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Breeding Habitat Structure And Use By Kansas-Occurring Black Rail

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BREEDING HABITAT STRUCTURE AND USE

BY KANSAS-OCCURRING BLACK RAIL

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This thesis is written in the style appropriate for publication in *The Wilson Journal of Ornithology.*

ABSTRACT

Two subspecies of Black Rail (*Laterallus jamaicensis*) occur in the United States, and neither has been studied extensively. Of the two, the Eastern subspecies (*L. j. jamaicensis*) has a larger range, but has been studied to a lesser degree than the California subspecies (*L. j. coturniculus*). Eastern Black Rail are known to breed at several locations in Kansas, but as in other inland populations, precisely where these individuals overwinter is unknown. Additionally, little information is available on characteristics of breeding habitat for inland Eastern Black Rail populations, and few studies have investigated the effect of habitat management techniques on these populations. Eastern Black Rail are most often observed in Kansas at Quivira National Wildlife Refuge (NWR) and private lands surrounding it. Call playback surveys were conducted in the summers of 2009 and 2010 to locate breeding individuals and identify nesting habitat. Drift-fences and traps were set in locations where individual Black Rail were detected, and sound samples were used to attract individuals for capture. Rectrices and body coverts were plucked from similar regions on two captured individuals and used for deuterium stable isotope analysis. Coverts had average deuterium values of -86.2 and -77.8 per mil, respectively. These values are more typical for southern Canada and portions of the western United States. These feather values suggest that Kansas-occurring Black Rail either winter away from the Gulf Coast, in contrast to current understanding, or grow feathers during or soon after spring migration. Quivira NWR and surrounding private lands use prescribed burning, grazing and haying to manage vegetation in the wet-meadow habitat that the rails typically occupy. To characterize breeding habitat, I quantified vertical vegetation structure, water presence and depth, and plant height in areas where Black Rail responded during playback surveys. A Kruskal-Wallis one-way analysis of variance was used to compare these variables among 13 treatment types. Although test results indicated these variables were significantly different among treatment types, a non-parametric Tukey's post-hoc test could not detect where the differences occurred. A backward stepwise (Wald) logistic regression indicated higher percentages of dead vegetation in upper vertical layers and plant height positively influenced rail presence, whereas a higher percentage of living vegetation at lower layers negatively influenced rail presence (Nagelkerke R Square 0.57, $p < 0.001$). Black Rail were most often detected in sections with moderate levels of disturbance (e.g., burned annually, burned and grazed), while areas with higher levels of disturbance (e.g., annual haying, haying and burning) did not appear to possess suitable habitat, as no rails were detected in these locations. Moderately disturbed areas, such as those burned every two years, might contain the mosaic of living and dead vegetation necessary for Black Rail nesting habitat in this portion their breeding range.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Wetlands are frequently described as areas covered in water most of the year, and usually occur at the convergence of multiple ecosystems (U.S. Environmental Protection Agency 2009). They can be surrounded by uplands, pasture, or forests, and can be estuarine, inland salt-marshes, or freshwater. Though wetlands provide habitat for a diversity of organisms, and are important in watersheds and for ecosystem function, many continue to be modified by human activity (U.S. Environmental Protection Agency 2004). Wetlands can be protected at the state or national level through the formation of refuges or parks. International agreements, such as the Ramsar Convention, also help protect wetlands. The Ramsar Convention on Wetlands designates Wetlands of International Importance; two of these, Cheyenne Bottoms and Quivira National Wildlife Refuge (NWR), occur in Kansas (Ramsar Convention of Wetlands 2011). Wetlands in the central flyway serve as essential stopover habitat for many migratory birds, and marsh birds, such as rails, bitterns, and herons occupy wetlands during the summer breeding season (U.S. Environmental Protection Agency 2009; Griggs et al. 2002).

The Black Rail (*Laterallus jamaicensis*) is a small (30 g) marsh-bird known for its elusive behavior (Ripley 1977). Two subspecies of Black Rail occur in North America, the California Black Rail (*L. j. coturniculus*) and the Eastern Black Rail (*L. j. jamaicensis*). As implied by their names, the California Black Rail occurs primarily in California, though there are smaller populations in Arizona (Eddleman et al. 1994; Figure 1); the Eastern Black Rail has a larger range, with records from southeastern Colorado to the Atlantic coast. However, records of successful breeding in the western part of its habitat, such as Kansas, are rare (Eddleman et al. 1994; Busby & Zimmerman 2001). The Black Rail is categorized as "Near Threatened" by the IUCN (BirdLife International 2008), and is listed as a "Species in Need of Conservation" by the state of Kansas (Kansas Department of Wildlife and Parks 2009).

Although coastal populations of Black Rail have been relatively well studied (e.g., Legare & Eddleman 2001; Conway & Sulzman 2007), remarkably little information on nesting and other components of basic biology exists for interior populations of Eastern Black Rail. It is suspected that individuals of this subspecies breed in the interior United States and most likely spend the winter along the Gulf Coast, Mexico, Belize and portions of the Caribbean Islands and South America (Ripley 1977; Eddleman et al. 1994; American Ornithologists' Union 1998). Few studies confirming the location of these wintering grounds have been conducted, although there have been some records of wintering Eastern Black Rails in the southeastern United States (Williams 1919; Jackson 1987). Assessing migration behavior and habitat for interior populations would contribute to the pool of knowledge for the eastern subspecies, and likely aid with conservation and management efforts.

Wildlife refuge and other land agencies are often charged with managing habitat for a variety of organisms, as well as various stakeholders who are interested in those organisms, such as hunters, birders, and conservationists. Land managers of wetland areas have to make a variety of decisions every year regarding habitat management, such as selecting water levels, controlling invasive species, increasing or decreasing woody vegetation, and maintaining specific habitats. They might use techniques such as flooding, prescribed burning, haying, and grazing to achieve these goals. Few studies are available on the possible effects of such practices on Black Rail habitat, particularly for eastern populations. Given the general trend of decline of Black Rail populations (The Center for Conservation Biology 2009; BirdLife International 2008), it is essential for land managers to understand effects of vegetation management techniques on known and potential Black Rail habitat.

The habitat occupied by Black Rail is similar for both subspecies, although characteristic plant species varies (Eddleman et al., 1994). Both subspecies are usually associated with salt-marsh habitat occurring where wetlands and surrounding upland meet (Eddleman et al. 1988; Eddleman et al. 1994; American Ornithologists' Union 1998). Characteristic vegetation of this habitat varies with region: in California, Black Rail occupy habitat dominated by pickleweed (*Salicornia virginica*), cattail (*Typha* spp.), rushes (*Juncus* spp.) and alkalai bulrush (*Scirpus maritimus*) (Spautz et al. 2005); in Oklahoma, Cyperaceae species dominate the wet meadows, with cattail and other aquatic plants also present (Beck and Patten 2007); Pantry et al., (2004) reported that Black Rail in Florida were detected most often in high marshes dominated by saw-grass (*Cladium jamaicensis*). Vertical structure of these wet meadow habitats may also vary. Spautz et al., (2005) reported that Black Rail were positively associated with habitat with higher densities of living vegetation below 10 cm, whereas Eddleman and Legare (1995) found that Black Rail in Florida occupied emergent vegetation habitat with little dead vegetation and dense living vegetation. Black Rail throughout their range typically occupy habitat with moist soil or shallow water (Eddleman et al. 1994; Repking and Ohmart 1977).

A relatively recent technique used to assess some aspects of avian life history is the use of stable isotope analysis. An isotope is a variable form of an element, with each isotope having a different number of neutrons in its nucleus (i.e., Carbon-13 (^{13}C) has one more neutron in its nucleus than Carbon-12 (^{12}C). Although isotopes of an element function the same chemically, each can react at different rates during a chemical or physical process. Due to these differences, substances, like precipitation or feathers, can have different ratios of heavy (isotopes with more neutrons) to light (isotopes with fewer neutrons) isotopes. The amount of each isotope (heavy and light) in a substance is measurable and often reported as a ratio of heavy to light isotopes, noted as δ. This ratio can reveal much about the ecology of an organism, such as migration patterns or feeding ecology (Fry 2006).

Analysis of deuterium isotopes can be used to assess the approximate location birds when they are molting (Fry 2006). This technique has been used to describe migrations patterns and breeding origins in songbirds (Chamberlain et al. 1997), raptors (Lott et al. 2003), and seabirds (Cherel et al. 2000), and some studies have used this technology with other rail species (Perkins 2007). Deuterium ratios occur in predictable latitudinal gradients, and these ratios are reflected in the tissues of organisms that ingest it (Fry 2006). After a feather is grown, the keratin is metabolically inert and retains a deuterium ratio reflective of the local environment; thus, the ratio can indicate the location of a bird when a particular feather was grown (Kelly et al. 2001; Bowen et al. 2005; Fry 2006). Assessing where Kansas-occurring Black Rail are spending their winter could shed light on where populations of Black Rail occur in the non-breeding season, which would allow for more informed conservation efforts.

The objectives of this study were to quantify Black Rail habitat at Quivira NWR, assess the effects of habitat management practices on Black Rail presence, and use stable isotope analysis to establish where individuals captured at Quivira NWR are wintering. My hypotheses were: 1) Black Rails at Quivira NWR most often occupy wet meadows dominated by spike-rush (*Eleocharis*) species with complex vertical structure, and relatively low water levels; 2) Areas with frequent disturbances (disturbances that occur in concurrent or consecutive years), habitats with high levels of disturbance (e.g. haying, haying and burning), or a combination thereof, will have fewer Black Rail present than in other habitats; 3) Black Rails captured at Quivira NWR during the breeding season winter along the Gulf Coast of the United States or Mexico.

METHODS

I. Surveying

Surveys were conducted on the portion of Quivira NWR located in Stafford County, Kansas, and on private land bordering the refuge. Private land was selected based on: shared borders with sections of Quivira NWR with known Black Rail habitat; vegetation that appeared to be suitable Black Rail habitat; or Black Rails were heard on the property. Areas thought to have suitable Black Rail habitat were surveyed first, followed by areas with possible patches of Black Rail habitat. "Suitable" or "good" habitat was used to indicate habitat around the points or trap sites with vegetation similar to that of the Richardson Tract, an area on Quivira NWR where Black Rails have been reliably detected in prior years.

The survey protocol set by the National Marsh Bird Monitoring Program (NMMP; Conway 2008) was used in both the 2009 and 2010 field seasons. Surveys were used to establish locations of Black Rail (*L. j. jamaicensis)* on Quivira NWR and adjacent private land. A broadcast sequence for the surveys was obtained from the NMMP with the following rallid calls (listed in broadcast sequence): Black Rail (*L. jamaicensis*), Sora (*Rallus carolina*), Virginia Rail (R. *limicola*), and King Rail (R. *elegans*).

A) 2009 Sampling

The 2009 field season ran from 14 June to 13 August; surveys were also performed on 06 September and 17 October. Survey points were placed 400 m apart, as recommended by the NMMP (Conway 2008), to reduce the probability of an individual being counted twice. A Garmin GPS 12 (Garmin International, Inc., Olathe, Kansas USA) was used to mark the location of survey points. Survey points were first placed along property borders, and then interior areas were surveyed by creating a grid of survey points placed 400 m apart.

Data collected at each point were chosen based on NMMP suggested protocols, and data sheets provided by the program were customized to accommodate the data collected (Conway 2008). Data collected at each point included: wind speed, background noise, water depth and salinity, speaker direction, and notes about the vegetation. A Cass Creek Big Horn Remote Speaker (Cass Creek, Traverse City, Michigan, USA) and a Nextar Digital mP3 (Nextar Inc., La Verne, CA, USA) player were used to broadcast calls. Calls were played at the highest volume possible without distortion, and the speaker was typically pointed towards the interior of the refuge. Background noise was estimated according to a scale standardized by the NMMP (Conway 2008), and wind speed was estimated using the Beufort Wind Scale. If water was present at the survey point, its depth and salinity were recorded. Water depth was measured by using a pole with ten cm increments, or by inserting a finger in shallow (less than five cm) water. A Sper Scientific Salt Refractometer 300011 (Sper Scientific, Ltd., Scottsdale, AZ, USA) was used to measure salinity.

Basic vegetation characters around each survey point were also recorded, as recommended by the NMMP (Conway 2008). Vegetation was described by using general categories according to the most dominant vegetation type. The categories included: road, marsh, emergent, wet meadow, wooded/riparian, upland, or open water. Emergent vegetation was most often used to describe wet sedge meadows and marsh was used to describe areas with cattail or inland saltgrass. If more than one habitat type occurred at the survey point, all types were recorded.

Individuals of any rail species that responded during the broadcast interval were recorded; low numbers of Sora, Virginia Rail, and King Rail were detected in emergent vegetation habitats. The portion of the broadcast sequence during which the rallid called, the bird's call type, and its approximate distance and direction from the survey point were recorded. Detailed notes on the approximate location of the individual were recorded.

B) 2010 Sampling

The 2010 field season was conducted from 15 April to 20 August; single surveys also were performed on 18 September and 17 October. Surveys were conducted in areas from the previous season where Black Rail had been detected, and in areas with potential Black Rail habitat. Survey points were placed 400 m apart, and a Garmin GPS 12 (Garmin International, Inc., Olathe, KS, USA) was used to mark the location of the survey points. A grid system was used to place survey points 400 m apart, although points located in the Big Salt Marsh were subsequently moved (see below).

Some of the areas surveyed in 2009 were again surveyed in 2010. These points were located in the Richardson Tract, the area south of the Richardson Tract, Ron Rougan's private land, Keith Widener's private land, along the Wildlife Drive, and along the Marsh Road (Figure 2). Other points from the 2009 field season were not used, although some of the areas were surveyed, but the survey points were in different locations. Survey points were excluded because of lack of good Black Rail habitat, or a lack of time to survey them. Excluded points were within the Wildlife Drive, most points in Allen Sleeper's property, areas around the Little and Big Salt Marshes, and some points east of the Least Tern (*Sterna antillarum*) Pads. Points north of the Tern Pads were moved, and placed to fit with the 400 m grid system based on the Richardson Tract and Ron Rougan's property. Two sample points were placed on Allen Sleeper's property to survey wet depressions in which Black Rail individuals had been detected in 2009 (Figure 2). Points around the Big Salt Marsh were placed every 400 m along areas thought to be potential Black Rail habitat.

A replacement speaker was used to broadcast calls in 2010 (Western Rivers Predation mP3 Caller Model 789, LG Enterprises, LLC, Montgomery, AL, USA). Call volume was set to 80-90 decibels at one meter from the speaker, the level set by NMMP standards (Conway 2008). Data collected at each survey point were: temperature, wind speed, background noise, water salinity and depth, and notes about the surrounding habitat. The speaker was usually directed towards the center of the area being surveyed, or towards patches of suitable Black Rail habitat.

Temperature and wind speed were estimated until 06 June 2010, when a Kestrel 2500 anemometer (Nielsen-Kellerman, Sylvan Lake, M, USA) was obtained and used to record these measurements. Water salinity and depth was measured by using the same methods as the 2009 season, until a Black Rail-footed Water Measuring Device was designed to measure water depth. The device was constructed using 14-gauge galvanized wire, and weighed 28 grams (the approximate median mass for Eastern Black Rail). The two "feet" were constructed so that the middle toe was 25 mm long (the approximate length of a Black Rail's longest toe) and the outer toes were slightly shorter and splayed out. The device was suspended by a string, and lowered into the water.

General categories of characteristic vegetation were established based on most dominant vegetation type at each survey point, following the NMMP (Conway 2008). Most of the categories from 2009 were used again (road, wooded/riparian, upland, wet sedge meadow, and open water); inland saltgrass was added as a new category. If more than one habitat type occurred at the survey point, all types were recorded. If the surveyor was unsure about what to mark for habitat type, the dominant type of vegetation was recorded (e.g., cattail, rushes, and sedges). It was also noted if the area had been recently hayed, burned, or grazed.

II. Trapping

A) 2009

Trapping typically occurred within one week of hearing an individual in accessible areas. Drift fencing was 2 mm by 4 mm metal mesh, 33 cm high; the length of the fencing varied. Fourteen-gauge galvanized wire hooks were woven into the mesh, and secured by using 22-gauge galvanized steel wire to support the fencing. The trap-line configuration was best fit to the area in which the rail was detected, and set according to vegetation, ground topography, and the presence of property fences. Vegetation was parted so the bottom of the fence would be touching, or nearly touching, the ground. Dead vegetation was piled up along the bottom of the fence in areas where gaps between the fence and the ground occurred. Three trap types were used: 40.6 cm by 40.2 cm by 20.3 cm four-way drop-door, 48.3 cm by 17.8 cm by 17.8 cm single drop-door Tomahawk live traps (Tomahawk, Toahawk, WI USA), and 50.8 cm by 50.8 cm by 15.2 cm funnel trap with a ramped entrance (Kearns et al. 1998; Perkins 2007). Traps were place along the drift fence lines so that birds following the fence would encounter a trap.

Trapping occurred from approximately sunrise to three hours after sunrise, and two hours prior to sunset to approximately 30 min after sunset. Traps were open for one morning and one evening within a 24 hr period, unless rainy weather precluded it; trapping resumed when the weather cleared. Traps were closed and removed from the drift-fence lines during non-trapping periods. The number of people present during trapping, the times traps were open, weather, and observations during the trapping period were recorded.

A Cass Creek Big Horn Remote Speaker (Cass Creek, Traverse City, Michigan, USA) and a Nextar Digital mP3 (Nextar Inc., La Verne, CA USA) player were used to play recordings of the *kikidoo* and *growl* vocalizations in order to lure birds to the traps. The recordings were by Pierre Deviche, and downloaded from the Arizona Field Ornithologists (AZFO) Bird Sounds Library (2008). The *kikidoo* and *growl* calls were played every 2 min for a length of 60 sec during a 10-min period. This process was repeated every 20 min. If a rail responded to calls after the playback period, the trapper "responded" to the rail with calls lasting approximately 10 sec. Traps were checked approximately every 30 min.

Captured individuals were banded by using a size two U.S. Fish and Wildlife Service (USFWS) aluminum band; the band was placed on the left leg. Iris and vent color, and feather molt and its location, were recorded for each individual, in an effort to quantify age, sex, and condition.

B) 2010

The 2010 trapping methods matched the protocol established in the 2009 season, except for several modifications: drift fences were constructed by using Easy Gardener BirdBlock Protective Mesh Covering (Easy Gardener Products, Inc., Waco, TX, USA) with

1.25-cm mesh; fences were 6.8 m long and 61 cm high, following successful capture methods by Perkins (2007) for King Rail in Louisiana. Garden stakes 91 cm tall were woven through the mesh every 2.3 m and secured with zip-ties. The bottom of the fence was staked down by using 6-cm 14-gauge galvanized wire hooks, or dead vegetation was placed along the fence where gaps occurred. Between zero to four 7.6 cm by 8.9 cm by 22.9 cm non-folding Aluminum Sherman traps (H.B Sherman Traps, Inc., Tallahassee, FL USA) with 1.27-cm diameter holes were used in addition to the four-way drop-door and single drop-door traps used in 2009.

Trap sites were placed near the point where the rail was heard during surveys, or where the rail was heard on the day of trap set-up. Trap-lines were arranged in one of two ways: 1) Fit to the site according to location of appropriate vegetation and borders (roads or property fences); 2) In the majority of cases, fences and traps were arranged in an eight-pointed star formation, with four spokes radiating off the four-way drop-door trap, and one spoke angling off each of the original four spokes. The traps were placed in a manner to encourage birds to be funneled into the traps. Some variation occurred on this formation, dependent on surrounding vegetation, and the direction the bird most often was heard or approached the trap-line. The approximate location of the rails during trapping sessions were typically known, so traps were only checked during period of silence lasting longer than 30 min, or if it sounded like an individual had entered the trap.

Trapping intervals were initially two to three days in length. This interval was decreased to a single 24-hr period after observations indicated individuals' responses to call playbacks decreased, or stopped after the second trap session. Trapping periods then followed methods used in the 2009 season.

A Western Rivers Predation MP3 Caller Model (LG Enterprises, LLC., Montgomery, AL USA) was used to broadcast recorded calls of the *kikidoo*, *growl*, and *churt* vocalizations to lure the birds to the traps. Calls were primarily from recordings made by Orien Richmond (University of California, Berkeley, pers. comm.), and secondarily from the recordings by Pierre Deviche downloaded from the AZFO Bird Sounds Library (AZFO 2008). The *kikidoo* vocalization was used most frequently, although the *growl* and *churt* vocalizations were also broadcasted. The latter two vocalizations were used when an individual used one of those calls, or if two individuals were in the area. The call playback protocol followed that of the 2009 season.

A drag-rope was used to aid in directing Black Rail towards the trap-lines (Tsao et al. 2009). The rope was made of 0.48-cm poly-rope, and cut to seven m in length. Three 1.9-L milk jugs filled with sand were tied to the rope to weigh it down.

Captured individuals were weighed, contour feathers were removed from the upper right breast, right-side rectrices were removed, had a USFWS band attached to the left leg, and the following data were collected: iris and vent color, feather wear and/or molt and its location, wing chord, tail, tarsus and culmen lengths, and an estimate of condition by using subcutaneous fat levels.

III. Vegetative Structure

A) 2009

Vegetation structure and species composition were quantified at traps sites, and where Black Rail were detected. Measurements were completed within one month of detecting an individual. Single 400 m long transects were positioned to pass through the approximate point where individuals were detected. Distance from, and bearing through, the trap/detection site were chosen randomly. Data collection points were placed every 25 m, for a total of 16 collection points along each transect. At each collection point, canopy cover was measured following protocol established by Daubenmire (1959). Canopy cover measurements were taken in three vertically-layered plots at each point (Spautz et al. 2005, Tana Ellis *in litt*): 0 - 10 cm (0 cm level), 11 - 20 cm (10 cm level), and 21 cm – to top of canopy (20 cm level). Percent cover of individual plant species, ground, dead vegetation, water, and open space were recorded at each level.

The tallest plant height and species, and water depth and salinity were recorded for each point. Plant height was measured by using a pole with 10-cm demarcations, and rounded to the nearest centimeter. Water depth was measured by the same method, or visually estimated to the nearest one-half cm by inserting a finger into the water. Water salinity was measured using a Sper Scientific 300011 Salt Refractometer (Sper Scientific, Ltd., Scottsdale, AZ, USA).

B) 2010

As in the first year of sampling, vegetation measurements were taken at trap sites, or where individual Black Rail had been detected during surveys. Measurements were typically completed within one month of detection or trapping, unless weather or trapping sessions interfered with the sample date. Transects were 200 m long, with 16 collections points placed 13.4 m apart. If the trap site and original detection point were within 200 m of one another, the transect line was positioned to run through both areas. For most sites, the transect line was placed at a random bearing and distance, rounded to the nearest 25-m interval, through the point where the individual was detected. A measuring tape and compass were used to follow bearing and distance through the detection point/trap site.

If a transect passed into a road, the end of the measuring tape was thrown onto the road along the same trajectory as the transect line. At the point where the measuring tape landed, the distance from the previous data collection plot was recorded; this number was subtracted from 13.4 (the distance between plots). The resulting number was used as the remaining distance to the next point. A new bearing back into suitable habitat was randomly chosen using a compass, and the transect continued along that bearing.

Vegetation measurements followed the protocol used in 2009. Percent cover of individual plant species, dead vegetation, leaf litter (dead vegetation that did not look to be a result of the current year's growth), bare ground, water, and open space were recorded. If no water was present, ground moisture level (moist or not moist) was recorded.

IV. Stable Isotope Analyses

During the 2010 field season, contour feathers and rectrices were successfully collected from two captured birds. Feathers were placed in resealable freezer bags, labeled, and stored in a -20 degree C freezer. Feathers were prepared for stable isotope analysis following the protocol of Hobson & Wassenaar (2008). All feathers were rinsed and soaked in a 2:1 chloroform/methanol solvent for two 24-hr periods. The feathers were then rinsed one more time in the 2:1 chlolorform/methanol solvent, and left to air dry in a fume hood for approximately 46 hours.

In March of 2011, water samples were collected from three locations at Quivira NWR: the artesian well along County Road NE 140th Street, the Big Salt Marsh, and surface water from the Richardson Tract. Samples were collected in microcentrifuge capsules and placed on ice. A Micromass Isoprime isotope ratio mass spectrometer (Microsmass, Manchester, England) was used to analyze deuterium values in the feather and water samples.

V. Statistical Analyses

To test for potential effects of management regime on vertical structure, separate Kruskal-Wallis tests were run for each of the three vertical layers (0 cm, 10 cm, and 20 cm). Comparisons included: cover of dead vegetation, cover of living vegetation, open area, water cover and depth, and plant height. Data for dead vegetation, living vegetation, open, and water were transformed by using an arcsine transformation, while data for plant height were transformed by using a logarithmic transformation. A Backward (Wald) logistic regression was run to assess the possible influence of habitat structure on Black Rail presence within an area. The same categories and transformations were used for this analysis as in the Kruskal-Wallis test. Multiple logistic regressions were run, and I only utilized the regressions with the best fit model. Alpha was set at 0.05.

RESULTS

I. Surveying and Trapping

In 2009, 28 surveys were performed from June to October, and an estimated 13 Black Rail were detected by sound (Figure 3). The earliest detection was 14 June (the first day of sampling), and the latest detection was 13 August. Almost half of the detections occurred in June (6 of 13), while the remaining were spread between July (three) and August (two). Of the 13 detections, two occurred at the same survey point on or around the same day; thus, the detections were counted as the same individual. Birds were detected most often in the morning, before 0900 (9 of 13 detections). Water was present at ten of the survey points, with a mean depth of 8.4 cm and a standard deviation of 12.7 cm. Most Black Rail were detected when no water was present at the survey points; one individual was detected in a location with a water depth of two cm.

Trapping attempts were made for five of the detected Black Rail; two Black Rail responded to call lures at two of five trap sites. Trap effort totaled 94.5 hrs, and resulted in the capture of a single individual. The captured individual was an adult, although it lacked a brood patch; two individuals were active at this trap site. Plumage coloration at the vent was light to medium grey in color, and no molt was evident. Feathers were not plucked for stable isotope analysis.

Fifty-two surveys were conducted from April to October 2010, resulting in 65 Black Rail detections. Of the 65 auditory detections, an estimated 17 rails had been detected at prior points or days in the same location, and were considered as repeated observations. In addition, one individual was detected outside of the survey period, and two individuals were present at trap sites. Therefore, I considered 51 detections to be independent observations and used this number in subsequent analyses. The majority of individuals were detected in May (23 of 65) and June (19 of 65), with fewer in July (9) and April (5). The fewest detections occurred in August and September, with three each month. Black Rail were first detected on 15 April (the first day of sampling), and last detected on 19 September. The majority (47 of 65) of individuals were detected in the morning, with 43 (66 %) detections occurring before 0900. Water was present at 24 of the survey points, with a mean depth of 4.2 cm and standard deviation of 5.6 cm. Black Rail were detected at only two of these survey points, and mean water depth equaled 2.0 cm with a standard deviation of 1.0 cm.

Trapping attempts were made at 13 of the 51 of the detection locations; two Black Rail responded to lure calls at five of the 13 trap sites. A total of 440 hrs of trap effort were logged, and two individual Black Rail were captured. The first was caught on 10 May, and a second individual was simultaneously present at the location. The captured bird had a mass of 33.5 g, lacked a brood patch, and ventral coloration was light gray. Feathers were plucked from the breast and right rectrices. The second individual was caught on 26 May; it also lacked a brood patch, and feathers from the breast and right rectrices were plucked. The individual's mass was 32.3 g, and its ventral coloration was a medium gray.

Information concerning land management in 2009 and 2010 were obtained from Quivira NWR and private landowners and used to determine type and number of habitat treatments. Over the two field seasons, Black Rail were detected across twelve treatment types (Table 1). ArcGIS was used to determine how many rail were detected in each treatment type, as well as where individuals were located within that treatment.

II. Stable Isotope Analysis

Two Black Rail were captured and sampled in 2010, and rectrices and body coverts were plucked for deuterium stable isotope analysis. Four samples of each feather type were used for analysis, with half from each individual (i.e., two coverts and two rectrices from the first individual, and two of each type from the second).

Rectrix stable isotope values equaled -76.8 and -92.1 per mil for the first individual, and -79.5 and -77.1 for the second bird (mean = -81.6 per mil, SD = 7.1 per mil for all four retrices). Body covert values were -86.2 and -77.8 per mil, and -81.5 and -76.1 per mil, respectively for the two individuals (mean = -81.5 per mil, SD = 3.5 per mil).

III. Habitat Analyses

Habitat data from 2009 (Figure 4) and 2010 (Figure 5) were combined by treatment type; in all, thirteen different treatments were surveyed (Table 1). In 2009, nine transects were used for habitat analysis. Transects did not cross between treatment types, and a new trajectory was not selected if the transect passed into unsuitable habitat. In 2010, 37 transects were completed. Of these, one was placed in an area where no rails were detected, and 18 crossed between two or more treatments. Data from these 18 transects were proportionately split according to each treatment type. One transect was placed so it passed through two points where individuals were detected because these individuals were within 40 m of each other, and it was assumed the two were utilizing the same habitat. As a result of the transects crossing between treatment types, sample size varied between treatments (Table 2).

The Kruskal-Wallis tests indicated treatment had a significant effect on all measured categories (plant height, water depth, and percent cover of water, open space, living and dead vegetation, Table 3). However, results from the non-parametric post-hoc Tukey's tests for each category showed no significant difference between the treatment types, and thus overall results for these analyses were ambiguous.

Backward stepwise (Wald) logistic regressions were used to test which of the habitat categories (living or dead vegetation, water cover and depth, plant height, and total vegetative cover) influenced Black Rail occupancy of potential habitat. Three transects were removed from the analysis, as the birds at those points were present along edges of treatments in which no individuals had been detected, and it was not possible to determine which treatment area the individuals were using. Sample size of vegetation transect points in areas with no Black Rail was drastically smaller ($n = 62$) than the sample size of areas with Black Rail ($n = 608$); this was a result of biased sampling earlier in the field season as previously discussed. Therefore, a subset of the values for Black Rail presence were randomly selected and used in the analyses.

The results of the Backward Stepwise (Wald) logistic regression with separate living and dead vegetation categories were significant (Tables 3), and indicated higher percentages of dead vegetation structure at middle (10 cm, $B = 2.19$) and top (20 cm, $B = 4.08$) layers positively influenced Black Rail presence, while higher percents of living vegetation structure at the bottom (0 cm, $B = 6.67$) layer negatively affected Black Rail presence. Water at the bottom layer has neither a positive nor negative influence on rail presence. The Nagelkerke R Square value was 0.57 ($p < 0.001$). The test correctly predicted Black Rail presence 74.2 percent of the time, and absence 87.1 percent of the time. It incorrectly predicted presence 25.8 percent of the time, and absence 12.9 percent of the time. (The Omnibus Test of Model

Coefficient values equaled: Step Chi-square = 8.26, $p < 0.004$; Block Chi-square = 69.40, $p < 0.001$; Model Chi-square = 69.40, $p < 0.001$.) The regression was iterated five times, as the sample size for Black Rail presence was much larger than samples from areas where no rails were detected. All five iterations reported similar results, and two indicated plant height (tallest plant in a plot) might positively influence rail presence (Table 4 and 5).

A second set of logistic regressions was run to test the influence of total vegetative structure on Black Rail presence. The results were significant, and consistent with those from the first logistic regression set, and indicated total cover at higher levels (10 and 20 cm) positively influenced Black Rail presence. Water cover and depth had no significant effect on bird presence, and plant height had a potential positive influence. The test correctly predicted Black Rail presence 66.1 percent of the time, and absence 72.6 percent of the time; it incorrectly predicted presence 33.9 percent of the time, and absence 27.4 percent of the time. (The Omnibus Test of Model Coefficient Values were: Step Chi-square = 9.15, $p < 0.002$; Block Chi-square = 44.08, $p < 0.001$; Model Chi-square = 44.08, $p < 0.001$. The Nagelkerke R Square value equaled 0.4.) Five analyses were run to accommodate for the large discrepancy in sample sizes between areas with rail presence and absence (Tables 6 and 7). One test indicated none of the habitat characteristics influenced Black Rail presence, and two tests indicated plant height had a small, positive influence on presence.

Spike-rush (*Eleocharis*) species were the most dominant species on the study sites (present at 79% of the sample plots), followed by prairie bulrush (*Schoenoplectus maritimus*, present at 76% of the sample plots). Other species sampled included: several milkweeds (*Ascelpias* spp.), false indigo (*Amorpha fructicosa*), cattail (*Typha longifolia* and *T. angustifolia*), soft-stem bulrush (*Schoenoplectus tabernaemontani*), inland saltgrass (*Distichlis spicata*) and a variety of other rushes and grasses. Prairie bulrush was most often the tallest plant, with a mean height of 97 ± 50 cm. Water was present at 46 of the 559 habitat points; mean depth at these points was 8.95 ± 14.1 cm.

DISCUSSION

I. Chronology and Breeding Habitat

Black Rail were most often detected in May and June, within two hours of sunrise. Vocalizing individuals were first detected on the earliest survey date (15 April), but rails were likely on the refuge prior to this. After this date, detections were rare until May. Individuals detected in April were probably passing through the area on migration, or setting up territories, as the dates and locations of detections varied. Eddleman et al. (1994) reported Black Rail spring migration occurs from late March to early May, with a breeding season extending from March to July, although it varies across their range. Increased detections in the late spring and early summer likely coincide with a peak in breeding activity. In Kansas, historical records suggest most clutches are laid by at mid- to late- June (Johnston 1964), which matches with the mean reported date of 20 June ± 16 d for Eastern Black Rail throughout their breeding range (Eddleman et al. 1994). Individuals that have successfully nested might not vocalize as much (Eddleman et al. 1994), which might in part explain the decrease in detections during July. Black Rail might renest during the breeding season (Eddleman et al. 1994), so the few individuals detected in July could be defending territories or mates. This interpretation is supported by Busby and Zimmerman (2001), who report that Black Rail in Kansas are likely breeding into at least early July. Some Black Rail were still vocalizing in August and September, although the number of detections during these months was much lower than earlier in the breeding season. In 2010, a bird was detected in the same patch of cattail in July through September. Although a month passed between each of the surveys in this area, this detection could represent a younger or less dominant male that set up a territory in a lower quality habitat. No Black Rail were detected at this location in 2009.

The majority of Black Rail were detected in wet sedge meadows dominated by spike-rush species. A few individuals were detected in patches of cattail or soft-stem bulrush. Two individuals were detected on one day in late May 2010, in a riparian area that primarily contained grasses and shrubs. Over the course of the two field seasons, water was present at 40 of the 418 surveys points. Black Rail were only detected at three survey points at the same time water was present. If no water was present, soil moisture level (moist or not) was recorded for 31 of the 418 points. Twenty-seven of the points had moist soil, and Black Rail were at 22 of these points. This phenomenon is support by findings by Repking and Ohmart (1977), who noted that Black Rail were typically found in areas of moist soil or very shallow water.

The number of Black Rail detected in each treatment type varied, which is due in part to a bias in sampling effort. The original goal of surveying was to detect and capture Black Rail. The Richardson Tract, a wet-meadow dominated by spike-rushes is known for reliable presence of Black Rail on the refuge (Figure 3). Thus, it was surveyed more regularly than other areas. The increased number of detections in this area is due in part to more survey attempts; however Black Rail could also be differentially selecting this habitat, thus increasing detections.

II. Trapping

Three adult Black Rail were captured over the course of two field seasons. None of the captured individuals had evidence of brood patches, or recent molt. Feathers from individuals caught in May showed little feather wear. One rail was captured in July 2009, and two rail were captured in May 2010. One of the captures was in late May 2010, and one individual was present at the trap location. It was probably a male, given the vocalization type (*kikidoo* and faint *rattles*) during the trap session.

Two Black Rail responded to lure calls at the other trap locations (one in July 2009, one in May 2010). The rails at the July trapping were likely a mated pair. One rail was vocal, often responding with a *kikidoo* or *growl* call to the lure calls; the other individual rarely vocalized, using the *churt* or *rattle* call. The age of this individual was unknown, but observed plumage was similar to the vocal rail. These two individuals likely had an active nest in the vicinity. The individual captured was probably the male, as it was emitting the *kikidoo* call just prior to entering the trap.

The two individuals at the May trap site both vocalized, using the territorial *kikidoo* call, or *growls*. When the trapping initially started, one rail was at the west end of the trap site, and the other was about 40 m east of the other rail. Both birds actively responded to lure calls, eventually coming within one meter or less of the speaker.

Water presence and depth varied at the 15 trap sites, ranging between moist soil (no pooled water) to water present with a depth of 15 cm. The July capture site had no water present, but the soil was moist; water at the May capture sites had either puddles of water varying between zero to twelve cm deep (10 May), or small puddles less than two cm in depth (26 May). Sites with deeper water were usually in patches of cattail or soft-stem bulrush, with enough accumulated dead vegetation in the water to allow Black Rail to walk through the water. Sites with more shallow water were usually in spike-rush meadows.

III. Stable Isotope Analysis

Isotope analysis of the feathers collected from the Black Rail in 2010 produced some unexpected results. Rectrix deuterium mean values equaled -84.46 and -78.77 per mil for the two individuals; the deuterium precipitation gradient proposed by Bowen (2009) indicates values in August for Kansas, a proposed pre-basic molt month for Black Rail, is approximately -48.00 to -55.00 per mil. Hobson et al. (2007) reported feathers can be depleted as much as 25 per mil compared to precipitation deuterium values, and that factors such as surface and subsurface water deuterium values, or free exchange of atmospheric hydrogen with inactive hydrogen in the feathers (Bowen et al. 2005), might enrich or deplete isotopic values of feathers. After considering these factors, the isotopic values seen in the rectrices indicate the feathers could have been grown in Kansas.

It was hypothesized was that Black Rail breeding in Kansas in summer spend their winter and have a pre-alternate molt on the Gulf Coast (Eddleman et al. 1994). Deuterium values in precipitation along the Gulf Coast are more enriched than inland values (Bowen 2009; Wassenaar and Hobson 2000), with values of -8.00 to -23.00 per mil in March, when Black Rail pre-alternate molt is hypothesized to begin. δD values of body coverts (means of -82.01 and -79.22 per mil) were more depleted than expected. If one factors in a possible 25 per mil depletion, feather δD values indicated a feather growth origin in the Midwest or northeastern coast of the United States based on the deuterium precipitation map produced by Bowen (2009; Figure 6).

These data support three possible explanations: 1) Kansas Black Rail are wintering on the eastern coast of the United States, around New Jersey, Delaware, or Maryland.

Current knowledge of Black Rail wintering range does not include this region, although some birds have been recorded in this area during Christmas Bird Counts (Root 1988). Most Black Rail detection records in these states are from the breeding season. 2) Black Rail occurring in Kansas during the breeding season are wintering in Kansas, or other sections of the interior United States. Records for Black Rail in Kansas are found from mid-March to mid-September, with no winter records (Johnston 1964). Birds in the non-breeding season rarely vocalize or respond to broadcast calls (Spear et al. 1999), so it is unlikely chance that individuals are wintering in Kansas. Year-round records for Black Rail are from regions that receive little or no snow, and have mean low winter temperatures above freezing. Black Rail primarily feed on small seeds and invertebrates (Eddleman et al. 1994), and winter conditions in Kansas (i.e., freezing temperatures, frozen ground, and snow) would prevent individuals from successfully acquiring sufficient resources. Records for other Midwest states include some migration and rare breeding occurrences. There are also breeding and migration records for Oklahoma (Beck and Patten 2007). However, no winter records exist for either of these regions. As there are very few winter records for Black Rail in areas that fit with the observed deuterium values of the breast feathers, this finding supports the paradigm that most Eastern Black Rail do not winter on their breeding grounds, but more likely winter further south along the Gulf Coast of the United States or Mexico, or in the Caribbean. 3) Black Rail are molt migrants. Kansas-occurring Black Rail might most likely are wintering in southern portions of their range, and molting their body coverts while en route and/or upon arrival at their breeding grounds.

IV. Habitat Structure

The Backwards Stepwise (Wald) logistic regressions indicated that vertical structure of vegetation had an effect on Black Rail presence in a habitat. Two sets of regressions, those separating living and dead vegetation categories and those combing the categories, compared cover classes and their influences on Black Rail presence in a treatment. When the two vegetation categories were run separately, all five logistic regressions indicated dead vegetation in higher layers (10 cm or more above ground level) positively influences if rail will be found in a habitat. These analyses support observations in the field; no Black Rail were detected in areas with no dead vegetation at higher layers, such as locations hayed on a semi-annual or annual basis. The analyses did not explain why individuals were detected in areas with a higher percentage cover of living vegetation and little dead vegetation at upper vertical layers (10 cm or above). The second set of analyses, testing total vegetative cover, indicated total vegetative cover in higher layer positively influences Black Rail presence. This explains the detections in areas with less dead vegetation in upper vertical layers. Flores and Eddleman (1995) reported similar findings for California Black Rail, whose presence in a habitat is correlated with increased overhead canopy cover, decreased water depth, and decreased distance to upland vegetation edges.

The first set of regressions also indicated presence of Black Rail in breeding habitat is negatively influenced with higher percentages of living vegetation near the ground. More vegetative structure at this lower level likely inhibits a rail's ability to move through the environment. Dense vegetation in the canopy provides various forms of protection, while sparse cover at lower levels allows the bird to easily maneuver through the vegetation. These data contrast findings by Spautz et al. (2005), who reported that California Black Rail in the San Francisco Bay area might prefer areas with higher vegetation density below the ten centimeter level.

Water cover, and its depth, had neither a positive nor negative influence on Black Rail presence. Soil was moist in plots that lacked water, indicating these rails might not require open water, but apparently choose areas near it. This finding supports findings by Repking and Ohmart (1977), who reported areas with very shallow water or moist soil were preferred by Black Rail, as well as Flores and Eddleman (1995), who reported that rail prefer areas with three or fewer centimeters of water. Repking and Ohmart (1977) also reported Black Rail tended to avoid recently flooded areas with deeper water or areas where water levels greatly fluctuated within a 24-hr period. Three of the Black Rail detected at Quivira NWR were located in patches of soft-stem bulrush or cattail in which total water depth was greater than 10 cm, but effective depth for a 30 g bird was up to three centimeters. Therefore, although water depth might appear to be deeper, to a bird that is light enough to walk on submerged vegetation, the water might effectively not be too deep.

V. Management Effects

The type of vegetation management technique has an effect on habitat characteristics, particularly vegetation structure. Statistical results indicated that treatment regime did have an effect on habitat characteristics, like vertical structure and plant height. A logistic regression indicated higher densities of vegetation, living and/or dead, at higher vertical levels had a positive influence on Black Rail presence, although higher percentages of dead vegetation might have a stronger influence. Higher densities of living vegetation at lower vertical layers have a negative influence on Black Rail presence.

Differences in cover of living and dead vegetation could be visually detected between treatment regimes. Treatments that allowed for growth and death of vegetation over consecutive years lead to greater dead vegetation cover at higher levels. This was particularly observed in spike-rush meadows; these species have little internal support, and tend to fall over. This provides some living cover and a net for dead vegetation to be caught on before reaching the ground. Areas burned every one to two years allowed for this build-up, and 29 Black Rail were detected in areas with this management regime. These data support Eddleman et al. (1988) who stated Black Rail select habitat with thick cover during migration.

Although five Black Rail were detected in a potion of the refuge with no known historical management regime, none of the individuals were detected in the spike-rush meadows. Spike-rush meadows disturbed at less frequent intervals, such as not being burned for at least four years, typically have greater percentages of living and dead vegetation cover at all vertical layers of vegetation. Increased structure at lower levels of vegetation probably decreases a bird's ability to move through their habitat, thus decreasing the likelihood of the bird occupying that area. Five Black Rail were detected either within a large patch of soft-stem bulrush, or within an area of grasses and shrubs next to a spike-rush meadow. Birds occupying areas such as this, or patches of cattail, are uncommon but not unusual if more suitable habitat is unavailable (Flores and Eddleman 1995).

Observations made in the field suggest that more frequent disturbances, or disturbances that greatly alter vegetation vertical structure, negatively influence Black Rail presence. Habitat with semi-annual or annual haying did not have any Black Rail detections. Frequently hayed areas lack habitat characteristics that appear be preferred by Black Rail, such as taller plants and dead vegetation present within multiple vertical layers. Areas hayed within one year of sampling had very short vegetation, ranging from less than 20 cm to one m, dependent on the time of year it was hayed. Overall, vegetation height was typically shorter in drier areas, or in areas surveyed within one or two months of the haying treatment. Taller vegetation heights were observed later in the growing season (July and August). In two of the hayed treatments, all vegetation was baled, and no Black Rail were detected in those areas. A third treatment area had been burned, and then had about half of it cut within the same year. In this field vegetation was not baled, and left in windrows. Rails were detected on the edge of the hayed portion, but not within it. Two individuals occupied an area with taller spike-rushes, prairie bulrush, and cattail located between a roadside ditch and the hayed land. Although the rails could be flushed into the hayed area, they would immediately return to taller vegetation, suggesting habitat preference. These individuals were detected at this location for nearly four weeks, and were never observed in the hayed area.

Two other Black Rail were detected near the edge of the hayed and unhayed portions. One individual was not observed entering the hayed potion, but the other occupied a taller patch of spike-rushes and prairie bulrush near a windrow on the border of the unhayed and hayed portions. These observations suggest that although rails might not occupy the interior of a recently hayed area, edges appear acceptable, and the individuals might utilize the hayed portion during some part of their annual cycle.

Two of the five logistic regression models suggested plant height might positively influence Black Rail presence. Mean plant height across all vegetation sample points was 95 cm, and few individuals were detected in treatments in which plant height was less than 50 cm. No rails were in treatments where mean plant height was less than 20 cm. Field observations, plus statistical analyses, imply that preferred rail habitat contains taller plants, regardless of species. These data contradict the results of Spautz et al. (2005), who found habitats with taller plants in the San Francisco Bay area were negatively associated with California Black Rail presence.

VI. The Disturbance Continuum

The habitat management regimes (prescribed burning, haying, and grazing) used by Quivira NWR and surrounding private landowners, impact habitat in a variety of ways. Timing and type of disturbance affects vegetation habitat structure, and thus affects the likelihood of whether a Black Rail will be present or absent in an area. The relationship of the management regime and level of disturbance can be depicted along a "Disturbance Continuum" (Figure 7), and used to estimate the type of managed area a Black Rail is likely to use.

The Disturbance Continuum is a model depicting multiple disturbance factors and their relative disturbance impact. The bottom "axis" depicts management practices, with little to no management on one end, and frequent and multiple simultaneous practices at the other. The top "axis" depicts the degree of intensity for a particular management practice. A light disturbance management regime would consist of no management, or one type of management on an infrequent basis (i.e., burning every other year or even less frequently). A moderate management disturbance would consist of burning every other year plus annual grazing. A heavy disturbance regime would constitute burning, haying, and grazing within one concurrent year.

Black Rail were most often detected in areas with light to moderate disturbance levels. The most detections occurred in areas burned earlier in the year, areas one year post-burn with or without grazing, or areas two years post-burn with grazing. These observations can be applied to the Disturbance Continuum, and used to prioritize future management decisions. Land managers can consider current or proposed management practices, and utilize the Continuum to see what effects the practice could have on local Black Rail populations. Conversely, managers desiring to maintain or enhance potential Black Rail habitat can use the same information to aide management decisions that affect vegetative structure.

The time of year when a management technique is applied also matters. The breeding season of Black Rail ranges from April to July (Eddleman et al. 1994); burning or haying during this period disrupts nesting attempts (Eddleman et al. 1988). Burning later during the calendar year (i.e., September) will allow time for adults to complete nesting and synchronous pre-basic molt, and young to develop to age of independence. In addition, fall or winter burns allow for vegetative regeneration by the next breeding season (Gabrey et al, 2001). Haying Black Rail habitat negatively influences Black Rail presence; as with prescribed burning, mowing after Black Rail are finished molting would be less detrimental. Although

Eddleman et al. (1988) report grazing has a negative effect on Black Rail, particularly during nesting, results from this study indicate that rotational grazing during the breeding season and while individuals are molting may not negatively affect Black Rail. Since Black and Virginia Rail occupy similar habitats at Quivira NWR, excessive winter grazing will likely negatively impact habitat quality, as grazing might decrease vegetative characteristics necessary for successful reproduction (Zimmerman et al. 2002).

Ideal Black Rail habitat at Quivira National Wildlife Refuge, based on detects and subsequent habitat sampling, appears to include both vegetative and water characteristics. Individuals will most often occupy wet meadows dominated by spike-rush species with denser vegetation in the upper canopy layers (11 cm and above). Black Rail might also occupy stands of cattail or soft-stem bulrush, although wet sedge-meadows likely represent preferred habitat. Although the presence of water might not be required, moist soil is necessary for Black Rail to occupy an area.

VII. Conclusions

Many coastal populations of Eastern Black Rail have declined by 75 percent or more in the last 20 years (The Center for Conservation Biology 2009), but little information is available for inland populations. Populations in Kansas appear stable, with consistent records of calling adults at Quivira National Wildlife Refuge, and new records have been reported for other locations in the state (Gann pers. comm.; Janzen et al. pers. comm.). However, Eddleman et al. (1994) reported that Midwestern populations are declining. Little information is available on nesting ecology or reproductive success in inland populations, but results from this study add to a pool of knowledge that federal, state, and other conservation agencies can utilize when making management decisions about Eastern Black Rail.

Kansas-occurring Eastern Black Rail most often occur in areas dominated by spike-rushes with shallow to no water. Dense canopy cover, with more open space in lower layers, appears to be the best indicator of Black Rail habitat. When managing for this species in Kansas, vegetation management technique and timing matter, as these affect vegetative structure. The Disturbance Continuum model could be a particularly useful tool for understanding the relationship between management regime and Black Rail breeding habitat use.

Little is known about the migration patterns of Eastern Black Rail. Populations occurring both along sections of the northeastern coast and in interior portions of their range in the U.S. are thought to winter farther south. Winter records for this species exist along the Gulf Coast, the Caribbean, and into Central America, although where these particular birds spend the summer and breeding season is unknown. In an effort to find where Kansas-occurring Black Rail overwinter, a deuterium stable isotope analysis was performed. Isotopic values indicated body coverts were likely grown while the individuals were at an interior location of the U.S. Although this information does not help with locating the birds' winter ranges, it reveals birds were likely in transit or already on their breeding grounds when they molted their alternate body feathers.

More information on both migration strategies and breeding habitat requirements of Eastern Black Rail is needed. Concerted conservation efforts for this species will benefit if information about where individuals are spending both the summer and winter becomes available. Knowledge of habitat preferences of inland populations of Eastern Black Rail is also necessary so that survey efforts in other portions of the interior range can target potential habitat. Additionally, understanding how vegetation management practices affect Black Rail habitat, and thus reproductive productively, will aid with population management and conservation efforts throughout their range.

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Table 1. Treatment types with corresponding management regime, number of surveys, and number of birds detected at Quivira NWR and bordering private lands in 2009 and 2010. The number of surveys (n = 585) in each treatment type was calculated by taking the number of sample points in each treatment area, and multiplying that by the number of surveys. Points on borders between treatments were used in calculations for each treatment. The majority of points in the "one-year post-burn" ($T_{Burn} = 1$), and 52 of the points from "year of burn" ($T_{Burn} = 0$) were in a section of Quivira NWR previously known for Black Rail presence. The apparent high density of individuals in "Annual Grazing" is due to the small area of the patches (0.21 and 0.12 hectares) where the individuals were detected.

Treatment Number	Treatment Type	Number of Surveys	Number of Rail Detected per Survey
1	No Management within 6 years	47	0.11
2	Annual Grazing	17	0.12
3	Annual Haying	11	0
4	$T_{Burn} = 0$	160	0.05
5	$T_{Burn} = 1$	116	0.24
6	$T_{Burn} = 2$	15	0.07
7	$T_{Burn} = 4$ or more	23	0.04
8	$T_{Burn} = 0$, Annual Grazing	6	0.7
9	$T_{Burn} = 1$, Annual Grazing	28	0.12
10	$T_{Burn} = 2$, Annual Grazing	74	0.14
11	$T_{Burn}=0$, Annual Haying	14	0
12	$T_{Burn} = 0$, Annual Haying	49	0
13	$T_{Burn} = 1$, $T_{Hay} = 1$, Annual Grazing	25	0

Table 2. Number of habitat survey points in each treatment type for 2009 and 2010 at Quivira NWR and bordering private lands. The habitat survey points (n = 718) were split among 12 of the 13 treatment types. "$T_{Burn\ or\ Hay}$ = X" indicates time in years since disturbance.

Treatment Number	Treatment Type	Number of Habitat Survey Points
1	No Management within 6 years	95
2	Annual Grazing	32
3	Annual Haying	0
4	$T_{Burn} = 0$	59
5	$T_{Burn} = 1$	300
6	$T_{Burn} = 2$	16
7	$T_{Burn} = 4$ or more	16
8	$T_{Burn} = 0$, Annual Grazing	16
9	$T_{Burn} = 1$, Annual Grazing	32
10	$T_{Burn} = 2$, Annual Grazing	90
11	$T_{Burn}=0$, Annual Haying	28
12	$T_{Burn} = 0$, Annual Haying	21
13	$T_{Burn} = 1$, $T_{Hay} = 1$, Annual Grazing	13

Table 3. Effect of treatment type on vertical structure of Black Rail breeding habitat at Quivira NWR and bordering private lands, 2009 and 2010. The values for living, dead, open, and water cover are reported as proportions. $P < 0.005$, $df = 11$ for all categories. Sample size for cover classes and water equaled 719; sample size for plant height equaled 713, because four plots were covered entirely by water.

Category	Living 0 cm	Living 10 cm	Living 20 cm	Dead 0 cm	Dead 10 cm	Open 0 cm	Open 10 cm	Open 20 cm	Water Cover	Water Depth	Plant Height
Mean	0.41	0.45	0.64	0.75	0.55	0.54	0.71	0.71	0.13	0.001	2.85
Standard Deviation	0.14	0.19	0.33	0.40	0.33	0.38	0.31	0.35	0.45	0.02	1.63
Chi-Squared	151.66	73.99	47.38	75.78	118.72	113.45	36.04	67.19	61.01	62.95	61.03

Table 4. Logistic regression model values for the influence of living and dead vegetation structure, water cover and depth, and plant height on Black Rail presence at Quivira NWR and bordering private lands in 2009 and 2010. Regression models 1, 2, and 5 produced the most similar results (df =1 for all categories).

Logistic Regression	Step Number	Category	B-value	Wald-value	Significance	Exp(B)
1	7	Dead 10 cm	3.12	10.20	0.001	0.04
		Dead 20 cm	4.4	8.96	0.003	0.01
		Open 0 cm	-2.6	10.93	0.001	13.65
		Open 10 cm	-1.97	4.68	0.031	7.18
		Open 20 cm	1.67	3.82	0.051	0.19
		Living 0 cm	-5.82	6.89	0.009	336.94
2	8	Dead 10 cm	12.91	4.07	0.002	0.001
		Dead 20 cm	10.41	3.86	0.007	0.001
		Open 10 cm	-5.25	2.34	0.025	190.51
		Living 0 cm	-15.54	5.5	0.005	5629919.0
		Living 10 cm	-8.43	3.50	0.016	4571.68
3	9	Dead 10 cm	3.18	10.32	0.001	0.04
		Dead 20 cm	4.94	8.60	0.003	0.01
		Open 0 cm	-1.47	2.96	0.085	4.33
		Living 0 cm	-8.12	11.85	0.001	3367.56
		Water Cover	37.31	0.01	0.998	0.001
		Plant Height	0.63	7.5	0.006	1.06
4	8	Dead 10 cm	2.27	1.09	0.012	0.07
		Dead 20 cm	4.24	1.7	0.012	0.01
		Open 0 cm	-1.44	0.79	0.07	4.20
		Living 0 cm	-3.94	1.92	0.040	51.26
		Living 10 cm	-3.20	1.75	0.067	24.55
		Water Cover	27.92	9566.08	0.998	0.001
		Plant Height	0.50	0.22	0.022	0.65

Table 4, continued

Logistic Regression	Step Number	Category	B-value	Wald-value	Significance	Exp(B)
5	10	Dead 10 cm	2.19	0.89	0.013	0.11
		Dead 20 cm	4.08	1.66	0.014	0.02
		Open 0 cm	-1.13	0.80	0.160	3.09
		Living 0 cm	-6.67	2.24	0.003	791.63
		Water Cover	29.84	10467.09	0.998	0.001

Table 5. Logistic regression model Chi-square values for the influence of living and dead vegetation structure, water cover and depth, and plant height on Black Rail presence at Quivira NWR and bordering private lands in 2009 and 2010. Regression models 1, 2, and 5 produced the most similar results; total sample size equaled 124, and presence and absence each contained 62 samples.

Logistic Regression	Step Chi-Square	Block Chi-Square	Model Chi-Square	Nagelkerke R Square	Correct Presence	Correct Absence	Incorrect Presence	Incorrect Absence
1	-1.56	66.41	66.41	0.55	50	51	12	11
2	-2.34	85.24	85.24	0.89	59	28	3	1
3	11.63	77.40	77.40	0.62	50	51	12	11
4	5.43	66.50	66.50	0.55	48	50	14	12
5	8.26	69.40	69.40	0.57	46	54	16	8

Table 6. Logistic regression model values for the influence of total vegetation structure, water cover and depth, and plant height on Black Rail presence at Quivira National Wildlife Refuge and bordering private lands in 2009 and 2010. Regression models 1, 2, and 4 gave the most similar results (df = 1 for all categories).

Logistic Regression	Step Number	Category	B-value	Wald-value	Significance	Exp(B)
1	6	Cover 10 cm	1.43	3.62	0.57	4.18
		Cover 20 cm	1.2	4.6	0.32	3.31
		Water Cover	34.43	0.01	1.0	8.9E+14
2	5	Cover 10 cm	1.77	5.4	0.02	5.86
		Cover 20 cm	1.12	3.6	0.06	3.06
		Water Depth	-6.627	0.01	1.0	0.001
		Plant Height	0.55	7.72	0.01	1.73
3	6	Cover 0 cm	1.46	7.181	0.01	4.3
		Cover 20 cm	1.74	8.276	0.004	5.7
		Water Cover	31.96	0.01	1.0	7.6E+13
		Plant Height	0.625	7.498	0.01	1.058
4	5	Cover 10 cm	2.24	6.96	0.01	9.37
		Cover 20 cm	2.13	11.46	0.001	8.44
		Water Depth	-8.12	0.01	1.0	0.001
		Plant Height	0.6	5.17	0.2	1.81
5	7	Cover 20 cm	0.96	3.53	0.08	2.60
		Water Cover	34.34	2.98	1.0	8.6E+14

Table 7. Logistic regression model Chi-square values for the influence of total vegetation structure, water cover and depth, and plant height on Black Rail presence at Quivira National Wildlife Refuge and bordering private lands in 2009 and 2010. Regression models 1, 2, and 4 gave the most similar results; total sample size equaled 124, and presence and absence each contained 62 samples.

Logistic Regression	Step Chi-Square	Block Chi-Square	Model Chi-Square	Nagelkerke R Square	Correct Presence	Correct Absence	Incorrect Presence	Incorrect Absence
1	16.28	29.05	29.05	0.28	33	49	13	29
2	11.5	27.34	27.34	0.26	38	43	19	24
3	18.22	28.37	28.37	0.27	39	44	18	23
4	9.15	44.08	44.08	0.34	41	45	17	21
5	10.29	14.72	14.72	0.15	35	41	21	27

Figure 1. Range of the Black Rail (*Laterallus jamaicensis*) across North America (from Eddleman et al. 1994). The California subspecies (*L. j. coturniculus*, black areas) has a much smaller range than that proposed for the Eastern subspecies (*L. j. jamaicensis*, other shaded areas). California Black Rail populations are residential, while Eastern Black Rail populations vary.

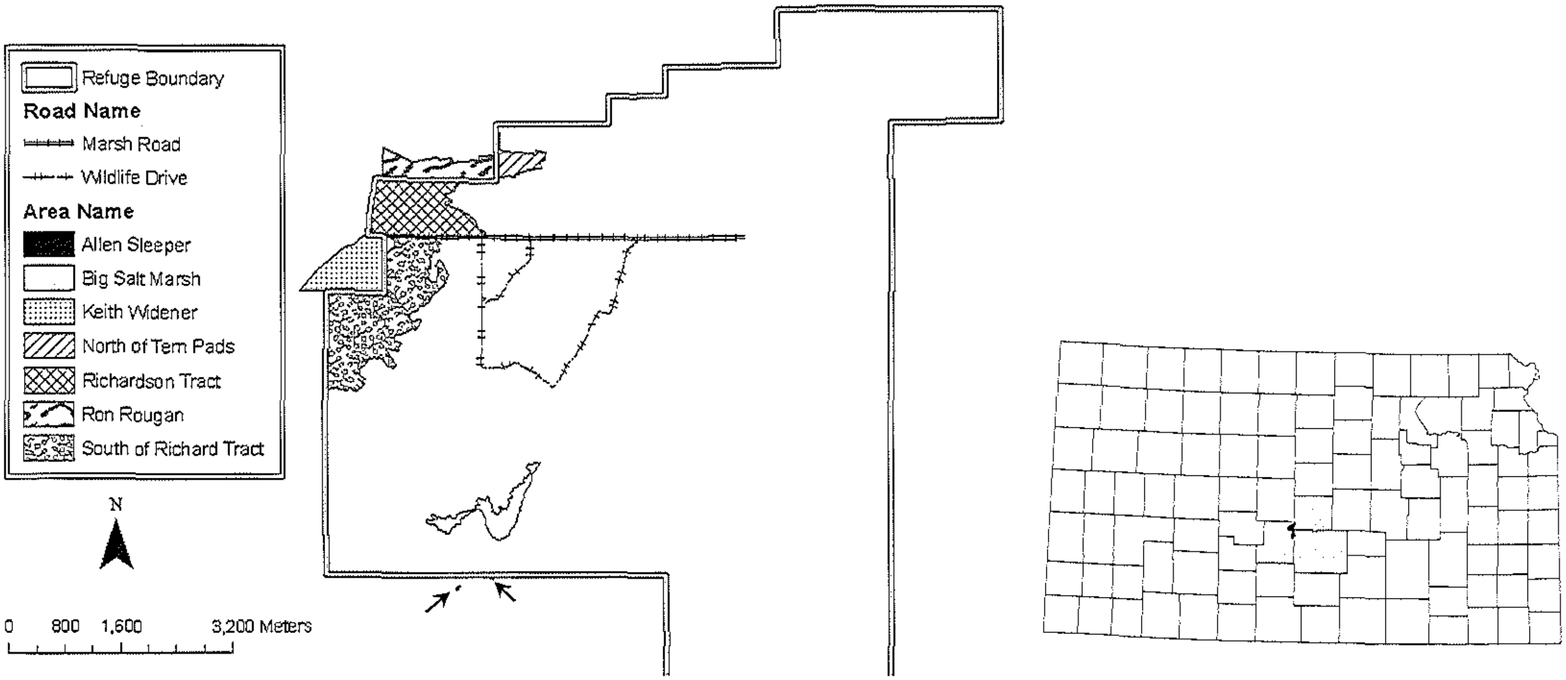

Figure 2. Kansas map denoting Reno, Rice, and Stafford counties, with Quivira NWR outlined in black. Inset map shows areas surveyed on Quivira NWR and bordering private lands both in 2009 and 2010. Surveys were performed from both roadways that passed through marshy areas, and on land with potential Black Rail habitat. Arrows south of the refuge border denote wet depressions on land owned by Allen Sleeper.

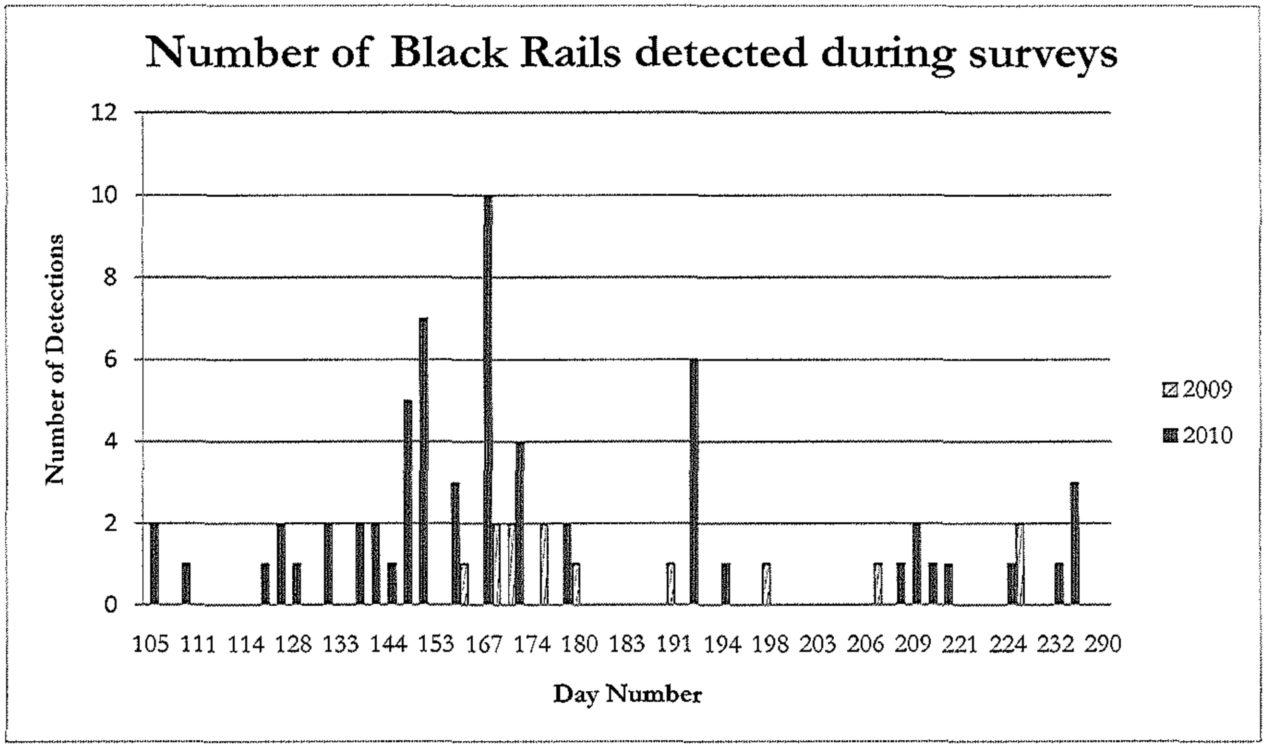

Figure 3. The number of Black Rail detected at Quivira NWR and bordering private lands in 2009 and 2010. An estimated sixty-three Black Rail were detected during the two field seasons.

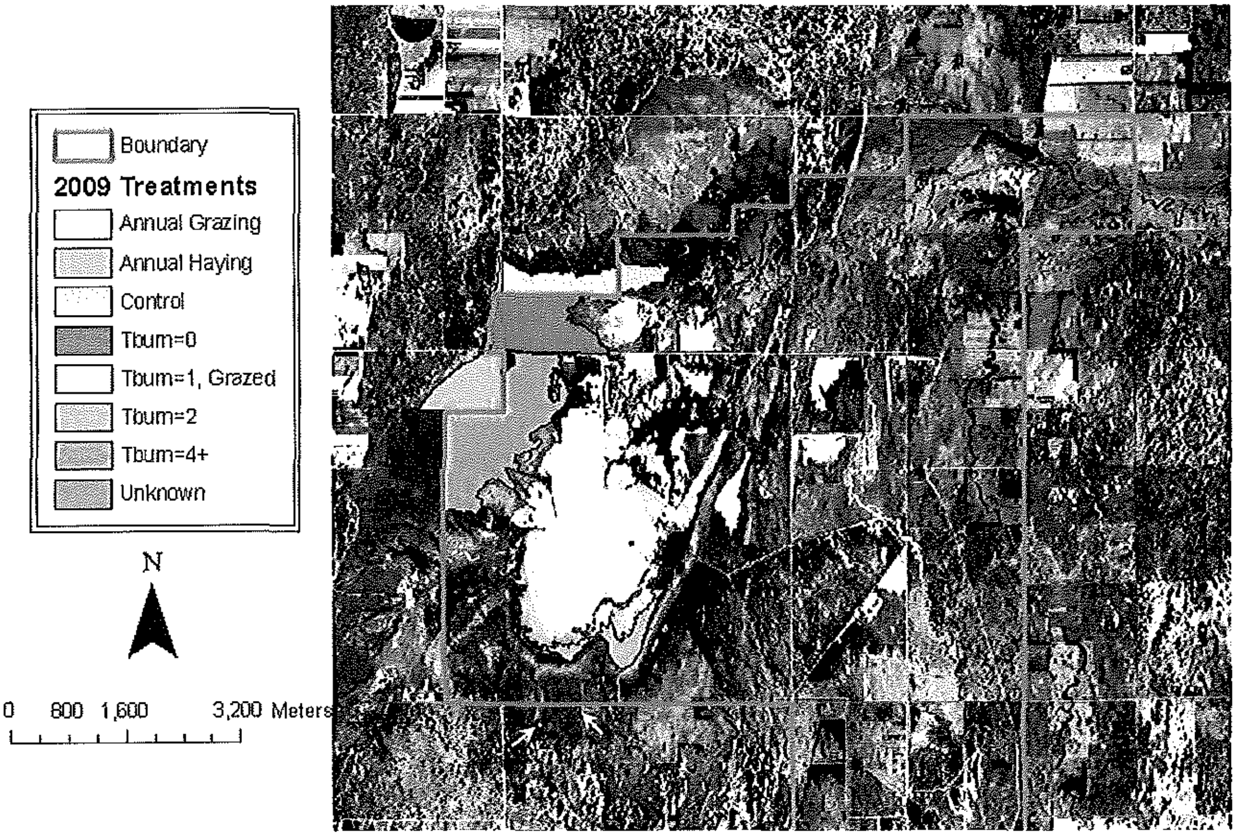

Figure 4. Treatment areas surveyed at Quivira National Wildlife Refuge and bordering private lands in 2009. All seven possible treatment areas were sampled, but only six were used in subsequent analyses; the "unknown" treatment was excluded. The arrows indicated the position of the "Annual Grazing" treatment. . "T_{Burn} = X" indicates time in years since disturbance. (After Kansas Data Access and Support Center 2011).

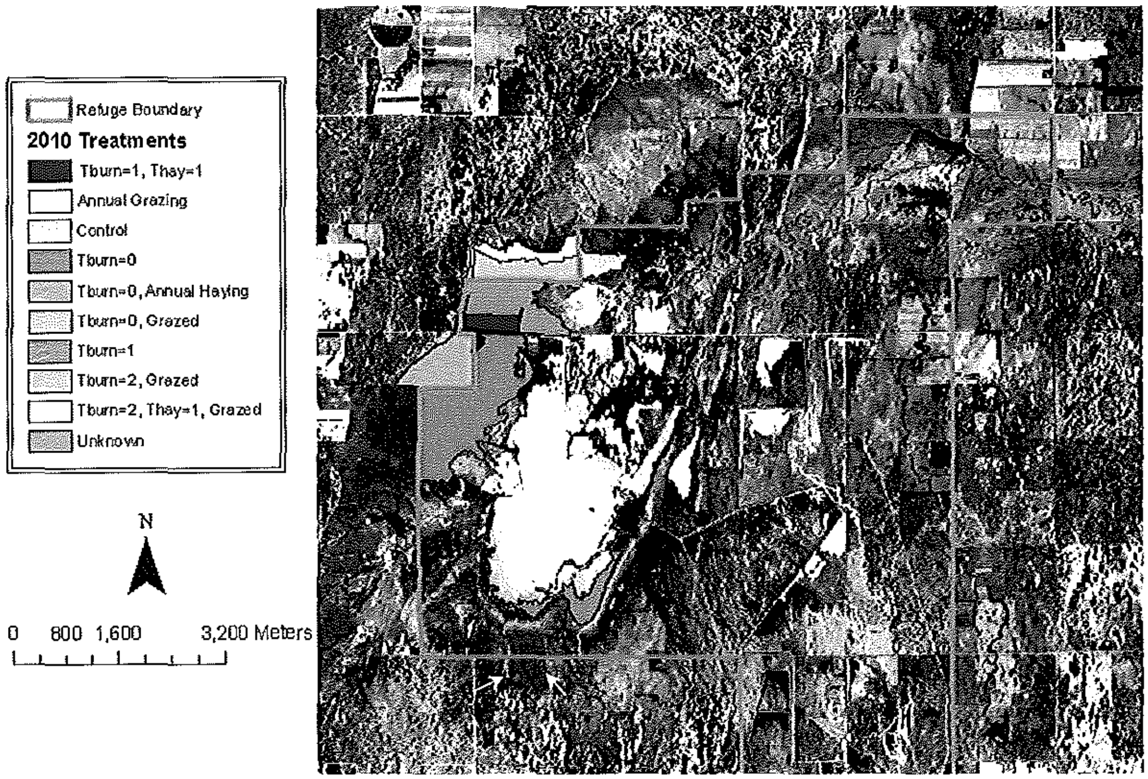

Figure 5. Treatment areas surveyed at Quivira National Wildlife Refuge and bordering private lands in 2010. All ten potential treatment areas were sampled, but only nine were used in subsequent analyses; the "unknown" treatment was excluded. Arrows indicated the position of the "Annual Grazing" treatment. . "$T_{\text{Burn or Hay}}$ = X" indicates time in years since disturbance. (After Kansas Data Access and Support Center 2011).

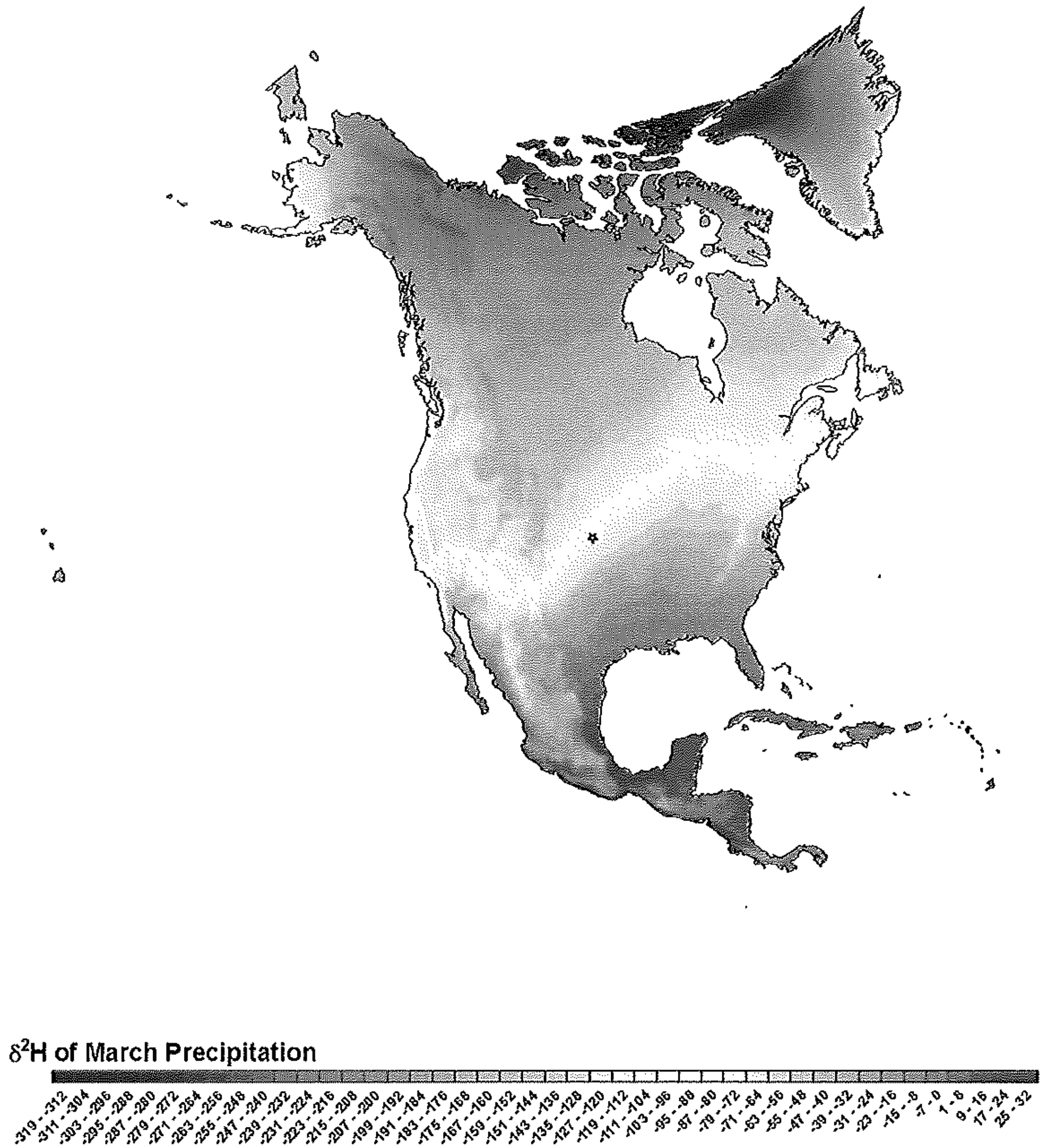

Figure 6. Spatial distribution of deuterium in precipitation for the month of March according to Bowen (2009). Deuterium isotopes fall in a known precipitation gradients across the United States. Regions that fall into the light orange/yellow (-80 to -87 gradient are approximate to the values reflected in the Black Rail body coverts. The star denotes the approximate location of the study site.

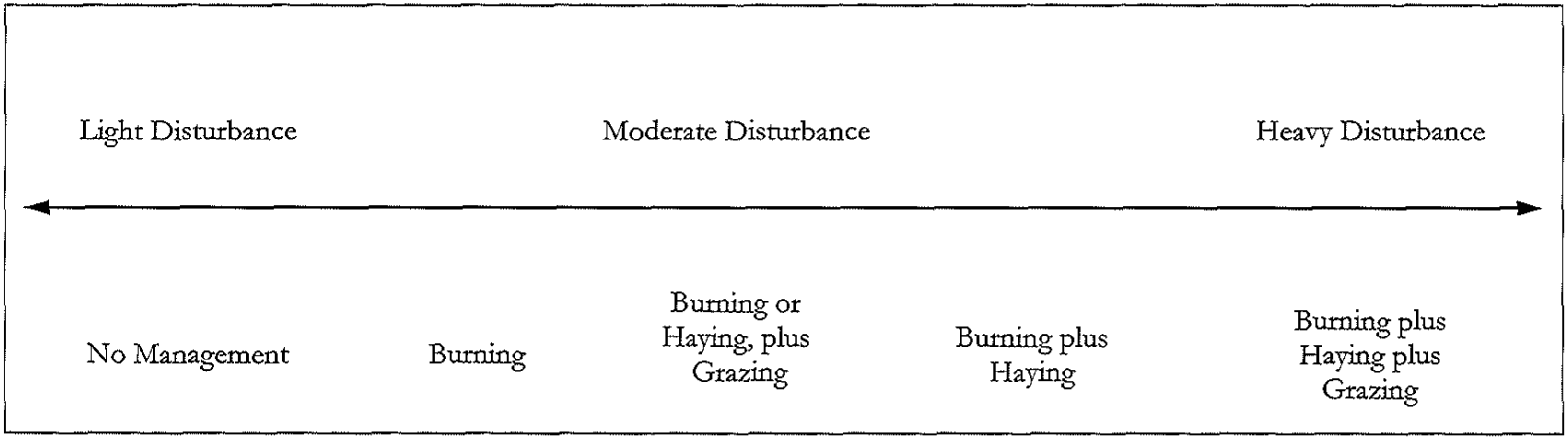

Figure 7. The Disturbance Continuum depicts management practices occurring in a concurrent year. For practices that occur on a less frequent interval, the level of disturbance becomes lighter. Level of disturbance affects Black Rail presence in a habitat; detections were highest in the light to moderate disturbance range.