A species richness metric to quantify the response of grassland birds to the Conservation Reserve Program

2019

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Connecting People, Birds and Land

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Bird Conservancy of the Rockies
Connecting people, birds and land

Mission: Conserving birds and their habitats through science, education and land stewardship

Vision: Native bird populations are sustained in healthy ecosystems

Bird Conservancy of the Rockies conserves birds and their habitats through an integrated approach of science, education, and land stewardship. Our work radiates from the Rockies to the Great Plains, Mexico and beyond. Our mission is advanced through sound science, achieved through empowering people, realized through stewardship, and sustained through partnerships. Together, we are improving native bird populations, the land, and the lives of people.

Core Values:

1. **Science** provides the foundation for effective bird conservation.
2. **Education** is critical to the success of bird conservation.
3. **Stewardship** of birds and their habitats is a shared responsibility.

Goals:

1. Guide conservation action where it is needed most by conducting scientifically rigorous monitoring and research on birds and their habitats within the context of their full annual cycle.
2. Inspire conservation action in people by developing relationships through community outreach and science-based, experiential education programs.
3. Contribute to bird population viability and help sustain working lands by partnering with landowners and managers to enhance wildlife habitat.
4. Promote conservation and inform land management decisions by disseminating scientific knowledge and developing tools and recommendations.

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Executive Summary

The long-term population declines of grassland birds have elevated the recovery of the grassland avifauna to among the highest conservation priorities in North America. Habitat loss is widely considered the primary threat to the population viability of grassland bird species. Although the Conservation Reserve Program (CRP) was designed to address economic and environmental issues associated with agricultural land, the program has become an important tool for managing the effects of habitat loss on grassland birds. Our research objectives are to 1) investigate community responses of grassland birds to the loss of grassland vegetation at the landscape scale in the western Great Plains, 2) evaluate the effectiveness of the Conservation Reserve Program (CRP) for increasing the species richness of grassland birds and 3) map the responses of grassland birds to the amount of CRP throughout the western Great Plains to prioritize landscapes for conservation. We applied modern methods for estimating biodiversity to data from the Integrated Monitoring in Bird Conservation Regions Program to evaluate several hypotheses for habitat loss and CRP landscape management.

Our results suggested grassland loss resulted in declining species richness of grassland obligate birds in both the Northern and Southern Great Plains. In contrast, we found little evidence that the species richness of grassland birds declined with the amount of shrub-land in the surrounding landscape. Nevertheless, our results suggested large-scale conversion of shrub-land to grassland will likely increase the species richness of grassland obligates in the Southern Great Plains. We found strong support for the hypothesis that landscape management of CRP increased the species richness of grassland obligate birds in the Northern and Southern Great Plains. Although species richness was greater in the Northern than in the Southern Great Plains, landscape management benefited the community of grassland obligates to similar degrees in both regions. The results of this study suggested CRP landscape management can be used to partially restore species richness of grassland obligates in landscapes impacted by grassland loss. The CRP was capable of restoring 24% of historical declines in species richness of grassland obligates for the Northern Great Plains, and 34% of historical declines in species richness for the Southern Great Plains.

The results of this study may be useful for conservation planning and decision making for grassland bird conservation and sustainable agricultural production in the western Great Plains. Mapping the species richness of grassland obligates provided a benchmark for the grassland bird conservation in the western Great Plains. In addition, mapping the marginal effect of CRP provided a spatially explicit framework for prioritizing landscape management to achieve the most effective conservation outcomes for grassland obligates. Finally, the results of this project may prove useful in Systematic Conservation Planning to provide optimal solutions to the most pressing problems involving bird conservation and agricultural production in the western Great Plains.

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Introduction

The long-term population declines of grassland birds have elevated the recovery of the grassland avifauna to among the highest conservation priorities in North America (Vickery and Herkert 2001, Brennan and Kuvlesky 2005). Habitat loss is widely considered to be the primary threat to the population viability of grassland bird species (Brennan and Kuvlesky 2005, Ribic et al. 2009). Because a large percentage of the Great Plains are privately owned, the recovery of grassland bird populations depends on conservation initiatives with strong partnerships between private landowners and resource professionals (Askins et al. 2007).

Monitoring the effectiveness of conservation efforts on private land to increase the biodiversity of grassland birds is important for evaluating the success of Farm Bill rangeland practices toward a program of evidence-based conservation (Briske et al. 2017). The effectiveness of conservation practices can be integrated into Conservation Planning (Margules and Pressey 2000) and decision making (Williams 2011, Sauer et al. 2013) to simultaneously address objectives for grassland bird conservation and sustainable agricultural production in the western Great Plains.

The Conservation Reserve Program (CRP) is a voluntary program for agricultural producers administered by Farm Service Agency providing incentives to landowners to take cropland out of production and plant it back into grassland (Vandever and Allen 2015). The primary purpose of the CRP is to improve soil and protect water quality on highly erodible lands in agricultural production, and although the recovery of wildlife populations associated with agro-ecosystems was not a primary goal of the CRP, the program has become an important tool for managing the effects of habitat loss on grassland birds (Vandever and Allen 2015).

The research objectives are to 1) investigate community responses of grassland birds to the loss of grassland vegetation at the landscape scale in the western Great Plains, 2) evaluate the effectiveness of the CRP for increasing the species richness of grassland birds and 3) map the responses of grassland birds to the amount of CRP throughout the western Great Plains to prioritize landscapes for conservation.

Methods

Study Area

The study took place within four Bird Conservation Regions (BCR) of the western Great Plains (US NABCI Committee 2000a;b), including the entire Badlands and Prairies (BCR 17), and Shortgrass Prairie (BCR 18), and portions of the Prairie Potholes (BCR 11) and Central Mixed Grass Prairie (BCR 19; Fig. 1). We developed separate analyses for the Northern Great Plains composed of BCR 11 and 17, and the Southern Great Plains composed of BCR 18 and 19 (Fig. 1).

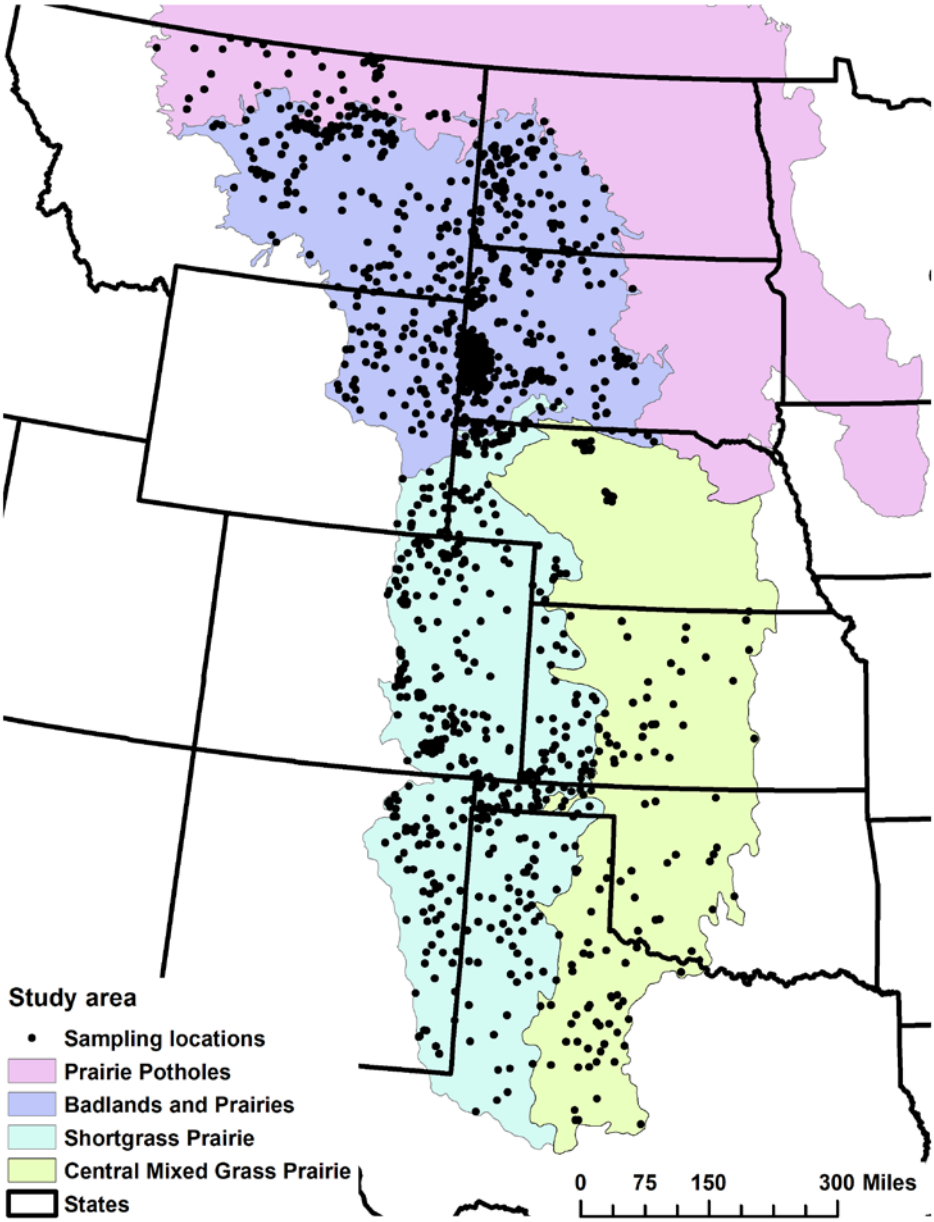

Figure 1. Study area in the western Great Plains, USA, 2010 - 2018. The sampling locations are represented by round symbols and the Bird Conservation Regions are depicted by color-coded regions.

Study Species

We detected 77 grassland bird species in the study area on IMBCR surveys during the course of study (Appendix, Table A1). Species were classified as obligate (29) or facultative (48) grassland species according to Vickery and Herkert (1999), and Johnsgard (2009). Facultative species are those not entirely dependent on grasslands but use grasslands as a substantial part of their habitat requirements (Vickery and Herkert 1999). Because facultative species use a variety of vegetation types in addition to grasslands, we defined facultative species as grassland generalists in the current study. We indicated the continental population status of the bird species according to the Breeding Bird Survey (Sauer et al. 2017).

Sampling Design

We selected a spatially balanced sample of 4,140 1 km^2 sampling units within the study area (Table 1) using Generalized Random Tessellation Stratification (Stevens and Olsen 2004). Each sample unit was surveyed at least once between 2010 and 2018 using the Integrated Monitoring in Bird Conservation Regions (IMBCR) protocol (Box 1, White et al. 2013, Pavlacky et al. 2017). The sampling units for the IMBCR program are defined by 1 km^2 grid cells, each containing 16 point count stations located 250 m apart and ≥125 m from the grid cell boundaries (White et al. 2013, Pavlacky et al. 2017).

Table 1. The sample sizes of 1 km^2 sampling units by year and Bird Conservation Region in the western Great Plains, USA, 2010 - 2018.

Year	Bird Conservation Regions			
	Prairie Potholes	Badlands and Prairies	Shortgrass Prairie	Central Mixed Grass Prairie
2010	22	223	79	-
2011	22	169	135	6
2012	18	162	112	8
2013	24	315	150	8
2014	31	249	125	6
2015	20	241	201	6
2016	27	228	259	62
2017	36	222	280	76
2018	32	201	285	100

Data Collection

Avian Monitoring

We sampled avian occurrence using 6-min point counts (Buckland 2006) between one-half hour before sunrise and five hours after sunrise at each accessible point count location, and measured the distance to each bird detection using a laser rangefinder (White et al. 2013, Pavlacky et al. 2017). We binned the 6-min point count duration into three, 2-min time occasions in order to maintain a constant detection rate in each interval and ensure a monotonic decline in the detection frequency through time (Pavlacky et al. 2012).

Box 1. Integrated Monitoring in Bird Conservation Regions

The Integrated Monitoring in Bird Conservation Regions (IMBCR) program is a collaborative partnership between policy-makers, land managers, conservationists and scientists to leverage a common data platform over large spatial scales, promoting the efficient use of monitoring resources (Pavlacky et al. 2017). The Program was designed meet the North American Bird Conservation Initiative (NABCI) goals for improving avian monitoring and is well suited for addressing multiple management and conservation objectives (US NABCI Monitoring Subcommittee 2007). The IMBCR program uses modern sampling and analysis to provide reliable knowledge about bird populations (Pollock et al. 2002, Nichols et al. 2009). The design involves spatially balanced sampling (Stevens and Olsen 2004) to ensure representative geographic variation and data collection protocols to estimate population size and site occupancy while accounting for incomplete detection (Pavlacky et al. 2017). The spatially balanced properties of the design are maintained when sampling units are inaccessible and when sampling intensity varies between years. Accordingly, the spatially balanced design is well suited for regions with large amounts private land, when permission to access selected sampling units is denied, and is able to accommodate fluctuations in sampling intensity over time. The common data platform provides an economy of scale that allows pooling detection data across the monitoring region, allowing robust estimates of distribution and abundance in management units that have insufficient sample sizes on their own. The design of the IMBCR program provides an ecologically realistic framework for understanding hierarchical habitat use at local and landscape scales (Pavlacky et al. 2017), and the avian population metrics in local management units can be aggregated-up at multiple scales relevant to conservation and management objectives (Conroy et al. 2012).

Covariates

We measured 3 continuous landscape composition covariates in 3 km × 3 km (9 km^2) landscapes surrounding the 1 km^2 sampling units using remotely sensed data (Table 2). We quantified the area of grassland and shrub-land vegetation in the 9 km^2 landscapes using the LANDFIRE Existing Vegetation Type (EVT) spatial data layer (USGS 2016) with a Geographic Information System (GIS) and using the raster and spatialEco packages in the Program R computing environment (ArcGIS Version 10.1, Environmental Systems Research Institute, Redlands, CA, R Version 3.5.2, www.r-project.org, accessed 23 January 2019). We classified native vegetation as grassland or shrub-land vegetation according to the System Group Physiognomy EVT field, except we reclassified three grassland types, two conifer-hardwood types and one hardwood type as shrub-land based on expert opinion. In addition, we measured the area of CRP in the 9 km^2 landscapes using the Common Land Unit spatial data (USDA 2014). We included only the CRP conservation practices that involved grassland or wetland cover types, removing practices involving tree cover and parcels containing missing practice information across all years. For missing practice information within a particular year, including all CRP raster data from 2008 – 2010, we updated values with data from the closest available year, excluding CRP parcels with an expiration date > 15 years after the data year or with a missing expiration date. When possible, we replaced missing parcel data at the county or state level with data from the closest available year. Within the GIS environment, we intersected the annual CRP and land cover data and replaced the intersected land cover with CRP to arrive at annual vegetation mosaics composed of grassland, shrub-land and CRP land cover. In addition

to the landscape composition covariates, we used GIS to calculate latitude and longitude for the centroid of the 1 km^2 sampling units (Table 2).

Table 2. The name, description, and mean and range of covariates for 9 km^2 landscapes, 1 km^2 sampling units and point count plots within the western Great Plains, USA, 2010 - 2018.

Covariate	Description	Mean (range)
Grass	Area (km^2) of grassland vegetation within 9 km^2 landscapes.	4.3 km^2 (0.0 km^2, 9.0 km^2)
Shrub	Area (km^2) of shrub-land vegetation within 9 km^2 landscapes.	1.0 km^2 (0.0 km^2, 8.9 km^2)
CRP	Area (km^2) of Conservation Reserve Program (CRP) within 9 km^2 landscapes.	0.2 km^2 (0.0 km^2, 8.7 km^2)
Lat	Latitude (DD) for the centroid of the 1 km^2 sampling units	42.2 DD (31.3 DD, 49.0 DD)
Long	Longitude (DD) for the centroid of the 1 km^2 sampling units	-103.8 DD (-112.5 DD, -97.0 DD)

We transformed the Grass, Shrub and CRP covariates using the natural logarithm after adding 1 to the covariate values. We standardized the covariates using the *z*-transformation (Sokal and Rohlf 1981, Schielzeth 2010).

Hypotheses and Model Justification

We used predictive modelling to evaluate *a priori* hypotheses about the effects of habitat loss and landscape management of CRP on avian species richness in the Northern and Southern Great Plains. We hypothesized 1) the species richness of grassland birds declined with the loss of grassland, 2) the species richness of grassland birds declined with the increasing area of shrub-land, 3) the species richness of grassland birds increased with the increasing area of CRP in the landscape and 4) the effect of CRP on species richness was greater in landscapes impacted by grassland loss than in intact landscape.

Hypothesis 1) is justified on the basis that habitat loss is widely considered the primary threat to populations of grassland birds (Brennan and Kuvlesky 2005, Ribic et al. 2009). We used spatial patterns for the area of grassland vegetation in the landscape to make inference about processes influencing the temporal loss of grassland vegetation in the landscape (Fischer and Lindenmayer 2007). We assumed the complement of grassland and shrub-land vegetation is primarily comprised of agricultural land with smaller components of forest and other anthropogenic land use.

Hypothesis 2) proposed that landscapes with high land cover of shrub-land vegetation have depauperate communities of grassland birds (Coppedge et al. 2001, Brennan and Kuvlesky 2005). Because the shrub-land classification used in this study included vegetation types such as mesquite, red cedar and juniper that are currently undergoing range expansion (Archer et al. 2017), we predicted the species richness of grassland birds to respond negatively to increasing area of shrub-land (Brennan and Kuvlesky 2005).

Hypothesis 3) is based on findings that CRP plantings can ameliorate the negative effects of grassland loss on bird communities (Herkert 2009, Vandever and Allen 2015). Restoring grassland in agricultural landscapes may partially stabilize biodiversity declines from the loss of grassland vegetation. However, because grassland bird species are expected show variable responses to the area of CRP in the landscape, community responses may provide a

general metric for evaluating the effectiveness of CRP for managing the loss of grassland vegetation.

Hypothesis 4) proposed that CRP landscape management will increase species richness to a greater extent in landscapes with high grassland loss compared to landscapes with low grassland loss. This hypothesis resolves a key management uncertainty about the conservation value of implementing CRP in landscapes with intact grassland relative to landscapes impacted by grassland loss.

We defined the spatial scale using the extent and grain of ecological processes involving the loss of native vegetation and CRP landscape management (Turner et al. 2001). We defined the extent as a 9 km^2 square buffer centered on the 1 km^2 sampling unit to evaluate the loss of native vegetation and CRP landscape management on avian species richness. For the composition of native vegetation, we defined the grain as a 900 m^2 pixel as represented in the LANDFIRE EVT data layer (USGS 2016). Because we coerced the CRP polygons into the EVT land cover layer, we re-defined the grain of the CRP feature as a 900 m^2 pixel.

Statistical Analysis

We extended the hierarchical Bayes multi-scale occupancy model of Mordecai et al. (2011) to accommodate multiple species (Dorazio and Royle 2005, Royle and Dorazio 2008) and two spatial scales (Pavlacky et al. 2012). For each species, we estimated the probability of large-scale occupancy (ψ) for grid cells, probability of small-scale occupancy (θ) for point count plots given presence at the grid cells, and probability of detection (p) in minute intervals given presence at the point count plots (Pavlacky et al. 2012). We used a state-space formulation (Royle and Dorazio 2008) composed of two sub-models for partially observed processes of large-scale and small-scale occupancy and an observation model for repeated detections (Mordecai et al. 2011). The latent state z_{itk} is the estimated presence (z = 1) or absence (z = 0) of species i in year t and grid cell k, and the latent state u_{itkj} is the estimated presence (u = 1) or absence (u = 0) of species i in year t, grid cell k and point j. The observations y_{itkj} are the frequency of detections for species i in year t, grid cell k and point j using a removal design for 3, 2-min time occasions (Pavlacky et al. 2012, MacKenzie et al. 2018). The state process model is comprised of two equations, one for the occupancy state of grid cells z_{itk} ~Bernoulli(ψ_{itk}), and the other for the occupancy state of point count plots conditional on the occupancy of grid cells $u_{itkj}|z_{itk}$ ~Bernoulli($\theta_{itk}z_{itk}$). The observation model for the frequency of repeated detections $y_{itkj}|u_{itkj}$ ~Binomial($p_{itl}u_{itkj}$, J_{itkj}) is conditional on the occupancy state of the point count plots, where p_{itl} is the probability of detection for species i, year t and BCR l, and J_{itkj} is the time occasion in which species i was first detected in year t, grid cell k and point j using a removal design (Pavlacky et al. 2012, MacKenzie et al. 2018). When a species was not detected, or when a species was detected on the last time occasion, J = 3.

We used a series of logistic regression equations to model hypotheses for CRP, grassland, shrub-land and spatial location on large-scale (ψ) and small-scale (θ) occupancy. We estimated beta coefficients (d) for large-scale occupancy to evaluate the hypotheses, and we estimated covariate effects (b) for small-scale occupancy to control for incomplete availability of the species along the covariate gradients. We estimated spatial and temporal variability in the probability of detection (p) account for imperfect detection of the species in the Northern or Southern Great Plains:

$$\text{logit}(\psi_{itk}) = d_{0i} + d_{1i}\text{Grass}_{tk} + d_{2i}\text{Shrub}_{tk} + d_{3i}\text{CRP}_{tk} + d_{4i}\text{Grass*CRP}_{tk} + d_{5i}\text{Lat}_{tk} + d_{6i}\text{Lat}_{tk}^2 + d_{7i}\text{Long}_{tk} + d_{8i}\text{Long}_{tk}^2 + \eta_{3it},$$

$$\text{logit}(\theta_{itk}) = b_{0i} + b_{1i}\text{Grass}_{tk} + b_{2i}\text{Shrub}_{tk} + b_{3i}\text{CRP}_{tk} + b_{4i}\text{Grass*CRP}_{tk} + \eta_{2it},$$
$$\text{logit}(p_{itl}) = a_{0i} + \eta_{1it} + \varepsilon_{il},$$

where d_{0i} is the random intercept for the large-scale occupancy of species i, d_{xi} are the beta coefficients for the x covariates of species i, year t and grid cell k, and η_{3it} is the random effect for species i and year t. The parameter b_{0i} is the random intercept for the small-scale occupancy of species i, b_{xi} are the beta coefficients of the x covariates for species i, year t and grid cell k, and η_{2it} is the random effect for species i and year t. The parameter a_{0i} is the random intercept for detection, η_{1it} is the random effect for species i and year t, and ε_{il} is the random effect for species i and BCR l.

We used the multivariate normal distribution to approximate the correlation between the species' occupancy and detection parameters (Dorazio et al. 2011),

$$\begin{bmatrix} a_{0i} \\ b_{0i} \\ d_{0i} \end{bmatrix} \sim \text{Normal}\left(\begin{bmatrix} \alpha_0 \\ \beta_0 \\ \delta_0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{a_0} & \rho_{ab}\sigma_{a_0}\sigma_{b_0} & 0 \\ \rho_{ab}\sigma_{a_0}\sigma_{b_0} & \sigma^2_{b_0} & \rho_{bd}\sigma_{b_0}\sigma_{d_0} \\ 0 & \rho_{bd}\sigma_{b_0}\sigma_{d_0} & \sigma^2_{d_0} \end{bmatrix} \right),$$

where α_0 is mean detection, β_0 is mean small-scale occupancy, and δ_0 is mean large-scale occupancy among the i species on the logit scale. The parameters $\sigma^2_{a_0}$, $\sigma^2_{b_0}$ and $\sigma^2_{d_0}$ represent the variance of detection, small-scale occupancy and large-scale occupancy, respectively among the i species. The parameter ρ_{ab} estimates the correlation between detection and small-scale occupancy, and the ρ_{bd} estimates the correlation between small-scale occupancy and large-scale occupancy. The parameters a_{0i}, b_{0i}, d_{0i} represent the random intercepts for detection, small-scale occupancy and large-scale occupancy, respectively for species i.

In addition, we assumed the species-level beta coefficients were drawn from normal distributions for the 77 species in the community (Dorazio et al. 2006, Royle and Dorazio 2008). We defined the community-level covariate effects according to:

$$d_{xi} \sim \text{Normal}\left(\mu_{d_x}, \sigma^2_{d_x}\right),$$

and

$$b_{xi} \sim \text{Normal}\left(\mu_{b_x}, \sigma^2_{b_x}\right),$$

where μ is the mean and σ^2 is the variance for the x beta coefficients of large-scale (d) and small-scale (b) occupancy among the i species.

Accordingly, we assumed random effects for heterogeneity of repeated observations among years or BCRs were drawn from normal distributions. We defined the community-level random effects according to:

$$\eta_{1it} \sim \text{Normal}\left(0, \sigma^2_{\eta_{1t}}\right),$$
$$\eta_{2it} \sim \text{Normal}\left(0, \sigma^2_{\eta_{2t}}\right),$$
$$\eta_{3it} \sim \text{Normal}\left(0, \sigma^2_{\eta_{3t}}\right),$$

and

$$\varepsilon_{il} \sim \text{Normal}\left(0, \sigma^2_{\varepsilon_l}\right),$$

where the mean is zero and σ^2 is the variance for the random effects of η_{1t}, η_{2t} and η_{3t} among the *i* species in year *t* for detection, small-scale and large-scale occupancy, respectively, and the random effect ε_l for the detection of the *i* species in BCR *l*.

We estimated model parameters separately for the Northern and Southern Great Plains using Markov Chain Monte Carlo (MCMC) simulation implemented in program JAGS (Plummer 2003, JAGS Version 4.3.0, www.sourceforge.net, accessed 5 April 2018) using packages rjags and jagsUI in the R statistical computing environment (R Version 3.6.1, www.r-project.org, accessed 26 July 2019). We used vague and weakly informative prior distributions for all estimated parameters (Dorazio et al. 2011):

$$\rho_{ab}, \rho_{bd} \sim \text{Uniform}(-1, 1),$$
$$\alpha_0, \beta_0, \delta_0, \mu_{b_x}, \mu_{d_x} \sim t(\tau, \nu),$$

and

$$\sigma_{a_0}, \sigma_{b_0}, \sigma_{d_0}, \sigma_{b_x}, \sigma_{d_x}, \sigma_{\eta_{1t}}, \sigma_{\eta_{2t}}, \sigma_{\eta_{3t}}, \sigma_{\varepsilon_l} \sim \text{half-Cauchy}(\sigma),$$

where the zero-centered, *t*-distribution prior specified the mean with scale parameter $\tau = 1.566$ and degrees of freedom $\nu = 7.763$. The priors for the standard deviation (σ) of the hyper-parameters are represented by a scalar function for the half-Cauchy distribution with probability density function $f(\sigma) = 2 / [\pi(1+\sigma^2)]$. We used the Student *t* approximation for the prior standard deviation of the half-Cauchy distribution with mean = 0, degrees of freedom = 1 and non-centrality parameter = 1 (Dorazio et al. 2011). We generated 10,000 MCMC samples, specified a burn-in period of 5,000 iterations, and used $\hat{R} < 1.1$ as an indication of model convergence (Gelman and Rubin 1992).

We estimated the parameters using the mean and standard deviation of the MCMC samples of the posterior distributions, calculated 95% Credible Intervals (CI) using the quantiles of the posterior distributions, and calculated Bayesian *P*-values for beta regression coefficients greater than or less than zero using posterior predictive distributions (Hobbs and Hooten 2015). The Bayesian CI indicated a two-tailed probability of 0.95, given the data, that the true value of the beta coefficient fell within the credible region. The Bayesian *P*-values provided support for one-tailed hypotheses and represented the probabilities, given the data, that the beta regression coefficients were greater than [e.g., $P(b_{xi} > 0)$] or less than [e.g., $P(b_{xi} < 0)$] zero. We considered beta coefficients with *P*-values >0.95 as considerable support for the one-tailed hypotheses. The Bayesian *P*-value may be easier to interpret than the frequentist *P*-value, which represents the probability of obtaining a test statistic at least as extreme as the observed one, given the null hypothesis is true (Anderson et al. 2000)

We used the above multi-species, multi-scale occupancy model to develop a species richness metric for grassland birds in the Northern and Southern Great Plains. The model estimated the large-scale occupancy (ψ) of 1 km^2 grid cells for each species while accounting for incomplete availability and detection of the species (Pavlacky et al. 2012). We estimated the species richness of 1 km^2 sampling units for all grassland species as well as grassland obligate species (Vickery and Herkert 1999) according to $SR_k = \sum_{i=1}^{M} \hat{\psi}_{ik}$ (Zipkin et al. 2009, MacKenzie et al. 2018). We applied SR_k to the posterior distributions of the model to estimate precision in species richness along gradients of native vegetation, CRP landscape management, and latitude and longitude. The predictions of species richness were plotted along gradients of the vegetation covariates at zero values of the other covariates in the model to evaluate the predictions along the full gradient of the vegetation covariate values.

Mapping Biodiversity Responses to CRP

We used GIS to superimpose a 3 km × 3 km grid over the portions of the Northern and Southern Great Plains that were sampled by the IMBCR program (Fig. 1). We attributed each grid cell with covariate values for year 2018 (Table 2) using the Common Land Unit (USDA 2014) and modified land cover data (USGS 2016). We used the beta coefficients for large-scale occupancy (ψ; Appendix) to predict the site occupancy of each grassland obligate bird species to covariate values in the gridded sampling frame. We summed the species-specific occupancy probabilities for each grid cell to represent the expected mean number of grassland obligate bird species for each grid cell.

We estimated the marginal effect of CRP by adding 1 km^2 of CRP to the covariate data for all 3 km × 3 km grid cells with ≤ 8 km^2 of native vegetation and CRP, and ≥ 1 km^2 of cropland as measured by the National Land Cover Database (USGS 2019). We predicted the species richness of grassland obligates to the modified covariate data as above. We estimated the marginal effect of adding 1 km^2 of CRP for each grid cell by subtracting baseline predictions of species richness from the modified predictions of species richness.

Results

Landscape Relationships

Northern Great Plains

Overall species richness increased with the area of grassland in the surrounding landscape ($\mu_{d_{Grass}}$ = 0.430; SD = 0.077; CI = 0.279, 0.585; P > 0.999; Fig. 2A), supporting hypothesis 1) that the species richness of grassland birds declined with the loss of grassland. The species richness response resulted from increasing occupancy of 32 species with increasing grassland area, whereas only 5 species declined along the gradient of grassland area (Appendix, Table A2).

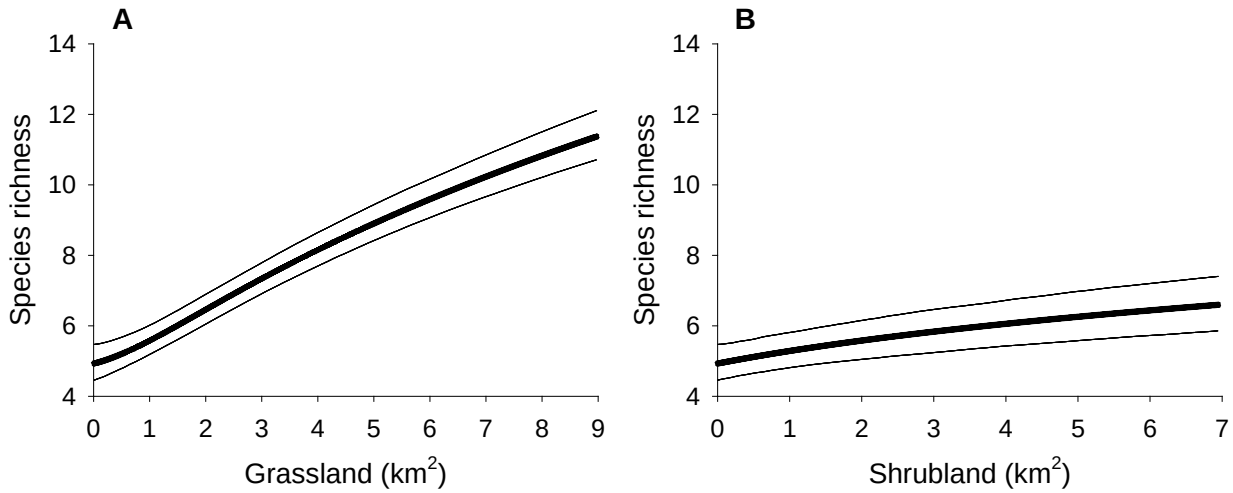

Figure 2. The species richness of the entire community of grassland birds by the area (km^2) of (A) grassland and (B) shrub-land in the surrounding 9 km^2 landscape, Northern Great Plains, USA, 2010 - 2018. The bold trend lines represent summed predictions of large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

Opposite our predictions, we found overall species richness increased with the area of shrub-land in the surrounding landscape ($\mu_{d_{Shrub}}$ = 0.113; SD = 0.041; CI = 0.032, 0.199; *P* > 0.999; Fig. 2B). The positive effect of shrub-land on species richness did not support the hypothesis 2) that species richness declined with the increasing area of shrub-land. The positive effect was driven by the increasing site occupancy of 13 species with increasing shrub-land area, whereas only 5 species declined with increasing shrub-land area (Appendix, Table A3).

The species richness of grassland obligates increased with the area of grassland in the surrounding landscape ($\mu_{d_{Grass}}$ = 0.578; SD = 0.056; CI = 0.476, 0.695; *P* > 0.999; Fig. 3A), supporting hypothesis 1) that the species richness of grassland birds declined with the loss of grassland. The effect of grassland area on the species richness of 28 grassland obligates was primarily driven by increasing site occupancy of 14 species, whereas only 1 obligate declined (Appendix, Table A2).

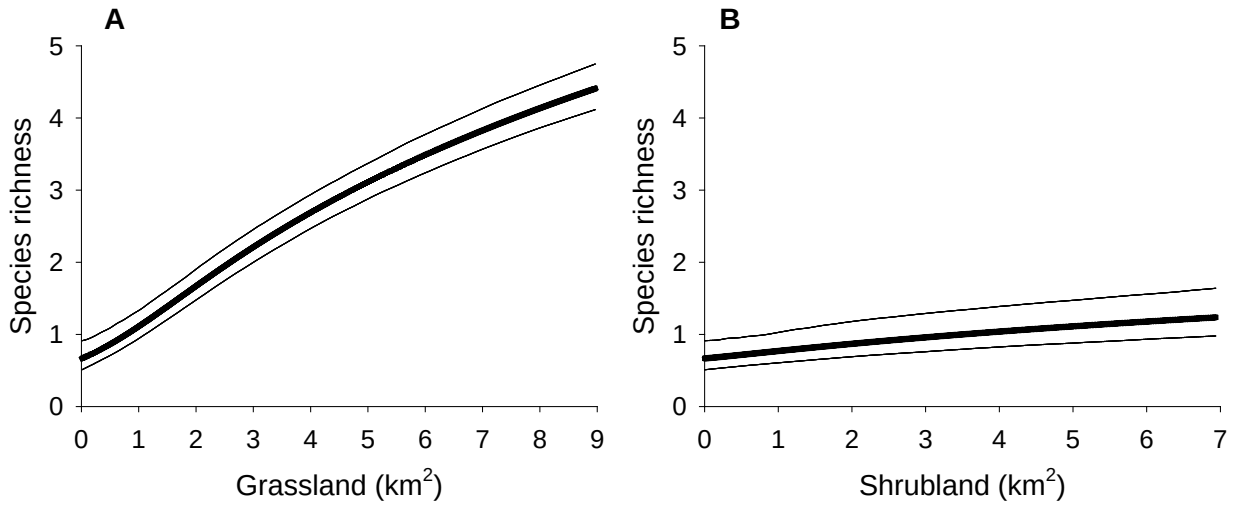

Figure 3. The species richness of grassland obligates by the area (km^2) of (A) grassland and (B) shrub-land in the surrounding 9 km^2 landscape, Northern Great Plains, USA, 2010 - 2018. The bold trend lines represent summed predictions of the large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

In addition, the species richness of grassland obligates increased with the area of shrub-land in the surrounding landscape ($\mu_{d_{Shrub}}$ = 0.088; SD = 0.037; CI = 0.014, 0.161; *P* = 0.989; 3B), which did not support hypothesis 2) that species richness of grassland birds declined with the increasing area of shrub-land. The species richness response resulted from large increases in site occupancy of 5 obligates, with smaller declines for 4 species along the gradient in shrub-land area (Appendix, Table A3).

Southern Great Plains

The overall species richness of grassland birds showed a marginal increase with increasing area of grassland in the surrounding landscape ($\mu_{d_{Grass}}$ = 0.158; SD = 0.092; CI = -0.027, 0.346; Fig. 4A). Although the 95% CI for the effect of grassland narrowly covered 0, there was a 0.96 probability that species richness increased with increasing grassland area (*P* = 0.961). This provided limited support for hypothesis 1) that the species richness of grassland birds declined

with the loss of grassland. The marginal effect of grassland on species richness was largely cancelled-out from increasing site occupancy of 22 species and declining occupancy of 15 species along the gradient of grassland area (Appendix, Table A4).

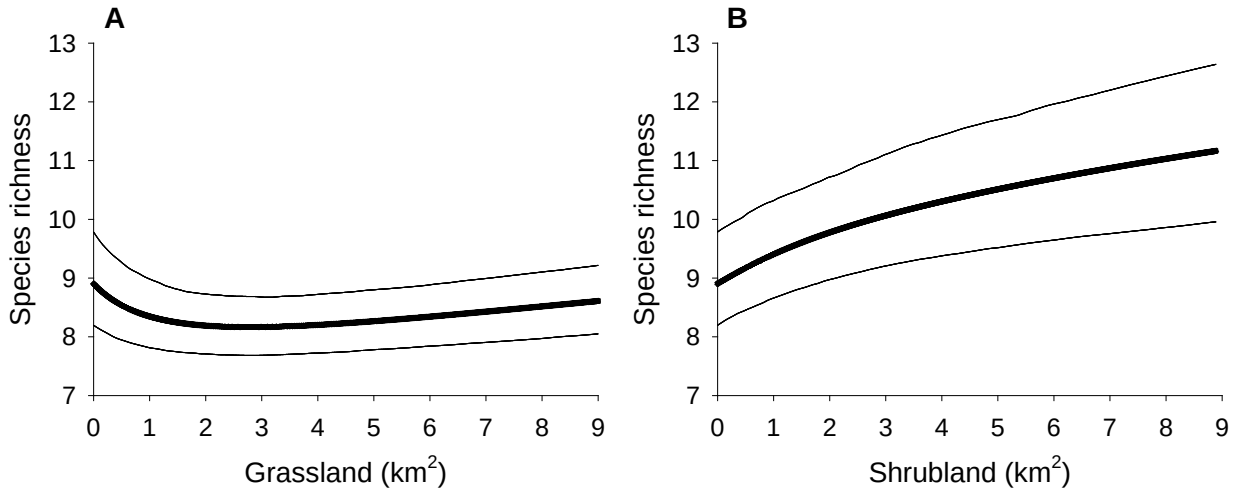

Figure 4. The species richness of the entire community of grassland birds by the area (km^2) of (A) grassland and (B) shrub-land in the surrounding 9 km^2 landscape, Southern Great Plains, USA, 2010 - 2018. The bold trend lines represent summed predictions of large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

The overall species richness of grassland birds did not vary considerably with the area of shrub-land in the surrounding landscape ($\mu_{d_{Shrub}}$ = 0.099; SD = 0.064; CI = -0.021, 0.227; P = 0.943; Fig. 4B). Although the site occupancy of 16 species increased with increasing shrub-land area, the lack of an effect on species richness was due to large declines of 8 species along the gradient of shrub-land area (Appendix, Table A5).

In terms of grassland obligates, species richness increased with the area of grassland in the surrounding landscape ($\mu_{d_{Grass}}$ = 0.396; SD = 0.069; CI = 0.263, 0.536; P > 0.999; Fig. 5A), supporting hypothesis 1) that the species richness of grassland birds declined with the loss of grassland. The large effect of grassland on species richness resulted from increasing site occupancy of 12 obligates, whereas only 2 obligates declined with increasing grassland area (Appendix, Table A4).

The species richness of grassland obligates did not vary considerably with the area of shrub-land in the surrounding landscape ($\mu_{d_{Shrub}}$ = 0.025; SD = 0.056; CI = -0.083, 0.140; P = 0.675; Fig. 5B), which did not support hypothesis 2) that species richness of grassland birds declined with the increasing area of shrub-land. The lack of a species richness effect was in a large part due to low precision from increasing occupancy of 4 obligates and declining occupancy of 6 obligates along the gradient of shrub-land area (Appendix, Table A5).

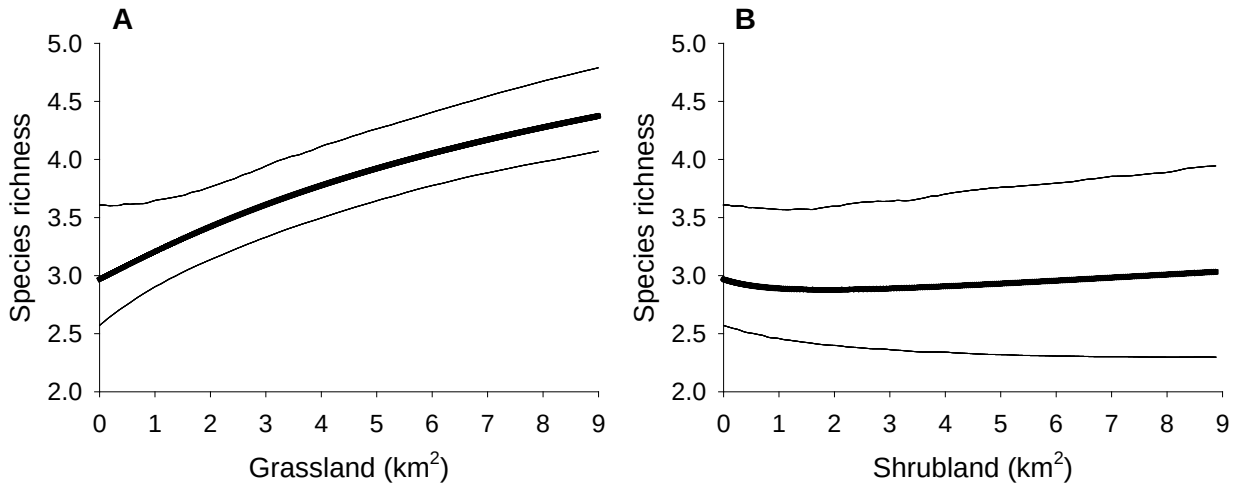

Figure 5. The species richness of grassland obligates by the area (km^2) of (A) grassland and (B) shrub-land in the surrounding 9 km^2 landscape, Southern Great Plains, USA, 2010 - 2018. The bold trend lines represent summed predictions of large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

CRP Landscape Management

Northern Great Plains

Overall species richness of grassland birds increased with the area of CRP in the surrounding landscape ($\mu_{d_{CRP}}$ = 1.22; SD = 0.028; CI = 0.066, 0.180; *P* = 0.999; Fig. 6), supporting hypothesis 3) that species richness of grassland birds increased with the increasing area of CRP in the landscape. The large effect of CRP on species richness was driven by increasing site occupancy of 19 species, whereas no species declined with increasing area of CRP in the surrounding landscape (Appendix, Table A6).

Overall species richness did not show larger responses to the area of CRP in landscapes with low land cover of grassland ($\mu_{d_{CRP*grass}}$ = 0.029; SD = 0.032; CI = -0.035, 0.092; *P* = 0.825), which failed to support hypothesis 4) that CRP increased species richness to greater extent in highly modified landscapes impacted by grassland loss than in more intact landscapes. The lack of the interaction was due to few species responding to the effect, with increasing site occupancy of 2 species and declining occupancy of 1 species along the gradient of CRP in landscapes with low land cover of grassland (Appendix, Table A7).

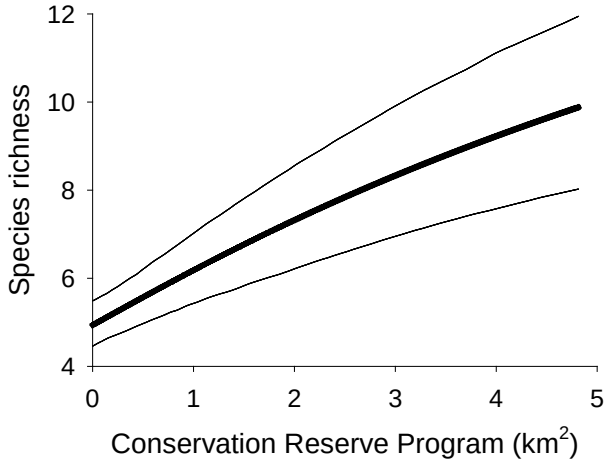

Figure 6. The species richness of the entire community of grassland birds by the area (km^2) of Conservation Reserve Program (CRP) in the surrounding 9 km^2 landscape, Northern Great Plains, USA, 2010 - 2018. The bold trend line represents summed predictions of large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

In terms of grassland obligates, species richness increased with the area of CRP in the surrounding landscape ($\mu_{d_{CRP}}$ = 0.136; SD = 0.026; CI = 0.085, 0.190; $P > 0.999$; Fig. 7), which supported hypothesis 3) that species richness of grassland birds increased with the increasing area of CRP in the landscape. The large effect of CRP on species richness resulted from increasing site occupancy of 19 species, whereas no species declined along the gradient of CRP (Appendix, Table A6).

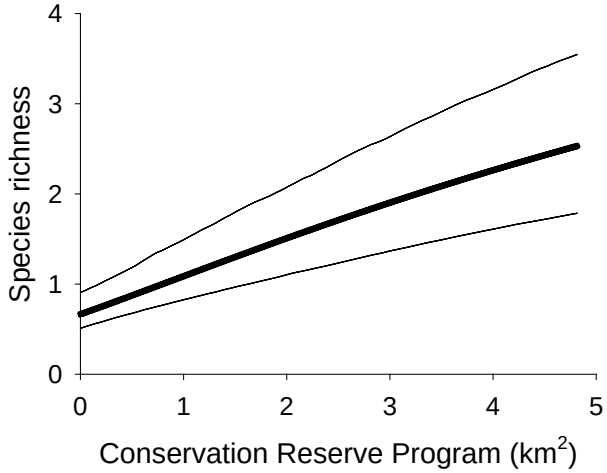

Figure 7. The species richness of grassland obligates by the area (km^2) of Conservation Reserve Program (CRP) in the surrounding 9 km^2 landscape, Northern Great Plains, USA, 2010 - 2018. The bold trend line represents summed predictions of large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

The species richness of grassland obligates did not increase with the area of CRP to a greater extent in landscapes with low land cover of grassland ($\mu_{d_{CRP*grass}}$ = 0.026; SD = 0.030; CI = -0.036, 0.087; *P* = 0.811), which failed to support hypothesis 4) that CRP increased species richness to greater extent in highly modified landscapes impacted by grassland loss than in more intact landscapes. As above, the lack of the interaction resulted from few species responding to the effect, with increasing site occupancy of 1 obligate and no obligates declining along the gradient of CRP in landscapes with low land cover of grassland (Appendix, Table A7).

Southern Great Plains

Overall species richness of grassland birds declined with increasing area of CRP in the surrounding landscape ($\mu_{d_{CRP}}$ = -0.176; SD = 0.087; CI = -0.349, -0.013; *P* = 0.983; Fig. 8), which failed to support hypothesis 3) that species richness of grassland birds increased with increasing area of CRP in the landscape. The negative effect of CRP on species richness was driven by declining site occupancy of 17 species with a fewer number of 10 species increasing along the gradient of CRP (Appendix, Table A8).

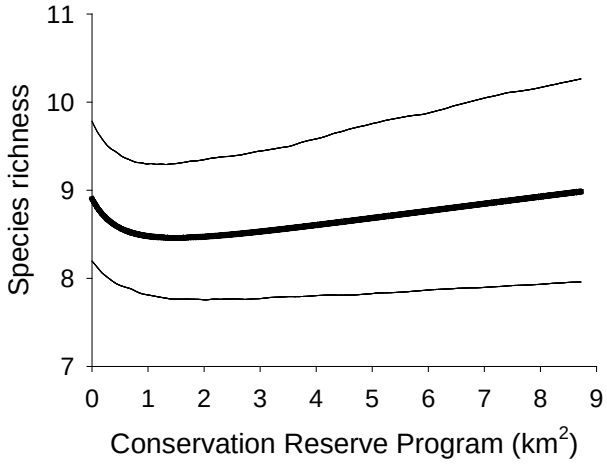

Figure 8. The species richness of the entire community of grassland birds by the area (km^2) of Conservation Reserve Program (CRP) in the surrounding 9 km^2 landscape, Southern Great Plains, USA, 2010 - 2018. The bold trend line represents summed predictions of large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

Overall species richness of grassland birds increased with the area of CRP to a greater extent in landscapes with low land cover of grassland ($\mu_{d_{CRP*grass}}$ = -0.097; SD = 0.027; CI = -0.149, -0.049; *P* > 0.999), supporting hypothesis 4) that CRP increased species richness to greater extent in highly modified landscapes impacted by grassland loss than in more intact landscapes. The large interaction effect resulted from increasing site occupancy of 10 species with increasing area of CRP and no species declining along the gradient of CRP in landscapes with low land cover of grassland (Appendix, Table A9).

Considering grassland obligates, species richness increased with the area of CRP in the surrounding landscape ($\mu_{d_{CRP}}$ = 0.130; SD = 0.068; CI = -0.001, 0.262; *P* = 0.974; Fig. 9), supporting support hypothesis 3) that species richness of grassland birds increased with increasing area of CRP in the landscape. The species richness response resulted from

increasing site occupancy of 9 obligates with no obligates declining with increasing area of CRP in the surrounding landscape (Appendix, Table A8).

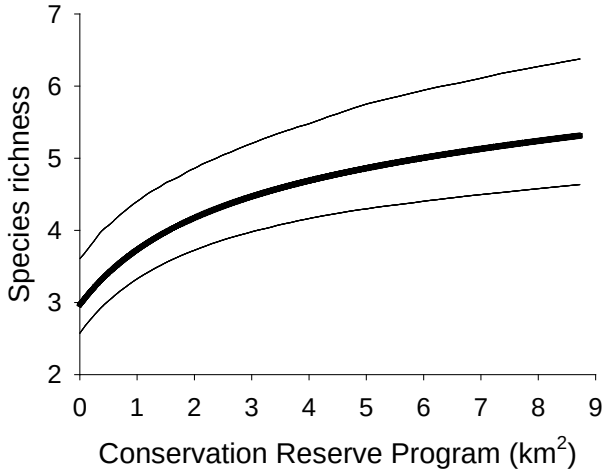

Figure 9. The species richness of grassland obligates by the area (km^2) of Conservation Reserve Program (CRP) in the surrounding 9 km^2 landscape, Southern Great Plains, USA, 2010 - 2018. The bold trend line represents summed predictions of large-scale occupancy at mean values of latitude, longitude, and the interaction between grassland and Conservation Reserve Program, and zero values for the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

The species richness of grassland obligates increased with the area of CRP to a greater extent in landscapes with low land cover of grassland ($\mu_{d_{CRP*\_grass}}$ = -0.095; SD = 0.027; CI = -0.147, -0.040; *P* = 0.998), which supported hypothesis 4) that CRP increased species richness to greater extent in highly modified landscapes impacted by grassland loss than in more intact landscapes. The interaction effect was driven by increasing site occupancy of 5 obligates with no obligates declining with increasing CRP in landscapes with low land cover of grassland (Appendix, Table A9).

Mapping Biodiversity Responses to CRP

Northern Great Plains

The species richness of grassland obligates increased with latitude in the Northern Great Plains ($\mu_{d_{Lat}}$ = 0.459; SD = 0.060; CI = 0.337, 0.574; *P* > 0.999; Fig. 10; Fig. 11). The latitudinal effect was driven by increasing site occupancy of 12 obligates, whereas only 3 species declined with latitude (Appendix, Table A10). We found little support for the quadratic term of latitude ($\mu_{d_{Lat2}}$ = 0.019; SD = 0.041; CI = -0.060, 0.102; *P* = 0.670; Fig. 10). The quadratic effect resulted from the occupancy of 5 obligates showing concave relationships with only 3 obligates showing convex relationships with latitude (Appendix, Table A11).

The species richness of grassland obligates increased with longitude in the Northern Great Plains ($\mu_{d_{Long}}$ = 0.370; SD = 0.061; CI = 0.255, 0.489; *P* > 0.999; Fig. 10; Fig. 11). The longitudinal effect was largely due to increasing site occupancy of 13 obligates, whereas only 5 obligates declined with longitude (Appendix, Table A12). We found strong support for the positive quadratic effect of latitude ($\mu_{d_{Long2}}$ = 0.118; SD = 0.033; CI = 0.055, 0.183; *P* > 0.999; Fig. 10; Fig. 11). The quadratic effect was driven by 10 obligates showing site occupancy with

convex relationships with only 1 obligate showing concave relationships and with latitude (Appendix, Table A13).

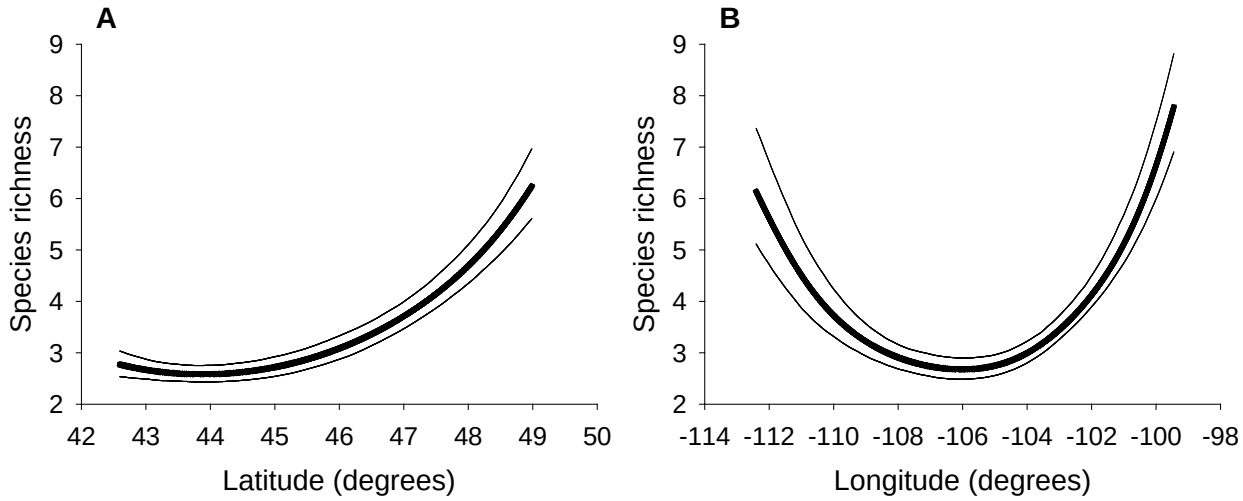

Figure 10. The species richness of grassland obligates by (A) latitude and (B) longitude, Northern Great Plains, USA, 2010 - 2018. The bold trend line represents summed predictions of large-scale occupancy at mean values of the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

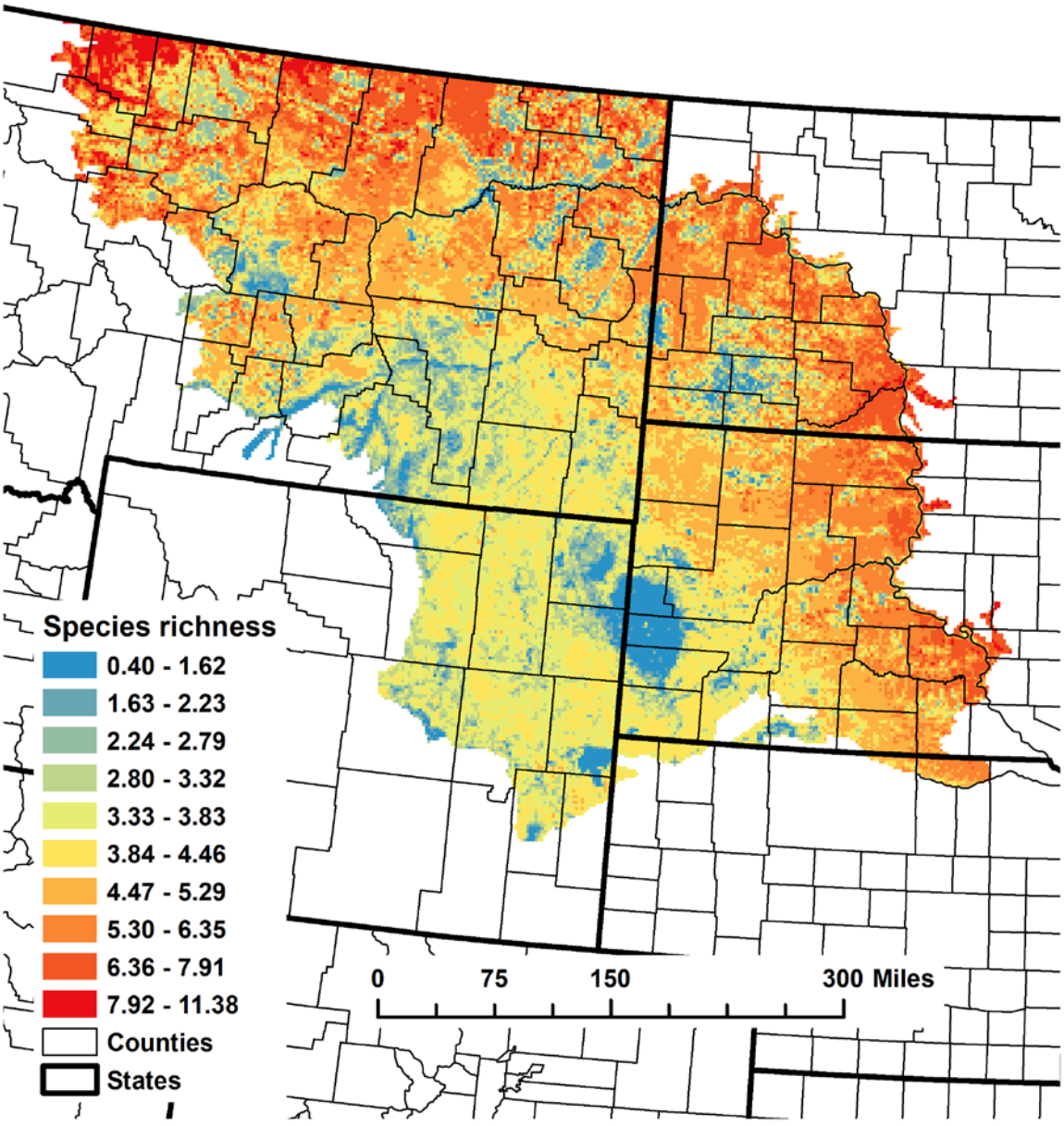

Figure 11. The predicted species richness of grassland obligates in the Northern Great Plains, USA. The color ramp represents predicted species richness for 9 km^2 landscapes as a function of land cover data calculated for 2018.

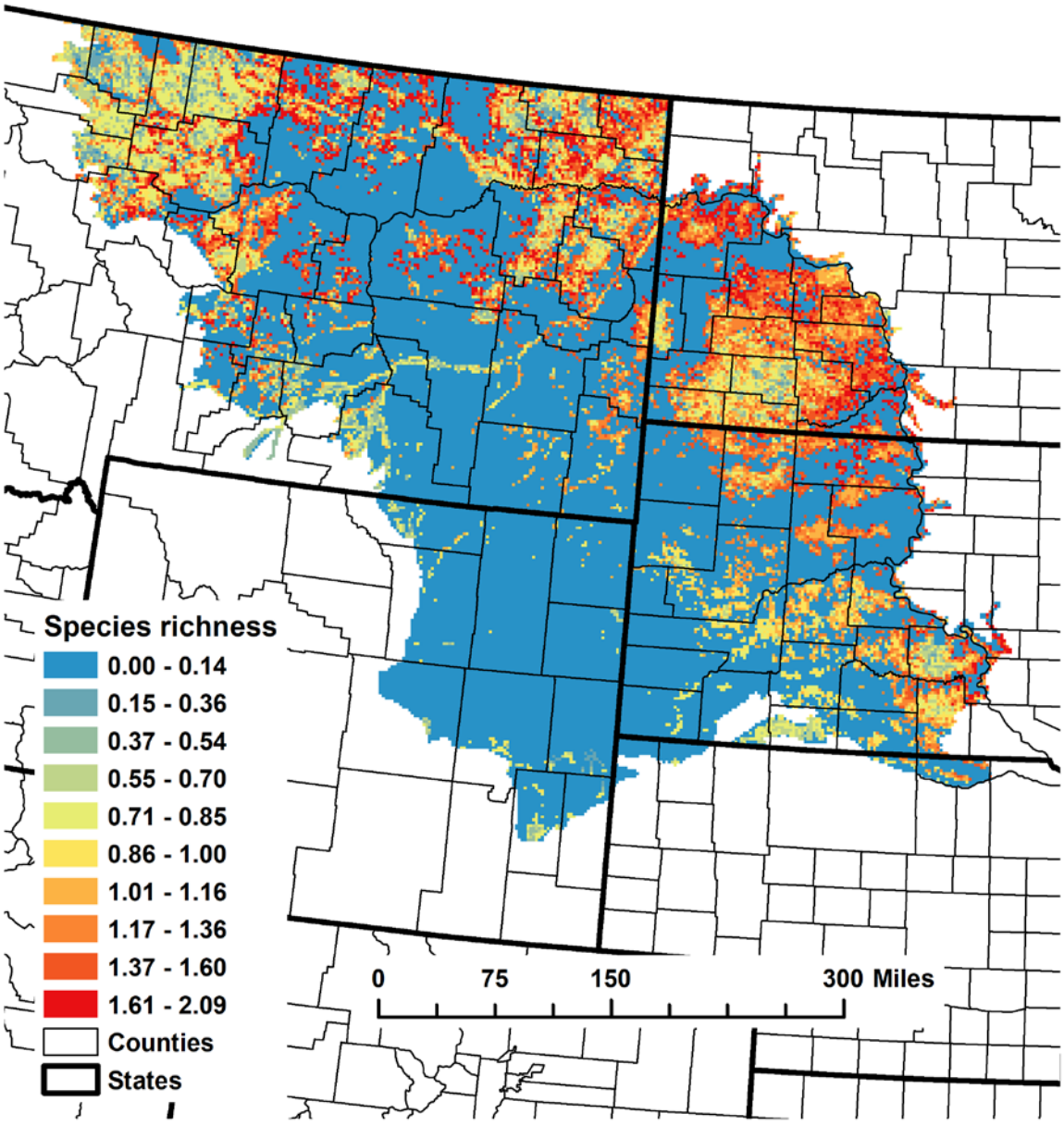

Figure 12. The predicted species richness response of grassland obligates from adding 1 km^2 of the Conservation Reserve Program in the Northern Great Plains, USA. The color ramp represents marginal species richness above the background estimates for 9 km^2 landscapes.

Southern Great Plains

The species richness of grassland obligates increased with latitude in the Southern Great Plains ($\mu_{d_{Lat}}$ = 0.447; SD = 0.122; CI = 0.216, 0.718; P > 0.999; Fig. 13; Fig. 14). The latitudinal effect was driven by increasing site occupancy of 11 obligates with only 5 obligates declining with latitude (Appendix, Table A14). We found strong support for a negative quadratic effect of latitude ($\mu_{d_{Lat2}}$ = -0.430; SD = 0.067; CI = -0.654, -0.297; P > 0.999; Fig. 13; Fig. 14). The quadratic effect resulted from the site occupancy of 10 obligates showing concave relationships and no obligates showing convex relationships with latitude (Appendix, Table A15).

We found little evidence that the species richness of grassland obligates increased with longitude in the Southern Great Plains ($\mu_{d_{Long}}$ = -0.048; SD = 0.081; CI = -0.210, 0.105; P = 0.269; Fig. 13; Fig. 14). The lack of the longitudinal effect was primarily due to variable responses, with increasing site occupancy of 5 obligates and declining occupancy of 7 obligates along the longitudinal gradient (Appendix, Table A16). We found strong support for the negative quadratic effect of latitude ($\mu_{d_{Long2}}$ = -0.172; SD = 0.047; CI = -0.263, -0.082; P > 0.999; Fig. 13; Fig. 14). The negative quadratic effect was due to site occupancy of 7 obligates showing concave relationships and fewer 2 obligates showing convex relationships with latitude (Appendix, Table A17).

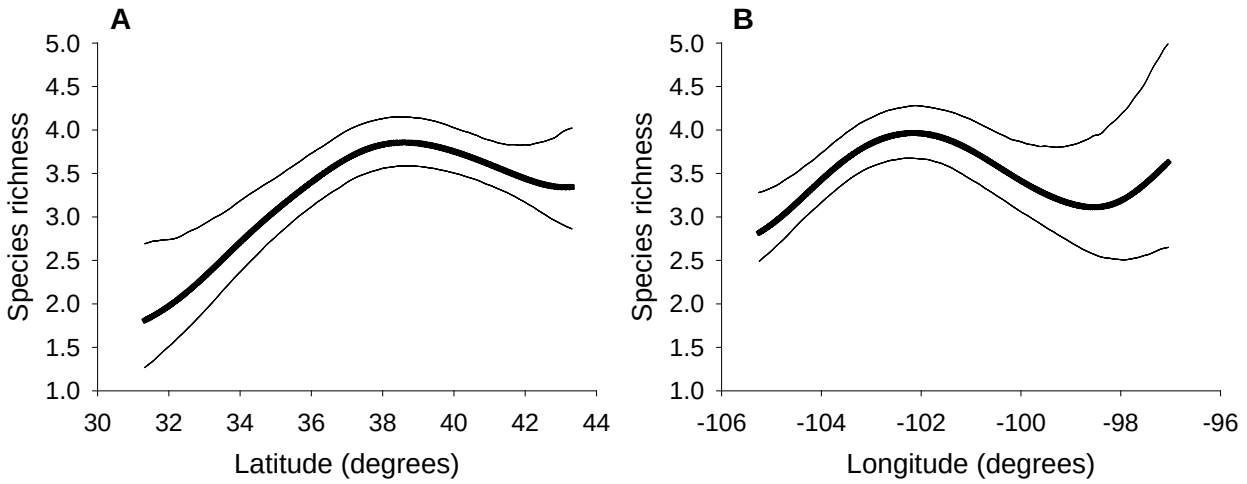

Figure 13. The species richness of grassland obligates by (A) latitude and (B) longitude, Southern Great Plains, USA, 2010 - 2018. The bold trend line represents summed predictions of large-scale occupancy at mean values of the other covariates in the model. The bounding lines represent 95% Credible Intervals for predicted species richness.

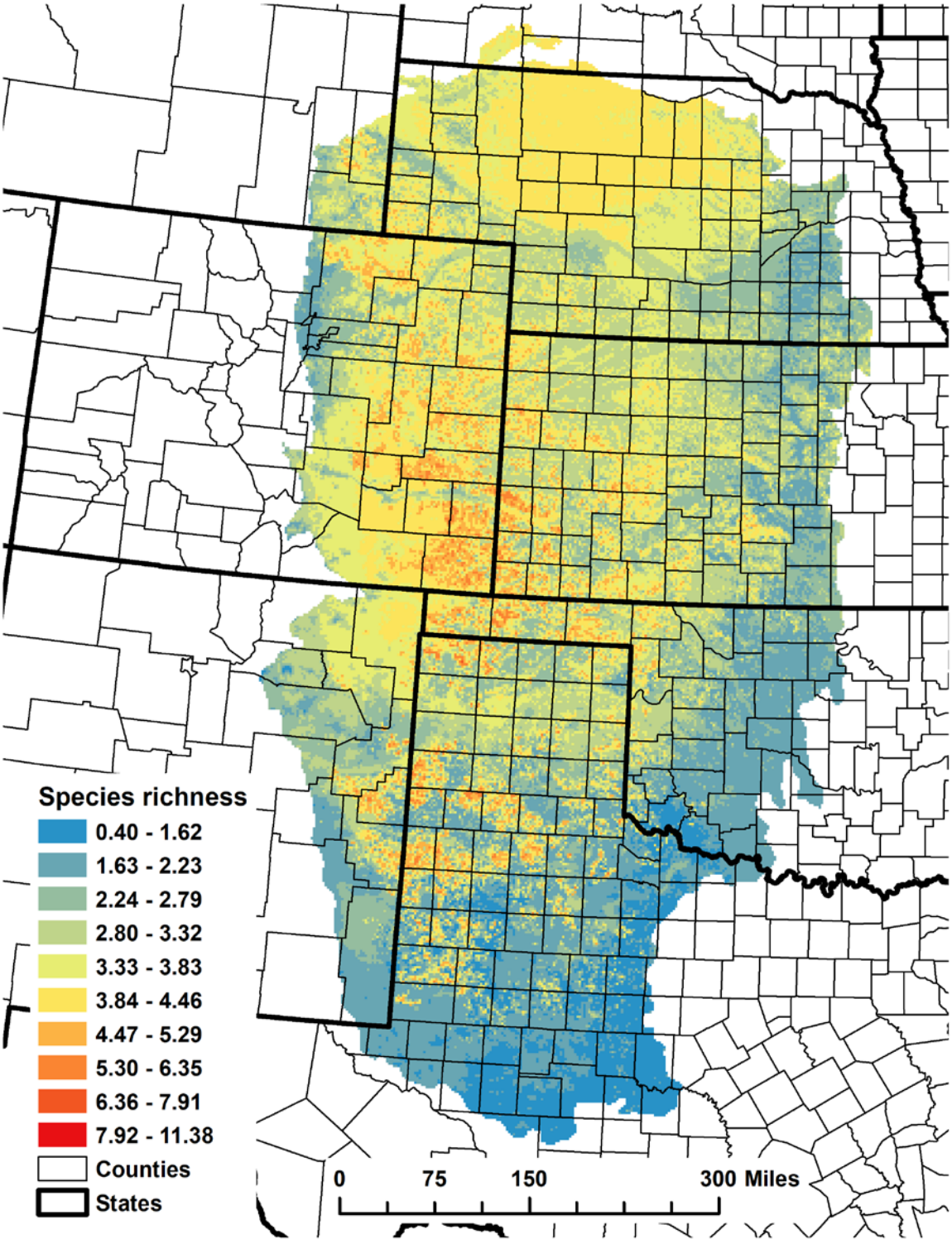

Figure 14. The predicted species richness of grassland obligates in the Southern Great Plains, USA. The color ramp represents predicted species richness for 9 km^2 landscapes as a function of land cover data calculated for 2018.

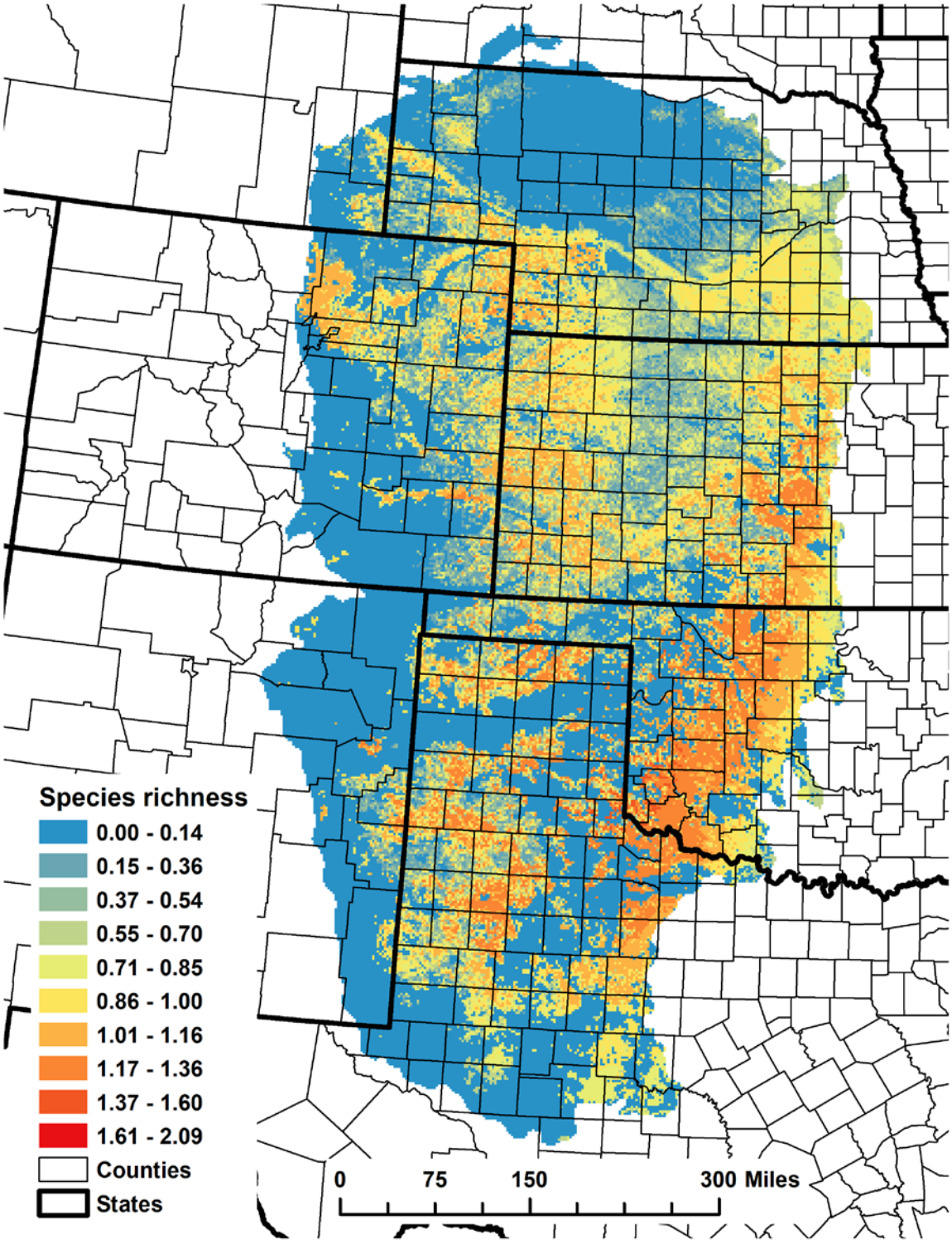

Figure 15. The predicted species richness response of grassland obligates from adding 1 km^2 of the Conservation Reserve Program in the Southern Great Plains, USA. The color ramp represents marginal species richness above the background estimates for 9 km^2 landscapes.

Discussion

The objectives of the project are to 1) investigate community responses of grassland birds to the loss of grassland vegetation at the landscape scale in the western Great Plains, 2) evaluate the effectiveness of the CRP for increasing the species richness of grassland birds and 3) map the responses of grassland birds to the amount of CRP throughout the western Great Plains to prioritize landscapes for conservation. We hypothesized that 1) the species richness of grassland birds declined with the loss of grassland, 2) the species richness of grassland birds declined with the increasing area of shrub-land, 3) the species richness of grassland birds increased with the increasing area of CRP in the landscape and 4) the effect of CRP on species richness was greater in highly modified than in landscapes impacted by grassland loss.

Our results provided evidence that grassland loss resulted in declining species richness of grassland birds in Northern and Southern Great Plains. In the Northern Great Plains, we found strong evidence that grassland loss resulted in declining species richness for both grassland obligates and the entire grassland bird community. In the Southern Great Plains, we found limited evidence that grassland loss resulted in declining species richness of the entire grassland bird community, but found strong evidence that grassland loss resulted in declining species richness of grassland obligates.

In contrast, we were unable to confirm the hypothesis that the species richness of grassland birds declined with increasing area of shrub-land in the Northern and Southern Great Plains. In the Northern Great Plains, species richness of grassland birds increased with increasing land cover of shrub land vegetation. In the Southern Great Plains, species richness did not vary considerably along the gradient of shrub-land land cover. Although we found little evidence of declining species richness of grassland obligates with increasing area of shrub-land in the landscape, the results suggested large-scale conversion of shrub-land to grassland will likely increase the species richness of grassland obligates in the Southern Great Plains.

We found strong support that landscape management of CRP increased the species richness of grassland birds. In the Northern Great Plains, increasing the area of CRP resulted in increasing species richness of grassland obligates, as well as the entire assemblage of grassland birds. In the Southern Great Plains, increasing the area of CRP increased the species richness of grassland obligates, but did not increase the species richness of the entire grassland bird community. All species that declined with increasing area of CRP in the Southern Great Plains were facultative grassland species that require other habitat features in addition to grassland. In the Southern Great Plains, increasing the area of CRP increased the species richness of grassland obligates, but did not increase the species richness of the entire grassland bird community.

The results suggested CRP landscape management benefited the community of grassland obligates to similar degrees in the Northern and Southern Great Plains. In the Northern Great Plains, the odds ratio indicated the odds of community occupancy for grassland obligates increased by 13% for every $\log_e$ increase in CRP. In the Southern Great Plains, the odds ratio indicated the odds of community occupancy for grassland obligates increased by 14% for every $\log_e$ increase in CRP.

We investigated the interaction between CRP and grassland to evaluate the hypothesis that CRP increased species richness to a greater extent in landscapes with low land cover of grassland. In the Northern Great Plains, we found the effect of CRP on the species richness of grassland birds was independent of the area of native grassland in the landscape. In contrast, CRP had a larger effect on the species richness of grassland obligates when implemented in landscapes with low land cover of native grassland in the Southern Great Plains.

Management Implications

The results of this study suggested CRP landscape management can be used to partially restore species richness of grassland obligates in landscapes impacted by grassland loss in both the Northern and Southern Great Plains. In the Northern Great Plains, a comparison of standardized effect sizes for grassland obligate responses to CRP ($\mu_{d_{CRP}} = 0.122$) and grassland ($\mu_{d_{Grass}} = 0.578$) suggested CRP landscape management is able to restore 24% (95% CI = 14% - 34%) of the historical declines in species richness of grassland obligates. In the Southern Great Plains, comparing the standardized effect sizes for grassland obligate responses to CRP ($\mu_{d_{CRP}} = 0.130$) and grassland ($\mu_{d_{Grass}} = 0.396$) suggested CRP landscape management is capable of restoring 34% (95% CI = 0% - 76%) of the historical declines in the species richness of grassland obligates.

Mapping the species richness distributions of grassland obligates provides a spatially explicit benchmark for the biological conservation of grassland birds in the western Great Plains. The species richness distributions depict variation in the potential of landscapes to support high biodiversity of grassland obligates. Regions of high species richness may identify landscape priorities for protection and regions of low biodiversity may identify landscapes with opportunities for conservation. Although the species richness distributions carry important information on benchmarks and potential of landscapes to support the biodiversity, landscape prioritization on its own without evaluating species responses to conservation action is of limited use for landscape management. Alternately, prioritizing management actions within landscapes provides the necessary information for conserving landscapes for biodiversity (Game et al. 2013).

Following Hellerstein (2018), we provide ecological assessments of landscapes, using remotely sensed data on ecosystem and species measures, that can be used in an objective framework for prioritizing the outcome of a specific conservation practice for a particular parcel of land. We mapped the marginal effect of species richness of grassland obligates from converting 1 km² of cropland to CRP, and this provided a spatially explicit framework for prioritizing landscape conservation to increase the biodiversity of grassland obligate birds. The marginal effect on species richness can be summarized by county to identify priorities for restoring species richness in landscapes impacted by grassland loss. In addition, we can evaluate the consequences of subtracting 1 km² of CRP to identify landscape priorities for mediating the expiry of CRP contracts. The approach used in this study for the marginal conservation benefit of CRP can be extended to optimize outcomes for the general CRP sign-up using the tools of Systematic Conservation Planning (Lethbridge et al. 2010, McBride et al. 2010). By considering constraints for a fixed budget for the general sign-up and cumulative effects of CRP, this study can provide the building blocks for identifying landscape management priorities for the optimal conservation of grassland birds for the minimum cost (Wilson et al. 2007). Finally, the results of this project may prove useful in Systematic Conservation Planning to provide optimal solutions to the most pressing problems involving bird conservation and agricultural production in the Great Plains.

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Appendix

Table A1. The common name, scientific name, guild (Vickery and Herkert 1999, Johnsgard 2009), population status from the Breeding Bird Survey (Sauer et al. 2017) and number of point count detections for 77 species of grassland birds observed in the study, western Great Plains, USA, 2010 - 2018.

Common name	Scientific name	Guild	Status	Detections
Baird's Sparrow	*Ammodramus bairdii*	Obligate	Declining	820
Bobolink	*Dolichonyx oryzivorus*	Obligate	Declining	1,255
Burrowing Owl	*Athene cunicularia*	Obligate	Declining	74
Cassin's Sparrow	*Peucaea cassinii*	Obligate	Stable	4,230
Chestnut-collared Longspur	*Calcarius ornatus*	Obligate	Declining	2,145
Dickcissel	*Spiza americana*	Obligate	Stable	1,115
Eastern Meadowlark	*Sturnella magna*	Obligate	Declining	626
Ferruginous Hawk	*Buteo regalis*	Obligate	Declining	20
Grasshopper Sparrow	*Ammodramus savannarum*	Obligate	Declining	12,737
Greater Prairie-Chicken	*Tympanuchus cupido*	Obligate	Stable	24
Horned Lark	*Eremophila alpestris*	Obligate	Declining	14,701
Lark Bunting	*Calamospiza melanocorys*	Obligate	Declining	8,493
Le Conte's Sparrow	*Ammodramus leconteii*	Obligate	Stable	1
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	Obligate	Declining	8
Long-billed Curlew	*Numenius americanus*	Obligate	Stable	217
Long-eared Owl	*Asio otus*	Obligate	Stable	4
Marbled Godwit	*Limosa fedoa*	Obligate	Increasing	218
McCown's Longspur	*Rhynchophanes mccownii*	Obligate	Stable	641
Mountain Plover	*Charadrius montanus*	Obligate	Declining	63
Northern Harrier	*Circus cyaneus*	Obligate	Declining	126
Savannah Sparrow	*Passerculus sandwichensis*	Obligate	Declining	1,147
Sedge Wren	*Cistothorus platensis*	Obligate	Stable	45
Sharp-tailed Grouse	*Tympanuchus phasianellus*	Obligate	Stable	114
Short-eared Owl	*Asio flammeus*	Obligate	Stable	51
Sprague's Pipit	*Anthus spragueii*	Obligate	Stable	367
Swainson's Hawk	*Buteo swainsoni*	Obligate	Increasing	129
Upland Sandpiper	*Bartramia longicauda*	Obligate	Increasing	938
Vesper Sparrow	*Pooecetes gramineus*	Obligate	Declining	4,489
Western Meadowlark	*Sturnella neglecta*	Obligate	Declining	23,817
American Bittern	*Botaurus lentiginosus*	Facultative	Declining	5
American Kestrel	*Falco sparverius*	Facultative	Declining	319
American Wigeon	*Mareca americana*	Facultative	Stable	78
Ash-throated Flycatcher	*Myiarchus cinerascens*	Facultative	Increasing	432
Barn Owl	*Tyto alba*	Facultative	Increasing	2
Blue-winged Teal	*Anas discors*	Facultative	Stable	182
Brewer's Blackbird	*Euphagus cyanocephalus*	Facultative	Declining	1,299

Common name	Scientific name	Guild	Status	Detections
Brown-headed Cowbird	*Molothrus ater*	Facultative	Declining	11,309
Canada Goose	*Branta canadensis*	Facultative	Increasing	172
Canyon Towhee	*Melozone fusca*	Facultative	Stable	102
Cassin's Kingbird	*Tyrannus vociferans*	Facultative	Stable	180
Cattle Egret	*Bubulcus ibis*	Facultative	Declining	9
Chihuahuan Raven	*Corvus cryptoleucus*	Facultative	Stable	67
Clay-colored Sparrow	*Spizella pallida*	Facultative	Stable	1,110
Common Nighthawk	*Chordeiles minor*	Facultative	Declining	770
Common Poorwill	*Phalaenoptilus nuttallii*	Facultative	Stable	12
Common Yellowthroat	*Geothlypis trichas*	Facultative	Declining	943
Eastern Bluebird	*Sialia sialis*	Facultative	Increasing	313
Eastern Kingbird	*Tyrannus tyrannus*	Facultative	Declining	1,608
Field Sparrow	*Spizella pusilla*	Facultative	Declining	1,790
Franklin's Gull	*Phalaenoptilus nuttallii*	Facultative	Declining	18
Gadwall	*Mareca strepera*	Facultative	Increasing	100
Gray Partridge	*Perdix perdix*	Facultative	Declining	6
Green-winged Teal	*Anas carolinensis*	Facultative	Declining	22
Killdeer	*Charadrius vociferus*	Facultative	Declining	1,681
Lark Sparrow	*Chondestes grammacus*	Facultative	Declining	5,857
Loggerhead Shrike	*Lanius ludovicianus*	Facultative	Declining	298
Mallard	*Anas platyrhynchos*	Facultative	Increasing	611
Merlin	*Falco columbarius*	Facultative	Stable	7
Mountain Bluebird	*Sialia currucoides*	Facultative	Stable	1,035
Mourning Dove	*Zenaida macroura*	Facultative	Declining	7,761
Northern Bobwhite	*Colinus virginianus*	Facultative	Declining	770
Northern Pintail	*Anas acuta*	Facultative	Declining	103
Northern Shoveler	*Anas clypeata*	Facultative	Stable	93
Peregrine Falcon	*Falco peregrinus*	Facultative	Stable	2
Prairie Falcon	*Falco mexicanus*	Facultative	Increasing	17
Red-winged Blackbird	*Agelaius phoeniceus*	Facultative	Declining	4,733
Ring-necked Pheasant	*Phasianus colchicus*	Facultative	Declining	959
Rufous-crowned Sparrow	*Aimophila ruficeps*	Facultative	Declining	170
Say's Phoebe	*Sayornis saya*	Facultative	Increasing	627
Scaled Quail	*Callipepla squamata*	Facultative	Stable	343
Scissor-tailed Flycatcher	*Tyrannus forficatus*	Facultative	Declining	221
Turkey Vulture	*Cathartes aura*	Facultative	Increasing	213
Western Bluebird	*Sialia mexicana*	Facultative	Stable	29
Western Kingbird	*Tyrannus verticalis*	Facultative	Stable	2,521
Willet	*Tringa semipalmata*	Facultative	Stable	104
Wilson's Phalarope	*Phalaropus tricolor*	Facultative	Stable	186
Wilson's Snipe	*Gallinago delicata*	Facultative	Stable	123

Table A2. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of grassland on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	0.137	0.380	-0.550	0.889	0.621
American Bittern	Facultative	Declining	-0.126	0.401	-0.899	0.627	0.611
American Kestrel	Facultative	Declining	0.179	0.260	-0.321	0.695	0.757
American Wigeon	Facultative	Stable	**1.284**	**0.311**	**0.680**	**1.878**	**1.000**
Baird's Sparrow	Obligate	Declining	**0.756**	**0.141**	**0.486**	**1.034**	**1.000**
Brown-headed Cowbird	Facultative	Declining	**0.234**	**0.066**	**0.102**	**0.363**	**1.000**
Bobolink	Obligate	Declining	0.088	0.105	-0.123	0.287	0.807
Brewer's Blackbird	Facultative	Declining	**0.493**	**0.075**	**0.347**	**0.640**	**1.000**
Burrowing Owl	Obligate	Declining	0.698	0.397	-0.105	1.449	0.949
Blue-winged Teal	Facultative	Stable	**0.597**	**0.191**	**0.226**	**0.966**	**0.999**
Cassin's Kingbird	Facultative	Stable	0.409	0.328	-0.227	1.067	0.886
Canada Goose	Facultative	Increasing	**0.648**	**0.221**	**0.224**	**1.080**	**1.000**
Cassin's Sparrow	Obligate	Stable	0.648	0.453	-0.172	1.544	0.933
Chestnut-collared Longspur	Obligate	Declining	**1.251**	**0.128**	**1.008**	**1.515**	**1.000**
Clay-colored Sparrow	Facultative	Stable	0.109	0.099	-0.076	0.301	0.866
Common Nighthawk	Facultative	Declining	0.099	0.099	-0.096	0.292	0.849
Common Poorwill	Facultative	Stable	0.493	0.408	-0.278	1.287	0.883
Common Yellowthroat	Facultative	Declining	**-0.848**	**0.094**	**-1.032**	**-0.663**	**1.000**
Dickcissel	Obligate	Stable	0.233	0.192	-0.147	0.624	0.894
Eastern Bluebird	Facultative	Increasing	**-0.488**	**0.130**	**-0.741**	**-0.249**	**1.000**
Eastern Kingbird	Facultative	Declining	**0.460**	**0.074**	**0.314**	**0.604**	**1.000**
Eastern Meadowlark	Obligate	Declining	0.322	0.514	-0.727	1.244	0.733
Ferruginous Hawk	Obligate	Declining	0.378	0.413	-0.453	1.192	0.829
Field Sparrow	Facultative	Declining	**0.466**	**0.098**	**0.271**	**0.656**	**1.000**
Franklin's Gull	Facultative	Declining	0.297	0.366	-0.425	1.014	0.791
Gadwall	Facultative	Increasing	**0.838**	**0.249**	**0.360**	**1.366**	**1.000**
Gray Partridge	Facultative	Declining	0.010	0.403	-0.771	0.844	0.499
Greater Prairie-Chicken	Obligate	Stable	0.732	0.437	-0.051	1.635	**0.964**
Grasshopper Sparrow	Obligate	Declining	**1.364**	**0.077**	**1.222**	**1.514**	**1.000**
Horned Lark	Obligate	Declining	**0.943**	**0.064**	**0.824**	**1.072**	**1.000**
Killdeer	Facultative	Declining	**0.762**	**0.086**	**0.603**	**0.937**	**1.000**
Lark Bunting	Obligate	Declining	**1.307**	**0.093**	**1.129**	**1.491**	**1.000**
Lark Sparrow	Facultative	Declining	**0.487**	**0.063**	**0.360**	**0.606**	**1.000**
Long-billed Curlew	Obligate	Stable	**0.507**	**0.162**	**0.178**	**0.830**	**0.999**
Le Conte's Sparrow	Obligate	Stable	-0.013	0.464	-0.929	0.855	0.499
Long-eared Owl	Obligate	Stable	-0.325	0.390	-1.099	0.414	0.795
Loggerhead Shrike	Facultative	Declining	**0.944**	**0.240**	**0.463**	**1.406**	**1.000**
Marbled Godwit	Obligate	Increasing	**0.792**	**0.197**	**0.399**	**1.200**	**1.000**
Mallard	Facultative	Increasing	**0.720**	**0.141**	**0.452**	**1.005**	**1.000**
McCown's Longspur	Obligate	Stable	0.180	0.195	-0.191	0.581	0.813
Merlin	Facultative	Stable	0.398	0.417	-0.382	1.213	0.831

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mountain Bluebird	Facultative	Stable	**-0.488**	**0.075**	**-0.637**	**-0.342**	**1.000**
Mourning Dove	Facultative	Declining	**0.289**	**0.054**	**0.180**	**0.397**	**1.000**
Mountain Plover	Obligate	Declining	**0.707**	**0.370**	**0.050**	**1.534**	**0.985**
Northern Bobwhite	Facultative	Declining	0.264	0.458	-0.566	1.143	0.704
Northern Harrier	Obligate	Declining	0.412	0.277	-0.121	0.966	0.933
Northern Pintail	Facultative	Declining	0.345	0.261	-0.191	0.854	0.913
Northern Shoveler	Facultative	Stable	0.361	0.271	-0.183	0.890	0.907
Peregrine Falcon	Facultative	Stable	0.569	0.529	-0.489	1.639	0.872
Prairie Falcon	Facultative	Increasing	0.456	0.446	-0.393	1.362	0.841
Ring-necked Pheasant	Facultative	Declining	-0.005	0.126	-0.255	0.245	0.519
Red-winged Blackbird	Facultative	Declining	**0.437**	**0.059**	**0.324**	**0.550**	**1.000**
Say's Phoebe	Facultative	Increasing	**0.627**	**0.132**	**0.353**	**0.877**	**1.000**
Savannah Sparrow	Obligate	Declining	-0.079	0.091	-0.256	0.088	0.811
Short-eared Owl	Obligate	Stable	0.392	0.310	-0.260	0.960	0.896
Sedge Wren	Obligate	Stable	-0.536	0.309	-1.142	0.104	**0.956**
Sprague's Pipit	Obligate	Stable	**1.089**	**0.332**	**0.446**	**1.806**	**0.999**
Sharp-tailed Grouse	Obligate	Stable	**0.654**	**0.262**	**0.152**	**1.145**	**0.991**
Swainson's Hawk	Obligate	Increasing	0.479	0.315	-0.129	1.138	0.934
Turkey Vulture	Facultative	Increasing	-0.470	0.250	-0.972	0.020	**0.971**
Upland Sandpiper	Obligate	Increasing	**1.002**	**0.113**	**0.792**	**1.223**	**1.000**
Vesper Sparrow	Obligate	Declining	**0.402**	**0.062**	**0.280**	**0.521**	**1.000**
Western Bluebird	Facultative	Stable	0.247	0.365	-0.447	0.941	0.746
Western Kingbird	Facultative	Stable	**0.467**	**0.100**	**0.259**	**0.666**	**1.000**
Western Meadowlark	Obligate	Declining	**1.812**	**0.086**	**1.645**	**1.976**	**1.000**
Willet	Facultative	Stable	**0.622**	**0.261**	**0.097**	**1.135**	**0.989**
Wilson's Phalarope	Facultative	Stable	**0.712**	**0.178**	**0.370**	**1.071**	**1.000**
Wilson's Snipe	Facultative	Stable	-0.098	0.203	-0.473	0.297	0.687

Table A3. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of shrub-land on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	0.071	0.224	-0.350	0.504	0.625
American Bittern	Facultative	Declining	0.178	0.225	-0.281	0.602	0.783
American Kestrel	Facultative	Declining	0.180	0.175	-0.146	0.536	0.861
American Wigeon	Facultative	Stable	0.127	0.167	-0.209	0.462	0.789
Baird's Sparrow	Obligate	Declining	-0.214	0.118	-0.451	0.023	**0.962**
Brown-headed Cowbird	Facultative	Declining	0.061	0.072	-0.076	0.199	0.790
Bobolink	Obligate	Declining	**-0.340**	**0.126**	**-0.605**	**-0.117**	**0.998**
Brewer's Blackbird	Facultative	Declining	**0.325**	**0.065**	**0.196**	**0.453**	**1.000**
Burrowing Owl	Obligate	Declining	0.177	0.203	-0.220	0.564	0.810
Blue-winged Teal	Facultative	Stable	0.089	0.160	-0.226	0.404	0.715
Cassin's Kingbird	Facultative	Stable	0.154	0.200	-0.228	0.537	0.769
Canada Goose	Facultative	Increasing	0.229	0.162	-0.084	0.545	0.921
Cassin's Sparrow	Obligate	Stable	0.043	0.239	-0.448	0.483	0.594
Chestnut-collared Longspur	Obligate	Declining	-0.032	0.091	-0.214	0.143	0.637
Clay-colored Sparrow	Facultative	Stable	**0.229**	**0.101**	**0.036**	**0.426**	**0.988**
Common Nighthawk	Facultative	Declining	0.027	0.096	-0.156	0.224	0.596
Common Poorwill	Facultative	Stable	0.179	0.223	-0.257	0.597	0.778
Common Yellowthroat	Facultative	Declining	0.105	0.102	-0.097	0.302	0.841
Dickcissel	Obligate	Stable	0.243	0.178	-0.107	0.579	0.912
Eastern Bluebird	Facultative	Increasing	-0.087	0.159	-0.398	0.225	0.712
Eastern Kingbird	Facultative	Declining	-0.040	0.077	-0.188	0.114	0.702
Eastern Meadowlark	Obligate	Declining	0.091	0.235	-0.390	0.570	0.662
Ferruginous Hawk	Obligate	Declining	0.375	0.222	-0.070	0.800	0.947
Field Sparrow	Facultative	Declining	**0.538**	**0.076**	**0.385**	**0.687**	**1.000**
Franklin's Gull	Facultative	Declining	0.099	0.203	-0.293	0.497	0.679
Gadwall	Facultative	Increasing	0.085	0.174	-0.263	0.432	0.697
Gray Partridge	Facultative	Declining	0.088	0.232	-0.343	0.562	0.647
Greater Prairie-Chicken	Obligate	Stable	0.045	0.231	-0.400	0.499	0.587
Grasshopper Sparrow	Obligate	Declining	**0.269**	**0.062**	**0.152**	**0.391**	**1.000**
Horned Lark	Obligate	Declining	0.075	0.057	-0.038	0.185	0.908
Killdeer	Facultative	Declining	**0.164**	**0.076**	**0.013**	**0.314**	**0.983**
Lark Bunting	Obligate	Declining	**0.464**	**0.061**	**0.344**	**0.583**	**1.000**
Lark Sparrow	Facultative	Declining	**0.244**	**0.057**	**0.134**	**0.359**	**1.000**
Long-billed Curlew	Obligate	Stable	-0.280	0.145	-0.559	0.014	**0.970**
Le Conte's Sparrow	Obligate	Stable	0.084	0.232	-0.376	0.518	0.651
Long-eared Owl	Obligate	Stable	0.031	0.235	-0.426	0.485	0.564
Loggerhead Shrike	Facultative	Declining	**0.523**	**0.136**	**0.265**	**0.791**	**1.000**
Marbled Godwit	Obligate	Increasing	0.060	0.140	-0.221	0.336	0.681
Mallard	Facultative	Increasing	0.063	0.122	-0.165	0.305	0.692
McCown's Longspur	Obligate	Stable	0.018	0.135	-0.234	0.290	0.549
Merlin	Facultative	Stable	0.286	0.217	-0.157	0.711	0.907

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mountain Bluebird	Facultative	Stable	**-0.245**	**0.074**	**-0.392**	**-0.101**	**1.000**
Mourning Dove	Facultative	Declining	**0.275**	**0.063**	**0.151**	**0.391**	**1.000**
Mountain Plover	Obligate	Declining	-0.016	0.216	-0.443	0.386	0.531
Northern Bobwhite	Facultative	Declining	0.093	0.237	-0.386	0.562	0.661
Northern Harrier	Obligate	Declining	0.097	0.180	-0.237	0.475	0.694
Northern Pintail	Facultative	Declining	0.210	0.185	-0.138	0.583	0.872
Northern Shoveler	Facultative	Stable	0.145	0.170	-0.189	0.465	0.795
Peregrine Falcon	Facultative	Stable	0.168	0.232	-0.273	0.631	0.771
Prairie Falcon	Facultative	Increasing	0.128	0.215	-0.271	0.568	0.721
Ring-necked Pheasant	Facultative	Declining	0.093	0.123	-0.150	0.328	0.767
Red-winged Blackbird	Facultative	Declining	**0.155**	**0.059**	**0.041**	**0.271**	**0.995**
Say's Phoebe	Facultative	Increasing	0.080	0.106	-0.124	0.286	0.766
Savannah Sparrow	Obligate	Declining	**-0.317**	**0.093**	**-0.512**	**-0.138**	**0.999**
Short-eared Owl	Obligate	Stable	0.053	0.184	-0.309	0.390	0.621
Sedge Wren	Obligate	Stable	-0.016	0.235	-0.493	0.431	0.525
Sprague's Pipit	Obligate	Stable	0.131	0.171	-0.201	0.472	0.777
Sharp-tailed Grouse	Obligate	Stable	0.143	0.171	-0.181	0.479	0.805
Swainson's Hawk	Obligate	Increasing	0.057	0.194	-0.312	0.443	0.631
Turkey Vulture	Facultative	Increasing	-0.025	0.213	-0.441	0.409	0.563
Upland Sandpiper	Obligate	Increasing	**0.336**	**0.085**	**0.171**	**0.501**	**1.000**
Vesper Sparrow	Obligate	Declining	**0.410**	**0.060**	**0.289**	**0.529**	**1.000**
Western Bluebird	Facultative	Stable	0.166	0.225	-0.288	0.579	0.765
Western Kingbird	Facultative	Stable	-0.104	0.094	-0.286	0.088	0.865
Western Meadowlark	Obligate	Declining	**0.485**	**0.087**	**0.309**	**0.648**	**1.000**
Willet	Facultative	Stable	0.075	0.167	-0.253	0.392	0.668
Wilson's Phalarope	Facultative	Stable	-0.083	0.135	-0.361	0.173	0.727
Wilson's Snipe	Facultative	Stable	0.131	0.160	-0.175	0.434	0.784

Table A4. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of grassland on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.104	0.421	-0.921	0.753	0.598
American Bittern	Facultative	Declining	0.341	0.627	-0.829	1.614	0.700
American Kestrel	Facultative	Declining	**-0.797**	**0.336**	**-1.503**	**-0.224**	**0.997**
American Wigeon	Facultative	Stable	0.396	0.575	-0.696	1.541	0.751
Ash-throated Flycatcher	Facultative	Increasing	**0.465**	**0.166**	**0.160**	**0.787**	**0.997**
Baird's Sparrow	Obligate	Declining	0.319	0.581	-0.818	1.456	0.717
Brown-headed Cowbird	Facultative	Declining	**-0.204**	**0.068**	**-0.340**	**-0.072**	**0.999**
Barn Owl	Facultative	Increasing	-0.385	0.599	-1.576	0.721	0.727
Bobolink	Obligate	Declining	-0.171	0.410	-1.033	0.594	0.655
Brewer's Blackbird	Facultative	Declining	-0.269	0.143	-0.542	0.016	**0.967**
Burrowing Owl	Obligate	Declining	0.455	0.269	-0.044	1.030	**0.955**
Blue-winged Teal	Facultative	Stable	-0.277	0.247	-0.749	0.220	0.876
Cattle Egret	Facultative	Declining	-0.162	0.483	-1.029	0.871	0.657
Cassin's Kingbird	Facultative	Stable	**0.647**	**0.235**	**0.188**	**1.125**	**0.998**
Canada Goose	Facultative	Increasing	**-0.993**	**0.276**	**-1.534**	**-0.440**	**0.999**
Canyon Towhee	Facultative	Stable	**0.578**	**0.263**	**0.072**	**1.119**	**0.985**
Cassin's Sparrow	Obligate	Stable	**1.055**	**0.097**	**0.865**	**1.243**	**1.000**
Chestnut-collared Longspur	Obligate	Declining	**1.271**	**0.382**	**0.579**	**2.061**	**1.000**
Clay-colored Sparrow	Facultative	Stable	0.273	0.467	-0.624	1.164	0.719
Chihuahuan Raven	Facultative	Stable	**0.616**	**0.264**	**0.124**	**1.128**	**0.995**
Common Nighthawk	Facultative	Declining	**0.540**	**0.144**	**0.258**	**0.830**	**1.000**
Common Poorwill	Facultative	Stable	0.311	0.440	-0.502	1.196	0.753
Common Yellowthroat	Facultative	Declining	**-0.239**	**0.107**	**-0.451**	**-0.022**	**0.984**
Dickcissel	Obligate	Stable	**-0.325**	**0.100**	**-0.516**	**-0.135**	**1.000**
Eastern Bluebird	Facultative	Increasing	0.415	0.332	-0.310	0.981	0.880
Eastern Kingbird	Facultative	Declining	**-0.282**	**0.100**	**-0.475**	**-0.092**	**0.998**
Eastern Meadowlark	Obligate	Declining	**0.794**	**0.144**	**0.501**	**1.084**	**1.000**
Ferruginous Hawk	Obligate	Declining	0.450	0.427	-0.357	1.294	0.851
Field Sparrow	Facultative	Declining	**1.244**	**0.214**	**0.842**	**1.683**	**1.000**
Greater Prairie-Chicken	Obligate	Stable	0.170	0.527	-0.806	1.184	0.619
Grasshopper Sparrow	Obligate	Declining	**0.485**	**0.069**	**0.351**	**0.617**	**1.000**
Horned Lark	Obligate	Declining	**0.252**	**0.061**	**0.132**	**0.370**	**1.000**
Killdeer	Facultative	Declining	**-0.523**	**0.079**	**-0.679**	**-0.378**	**1.000**
Lark Bunting	Obligate	Declining	**0.553**	**0.075**	**0.404**	**0.704**	**1.000**
Lark Sparrow	Facultative	Declining	**0.635**	**0.068**	**0.508**	**0.769**	**1.000**
Long-billed Curlew	Obligate	Stable	**0.857**	**0.327**	**0.253**	**1.511**	**0.992**
Lesser Prairie-Chicken	Obligate	Declining	0.188	0.469	-0.812	1.054	0.682
Loggerhead Shrike	Facultative	Declining	**1.121**	**0.294**	**0.551**	**1.712**	**1.000**
Marbled Godwit	Obligate	Increasing	0.314	0.526	-0.668	1.372	0.727
Mallard	Facultative	Increasing	**-0.627**	**0.210**	**-0.990**	**-0.139**	**0.989**

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
McCown's Longspur	Obligate	Stable	**1.499**	**0.284**	**0.976**	**2.104**	**1.000**
Mountain Bluebird	Facultative	Stable	**-0.823**	**0.233**	**-1.304**	**-0.376**	**1.000**
Mourning Dove	Facultative	Declining	**-0.409**	**0.081**	**-0.575**	**-0.257**	**1.000**
Mountain Plover	Obligate	Declining	0.245	0.260	-0.263	0.762	0.826
Northern Bobwhite	Facultative	Declining	0.215	0.124	-0.022	0.458	**0.961**
Northern Harrier	Obligate	Declining	-0.709	0.429	-1.729	0.040	**0.970**
Northern Pintail	Facultative	Declining	0.166	0.553	-0.918	1.252	0.603
Northern Shoveler	Facultative	Stable	-0.350	0.352	-1.071	0.327	0.848
Peregrine Falcon	Facultative	Stable	0.432	0.567	-0.707	1.451	0.779
Prairie Falcon	Facultative	Increasing	0.362	0.492	-0.461	1.437	0.762
Rufous-crowned Sparrow	Facultative	Declining	**0.863**	**0.232**	**0.432**	**1.328**	**1.000**
Ring-necked Pheasant	Facultative	Declining	**-0.790**	**0.115**	**-1.017**	**-0.572**	**1.000**
Red-winged Blackbird	Facultative	Declining	**-0.831**	**0.066**	**-0.962**	**-0.698**	**1.000**
Say's Phoebe	Facultative	Increasing	0.137	0.193	-0.262	0.499	0.773
Savannah Sparrow	Obligate	Declining	-0.299	0.286	-0.876	0.240	0.854
Scaled Quail	Facultative	Stable	0.214	0.165	-0.105	0.528	0.897
Scissor-tailed Flycatcher	Facultative	Declining	-0.250	0.293	-0.868	0.265	0.803
Sharp-tailed Grouse	Obligate	Stable	0.713	0.571	-0.346	1.929	0.893
Swainson's Hawk	Obligate	Increasing	-0.363	0.268	-0.963	0.109	0.939
Turkey Vulture	Facultative	Increasing	-0.120	0.372	-0.996	0.478	0.591
Upland Sandpiper	Obligate	Increasing	**1.002**	**0.328**	**0.382**	**1.651**	**1.000**
Vesper Sparrow	Obligate	Declining	**0.464**	**0.125**	**0.227**	**0.708**	**1.000**
Western Bluebird	Facultative	Stable	-0.011	0.372	-0.693	0.764	0.525
Western Kingbird	Facultative	Stable	**-0.311**	**0.065**	**-0.435**	**-0.179**	**1.000**
Western Meadowlark	Obligate	Declining	**0.292**	**0.075**	**0.146**	**0.446**	**1.000**
Wilson's Phalarope	Facultative	Stable	0.350	0.569	-0.718	1.529	0.723
Wilson's Snipe	Facultative	Stable	-0.356	0.270	-0.893	0.157	0.906

Table A5. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of shrub-land on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.189	0.357	-0.922	0.505	0.691
American Bittern	Facultative	Declining	0.032	0.406	-0.833	0.777	0.561
American Kestrel	Facultative	Declining	**0.980**	**0.296**	**0.437**	**1.595**	**1.000**
American Wigeon	Facultative	Stable	0.037	0.409	-0.767	0.812	0.514
Ash-throated Flycatcher	Facultative	Increasing	**0.694**	**0.110**	**0.481**	**0.902**	**1.000**
Baird's Sparrow	Obligate	Declining	0.117	0.358	-0.604	0.805	0.638
Brown-headed Cowbird	Facultative	Declining	**0.278**	**0.064**	**0.150**	**0.399**	**1.000**
Barn Owl	Facultative	Increasing	0.228	0.361	-0.477	0.948	0.737
Bobolink	Obligate	Declining	-0.077	0.339	-0.798	0.534	0.575
Brewer's Blackbird	Facultative	Declining	**0.470**	**0.143**	**0.186**	**0.747**	**0.999**
Burrowing Owl	Obligate	Declining	-0.039	0.241	-0.484	0.450	0.572
Blue-winged Teal	Facultative	Stable	-0.139	0.247	-0.634	0.326	0.705
Cattle Egret	Facultative	Declining	0.117	0.329	-0.564	0.744	0.659
Cassin's Kingbird	Facultative	Stable	-0.115	0.170	-0.444	0.217	0.753
Canada Goose	Facultative	Increasing	-0.026	0.291	-0.602	0.562	0.545
Canyon Towhee	Facultative	Stable	0.128	0.177	-0.218	0.479	0.769
Cassin's Sparrow	Obligate	Stable	**0.548**	**0.071**	**0.412**	**0.690**	**1.000**
Chestnut-collared Longspur	Obligate	Declining	-0.501	0.292	-1.086	0.064	**0.960**
Clay-colored Sparrow	Facultative	Stable	0.152	0.355	-0.537	0.859	0.677
Chihuahuan Raven	Facultative	Stable	-0.009	0.196	-0.396	0.369	0.505
Common Nighthawk	Facultative	Declining	0.061	0.131	-0.173	0.325	0.667
Common Poorwill	Facultative	Stable	-0.062	0.330	-0.738	0.568	0.579
Common Yellowthroat	Facultative	Declining	0.146	0.102	-0.058	0.347	0.920
Dickcissel	Obligate	Stable	-0.046	0.085	-0.214	0.122	0.699
Eastern Bluebird	Facultative	Increasing	0.273	0.172	-0.048	0.616	0.941
Eastern Kingbird	Facultative	Declining	0.147	0.096	-0.045	0.333	0.935
Eastern Meadowlark	Obligate	Declining	**0.279**	**0.108**	**0.071**	**0.505**	**0.997**
Ferruginous Hawk	Obligate	Declining	-0.200	0.315	-0.859	0.373	0.737
Field Sparrow	Facultative	Declining	**0.420**	**0.144**	**0.149**	**0.709**	**0.999**
Greater Prairie-Chicken	Obligate	Stable	**0.744**	**0.362**	**0.053**	**1.474**	**0.984**
Grasshopper Sparrow	Obligate	Declining	**-0.225**	**0.058**	**-0.342**	**-0.114**	**1.000**
Horned Lark	Obligate	Declining	**-0.372**	**0.058**	**-0.492**	**-0.260**	**1.000**
Killdeer	Facultative	Declining	0.152	0.106	-0.040	0.365	0.932
Lark Bunting	Obligate	Declining	**-0.218**	**0.073**	**-0.358**	**-0.073**	**0.999**
Lark Sparrow	Facultative	Declining	**0.187**	**0.060**	**0.072**	**0.304**	**0.999**
Long-billed Curlew	Obligate	Stable	-0.258	0.220	-0.710	0.154	0.884
Lesser Prairie-Chicken	Obligate	Declining	0.131	0.330	-0.526	0.776	0.660
Loggerhead Shrike	Facultative	Declining	0.227	0.189	-0.161	0.590	0.887
Marbled Godwit	Obligate	Increasing	-0.002	0.409	-0.850	0.791	0.510
Mallard	Facultative	Increasing	-0.108	0.205	-0.461	0.354	0.733

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
McCown's Longspur	Obligate	Stable	**-0.445**	**0.213**	**-0.855**	**-0.047**	**0.984**
Mountain Bluebird	Facultative	Stable	0.090	0.218	-0.311	0.545	0.661
Mourning Dove	Facultative	Declining	**0.299**	**0.081**	**0.139**	**0.459**	**1.000**
Mountain Plover	Obligate	Declining	0.312	0.210	-0.107	0.734	0.929
Northern Bobwhite	Facultative	Declining	**0.426**	**0.093**	**0.238**	**0.611**	**1.000**
Northern Harrier	Obligate	Declining	0.229	0.287	-0.327	0.840	0.794
Northern Pintail	Facultative	Declining	0.115	0.368	-0.568	0.852	0.599
Northern Shoveler	Facultative	Stable	-0.360	0.316	-1.023	0.228	0.887
Peregrine Falcon	Facultative	Stable	0.018	0.377	-0.810	0.727	0.545
Prairie Falcon	Facultative	Increasing	-0.071	0.331	-0.723	0.560	0.575
Rufous-crowned Sparrow	Facultative	Declining	**0.607**	**0.142**	**0.343**	**0.886**	**1.000**
Ring-necked Pheasant	Facultative	Declining	0.075	0.100	-0.115	0.267	0.767
Red-winged Blackbird	Facultative	Declining	**-0.146**	**0.061**	**-0.270**	**-0.027**	**0.992**
Say's Phoebe	Facultative	Increasing	0.007	0.141	-0.264	0.304	0.509
Savannah Sparrow	Obligate	Declining	0.223	0.263	-0.284	0.762	0.806
Scaled Quail	Facultative	Stable	**0.435**	**0.120**	**0.198**	**0.676**	**1.000**
Scissor-tailed Flycatcher	Facultative	Declining	**0.751**	**0.225**	**0.324**	**1.201**	**1.000**
Sharp-tailed Grouse	Obligate	Stable	0.275	0.354	-0.432	0.936	0.779
Swainson's Hawk	Obligate	Increasing	0.325	0.247	-0.116	0.854	0.920
Turkey Vulture	Facultative	Increasing	0.293	0.215	-0.154	0.700	0.911
Upland Sandpiper	Obligate	Increasing	-0.093	0.277	-0.625	0.453	0.641
Vesper Sparrow	Obligate	Declining	**0.239**	**0.116**	**0.005**	**0.459**	**0.977**
Western Bluebird	Facultative	Stable	0.201	0.294	-0.419	0.756	0.752
Western Kingbird	Facultative	Stable	**0.131**	**0.059**	**0.010**	**0.242**	**0.985**
Western Meadowlark	Obligate	Declining	**-0.341**	**0.070**	**-0.483**	**-0.213**	**1.000**
Wilson's Phalarope	Facultative	Stable	-0.043	0.395	-0.851	0.746	0.534
Wilson's Snipe	Facultative	Stable	**-0.832**	**0.378**	**-1.699**	**-0.189**	**0.997**

Table A6. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of the Conservation Reserve Program on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	0.126	0.142	-0.137	0.420	0.813
American Bittern	Facultative	Declining	0.101	0.146	-0.198	0.382	0.764
American Kestrel	Facultative	Declining	0.106	0.120	-0.125	0.349	0.821
American Wigeon	Facultative	Stable	0.102	0.125	-0.131	0.367	0.807
Baird's Sparrow	Obligate	Declining	**0.134**	**0.062**	**0.010**	**0.256**	**0.984**
Brown-headed Cowbird	Facultative	Declining	0.000	0.066	-0.127	0.131	0.493
Bobolink	Obligate	Declining	**0.182**	**0.074**	**0.035**	**0.328**	**0.997**
Brewer's Blackbird	Facultative	Declining	**0.166**	**0.070**	**0.032**	**0.304**	**0.993**
Burrowing Owl	Obligate	Declining	0.127	0.135	-0.142	0.402	0.845
Blue-winged Teal	Facultative	Stable	0.148	0.103	-0.046	0.361	0.926
Cassin's Kingbird	Facultative	Stable	0.083	0.145	-0.208	0.359	0.731
Canada Goose	Facultative	Increasing	0.077	0.110	-0.144	0.289	0.770
Cassin's Sparrow	Obligate	Stable	0.114	0.146	-0.181	0.398	0.793
Chestnut-collared Longspur	Obligate	Declining	**0.290**	**0.060**	**0.177**	**0.413**	**1.000**
Clay-colored Sparrow	Facultative	Stable	**0.147**	**0.058**	**0.036**	**0.263**	**0.995**
Common Nighthawk	Facultative	Declining	0.037	0.102	-0.170	0.234	0.648
Common Poorwill	Facultative	Stable	0.095	0.140	-0.194	0.374	0.771
Common Yellowthroat	Facultative	Declining	0.029	0.078	-0.123	0.176	0.654
Dickcissel	Obligate	Stable	0.106	0.116	-0.136	0.333	0.820
Eastern Bluebird	Facultative	Increasing	-0.072	0.143	-0.368	0.198	0.689
Eastern Kingbird	Facultative	Declining	0.103	0.065	-0.019	0.232	0.947
Eastern Meadowlark	Obligate	Declining	0.114	0.146	-0.177	0.402	0.797
Ferruginous Hawk	Obligate	Declining	0.056	0.134	-0.224	0.302	0.691
Field Sparrow	Facultative	Declining	-0.091	0.111	-0.315	0.123	0.805
Franklin's Gull	Facultative	Declining	0.163	0.127	-0.077	0.431	0.907
Gadwall	Facultative	Increasing	0.160	0.116	-0.063	0.404	0.923
Gray Partridge	Facultative	Declining	0.172	0.131	-0.084	0.435	0.905
Greater Prairie-Chicken	Obligate	Stable	0.146	0.138	-0.131	0.408	0.867
Grasshopper Sparrow	Obligate	Declining	**0.389**	**0.070**	**0.256**	**0.531**	**1.000**
Horned Lark	Obligate	Declining	0.038	0.056	-0.070	0.150	0.759
Killdeer	Facultative	Declining	0.063	0.063	-0.057	0.194	0.849
Lark Bunting	Obligate	Declining	**0.250**	**0.057**	**0.140**	**0.362**	**1.000**
Lark Sparrow	Facultative	Declining	-0.042	0.064	-0.168	0.086	0.741
Long-billed Curlew	Obligate	Stable	**0.173**	**0.088**	**0.002**	**0.362**	**0.976**
Le Conte's Sparrow	Obligate	Stable	0.102	0.148	-0.172	0.398	0.758
Long-eared Owl	Obligate	Stable	0.109	0.145	-0.182	0.396	0.779
Loggerhead Shrike	Facultative	Declining	**0.228**	**0.109**	**0.019**	**0.459**	**0.984**
Marbled Godwit	Obligate	Increasing	**0.218**	**0.121**	**0.004**	**0.468**	**0.977**
Mallard	Facultative	Increasing	0.150	0.110	-0.051	0.384	0.922
McCown's Longspur	Obligate	Stable	-0.069	0.086	-0.246	0.100	0.787

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Merlin	Facultative	Stable	0.101	0.145	-0.186	0.365	0.762
Mountain Bluebird	Facultative	Stable	0.019	0.109	-0.208	0.229	0.581
Mourning Dove	Facultative	Declining	0.087	0.056	-0.025	0.197	0.933
Mountain Plover	Obligate	Declining	0.092	0.136	-0.200	0.351	0.759
Northern Bobwhite	Facultative	Declining	0.098	0.146	-0.188	0.392	0.761
Northern Harrier	Obligate	Declining	-0.002	0.139	-0.284	0.275	0.505
Northern Pintail	Facultative	Declining	0.060	0.118	-0.169	0.300	0.693
Northern Shoveler	Facultative	Stable	**0.229**	**0.114**	**0.017**	**0.465**	**0.981**
Peregrine Falcon	Facultative	Stable	0.109	0.154	-0.196	0.409	0.780
Prairie Falcon	Facultative	Increasing	0.115	0.130	-0.131	0.378	0.823
Ring-necked Pheasant	Facultative	Declining	**0.203**	**0.073**	**0.068**	**0.352**	**0.995**
Red-winged Blackbird	Facultative	Declining	**0.221**	**0.068**	**0.093**	**0.361**	**1.000**
Say's Phoebe	Facultative	Increasing	0.074	0.098	-0.125	0.264	0.781
Savannah Sparrow	Obligate	Declining	**0.317**	**0.070**	**0.188**	**0.456**	**1.000**
Short-eared Owl	Obligate	Stable	**0.212**	**0.114**	**-0.002**	**0.460**	**0.973**
Sedge Wren	Obligate	Stable	0.085	0.131	-0.184	0.326	0.756
Sprague's Pipit	Obligate	Stable	0.031	0.087	-0.155	0.200	0.655
Sharp-tailed Grouse	Obligate	Stable	0.120	0.125	-0.115	0.376	0.825
Swainson's Hawk	Obligate	Increasing	0.144	0.117	-0.074	0.372	0.895
Turkey Vulture	Facultative	Increasing	0.042	0.138	-0.251	0.299	0.623
Upland Sandpiper	Obligate	Increasing	**0.168**	**0.075**	**0.013**	**0.319**	**0.983**
Vesper Sparrow	Obligate	Declining	0.102	0.064	-0.022	0.228	0.944
Western Bluebird	Facultative	Stable	0.076	0.148	-0.225	0.346	0.711
Western Kingbird	Facultative	Stable	**0.318**	**0.088**	**0.162**	**0.502**	**1.000**
Western Meadowlark	Obligate	Declining	0.068	0.088	-0.099	0.250	0.792
Willet	Facultative	Stable	**0.263**	**0.129**	**0.015**	**0.516**	**0.982**
Wilson's Phalarope	Facultative	Stable	**0.299**	**0.110**	**0.099**	**0.523**	**0.999**
Wilson's Snipe	Facultative	Stable	0.132	0.098	-0.065	0.330	0.913

Table A7. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of the interaction between Conservation Reserve Program and grassland on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.007	0.143	-0.310	0.258	0.493
American Bittern	Facultative	Declining	0.025	0.126	-0.233	0.275	0.595
American Kestrel	Facultative	Declining	0.062	0.128	-0.197	0.321	0.689
American Wigeon	Facultative	Stable	-0.016	0.123	-0.276	0.208	0.531
Baird's Sparrow	Obligate	Declining	0.128	0.087	-0.040	0.320	0.937
Brown-headed Cowbird	Facultative	Declining	0.119	0.071	-0.015	0.264	**0.959**
Bobolink	Obligate	Declining	-0.119	0.086	-0.299	0.056	0.920
Brewer's Blackbird	Facultative	Declining	0.004	0.081	-0.162	0.158	0.529
Burrowing Owl	Obligate	Declining	0.008	0.135	-0.263	0.289	0.535
Blue-winged Teal	Facultative	Stable	-0.082	0.128	-0.375	0.135	0.737
Cassin's Kingbird	Facultative	Stable	0.030	0.128	-0.219	0.291	0.600
Canada Goose	Facultative	Increasing	0.064	0.113	-0.150	0.304	0.729
Cassin's Sparrow	Obligate	Stable	0.021	0.133	-0.257	0.272	0.586
Chestnut-collared Longspur	Obligate	Declining	0.097	0.077	-0.048	0.249	0.900
Clay-colored Sparrow	Facultative	Stable	0.086	0.074	-0.053	0.231	0.891
Common Nighthawk	Facultative	Declining	0.100	0.113	-0.124	0.326	0.823
Common Poorwill	Facultative	Stable	0.028	0.139	-0.255	0.303	0.607
Common Yellowthroat	Facultative	Declining	0.130	0.091	-0.050	0.325	0.930
Dickcissel	Obligate	Stable	0.031	0.117	-0.214	0.246	0.611
Eastern Bluebird	Facultative	Increasing	0.054	0.124	-0.203	0.308	0.679
Eastern Kingbird	Facultative	Declining	0.093	0.083	-0.062	0.265	0.869
Eastern Meadowlark	Obligate	Declining	0.030	0.132	-0.223	0.302	0.589
Ferruginous Hawk	Obligate	Declining	0.035	0.124	-0.213	0.284	0.623
Field Sparrow	Facultative	Declining	0.071	0.117	-0.156	0.319	0.740
Franklin's Gull	Facultative	Declining	0.120	0.134	-0.126	0.404	0.831
Gadwall	Facultative	Increasing	0.012	0.136	-0.285	0.256	0.573
Gray Partridge	Facultative	Declining	-0.008	0.129	-0.283	0.224	0.506
Greater Prairie-Chicken	Obligate	Stable	0.069	0.127	-0.174	0.331	0.717
Grasshopper Sparrow	Obligate	Declining	0.056	0.075	-0.085	0.208	0.777
Horned Lark	Obligate	Declining	**-0.142**	**0.069**	**-0.286**	**-0.005**	**0.982**
Killdeer	Facultative	Declining	-0.012	0.080	-0.181	0.138	0.544
Lark Bunting	Obligate	Declining	0.014	0.077	-0.136	0.165	0.567
Lark Sparrow	Facultative	Declining	-0.150	0.100	-0.362	0.032	0.937
Long-billed Curlew	Obligate	Stable	0.024	0.094	-0.173	0.207	0.613
Le Conte's Sparrow	Obligate	Stable	0.035	0.134	-0.257	0.302	0.615
Long-eared Owl	Obligate	Stable	0.047	0.133	-0.201	0.320	0.636
Loggerhead Shrike	Facultative	Declining	-0.102	0.121	-0.353	0.111	0.799
Marbled Godwit	Obligate	Increasing	0.109	0.105	-0.098	0.317	0.859
Mallard	Facultative	Increasing	-0.071	0.153	-0.410	0.186	0.653
McCown's Longspur	Obligate	Stable	-0.050	0.086	-0.230	0.104	0.711

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Merlin	Facultative	Stable	0.032	0.131	-0.228	0.293	0.611
Mountain Bluebird	Facultative	Stable	0.051	0.116	-0.176	0.288	0.683
Mourning Dove	Facultative	Declining	-0.003	0.067	-0.130	0.133	0.519
Mountain Plover	Obligate	Declining	0.027	0.133	-0.227	0.306	0.585
Northern Bobwhite	Facultative	Declining	0.038	0.132	-0.230	0.304	0.624
Northern Harrier	Obligate	Declining	0.050	0.122	-0.179	0.306	0.664
Northern Pintail	Facultative	Declining	0.028	0.134	-0.254	0.281	0.608
Northern Shoveler	Facultative	Stable	-0.056	0.136	-0.338	0.187	0.638
Peregrine Falcon	Facultative	Stable	0.031	0.132	-0.246	0.302	0.609
Prairie Falcon	Facultative	Increasing	0.006	0.134	-0.279	0.253	0.519
Ring-necked Pheasant	Facultative	Declining	0.058	0.079	-0.094	0.225	0.766
Red-winged Blackbird	Facultative	Declining	**0.148**	**0.071**	**0.014**	**0.289**	**0.985**
Say's Phoebe	Facultative	Increasing	-0.010	0.114	-0.252	0.207	0.533
Savannah Sparrow	Obligate	Declining	0.053	0.084	-0.111	0.219	0.741
Short-eared Owl	Obligate	Stable	0.035	0.129	-0.232	0.281	0.620
Sedge Wren	Obligate	Stable	0.096	0.128	-0.141	0.374	0.778
Sprague's Pipit	Obligate	Stable	0.015	0.103	-0.195	0.229	0.551
Sharp-tailed Grouse	Obligate	Stable	0.004	0.124	-0.261	0.252	0.523
Swainson's Hawk	Obligate	Increasing	0.026	0.117	-0.226	0.254	0.595
Turkey Vulture	Facultative	Increasing	0.075	0.127	-0.166	0.345	0.737
Upland Sandpiper	Obligate	Increasing	0.045	0.093	-0.137	0.233	0.686
Vesper Sparrow	Obligate	Declining	0.076	0.069	-0.051	0.214	0.872
Western Bluebird	Facultative	Stable	0.042	0.130	-0.218	0.306	0.641
Western Kingbird	Facultative	Stable	0.062	0.082	-0.092	0.240	0.784
Western Meadowlark	Obligate	Declining	-0.104	0.084	-0.272	0.047	0.902
Willet	Facultative	Stable	0.094	0.123	-0.133	0.348	0.781
Wilson's Phalarope	Facultative	Stable	0.118	0.113	-0.080	0.356	0.851
Wilson's Snipe	Facultative	Stable	0.080	0.111	-0.135	0.301	0.775

Table A8. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of the Conservation Reserve Program on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.123	0.387	-0.968	0.552	0.613
American Bittern	Facultative	Declining	-0.243	0.508	-1.325	0.642	0.670
American Kestrel	Facultative	Declining	**-0.645**	**0.271**	**-1.212**	**-0.114**	**0.991**
American Wigeon	Facultative	Stable	-0.254	0.520	-1.357	0.693	0.675
Ash-throated Flycatcher	Facultative	Increasing	**-0.622**	**0.203**	**-1.025**	**-0.241**	**0.999**
Baird's Sparrow	Obligate	Declining	-0.212	0.533	-1.339	0.773	0.639
Brown-headed Cowbird	Facultative	Declining	**-0.459**	**0.075**	**-0.609**	**-0.316**	**1.000**
Barn Owl	Facultative	Increasing	-0.353	0.449	-1.244	0.496	0.787
Bobolink	Obligate	Declining	-0.518	0.492	-1.525	0.369	0.863
Brewer's Blackbird	Facultative	Declining	-0.190	0.160	-0.501	0.122	0.882
Burrowing Owl	Obligate	Declining	-0.051	0.270	-0.550	0.553	0.597
Blue-winged Teal	Facultative	Stable	-0.491	0.294	-1.106	0.066	**0.958**
Cattle Egret	Facultative	Declining	-0.386	0.444	-1.358	0.396	0.803
Cassin's Kingbird	Facultative	Stable	**-0.831**	**0.368**	**-1.598**	**-0.167**	**0.991**
Canada Goose	Facultative	Increasing	**-0.938**	**0.469**	**-1.954**	**-0.152**	**0.992**
Canyon Towhee	Facultative	Stable	**-1.150**	**0.414**	**-2.011**	**-0.388**	**0.998**
Cassin's Sparrow	Obligate	Stable	**0.336**	**0.073**	**0.192**	**0.480**	**1.000**
Chestnut-collared Longspur	Obligate	Declining	0.329	0.237	-0.192	0.757	0.911
Clay-colored Sparrow	Facultative	Stable	-0.262	0.466	-1.237	0.580	0.699
Chihuahuan Raven	Facultative	Stable	0.163	0.180	-0.183	0.533	0.820
Common Nighthawk	Facultative	Declining	-0.022	0.105	-0.226	0.189	0.591
Common Poorwill	Facultative	Stable	-0.458	0.444	-1.377	0.363	0.860
Common Yellowthroat	Facultative	Declining	**-1.319**	**0.321**	**-2.037**	**-0.779**	**1.000**
Dickcissel	Obligate	Stable	**0.222**	**0.094**	**0.035**	**0.411**	**0.991**
Eastern Bluebird	Facultative	Increasing	-0.015	0.222	-0.432	0.426	0.524
Eastern Kingbird	Facultative	Declining	**-0.467**	**0.140**	**-0.756**	**-0.193**	**1.000**
Eastern Meadowlark	Obligate	Declining	**0.776**	**0.096**	**0.587**	**0.967**	**1.000**
Ferruginous Hawk	Obligate	Declining	0.048	0.373	-0.708	0.784	0.555
Field Sparrow	Facultative	Declining	-0.186	0.202	-0.594	0.206	0.813
Greater Prairie-Chicken	Obligate	Stable	-0.495	0.482	-1.476	0.438	0.839
Grasshopper Sparrow	Obligate	Declining	**0.628**	**0.070**	**0.494**	**0.773**	**1.000**
Horned Lark	Obligate	Declining	**0.714**	**0.091**	**0.548**	**0.892**	**1.000**
Killdeer	Facultative	Declining	**-0.338**	**0.089**	**-0.518**	**-0.166**	**1.000**
Lark Bunting	Obligate	Declining	**0.584**	**0.071**	**0.443**	**0.721**	**1.000**
Lark Sparrow	Facultative	Declining	**-0.257**	**0.065**	**-0.385**	**-0.129**	**1.000**
Long-billed Curlew	Obligate	Stable	0.382	0.203	-0.004	0.803	**0.973**
Lesser Prairie-Chicken	Obligate	Declining	0.434	0.284	-0.114	1.025	0.941
Loggerhead Shrike	Facultative	Declining	**0.517**	**0.225**	**0.104**	**0.963**	**0.996**
Marbled Godwit	Obligate	Increasing	-0.330	0.542	-1.349	0.774	0.739

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mallard	Facultative	Increasing	**-0.484**	**0.187**	**-0.844**	**-0.087**	**0.989**
McCown's Longspur	Obligate	Stable	**0.510**	**0.143**	**0.229**	**0.790**	**1.000**
Mountain Bluebird	Facultative	Stable	**-0.871**	**0.365**	**-1.663**	**-0.226**	**1.000**
Mourning Dove	Facultative	Declining	0.021	0.074	-0.120	0.174	0.593
Mountain Plover	Obligate	Declining	0.128	0.214	-0.285	0.555	0.731
Northern Bobwhite	Facultative	Declining	0.163	0.099	-0.045	0.347	0.946
Northern Harrier	Obligate	Declining	-0.083	0.314	-0.694	0.566	0.606
Northern Pintail	Facultative	Declining	-0.289	0.526	-1.454	0.674	0.704
Northern Shoveler	Facultative	Stable	-0.329	0.376	-1.111	0.372	0.807
Peregrine Falcon	Facultative	Stable	0.068	0.470	-0.863	0.981	0.557
Prairie Falcon	Facultative	Increasing	-0.485	0.492	-1.497	0.418	0.833
Rufous-crowned Sparrow	Facultative	Declining	**-1.209**	**0.349**	**-1.966**	**-0.577**	**1.000**
Ring-necked Pheasant	Facultative	Declining	0.121	0.106	-0.088	0.325	0.877
Red-winged Blackbird	Facultative	Declining	**-0.305**	**0.074**	**-0.446**	**-0.161**	**1.000**
Say's Phoebe	Facultative	Increasing	-0.169	0.160	-0.469	0.151	0.851
Savannah Sparrow	Obligate	Declining	0.100	0.249	-0.420	0.567	0.669
Scaled Quail	Facultative	Stable	-0.140	0.132	-0.398	0.109	0.857
Scissor-tailed Flycatcher	Facultative	Declining	0.226	0.198	-0.155	0.638	0.877
Sharp-tailed Grouse	Obligate	Stable	-0.426	0.522	-1.529	0.545	0.793
Swainson's Hawk	Obligate	Increasing	-0.017	0.210	-0.403	0.408	0.541
Turkey Vulture	Facultative	Increasing	-0.461	0.250	-1.004	0.001	**0.975**
Upland Sandpiper	Obligate	Increasing	-0.500	0.427	-1.399	0.261	0.889
Vesper Sparrow	Obligate	Declining	0.011	0.122	-0.240	0.230	0.557
Western Bluebird	Facultative	Stable	-0.478	0.479	-1.582	0.308	0.851
Western Kingbird	Facultative	Stable	0.031	0.076	-0.121	0.179	0.665
Western Meadowlark	Obligate	Declining	**0.538**	**0.105**	**0.341**	**0.751**	**1.000**
Wilson's Phalarope	Facultative	Stable	-0.273	0.539	-1.421	0.628	0.679
Wilson's Snipe	Facultative	Stable	-0.746	0.453	-1.762	0.059	**0.962**

Table A9. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of the interaction between Conservation Reserve Program and grassland on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.100	0.083	-0.283	0.061	0.904
American Bittern	Facultative	Declining	-0.099	0.083	-0.276	0.079	0.897
American Kestrel	Facultative	Declining	-0.072	0.083	-0.228	0.117	0.843
American Wigeon	Facultative	Stable	-0.097	0.083	-0.276	0.076	0.901
Ash-throated Flycatcher	Facultative	Increasing	-0.138	0.085	-0.328	0.003	**0.972**
Baird's Sparrow	Obligate	Declining	-0.096	0.080	-0.261	0.080	0.897
Brown-headed Cowbird	Facultative	Declining	**-0.135**	**0.059**	**-0.268**	**-0.030**	**0.991**
Barn Owl	Facultative	Increasing	-0.089	0.084	-0.246	0.100	0.883
Bobolink	Obligate	Declining	-0.093	0.086	-0.267	0.081	0.891
Brewer's Blackbird	Facultative	Declining	-0.086	0.075	-0.236	0.075	0.885
Burrowing Owl	Obligate	Declining	-0.114	0.081	-0.290	0.042	0.935
Blue-winged Teal	Facultative	Stable	-0.098	0.082	-0.255	0.077	0.903
Cattle Egret	Facultative	Declining	-0.092	0.085	-0.258	0.099	0.875
Cassin's Kingbird	Facultative	Stable	-0.120	0.086	-0.318	0.045	0.938
Canada Goose	Facultative	Increasing	-0.078	0.085	-0.235	0.114	0.853
Canyon Towhee	Facultative	Stable	-0.104	0.083	-0.282	0.065	0.909
Cassin's Sparrow	Obligate	Stable	**-0.113**	**0.056**	**-0.233**	**-0.003**	**0.977**
Chestnut-collared Longspur	Obligate	Declining	-0.089	0.080	-0.250	0.087	0.887
Clay-colored Sparrow	Facultative	Stable	-0.095	0.089	-0.280	0.079	0.885
Chihuahuan Raven	Facultative	Stable	-0.075	0.083	-0.230	0.102	0.843
Common Nighthawk	Facultative	Declining	**-0.176**	**0.078**	**-0.351**	**-0.058**	**0.999**
Common Poorwill	Facultative	Stable	-0.098	0.087	-0.278	0.089	0.895
Common Yellowthroat	Facultative	Declining	-0.082	0.083	-0.241	0.094	0.878
Dickcissel	Obligate	Stable	-0.031	0.073	-0.143	0.138	0.699
Eastern Bluebird	Facultative	Increasing	-0.081	0.080	-0.237	0.096	0.860
Eastern Kingbird	Facultative	Declining	-0.093	0.071	-0.239	0.062	0.914
Eastern Meadowlark	Obligate	Declining	-0.054	0.066	-0.166	0.098	0.805
Ferruginous Hawk	Obligate	Declining	-0.080	0.085	-0.249	0.096	0.857
Field Sparrow	Facultative	Declining	-0.104	0.078	-0.282	0.056	0.916
Greater Prairie-Chicken	Obligate	Stable	-0.096	0.085	-0.270	0.070	0.885
Grasshopper Sparrow	Obligate	Declining	-0.048	0.059	-0.147	0.077	0.792
Horned Lark	Obligate	Declining	**-0.148**	**0.066**	**-0.296**	**-0.034**	**0.995**
Killdeer	Facultative	Declining	-0.067	0.062	-0.184	0.067	0.860
Lark Bunting	Obligate	Declining	-0.108	0.056	-0.224	0.009	**0.973**
Lark Sparrow	Facultative	Declining	**-0.147**	**0.055**	**-0.270**	**-0.049**	**0.997**
Long-billed Curlew	Obligate	Stable	-0.077	0.084	-0.231	0.113	0.845
Lesser Prairie-Chicken	Obligate	Declining	-0.123	0.083	-0.328	0.034	0.950
Loggerhead Shrike	Facultative	Declining	-0.097	0.083	-0.271	0.070	0.899
Marbled Godwit	Obligate	Increasing	-0.100	0.085	-0.286	0.079	0.903

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mallard	Facultative	Increasing	-0.104	0.075	-0.258	0.055	0.931
McCown's Longspur	Obligate	Stable	-0.059	0.081	-0.192	0.125	0.790
Mountain Bluebird	Facultative	Stable	-0.078	0.087	-0.235	0.133	0.851
Mourning Dove	Facultative	Declining	-0.056	0.065	-0.166	0.094	0.815
Mountain Plover	Obligate	Declining	-0.099	0.079	-0.269	0.071	0.911
Northern Bobwhite	Facultative	Declining	-0.108	0.067	-0.258	0.026	0.948
Northern Harrier	Obligate	Declining	-0.091	0.079	-0.243	0.067	0.884
Northern Pintail	Facultative	Declining	-0.099	0.085	-0.289	0.072	0.889
Northern Shoveler	Facultative	Stable	-0.083	0.079	-0.232	0.091	0.860
Peregrine Falcon	Facultative	Stable	-0.090	0.085	-0.262	0.090	0.874
Prairie Falcon	Facultative	Increasing	-0.099	0.083	-0.273	0.067	0.896
Rufous-crowned Sparrow	Facultative	Declining	-0.095	0.083	-0.265	0.078	0.889
Ring-necked Pheasant	Facultative	Declining	-0.098	0.066	-0.232	0.038	0.929
Red-winged Blackbird	Facultative	Declining	**-0.133**	**0.055**	**-0.255**	**-0.034**	**0.995**
Say's Phoebe	Facultative	Increasing	-0.089	0.074	-0.236	0.076	0.899
Savannah Sparrow	Obligate	Declining	-0.079	0.085	-0.231	0.121	0.853
Scaled Quail	Facultative	Stable	-0.104	0.071	-0.252	0.041	0.937
Scissor-tailed Flycatcher	Facultative	Declining	-0.118	0.079	-0.301	0.034	0.944
Sharp-tailed Grouse	Obligate	Stable	-0.099	0.083	-0.273	0.068	0.903
Swainson's Hawk	Obligate	Increasing	-0.104	0.078	-0.266	0.053	0.921
Turkey Vulture	Facultative	Increasing	-0.086	0.076	-0.242	0.084	0.877
Upland Sandpiper	Obligate	Increasing	-0.110	0.086	-0.292	0.058	0.917
Vesper Sparrow	Obligate	Declining	**-0.165**	**0.084**	**-0.365**	**-0.035**	**0.994**
Western Bluebird	Facultative	Stable	-0.093	0.085	-0.261	0.093	0.878
Western Kingbird	Facultative	Stable	-0.060	0.065	-0.173	0.084	0.827
Western Meadowlark	Obligate	Declining	-0.110	0.062	-0.250	0.012	**0.967**
Wilson's Phalarope	Facultative	Stable	-0.098	0.082	-0.268	0.075	0.905
Wilson's Snipe	Facultative	Stable	-0.089	0.086	-0.259	0.089	0.874

Table A10. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of latitude on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	0.161	0.361	-0.495	0.867	0.663
American Bittern	Facultative	Declining	0.675	0.484	-0.236	1.733	0.923
American Kestrel	Facultative	Declining	-0.017	0.151	-0.301	0.278	0.548
American Wigeon	Facultative	Stable	**0.755**	**0.233**	**0.321**	**1.222**	**1.000**
Baird's Sparrow	Obligate	Declining	**1.394**	**0.165**	**1.084**	**1.730**	**1.000**
Brown-headed Cowbird	Facultative	Declining	**1.084**	**0.097**	**0.905**	**1.271**	**1.000**
Bobolink	Obligate	Declining	**1.680**	**0.124**	**1.435**	**1.932**	**1.000**
Brewer's Blackbird	Facultative	Declining	0.049	0.072	-0.091	0.186	0.753
Burrowing Owl	Obligate	Declining	-0.357	0.315	-1.029	0.241	0.869
Blue-winged Teal	Facultative	Stable	**0.716**	**0.165**	**0.417**	**1.052**	**1.000**
Cassin's Kingbird	Facultative	Stable	-0.240	0.394	-1.041	0.555	0.736
Canada Goose	Facultative	Increasing	**0.901**	**0.189**	**0.535**	**1.300**	**1.000**
Cassin's Sparrow	Obligate	Stable	-0.334	0.498	-1.300	0.643	0.751
Chestnut-collared Longspur	Obligate	Declining	**1.245**	**0.108**	**1.042**	**1.464**	**1.000**
Clay-colored Sparrow	Facultative	Stable	**1.976**	**0.150**	**1.700**	**2.275**	**1.000**
Common Nighthawk	Facultative	Declining	**-0.309**	**0.098**	**-0.511**	**-0.112**	**0.999**
Common Poorwill	Facultative	Stable	0.233	0.389	-0.519	1.038	0.715
Common Yellowthroat	Facultative	Declining	**1.507**	**0.134**	**1.249**	**1.764**	**1.000**
Dickcissel	Obligate	Stable	-0.019	0.189	-0.411	0.335	0.515
Eastern Bluebird	Facultative	Increasing	0.218	0.138	-0.047	0.488	0.940
Eastern Kingbird	Facultative	Declining	**0.585**	**0.074**	**0.443**	**0.731**	**1.000**
Eastern Meadowlark	Obligate	Declining	0.260	0.572	-0.878	1.334	0.685
Ferruginous Hawk	Obligate	Declining	0.287	0.377	-0.437	1.054	0.777
Field Sparrow	Facultative	Declining	**1.257**	**0.083**	**1.101**	**1.419**	**1.000**
Franklin's Gull	Facultative	Declining	**1.397**	**0.515**	**0.468**	**2.505**	**1.000**
Gadwall	Facultative	Increasing	**1.014**	**0.243**	**0.562**	**1.502**	**1.000**
Gray Partridge	Facultative	Declining	**1.245**	**0.475**	**0.295**	**2.177**	**0.997**
Greater Prairie-Chicken	Obligate	Stable	-0.268	0.475	-1.251	0.642	0.705
Grasshopper Sparrow	Obligate	Declining	**0.245**	**0.066**	**0.117**	**0.376**	**1.000**
Horned Lark	Obligate	Declining	**-0.188**	**0.058**	**-0.298**	**-0.070**	**1.000**
Killdeer	Facultative	Declining	**0.240**	**0.077**	**0.096**	**0.399**	**0.999**
Lark Bunting	Obligate	Declining	**-0.214**	**0.060**	**-0.331**	**-0.097**	**1.000**
Lark Sparrow	Facultative	Declining	**0.191**	**0.059**	**0.084**	**0.311**	**0.999**
Long-billed Curlew	Obligate	Stable	-0.249	0.153	-0.535	0.051	0.949
Le Conte's Sparrow	Obligate	Stable	0.865	0.617	-0.420	1.949	0.918
Long-eared Owl	Obligate	Stable	-0.108	0.507	-1.119	0.870	0.591
Loggerhead Shrike	Facultative	Declining	-0.102	0.127	-0.340	0.144	0.772
Marbled Godwit	Obligate	Increasing	**1.030**	**0.185**	**0.682**	**1.402**	**1.000**
Mallard	Facultative	Increasing	**0.377**	**0.113**	**0.159**	**0.600**	**0.999**
McCown's Longspur	Obligate	Stable	0.066	0.208	-0.332	0.458	0.621
Merlin	Facultative	Stable	-0.105	0.488	-1.110	0.802	0.584

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mountain Bluebird	Facultative	Stable	**0.215**	**0.078**	**0.063**	**0.370**	**0.999**
Mourning Dove	Facultative	Declining	**0.423**	**0.065**	**0.299**	**0.555**	**1.000**
Mountain Plover	Obligate	Declining	-0.598	0.358	-1.307	0.051	**0.962**
Northern Bobwhite	Facultative	Declining	0.336	0.480	-0.640	1.294	0.767
Northern Harrier	Obligate	Declining	**0.595**	**0.164**	**0.276**	**0.921**	**0.999**
Northern Pintail	Facultative	Declining	**0.675**	**0.224**	**0.251**	**1.126**	**0.999**
Northern Shoveler	Facultative	Stable	**0.526**	**0.208**	**0.129**	**0.941**	**0.995**
Peregrine Falcon	Facultative	Stable	0.698	0.621	-0.481	1.964	0.875
Prairie Falcon	Facultative	Increasing	0.383	0.427	-0.454	1.372	0.841
Ring-necked Pheasant	Facultative	Declining	**2.095**	**0.190**	**1.717**	**2.477**	**1.000**
Red-winged Blackbird	Facultative	Declining	**0.263**	**0.066**	**0.135**	**0.394**	**1.000**
Say's Phoebe	Facultative	Increasing	**0.221**	**0.098**	**0.024**	**0.414**	**0.984**
Savannah Sparrow	Obligate	Declining	**1.527**	**0.134**	**1.276**	**1.796**	**1.000**
Short-eared Owl	Obligate	Stable	0.272	0.255	-0.244	0.796	0.863
Sedge Wren	Obligate	Stable	**1.739**	**0.379**	**1.060**	**2.551**	**1.000**
Sprague's Pipit	Obligate	Stable	**1.447**	**0.305**	**0.911**	**2.106**	**1.000**
Sharp-tailed Grouse	Obligate	Stable	**0.867**	**0.169**	**0.549**	**1.229**	**1.000**
Swainson's Hawk	Obligate	Increasing	**0.971**	**0.254**	**0.487**	**1.452**	**1.000**
Turkey Vulture	Facultative	Increasing	-0.138	0.187	-0.509	0.241	0.777
Upland Sandpiper	Obligate	Increasing	0.029	0.076	-0.125	0.178	0.646
Vesper Sparrow	Obligate	Declining	**0.601**	**0.066**	**0.471**	**0.730**	**1.000**
Western Bluebird	Facultative	Stable	0.265	0.430	-0.584	1.151	0.735
Western Kingbird	Facultative	Stable	**0.278**	**0.083**	**0.114**	**0.438**	**0.999**
Western Meadowlark	Obligate	Declining	0.057	0.099	-0.137	0.254	0.711
Willet	Facultative	Stable	**1.439**	**0.386**	**0.732**	**2.258**	**1.000**
Wilson's Phalarope	Facultative	Stable	**0.461**	**0.155**	**0.171**	**0.765**	**0.999**
Wilson's Snipe	Facultative	Stable	**1.325**	**0.249**	**0.866**	**1.860**	**1.000**

Table A11. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the quadratic effects of latitude on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	0.301	0.294	-0.240	0.892	0.850
American Bittern	Facultative	Declining	-0.473	0.306	-1.141	0.089	0.949
American Kestrel	Facultative	Declining	0.209	0.182	-0.148	0.597	0.891
American Wigeon	Facultative	Stable	**-0.376**	**0.164**	**-0.702**	**-0.064**	**0.993**
Baird's Sparrow	Obligate	Declining	-0.020	0.108	-0.224	0.197	0.573
Brown-headed Cowbird	Facultative	Declining	**-0.549**	**0.082**	**-0.710**	**-0.385**	**1.000**
Bobolink	Obligate	Declining	**-0.368**	**0.113**	**-0.595**	**-0.142**	**0.999**
Brewer's Blackbird	Facultative	Declining	-0.062	0.072	-0.196	0.082	0.807
Burrowing Owl	Obligate	Declining	-0.004	0.230	-0.448	0.432	0.501
Blue-winged Teal	Facultative	Stable	-0.141	0.145	-0.422	0.147	0.838
Cassin's Kingbird	Facultative	Stable	**-0.570**	**0.281**	**-1.161**	**-0.060**	**0.981**
Canada Goose	Facultative	Increasing	-0.188	0.162	-0.504	0.127	0.871
Cassin's Sparrow	Obligate	Stable	-0.088	0.309	-0.689	0.510	0.624
Chestnut-collared Longspur	Obligate	Declining	-0.044	0.086	-0.216	0.121	0.702
Clay-colored Sparrow	Facultative	Stable	-0.098	0.105	-0.307	0.106	0.821
Common Nighthawk	Facultative	Declining	0.124	0.097	-0.063	0.321	0.899
Common Poorwill	Facultative	Stable	0.022	0.271	-0.527	0.556	0.541
Common Yellowthroat	Facultative	Declining	**-0.387**	**0.116**	**-0.623**	**-0.157**	**0.999**
Dickcissel	Obligate	Stable	-0.164	0.206	-0.600	0.211	0.781
Eastern Bluebird	Facultative	Increasing	0.021	0.173	-0.308	0.372	0.557
Eastern Kingbird	Facultative	Declining	-0.084	0.082	-0.247	0.077	0.839
Eastern Meadowlark	Obligate	Declining	-0.232	0.313	-0.898	0.347	0.775
Ferruginous Hawk	Obligate	Declining	0.066	0.252	-0.422	0.580	0.601
Field Sparrow	Facultative	Declining	-0.107	0.087	-0.280	0.063	0.891
Franklin's Gull	Facultative	Declining	0.208	0.253	-0.261	0.722	0.790
Gadwall	Facultative	Increasing	-0.222	0.182	-0.568	0.136	0.883
Gray Partridge	Facultative	Declining	-0.218	0.294	-0.793	0.347	0.773
Greater Prairie-Chicken	Obligate	Stable	-0.256	0.288	-0.807	0.345	0.820
Grasshopper Sparrow	Obligate	Declining	**0.222**	**0.067**	**0.088**	**0.352**	**1.000**
Horned Lark	Obligate	Declining	**0.419**	**0.064**	**0.291**	**0.544**	**1.000**
Killdeer	Facultative	Declining	**-0.198**	**0.079**	**-0.351**	**-0.032**	**0.991**
Lark Bunting	Obligate	Declining	**-0.182**	**0.063**	**-0.302**	**-0.057**	**0.997**
Lark Sparrow	Facultative	Declining	**-0.251**	**0.064**	**-0.375**	**-0.119**	**1.000**
Long-billed Curlew	Obligate	Stable	**0.275**	**0.124**	**0.029**	**0.528**	**0.985**
Le Conte's Sparrow	Obligate	Stable	-0.123	0.324	-0.796	0.464	0.625
Long-eared Owl	Obligate	Stable	-0.171	0.305	-0.772	0.421	0.709
Loggerhead Shrike	Facultative	Declining	0.092	0.139	-0.174	0.374	0.739
Marbled Godwit	Obligate	Increasing	0.138	0.135	-0.120	0.409	0.847
Mallard	Facultative	Increasing	**-0.256**	**0.112**	**-0.459**	**-0.029**	**0.983**
McCown's Longspur	Obligate	Stable	**0.683**	**0.160**	**0.380**	**1.028**	**1.000**
Merlin	Facultative	Stable	0.068	0.295	-0.531	0.649	0.595

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mountain Bluebird	Facultative	Stable	**0.308**	**0.108**	**0.096**	**0.518**	**0.998**
Mourning Dove	Facultative	Declining	**-0.159**	**0.066**	**-0.289**	**-0.025**	**0.991**
Mountain Plover	Obligate	Declining	0.172	0.258	-0.327	0.688	0.731
Northern Bobwhite	Facultative	Declining	-0.010	0.311	-0.577	0.619	0.522
Northern Harrier	Obligate	Declining	0.062	0.168	-0.270	0.427	0.637
Northern Pintail	Facultative	Declining	0.045	0.183	-0.311	0.402	0.596
Northern Shoveler	Facultative	Stable	0.023	0.171	-0.308	0.372	0.532
Peregrine Falcon	Facultative	Stable	-0.164	0.317	-0.825	0.447	0.691
Prairie Falcon	Facultative	Increasing	0.088	0.260	-0.423	0.587	0.635
Ring-necked Pheasant	Facultative	Declining	**-0.867**	**0.148**	**-1.154**	**-0.573**	**1.000**
Red-winged Blackbird	Facultative	Declining	**-0.309**	**0.068**	**-0.453**	**-0.171**	**1.000**
Say's Phoebe	Facultative	Increasing	-0.062	0.132	-0.318	0.196	0.682
Savannah Sparrow	Obligate	Declining	**-0.216**	**0.098**	**-0.399**	**-0.020**	**0.985**
Short-eared Owl	Obligate	Stable	-0.058	0.191	-0.426	0.313	0.608
Sedge Wren	Obligate	Stable	0.002	0.264	-0.515	0.520	0.510
Sprague's Pipit	Obligate	Stable	**0.472**	**0.168**	**0.127**	**0.810**	**0.996**
Sharp-tailed Grouse	Obligate	Stable	-0.017	0.195	-0.394	0.355	0.535
Swainson's Hawk	Obligate	Increasing	-0.163	0.202	-0.539	0.235	0.799
Turkey Vulture	Facultative	Increasing	**-0.456**	**0.201**	**-0.852**	**-0.054**	**0.985**
Upland Sandpiper	Obligate	Increasing	-0.060	0.088	-0.232	0.104	0.741
Vesper Sparrow	Obligate	Declining	0.043	0.071	-0.095	0.180	0.719
Western Bluebird	Facultative	Stable	-0.362	0.291	-0.970	0.198	0.898
Western Kingbird	Facultative	Stable	-0.141	0.099	-0.336	0.050	0.916
Western Meadowlark	Obligate	Declining	0.154	0.110	-0.058	0.379	0.923
Willet	Facultative	Stable	0.017	0.209	-0.371	0.444	0.517
Wilson's Phalarope	Facultative	Stable	-0.158	0.132	-0.417	0.107	0.889
Wilson's Snipe	Facultative	Stable	**-0.426**	**0.184**	**-0.791**	**-0.060**	**0.989**

Table A12. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of longitude on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	0.078	0.379	-0.708	0.818	0.588
American Bittern	Facultative	Declining	0.201	0.454	-0.708	1.078	0.680
American Kestrel	Facultative	Declining	**-0.594**	**0.177**	**-0.967**	**-0.264**	**0.999**
American Wigeon	Facultative	Stable	-0.150	0.200	-0.544	0.238	0.771
Baird's Sparrow	Obligate	Declining	**0.360**	**0.123**	**0.118**	**0.617**	**0.997**
Brown-headed Cowbird	Facultative	Declining	**1.043**	**0.133**	**0.792**	**1.315**	**1.000**
Bobolink	Obligate	Declining	**1.675**	**0.128**	**1.435**	**1.932**	**1.000**
Brewer's Blackbird	Facultative	Declining	**-0.465**	**0.094**	**-0.648**	**-0.276**	**1.000**
Burrowing Owl	Obligate	Declining	0.196	0.308	-0.423	0.787	0.739
Blue-winged Teal	Facultative	Stable	**0.872**	**0.157**	**0.572**	**1.191**	**1.000**
Cassin's Kingbird	Facultative	Stable	**-0.984**	**0.452**	**-1.892**	**-0.119**	**0.985**
Canada Goose	Facultative	Increasing	-0.222	0.205	-0.612	0.177	0.855
Cassin's Sparrow	Obligate	Stable	-0.194	0.590	-1.400	0.852	0.609
Chestnut-collared Longspur	Obligate	Declining	**0.636**	**0.093**	**0.464**	**0.826**	**1.000**
Clay-colored Sparrow	Facultative	Stable	**0.917**	**0.108**	**0.709**	**1.128**	**1.000**
Common Nighthawk	Facultative	Declining	**-0.286**	**0.126**	**-0.524**	**-0.032**	**0.989**
Common Poorwill	Facultative	Stable	0.055	0.411	-0.755	0.835	0.545
Common Yellowthroat	Facultative	Declining	**0.926**	**0.117**	**0.689**	**1.156**	**1.000**
Dickcissel	Obligate	Stable	**1.499**	**0.319**	**0.956**	**2.194**	**1.000**
Eastern Bluebird	Facultative	Increasing	**1.303**	**0.262**	**0.814**	**1.803**	**1.000**
Eastern Kingbird	Facultative	Declining	**0.534**	**0.087**	**0.370**	**0.708**	**1.000**
Eastern Meadowlark	Obligate	Declining	0.349	0.596	-0.786	1.560	0.721
Ferruginous Hawk	Obligate	Declining	-0.779	0.479	-1.771	0.103	**0.951**
Field Sparrow	Facultative	Declining	**1.128**	**0.110**	**0.918**	**1.346**	**1.000**
Franklin's Gull	Facultative	Declining	-0.343	0.451	-1.272	0.490	0.781
Gadwall	Facultative	Increasing	**0.779**	**0.206**	**0.399**	**1.218**	**1.000**
Gray Partridge	Facultative	Declining	**0.771**	**0.385**	**0.033**	**1.498**	**0.978**
Greater Prairie-Chicken	Obligate	Stable	**1.478**	**0.453**	**0.624**	**2.398**	**1.000**
Grasshopper Sparrow	Obligate	Declining	**1.672**	**0.110**	**1.462**	**1.902**	**1.000**
Horned Lark	Obligate	Declining	0.075	0.071	-0.061	0.223	0.851
Killdeer	Facultative	Declining	0.091	0.089	-0.081	0.265	0.847
Lark Bunting	Obligate	Declining	**-0.332**	**0.080**	**-0.490**	**-0.174**	**1.000**
Lark Sparrow	Facultative	Declining	**-0.138**	**0.074**	**-0.283**	**0.009**	**0.968**
Long-billed Curlew	Obligate	Stable	**-0.784**	**0.191**	**-1.179**	**-0.407**	**1.000**
Le Conte's Sparrow	Obligate	Stable	0.724	0.555	-0.353	1.847	0.909
Long-eared Owl	Obligate	Stable	0.618	0.579	-0.513	1.807	0.857
Loggerhead Shrike	Facultative	Declining	-0.303	0.177	-0.667	0.031	**0.958**
Marbled Godwit	Obligate	Increasing	**0.658**	**0.140**	**0.388**	**0.930**	**1.000**
Mallard	Facultative	Increasing	**0.350**	**0.130**	**0.093**	**0.608**	**0.998**
McCown's Longspur	Obligate	Stable	**-1.022**	**0.299**	**-1.613**	**-0.449**	**1.000**
Merlin	Facultative	Stable	0.290	0.527	-0.709	1.283	0.706

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mountain Bluebird	Facultative	Stable	**-0.726**	**0.110**	**-0.954**	**-0.519**	**1.000**
Mourning Dove	Facultative	Declining	**0.674**	**0.085**	**0.512**	**0.843**	**1.000**
Mountain Plover	Obligate	Declining	-0.397	0.442	-1.291	0.455	0.820
Northern Bobwhite	Facultative	Declining	**1.006**	**0.503**	**0.017**	**2.011**	**0.976**
Northern Harrier	Obligate	Declining	-0.036	0.185	-0.405	0.315	0.573
Northern Pintail	Facultative	Declining	**0.623**	**0.195**	**0.242**	**1.026**	**0.999**
Northern Shoveler	Facultative	Stable	**0.510**	**0.196**	**0.129**	**0.919**	**0.996**
Peregrine Falcon	Facultative	Stable	-0.099	0.626	-1.383	1.076	0.562
Prairie Falcon	Facultative	Increasing	-0.218	0.398	-1.028	0.524	0.708
Ring-necked Pheasant	Facultative	Declining	**1.542**	**0.139**	**1.267**	**1.818**	**1.000**
Red-winged Blackbird	Facultative	Declining	**0.813**	**0.090**	**0.640**	**0.999**	**1.000**
Say's Phoebe	Facultative	Increasing	-0.161	0.120	-0.399	0.071	0.903
Savannah Sparrow	Obligate	Declining	**0.276**	**0.095**	**0.080**	**0.469**	**0.999**
Short-eared Owl	Obligate	Stable	-0.280	0.243	-0.745	0.178	0.879
Sedge Wren	Obligate	Stable	**2.228**	**0.417**	**1.498**	**3.102**	**1.000**
Sprague's Pipit	Obligate	Stable	-0.192	0.241	-0.656	0.278	0.783
Sharp-tailed Grouse	Obligate	Stable	**0.799**	**0.194**	**0.444**	**1.191**	**1.000**
Swainson's Hawk	Obligate	Increasing	0.414	0.239	-0.050	0.890	**0.959**
Turkey Vulture	Facultative	Increasing	0.165	0.210	-0.236	0.571	0.785
Upland Sandpiper	Obligate	Increasing	**1.011**	**0.109**	**0.791**	**1.224**	**1.000**
Vesper Sparrow	Obligate	Declining	**-0.827**	**0.088**	**-1.000**	**-0.650**	**1.000**
Western Bluebird	Facultative	Stable	-0.673	0.483	-1.687	0.204	0.925
Western Kingbird	Facultative	Stable	**0.239**	**0.098**	**0.051**	**0.433**	**0.994**
Western Meadowlark	Obligate	Declining	**0.528**	**0.119**	**0.300**	**0.775**	**1.000**
Willet	Facultative	Stable	**-0.682**	**0.326**	**-1.356**	**-0.089**	**0.987**
Wilson's Phalarope	Facultative	Stable	**0.284**	**0.136**	**0.001**	**0.542**	**0.975**
Wilson's Snipe	Facultative	Stable	0.331	0.197	-0.059	0.714	**0.957**

Table A13. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the quadratic effects of longitude on the large-scale occupancy of the bird species, Northern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	0.305	0.212	-0.072	0.755	0.936
American Bittern	Facultative	Declining	-0.042	0.246	-0.527	0.427	0.562
American Kestrel	Facultative	Declining	-0.195	0.122	-0.442	0.046	0.949
American Wigeon	Facultative	Stable	**0.351**	**0.110**	**0.134**	**0.561**	**0.999**
Baird's Sparrow	Obligate	Declining	**0.198**	**0.067**	**0.069**	**0.327**	**0.999**
Brown-headed Cowbird	Facultative	Declining	**0.207**	**0.068**	**0.075**	**0.347**	**1.000**
Bobolink	Obligate	Declining	0.124	0.073	-0.023	0.265	0.945
Brewer's Blackbird	Facultative	Declining	-0.022	0.055	-0.133	0.094	0.669
Burrowing Owl	Obligate	Declining	0.109	0.176	-0.257	0.439	0.739
Blue-winged Teal	Facultative	Stable	**0.502**	**0.089**	**0.328**	**0.672**	**1.000**
Cassin's Kingbird	Facultative	Stable	-0.378	0.242	-0.868	0.110	0.939
Canada Goose	Facultative	Increasing	-0.158	0.120	-0.409	0.067	0.911
Cassin's Sparrow	Obligate	Stable	-0.137	0.278	-0.700	0.369	0.680
Chestnut-collared Longspur	Obligate	Declining	**0.250**	**0.053**	**0.149**	**0.356**	**1.000**
Clay-colored Sparrow	Facultative	Stable	**0.168**	**0.059**	**0.047**	**0.282**	**0.999**
Common Nighthawk	Facultative	Declining	**-0.207**	**0.075**	**-0.356**	**-0.069**	**1.000**
Common Poorwill	Facultative	Stable	-0.127	0.241	-0.617	0.336	0.698
Common Yellowthroat	Facultative	Declining	**0.127**	**0.062**	**0.005**	**0.253**	**0.983**
Dickcissel	Obligate	Stable	0.126	0.151	-0.193	0.401	0.807
Eastern Bluebird	Facultative	Increasing	-0.250	0.148	-0.552	0.031	**0.959**
Eastern Kingbird	Facultative	Declining	0.055	0.051	-0.048	0.152	0.855
Eastern Meadowlark	Obligate	Declining	-0.093	0.311	-0.741	0.516	0.617
Ferruginous Hawk	Obligate	Declining	-0.175	0.233	-0.634	0.274	0.765
Field Sparrow	Facultative	Declining	**-0.425**	**0.076**	**-0.581**	**-0.282**	**1.000**
Franklin's Gull	Facultative	Declining	-0.073	0.194	-0.470	0.324	0.657
Gadwall	Facultative	Increasing	**0.646**	**0.110**	**0.445**	**0.872**	**1.000**
Gray Partridge	Facultative	Declining	0.360	0.211	-0.065	0.766	**0.951**
Greater Prairie-Chicken	Obligate	Stable	**0.479**	**0.228**	**0.040**	**0.948**	**0.986**
Grasshopper Sparrow	Obligate	Declining	**0.498**	**0.070**	**0.359**	**0.634**	**1.000**
Horned Lark	Obligate	Declining	**0.281**	**0.043**	**0.199**	**0.364**	**1.000**
Killdeer	Facultative	Declining	**0.195**	**0.054**	**0.089**	**0.302**	**0.999**
Lark Bunting	Obligate	Declining	-0.074	0.049	-0.173	0.024	0.931
Lark Sparrow	Facultative	Declining	**-0.162**	**0.048**	**-0.262**	**-0.069**	**1.000**
Long-billed Curlew	Obligate	Stable	0.071	0.096	-0.119	0.252	0.770
Le Conte's Sparrow	Obligate	Stable	0.056	0.278	-0.529	0.586	0.599
Long-eared Owl	Obligate	Stable	0.043	0.243	-0.437	0.495	0.573
Loggerhead Shrike	Facultative	Declining	**-0.312**	**0.123**	**-0.563**	**-0.088**	**0.995**
Marbled Godwit	Obligate	Increasing	**0.566**	**0.090**	**0.401**	**0.748**	**1.000**
Mallard	Facultative	Increasing	**0.508**	**0.078**	**0.363**	**0.678**	**1.000**
McCown's Longspur	Obligate	Stable	-0.083	0.128	-0.334	0.158	0.741
Merlin	Facultative	Stable	-0.199	0.283	-0.742	0.334	0.746

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Mountain Bluebird	Facultative	Stable	**-0.471**	**0.079**	**-0.629**	**-0.321**	**1.000**
Mourning Dove	Facultative	Declining	0.053	0.050	-0.049	0.150	0.853
Mountain Plover	Obligate	Declining	-0.292	0.260	-0.810	0.196	0.863
Northern Bobwhite	Facultative	Declining	0.256	0.244	-0.269	0.711	0.845
Northern Harrier	Obligate	Declining	-0.128	0.122	-0.368	0.113	0.856
Northern Pintail	Facultative	Declining	**0.625**	**0.123**	**0.402**	**0.871**	**1.000**
Northern Shoveler	Facultative	Stable	**0.502**	**0.113**	**0.293**	**0.735**	**1.000**
Peregrine Falcon	Facultative	Stable	0.025	0.325	-0.604	0.669	0.531
Prairie Falcon	Facultative	Increasing	0.259	0.203	-0.161	0.651	0.907
Ring-necked Pheasant	Facultative	Declining	**0.577**	**0.068**	**0.447**	**0.719**	**1.000**
Red-winged Blackbird	Facultative	Declining	**0.538**	**0.056**	**0.435**	**0.648**	**1.000**
Say's Phoebe	Facultative	Increasing	-0.147	0.080	-0.311	0.007	**0.968**
Savannah Sparrow	Obligate	Declining	**0.357**	**0.059**	**0.241**	**0.473**	**1.000**
Short-eared Owl	Obligate	Stable	**0.346**	**0.142**	**0.067**	**0.627**	**0.995**
Sedge Wren	Obligate	Stable	0.241	0.208	-0.216	0.598	0.866
Sprague's Pipit	Obligate	Stable	-0.070	0.138	-0.339	0.200	0.687
Sharp-tailed Grouse	Obligate	Stable	0.115	0.119	-0.119	0.344	0.834
Swainson's Hawk	Obligate	Increasing	0.071	0.135	-0.198	0.314	0.704
Turkey Vulture	Facultative	Increasing	**-0.383**	**0.148**	**-0.692**	**-0.102**	**0.996**
Upland Sandpiper	Obligate	Increasing	**0.246**	**0.072**	**0.105**	**0.391**	**1.000**
Vesper Sparrow	Obligate	Declining	**-0.272**	**0.053**	**-0.376**	**-0.166**	**1.000**
Western Bluebird	Facultative	Stable	-0.252	0.253	-0.788	0.211	0.848
Western Kingbird	Facultative	Stable	-0.027	0.062	-0.153	0.093	0.671
Western Meadowlark	Obligate	Declining	**0.441**	**0.072**	**0.303**	**0.581**	**1.000**
Willet	Facultative	Stable	0.185	0.173	-0.139	0.523	0.852
Wilson's Phalarope	Facultative	Stable	**0.536**	**0.081**	**0.389**	**0.705**	**1.000**
Wilson's Snipe	Facultative	Stable	0.162	0.114	-0.058	0.374	0.919

Table A14. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of latitude on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.382	0.560	-1.454	0.783	0.757
American Bittern	Facultative	Declining	1.257	1.068	-0.576	3.511	0.876
American Kestrel	Facultative	Declining	-0.336	0.291	-0.984	0.159	0.888
American Wigeon	Facultative	Stable	1.204	0.948	-0.404	3.405	0.912
Ash-throated Flycatcher	Facultative	Increasing	**-3.284**	**0.393**	**-4.065**	**-2.524**	**1.000**
Baird's Sparrow	Obligate	Declining	0.740	1.118	-1.192	3.170	0.739
Brown-headed Cowbird	Facultative	Declining	**0.661**	**0.068**	**0.527**	**0.789**	**1.000**
Barn Owl	Facultative	Increasing	**-1.875**	**0.922**	**-3.667**	**-0.057**	**0.978**
Bobolink	Obligate	Declining	**1.828**	**0.743**	**0.419**	**3.319**	**1.000**
Brewer's Blackbird	Facultative	Declining	**1.270**	**0.252**	**0.845**	**1.817**	**1.000**
Burrowing Owl	Obligate	Declining	-0.388	0.231	-0.824	0.046	**0.953**
Blue-winged Teal	Facultative	Stable	-0.008	0.251	-0.514	0.465	0.503
Cattle Egret	Facultative	Declining	-1.136	0.707	-2.649	0.071	**0.968**
Cassin's Kingbird	Facultative	Stable	**-1.311**	**0.232**	**-1.783**	**-0.876**	**1.000**
Canada Goose	Facultative	Increasing	-0.139	0.371	-0.865	0.592	0.644
Canyon Towhee	Facultative	Stable	**-2.318**	**0.381**	**-3.103**	**-1.613**	**1.000**
Cassin's Sparrow	Obligate	Stable	**-1.765**	**0.105**	**-1.971**	**-1.557**	**1.000**
Chestnut-collared Longspur	Obligate	Declining	**2.198**	**0.656**	**1.046**	**3.489**	**1.000**
Clay-colored Sparrow	Facultative	Stable	0.732	0.792	-0.836	2.176	0.815
Chihuahuan Raven	Facultative	Stable	**-2.785**	**0.607**	**-4.055**	**-1.694**	**1.000**
Common Nighthawk	Facultative	Declining	-0.119	0.102	-0.320	0.077	0.885
Common Poorwill	Facultative	Stable	0.022	0.485	-0.876	1.013	0.492
Common Yellowthroat	Facultative	Declining	**0.449**	**0.119**	**0.218**	**0.693**	**1.000**
Dickcissel	Obligate	Stable	**0.371**	**0.107**	**0.163**	**0.582**	**0.999**
Eastern Bluebird	Facultative	Increasing	**1.333**	**0.231**	**0.900**	**1.812**	**1.000**
Eastern Kingbird	Facultative	Declining	**1.455**	**0.134**	**1.213**	**1.733**	**1.000**
Eastern Meadowlark	Obligate	Declining	**-3.491**	**0.477**	**-4.492**	**-2.629**	**1.000**
Ferruginous Hawk	Obligate	Declining	-0.429	0.482	-1.384	0.486	0.813
Field Sparrow	Facultative	Declining	**0.880**	**0.160**	**0.571**	**1.199**	**1.000**
Greater Prairie-Chicken	Obligate	Stable	1.240	0.816	-0.304	3.308	**0.961**
Grasshopper Sparrow	Obligate	Declining	**0.781**	**0.072**	**0.642**	**0.928**	**1.000**
Horned Lark	Obligate	Declining	0.065	0.065	-0.066	0.190	0.845
Killdeer	Facultative	Declining	0.000	0.084	-0.162	0.170	0.504
Lark Bunting	Obligate	Declining	**1.066**	**0.110**	**0.854**	**1.280**	**1.000**
Lark Sparrow	Facultative	Declining	-0.028	0.068	-0.156	0.112	0.661
Long-billed Curlew	Obligate	Stable	**-1.792**	**0.428**	**-2.731**	**-1.060**	**1.000**
Lesser Prairie-Chicken	Obligate	Declining	**-1.528**	**0.763**	**-3.382**	**-0.282**	**0.995**
Loggerhead Shrike	Facultative	Declining	**-1.095**	**0.222**	**-1.581**	**-0.692**	**1.000**
Marbled Godwit	Obligate	Increasing	1.400	1.111	-0.560	3.762	0.919
Mallard	Facultative	Increasing	0.269	0.149	-0.010	0.565	**0.965**

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
McCown's Longspur	Obligate	Stable	**3.068**	**0.577**	**2.007**	**4.227**	**1.000**
Mountain Bluebird	Facultative	Stable	**1.711**	**0.392**	**1.056**	**2.537**	**1.000**
Mourning Dove	Facultative	Declining	**0.225**	**0.081**	**0.069**	**0.389**	**0.999**
Mountain Plover	Obligate	Declining	0.521	0.380	-0.172	1.327	0.923
Northern Bobwhite	Facultative	Declining	**-1.477**	**0.208**	**-1.902**	**-1.065**	**1.000**
Northern Harrier	Obligate	Declining	-0.323	0.361	-1.059	0.404	0.819
Northern Pintail	Facultative	Declining	0.660	0.804	-0.998	2.239	0.801
Northern Shoveler	Facultative	Stable	-0.383	0.417	-1.307	0.348	0.829
Peregrine Falcon	Facultative	Stable	-1.295	0.950	-3.546	0.323	0.928
Prairie Falcon	Facultative	Increasing	-0.064	0.703	-1.499	1.294	0.530
Rufous-crowned Sparrow	Facultative	Declining	**-2.915**	**0.534**	**-3.922**	**-1.896**	**1.000**
Ring-necked Pheasant	Facultative	Declining	**0.919**	**0.127**	**0.684**	**1.178**	**1.000**
Red-winged Blackbird	Facultative	Declining	**0.162**	**0.065**	**0.031**	**0.293**	**0.993**
Say's Phoebe	Facultative	Increasing	-0.022	0.119	-0.259	0.211	0.570
Savannah Sparrow	Obligate	Declining	0.372	0.393	-0.346	1.146	0.820
Scaled Quail	Facultative	Stable	**-2.390**	**0.323**	**-3.054**	**-1.807**	**1.000**
Scissor-tailed Flycatcher	Facultative	Declining	**-3.504**	**0.881**	**-5.718**	**-2.118**	**1.000**
Sharp-tailed Grouse	Obligate	Stable	**2.965**	**1.022**	**1.232**	**5.079**	**1.000**
Swainson's Hawk	Obligate	Increasing	-0.107	0.189	-0.497	0.238	0.700
Turkey Vulture	Facultative	Increasing	**-0.477**	**0.197**	**-0.913**	**-0.137**	**0.998**
Upland Sandpiper	Obligate	Increasing	**2.428**	**0.704**	**1.206**	**3.981**	**1.000**
Vesper Sparrow	Obligate	Declining	**0.584**	**0.161**	**0.276**	**0.923**	**1.000**
Western Bluebird	Facultative	Stable	**-1.990**	**0.642**	**-3.308**	**-0.804**	**1.000**
Western Kingbird	Facultative	Stable	-0.023	0.067	-0.152	0.112	0.643
Western Meadowlark	Obligate	Declining	**0.934**	**0.095**	**0.753**	**1.120**	**1.000**
Wilson's Phalarope	Facultative	Stable	1.215	1.130	-0.830	3.407	0.861
Wilson's Snipe	Facultative	Stable	**2.472**	**0.891**	**1.026**	**4.727**	**1.000**

Table A15. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the quadratic effects of latitude on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.047	0.405	-0.812	0.790	0.557
American Bittern	Facultative	Declining	-0.093	0.471	-1.067	0.722	0.551
American Kestrel	Facultative	Declining	**1.027**	**0.313**	**0.468**	**1.736**	**1.000**
American Wigeon	Facultative	Stable	-0.124	0.489	-1.155	0.864	0.601
Ash-throated Flycatcher	Facultative	Increasing	**-0.670**	**0.170**	**-1.000**	**-0.339**	**1.000**
Baird's Sparrow	Obligate	Declining	-0.359	0.529	-1.447	0.577	0.729
Brown-headed Cowbird	Facultative	Declining	**0.148**	**0.056**	**0.038**	**0.256**	**0.997**
Barn Owl	Facultative	Increasing	-0.183	0.388	-0.964	0.561	0.681
Bobolink	Obligate	Declining	-0.363	0.442	-1.212	0.559	0.802
Brewer's Blackbird	Facultative	Declining	-0.330	0.207	-0.753	0.048	**0.959**
Burrowing Owl	Obligate	Declining	**-0.440**	**0.195**	**-0.828**	**-0.077**	**0.993**
Blue-winged Teal	Facultative	Stable	0.005	0.193	-0.392	0.368	0.534
Cattle Egret	Facultative	Declining	-0.596	0.403	-1.479	0.186	0.937
Cassin's Kingbird	Facultative	Stable	**-0.453**	**0.206**	**-0.888**	**-0.076**	**0.993**
Canada Goose	Facultative	Increasing	-0.492	0.292	-1.089	0.050	**0.957**
Canyon Towhee	Facultative	Stable	**-0.372**	**0.198**	**-0.794**	**-0.008**	**0.978**
Cassin's Sparrow	Obligate	Stable	**-0.524**	**0.074**	**-0.675**	**-0.380**	**1.000**
Chestnut-collared Longspur	Obligate	Declining	-0.196	0.418	-0.982	0.618	0.664
Clay-colored Sparrow	Facultative	Stable	-0.605	0.457	-1.536	0.217	0.919
Chihuahuan Raven	Facultative	Stable	**-0.556**	**0.259**	**-1.103**	**-0.084**	**0.991**
Common Nighthawk	Facultative	Declining	0.131	0.084	-0.033	0.302	0.943
Common Poorwill	Facultative	Stable	0.060	0.327	-0.606	0.693	0.591
Common Yellowthroat	Facultative	Declining	-0.049	0.107	-0.256	0.166	0.688
Dickcissel	Obligate	Stable	-0.143	0.073	-0.286	0.004	**0.972**
Eastern Bluebird	Facultative	Increasing	**0.611**	**0.127**	**0.347**	**0.853**	**1.000**
Eastern Kingbird	Facultative	Declining	-0.085	0.105	-0.292	0.110	0.787
Eastern Meadowlark	Obligate	Declining	**-0.930**	**0.204**	**-1.364**	**-0.564**	**1.000**
Ferruginous Hawk	Obligate	Declining	-0.441	0.403	-1.274	0.354	0.871
Field Sparrow	Facultative	Declining	**0.373**	**0.108**	**0.163**	**0.586**	**1.000**
Greater Prairie-Chicken	Obligate	Stable	-0.609	0.428	-1.667	0.117	0.949
Grasshopper Sparrow	Obligate	Declining	0.041	0.055	-0.071	0.149	0.786
Horned Lark	Obligate	Declining	**-0.575**	**0.061**	**-0.694**	**-0.453**	**1.000**
Killdeer	Facultative	Declining	**-0.395**	**0.071**	**-0.537**	**-0.259**	**1.000**
Lark Bunting	Obligate	Declining	**-1.203**	**0.117**	**-1.431**	**-0.973**	**1.000**
Lark Sparrow	Facultative	Declining	**0.257**	**0.061**	**0.138**	**0.382**	**1.000**
Long-billed Curlew	Obligate	Stable	-0.480	0.283	-1.063	0.013	**0.971**
Lesser Prairie-Chicken	Obligate	Declining	-0.247	0.377	-1.027	0.435	0.736
Loggerhead Shrike	Facultative	Declining	0.182	0.152	-0.102	0.488	0.889
Marbled Godwit	Obligate	Increasing	-0.210	0.436	-1.096	0.599	0.671
Mallard	Facultative	Increasing	**-0.256**	**0.119**	**-0.491**	**-0.017**	**0.983**

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
McCown's Longspur	Obligate	Stable	**-1.910**	**0.439**	**-2.734**	**-1.071**	**1.000**
Mountain Bluebird	Facultative	Stable	**0.556**	**0.262**	**0.010**	**1.044**	**0.979**
Mourning Dove	Facultative	Declining	**0.159**	**0.075**	**0.013**	**0.311**	**0.987**
Mountain Plover	Obligate	Declining	**-0.664**	**0.340**	**-1.422**	**-0.077**	**0.988**
Northern Bobwhite	Facultative	Declining	**-0.431**	**0.116**	**-0.659**	**-0.202**	**1.000**
Northern Harrier	Obligate	Declining	0.017	0.249	-0.479	0.504	0.534
Northern Pintail	Facultative	Declining	-0.592	0.439	-1.472	0.247	0.912
Northern Shoveler	Facultative	Stable	0.071	0.279	-0.486	0.613	0.618
Peregrine Falcon	Facultative	Stable	-0.065	0.430	-0.962	0.759	0.541
Prairie Falcon	Facultative	Increasing	-0.668	0.439	-1.610	0.147	0.935
Rufous-crowned Sparrow	Facultative	Declining	**-0.845**	**0.229**	**-1.281**	**-0.395**	**1.000**
Ring-necked Pheasant	Facultative	Declining	**-0.656**	**0.109**	**-0.879**	**-0.445**	**1.000**
Red-winged Blackbird	Facultative	Declining	**-0.351**	**0.056**	**-0.456**	**-0.240**	**1.000**
Say's Phoebe	Facultative	Increasing	0.039	0.113	-0.183	0.263	0.642
Savannah Sparrow	Obligate	Declining	-0.462	0.355	-1.267	0.191	0.915
Scaled Quail	Facultative	Stable	-0.116	0.174	-0.456	0.208	0.736
Scissor-tailed Flycatcher	Facultative	Declining	-0.525	0.445	-1.496	0.299	0.885
Sharp-tailed Grouse	Obligate	Stable	0.024	0.458	-1.019	0.789	0.555
Swainson's Hawk	Obligate	Increasing	-0.170	0.161	-0.470	0.150	0.857
Turkey Vulture	Facultative	Increasing	0.278	0.197	-0.031	0.777	**0.960**
Upland Sandpiper	Obligate	Increasing	0.060	0.409	-0.715	0.851	0.559
Vesper Sparrow	Obligate	Declining	-0.142	0.151	-0.441	0.155	0.845
Western Bluebird	Facultative	Stable	**-0.777**	**0.371**	**-1.601**	**-0.104**	**0.990**
Western Kingbird	Facultative	Stable	0.001	0.051	-0.099	0.099	0.519
Western Meadowlark	Obligate	Declining	**-0.404**	**0.077**	**-0.552**	**-0.255**	**1.000**
Wilson's Phalarope	Facultative	Stable	-0.255	0.504	-1.173	0.753	0.704
Wilson's Snipe	Facultative	Stable	0.020	0.452	-1.038	0.803	0.547

Table A16. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the effects of longitude on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.811	0.670	-2.170	0.410	0.883
American Bittern	Facultative	Declining	0.805	0.914	-1.104	2.604	0.812
American Kestrel	Facultative	Declining	**-0.487**	**0.237**	**-0.941**	**-0.026**	**0.982**
American Wigeon	Facultative	Stable	-0.379	0.777	-1.949	1.175	0.693
Ash-throated Flycatcher	Facultative	Increasing	**-0.670**	**0.184**	**-1.017**	**-0.313**	**1.000**
Baird's Sparrow	Obligate	Declining	-0.570	0.794	-2.176	0.974	0.775
Brown-headed Cowbird	Facultative	Declining	**0.636**	**0.085**	**0.479**	**0.804**	**1.000**
Barn Owl	Facultative	Increasing	-0.753	0.908	-2.413	1.210	0.821
Bobolink	Obligate	Declining	0.226	0.495	-0.819	1.170	0.692
Brewer's Blackbird	Facultative	Declining	**-0.867**	**0.195**	**-1.251**	**-0.499**	**1.000**
Burrowing Owl	Obligate	Declining	0.223	0.272	-0.312	0.735	0.788
Blue-winged Teal	Facultative	Stable	0.224	0.268	-0.286	0.770	0.793
Cattle Egret	Facultative	Declining	0.872	0.591	-0.211	2.000	0.931
Cassin's Kingbird	Facultative	Stable	**-1.291**	**0.337**	**-2.023**	**-0.714**	**1.000**
Canada Goose	Facultative	Increasing	**-1.858**	**0.349**	**-2.548**	**-1.190**	**1.000**
Canyon Towhee	Facultative	Stable	**-0.781**	**0.238**	**-1.228**	**-0.314**	**0.999**
Cassin's Sparrow	Obligate	Stable	**0.765**	**0.117**	**0.535**	**0.997**	**1.000**
Chestnut-collared Longspur	Obligate	Declining	**-1.519**	**0.506**	**-2.609**	**-0.627**	**1.000**
Clay-colored Sparrow	Facultative	Stable	-0.037	0.713	-1.504	1.252	0.500
Chihuahuan Raven	Facultative	Stable	-0.155	0.293	-0.737	0.422	0.703
Common Nighthawk	Facultative	Declining	**0.531**	**0.143**	**0.242**	**0.826**	**1.000**
Common Poorwill	Facultative	Stable	-0.376	0.635	-1.641	0.815	0.733
Common Yellowthroat	Facultative	Declining	**-0.409**	**0.166**	**-0.712**	**-0.074**	**0.993**
Dickcissel	Obligate	Stable	**1.990**	**0.186**	**1.630**	**2.369**	**1.000**
Eastern Bluebird	Facultative	Increasing	**1.857**	**0.475**	**0.977**	**2.762**	**1.000**
Eastern Kingbird	Facultative	Declining	**0.541**	**0.116**	**0.317**	**0.775**	**1.000**
Eastern Meadowlark	Obligate	Declining	-0.063	0.188	-0.434	0.315	0.645
Ferruginous Hawk	Obligate	Declining	0.110	0.546	-1.050	1.120	0.597
Field Sparrow	Facultative	Declining	**3.015**	**0.286**	**2.475**	**3.592**	**1.000**
Greater Prairie-Chicken	Obligate	Stable	0.724	0.585	-0.480	1.802	0.884
Grasshopper Sparrow	Obligate	Declining	**0.969**	**0.093**	**0.796**	**1.154**	**1.000**
Horned Lark	Obligate	Declining	**0.193**	**0.075**	**0.044**	**0.339**	**0.997**
Killdeer	Facultative	Declining	0.134	0.101	-0.061	0.334	0.903
Lark Bunting	Obligate	Declining	**-0.251**	**0.101**	**-0.451**	**-0.055**	**0.996**
Lark Sparrow	Facultative	Declining	**0.449**	**0.086**	**0.294**	**0.624**	**1.000**
Long-billed Curlew	Obligate	Stable	-0.597	0.345	-1.295	0.077	**0.957**
Lesser Prairie-Chicken	Obligate	Declining	0.223	0.608	-0.867	1.581	0.632
Loggerhead Shrike	Facultative	Declining	**-0.577**	**0.251**	**-1.087**	**-0.102**	**0.993**
Marbled Godwit	Obligate	Increasing	-0.251	0.770	-1.784	1.277	0.629
Mallard	Facultative	Increasing	**-0.388**	**0.164**	**-0.699**	**-0.068**	**0.991**

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
McCown's Longspur	Obligate	Stable	**-1.490**	**0.463**	**-2.469**	**-0.712**	**1.000**
Mountain Bluebird	Facultative	Stable	-0.303	0.333	-1.002	0.327	0.819
Mourning Dove	Facultative	Declining	**0.306**	**0.102**	**0.102**	**0.515**	**0.999**
Mountain Plover	Obligate	Declining	**-0.720**	**0.422**	**-1.661**	**-0.003**	**0.976**
Northern Bobwhite	Facultative	Declining	**2.619**	**0.255**	**2.156**	**3.134**	**1.000**
Northern Harrier	Obligate	Declining	-0.162	0.422	-0.978	0.702	0.669
Northern Pintail	Facultative	Declining	-0.106	0.837	-1.971	1.410	0.535
Northern Shoveler	Facultative	Stable	-0.330	0.481	-1.388	0.557	0.760
Peregrine Falcon	Facultative	Stable	0.671	0.760	-0.745	2.136	0.813
Prairie Falcon	Facultative	Increasing	-1.157	0.661	-2.409	0.111	**0.964**
Rufous-crowned Sparrow	Facultative	Declining	0.414	0.231	-0.026	0.865	**0.968**
Ring-necked Pheasant	Facultative	Declining	**1.383**	**0.152**	**1.092**	**1.680**	**1.000**
Red-winged Blackbird	Facultative	Declining	**0.255**	**0.082**	**0.100**	**0.423**	**0.999**
Say's Phoebe	Facultative	Increasing	**-1.253**	**0.200**	**-1.669**	**-0.890**	**1.000**
Savannah Sparrow	Obligate	Declining	**-1.178**	**0.453**	**-2.067**	**-0.337**	**0.998**
Scaled Quail	Facultative	Stable	**-1.293**	**0.225**	**-1.742**	**-0.833**	**1.000**
Scissor-tailed Flycatcher	Facultative	Declining	**1.030**	**0.395**	**0.269**	**1.855**	**0.997**
Sharp-tailed Grouse	Obligate	Stable	0.841	0.509	-0.151	1.874	0.949
Swainson's Hawk	Obligate	Increasing	-0.366	0.237	-0.863	0.057	0.949
Turkey Vulture	Facultative	Increasing	**-0.460**	**0.232**	**-0.944**	**-0.040**	**0.983**
Upland Sandpiper	Obligate	Increasing	0.346	0.289	-0.184	0.946	0.899
Vesper Sparrow	Obligate	Declining	**-0.930**	**0.159**	**-1.243**	**-0.628**	**1.000**
Western Bluebird	Facultative	Stable	**-1.979**	**0.626**	**-3.286**	**-0.838**	**1.000**
Western Kingbird	Facultative	Stable	-0.133	0.080	-0.295	0.025	**0.952**
Western Meadowlark	Obligate	Declining	**0.330**	**0.097**	**0.139**	**0.522**	**0.998**
Wilson's Phalarope	Facultative	Stable	-0.034	0.934	-1.856	1.832	0.493
Wilson's Snipe	Facultative	Stable	**-1.714**	**0.557**	**-2.837**	**-0.735**	**1.000**

Table A17. The beta coefficients (Mean), Standard Deviations (SD), Upper (UCL) and Lower (LCL) 95% Credible Limits, respectively, and Bayesian *P*-values (*P*) for the quadratic effects of longitude on the large-scale occupancy of the bird species, Southern Great Plains, USA, 2010 – 2018. The bold values indicate measureable effects sizes at the 95% confience level.

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
Green-winged Teal	Facultative	Declining	-0.243	0.317	-0.877	0.361	0.779
American Bittern	Facultative	Declining	-0.176	0.319	-0.795	0.442	0.716
American Kestrel	Facultative	Declining	-0.035	0.180	-0.392	0.328	0.599
American Wigeon	Facultative	Stable	-0.264	0.347	-0.966	0.393	0.778
Ash-throated Flycatcher	Facultative	Increasing	0.134	0.101	-0.069	0.337	0.916
Baird's Sparrow	Obligate	Declining	-0.087	0.313	-0.684	0.511	0.607
Brown-headed Cowbird	Facultative	Declining	**0.205**	**0.068**	**0.076**	**0.344**	**1.000**
Barn Owl	Facultative	Increasing	-0.275	0.328	-0.936	0.361	0.799
Bobolink	Obligate	Declining	-0.053	0.269	-0.603	0.451	0.558
Brewer's Blackbird	Facultative	Declining	0.205	0.147	-0.107	0.481	0.911
Burrowing Owl	Obligate	Declining	**-0.435**	**0.216**	**-0.892**	**-0.049**	**0.989**
Blue-winged Teal	Facultative	Stable	-0.074	0.139	-0.352	0.188	0.689
Cattle Egret	Facultative	Declining	0.243	0.335	-0.287	0.985	0.768
Cassin's Kingbird	Facultative	Stable	-0.361	0.274	-0.981	0.128	0.917
Canada Goose	Facultative	Increasing	**0.696**	**0.170**	**0.357**	**1.039**	**1.000**
Canyon Towhee	Facultative	Stable	0.171	0.154	-0.137	0.473	0.872
Cassin's Sparrow	Obligate	Stable	**-0.809**	**0.084**	**-0.984**	**-0.648**	**1.000**
Chestnut-collared Longspur	Obligate	Declining	-0.241	0.271	-0.789	0.278	0.819
Clay-colored Sparrow	Facultative	Stable	-0.279	0.325	-0.969	0.286	0.788
Chihuahuan Raven	Facultative	Stable	-0.337	0.197	-0.734	0.025	**0.968**
Common Nighthawk	Facultative	Declining	0.016	0.084	-0.132	0.195	0.558
Common Poorwill	Facultative	Stable	-0.272	0.309	-0.913	0.295	0.814
Common Yellowthroat	Facultative	Declining	0.101	0.144	-0.163	0.391	0.759
Dickcissel	Obligate	Stable	**-0.241**	**0.076**	**-0.384**	**-0.087**	**0.999**
Eastern Bluebird	Facultative	Increasing	-0.082	0.117	-0.307	0.131	0.747
Eastern Kingbird	Facultative	Declining	0.040	0.062	-0.079	0.163	0.735
Eastern Meadowlark	Obligate	Declining	**0.521**	**0.085**	**0.359**	**0.695**	**1.000**
Ferruginous Hawk	Obligate	Declining	-0.468	0.320	-1.144	0.097	0.945
Field Sparrow	Facultative	Declining	**-0.517**	**0.112**	**-0.743**	**-0.298**	**1.000**
Greater Prairie-Chicken	Obligate	Stable	-0.252	0.306	-0.847	0.349	0.801
Grasshopper Sparrow	Obligate	Declining	**-0.260**	**0.045**	**-0.350**	**-0.171**	**1.000**
Horned Lark	Obligate	Declining	**-0.254**	**0.045**	**-0.344**	**-0.168**	**1.000**
Killdeer	Facultative	Declining	**0.140**	**0.071**	**0.004**	**0.287**	**0.981**
Lark Bunting	Obligate	Declining	**-0.705**	**0.110**	**-0.929**	**-0.500**	**1.000**
Lark Sparrow	Facultative	Declining	**-0.115**	**0.047**	**-0.212**	**-0.028**	**0.996**
Long-billed Curlew	Obligate	Stable	-0.258	0.251	-0.770	0.211	0.844
Lesser Prairie-Chicken	Obligate	Declining	-0.046	0.258	-0.557	0.438	0.561
Loggerhead Shrike	Facultative	Declining	-0.048	0.178	-0.400	0.289	0.596
Marbled Godwit	Obligate	Increasing	-0.309	0.325	-0.969	0.321	0.837
Mallard	Facultative	Increasing	-0.014	0.096	-0.203	0.164	0.542

Common name	Guild	Status	Mean	SD	LCL	UCL	*P*
McCown's Longspur	Obligate	Stable	-0.112	0.292	-0.731	0.404	0.633
Mountain Bluebird	Facultative	Stable	**-0.634**	**0.270**	**-1.198**	**-0.141**	**0.993**
Mourning Dove	Facultative	Declining	0.014	0.068	-0.106	0.161	0.554
Mountain Plover	Obligate	Declining	-0.129	0.273	-0.741	0.329	0.651
Northern Bobwhite	Facultative	Declining	**-0.442**	**0.095**	**-0.631**	**-0.258**	**1.000**
Northern Harrier	Obligate	Declining	-0.178	0.273	-0.704	0.399	0.767
Northern Pintail	Facultative	Declining	-0.283	0.340	-0.994	0.347	0.816
Northern Shoveler	Facultative	Stable	-0.015	0.242	-0.521	0.470	0.529
Peregrine Falcon	Facultative	Stable	-0.145	0.300	-0.708	0.429	0.685
Prairie Falcon	Facultative	Increasing	-0.198	0.305	-0.841	0.401	0.746
Rufous-crowned Sparrow	Facultative	Declining	-0.204	0.140	-0.483	0.060	0.928
Ring-necked Pheasant	Facultative	Declining	**-0.466**	**0.073**	**-0.620**	**-0.323**	**1.000**
Red-winged Blackbird	Facultative	Declining	0.038	0.052	-0.058	0.144	0.759
Say's Phoebe	Facultative	Increasing	-0.253	0.184	-0.636	0.092	0.919
Savannah Sparrow	Obligate	Declining	0.011	0.273	-0.527	0.514	0.527
Scaled Quail	Facultative	Stable	**-0.704**	**0.194**	**-1.114**	**-0.333**	**1.000**
Scissor-tailed Flycatcher	Facultative	Declining	0.145	0.157	-0.144	0.456	0.819
Sharp-tailed Grouse	Obligate	Stable	-0.051	0.275	-0.636	0.443	0.550
Swainson's Hawk	Obligate	Increasing	0.042	0.139	-0.214	0.320	0.614
Turkey Vulture	Facultative	Increasing	**0.421**	**0.196**	**0.120**	**0.865**	**0.999**
Upland Sandpiper	Obligate	Increasing	0.156	0.176	-0.179	0.506	0.801
Vesper Sparrow	Obligate	Declining	**0.469**	**0.088**	**0.291**	**0.643**	**1.000**
Western Bluebird	Facultative	Stable	-0.012	0.279	-0.522	0.557	0.543
Western Kingbird	Facultative	Stable	**-0.237**	**0.055**	**-0.350**	**-0.135**	**1.000**
Western Meadowlark	Obligate	Declining	**-0.434**	**0.057**	**-0.548**	**-0.319**	**1.000**
Wilson's Phalarope	Facultative	Stable	-0.196	0.339	-0.945	0.412	0.717
Wilson's Snipe	Facultative	Stable	-0.081	0.311	-0.688	0.503	0.589