AN ABSTRACT OF THE THESIS OF

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Title: Phenological assessment of marsh bird distribution within and among moist-soil managed wetlands in Kansas

Thesis Chair: William E. Jensen

Abstract approved: ____

Moist-soil management is a form of wetland management where marshes are drawn-down to enhance vegetative production during the growing season and flooded in the fall to accommodate waterfowl. My objectives were to determine variation in relative abundance and encounter rates of bitterns (Ardeidae) and rails (Rallidae) (i.e., "secretive marsh birds") in relation to habitat structure within and among moist-soil wetlands and to compare habitat structure to wetland drawdown timings. I used call-playback surveys (spring, summer) and flush counts (fall). Target species included American Bittern (*Botaurus* lentiginosus); Least Bittern (*Ixobrychus exilis*); King Rail (*Rallus elegans*); Virginia Rail (*Rallus limicola*); and Sora (*Porzana carolina*). In spring, Sora were found in marshes with relatively tall *Polygonum*. In summer, American Bittern were found in marshes with high coverage and height of *Polygonum*. During fall, American Bitterns were detected in areas with higher cattail (*Typha* spp.) coverage than Sora locations or systematic sampling points within marshes. Sora were detected in areas within marshes with taller grass and *Polygonum*, higher *Polygonum* cover, and deeper water than American Bittern locations.

Wetlands with later-season drawdowns generally had greater water coverage and depth in spring than early-season drawdowns. *Polygonum* cover and height were occasionally greater in later season drawdowns; however, seasonal and annual variation in flooding affected this pattern.

Moist-soil management of wetlands could provide habitat for marsh birds through the use of mid to late season drawdowns in the spring, and early pumping of water, or the closing of water control structures to allow natural precipitation to fill wetlands in the fall. It is not likely that this type of management will provide adequate habitat for breeding marsh birds in a typical year due to a lack of water.

Keywords: Secretive marsh birds, Sora, American Bittern, moist-soil management

PHENOLOGICAL ASSESSMENT OF MARSH BIRD DISTRIBUTION WITHIN AND AMONG MOIST-SOIL MANAGED WETLANDS IN KANSAS

A Thesis

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by

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PREFACE

My thesis contains one chapter. I will begin by discussing moist-soil management, how it relates to secretive marsh birds and the state of wetlands in Kansas. I will discuss the survey methods and statistical analyses used to do the research, then present the results and discussion of what we found during the spring migration, breeding, and fall migration seasons of my study species. I will end with suggestions on how to better manage wetlands for secretive marsh birds. My thesis is written in the format required by *The Journal of Wildlife Management*, the intended target for external publication.

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INTRODUCTION

Moist-soil management is a common form of wetland management used to create productive foraging habitat for migrating and wintering waterfowl (i.e., ducks and geese in the family Anatidae) (Fredrickson and Taylor 1982), an economically and culturally important suite of gamebirds. Moist-soil management involves the active flooding and dewatering of wetlands, establishing a cycle of wet and dry periods. Beginning in the fall, wetland units are flooded wherein seeds and invertebrates are consumed by migrant and winter resident waterfowl (Fredrickson and Taylor 1982). In spring and summer, wetlands are drawn-down to encourage growth of important annual plants for waterfowl, such as smartweeds (*Polygonum* spp.), sedges (*Carex* and *Cyperus* spp.), and other seed producers (Strader and Stinson 2005). Heterogeneity in the timing of drawdowns can encourage growth of plants with varying nutritional and structural qualities; for example, earlier drawdowns are used to encourage growth of *Polygonum* spp. whose seeds are eaten by waterfowl (Fredrickson and Taylor 1982).

Drawdown strategies are typically classified as early, middle, and late (Fredrickson and Taylor 1982). Drawdowns early in the growing season are generally finished within the first 45 days after the last frost. Middle-season drawdowns are performed after the first 45 days, but before the late drawdown periods, which are generally performed 90 days before the first frost (Fredrickson and Taylor 1982). The moist-soil unit (MSU) management guidelines for the Southeast Region management unit of the U.S. Fish and Wildlife Service (Region 4, south of a line from Arkansas to North Carolina) suggest that management optimal for most waterfowl would begin with flooding in September with 100% of wetlands in a complex flooded by January. After flooding is completed, a gradual drawdown should begin with 80% of the area drawn-down by March (Strader and Stinson 2005).

Though use of MSUs by waterfowl has been thoroughly investigated (Fredrickson and Taylor 1982, Bowyer et al. 2005, Strader and Stinson 2005, Hagy and Kaminski 2012), little is known about the use of MSUs by other water birds throughout the annual cycle. Bitterns (order Pellicaniformes) and rails (order Gruiformes), often categorized as "secretive marsh birds" (Conway 2011) due to their association with emergent marsh plants and secretive behavior, require wetlands with vegetation emerging from standing water for foraging and breeding areas (Bolenbaugh et al. 2011) (Table 1). Though MSUs are not managed specifically for secretive marsh birds, they may provide usable habitat during some periods of the annual cycle. The fall migration of rails generally occurs when wetlands are being filled in anticipation of the wintering waterfowl (Table 1), but spring and summer habitat might be inadequate in MSUs due to early drawdowns of MSUs to encourage the germination of *Polygonum* and other waterfowl forage (Fredrickson and Taylor 1982). The bitterns and rails of focus in my study generally breed beginning in late April or early May, and can continue nesting through June-July (Table 1). This period coincides with the growing season, when MSUs have typically been—or are in the process of being—drawn-down to encourage seed production for wintering and migrating waterfowl (Fredrickson and Taylor 1982). Due to the status as game animals, namely Virginia Rail (*Rallus limicola*) and Sora (*Porzana carolina*), or other special designations of concern (Table 1), it is important to know how secretive marsh bird populations are affected by management of habitat within their ranges.

Table 1. Secretive marsh birds and their natural history range wide, including status as game in Kansas and conservation listings of concern, abundance, confirmed breeding sites in Kansas, habitat, fall and spring migration periods and breeding seasons in Kansas.

Species	Game Species (Kansas)	Special Listing in Kansas	Abundance	Breeding Confirmation (Counties)	Habitat	Fall Migration	Spring Migration	Breeding Season	References
Virginia Rail (*Rallus limicola*)	Yes	MC	Uncommon	Douglas, Labette	Marshes with shallow water, cover from emergent plants, and high invertebrate abundance. Avoids dry stands of emergent plants. Builds well concealed nests at water level in thick vegetation.	Sept – mid Oct	Mid -April to May	Nest building and first laying in May; incubation 18-20 days; latest hatch by late August.	Thompson et al. 2011, Busby and Zimmerman 2001, Conway1995
Sora (*Porzana Carolina*)	Yes	HC	Common during spring and fall	Douglas	Marshes with shallow	Aug - Nov	Mid – April to mid – May	Nest building and first	Melvin and Gibbs 2012, Thompson

			migration, rare during summer		and intermediate water, dominated by robust or fine-leaved emergent vegetation. Similar habitat as Virginia Rail. Nests on vegetation in areas with shallow water and emergent vegetation.			laying in May; Incubation 16-19 days; hatch (at the latest) in August.	et al. 2011 Busby and Zimmerman 2001
King Rail (*Rallus elagans)*	No	HC	Local, uncommon summer resident	Douglas	Successional stages of marsh-shrub swamp. Habitat with grasses, sedges, and rushes, as well as	Sept – Nov, occasional overwintering	Late March – early May	Egg laying in mid may. Incubation for 21-25 days; hatch early June.	Thompson et al. 2011, Poole et al. 2005, and Zimmerman 2001

					cattail. Nests built on clumps of grasses or sedges.				
American Bittern (*Botaurus lentiginosus*)	No	Tier II, HC	Uncommon migrant, fairly common summer resident	Douglas, Anderson	Marshes with expanses of tall emergent vegetation (cattails), and a high degree of interspersion. More abundant in larger wetlands. Nests in dense vegetation over shallow water, or occasionally on dry ground in dense herbaceous cover.	Aug – Nov	March – mid-May	Nest building and first laying late April – June. Incubation 24-28 days.	, Thompson et al. 2011, Lowther et al 2009, and Busby and Zimmerman 2001

Least Bittern (*Ixobrychus exilis*)	No	Tier 1, HC	Uncommon	Johnson, Douglas, Osage, Lyon	Tall, dense clumps of emergent plants, with interspersed woody plants; close association with deep waters. Nests built above water in tall, dense stands of emergent or woody vegetation.	Aug – early Oct	April – mid June	First egg laying in June; Hatching mid-July; Incubation 17-20 days.	Thompson et al. 2011, Poole et al. 2009, Busby and Zimmerman 2001

Conservation listings: Tier # = Species of Greatest Conservation Need ranking in Kansas (lower # = higher priority for survey and research) (Wasson et al. 2005); Waterbird Conservation for the Americas initiative (Steinkamp et al. 2005) rankings (HC = High Concern, MC = Moderate Concern)

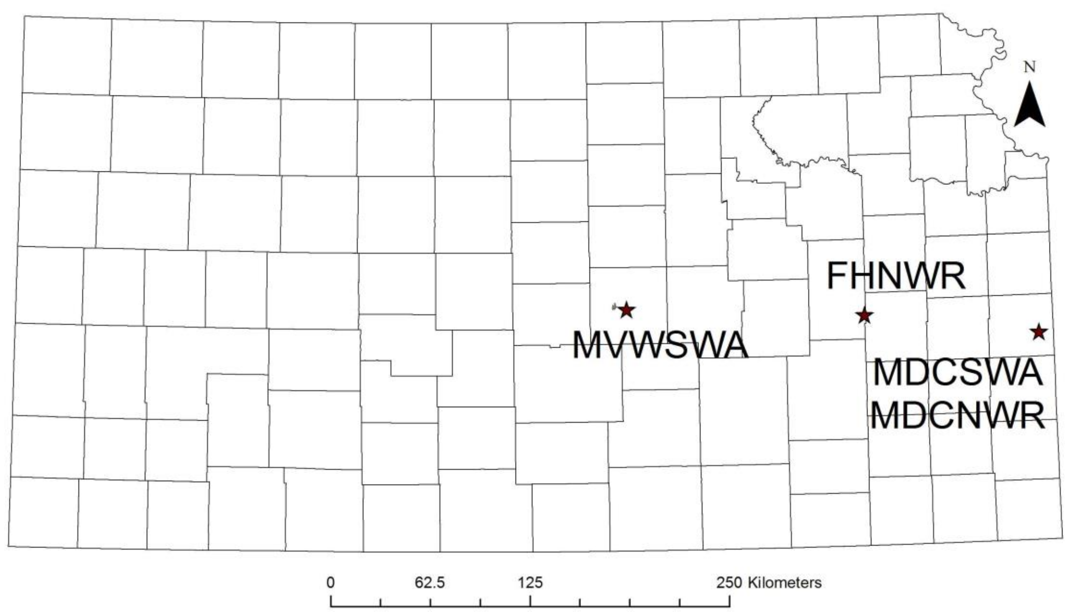
Many of the state and federally owned wetlands in Kansas are managed as MSUs (Kansas Conservation Commission 2008). Moist-soil management is more common in the eastern part (R. Schultheis, personal communication). Prior to westward expansion of the United States, it is estimated that Kansas had about 334,000 ha of wetlands (Kansas Conservation Commission 2008). Of these only about 176,240 ha were remaining in Kansas by 1980 (Kansas Conservation Commission 2008). Only 11,641 ha of that wetland habitat in Kansas is located on federal or state controlled land, with the majority of wetlands in Kansas being found on private land (Kansas Conservation Commission 2008). Due to the relatively small number of public wetlands in Kansas, and the prevalence of moist-soil management on public lands, it is important to know how secretive marsh birds use moist-soil managed habitats.

The objectives of my study were to assess patterns of habitat use by secretive marsh birds at state and federally managed MSUs in Kansas during spring and fall migrations and breeding seasons of these species. I used a nationally standardized monitoring protocol (Conway 2011) and flush counts to compare marsh-scale relative abundance and density of birds in relation to (1) aerial extents of water and emergent vegetation, (2) vertical vegetation structure, and (3) variation in water depth. Both vegetation structure and water cover and depth are likely affected by managed drawdowns or flooding, evaporation, or natural inundation through precipitation. Therefore, I also compared habitat variables in relation to the timing of water drawdowns in MSU wetlands. By identifying habitat use patterns of secretive marsh birds in MSU wetlands, managers could be better informed in how their activities might affect wetland use by these bird species. I performed surveys encompassing seasons of spring migration, breeding, and fall migration of five focal species: the American Bittern (*Botaurus lentiginosus*), Least Bittern (*Ixobrychus exilis*), King Rail (*Rallus elegans*), Virginia Rail, and Sora. All five species are known to migrate through—and breed in—eastern Kansas (Thompson et al. 2011) (Table 1).

STUDY AREA

Four state or federally-managed properties were used to conduct surveys: Flint Hills National Wildlife Refuge (FHNWR hereafter) in Hartford, Kansas; Marais des Cygnes National Wildlife Refuge (MDCNWR hereafter) and Marais des Cygnes State Wildlife Area in Pleasanton (MDCSWA hereafter), Kansas; McPherson Valley Wetlands State Wildlife Area (MVWSWA hereafter) in McPherson, Kansas (Fig 1.). The MDCNWR and MDCSWA were neighboring properties and thus considered in the current study as part of a single wetland complex. These sites were chosen due to the large complexes of moist soil managed wetlands located on each property. They offer a variety of marsh sizes and vegetation communities. All four properties are located in eastern Kansas and include a mixture of MSUs with variable hydroperiods (T.M. Menard, United States Fish and Wildlife Service Biologist, personal communication; K. Karrow, MDCSWA Manager, personal communication; J. Black, MVWSWA Manager, personal communication) and hydrologically passive managed marshes.

Figure 1. Locations (stars) of Flint Hills National Wildlife Refuge (FHNWR), Marais des Cygnes National Wildlife Refuge (MDCNWR) and Marais des Cygnes State Wildlife Area (MDCSWA) (both neighboring properties are symbolized by one star), and McPherson Valley Wetlands State Wildlife Area (MVWSWA) within the state of Kansas.


N
FHNWR
MVWSWA
MDCSWA
MDCNWR
0
62.5
125
250 Kilometers

Flint Hills National Wildlife Refuge (FHNWR) has a total area of 7,471 ha and is located in the Neosho River floodplain. The refuge consists of wetlands, riparian forests, tallgrass prairie, and some farmed land. The property contains 1,124 ha of wetland habitat, which can be filled by natural runoff, flooding, or by mechanical pumping via portable and permanent pumping stations (T.M Menard, personal communication). The wetlands are normally pumped beginning in September or October (T.M Menard, personal communication). There are 59 wetland units (<1 to 107 ha) located on the property, 19 of which were systematically selected for use in my study based on whether they were managed less intensively or for moist-soil, and size (T.M Menard, personal communication). The majority of the wetlands are managed as MSUs with a two oxbow lakes that typically hold water year round, and other small ephemeral wetlands (T.M Menard, personal communication). Drawdowns have historically begun in early march, with the majority of the units dry by the end of the spring, the only exceptions being oxbow lakes or wetlands without water control structures. The wetland units exhibit a variety of vegetation types, such as smartweeds, giant ragweed (*Ambrosia*), sedges, and spike rush (*Eleocharis*). At the end of the breeding season of our study species (Mid May – end of June; Table 1) in 2014, the third visit to FHNWR was canceled due to major flooding. In 2015, a major flood event caused the wetlands to be inaccessible throughout the breeding season. Flint Hills National Wildlife Refuge was included for bird surveys during spring migration in 2014-2015, the breeding season of 2014, and fall migration in 2014-2015.

Marais des Cygnes National Wildlife Refuge (MDCNWR) covers 3,035 ha and is adjacent to the Marais des Cygnes River. Only 7% of the total area is managed wetland habitat, though a third of the total area is within in the floodplain of the Marais des Cygnes River and is subjected to periodic flooding (US Fish and Wildlife Service 2013). The wetland unit surveyed at MDCNWR (23 ha) consisted of sedges, grasses, and forbs with ephemeral pools filled only by natural runoff and precipitation. This wetland was chosen due to its unique passive management and vegetation community (*Carex, Typha*, *Cyperus* etc.) and other wetlands at MDCNWR were too small to include (insufficient space for point-count and transect surveys). In the summer of 2014, the refuge staff mechanically removed a large number of eastern cottonwood (*Populus deltoides*) that had encroached upon the site. Marais des Cygnes National Wildlife Refuge was included for bird surveys during the spring migration and breeding season surveys of 2014 and 2015.

Marais des Cygnes State Wildlife Area (MDCSWA) encompasses 3,097 ha in the floodplain of the Marais des Cygnes River. Of the 3,097 ha, approximately 2,063 ha is managed wetland habitat (K. Karrow, personal communication). The area contains 10 major units containing multiple wetlands within each unit managed as MSUs (K. Karrow, personal communication). Nine individual wetlands in six of the larger units were randomly selected for this study. One of the 10 units was omitted due to farming. These wetland units are managed as a mosaic, with a variety of drawdown strategies to promote different vegetation types across the area (K. Karrow, personal communication). Drawdowns usually begin in early March, and can run to as late as mid-July in some wetlands. Vegetation on these sites was mostly a mix of barnyard grass (*Echinochloa*), smartweeds, sedges, grasses, and other wetland plants (K. Karrow, personal communication). Though the majority of the habitat is managed as MSUs, a small number of the wetlands recharge naturally through rainfall. A flood event in the breeding season of 2015 caused all but three of the wetlands to be inaccessible for the duration of the season. Marais des Cygnes State Wildlife Area was used for bird surveys during spring migration in 2014-2015, breeding season in 2014, and fall migration in 2014-2015.

McPherson Valley Wetlands State Wildlife Area (MVWSWA) encompasses 1,868 ha with 712 ha managed as wetlands. The wildlife area contains 51 total wetlands at three sites (J. Black, personal communication). The Big Basin unit was chosen for the study based on the size and number of marshes. Fifteen marshes within the site were chosen systematically due to unit sizes and whether or not they were available for hunting. Units from both hunted and non-hunted areas were selected. Nine of those marshes can be pumped using groundwater wells; however, due to water rights the majority of the units have to be managed using surface flow diversion during high runoff precipitation events and natural precipitation (J. Black, personal communication). The general lack of pumping ability leads to a much more passive style of water management, though wetlands are mechanically disturbed as needed to manage for cattails (*Typha* spp.) and invasive plant species, such as Purple loosestrife (*Lythrum salicaria*) (J. Black, personal communication). Generally there are no active drawdowns performed at MVWSWA. The marshes at MVWSWA contain a mix of grasses (*Echinocloa*, *Eleocharis*, etc.), smartweeds, cattails, and sedges. McPherson Valley Wetlands State Wildlife Area was included for bird surveys during the breeding season survey in 2015 and fall migration surveys in 2014 and 2015.

METHODS

Bird Surveys

During the spring migration (mid-March to early May) and breeding seasons (mid May to the end of June), I used a nationally standardized method for call-playback surveys, used for marsh bird monitoring programs across the United States, to detect birds within wetlands when male birds were using vocalizations to defend breeding territories and attract mates (Conway 2011). In the fall (late August to early November), when birds rarely respond to calls (Conway 1995, Lowther et al. 2005, Melvin and Gibbs 2012) and are unresponsive to call playbacks (Zimmerman 1984), an active flush count was used to detect individuals.

I did point counts of birds within each management unit during spring migration and the breeding seasons of the target species. Survey points were systematically distributed in a grid with 400 m between points in arrangements that allowed for sampling of 16-ha blocks per management unit (Conway 2011), yet spaced ≥100 m from the edge of each management unit. There were 51 systematically created survey points at FHNWR, 39 at MDCSWA, and one at MDCNWR. Point counts utilized a call-response survey approach (hereafter “playback surveys”) that demanded the 400-m spacing between points to maintain independence among sampling units (Conway 2011). As a result, some smaller management units only had a single survey point. These points were created using the Fishnet tool in ArcMap 10 (ESRI. Redlands, CA). Points that fell within a 100-m buffer of the edge of the wetland were censored. Each survey point was visited for playback surveys at least three times during spring migration (March-April) and breeding seasons (mid-May to mid-July).

During each visit I used the Standardized North American Marsh Bird Monitoring Protocol developed by Conway (2011). This method involved a passive 5-min point count followed by broadcasts of digital recordings of calls (acquired from the National Marsh Bird Monitoring Program) through a game caller loudspeaker. Five focal species were featured in the recorded playbacks including American Bittern, Least Bittern, King Rail, Virginia Rail, and Sora. Each species' call was broadcast for 30 s followed by a silent 30-s interval. Thus, the total survey period per point was 10 min. During this period I documented all individual birds heard and seen per species. This included non-target bird species, but priority was given to counting the five target species (Conway 2011). Wind speed (kph) was documented and distance to each bird response was estimated. Surveys were not performed when the wind speed exceeded 15 kph. Unlimited-distance point counts were used for documenting the occurrence of target species (Conway 2011); however, non-target species were only recorded within 100m of the point.. Surveys were conducted between 30 min before sunrise to 2 h after sunrise to coincide with the period of greatest call frequency by the focal species (Conway 2011). The point counts were used to estimate relative abundance (numbers of birds detected per point). Due to insufficient sample sizes and open populations during the spring, program DISTANCE and occupancy modeling could not be used for analyses. However, I feel that relative abundance estimates were sufficient to represent patterns of habitat use (Johnson 2008).

For the fall flush counts, I used a dependent double-observer method to count flushed birds and account for their imperfect detectability in estimating density (Nichols et al. 2000). Three flush counts were done per wetland unit from August to November.

This method involved two observers (approximately 10 meters apart) walking line transects to flush birds. The primary surveyor noted counted birds to the secondary observer, who recorded the primary's data along with any other birds that additionally were seen by the secondary observer (Nichols et al. 2000). Two parallel, variable-length transects were walked across the longitudinal or latitudinal axis of the wetland, depending on which was longer. These transects were spaced approximately a third of the way across the width of the wetland. The effective transect width, i.e., the maximum distance between observers and birds that flushed, was unknown but was assumed to be closely proximate to the observers, generally around 5-15 m distant.

Habitat Surveys

Point-scale habitat variables during spring migration and breeding season surveys were measured at six sampling points distributed within a 60-m radius of the point-count centers. Within each 60-m radius, two sampling points were spaced every 30-m along three transects, separated by 120°, that radiated from point centers. During the fall, vegetation surveys were performed at points spaced 100-m apart along each transect and at locations where individual birds were flushed during surveys. At all sampling points (all seasons surveyed) I measured the vegetation height and water depth (cm) using a measuring tape 5 m from the point center in each cardinal direction, and visually estimated the percent aerial cover of emergent vegetation, per plant genus, and bare ground within a 5-m radius centered on the point. Recording water depth allowed for measurement of temporal variation of water depth over the course of seasons and annual cycles. Habitat surveys occurred during the second survey period during the spring migration, twice during the breeding season, and after each flush count in the fall (August – November). Data collected at the sample point scale was averaged per point-count and across each line transect to arrive at a single measure (per variable) for each survey point or wetland unit, respectively. Each habitat measure was treated as a numerical value for regression analysis.

Statistical Analyses

Mean and maximum relative abundance estimates per survey point from point-count surveys were modeled against point-averaged habitat covariates in generalized linear models using Proc Mixed in program SAS (SAS Institute, Cary, NC). Data were not analyzed separately per year due to small sample sizes during each survey season. Habitat values were averaged per survey point for spring and breeding season data. Means of habitat variables across sampling periods were used in models for breeding season data. Species of grasses (*Echinocloa, Eleocharis, Panicum*) were pooled into one category due to similarity of habitat structure. Study site identity was included as a covariate. Covariates that were correlated (P<0.1, r>0.3) were not included in the same models to prevent multicollinearity. Property identity (covariate "Refuge" refers to study site) was included as a main effect in models of relative abundance. Year of study was not included as a covariate due to its widespread correlation with habitat variables. The most plausible models ($\Delta AIC_c \leq 2$), from all possible combinations of uncorrelated covariates and constant (intercept-only) models, were selected for each response variable using an information theoretic approach, where effect parameters (β, i.e., slopes) per covariate were averaged across plausible models (Burnham and Anderson 2002).

However, model averaging was only done across models within plausible model sets where covariates among those models were not correlated (otherwise model weights for redundant covariates are unreasonably penalized; Holoubek and Jensen 2015). Model-averaged parameter estimates were determined as important predictors if their 85% CIs did not include 0 (Arnold 2010).

The dependent double-observer method allowed for an adjustment for imperfect detectability in estimating bird species density from flush count data collected during fall migration. The data collected between observers was analyzed using program DOBSERV (http://www.mbr-pwrc.usgs.gov/software/dobserv.shtml; accessed 29 October 2013), which generated detection probabilities and estimates of population size based on detection probability. The basic form of the equation for estimating population size ($\widehat{N}$) using this approach is:

$$(\widehat{N} = \frac{n_1 n_2}{m}) \qquad (1)$$

where:

n_1 = total number of individuals seen by observer 1

n_2 = total number of individuals seen by observer 2

m = total number of individuals seen by both observers

These abundance estimates ($\widehat{N}$) were divided by the total length (m) of the transects per wetland to arrive at an encounter rate (density) for each species (i.e., numbers of birds per m of transect). These encounter rates were modeled in relation to average marsh-scale habitat covariates using Proc Mixed in SAS (SAS Institute Inc., Cary, NC, USA) and the information theoretic approach described previously, though here encounter rates of species were compared to habitat measured during respective survey periods (i.e., there were no mean and maximum estimates, only real-time measures).

I used an analysis of variance (ANOVA) with Proc GLM (SAS Institute Inc., Cary, NC, USA) to determine marsh bird habitat preferences within marshes in the fall by comparing habitat characteristics at points where marsh birds flushed (per species) relative to habitat characteristics at points along transect survey points. A GPS was used to record location of bird points at the time of flushing. Habitat data at these points was collected after the completion of each flush count and compared with per-survey habitat data from transects for these analyses.

I also used ANOVA to compare each habitat covariate in relation to water drawdown timing per year for each survey season at FHNWR and MDCSWA. I did not include MVWSWA in these analyses due to a lack of data on drawdowns for both years from that site (this deficiency also prevented cross-site inclusion of drawdown timing as a predictor variable in models of bird relative abundance and encounter rate). Breeding season data were only compared to drawdown timing in 2014 due to flooding at FHNWR and MDCSWA in 2015 that rendered those sites inaccessible during the breeding season. Mean wetland habitat variables per wetland (i.e., across sampling points per wetland) were compared to drawdown timing per year. Drawdown timing was categorized as early, middle, and late. The categories were defined by the estimated date at which the wetlands began to be drawn-down. “Early” was defined as a drawdown beginning in February or March, “middle” as beginning in April or May, and "late” being June or later. Habitat variables were compared to drawdowns preceding habitat measurements in the same calendar year. Due to flood events in the summers of 2014 and 2015, affected wetlands which were categorized as "late" drawdowns for analysis of fall habitat, regardless of the start date for the dewatering that may have occurred before inundation by floodwaters. Mean (±SE) water levels across all sampling points per site in were compared between 2014 and 2015 during spring and fall migrations. The breeding season was not included due to flooding in 2015 that made both FHNWR and MDCSWA inaccessible. Water cover and depth was not included in the analysis of fall habitat in relation to drawdown timing due to the pumping of wetlands beginning in late September.

RESULTS

In the springs of 2014 and 2015, 56 points in 31 wetlands at FHNWR, MDCSWA and MDCNWR were visited 154 times. During the breeding seasons of 2014 and 2015, 85 points in 40 wetlands at FHNWR, MDCSWA, MDCNWR and MVWSWA were visited 216 times. In the falls of 2014 and 2015, 52 transects in 26 wetlands at FHNWR, MDCSWA and MVWSWA were visited 123 times. During the spring migration of 2014, only 1 American Bittern (first detection 3 May), 2 Least Bittern (first detection on 14 March), and 3 Sora (first detection on 26 April) were detected. Detections of birds were higher in the spring of 2015, with 14 American Bittern (first detection 14 April), 3 Virginia Rail (first detection 21 April), and 28 Sora (first detection 21 April) detected. Due to low sample sizes of other species (<20 detections), Sora was the only species included in the analysis of relative abundance during spring migration. None of the target species were detected in the breeding season of 2014, though 39 other non-target bird species were detected, with Dickcissels (*Spiza americana)* and Red-winged blackbirds (*Agelaius phoeniceus*) being the most common. In the breeding season of 2015, a total of 64 American Bittern (all of which were found at MVWSWA), 4 Least Bittern, 2 Virginia Rail, and 6 Sora were detected. Due to low sample sizes, only American Bitterns at MVWSWA were included in analysis of relative abundance during the breeding season. During fall migration of 2014, 24 American Bittern, 4 Least Bittern, and 57 Sora were detected. The dates of first detection for all species was 2 September. During fall migration of 2015, 15 American Bittern (first detection 2 August), 3 Virginia Rail (first detection 27 August), and 12 Sora (first detection 27 August) were detected. Only American Bittern and Sora were included in the analysis of encounter rate in relation to habitat covariates.

During the spring migration, water cover and depth were lower at FHNWR and MDCSWA in 2014 than in 2015 (Fig 2). Water levels did not differ substantially between years at MDCNWR. During the fall migration, water cover and depth were higher at MDCSWA and MVWSWA in 2014 than in 2015 (Fig 3). Water cover at FHNWR was lower in 2014 than 2015, the site having deeper water in 2014 than 2015 (Fig 3).

Habitat covariates or the refuge covariate were included in most plausible models of relative abundance and encounter rates of American Bittern and Sora (Table 2).

Fig 2. Water aerial coverage and depths during the spring migrations of 2014 (open bars) and 2015 (solid bars) at Flint Hills National Wildlife Refuge (FHNWR), Marais des Cygnes National Wildlife Refuge (MDCNWR) and Marais des Cygnes State Wildlife Area (MDCSWA).

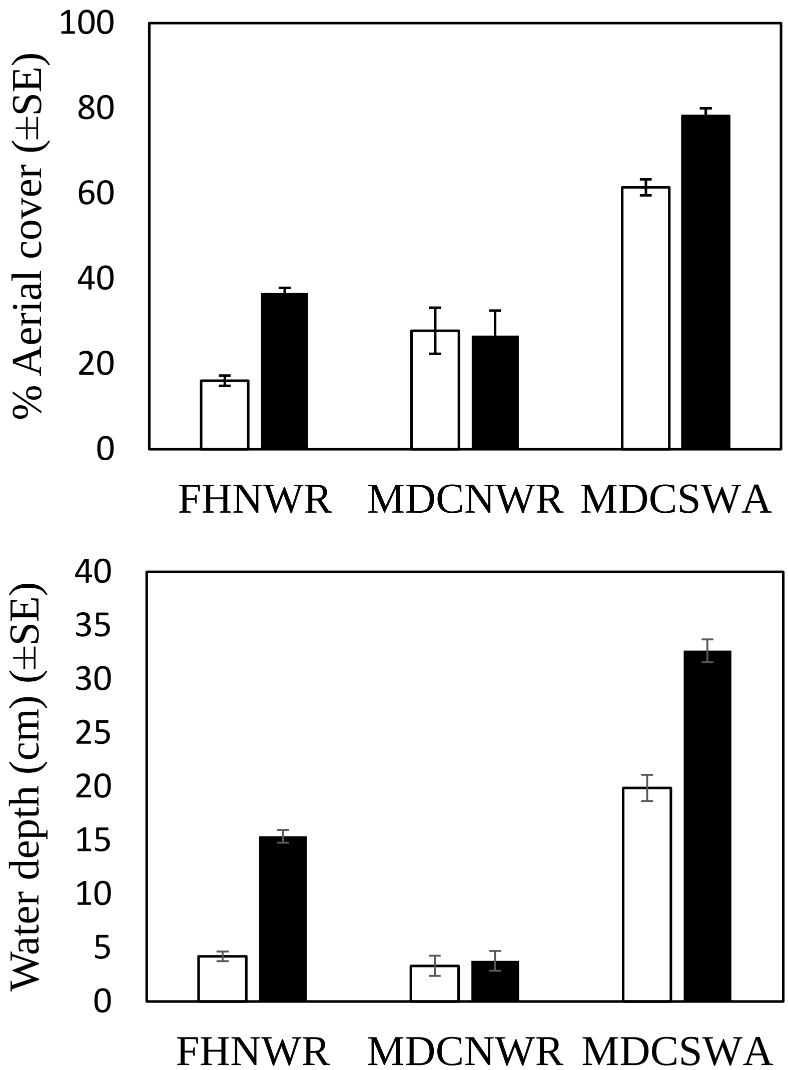
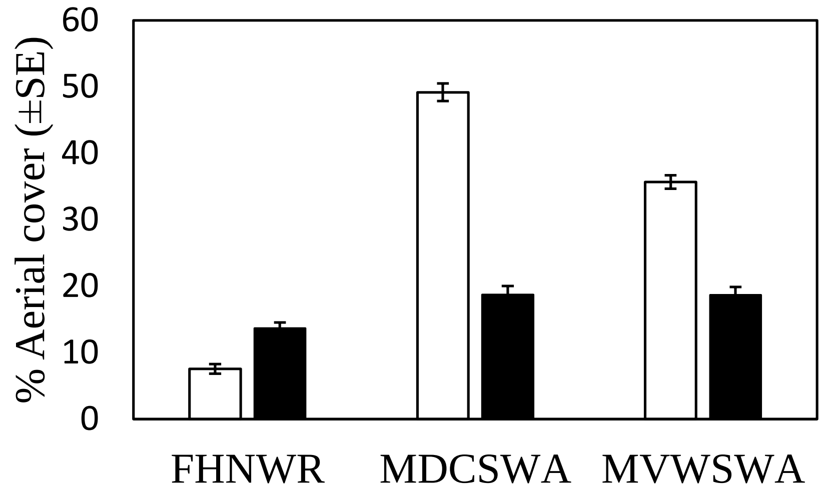

% Aerial cover (±SE)
100
80
60
40
20
0
FHNWR
MDCNWR
MDCSWA
Water depth (cm) (±SE)
40
35
30
25
20
15
10
5
0
FHNWR
MDCNWR
MDCSWA

Fig 3. Water aerial coverage and depths during the fall migrations of 2014 (open bars) and 2015 (solid bars) at Flint Hills National Wildlife Refuge (FHNWR), Marais des Cygnes State Wildlife Area (MDCSWA), and McPherson Valley Wetlands State Wildlife Area (MVWSWA). Marais des Cygnes National Wildlife Refuge was not included in Fall surveys.


60
50
40
30
20
10
0
% Aerial cover (±SE)
FHNWR
MDCSWA
MVWSWA

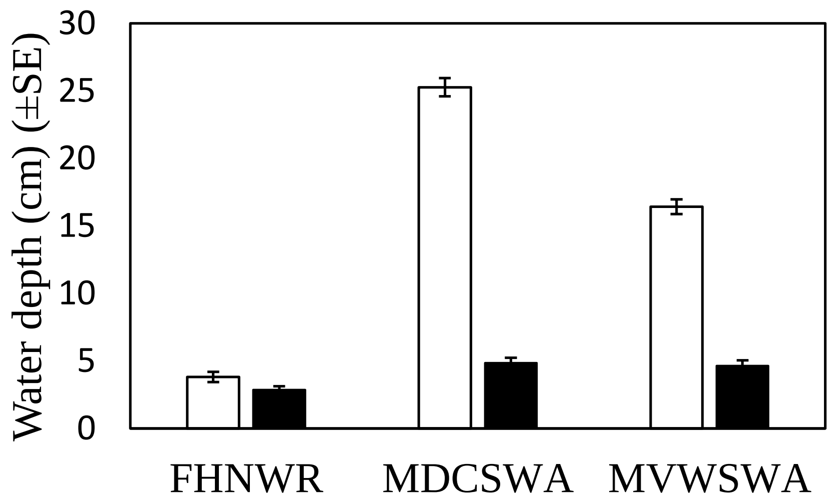

30
25
20
15
10
5
0
Water depth (cm) (±SE)
FHNWR
MDCSWA
MVWSWA

Table 2. Plausible (ΔAIC≤2) models for relative abundance and encounter rates of American Bittern (AMBI) and Sora (SORA) across different seasons in eastern Kansas, 2014 and 2015 (ordering of species follows phylogeny). Multiple models may appear per plausible model set where correlation of covariates among models prevented model averaging.

Species and metric	Season	AIC$_c$	$\sum w_i$[a]	Covariate β (± SE)
Mean AMBI relative abundance	Summer	50.2	0.5701	*Polygonum* cover[a] 0.0901 (0.0433)
		50.5	0.3533	*Polygonum* height[a] 0.0694 (0.0322)
Max AMBI relative abundance	Summer	58.6	0.486	*Polygonum* height[a] 0.1005 (0.0431)
AMBI encounter rate	Fall	429.8	0.279	Grass cover -0.007 (0.011) Refuge[d]
		430.1	0.239	Grass height -0.006 (0.0075) Refuge[d]
		430.4	0.205	*Polygonum* cover

				-0.0038 (0.0106) Refuge[d]
		431.1	0.144	*Polygonum* height -0.003 (0.0071) Refuge[d]
Mean SORA relative abundance	Spring	95.5	0.885	*Polygonum* height[b] 0.011 (0.005) Refuge[d]
Max SORA relative abundance	Spring	216.4	0.986	*Polygonum* height[b] 0.028 (0.009) Refuge[d]
SORA encounter rate	Fall	473	0.320	Constant[f]
		474.1	0.215	Mean *Polygonum* height 0.012 (0.013) Refuge[d]
		475	0.119	Grass cover -0.008 (0.0132) Refuge[d]

[a]Shows summed weights for every model in the set in which the covariate appeared.

[b]Indicates a strong association (85% CI for β does not include 0).

[c]Model averaged estimate.

[d]Among refuge patterns are described in Table 3.

[e]Intercept only model.

I reported only those associations of bird abundance with habitat covariates from plausible models ($\Delta AIC_c \leq 2$) where 85% CIs of β did not include 0. In the spring, mean and maximum relative abundance of Sora was positively associated with the height of *Polygonum* and varied among refuges (Table 2, Table 3). In the breeding season, mean relative abundance of AMBI was positively associated with both *Polygonum* cover and height. Max relative abundance of AMBI was positively associated with *Polygonum* height. There were no plausible models for any species during the fall migration of 2014 and 2015 where 85% CIs for β did not include 0 (Table 2), with the intercept-only model being best fit for Sora, so the effects of habitat variables were weak. The refuge covariate was included in plausible models for mean and maximum relative abundance of Sora in the spring, and encounter rate of American Bittern and Sora in the fall. The highest mean number of Sora was found at the wetland surveyed at MDCNWR, the lowest was found at MDCSWA (Table 3). The highest mean encounter rate for American Bittern was found at MVWSWA (Table 3). No American Bitterns were detected at FHNWR during the fall migration (Table 3). The refuge with the highest mean encounter rate for Sora during fall was MVWSWA, with the lowest encounter rate at MDCSWA (Table 3).

In comparing habitat variables between bird detection points and transect points within wetlands in the fall, American Bittern and Sora were associated with areas of significantly ($P < 0.05$) less bare ground and higher water cover than systematically surveyed transect points (Table 4). Sora were found in areas with deeper water than American Bittern, both species being found in deeper water than systematically surveyed transect points (Table 4). Sora were found in areas with higher *Polygonum* height and cover than both American Bittern and systematically surveyed transect points (Table 4).

Table 3. Mean number of Sora detections (± SE) during the spring migration, and mean encounter rates (± SE) of American Bittern and Sora during fall migration of 2014 and 2015 at Flint Hills National Wildlife Refuge, Marais des Cygnes National Wildlife Refuge, Marais des Cygnes State Wildlife Area and McPherson Valley Wetlands State Wildlife Area in Kansas. Encounter rate refers to the number of detections per meter of transect walked.

	FHNWR	MDCNWR	MDCSWA	MVWSWA
Sora detections	0.17 ± 0.06	1.00 ± 0	0.12 ± 0.07	[a]
American Bittern encounter rate	0	[a]	0.07 ± 0.05	1.28 ± 0.46
Sora encounter rate	0.55 ± 0.23	[a]	0.22 ± 0.12	1.25 ± 0.48

[a] Site was not included in the survey for that season.

Table 4. Comparison of habitat variables (mean ±SE) among point estimates of American Bitterns and Sora locations in marshes and systematic transect points during fall surveys in eastern Kansas, 2014-2015.

Covariate	American Bittern	Sora	Transect points
Bare ground	7.04 ± 2.70^{a}	1.40 ± 1.67^{a}	18.49 ± 0.45^{b}
Water cover	38.45 ± 3.00^{a}	42.60 ± 1.84^{a}	22.42 ± 0.50^{b}
Water depth	14.36 ± 1.39^{a}	18.34 ± 0.86^{b}	9.20 ± 0.23^{c}
Polygonum height	29.66 ± 4.21^{a}	52.44 ± 2.64^{b}	36.88 ± 0.72^{a}
Polygonum cover	16.40 ± 2.92^{a}	28.67 ± 1.80^{b}	20.79 ± 0.49^{a}
Typha height	25.13 ± 2.32^{a}	5.23 ± 1.43^{b}	4.47 ± 0.39^{b}
Typha cover	4.92 ± 0.60^{a}	0.52 ± 0.37^{b}	0.86 ± 0.10^{b}
Grasses height	24.85 ± 4.42^{a}	44.60 ± 2.73^{b}	38.04 ± 0.74^{b}
Grasses cover	16.21 ± 2.96^{a}	17.75 ± 1.83^{a}	25.08 ± 0.50^{b}

^{a,b,c} Means with different superscript letters are significantly different ($P < .05$) between location categories.

American Bitterns were associated with areas of with significantly higher heights and covers of *Typha*, and with areas with shorter grasses, than either Sora or systematic transect points (Table 4). Both American Bittern and Sora were detected in areas with lower grass cover than systematically surveyed transect points (Table 4).

During spring migration in 2014, middle-season drawdowns had the most bare ground cover, late-season having the least (Table 5). Water cover was lowest in wetlands with early drawdowns, and highest in wetlands with late-season drawdowns (Table 5). Water was deepest in wetlands with middle-season drawdowns, and shallowest in wetlands with early-season drawdowns, but there was no significant difference in water depth between late-season drawdowns and either early or middle-season drawdowns (Table 5). *Polygonum* cover and height was highest in wetlands with middle-season drawdowns, with no *Polygonum* recorded in late-season drawdown wetlands (Table 5). Grass cover and height was highest in wetlands with early drawdowns, and not detected in wetlands with late-season drawdowns (Table 5).

In 2015, bare ground cover was highest in wetlands with early-season drawdowns and lowest in wetlands with late-season drawdowns (Table 5). Water cover was highest with middle-season drawdowns, and water was deepest in wetlands with a late drawdown (Table 5). *Polygonum* cover was highest in wetlands with late and early drawdowns, and lowest in wetlands with middle-season drawdowns (Table 5). *Polygonum* was tallest in wetlands with middle-season drawdowns.(Table 5). Grass was not found in wetlands with late-season drawdowns (Table 5). Grass cover and height were higher in wetlands with early-season drawdowns, (Table 5). *Typha* was not present at either FHNWR or MDSWA, therefore it was not included in the analysis.

Table 5. Comparison of mean (± SE) habitat variables to drawdown strategies at Marais des Cygnes State Wildlife Area and Flint Hills National Wildlife Refuge in the spring of 2014 and 2015. "Early" indicates a drawdown beginning in February or March. "Middle" indicates a drawdown beginning in April or May. "Late" indicates a drawdown beginning in June or later.

2014

	Early	Middle	Late
Bare ground	22.59 ± 1.54[a]	28.05 ± 1.59[b]	12.07 ± 4.10[c]
Water cover	23.76 ± 1.63[a]	32.28 ± 1.68[b]	87.88 ± 4.34[c]
Water depth (cm)	5.84 ± 0.48[a]	12.23 ± 0.79[b]	7.56 ± 2.02[ab]
Polygonum cover	0.08 ± 0.26[a]	2.15 ± 0.27[b]	0 ± 0.70[a]
Polygonum height (cm)	0.08 ± 0.17[a]	0.91 ± 0.18[b]	0 ± 0.46[ab]
Grass cover	3.65 ± 0.42[a]	0.27 ± 0.43[b]	0 ± 1.13[b]
Grass height	3.46 ± 0.39[a]	0.50 ± 0.40[b]	0 ± 1.03[b]

2015

	Early	Middle	Late
Bare ground	41.5 ± 1.41[a]	18.63 ± 1.27[b]	16.83 ± 2.64[b]
Water cover	30.08 ± 1.58[a]	53.7 ± 1.43[b]	74.26 ± 2.96[c]
Water depth (cm)	10.32 ± 0.80[a]	22.71 ± 0.72[b]	38.02 ± 1.50[c]
Polygonum cover	4.49 ± 0.51[a]	3.31 ± 0.47[b]	6.38 ± 0.96[a]
Polygonum height (cm)	11.36 ± 1.19[a]	16.65 ± 1.08[b]	12.97 ± 2.23[a]
Grass cover	1.01 ± 0.16[a]	0.22 ± 0.15[b]	0 ± 0.31[b]

Grass height	1.71 ± 0.32^{a}	1.1 ± 0.29^{b}	0 ± 0.60^{b}

[a,b,c] Means with different superscript letters are significantly different ($P < .05$) between location categories.

During the breeding season of 2014, the highest amount of bare ground was found in wetlands with a middle-season drawdowns.(Table 6). Water cover and depth was lower in wetlands with early-season drawdowns than middle-season drawdowns (Table 6). *Polygonum* cover and height did not differ between early and middle-season drawdowns. (Table 6). Grass cover and height was higher in wetlands with early-season drawdowns (Table 6). There were no late drawdowns at either FHNWR or MDCSWA in 2014

In the fall of 2014, bare ground was higher in wetlands with late-season drawdowns. *Polygonum* cover and height were both lower in wetlands with middle-season drawdowns (Table 7). Grass cover was higher in late-season drawdowns; however, there was no difference in grass height between treatments (Table 7). In 2015, bare ground was lower in wetlands with a middle-season drawdown (Table 7). *Polygonum* cover and height depth were all greater in wetlands with middle-season drawdowns (Table 7). No grasses were detected in wetlands with middle-season drawdowns (Table 7). Water cover and depth was not included in the analysis of fall habitat in relation to drawdown timing due to the pumping of wetlands beginning in late September.

DISCUSSION

The amount of water in the wetlands surveyed, and numbers of secretive march birds, were highly variable between years. During the wetter periods (greater water depth and coverage), more marsh birds were detected during spring and fall. In the spring of 2015, later drawdowns resulted in greater water depth and coverage and a higher number of

Table 6. Comparison of mean (± SE) habitat responses to drawdown strategies at Marais des Cygnes State Wildlife Area and Flint Hills National Wildlife Refuge during the breeding season of focal marsh bird species in 2014. "Early" indicates a drawdown beginning in February or March. "Middle" indicates a drawdown beginning in April or May. There were no late drawdowns in 2014.

	Early	Middle
Bare ground	28.01 ± 0.96[a]	35.88 ± 1.33[b]
Water cover	6.69 ± 0.80[a]	34.58 ± 1.11[b]
Water depth (cm)	1.50 ± 0.29[a]	8.61 ± 0.40[b]
Polygonum cover	21.51 ± 0.79[a]	17.24 ± 1.10[a]
Polygonum height (cm)	28.40 ± 0.92[a]	15.02 ± 1.27[a]
Grass cover	6.20 ± 0.38[a]	2.97 ± 0.52[b]
Grass height (cm)	13.23 ± 0.66[a]	6.86 ± 0.92[b]

[a,b,c] Means with different superscript letters are significantly different ($P < .05$) between location categories.

Table 7. Comparison of mean (± SE) habitat responses to drawdown strategies at Marais des Cygnes State Wildlife Area and Flint Hills National Wildlife Refuge in the fall of 2014 and 2015. "Middle" indicates a drawdown beginning in April or May. "Late" indicates a drawdown beginning in June or later. "Early" drawdowns were omitted due to flooding during the summers of both 2014 and 2015.

	2014	
	Middle	Late
Bare ground	2.20 ± 0.47[a]	5.45 ± 0.46[b]
Polygonum cover	20.48 ± 1.30[a]	44.65 ± 1.29[b]
Polygonum height (cm)	34.05 ± 1.92[a]	77.15 ± 1.92[b]
Grass cover	16.5 ± 1.11[a]	22.79 ± 1.10[b]
Grass height (cm)	37.02 ± 1.95	37.07 ± 1.94

	2015	
	Middle	Late
Bare ground	13.75 ± 4.20[a]	37.46 ± 0.94[b]
Polygonum cover	24.11 ± 3.01[a]	13.40 ± 0.67[b]
Polygonum height (cm)	57.02 ± 3.75[a]	22.23 ± 0.84[b]
Grass cover	0 ± 3.79[a]	26.03 ± 0.84[b]
Grass height (cm)	0 ± 4.79[a]	37.27 ± 1.07[b]

[a,b] Means with different superscript letters are significantly different ($p < .05$) between location categories

Sora detections. Greater water depth and coverage in the fall of 2014 was associated with an increased encounter rate of American Bittern and Sora when compared to 2015.

Very few birds were detected in the spring migration or breeding season of 2014. In 2015, the water management strategy at FHNWR changed from early drawdowns site-wide to a more varied approach, where water was held later into the spring migration in numerous wetlands (T. M. Menard, personal communication). The change in water management in the spring of 2015 created more areas with a mixture of vegetative cover and water, and likely resulted in more detections for the spring. Later drawdowns of wetlands in the spring could provide usable habitat for migrating marsh birds in moist-soil wetlands.

By mid-May in 2014, drawdowns in all of the wetlands I surveyed at FHNWR and MDCSWA had been completed, resulting in no water during the breeding season and no detections of marsh birds. In the breeding season of 2015, major floods following high precipitation events rendered FHNWR and the majority of MDCSWA inaccessible. The addition of MVWSWA, a more hydrologically passive managed wetland complex than the other sites, likely resulted in the large increase in the number of American Bittern detections in 2015. Compared to the sites that I surveyed in 2014, MVWSWA offered a mix of habitats with persistent water and emergent vegetation, which American Bitterns use as nesting habitat (Lowther et al. 2009). Because drawdowns are either finished or being completed during the breeding season for marsh birds, it is unlikely that moist-soil management can provide adequate breeding habitat for these species. In fall there was greater water depth and coverage at FHNWR, MDCSWA and MVWSWA in 2014 than in 2015, which likely resulted in a higher number of marsh bird detections in

2014. The combination of emergent vegetation and open water found in 2014 likely offered higher quality habitat for migrating marsh birds.

While there were a small number of Least Bittern and Virginia Rail detections, no King Rail were found at any of my study sites. Least Bittern generally prefer habitats with deep water and a mix of emergent herbaceous vegetation and woody plants (Thompson et al. 2011). The study sites I surveyed generally did not have such habitat due to management for annual forbs and grasses. Virginia Rail generally coexist with Sora; however, they prefer to use wetlands that contain small pools of water and mudflats for foraging, which were not present in the wetlands at my study sites (Conway 1995). King Rails are said to be rare and transient within Kansas (Thompson et al. 2011).

Spring Migration

In 2014, I detected only six marsh birds at MDCSWA and MDCNWR. Due to the site-wide early season drawdowns at FHNWR, water levels and depth were much lower in 2014 than 2015, which likely offered no suitable habitat for migrating rails (Sayre and Rundle 1984) and bitterns (Lowther et al. 2009). During the spring migration of 2015, several more American Bittern and Sora were detected among all three sites, with the majority of detections occurring at FHNWR, where the water management strategy was altered to include more middle and late season drawdowns across the site than in 2014. The increase in detections of Sora in 2015 allowed for analysis to determine habitat associations of that species among wetlands during spring migration. I found that in the spring, Sora selected habitats based on the height of *Polygonum*. Sayre and Rundle (1984) also found that Sora selected habitats based on thick, standing vegetation. Other studies have suggested migrating Sora prefer wetlands with a mix of tall, dense cover and short seed producing plants (Melvin and Gibbs 2012). Due to the vegetative response to flooding in the late summer of 2014, thick standing *Polygonum* stems and middle- to late-season drawdowns probably offered the habitat structure that Sora preferred during spring migration. However, Rundle and Fredrickson (1981) found a higher numbers of rails at the Mingo National Wildlife Refuge in Missouri in a wetland managed with a middle season drawdown (drawn-down in mid-May), the former being done specifically for rails. The wetlands in which they found rails were at a much later stage of succession than others at Mingo and our sites, having contained more woody forbs than grasses and sedges (Rundle and Fredrickson 1981). Due to intense management for waterfowl at FHNWR and MDCSWA through the use of drawdowns and mechanical disturbance to limit shrub encroachment into wetlands, later successional habitats are generally not present.

I detected Sora until early May when they appeared to leave the sites until they would return for the fall; though this is only based on lack of detections from playback surveys during the breeding season. However, this observation agrees with Zimmerman (1984), who suggested that rails likely do not breed regularly in eastern Kansas due to a historical lack of wetland habitat.

Few American Bitterns were detected in the spring; however, the later drawdowns at FHNWR may have made more habitat available where water was held later in the season, as the number of American Bitterns detected at FHNWR increased from zero detections in 2014 to 12 in 2015. Lowther et al. (2009) stated that habitat for migrating American Bitterns generally included wetlands dominated by thick stemmed plants like

Typha and *Polygonum* with deep water. Holding water later in wetlands with standing vegetation might also be beneficial for American Bittern during the spring migration.

Breeding Season

In 2014, the timing of drawdowns were generally early to middle-season on both MDCSWA and FHNWR, which led to very little water cover in the wetlands that were surveyed during the breeding season, and a lack of breeding marsh bird detections. In the breeding season of 2015, MVWSWA was included after flooding made all of FHNWR and the majority of MDCSWA inaccessible for surveys in that year. However, in 2015 the addition of MVWSWA's more hydrologically passive managed wetlands likely resulted in an increase in detections of breeding marsh birds in 2015, specifically American Bittern.

Of all species I detected during the breeding season, American Bittern were of sufficient abundance (64 detected) for analysis to determine habitat associations among wetlands. American Bitterns seemed to favor the passively-managed wetlands at MVWSWA that had a mix of *Typha* and *Polygonum* with some common species of graminoids—such as *Echinocloa*, *Panicum*, and *Eleocharis*—over other areas surveyed in 2014. I found that the relative abundance of American Bittern was positively associated with the cover and height and coverage of *Polygonum*. Other studies have also shown that breeding American Bitterns tend to select habitats based on standing water and thick vegetative cover (Lor and Malecki 2006, Bolenbaugh et al. 2011, Baschuk et al. 2012). At MVWSWA American Bitterns were more often detected in clumps of vegetation in marshes that did not necessarily have high vegetation cover-to-water ratio, contrary to what had been found at other breeding sites (Rehm and Baldassarre 2007, Bolenbaugh et al. 2011). This could partly be explained by the difference in management strategies: the sites Rehm and Baldassarre studied in New York were dominated by *Typha*, whereas the wetlands at MVWSWA had pockets of *Typha* mixed with *Polygonum* and grass species common in MSUs.

The interspersion, or mixing of these habitat types, could be an important feature (Rehm and Baldassarre 2007) for the wetlands we surveyed at MVWSWA; however, we did not have the ability to accurately describe such a pattern. *Typha* is generally found in wetlands in a later stage of succession than what is otherwise desirable for waterfowl management in MSUs, so this plant is rarely present within intensively-managed wetlands (Fredrickson and Taylor 1982, Strader and Stinson 2005). Very few cattails or robust emergent vegetation were present at FHNWR and MDCNWR, which is a likely one reason breeding American Bitterns were not detected in either year. Thompson et al. (2011) report few confirmed American Bittern breeding records scattered across Kansas, which could suggest that they may rarely breed in the state regardless of habitat conditions. Sora tend to prefer similar breeding habitats to American Bittern, and are generally found in wetlands with a mix of robust vegetation like *Typha*, sedges (*Carex* spp., *Cyperus* spp.) and bulrushes (*Scirpus* spp.) (Melvin and Gibbs 2012).

Fall Migration

There has been very little research done to determine habitat associations of secretive marsh birds during their fall migration. Water levels differed between years during our study, in 2014 there was generally more water at all three sites, which may have led to a higher encounter rate of secretive marsh birds in that year. Our models showed no strong associations between habitat covariates and encounter rate of American Bittern or Sora among wetlands. However, habitat use patterns of American Bittern and Sora were apparent within wetlands during fall migration. American Bittern and Sora were generally used habitats with higher vegetative cover (particularly *Polygonum* and *Typha*) and water than the systematically surveyed transect points. During migration in both spring and fall, the presence of water and emergent vegetation could be more important than the specific type of plant species found in the wetlands due to cover requirements for secretive species of marsh birds (Melvin and Gibbs 2012, Lowther et al. 2009, Conway 1995). Melvin and Gibbs (2012) found that during migration, Sora partly feed by stripping seeds from plants such as *Polygonum*, and that water depth relative to the seed heads of these plants, where deeper water in areas with taller plants would allow for more available food, could be important in their habitat selection. Earlier flooding (beginning in late August) of some wetlands may be all that is required to provide fall migration habitat for bitterns and rails.

Management Implications

At large wetland complexes like FHNWR, MDCSWA, and MVWSWA, it may be possible to manage for a variety of different habitat needs through heterogeneity of drawdown timings of MSUs. While early-season drawdowns are important for the production of important waterfowl food sources like *Polygonum*, we found that holding water later provided habitat for migrating rails and bitterns (Fredrickson and Taylor 1982, Strader and Stinson 2005). The use of later drawdowns (beginning in April) drawdowns in MSUs with areas of standing vegetation could provide habitat for migrating marsh birds, while also providing some *Polygonum* production for waterfowl.

Although I detected some marsh bird use during the breeding season, use of MSU habitats is likely limited in the areas we studied, especially in years with a more typical hydroperiod; however it may not be practical to manage for breeding rails in eastern Kansas as they may not be regular breeders (Zimmerman 1984). Zimmerman suggests it could be due to the lack of natural wetlands (Zimmerman 1984).

During fall migration, secretive marsh bird use of MSUs may be limited by timing of initial flooding. I detected use as early as the first week of September, and historical information suggests use even earlier. Flooding by late August or early September would provide vital marsh bird habitat. Management of wetlands for early fall migrant waterfowl could provide adequate habitat for secretive marsh birds.

Overall, the management of MSUs using a diverse mix of drawdown timings could provide habitat for migrating secretive marshbirds. Due to the overlap with migrating waterfowl, the best habitat conditions are likely present in the fall. However, because moist-soil management may not provide habitat that reliably meets the needs of secretive marsh birds throughout their annual cycle, the protection and management of semi-permanent wetlands should also be a priority.

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