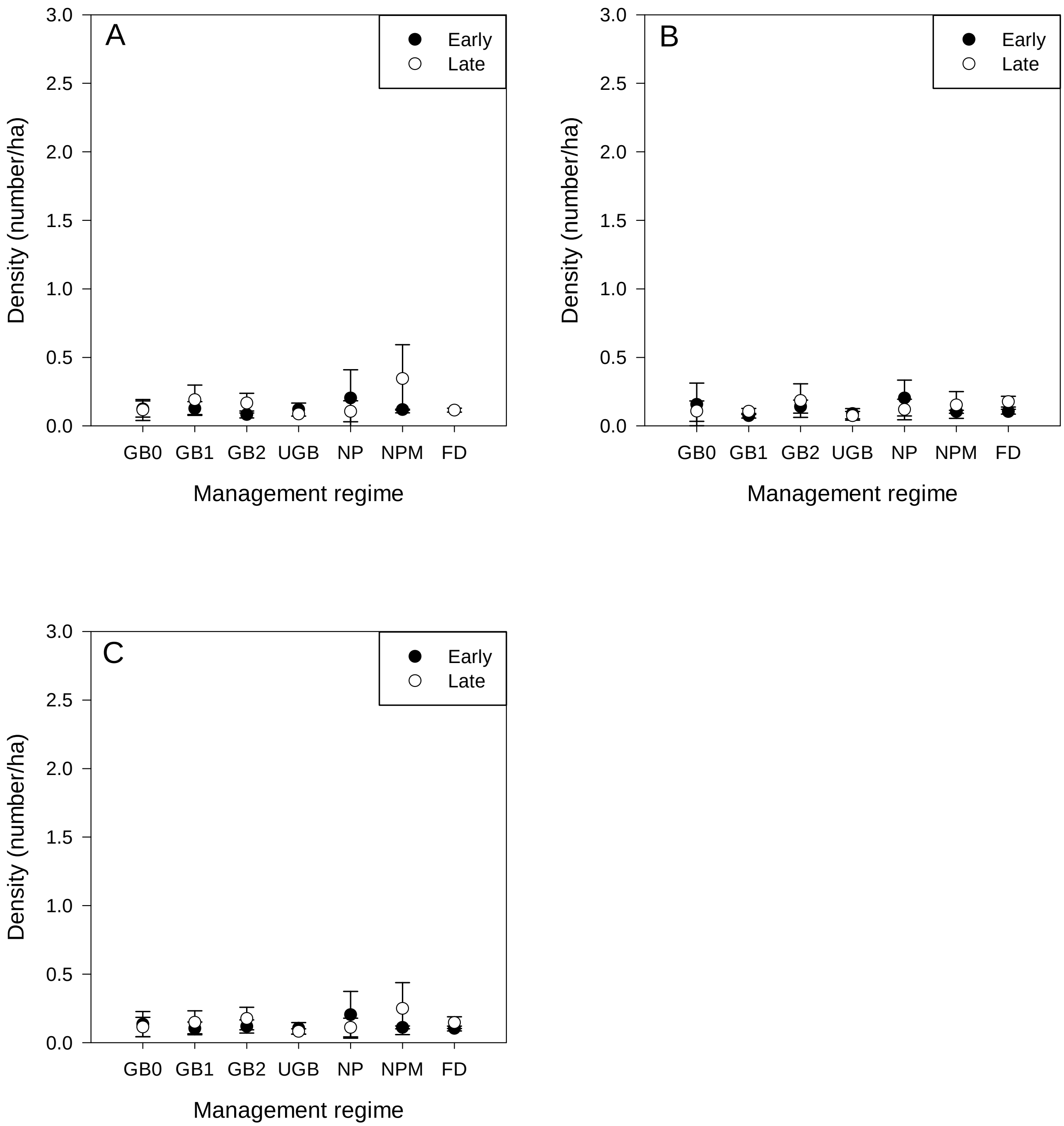


Figure 4. Density estimates (number/ha) of Sedge Wren (*Cistothorus platensis*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during (A) winter 2008 – 2009, (B) winter 2009 – 2010, and (C) both years combined. (See Table 1 for management regime descriptions).

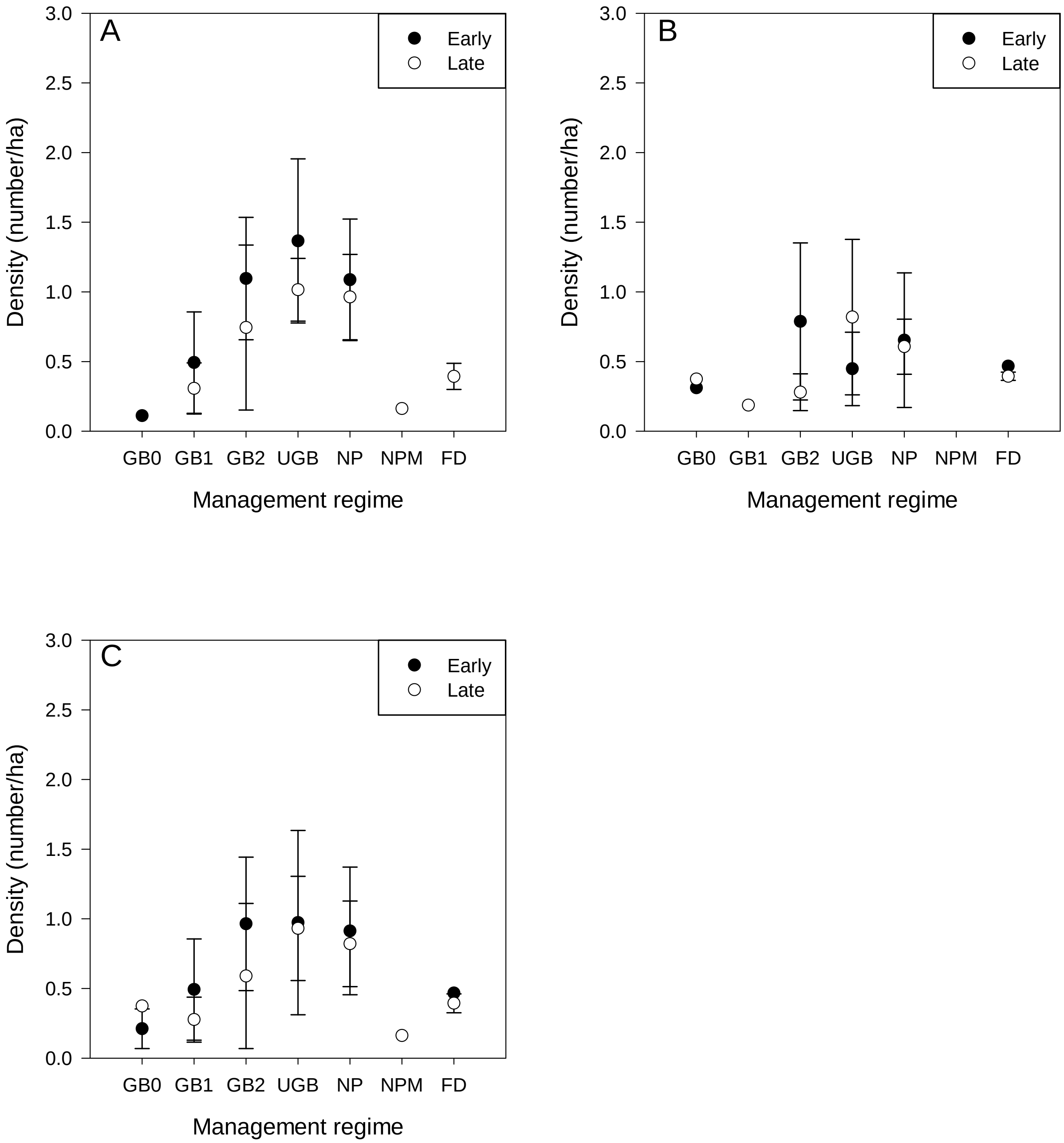


Figure 5. Density estimates (number/ha) of Le Conte's Sparrow (*Ammodramus leconteii*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during (A) winter 2008 – 2009, (B) winter 2009 – 2010, and (C) both years combined. (See Table 1 for management regime descriptions).

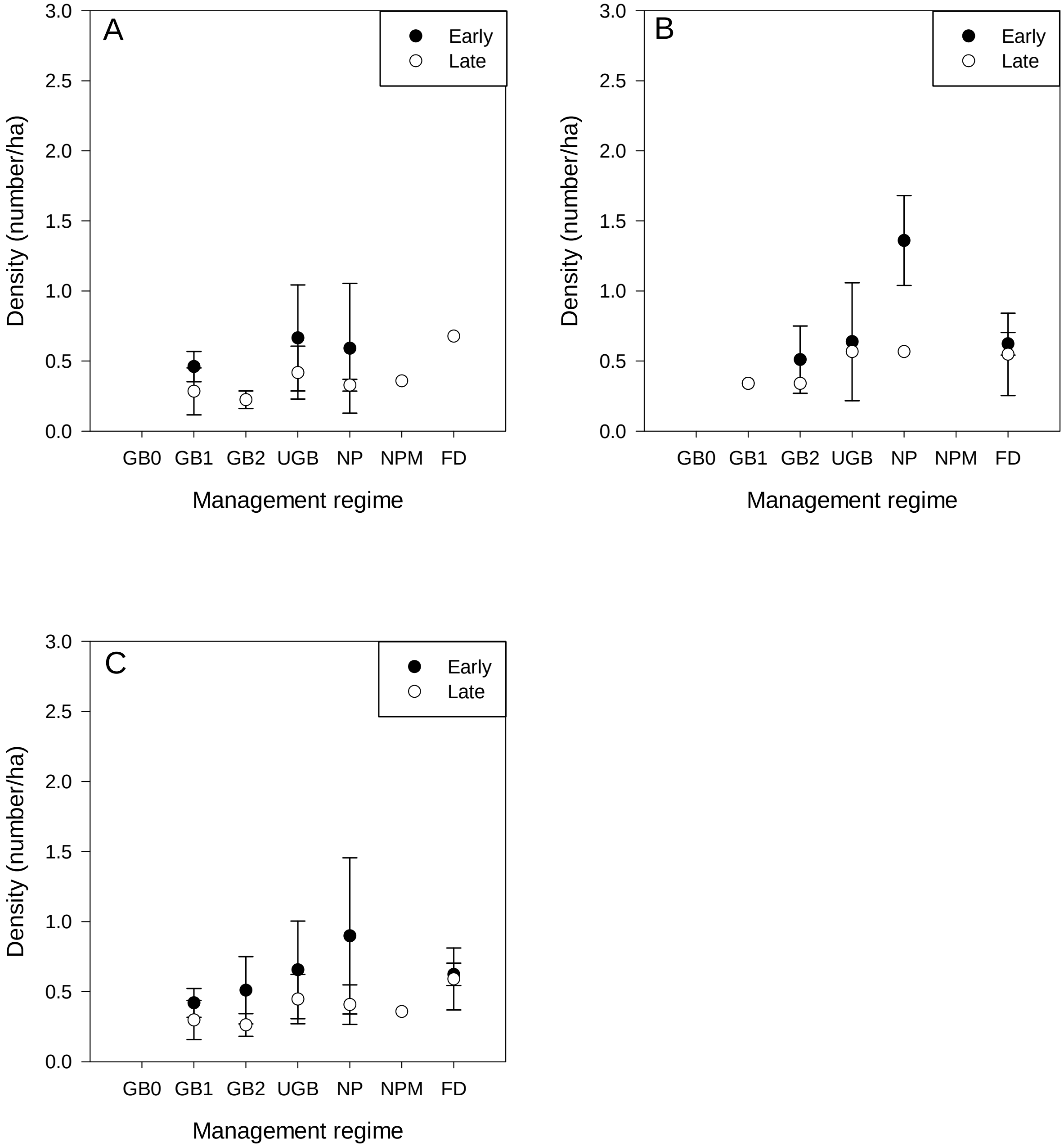


Figure 6. Density estimates (number/ha) of Swamp Sparrow (*Melospiza georgiana*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during winter 2008 – 2009. (See Table 1 for management regime descriptions).

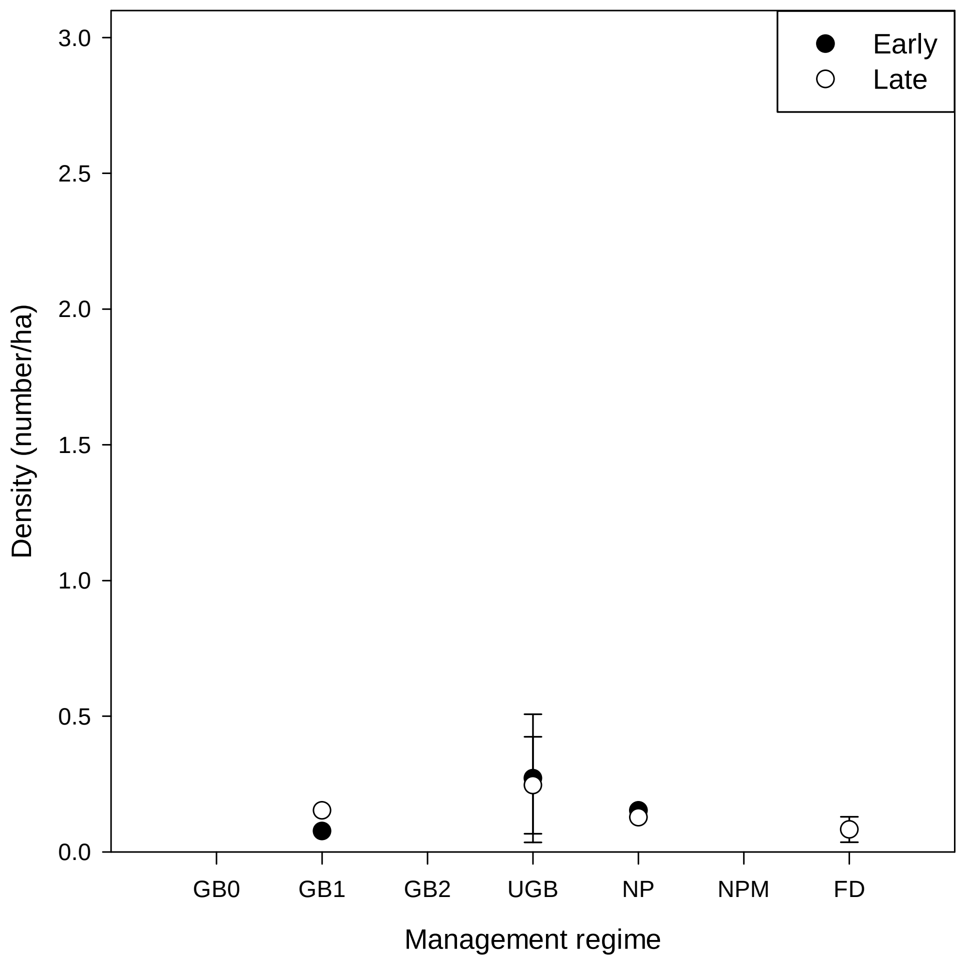


Figure 7. Density estimates (number/ha) of Sprague's Pipit (*Anthus spragueii*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during (A) winter 2008 – 2009, (B) winter 2009 – 2010, and (C) both years combined. (See Table 1 for management regime descriptions).

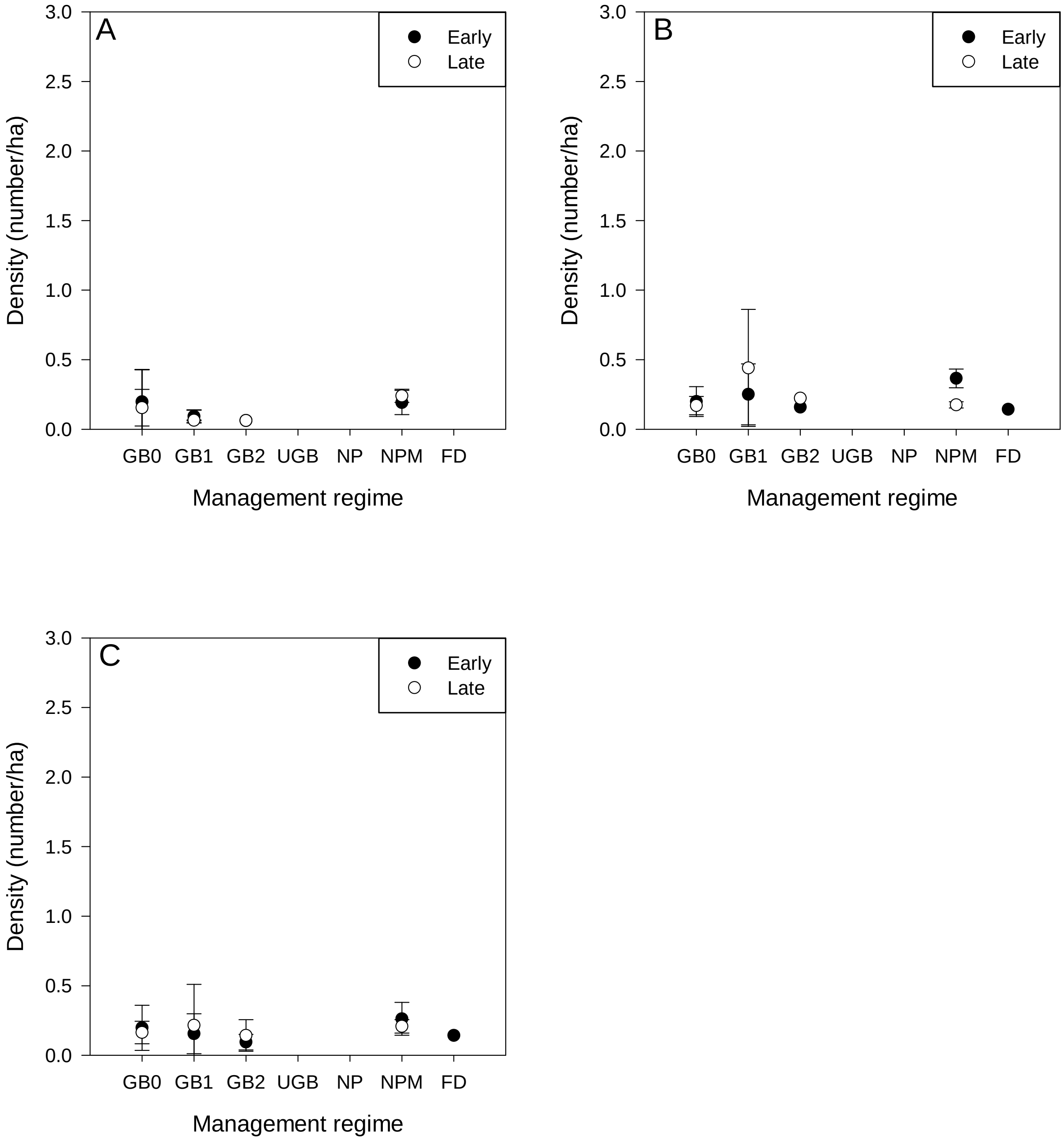


Figure 8. Density estimates (number/ha) of American Pipit (*Anthus rubescens*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during winter 2008 – 2009. (See Table 1 for management regime descriptions).

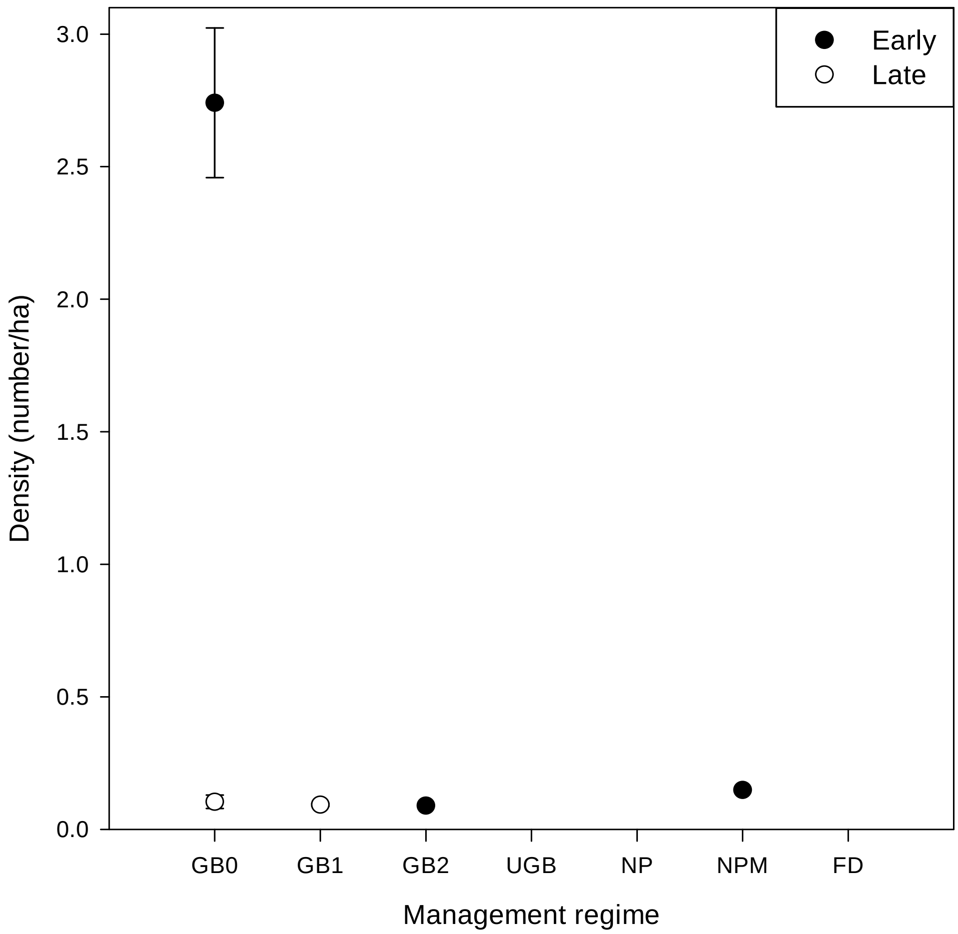


Figure 9. Density estimates (number/ha) of Killdeer (*Charadrius vociferous*) among management regimes during early (28 October – 2 January) and late (17 January – 7 April) sampling periods in coastal Texas during winter 2008 – 2009. (See Table 1 for management regime descriptions).

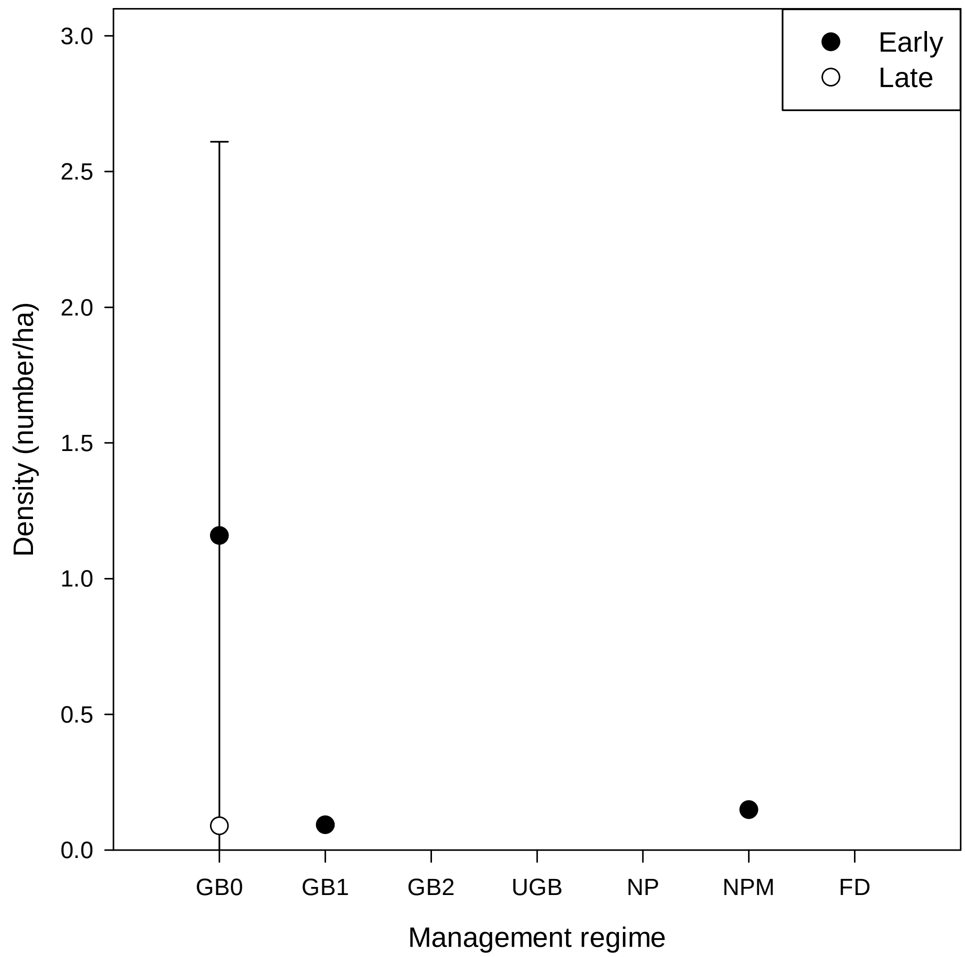


Figure 10. Parameter estimates from a repeated measures analysis of variance testing for differences in Eastern Meadowlarks (*Sturnella magna*) densities among management regimes within coastal prairies in Texas. Means followed by the same letter are not different ($P > 0.05$; least squares cross validation). (See Table 1 for management regime descriptions).

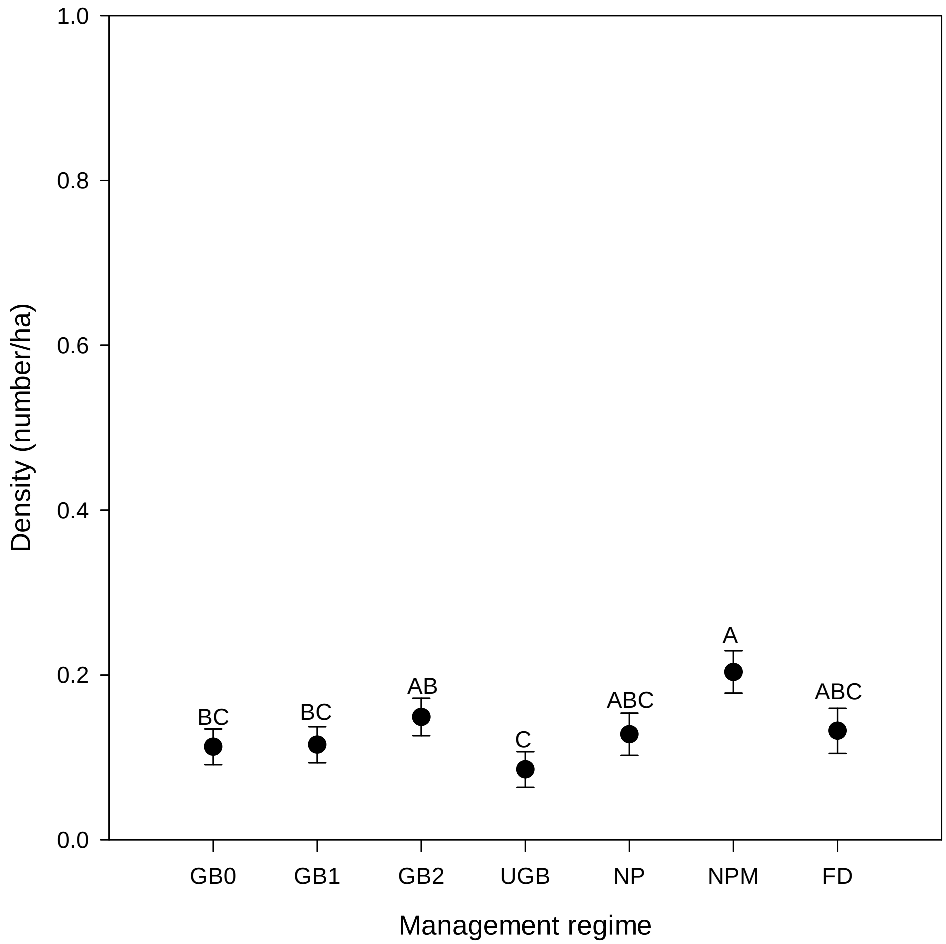


Figure 11. Parameter estimates from a repeated measures analysis of variance testing for differences in Le Conte's Sparrow (*Ammodramus leconteii*) densities among management regimes within coastal prairies in Texas. Means followed by the same letter are not different ($P > 0.05$; least squares cross validation). (See Table 1 for management regime descriptions).

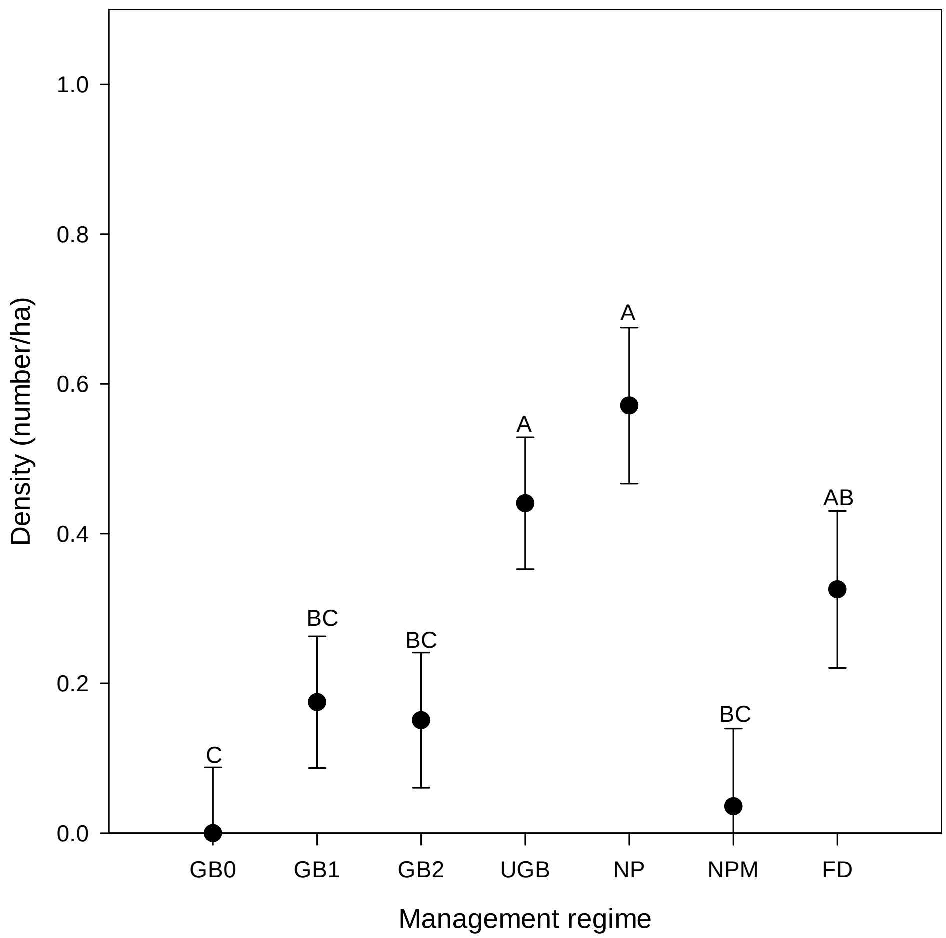


Figure 12. Parameter estimates from a repeated measures analysis of variance testing for differences in Le Conte's Sparrow (*Ammodramus leconteii*) densities among periods (early [28 October – 2 January] and late [17 January – 7 April]) within coastal prairies in Texas. (See Table 1 for management regime descriptions).

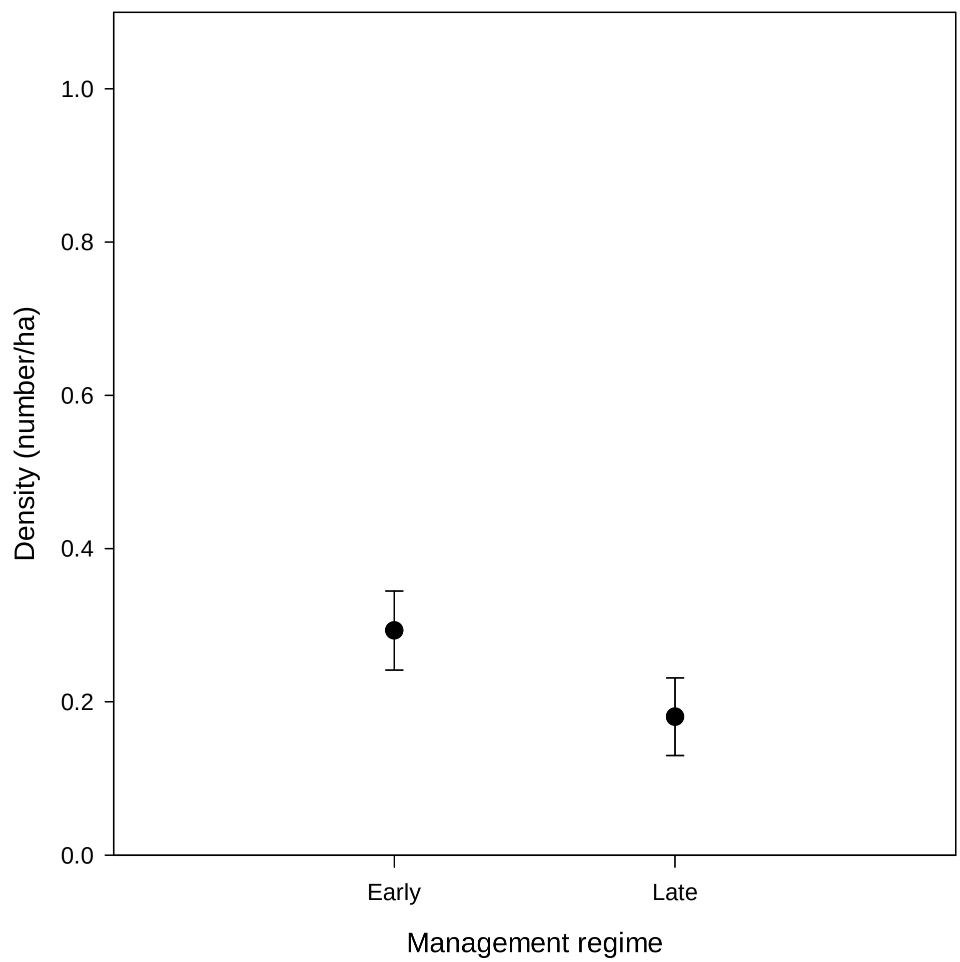


Figure 13. Parameter estimates from a repeated measures analysis of variance testing for an interaction between management regimes and periods (early [28 October – 2 January] and late [17 January – 7 April]) for Le Conte's Sparrow (*Ammodramus leconteii*) densities within coastal prairies in Texas. (See Table 1 for management regime descriptions).

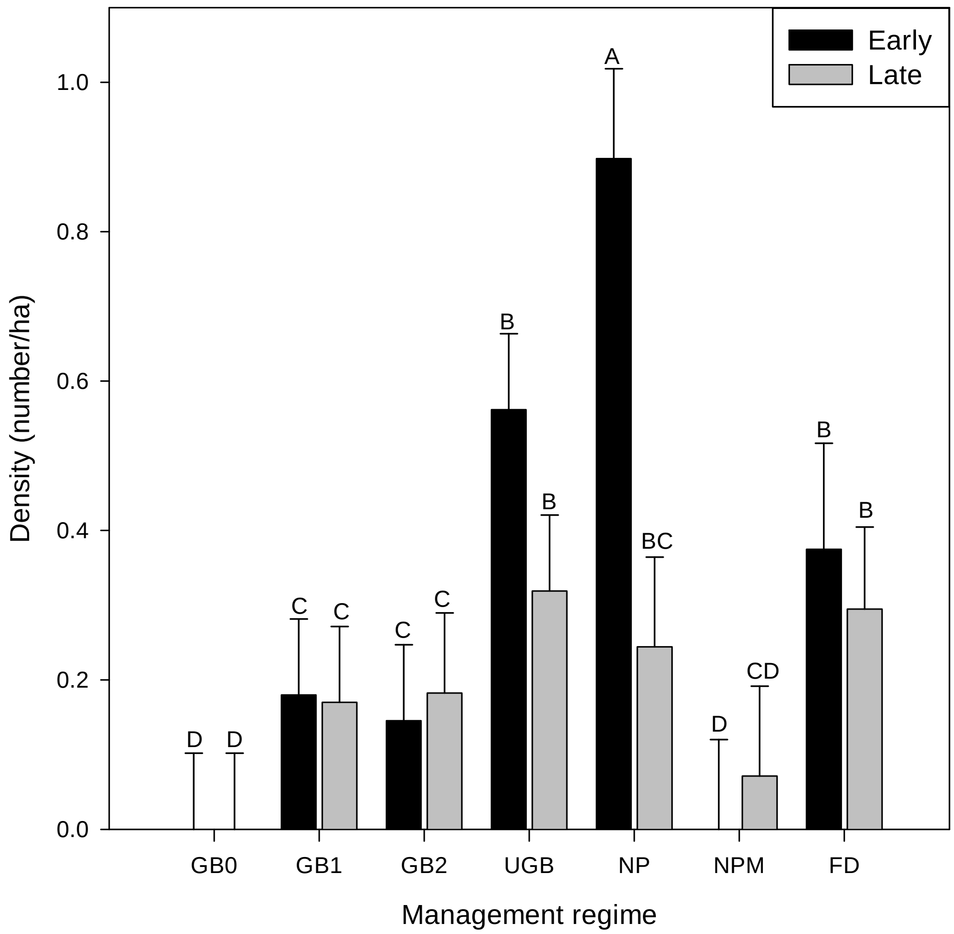


Figure 14. Parameter estimates from a repeated measures analysis of variance testing for differences in Sedge Wren (*Cistothorus platensis*) densities among management regimes within coastal prairies in Texas. Means followed by the same letter are not different ($P > 0.05$; least squares cross validation). (See Table 1 for management regime descriptions).

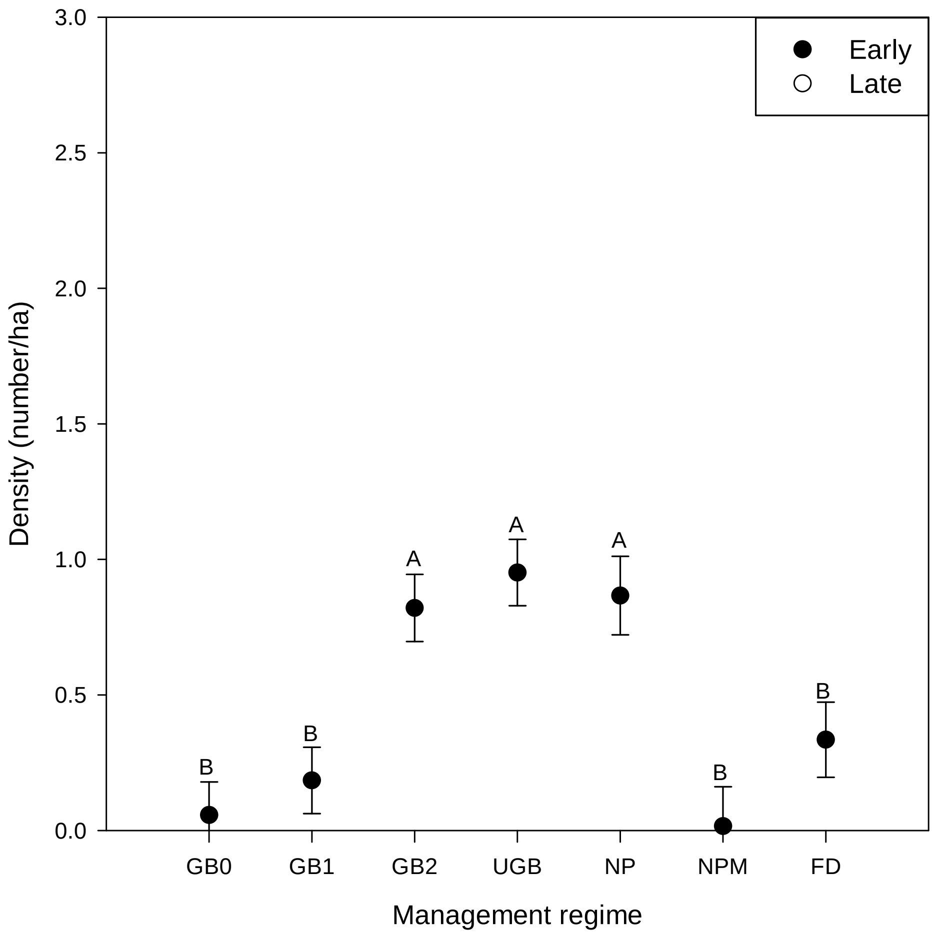


Figure 15. Parameter estimates from a repeated measures analysis of variance testing for an interaction between periods (early [28 October – 2 January] and late [17 January – 7 April]) and years for Sedge Wren (*Cistothorus platensis*) densities within coastal prairies in Texas.

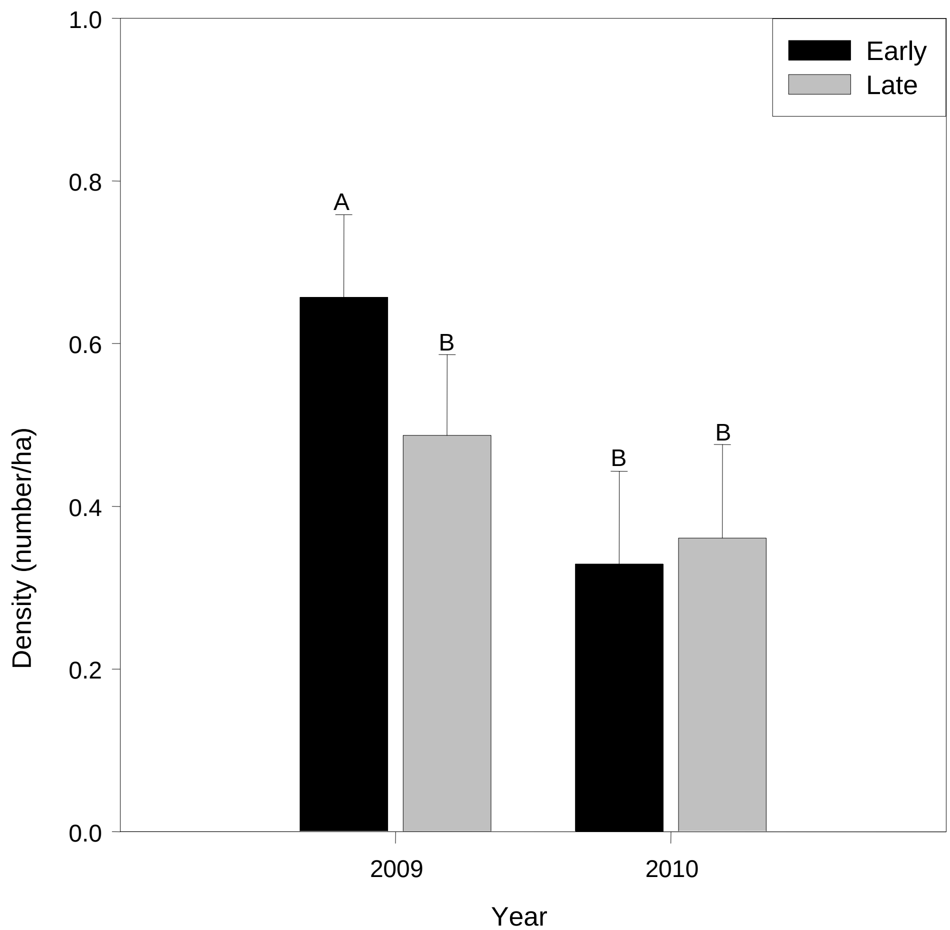


Figure 16. Parameter estimates from a repeated measures analysis of variance testing for differences in Sprague's Pipit (*Anthus spragueii*) densities among management regimes within coastal prairies in Texas. Means followed by the same letter are not different ($P > 0.05$; least squares cross validation). (See Table 1 for management regime descriptions).

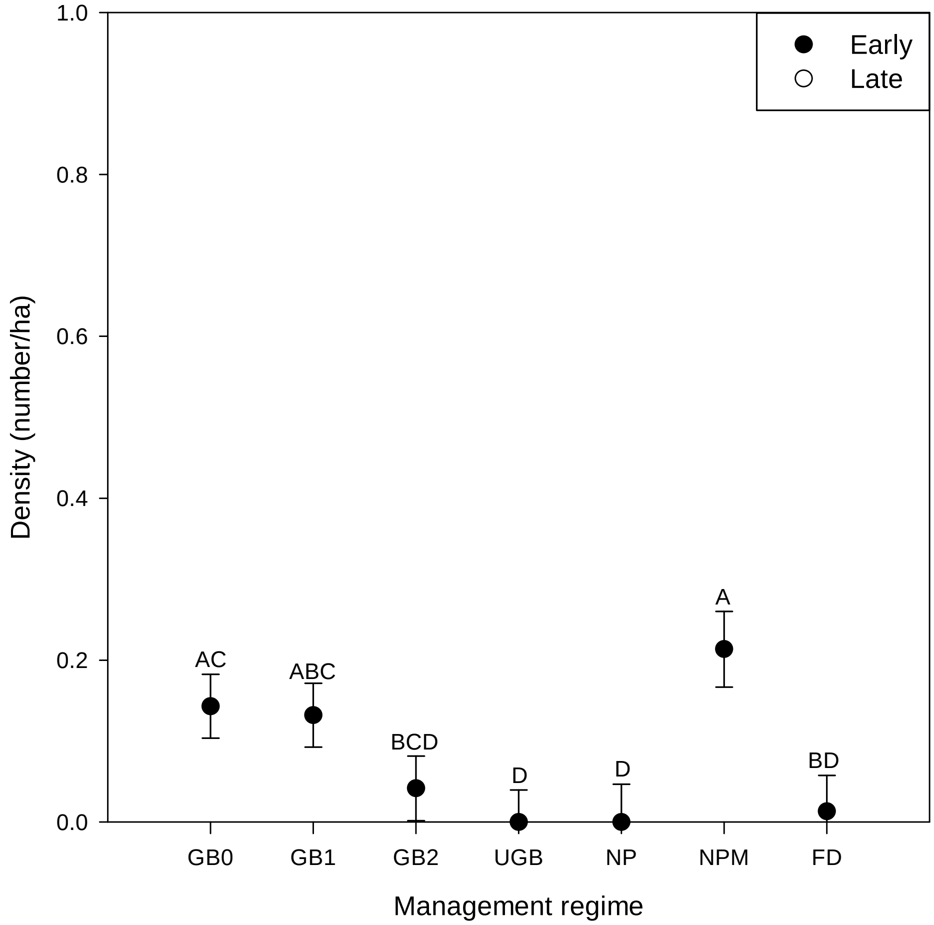


Table 1. Abbreviations, number of study sites, and management descriptions of grassland study sites used to quantify wintering grassland bird abundance and habitat use in Texas coastal prairies, October 2008 – April 2009 (Year 1) and November 2009 – March 2010 (Year 2).

Abbreviations	Number of Study Sites		Descriptions
	Year 1	Year2	
GBO	4	3	Sites grazed by cattle and exposed to prescribed fire after the growing season directly prior to data collection.
GB1	4	3	Sites grazed by cattle and exposed to prescribed fire one growing season prior to initiating data collection.
GB2	4	3	Sites grazed by cattle and exposed to prescribed fire two growing seasons prior to initiating data collection.
UGB	4	3	Sites non-grazed and not exposed to prescribed fire ≥ two growing seasons prior to initiating data collection.

Table 1. Continued

Abbreviations	Number of Study Sites		Descriptions
	Year 1	Year2	
NP	3	3	Native prairie; Sites non-grazed and not exposed to prescribed fire, that contain high floristic species richness. These areas were not mowed during the current year's growing season.
NPM	3	3	Native prairie; Sites non-grazed and not exposed to prescribed fire, that contain high floristic species richness. These areas were mowed during current year's growing season.
FD	3	3	Sites containing primarily exotic invasive species and are non-grazed, non-mowed and not exposed to prescribed fire.

Table 2. Species observed on grassland bird surveys during October 2008 – April 2009 and November 2009 – March 2010 in 28 study site prairies exposed to seven management regimes[a] in coastal Texas.

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
American Bittern (*Botaurus lentiginosus*)	-	-	-	-	-	-	X
Great Blue Heron (*Ardea herodias*)	-	X	-	X	-	-	-
Great Egret (*Ardea alba*)	X	X	X	X	-	X	-
Cattle Egret (*Bubulcus ibis*)	-	X	-	-	-	-	-
White Ibis (*Eudocimus albus*)	X	X	X	-	-	X	-
Greater White-fronted Goose (*Anser albifrons*)[c]	X	-	-	-	-	-	-
Snow Goose (*Chen caerulescens*)[c]	X	-	-	-	-	-	-
Turkey Vulture (*Cathartes aura*)[c]	X	X	-	-	-	X	-
Black Vulture (*Coragyps atratus*)	-	X	-	-	-	-	-
Northern Harrier (*Circus cyaneus*)[b]	X	X	X	X	X	X	X
White-tailed Kite (*Elanus leucurus*)[c]	-	-	X	X	-	-	-
Cooper's Hawk (*Accipiter cooperii*)	X	-	-	-	-	-	-
Red-shouldered Hawk (*Buteo lineatus*)	-	-	-	X	-	-	X
White-tailed Hawk (*Buteo albicaudatus*)[c]	-	X	-	-	-	-	X
Red-tailed Hawk (*Buteo jamaicensis*)	X	X	X	X	X	-	X
Bald Eagle (*Haliaeetus leucocephalus*)	-	-	-	X	-	-	-
Osprey (*Pandion haliaetus*)	-	-	-	-	X	-	X

Table 2. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Crested Caracara (*Caracara cheriway*)[c]	X	X	X	X	-	X	X
Merlin (*Falco columbarius*)[c]	X	-	X	-	-	-	-
American Kestrel (*Falco sparverius*)[c]	X	X	X	X	X	X	X
Peregrine Falcon (*Falco peregrines*)[c]	X	X	-	-	-	-	-
Northern Bobwhite (*Colinus virginianus*)[c]	X	-	-	X	-	-	-
Greater Prairie-Chicken (*Tympanuchus cupido*)[b]	-	X	X	-	-	-	-
Clapper Rail (*Rallus longirostris*)	-	X	-	-	-	-	-
Yellow Rail (*Coturnicops noveboracensis*)[c]	-	-	-	-	X	-	-
Sandhill Crane (*Grus canadensis*)[c]	X	X	-	-	-	X	-
Killdeer (*Charadrius vociferous*)[c]	X	X	X	-	-	X	X
Greater Yellowlegs (*Tringa melanoleuca*)	X	X	-	-	-	-	-
Lesser Yellowlegs (*Tringa flavipes*)[c]	X	-	-	-	-	-	-
Upland Sandpiper (*Bartramia longicauda*)[b]	X	X	X	-	-	-	-
Long-billed Curlew (*Numenius americanus*)[b]	X	X	-	-	-	-	-
Common Snipe (*Gallinago gallinago*)[c]	X	X	-	X	X	X	X
Mourning Dove (*Zenaida macroura*)[c]	X	X	X	X	X	X	X
Barn Owl (*Tyto alba*)[c]	-	-	X	X	-	-	X
Short-eared Owl (*Asio flammeus*)[b]	-	X	X	-	-	-	-
Great Horned Owl (*Bubo virginianus*)	-	X	-	X	-	-	-

Table 2. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Burrowing Owl (*Athene cunicularia*)[b]	X	-	-	-	-	-	-
Belted Kingfisher (*Ceryle alcyon*)	-	-	-	-	-	-	X
Red-bellied Woodpecker (*Melanerpes carolinus*)	X	-	-	X	-	X	-
Eastern Phoebe (*Sayornis phoebe*)	X	-	X	X	X	-	X
Loggerhead Shrike (*Lanius ludovicianus*)[c]	X	X	X	X	X	X	X
White-eyed Vireo (*Vireo griseus*)	-	-	-	-	-	-	X
American Crow (*Corvus brachyrhynchos*)	-	-	-	X	-	X	-
Purple Martin (*Progne subis*)	-	-	-	-	-	X	X
Bank Swallow (*Riparia riparia*)	-	X	X	-	-	-	-
Cliff Swallow (*Petrochelidon pyrrhonota*)	-	X	-	-	-	X	-
Barn Swallow (*Hirundo rustica*)	X	-	-	-	-	-	-
Carolina Wren (*Thryothorus ludovicianus*)	-	-	-	X	X	-	-
House Wren (*Troglodytes troglodytes*)	-	-	-	-	-	-	X
Sedge Wren (*Cistothorus platensis*)[b]	X	X	X	X	X	X	X
Marsh Wren (*Cistothorus palustris*)	-	-	X	X	-	-	-
Northern Mockingbird (*Mimus polyglottos*)	X	X	X	X	-	X	X
Sprague's Pipit (*Anthus spragueii*)[b]	X	X	X	-	-	X	X
American Pipit (*Anthus rubescens*)[b]	X	X	X	X	-	X	-
Cedar Waxwing (*Bombycilla cedrorum*)	-	-	-	X	-	-	-

Table 2. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Yellow-rumped Warbler (*Dendroica coronate*)							
Palm Warbler (*Dendroic palmarum*)	-	-	-	X	-	-	-
Common Yellowthroat (*Geothlypis trichas*)[c]	X	-	X	X	-	-	-
Northern Cardinal (*Cardinalis cardinalis*)	-	-	-	-	X	-	X
Grasshopper Sparrow (*Ammodramus savannarum*)[b]	-	-	-	X	-	-	-
Le Conte's Sparrow (*Ammodramus leconteii*)[b]	-	X	X	X	X	X	X
Henslow's Sparrow (*Ammodramus henslowii*)[b]	-	-	-	-	X	-	-
Savannah Sparrow (*Passerculus sandwichensis*)[b]	X	X	X	X	X	X	X
Vesper Sparrow (*Pooecetes gramineus*)[b]	X	-	-	-	-	-	-
Lincoln's Sparrow (*Melospiza lincolnii*)	-	-	-	-	-	-	X
Swamp Sparrow (*Melospiza georgiana*)	-	X	-	X	X	-	X
Dark-eyed Junco (*Junco hyemalis*)	-	-	-	-	-	-	X
Eastern Meadowlark (*Sturnella magna*)[b]	X	X	X	X	X	X	X
Brown-headed Cowbird (*Molothrus ater*)[c]	X	X	-	-	X	-	-
Red-winged Blackbird (*Agelaius phoeniceus*)[c]	X	-	X	X	X	X	X
Great-tailed Grackle (*Quiscalus mexicanus*)	X	-	-	-	-	-	-
Common Grackle (*Euphagus cyanocephalus*)	X	-	-	-	-	-	-
American Goldfinch (*Carduelis tristis*)	-	-	-	-	-	-	X

Table 2. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
House Sparrow (*Passer domesticus*)	-	-	-	-	X	-	-

[a]Refer to Table 1 for descriptions of management regimes.

[b]Obligate grassland specialists: species that are exclusively adapted to and entirely dependent on grassland habitats and make little or no use of other habitat types (Vickery et al. 1999).

[c]Facultative grassland specialists: species that use grasslands as part of a wider array of habitats (Vickery et al. 1999).

Table 3. Species observed on grassland bird surveys during October 2008 – April 2009 in 23 study site prairies exposed to seven management regimes[a] in coastal Texas.

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
American Bittern (*Botaurus lentiginosus*)	-	-	-	-	-	-	X
Great Egret (*Ardea alba*)	-	X	-	-	-	-	-
White Ibis (*Eudocimus albus*)	-	X	-	-	-	-	
Northern Harrier (*Circus cyaneus*)[b]	X	X	X	-	X	X	X
White-tailed Kite (*Elanus leucurus*)[c]	-	-	X	X	-	-	-
Cooper's Hawk (*Accipiter cooperii*)	X	-	-	-	-	-	-
White-tailed Hawk (*Buteo albicaudatus*)[c]	-	X	-	-	-	-	X
Red-tailed Hawk (*Buteo jamaicensis*)	-	-	-	-	-	-	X
Crested Caracara (*Caracara cheriway*)[c]	-	X	-	-	-	-	X
Merlin (*Falco columbarius*)[c]	X	-	-	-	-	-	-
American Kestrel (*Falco sparverius*)[c]	X	-	X	X	-	-	-
Northern Bobwhite (*Colinus virginianus*)[c]	X	-	-	-	-	-	-
Greater Prairie-Chicken (*Tympanuchus cupido*)[b]	-	-	X	-	-	-	-
Clapper Rail (*Rallus longirostris*)	-	X	-	-	-	-	-
Sandhill Crane (*Grus canadensis*)[c]	X	-	-	-	-	X	-
Killdeer (*Charadrius vociferous*)[c]	X	X	-	-	-	X	-
Upland Sandpiper (*Bartramia longicauda*)[b]	X	X	X	-	-	-	-
Long-billed Curlew (*Numenius americanus*)[b]	X	X	-	-	-	-	-

Table 3. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Common Snipe (*Gallinago gallinago*)[c]	-	X	-	-	X	X	-
Mourning Dove (*Zenaida macroura*)[c]	X	X	X	X	-	X	X
Barn Owl (*Tyto alba*)[c]	-	-	X	X	-	-	X
Short-eared Owl (*Asio flammeus*)[b]	-	X	X	-	-	-	-
Great Horned Owl (*Bubo virginianus*)	-	X	-	-	-	-	-
Burrowing Owl (*Athene cunicularia*)[b]	X	-	-	-	-	-	-
Red-bellied Woodpecker (*Melanerpes carolinus*)	-	-	-	X	-	-	-
Eastern Phoebe (*Sayornis phoebe*)	X	-	X	-	X	-	X
Loggerhead Shrike (*Lanius ludovicianus*)[c]	X	-	-	X	X	X	X
White-eyed Vireo (*Vireo griseus*)	-	-	-	-	-	-	X
Carolina Wren (*Thryothorus ludovicianus*)	-	-	-	X	X	-	-
House Wren (*Troglodytes troglodytes*)	-	-	-	-	-	-	X
Sedge Wren (*Cistothorus platensis*)[b]	X	X	X	X	X	X	X
Marsh Wren (*Cistothorus palustris*)	-	-	X	X	-	-	-
Northern Mockingbird (*Mimus polyglottos*)	X	-	X	X	-	-	X
Sprague's Pipit (*Anthus spragueii*)[b]	X	X	X	-	-	X	-
American Pipit (*Anthus rubescens*)[b]	X	X	X	-	-	X	-
Yellow-rumped Warbler (*Dendroica coronate*)	X	X	X	X	X	X	X
Palm Warbler (*Dendroic palmarum*)	-	-	-	X	-	-	-

Table 3. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Common Yellowthroat (*Geothlypis trichas*)[c]	-	-	X	X	-	-	-
Northern Cardinal (*Cardinalis cardinalis*)	-	-	-	-	-	-	X
Grasshopper Sparrow (*Ammodramus savannarum*)[b]	-	-	-	X	-	-	-
Le Conte's Sparrow (*Ammodramus leconteii*)[b]	-	X	X	X	X	X	X
Savannah Sparrow (*Passerculus sandwichensis*)[b]	X	X	X	X	X	X	X
Swamp Sparrow (*Melospiza georgiana*)	-	X	-	X	X	-	X
Eastern Meadowlark (*Sturnella magna*)[b]	X	X	X	X	X	X	X
Brown-headed Cowbird (*Molothrus ater*)[c]	X	-	-	-	-	-	-
Red-winged Blackbird (*Agelaius phoeniceus*)[c]	-	-	-	X	X	X	-
Common Grackle (*Euphagus cyanocephalus*)	X	-	-	-	-	-	-
House Sparrow (*Passer domesticus*)	-	-	-	-	X	-	-

[a]Refer to Table 1 for descriptions of management regimes.

[b]Obligate grassland specialists: species that are exclusively adapted to and entirely dependent on grassland habitats and make little or no use of other habitat types (Vickery et al. 1999).

[c]Facultative grassland specialists: species that use grasslands as part of a wider array of habitats (Vickery et al. 1999).

Table 4. Species observed on grassland bird surveys during November 2009 – March 2010 in 21 study site prairies exposed to seven management regimes[a] in coastal Texas.

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Great Blue Heron (*Ardea herodias*)	-	X	-	X	-	-	-
Great Egret (*Ardea alba*)	X	-	X	X	-	X	-
Cattle Egret (*Bubulcus ibis*)	-	X	-	-	-	-	-
White Ibis (*Eudocimus albus*)	X	-	X	-	-	X	-
Greater White-fronted Goose (*Anser albifrons*)[c]	X	-	-	-	-	-	-
Snow Goose (*Chen caerulescens*)[c]	X	-	-	-	-	-	-
Turkey Vulture (*Cathartes aura*)[c]	X	X	-	-	-	X	-
Black Vulture (*Coragyps atratus*)	-	X	-	-	-	-	-
Northern Harrier (*Circus cyaneus*)[b]	X	-	X	X	X	X	X
Red-shouldered Hawk (*Buteo lineatus*)	-	-	-	X	-	-	X
White-tailed Hawk (*Buteo albicaudatus*)[c]	-	X	-	-	-	-	X
Red-tailed Hawk (*Buteo jamaicensis*)	X	X	X	X	X	-	X
Bald Eagle (*Haliaeetus leucocephalus*)	-	-	-	X	-	-	-
Osprey (*Pandion haliaetus*)	-	-	-	-	X	-	X
Crested Caracara (*Caracara cheriway*)[c]	X	-	X	X	-	X	X
Merlin (*Falco columbarius*)[c]	X	-	X	-	-	-	-
American Kestrel (*Falco sparverius*)[c]	X	X	X	-	X	X	X
Peregrine Falcon (*Falco peregrines*)[c]	X	X	-	-	-	-	-

Table 4. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Northern Bobwhite (*Colinus virginianus*)[c]	-	-	-	X	-	-	-
Greater Prairie-Chicken (*Tympanuchus cupido*)[b]	-	X	-	-	-	-	-
Yellow Rail (*Coturnicops noveboracensis*)[c]	-	-	-	-	X	-	-
Sandhill Crane (*Grus canadensis*)[c]	X	X	-	-	-	X	-
Killdeer (*Charadrius vociferous*)[c]	X	X	X	-	-	X	X
Greater Yellowlegs (*Tringa melanoleuca*)	X	X	-	-	-	-	-
Lesser Yellowlegs (*Tringa flavipes*)[c]	X	-	-	-	-	-	-
Long-billed Curlew (*Numenius americanus*)[b]	X	-	-	-	-	-	-
Common Snipe (*Gallinago gallinago*)[c]	X	X	-	X	X	X	X
Mourning Dove (*Zenaida macroura*)[c]	X	X	X	X	X	X	X
Great Horned Owl (*Bubo virginianus*)	-	-	-	X	-	-	-
Burrowing Owl (*Athene cunicularia*)[b]	X	-	-	-	-	-	-
Belted Kingfisher (*Ceryle alcyon*)	-	-	-	-	-	-	X
Red-bellied Woodpecker (*Melanerpes carolinus*)	X	-	-	-	-	X	-
Eastern Phoebe (*Sayornis phoebe*)	X	-	X	X	X	-	X
Loggerhead Shrike (*Lanius ludovicianus*)[c]	X	X	X	X	X	-	X
American Crow (*Corvus brachyrhynchos*)	-	-	-	X	-	X	-
Purple Martin (*Progne subis*)	-	-	-	-	-	X	X
Bank Swallow (*Riparia riparia*)	-	X	X	-	-	-	-

Table 4. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Cliff Swallow (*Petrochelidon pyrrhonota*)	-	X	-	-	-	X	-
Barn Swallow (*Hirundo rustica*)	X	-	-	-	-	-	-
House Wren (*Troglodytes troglodytes*)	-	-	-	-	-	-	X
Sedge Wren (*Cistothorus platensis*)[b]	-	X	X	X	X	X	X
Northern Mockingbird (*Mimus polyglottos*)	X	X	-	-	-	X	X
Sprague's Pipit (*Anthus spragueii*)[b]	X	X	X	-	-	X	X
American Pipit (*Anthus rubescens*)[b]	X	X	-	X	-	X	-
Cedar Waxwing (*Bombycilla cedrorum*)	-	-	-	X	-	-	-
Yellow-rumped Warbler (*Dendroica coronate*)	-	-	-	X	X	-	X
Common Yellowthroat (*Geothlypis trichas*)[c]	X	-	-	-	-	-	-
Northern Cardinal (*Cardinalis cardinalis*)	-	-	-	-	X	-	-
Le Conte's Sparrow (*Ammodramus leconteii*)[b]	-	X	X	X	X	-	X
Henslow's Sparrow (*Ammodramus henslowii*)[b]	-	-	-	-	X	-	-
Savannah Sparrow (*Passerculus sandwichensis*)[b]	X	X	X	X	X	X	X
Vesper Sparrow (*Pooecetes gramineus*)[b]	X	-	-	-	-	-	-
Lincoln's Sparrow (*Melospiza lincolnii*)	-	-	-	-	-	-	X
Swamp Sparrow (*Melospiza georgiana*)	-	-	-	X	-	-	X
Dark-eyed Junco (*Junco hyemalis*)	-	-	-	-	-	-	X
Eastern Meadowlark (*Sturnella magna*)[b]	X	X	X	X	X	X	X

Table 4. Continued

Species	GB0	GB1	GB2	UGB	NP	NPM	FD
Brown-headed Cowbird (*Molothrus ater*)[c]	-	X	-	-	X	-	-
Red-winged Blackbird (*Agelaius phoeniceus*)[c]	X	-	X	X	X	X	X
Great-tailed Grackle (*Quiscalus mexicanus*)	X	-	-	-	-	-	-
American Goldfinch (*Carduelis tristis*)	-	-	-	-	-	-	X

[a]Refer to Table 1 for descriptions of management regimes.

[b]Obligate grassland specialists: species that are exclusively adapted to and entirely dependent on grassland habitats and make little or no use of other habitat types (Vickery et al. 1999).

[c]Facultative grassland specialists: species that use grasslands as part of a wider array of habitats (Vickery et al. 1999).

Table 5. Total species richness (number of species) broken down by obligate grassland birds, facultative grassland birds, and management regimes[a] for grassland bird surveys conducted within 28 study site prairies in coastal Texas during October 2008 – April 2009 and November 2009 – March 2010.

	GB0	GB1	GB2	UGB	NP	NPM	FD
Obligate Grassland Species[b]	10	11	10	7	6	7	6
Facultative Grassland Species[c]	16	10	10	8	7	8	8
Total Species Richness	38	35	27	32	20	23	30

[a]Refer to Table 1 for descriptions of management regimes.

[b]Obligate grassland specialists: species that are exclusively adapted to and entirely dependent on grassland habitats and make little or no use of other habitat types (Vickery et al. 1999).

[c]Facultative grassland specialists: species that use grasslands as part of a wider array of habitats (Vickery et al. 1999).

Table 6. Analysis of variance results examining differences in bird densities among management regimes[a], between periods (early [28 October – 2 January] and late [17 January – 7 April]) and years, and their interactions for grassland birds within coastal prairies in Texas.

Effects	df	*F*	*P*
Eastern Meadowlark			
Management * Period * Year	5, 27	0.13	0.983
Management * Period	6, 33	0.53	0.781
Management * Year	6, 30	1.56	0.192
Period * Year	1, 38	0.00	0.973
Management	6, 37	2.37	<0.049*
Period	1, 39	0.16	0.690
Year	1, 42	0.15	0.699
LeConte's Sparrow			
Management * Period * Year	5, 27	2.00	0.112
Management * Period	6, 33	5.62	<0.001*
Management * Year	6, 30	1.37	0.258
Period * Year	1, 38	1.30	0.261
Management	6, 37	4.80	0.001*
Period	1, 39	4.95	0.032*
Year	1, 42	0.30	0.589

Table 6. Continued.

Effects	df	*F*	*P*
Savannah Sparrow			
Management * Period * Year	5, 27	0.18	0.969
Management * Period	6, 33	0.91	0.500
Management * Year	6, 30	2.03	0.092
Period * Year	1, 38	0.00	0.978
Management	6, 37	1.45	0.221
Period	1, 39	2.57	0.117
Year	1, 42	0.00	0.994
Sedge Wren			
Management * Period * Year	5, 27	1.64	0.183
Management * Period	6, 33	0.90	0.505
Management * Year	6, 30	0.83	0.555
Period * Year	1, 38	5.08	0.030*
Management	6, 37	9.76	<0.001*
Period	1, 39	2.77	0.104
Year	1, 42	2.26	0.140

Table 6. Continued.

Effects	df	*F*	*P*
Sprague's Pipit			
Management * Period * Year	5, 27	1.86	0.135
Management * Period	6, 33	1.47	0.219
Management * Year	6, 30	0.55	0.768
Period * Year	1, 38	0.34	0.564
Management	6, 37	3.78	0.005*
Period	1, 39	1.46	0.235
Year	1, 42	2.23	0.143

[a]Refer to Table 1 for descriptions of management regimes.

Table 7. Means ($\bar{x}$) and standard errors (SE) of habitat variables potentially influencing bird densities by management regimes[a] within coastal prairies in Texas.

Variable	GB0	GB1	GB2	UGB	NP	NPM	FD
Robel Pole	11.79 (1.22)	17.50 (1.45)	22.42 (2.55)	38.17 (1.98)	49.80 (3.61)	11.32 (0.38)	34.61 (3.11)
Litter depth (cm)	1.02 (0.15)	1.26 (0.26)	5.48 (1.06)	8.35 (1.00)	7.13 (1.00)	1.03 (0.06)	6.19 (0.95)
% Live Plants[b]							
Deep Rooted Sedge	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	14.75 (2.82)
Gordo Bluestem	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Native grass	23.46 (2.35)	15.90 (2.62)	16.92 (3.40)	6.28 (1.72	18.68 (2.09)	15.79 (2.07)	10.25 (2.71)
Forbs	14.36 (2.24)	12.44 (2.00)	12.69 (2.69)	11.98 (2.23)	2.89 (0.96)	15.79 (2.76)	16.38 (3.58)
Shrubs	2.33 (0.99)	2.44 (0.86)	1.92 (1.24)	8.26 (2.50)	0.05 (0.05)	0.00 (0.00)	10.25 (2.39)
Gulf Cordgrass	2.69 (0.95)	7.05 (2.30)	7.88 (3.24)	15.70 (3.19)	0.00 (0.00)	0.00 (0.00)	7.63 (3.15)

Table 7. Continued.

Variable	GB0	GB1	GB2	UGB	NP	NPM	FD
% Dead Plants[b]							
Deep Rooted Sedge	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	30.88 (4.33)
Gordo Bluestem	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Native grass	26.41 (3.89)	15.26 (3.29)	31.73 (6.05)	35.35 (5.52)	66.05 (3.56)	37.37 (4.45)	3.13 (1.14)
Forbs	0.00 (0.00)	0.00 (0.00)	1.15 (0.85)	1.16 (0.76)	0.00 (0.00)	0.00 (0.00)	0.25 (0.25)
Shrubs	0.64 (0.53)	1.15 (0.53)	0.00 (0.00)	0.23 (0.16)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Gulf Cordgrass	0.51 (0.36)	8.08 (2.94)	10.00 (4.44)	18.49 (4.35)	0.00 (0.00)	0.00 (0.00)	0.50 (0.30)
% Bare Ground[b]							
Bare ground	32.56 (3.61)	41.28 (3.75)	19.62 (4.00)	11.05 (2.27)	12.37 (2.34)	31.05 (4.75)	16.50 (2.54)
Height of Live Plants							
Deep Rooted Sedge	.	.	.	.	.	.	26.74 (2.62)

Table 7. Continued.

Variable	GB0	GB1	GB2	UGB	NP	NPM	FD
Gordo Bluestem	.	.	.	.	.	.	.
Native grass	11.99 (0.58)	8.73 (0.72)	25.77 (4.57)	22.92 (3.15)	22.05 (1.28)	13.41 (1.00)	21.96 (3.87)
Forbs	7.08 (1.01)	4.70 (0.61)	9.45 (1.46)	15.39 (2.13)	7.51 (2.64)	5.29 (0.62)	27.24 (15.28)
Shrubs	113.64 (35.81)	227.22 (28.37)	48.33 (9.28)	97.02 (18.32)	85.00 (1.30)	.	272.42 (49.31)
Gulf Cordgrass	14.89 (2.24)	16.31 (2.19)	30.46 (8.84)	41.50 (4.32)	.	.	38.57 (8.27)
Height of Dead Plants							
Deep Rooted Sedge	.	.	.	.	.	.	31.17 (3.39)
Gordo Bluestem	.	.	.	.	.	.	.
Native grass	10.25 (1.26)	10.28 (1.85)	21.11 (3.20)	36.49 (4.68)	63.62 (6.62)	13.37 (1.15)	30.65 (6.42)
Forbs	.	.	30.10 (7.60)	11.40 (3.80)	.	.	21.00 (0.57)
Shrubs	72.00 (37.80)	279.00 (96.13)	.	75.00 (5.00)	.	.	.

Table 7. Continued.

Variable	GB0	GB1	GB2	UGB	NP	NPM	FD
Gulf Cordgrass	9.53 (4.72)	25.02 (4.04)	24.17 (6.34)	48.59 (3.82)	.	.	38.33 (6.67)

[a]Refer to Table 1 for descriptions of management regimes.

[b]Percent composition of habitat categories within a 0.25m^2 plot.

Table 8. Linear regression models for habitat variables predicting Eastern Meadowlark (*Sturnella magna*) densities within coastal prairies in Texas.

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
% Native Grass	2	0.00	0.13
Intercept[c]	1	0.11	0.12
% Shrubs	2	0.91	0.08
% Native Grass + % Shrubs[d]	3	1.10	0.07
% Forbs	2	1.34	0.06
% Cordgrass	2	1.35	0.06
% Native Grass + % Forbs	3	1.44	0.06
% Native Grass + Litter Depth	3	1.55	0.06
Litter Depth	2	1.78	0.05
% Bare Ground	2	2.03	0.05
Robel	2	2.07	0.04
% Rose	2	2.13	0.04
% Deep Rooted Sedge	2	2.21	0.04
% Forbs + % Shrubs	3	2.23	0.04
% Forbs + Robel	3	3.41	0.02
% Cordgrass + % Rose	3	3.49	0.02
% Deep Rooted Sedge + % Forbs	3	3.51	0.02

Table 8. Continued

Model	No. Parameters	ΔAIC_c [a]	AIC_w [b]
% Deep Rooted Sedge + Litter Depth	3	3.94	0.02

[a]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value.

[b]AIC_c relative weight attributed to model.

[c]Model of no effects on nest site selection.

[d]Model of additive effects % native grass and % shrubs.

Table 9. Linear regression models for habitat variables predicting Le Conte's Sparrow (*Ammodramus leconteii*) densities within coastal prairies in Texas.

Model	No. Parameters	ΔAIC_c [a]	AIC_w [b]
Robel	2	0.00	0.67
% Forbs + Robel[c]	3	1.45	0.33
Litter Depth	2	14.78	0.00
% Bare Ground	2	16.17	0.00
% Cordgrass	2	16.58	0.00
% Native Grass + Litter Depth	3	16.79	0.00
% Deep Rooted Sedge + Litter Depth	3	16.92	0.00
% Cordgrass + % Rose	3	18.53	0.00
Intercept[d]	1	21.09	0.00
% Forbs	2	22.08	0.00
% Rose	2	22.74	0.00
% Native Grass	2	22.79	0.00
% Deep Rooted Sedge	2	23.09	0.00
% Shrubs	2	23.22	0.00
% Native Grass + % Forbs	3	23.72	0.00
% Deep Rooted Sedge + % Forbs	3	24.13	0.00
% Forbs + % Shrubs	3	24.27	0.00

Table 9. Continued

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
% Native Grass + % Shrubs	3	24.99	0.00

[a]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value.

[b]AIC_c relative weight attributed to model.

[c]Model of additive effects % forbs and robel.

[d]Model of no effects on nest site selection.

Table 10. Linear regression models for habitat variables predicting Savannah Sparrow (*Passerculus sandwichensis*) densities within coastal prairies in Texas.

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
% Deep Rooted Sedge + Litter Depth[c]	3	0.00	0.36
% Deep Rooted Sedge	2	0.63	0.26
% Rose	2	2.54	0.10
% Deep Rooted Sedge + % Forbs	3	2.82	0.09
% Cordgrass + % Rose	3	4.73	0.03
Litter Depth	2	5.32	0.02
Intercept[d]	1	5.54	0.02
% Bare Ground	2	5.67	0.02
% Native Grass	2	5.80	0.02
% Native Grass + Litter Depth	3	5.84	0.02
Robel	2	7.19	0.01
% Shrubs	2	7.34	0.01
% Cordgrass	2	7.59	0.01
% Forbs	2	7.66	0.01
% Native Grass + % Shrubs	3	7.79	0.01
% Native Grass + % Forbs	3	7.99	0.01
% Forbs + Robel	3	9.39	0.00

Table 10. Continued.

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
% Forbs + % Shrubs	3	9.53	0.00

[a]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value.

[b]AIC_c relative weight attributed to model.

[c]Model of additive effects % deep rooted sedge and litter depth.

[d]Model of no effects on nest site selection.

Table 11. Linear regression models for habitat variables predicting Sedge Wren (*Cistothorus platensis*) densities within coastal prairies in Texas.

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
% Deep Rooted Sedge + Litter Depth[c]	3	0.00	0.50
Litter Depth	2	1.17	0.28
% Native Grass + Litter Depth	3	1.58	0.23
Robel	2	24.49	0.00
% Forbs + Robel	3	24.84	0.00
% Bare Ground	2	31.73	0.00
% Cordgrass	2	55.99	0.00
% Cordgrass + % Rose	3	58.08	0.00
% Native Grass + % Shrubs	3	58.85	0.00
% Native Grass + % Forbs	3	58.96	0.00
% Native Grass	2	59.16	0.00
% Forbs	2	59.19	0.00
Intercept[d]	1	59.21	0.00
% Shrubs	2	59.38	0.00
% Forbs + % Shrubs	3	59.54	0.00
% Deep Rooted Sedge	2	60.09	0.00
% Deep Rooted Sedge + % Forbs	3	60.14	0.00

Table 11. Continued.

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
% Rose	2	61.32	0.00

[a]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value.

[b]AIC_c relative weight attributed to model.

[c]Model of additive effects % deep rooted sedge and litter depth.

[d]Model of no effects on nest site selection.

Table 12. Linear regression models for habitat variables predicting Sprague's Pipit (*Anthus spragueii*) densities within coastal prairies in Texas.

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
Robel	2	0.00	0.56
% Forbs + Robel[c]	3	0.89	0.36
Litter Depth	2	5.35	0.04
% Deep Rooted Sedge + Litter Depth	3	6.16	0.03
% Native Grass + Litter Depth	3	7.27	0.01
% Shrubs	2	14.53	0.00
% Bare Ground	2	15.13	0.00
% Forbs + % Shrubs	3	16.26	0.00
% Native Grass + % Shrubs	3	16.73	0.00
% Cordgrass	2	17.92	0.00
% Cordgrass + % Rose	3	18.18	0.00
% Rose	2	20.52	0.00
Intercept[d]	1	20.71	0.00
% Deep Rooted Sedge	2	21.45	0.00
% Forbs	2	22.54	0.00
% Native Grass	2	22.79	0.00
% Deep Rooted Sedge + % Forbs	3	23.35	0.00

Table 12. Continued.

Model	No. Parameters	ΔAIC_c[a]	AIC_w[b]
% Native Grass + % Forbs	3	24.68	0.00

[a]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value.

[b]AIC_c relative weight attributed to model.

[c]Model of additive effects % forbs and robel.

[d]Model of no effects on nest site selection.

Table 13. Preliminary estimates of total seed biomass production as estimated from seed rain sampling in 23 study site pastures exposed to seven management regimes in Texas coastal prairie, 28 October 2008 – 7 April 2009.

Management Regime	Mean (g/m^2)	SD
GB0	0.053	0.761
GB1	1.228	0.751
GB2	1.940	0.772
UGB	1.242	0.751
NP	0.866	0.627
NPM	0.038	0.657
FD	0.411	0.779

Table 14. Species banded during grassland bird surveys in study site prairies exposed to seven management regimes[a] in coastal Texas.

Species	GB0	GB1	GB2	UGB	NP	FD
Eastern Phoebe (*Sayornis phoebe*)	-	-	X	-	-	-
House Wren (*Troglodytes troglodytes*)	-	-	X	-	-	-
Sedge Wren (*Cistothorus platensis*)	X	X	X	X	X	X
Northern Mockingbird (*Mimus polyglottos*)	-	-	-	X	-	-
Ruby Crowned Kinglet (*Regulus calendula*)	-	-	-	X	-	-
Yellow-rumped Warbler (*Dendroica coronate*)	-	-	-	X	-	-
Palm Warbler (*Dendroic palmarum*)	-	-	X	-	-	-
Common Yellowthroat (*Geothlypis trichas*)	-	-	-	X	-	X
Grasshopper Sparrow (*Ammodramus savannarum*)	-	-	-	X	-	-
Le Conte's Sparrow (*Ammodramus leconteii*)	X	X	X	X	X	X
Henslow's Sparrow (*Ammodramus henslowii*)	-	-	-	-	X	-
Nelson's Sharptail Sparrow (*Ammodramus nelsoni*)	-	-	-	X	-	-
Savannah Sparrow (*Passerculus sandwichensis*)	X	X	X	X	X	X
Lincoln's Sparrow (*Melospiza lincolnii*)	-	-	X	-	-	-
Swamp Sparrow (*Melospiza georgiana*)	X	-	X	X	-	X
Eastern Meadowlark (*Sturnella magna*)	-	-	X	-	X	-

[a]Refer to Table 1 for descriptions of management regimes.

APPENDIX A

CITATIONS FOR PROFESSIONAL AND INVITED PRESENTATIONS DELIVERED AS A PORTION OF RESEARCH RELATED TO TPWD-SFASU CONTRACT 189691

Conway, W. C., C. M. Frey, D. T. Saalfeld, and K. J. Hartke. 2010. Wintering grassland bird community structure in Texas coastal prairie. 45th Annual Meeting of the Texas Chapter of The Wildlife Society. Galveston, Texas. February 17-19, 2010.

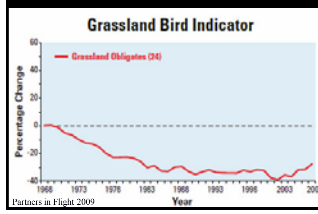
Wintering grassland bird community structure in Texas coastal prairie

Warren C. Conway, Christopher M. Frey, David T. Saalfeld
Arthur Temple College of Forestry and Agriculture
Stephen F. Austin State University

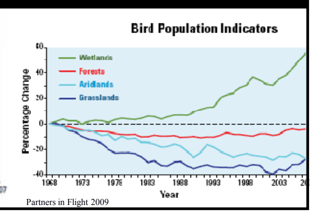
Kevin J. Hartke
Texas Parks and Wildlife Department

Introduction: grassland bird conservation concerns

- Grassland birds have been experiencing long term population declines
  - at rates exceeding any other ecological avian guild
- Declines hypothesized to be result of a combination of outright loss, degradation, and decreasing patch size of breeding and wintering grassland habitats



Partners in Flight 2009

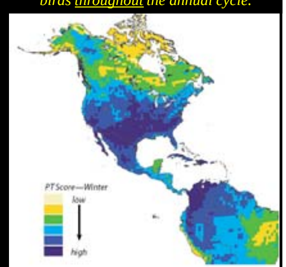


Partners in Flight 2009

Introduction: grassland bird conservation concerns

- Vickery and Herkert (2001) emphasized
  - (1) information gaps existing in wintering grassland bird ecology
    - responses to grazing, prescribed fire, exotic invasive species, and patch size during winter are poorly known
  - (2) possibility that population declines are a result of grassland habitat management issues during winter *within* the United States
- As opposed to Neotropical migrant landbirds (NTMs), which generally winter outside the continental U.S.

Many grassland birds are temperate migrants, *whereby land management practices within the U.S. impact these birds* *throughout* *the annual cycle.*



A higher proportion of short-distance migrants wintering in the central and southern U.S, northern Mexico are exhibiting more significant declines than long distance migrants

Introduction: coastal prairie conservation concerns

- Coastal Prairie region ca. 3,800,000 ha
  - Now exists as a network of disjunct and isolated patches in various stages of condition and size
- Due to fragmentation and land-use changes, Texas coastal prairie now remains at < 1% (approx. 65,000 acres) of its original composition and size
  - Loss, degradation, and destruction of remaining tracts accelerated over the last decade from development pressures
  - Poses the greatest risk to what remains
- Considered to be imperiled and one of the most endangered ecoregions in North America
- *Preservation, conservation, management, and restoration are high conservation priorities*
- *Coastal Prairie exists as a Tier I, High Priority Ecoregion in the 2005-2010 Texas Comprehensive Wildlife Conservation Strategy*

Ducks Unlimited

Introduction: coastal prairie conservation concerns

- Additive or cumulative impacts of alterations in
  - historical disturbance regimes (i.e., fire, grazing, and flooding)
  - land use (i.e., urbanization and agriculture)
  - fragmentation and patch size reduction
    - *have all contributed to coastal prairie degradation*
- Beyond these direct impacts
  - hypothesized that these alterations in natural disturbance regimes and associated anthropogenic pressures have contributed *directly* to exotic species
    - *establishment, naturalization, & proliferation*
- Impacts from naturalized exotic invasive species are further deteriorating the structure and function of the region
- *Cumulatively: can negatively impact habitat quality and availability for grassland birds*

Justification

- Texas coastal prairie is important for wintering grassland birds
  - species of concern such as, Grasshopper Sparrow, Henslow's Sparrow, LeConte's Sparrow, and Sedge Wren
- Few studies have specifically examined how grassland birds use habitats dominated by exotic invasive species in grassland ecosystems
- Important to evaluate wintering grassland bird abundance, composition, and density as related to patch size, grazing and fire regimes, and native/exotic invasive plant composition within grasslands

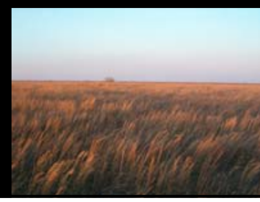
Objectives

1. Quantify wintering grassland bird presence, density, and species composition in Texas coastal prairies

2. Relate coastal prairie habitat features (i.e., vegetative structure) and management practices (i.e., grazing, burning, etc.) with wintering bird density

Study Areas

- We selected 23 study site pastures on eight different private or publicly owned properties throughout the mid-upper Texas coast
- From southern Fort Bend County, west to southeastern Goliad County, and east to eastern Galveston County
- Study site pastures were deployed among seven treatments encompassing both common regional management practices and range of floristic conditions



Management Regimes

Abbreviation	Number of study sites	Description
GB0	4	Sites grazed by cattle; exposed to prescribed fire during 2008 growing season
GB1	4	Sites grazed by cattle; exposed to prescribed fire during 2007 (one growing season has passed prior to initiating data collection).
GB2	4	Sites grazed by cattle; exposed to prescribed fire during 2006 (two growing seasons have passed prior to initiating data collection).
UBG	4	Sites non-grazed; not exposed to prescribed fire between 2006-2008 (at least two growing seasons have passed prior to initiating data collection)
NP	3	Native prairie; non-grazed; not exposed to prescribed fire; containing high floristic species richness. These areas were not mowed during 2008 (at least one growing season has passed since last mowing prior to initiating data collection).
NPM	3	Native prairie, non-grazed, not exposed to prescribed fire, containing high floristic species richness. These areas were mowed during 2008 growing season.
FD	3	Sites containing primarily exotic invasive species, non grazed, non mowed, not exposed to prescribed fire

Bird Survey Transect Deployment

- Within each study site pasture, a single 500 m transect was randomly deployed by defining the possible area to be surveyed in ArcView 9.3
  - Selecting two random points within the polygon that defined the starting point and direction
- Transects were placed a minimum of 50 m from pasture borders
  - Minimal adjustment of the starting point and/or the direction if random points were near edges

Bird Surveys

- Surveys were conducted using variable width transects and distance sampling techniques
- During two discrete temporal windows:
  - Early (28 October 2008 – 2 January 2009) and late (17 January – 7 April 2009)
- Each transect was surveyed 3-4 times during each sampling window
  - Consecutive surveys performed on individual transect separated by ≥ 10 days
- Surveys were initiated when ambient light allowed reliable visual bird identification and were terminated 3 h after sunrise
- Each bird detected was identified to species (and sex when possible) using visual and/or vocal cues
  - Perpendicular distance (m) from the transect for each bird was ocularly estimated or measured using a laser range finder

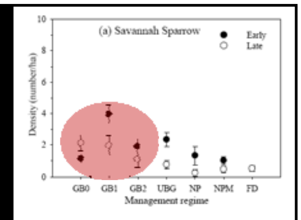
Data Analyses

- Calculated species richness among sites and among treatments
- Density estimates were calculated for the most common species (> 30 detections, within sampling periods) using program Distance
  - Global detection curve models were used to develop species specific detection probability curves
  - For species in which most detections occurred in groups, detection probability models were fit for "clusters"
- Species specific density estimates were calculated for each sampling period and management regime
- Proc Mixed (SAS) was used to compare density estimates within species among management regimes and between sampling periods, using individual transects as replicates
  - Model fit assessed using information theoretic approach

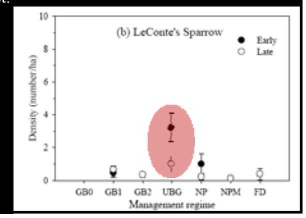
Results: Species Richness Patterns

- 48 species were detected on 134 surveys
- Total species richness *was greatest* in GB0 and GB1 (richness = 21)
  - Grazed and burned ≤ 1 growing seasons prior
- Total species richness *was least* in NP (richness = 13)
  - Native, non-mowed prairies
- Obligate grassland bird richness was greatest
  - Native mowed prairie pastures
  - Grazed, burned ≤ 1 growing season prior
- *Obligate grassland and grassland associated* richness combined was greatest in
  - Native mowed prairie (richness = 8)
  - Grazed, burned 2008 growing season (richness = 8)
  - Grazed, burned > 2 growing seasons ago (richness = 9)
- *Obligate grassland and grassland associated* richness combined was least in
  - Native, non-mowed prairie (richness = 5)
  - Exotic invasive pastures (richness = 6)

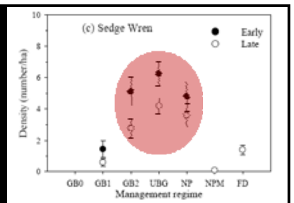
- Savannah Sparrow densities were greater:
  - During the early sampling window
  - In grazed/burned pastures
  - Occurred in all management regimes
- Interactive model best described density variation



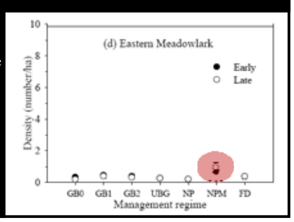
- LeConte's Sparrow densities were greatest:
  - During the early sampling window
  - In pastures that had not been grazed nor burned
  - Occurred in all management regimes, except for the grazed/recently burned pastures
- Interactive model best described density variation



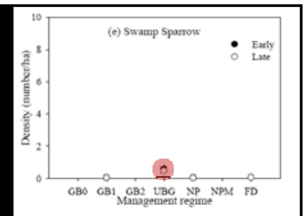
- Sedge wren densities were greatest:
  - During the early sampling window
  - In native prairie (not mowed) and pastures that had not been recently burned nor grazed
  - Absent from recently burned (≤ 1 growing seasons prior) and very few detected in mowed native prairie and in exotic pastures
- Interactive model best described density variation



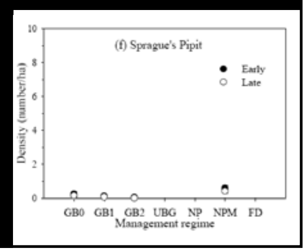
- Eastern Meadowlarks reached maximum densities (0.8 birds/ha) in the mowed native prairie
  - Densities were typically low (< 1 bird/ha) in both seasons and among all management regimes
- Management regime best described density variation



- Swamp Sparrow densities were:
  - Low throughout the study
  - Highest densities (0.3 birds/ha) in pastures that had not been recently burned nor grazed
- Poor model fit



- Sprague's Pipit densities were:
  - Typically low in both seasons and among all management regimes
  - When detected, occurred in short-stature pastures
- Singular model with management regime best described density variation (poor model fit)



Discussion

- Preliminary analyses appear to show clear seasonal trends of occurrence
  - Nearly 70% of all observations occurred during the early sampling period (October-January)
- Obligate grassland birds tended to reach greater densities from late fall through early winter
  - Then declined as winter progressed
  - Perhaps due to settlement and/or migration patterns during arrival and then as winter extended

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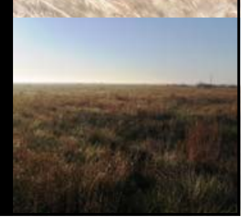
Discussion

- Most obligate grassland species associated with established/perceived winter habitat (structurally-based associations)
  - Savannah Sparrow
    - Ubiquitous
    - Occur in grazed and recently burned pastures
  - LeConte's Sparrow and Sedge Wren:
    - Occurred in more vegetatively dense pastures
    - Not recently burned, grazed, or mowed
  - Meadowlark and Pipits
    - Never attained high densities
    - Occurred in typically short stature; grazed and recently burned pastures



Discussion

- Obviously, burning/grazing does influence composition and densities of wintering grassland birds
  - *Appears to be strongly related to structural composition*
- However, very few obligate grassland birds detected in pastures dominated by exotic invasive species
  - *Primarily deep-rooted sedge pastures*
  - *Only 93 total detections (of >2000 for all species combined) in exotic dominated pastures*

- *Appears to be generalized avoidance of these exotic dominated pastures*

Management Implications

- Initial results suggest that exotic invasive-dominated pastures *do not*
  - Support comparable densities of wintering grassland birds
  - Provide suitable alternative habitats for wintering grassland birds
- Seed production (food resources) may be driving lack of use
  - As structurally, these habitats appear to be coarsely similar to more frequently used pastures under different management regimes
- Provide evidence that elements other than structure drive occupancy and densities of grassland birds during winter

Financial and logistical support provided by

Texas Parks and Wildlife Department

Matt Wagner & Brent Ortego

The Nature Conservancy of Texas

Jared Laing & Jared Judy

U.S. Fish and Wildlife Service

Jennifer Wilson & Jennifer Sanchez

Many Private Landowners for access to their property

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