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Texas Comptroller

Texas Species Research

IAC # 15-5545RR

Black Rail

(*Laterallus jamaicensis*)

Photo: Black Rail at San Bernard NWR, 2017

(Credit: A. A. Moore)

Prepared by:

Amanda A. Moore

Texas State University, San Marcos

Department of Biology

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Primary respondent: Dr. Floyd Weckerly

Department of Biology, 601 University Drive, Texas State University, San Marcos, Texas 78666. E-mail: fw11@txstate.edu; Phone: 512-245-3353

Co-respondent: Dr. M. Clay Green
Department of Biology, 601 University Drive, Texas State University, San Marcos, Texas 78666. E-mail: claygreen@txstate.edu; Phone: 512-245-8037

Research Collaborator: James D. M. Tolliver

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Summary

The enigmatic Black Rail (*Laterallus jamaicensis*) is often regarded as the most secretive marsh bird in North America. The Eastern Black Rail *(L. j. jamaicensis*) may be the most endangered bird species along the Atlantic and Gulf coasts of North America, as it is listed as endangered in six eastern states and is proposed for federal listing as threatened. Determining the status of a species or its populations is an arduous task but there are some principles that can help inform conservation efforts: resiliency and redundancy. The objective of this research is to assess the current status of the Eastern Black Rail in coastal Texas, specifically in terms of resiliency and redundancy of rail populations. In 2015 and 2016, we conducted the first large scale study of Black Rail occupancy and abundance in Texas. Six-minute call-playback surveys were conducted to detect rails acoustically. We modeled Black Rail occurrence while accounting for imperfect detection and used the top model to predict important areas for the species. We used a geographic information system (GIS) to extrapolate habitat associations to the Texas gulf coast. We found that Black Rail occupancy increased in marsh habitats with high levels of herbaceous vegetative cover (>60%), dominated primarily by graminoids, and with sparse woody cover. In the winter and spring of 2017 and 2018, we conducted a radio telemetry study to obtain home range information on Black Rails in Texas. Average home range was 0.52 (SD = 0.36, 95% MCP, n=14), with no difference between males and females, and birds were found using habitats dominated by *Spartina spartinae* (gulf cordgrass) in the lower areas of the intermediate marsh. We also conducted a mark-recapture study with Black Rails and Yellow Rails in six habitat plots that differed in number of years since last burned. Results showed that the amount of years post-burn was not as important as the vegetative state of the habitat. We hope our findings enable a better understand of Black Rail status and habitat requirements in coastal Texas.

Introduction

The enigmatic Black Rail (*Laterallus jamaicensis*) is often regarded as the most secretive marsh bird in North America. According to the Eastern Black Rail Conservation & Management Working Group, the Eastern Black Rail *(L. j. jamaicensis)* may be "the most endangered bird species along the Atlantic and Gulf coasts of North America". Some estimates indicate a 75% or greater decline in population sizes over the past 10-20 years (Watts, 2016). The Eastern Black Rail (hereafter: Black Rail) is listed as endangered in six eastern states and has been proposed to be listed as threatened Under the Endangered Species Act. Black Rails were first documented in Texas as far back as 1879 (Cooke, 1914), but throughout those nearly 140 years only one study has been published (Tolliver et al., 2018), which was a direct result of the data collected for the project reported here. Furthermore, based on the amount of marsh habitat in the state, Texas may have an abundance of Eastern Black Rails. Thus, Texas represents a knowledge gap critical for conservation planning of the species.

This report describes the findings of research conducted from 2015 – 2018 along the Texas gulf coast. In 2015 and 2016 we conducted repeated call-playback surveys at 6 study sites and measured covariates of Black Rail detection, occupancy, and abundance. Data collected from these surveys was used to create a species distribution model for Black Rails along the Texas gulf coast. Other objectives for these surveys were to: (1) determine covariates relating to Black Rail detection, occupancy, and abundance; (2) estimate Black Rail occupancy and abundance along the Texas coast; and (3) estimate the required survey effort to precisely estimate Black Rail occupancy with and without correcting for detection. See Tolliver et al. (2018) for details and results of estimates of abundance and survey effort.

In 2017 and 2018 two other studies were conducted: a radio telemetry study and a burn regime study. The objectives for the radio telemetry study were to: (1) estimate the home range size for Black Rails at San Bernard National Wildlife Refuge (NWR) in Texas; and (2) examine habitat selection within home ranges. The purpose of this study

was to better understand Black Rail habitat requirements in Texas by examining home range size, movements, and habitat selection through the use of radio telemetry.

The objectives of the burn regime selection study were to obtain and compare abundances of wintering Black Rails and Yellow Rails (*Coturnicops noveboracensis*) in study plots differing in time since burned at San Bernard NWR in Texas to examine interspecific abundance relationships and which burn regimes contain the highest/lowest numbers of rails. In Texas, Black Rail and Yellow Rail wintering habitat overlaps. Since Yellow Rails and Black Rails are known to share some of the same wintering grounds, it is possible that interspecific competition is occurring in one form or another.

Chapter 1: Species distribution models for the Eastern Black Rail
Introduction

Species distribution models (SDMs, or ecological niche models, species or climatic envelope models, etc.) are used to derive spatially explicit predictions of habitat suitability for a species. This is accomplished by combining species occurrence or abundance data at known locations with environmental and spatial parameters at those locations (Elith and Leathwick, 2009). Predictions can be made to identify new sites within the range of sites sampled (interpolation) and to novel, unsampled sites (extrapolation) across a landscape (Elith and Leathwick, 2009). Projecting the generated functions to areas that have not been sampled but where the environmental characteristics are known is a cost-effective method of predicting suitable habitat for a species. Estimating suitable habitat for a species is critical for species conservation as suitable habitat that has not been sampled can be evaluated for species presence or if absent, potentially species reintroduction.

The Black Rail is often thought of as one of the most elusive birds on the continent. The small body size and particularly shy nature of this rail, coupled with occupying dense, marsh vegetation has made the species difficult to study. Species distribution models can be particularly useful in determining the distribution of hard to detect species such as the Black Rail. By predicting suitable areas with high probability of

occupancy, refuge managers can eliminate surveying sites with little probability of presence and focus efforts in more likely suitable areas, thereby increasing efficiency in locating occupied sites.

There are many different methods available to generate SDMs and the results can be as general or specific as data inputs. There is a wide variety of modeling algorithms that can be used in building SDMs but there are 4 types of species data typically used: presence-only, presence-background, presence-absence, and occupancy-detection (Guillera-Arroita et al., 2015; Guillera-Arroita, 2017). Occupancy-detection data (DET) are the most robust in that they enable models to account for imperfect detection using the estimate of occupancy probability. Since DET data are collected via repeated visits, it is possible to obtain a detection probability, or an estimate of the probability of detecting a species if it is present at a site (MacKenzie et al., 2002). Not accounting for detectability can lead to underestimated probability of occurrence, and overestimation or underestimation of habitat suitability (Tyre et al., 2003; Guillera-Arroita et al., 2015). Occupancy-detection data can be modeled hierarchically using a logistic regression to describe the distribution of the species and relate the probability of its presence at a site to environmental predictors through a logit link function (Guillera-Arroita, 2017).

Failing to detect a species at a location does not guarantee that the species is absent. A fundamental complication with species occurrence data is that species are often detected imperfectly (Chen et al., 2013). Treating observed species occurrence and distribution as the actual or true occurrence and distribution without accounting for imperfect detection can lead to poorly formulated SDMs and reduce their predictive accuracy (Gu and Swihart, 2004; Lahoz-Monfort et al., 2014). Further, failure to account for imperfect detection can lead to biased estimates of habitat relationships and possibly incorrect inference (Gu and Swihart, 2004; Martin et al., 2005).

Moreover, the detection probability of occupancy can be influenced by sampling methods and effort, habitat characteristics, and environmental variables such as wind speed and temperature. Taking all these factors into account, in certain situations

underestimation of occupancy for rare and cryptic species such as Black Rails could be common if imperfect detection is not accommodated.

Texas has been suggested as a stronghold for the Black Rail, despite dramatic declines elsewhere within its range (Watts, 2016), yet data is lacking. In this study, we used DET data in an occupancy framework to develop SDMs for the Black Rail along the Texas coast. Because this species has such low detectability, it is difficult to estimate distribution, abundance, and population trends without accounting for imperfect detection. By separately recording detections and non-detections at sites visited multiple times, Tolliver et al. (2018) has estimated detection probability for Black Rails at the study sites (p = 0.18, SE = 0.02). Using the same covariates as Tolliver *et al.* 2018 for detection (lunar phase and noise), we selected GIS data with habitat variables hypothesized to be the driving forces for Black Rail occupancy in the Texas gulf coast region.

Methods

Study Area

The study area consists of multiple refuges within the Gulf Prairie and Marshes ecoregion (Gould et al., 1960) along the Texas coast (Figure 1). This region is a fairly level, slow-draining plain intersected by rivers and streams that drain into the Gulf of Mexico. This region occupies about 3,844,500 ha, is less than 150ft in elevation, and includes tidal flats, dunes, bays and estuaries surrounded by salt grass marshes, remnant tallgrass prairies, scattered oak parklands and mottes, and tall woodlands in the river bottomlands (Gould et al., 1960).

The 6 sites where call-playback surveys were conducted include Anahuac National Wildlife Refuge (NWR; 13,759 ha) in Chambers County, Brazoria NWR (17,973 ha) in Brazoria County, San Bernard NWR (21,853 ha) in Brazoria and Matagorda Counties, Mad Island Wildlife Management Area (2,913 ha), Clive Runnells Family Mad Island Marsh Preserve (2,858 ha) in Matagorda County, and Powderhorn Ranch (6,981 ha) in Calhoun County. These sites represent a gradient of climatic conditions as they occur along an annual precipitation gradient with the highest precipitation (~145 cm/year) at

Anahuac NWR and lowest (~106 cm/year) at Powderhorn Ranch (Baker et al., 1994). Additionally, temperatures along the Texas coast increase from northeast (32°C max and 5°C min) to southwest (33°C max and 7°C min; Baker et al., 1994).
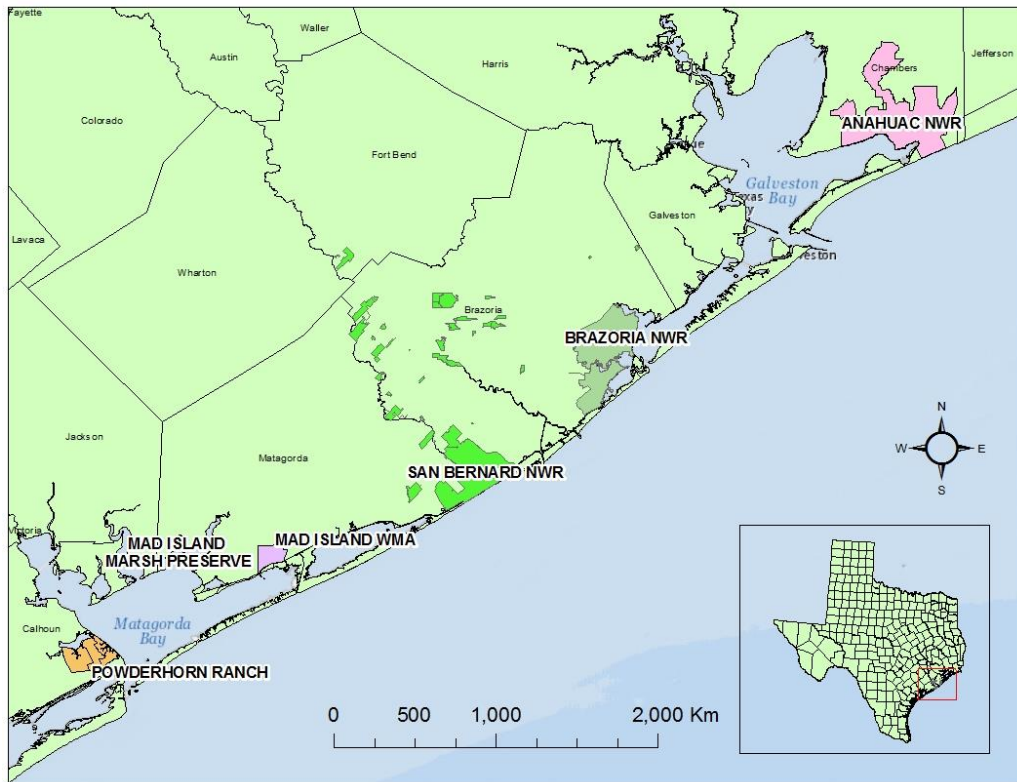
Figure 1: Location of 6 study sites along the Texas coast where Black Rail call-playback surveys were conducted in 2015 and 2016.

Species occurrence data

Using GIS, transects were established along roads and firebreaks that ran through potential and unsuitable habitat and then a subset was randomly selected. Survey points were spaced 400m apart to avoid risk of double counting individual birds and to increase total area covered by monitoring efforts. Surveys were conducted twice a day: 30min prior to sunrise until 2hrs after sunrise, and 2hrs prior to sunset until 30min after sunset. Observers recorded the number of Black and Clapper Rails to respond to call-playback, as well as direction of each bird using a compass and an estimate of the distance of each bird within distance bands (0-50m, 50-100m, 100-150m, >100m).

Numerous environmental variables were recorded during each survey including weather data, lunar phase, ambient noise level, and disturbance (i.e. cattle grazing or recently burned).

Call play-back surveys were conducted up to 6 times per survey point following the general methodology described by Conway (2011). The survey sequence was slightly modified to as follows: 4 minutes of passive listening followed by 30 seconds of Black Rail calls, then 30 seconds of silence followed by 30 seconds of Clapper Rail (*Rallus crepitans*) calls, and then a final 30 seconds of silence. Clapper Rail calls were included since a previous study found an increase in response of some marsh birds with the broadcast of a conspecific's call (Conway and Nadeau, 2010). Calls on mp3s were obtained to reflect the regional dialect. Sound pressure in the broadcast speakers was measured at 80-90db and the surveyor stood at least 2m away from the speaker.

Modeling detectability and occupancy

We modeled Black Rail occupancy as a function of habitat covariates affecting presence-absence of the species, contingent on sampling covariates (*i.e.* those recorded at each survey) affecting detectability (MacKenzie et al., 2002). For this analysis, we used detection covariates previously determined to be influential by Tolliver et al. (2018) as the base model in the set of occupancy ($\hat{\psi}$) models. Lunar phase and ambient noise were each coded as discrete variables. Lunar phase ranged from 0 (no moon) to 15 (full moon), and ambient noise ranged from 0 (no noise) to 9 (no detections recorded because of noise). Based upon the species' life-history information, we selected GIS data that we thought would affect Black Rail occupancy and developed the occupancy models using the following habitat covariates: ecotype, existing vegetation cover (EVC, layer represents the vertically projected percent cover of the live canopy layer for a 30-m grid cell), soil slope, soil drainage, percent emergent wetland, and distance to open water. To determine which of these habitat covariates were influential, we first estimated multi-seasonal occupancy models for each candidate covariate while holding all other parameters constant. We considered covariates influential if they were

statistically significant at an 85% (|Z| ≥ 1.41, P ≤ 0.15) confidence level (Arnold, 2010). The program R (R Development Core Team 2009) was used for all statistical analyses.

We conducted a multi-year analysis of occupancy dynamics using the *colext* function in the R-package "unmarked" (Fiske and Chandler, 2011). We fitted multi-season occupancy models with increasing complexity holding colonization, and extinction parameters constant, and used Akaike's information criterion adjusted for small sample size (AIC$_C$) for model selection. Models with ΔAIC$_c$ values ≤2 were considered to have strong support (Burnham and Anderson, 2003). We used the *predict* function in UNMARKED to obtain predictions of occupancy which we then used to produce maps of potentially important areas.

We obtained GIS data on ecotype from The Ecological Mapping Systems of Texas (Texas Parks & Wildlife Department, https://tpwd.texas.gov/gis/programs/landscape-ecology/by-ecoregion-vector/western-gulf-coastal-plain, accessed June 2018), soil slope and soil drainage from United States Department of Agriculture, Natural Resources Conservation Service (http://datagateway.nrcs.usda.gov/, accessed Aug 2018), emergent wetland and open water from U. S. Fish and Wildlife Service (http://www.fws.gov/wetlands/, accessed Aug 2018), and EVC data from LANDFIRE: LANDFIRE Existing Vegetation Type layer (http://landfire.cr.usgs.gov/viewer/, accessed Aug 2018).

Percent emergent wetland was obtained by calculating the proportion of pixels categorized as a type of emergent wetland within 100m^2 buffered area around survey points. Ecotype was a categorical variable that was parsed into 5 categories representing the ecotypes we surveyed the most: Gulf Coast: Coastal Prairie Pondshore, Gulf Coast: Salty Prairie, Gulf Coast: Salty Prairie, Coastal: Salt and Brackish High Tidal Marsh, and Coastal: Salt and Brackish Low Tidal Marsh (see

Table 1 for partial ecotype descriptions). The EVC data was also categorical but we converted EVC to a continuous scale of 1 to 9, with 1 representing the lowest cover category (≥10% and <20% herbaceous cover) and 9 the highest (≥90 and ≤100% herbaceous cover). To obtain values most representative of the area around a survey

point or Black Rail estimated location via distance sampling, we used the Spatial Analyst tool in ArcGIS 10.6 (ESRI, Redlands, CA) to calculate focal statistics for the soil data, EVC, and ecotype variables. This analysis calculates the majority (value that occurs most often) of the cells in the specified neighborhood around it. All continuous covariates were standardized before the analysis (MacKenzie et al., 2017).

Table 1. Descriptions (partial) from Elliott (2014) of ecotypes used as habitat covariates in occupancy models.

Ecotype	Description
Chenier Plain: Fresh and Intermediate Tidal Marsh	Herbaceous system, mucky soils, salinity <4ppt. Dominants are graminoids and woody cover is minor.
Coastal: Salt and Brackish High Tidal Marsh	Irregularly flooded marsh dominated by graminoids such as *Spartina patens* (marshhay cordgrass), *Distichlis spicata* (saltgrass), and *Schoenoplectus* spp. (bulrushes).
Coastal: Salt and Brackish High Tidal Marsh	Irregularly flooded marsh dominated by graminoids such as *Spartina patens* (marshhay cordgrass), *Distichlis spicata* (saltgrass), and *Schoenoplectus* spp. (bulrushes).
Coastal: Salt and Brackish Low Tidal Marsh	Marshes frequently inundated by tides and often dominated by *Spartina alterniflora* (smooth cordgrass).
Gulf Coast: Coastal Prairie Pondshore	Ponds or swales within the coastal prairie matrix. Soils are poorly-drained, and surface water from rainfall and local runoff is retained for much of the year. Primarily herbaceous, sometimes with sparse woody cover.

Results

Over the 2 years of surveys combined, a total of 3,425 surveys were conducted at 308 individual survey points. We detected 239 individual Black Rails at 92 points during 190 of the surveys. Across all study sites, naïve occupancy (not accounting for detection) was 0.20 in 2015 and 0.18 in 2016, and naïve mean abundance was 0.25 rails/point in 2015 and 0.26 in 2016 (Tolliver et al., 2018).

Occupancy covariates determined to be influential from preliminary analysis, and thus used in the model selection, were ecotype, soil slope, and EVC. Results from the model selection analysis showed two competing models (ΔAIC$_c$ <2): the global model and the model that included ecotype and EVC (Table 2). We selected the model with one with less parameter, ecotype and EVC. The ecotype and EVC combination with the highest $\hat{\psi}$ (0.79, ±0.13) was Gulf Coast: Coastal Prairie Pondshore and Herbaceous Cover ≥70 and <80% (Figure 2). The w$_i$ for each occupancy covariate were: ecotype = 0.99, VC = 0.99, and slope = 0.45.

Table 2. Candidate models explaining Black Rail occurrence in the coastal region of Texas from 2015 to 2016. Models accounted for imperfect detection. *K* is the number of parameters in the model, AIC$_c$ is Akaike's Information Criterion adjusted for small sample size, ΔAIC$_c$ is the difference in AIC$_c$ value relative to the top model, and *w$_i$* is the AIC$_c$ weight.

Model[b]	*K*	ΔAIC$_c$	*w$_i$*	*−2 Log-likelihood*
$\hat{\psi}$ (Ecotype + EVC)	12	0	0.55	1333.76
$\hat{\psi}$ (Ecotype + EVC + soil slope)	13	0.66	0.40	1332.42
$\hat{\psi}$ (Ecotype + soil slope)	12	6.16	0.03	1340.02
$\hat{\psi}$ (Ecotype)	11	6.26	0.02	1341.92
$\hat{\psi}$ (EVC + soil slope)	8	18.87	0	1360.63
$\hat{\psi}$ (EVC)	7	19.59	0	1363.35
$\hat{\psi}$ (Soil slope)	7	32.65	0	1376.41
$\hat{\psi}$ (Intercept only)	6	37.46	0	1383.22

[b]Base model for all models included $\hat{p}$(noise + lunar phase), where $\hat{p}$ denotes detection probability. VC = vegetation percent cover.
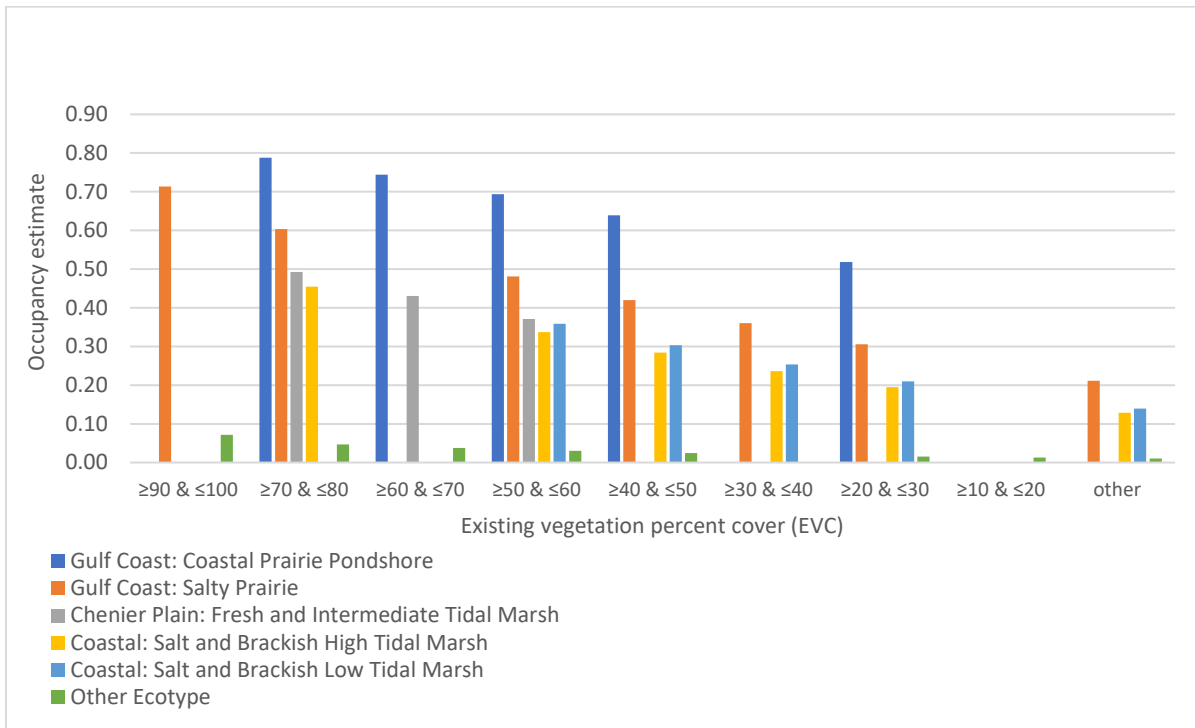
Figure 2. Predicted probabilities of occupancy ($\hat{\psi}$) for Black Rails in the coastal region of Texas as described by 2 habitat covariates: ecotype and vegetation percent cover (VC). All VC categories are for herbaceous cover. Categories titled as "other" represent all other categories combined. The absence of an $\hat{\psi}$ within a VC category indicates the combination of ecotype and VC did not occur within the areas surveyed.

Occupancy was influenced positively by EVC and by all ecotypes besides "other", which was the reference category (Table 4). As was also reported in Tolliver et al. (2018), detection was negatively influenced by ambient noise level and positively influenced by lunar cycle, where detection probability increased under quieter conditions (less ambient noise) closer to a full moon (Table 4). A very low proportion of the study region was predicted to have habitat suitable for Black Rails (Table 3 and Figure 3). The study site with the greatest proportion of the best predicted habitat ($\hat{\psi}$ ≥50%) relative to its size was the Mad Islands (28.9%), whereas Powderhorn Ranch had the least (0.13%). The study site with the greatest amount of the best predicted habitat was Anahuac NWR (43,209 pixels), whereas Powderhorn Ranch was the smallest (1,519 pixels).

Discussion

We found that Black Rail occupancy increased in marsh habitats with high levels of herbaceous vegetative cover (>60%), dominated primarily by graminoids and with sparse woody cover. We detected the most Black Rails at Anahuac NWR (*n* = 139) which also had the highest amount of best predicted habitat, and the least amount of Black Rails at Powderhorn Ranch (*n* = 0) which had the least amount of best predicted habitat. Somewhat contrary to our survey results since we detected a relatively low number of Black Rails at the Mad Islands (*n* = 30), the model showed a high proportion of suitable habitat at the Mad Islands. Some areas that we surveyed with high predicted occupancy had no Black Rail detections. This could be due to Black Rail presence that was undetected or to issues with the SDM.

One possible issue with our model is that some areas where Black Rails were detected show a relatively low probability of occurrence. This is due to the relatively high occupancy probabilities of specific combinations of ecotype and EVC that are not found everywhere along the coast. For instance, the ecotype Chanier Plain: Fresh and Intermediate Tidal Marsh, only occurred at one of our study sites (Anahuac NWR) and the ecotype with the highest occupancy probability, Gulf Coast: Coastal Prairie Pondshore occurred sparingly at most study sites and not at all at San Bernard NWR.

Another possible problem with our SDM is errors in the GIS data. Ideally refuge managers can use the outputs of a SDM to focus survey efforts in more likely suitable areas. However, an important factor in model performance is accuracy of GIS data. Miss-categorization of areas can lead to inaccurate occupancy predictions and so ground-truthing GIS data is an important step that should be taken before implementing rigorous survey efforts.

The performance and accuracy of a SDM is in part contingent upon understanding what habitat covariates may be important to the species in question and also on the availability of that data in a GIS format. It is possible we missed some important covariates that would have improved model performance. Average annual precipitation

and elevation were considered for use in the model but the appropriate spatial scale
and resolution for these variables was not available.

Table 3. Predicted probability of occurrence of Black Rails within coastal Texas study region

Probability of occurrence	Number of 3km cells	Percent of study area
0-0.2	20720	94.6
0.2-0.4	768	3.5
0.4-0.6	307	1.4
0.6-0.8	118	0.5
0.8-1.0	0	0
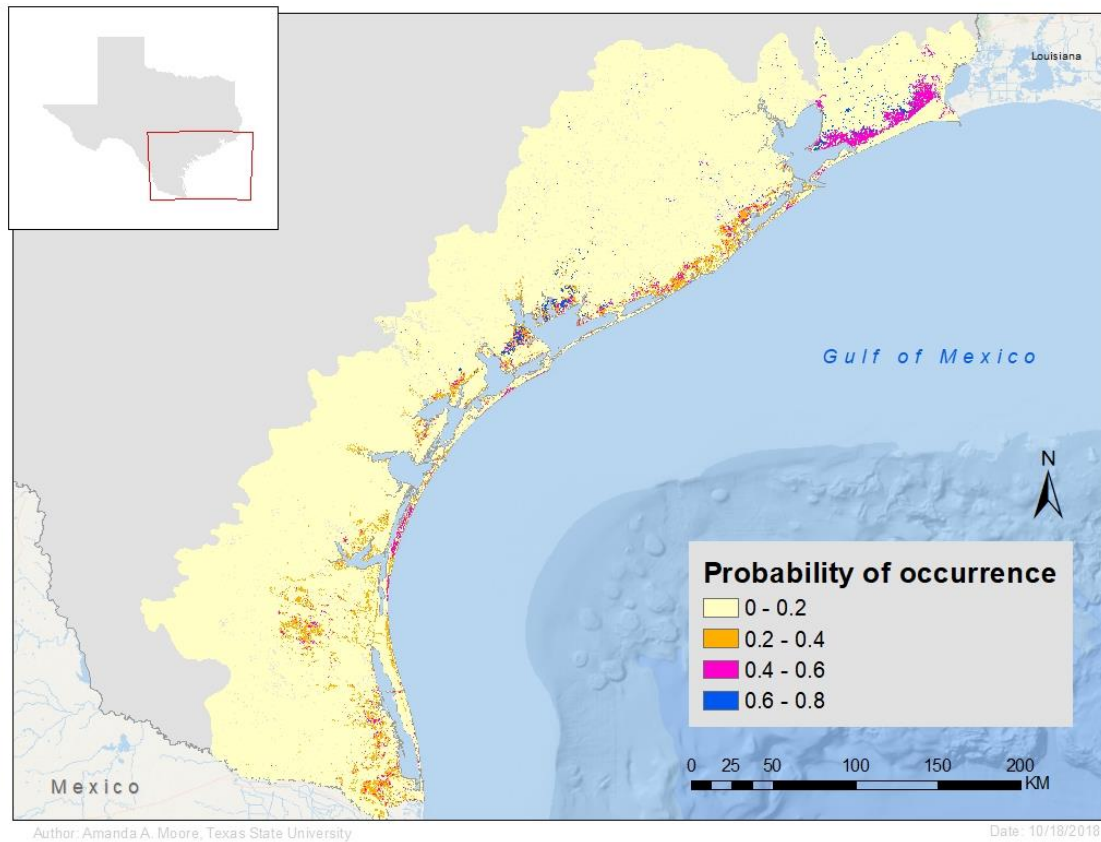
Figure 3. Predicted probability of occurrence for the Black Rail in coastal Texas. No predicted
value for occupancy was higher than 0.79.

Table 4. Untransformed regression coefficients for the covariates potentially affecting site occupancy ($\widehat{\psi}$) and detection probabilities ($\hat{p}$) of Black Rails in coastal Texas in 20115 and 2016.

Covariate	$\hat{\beta}$	SE	p-value
$\widehat{\psi}$ intercept	-3.74	1.02	<0.001
Gulf Coast: Coastal Prairie Pondshore	4.27	1.27	0.001
Gulf Coast: Salty Prairie	3.37	1.05	0.001
Chenier Plain: Fresh and Intermediate Tidal Marsh	2.92	1.07	0.006
Coastal: Salt and Brackish Low Tidal Marsh	2.87	1.27	0.025
Coastal: Salt and Brackish High Tidal Marsh	2.77	1.11	0.013
Existing vegetation cover (EVC)	0.65	0.26	0.013
$\hat{p}$ intercept	-1.43	0.12	<0.001
Ambient noise	-0.23	0.09	0.009
Lunar phase	0.30	0.09	0.001

Chapter 2: Radio Telemetry

Introduction

Understanding habitat requirements is imperative for managing and protecting habitat for species of conservation need (Noss et al., 1997). For species conservation, we must begin by protecting the appropriate amount and type of habitats required to maintain a viable population. Also of great importance is understanding species-specific area requirements which factor into the determination of habitat suitability (Noss et al., 1997). For species that are elusive or shy and therefore difficult to detect and observe, telemetry studies, radio or satellite, are often useful tools to understand habitat requirement for species. Radio telemetry can help answer questions and strengthen the knowledge base in many research areas such as home range and territory size, movement and habitat relationships, survival, dispersal, breeding behavior, and some aspects of demography (Kenward, 2000; Warnock and Takekawa, 2003).

Several studies have used radio telemetry to estimate home range and core usage area of Black Rails, but no research has been conducted on movement and home range of Eastern Black Rails in Texas. Previous studies on estimating home range of Black Rails

has focused on the Atlantic population of the Eastern Black Rail and the California Black Rail. In Florida, males used 1.3 ha while females used 0.62 ha during egg laying and incubation(Legare and Eddleman, 2001). Estimates in Maryland of home range size (though not determined through telemetry) were 3-4 ha (Davidson, 1992), and in Virginia, home range mapped by tracking vocalizations of one individual over a period of 7 days in June/July was estimated to be 0.47 (Graves, 2013). Radio-tagged California Black Rails at Mittry Lake in Arizona where water levels are stable year-round had a home range of 0.50 for males and 0.44 ha for females during the breeding season (Flores and Eddleman, 1991). California Black Rails in the tidal marshes in San Francisco Bay were found to have a fixed-kernel home range of 0.59 ha with a mean core area of 0.14 ha, where female's home range was 0.26 ha (males were a 46% larger), with no difference in core-area size between the sexes(Tsao et al., 2009). The purpose of this study was to better understand Black Rail habitat requirements in Texas by examining home range size, movements, and habitat selection through the use of radio telemetry.

Methods

Capture and Radio Marking

Black Rails were captured and fitted with 0.9g radio transmitters (model BD-2, Holohil Systems Ltd., Carp, Ontario, Canada). There is no published mass data for Black Rails in Texas, however the average mass is 29.3g for the California subspecies (Tsao *et al.* 2009) and 35g for those in Florida (Eddleman *et al.* 1994). Birds were weighed upon capture to ensure the transmitters did not exceed 3% of the bird's body mass. Transmitters were glued to the bird's back using Loctite® Epoxy Gel with a 6-minute setting time (Henkel Corporation North America). After a transmitter was set in place, birds were placed in an observation pen for 5 minutes and then inspected to ensure that the glue was dry and that the bird's wings were free from the glue. Black Rails were captured and marked under a USGS banding permit (#23546), Texas Parks and Wildlife Scientific Collection Permit (SPR-0106-005) and approved IACUC protocol (IACUC201533955) through Texas State University, San Marcos.

We captured Black Rails at San Bernard NWR (Figure 4) from January to May of 2017 and 2018 using the bottle-line method or an audio-lure method, both of which were conducted 30 min after local sunset. The bottle-line is a 15m length of rope weighted with 5 small paint cans spaced ~1.5m apart along the rope. The cans contain various objects (rocks, jingle bells) that create noise and cause a physical disturbance when dragged through the vegetation. Each crew member had a headlamp and/or hand-held spot-lights to spot for birds. Two people held opposite ends of the rope and walked slowly, remaining equidistant to each other while the other two crew members walked ~2m behind the rope. Each person was spaced ~5m from each other. We used dip-nets to capture any Black Rails that flushed. For the audio-lure method, we would carefully walk through Black Rail territories playing various calls on portable speakers in attempt to elicit a response. Once a Black Rail responded, we repeatedly played calls to lure the bird out of the vegetation where we were able to either hand-capture the bird or capture with small (20cm) aquarium fish nets.
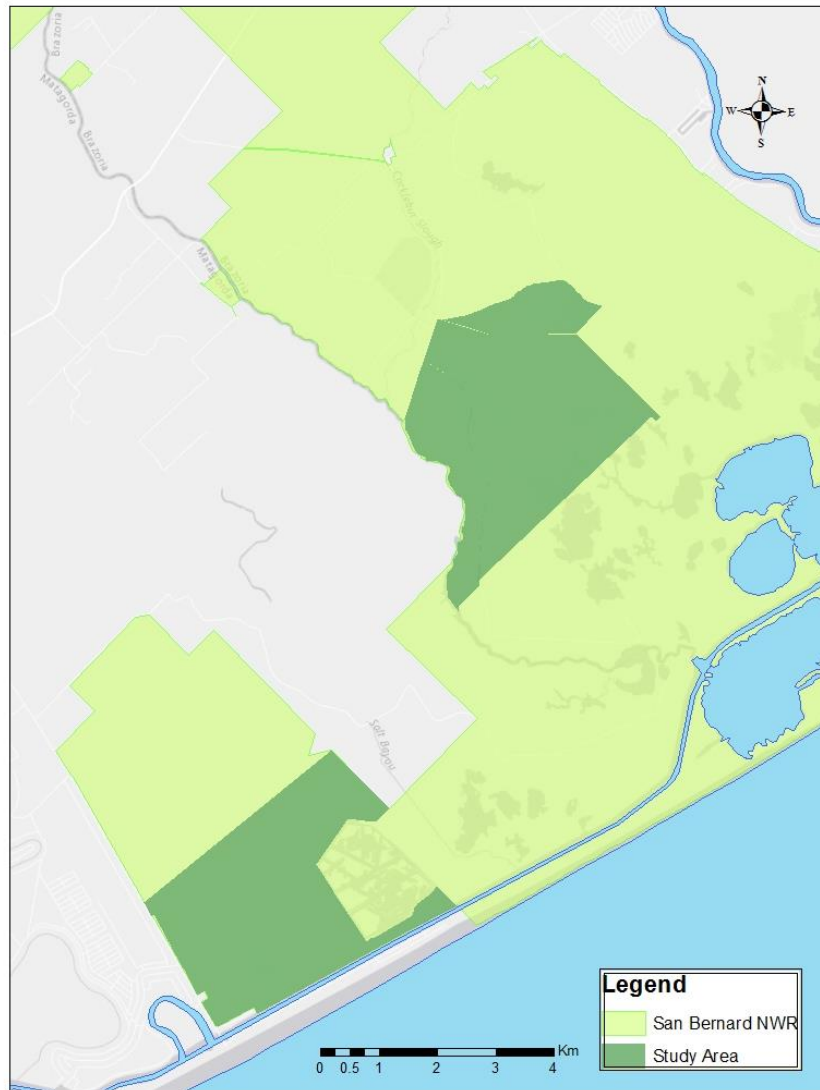
Figure 4. Location of areas at San Bernard NWR, Texas, where Black
Rail radio telemetry study took place (2017-18).

Radio Tracking

Radio-tagged Black Rails were located using the homing method or by triangulation, as
described by White and Garrott (1990), with hand-held three-element Yagi antennas
and receivers (Model R4000, Advanced Telemetry Systems, Inc., Insanti, MN). When
homing, observers would approach rails within 5 meters and record a GPS waypoint to
estimate its location (Garmin GPS eTrex 20x, WAAS enabled <3m position accuracy,
Garmin International, Inc., Olathe, KS). To minimize impact on the sensitive vegetation

in the birds' habitat and reduce potential of trampling nests, triangulation was used as the season neared spring when nesting was possible. Birds were located 1–4 times daily until the transmitter fell off or the battery failed. Bird locations were obtained ≥1 hr apart to reduce potential autocorrelation among locations (White and Garrott, 1990). Tracking sessions were conducted daily between 30 min prior to sunrise and 30 after sunset and at least once during each hour of the day. Since Black Rails are reportedly inactive at night (Flores and Eddleman, 1995), we did not regularly track the birds after sunset.

Statistical analyses

Home Range
A commonly used definition of home range is "that area traversed by the animal during its normal activities of food gathering, mating and caring for young" (Burt, 1943). We calculated 95% minimum convex polygons (MCP) plus 95% (home range) and 50% (core use area) kernel density estimates (KDE) to measure the utilization distribution for each bird (Worton, 1989). The MCP method measures the area within all (or a certain percentage of *i.e.* 95%) the relocations, while KDE measures intensity of use of an area and excludes areas used minimally (White and Garrott, 1990). We used referenced bandwidth as the smoothing parameter for the KDEs. The smoothing parameter controls the "width" of the kernel functions placed over each relocation. We calculated MCPs and KDEs using the R package "adehabitatHR" (Calenge, 2011).

Habitat Selection
To examine habitat selection, we extracted raster data from within 95% MCP home ranges using ArcMap (Spatial Analyst, ArcGIS 10.6 ESRI, Inc., Redlands, CA). We extracted ecotype data from The Ecological Mapping Systems of Texas (https://tpwd.texas.gov/gis/programs/landscape-ecology/by-ecoregion-vector/western-gulf-coastal-plain, accessed June 2018), elevation from Light Detection and Ranging (LIDAR) data for the Texas Mid-coast National Wildlife Refuge Complex (obtained directly from USFWS on an external hard drive).

Results

Home Range

We captured 9 birds from February – May 2017 and 7 birds from February – April 2018. We obtained an average of 22.2 (SD = 9.7) relocations per bird and home range was analyzed for birds with at least 10 relocations (n=14). The average 95% minimum convex polygon (MCP) home range for all birds was 0.91 (SD = 1.5) ha, however the home range for one bird was over 11 times greater than the rest. Excluding this outlier bird from the sample, the average home range was 0.52 (SD = 0.36). This outlier bird was a male and made more large-scale movements than any other bird we tracked and did not seem to have a core use area, coinciding with "wandering activity" seen in winter and post-nesting in Arizona (Flores and Eddleman, 1991), and mentioned by Todd (1980). We were able to record a large movement of roughly 415m within the span of 2 hours during one of our tracking sessions of this bird. We tracked this bird for 12 days before he ostensibly left the area and was not relocated again.

The MCP and KDE home range core area size did not differ between years or between males and females (*t*-test: *P* > 0.05, Table 5) and home ranges did not overlap except for those of 2 male and female pairs captured together. Our study spanned winter and breeding seasons but using March as the beginning of breeding season in Texas since this is when we located a Black Rail nest and egg, birds captured during breeding (*n* = 7) average home range was 0.56 ha (SD = 0.39), and those tracked in the winter, *i.e.* before March (*n* = 3), had an average home range size 0.37 ha (SD = 0.24). However, there was no difference between these groups (*t*-test: *P* > 0.05).

Table 5. Means (±SD) of home range (95%) and core use area (50% kernel) of 14 radio-marked Black Rails captured at San Bernard NWR, Texas, winter and spring 2017 and 2018.

Home range estimation method		Females (n = 4)	Males (n = 10)
Minimum convex polygon			
	Home range (ha)	0.37 (±0.18)	1.1 (±1.8)
	Core area (ha)	0.08 (±0.04)	0.26 (±0.46)
Kernel density estimation			
	Home range (ha)	1.6 (±1.3)	4.6 (±8.3)
	Core area (ha)	0.36 (±0.21)	0.98 (1.7)

Habitat Selection

The most common ecotype categories found within Black Rail home ranges were "Gulf Coast: Salty Prairie", "Coastal: Salt and Brackish Low Tidal Marsh", and "Costal: Salt and Brackish High Tidal Marsh" (Table 6). Also notable within home ranges was a small percentage (10%) of the ecotype "Native Invasive: Baccharis Shrubland". The elevation range at San Bernard NWR's main refuge (not including disjunct upland parcels of land that belong to the refuge) was 26.4 - 145.2 cm, with an average of 91.4 cm, whereas the mean elevation of Black Rail relocations was 67.8 cm (SD = 15.2) (Table 6).

During radio tracking we incidentally located 1 Black Rail nest that contained a single egg on 19 March 2018. We presumed this nest belonged to one of the radio tagged birds we were tracking since the dropped transmitter (the bird had pulled it off) was located directly under the nest. The nest was constructed in a clump of gulf cordgrass (*Spartina spartinae*) and appeared to be made entirely of *S. spartinae* and a few Black Rail feathers. The rim of the nest was 16 cm from the ground and the nest bowl measured 8 cm wide and 1.5 cm deep. The surrounding vegetation consisted of ~75% *S. spartinae* and sea oxeye daisy (*B. fructescens*), 20% key grass (*Monanthochloe littoralis*), with small amounts of saltgrass (*Distichlis spicata*), Carolina wolfberry (*Lycium carolinianum*), pickleweed (*Salicornia* sp.) and dodder (*Cuscuta* sp.). The surrounding canopy height of the vegetation was ~70 cm. We did not approach the nest for 3 days

after it was initially located but when we eventually returned to the nest it appeared unchanged and ultimately the birds abandoned the nest and the egg.

Table 6. Ecotypes within 95% MCP home ranges of 14 radio-marked Black Rails captured at San Bernard NWR, Texas, winter and spring 2017 and 2018.

Ecotype*	Number of 10m^2 cells	Percent of all home ranges
Gulf Coast: Salty Prairie	642	51%
Coastal: Salt and Brackish Low Tidal Marsh	255	20%
Coastal: Salt and Brackish High Tidal Marsh	221	18%
Native Invasive: Baccharis Shrubland	129	10%
Columbia Bottomlands: Hardwood Forest and Woodland	1	0%

*See Table 1 for partial descriptions of ecotypes
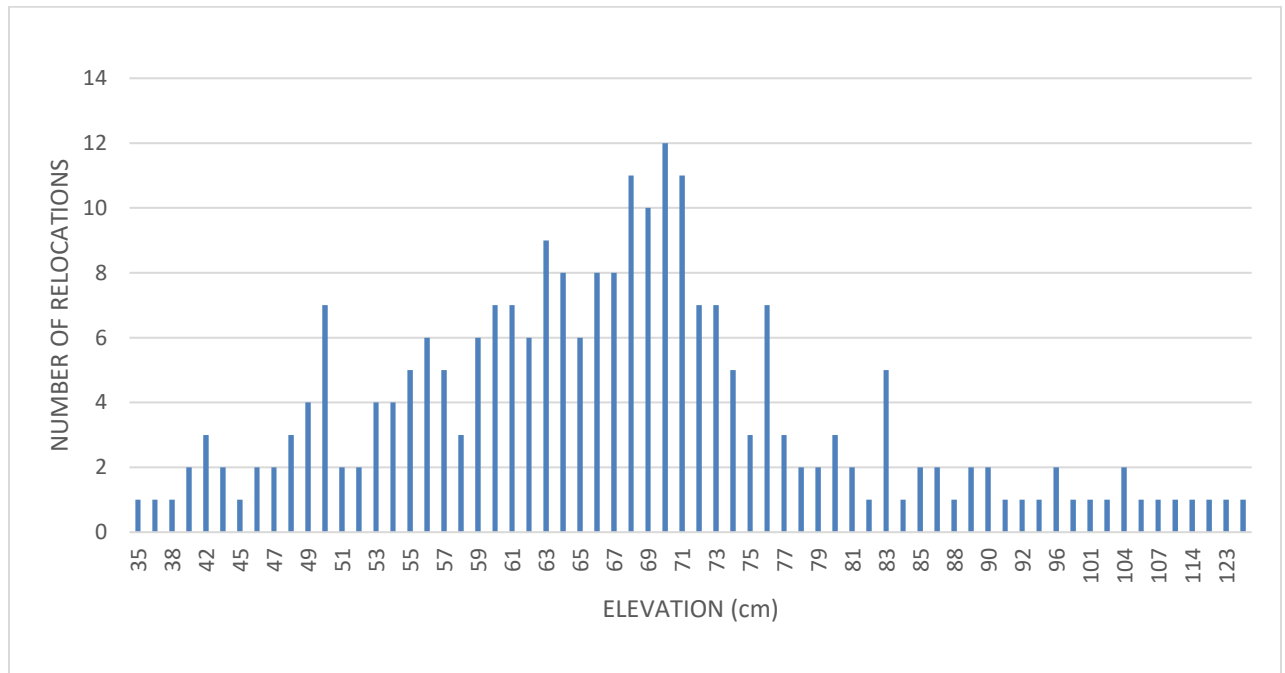
Figure 5. Elevation at 243 relocations of radio-marked Black Rails captured at San Bernard NWR, Texas, winter and spring 2017 and 2018. Mean elevation: 67.8 cm (SD = 15.2).

Discussion

At San Bernard NWR in Texas, Black Rails had home ranges that were closer in size to those of California Black Rails in Arizona (0.44 - 0.50 ha; Flores and Eddleman, 1991) and San Francisco Bay, California (0.59 ha; Tsao et al., 2009). Home ranges in this study were about half the size of those in Florida (0.62 - 1.3 ha; Legare and Eddleman, 2001),

excluding the outlier bird with the exceedingly large home range. Smaller home ranges may indicate an abundance of food, or a higher density of Black Rails at our study site.

We found no seasonal difference in home range estimates. Studies of other members of Rallidae have found seasonal variation in home range size (Conway et al., 1993; Kolts and McRae, 2017), however at Mittry Lake WMA in Arizona, home ranges of California Black Rails did not vary seasonally (Flores and Eddleman, 1991), the authors suggesting this may be due to the study area being a relatively stable environment throughout breeding and winter. At San Bernard NWR, it is more likely that the seasonally static home range size is a function of density of birds rather than stable environment since droughts, floods, freezes and fire likely cause resources to fluctuate. We also found no difference in home range size between males and females, whereas for Black Rails in Florida they found significant differences between sexes (Legare and Eddleman, 2001). We tracked over twice as many males as females and our findings of no significant difference may be due to high variances and low samples sizes, which reduces power of tests.

The majority of Black Rail home ranges were in the "Gulf Coast: Salty Prairie", which is described in part having "*Spartina spartinae* (gulf cordgrass) typically dominating these sites, sometimes to the near exclusion of other species" (Elliott 2014). The clumpy and dense nature of this grass provides visually impenetrable cover for Black Rails as well as refuge from high water levels after a storm since the birds can climb into the matrix created by the leaf blades. The average elevation of areas used by Black Rails was ~23 cm lower than the average elevation at San Bernard NWR and ~41 cm higher than the lowest elevation at the refuge. The average elevation Black Rails are using represents the lower areas of the intermediate marsh.

Chapter 3: Habitat selection of Black Rails and Yellow Rails in the context of fire

Introduction

Fire is an essential part of Gulf coast marsh ecology (Lynch, 1941), and many coastal marshes are managed through a combination of fall or winter burning, herbicide application, and structural marsh management (i.e. levees and water control structures). When the U.S. Fish and Wildlife Service (USFWS) first recognized controlled burning as an important marsh management tool over 70 years ago, it was initially concerned with waterfowl management on its Gulf Coast refuges, for example removing plants of little or no use to game species and stimulation of food plants eaten by waterfowl (Lynch, 1941). Nonetheless, the purposes of burning vary depending on a range of management goals. Burning can help limit the encroachment of woody vegetation or dominant plant species, remove the litter layer, and improve and maintain the marsh habitat for waterfowl, muskrats (*Ondatra zibethicus*) and American alligators (*Alligator mississippiensis*) (Lynch, 1941; Chabreck, 1988; Gabrey and Afton, 2001; Mitchell et al., 2006). The USFWS current use of frequent fires in management practices in the Texas Mid-Coast National Wildlife Refuge Complex is aimed at maintaining or recovering a grass-dominated ecosystem in former marshland and prairies (Grace et al., 2005).

Avian communities that inhabit fire-dependent ecosystems are directly influenced by spatial and temporal heterogeneity created by fire (Wiens, 1974). Prairie grassland birds vary in their association with prairies based on years post burn (Gabrey and Afton, 2000; Grace et al., 2005). While widely practiced in coastal marshes for many decades, prescribed burning may have indirect effects on non-target species such as marsh birds and some passerines by altering vegetation structure, the amount and distribution of open water, and the quality and availability of food items (Gabrey et al., 1999; Walters et al., 2000; Gabrey and Afton, 2001; Mitchell et al., 2006)

Primarily due to human influence, it is likely that natural fire occurs less in coastal marshes than it did historically. Examples of human influence include fire suppression

practices, reduction of natural fire starts due to conversion of land for agriculture, as well as the construction of ditches, roads and levees that can serve as firebreaks and affect fire spread. The reduction of fire disturbance has allowed encroachment of some woody species like eastern baccharis (*Baccharis halimifolia*) and also cordgrasses *(S. patens* and *S. spartinae*) to form dense, homogenous stands, which are less diverse than marshes in which burning creates a mosaic of plant communities (USFWS, 2008b).

The Yellow Rail (*Coturnicops noveboracensis*) is the second smallest rail in North America and known to be almost as secretive as the Black Rail. It is also difficult to survey and reluctant to fly. The species is listed as endangered or threatened in some states, a Species of Conservation Concern in Canada (COSEWIC, 2009), and as a Migratory Nongame Bird of Special Management Concern by the U.S. Fish and Wildlife Service (USFWS, 2008a; Leston and Bookhout, 2015). Yellow Rails breed in northern United States east of the Rocky Mountains, and the eastern two-thirds of Canada to the Atlantic coast, and over-winter along the Atlantic coast from North Carolina south to the Florida coast, along the Gulf coast to the Texas mid-coast and were recently discovered overwintering in Oklahoma (Butler et al., 2010)*.* Butler et al. (2014) estimated the population overwintering in sampled marshes at San Bernard NWR in Brazoria County, Texas, consisted of 1,170 ± 300 individuals, or ~5.2 ± 1.3 rails per hectare.

Ecological theory predicts that two or more species rarely coexist in the same niche but instead one species will displace the other (Volterra, 1926; Gauze, 1934). The Yellow Rail and Black Rail share wintering grounds in Texas. The two species have similar morphology and diet (aquatic and terrestrial invertebrates and seeds). Since Yellow Rails are larger, they may displace the resident Black Rails from their winter territories. We predict the responses of Yellow Rails and Black Rails to wintering habitat burning will be similar to one another. Effects of controlled burns on Black Rails in Texas are unknown but could be substantial, given the apparent effects on Yellow Rails detailed in other studies (Burkman, 1993; Austin and Buhl, 2013; Morris et al., 2017).

Methods

Survey Methods

This study took place at San Bernard NWR where we delineated six, ~10 ha plots that differed in years since they were last burned (Figure 6). Since rails are typically secretive, most studies rely on vocalizations to estimate population size, however this is not a practical technique since rail vocalizations are rare in winter. Instead, the dragline method was used to capture and band Black Rails and Yellow Rails from January through March 2017-2018. We conducted surveys with a four-person crew and began dragline ~30 mins after sunset and ended once the entire plot had been systematically covered by walking along parallel transects or until 2.5 hours had passed. We attempted to dragline each plot 4 times during each field season with repeat surveys at the same site ~3 weeks apart. We used dip-nets to capture any Black Rails and Yellow Rails that flushed. We collected a series of metrics from each bird, affixed a USGS aluminum band, and took a waypoint for each bird at the point from where it flushed to conduct a habitat and vegetation assessment at each point the next day.
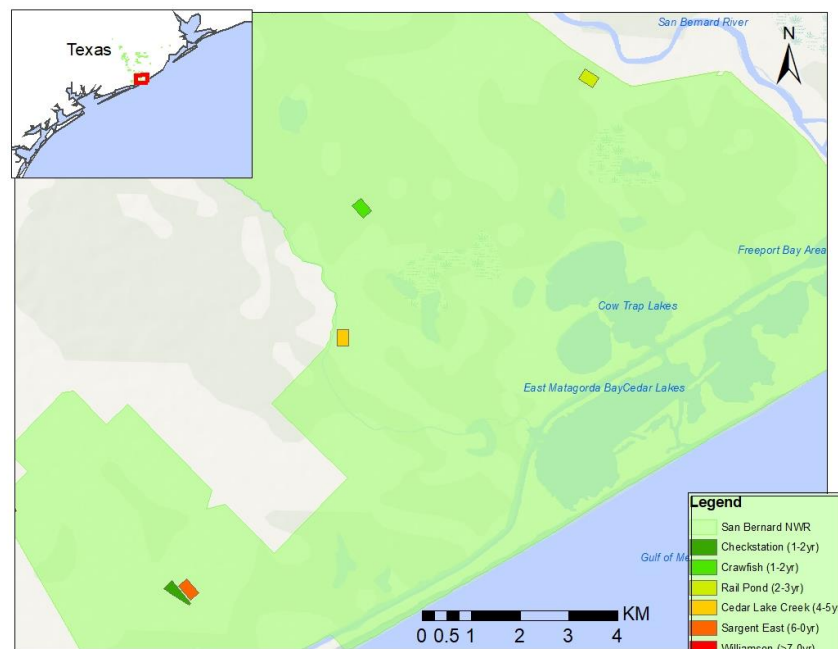

Figure 6. Location of burn plots at San Bernard NWR, Texas, where Black Rails and Yellow Rails were captured and banded (2017-18).

Vegetation Assessment

Habitat assessments were conducted the day after each bird capture. Habitat variables were measured in the 50 x 50 m area surrounding each location where a Black Rail or Yellow Rail was flushed and captured. Substrate type (dry, moist, muddy) or water depth was recorded at the center and at 1m in each cardinal direction. Dominant cover types were recorded for the entire plot and more in-depth measurements were taken within 6 randomly selected 10 x 10 m subplots, including Robel pole (Robel et al., 1970) readings, tallies of trees species within size classes, presence of a senescent layer, and cover class for a 1 x 1 m square chosen at random. Cover classes were as follows: 1 = trace, 2 = 0-1%, 3 = 1-2%, 4 = 2-5%, 5= 5-10%, 6 = 10-25%, 7 = 25-50%, 8 = 50-75%, 9 = 75-95%, 10 = >95% cover. Robel poles are used as a visual obstruction measurement to evaluate the height and vertical density of vegetation. We also conducted a count of the invasive Red Imported Fire Ant (*Solenopsis invicta*) mounds with in the 10 m plot. This ant may directly affect a species of bird by eating eggs and killing chicks (Sikes and Arnold, 1986; Mueller et al., 1999), or indirectly by lowering populations of invertebrate species that may be important dietary components (Epperson and Allen, 2010; Morrow et al., 2015). Since the habitat within each plot was fairly uniform due to relatively flat topography of the wetlands, separate measurements for birds captured within 25 m of one another were not taken unless an obvious difference in habitat structure was observed (i.e. a stand of *Baccharis*, *Typha*, or a salt pan).

Statistical analysis

We used generalized mixed effects models (GLMM) with the with the *lme4* package in R to examine Black Rail and Yellow Rail relative abundance as a response to year-post-burn (YPB) and burn-plot vegetative characteristics, where burn plot was the random factor. We used a Poisson distribution and the log-link function, and Akaike information criterion, corrected for sample size (AIC$_c$), to select the best model (Burnham and Anderson, 2003).

Results

Between 23 January and 27 March 2017, and 24 January and 19 March 2018, we conducted 84 dragline surveys (42 each year). In 2017, we captured and banded 10 Black Rails and 48 Yellow Rails, and in 2008: 2 Black Rails and 17 Yellow Rails. In 2017 we captured the highest number of Black Rails (6) in the 4-years-post-burn plot and the highest number of Yellow Rails (16) in one of the 1-year-post-burn plots (Figure 7). Since the same plots were used in the second year, each plot increased by 1-year-post-burn, however, 2 plots (the 6-year and >7year plots) were burned in a wildfire 3 months before season 2 began so those were set back to 0. In 2018 we captured both Black Rails in one of the 2-year-post-burn plots, and the most Yellow Rails (11) in the other 2-year-post-burn plot (Figure 8).

Figure 7. Black Rails (BLRA) and Yellow Rails (YERA) captured in 2017 in 6 plots at San Bernard NWR, Texas, that differed in number of years since last burned. (note: there are two 1-year post burn plots).
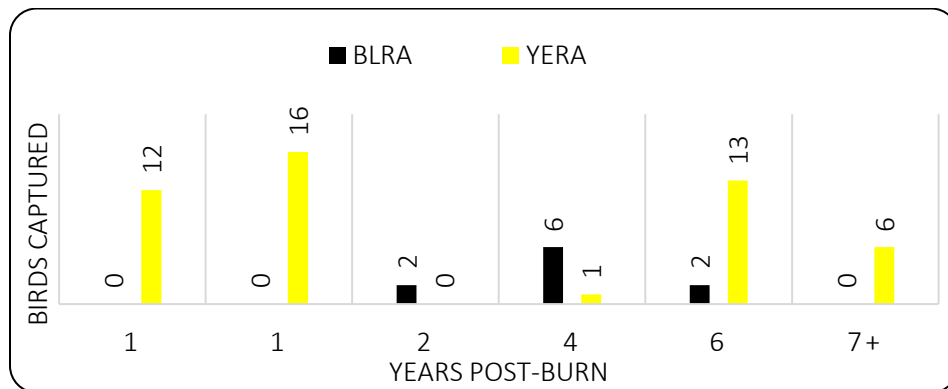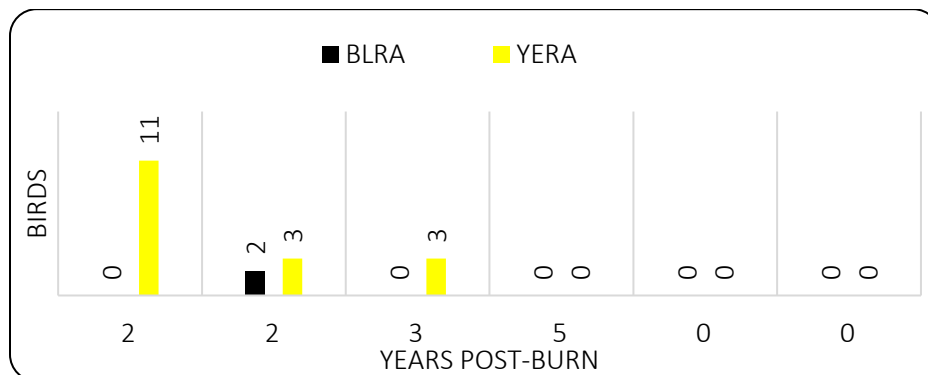

Figure 8. Black Rails (BLRA) and Yellow Rails (YERA) captured in 2018 in 6 plots at San Bernard NWR, Texas, that differed in number of years since last burned (note: there are two 2-year post burn plots and 2 plots were burned in a wildfire and are thus 0).

Dominant vegetation was the same across years and plots (Table 7). Gulf cordgrass (*Spartina spartinae*) was the dominant plant species in each plot, and sea-oxeye daisy (*Borrichia frutescens*) was the second dominant in 3 plots. Eastern baccharis (*Baccharis halimifolia*) and marshhay cordgrass (*Spartina patens*) were the second dominant plants in one plot each. The >7-year plot consisted of a mix of grasses and forbs and there was no second dominant plant species. Since there were multiple plots in season where we had no captures, we randomly selected and surveyed a subset of points that were surveyed the previous season. We selected 6 points for the 5-year plot and 3 points each for the 2 plots that were burned in the wildfire. We chose to survey less points for the wildfire burned plots since they were somewhat more homogenous in appearance *i.e.* lots of bare ground. Overhead cover, which we rated on a scale of 1 to 10 was similar across plots: between 9 and 10, or 75% - 100% in each plot except in the second season where 2 plots had been burned (Figure 9). Robel pole measurements showed that density and height did not increase linearly with the increase in years post-burn, for instance one of the 2-year plot was denser than the 6-year plot.

Table 7**.** Dominant plant species in burn plots where Black Rails and Yellow Rails were captured in 2017 and 2018, San Bernard NWR, Texas.

Burn plot	Dominant species 1	Dominant species 2
1yr / 2yr	*S. spartinae*	*B. halimifolia*
1yr / 2yr	*S. spartinae*	*B. frutescens*
2yr / 3yr	*S. spartinae*	*B. frutescens*
4yr / 5yr	*S. spartinae*	*S. patens*
6yr / <1yr	*S. spartinae*	*B. frutescens*
>7yr / <1yr	*S. spartinae*	none
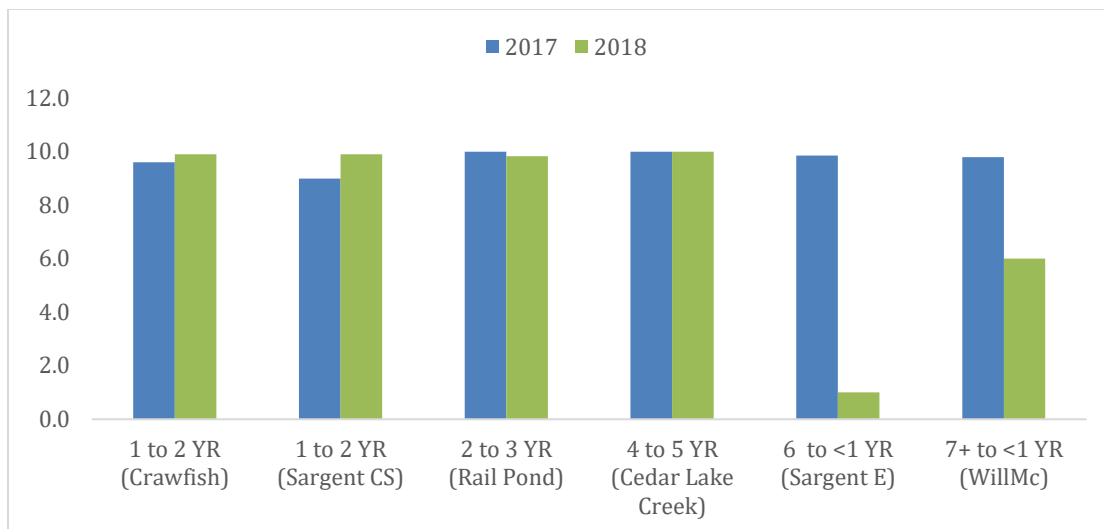
Figure 9. Overhead cover measured in burn plots at locations were Black Rails and Yellow Rails were captured in 2017 and 2018 at San Bernard NWR, Texas. Cover was rated using categories: 1 = trace, 2 = 0-1%, 3 = 1-2%, 4 = 2-5%, 5= 5-10%, 6 = 10-25%, 7 = 25-50%, 8 = 50-75%, 9 = 75-95%, 10 = >95%.

The AIC$_c$ analysis of the candidate models showed the model of woody average was the best model over all, with the model woody average and RIFA mounds as a competing model, for both Black Rails and Yellow Rails (Table 8).

Table 8. Candidate models examining relative abundance of Black Rails and Yellow Rails in relation to average woody coverage (wood), mean Robel pole readings (Robel), red imported fire ant mounds (RIFA), and years-post-burn (YPB), in burn-plots located at San Bernard NWR, Texas, winter 2017 and 2018. K is the number of parameters in the model, AIC_c is Akaike's Information Criterion adjusted for small sample size, ΔAIC_c is the difference in AIC_c value relative to the top model, and w_i is the AIC_c weight.

Model		K	ΔAIC_c	w_i
Black Rail				
	wood	3	0	0.551
	RIFA+wood	4	1.62	0.245
	Robel+wood	4	4.25	0.066
	wood+YPB	4	4.53	0.057
	Robel	3	6.26	0.024
	RIFA+wood+Robel	5	7.19	0.015
	null	2	7.54	0.013
	RIFA+wood+YPB	5	7.80	0.011
	RIFA+Robel	4	9.15	0.006
	YPB	3	10.05	0.004
	Robel+wood+YPB	5	10.51	0.003
	RIFA	3	10.89	0.002
	Robel+YPB	4	10.92	0.002
	RIFA+YPB	4	14.52	0.000
	RIFA+Robel+YPB	5	14.97	0.000
	RIFA+wood+Robel	6	15.43	0.000
Yellow Rail				
	wood	3	0	0.442
	RIFA+wood	4	1.73	0.186
	wood+YPB	4	1.86	0.175
	Robel+wood	4	3.73	0.069
	RIFA+YPB	4	5.29	0.031
	RIFA+Robel	4	5.59	0.027
	RIFA+wood+YPB	5	5.88	0.023
	RIFA+YPB	5	6.99	0.013
	RIFA+wood+Robel	5	7.11	0.013
	YPB	3	7.93	0.008
	RIFA	3	8.89	0.005
	Robel	3	9.33	0.004
	RIFA+Robel+YPB	5	11.41	0.001
	Robel+YPB	4	12.58	0.001
	RIFA+wood+Robel+YPB	6	14.32	0.000
	Intercept only	2	16.34	0.000

Discussion

Amount of woody cover was an important factor explaining relative abundance of Black Rails and Yellow Rails: bird abundance increased as woody cover decreased. Years-post-burn was not a significant factor in explaining relative abundance which is contrary to what we originally thought, but vegetation assessments in the plots make the reason for this clear. We found that some plots that were burned at the same time as one another were not equal in terms of vegetation density. These findings indicate that vegetation growth rates vary within the refuge, illustrating the need for habitat assessment prior to a scheduled controlled burn to achieve management goals. Though just below the cutoff for statistical significance, it is worth mentioning the number of RIFA mounds was negatively associated with Yellow Rail abundance.

We captured a substantially lower number of rails in the second season (n = 19) compared to season 1 (n = 57). Wildfire consumed 2 of the burn plots on 17 October 2017, just 3 months before the second season of the study began. The low amount of cover these plots provided was seemingly not efficient enough for either rail species to use. Interestingly, overhead cover estimates were different between the two plots, despite being burned at the same time by the same wildfire, exemplifying the difference in growth rates around the refuge.

We also had lower numbers of birds during the second season in plots that were not affected by the wildfire. Another factor that may have influenced the difference in number of rails captured between seasons is Hurricane Harvey which made landfall on the gulf coast of Texas on 25 August 2017 just south of San Bernard NWR before becoming a tropical storm and making its way up the coast. Tropical storm Harvey caused substantial flooding on the refuge that remained well into September (J. Wilson, personal communication). The storm induced standing water may have impacted prey populations (e.g. gastropods and arthropods). Hurricanes can significantly impact bird populations over an extended period due to loss of resources like fruits, seeds, and insects. Waide (1991) found a reduced number of arthropods in the stomach of birds

prior to a hurricane. Alternately, both rails in the study have relatively short legs and standing water of over a few cm may not be suitable and the birds may have avoided areas inundated with substantial levels of standing water. For instance, Yellow Rails have been found to prefer moderate water levels that are not too deep and not too shallow (Austin and Buhl, 2013).

Overall, we captured markedly more Yellow Rails than Black Rails. This was likely due to higher abundance levels of Yellow Rails, but we speculate that it may also be in part due to Black Rails being less catchable. It is possible that Yellow Rails will flush more readily upon being disturbed by the bottle-line whereas Black Rails are more reluctant to fly and instead remain on the ground and run away. However, further research is necessary to make this conclusion.

Conclusion and recommendations

This research provides baseline data for Black Rails in coastal Texas. We hope the SDM can be used to focus the assessment of new areas where Black Rails might be present. In addition, our survey data will be invaluable for future surveys, as monitoring known populations is vital to understanding population trends and resiliency of a species.

The focus of Black Rail habitat management in coastal Texas should be on the conservation, enhancement, and proliferation of intermediate marshes with substantial herbaceous cover that includes plant species such as *Spartina spartinae* (gulf cordgrass), *Spartina patens* (marshhay cordgrass), sea-oxeye daisy (*Borrichia frutescens*), and has minimal woody cover. Protection of intermediate marsh habitats will also benefit many other avian species and large numbers of wintering waterfowl.

With Black Rail population states tied to *Spartina* and intermediate marsh cover, the species is likely susceptible to impacts from controlled burning, and proper habitat management may limit those impacts. Controlled burning to mitigate woody cover should be applied in such a way that patches of appropriately dense herbaceous cover remain on the landscape.

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