FINAL PERFORMANCE REPORT

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THE ENDANGERED SPECIES PROGRAM

TEXAS

Grant No. TX E-157-R

(F13AP00686)

Endangered and Threatened Species Conservation

Winter ecology of a declining grassland bird, the Sprague's Pipit

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FINAL REPORT

STATE: ____Texas_______________ GRANT NUMBER: ___TX E-157-R-1__

GRANT TITLE: Winter ecology of a declining grassland bird, the Sprague's Pipit.

REPORTING PERIOD: ____1 September 2013 to 31 August 2015_

OBJECTIVE(S). To estimate abundance of Sprague's Pipit and quantify local and landscape-level characteristics of occupied wintering habitat at sites along the mid- and upper-Texas coast.

Segment Objectives:

Task 1. September-November 2013: Establish survey transects and other field season preparation.

Task 2. December 2013-March 2014: Established transects will be surveyed for Sprague's Pipits.

Task 3. April 2014-August 2015: Model and analyze pipit-habitat relationships at a landscape scale using data from the National Land Cover Database to quantify landscapes around observed locations of Sprague's Pipits.

Significant Deviations:

None.

Summary Of Progress:

Please see: Attachment A, Final Report by Principal Investigator, Dr. Rich Kostecke, with Sprague's Pipit distribution probability map. Supplemental materials, saved to CD, mailed separately: MS Thesis by John Muller, addressing Tasks 1 and 2; and, GIS shapefiles associated with Sprague's Pipit detections and distribution probability map (Task 3).

Location: Nash Prairie Preserve (Brazoria Co.), Texas City Prairie Preserve (Galveston Co.) Mad Island Marsh Preserve and Mad Island Wildlife Management Area (Matagorda Co.), Attwater's Prairie Chicken National Wildlife Refuge (Colorado Co.), Refugio-Goliad Prairie (Refugio and Goliad cos.), Texas, USA.

Cost: ___Costs were not available at time of this report, they will be available upon completion of the Final Report and conclusion of the project.__

Prepared by: _Craig Farquhar_____________ Date: _14 September 2015

Approved by: ___________________________ Date:_____14 September 2015_
C. Craig Farquhar

ATTACHMENT A

Winter Ecology of a Declining Grassland Bird, the Sprague's Pipit (*Anthus spragueii*)

TX ET-157-R

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Final Report
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Introduction

Sprague's Pipit (*Anthus spragueii*) is a small, migratory songbird endemic to the North American grasslands (Davis et al. 2014, Jones 2015). Sprague's Pipits breed in the central plains of northern United States and southern Canada and overwinter in the central grasslands of northern México and southern United States. The species has experienced a substantial population decline over the last half century. Data from the North American Breeding Bird Survey reveal a population decline of 65.7% across the breeding range in the United States and Canada from 1966 through 2011 (Sauer et al. 2011). Christmas Bird Count (CBC) data indicate a population decline of similar magnitude, 73.1%, within the wintering range for the period from 1966/1967 through 2005/2006 (Schmidt 2010). This dramatic decline has been attributed to degradation and loss of native prairies associated with anthropogenic changes to the landscape such as conversion of prairie to cropland, fire suppression, fragmentation, and overgrazing (Brennan and Kuvlesky 2005, Herket 1994, Samson and Knopf 1994, Pool et al. 2014). Grasslands are one of the most modified and destroyed habitat types in North America with roughly 20% of the 162 million ha of the Great Plains left in a natural, though often fragmented, condition (Samson and Knopf 1994).

Because of its significant population decline and substantial reduction of its native prairie habitat, the Sprague's Pipit has been identified as a species of conservation concern (Hilton-Taylor 2000, Rich et al. 2004, U.S. Fish and Wildlife Service 2002, Texas Parks and Wildlife Department 2005). The Sprague's Pipit was petitioned by Wild Earth Guardians (2008) for listing under the Endangered Species Act (U. S. Fish and Wildlife Service 2008), resulting in the initiation of a status review in December 2009. On September 15, 2010, the Sprague's Pipit was designated as a Candidate species (Schmidt 2010), which means that listing as threatened or endangered is warranted, but is currently precluded by higher priority actions.

Research on Sprague's Pipit has focused to a greater extent on the breeding grounds than on the wintering grounds (Davis et al. 2014, Jones 2010). Within the breeding range, Sprague's Pipits exhibit a preference for short and mixed grass native prairie and are most likely to occur in larger patches with less edge (Davis 2004, Grant et. al. 2004, Jones 2010). Sprague's Pipit occurrence and abundance within the breeding range is also influenced by landscape-level features such as the amount of native prairie adjacent to a habitat patch (Davis et al. 2013) and the proximity of other (e.g., cropland and wetland) land cover types to the habitat patch (Koper et al. 2009). Habitat patches that are overgrazed or overly disturbed also tend to be avoided by Sprague's Pipits on the breeding grounds, presumably due to reduced grass height and density (Davis et al. 1999).

Less research has been conducted within the wintering range of the Sprague's Pipit, and conservation of wintering habitat for Sprague's Pipits is limited by a lack of information on their wintering ecology (Jones 2010). Wintering habitats have been described as being similar to breeding habitats (i.e., large patches of native short- and mixed-grass prairie with minimal to, at most, moderate disturbance; Jones 2010), but there is at least some evidence for broader use of habitats during the winter when the species has also been found in agricultural areas (Lockwood and Freeman 2004, Stevens et al. 2013), heavily grazed areas (Grzybowski 1982), shrub-encroached grasslands (Grzybowski

1982, Contretas-Balderas et al 1997), sparsely vegetated grasslands (Desmond et al. 2005), and other highly disturbed grasslands (e.g., military training lands; Engelman and Kostecke 2009). Several studies indicate that Sprague's Pipit densities are greatest in grasslands with a high percentage of grass cover and low shrub cover and density (Igl and Ballard 1999, Macias-Duarte 2011, Pool et al. 2012). On the wintering grounds, Sprague's Pipits are also typically associated with short (<50 cm) grass (Grzybowski 1982, Macias-Duarte 2011). Although the Sprague's Pipit is known to be area-sensitive on the breeding grounds, primarily occupying larger, more contiguous grasslands (Davis 2004, Davis et al. 2006), it is unknown whether similar landscape-level characteristics affect occurrence and abundance on the wintering grounds.

Current status of wintering habitats, as well as factors that threaten the quantity and quality of these habitats, is unknown (Jones 2010) and potentially limits conservation efforts for the Sprague's Pipit. Among the research priorities listed in the Sprague's Pipit Status Assessment and Research Conservation Plan (Jones 2010) is the description of wintering distribution, abundance, and habitats, as well as definition of essential habitat components in the wintering range. Because the Sprague's Pipit appears to winter in highest densities in Texas grasslands (National Audubon Society 2009, Jones 2010), research and conservation conducted in Texas could have a substantial impact on the recovery of the species. Therefore, our goal was to collect data on the wintering distribution and abundance of the species in Texas and to analyze pipit-habitat relationships at both landscape (population) and local (individual) levels. Results of the landscape level analyses are reported separately in Muller (2015). Additional landscape level analyses, as well as the development of a species-distribution model (probability of occurrence map) for the Sprague's Pipit in Texas, are in progress. That research is being led by Dr. Joseph Veech at Texas State University under a grant from the Texas Comptroller of Public Accounts (Hegar 2015) and will build upon the research reported in Muller (2015). In this report, we provide the results of site-based survey efforts and local (individual) level habitat relationships for Sprague's Pipits on a range of private and public conservation lands on the Texas Gulf Coastal Plain.

Methods

Study Area – We focused our study of local (individual) level habitat selection by Sprague's Pipits on a range of private and public conservation lands within the Gulf Coastal Plain of the middle and upper Texas Gulf Coast (Fig. 1, Table 1). During the winter of 2013-2014, these lands consisted of Attwater Prairie Chicken National Wildlife Refuge, Clive Runnells Family Mad Island Marsh Preserve, Francine Cohn Preserve, Texas City Prairie Preserve, Mad Island Wildlife Management Area, and Nash Prairie Preserve. During the winter of 2014-2015, we added the newly protected Powderhorn Ranch as a study site while dropping Francine Cohn Preserve and Nash Prairie Preserve as study sites.

Pipit surveys – We surveyed for Sprague's Pipits along transects using a distance-sampling framework (Buckland et al. 2001, Pool et al. 2012). We used ArcGIS to generate a pool of random points within available grassland habitat on each property. From each of those points, we generated transects at a randomly selected bearing. If a transect fell substantially outside of a study site boundary or fell in large part outside of grassland habitat, it was eliminated from consideration. For each study site, we then randomly selected 2 to 7 transects, dependent on the size of the property and availability of

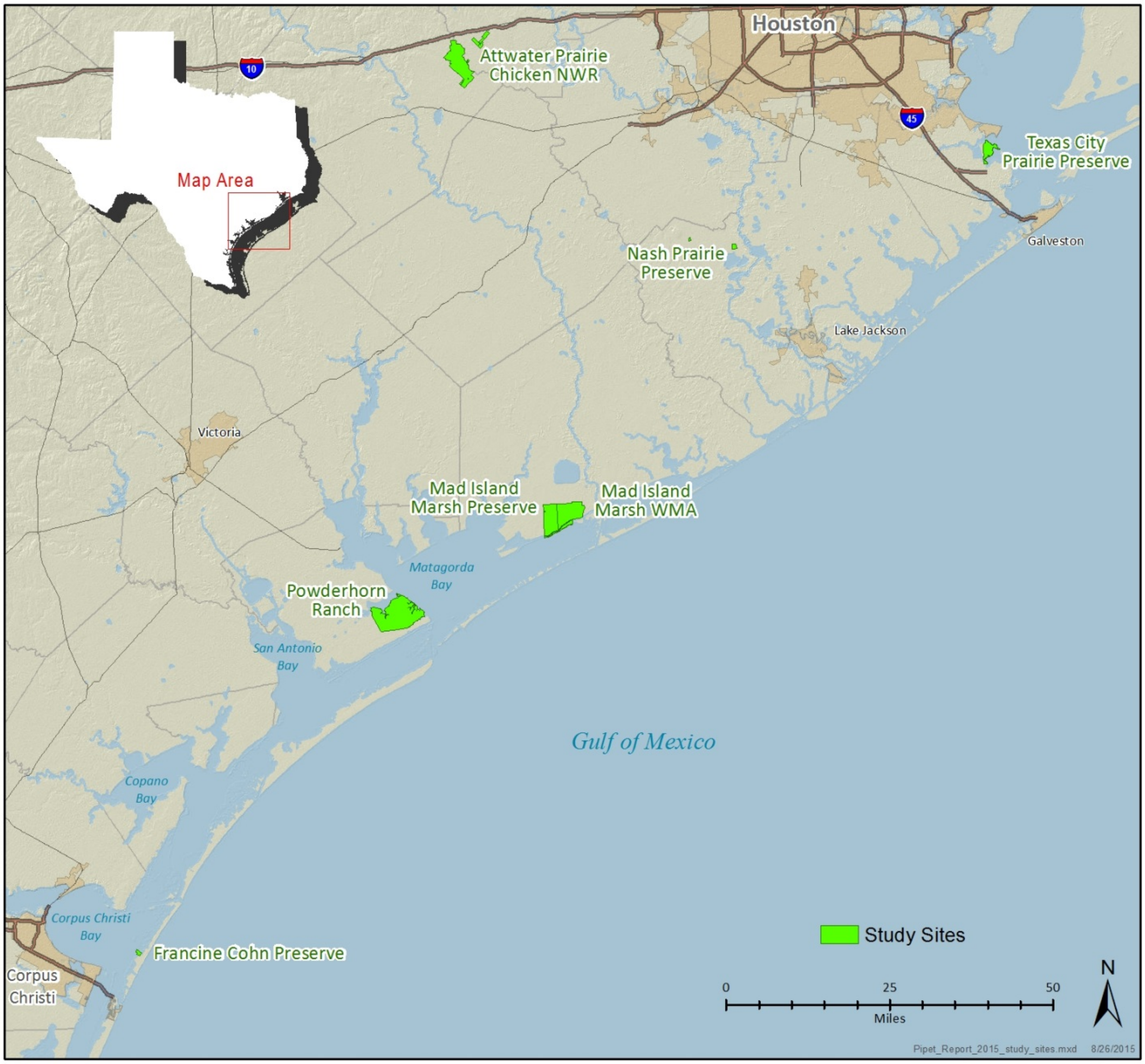

Figure 1. Location of private and public conservation lands on the middle and upper Texas Gulf Coastal Plain where we conducted surveys for Sprague's Pipits during the winters of 2013-2014 and 2014-2015.

Table 1. Private and public conservation lands on the middle and upper Texas Gulf Coastal Plain where Sprague's Pipit surveys were conducted during winter 2013-2014 and winter 2014-2015.

Study site	Ownership[1]	County	Total acreage	Estimated prairie acreage	% of study site in prairie
Attwater Prairie Chicken National Wildlife Refuge	USFWS	Austin, Colorado	10,566	8,388	79
Clive Runnells Family Mad Island Marsh Preserve	TNC	Matagorda	6,976	3,795	54
Francine Cohn Preserve	TNC	Nueces	292	32	11
Mad Island Wildlife Management Area	TPWD	Matagorda	7,256	2,893	40
Nash Prairie Preserve	TNC	Brazoria	428	378	88
Powderhorn Ranch	CF, TNC, TPWF	Calhoun	17,351	3,769	22
Texas City Prairie Preserve	TNC	Galveston	2,410	1,824	76

[1] CF = Conservation Fund, TNC = The Nature Conservancy, TPWD = Texas Parks and Wildlife Department, TPWF = Texas Parks and Wildlife Foundation, USFWS = United States Fish and Wildlife Service.

grassland habitat, to survey. Each transect was surveyed three times per winter. During surveys, observers used laser rangefinders to measure radial distance to each pipit or cluster of pipits that was detected. We define a cluster of pipits as two or more individuals occurring in close proximity to each other that were detected simultaneously. We recorded the angle and means of detection (call and/or visual) for all pipit detections, as well as basic weather information (cloud cover, temperature, wind speed and direction). All surveys were completed before 15:00 hours. We did not conduct surveys during high winds (>20 km/hr) or during precipitation greater than drizzle. During both winters of the study (2013-2014 and 2014-2015), we also recorded GPS locations of Sprague's Pipits that we opportunistically detected (e.g., while driving roads or walking to or from survey transects) at each of the study sites.

We present pipit survey data as distance-based density and abundance estimates generated using Program Distance (Version 6.2; Thomas et al. 2010). We fit models with the half-normal key function and cosine series expansion. We also present survey data as indices of relative abundance (Johnson 2008, Ruth et al. 2014). We used the maximum number of detections per transect averaged across transects at each site as the index of relative abundance.

Vegetation sampling – To assess the influence of local-level habitat characteristics on Sprague's Pipit occurrence, we measured vegetation structure within plots systematically established at 100-m intervals along each survey transect and within plots centered on locations where Sprague's Pipits were flushed during surveys. For a 1-km transect, there were 10 plots. We also measured vegetation structure within plots centered on locations where we opportunistically flushed pipits.

Within each 2.82 m radius circular plot, we visually estimated percent cover for all herbaceous species. Herbaceous species with <1% cover were grouped as forbs or graminoids for analysis. We also counted the number of woody stems by species within each 2.82 m radius circular plot. We counted stems <0.5 m tall and stems >0.5 m tall separately. We also counted dead and living stems separately. If there were no woody stems within a 2.82-m radius circular plot, we increased the plot area and counted woody stems within a 5.63-m radius circular plot. Such adaptive sampling has been found to be efficient for finding relatively rare or clustered plants, such as woody species in grassland (Yang et al. 2011). We used photo-based techniques to measure horizontal and vertical vegetation structure (Limb et al. 2007, Cagney et al. 2011). Analysis of digital images can result in significantly lower variance (e.g., by reducing observer variability) and provide greater repeatability for studies spanning multiple seasons or years. Nadir (vertical) and horizontal images were obtained with Canon PowerShot ELPH 115 IS cameras. For horizontal images, a 0.82 x 0.61 m (0.5 m^2) rectangular frame was placed on the ground 2 m right of center from (perpendicular to) the transect and photographed from directly above so that the edges of the frame aligned with the edges of the photograph. We then placed a grid of 100 points over each horizontal digital image using SamplePoint v1.56 software (Booth et al. 2006). Each point was assigned a category of bare ground, grass, grass litter, forb, forb litter, or shrub. However, we ultimately only used this technique to estimate percent cover of bare ground. We used ocular estimates of cover for each plant species. For analysis, we then categorized each plant species as either forb or grass. Because species can have overlapping coverages, it is possible for estimates of forb and grass to exceed 100%. Vertical cover was estimated using a 1.5 x 1 m (1.5 m^2) frame as a white backdrop placed 2 m right of the plot center. We photographed the frame holding the camera approximately 1 m above the ground, thus capturing standing vegetation against the white backdrop. We used ImageJ v1.47 software to estimate the amount of vertical cover in each photo for three height categories (0-0.5 m, 0.5-1 m, and 1-1.5 m) (Abramoff et al. 2004). By converting the color scheme of the vertical frame photos to black and white binary, we were able to calculate the vertical percent cover of standing vegetation (converted to black pixels) in front of the white backdrop using the histogram function. The only difference in methodology for plots centered on locations where pipits were detected during surveys or flushed opportunistically was that digital imagery was taken 2 m from the plot center in each cardinal direction and the measurements from each cardinal direction were averaged.

Vegetation statistical analysis – We used generalized linear models with a link logit function to assess the effects of study site (Site), year (Year), and a variety of vegetative variables on local (individual) level habitat use by Sprague's Pipit using the MuMIn package in R software v3.2.1 (R Core Team 2015). Vegetative variables included percent forb cover (Forb), number of woody stems (Woody), percent native grass cover (Nat_Gr), percent total grass cover (Grass), percent bare ground (Soil), and percent vertical cover from 0.0-0.5 m (HT_0.5m). We employed an information-theoretic approach to model selection (Burnham and Anderson 2002). The standard candidate-models that we evaluated are listed in Appendix A. The variables incorporated into our models have been found to be associated with pipit occurrence either on the breeding grounds (Fisher and Davis 2011, Sutter and Brigham 1998) or winter grounds (Grzybowski 1982, Macias-Duarte 2011). We also evaluated site and year effects in our models.

Results

During winter 2013-2014, we surveyed 29 transects between 13 January and 27 March, 2014; 6 at Attwater's Prairie Chicken National Wildlife Refuge, 7 at Clive Runnells Family Mad Island Marsh Preserve, 2 at Francine Cohn Preserve, 5 at Texas City Prairie Preserve, 7 at Mad Island Wildlife Management Area, and 2 at Nash Prairie Preserve. During winter 2014-2015, we re-surveyed all of the aforementioned transects except the ones at Francine Cohn Preserve and Nash Prairie Preserve, which we dropped from the study. However, we established 7 new transects at Powderhorn Ranch. In total during winter 2014-2015, we surveyed 32 transects between 3 December, 2014, and 17 March, 2015. We initiated surveys for all transects between 0730 and 1422. On average, it took 16.5 minutes to complete a survey, but the amount of time per survey ranged between 7.5 to 40 minutes dependent largely on factors such as ease of walking through the habitat and number of Sprague's Pipits detected.

We found Sprague's Pipits at all study sites (Table 2). During winter 2013-2014, we had 24 detections of Sprague's Pipits during transect surveys. Most detections were of single individuals (n = 20), but a few detections consisted of clusters of pipits in groups of 2 (n = 3) and 23 (n = 1) individuals. During winter 2014-2015, we had 29 detections of Sprague's Pipits during transect surveys. All accept one of these detections were of single pipits. The only detection of a cluster of pipits during winter 2014-2015 was of 2 individuals. Relative abundance of Sprague's Pipits detected during surveys varied across sites and, in several instances, between years (Table 2). Attwater's Prairie Chicken National Wildlife Refuge was the most consistent site for pipits with relatively high numbers detected during both winter 2013-2014 and winter 2014-2015. We also opportunistically obtained GPS locations for 21 pipits during winter 2013-2104 and 56 pipits during winter 2014-2015 (Table 2).

We provide distance-based estimates of density and abundance, but sample size (i.e., number of detections) was relatively low and generally below the threshold (n < 60-80) to generate reliable estimates (Buckland et al. 2001), particularly on a site by site basis. The distance model with the half-normal key function and cosine series expansion fit the data adequately during winter 2013-2014 (P-value for Kolmogorov-Smirnov goodness of fit test = 0.22). Overall, estimated detection probability was 46.0% (95% CI = 36.2–58.4%) and effective strip width (ESW) was 40.7 m (95% CI = 32.0–51.6 m). Pipit density was estimated at 0.07 pipit/acre (95% CI = 0.19–0.31) or 17.3 pipits km^{-2} for winter 2013-2014. The estimated number of pipits on all of our study areas during winter 2013-2014 was 494 (95% CI = 207–1,175). The distance model with the half-normal key function and cosine series expansion fit the winter 2014-2015 data well (P-value for Kolmogorov-Smirnov goodness of fit test = 0.69). Overall, estimated detection probability was 25.8% (95% CI = 21.0–31.6%) and effective strip width (ESW) was 26.8 m (95% CI = 21.9–32.9 m). Pipit density was estimated at 0.10 pipit/acre (95% CI = 0.05–0.18) or 24.7 pipits km^{-2} during winter 2014-2015. The estimated number of pipits on all our study sites during winter 2014-2014 was 617 (95% CI = 317–1,198).

Four models had $\Delta AICc$ values ≤2. Local (individual) level pipit occurrence was best explained by the model including percent vertical cover from 0.0-0.5 m (Ht_0.5) and site. Percent vertical cover from 0.0-0.5 m was the only variable represented in all of the top models. However, in addition to site, percent bare ground (Soil) and year were variables that were also represented in the top models. For ease of presentation and initial interpretation, we present statistics for vegetative variables averaged across sites and years for all study sites combined for each winter (Table 4). However, we provide statistics for each site for each winter in Appendix B. We also present statistics for vegetation at points where we opportunistically detected pipits for comparison with the vegetation at flush and transect points. Overall, percent vertical cover from 0.0-0.5 m (Ht_0.5) was lower where pipits flushed than at points along survey transects. Percent bare ground (Soil) was higher where pipits flushed than at points

Table 2. Detections of Sprague's Pipits, during transect surveys and opportunistically, and relative abundance by study site and winter.

Study Site[1]	Winter	Transects (n)	Total no. detections for all transect surveys	Max. no. detections per transect summed across transects	Mean of max. no. detections per transect summed (SE)	No. opportunistic detections on the study site
APCNWR	2013-2014	6	13	6	1.00 (0.52)	13
	2014-2015	6	13	7	1.17 (0.40)	28
CRFMIMP	2013-2014	7	29	29	4.14 (4.14)	-
	2014-2015	7	4	3	0.43 (0.30)	10
FCP	2013-2014	2	1	1	0.50 (0.50)	-
MIWMA	2013-2014	7	2	1	0.29 (0.18)	-
	2014-2015	7	1	1	0.14 (0.14)	12
NPP	2013-2014	2	1	1	0.50 (0.50)	-
PR	2014-2015	7	4	3	0.43 (0.50)	1
TCPP	2013-2014	5	0	0	0.00 (0.00)	8
	2014-2015	5	8	6	1.20 (0.82)	5

[1] APCNWR = Attwater Prairie Chicken National Wildlife Refuge, CRFMIMP = Clive Runnels Family Mad Island Marsh Preserve, FCP = Francine Cohn Preserve, MIWMA = Mad Island Wildlife Management Area, NPP = Nash Prairie Preserve, PR = Powderhorn Ranch, TCPP = Texas City Prairie Preserve.

Table 3. Best model (lowest AIC*c*) and top models (ΔAIC*c* ≤2) used to assess the relationship between Sprague's Pipit occurrence and local (individual) level habitat variables. Log-likelihood values [Log(*L*)], number of parameters (*K*), minimum AIC*c*, ΔAIC*c*, and Akaike weight (w_i) are reported.

Model	Log(*L*)	*K*	Minimum AIC_c	ΔAIC_c	w_i
Ht_0.5 + Site	-148.98	4	316.3	0.00	0.361
Ht_0.5 + Soil + Site + Year	-147.69	6	317.8	1.55	0.166
Ht_0.5 + Site + Year	-148.83	5	318.0	1.75	0.150
Ht_0.5 + Soil	-156.07	4	318.2	1.92	0.138

Table 4. Vegetative characteristics of Sprague's Pipit flush points, points along survey transects, and points where Sprague's pipits were opportunistically flushed. For flush points and transect points, means for a variable with the same superscript letter were not statistically different ($P > 0.5$; t-tests).

Model variable	Flush points		Transect points		Opportunistic points	
	Mean ± SE	95% CI	Mean ± SE	95% CI	Mean ± SE	95% CI
Forb	62.4 ± 6.4[a]	(49.8, 75.0)	31.0 ± 1.6[b]	(27.8, 34.2)	46.6 ± 5.7	(35.4, 57.7)
Grass	62.4 ± 6.4[a]	(49.8, 75.0)	66.7 ± 1.9[a]	(62.9, 70.5)	52.2 ± 4.6	(43.2, 61.3)
HT_0-0.5m	15.6 ± 2.1[a]	(11.6, 20.0)	36.5 ± 1.2[b]	(34.2, 38.7)	18.2 ± 1.8	(14.7, 21.7)
Nat_Gr	40.9 ± 6.4[a]	(28.4, 53.5)	55.2 ± 2.0[b]	(51.3, 59.1)	28.8 ± 3.9	(20.1, 35.4)
Woody	1.0 ± 0.4[a]	(0.3, 1.8)	5.8 ± 0.6[a]	(4.5, 7.0)	0.6 ± 0.2	(0.3, 1.2)
Soil	20.3 ± 3.5[a]	(15.4, 25.1)	16.5 ± 26.0[a]	(14.3, 18.6)	15.5 ± 2.0	(11.6, 19.3)

along survey transects. Although not identified as important variables in our top model set, percent forb cover (Forb) and percent native grass cover (Nat_Gr) also differed between points where pipits flushed and points along survey transects. Percent forb cover was higher where pipits flushed than at points along survey transects. Percent native grass cover was lower where pipits flushed than at points along survey transects. Overall percent grass cover and number of woody stems did not differ between pipit flush points and transect points.

Discussion and Management Implications

Sprague's Pipit appears to winter in highest densities in Texas grasslands (National Audubon Society 2009, Jones 2010); thus, research conducted and conservation actions implemented in Texas could have a substantial impact on the recovery of the species. However, assessments of the species' habitat use in Texas have largely been anecdotal (see Jones 2010) or included as part of more general assessments of wintering grassland bird communities (Emlen 1972, Grzybowski 1982, Igl and Ballard 1999, Heath et al. 2008, Marx et al. 2008). To our knowledge, our research is the first focused, quantitative assessment of local (individual) level habitat use by Sprague's Pipits in Texas.

Although concentrations of Sprague's Pipits have been reported (Jones 2010), particularly from southern Texas, we generally found Sprague's Pipits to be solitary and occurring in low densities on the middle and upper Texas Gulf Coastal Plain. The species seems to be widely distributed, though, and we observed pipits on all of our study sites. However, relative abundance generally varied among sites and between winters. Overall density and abundance also varied between years. Similar patterns have been observed on the wintering grounds in Arizona (Ruth et al. 2014), Texas (Grzybowski 1982, Marx et al. 2008), and in the Chihuahuan Desert (Contreras-Balderas 1997, Pool et al. 2012). Annual and spatial variation in climate, plant productivity and species composition, and management (e.g., grazing pressure) likely explain this pattern. Such variability in density estimates could complicate the identification of core areas for protection and management of Sprague's Pipit habitat. While all of the conservation lands we surveyed had Sprague's Pipits, application of management (grazing and prescribed fire) generally varied, not only among sites, but also within sites, from year to year. Annual variability in the application of management could have significant impacts on the availability and suitability of habitat for Sprague's Pipits on protected and managed conservation lands. Although some

Table 5. Reported densities of Sprague's Pipits on the wintering grounds in the central grasslands of northern México and southern United States.

Mean density	Location	Citation
0.07-0.10 pipits/acre 17.3-24.7 pipits km^{-2}	Austin, Brazoria, Calhoun, Colorado, Galveston, Matagorda, and Nueces counties, TX	Kostecke et al. 2015
- 4.4 pipits km^{-2}	Welder Wildlife Refuge, San Patricio County, TX	Emlen 1972
0.00-0.36 pipits/acre -	Welder Wildlife Refuge, San Patricio County, TX	Grzybowski 1982
0.00-0.08 pipits/acre -	Brooks, Jim Wells, Kenedy, and Kleburg counties, TX	Igl and Ballard 1999
- 0.4-12.0 pipits km^{-2}	Chihuahuan Desert, Mexico and U.S.	Pool et al. 2012

of our study sites (i.e., Clive Runnels Mad Island Marsh Preserve and Texas City Preserve Preserve) had higher relative abundances of Sprague's Pipits at least during one of our two winter field seasons, Attwater Prairie Chicken National Wildlife was the only study site which consistently had high and stable relative abundance of Sprague's Pipits during both of our winter field seasons. The consistency in occurrence and relative abundance of pipits on the refuge likely results from their sustained focus on managing native grassland to benefit the endangered Attwater's Prairie Chicken (*Tympanuchus cupido attwateri*) using a combination of grazing and prescribed fire.

While private and public conservation lands like the ones surveyed in our study will undoubtedly play a significant role in the conservation and recovery of the Sprague's Pipit, it is important to note they comprise a small amount of the land base and potential Sprague's Pipit habitat in Texas. Further research is needed to determine the status of the species on private, working grasslands and in regions within Texas other than the middle and upper Texas Gulf Coastal Plain.

Percent vertical cover from 0.0-0.5 m (Ht_0.5) was the most ubiquitous variable in our set of top models of pipit occurrence. Reduced vertical cover or vertical grass density has previously been associated with Sprague's Pipit occurrence and density (Pool et al. 2012, Ruth et al. 2014). In general, the species has been found to use areas of short grass, <50 cm in height, on the wintering grounds (Grzybowski 1982, Macias-Duarte 2011). In the Chihuahuan Desert, peak densities occurred in grasslands around 28 cm high (Pool et al. 2012). Lower or higher grass had a negative effect on density. In the breeding range, pipit territories have also been found to have an average vegetation height of 20-25 cm (Fisher and Davis 2011). Percent bare ground (Soil) was also highlighted as an important variable in one of our top models. Ruth et al. (2014) also found Sprague's Pipits to be positively associated with amount of bare ground. In contrast, the species seems to prefer less bare ground on the breeding grounds (Dechant et al. 2001). On the wintering grounds, percent bare ground cover could be indicative of a bunchgrass type vegetative structure. The open structure of a bunchgrass community with bare-ground between the plants could allow for easier movement while providing some protective overhead cover, which could benefit foraging efficiency.

Although pipits are typically associated with native grass cover on the breeding grounds (Davis 2004, Grant et. al. 2004, Jones 2010) and it has been suggested that winter habitats are similar (see Jones 2010), none of our top models indicated that native grass cover was an important indicator of pipit occurrence at our study sites on the middle and upper Texas Gulf Coastal Plain. Further, native grass cover was lower at points where we flushed pipits during surveys or opportunistically. This result could be related to a couple different factors. In Arizona, pipits were negatively associated with native grass (Ruth et al. 2014). Although counter to the impression we have of the pipit as a native grassland specialist, such a result could be explained if vegetative structure is more important than species composition (Davis and Duncan 1999). This could be the case in our study. For example, all of the pipits we detected during surveys at Texas City Prairie Preserve were from the dike or fire breaks, both mowed areas dominated by exotic Bermuda grass (*Cynodon* sp.). Additionally, pipits are known to use paved or unpaved secondary or tertiary roads with grass shoulders, particularly in agricultural or rural settings (Freeman 1999). Exotic grasses are more likely to be present along road shoulders. Many of our opportunistic pipit detections were from road shoulders.

In the Chihuahuan Desert, pipits have been positively associated with overall grass cover and negatively associated with shrub cover (Pool et al. 2012). Sprague's Pipits have also been negatively associated with shrub cover in Texas (Emlen 1972, Igl and Ballard 1999). However, neither overall grass nor woody (i.e. stem density) cover were included as variables in any of our top models of pipit occurrence. Because all of our study sites actively manage for grasslands, on average, these variables may not have differed greatly between or within sites. It is also important to note that the grasslands on the managed conservation lands we conducted our surveys on might not be representative of the greater landscape as a whole. Additional research is needed to assess whether pipit occurrence is associated with similar vegetative variables on private, working grasslands and in regions within Texas other than the middle and upper Texas Gulf Coastal Plain.

Grassland management typically requires some form of disturbance, typically by fire, grazing, mowing, or herbicide. Vegetative structure favored by Sprague's Pipits, such as low vertical cover from 0.0-0.5 m, can likely be created by such disturbances. Indeed, we consistently found pipits on the mowed dike at Texas City Prairie Preserve, and after haying, when it has occurred, at Nash Prairie Preserve. Sprague's Pipits also seem to respond well to the combination of prescribed fire and light to moderate intensity grazing at Attwater Prairie Chicken National Wildlife Refuge. In general, use of various means of disturbance in conjunction or rotation, particularly on smaller habitat patches rather than over large areas, can be an effective means of creating a vegetative mosaic and a mix of habitat structures that could benefit pipits as well as other grassland birds (Fuhlendorf et al. 2006). However, while disturbance can create habitat structure suitable for the Sprague's Pipit, habitat suitability can also potentially be reduced by disturbance if the timing, frequency, intensity, or duration is inappropriate (Askins et al. 2007). There is little data on optimal levels of disturbance (e.g., low versus moderate versus heavy grazing) for benefitting Sprague's Pipits on the wintering grounds. Further, management strategies may vary by region or even site. Further research is needed to elucidate the response of Sprague's Pipits to various management regimes.

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Appendix A – Standard set of candidate-models used to evaluate the association of Sprague's Pipit occurrence with local level habitat variables.

Standard candidate-models:
Forb + Soil
Forb + Soil + Site + Year
Ht_0.5
Ht_0.5 + Nat_Gr
Ht_0.5 + Site
Ht_0.5 + Soil
Ht_0.5 + Year
Ht_0.5 + Site + Year
Ht_0.5 + Nat_Gr + Site + Year
Ht_0.5 + Soil + Site + Year
Intercept
Nat_Gr
Nat_Gr + Forb
Nat_Gr + Soil
Nat_Gr + Woody
Nat_Gr + Forb + Soil
Nat_Gr + Site + Year
Nat_Gr + Forb + Site + Year
Nat_Gr + Soil + Site + Year
Nat_Gr + Woody + Site + Year
Nat_Gr + Forb + Soil + Site + Year
Site
Site + Year
Year

Appendix B: Vegetative characteristics of Sprague's Pipit flush points, points along survey transects, and points where Sprague's pipits were opportunistically flushed at attwater's Prairie Chicken National Wildlife Refuge during winters 2013-2014 and 2014-2015.

	Flush Point				Opportunistic				Transect			
			95% CI				95% CI				95% CI	
	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower
2013-2014												
Soil	25.5	2.4	30.2	20.8	11.2	0.9	12.9	9.5	10.0	0.6	11.2	8.8
Forb	64.1	7.5	78.9	49.3	97.4	7.4	111.8	82.9	54.9	2.3	59.5	50.4
Woody	1.8	0.5	2.8	0.7	0.6	0.2	0.9	0.2	5.7	0.6	6.9	4.4
Grass	77.4	4.7	86.7	68.1	74.0	3.2	80.2	67.9	80.1	1.7	83.5	76.6
Nat_Gr	64.8	3.4	71.6	58.1	72.8	3.3	79.1	66.4	70.8	1.8	74.4	67.3
HT_0-0.5m	9.5	0.9	11.4	7.7	12.8	1.0	14.8	10.7	35.7	1.0	37.7	33.8
2014-2015												
Soil	20.2	2.5	25.0	15.3	17.0	2.2	21.3	12.8	15.9	0.8	17.5	14.2
Forb	39.0	4.7	48.1	29.9	33.9	4.0	41.7	26.1	29.2	1.4	31.9	26.5
Woody	0.9	0.2	1.3	0.4	036	0.3	1.1	0.1	5.8	0.6	6.9	4.7
Grass	21.4	2.2	25.7	17.0	36.4	4.0	44.3	28.5	56.1	1.7	59.4	52.8
Nat_Gr	19.2	2.2	23.4	14.9	23.5	3.6	30.6	16.4	49.5	1.8	53.0	46.0
HT_0-0.5m	24.2	2.7	29.4	19.0	29.4	2.2	33.8	25.0	29.9	1.0	31.9	27.9

Appendix B: Vegetative characteristics of Sprague's Pipit flush points, points along survey transects, and points where Sprague's pipits were opportunistically flushed at Clive Runnells Family Mad Island Marsh Preserve during winters 2013-2014 and 2014-2015.

	Flush Point				Opportunistic				Transect			
			95% CI				95% CI				95% CI	
	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower
2013-2014												
Soil	20.5	1.4	23.4	17.7	-	-	-	-	29.3	1.5	32.2	26.3
Forb	136.2	6.5	148.9	123.5	-	-	-	-	36.6	1.9	40.3	32.9
Woody	-	-	-	-	-	-	-	-	3.5	0.5	4.5	2.4
Grass	53.4	5.9	65.0	41.8	-	-	-	-	54.5	1.9	58.2	50.8
Nat_Gr	47.3	6.1	59.3	35.3	-	-	-	-	49.1	1.8	52.6	45.7
HT_0-0.5m	14.7	1.2	17.0	12.3	-	-	-	-	31.4	1.1	33.7	29.2
2014-2015												
Soil	35.7	2.7	41.1	30.3	19.5	2.0	23.3	15.6	19.2	1.2	21.5	16.9
Forb	18.4	2.9	24.0	12.7	48.6	4.9	58.2	38.9	27.9	1.4	30.7	25.1
Woody	-	-	-	-	0.5	0.1	0.8	0.2	3.8	0.6	4.9	2.6
Grass	36.6	4.4	45.2	28.1	15.1	2.3	19.5	10.6	51.7	1.7	55.0	48.4
Nat_Gr	10.1	2.0	14.1	6.2	13.5	2.3	17.9	9.1	43.6	1.7	46.9	40.2
HT_0-0.5m	3.3	0.4	4.0	2.6	14.1	1.4	16.9	11.3	33.0	1.1	35.3	30.8

Appendix B: Vegetative characteristics of Sprague's Pipit flush points, points along survey transects, and points where Sprague's pipits were opportunistically flushed at Mad Island Wildlife Management Area during winters 2013-2014 and 2014-2015.

	Flush Point				Opportunistic				Transect			
			95% CI				95% CI				95% CI	
	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower
2013-2014												
Soil	2.8	0.6	3.8	1.7	-	-	-	-	13.2	1.2	15.5	10.9
Forb	115.5	3.9	123.2	107.8	-	-	-	-	44.9	1.8	48.4	41.4
Woody	1	0.2	1.4	0.6	-	-	-	-	6.4	1.1	8.5	4.3
Grass	124.5	1.3	39.2	34.2	-	-	-	-	95.9	2.1	100.1	91.7
Nat_Gr	124.5	1.3	39.2	34.2	-	-	-	-	91.8	2.2	96.1	87.6
HT_0-0.5m	36.7	1.3	39.2	34.2	-	-	-	-	40.6	1.0	42.6	38.6
2014-2015												
Soil	-	-	-	-	26.1	2.3	30.7	21.5	26.5	1.3	29.0	24.0
Forb	-	-	-	-	32.1	4.3	40.5	23.6	16.7	0.7	15.0	12.3
Woody	-	-	-	-	0.2	0.1	0.3	0.1	1.8	0.2	2.2	1.3
Grass	-	-	-	-	42.1	3.6	49.2	35.1	56.5	1.5	59.3	53.6
Nat_Gr	-	-	-	-	22.9	2.9	28.6	17.1	51.4	1.3	53.8	48.5
HT_0-0.5m	-	-	-	-	13.9	1.1	16.1	11.7	32.8	1.2	35.1	30.4

Appendix B: Vegetative characteristics of Sprague's Pipit flush points, points along survey transects, and points where Sprague's pipits were opportunistically flushed at Powderhorn Ranch during winter 2014-2015.

	Flush Point				Opportunistic				Transect			
			95% CI				95% CI				95% CI	
	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower
2014-2015												
Soil	30.0	2.6	35.1	24.9	22.6	1.0	24.7	20.6	13.7	0.7	15.1	12.4
Forb	7.2	1.0	19.5	15.5	26.0	0.7	27.3	24.7	33.1	1.3	35.7	30.6
Woody	2.3	0.4	3.0	1.5	6.5	0.4	7.3	5.7	2.7	0.3	3.2	2.2
Grass	45.6	3.6	52.6	38.6	19.5	0.4	20.3	18.7	57.8	1.1	61.0	56.6
Nat_Gr	27.6	1.6	30.7	24.6	4.0	0.7	5.3	2.7	51.9	1.4	54.6	49.2
HT_0-0.5m	32.3	2.8	37.7	26.9	2.9	0.2	3.3	2.4	38.5	1.0	40.5	36.5

Appendix B: Vegetative characteristics of Sprague's Pipit flush points, points along survey transects, and points where Sprague's pipits were opportunistically flushed at Texas City Prairie Preserve during winters 2013-2014 and 2014-2015.

	Flush Point				Opportunistic				Transect			
			95% CI				95% CI				95% CI	
	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower
2013-2014												
Soil	-	-	-	-	5.8	0.9	7.6	3.9	4.5	0.4	5.4	3.6
Forb	-	-	-	-	98.0	6.5	110.7	85.3	46.6	1.8	50.0	43.1
Woody	-	-	-	-	1.1	0.3	1.6	0.5	13.7	0.7	15.0	12.3
Grass	-	-	-	-	93.8	3.1	100.0	87.7	92.8	1.6	95.9	89.6
Nat_Gr	-	-	-	-	44.1	4.8	53.5	34.7	52.6	2.3	57.0	48.1
HT_0-0.5m	-	-	-	-	13.9	0.9	15.7	12.1	46.2	1.4	48.9	43.6
2014-2015												
Soil	0.3	0.1	0.5	0.2	0.8	0.1	1.0	0.6	3.0	0.2	3.4	2.6
Forb	3.4	0.3	4.0	2.9	3.4	0.1	3.7	3.1	9.8	0.7	11.3	8.3
Woody	-	-	-	-	0.2	0.1	0.3	0.1	13.2	0.9	14.9	11.5
Grass	91.8	3.0	97.6	86.0	89.6	2.7	94.9	84.3	64.7	1.7	68.0	61.2
Nat_Gr	-	-	-	-	-	-	-	-	32.9	1.6	36.1	29.7
HT_0-0.5m	6.0	0.2	6.4	5.7	9.9	1.5	12.9	7.0	48.2	1.2	50.7	45.8

Appendix B: Vegetative characteristics of Sprague's Pipit flush points, points along survey transects, and points where Sprague's pipits were opportunistically flushed at Francine Cohn Preserve (FC), and Nash Prairie Preserve (NP = Nash Prairie Unit, NPW = Mowotony Prairie Unit) during winter 2013-2014.

	FC				NP				NPW			
			95% CI				95% CI				95% CI	
	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower	Mean	SE	Upper	Lower
Soil	24.3	1.2	26.7	21.8	16.9	1.2	19.2	14.7	0.2	<0.0	0.2	0.2
Forb	11.3	0.8	12.8	9.8	8.8	0.5	9.8	7.7	12.7	0.7	14.1	11.3
Woody	10.9	0.8	12.4	9.3	0.2	<0.0	0.3	0.1	-	-	-	-
Grass	96.0	2.2	100.3	91.7	122.3	2.5	127.1	117.5	99.9	0.5	100.8	98.9
Nat_Gr	96.0	2.2	100.3	91.7	103.6	3.4	110.2	97.0	87.1	1.4	89.9	84.2
HT_0-0.5 m	34.0	1.0	36.0	32.0	32.5	1.6	35.6	29.3	50.2	0.6	51.4	49.0

Development of a probability map for occurrence of Sprague's Pipit along the Texas coast

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Data from the Christmas Bird Count and eBird indicate that the coast of Texas, here defined as the Western Gulf Coastal Plain[1], serves as an important region for wintering Sprague's Pipits. Therefore, we sought to create a map that would provide habitat-based occurrence probabilities for the species throughout this region. Previous analyses of land cover associations of this species throughout Texas revealed that the species associates with the following broad land cover types: grassland, pasture/hay, grassy wetland, and cropland[2]. These cover types have the common feature of being relatively devoid of woody canopy cover. That is, the species seems to avoid areas with substantial canopy cover. Our probability map was developed in ArcGIS 10.2 at a resolution of 4 km (each pixel is 4 x 4 km). For each pixel within the focal region, we determined the proportion of the four cover types with data provided by the National Land Cover Database 2011 edition[3]. We then used the following equation to determine a probability of occurrence for each pixel: $P(occurrence) = p(grassland) + p(pasture)/1.5 + p(wetland)/1.5 + p(cropland)/2$, where $p(x)$ = the proportion of the cover type in the 16 km^2 area. In this equation, grassland was given the greatest weight followed by pasture and wetland each of which was given a weight of 0.67 and cropland which was given a weight of 0.5 relative to grassland. Grassland was given the greatest weight in that it is the natural habitat of this species. The other cover types were given weights in accordance to their physical resemblance to grassland and/or their degree of "naturalness".

The map reveals areas of very low probability of occurrence to very high probability (Fig. 1). Areas immediately adjacent to the coastline are generally low probability due to urbanization/development and pixels sometimes being positioned such that they include substantial open water. There is a small strip of higher probability along the middle portion of the coast; this might represent the grassy dune areas of San Jose Island and Matagorda Island. As expected, areas of urbanization (e.g., Houston and surrounding area, Galveston, Beaumont/Port Arthur, Corpus Christi, and south Texas) have very low probability of occurrence. Areas of the highest probability of occurrence include Katy Prairie and Attwater Prairie Chicken National Wildlife Refuge both of which have numerous eBird records of Sprague's Pipits (Figs. 1 and 2). The agricultural and ranching area immediately west of Beaumont also has high probability as does a very broad area of extreme south Texas. This latter area encompasses the eastern half of Jim Hogg County and extends eastward into smaller portions of Brooks, Hidalgo, and Kenedy counties. Interestingly, both of these areas are relatively "under-surveyed" by eBird, particularly the high-probability area in south Texas (Fig. 2). This map could be used to guide future survey efforts for Sprague's Pipit and perhaps regional conservation planning. However, we stress that the map is only a guide. Further research efforts could modify and improve the map.

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[1] US EPA (2004) revision of Omernik (1987) Level III ecoregions. Ecoregion also referred to as Gulf Coast Prairies and Marshes by TPWD.
[2] Muller, JA (2015), Landscape scale habitat associations of Sprague's Pipit (*Anthus spragueii*) overwintering in the southern United States. Unpublished M.S. thesis, Texas State University.
[3] Based on satellite imagery, the NLCD classifies 30 x 30 m pixels to 15 broad cover types. Our mapping used a subset of these cover types relevant to Sprague's Pipit.

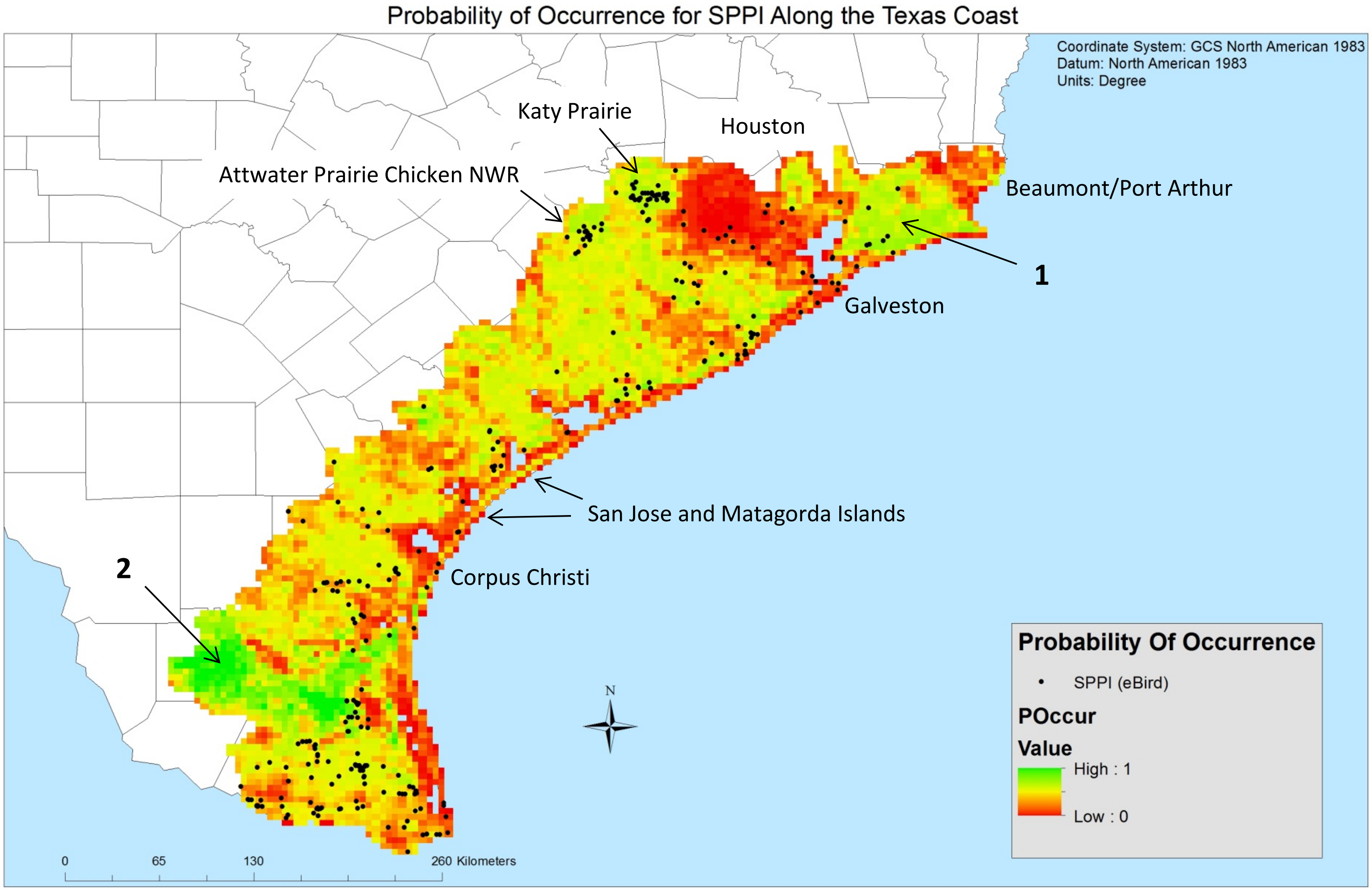
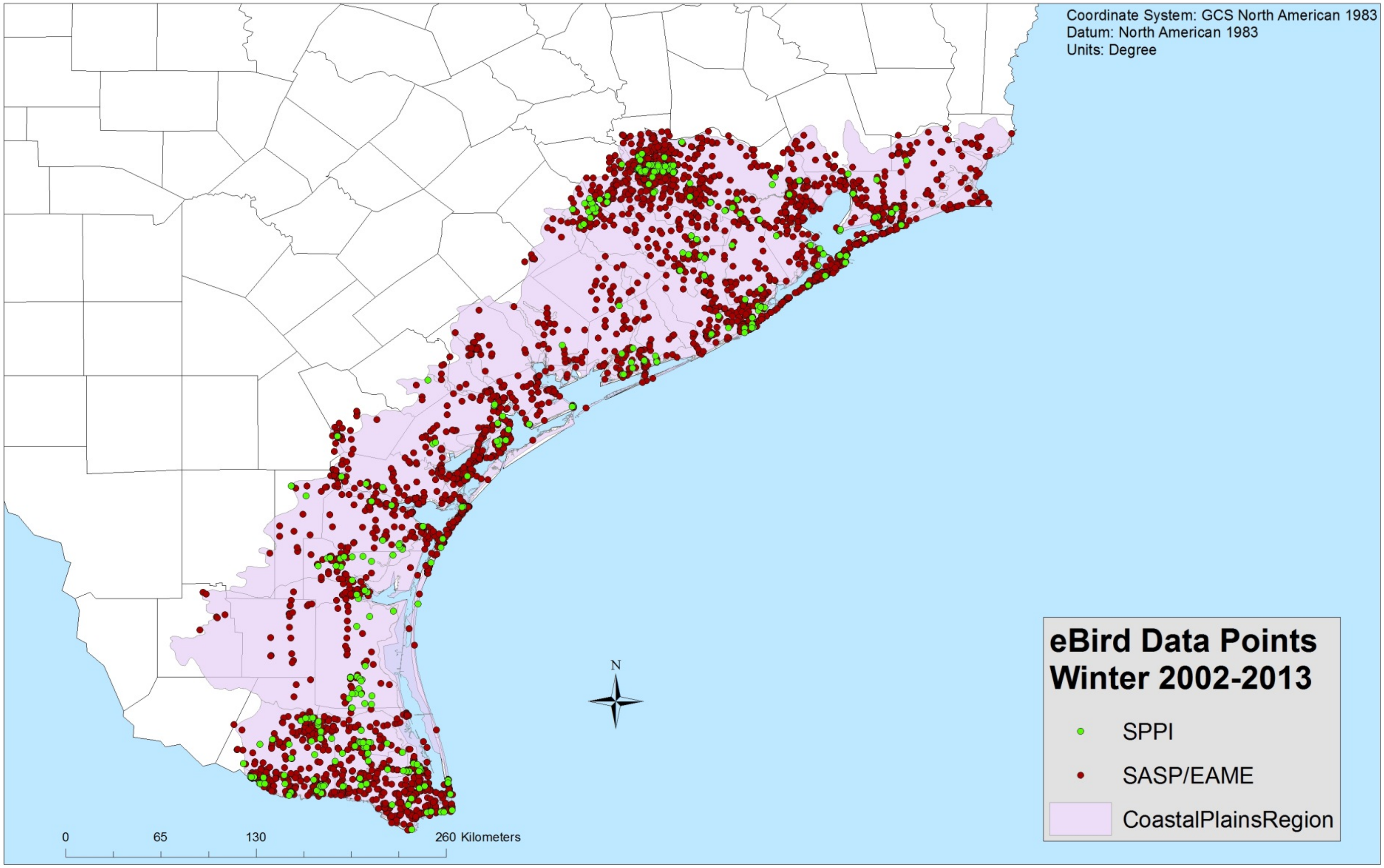


Figure 1. Probability map for occurrence of Sprague's Pipit in coastal Texas, including eBird locations of the species between 2002 – 2013. Map resolution is 4 x 4 km. Labels 1 and 2 indicate two areas of high probability that are relatively under-surveyed by eBird (also see Figure 2).

Date: 9/11/2015

eBird Effort Map



Date: 9/11/2015

Figure 2. Map depicting eBird locations of Sprague's Pipit (SPPI) and survey effort. eBird checklists having either Savannah Sparrow or Eastern Meadowlark (SASP/EAME) were used as a proxy for survey effort. Both are relatively common grassland bird species that occupy habitat similar to that occupied by Sprague's Pipit.