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Optimizing surveys for marsh songbirds: does timing matter?

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ABSTRACT. Analysis of data from point counts, a common method for monitoring bird population trends, has evolved to produce estimates of various population parameters (e.g., density, abundance, and occupancy) while simultaneously estimating detection probability. An important consideration when designing studies using point counts is to maximize detection probability while minimizing variation in detection probability both within and between counts. Our objectives were to estimate detection probabilities for three marsh songbirds, including Marsh Wrens (*Cistothorus palustris*), Swamp Sparrows (*Melospiza georgiana*), and Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), as a function of weather covariates and to evaluate temporal variability in detection probability of these three species. We conducted paired, unlimited radius, 10-min point counts during consecutive morning and evening survey periods for our three focal species at 56 wetlands in Iowa from 20 April to 10 July 2010. Mean detection probabilities ranged from 0.272 (SE = 0.042) for Marsh Wrens to 0.365 (SE = 0.052) for Swamp Sparrows. Time of season was positively correlated with detection probability for Swamp Sparrows, but was negatively correlated with detection probability for Yellow-headed Blackbirds, suggesting that detection probability increased during the breeding season for Swamp Sparrows and was highest early in the breeding season for Yellow-headed Blackbirds. Understanding how detection probabilities of marsh songbirds vary throughout the breeding season allows targeted survey efforts that maximize detection probabilities for these species. Furthermore, consistent detection probabilities of marsh songbirds during morning and evening survey periods mean that investigators have more time to conduct surveys for these birds, allowing greater flexibility to increase spatial and temporal replication of surveys that could provide more precise estimates of desired population parameters.

RESUMEN. **Optimizando el muestreo de aves de pantano: es importante el tiempo en el que se hace?**

El análisis de datos de puntos de conteo, un método común para el monitoreo de tendencias poblacionales en aves, ha evolucionado con el fin de producir estimados de varios parámetros poblacionales (e.g., densidad, abundancia, ocupación), estimando simultáneamente la probabilidad de detección. Una consideración importante en el diseño de estudios que usan puntos de conteos es maximizar la probabilidad de detección y minimizar la variación en la probabilidad de detección dentro y entre conteos. Nuestros objetivos fueron la estimación de la detección de probabilidad en tres especies de aves paseriformes de pantano, incluyendo *Cistothorus paulstris*, *Melospiza georgiana* y *Xanthocephalus xanthocephalus* como una función de covariables climáticas y la evaluación de la variabilidad temporal en la probabilidad de detección de estas tres especies. Realizamos conteos pareados sin limite de radio y de 10 minutos de duración durante periodos de muestreo consecutivos en la mañana y en la tarde para nuestras tres especies focales en 56 humedales en Iowa entre el 20 de Abril y el 10 de Julio de 2010. La probabilidad de detección promedio estuvo entre 0.272 (SE = 0.042) para *Cistothorus palustris* y 0.365 (SE = 0.052) para *Melospiza georgiana*. El día de la temporada estuvo positivamente relacionado con la probabilidad de detección de *Melospiza georgiana,* pero negativamente relacionada con la probabilidad de detección de *Xanthocephalus xanthocephalus*, lo cual sugiere que la probabilidad de detección incrementó durante la temporada de reproducción de *Melospiza georgiana* y fue mayor al inicio de la temporada de reproducción en *Xanthocephalus xanthocephalus*. Entender como varían las probabilidades de detección de aves de pantano a través de su temporada de reproducción permite hacer esfuerzos de monitoreo focalizados que maximizan la probabilidad de detección de estas especies. Adicionalmente, la consistencia en las probabilidades de detección de estas aves de pantano durante los monitoreos de la mañana y la tarde sugieren que los investigadores tienen más tiempo para realizar estos monitoreos para estas aves, permitiendo mayor flexibilidad para incrementar la replicación espacial y temporal de los monitoreos, los cuales puede proveer estimados mas precisos de los parámetros poblacionales.

Key words: detection probability, Marsh Wren, point count, survey timing, Swamp Sparrow, Yellow-headed Blackbird

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Point counts have long been established as the preferred method for estimating population trends in birds (Hutto et al. 1986, Ralph et al. 1995, Rosenstock et al. 2002, Bart 2005). Data obtained through such counts can vary in two ways: (i) by the presence, absence, or abundance of birds at the count location; and (ii) the ability of the observer to detect birds at the count location given they are present (Bas et al. 2008). Researchers are often interested in estimating the first form of variation directly to evaluate population trends in birds. However, failure to account for the second form of variation, namely detection probability, can lead to increased variation and bias in the resulting population estimates (Diefenbach et al. 2003, Gu and Swihart 2004, Bas et al. 2008). In light of this, various methods have been developed to directly estimate detection probability from point count data (Nichols et al. 2000, Farnsworth et al. 2002, Rosenstock et al. 2002, Royle 2004, Kéry et al. 2005). Although requiring either additional data (e.g., replicated counts or linear distances to individual birds) or imposing added logistical constraints (e.g., double observer), these methods are important if the goal is to obtain accurate and precise estimates of population parameters (Rosenstock et al. 2002, Thompson 2002).

An important consideration when designing studies using point counts is to simultaneously maximize detection probability of the species of interest while minimizing both within- and between-count variation in detection probability (Lynch 1995). Variation in detection probability both within and between counts can be caused by several factors including weather (Bas et al. 2008), habitat characteristics (Schieck 1997, Wilson et al. 2000, Tozer et al. 2006), observer abilities (Kendall et al. 1996, Diefenbach et al. 2003), and background noise (Simons et al. 2007). Detection probability can also vary temporally within individual point count periods (Shields 1977, Verner and Ritter 1986), among point counts conducted at different times of day (Robbins 1981, Kessler and Milne 1982, Rollfinke and Yahner 1990, Smith and Twedt 1999, Bas et al. 2008), and seasonally (Rollfinke and Yahner 1990, Selmi and Boulinier 2003). Thus, several investigators have attempted to establish optimal timing and duration of point counts to maximize detection probability and ultimately improve estimates of population trends and species richness (Barker et al. 1993, Petit et al. 1995, Siegel et al. 2001, Thompson et al. 2002, Tozer et al. 2006, Bonthoux and Balent 2012). No one to date, however, has attempted to establish the optimal timing of point counts for marsh passerines that can be counted during surveys for other species of marsh birds. Furthermore, marsh birds are of conservation concern throughout the United States, thus elevating the need to optimize surveys to gather population information on these species to inform conservation decisions.

The Standardized North American Marsh Bird Monitoring Protocol (hereafter, marsh bird protocol) was established in 2011 as a framework for surveying and estimating population trends of secretive marsh birds (Conway 2011). The protocol recommends the use of call-broadcasts during point counts to increase detection probability of secretive species (e.g., bitterns, rails, and grebes) and suggests that surveys be conducted both in the morning (30 m before sunrise to 3 h after sunrise) and evening (3 h before sunset to 30 m after sunset). In addition to secretive species, the protocol lists other non-focal species that can be recorded during point counts where call-broadcasts are not necessary, e.g., Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*) and Swamp Sparrows (*Melospiza georgiana*). Despite using call-broadcast methodology, detection probability of secretive marsh birds has been found to vary both by time of day and seasonally (Rehm and Baldassarre 2007, Nadeau et al. 2008, Harms and Dinsmore 2014, Wiest and Shriver 2016). No one, however, has examined temporal differences in detection probability of non-focal marsh bird species, information valuable not only to validate the marsh bird protocol for surveying non-focal species, but also to aid managers interested in estimating population trends of marsh passerines using data collected under the marsh bird protocol or other count methods.

Some investigators have compared bird detections between surveys conducted in the morning (3 h after sunrise) to those conducted in the evening (3 h before sunset). Most have found that more birds are detected during morning surveys than evening surveys

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(Kessler and Milne 1982, Rollfinke and Yahner 1990, Smith and Twedt 1999). However, all of these studies used counts of birds, or bird detections, as an index for comparing morning and evening studies. No study, to our knowledge, has estimated detection probabilities for passerines on evening surveys. Furthermore, no study has compared passerine detection probabilities for evening surveys to those estimated for morning surveys. This information is valuable for survey design for all passerine species because if no difference is found, the amount of time available for passerine surveys during a given survey season could be doubled. This allows for added spatial and temporal replication of surveys, therefore potentially increasing the precision of parameter estimates and, ultimately, the reliability of information gained from passerine surveys.

Our objective was to estimate detection probabilities for three species of marsh passerines, including Marsh Wrens (*Cistothorus palustris*), Swamp Sparrows, and Yellow-headed Blackbirds (hereafter, marsh passerines) for both morning (30 m before sunrise to 3 h after sunrise) and evening (3 h before sunset to 30 m after sunset) surveys and compare detection probabilities for each species between the two survey windows. We also evaluated the possible influence of weather covariates (wind speed, temperature, and cloud cover) on detection probabilities for each species during both morning and evening surveys. Lastly, we evaluated temporal trends in detection probabilities for each species during both morning and evening survey windows. Based on our observations and biological knowledge of our study species (Harms 2011), we predicted that detection probability of Swamp Sparrows would be greater during morning surveys than evening surveys, but that detection probabilities of Yellow-headed Blackbirds and Marsh Wrens would not differ between morning and evening surveys. We also predicted that detection probabilities of Swamp Sparrows and Yellow-headed Blackbirds would decrease throughout the breeding season, but detection probability for Marsh Wrens would not vary as a function of season. Lastly, we predicted that detection probability of all three species would be negatively influenced by wind speed during both morning and evening surveys.

METHODS

We conducted our study in the Prairie Pothole Region (PPR) of north-central and northwest Iowa (Fig. 1). The PPR extends across five states and three Canadian provinces, from north-central Alberta south and east across southern Saskatchewan, Manitoba, and northern Montana extending down through the Dakotas, western Minnesota, and northwestern Iowa. In Iowa, the PPR encompasses ~310,607 ha and portions of 30 counties. This area was historically dominated by a mix of tall- and mid-grass prairie and shallow, depressional wetlands. Since European settlement, however, the landscape in the PPR has experienced drastic modification to facilitate agricultural development. In the Iowa portion of the PPR, < 1% of historic grassland and wetland habitats exist, resulting in a landscape currently dominated by row-crop agriculture (Bishop et al. 1998).

Wetland selection. We selected survey wetlands in the Iowa PPR from the National Wetlands Inventory database (NWI; U.S. Fish and Wildlife Service 2009). The NWI classifies wetlands into systems, classes, and subclasses based on the type of wetland (e.g., palustrine, lacustrine, and riverine) and the habitat characteristics within the wetland (Cowardin et al. 1979). Approximately 95% of the wetlands in Iowa fall in one of three NWI classes in the Palustrine system: Aquatic Bed (AB), Unconsolidated Bottom (UB), or Emergent (EM; Cowardin et al. 1979). Therefore, we included all wetlands in these three classes in our sampling frame. Furthermore, wetlands in these three classes had habitat characteristics suitable for our study species, including shallow water (< 1 m deep), surrounded by few or no trees, and the presence of both emergent and submergent vegetation. We considered both natural and constructed wetlands for selection and only considered wetlands on public land, which constituted ~ 8% of wetlands in the above-mentioned sampling frame, to facilitate access for surveys. Vegetation communities at most surveyed wetlands consisted of cattails (*Typha* spp.), sedges (*Carex* spp.), bulrushes (*Scirpus* spp. and *Schoenoplectus* spp.), and reed canary grass (*Phalaris arundinacea*). Most wetlands were either permanent or semi-permanent as defined by Stewart and Kantrud (1971), but

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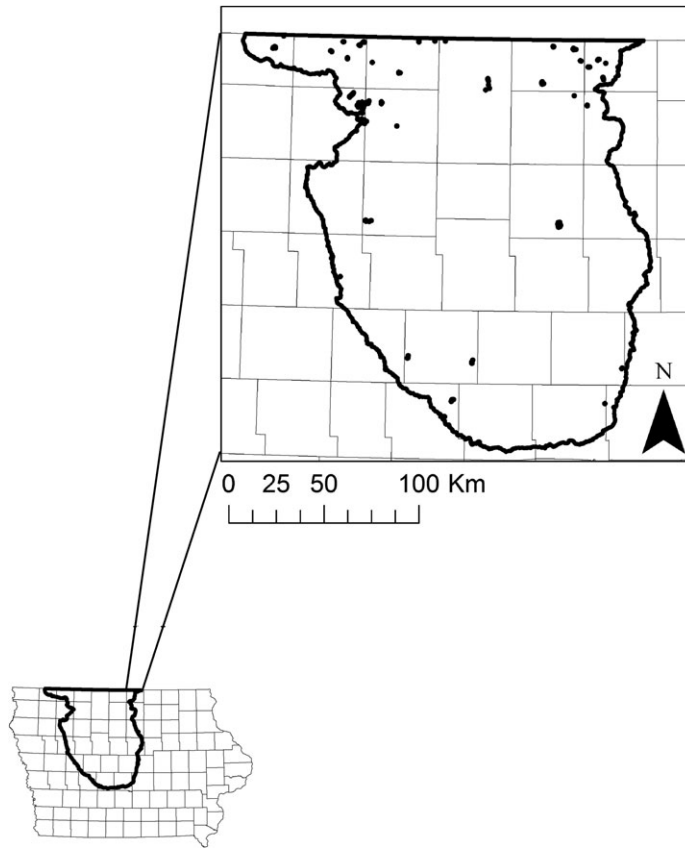

Fig. 1. Locations of survey wetlands in the Prairie Pothole Region of Iowa, 2010. The thin black lines outline counties and the thick black line outlines the Prairie Pothole Region in Iowa.

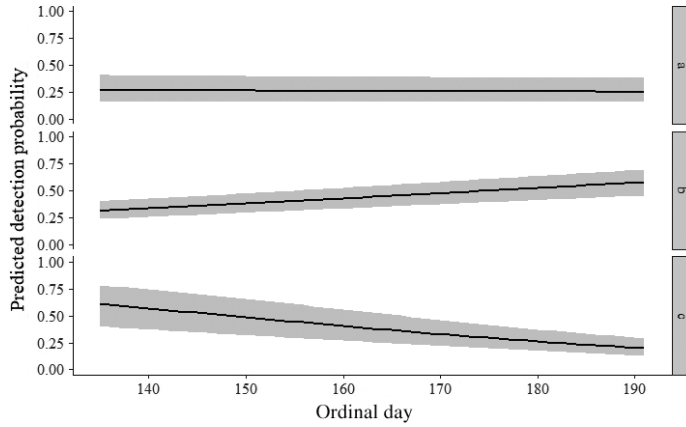

Fig. 2. Predicted detection probabilities of (A) Marsh Wrens, (B) Swamp Sparrows, and (C) Yellow-headed Blackbirds as a function of time of season (i.e. ordinal day) in Iowa, 2010. Gray shading represents 95% confidence intervals.

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some temporary and seasonal wetlands were also included in our study.

Following procedures outlined in Harms and Dinsmore (2012), we stratified wetlands into six different size classes and randomly selected wetlands in each size class. Next, we randomly placed survey points at least 400 m apart in each wetland, with the number varying by size class (Harms and Dinsmore 2012).

Bird surveys. We conducted unlimited radius, 10-min point counts for marsh songbirds from 20 April to 10 July 2010, a period that encompassed the breeding seasons of all species (Blondel et al. 1981). We conducted paired surveys at 56 wetlands during the early morning (30 min before sunrise to 3 h after sunrise) and late evening (3 h before sunset to 30 min after sunset). Surveys were conducted during consecutive survey periods (e.g., evening-morning or morning-evening) to avoid any daily variation in detection probability (Nadeau et al. 2008). We also varied the order in which surveys were conducted at different times of day so that surveys at any given point were not always conducted during the morning or the evening (Conway et al. 2004). We repeated the paired surveys both early in the breeding season (15 May–14 June) and late in the breeding season (15 June–14 July), resulting in a total of four surveys for each wetland. We recorded individuals of all species heard and seen during the survey period, taking care not to double-count birds. We recorded temperature (°C) and wind speed (Beaufort scale, or bft) prior to surveys at each point and visually estimated the amount of cloud cover (0 – few or no clouds, 1 – partly cloudy, 2 – cloudy or overcast, or 4 – fog). We did not conduct surveys during periods of rain or when wind speeds exceeded 3 bft.

For each point, we recorded the start time of the survey so we could determine if the survey was conducted in the morning or evening. We also calculated the time difference (min) between when a survey was started and the time of sunrise or sunset, depending on whether the survey was conducted in the morning or evening. The time was centered on sunrise or sunset, so if a survey was started before sunrise or sunset the time difference was negative. For example, if sunset was at 21:00 and a survey was started at 20:00, the covariate value would be −60 for that point. Lastly, we included ordinal date as a covariate for surveys conducted at each point to evaluate potential seasonal differences in detection probability.

Models. We used N-mixture models to estimate detection probability and abundance (e.g., birds/survey point) of marsh passerines (Royle 2004). We considered each point as the sampling unit in our analyses because we were interested in how survey timing influenced detection probability. We assumed survey points were independent because they were > 400 m apart (Conway 2011). Our model set contained 15 models that included individual effects of temperature, wind speed, cloud cover, time of day (e.g., morning or evening), time of season (i.e. ordinal day), and time since sunrise/sunset on detection probability as well as a global model (i.e. all additive effects). Because we were most interested in effects of survey timing on detection probability, we included the interactions of time of day and all other variables as well as the interactions of time of season and time of day and time of season and time since sunrise/sunset on this parameter. We also included the quadratic effect of time of season because we deemed it plausible that detection probability could peak in the middle of the breeding season. Because we were not interested in evaluating effects on abundance, we kept this parameter constant in all models. Lastly, we modeled constant detection probability and abundance (i.e. no covariate effects) to obtain an overall estimate of each parameter.

We modeled our count data as a Poisson mixture using package "unmarked" in Program R (Fiske and Chandler 2011, R Core Team 2016). We evaluated the relative contribution of each model compared to all other models using Akaike's Information Criterion (AIC; Akaike 1973). We considered the model with the lowest AIC value for each species as the best supported model for that species and also considered important any models within two AIC units ($\Delta AIC \leq 2$) of the best model (Burnham and Anderson 2002). Covariate effects were considered significant if the respective 95% confidence interval did not include zero. We assessed fit of the top model to the data for each species by simulating 50 individual data sets from

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the fitted model and calculating a chi-square fit statistic using the "Nmix.gof.test" function in package "AICcmodavg".

RESULTS

We surveyed 128 points at 56 wetlands in 2010, and counted 1126 Marsh Wrens (613 in the morning and 513 in the evening), 647 Swamp Sparrows (328 in the morning and 319 in the evening), and 537 Yellow-headed Blackbirds (267 in the morning and 270 in the evening). The top model for each species exhibited lack of fit ($P > 0.05$) according to the chi-square goodness-of-fit test, likely due to overdispersion in the data (Ver Hoef and Boveng 2007). Therefore, we multiplied the standard errors of our estimates of detection probability for each species by the square-root of the overdispersion parameter ($\hat{c}$) to account for additional variability generated by overdispersion (Kéry and Royle 2016).

For Marsh Wrens, we estimated overall detection probability to be 0.272 ± 0.063 (SE) and abundance per point to be 8.26 ± 2.10 (SE) birds. The best model indicated the interaction of time of day and time since sunrise/sunset as an important predictor of detection probability for Marsh Wrens (Table 2), although this effect was not significant ($\beta = -0.003$, 95% CI = -0.007, 0.001). Detection probability did not differ between morning and evening survey periods (Table 1).

We estimated the overall detection probability for Swamp Sparrows to be 0.365 (SE = 0.052) and detection probability did not differ between morning and evening survey periods (Table 1). We estimated abundance of Swamp Sparrows to be 3.54 ± 0.50 (SE) birds per point. The best model included a positive effect of time of season on detection probability for Swamp Sparrows ($\beta = 0.020$, 95% CI = 0.013, 0.027; Table 2), meaning that detection probability increased later in the season.

Table 1. Estimated detection probability (95% CI) for Marsh Wrens, Swamp Sparrows, and Yellow-headed Blackbirds by survey period in Iowa, 2010.

	Morning	Evening
Marsh Wren	0.25 (0.18, 0.34)	0.23 (0.16, 0.32)
Swamp Sparrow	0.37 (0.27, 0.478	0.37 (0.26, 0.50)
Yellow-headed Blackbird	0.32 (0.25, 0.42)	0.33 (0.24, 0.44)

Estimated detection probability and abundance for Yellow-headed Blackbirds were 0.316 ± 0.061 (SE) and 3.40 ± 0.43 (SE) birds per point, respectively. The best model included a negative effect of time of season as an important predictor of detection probability for Yellow-headed Blackbirds ($\beta = -0.033$, 95% CI = -0.041, -0.025; Table 2), indicating that detection probability was greatest earlier in the season. The single competitive model ($\Delta AIC = 0.41$) included the interaction of time of day and time of season as an important predictor of detection probability for Yellow-headed Blackbirds, but this effect was not significant (95% CI = -0.014, 0.001; Table 2). Again, detection probability did not differ between morning and evening survey periods (Table 1).

DISCUSSION

An important consideration when designing effective point count surveys is the temporal variation (both diel and seasonal) in detectability (Lynch 1995, Selmi and Boulinier 2003, Rehm and Baldassarre 2007, Bas et al. 2008). Failing to account for this variation can introduce extreme bias in population trends estimated from point-count data (Selmi and Boulinier 2003, Schmidt et al. 2013). Understanding these patterns in detection probability also has clear implications for designing monitoring surveys (Converse and Royle 2012). Surprisingly, this topic has received little attention in songbird surveys, despite the number and taxonomic diversity of studies of this group. Our study is the first to our knowledge to report detection probabilities for these three non-focal species of marsh passerines. Detection probabilities for two other marsh songbirds, Seaside Sparrows (*Ammodramus maritimus*) and Saltmarsh Sparrows (*A. caudacutus*), were 0.03 ± 0.01 and 0.43 ± 0.06, respectively (Wiest and Shriver 2016). Our estimates of detection probability for all three of our focal species are comparable to those as well as to those reported for focal marsh bird species

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Table 2. Model selection results for Marsh Wrens, Swamp Sparrows, and Yellow-headed Blackbirds in Iowa, 2010.

Covariates	*K*	AICc	ΔAICc	wt
Marsh Wren				
TOD*Time	5	1875.75	0.00	0.97
Time	3	1882.77	7.02	0.03
Temp	3	1897.83	22.08	0.00
TOD*Wind	5	1899.17	23.42	0.00
TOD*Temp	5	1899.30	23.55	0.00
Wind	3	1900.00	24.25	0.00
Cloud	3	1900.15	24.40	0.00
TOD*Cloud	5	1902.06	26.31	0.00
TOD*TOS	5	1913.02	37.27	0.00
TOS	3	1913.50	37.75	0.00
TOD	3	2034.50	158.75	0.00
Constant	2	2035.90	160.15	0.00
TOS*Time	5	2116.23	240.48	0.00
TOS^2	3	2175.01	299.26	0.00
Global	15	3013.82	1138.07	0.00
Swamp Sparrow				
TOS	3	1336.68	0.00	0.79
TOD*TOS	5	1339.31	2.63	0.21
TOS*Time	5	1352.12	15.44	0.00
Temp	3	1352.97	16.29	0.00
Time	3	1353.91	17.23	0.00
TOD*Temp	5	1354.45	17.77	0.00
TOD*Time	5	1357.50	20.82	0.00
TOD*Cloud	5	1362.18	25.50	0.00
Wind	3	1362.71	26.03	0.00
Cloud	3	1362.83	26.15	0.00
TOD*Wind	5	1366.42	29.74	0.00
Constant	2	1445.81	109.13	0.00
TOD	3	1447.78	111.10	0.00
TOS^2	3	1590.07	253.39	0.00
Global	15	1594.66	257.98	0.00
Yellow-headed Blackbird				
TOS	3	1538.61	0.00	0.55
TOD*TOS	5	1539.03	0.41	0.45
TOS*Time	5	1567.06	28.45	0.00
TOD*Temp	5	1580.02	41.40	0.00
TOD*Wind	5	1594.97	56.36	0.00
Temp	3	1603.07	64.45	0.00
Time	3	1617.40	78.78	0.00
TOD*Time	5	1620.45	81.84	0.00
Wind	3	1621.30	82.69	0.00
Cloud	3	1623.93	85.32	0.00
TOD*Cloud	5	1624.73	86.12	0.00
Constant	2	1678.26	139.65	0.00
TOD	3	1679.93	141.31	0.00
TOS^2	3	1858.27	319.66	0.00
Constant	15	1904.71	366.10	0.00

"TOD" represents time of day, "TOS" represents time of season, "Time" represents time since sunrise/sunset, and "TOS^2" represents the quadratic effect of time of season. The constant model included no covariate effects and the global model included the additive effects of all covariates.

estimated from call-broadcast surveys (Tozer et al. 2016, Wiest and Shriver 2016). These results suggest that passive surveys for nonfocal species of marsh passerines are sufficient for obtaining detection probabilities similar to those obtained for focal marsh bird species during call-broadcast surveys.

Our results suggest that surveys for our three focal species of marsh songbirds can be conducted during both morning and evening hours because we found no significant effect of time of day on their detection probabilities. This contrasts with the results of other studies evaluating time-of-day differences in point-count data for passerines (Kessler and Milne 1982, Rollfinke and Yahner 1990, Smith and Twedt 1999) and other bird species (Nadeau et al. 2008, Harms and Dinsmore 2014). Both Marsh Wrens and Yellow-headed Blackbirds are known to sing in both morning and evening (Twedt and Crawford 1995, Kroodsma and Verner 2013). This is likely driven by the need to attract mates, maintain pair-bonds, or defend breeding territories (La 2011), the latter of which could be intensified by the aggressive and competitive relationship between Marsh Wrens and Yellow-headed Blackbirds (Bump 1986). Marsh Wrens are more vocal during morning and evening hours because food is most available during these times (Kroodsma and Verner 2013). Although not stated explicitly, this could also be true for Swamp Sparrows and Yellow-headed Blackbirds because their diets are similar to that of Marsh Wrens (e.g., aquatic insects; Twedt and Crawford 1995, Mowbray 1997). This adds to the idea that these three species that occupy similar habitats and have similar diets during the breeding season are expanding their singing into the evening hours for territory defense. This could also be true of other bird species (La 2011). Therefore, we suggest that point counts could be conducted during the evening for other species of birds known to vocalize throughout the day and that investigators conducting point-count surveys consider evening surveys to increase replication.

Within-season variation in detection probability has previously been documented in songbirds as a result of different breeding and singing phenologies (Selmi and Boulinier 2003, Schmidt et al. 2013). Males have predictable within-season patterns driven by

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hormone levels, inter- and intra-specific competition, and other factors (Naguib and Riebel 2014). Another set of factors, such as habitat and food availability, climate, and activity of conspecifics, causes the timing of breeding to differ among species, hinting at the complexity of within-season patterns of singing by songbirds (Charmantier and Gienapp 2014). We conducted surveys through mid-July and found a negative effect of season on detection probability of Yellow-headed Blackbirds and a positive effect of season on detection probability of Swamp Sparrows (Fig. 1). All three of our focal species regularly breed in Iowa from early May through mid-July (Kent and Dinsmore 1996) and, with the exception of Yellow-headed Blackbirds, can be heard singing in wetlands throughout the breeding season (T. M. Harms, pers. observ.). Yellow-headed Blackbirds, despite still being present in Iowa wetlands through late July, have largely stopped singing because they are tending to broods (T. M. Harms, pers. observ.). Some investigators have recommended extending the survey window for other species of marsh birds, e.g., Least Bitterns (*Ixobrychus exilis*) and Virginia Rails (*Rallus limicola*) (Rehm and Baldassarre 2007), with variation in the end date based on geographic location (Rehm and Baldassarre 2007, Harms and Dinsmore 2014). Extending the survey window for marsh songbirds to mid-July would coincide with the recommended survey window for other marsh birds of conservation concern in Iowa, e.g., Least Bitterns and Common Gallinules (*Gallinula galeata*; Harms and Dinsmore 2014), allowing implementation of an efficient monitoring program for all species of marsh birds (Conway 2011). However, if Yellow-headed Blackbirds are included as a priority species, surveys should be conducted earlier in the season. For our study in Iowa, this was prior to June 15, but investigators conducting surveys for Yellow-headed Blackbirds elsewhere should pay careful attention to the breeding phenology in their study area and focus survey efforts early in the breeding season.

We found no effect of season, time of day, or time since sunrise/sunset on detection probability of Marsh Wrens. As mentioned previously, Marsh Wrens sing while foraging during both morning and evening hours throughout the breeding season (Kroodsma and Verner 2013). Marsh Wrens are also polygynous and males often sing throughout the day to attract additional mates, even when already mated with one or more females (Kroodsma and Verner 2013). Our results confirm singing throughout the day and breeding season, and suggest that surveys for Marsh Wrens can be conducted in both morning and evening through the end of the breeding season. Furthermore, we found no evidence to suggest that this conclusion varies across their breeding range (Kroodsma and Verner 2013).

Consistent detection probability of marsh songbirds during morning and evening survey periods increases opportunities to conduct surveys for these birds, which ultimately increases survey efficiency (Smith and Twedt 1999). Increased time for conducting surveys also offers greater flexibility in analytical methods for evaluating population trends (Matsuoka et al. 2014). For example, more time available for surveys makes it easier to conduct repeated visits at survey points during a single survey period, which can increase the precision of and reduce bias in population estimates (Selmi and Boulinier 2003, Kéry et al. 2005, Schmidt et al. 2013) and result in a more representative list of species at any given site (Petit et al. 1995). Furthermore, the North American Marsh Bird Monitoring Protocol, frequently used as a guide for surveys of secretive marsh birds (Rehm and Baldassarre 2007, Nadeau et al. 2008, Bolenbaugh et al. 2011, Harms and Dinsmore 2014), suggests that surveys be conducted during both morning and evening hours (Conway 2011). We also suggest that there would be no consequence in conducting surveys for non-focal marsh passerines while simultaneously surveying for focal species of secretive marsh birds during both morning and evening hours. However, the potential influence of call-broadcasts for focal species of marsh birds on detections of other species must be considered (Conway and Nadeau 2010).

Detection probability is becoming an increasingly important factor to consider when estimating population parameters using bird survey data because failing to account for detection probability can bias population parameters (Rosenstock et al. 2002, Diefenbach et al. 2003, Bas et al. 2008).

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Furthermore, an important consideration in designing bird surveys is to simultaneously maximize detection probability while minimizing its temporal variability between counts (Lynch 1995). Having more opportunities to conduct surveys (e.g., both morning and evening survey periods) during a period of maximum detection probability for songbirds of interest provides greater flexibility in designing surveys to increase the precision of population parameters, perhaps by increasing spatial and temporal replication. Although most songbird surveys have traditionally been conducted during early morning hours, investigators conducting surveys of songbirds in the future should at least consider and, if possible, evaluate differences in detection probability between surveys conducted during the traditional morning period and those conducted later in the day. This evaluation could lead to a more robust survey design and ultimately a more precise parameter estimate.

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