King Rail Nesting and Brood Rearing Ecology in Managed Wetlands

Final Report

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Section 1 – King Rail Nesting and Brood Rearing Ecology

The King Rail (*Rallus elegans*) is a secretive marsh bird of conservation concern. King Rails have a large range throughout the eastern half of the United States extending from southern Canada to the Gulf Coast. Qualitative accounts indicate that inland migratory populations were once quite common, but have experienced major population declines in the latter half of the 20^{th} century (Cooper 2008). North American Breeding Bird Survey data suggest a significant annual King Rail population decline of 3.44% (97.5% CI: -6.72, 1.43) across its range in the United States from 1990 to 2009, though the Breeding Bird Survey has been shown to be a poor representation of trends for secretive marshbirds (Sauer et al. 2011). Because of this population decline, King Rails are listed as threatened or endangered in 12 states (Cooper 2008).

Wetland loss and alteration are considered the major factors responsible for declines in King Rail and many other wetland-dependent birds (Eddleman et al. 1988). Wetland management approaches, specifically water level management and control of woody encroachment, can also affect habitat use during the breeding season (Naugle et al. 1999, McWilliams 2010). King Rails are more likely to select nest sites in standing water, but little is known about how water drawdowns affect nest survival, brood habitat use, movement, and chick survival (Reid 1989). The 2006 King Rail Workshop participants hypothesized chick survival to be a limiting factor for population growth and highlighted the need for more information regarding brood ecology (Cooper 2008).

We investigated the nest and brood rearing ecology of the King Rail.

Objectives of the study were to:

1) Determine King Rail habitat use and selection during the nesting and brood rearing period,

2) Estimate nest survival rates and document sources of nest and fledgling loss,

3) Document movements and estimate home range size during the breeding season, and

4) Estimate occupancy rates within management units under different treatments.

This information should help wetland managers make better management decisions for King Rails during the breeding season. Estimates of brood survival and habitat use will help to determine if this stage limits population growth and where to target local conservation efforts.

Methods

Study area

The study area included restored wetlands in McCurtain County, Oklahoma in the Red River floodplain. We surveyed for King Rail at two public sites (Red Slough Wildlife Management Area [WMA] and Grassy Slough WMA), a private wetland complex (Walnut Bayou), and four additional unnamed private wetlands adjacent to Red Slough WMA (Fig. 1). The wetland complexes were approximately 1 km apart and had different management approaches and hydrology.

Red Slough WMA had multiple impounded wetland units totaling 2,158 ha in size (Fig. 2). Dominant vegetation included common rush (*Juncus effusus*), short-bristle horned beaksedge (*Rhynchospora corniculata*), ovate false fiddleleaf (*Hydrolea ovata*), cattail (*Typha* spp.), eastern annual saltmarsh aster (*Symphyotrichum subulatum*), black willow (*Salix nigra*), smartweed (*Polygonum* spp.), and arrowhead (*Sagittaria* spp.). A levee that includes a stop-log water control structure surrounded each unit. Management in the units usually included water level manipulation, disking and fire. Most units were disturbed by disking, mowing, and/or burning every 3-years to reduce invasion of woody species. A few units contained deep water from which waters to flood other impoundments was obtained.

Grassy Slough WMA consisted of three impounded wetlands totaling 264 ha. One unit had no standing water and similar vegetation as Red Slough WMA from late April 2011 through early August 2011. The other two units contained shallow water (5-15 cm) with a diverse emergent plant community similar to that at Red Slough WMA. By late June 2011, most units had no standing water aside from a couple channel segments. The two northern most units did not contain water during the study period in 2012. The southern unit contained shallow water (5-20 cm) with a diverse emergent plant community similar to Red Slough WMA. By late June 2012 this unit had little to no standing water except for the borrow ditches.

Walnut Bayou consisted of multiple wetland units owned by different landowners all surrounding a deep oxbow lake. Excavation of a number of shallow pools had created a ridge-swale topography. Water drained into the oxbow lake and most of the marshes were dry by mid-April except for portions of the lake shoreline with a shallow slope. Dominate vegetation within the oxbow lake included giant cutgrass (*Zizaniopsis miliacea*) and American lotus (*Nelumbo lutea*). Common rush, ravenfoot sedge (*Carex crus-corvi*), and spikerush (*Eleocharis* spp.) dominated sites adjacent to the lake that remained flooded through most of the breeding season. The remaining wetlands contained vegetation typical of temporarily flooded sites and were dominated by annual marsh elder (*Iva annua*), cocklebur (*Xanthium strumarium*), and winged loosestrife (*Lythrum alatum*).

Standardized Surveys

In 2011, we broadcasted King Rail calls to elicit a territorial response at all wetland units to locate breeding territories. We surveyed sites opportunistically and we broadcast calls on the levee and inside the wetland. We surveyed all wetland units at least twice and up to 5 times where wetlands appeared to have ideal habitat conditions based on review of the scientific literature. In 2012, we randomly selected survey points at Red Slough WMA (*n* = 50 sites), Grassy Slough WMA (*n* = 4 sites), and Walnut Bayou (*n* = 10 sites) stratified by dominant cover types: tall emergent vegetation (≥1m), short emergent vegetation (< 1m) and shrub-scrub. We conducted four surveys at each point from April 14 through June 29, 2012 following the Standardized North American Marsh Bird Monitoring Protocols (Conway 2011). We considered adult King Rails paired when two birds would vocalize together ("duet") or when two individual birds were detected ≤10 m apart.

Trapping & Telemetry

We attempted to capture King Rails using mist nests, hoop-net traps, toe-snares, and airboat. We set up two mist nets in a "v" in the emergent vegetation and placed a King Rail decoy in the center and played calls. When a bird was close to the net, we would attempt to flush it into the mist net. Toe-snare traps consisted of monofilament tied into a loop with a slipknot and attached to a thin bamboo dowel. We tied a series of 30 toe-snares together with trotline and inserted them into the ground around the decoy. We used an airboat at night in July 2011 and April 2012 to capture birds with a dip-net. Hoop-net traps were modified fish traps hidden in the emergent vegetation at known King Rail territories (Fuertes et al. 2002).

We fitted birds with VHF transmitters using a backpack harness modified for rails (Haramis and Kearns 2000). We allowed each marked bird 3 days to adjust to the harness and transmitter. We used triangulation with a hand-held 3-element Yagi antenna to estimate the daily location of birds. We marked locations with a GPS unit and collected water depth on the same day or within 3 days of locating the bird. We tracked marked individuals throughout the 24-hour period.

Brood Observations

We located broods by locating telemetry marked birds or by listening for territorial and brood-rearing vocalizations (Meanley 1969). Once a brood was located, the observer would watch from a distance (~15 m) and record the number of chicks and make behavioral observations every minute for 15 minutes. Chick behavior included grooming, foraging, hiding/out of view, resting, antagonistic behavior, or other. We marked the point where the brood was first located with a GPS unit. We measured water depth on the same day or within a few days after observations were made, when the brood was no longer at the location. We made these observations before any subsequent rain or managed flooding events.

Habitat Data

We collected habitat data in a 50 m radius circular plots centered on the survey point, telemetry location and brood location point. Water depth was the average of the survey point and the four cardinal directions (5 m away) after every survey, telemetry location or brood. We visually estimated the percent cover of short emergent vegetation (< 1 m), tall emergent vegetation (≥ 1 m), and open water. We used transects running north-south and east-west to count the number of woody stems in every other 5m square plot along the transects. Woody stems included shrubs and trees ≥ 4 cm DBH. We counted shrubs with multiple stems coming from the same rootstock as one. We estimated interspersion using categorical cover types adapted from Stewart and Kantrud (1971).

We collected nest site habitat data within a 12 m radius circular plot centered on the nest or the first sighting of the brood. We also collected habitat data at randomly selected sites in a 200 m radius plot corresponding to King Rail home range size estimated in South Carolina (McGregor et al. 2009). We measured water depth at the nest/brood site and 4 m away in the four cardinal directions. We visually estimated the percent cover of short emergent, tall emergent and open water and counted the total number of woody stems in the plot. We quantified visual obstruction at three height intervals (0-0.3 m, 0.3-1m, and 1-2 m) using a density cover board placed 4 m from the nest in the four cardinal directions. We quantified microtopography by measuring the distance from the ground to a level string at 1 m intervals (Courtwright and Findlay 2011). We made six measurements in each of the four cardinal directions.

Results

Standardized Surveys

We detected no King Rails at Grassy Slough WMA, Walnut Bayou or any of the private wetlands in either 2011 or 2012. We located 17 King Rail territories at Red Slough WMA in early to mid-May 2011 (Fig. 3). Because vocal detections of King Rails declined greatly at these sites after June, we were unsure whether these birds moved from their territories because of a lack of water or if vocalizations ceased because of changes in the breeding status of the birds/pairs. A resurgence of territorial behavior (vocalizations and response to call-broadcasts) occurred in units 27A and 27B on 17 June 2011 in locations where a territory had not been identified previously.

In 2012, we detected King Rails at four survey points at Red Slough WMA. Based on our standardized surveys, informal surveys, and reports from Oklahoma Department of Wildlife Conservation staff, we estimated the presence of 10-12 breeding pairs and 2 - 3 unpaired adults at Red Slough WMA. An observer detected a King Rail at a privately owned wetland just south of Red Slough in late April 2012 but this site did not yield a detection thereafter.

We detected too few King Rails to model occupancy, detection or formal habitat associations. In 2012, sites occupied by King Rails had a mean water depth of 12.6 cm (range =

2-23 cm), percent emergent or grassland cover ranged from 33 - 95%, and a mean woody stem density of 0.43 stems/m^2.

Capture & Telemetry

In 2011, despite much effort, no king rails were captured using walk-in traps, toe-snares, or spotlighting on foot (Table 1). We were most successful at capturing King Rails using an airboat and dip nets at night (Table 1). We caught one adult and one juvenile in unit 5 on 6 July 2011. We fitted both birds with a VHF transmitter harness. We found the transmitter and remains of the juvenile King Rail two days later near the release site. We tracked the adult King Rail captured in unit 5 for 17 days. The individual remained in an area dominated by blue waterleaf for 11 days. The site had high interspersion (class 2 and 4) with patches of both saturated soil and standing water. Mean water depth ranged from 0-15 cm. Standing water was found only in the borrow ditches surrounding the unit and not in the marsh when the adult left unit 5. The marked bird then traveled ~3 km to unit 27B where it remained for 5 days. Dominant vegetation included soft rush and willows and a small patch of standing water with arrowhead. The bird remained near the western end of the levee adjacent to a deep-water reservoir. We found the transmitter on 29 July 2011 with the harness intact. Habitat at the telemetry locations tended to have a higher proportion of open water or saturated soil than randomly selected points (Table 2).

Using mist nets and decoys, we captured a downy chick in unit 27a on 2 August 2011. The chick was likely 4-5 weeks old based on plumage descriptions from captive chicks (Meanley 1969). We marked the chick with a transmitter using a necklace harness. On 3 August 2011, we found the transmitter but no remains.

On 10 April 2012 at Red Slough WMA, we trapped with a toe-snare, one adult King Rail and attached a transmitter to it. We recorded 51 locations before the transmitter apparently fell off on 11 June 2012. The marked King Rail made individual movements away from its nest ranging from 7–90 m during the incubation period. The nest hatched on April 19. We tracked the bird during brood rearing from 21 April – 23 May and we calculated a mean distance moved per day of 16 m (SE = 0.05 m). The marked King Rail made a second nesting attempt that failed on 13 May and afterwards it moved 565 m from the second nest site. The marked King Rail made a third nesting attempt that failed on 23 May and afterwards moved 1,000 m (Fig. 4). The marked King Rail used habitat between 0 – 140 m from the nearest levee and avoided areas that had been burned or disked the previous fall (Fig. 5). The marked King Rail tended to use drier sites with less woody cover than was available at random (Table 3).

King Rail Reproduction

We found nine nests in Red Slough WMA in 2012 (Table 4). The marked King Rail incubated a nest while rearing a brood, confirming that King Rails attempt to double brood. Nests were located in short (<1 m) and tall vegetation (≥1 m) including six plant species with *Juncus effuses* being used most often (n = 4, Table 5). The distance of nests to the nearest levee ranged from 0 – 180 m. Water depth at the nest varied. King Rails made nests in emergent vegetation with standing water, on man-made islands, and in dry grasslands (Table 5). King Rail nest sites had more visual obstruction, more microtopographic variation and more woody stems, but less open water coverage than random sites (Table 6). Early in the nesting season when impoundments had deeper water, King Rails used nesting sites with more emergent vegetation. As the breeding season advanced, observations of nest sites in short emergent vegetation increased.

We did not locate any nests within units drawn down during the 2012 breeding season or at sites burned or disked in fall 2011. Emergent vegetation characteristic of moist soil management applications do not emerge until later in the breeding season (mid-June to July) and use by King Rails may depend on presence of standing water and food availability in the unit.

We collected behavioral data on two broods. Young chicks (< 3 weeks old) hid in dense emergent vegetation just over half of the time (58.1%) under observation (Table 7). As chicks became older, they spent more time in open areas foraging, resting, or grooming. Brood rearing sites tended to have deeper water, a greater percent of tall emergent vegetation and more woody vegetation than random sites (Table 8). Random sites tended to have a higher percent of open water or exposed soil. However, the presence of shallow standing water or saturated soil with dense emergent cover nearby appeared an important aspect of brood rearing habitat especially when other areas of the wetland complex went dry. Portions of wetland units burned or disked the previous year were generally avoided by brood rearing adults, only 2 of 24 observations occurred in burned or disked sites. We think the lack of emergent cover in these sites was the reason for few brood observations (Fig. 5).

Future Direction

Red Slough experienced three exceptional droughts since 2009. Beginning in the winter of 2010, King Rails ceased to overwinter there. Populations of King Rails began to decline in 2010 and continued to decline through 2012. The long-term forecast for Red Slough calls for continuing drought. As the King Rail populations have declined at Red Slough to levels that are very difficult to study, we decided to terminate this project. We decided to funnel the remaining funds into a sister study that was investigating autumn migration ecology of rails in Missouri. King Rails both breed in and migrate through Missouri.

Literature Cited

Conway, C. J. 2011. Standardized North American Marsh Bird Monitoring Protocol. Waterbirds 34:319-346.

Cooper, T. R. 2008. King Rail conservation plan. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota.

Courtwright, J. and S. E. G. Findlay. 2011. Effects of microtopography on hydrology, physiochemistry, and vegetation in a tidal swamp of the Hudson River. Wetlands. 31:239-249.

Eddleman, W. R., F. L. Knopf, B. Meanley, F. A. Reid and R. Zembal. 1988. Conservation of North American rallids. Wilson Bulletin 100: 458-475.

Fuertes, B., J. Garcia, and J. M. Colino. 2002. Use of fish nets as a method to capture small rails. Journal of Field Ornithology. 73:220-223.

Haramis, G. M., and G. D. Kearns. 2000. A radio transmitter attachment technique for soras. Journal of Field Ornithology. 71:135-139.

McGregor, S. P., S. H. Schweitzer, W. E. Mills, and E. P. Wiggers. 2009. Distribution of King and Clapper Rails in managed impoundments and tidal marshes of South Carolina. The Chat. 73:139-148.

McWilliams, H. N. 2010. Estimating foraging production for waterbirds and waterbird response to habitat management at Lacreek National Wildlife Refuge, South Dakota. Thesis, South Dakota State University, Brookings, USA.

Meanley, B. 1969. Natural history of the King Rail. *In* North American Fauna, No. 67. Bureau of Sport Fisheries and Wildlife, Washington, D.C.

Naugle, D. E., K. F. Higgins, and S. M. Nusser. 1999. Effects of woody vegetation on prairie wetland birds. Canadian Field-naturalist. 113:487-492.

Poole, A. F., L. R. Bevier, C. A. Marantz and B. Meanley. 2005. King Rail (*Rallus elegans*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/003doi:10.2173/bna.3

Reid, F.A. 1989. Differential habitat use by waterbirds in a managed wetland complex. Unpublished Ph.D. Dissertation, University of Missouri, Columbia, Missouri.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. The North American breeding bird survey, results and analysis 1966-2009. Version 3.23.2011 USGS Patuxent Wildlife Research Center, Laurel, MD.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of Natural Ponds and Lakes in the Glaciated Prairie Region. Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Washington, D. C. USA. Resource Publication 92. 57pp.

Table 1. Numbers of King Rails captured by method at Red Slough Wildlife Management Area, May-August 2011, and April-August 2012.

Method	**Hours**	**# individuals captured**	**Catch rate per hour**
2011			
Airboat	4.2	2	0.48
Mist net	23.8	1	0.04
Spotlighting	2	0	0
Toe trap	10.8	0	0
Walk-in Trap	51.9	0	0
2012			
Air Boat	6.8	0	0
Mist net	3.0	0	0
Toe-snare	94.0	1	0.01
Hoop net	2415.3	0	0

Table 2. Mean and standard deviation (S.D.) of habitat variables collected from random and telemetry locations at Red Slough Wildlife Management Area in July 2011.

Habitat Feature	**Telemetry Location**		**Random Location**	
	Average	S.D	Average	S.D.
Mean Water Depth (cm)	3.2	4.8	2.1	8.2
% Open Water/Exposed Soil	29.5	21.7	2.4	5.7
% Short Emergent (<1 m)	41.8	28.8	42.7	30.4
% Tall Emergent (≥1 m)	20.3	31.1	30.8	28.0

Table 3. Mean habitat measurements (standard error) collected at King Rail telemetry locations and random sites at Red Slough Wildlife Management Area from 15 April - June 11 2012.

	Water Depth (cm)	**% Short Emergent (< 1m)**	**% Tall Emergent (≥ 1m)**	**Woody Stem Density (#/m^2)**
Telemetry	5.0 (0.25)	32 (1.66)	40 (0.62)	0.2 (0.09)
Random	11.5 (0.22)	26 (0.47)	35 (0.57)	1.6 (0.06)

Table 4. Date discovered, clutch size, and fate of King Rail nests found at Red Slough Wildlife Management Area from 19 April through 13 July 2012.

Date Found	**Clutch Size**	**Fate**
19 Apr	11	Hatched 21 Apr
10 May	12	Failed 13 May
12 May	13	Hatched 3 Jun
13 May	4[a]	Failed 18 May
25 May	9	Failed 27 May
1 Jun	1[a]	Failed 8 Jun
8 Jun	1[a]	Failed 10 Jun
24 Jun	9	Failed 29 Jun
13 Jul	8	Hatched 27 Jul

[a]We believe that the hens at these nests did not complete their clutch.

Table 5. Nest site habitat characteristics, collected in a 12 m radius circular plot, for 9 King Rail nests found at Red Slough WMA from 19 April – 13 July 2012.

Predominant nest material/cover	**Water depth at nest (cm)**	**% Tall Emergent Vegetation ($\geq$ 1m)**	**Distance to nearest levee (m)**	**# Woody stems**
Juncus effusus	11	40	39	10
Juncus effusus	0	90	12	6
Elymus virginicus	0	45	180	2
Carex hyalinolepis	15	63	32	0
Juncus effusus	5	10	0	22
Dichanthelium scoparium	0	15	6	5
Juncus effusus	10	25	58	9
Rynchospora corniculata/Hydrolea ovata	9	0	31	0
Iva annua/Poaceae	0	100	17	11

Table 6. Mean habitat characteristics (standard error) in a 12 m radius circular plot at King Rail nest sites and randomly chosen emergent wetland sites at Red Slough Wildlife Management Area from 19 Apr – 13 July 2012.

	Water depth (cm)	**Cover[a] (0-0.3m)**	**Cover (0.3-1m)**	**Cover (1-2m)**	**Microtopographic Variance[b]**	**% Open water**	**% Tall Emergent (≥ 1m)**	**% Short Emergent (< 1m)**	**# woody stems[c]**
Nest sites (*n*=9)	8.4 (1.04)	14.5 (0.14)	25.5 (0.82)	4.7 (0.57)	50.4 (10.1)	13.3 (1.35)	43.1 (3.66)	25.8 (3.18)	7.2 (0.77)
Random Sites (*n*=9)	7.8 (0.98)	7.7 (0.95)	11.2 (1.39)	0.1 (0.02)	9.93 (1.71)	24.6 (2.81)	33.2 (2.52)	22.0 (2.73)	2.3 (0.33)

[a]Cover refers to visual obstruction estimated with a density cover board at indicated height increments

[b]Microtopography was determined by measuring the distance from ground to level string at 1m increments in the four cardinal directions

[c]Woody stem includes trees with DBH ≥4cm and shrubs with multiple stems were counted as one

Table 7. Time budget for behavioral observations of 2 King Rail broods over a 15 minute period at Red Slough Wildlife Management Area from 6 May - 13 June 2012.

Brood ID	Date	Approx. Age (weeks)	% of Observation Time Spent			
			Hidden	Foraging	Grooming	Resting
B1	6 May	2	87	13	0	0
B1	8 May	2.5	73	27	0	0
B1	11 May	3	80	20	0	0
B1	15 May	4	27	20	53	0
B1	26 May	5	60	33	0	7
B1	20 Jun	9	0	60	40	0
B2	5 Jun	0.5	47	40	0	13
B2	13 Jun	1.5	33	27	0	40

Table 8. Mean habitat characteristics (standard error) at brood rearing and random sites at Red Slough Wildlife Management Area from 21 April – 20 June 2012.

	Water Depth (cm)	**% Open Water or Exposed Soil**	**% Short Emergent (< 1m)**	**% Tall Emergent (≥ 1m)**	**# Woody Stems**
Brood Site	6.2 (0.36)	20 (1.35)	7 (1.07)	61 (2.17)	3.6 (0.50)
Random Site	0.69 (0.15)	40 (2.79)	29 (2.68)	37 (2.58)	1.4 (0.21)

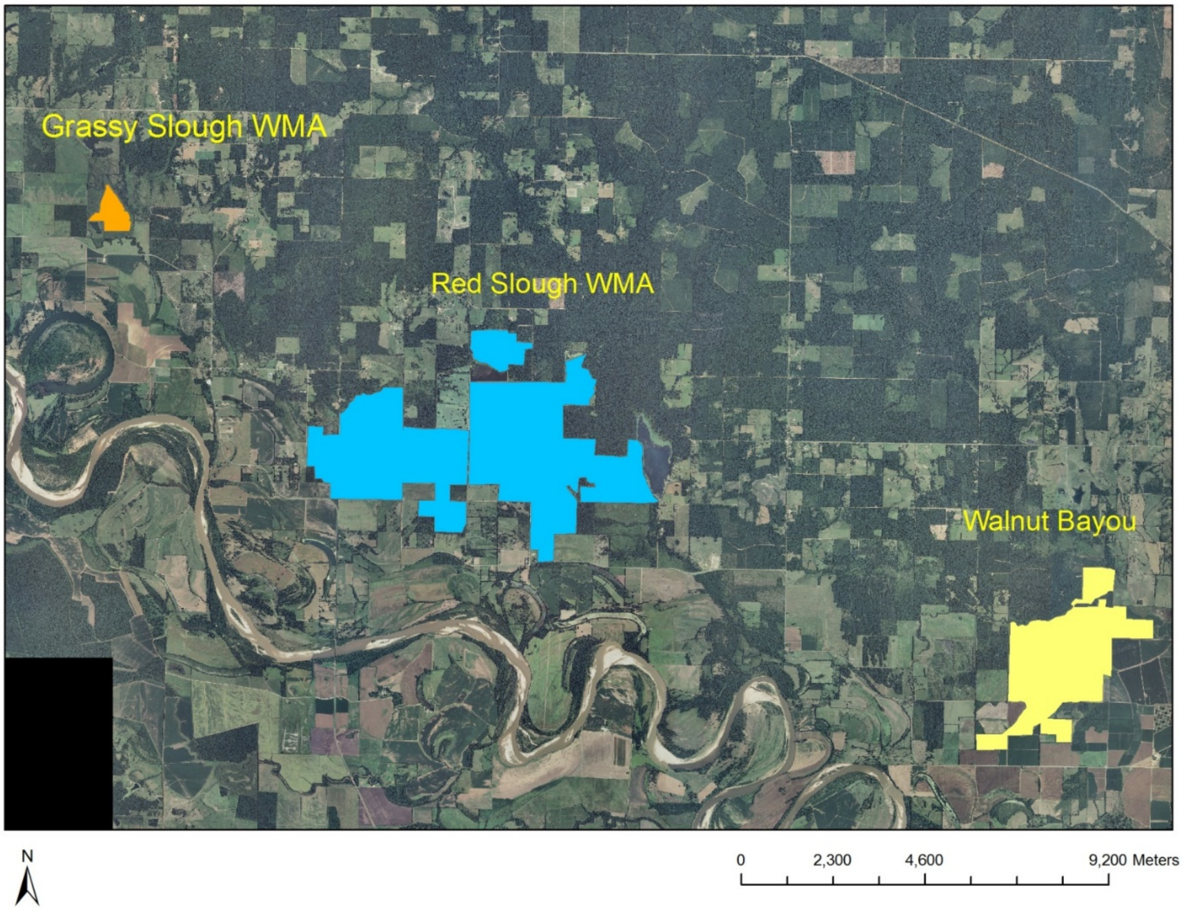

Figure 1. Three wetland complexes included in this study of King Rail breeding ecology in McCurtain County, Oklahoma.

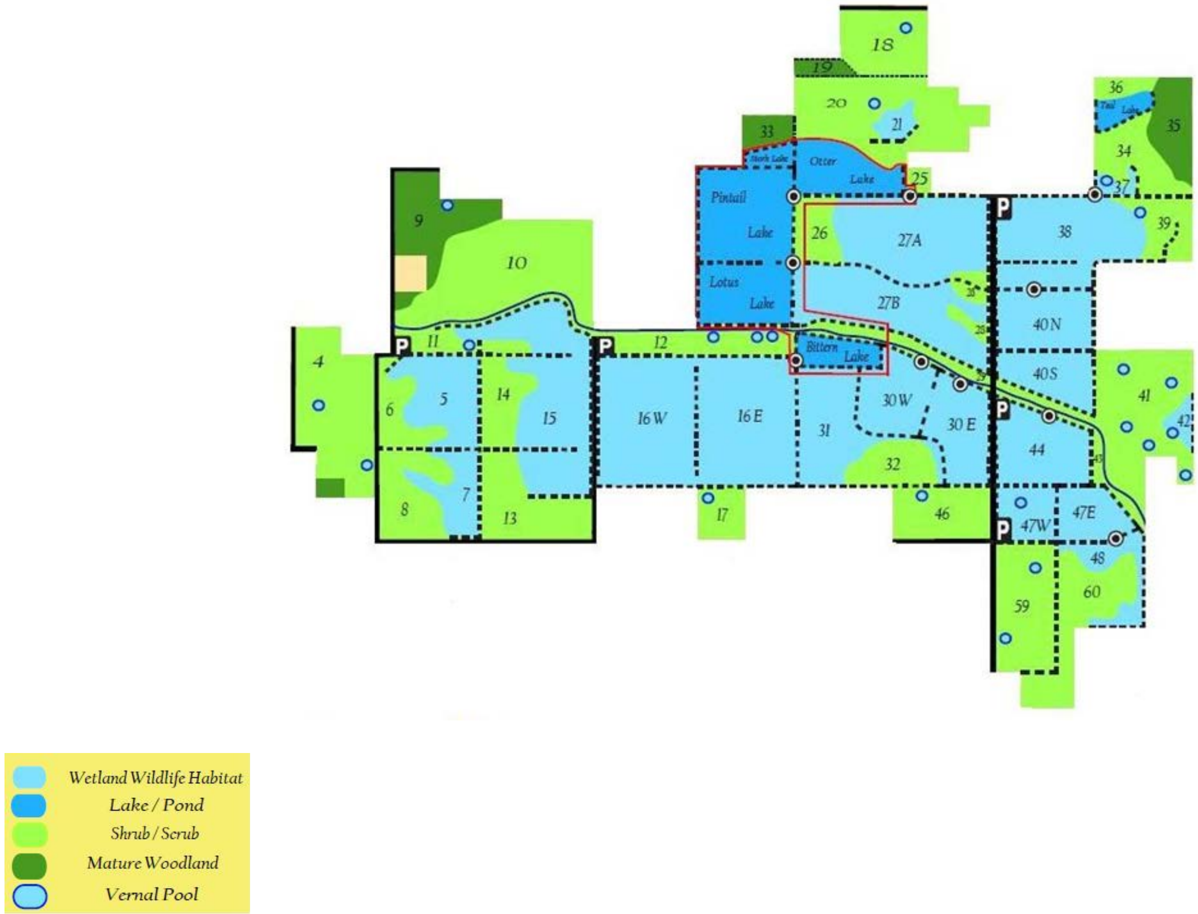

Figure 2. Red Slough Wildlife Management Area wetland units surveyed May-August 2011-2012 to locate breeding King Rail territories and document brood rearing habitat use.

Figure 3. Locations of King Rail breeding territories (yellow stars) identified at Red Slough Wildlife Management Area, Oklahoma in May 2011. Classification of breeding territory based on detection of adult King Rail at the site on more than one occasion or detection of an adult pair on at least one occasion.

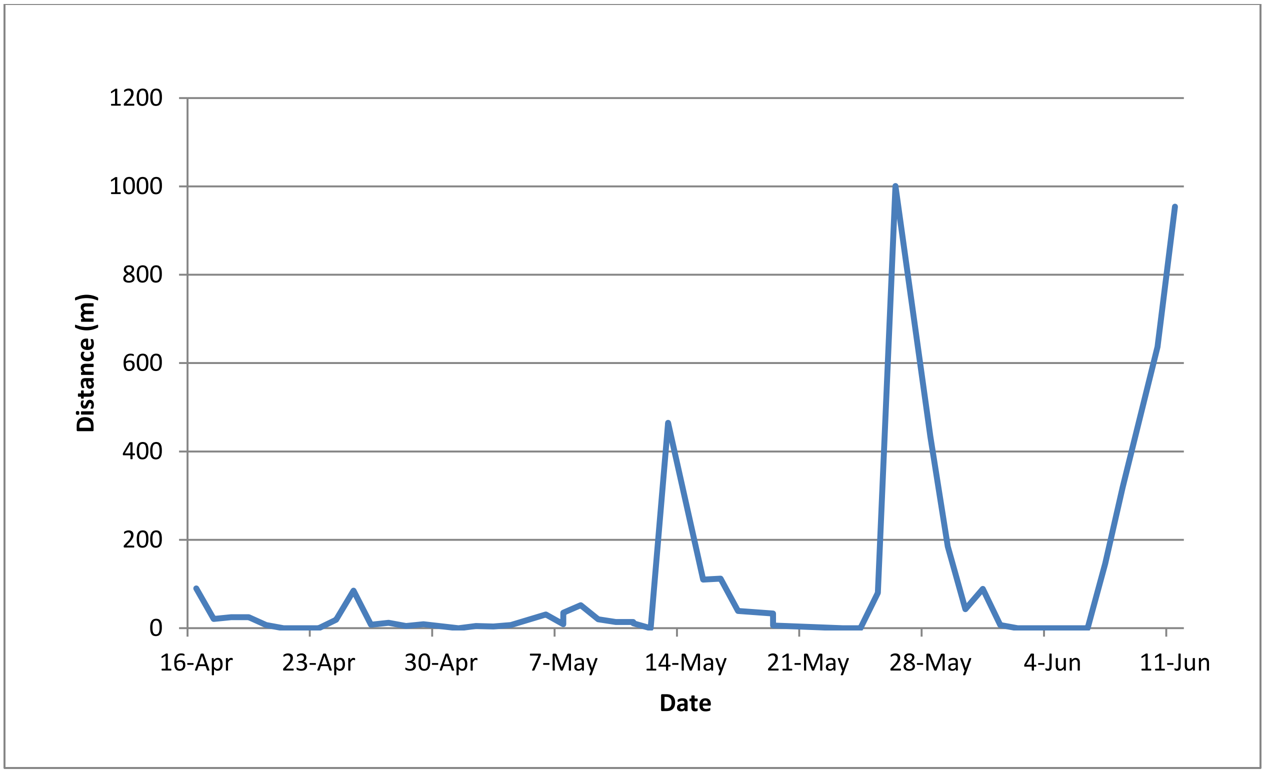

Figure 4. The estimated straight-line distance (m) between daily King Rail telemetry locations over time, at Red Slough Wildlife Management Area, Oklahoma from April 15 through June 11, 2012. Peaks in movement distance corresponded to the day after each nesting attempt failed.

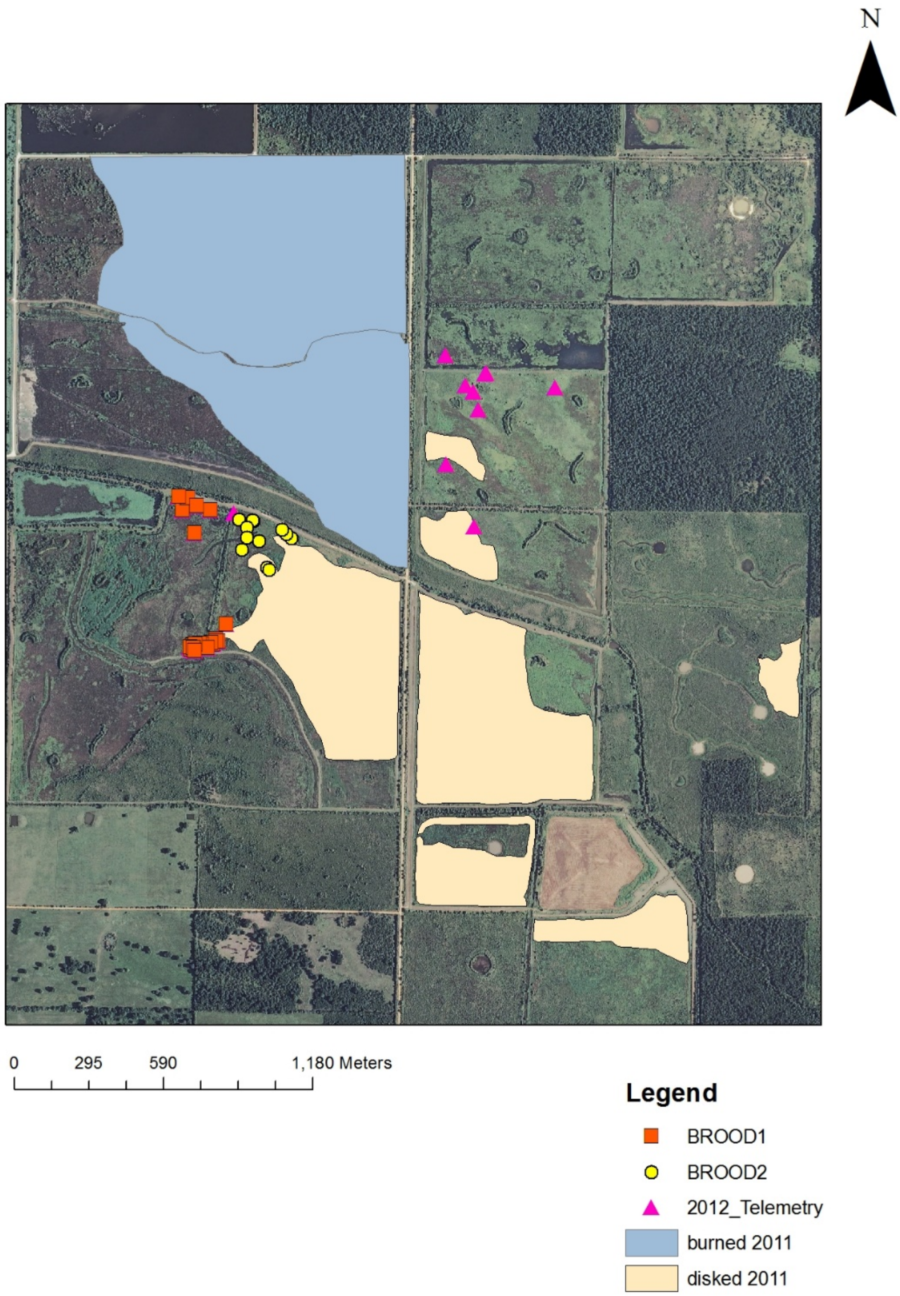

Figure 5. Telemetry locations of one adult and brood rearing sites of two King Rail broods in relation to management treatments at Red Slough Wildlife Management Area, Oklahoma during the 2012 breeding season.

Section 2 – Rail Autumn Migration Ecology in Missouri

INTRODUCTION

Despite apparently declining populations of most rails, research on rails has either been conducted on the breeding or wintering grounds (Tacha and Braun 1994). Research during the autumn migration period is limited and almost entirely focused on habitat use in Missouri (Rundle and Fredrickson 1981, Sayre and Rundle 1984, Reid 1989, 1993). Many issues confront rails during autumn migration on managed wetlands including: 1) stability of hydrology, 2) excessive water depths that inhibit adequate forage opportunity, and 3) lack of available wetlands, especially on private lands (Reid 1989, 1993). Of these issues, the consensus of researchers is that the management of hydrology is most important to providing suitable habitat (Rundle and Fredrickson 1981, Sayre and Rundle 1984, Reid 1989, 1993). The lack of information on autumn rail migration ecology limits wetland management strategies and is an area of research need (Case and McCool 2009).

Our original goal was to examine habitat use of King Rails during the autumn. Pilot work suggested that King Rails were rare and so we opted to broaden our scope and examine all rails migrating through Missouri. In addition, we designed an experiment to investigate the importance of fall flooding on habitat use by migrating rails. We will not report on those findings here because that experiment will not be completed until 2017.

METHODS

Study Area

We selected public properties in four regions of Missouri, USA - northwest, north central, northeast and southeast – because of their historic importance for migrating waterfowl and active wetland management. Each region included multiple Conservation Areas (CA) managed by Missouri Department of Conservation and one National Wildlife Refuge (NWR) managed by U.S. Fish and Wildlife Service (Fig. 6). We conducted all work under Special Use Permits from Missouri Department of Conservation, U.S. Fish and Wildlife Service, and IACUC proposal #13044 from the University of Arkansas.

At each property, we selected wetland impoundments under one of three management strategies (moist soil, perennial emergent and upland). Moist soil wetlands were actively managed using a combination of water level and soil disturbance manipulation on a regular (~3-year return) basis to promote annual plants that produce large quantities of seeds. Perennial emergent wetlands were managed on a longer return interval (~5 year) to promote perennial plants that produce persistent emergent vegetation (Cowardin et al. 1979). Upland areas were areas either within a managed wetland or adjacent to a managed wetland that had upland native non-woody vegetation or crops. We considered the impoundment as the survey unit because the impoundment is often the scale at which wetland management decisions (especially water manipulation) are made.

In 2012, Missouri experienced a moderate to severe drought (NOAA 2015) and water was limited throughout the state. Because of that drought, we surveyed all flooded non-forested wetland impoundments on each property in addition to a subset of dry wetland impoundments. Weather conditions were normal in 2013 and 2014 (NOAA 2015). In 2012 and 2013, in addition to moist soil impoundments, we surveyed some impoundments dominated by upland and perennial emergent vegetation. In 2014, we only surveyed moist soil impoundments.

Surveys

We surveyed for all rails at night using distance-sampling based spotlight surveys from ATVs. We drove transects running parallel to a random side of the impoundment and spaced at least 30 m apart through wetland impoundments and recorded the point of first detection and the perpendicular distance from the transect line to each rail. Because 96 % of detections occurred within 5 m of the transect line, we truncated the survey data at 5 m. We recorded rails detected on the ground and those that flushed. We surveyed for two hours each night in 2012, beginning a half hour after sunset. We surveyed for 3 hours each night in 2013 and 2014, also beginning a half hour after sunset, split into two 1.5-hour blocks. Observers switched impoundments after the first block to allow us to investigate observer effects and to increase our opportunities to detect rarer species (Yellow, King, and Virginia Rail).

We collected habitat data at the locations of rail detections and at 20 randomly distributed points in each surveyed impoundment. We measured water depth at the detection and 5 m away in the four cardinal directions; we used the average of all 5 measurements. We visually estimated the percent coverage of the plot for water-vegetation interspersion (Rehm and Baldassarre 2007), non-persistent short emergent vegetation (<1 m tall, e.g. smartweeds, spikerushes, and arrowleafs), persistent tall emergent vegetation (> 1m tall, e.g. cattails and bulrushes), perennial vegetation, upland vegetation, bare ground, open water, woody vegetation (e.g., buttonbushes, willows), and cropland.

We began surveys each year in the northwest region and moved clockwise around the state, spending four to five nights in each region. We refer to each of these four to five nights of surveying as a ‘visit’. In 2012, we visited each region three times (August 15 - October 7). In

2013, we visited state properties three times and federal properties four times (August 13 - October 14 and August 13 - October 27, respectively). In 2014, we visited all properties four times (August 11 - October 22). We attempted to keep our survey effort as consistent as possible in each region given logistical constraints and severe weather.

Abundance

We originally hoped to estimate rail abundance by species using an occupancy approach but we determined that too few Yellow, King and Virginia Rails (n = 38, n = 4, n = 73,) were detected to use this method. We estimated Sora abundance using the generalized distance sampling model of Chandler et al. (2011) in program unmarked (R version 3.1.3, Fiske and Chandler 2011, R Core Team 2014). Unmarked fits data collected through repeated surveys to hierarchical models that estimate abundance while accounting for imperfect detection. We estimated abundance for each visit separately to avoid violating closure assumptions between visits. We created a set of candidate models using combinations of covariates to explain abundance. We ranked models using AIC and then examined whether the beta values of the coefficients were significantly different from zero (Table 1). In the absence of sufficient rail detections, we could not formally examine the relationship among habitat covariates and abundance. We chose instead to present comparisons of the means (± 95% CIs) of habitat variables at sites with rails and available sites to give the reader some understanding of habitat variables associated with use.

RESULTS

We detected 38 Yellow Rails, 4 King Rails, 73 Virginia Rails, and 5039 Sora during 699 hours of surveying in autumns 2012-2014 (Table 1). We detected more rails in 2012 than in either 2013 or 2014 despite an increase in survey effort during the latter two years. With the exception of 2012, when we detected 33 Yellow Rails, we rarely detected Yellow or King Rails in any year. We detected Virginia Rails consistently across all three years but in relatively low numbers compared to the much more abundant Sora. In all three years, we detected Sora on the first through the last day of surveying while we detected all other rails during a much shorter window within the survey period.

Across all locations where we detected rails, we found that habitat use for at least two species differed significantly from available habitat in every category (Table 2). In two categories (perennial, woody), all species habitat use differed significantly from available. King Rail habitat use patterns differed from other rail habitat use in large part because we did not detect King Rails in 6 habitat types. We simply had too few King Rail detections to establish any patterns. For all other rails, we found that they used sites with less perennial, bare ground, woody and lower average water depth than available. Yellow and Sora Rails used sites with more short emergent vegetation than available. Yellow and Virginia Rails used only upland, open water and cropland in accordance to availability.

When we examined just annual Sora habitat use patterns, we found that habitat variables explaining Sora abundance differed among years, although there was some uncertainty when selecting models each year (Table 3). In 2012, we found Sora abundance increased with average water depth, and with increasing percent cover of non-persistent short emergent vegetation, and varied across region with the northcentral having higher Sora abundances than in the southeast (Table 4). In 2013, we found Sora abundance increased with average water depth and with percent interspersion (Table 4). In 2014, we found Sora abundance increased with average water depth (Table 4). Thus, across all three years, Sora abundance was consistently and positively related to average water depth; no other variable consistently explained Sora abundance across years (Fig. 7).

DISCUSSION

Yellow, King, and Virginia Rails were all relatively rare as compared to the very abundant Sora across all of our study sites in all years. Rundle and Fredrickson (1981) surveyed over two years during both spring and autumn at Mingo NWR, MO, one of our study sites, and also found that Yellow (n=16) and Virginia Rails (n=141) were relatively rare as compared to the more abundant Sora (n=1128), however they did not encounter any King Rails. Sayre and Rundle (1984) surveyed just Virginia Rails and Sora at Mingo NWR during autumn 1980 and found again that Virginia Rails (n = 13) were relatively rare compared to Sora (n=55). All three of these studies suggest that Yellow, King and Virginia Rails are relatively rare as compared to the more abundant Sora during the autumn migration period in Missouri.

We investigated two components of habitat use for autumn migrating rails: 1) the physiognomy/floristics of vegetation used, and 2) the importance of water level. Regarding the former, we detected so few non-Sora rails over the study period that we could not conduct statistical comparisons of vegetative use patterns. We relied instead on general comparisons and are therefore reluctant to draw strong conclusions based on our results. However, we can describe the trends present from these general comparisons. All four species of rails consistently used sites with more non-persistent emergent vegetation and less woody vegetation than was available. With only four King Rail detections, we could not draw any conclusions about habitat use for this species. Regarding the latter habitat component, water depth, we found Yellow, King and Virginia Rails all tended to use shallower water than was available, granted the data for drawing this conclusion on King Rails in Missouri were sparse. Further, we found Yellows used significantly shallower water than did Virginia Rails. Furthermore, taking into account the King Rail sample size, the mean water depth at King Rail detection sites was even deeper than those for Virginia Rails. Rundle and Fredrickson (1981) found no significant difference in water depths used by Virginia Rails and Sora during both spring and autumn, and they further noted that Sora used shallower water (mean = 8.5 $\pm$ 1.2 cm) in the autumn than during the spring (mean = 20.1 $\pm$ 3.5 cm). Rundle and Fredrickson (1981) concluded that Soras during the autumn used shallower water because of availability and not selection, i.e., only shallow water was available during the autumn compared to that available during the spring. Sora at our study areas used water twice as deep (mean = 16.5, 95% CI - 16.02 – 17.08) as what Rundle and Fredrickson (1981) found. Sayre and Rundle (1984) concluded that Virginia Rails preferred saturated to shallowly flooded sites (mean = 5.0 $\pm$ 1.0 cm); this species was rarely encountered in water depths > 15 cm. In contrast, Sora preferred water depths 5-15 cm (mean = 9.3 $\pm$ 0.8 cm) but often used much deeper sites (> 15 cm). From our data and those of others studying rails during autumn migration in Missouri (Rundle and Fredrickson 1981, Sayre and Rundle 1984), it seems that rails generally prefer water depths according to the length of their legs, i.e., Yellow Rails occupy the shallowest water, then Virginia Rails, and finally King Rails. The one outlier is the Sora that were detected in a much wider range of water depths. At deeper water sites, we observed Sora walking on top of floating vegetation, a behavior that may explain their use of these locations.

State and federal agencies manage many public wetlands in Missouri as moist soil wetlands with the goal of creating migratory waterfowl habitat (Rundle and Fredrickson 1981). These agencies are interested in managing for a wider suite of wetland species, but lack the information to do so. Current management regimes often result in wetlands being dry for large parts of July and August to allow for plant germination. Some impoundments may be flooded immediately before teal hunting season in September, but many remain dry through October or November. A dry landscape in late summer and early autumn limits the availability of suitable habitat for rails, especially since most rails are passing through Missouri before waterfowl migration. The primary concern of waterfowl managers in putting water on dry impoundments too soon is degradation of forage (seeds) before the peak of waterfowl migration later in the autumn. We have undertaken a field experiment to investigate the trade-off between flooding early for rails and reduced use of those impoundments by later arriving waterfowl. Our experiments will wrap up in autumn 2017.

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Literature Cited

Case, D. J., and D. D. McCool, editors. 2009. Priority information needs for rails and snipe: A funding strategy. Available at: http://www.fws.gov/migratorybirds/pdf/surveys-and-data/Info-Needs-Rails-Snipe.pdf. Accessed 31 August 2015.

Cooper, T. R. (Plan Coordinator). 2008. King Rail Conservation Plan, Version 1. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 121 pp.

Cowardin, L. M., V. Carter and F. C. Golet. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C.

Eddleman, W. R., F. L. Knopf, B. Meanley, F. A. Reid, and R. Zembal. 1988. Conservation of North American rallids. Wilson Bulletin. 100:458-475.

Fiske, I. J., and R. B. Chandler. 2011. unmarked: An R Package for Fitting Hierarchical Models of Wildlife Occurance and Abundance. Journal of Statistical Software 43:1–23.

NOAA/ National Weather Service Center for Weather and Climate Prediction. 2015. Available at: http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml. Accessed 18 August 2015.

Rehm, E. M., and G. A. Baldassarre. 2007. The influence of interspersion on marsh bird abundance in New York. Wilson

Reid, F.A. 1989. Differential habitat use by waterbirds in a managed wetland complex. Dissertation, Iowa State College, Ames, USA.

Reid, F. A. 1993. Managing wetlands for waterbirds. Transactions of the North American Wildlife &Natural Resources Conference 58:345-350.

Rundle, W. D., and L. H. Fredrickson. 1981. Managing seasonally flooded impoundments for migrant rails and shorebirds. Wildlife Society Bulletin 9:80-87.

Sayre, M. W., and W. D. Rundle. 1984. Comparison of habitat use by migrant soras and Virginia rails. Journal of Wildlife Management 48:599-605.

Tacha, T. C., and C. E. Braun, editors. 1994. Migratory shore and upland game bird management in North America. International Association of Fish and Wildlife Agencies, Washington, D.C. 223 pp.

Table 1. Numbers of Yellow Rails, King Rails, Virginia Rails, and Sora detected during nocturnal surveys of autumns 2012-2014 in Missouri.

Year	Yellow Rail	King Rail	Virginia Rail	Sora	Total
2012	33	3	33	1895	1964
2013		1	26	1876	1907
2014	1		14	1241	1256
Total	38	4	73	5039	5127

Table 2. Mean (±95% CIs) values of habitat measurements at Rail detection sites as compared to available (random) measurements during nocturnal surveys of autumns 2012-2014 in Missouri. Cells highlighted in blue are significantly different from the available vegetation mean values based on no overlap in 95% CIs.

	Interspersion	Short Emergent Vegetation	Tall Emergent Vegetation	Perennial	Upland	Bare ground	Open water	Woody Vegetation	Cropland	Average Water Depth
Yellow Rail Mean (n=38)	0.0 0.01 – 0.04	57.7 49.16 – 66.23	13.9 8.06 – 19.83	0.7 0.34 – 0.99	14.7 8.23 – 21.22	4.0 1.47 – 6.59	5.0 0.24 – 9.76	0.1 -0.02 – 0.19	1.0 -0.28 – 2.22	6.5 3.96 – 8.95
Kira Mean (n=3)	0.1 -0.02 – 0.17	93.7 80.9 – 106.43	0.0	0.0	0.0	0.0	3.0 -0.37-6.37	0.0	0.0	17.0 -7.38-41.32
Vira Mean (n=31)	0.8 -0.09 – 1.61	40.7 29.95 – 51.47	27.2 19.48-34.97	0.0	12.4 4.37-20.46	1.0 -0.03-1.96	10.9 4.14-17.73	1.3 0.18-2.4	1.3 -0.23-2.81	12.8 9.55-16.03
Sora Mean (n=1783)	1.5 1.37 – 1.73	35.0 33.68 – 36.24	32.0 30.82 – 33.20	5.1 4.48 – 5.62	11.1 10.27 – 11.87	3.45 3.06 – 3.84	8.06 7.56 – 8.56	2.0 1.73 – 2.25	1.7 1.50 – 1.97	16.5 16.02 – 17.08
Available Vegetation Mean (n=3720)	1.3 1.44 - 1.16	29.2 30.08 - 28.37	27.2 28.01 - 26.36	9.2 9.80 - 8.67	12.8 13.40 - 12.13	7.2 7.68 - 6.76	8.0 8.42 - 7.60	3.3 3.56 - 3.09	2.4 2.66 - 2.04	34.8 38.99 - 30.61

Table 3 – Models of Sora abundance at night in impounded public wetlands during autumn migration in Missouri 2012-2014. We only present models that had more support than the null model. Models are ordered by Akaike's Information Criterion (AIC), K is the number of parameters, and ΔAIC is the difference in AIC from the top model.

Model Name	Year	K	AIC	ΔAIC
Average Water + Non Persistent Short Vegetation	2012	7	-957.65	0
Region + Average Water		9	-957.29	0.36
Region		8	-956.62	1.03
Non Persistent Short Vegetation		6	-956.06	1.59
Region + Non Persistent Short Vegetation		9	-955.17	2.48
Region + Interspersion		9	-954.89	2.76
Region + Open Water		9	-954.78	2.87
Interspersion + Non Persistent Short Vegetation		7	-954.67	2.98
Non Persistent Short Vegetation + Open Water		7	-954.41	3.24
Average Water + Interspersion		7	-954.1	3.55
Global		12	-954.06	3.59
Average Water		6	-952.92	4.73
Average Water + Open Water		7	-952.7	4.95
Interspersion		6	-952.22	5.43
Null		5	-952	5.65
Average Water + Interspersion	2013	7	529.12	0
Interspersion		6	529.17	0.05
Interspersion + Open Water		7	531.16	2.04
Interspersion + Non Persistent Short Vegetation		7	531.15	2.03
Region + Average Water		9	532.32	3.2
Global		12	532.4	3.28
Average Water		6	532.88	3.76
Region + Average Water		8	533.07	3.95
Average Water + Open Water		7	533.46	4.34
Region		8	533.82	4.7
Null		5	534.53	5.41
Average Water	2014	6	1152.49	0
Average Water + Interspersion		7	1152.67	0.18
Average Water + Non Persistent Short Vegetation		7	1153.87	1.38
Region + Average Water		9	1153.97	1.48
Null		5	1161.96	9.47

Table 4. Average Sora abundance estimates (± 95% CI) at the mean value for each covariate that was significantly different from zero. Results are based on surveys conducted at night in impounded public wetlands during autumn migration in Missouri 2012-2014.

				Region			
Year	Average Water Depth	Non-Persistent Short Vegetation	Interspersion	Northwest	Northcentral	Northeast	Southeast
2012	57 36.1 – 90.9	58 30.8 – 104.6		45 19.6-105.4	96 56.8-161.8	52 28.9-94.9	26 15.5-44.7
2013	24 38.6 – 15.6		66 12.8 – 97.9				
2014	25 11.0 – 58.6						

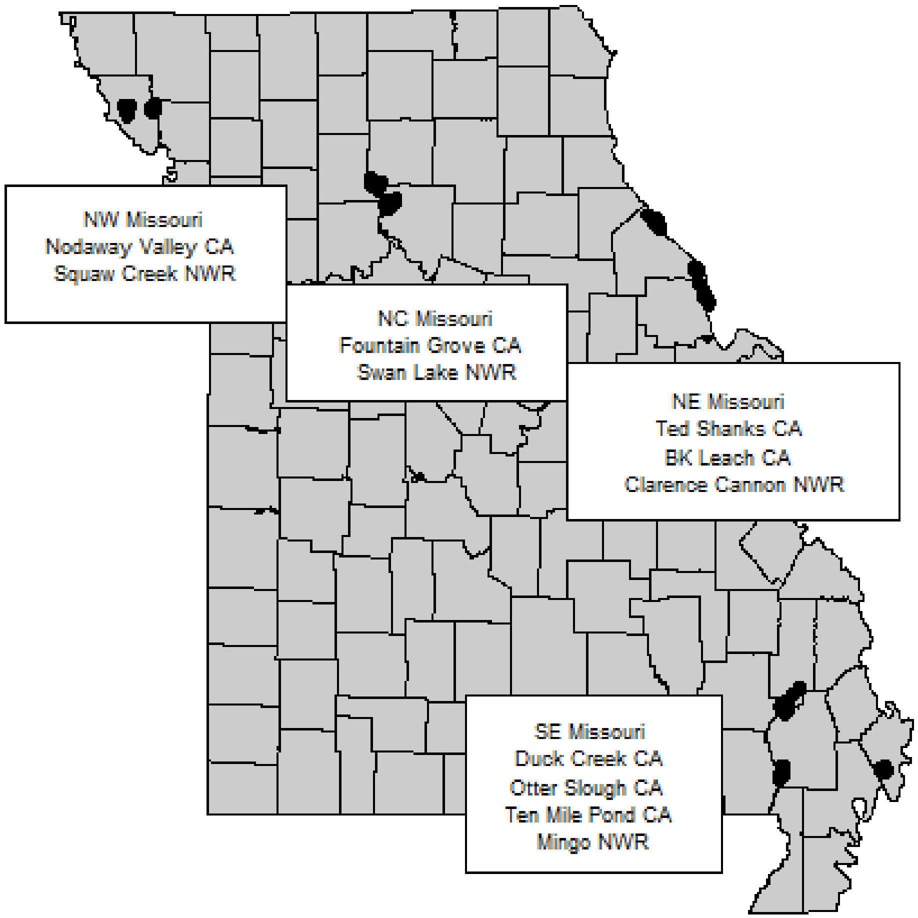

Figure 6. Study sites by region across Missouri, USA.

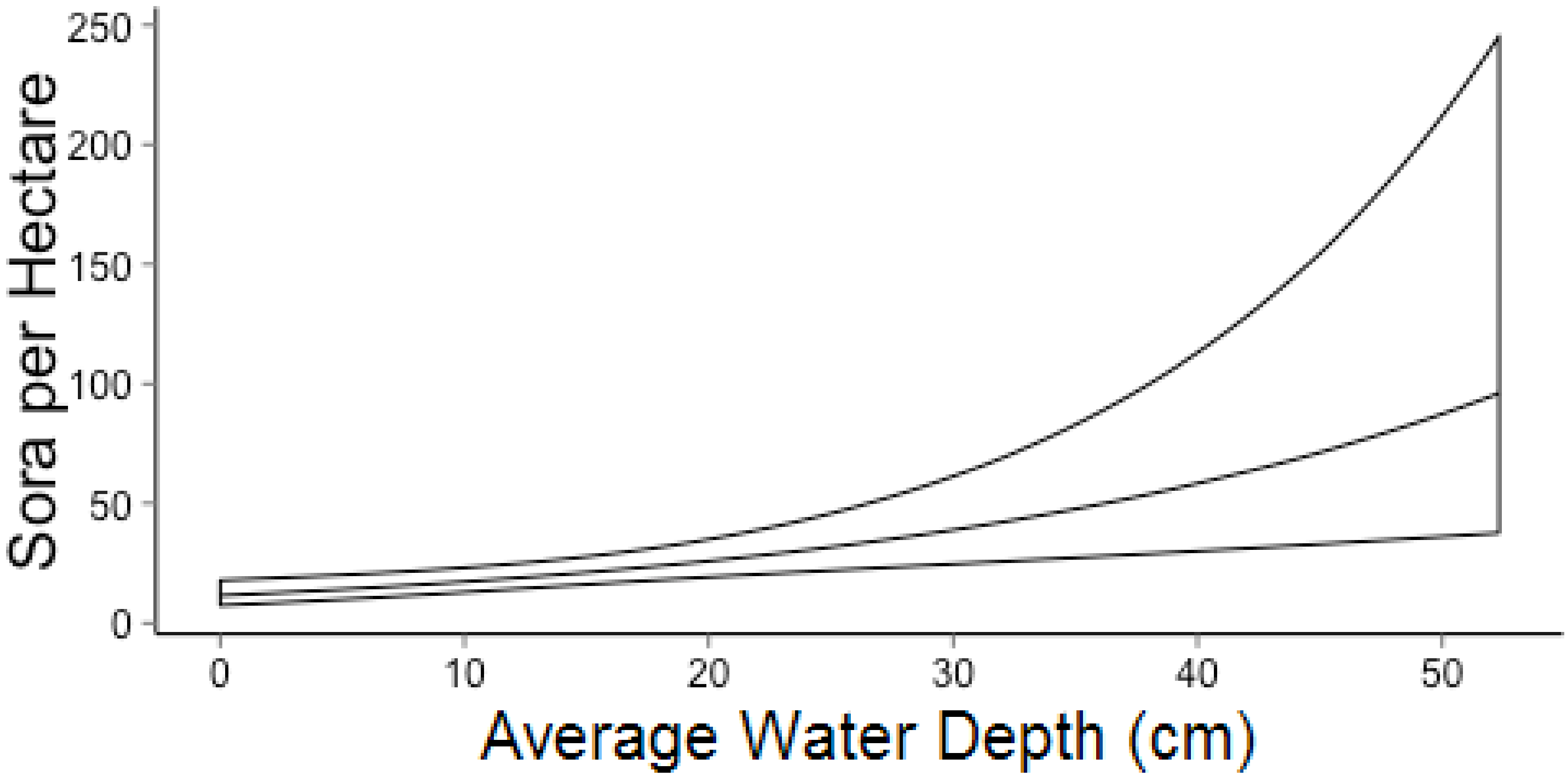

Figure 7. Relationship between average water depth (cm) and estimated Sora abundance based on nocturnal surveys in impounded public wetlands during autumn migration in Missouri 2012-2014.