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Original Article

Assessment of Repeat-Visit Surveys as a Viable Method for Estimating Brood Abundance at the 10.4-km^2 Scale

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ABSTRACT Regional estimates of duck brood abundance could help conservation managers assess landscape productivity and thereby improve spatially explicit allocation of limited conservation funds in the Prairie Pothole Region. We assessed the utility of repeat-visit brood counts from 2012 to 2013 surveys in the Prairie Pothole Region (ND, SD, and MT, USA) and hierarchical N-mixture models for providing estimates of abundance at a 10.4-km^2 scale. Models provided reliable estimates of brood abundance and underscored the importance of small wetlands and landscape characteristics to some dabbling duck broods in the Prairie Pothole Region.

KEY WORDS *Anas*, breeding ducks, brood abundance, conservation planning, Prairie Pothole Region, waterfowl conservation.

Habitat protection for breeding ducks in the Prairie Pothole Region is expensive with wetland and grassland easements increasing an average of US$2,085.57 and $1,102.09/ha, respectively, from 2011 to 2015 (USFWS 2011, 2015). Conservation costs continue to increase as land values increase, which encourages grassland conversion (Stephens et al. 2008, Rashford et al. 2011, Feng et al. 2013, Wright and Wimberly 2013) and wetland loss in the region (Johnston 2013, Dahl 2014). Such conditions emphasize the importance of efficient conservation targeting practices.

In this socioeconomic environment, it is critical that managers make fully informed decisions when targeting landscapes for conservation. Current waterfowl conservation practices in the Prairie Pothole Region are based on an extensive knowledge of the density and distribution of breeding duck pairs and nest success (Greenwood et al. 1995; Reynolds et al. 2001, 2006). However, wetland–grassland landscapes valuable to duck pairs may not be of equal value to duck broods due to differences in resource availability resulting from the intra-annual wet–dry cycle that is common within the Prairie Pothole Region (Larson 1995, Johnson et al. 2004). Incorporating an additional metric that identifies wetlands or wetland complexes and their associated upland habitats that are valuable during the later stages of the breeding cycle may provide a more holistic understanding of the trade-offs inherent in conservation decisions.

Obtaining a reliable understanding of brood abundance and habitat use at a landscape scale has been historically difficult because of the elusive and cryptic nature of waterfowl young. Recent investigations have experimented with the use of repeat-visit count surveys and hierarchical modeling techniques to estimate occupancy and abundance for cryptic animals (e.g., Pagano and Arnold 2009, Kirchberg et al. 2016, Xu et al. 2016). Walker et al. (2013) investigated waterfowl brood occupancy across the Prairie Pothole Region in North and South Dakota, USA, using a repeat-visit survey design and hierarchical occupancy models (MacKenzie et al. 2006). Within a Bayesian framework, Walker et al. (2013) were able to develop a greater understanding of the relationship of species-specific occupancy rates to basin- and landscape-level environmental covariates. Although brood occupancy estimates provide evidence of successful nesting in the surrounding uplands and wetland use by broods, we were interested in learning whether repeat-visit survey methods could be used to provide managers with landscape-level information about brood abundance comparable to pair density estimates currently incorporated into conservation targeting decisions.

STUDY AREA

We surveyed broods in the area of North Dakota, South Dakota, and Montana, USA, lying east and north of the Missouri River, known as the glaciated Prairie Pothole

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Region (Fig. 1). Landscape characteristics included millions of depressional wetlands interspersed among a mixture of grasslands, largely used for livestock grazing, and annually cultivated small grains and row crops (van der Valk and Pederson 1989). This area has the highest density of breeding dabbling ducks (*Anas, Mareca,* and *Spatula* spp.) in the United States (Bellrose 1980). Detailed climatic, physiographic, and ecological descriptions of the study area are available in previously published work (e.g., Cowardin et al. 1995, Reynolds et al. 2006, Walker et al. 2013).

METHODS

Field Methods

We selected 61 10.4-km^2 sample plots in the study area based on key landscape characteristics including the proportion of perennial herbaceous cover and wetland density (Fig. 1). The 10.4-km^2 plot size was used because of the observed relationship of this landscape scale to the home range of breeding female mallards (*Anas platyrhynchos;* Dwyer et al. 1979, Cowardin et al. 1985). We surveyed wetland basins, delineated by the National Wetlands Inventory (NWI; USFWS 2010) and subsequently converted to a basin classification (Johnson and Higgins 1997), on each plot for broods of the 5 most common breeding duck species in the Prairie Pothole Region (blue-winged teal [*Spatula discors*], gadwall [*Mareca strepera*], mallard, northern pintail [*Anas acuta*], and northern shoveler [*Spatula clypeata*]). We

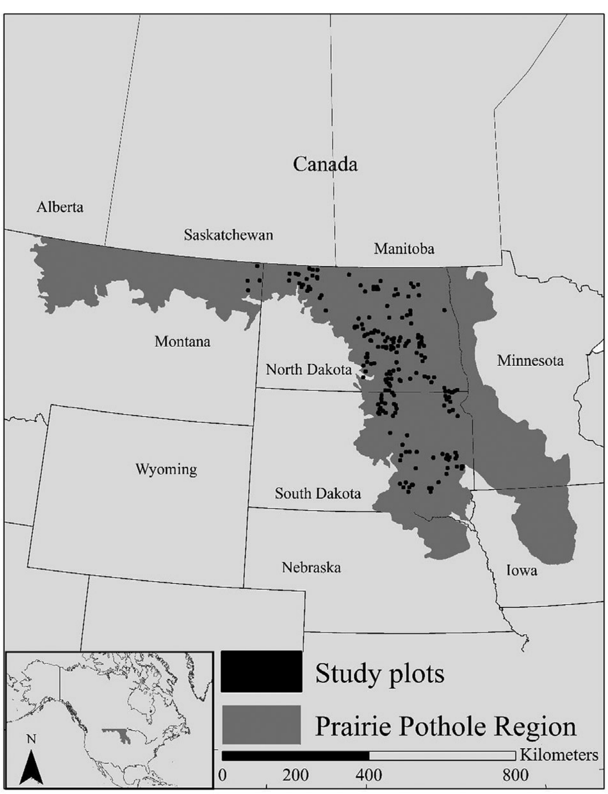

Figure 1. United States portion of the Prairie Pothole Region and 61 10.4-km^2 study plots used to survey waterfowl broods during 2012–2013.

sampled temporary, seasonal, and semipermanent wetlands because they are the most important to dabbling ducks and the most common wetland classes in the region; 91% of basins within the Prairie Pothole Region fall within one of these classes (Krapu et al. 1997, Reynolds et al. 2006, Dahl 2014).

We sampled basins in early July 2012 and 2013 for broods from early nesting species (i.e., mallard, northern pintail), and then again in early August 2012 and 2013 for broods from later nesting species (i.e., blue-winged teal, gadwall, northern shoveler). Some ponds sampled in August were the same as those sampled in July, whereas others were added as substitutes for basins that were dry during the July survey.

To increase brood detection rates, we revised the survey methods from Walker et al. (2013). Observers conducted all surveys on foot. During each survey, every sample basin on a plot was visited twice in the same day: once in the morning and a second time in the afternoon. To reduce the effect of knowledge gained in the morning visit, a different observer conducted the afternoon visit. Observers spent a minimum of 2 min at each surveyed basin to ensure they were thoroughly viewing even those basins with no vegetation. They were encouraged to spend longer when visiting basins with vegetation. During each visit, the observer surveyed the entire wetland, making sure to walk through shoreline areas obscured by vegetation or other obstructions.

Observers conducted visits between sunrise and sunset and a minimum of 4 hours elapsed between wetland visits. At the beginning of each visit to a plot, observers recorded date, time, and wind speed (Beaufort scale; Simpson 1926). During each wetland visit, observers used binoculars and spotting scopes to identify individual broods to species, age class, and number of ducklings. Observers recorded a zero if no broods were observed. During the first visit of each surveyed wetland within a survey period (i.e., Jul or Aug), observers also estimated (±10%) the proportion of the wet area covered by emergent vegetation.

Wetland Conditions

We assessed spring and summer wetland condition as potential covariates in brood abundance. We defined wetland condition by the presence and surface area of ponded water during the respective time periods. We collected high-resolution aerial photographs (1.5 m) for all plots during May or June and again in July or August to represent spring and summer wetland conditions, respectively. We georeferenced images and mapped wet area using a combination of unsupervised and supervised classification procedures. We spatially aligned wet basin signatures with digital wetland basins (i.e., temporary, seasonal, and semipermanent) and summarized them by basin, wetland class, and plot.

Data Analysis

We used hierarchical abundance models (Royle 2004) within the Program R package *unmarked* (Fiske and Chandler 2011) to determine if a 2-visit walk-in survey design and brood count data could be used to estimate brood abundance at a 10.4-km^2 scale. We assessed support for a number of hypotheses regarding the relationship of brood abundance and detection to both basin and plot-level environmental covariates. Similar to Walker et al. (2013), in the abundance models we incorporated a quantitative emergent vegetation covariate, a log-transformed wet area covariate, a covariate to describe plot wet area in July, a covariate to describe wet basin count in May, and a covariate to describe plot-level herbaceous perennial cover. Also, as in Walker et al. (2013), all wetland covariates referred only to temporary, seasonal, and semipermanent basins. We expected to see similar relationships between these covariates and brood count data to those relationships observed by Walker et al. (2013). Finally, we expected that differences in environmental conditions across years would affect observed brood abundance, so we included covariates in our models to represent the years of the survey.

We also considered a number of covariates in our detection models that we expected to behave similarly to those tested by Walker et al. (2013). We incorporated quantitative covariates describing time of day, emergent vegetation on a wetland, and wet area of the surveyed basin. We included a covariate for date; however, we log-transformed this variable to represent what we thought might be increasing observer experience and comfort with survey protocol and bird identification. Prior to running models, we scaled all quantitative parameters to a z-distribution.

The Poisson-binomial models we selected for the analysis have a hierarchical structure and can be described as follows:

$$N_i \sim \text{Poisson}(\lambda_{i,})$$

$$y_{ij} \sim \text{Binomial}\left(N_{i,}p_{ij}\right)$$

$$\log(\lambda_i) = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_U x_{iU}$$

$$\text{logit}\left(p_{ij}\right) = \gamma_0 + \gamma_1 x_{ij1} + \ldots + \gamma_V x_{ijV}$$

Where N_i is the wetland-level abundance and treated as a random variable with a Poisson distribution. The observed abundance of broods y_{ij} on site i and during visit j then follows a binomial distribution with index parameter N_i and success parameter $p_{ij.}$ Abundance ($\lambda_{i,}$) is modeled through a log link as a function of U covariates and detection probabilities are modeled through a logit link as a function of V covariates (Royle 2004).

The N-mixture model assumes that 1) the abundance of broods on a wetland remains constant across visits, 2) false detections are rare or nonexistent, 3) all broods at occasion j have the same detection probability p_{ij}, and 4) broods are detected independently (Kéry et al. 2005, Royle and Dorazio 2008). We addressed the first assumption by conducting the first and second visits within a 15-hr period. We addressed the second and third assumptions by requiring observers to spend a minimum of 2 min at each basin, regardless of size or vegetation density, to maximize detection. Further, false-positive detections during the survey would likely come from identifying fully feathered adults as an older brood. In anticipation of this challenge, observers were instructed to identify behavioral and visual cues that would differentiate older broods from adults. Finally, we addressed the fourth assumption by using different observers for the first and second visit.

We tested our hypotheses within a maximum likelihood framework using Akaike's Information Criterion (AIC) values (Burnham and Anderson 2002). Instead of running all possible combinations of variables, we applied a remove-one approach in which one variable was removed and the AIC value (Burnham and Anderson 2002) was compared with that of the full global model. If the AIC value of the reduced model was less than that of the global, we considered the removed variable uninformative. We removed all uninformative variables at the end of the analysis to provide a final reduced model for producing predictions. This model was assessed for lack-of-fit at the basin level using a parametric bootstrap procedure (MacKenzie and Bailey 2004).

RESULTS

We sampled 20 plots in 2012 and 44 plots in 2013. In 2013, 3 of the sample plots were also visited in 2012; the remaining 41 were new additions. Thus, we visited 61 unique plots across the study. Our sample comprised 2,098 wetland basins, of which 744 were sampled in 2012 and 1,354 were sampled in 2013. In 2012, we observed 860 broods during the first visit to these wetlands and 708 broods during the second visit. In 2013, we observed 318 broods during the first visit and 234 during the second visit.

Model Selection and Parameter Estimates

Model selection indicated support for a full abundance and a reduced detection model (Table 1). Model-based predictions

Table 1. Log and logit-based parameter estimates with standard errors from the best fitting models of abundance and detection, respectively, of waterfowl brood repeat-visit survey data from 2012 to 2013 surveys in the Prairie Pothole Region of North Dakota, South Dakota, and Montana, USA.

Abundance			Detection		
Parameter	Estimate	SE	Parameter	Estimate	SE
Intercept	0.59	0.07	Intercept	−0.39	0.09
Emergent vegetation	−0.21	0.07	Emergent vegetation	−0.35	0.11
Emergent vegetation^2	−0.36	0.04	Time of day	0.04	0.04
Perennial cover	0.32	0.03	Time of day^2	0.06	0.03
July wet area	−0.12	0.03	Log (Date)	0.27	0.05
May basin count	−0.12	0.04			
Log (Basin wet area)	0.70	0.03			
Year (2013)	−1.23	0.08			

indicated greater brood abundance in landscapes with more perennial cover and basins with intermediate amounts of emergent vegetation. Predictions indicated lower brood abundance in landscapes with greater numbers of wet basins in May and larger wet total area in July. Brood abundance increased at a decreasing rate with wetland size, with highest rates of increase observed at sizes <1 ha (Fig. 2). We also observed substantial variability between years.

Predictions from our reduced detection model indicated lower detection rates at basins with greater amounts of emergent vegetation. We also observed support for a logarithmic relationship of survey day with detection rate, suggesting that observers' detection rates increased rapidly early in the survey but then leveled off after the first week (Fig. 3). Time of day was also a supported covariate in the detection model and highest rates of detection occurred at basins that were surveyed in the evenings (e.g., after 1800; Fig. 3).

We observed some evidence of overdispersion in our models ($\hat{c} = 1.80$). Predicted plot-level counts correlated well with observed plot-level counts (Fig. 4: $r = 0.88$).

DISCUSSION

Information about duck broods and waterfowl production could help improve current conservation decision-making as protection costs increase and habitat conversion continues in the Prairie Pothole Region. Our study provides a foundation for estimating brood abundance at a landscape scale. Models provided reliable estimates of brood abundance at the plot level and underscored relationships of key environmental factors with this important aspect of duck demography. Brood numbers increased rapidly with basin wet area, and basins with more perennial cover in the surrounding 10.4 km^2 had larger numbers of broods. However, the relationship of brood numbers with basin wet area leveled off substantially at areas >1 ha. High correlation between predicted and observed values underscored the potential of this study and similar studies such as Walker et al. (2013) to support a framework for incorporating brood recruitment information into conservation targeting tools in the future.

Tests for lack-of-fit suggested that our models contained some overdispersion at the level of individual wetlands. However, plot-level predictions suggested that repeat-visit brood surveys are a useful tool for making predictions of brood abundance at the 10.4-km^2 scale, which is more consistent with the scale of current waterfowl-conservation targeting tools (Reynolds et al. 2006). When combined with pair density, estimates of brood abundance at this scale could be used by conservation managers to assess potential trade-offs between landscapes that may support larger numbers of broods and fewer nesting pairs versus landscapes that may support more pairs and fewer broods.

Results from our study also validated some important relationships revealed in Walker et al. (2013). At the landscape scale, brood abundance decreased as the number of wet basins in May increased and the area of ponded water in July increased. We also saw inter-annual variation in brood abundance with strong support for greater numbers in 2012. These patterns might be a result of breeding ducks and duck broods spreading out at the landscape scale when more resources are available, making basin-level abundance appear smaller. This pattern of breeding duck distribution has been demonstrated in previous studies of duck brood occupancy rates (Walker et al. 2013). Indeed, 2013 was a much wetter period in the Prairie Pothole Region than 2012 (NOAA 2017).

Another landscape-level relationship observed in our models for which Walker et al. (2013) also found evidence was that of perennial cover with brood abundance. Our model-based predictions indicate that brood abundance on a wetland is positively related to the amount of perennial cover on the survey plot. Areas with greater amounts of upland

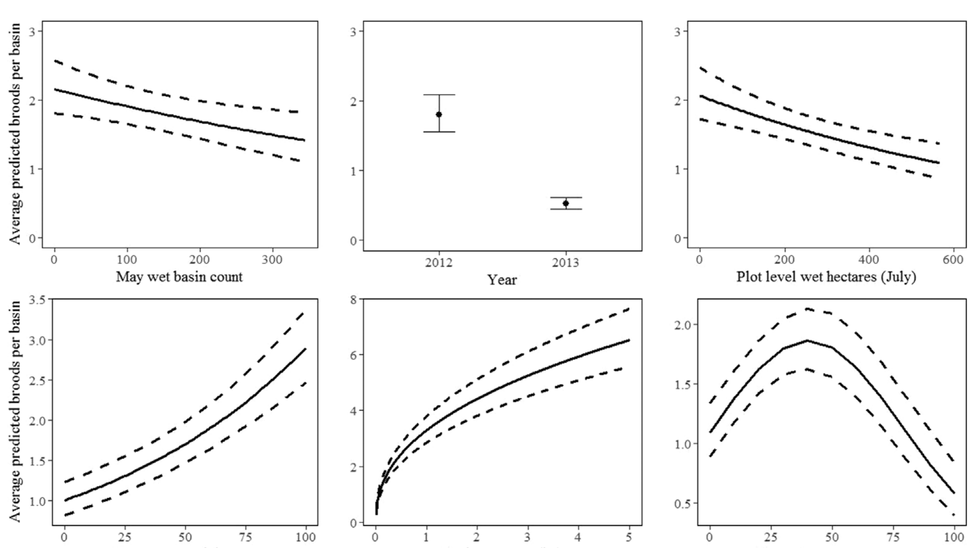

Figure 2. Model-based predictions of basin-level waterfowl brood abundance in the Prairie Pothole Region, USA, during a 2-visit, late-summer survey (2012–2013) relative to variation in covariates. We held other covariates in the model constant at their mean values. Dotted lines represent 95% confidence intervals.

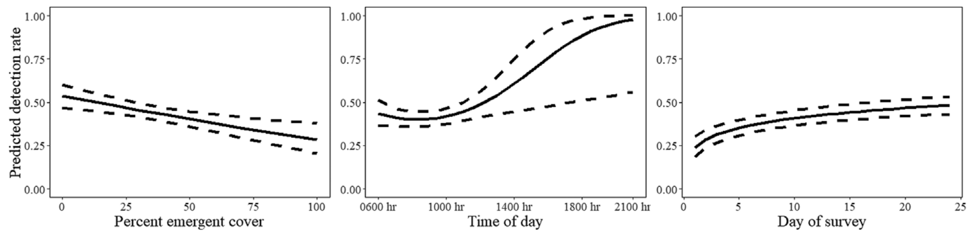

Figure 3. Model-based predictions of basin-level detection rates in the Prairie Pothole Region, USA, during a 2-visit, late-summer survey (2012–2013) relative to variation in covariates. We held other covariates in the model constant at their mean values. Dotted lines represent 95% confidence intervals.

cover are believed to also have greater levels of nest survival (Greenwood et al. 1995, Reynolds et al. 2001, Stephens et al. 2003). Greater nest survival could be indicative of high-quality habitat, and might translate to larger brood numbers in a given landscape. In contrast, other studies have found neutral or negative effects of perennial cover on broods, suggesting a potential temporal or spatial influence that was not tested in this analysis (Krapu et al. 2000, Amundson and Arnold 2011, Bloom et al. 2012).

The relationship of perennial cover and waterfowl breeding ecology often overshadows the ecological importance of wetlands embedded in comparatively cultivated landscapes. Our model predictions indicate that holding all other variables constant, a 10.4-km^2 plot that contains 72% perennial cover (749 ha) and becomes completely cultivated would be expected to lose 16% of its predicted brood abundance ($n = 63$ broods). However, if this same plot were to lose all of its wet basins <1 ha in size ($n = 74/263$ basins), brood abundance would be expected to decrease by at least 31% ($n = 120$ broods). In other words, a loss of 749 ha of perennial cover would result in losing 63 broods while losing only 74 basins and 19 ha of wet area would result in a loss of 15% more broods. These results support similar findings from Walker et al. (2013), and further underscore the importance of small wet basins to waterfowl broods.

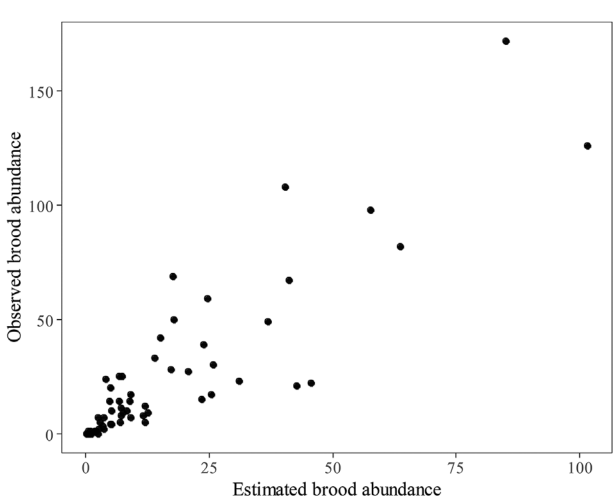

Figure 4. Plot-level waterfowl brood counts in the Prairie Pothole Region, USA, during 2012–2013 predicted by the best-approximating model and observed plot-level brood counts.

MANAGEMENT IMPLICATIONS

Rapid development and increasing rates of grassland conversion in the Prairie Pothole Region coupled with high conservation costs necessitate effective and efficient conservation targeting tools. Our study built upon the brood occupancy work completed by Walker et al. (2013) and provides additional information that may be valuable for guiding conservation planning efforts for ducks in the Prairie Pothole Region. Brood abundance estimates, like those derived in this study, taken together with breeding pair distributions and nest survival probabilities provide a comparatively holistic view and may help identify areas that contribute most to population growth. The importance of wetland quality and quantity to brood abundance might also encourage prioritizing conservation easements for waterfowl in landscapes with wetlands embedded in cropland over low density wetland landscapes with large expanses of grassland.

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LITERATURE CITED

Amundson, C. L., and T. W. Arnold. 2011. The role of predator removal, density-dependence, and environmental factors on mallard duckling survival in North Dakota. Journal of Wildlife Management 75:1330–1339.

Bellrose, F. C. 1980. Ducks, geese and swans of North America. Third edition. Stackpole Books, Harrisburg, Pennsylvania, USA.

Bloom, P. M., R. G. Clark, D. W. Howerter, and L. M. Armstrong. 2012. Landscape-level correlates of mallard duckling survival: implications for conservation program. Journal of Wildlife Management 76:813–823.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.
Cowardin, L. M., D. S. Gilmer, and C. W. Shaiffer. 1985. Mallard recruitment in the agricultural environment of North Dakota. Wildlife Monographs 92.
Cowardin, L. M., T. L. Shaffer, and P. M. Arnold. 1995. Evaluations of duck habitat and estimation of duck population sizes with a remote sensing-based system. National Biological Service, Biological Science Report 2. U.S. Fish and Wildlife Service, Washington, D.C., USA.
Dahl, T. E. 2014. Status and trends of prairie wetlands in the United States 1997 to 2009. U.S. Department of the Interior, Fish and Wildlife Service, Ecological Services, Washington, D.C., USA.
Dwyer, T. J., G. L. Krapu, and D. M. Janke. 1979. Use of prairie pothole habitat by breeding mallards. Journal of Wildlife Management 43:526–531.
Feng, H., D. A. Hennessy, and R. Miao. 2013. The effects of government payments on cropland acreage, Conservation Reserve Program enrollment, and grassland conversion in the Dakotas. American Journal of Agricultural Economics 95:412–418.
Fiske, I., and R. B. Chandler. 2011. Unmarked: an R package for fitting hierarchical models of wildlife occurrence and abundance. Journal of Statistical Software 43:1–23.
Greenwood, R. J., A. B. Sargeant, D. H. Johnson, L. M. Cowardin, and T. L. Shaffer. 1995. Factors associated with duck nest success in the prairie pothole region of Canada. Wildlife Monographs 128.
Johnson, R. R., and K. Higgins. 1997. Wetland resources in eastern South Dakota. South Dakota State University, Brookings, USA.
Johnson, W. C., S. E. Boettcher, K. A. Poiani, and G. Guntenspergen. 2004. Influence of weather extremes on the water levels of glaciated prairie wetlands. Wetlands 24:385–398.
Johnston, C. A. 2013. Wetland losses due to row crop expansion in the Dakota prairie pothole region. Wetlands 33:175–182.
Kéry, M., J. Royle, and H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. Ecological Applications 15:1450–1461.
Kirchberg, J., K. Cecala, S. J. Price, E. M. White, and D. G. Haskell. 2016. Evaluating the impacts of small impoundments on stream salamanders. Aquatic Conservation: Marine and Freshwater Ecosystems 26:1197–1206.
Krapu, G. L., R. J. Greenwood, C. P. Dwyer, K. M. Kraft, and L. M. Cowardin. 1997. Wetland use, settling patterns, and recruitment in mallards. Journal of Wildlife Management 61:736–746.
Krapu, G. L., P. J. Pietz, D. A. Brandt, and R. R. Cox, Jr. 2000. Factors limiting mallard brood survival in prairie pothole landscapes. Journal of Wildlife Management 64:553–561.
Larson, D. L. 1995. Effects of climate on numbers of northern prairie wetlands. Climatic Change 30:169–180.
MacKenzie, D. I., and L. L. Bailey. 2004. Assessing the fit of site-occupancy models. Journal of Agricultural, Biological and Environmental Statistics 9:300–318.
MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier Academic Press, New York, New York, USA.
National Oceanic and Atmospheric Administration [NOAA]. 2017. National Centers for Environmental Information, climate at a glance. U.S. Time Series: precipitation. Published May 2017. http://www.ncdc.noaa.gov/cag/. Accessed 24 May 2017.
Pagano, A. M., and T. W. Arnold. 2009. Estimating detection probabilities of waterfowl broods from ground-based surveys. Journal of Wildlife Management 73:686–694.
Rashford, B. S., J. A. Walker, and C. T. Bastian. 2011. Economics of grassland conversion to cropland in the prairie pothole region. Conservation Biology 25:276–284.
Reynolds, R. E., T. L. Shaffer, C. R. Loesch, and R. R. Cox, Jr. 2006. The farm bill and duck production in the prairie pothole region: increasing benefits. Wildlife Society Bulletin 34:963–974.
Reynolds, R. E., T. L. Shaffer, R. W. Renner, W. E. Newton, and B. D. J. Batt. 2001. Impact of the Conservation Reserve Program on duck recruitment in the U.S. prairie pothole region. Journal of Wildlife Management 65:765–780.
Royle, J. A. 2004. N-mixture models for estimating population size from spatially replicated counts. Biometrics 60:108–115.
Royle, J. A., and R. M. Dorazio. 2008. Hierarchical modeling and inference in ecology: the analysis of data from populations, metapopulations and communities. Academic Press, San Diego, California, USA.
Simpson, G. C. 1926. The velocity equivalents of the Beaufort scale. Meteorological Office Professional Notes 44:1–24.
Stephens, S. E., D. N. Koons, J. J. Rotella, and D. W. Willey. 2003. Effects of habitat fragmentation on avian nesting success: a review of the evidence at multiple spatial scales. Biological Conservation 115:101–110.
Stephens, S. E., J. A. Walker, D. R. Blunck, A. Jayaraman, D. E. Naugle, J. K. Ringelman, and A. J. Smith. 2008. Predicting risk of habitat conversion in native temperate grasslands. Conservation Biology 22:1320–1330.
U.S. Fish and Wildlife Service [USFWS]. 2010. National wetlands inventory. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Branch of Resource and Mapping Support, Washington, D.C., USA.
U.S. Fish and Wildlife Service [USFWS]. 2011. Annual report of lands under the control of the U.S. Fish and Wildlife Service. U.S. Department of the Interior, U.S. Fish and Wildlife Service Division of Realty, Washington, D.C., USA.
U.S. Fish and Wildlife Service [USFWS]. 2015. Annual report of lands under the control of the U.S. Fish and Wildlife Service. U.S. Department of the Interior, U.S. Fish and Wildlife Service Division of Realty, Washington, D.C., USA.
van der Valk, A. G., and R. L. Pederson. 1989. Seed banks and the management and restoration of natural vegetation. Pages 329–346 *in* M. A. Leck, V. T. Parker, and R. L. Simpson, editors. Ecology of soil seed banks. Academic Press, San Diego, California, USA.
Walker, J., J. J. Rotella, J. H. Schmidt, C. R. Loesch, R. E. Reynolds, M. S. Lindberg, J. K. Ringelman, and S. E. Stephens. 2013. Distribution of duck broods relative to habitat characteristics in the prairie pothole region. Journal of Wildlife Management 77:392–404.
Wright, C. K., and M. C. Wimberly. 2013. Recent land use change in the western corn belt threatens grasslands and wetlands. Proceedings of the National Academy of Science 110:4134–4139.
Xu, Y., B. Wang, L. Dou, H. Yue, N. Yang, L. Yang, S. Liu, and J. Ran. 2016. Estimating density of a rare and cryptic high-mountain Galliform species, the buff-throated partridge *Tetraophasis szechenyii*. Avian Conservation and Ecology 11:10.

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