Assessing Black Rail occupancy and vocalizations along the Texas Gulf Coast

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Photo: Black Rail at San Bernard National Wildlife Refuge.

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ABSTRACT

The Black Rail (*Laterallus jamaicensis*) is the smallest North American rail and one of the most secretive. It breeds in several disjunct populations along the Atlantic and Gulf coasts, in California, and in the interior US. Within Texas, Black Rails are resident along the upper and central coasts and may breed locally along the lower coast. However, the exact distribution of this species is unclear. The preferred habitat of this species varies by location, with some populations preferring *Spartina* and *Salicornia* while others utilize *Typha*. Furthermore, Black Rails are difficult to detect and may not be well monitored by existing survey methods. Peak months for vocalization vary depending upon location and may extend from February through June. In addition, some populations vocalize primarily at dusk, while others never vocalize at night, and still others vocalize solely at night. The goal of this project was to determine the habitat requirements of Black Rails along the Texas Gulf Coast and to determine the best months and time of day to conduct surveys. Surveys were conducted at San Bernard NWR and Brazoria NWR from 5 March through 31 May 2014. Ninety points were surveyed during this period, and each point was visited six times; twice during a dawn survey, twice during a dusk survey, and twice during a night survey. Vegetative characteristics for each point were measured using the grassland BBIRD protocol. Playback surveys generally followed the methods outlined by the Standardized North American Marsh Bird Monitoring Protocol. However, we reduced the survey time from ten minutes to five minutes and increasing the broadcast duration for a species from 30 seconds to two minutes. Occupancy and the probability of detection were modeled using program PRESENCE. ARUs

(Autonomous Recording Units) were used to determine temporal and seasonal variation in vocalizations. We found occupancy rates at our study sites to be 0.706 ± 0.145. Occupancy was highly affected by vegetative structure, particularly the number of stems between 10 and 20 cm in height. Occupancy was moderately affected by the location, with the greatest occupancy rates occurring at the Sargent Unit of San Bernard NWR. Occupancy was only weakly affected by month, burn regime or type of habitat (high salt marsh or salty prairie). The probability of detection was low, averaging only 0.094. Detection probability was greatest at night and varied by location, with the greatest probability of detection correlating with the occupancy. The probability of detection was positively associated with the extent of cloud cover and negatively associated with wind speed. ARU data show that the vocalizations peak before midnight, with a second, smaller peak within two hours of dawn. We suggest that future surveys search for this species during the months of March through early June, as ARU recordings show a slow decline in vocalization rates after early June Due to the low probability of detection, repeated call-broadcast surveys will be required to detect this species. We suggest that each site should be visited at night at least four times during this period in order to have a 50% chance of detecting Black Rails.

ACKNOWLEDGEMENTS

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CHAPTER 1: BLACK RAIL

Rail species throughout the world are declining due to habitat loss and alteration (Taylor 1996). In the United States, for example, many of the nine species of rails are declining due to the disappearance of wetlands (Eddleman et al. 1988). Systematic wetland conversion in the conterminous United States from the 1600s to mid-1980s accounted for the loss of 48 million ha of wetland area, or about 53% of the original total (Dahl and Allord 1996). Legal protection has stabilized the overall rate of wetland loss in the 21st century, but coastal wetland area still declined by 1.4% between 2004 and 2009 (Dahl 2011). These coastal (estuarine) wetlands are vital breeding and wintering habitat for some rail species.

Both coastal and inland wetlands are susceptible to the effects of climate change and rising sea levels. During the 21st century, sea level is projected to rise globally by 17 to 82 cm (Intergovernmental Panel on Climate Change 2013). Rising sea levels will inundate estuarine and low-lying areas along the Gulf Coast and Atlantic Coast (Galbraith et al. 2002, Woodrey et al. 2012). Climate change is also forecast to affect hydrology. By the mid-21st century, annual river runoff and water availability is projected to increase at high latitudes and decrease in mid-latitudes and the tropics (Intergovernmental Panel on Climate Change 2013). In addition to inundating estuarine wetlands, the decrease of snowpack in the Rocky Mountains is projected to cause more winter flooding and reduced summer flows (Intergovernmental Panel on Climate Change 2013). The altered hydrology of wet meadows, fringe, and other wetland habitats may disrupt the vegetation communities resulting in additional habitat loss.

Black Rail

One species that may be affected by wetland loss is the rare and elusive Black Rail (*Laterallus jamaicensis*; Fig. 1). This species is the smallest of the North American rails and one of the most secretive bird species on the continent (Eddleman et al. 1994). The International Union for the Conservation of Nature considers Black Rails to be "Near Threatened" (IUCN 2010) and the American Bird Conservancy considers it to be "At Risk" (American Bird Conservancy 2012). Few baseline data exist to estimate populations of Black Rails, but qualitative observations note a drastic population decrease between the 1920s and 1970s (Eddleman et al. 1994). This decline has not been quantified, however, due to difficulties in surveying for this species.

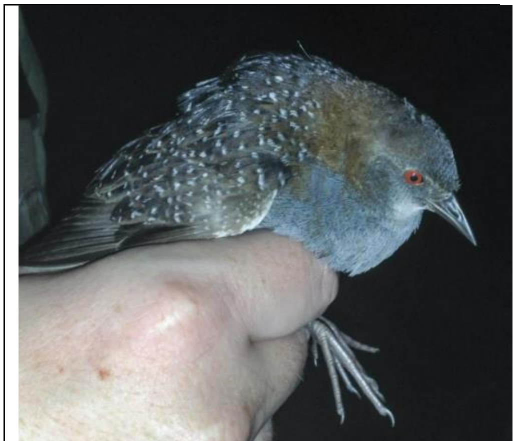

Figure 1. Black Rail banded at San Bernard National Wildlife Refuge. Photo by Chris Butler.

Black Rails occur in several disjunct populations across North and South America (Fig. 2). The California subspecies (*L. j. coturniculus*) occurs in wetlands along the Pacific Coast of California from San Francisco south to Baja California, with the greatest concentrations in north San Francisco Bay (Eddleman et al. 1994). Additionally, California Black Rails are associated with the Colorado River along the southern border of California and Arizona (Eddleman et al. 1994). Finally, California Black Rails have also recently been found in the northern foothills of the Sierra Nevadas (Richmond et al. 2008). The nominate subspecies (*L. j. jamaicensis*) occurs along the

Atlantic and Gulf Coasts from Connecticut to the southern Alabama with a disjunct population in southeastern Texas (Eddleman et al. 1994). However, it should be noted that surveys for Black Rails along coastal Alabama failed to find any during 2004 (Soehren et al. 2014). Black Rails are apparently resident along the upper and central coasts of Texas and may breed locally on the lower coast (Lockwood and Freeman 2014). The distribution of inland breeding populations are not well understood and they are thought to breed irregularly from Colorado to New England (Eddleman et al. 1994). It is believed that inland populations winter along the southeastern US coastline (Eddleman et al. 1994).

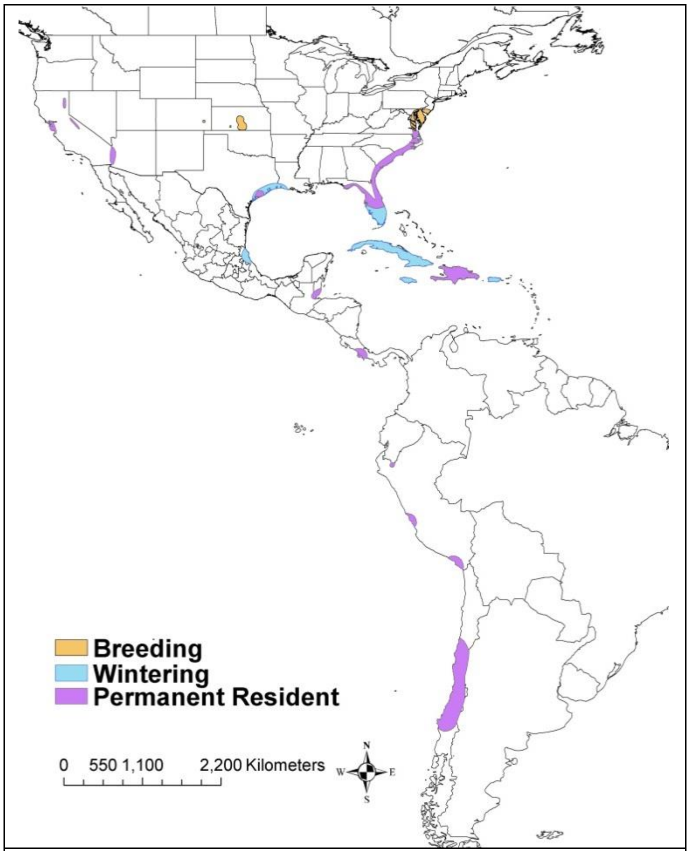

Figure 2. Black Rails breed along the Atlantic and Gulf Coasts as well as the interior U.S. California Black Rails and Black Rails in Central and South America are non-migratory. Additionally, non-migratory populations of Black Rails occur on the Atlantic Coast and the Coast of the Gulf of Mexico. This map was created using data provided by BirdLife International and NatureServe (2012) and modified to show populations in Kansas and Colorado (Butler et al. 2014).

While Black Rails are typically found in shallow wetlands (Eddleman et al. 1994), the dominant vegetative community varies depending upon location. Black Rails on the Atlantic coast, for example, utilize high salt marsh dominated by *Spartina* spp. and *Salicornia* spp. (Eddleman et al. 1994). Along the Lower Colorado River, Black Rails use habitat dominated by *Scirpus* *spp.* (Repking and Ohmart 1977). In Colorado, Black Rails near John Martin Reservoir utilize primarily *Typha* spp. (Butler pers. obs.).

Black Rails are seldom detected on national avian surveys such as the Breeding Bird Survey (BBS) or Christmas Bird Counts (CBCs). Insufficient numbers of Black Rails are found during BBS routes to track trends (Sauer et al. 2012), and for the period 1966-2011, an average of only 21 Black Rails per year were detected on CBCs in North America (National Audubon Society 2014). In order to more efficiently monitor Black Rails, surveys for secretive marsh species are required. Recently, a protocol has been developed to monitor marsh birds (Conway 2011). However, Black Rails may not be well surveyed by the new protocol due to variation in both seasonal and daily vocalization patterns.

Seasonal patterns of vocalization are poorly described and may vary between subspecies and among years (Weske 1969, Repking 1975, Kerlinger and Wiedner 1990, Flores and Eddleman 1991, Eddleman et al. 1994). Vocalization peaks from March to June for California Black Rails in Arizona (Repking 1975, Flores and Eddleman 1991). Vocalization peaks in New Jersey from late April to mid-May (Kerlinger and Wiedner 1990). In Maryland, vocalization peaks from mid-May to late June (Weske 1969).

Daily patterns of vocalization vary among subspecies and populations (Eddleman et al. 1994). California Black Rails (*L. j. coturniculus*) vocalize primarily at dusk and rarely at night (Flores and Eddleman 1991). Eastern Black Rails in Maryland vocalize from 1-2 hours after dusk until 1-2 hours before dawn, and they rarely vocalize during the day (Weske 1969, Reynard 1974). Black Rails in Florida vocalize most often 1-2 hours before dusk till 1-2 hours after dawn (Eddleman et al. 1994). In New Jersey, vocalization varied by location; one population never vocalized after dark, whereas other populations vocalized primarily at night (Kerlinger and Wiedner 1990). In Texas, Black Rails vocalized from one hour after dusk until at least 02:00, and Black Rails do not frequently respond to playback during the day (J. Tibbits, pers. obs.). In Colorado, Black Rails were observed vocalizing two hours after dusk (C. Butler, pers. obs.).

Due to the variation in seasonal and daily vocalization rates, there is an urgent need to modify the existing Conway (2011) protocol to more efficiently survey Black Rails in areas where they have not been well studied, such as the Gulf Coast of Texas. The goal of this project is to identify peak daily and seasonal times to conduct Black Rail surveys, as well as to identify the habitats that are most likely to contain Black Rails.

CHAPTER 2: OCCUPANCY MODELING

Call Broadcast Surveys and ARUs

INTRODUCTION

Several survey protocols have been used to study rails in North America. Bart et al. (1984) suggested that passive listening while engaged in strip surveys worked well for surveying Yellow Rails (*Coturnicops noveboracensis*). In contrast, Hinojosa-Huerta et al. (2002) suggested that call-playback surveys increased the detectability of Ridgway's Rail (*Rallus obsoletus*, formerly the Yuma Clapper Rail). In general, the incorporation of a call-broadcast portion of the survey improves detection rates (e.g. Lor and Malecki 2002, Conway and Gibbs 2005, DesRochers et al. 2008). The National Marsh Bird Monitoring Program has been established in order to standardize the surveys for multiple marsh bird species (Conway 2011). This approach calls for surveys to be carried out in the morning or the evening, with starting with an initial five-minute passive point-count survey, followed by broadcast surveys (Conway 2011). However, some authors suggest that modifications of the protocol are required in certain cases. For example, Nadeau et al. (2013) suggest that multi-species broadcast calls may improve detectability for many species and may be a more efficient method than single-species broadcast calls. Others suggest that timing of the survey may need to be adjusted to detect species that vocalize at night (Martin et al. 2014).

Detectability is a major confounding factor when conducting surveys on rails due to their retiring nature and infrequent vocalizations. One way to determine the best times to conduct surveys is to use Autonomous Recording Units (ARUs). ARUs are audio recording units that can be placed in the field and programmed to record sounds on a given schedule (Venier et al. 2012). They have been used by researchers to identify peak vocalization times, identify occupied habitats, and generate population estimates (e.g. Acevedo and Villanueva-Rivera 2006, Celis-Murillo et al. 2009). They may be particularly useful to monitor Yellow Rails and other secretive wetland bird species (Duke and Ripper 2013, HAPET 2013, Sidie-Slettedahl 2013). However, ARUs do have profound limitations, as they may not record as many avian species as human observers (primarily due to difficulty in detecting distant sounds) and analyzing the resulting data is time-intensive (Hutto and Stutzman 2009).

Despite this, because ARUs can be programmed to record nearly continuously, they are ideally suited to determine peak daily and seasonal vocalization rates. For example, Sidie-Slettedahl (2013) used ARUs to determine the best times and conditions to survey for Yellow Rails, Le Conte's Sparrows, and Nelson's Sparrows. The data from ARUs and from surveys are typically analyzed using occupancy modeling.

Occupancy modeling is widely employed for studies on secretive animals (e.g. Pierluissi and King 2008, Richmond et al. 2012) as it accounts for false absences, habitat covariates, and detectability (MacKenzie et al. 2006). Occupancy is estimated as the proportion of occupied sites to total sites where sites are defined as a spatial unit or natural landmark within a larger area of interest (MacKenzie et al. 2002, 2006). Occupancy models can incorporate single or multiple species, single or multiple seasons, habitat covariates, and survey-specific covariates (MacKenzie et al. 2006). Obtaining an accurate estimate of occupancy facilitates the creation of more accurate models of habitat preferences and ranges.

For example, the creation of a two-species occupancy model for the California Black Rail and the Virginia Rail (*Rallus limicola*) demonstrated that occupancy for both species was positively correlated, and that occupancy for both species increased with marsh size (Richmond et al. 2010). These results contradicted previous assumptions of niche partitioning between the two species. Another study in California used a single-season occupancy model to compare occupancy to multiple vegetation and land use variables and demonstrated that overgrazing by livestock reduced Black Rail occupancy in non-irrigated marshes (Richmond et al. 2012).

Occupancy modeling allows researchers to account for the low detection probability of rails when assessing and projecting populations and their response to dynamic habitats and habitat gradients. For example, although the detectability of King Rails (*Rallus elegans*) is low, ranging from 35-45% (Darrah and Krementz 2009), several studies have used occupancy modeling to examine the habitat requirements of this species. King Rail occupancy in the Illinois and Upper Mississippi River Valleys is positively associated with the interspersion of vegetation and water and negatively associated with woody vegetation (Darrah and Krementz 2009). In southwestern Louisiana, King Rail occupancy increased with the number and extent of irrigation channels and decreased with woody vegetation (Pierluissi and King 2008). In North Carolina and Virginia, King Rail occupancy is higher in natural wetlands than created wetlands (Rogers et al. 2013). The goal of this project was to create occupancy models to determine the biotic and abiotic factors that determine Black Rail occupancy and detectability as well as to examine temporal and seasonal variation in Black Rail vocalizations.

METHODS

Study Area

Brazoria NWR (29°03'56.47"N, 95°15'04.28"W; Brazoria County) and San Bernard NWR (28°52'25.61"N, 95°32'54.64"W; Brazoria and Matagorda Counties) are both part of the Texas mid-Coast NWR complex. They are located on the coastal plain of Texas south of Houston (Fig. 3). San Bernard contains approximately 9286 ha of salty prairie and salt marsh while Brazoria NWR includes 11,480 ha of similar habitat (NatureServe 2009).

The average high temperature of nearby Galveston during 1981-2010 was 25.1 °C and the average low temperature was 18.4 °C (National Weather Service 2014). The average yearly precipitation of nearby Galveston during 1981-2010 was 128.93 cm (National Weather Service 2014). During the study, the monthly precipitation was 4.7 cm for March (4.1 cm below average); 1.7 cm for April (4.7 cm below average) and 15.7 cm for May (5.4 cm above average). The monthly temperature was 14.7 °C for March (down 1.9 °C); 19.9 °C for April (down 0.4 °C); and 22.8 °C for May (down 1.4 °C; National Weather Service 2014).

Surveys were conducted in high salt marsh and salty prairie during the period 5 March – 31 May 2014 (Figures 4-5). High salt marsh is an occasionally flooded estuarine habitat and the plant composition varies depending upon the salinity gradient. The most saline areas are dominated by *Distichlis spicata* (saltgrass) and *Salicornia virginica* (Virginia glasswort), with some *Spartina alterniflora* (smooth cordgrass) also present. Areas with intermediate salinity are dominated by *Spartina patens* (saltmeadow cordgrass), *Distichlis spicata* and *Schoenoplectus robustus* (sturdy bulrush). The areas with the least salinity contain *Schoenoplectus americanus* (chairmaker's bulrush) and *Paspalum vaginatum* (seashore paspalum). Salty prairie is dominated by *Spartina spartinae* (gulf cordgrass), and also contains *Setaria parviflora* (marsh bristlegrass), *Andropogon glomeratus* (bushy bluestem), *Panicum virgatum (*switchgrass), and *Schizachyrium scoparium* (little blustem).

A total of 90 points (arranged along 12 routes) were surveyed six times each from March to May for a total of 540 surveys. Thirty-one points were in high salt marsh, while 59 points were in salty prairie. Two routes (including 18 points) were surveyed at Brazoria NWR, four routes (including 25 points) were surveyed at the Sargent Unit of San Bernard NWR, and six routes (including 47 points) were surveyed at the East Unit of San Bernard NWR. Each site was surveyed twice a month. Sites were surveyed twice at dawn, dusk, and night throughout the course of the 2014 spring field season. Table 1 summarizes the survey schedule.

Table 1. A summary of the time of day for each survey route.

	March		**April**		**May**	
Route	**Visit 1**	**Visit 2**	**Visit 3**	**Visit 4**	**Visit 5**	**Visit 6**
Brazoria 1	Morning	Evening	Night	Morning	Evening	Night
Brazoria 2	Evening	Night	Morning	Evening	Night	Morning
San Bernard – Sargent 1	Evening	Night	Morning	Evening	Night	Morning
San Bernard – Sargent 2	Night	Morning	Evening	Night	Morning	Evening
San Bernard – Sargent 3	Morning	Evening	Night	Morning	Evening	Night
San Bernard – Sargent 4	Night	Morning	Evening	Night	Morning	Evening
San Bernard – East 1	Morning	Evening	Night	Morning	Evening	Night
San Bernard – East 2	Evening	Night	Morning	Evening	Night	Morning
San Bernard – East 3	Evening	Night	Morning	Evening	Night	Morning
San Bernard – East 4	Morning	Evening	Night	Morning	Evening	Night
San Bernard – East 5	Night	Morning	Evening	Night	Morning	Evening
San Bernard – East 6	Night	Morning	Evening	Night	Morning	Evening

All surveys lasted two hours. Dawn surveys began 30 minutes before official sunrise while dusk surveys concluded 30 minutes after official sunset. Official sunrise and sunset times were obtained from the United States Naval Observatory website (USNO 2014). Nocturnal surveys began one hour after dusk surveys concluded. Survey routes for the 2014 are shown by Figures 6 and 7. Survey points were placed along roads and trails when possible to minimize disturbance to breeding birds. Survey points were inconspicuously marked in the field with flagging when natural landmarks are not available, as recommended by Conway (2011). When possible, natural landmarks were used to minimize impact. All survey points were recorded as GPS waypoints. Each point received a unique identification code and number which was recorded on the data sheet (Appendix A). Points were at least 400 m apart to reduce the possibility of influencing birds at adjacent points, as suggested by Conway (2011). Autocorrelation was minimized by sampling every other point along a route (i.e. sampling at an 800 m interval rather than at a 400 m interval) during a given morning, evening or night survey.

Playback surveys loosely followed the methods outlined by the Standardized North American Marsh Bird Monitoring Protocol (Conway 2011). We deviated from the standard protocol by reducing the survey time from ten minutes to five minutes and increasing the broadcast duration for a species from 30 seconds to two minutes. Surveys consisted of passive listening for two minutes, playing Black Rail *ki-ki-kerr* vocalizations for two minutes, and passive listening for one minute. Playback consisted of 20 seconds of *ki-ki-kerr* vocalizations followed by 10 seconds of silence, repeated four times.

Figure 3. Black Rails were surveyed at Brazoria and San Bernard NWRs.

Figure 4. *Spartina* spp. dominated most of the survey points.

Figure 5. Black Rails were most frequently found in areas where *Spartina* sp. tended to grow in clumps with patches of bare ground.

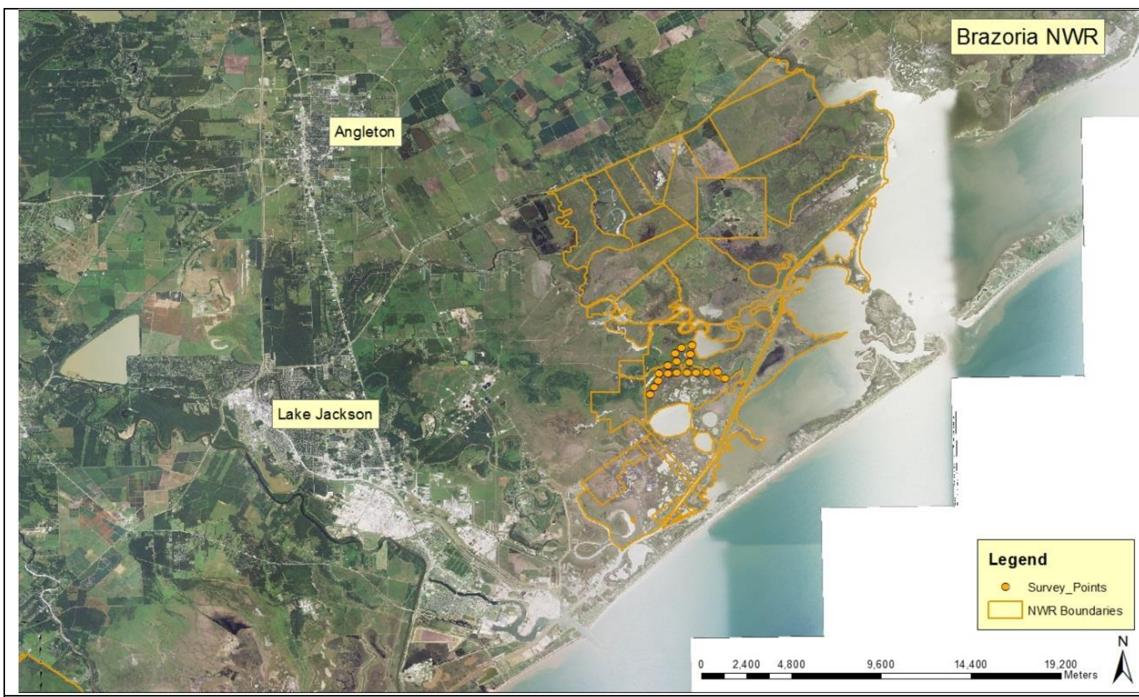

Figure 6. The location of the survey points at Brazoria NWR.

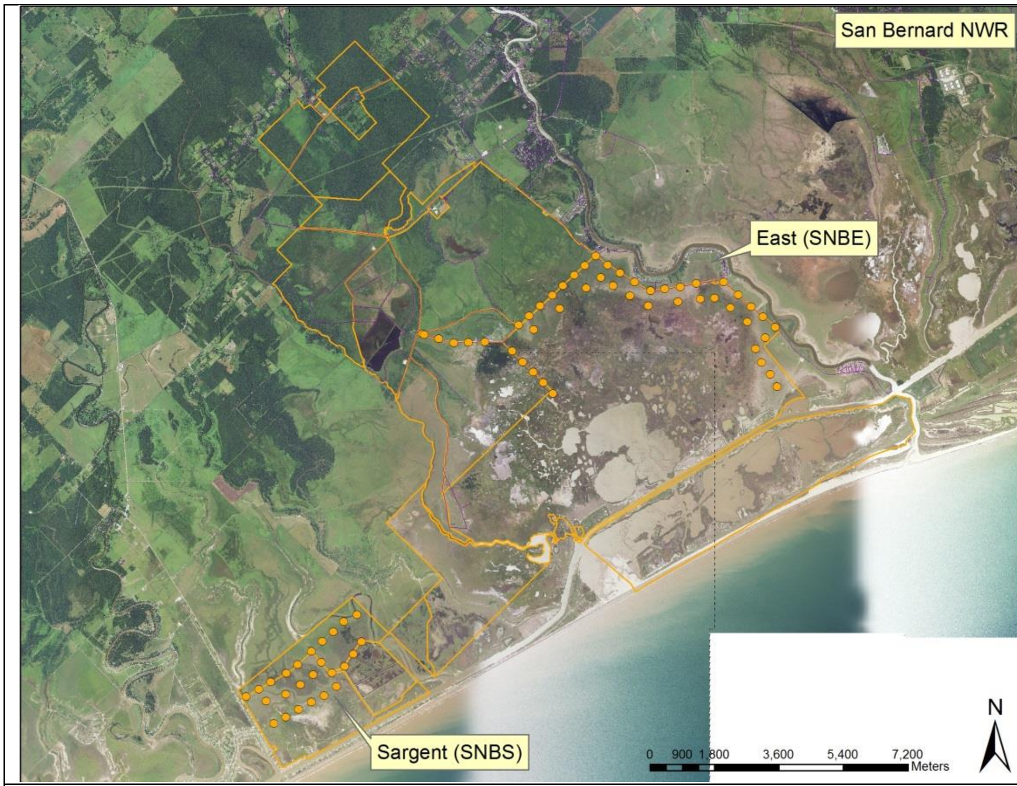

Figure 7. The location of the survey points at San Bernard NWR.

The game call used in this study (Western Rivers Apache Game Call) broadcasts at 80-90 dB at 1 m in front of the speaker, as per Conway (2011). Playback volume was measured with a Mini Sound Level Meter DT-85A. Wind speed and temperature were measured with a Kestrel 2000 Pocket Wind Meter. Surveys were postponed if wind speeds exceeded 15 km per hour because of the reduction in the observer's ability to detect birds. Data were recorded on standardized datasheets and (Appendix A).

Vegetation Sampling

The USFWS provided a vegetation cover map that was incorporated into an ArcMap workspace. This map was then groundtruthed and updated as needed, and this information was included as a covariate in the occupancy analysis. Prescribed burning history and data were provided by the USFWS, and was likewise included as a habitat covariate.

Vegetation at each survey site was assessed in June. Quantification of habitat covariates followed the BBIRD Grassland Protocol (Appendix B; Martin et al. 1997). Vegetation variables were measured at one, three, and five meter intervals in four cardinal directions from a central point. The vegetation variables for the four cardinal directions were averaged to a single value for the site. Coverage within the 10 m diameter circle was assessed by estimating the percentages of each cover type. Cover types were initially assessed broadly as vegetation, water, and bare ground. Furthermore, different cover types within the vegetation cover were assessed to determine percent cover by grasses, forbs, succulents, etc. Variables measured included: vegetation height, litter depth, water depth, stem density, canopy height, and species composition. Additionally, average distance between individual plants was quantified by measuring from the edge of the center-most plant to the edge of the nearest adjacent plant in four cardinal directions. These four measurements were then averaged to determine the width of corridors for rails running on the ground. A summary of all variables are shown in Tables 1 and 2.

Occupancy modeling

Occupancy models using multiple vegetation and land use variables were created in program PRESENCE. Models were evaluated using Akaike's Information Criterion (AIC) scores (Akaike 1983). Due to the large numbers of variables examined in

Table 1: Descriptions of site-specific variables included in the analysis of Black Rail occupancy and detectability.

Variable	Description
BareAvg	Average % of all four quadrants covered by bare ground.
BulAvg	Average %% of all four quadrants covered by bulrush
Burn	Number of years post-burn
Can_floor	Average *Spartina* and other species canopy floor height measured at 5 m, 3 m, and 1 m for the four cardinal directions
Canopy	Average *Spartina* and other species canopy ceiling height measured at 5 m, 3 m, and 1 m for the four cardinal directions
f_0to10	Average number of forb stems at 0-10 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
f_10to20	Average number of forb stems at 10-20 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
f_20to30	Average number of forb stems at 20-30 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
f_30to40	Average number of forb stems at 30-40 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
f_40to50	Average number of forb stems at 40-50 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
ForAvg	Average % of all four quadrants covered by forbs (primarily *Borrichia frutescens*, bushy seaside tansy)
g_0to10	Average number of grass stems at 0-10 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
g_10to20	Average number of grass stems at 10-20 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
g_20to30	Average number of grass stems at 20-30 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
g_30to40	Average number of grass stems at 30-40 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
g_40to50	Average number of grass stems at 40-50 cm height at 5 m, 3 m, and 1 m for the four cardinal directions
GrassAvg	Average % of all four quadrants covered by grasses
Habitat	High salt marsh or salty prairie
Litter_depth	Average litter depth (in cm) measured at 5 m, 3 m, and 1 m for the four cardinal directions
Robel	Average Robel pole vegetation density measured at 5 m, 3 m, and 1 m for the four cardinal directions
SedAvg	Average % of all four quadrants covered by sedges
ShrAvg	Average % of all four quadrants covered by shrubs
StoSAvg	Average stem-to-stem distance (in cm) between *Spartina* clumps
StTC	Average total *Spartina* canopy measured at 5 m, 3 m, and 1 m for the four cardinal directions
SucAvg	Average % of all four quadrants covered by succulents (primarily *Salicornia virginica*, Virginia glasswort)
VegAvg	Average % of all four quadrants covered by vegetation
Veg_ht	Average vegetation height (in cm) measured at 5 m, 3 m, and 1 m for the four cardinal directions
WatAvg	Average % of all four quadrants covered by water
Water_depth	Average water depth (in cm) measured at 5 m, 3 m, and 1 m for the four cardinal directions

Table 2: Descriptions of sample-specific variables included in the analysis of Black Rail occupancy and detectability at Brazoria and San Bernard NWRs during 2015.

Variable	Description
Cloud	Extent of cloud cover at the time of the survey
Location	National Wildlife Refuge (Brazoria NWR, East unit of San Bernard NWR, Sargent unit of San Bernard NWR)
Month	The month during which the survey occurred (March, April, or May)
Temp_end	Temperature at the end of the survey
Temp_start	Temperature at the beginning of the survey
Time	Time of day (dawn, dusk, or night)
Wind	Wind speed at the time of the survey, measured in kilometers per hour

this study, a logistic regression performed on site-specific covariates (i.e. those covariates that were measured only at the end of the study such as vegetation height and litter depth) in order to determine which variables were most important to include in the occupancy models. Models of occupancy (ψ) and detection probability ($\hat{p}$) were then created using all possible combinations of site-specific variables identified as significant ($p < 0.05$) by the logistic regression as well as sample-specific variables.

Nine ARUs (model SM-1, built by Wildlife Acoustics, Inc.) were deployed from 17 April through 7 July 2014 and recorded continuously during this period. Two of the ARUs were placed at Brazoria NWR (Fig. 11), three at the East Unit of San Bernard NWR (Fig. 12), and four at the Sargent Unit (Fig. 13). All ARUs were mounted on t-posts and housed in wooden boxes. Recordings were stored on four 32 gigabyte (GB) cards which were offloaded to a computer every two weeks. The batteries were changed every six days.

The resulting data were offloaded to Song Scope, a bioaccoustical software program. This software uses a Fast Fourier Transform (FFT) to show sound waves in the frequency domain. Recordings were reviewed on the spectrogram to detect Black Rail vocalizations (Fig. 14). Then a recognizer was built to automatically detect Black

Rails *ki-ki-kerr* vocalizations. The vocalization rate was examined by time of day and week. Once Song Scope had processed all files, visual and auditory spot-checking was used to determine the prevalence of false positives or false negatives.

Figure 11. Location of the two ARUs at Brazoria NWR

Figure 12. Location of the three ARUs at the East Unit of San Bernard NWR.

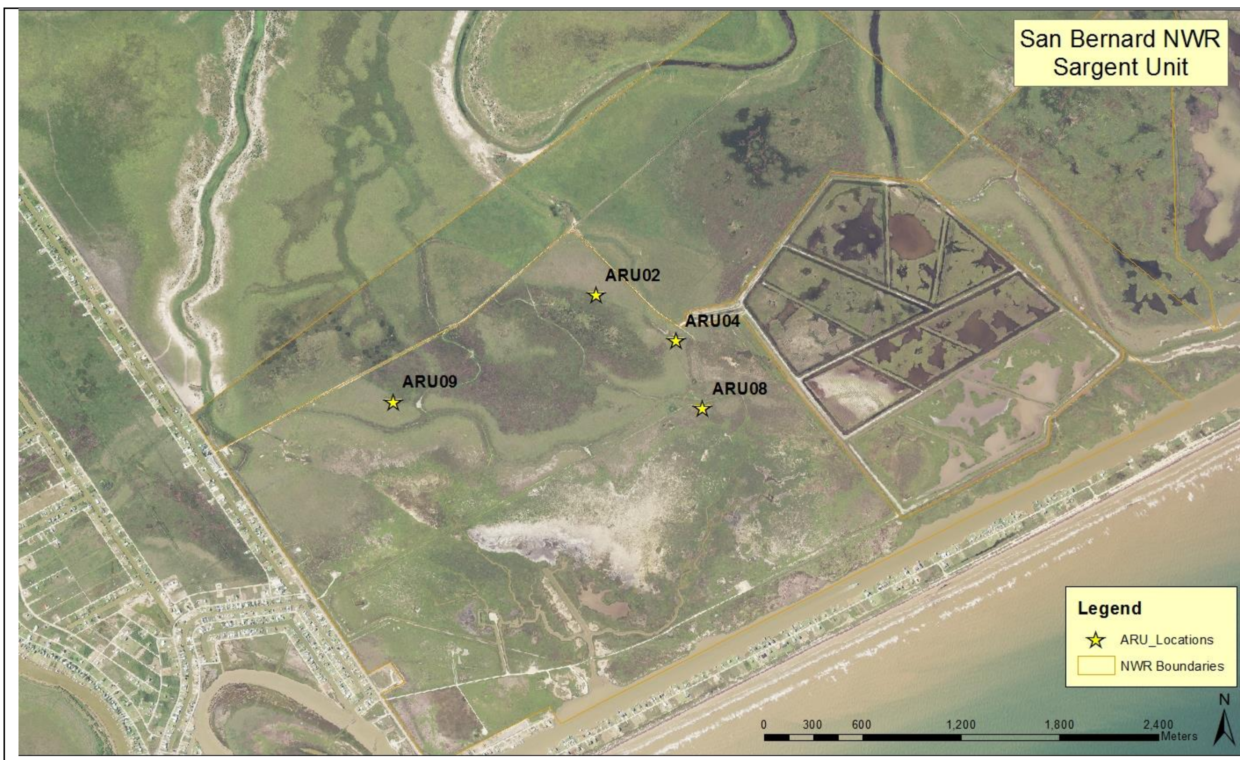

Figure 13. Location of the four ARUs at San Bernard NWR.

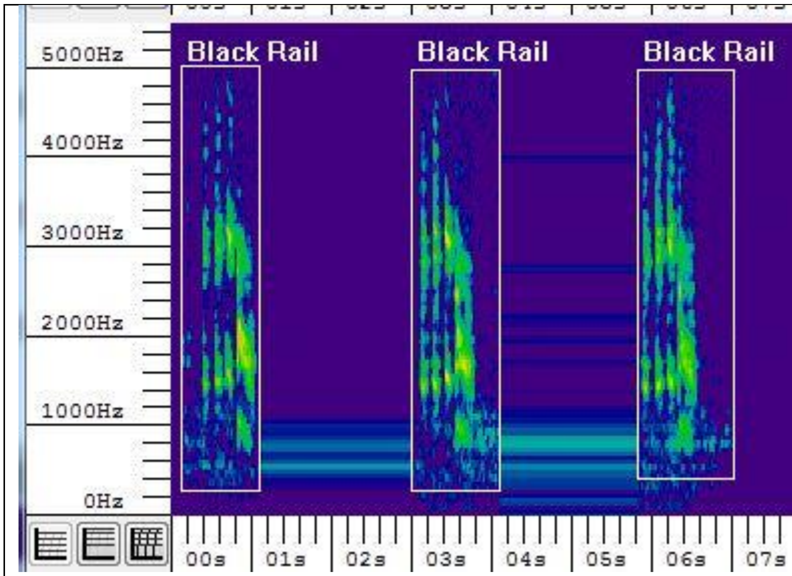

Figure 14. Spectrogram of Black Rail's *ki-ki-kerr* vocalization created using SongScope.

RESULTS

Occupancy modeling

Black Rails were detected at 31 points during 2015. They were detected at 16 points on the East Unit of San Bernard NWR, 12 points on the Sargent Unit of San Bernard NWR, and three points at Brazoria NWR. Black Rails were detected 40 times over the course of the survey, including seven times during morning surveys, 13 times during evening surveys, and 20 times during night surveys. A total of 57 individuals were detected, including 17 during March, 35 during April, and 5 during May. Of the 57 individuals, 19 individuals were detected before playback began, while 38 individuals were detected in response to playback.

Table 3 shows the full model selection results for the logistic regression on site-specific covariates. Only the number of stems touching the pole between 10-20 cm was significant (p = 0.045), although the number of stems touching the pole between 20-30 cm also approached significance (p = 0.052). However, these two variables were highly correlated (Spearman's rank correlation, r = 0.8, p < 0.001) and so only the numbers of stems between 10 and 20 cm were included in the models. Starting temperature and ending temperature were likewise highly correlated and so only starting temperature was included in the models (r = 0.9, p < 0.001).

Table 3. Full model selection results for logistic regression on site-specific covariates. An asterisk (*) denotes a significant variable.

Variable	β ± SE	P
Veg_ht	0.04 ± 0.06	P = 0.47
Litter_depth	0.47 ± 0.54	P = 0.39
Water_depth	0.14 ± 0.15	P = 0.34
Robel	-0.02 ± 0.07	P = 0.82
StoSAvg	0.01 ± 0.01	P = 0.23
SucAvg	0.02 ± 0.04	P = 0.74
ForAvg	0.01 ± 0.03	P = 0.86
BulAvg	0.00 ± 0.05	P = 0.97
ShrAvg	-0.03 ± 0.04	P = 0.48
SedAvg	-2.90 ± 0.03	P = 0.99
GrassAvg	-0.02 ± 0.03	P = 0.51
WatAvg	-0.04 ± 0.21	P = 0.86
BareAvg	0.04 ± 0.14	P = 0.75
VegAvg	-0.05 ± 0.14	P = 0.73
Canopy	-0.12 ± 0.14	P = 0.36
Can_floor	-3.35 ± 3.16	P = 0.29
StTC	0.05 ± 0.11	P = 0.65
0to10_f	-1.27 ± 1.60	P = 0.43
10to20_f	1.07 ± 2.00	P = 0.59
20to30_f	-2.05 ± 2.62	P = 0.43
30to40_f	-0.34 ± 1.76	P = 0.85
40to50_f	0.00 ± 0.46	P = 0.99
0to10_g	0.02 ± 0.16	P = 0.88
10to20_g	0.57 ± 0.28	P = 0.045*
20to30_g	-0.90 ± 0.47	P = 0.052
30to40_g	0.48 ± 0.50	P = 0.33
40to_50_g	0.57 ± 0.54	P = 0.29

Occupancy (ψ) was estimated to be 0.706 ± 0.145. A summary of the top ten models can be seen in Table 4. The best model included location, the number of stems touching the pole between 10 and 20 cm, and month. Several models had a ΔAIC of less than 2.0, indicating substantial support for these models. In order to clarify the relative importance of each variable, a summary of cumulative AIC weights is shown in Table 5. The number of stems between 10-20 cm was the most important variable, with a cumulative AIC weight of 0.79. As the number of stems touching the pole at 10-20 cm increased, occupancy also increased and leveled off at approximately 1.0 at sites with six or more stems (Fig. 8). Location was also important, with a cumulative AIC weight of 0.71. Occupancy was lowest at Brazoria NWR (ψ = 0.421), higher at the East Unit of San Bernard NWR (ψ = 0.709) and highest at the Sargent Unit of San Bernard NWR (ψ = 0.891). Occupancy was moderately influenced by habitat (cumulative AIC weight of 0.43) with higher occupancy rates in salty prairie (ψ = 0.741) than in high salt marsh (ψ = 0.620). Occupancy was only slightly affected by month (March ψ = 0.686; April ψ = 0.684; May ψ = 0.684) which was reflected by the relatively low cumulative AIC weight of 0.27. The number of years post-burn was likewise relatively unimportant.

Table 4. Model selection results for Black Rail site occupancy (ψ). This table shows the top ten models.

Model	AIC	ΔAIC	w_i	K
ψ(Location + g_10to20_g)$\hat{p}$(.)	276.92	0	0.17	4
ψ(Location + Habitat + g_10to20)$\hat{p}$(.)	277.86	0.94	0.10	5
ψ(Location + Burn + g_10to20)$\hat{p}$(.)	278.07	1.15	0.09	5
ψ (10to20_g)$\hat{p}$(.)	278.31	1.39	0.08	3
ψ (Location + Month + g_10to20)$\hat{p}$(.)	278.92	2.00	0.06	5
ψ(Location + Habitat)$\hat{p}$(.)	279.23	2.31	0.05	4
ψ(Location + Habitat + Burn)$\hat{p}$(.)	279.41	2.49	0.04	6
ψ(Habitat + g_10to20)$\hat{p}$(.)	279.55	2.63	0.04	4
ψ(Location + Habitat + Month + g_10to20)$\hat{p}$(.)	279.86	2.94	0.04	6
ψ(Location + Month + Burn + g_10to20)$\hat{p}$(.)	280.07	3.15	0.03	6

The probability of detection ($\hat{p}$) was estimated to be 0.094 ± 0.036. The best model included the extent of cloud cover, the location, the time of the survey, and the number of stems touching the pole between 10 and 20 cm (Table 6). A summary of cumulative AIC weights is shown in Table 5. Survey time and the number of stems between 10 and 20 cm had cumulative AIC scores of 0.90 and 0.88 respectively, indicating that these were the most important variables. Detection probabilities were highest at night ($\hat{p}$ = 0.16 ± 0.05; see Fig. 9) and increased with increasing number of stems (Fig. 10). Location and extent of cloud cover were less important, with cumulative AIC scores of 0.60 and 0.58 respectively. Detection rates were highest at the Sargent Unit of San Bernard NWR ($\hat{p}$ = 0.116), followed by the East Unit of San Bernard NWR ($\hat{p}$ = 0.083), and then Brazoria NWR ($\hat{p}$ = 0.059). Detection rates increased with increasing cloud cover (Fig. 10). Wind, month, starting temperature, habitat, and burn regime were relatively unimportant (Table 6).

Table 5. Cumulative AIC weights for each variable. The larger the number, the greater the importance.

Variable	Cumulative AIC weight for ψ	Cumulative AIC weight for $\hat{p}$
10to20_g	0.79	0.88
Location	0.71	0.60
Habitat	0.43	0.14
Burn	0.27	0.20
Month	0.27	0.33
Cloud		0.56
Time		0.90
Wind		0.33
Temp_start		0.28

Table 6. Model selection results for Black Rail detection probability ($\hat{p}$). Only the top 10 models are shown.

Model	AIC	ΔAIC	w_i	K
$\psi(.)\hat{p}$(Cloud + Location + Time + g_10to20)	272.16	0.00	0.07	6
$\psi(.)\hat{p}$(Cloud + Time + g_10to20)	273.22	1.06	0.04	5
$\psi(.)\hat{p}$(Location + Time + g_10to20)	273.46	1.30	0.04	5
$\psi(.)\hat{p}$(Cloud + Time + g_10to20 + Burn)	273.51	1.35	0.03	6
$\psi(.)\hat{p}$(Wind + Cloud + Location + Time + g_10to20)	273.56	1.40	0.03	7
$\psi(.)\hat{p}$(Time + g_10to20)	273.61	1.45	0.03	4
$\psi(.)\hat{p}$(Cloud + Location + Time + g_10to20 + Habitat)	273.67	1.51	0.03	7
$\psi(.)\hat{p}$(Cloud + Location + Time + g_10to20 + Burn)	273.77	1.61	0.03	7
$\psi(.)\hat{p}$(Cloud + Location + Time + Month + g_10to20)	274.01	1.85	0.03	7
$\psi(.)\hat{p}$(Cloud + Temp_start + Location + Time + g_10to20)	274.09	1.93	0.03	7

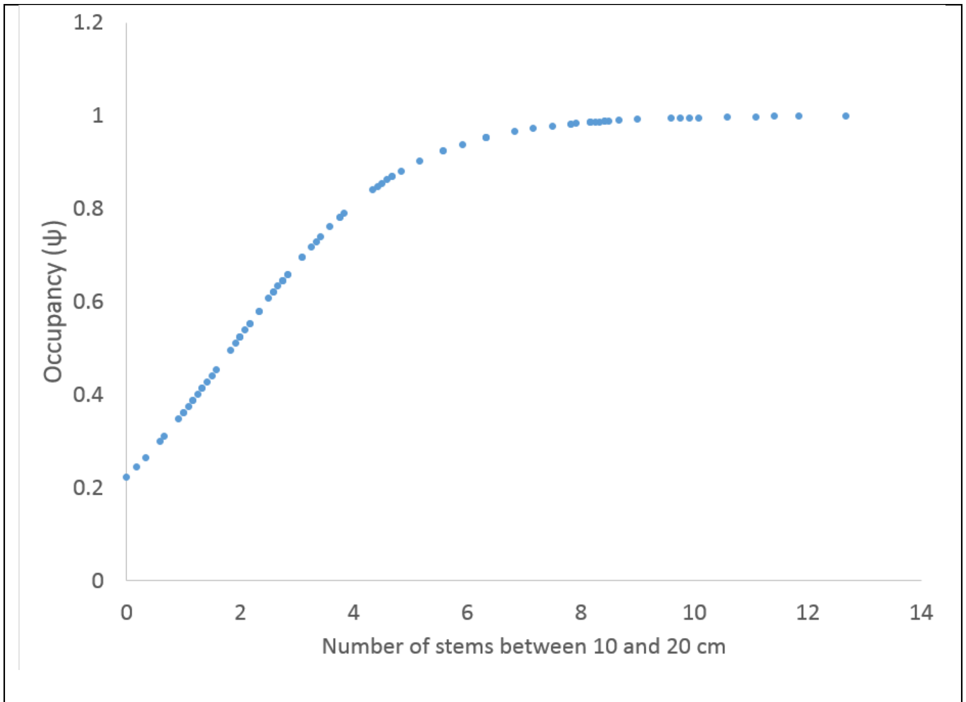

Fig. 8. Occupancy increased with the increasing number of stems between 10 and 20 cm, but leveled off if the number of stems touching the pole exceeded six.

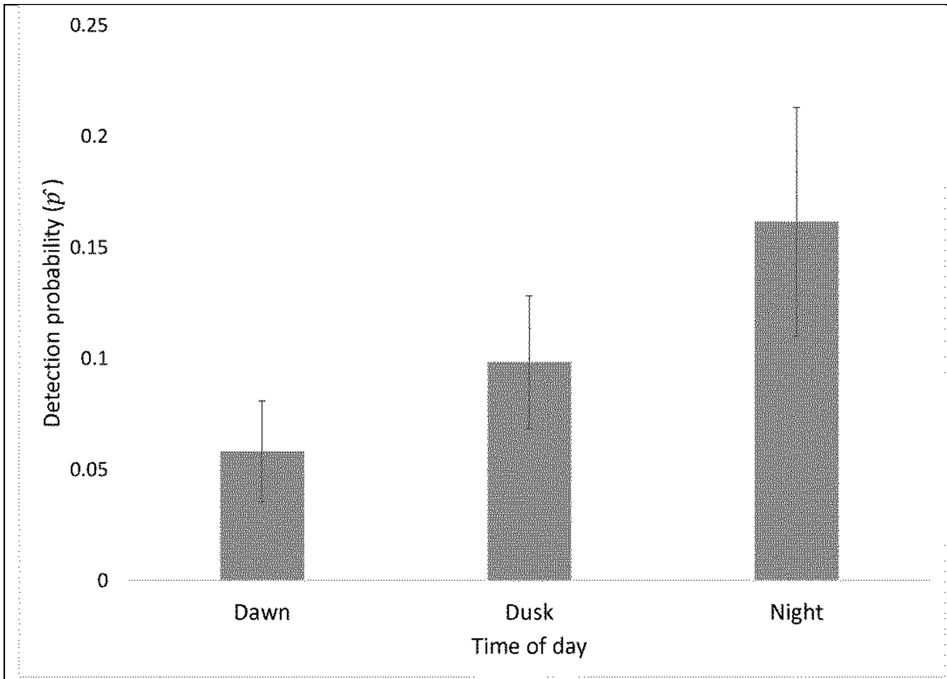

Fig. 9. The probability of detection was greatest at night. Errors bars indicate standard error.

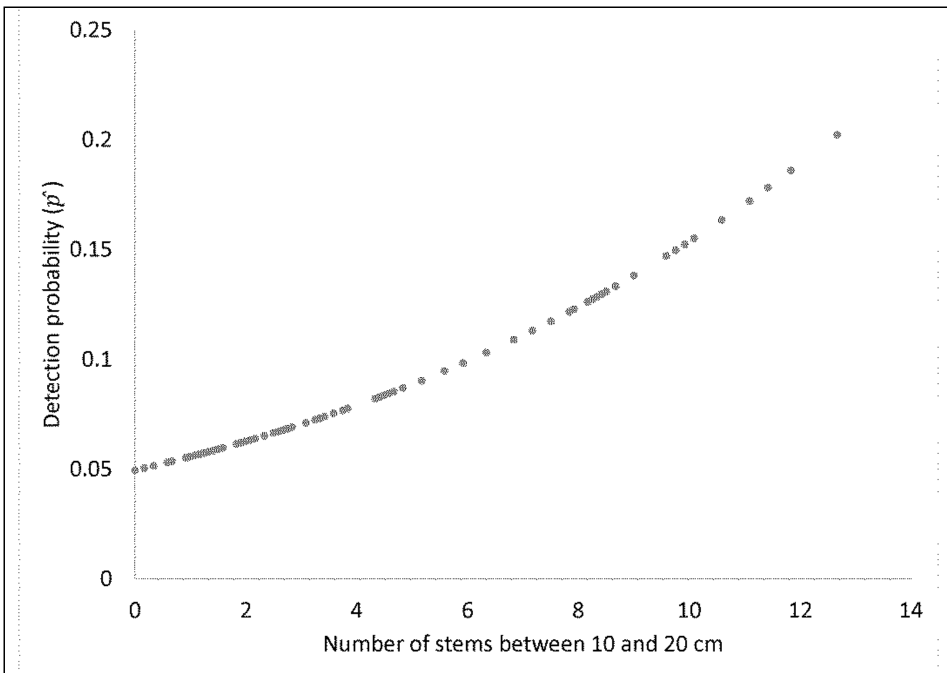

Fig. 10. The probability of detection increased with increasing number of stems between 10 and 20 cm.

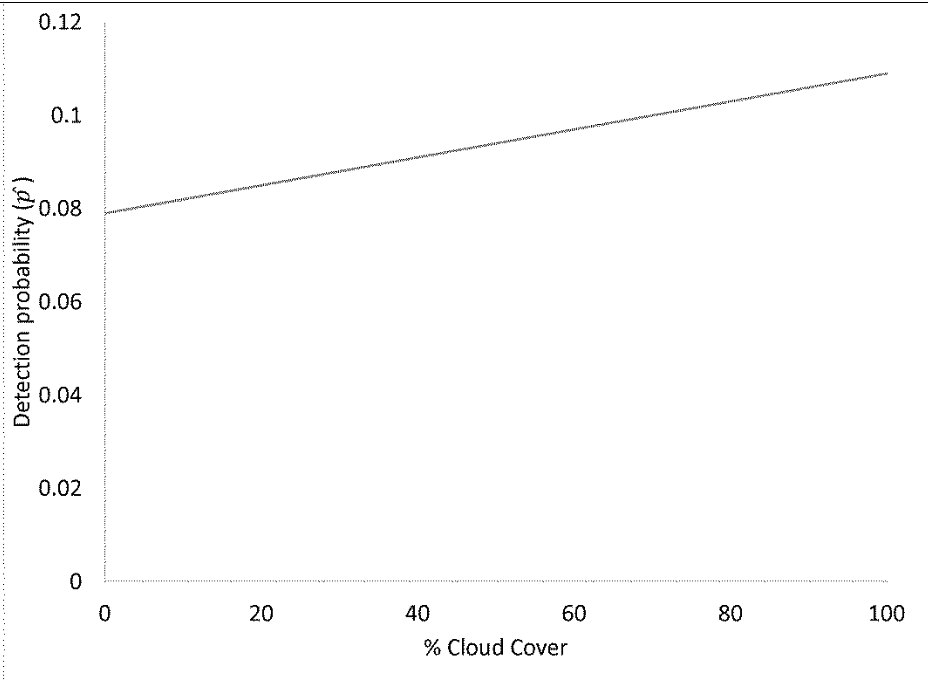

Fig. 11. The probability of detection increased with increasing cloud cover.

ARU results

Song Scope frequently confused Red-winged Blackbirds (*Agelaius phoeniceus*), and Great-tailed Grackles (*Quiscalus mexicanus*) with Black Rails. In addition, rain, Willets (*Tringa semipalmata*), and Dickcissels (*Spiza americana*) were also occasionally mistaken for Black Rails. Overall, the false positive rate was 37%. The false negative rate was 9% and appeared to be due to the fact that some Black Rails were too distant or soft to be detected by the bioaccoustical software.

The median vocalization rate of Black Rails over the course of the study was only one *ki-ki-kerr* vocalization per hour. However, there was considerable variation, with rates of up to 660 vocalizations per hour recorded. Although Black Rails were recorded vocalizing throughout the day, the ARU data showed a peak in vocalizations from 19:00 – 23:00, with a second, smaller peak from 3:00 – 6:00 AM (Figure 12). Black Rails vocalized throughout the study, but the largest numbers were detected during April, with a gradual decline in vocalization rates through early July (Figure 16).

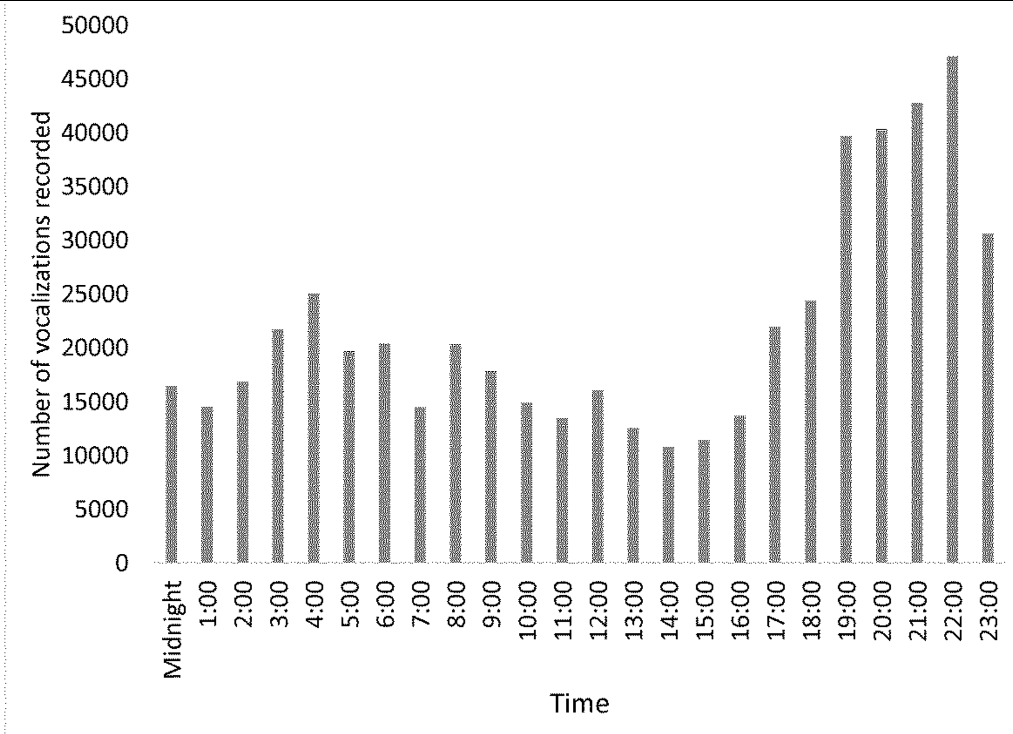

Figure 15. Black Rail vocalizations, as determined by the Song Scope analysis, peaked before midnight.

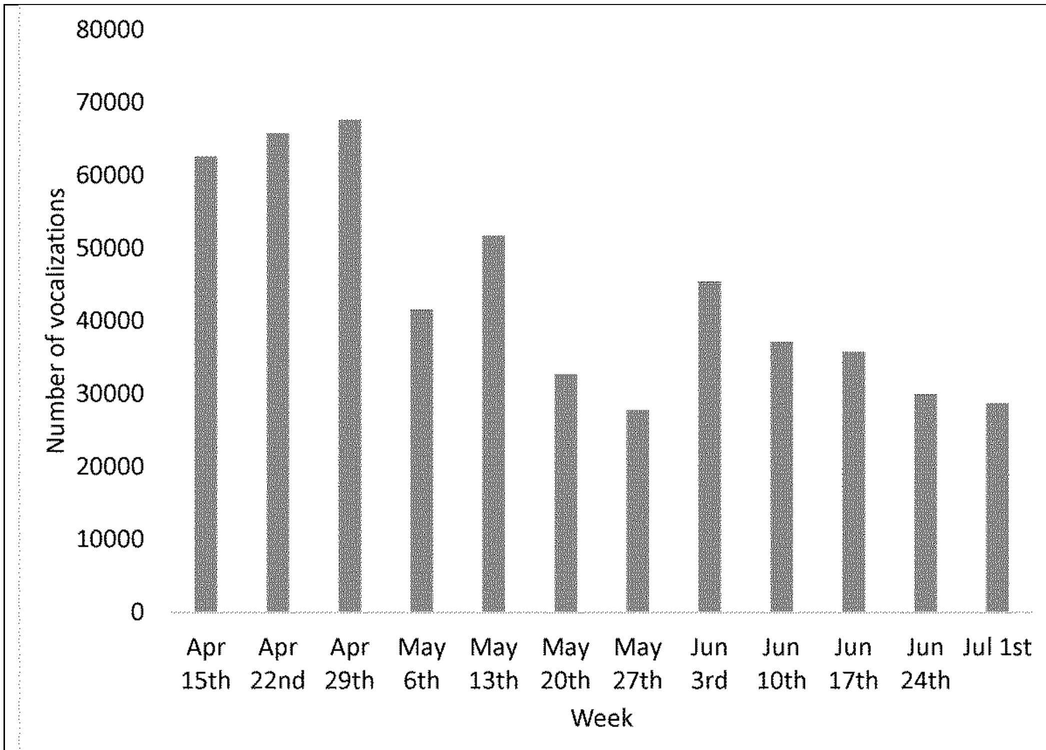

Figure 16. Black Rails vocalized most often during April, May and early June.

DISCUSSION

Although Black Rails are very secretive, occupancy in our study sites was approximately 70%. Occupancy was strongly affected by the number of stems between 10 and 20 cm in height. Due to the clumping nature of *Spartina* spp. (Figure 5), these were typically stems that drooped towards the ground, potentially shielding Black Rails from the view of predators above. Other studies have likewise found that vegetative structure and composition affected Black Rail occupancy. For example, Tsao et al. (2009) found that California Black Rails preferred areas dominated by Pacific swampfire (*Sarcocornia pacifica*). Richmond et al. (2012) found that Black Rail occupancy was negatively affected by grazing in marshes that were not irrigated, presumably because irrigated marshes are able to more rapidly regrow the necessary vegetative structure required for Black Rails occupancy. In Texas, Black Rails are also occasionally observed in upland bluestem prairies in the Texas mid-Coast NWR complex (Wilson, pers. obs.) and is possible that they may use this habitat if the stem count is similar to the stem count in salty prairies and high salt marshes.

Interestingly, occupancy was only very weakly affected by month. Black Rails will occasionally vocalize outside of the breeding season (Butler and Tibbits pers. obs., B. Ortego pers. comm.) and it is possible that birds detected during March and April may have been overwintering birds. However, the change in occupancy by month was minimal (ψ = 0.686 for March, 0.684 for April, and 0.684 for May), suggesting that the birds detected on this survey were non-migrants. A study on Black Rails in Florida likewise found that the number of detections was consistent from April through July (Legare et al. 1999).

It is possible that the noise created by the observer moving through dense vegetation may alert birds and reduce the likelihood of response during the first two minutes of the survey. However, some Black Rails responded to noises from sources other than Black Rails (observer, other bird species), and occasionally vocalized as the point was being approached. The vocalization was often the “pow” or “ik-ik-ik” growl which may not carry as far as the “ki-ki-kerr” vocalization. In general, we found that the number of rails detected during the first two minutes of passive listening was less than the number of rails detected after the call-broadcast. Conway et al. (2004) likewise found that call-broadcast surveys improved detection rates of Black Rails.

Although Black Rails occupied the majority of the sites in our study area, the probability of detection was only approximately 10%. This is a much lower rate than for other rail species. For example, Martin et al. (2014) found that Yellow Rail detection probabilities in Canada were 63%. Darrah and Krementz (2009) estimated the detection probability of King Rails to be 0.35 to 0.45. The probability of detection increased with increasing cloud cover and declined with increasing wind speed. The probability of detection also varied by location and time of day. The best chances of detecting Black Rails were during cloudy, relatively calm nights. Conway and Gibbs (2011) note that wind speed and cloud cover affected detection probabilities in some rail species, but not all. For example, Virginia Rails in Alberta were more likely to be detected during clear nights while Yellow Rails were more likely to be detected on nights where the moon was obscured (Prescott et al. 2002).

The detection probability also varied by location, with the probability of detection higher in areas with a higher occupancy rate. Robertson and Olsen (2014) likewise found that the odds of Virginia Rails and Soras (*Porzana carolina*) responding to call-broadcast surveys showed a positive relationship with density. Conway and Gibbs (2011) suggest that density also influences the vocalization rate of Ridgway's Rail.

Harms and Dinsmore (2014) found that the number of detections for rails in Iowa was not affected by the time of day (morning or evening) but was affected by date of the survey, with more vocalizations recorded earlier in the season. In contrast, we found the Black Rails detection varied by time of day, but not by season.

The occupancy rate of many rail species depends upon the fire regime. For example, King Rails in North Carolina and Virginia exhibited higher occupancy rates in areas that were recently burned (Rogers et al. 2013). Similarly, the occupancy rate of Yellow Rails was highest in areas that had burned within the last 10 years (Austin and Buhl 2013). However, the occupancy rate of Black Rails in Texas was only weakly affected by the years post-burn, suggesting that fire regime may be less important than the vegetative structure and community composition.

The analysis by Song Scope highlights the limitations of relying entirely upon bioaccoustical software. Although it only missed approximately 10% of vocalizing Black Rails, it produced many false positives due to both biotic (e.g. birds) and abiotic (e.g. rain) factors. This suggests both that recognizers need to be carefully constructed and that spot-checking the results are essential.

The ARU data suggests that the best time to survey Black Rails along the Texas Gulf Coast is from April through early June. These results are similar to those found by Repking (1975) as well as Flores and Eddleman (1991) who suggested that California Black Rails tend to vocalize most frequently from March through June.

Peak vocalizations occurred after sunset until shortly before midnight, with a secondary, smaller peak within two hours of sunrise. These results agree with previous studies that suggest that Black Rails primarily vocalize at night (Weske 1969, Reynard 1974, Eddleman 1994). However, it should be noted that California Black Rails prefer to vocalize at dusk rather than at night (Flores and Eddleman 1991). Interestingly, one study noted that populations within the same state may vocalize at different times (Kerlinger and Wiedner 1990).

In conclusion, Black Rails occupy salty prairie and high salt marsh and prefer areas where the grass stem count between 10 and 20 cm is higher. Surveys for this species in coastal Texas should primarily focus on these habitats. We found that the probability of detection for Black Rails is very low and suggest that future survey efforts should be carried out at night, when the probability of detection is highest. We also suggest that survey points be visited repeatedly from early March through early June, as vocalization rates begin to decline after early June. Additionally, grazing and frequent fires may potentially reduce vegetation density, and we suggest that future studies be carried out to examine the effects of these management activities on Black Rails.

CHAPTER 3: CONCLUSIONS AND RECOMMENDATIONS

Survey protocols

Although the occupancy of Black Rails in our study was relatively high (approximately 68%), the probability of detecting a Black Rail at a given point was approximately 10%. Consequently, multiple visits to a site will be required in order to document the presence of Black Rails in an area. The following are our recommendations for conducting surveys on Black Rails.

Time

Our surveys were conducted during March, April, and May. Neither occupancy nor the detection probability appears to be strongly affected by month. The ARUs suggest that Black Rail vocalizations begin declining after early June. We suggest that future surveys be conducted from early March through early June.

Detection rates did differ by time of day, with detection probabilities approximately 16% during the night. The ARU data shows that Black Rail vocalizations peaked before midnight. Consequently, we suggest that surveys be carried out beginning 1.5 hours after sunset and ending by midnight.

Number of surveys required

In order to verify the presence of Black Rails in an area, multiple surveys are required. The probability of detection at night, was approximately 16%, so four visits to the same location will be required in order to have a 50% chance of detecting Black Rails. To have an 80% chance of detecting Black Rails at a given location, nine visits will be required. We suggest that future surveys incorporate four or more visits to each location per field season.

Abiotic variables

Black Rails were negatively affected by wind speed and positively affected by cloud cover. We suggest that future surveys be limited to times when the wind speed is less than 15 kilometers per hour.

Biotic variables

Black Rails were found in both high salt marsh and in salty prairie. They tended to occur in areas dominated by *Spartina patens* and/or *S. spartinae.* They were much less common in areas dominated by *S. alterniflora*. We suggested that survey efforts for this species should focus on high salt marsh and in salty prairie, particularly in areas where the number of stems between 10 and 20 cm is relatively high.

Familiarity with vocalizations beyond the "ki-ki-kerr"

Although the *ki-ki-kerr* vocalization was the one most frequently encountered, other vocalizations were noted including the "pow" call as well as the"ik-ik-ik" growl. Observers surveying Black Rails should be familiar with these vocalizations.

SAFETY

Western Diamondback Rattlesnakes (*Crotalus atrox*) occur at high densities in *Spartina* dominated wetlands, and we had six close encounters that included rattling and striking. We highly recommended that surveyors wear appropriate personal protective equipment. Full-length Kevlar chaps proved effective at stopping a rattlesnake strike to the upper shin. One incident included a rattlesnake coiled on top of a *Spartina* tussock (Figure 17) which allowed the snake to strike above the knee, although this strike was also blocked by the full-length Kevlar chaps. Surveyors doing roadside surveys at night should be mindful that many snake species, including Western diamondback rattlesnakes and cottonmouths (*Agkistrodon piscivorus*), will bask on the still-warm road in the hour immediately following sunset.

Figure 17: Western Diamond-backed Rattlesnakes were common on the study sites.

Beginning in May, American alligators (*Alligator mississippiensis*) were encountered at the study sites. We observed no instances of agression from American Alligators, although an observer did inadvertently startle an adult in a wet grassland at night (Figure 18). Caution should beis advised when venturing into potential American alligator habitat in May.

Figure 18. American alligator.

FUTURE RESEARCH

Radio telemetry

In occupancy models, the closure assumption states that sites are closed to changes in occupancy between surveys (Rota et al. 2009). Thus, a site is assumed to be occupied during all surveys if it is occupied during at least one survey, and non-detections are assumed to be false negatives (Rota et al. 2009). Our survey assumed that territorial Black Rails vocalize from a specific territory throughout the breeding season survey period (March-May). However, little is known about the daily movements and area-specific home range of Black Rails along the Texas Gulf Coast. Understanding how Black Rail spatially occupy the study area throughout the survey period would enable researchers to optimize survey methods and occupancy models.

Furthermore, determining home range size will increase the reliability of population density estimates.

Radio-telemetry might provide the means to examine Black Rail home range and movement during the breeding season. Radio-telemetry was used to determine the daily and seasonal movements of Sora, although mortality caused by telemetry equipment was approximately 5% (Haramis and Kearns 2007). A study in southwest Lousiana and southeast Texas used radio telemetry to estimate home ranges and microhabitat selection of King Rails (Pickens and King 2013), and a study in California used radio telemetry to estimate home range size of the Ridgway's Rail (formerly the Light-footed Clapper Rail; Zembal et al. 1989).

Generating average estimates of spatial dispersion would allow researchers to determine if the closure assumption is a valid inclusion in occupancy models for Black Rails. Determining the home range size of breeding Black Rails in Texas would allow researchers to generate more accurate population density estimates. These density estimates could be extrapolated to generate quantitative population estimates for the Texas Black Rail population.

Stable Isotope Analysis and Banding

Bird-banding is currently not an effective method to determine migratory habits of Black Rails due to extremely low recapture rates. From 1960 to 2015, 652 Black Rails have been banded, and only one bird has been recaptured (USGS 2015). Stable isotope analysis provides an alternative method to determine where wintering birds are breeding. We suggest that feathers be collected from wintering Black Rails along the TX

Gulf Coast, and that these results be groundtruthed against feathers collected from breeding Black Rails from inland populations. This approach would enable researchers to determine the proportion of migratory to resident birds, and migratory connectivity.

From 1968 to 2013, a total of 77 Black Rails were banded in Texas with no birds being recaptured (USGS 2015). No birds were banded Kansas or Colorado, the breeding stronghold for inland populations that presumably winter along the Gulf Coast. Coordinating banding efforts between these states may improve recapture rates. Additionally, including Kansas and Colorado into the Eastern Black Rail Working Group may improve conservation strategies for these inland populations.

APPENDICES

Appendix A. Survey sheet for Black Rails.

Datasheets

UCO University of Central Oklahoma

Black Rail Survey Datasheet

Date:_____________ Page ____

Loc:______________ of ____

If found please contact:

Jeff Tibbits

(580)504-0964

DAWN / DUSK / NIGHT

Moon:________ Start Temp: End Temp:

TIME	POINT	CLOUD	WIND	SPECIES	QTY	H/S	DEG	DIST	NOTES

Appendix B. Vegetation survey datasheet.

Vegetation Survey Datasheet

Site:____________ Location:______________

Date:___________ Coord. Sys:____________

Lat/Long:____________________________

If found, please call
Jeff Tibbits (580)504-0964

		N	E	S	W
5m	Veg. Height				
	Litter Height				
	Water Depth				
	Robel				
	Stem # 40-50				
	Stem # 30-40				
	Stem # 20-30				
	Stem # 10-20				
	Stem # 0-10				
	Canopy Ceiling				
	Canopy Floor				
	Total Canopy				
3m	Veg. Height				
	Litter Depth				
	Water Depth				
	Robel				
	Stem # 40-50				
	Stem # 30-40				
	Stem # 20-30				
	Stem # 10-20				
	Stem # 0-10				
	Canopy Ceiling				
	Canopy Floor				
	Total Canopy				
1m	Veg. Height				
	Litter Depth				
	Water Depth				
	Robel				
	Stem # 40-50				
	Stem # 30-40				
	Stem # 20-30				
	Stem # 10-20				
	Stem # 0-10				
	Canopy Ceiling				
	Canopy Floor				
	Total Canopy				

Cover	NE	SE	SW	NW	total/4
% Green					
% Bare					
% Water					
% Grass					
% Sedge					
% Shrub					
% Brush					
% Forb					
% Fern					
% Moss					
% Cactus					
% Leaf Litter					
% Downed Logs					
% Rock					
% Emergent					
% Succulent					

	E	S	W	N	Total
Stem-to-stem					
Distance					
Average					

Notes:

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