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Timing of marsh passerine surveys

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Optimizing surveys for marsh passerines: 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, occupancy) while simultaneously estimating detection probability. An important consideration when designing point counts is to maximize detection probability while minimizing variation in detection probability both within and between counts. Our objective was to estimate detection probability for three marsh passerines (Marsh Wren [*Cistothorus palustris*], Swamp Sparrow [*Melospiza georgiana*], and Yellow-headed Blackbird [*Xanthocephalus xanthocephalus*]) as a function of weather covariates and evaluate the temporal variability in detection probability of these three species. We conducted paired, unlimited radius, 10-min point counts for our three study species at 56 wetlands in Iowa from 20 April – 10 July 2010. We conducted surveys in the early-morning (30 m before sunrise to 3 hr after sunrise) and late-evening (3 hr before sunset to 30 m after sunset) hours during consecutive survey periods to minimize any daily variation in detection probability. We recorded all birds detected during point counts and also recorded both weather variables and time to sunrise or sunset before each survey. We estimated detection probability for each species as a function of weather and temporal covariates using the N-mixture model in the "unmarked" package in Program R. Mean detection probability ranged from 0.272 (SE = 0.042) for Marsh Wren to 0.365 (SE = 0.052) for Swamp Sparrow. Time of season was positively correlated with detection probability for Swamp Sparrow but was negatively correlated with detection probability for Yellow-headed Blackbird, suggesting that detection probability increases throughout the breeding season for Swamp Sparrow and is highest early in the breeding season for Yellow-headed Blackbird. Detection probability of Marsh Wren did not vary temporally nor did we find any effect of weather covariates on detection probability for any species. Understanding how detection probability for marsh passerines varies throughout the breeding season allows for targeted survey efforts to maximize detection probability for these species. Furthermore, consistent detection probability of marsh passerines between morning and evening survey periods increases the opportunity to conduct surveys for these birds, which allows for greater flexibility to increase spatial and temporal replication of surveys could lead to more precise estimates for desired population parameters.

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

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: 1) by the presence, absence, or abundance of birds at the count location, and 2) 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 in order to evaluate population trends in birds. However, studies have shown that 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 bird point count data (Nichols et al. 2000, Farnsworth et al. 2002, Rosenstock et al. 2002, Royle 2004, Kéry et al. 2005). Although these methods either require additional data (e.g., replicated counts or linear distances to individual birds) or impose added logistical constraints (e.g., double observer), they are highly valuable if the goal is to obtain accurate and precise estimates of population parameters (Rosenstock et al. 2002, Thompson 2002).

An important consideration when designing 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 with increasing levels of 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 studies have sought 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).

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 using call-broadcast methodology during point counts to increase detection probability of secretive species (e.g., bitterns, rails, and grebes) and suggests surveys be conducted both in the morning (30 m before sunrise to 3 h after sunrise) and in the 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 but for which call-broadcasts are not necessary (e.g., Yellow-headed Blackbird [*Xanthocephalus xanthocephalus*] and Swamp Sparrow [*Melospiza georgiana*]). Despite using call-broadcast methodology, studies have found detection probability of secretive marsh birds to vary both by time of day and seasonally (Rehm and Baldassarre 2007, Nadeau et al. 2008, Harms and Dinsmore 2014). No study, 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 studies have compared bird detections between surveys conducted in the morning (3 h after sunrise) to those conducted in the evening (3 h before sunset) and found that, in general, more birds are detected on morning surveys than on evening surveys (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 between 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 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 goal was to estimate detection probabilities for three species of marsh passerines (Marsh Wren [*Cistothorus palustris*], Swamp Sparrow, and Yellow-headed Blackbird; hereafter collectively referred to as 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 formally compare detection probabilities for each species between the two survey windows. We also evaluated the influence of weather covariates (wind speed [bft], temperature [°C], 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 within both morning and evening survey windows. We predicted that detection probability of Swamp Sparrow would be higher during morning surveys than during evening surveys, but that detection probability for both Yellow-headed Blackbird and Marsh Wren would not differ between morning and evening surveys. We also predicted that detection probability for both Swamp Sparrow and Yellow-headed Blackbird would decrease throughout the season, but detection probability for Marsh Wren would not vary as a function of season. Lastly, we predicted that detection probability of all species would be negatively influenced by wind speed during both morning and evening surveys.

Methods

Study area

We conducted this study in the Prairie Pothole Region (PPR) of north-central and northwest Iowa (Figure 1). The PPR is an area that extends across five states and three Canadian provinces from north-central Alberta south and east across southern Saskatchewan, Manitoba, and northern Montana extending downward through the Dakotas, western Minnesota, and northwest Iowa. In Iowa, the PPR is approximately 310 607 ha in size and encompasses 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, less than 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 with 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, riverine) and the habitat characteristics within the wetland (Cowardin et al. 1979).

Approximately 95% of the wetlands in Iowa fall within one of three NWI classes within the Palustrine system: Aquatic Bed (AB), Unconsolidated Bottom (UB), or Emergent (EM; Cowardin et al. 1979). Therefore, we included all wetlands within these three classes in our sampling frame. Furthermore, wetlands within these three classes had similar habitat characteristics suitable for our study species: shallow water (<1 m deep), surrounded by few or no trees, and presence of both emergent and submergent vegetation. We considered both natural and constructed wetlands for selection and only considered those wetlands on public land, which constituted approximately 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 permanent or semi-permanent as defined by Stewart and Kantrud (1971), but some temporary and seasonal wetlands were also included in our selection.

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

Bird surveys

We conducted unlimited-radius, 10-min point counts for marsh passerines from 20 April to 10 July 2010, which 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) hours. 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 measured temperature (°C) and wind speed (Beaufort scale; bft) prior to starting surveys at each point and visually estimated the amount of cloud cover prior to starting surveys at each point (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 whether the survey was conducted in the morning or evening. We also calculated the time difference (min) between when an individual survey was started at a point and the sunrise or sunset time depending on whether the survey was conducted in the morning or evening. The time was centered on sunrise or sunset, so if survey was started before sunrise or sunset the time difference was negative. For example, if sunset was 2100 hrs and a survey was started at 2000 hrs, the covariate value would be -60 for that particular point. Lastly, we included Julian day as a covariate for surveys conducted at each point to evaluate potential seasonal differences in detection probability.

Models

We utilized N-mixture models to estimate detection probability and density (e.g., birds/survey point) of marsh passerines (Royle 2004). We considered each individual point as the sampling unit in our analyses because we were interested in how survey timing influences detection probability. We assumed survey points were independent because they were placed >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., Julian day), and time since sunrise/sunset on detection probability as well as a global model (i.e., all additive effects). Since 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 interaction of time of season and temperature on detection probability because we deemed it plausible that warmer temperatures late in the breeding season would affect detection probability. Because we were not interested in evaluating effects on density, we kept this parameter constant in all models. Lastly, we modeled constant detection probability and density (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 assessed fit of the global model to the data for each species by simulating ten individual data sets from the fitted model and calculating a chi-square fit statistic using the “parboot” function in package “unmarked”. 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.

Results

We surveyed 128 points at 56 wetlands in 2010. We counted 1126 Marsh Wrens, 647 Swamp Sparrows, and 537 Yellow-headed Blackbirds during both morning and evening survey periods (Table 1). The global model for each species exhibited good fit ($P \leq 0.05$) according to the chi-square goodness-of-fit test.

For Marsh Wren, we estimated overall detection probability to be 0.272 (SE = 0.042) and density per point to be 8.26 birds (SE = 1.26). 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, although this effect was not significant ($\beta = -0.003$, 95% CI = -0.007, 0.001).

We estimated overall detection probability for Swamp Sparrow to be 0.365 (SE = 0.052) and density to be 3.54 birds per point (SE = 0.503). 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), meaning that detection probability for Swamp Sparrows increased later in the survey season.

Yellow-headed Blackbird detection probability was estimated to be 0.316 (SE = 0.040) and density to be 3.40 birds per point (SE = 0.432). The best model included 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), indicating that detection probability for Yellow-headed Blackbirds was greatest earlier in the survey 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).

Discussion

Points counts have been frequently used to survey birds in North America for the purpose of population assessment, evaluating associations with habitat characteristics and the influence habitat management on bird communities, assessing landscape change on bird populations, and many other purposes to guide bird conservation (Rosenstock et al. 2002, Bart 2005, Fontaine and Kennedy 2012, Sauer et al. 2013, Harms et al. 2017). An important consideration when designing effective point count surveys, however, is the temporal variation (both diel and seasonal) in detectability of most bird species (Lynch 1995, Selmi and Boulinier 2003, Rehm and Baldassarre 2007, Bas et al. 2008). Failing to account for temporal variation in detectability of birds can introduce extreme bias in population trends estimated from point-count data (Selmi and Boulinier 2003, Schmidt et al. 2013). Our results suggest that surveys for marsh passerines can be conducted during both morning and evening hours because we found no significant effect of time of day on detection probability for any species. This contrasts with 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). Marsh Wrens, in particular, are more vocal during morning and evening hours because it is during these times when food is most available for this species (Kroodsma and Verner 2013). Although not stated explicitly, this could also be true for Swamp Sparrows and Yellow-headed Blackbirds because they have diets similar to that of the Marsh Wren (e.g., aquatic insects; Twedt and Crawfod 1995, Mowbray 1997).

We conducted surveys for marsh passerines 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 (Figure 1). Other studies have found within-season variation in detection probability of passerines (Selmi and Boulinier 2003, Schmidt et al. 2013), so this result was not surprising to us. All three of our study species breed regularly in Iowa from early May through mid-July (Kent and Dinsmore 1996) and, with the exception of Yellow-headed Blackbirds, can be heard frequently singing in wetlands throughout the breeding season (T.M. Harms, pers. obs.). Yellow-headed Blackbirds, despite still being present in Iowa wetlands through late July, have mostly stopped singing (T.M. Harms, pers. obs.). Studies have recommended extending the survey window for other species of marsh birds with variation in the end date based on geographic location (Rehm and Baldassarre 2007, Harms and Dinsmore 2014). Extending the survey window for marsh passerines to mid-July would coincide with the recommended survey window for other marsh bird species of conservation concern in Iowa (e.g., Least Bittern, Common Gallinule; Harms and Dinsmore 2014), allowing for the possibility to implement an efficient monitoring program for all species of marsh birds as suggested by Conway (2011). However, if Yellow-headed Blackbird is included as a priority species, surveys should be should be conducted earlier in the survey season (prior to 15 June in Iowa).

We found no effect of season, time of day, or time since sunrise/sunset on detection probability of Marsh Wrens. As mentioned above, Marsh Wrens actively sing while foraging during both morning and evening hours throughout the breeding season (Kroodsma and Verner 2013). Furthermore, Marsh Wrens are a highly polygynous species and males often sing throughout the day to attract additional mates, even when mated with one or more females (Kroodsma and Verner 2013). Our results confirm vigorous singing throughout the day and throughout the breeding season, therefore suggesting that surveys for Marsh Wrens can be conducted in both morning and evening through the end of the breeding season.

Consistent detection probability of marsh passerines between morning and evening survey periods increases the opportunity to conduct surveys for these birds, which ultimately increases survey efficiency (Smith and Twedt 1999). Increased time for conducting surveys also improves data collection opportunity and 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 within 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, which has been 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 surveys be conducted during both morning and evening hours (Conway 2011). Our results indicate there would be no consequence in surveying for non-focal marsh passerines while simultaneously surveying for focal species of secretive marsh birds during both morning and evening hours.

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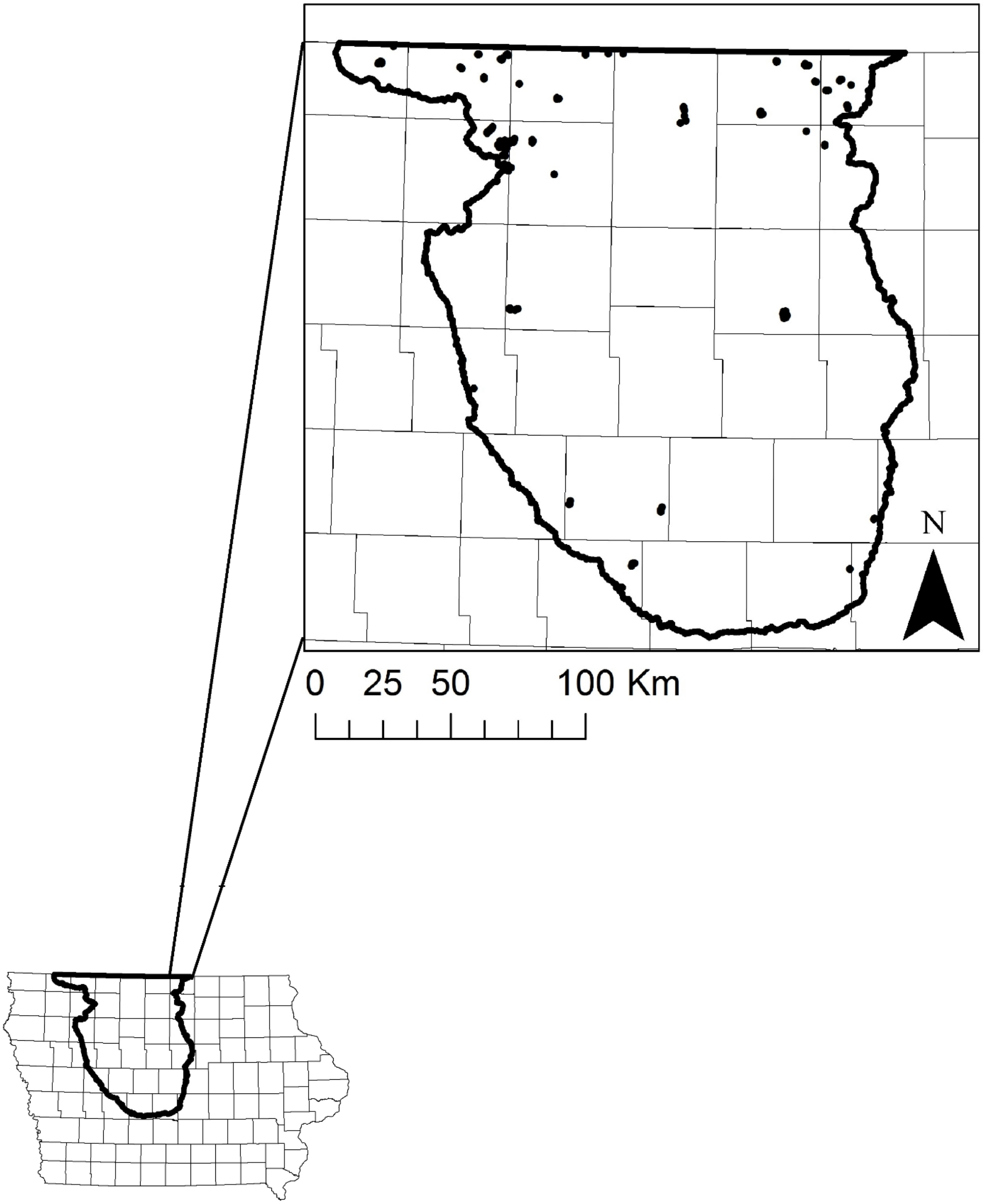
Table 1. Total number of detections of Marsh Wren (*Cistothorus palustris*), Swamp Sparrow (*Melospiza georgiana*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) by survey period in Iowa, 2010.

	Morning	Evening
Marsh Wren	613	513
Swamp Sparrow	328	319
Yellow-headed Blackbird	267	270

Figure legends

Figure 1. Locations of survey wetlands within the Prairie Pothole Region of Iowa, 2010.

Figure 2. Predicted detection probability of Marsh Wren (*Cistothorus palustris*), Swamp Sparrow (*Melospiza georgiana*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) as a function of time of season (i.e., Julian day) in Iowa, 2010. *Gray shading represents 95% confidence interval.*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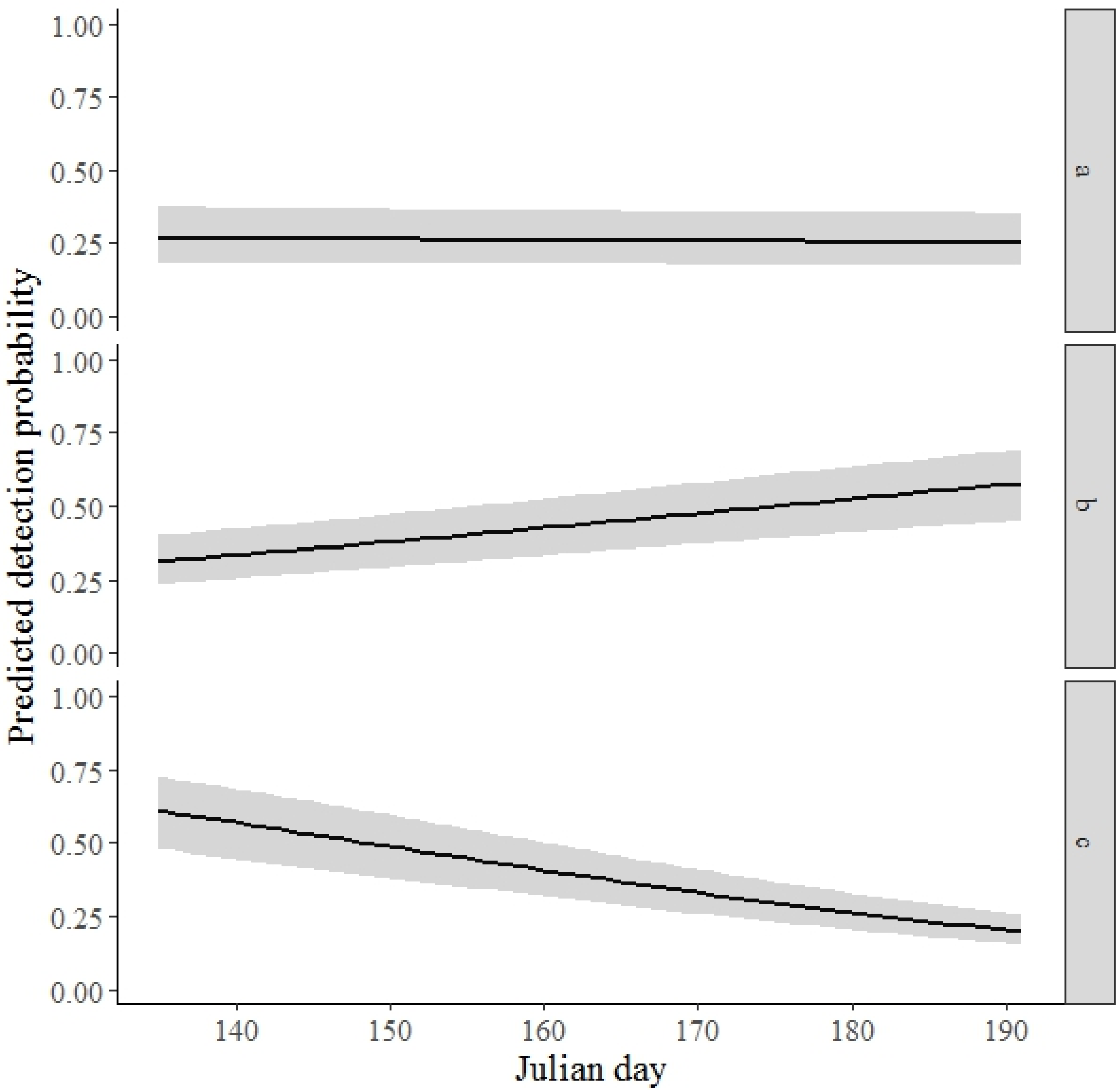
Predicted detection probability
1.00
0.75
0.50
0.25
0.00
a
b
c
140
150
160
170
180
190
Julian day