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# AN INTEGRATED EVALUATION OF THE CONSERVATION RESERVE ENHANCEMENT PROGRAM IN SOUTH DAKOTA

BY

JARRETT D. PFRIMMER

A dissertation submitted in partial fulfillment of the requirements for the

Doctor of Philosophy

Major in Wildlife and Fisheries Sciences

South Dakota State University

2017

# AN INTEGRATED EVALUATION OF THE CONSERVATION RESERVE ENHANCEMENT PROGRAM IN SOUTH DAKOTA

This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy in Wildlife and Fisheries Science degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidates are necessarily the conclusions of the major department.

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# ABSTRACT

# AN INTEGRATED EVALUATION OF THE CONSERVATION RESERVE ENHANCEMENT PROGRAM IN SOUTH DAKOTA

JARRETT PFRIMMER
2017

Grassland restoration efforts in North America typically share the goal of improving ecological conditions for wildlife; however, it is unclear in many cases if goals are met. The South Dakota Conservation Reserve Enhancement Program (CREP) was initiated to alleviate agriculturally-related environmental degradation by converting 40,469 hectares of eligible cropland and marginal pastureland to perennial vegetation. The program aims to provide habitat for obligate grassland breeding songbirds, while producing an additional 285,000 pheasants and 60,000 ducks annually. As part of a collaborative comprehensive evaluation effort, my research assessed the response of grassland-dependent breeding birds to CREP implementation at varying spatial scales between May 2013 and August 2015. My study highlighted both field and landscape scale variables are critical to understanding the interconnected ecological network and meeting program goals. Competitive model variables presented variability between avian demographics and our species groups (i.e., other species, song bird species, CREP focal species, and waterfowl species) related to the ecology of species and functional groups; emphasizing that implementation of conservation programs with broad and non-collaborative objectives may receive undesired outcomes. In addition to the biological assessment, I integrated a human dimensions study to evaluate CREP landowner motivations for program enrollment. My study highlighted three themes of motivation for

CREP enrollment. First, the requirement of providing public access with CREP enrollment delivered additional financial and non-financial incentive for enrollees. Second, based on demographics data, landowner age represented a potential shift of producers towards retirement and decisions to reduce active production fields. Third, CREP landowners conceptualized their own personal motivations within the program that would provide greater benefit to their family, community, and local fish and wildlife. Implementation of an integrated stepwise platform based on biological and socio-economic data will benefit resource managers' and policy makers' understanding of conservation program effectiveness and future success.

# CHAPTER 1: AN INTEGRATED EVALUATION OF THE CONSERVATION RESERVE ENHANCEMENT PROGRAM IN SOUTH DAKOTA: AN INTRODUCTION

Conversion of native prairie for agricultural production in the Mid-continental U.S. has been deemed one of the most rapid and comprehensive environmental alterations (Smith 1998). In South Dakota, >85% of native tallgrass prairie has been converted (Samson and Knopf 1994), with much of the landscape today being dominated by annual crops (Wright and Wimberly 2013). The expansion and intensification of agricultural production systems and subsequent loss of grasslands has driven significant declines in biodiversity in the region (Warner 1994, Fletcher and Koford 2002, Murphy 2003, Wiens et al. 2011). In particular, Midwestern grassland birds have experienced widespread population declines over the past four decades (Knopf 1994, Brennan and Kuvlesky 2005, Sauer et al. 2011). Current populations of these species have become dependent on intensively managed agricultural lands for breeding habitat (Askins et al. 2007).

Recent historically-high crop prices, combined with federal mandates promoting expanded corn ethanol and cellulosic biofuel production (EISA 2007, Sumner and Zulauf 2012), have further driven agricultural expansion and intensification in the Midwestern U.S. For example, approximately 5.7 million ha of grassland, wetland, and shrubland habitats were converted to corn (*Zea mays*) and soybean (*Glycine max*) production during 2008 to 2011, with conversion primarily occurring in the Midwest (Faber et al. 2012). From 2006 to 2011, grass-dominated land cover in the Western Corn Belt states (North and South Dakota, Nebraska, Minnesota, and Iowa) declined by 528,000 ha, concomitant with a significant expansion of corn and soybean production onto marginal lands (Wright and Wimberly 2013).

In response to declining ecological function and overall habitat loss in these important transitional zones, restoration of native landscapes and local riparian areas are now widely advocated through a variety of federal and state conservation programs (Allen 2005, Teels et al. 2006). The rate of decline in ecosystem functions (i.e., water supply, nutrient cycling, soil erosion, and biological diversity; Dodds et al. 2008) were greatest prior to 1985, but slowed following the inception of various conservation programs (e.g., the Conservation Reserve Program; Gray and Teels 2006). Throughout the Midwest, such conservation initiatives included provisions for the protection and restoration of specific features of degraded grassland and wetland habitats, with focus on environmentally and economically important watersheds (Goodwin et al. 1997, Allen 2005). Because it is not often realistic to return such systems to historical conditions, and few studies have documented changes in the condition of aquatic and terrestrial resources in response to conservation efforts (Kauffmann et al. 1997, Gray and Teels 2006, Teels et al. 2006), scientists must determine how best to manage systems for particular ecological benefits. Habitat reconstruction and restoration efforts undertaken throughout the U.S. typically share similar goals of improving conditions for terrestrial and aquatic resources; nonetheless, it remains unclear if projects tend to achieve such results (Kleiman et al. 2000, Bash and Ryan 2002, Stem et al. 2003). Currently, the relative effectiveness of most restoration practices to meet desired ecological goals is poorly understood, in part due to limited post-implementation monitoring and evaluation (~10%; Bernhardt et al. 2005, Palmer and Bernhardt 2006, De Bello et al. 2010). Restoration monitoring and subsequent assessment can offer resource managers valuable feedback and improve the outlook of achieving anticipated ecological goals, while also facilitating adaptive management opportunities. These efforts may ultimately improve future management of resources through refinement of restoration methods and techniques.

Widespread ecological restoration efforts focus generally on improving the capacity of select watersheds to provide clean water, consumable fisheries, wildlife habitat, and generally improve the overall health and function of such systems (Allen 2005, Palmer and Bernhardt 2006). However, conflicting needs of diverse interest groups have necessitated a clear understanding of the impacts of restoration at varying spatial scales and benefits to terrestrial and aquatic components (Sear et al. 1998, Cole et al. 2010, Shanahan et al. 2011, Kroll et al. 2014). Effective ecological restoration must include a comprehensive approach that embraces biological responses and human dimension integration (Meyerson et al. 2005, Palmer and Bernhardt 2006, Heneghan et al. 2008, Dallimer and Strange 2015, Selinskeet al. 2015, Velasco et al. 2015). Furthermore, an integrated approach must be taken to evaluate biological responses toward multiple variables. For example, the illumination of the link between large-scale ecological dynamics and local management, rather than limited focus on isolated manipulations of individual elements, will maximize functional benefits of restoration efforts (Cunningham and Johnson 2006, Shanahan et al. 2011, Kroll et al. 2014). Therefore, development of large-scale approaches that evaluate local, site-by-site improvements, as well as multi-scale changes, will provide important landscape concepts that can be used to prioritize future conservation efforts and effectively quantify environmental change to terrestrial and aquatic resources (Teels et al. 2006, Shanahan et al. 2010, Kroll et al. 2014). Present research using this multi-scale methodology often neglect to evaluate limiting factors (e.g., forage availability). This oversight may hinder modeled outcomes. For example, McIntyre and Thompson (2003) documented the positive influence of arthropod abundance on bird abundance in Conservation Reserve Program plantings. Modeling all factors previously discussed in this chapter could potentially identify the biological variables of significance to the success of a conservation program.

Along with the evaluation of ecological goals and restoration effectiveness, the social-economic impacts of these programs should not be ignored. With approximately 72% of the U.S. land base under private ownership (Vincent et al. 2014), and the demand for lower-cost foods and environmental sustainability at an all-time high (Godfray et al. 2010), it is a crucial time to understand agricultural producers' environmental beliefs. Landowner attitudes throughout the U.S. are highly complex and variable (Leatherman et al. 2007). For example, agricultural producers may evaluate a conservation program with entirely different beliefs based on requirements of conservation compliance, age, education, and attitude (Hua et al. 2004). Even farmers characterized as dedicated to environmental conservation have distinct gaps in their principles (Ahnström et al. 2009). Research has shown that factors such as benefits to wildlife and minimizing soil erosion were ranked as the most important factors influencing decision to enroll land into CRP (Kurzejeski et al. 1992). However, the most influential variable has been shown to fluctuate across the U.S. (Kurzejeski et al. 1992); therefore, it is crucial for conservation to integrate human dimensions surveys within biological research.

# DISSERTATION RESEARCH

My study was conducted as part of an integrated approach to evaluate conservation programs based on terrestrial and aquatic resources as well as the human dimensions of involved stakeholders. My dissertation will not include assessments or findings from the evaluation of aquatic resources. My evaluation of terrestrial resources was based on breeding bird response to implementation of the Conservation Reserve Enhancement Program (CREP) in South Dakota, U.S.

The CREP is a natural resource conservation program involving a federal-state partnership to enhance selected watersheds nationwide to address conservation priorities by alleviating agriculturally-related environmental concerns (Allen 2005, USDA 2011). Since the inception of the CREP in Maryland in 1997, the program has grown substantially in support in various states. From 2007 to 2012, the CREP increased from 3.7 million acres to 5.3 million acres nationwide (Hellerstein 2012) and has contributed to several large-scale conservation efforts in systems such as the Chesapeake Bay tributaries in Pennsylvania, Minnesota River Basin in Minnesota, the Saginaw Bay Watershed in Michigan, the Illinois River Watershed in Illinois, and the Lake Erie ecosystem in Ohio (Allen 2005, Teels et al. 2006, O’Neal et al. 2008). In South Dakota, the CREP project was proposed for the James River Basin in November 2009, with a goal of 40,469 hectares total enrollment (10-15 year contracts). The CREP is and has been a valuable tool for grassland and wetland conservation. The program was intended to restore hydrologic conditions (e.g., increase water quality and channel stabilization) and provide perennial habitat (e.g., grasslands and wetlands) for breeding game and non-game wildlife (USDA 2011). In addition to non-game wildlife species, a goal of the

South Dakota CREP was also to produce an additional 285,000 ring-necked pheasants (*Phasianus colchicus*) and 60,000 ducks (Anatidae) annually (USDA 2009). Further, the program is unique in that all lands under contract are required to allow public access through South Dakota's Walk-in Area Program and require all landowners to comply with aquatic and terrestrial monitoring. This program coupling has simultaneously allowed the program to provide increased financial incentive for private landowners in comparison to other conservation programs; thus, it provides unique opportunities for financial growth, public recreation, and research.

My study entailed surveys of breeding and nesting birds, vegetation, invertebrate assemblage and biomass, and landowner motivations for enrollment. Moreover, my study included a multi-scale approach to assess the influence of landscape-scale (1,500m field buffers) CREP implementation and local contract site selected variables. This integrated approach provided applicable assessment and identification of potential conservation thresholds for future program standards.

Conceptualizing my overarching goal of developing an integrated evaluation of CREP in South Dakota, my dissertation is comprised of 5 chapters. This introduction (chapter 1) was developed to provide background content and outline future chapters. Chapter 2 analyzes field and landscape factor models to identify variables most influential to overall breeding bird abundance and species richness by functional group and CREP focal species of concern. Chapter 3 further examines field and landscape factor models to identify variables most influential to nest density, species richness, and survival by functional group and CREP program focal species of concern. With this, chapters 2 and 3 stand to evaluate current CREP conditions and work to develop an integrated platform for future conservation program implantation. Chapter 4 integrates human dimensions evaluation of CREP enrolled landowners for analysis of demographics, conservation beliefs, and motivations for enrollment. I close my dissertation with chapter 5 as a discussion of conclusions and future implications made throughout my study to portray my findings and detail the benefits of this integrated evaluation approach.

My research highlights successes and points of concern to conservation program implementation, as well as potential limits to management strategies for future allocation of resources and prioritization of future enrollments. The conservation field in general could benefit from reflecting on the effects of individual contract management techniques to terrestrial resources with an integration of multi-scale and human dimensions perspectives.

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# CHAPTER 2: FIELD AND LANDSCAPE FACTOR INFLUENCES ON BREEDING BIRD USE OF CONSERVATION RESERVE ENHANCEMENT PROGRAM LANDS IN SOUTH DAKOTA

*This chapter is being prepared for submission in the Journal of Wildlife Management.*

# ABSTRACT

Habitat restoration and enhancement efforts in North America typically share the goal of improving ecological conditions for wildlife; however, in many cases it is unclear if goals are met. The South Dakota Conservation Reserve Enhancement Program (CREP) partnership was initiated in 2009 with the objective of improving agriculturally-related environmental degradation by enrolling and converting 40,469 hectares of eligible cropland or marginal pastureland in the James River Basin to perennial vegetation. The program also intended to provide habitat for obligate grassland breeding birds. As part of a comprehensive study, our research assessed the response of grassland-dependent breeding birds (i.e., upland game birds and songbirds) to CREP implementation at varying spatial extents between May 2013 and August 2015. Our study focused on a comprehensive approach that integrated field and landscape factor modeling to evaluate variables most influential to breeding bird abundance and species richness by 3 groups: 1) song bird species; 2) other species, and; 3) CREP focal species. Competitive models revealed unique influential variable differences between the 3 groups of breeding birds. In evaluation of scale, field level had statistically greater influences on dependent variables (e.g., abundance of all 3 bird groups, species richness of other and song bird species groups) than landscape level variables for all groups. However, landscape scale variables were influential in models of the songbird species group (i.e., abundance and species richness), with a negative influence from percent cropland and a positive influence from percent grassland and woodland. Evaluation across multiple focus levels in our 3 groups of grassland breeding birds identified key similarities and differences that must be accounted for by resource managers and policy makers in setting initial goals

(e.g., focal species selection, focus level influence varies by species or functional group) and assessing mid-contract management in order to reach anticipated conservation objectives.

# INTRODUCTION

Grassland landscapes are being continuously converted throughout the Midwest and Great Plains (Samson and Knopf 1994; Wright and Wimberly 2013) and environmental incentive program enrollment caps are declining; therefore, there is a need to assess current conservation program strategies to improve the effectiveness of conservation efforts. Unfortunately, wildlife managers often fail to evaluate and monitor implemented programs (Nichols and Williams 2006, De Bello et al. 2010). Many Midwestern grassland birds have experienced population declines in recent decades (Knopf 1994, Brennan and Kuvlesky 2005, Sauer et al. 2011) and are becoming more dependent on smaller parcels of lands for breeding habitats (Askins et al. 2007). Habitat reconstruction and restoration projects typically share basic goals of improving environmental conditions for both terrestrial and aquatic resources, yet it is unclear if the majority of projects achieve these goals (Bash and Ryan 2002). It has been recommended that a mosaic composition of vegetation structure, plant diversity, and management techniques may maximize useable space for multiple avian species with varying habitat requirements over time (Van Dyke et al. 2004, Coppedge et al. 2008). When evaluations are conducted, the majority of studies maintain a narrow focus that encompasses few influential factors, such as vegetation structure, landscape context, or forage availability (e.g., Delisle and Savidge 1997, Lloyd and Martin 2005). Comprehensive restoration monitoring and assessment can offer managers valuable information for adaptive management opportunities.

It is well established that conservation programs implemented throughout the United States since the 1985 Farm Bill have improved environmental conditions and ecosystem functions (i.e., disturbance regulation, water supply, nutrient cycling, soil erosion control production of commodities and biological diversity; Gray and Teels 2006, Dodds et al. 2008). However, with the current budget priority and reduction of government funding, conservation managers and policy makers must identify new options for maximizing remaining conservation funds. For example, this situation has generated conservation initiatives for the protection and restoration of specific watersheds of conservation concern (Goodwin et al. 1997, Allen 2005). Nonetheless, if implemented programs within these regions are not evaluated, program success remains unknown and it becomes difficult to impossible to target future conservation efforts and allocate funding efficiently.

The South Dakota CREP partnership was initiated in November 2009 to restore hydrologic conditions and upland buffers of prairie pothole wetlands by enrolling 40,469 hectares of cropland and/or marginal pastureland to perennial vegetation within the James River Basin (USDA 2011). The South Dakota CREP was intended to provide habitat for various game and non-game fish and wildlife species annually through 10-15 year contracts.

Our study was part of a large-scale evaluation of the Conservation Reserve Enhancement Program (CREP) in the James River Basin of South Dakota. We focused on quantifying field and landscape ecological dynamics via modeling to identify variables most influential to restoration success; that is, developing a large-scale approach to evaluate local, site-by-site variation to prioritize future conservation efforts (Teels et al. 2006, Shanahan et al. 2011, Kroll et al. 2014). Because it is not often realistic to return such systems to historic conditions, and few studies have documented changes in the condition of aquatic and terrestrial resources in response to conservation efforts (Kauffmann et al. 1997, Gray and Teels 2006, Teels et al. 2006), scientists must determine how best to manage systems for particular ecological benefits.

The overall goal of our study was to identify field and landscape level variables most influential on achieving the CREP goal of maximizing suitable habitat for grassland avifauna. Our specific research objectives were to model and evaluate avian abundance and species richness by functional and CREP focal species groups in relation to: 1) variation in vegetation composition and structure; 2) invertebrate abundance, species richness, and biomass, and; 3) variation in landscape context. This comprehensive approach was intended to provide managers with a framework that may be used to plan for the implementation of future CREP or other conservation programs.

## MATERIALS AND METHODS

### Site Selection

We used a stratified multi-stage sampling design (MSS) with 4 stages to estimate the effects of management and implementation of the CREP on terrestrial and aquatic resources within the James River Basin (Stafford et al. 2006). We selected 10 subwatersheds with a stratified random approach throughout the James River Basin in South Dakota, U.S.A. to allow for inferences to be drawn to the entire program area (Figure 1). We based stratification on the need for areas to have habitat components to support both terrestrial and aquatic studies, which resulted in 20 study fields (2-3 years post-seeding) for the terrestrial evaluation. Primary sample units were subwatersheds stratified by percent CREP enrollment of the total subwatershed area. We stratified secondary sample units to include subwatersheds, which contained a minimum of 2 CREP sites of which an individual site met the following criteria: 1) implementation of CREP management on both stream banks; 2) no inflowing tributaries, and; 3) aquatic sites contained water and were expected to maintain flowing conditions throughout the sampling period (Figure 1; aquatic sampling will not be discussed further). We deemed tertiary sample units as subwatersheds that included a CREP stream site and a supplementary CREP site that was not required to include a stream (Figure 2). All sites were randomly selected within each identified subwatershed for terrestrial sampling and comparisons. Quaternary sample units were randomly placed research transects within the stratified sites. We used PROC SURVEYSELECT in SAS v 9.2 (SAS Institute, 2008) to randomly select subwatersheds, CREP enrollment localities, and local sampling units, with respect to each proportional weighting value (i.e., relative probability of selection).

## Vegetation Surveys

We surveyed vegetation composition and structure in each study field during the avian breeding season (May-August) in 2013-2015. We randomly placed 4 100 $m^2$ plots at each CREP site and re-randomized these locations each year. We surveyed vegetation characteristics along the north-south 100 m transect using 10 1 $m^2$ quadrats placed at randomized distances up to 50 m east or west of the transect. We initiated vegetation quadrat surveys 5 m from the endpoint of each transect, and surveyed one quadrat every 10 m along the transect. In each 1 $m^2$ quadrat, we measured vegetation height-density (cm) by recording visual obstruction readings (VOR) using a Robel pole (Robel et al. 1970). We calculated canopy cover based on estimated visual overhead percent cover in each quadrat. We used the Daubenmire cover class method (Daubenmire 1959) to estimate percent bare ground, litter, and canopy coverage of standing dead and live grasses, forbs, and woody vegetation.

### Avian Surveys

We conducted visual surveys of breeding birds in 2 of the 100 $m^2$ vegetation sampling plots per CREP field by walking (1 m per 5 sec) the north-south transect. We counted all birds observed or heard within the survey plot, and excluded all birds flying overhead or using adjacent vegetation. We identified all birds with the aid of 10 x 40 binoculars and used auditory cues to ensure correct identification. For each observation, we recorded species, location within the plot, and whether the bird was alone, paired, or in a flock. We recorded behavior of each individual as: 1) entering plot; 2) flushed; 3) foraging; 4) perched; 5) singing male; 6) fighting males; 7) courting; 8) mating; 9) attending nest, or; 10) attending young.

We conducted breeding bird surveys between 30 min after sunrise and 1100, and did not survey when there was precipitation, fog, or local wind speeds exceeding 25 km/h (Ralph et al. 1993). We collected local weather data prior to surveys (temperature, wind speed, cloud cover, and humidity) using a Kestrel® 3500 Pocket Weather® Meter at each sampling location.

We surveyed each research plot 6 times between May and July each year (2 surveys per month). We randomly selected subsets of 6 to 14 fields to be surveyed per day during a survey period and randomly selected the order to be surveyed, to minimize bias associated with temporal or climatic variation. Each round of surveys (40 plots) was completed within 5 days. If plots within a field were randomly placed adjacent to one another, we conducted surveys simultaneously with 2 observers to avoid double counting birds flushed from adjacent plots.

### Arthropod Surveys

We surveyed arthropods in 2014 and 2015 using 2 common methods: pitfall trapping and sweep-net surveys (O'Leske et al. 1997, Standen 2000, Doxon et al. 2011). We surveyed arthropods in 10 of the 20 CREP fields, which were randomly selected based on grass monocultures vs. grass-forb mix plant communities present in the 2013 vegetation sampling data and by NRCS contract seeding plans. We used NRCS documents to provide insight into potential plant community shifts in future field seasons (2014 and 2015).

Pitfall traps consisted of 2 cm x 16 cm PVC pipes placed in the soil to ground level into which we inserted 18 mm x 150 mm glass test tubes 1/3 full of 70% ethanol (Olson 1991, Nemec 2014). We placed traps 10 m west and 10 m towards the plot center at both ends of each vegetation line transect 1 week prior to the first avian sampling period of each year and collected trap contents weekly through the end of July. We combined trap contents collected from a single transect each day.

We conducted sweep-net sampling 6 times during the field season in coordination with avian survey periods. We conducted sampling using a standard 38 cm canvas sweep-net and surveyed based on a 20 sweep collection method at approximately 1 sweep/meter across the upper 25% of the vegetation (O'Leske et al. 1997, Standen 2000, Doxon et al. 2011). We conducted surveys along each of the 4 vegetation transects, initiated 40 m from the endpoint of the north-south transect in each plot. Upon completion of the sweeps, we transferred all collected arthropods to a sealed freezer bag and placed in cold-storage for later sorting (Doxon et al. 2011). We classified arthropod samples to Suborder for evaluation of abundance and richness and we obtained dry-weight biomass by Suborder by drying samples at 60 degrees C for 48 hours in a drying oven (Taylor et al. 2006).

### Data Analysis

We separated observed bird species into 3 groups: 1) song bird species; 2) other species, and; 3) CREP focal species to assess influential variables (USDA 2009). The song bird group and other species group encompassed all observed bird species in the study with no overlap of species between them. The song bird group included all passerines, whereas the group titled "Other" encompassed the Upland Sandpiper (*Bartramia longicauda*), Ring-necked Pheasant (*Phasianus colchicus*), Mourning Dove (*Zenaida macroura*), and Sharp-tailed Grouse (*Tympanuchus phasianellus*). The CREP focal species group was an assemblage of the 8 bird species identified for conservation program focus and the goal of improving habitat for these species of concern, specifically: Bobolink (*Dolichonyx oryzivorus*), Chestnut-collared Longspur (*Calcarius ornatus*), Dickcissel (*Spiza americana*), Grasshopper Sparrow (*Ammodramus savannarum*), Savannah Sparrow (*Passerculus sandwichensis*), Sedge Wren (*Cistothorus platensis*), Upland Sandpiper, and Western Meadowlark (*Sturnella neglecta*).

In addition to evaluating breeding bird abundance and species richness, we used the Partners in Flight (PIF) species assessment database (Partners in Flight Science Committee 2012) for the Prairie Pothole Region to obtain Regional Conservation

Concern Scores for each evaluated bird species based on species density. Scores assess factors (i.e., population size, breeding distribution, non-breeding distribution, threats, and population trend) related to the vulnerability and regional conservation status for all North American landbird species (Panjabi 2012).

We evaluated the influence of field and landscape variables on breeding bird abundance, species richness, and PIF Regional Conservation Score by using the glmulti package in program R (R Foundation for statistical Computing; Vienna, Austria). This package allowed for creation of a global model to assess variables most influential in candidate models based on low Akaike Information Criterion values for small sample sizes ($AIC_c$). Further, we assessed a generalized linear model that was additive of all variables in the previous glmulti global model to evaluate significance of each variable and potential difference between the two methods. Anderson and Burnham (2002) suggested this methodology may be problematic if the research objective is to identify a best model. Corresponding to Anderson and Burnham's (2002) suggestions to avoid pitfalls, our study was based on a quality question using the information-theoretic approach that was not expected to reveal a best model. Our research intended to identify variables influential to breeding birds based on the presence and significance of variables in competitive candidate models ($\Delta AIC_c < 2$). We used this approach to evaluate and eliminate variables of potential influence included in the global model. Further, due to the objectives of our study as part of a comprehensive evaluation program to provide a platform for conservation program site selection criteria, field and landscape variable models were maintained as unique analyses, not combined evaluations. We evaluated influence of covariates of competitive models by calculating 95% confidence intervals about parameter estimates.

Variables included in the field model were in 3 categories: 1) vegetation structure and composition; 2) field characteristics, and; 3) invertebrate composition. We assessed vegetation structural characteristics based on the following variables: VOR, percent canopy coverage, and percent forb coverage. Field characteristics included: present wetland types (none, stream only, basin only, and both stream and basin), field size, edge within the field (i.e., fragmentation), percent grassland composition, and percent woodland composition. The invertebrate composition variable used invertebrate metrics (i.e., abundance, richness, and biomass) derived from pitfall and sweep-net data. Due to the lack of importance and presence in competitive models, we removed invertebrate variables from the global model and the model was re-evaluated to minimize total number of models. Herewith, invertebrate data will not be discussed within the results section.

We analyzed landscape context variables at 3 spatial scales (500 m, 1000 m, and 1500 m) using the Patch Analyst software extension for ArcGIS (Rempel et al. 2012). Research sites were buffered from the field edge out to the specified distance, so that only land cover variables outside the research site were included in landscape analyses. Land cover within the 1,500 m buffer was digitized by hand over aerial imagery and ground truthed. To eliminate error associated with total area variability within the landscape buffer due to field size differences, we calculated all land cover variables by percent of or density within total buffer area (i.e., percent cropland, development, grassland, woodland, wetland, and density of hard edge [i.e., transition between 2 cover types]). We found the

3 buffer scales to be correlated ($r \geq 0.68$) and opted to only use data from the 1,000 m buffer, since it was the middle distance of the 3 buffers.

## RESULTS

We recorded 3,011 bird observations from 46 species during the 2013–2015 field seasons. Field scale models were more influential than landscape scale models in our evaluation of bird abundance and species richness across all 3 avian groups (Table 1). Partners in Flight score was the only factor in the landscape scale model that was more influential ($\Delta AIC_c = 2.3$) than in the field level model (Table 1); however, no individual variable within the PIF competitive models had confidence intervals that excluded zero.

Competitive models (based on $AIC_c$) included unique influential variable differences between each of the 3 groups (Figure 3). The song bird species group was the only group that included substantial influences of variables at the landscape scale (percent cropland, grassland, and woodland). Species richness was negatively associated with percent cropland (β = -1.28, 95% CI = -0.15 – -2.41) and positively associated with percent grassland (β = 1.26, 95% CI = 2.40 – 0.13). Percent woodland was positively associated with abundance (β = 37.10, 95% CI = 12.82 – 61.38; Table 2).

Models of the influence of field variables on each of the 3 species groups indicated that only percent forb had a meaningful positive association (β = 38.74, 95% CI = 16.26 – 61.22) in competitive models of abundance and species richness (β = 1.41, 95% CI = 0.42 – 2.39) of the song bird species group. Further, mean visual obstruction supported a negative influence (β = -1.54, 95% CI = -2.94 – -0.14) in models of abundance for the other species group and species richness (β = -2.00, 95% CI = -0.99 – -3.02) for the song bird species group. Two field scale variables were negatively associated with species richness of the other species group: percent woodland (β = -0.60, 95% CI = -0.11 – -1.09) and field edge density (β = -0.58, 95% CI = -0.10 – -1.06). Wetland type was the only variable that was positively associated with abundance (β = 17.83, 95% CI = 5.37 – 30.29) of the CREP focal species, such that fields with no wetlands had lower CREP species abundance and fields with both streams and basins had highest abundances (Table 2).

## DISCUSSION

We modeled abundance and species richness of 3 breeding bird groups (other species, song bird species, and CREP focal species) with respect to field and landscape level variables. Our objective was to evaluate current program implementation based on a multi-scale assessment of factors influential to breeding grassland birds. The lack of a strong association between the dependent variables and the arthropod variables may suggest that all surveyed fields had sufficient invertebrate resources, or that arthropod availability for foraging was not a driving factor influencing abundance and species richness at our study sites (McIntyre and Thompson 2003). We suggest future research evaluate variables which can be directly influenced by resource managers (e.g., wetland type present, percent forb, and percent cropland) for conservation program improvement.

Each avian species group responded uniquely to field and landscape level variables, demonstrating that conservation programs with general/broad conservation goals for breeding grassland birds could result in vague or undesirable outcomes. Similar to previous research by Cunningham and Johnson (2006), we found field models of abundance and species richness included a greater percentage of informative variables for each species group than landscape scale models. We also observed that landscape variables were only influential (i.e., positive) to abundance and species richness of song bird species only (Ribic and Sample 2001).

### Field Scale

Patch size and area sensitivity have long been considered factors influential to grassland bird populations (Davis 2004, Renfrew and Ribic 2008, Ribic et al. 2009); however, we observed little influence of patch size on all dependent variables in our models. The influence of field level factors varied among the 3 bird groups. Mean VOR and in-field edge density were the only variables that had constant, negative influences in competitive models across all groups (Fletcher and Koford 2002, Davis 2004). All other variables suggested contradictory influences among avian groups, or appeared in only one group’s competitive models. Type of wetland and percent wetland cover within fields were represented only in competitive models of CREP focal species. Of these, wetland type was the only positive influence, suggesting that evaluating contract sites solely on wetland presence is likely inadequate for the species groups we evaluated (Homan et al. 2000, Reynolds et al. 2006); thus, sites encompassing wetland basins or both basins and streams would positively influence abundance and species richness of grassland breeding birds.

Evaluation of percent woody cover at the field scale demonstrated a negative influence on the abundance and species richness of the other species group, with no influence on the other two avian groups. Previous studies have documented trees increasing diversity of avian species; however, presence of woody species has also been known to have significant, negative effects on game and non-game grassland birds (Coppedge et al. 2008, Fletcher and Koford 2002, Bakker 2003, Fletcher and Koford

2003, Grant et al. 2004). Our results suggest selection of enrollment sites with minimal to no woody cover presence or implementation of woody species removal prior to program implementation. Adoption of this requirement on conservation programs could benefit obligate grassland avifauna with little negative association.

Percent forb cover was the only influential variable in competitive models of all 3 avian groups. The song bird group was the only group with a positive influence of forb cover on both abundance and species richness. Similar to previous research, our results suggested that grassland mixes that included an abundant and diverse forb component provided greater benefit to grassland bird populations than low diversity plantings (e.g., cool and warm-season monocultures). These data support the notion that managers and researchers should work to restore areas that more closely resemble diverse native sod prairies to benefit grassland birds (McIntyre and Thompson 2003, Bakker and Higgins 2009, Riffell et al. 2010).

### Landscape Scale

Our results revealed that landscapes with increased grassland and decreased cropland cover positively influenced grassland breeding birds, which coincides with other research findings (Ribic and Sample 2001, Koper and Schmiegelow 2006, Renfrew and Ribic 2008). With the continued conversion of land for agricultural production (Wright and Wimberly 2013), and reduced funding for conservation, our results support the need tailor integrated evaluation methods into conservation programs to maximize environmental and ecological benefits.

Evaluation of landscape variables indicated that edge (i.e., fragmentation) did not have a substantial influence on any of the 3 bird groups in our study. However, this lack of relationship may have been due to the homogeneous state of the landscape in our study region and the large size of surrounding agricultural fields. As reported by Askins et al. (2007), grasslands not only become fragmented in the Midwest and Great Plains, but existing tracts have become islands of remnant relics, or artificial habitats built to preserve populations even if conditions not ideal. For example, our results identified a positive relationship between song bird abundance and percent woodland cover in the landscape. Although we did not find this at the field level, avifauna may be required to use unfit and undesired locations based on availability of usable space (Van Horne 1983, Guthery 1997). Future research should continue to identify factors influencing avian site selection and preference to facilitate continued conservation program advancement, and focus on metrics influencing fitness (e.g., survival and reproduction).

Analysis of PIF score by field emphasized the importance of landscape variables over field scale variables to species of greatest conservation concern in the prairie pothole region. Though no individual variable showed a strong relationship with PIF score, research has demonstrated the impact of spatial dependence on many of these species. For this reason, we suggest using a multi-scale evaluation approach to conservation programs and believe our study design and approach might serve as a model for future evaluations (Vickery and Herkert 2001, Ribic et al. 2009).

### Management Implications

Our study highlighted the importance of setting detailed program goals that are complementing and consider habitat use of desired species at multiple (potentially influential) spatial extents. Goals should be dictated based on ecological similarities of species and environmental requirements. Our results suggest, that contract location selection and implementation be based on a stepwise process that incorporates landscape and field level factors. Within the program region of greatest conservation concern, emphasis on this process would allow program managers to designate landscapes with variables of greatest significance, especially to species with specific spatial requirements (e.g., Bobolink; Fletcher and Koford 2003). Following landscape selection, assessment of field scale attributes (i.e., individual contract requirements and implementation) would best capitalize on potential restoration success towards conservation program goals.

Our study stresses the importance for resource managers and policy makers to evaluate the effectiveness of current and future conservation program planning and implementation. Appraisal of potential constraints to program goals would benefit game and nongame birds of conservation concern throughout the Midwest and the Great Plains of North America.

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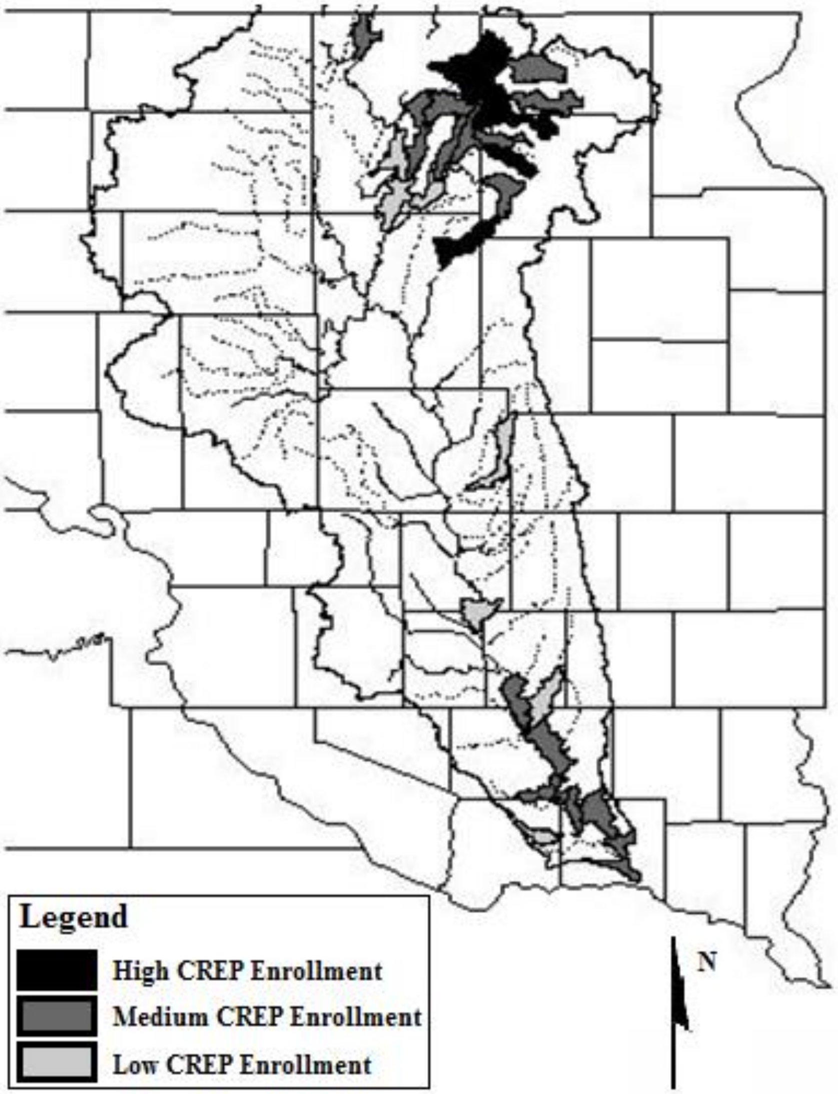

Figure 1. Subwatersheds (HUC12), distinguished by proportion of CREP enrollment to total subwatershed area, that meet selection criteria for use in landscape scale evaluations of responses of terrestrial and aquatic resources to implementation of the James River Basin CREP in South Dakota.

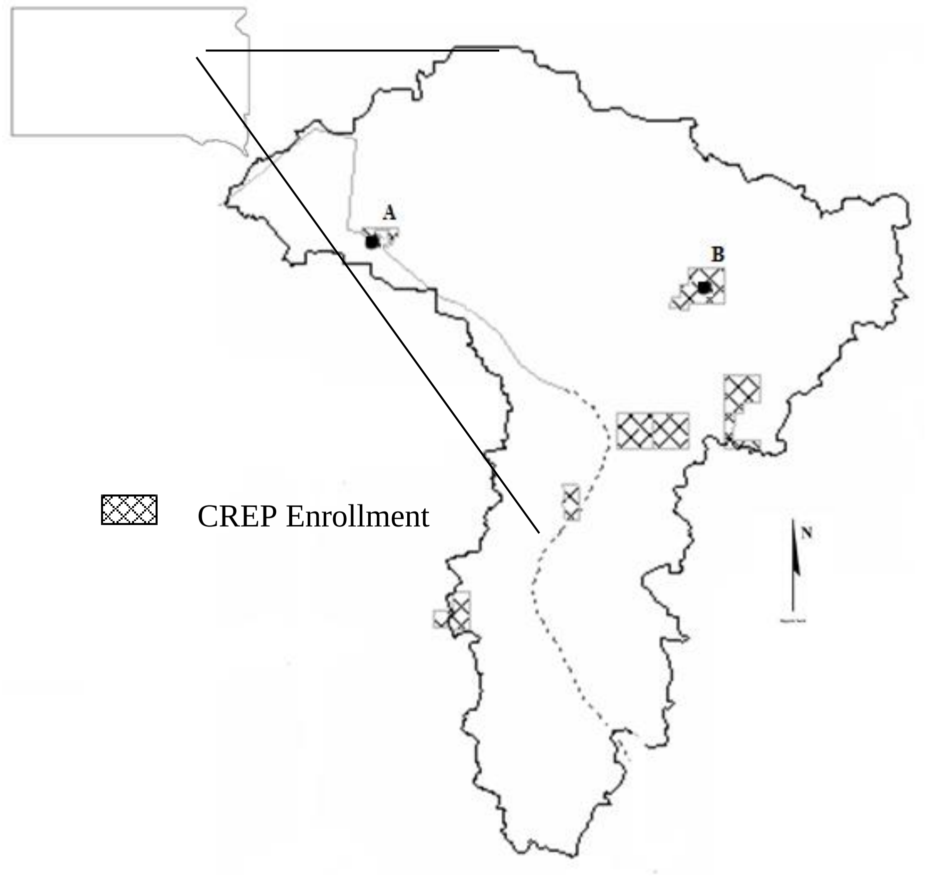

Figure 2. Visualization of distribution of sites selected for terrestrial sampling in a single subwatershed of the James River basin. Site “A” represents a randomly selected CREP enrollment site containing a intersecting stream for localized terrestrial sampling, and site “B” represents the randomly selected upland terrestrial site.

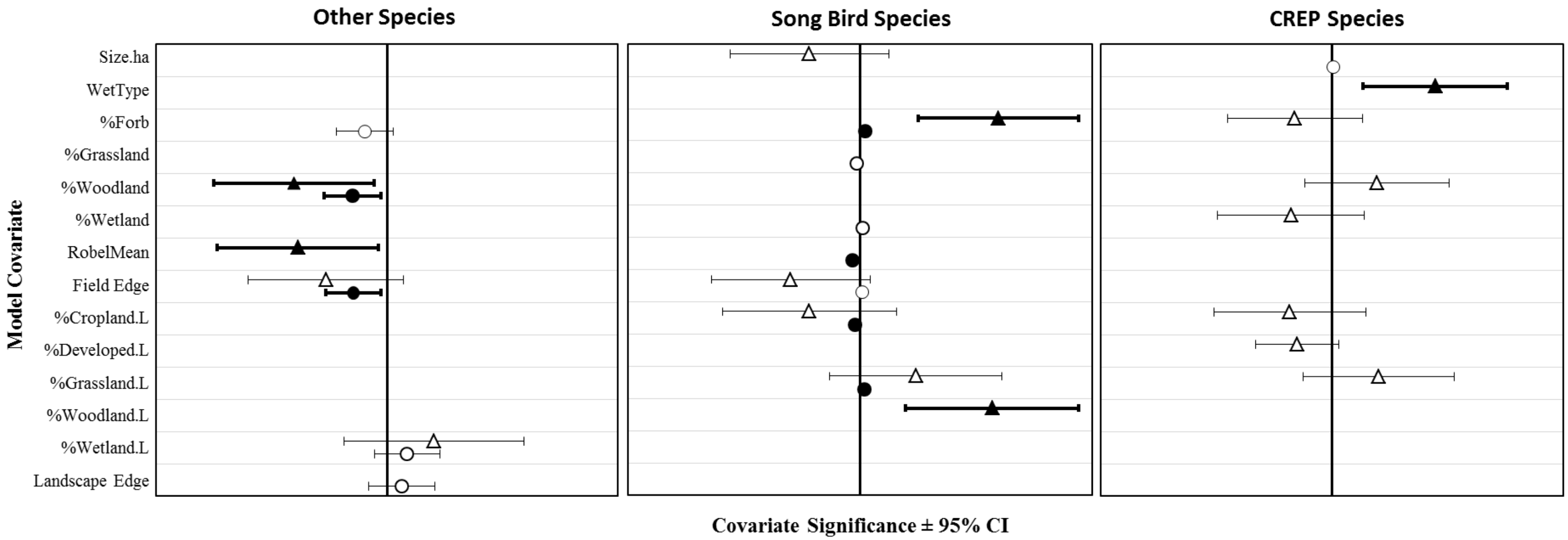

Figure 3. Influence of field and landscape level factors observed in competitive models on abundance (▲) and species richness (●) of 3 grassland breeding bird groups.

Table 1. Comparison of field and landscape level influence (AIC*c*) on abundance and species richness of the 3 breeding bird groups and Partners in Flight (PIF) Conservation Concern Score (Prairie Pothole Region). Bold AIC*c* scores represent greatest influence on the dependent variable.

| | **Other Species** | | | | **Song Bird Species** | | | | **CREP Species** | | | | **PIF** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Abundance** | | **Species Richness** | | **Abundance** | | **Species Richness** | | **Abundance** | | **Species Richness** | | | |
| | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** |
| **Field** | **113.72** | 0.00 | **73.36** | 0.00 | **217.21** | 0.00 | **95.01** | 0.00 | **194.71** | 0.00 | 73.98 | 0.00 | 34.12 | 2.31 |
| **Landscape** | 117.81 | 4.09 | 77.34 | 3.97 | 226.75 | 9.54 | 106.32 | 11.32 | 200.25 | 5.54 | 74.16 | 0.18 | **31.81** | 0.00 |

Table 2. Influence of field and landscape level factors observed in competitive models on abundance and species richness of 3 grassland breeding bird groups. Bold numbers represent factors with significant influence on the dependent variable.

| | **Other Species** | | | | | | **Song Bird Species** | | | | | | **CREP Focal Species** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Abundance** | | | **Species Richness** | | | **Abundance** | | | **Species Richness** | | | **Abundance** | | | **Species Richness** | | |
| | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | |
| **Size.ha** | | | | | | | -14.13 | -36.36 | 8.10 | | | | | | | 0.25 | -0.24 | 0.74 |
| **WetType** | | | | | | | | | | | | | **17.83** | **5.37** | **30.29** | | | |
| **%Forb** | | | | -0.38 | -0.88 | 0.11 | **38.74** | **16.26** | **61.22** | **1.41** | **0.42** | **2.39** | -6.43 | -18.07 | 5.21 | | | |
| **%Grassland** | | | | | | | | | | -0.79 | -1.77 | 0.19 | | | | | | |
| **%Woodland** | -1.61 | -3.00 | -0.22 | **-0.60** | **-1.09** | **-0.11** | | | | | | | 7.76 | -4.71 | 20.22 | | | |
| **%Wetland** | | | | | | | | | | 0.71 | -0.29 | 1.71 | -7.12 | -19.75 | 5.51 | | | |
| **RobelMean** | **-1.54** | **-2.94** | **-0.14** | | | | | | | **-2.00** | **-3.02** | **-0.99** | | | | | | |
| **Field Edge** | -1.06 | -2.40 | 0.29 | **-0.58** | **-1.06** | **-0.10** | -19.33 | -41.52 | 2.86 | 0.64 | -0.33 | 1.60 | | | | | | |
| **%Cropland** | | | | | | | -14.13 | -38.47 | 10.21 | **-1.28** | **-2.41** | **-0.15** | -7.28 | -20.42 | 5.87 | | | |
| **%Developed** | | | | | | | | | | | | | -6.04 | -19.32 | 7.23 | | | |
| **%Grassland** | | | | | | | 15.68 | -8.41 | 39.77 | **1.26** | **0.13** | **2.40** | 8.07 | -4.97 | 21.11 | | | |
| **%Woodland** | | | | | | | **37.10** | **12.82** | **61.38** | | | | | | | | | |
| **%Wetland** | 0.81 | -0.74 | 2.37 | 0.35 | -0.22 | 0.91 | | | | | | | | | | | | |
| **Landscape Edge** | | | | 0.26 | -0.32 | 0.83 | | | | | | | | | | | | |

# CHAPTER 3: MULTI-SCALE CONSERVATION PROGRAM INFLUENCES AFFECTING GRASSLAND NESTING AVIFAUNA IN SOUTH DAKOTA

*This chapter is being prepared for submission in the Journal of Wildlife Management.*

# ABSTRACT

With decreasing grasslands in the United States, maximizing the effectiveness of conservation programs is a critical conservation priority. Many of these programs highlight goals of benefiting grassland bird populations and the South Dakota Conservation Reserve Enhancement Program is no exception. The program intends to provide habitat for obligate grassland breeding songbirds, while producing an additional 285,000 pheasants and 60,000 ducks annually. As part of a multi-scale integrated evaluation, our study assessed the influence of field (vegetation composition and structure and arthropod demographics) and landscape (percent land cover and heterogeneity) variables to nest demographics of grassland breeding birds. Assessment of the three tiered multi-scale (i.e., nest site, field, and landscape level) influences validated the complexity and necessity of evaluating conservation program goals. Implementing conservation programs with broad objectives may receive undesired outcomes. Field models included a greater percentage of important variables for nest density and species richness for each species group, excluding waterfowl species and nest density of CREP focal species. Appraisal of nest survival identified field level influences significant only to the song bird species group. Inclusion of nest site level covariates detailed greatest influence on survival for the waterfowl species group. However, nest site level variables were found to resemble directional influence of variables at the field scale. Incorporating our findings into an integrated stepwise platform could benefit conservation planning and decision making to improve program effectiveness, implementation, and potential constraints to management strategies for grassland nesting birds.

# INTRODUCTION

Historical land use changes in the upper Midwest transformed continuous unbroken grasslands into fragmented refugia and continues to break patches into smaller parcels (Samson and Knopf 1994; Wright and Wimberly 2013). These alterations have resulted in several grassland bird species to experience population declines (Knopf 1994, Vickery and Herkert 2001, Fletcher and Koford 2002, Brennan and Kuvlesky 2005, Green et al. 2005, Askins et al. 2007, Sauer et al. 2011).

Historically, government conservation programs were viewed as a crucial component to the future of environmental conservation (Gray and Teels 2006, Dodds et al. 2008). Conversely, it is unclear if the majority of habitat reconstruction and restoration efforts in North America are achieving their goals of improving environmental conditions, primarily due to the limited monitoring and evaluation after implementation (Bash and Ryan 2002, De Bello et al. 2010). Many studies that have focused on evaluation of conservation programs have improperly investigate the true drivers of environmental health on these lands, due to the lack of a comprehensive approach (e.g., avian, invertebrate, and fisheries demographics; Delisle and Savidge 1997, McCoy et al. 1999, Lloyd and Martin 2005, Fletcher et al. 2006, Haroldson et al. 2006, Nichols and Williams 2006, De Bello et al. 2010). Properly done, restoration monitoring and subsequent assessment can offer resource managers valuable feedback toward achieving ecological goals and facilitate adaptive management for future conservation.

There are still many gaps in the knowledge of fish and wildlife response to the establishment and management of grassland conservation programs in an agricultural landscape. A comprehensive evaluation could significantly influence the success of a conservation program, especially with current budget deficits and limited funding sources. Conservation managers and policy makers will continue to be faced with finding new options for maximizing conservation funding.

Our study was part of a large-scale evaluation of the Conservation Reserve Enhancement Program (CREP) in South Dakota. Our research concentrated on a comprehensive approach that integrated field and landscape factor modeling to evaluate variables most influential (multi-scale land cover, vegetation composition and structure, and forage availability) to avian nest density, species richness, and survival. Therefore, developing a large-scale method that evaluates local, site-by-site, variation to prioritize future conservation efforts for future program implementation and success of focal species (Teels et al. 2006, Shanahan et al. 2011, Kroll et al. 2014). South Dakota CREP was implemented in 2009 to restore hydrologic conditions and perennial grasslands on 40,469 hectares within the James River Basin (USDA 2011). The South Dakota CREP was intended to provide habitat for various game and non-game fish and wildlife species annually through 10-15 year contracts.

The objectives of our study were to model and evaluate avian nest demographics in relation to: 1) variation in vegetation composition and structure; 2) invertebrate abundance, species richness, and biomass, and; 3) influences of landscape context, with the overall target of identifying landscape and field variables most influential to achieving the CREP goal of maximizing suitable habitat for grassland avifauna.

# MATERIALS AND METHODS

## Site Selection

We used a stratified multi-stage sampling design (MSS) with 4 stages to estimate the effects of management and implementation of the CREP on terrestrial and aquatic resources within the James River Basin (Stafford et al. 2006). We selected 10 subwatersheds with a stratified random approach throughout the James River Basin in South Dakota, U.S.A. to allow for inferences to be drawn to the entire program area (Figure 1). We based stratification on the need for areas to have habitat components to support both terrestrial and aquatic studies, which resulted in 20 study fields (2-3 years post-seeding) for the terrestrial evaluation. Primary sample units were subwatersheds stratified by percent CREP enrollment of the total subwatershed area. We stratified secondary sample units to include subwatersheds, which contained a minimum of 2 CREP sites of which an individual site met the following criteria: 1) implementation of CREP management on both stream banks; 2) no inflowing tributaries, and; 3) aquatic sites contained water and were expected to maintain flowing conditions throughout the sampling period (Figure 1; aquatic sampling will not be discussed further). We deemed tertiary sample units as subwatersheds that included a CREP stream site and a supplementary CREP site that was not required to include a stream (Figure 2). All sites were randomly selected within each identified subwatershed for terrestrial sampling and comparisons. Quaternary sample units were randomly placed research transects within the stratified sites. We used PROC SURVEYSELECT in SAS v 9.2 (SAS Institute, 2008) to randomly select subwatersheds, CREP enrollment localities, and local sampling units, with respect to each proportional weighting value (i.e., relative probability of selection).

### Vegetation Surveys

We surveyed vegetation composition and structure in each study field during the avian breeding season (May-August) in 2013-2015. We randomly placed 4 100 $m^2$ plots at each CREP site and re-randomized these locations each year. We surveyed vegetation characteristics along the north-south 100 m transect using 10 1 $m^2$ quadrats placed at randomized distances up to 50 m east or west of the transect. We initiated vegetation quadrat surveys 5 m from the endpoint of each transect, and surveyed one quadrat every 10 m along the transect. In each 1 $m^2$ quadrat, we measured vegetation height-density (cm) by recording visual obstruction readings (VOR) using a Robel pole (Robel et al. 1970). We calculated canopy cover based on estimated visual overhead percent cover in each quadrat. We used the Daubenmire cover class method (Daubenmire 1959) to estimate percent bare ground, litter, and canopy coverage of standing dead and live grasses, forbs, and woody vegetation.

### Nest Surveys and Monitoring

We conducted nest surveys 2 times per year in 2013 - 2015 in the 20 randomly selected CREP fields. We systematically searched each field for nests via ATV dragging, using a weighted nylon rope, at approximately 3-5 km/hr (Hughes et al. 1999, Renfrew et al. 2005, Kerns et al. 2010). We searched each site where a bird flushed for a nest or nesting material and included nests that were located opportunistically. At each nest site we recorded geographic coordinates, nesting species (host), number of eggs/nestlings, presence of parasitism, and age of eggs/nestlings. We monitored nests every 3-4 days to record nest status, nest stage, fate, and cause of termination (Johnson and Temple 1990, Winter 1999, Lusk et al. 2003).

### Arthropod Surveys

We surveyed arthropods in 2014 and 2015 using 2 common methods: pitfall trapping and sweep-net surveys (O'Leske 1997, Standen 2000, Doxon et al. 2011). We surveyed arthropods in 10 of the 20 CREP fields, which were randomly selected based on grass monocultures vs. grass-forb mix plant communities present in the 2013 vegetation sampling data and by NRCS contract seeding plans. We used NRCS documents to provide insight into potential plant community shifts in future field seasons (2014 and 2015).

Pitfall traps consisted of 2 cm x 16 cm PVC pipes placed in the soil to ground level into which we inserted 18 mm x 150 mm glass test tubes 1/3 full of 70% ethanol (Olson 1991, Nemec 2014). We placed traps 10 m west and 10 m towards the plot center at both ends of each vegetation line transect 1 week prior to the first avian sampling period of each year and collected trap contents weekly through the end of July. We combined trap contents collected from a single transect each day.

We conducted sweep-net sampling 6 times during the field season in coordination with avian survey periods. We conducted sampling using a standard 38 cm canvas sweep-net and surveyed based on a 20 sweep collection method at approximately 1 sweep/meter across the upper 25% of the vegetation (O'Leske 1997, Standen 2000, Doxon et al. 2011). We conducted surveys along each of the 4 vegetation transects, initiated 40 m from the endpoint of the north-south transect in each plot. Upon completion of the sweeps, we transferred all collected arthropods to a sealed freezer bag and placed in cold-storage for later sorting (Doxon et al. 2011). We classified arthropod samples to Suborder for evaluation of abundance and richness and we obtained dry-weight biomass by

Suborder by drying samples at 60 degrees C for 48 hours in a drying oven (Taylor et al. 2006).

### Data Analysis

We separated observed bird species into 4 groups: 1) song bird species; 2) other species; 3) CREP focal species, and; 4) waterfowl species to assess influential variables (USDA 2009). The waterfowl species, song bird species, and other species groups encompassed all observed bird species in the study with no overlap of species between them. The waterfowl species group included the American Bittern (*Botaurus lentiginosus*), Blue-winged Teal (*Anas discors*), Canada Goose (*Branta canadensis*), Gadwall (*Anas strepera*), Mallard (*Anas platyrhynchos*), Northern Pintail (*Anas acuta*), and Northern Shoveler (*Anas clypeata*). The song bird group included all passerines, whereas the group titled "Other" encompassed the Upland Sandpiper (*Bartramia longicauda*), Ring-necked Pheasant (*Phasianus colchicus*), Mourning Dove (*Zenaida macroura*), and Northern Harrier (*Circus cyaneus*). The CREP focal species group was an assemblage of the 8 bird species identified for conservation program focus and the goal of improving habitat for these species of concern, specifically: Bobolink (*Dolichonyx oryzivorus*), Chestnut-collared Longspur (*Calcarius ornatus*), Dickcissel (*Spiza americana*), Grasshopper Sparrow (*Ammodramus savannarum*), Savannah Sparrow (*Passerculus sandwichensis*), Sedge Wren (*Cistothorus platensis*), Upland Sandpiper, and Western Meadowlark (*Sturnella neglecta*).

We evaluated the influence of field and landscape variables on avian nest density, species richness, and survival using the glmulti package in program R (R Foundation for statistical Computing; Vienna, Austria). This package allowed for creation of a global model to assess variables most influential in candidate models based on low Akaike Information Criterion values corrected for small sample sizes ($AIC_c$). Further, we assessed a generalized linear model that was additive of all variables in the previous glmulti global model to evaluate significance of each variable and potential difference between the two methods. Anderson and Burnham (2002) suggested this methodology may be problematic if the research objective is to identify a best model. Corresponding to Anderson and Burnham's (2002) suggestions to avoid pitfalls, our study was based on a quality question using the information-theoretic approach that was not expected to reveal a best model. Our research intended to identify variables influential to breeding birds based on the presence and significance of variables in competitive candidate models ($\Delta AIC_c < 2$). We used this approach to evaluate and eliminate variables of potential influence included in the global model. Further, due to the objectives of our study as part of a comprehensive evaluation program to provide a platform for conservation program site selection criteria, field and landscape variable models were maintained as unique analyses, not combined evaluations. We evaluated influence of covariates of competitive models by calculating 95% confidence intervals about parameter estimates.

Variables included in the field model were in 3 categories: 1) vegetation structure and composition; 2) field characteristics, and; 3) invertebrate composition. We assessed vegetation structural characteristics based on the following variables: VOR, percent canopy coverage, and percent forb coverage. Field characteristics included: present wetland types (none, stream only, basin only, and both stream and basin), field size, edge within the field (i.e., fragmentation), percent grassland composition, and percent woodland composition. The invertebrate composition variable used invertebrate metrics (i.e., abundance, richness, and biomass) derived from pitfall and sweep-net data. Due to the lack of importance and presence in competitive models, we removed invertebrate variables from the global model and the model was re-evaluated to minimize total number of models. Herewith, invertebrate data will not be discussed within the results section.

We analyzed landscape context variables at 3 spatial scales (500 m, 1000 m, and 1500 m) using the Patch Analyst software extension for ArcGIS (Rempel et al. 2012). Research sites were buffered from the field edge out to the specified distance, so that only land cover variables outside the research site were included in landscape analyses. Land cover within the 1,500 m buffer was digitized by hand over aerial imagery and ground truthed. To eliminate error associated with total area variability within the landscape buffer due to field size differences, we calculated all land cover variables by percent of or density within total buffer area (i.e., percent cropland, development, grassland, woodland, wetland, and density of hard edge [i.e., transition between 2 cover types]). We found the 3 buffer scales to be correlated ($r \geq 0.68$) and opted to only use data from the 1,000 m buffer, since it was the middle distance of the 3 buffers.

We conducted logistic-exposure analysis of daily nest survival to explore field and landscape models (Lloyd and Tewksbury 2007, Shaffer and Thompson 2007, Walk et al. 2010). In addition, due to invertebrate variables being non-influential in regards to the presence in competitive candidate models, they were also excluded from final model analysis.

# RESULTS

## Nest Surveys

We documented 705 nests of 26 species in our CREP study fields from 2013 to 2015. The 10 most abundant nesting species were Mallard (32.3%), Red-winged Blackbird (*Agelaius phoeniceus*; 19.1%), Blue-winged Teal (7.7%), Mourning Dove (7.7%), Clay-colored Sparrow (*Spizella pallida*; 5.8%), Gadwall (5.5%), Sedge Wren (*Cistothorus platensis*; 2.8%), Ring-necked Pheasant (2.6%), Savanna Sparrow (*Passerculus sandwichensis*; 2.1%), and Meadowlark (*Sturnella spp.*; 1.8%); these species accounted for 87.5% of observed species.

In evaluation of focal scale on the 4 groups of nest birds, both field and landscape level influence varied between groups. Models for the waterfowl group at the landscape level were more influential than field scale models of nest density ($\Delta AIC_c = 6.5$) and species richness ($\Delta AIC_c = 4.8$). In contrast, field level models for the song bird and CREP species groups performed better than landscape models of nest density ($\Delta AIC_c = 10.5$ [song bird]; $\Delta AIC_c = 2.5$ [CREP]) and species richness ($\Delta AIC_c = 2.5$ [song bird]; $\Delta AIC_c = 3.1$ [CREP]; Table 1a). Models for the other species group indicated approximately equal support of field and landscape models of nest density ($\Delta AIC_c = 0.3$; landscape $AIC_c = 0.0$) and species richness ($\Delta AIC_c = 1.9$; field $AIC_c = 0.0$; Table 1b).

Competitive model variables of nest density and species richness concluded unique combinations of variables for the 4 avian groups. The other species group was the only group which encompassed all covariates at least one of competitive models for either nest density or species richness, although not all represented a meaningful influence within competitive models (Figure 3, Table 1b). Further, the other species group was the only group where parameter estimates of nest density and species richness had confidence intervals that excluded zero for a single covariate (Figure 3). Nest density of the other species group was negatively associated with field size (β = -0.04, 95% CI = -0.07 – -0.02) and positively associated with wetland type within the field (β = 0.04, 95% CI = 0.01 – 0.07) and percent developed area in the landscape (β = 0.04, 95% CI = 0.01 – 0.07). Species richness of the other species group was positively influenced by percent grassland (β = 2,186.20, 95% CI = 400.33 – 3,972.07) and woodland (β = 334.41, 95% CI = 61.40 – 607.42) within our study site. Conversely, percent wetland was negatively influential at both the field (β = -0.60, 95% CI = -1.01 – -0.18) and landscape levels (β = -0.53, 95% CI = -0.93 – -0.13) on species richness of the other species group. The waterfowl species group was influenced positively by 3 variables (Table 2a). Field size represented a substantial, positive influence on species richness (β = 0.62, 95% CI = 0.07 – 1.16) of the waterfowl species group, whereas wetland type (β = 0.07, 95% CI = 0.01 – 0.14) and landscape edge (β = 0.07, 95% CI = 0.01 – 0.14) were influential to nest density. In assessment of the song bird species group, no landscape level variable had parameter estimates where confidence intervals excluded zero (Figure 3, Table 2b). Nest density of the song bird species group was negatively associated with field size (β = -0.13, 95% CI = -0.22 – -0.05) and positively associated with percent forb (β = 0.15, 95% CI = 0.06 – 0.24) at the field level. Further, species richness of the song bird species group was positive influenced by the field level variables of field size (β = 0.73, 95% CI = 0.26 – 1.20) and percent woodland (β = 0.57, 95% CI = 0.06 – 1.08). Percent grassland and wetland within the field, visual obstruction reading, percent cropland and grassland at the landscape level, and total edge within the landscape buffer (i.e., fragmentation) were not present in competitive models (based on $AIC_c$) of nest density or species richness for the song bird species group (Figure 3, Table 2b). Similarly, visual obstruction reading, percent cropland at the landscape level, and edge within the landscape buffer were also not present in competitive models of nest density or species richness for the CREP focal species group (Figure 3, Table 2b). Wetland type and percent woodland at both focal levels also were not present in competitive models of the CREP focal species group. Field size was the only covariate with confidence intervals that did not overlap zero for the CREP focal species group, with nest density portraying a negative association (β = -0.03, 95% CI = -0.05 – -0.01) and positive influence on species richness (β = 0.63, 95% CI = 0.18 – 1.07).

### Nest Success

We calculated daily survival rate (DSR) for the waterfowl (98.0%), song bird (97.8%), other (98.1%), and CREP (98.4%) species groups, with a total nest success of 50.9%, 56.0%, 56.1%, and 65.3% respectively. Of the 359 failed nests, 70.2% were depredated (252 nests), 28.7% were abandoned (103 nests), and 1.1% were human caused (4 nests).

Models of daily nest survival indicated that the relative predictive ability of variables at the nest site, field, and landscape levels varied among the 4 groups (Figure 4, Table 1a and b). Daily nest survival models for the waterfowl species group at the nest-site scale had stronger support than those at the field ($\Delta AIC_c = 5.3$) and landscape levels ($\Delta AIC_c = 3.3$). Models of nest survival for the Song Bird and CREP species groups that included variables at the field scale were best supported. However, nest site models were competitive for the song bird group ($\Delta AIC_c = 1.6$) and nearly so for CREP species

($\Delta AIC_c$ = 3.1). Landscape models of nest survival were the least competitive for song bird ($\Delta AIC_c$ = 3.7) and CREP species ($\Delta AIC_c$ = 9.2; Table 1a and b). Models of nest survival with variables collected at the landscape level were best supported for the other species group over nest site ($\Delta AIC_c$ = 3.6) or field level models ($\Delta AIC_c$ = 4.0; Table 1b).

Assessment of 95% confidence intervals of parameter estimates in competitive models identified considerable variability regarding factors influential to nest survival for each of the 4 groups (Figure 4). The CREP species group was the only group influenced by variables from competitive models at all 3 focal levels (Figure 4, Table 2b). The waterfowl and song bird species groups were represented in competitive models with all covariates overlapping zero in the landscape level. Last, the other species group only contained a covariate with substantial influence in the field level competitive models.

Competitive models including variables collected at the nest site level emphasized the importance of percent forb cover and mean visual obstruction (i.e., Robel mean) on daily nest survival. Models of nest survival for the waterfowl species group supported a negative association of nest survival with percent forb cover ($\beta$ = -0.21, 95% CI = -0.38 – -0.03) and positive association with mean visual obstruction ($\beta$ = 0.24, 95% CI = 0.07 – 0.40). Percent forb also positive influenced nest survival of the song bird species group ($\beta$ = 0.22, 95% CI = 0.01 – 0.44), while mean visual obstruction was negatively associated with nest survival of the CREP species group ($\beta$ = -0.64, 95% CI = -1.13 – -0.14; Figure 4).

In assessment of field level covariates in competitive models of nest survival, percent forb and woodland, mean visual obstruction, and density of field edge were all found to be influential variables to 2 or more groups. Nest survival of the waterfowl species group was negatively influenced by percent forb (β = -0.54, 95% CI = -0.95 – -0.13) and positively associated with mean visual obstruction (β = 0.29, 95% CI = 0.07 – 0.51), percent grassland (β = 810.33, 95% CI = 17.63 – 1,603.04), woodland (β = 63.81, 95% CI = 1.33 – 126.29), and wetland (β = 808.28, 95% CI = 17.66 – 1,598.89). Percent forb was the only influential variable (negative) in field level models of nest survival for the other species group (β = -0.48, 95% CI = -0.90 – -0.05). Field level models of nest survival for the song bird species group indicated negative influences of field size (β = -0.33, 95% CI = -0.58 – -0.07), density of field edge (β = -0.28, 95% CI = -0.52 – -0.05), and a positive influence by type of wetland present (β = 0.47, 95% CI = 0.14 – 0.80). Models of nest survival for the CREP species group indicated all influential variables were negatively associated with the dependent variable (percent woodland = [β = -0.03, 95% CI = -0.05 – 0.00]; mean visual obstruction = [β = -0.79, 95% CI = -1.25 – -0.34]; density of field edge = [β = -0.45, 95% CI = -0.83 – -0.07]).

As previously mentioned, the most competitive models predicting the influence of landscape level variables on daily nest survival resulted in only 1 covariate with confidence intervals not overlapping zero. In this case, the density of edge within the surrounding landscape buffer was negatively associated with nest survival (β = -0.55, 95% CI = -1.00 – -0.09) of the CREP species group.

## DISCUSSION

We modeled nest site, field, and landscape level variables in relation to avian nesting demographics (i.e., nest density, species richness, and survival) from CREP contracts in eastern South Dakota as part of a comprehensive approach to understand program effectiveness. To accomplish this, we analyzed avian nesting data by 4 subgroups: waterfowl species, other species, song bird species, and CREP focal species, with the primary objective of evaluating contract assessment process in a multi-scale fashion to guide future platforms based on current program implementation.

Our initial modeling effort indicated that arthropod variables represented little influence in explaining variation in avian nest demographics. Research by McIntyre and Thompson (2003) suggested similar results, in that restored grasslands in their study represented similar levels of arthropod availability for avian foraging requirements, but were less abundant than in native sod prairies. With this, we suggest future research evaluate differences between restored and remnant grasslands for future improvement of conservation programs.

Assessment of the influence of nest site, field, and landscape level variables demonstrated the complexity of natural ecosystems and need to evaluate the progress of conservation programs with respect to goals. Implementing conservation programs with broad objectives may yield undesired outcomes due to the lack of specificity in the process to obtain goals or running a greater risk of including contradictory objectives that potentially negate other successes (McCoy et al. 1999, Fletcher et al. 2006). Our research revealed the importance of taking a multi-scale approach to program evaluation, given that field models included a greater number of important variables describing variation in nest density and species richness for each species group, except for waterfowl and nest density of CREP focal species, which were both best described by landscape-level variables (Ribic and Sample 2001, Cunningham and Johnson 2006). Similarly, our multi-scale approach to estimating nest survival also highlighted variability across avian groups, where song bird species were the only group where variables measured at the field level explained important variation in nest survival.

### Nest-site Scale

Our results indicated that the inclusion of variables collected at the nest site level were only important in nest survival models for the waterfowl species group, whereas nest survival for the other 3 groups was best estimated by variables collected at other spatial extents. Interestingly, nest site level covariates tended to mirror the directional influence of the field scale variables; for example, percent forb and mean visual obstruction (i.e., Robel mean) presented a negative and positive influence respectively for the waterfowl species group at both levels (Figure 4). This relationship also held true for variable influence on the song bird and CREP focal species groups. Further research is needed to assess the potential of evaluating avian demographics based on field level covariates vs nest site specific data. This study could highlight the potential ability of assessing avian use of conservation program sites based on field level data collection.

### Field Scale

Area sensitivity has been a topic of high importance in avian research and management for many years (Davis 2004, Renfrew and Ribic 2008, Ribic et al. 2009). Our study not only highlighted the importance of patch size on nest density, species richness, and daily survival rate of our 4 avian groups, but also the variability associated among nest demographics and avian groups. Our study represented a positive influence of field size on species richness of nesting birds and a negative influence on nest density; emphasizing the significance of field size to many species of conservation concern (i.e., grassland song bird species; Bollinger and Gavin 2004). Nest success in many cases has been shown to increase with size of grassland area (Skagen et al. 2005). Similar to Winter et al. (2006), our findings varied among species groups, with daily survival rate of the song bird species group representing the only significant influence (i.e., negative) to field size. Our results suggest that this relationship may have been driven by abandonment prone or high density nesting species (e.g., Red-winged Blackbird), but a species-specific evaluation would be required to evaluate this hypothesis. Area sensitivity was also shown to be influenced by fragmentation, in which, nest survival for the song bird and CREP focal species groups was negatively associated with edge density within fields. Within field edge density represented hard line transition zones between types of vegetation (i.e., grassland, wetland, woodland, etc.), which could be considered further fragmentation and potentially impacting rates of nest predation or availability of usable space within restored grasslands (Guthery 1997, Herkert et al 2003).

As reported in various studies, our findings depicted that presence of woody species increased species richness of nesting avifauna; however, these additional species tended to be generalist, edge preference species of lesser conservation concern (Bakker 2003, Grant et al. 2004, Stephens et al. 2004). Mean visual obstruction (i.e., nest site and field level) was only observed as influential to daily nest survival of the waterfowl (i.e., positive) and CREP focal species groups (i.e., negative). This variability may be due to the early season initiation of nesting by waterfowl species compared to the CREP focal species, implying waterfowl species select fields and nesting locations with increased visual obstruction for nest concealment (Hines and Mitchell 1983, Borgo and Conover 2016). Assessment of the ecology of CREP focal species in our study revealed that nest preferences were generally for mid-vegetation nesting and open vegetation for ground nesting species (DeCasare et al. 2013). Considering these ecological preferences for open visibility, increased mean visual obstruction may have led to stress-induced abandonment or behaviors that led to potential increased depredation (Seltmann et al. 2014, Tan et al. 2015). As documented in previous research, our study supports the notion that diverse forb-rich grassland mixes better support grassland avifauna (Bakker and Higgins 2009, Riffell et al. 2010). For example, percent forb supported a positive influence on the nest density (i.e., field level) and daily survival (i.e., nest site) of the song bird species group. Daily survival rate of the waterfowl (i.e., nest site and field level) and the other species groups (i.e., field level) represented a negative association; however, these results may have been an indirect result due to ecological dynamics. For example, prior research has documented that early nesting individuals tend to have higher rates of nest survival, while phenology of forb grow climax is mid-growing season; which may result in an indirect false influence between timing of nest initiation and percent forb cover (Dzus and Clark 1998, Arzel et al. 2014). We suggest further research be conducted to confirm our assumption.

Being that much of the CREP program region lies within the Prairie Pothole Region, and a sub-focus goal of the program is to provide habitat for waterfowl production, we found it crucial to incorporate percent wetland cover and type of wetland within the field. Interestingly, we observed type of wetland to have a positive influence not only on nest density of the waterfowl species group, but also nest density of the other species group and daily nest survival of the song bird species group. These results detail an opportunity for program managers to highlight the duel benefit of program contracts which include wetland basins or both wetland basins and streams to positively impact diverse avian populations and hydrology of enrolled sites (Homan et al. 2000, Reynolds et al. 2006). Further, we found wetland type to have a greater positive influence on avian dependent variables across our 4 nesting bird groups.

### Landscape Scale

Compared to local-scale models, results of modeling at the landscape level yielded more consistent directional influence of covariates on nest density, species richness, and daily survival of the 4 avian species groups. However, landscape scale competitive models detailed few variables which explain meaningful amounts of variation in the dependent variables (i.e., 95% confidence intervals overlapped zero). This may indicate that factors identified in competitive models contributed additively to the variation of dependent variables (Seltmann et al. 2014, Tan et al. 2015) or the global model was missing 1 or more influential covariates. Past research has emphasized increased grassland cover in agricultural dominated landscapes as a means of increasing demographic parameters for breeding birds (Ribic and Sample 2001, Renfrew and Ribic 2008); although, our results suggest that density of edge (i.e., fragmentation) within the landscape may be more influential to grassland nesting birds within conservation program sites (Schmidt and Whelan 1999). Even though we observed positive trends of landscape edge influence on nest density and species richness of avian species groups, we also found a negative influential trend on daily survival rate of avian species groups. This details that increased edge density at all focal levels may increase the interconnectedness of predator travel via corridors (Koper and Schmiegelow 2006).

## Management Implications

Our study highlights the importance of evaluating potential constraints to reaching program goals; in which, program objectives need to be interconnected and simultaneously obtainable. We recommend incorporating an integrated stepwise evaluation for conservation programs that would assess multi-scale factor variability, allowing obtainable benefits for species with diverse ecological preferences (Schmidt and Whelan 1999, Vickery and Herkert 2001, Ribic et al. 2009). For example, assessment of landscape variables within the program region, separated into zones if beneficial, to quantify a suite of potential species suitable to environmental factors (e.g., Bobolink; Best et al. 1997, Naugle et al. 1999, Fletcher and Koford 2002, Fletcher and Koford 2003, Pretelli et al. 2015). Within selected region or focal zones, assessment of field scale attributes (e.g., contract site selection and seed mixture) should tailor towards focal species within the landscape's avian suite to best capitalize restoration success towards program goals. Ascertaining further insights to preferred avian preference, stands as necessity to tailoring integrated conservation program targeting methods to maximize platform implementation for game and non-game bird species alike.

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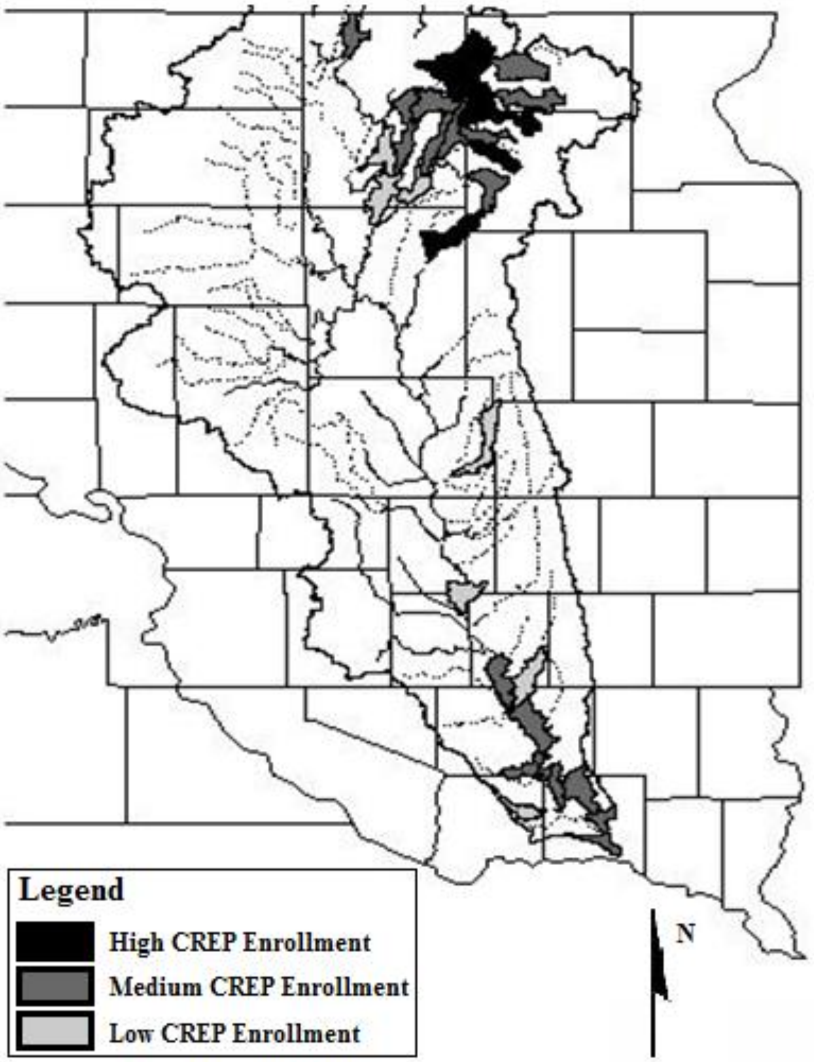

Figure 1. Subwatersheds (HUC12), distinguished by proportion of CREP enrollment to total subwatershed area, that meet selection criteria for use in landscape scale evaluations of responses of terrestrial and aquatic resources to implementation of the James River Basin CREP in South Dakota.

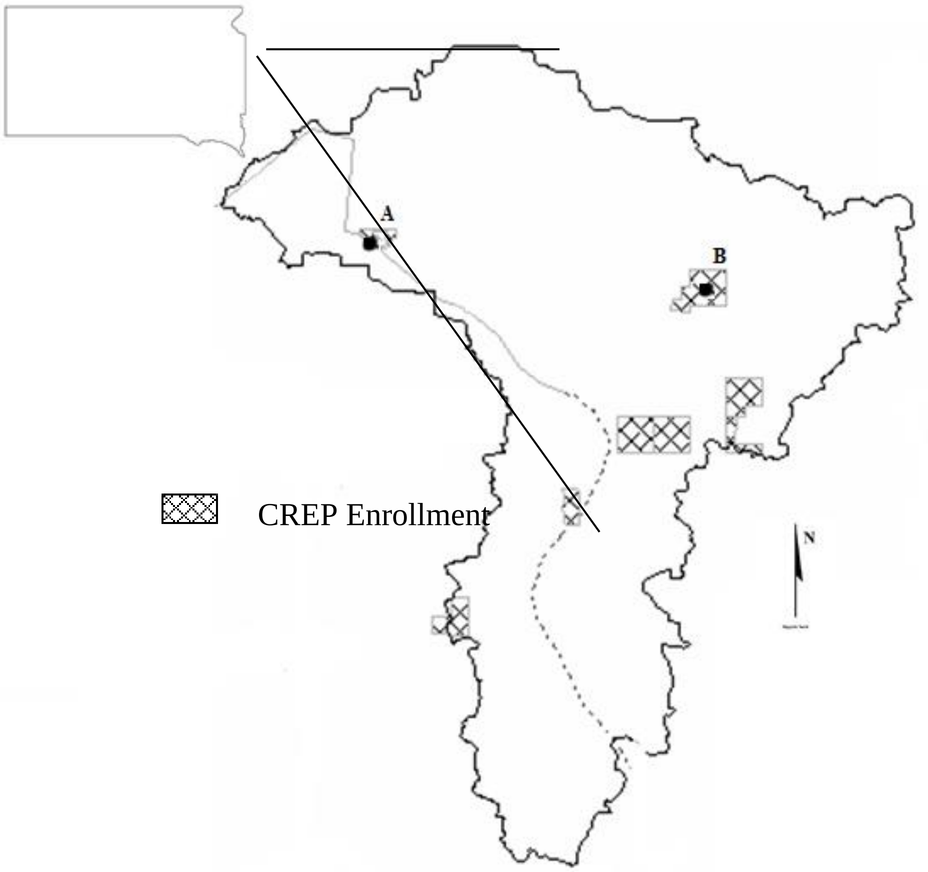

Figure 2. Visualization of distribution of sites selected for terrestrial sampling in a single subwatershed of the James River basin. Site “A” represents a randomly selected CREP enrollment site containing a intersecting stream for localized terrestrial sampling, and site “B” represents the randomly selected upland terrestrial site.

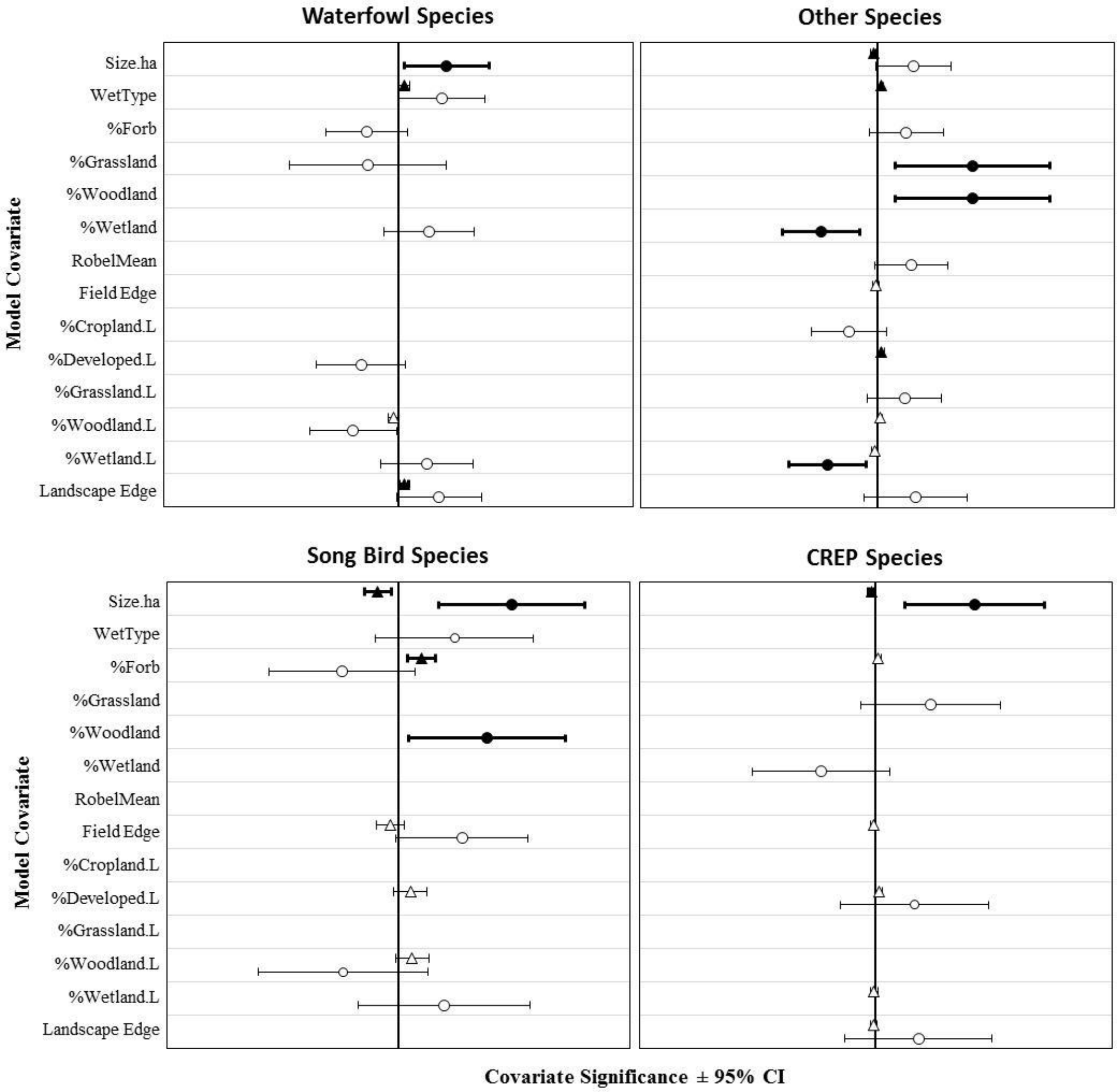

Figure 3. Influence of field and landscape level factors observed in competitive models on nest density (▲) and species richness (●) of 4 grassland nesting bird groups.

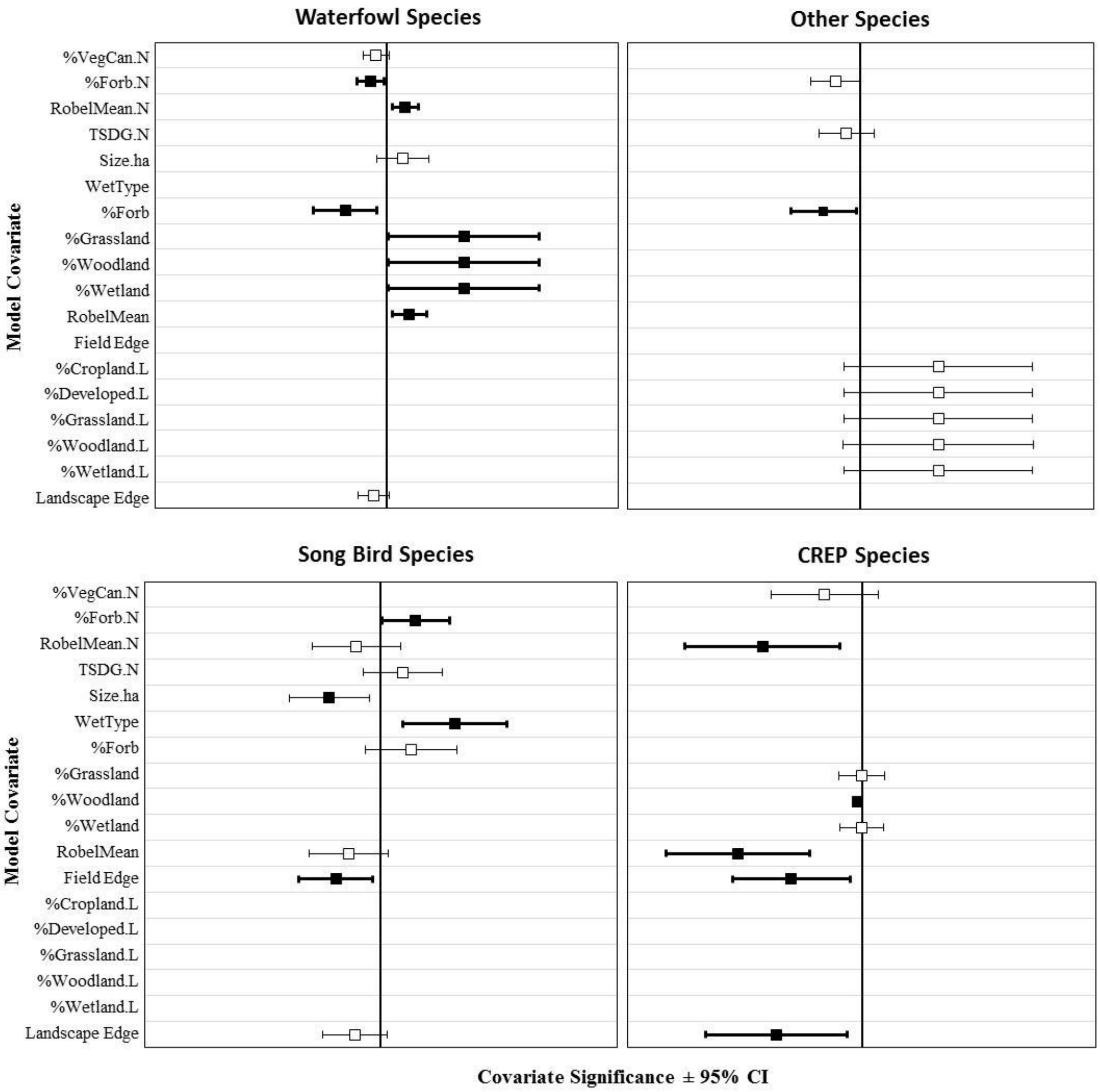

Figure 4. Influence of nest site, field, and landscape level factors observed in competitive models on daily survival (■) of 4 grassland nesting bird groups.

Table 1a. Comparison of nest site, field, and landscape level influence (based on AIC*c*) on nest density, species richness, and daily survival of 4 grassland nesting bird groups. Bold numbers represent factors of greatest influence (i.e., lowest $AIC_c$).

| | **Song Bird Species** | | | | | | **CREP Species** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Nest Density** | | **Species Richness** | | **Daily Survival** | | **Nest Density** | | **Species Richness** | | **Daily Survival** | |
| | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** |
| **Nest Site** | | | | | 727.63 | 3.12 | | | | | 225.62 | 1.59 |
| **Field** | **0.58** | 0.00 | **66.44** | 0.00 | **724.51** | 0.00 | **-54.63** | 0.00 | **63.59** | 0.00 | **224.03** | 0.00 |
| **Landscape** | 11.04 | 10.46 | 68.92 | 2.48 | 728.22 | 3.71 | -52.15 | 2.49 | 66.71 | 3.13 | 233.26 | 9.23 |

Table 1b. Comparison of nest site, field, and landscape level influence (based on AIC*c*) on nest density, species richness, and daily survival of 4 grassland nesting bird groups. Bold numbers represent factors of greatest influence (i.e., lowest $AIC_c$).

| | **Waterfowl Species** | | | | | | **Other Species** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Nest Density** | | **Species Richness** | | **Daily Survival** | | **Nest Density** | | **Species Richness** | | **Daily Survival** | |
| | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** | **$AIC_C$** | **$\Delta AIC_C$** |
| **Nest Site** | | | | | **1030.80** | 0.00 | | | | | 338.24 | 6.61 |
| **Field** | -5.07 | 6.50 | 76.08 | 4.77 | 1036.10 | 5.30 | -41.29 | 0.30 | 56.53 | 0.00 | 335.62 | 3.99 |
| **Landscape** | **-11.57** | 0.00 | **71.31** | 0.00 | 1034.10 | 3.30 | -41.59 | 0.00 | 58.47 | 1.94 | **331.63** | 0.00 |

Table 2a. Influence of nest site, field, and landscape level factors observed in competitive models on nest density, species richness, and daily survival of 2 grassland nesting bird groups. Bold numbers represent factors with significant influence (i.e., confidence intervals that do not overlap zero) on the dependent variable.

| | **Waterfowl Species** | | | | | | | | | **Other Species** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Nest Density** | | | **Species Richness** | | | **Daily Survival** | | | **Nest Density** | | | **Species Richness** | | | **Daily Survival** | | |
| | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | | **β** | **95% CI** | |
| **%VegCan** | | | | | | | -0.14 | -0.30 | 0.03 | | | | | | | | | |
| **%Forb** | | | | | | | **-0.21** | **-0.38** | **-0.03** | | | | | | | -0.32 | -0.64 | 0.00 |
| **RobelMean** | | | | | | | **0.24** | **0.07** | **0.40** | | | | | | | | | |
| **TSDG** | | | | | | | | | | | | | | | | -0.18 | -0.53 | 0.17 |
| **Size.ha** | | | | **0.62** | **0.07** | **1.16** | 0.21 | 0.06 | 15.51 | **-0.04** | **-0.07** | **-0.02** | 0.38 | -0.01 | 0.77 | | | |
| **WetType** | **0.07** | **0.01** | **0.14** | 0.56 | 0.01 | 1.11 | | | | **0.04** | **0.01** | **0.07** | | | | | | |
| **%Forb** | | | | -0.41 | -0.93 | 0.11 | **-0.54** | **-0.95** | **-0.13** | | | | 0.30 | -0.09 | 0.69 | **-0.48** | **-0.90** | **-0.05** |
| **%Grassland** | | | | -0.39 | -0.96 | 0.19 | **810.33** | **17.63** | **1603.04** | | | | **2186.20** | **400.33** | **3972.07** | | | |
| **%Woodland** | | | | | | | **63.81** | **1.33** | **126.29** | | | | **334.41** | **61.40** | **607.42** | | | |
| **%Wetland** | | | | 0.39 | -0.19 | 0.96 | **808.28** | **17.66** | **1598.89** | | | | **-0.60** | **-1.01** | **-0.18** | | | |
| **RobelMean** | | | | | | | **0.29** | **0.07** | **0.51** | | | | 0.36 | -0.03 | 0.75 | | | |
| **Field Edge** | | | | | | | | | | -0.02 | -0.05 | 0.01 | | | | | | |
| **%Cropland** | | | | | | | | | | | | | -0.31 | -0.70 | 0.09 | 754.09 | -161.69 | 1669.86 |
| **%Developed** | | | | -0.48 | -1.05 | 0.09 | | | | **0.04** | **0.01** | **0.07** | | | | 194.98 | -41.44 | 431.40 |
| **%Grassland** | | | | | | | | | | | | | 0.29 | -0.10 | 0.67 | 729.03 | -156.09 | 1614.16 |
| **%Woodland** | -0.07 | -0.13 | 0.00 | -0.58 | -1.14 | -0.02 | | | | 0.02 | -0.01 | 0.05 | | | | 37.56 | -8.28 | 83.41 |
| **%Wetland** | | | | 0.36 | -0.22 | 0.95 | | | | -0.03 | -0.06 | 0.00 | **-0.53** | **-0.93** | **-0.13** | 136.82 | -29.73 | 303.37 |
| **Landscape Edge** | **0.07** | **0.01** | **0.14** | 0.52 | -0.02 | 1.06 | -0.17 | -0.37 | 0.04 | | | | 0.40 | 0.00 | 0.81 | | | |

Table 2b. Influence of nest site, field, and landscape level factors observed in competitive models on nest density, species richness, and daily survival of 2 grassland nesting bird groups. Bold numbers represent factors with significant influence (i.e., confidence intervals that do not overlap zero) on the dependent variable.

| | Song Bird Species | | | | | | | | | CREP Focal Species | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nest Density | | | Species Richness | | | Daily Survival | | | Nest Density | | | Species Richness | | | Daily Survival | | |
| | β | 95% CI | | β | 95% CI | | β | 95% CI | | β | 95% CI | | β | 95% CI | | β | 95% CI | |
| %VegCan | | | | | | | | | | | | | | | | -0.24 | -0.58 | 0.11 |
| %Forb | | | | | | | **0.22** | **0.01** | **0.44** | | | | | | | | | |
| RobelMean | | | | | | | -0.15 | -0.43 | 0.12 | | | | | | | **-0.64** | **-1.13** | **-0.14** |
| TSDG | | | | | | | 0.14 | -0.11 | 0.39 | | | | | | | | | |
| Size.ha | **-0.13** | **-0.22** | **-0.05** | **0.73** | **0.26** | **1.20** | **-0.33** | **-0.58** | **-0.07** | **-0.03** | **-0.05** | **-0.01** | **0.63** | **0.18** | **1.07** | | | |
| WetType | | | | 0.36 | -0.15 | 0.87 | **0.47** | **0.14** | **0.80** | | | | | | | | | |
| %Forb | **0.15** | **0.06** | **0.24** | -0.36 | -0.83 | 0.11 | 0.19 | -0.09 | 0.48 | 0.01 | -0.01 | 0.03 | | | | | | |
| %Grassland | | | | | | | | | | | | | 0.35 | -0.10 | 0.79 | 0.00 | -0.15 | 0.14 |
| %Woodland | | | | **0.57** | **0.06** | **1.08** | | | | | | | | | | **-0.03** | **-0.05** | **0.00** |
| %Wetland | | | | | | | | | | | | | -0.35 | -0.79 | 0.09 | 0.00 | -0.14 | 0.14 |
| RobelMean | | | | | | | -0.20 | -0.45 | 0.05 | | | | | | | **-0.79** | **-1.25** | **-0.34** |
| Field Edge | -0.05 | -0.14 | 0.03 | 0.41 | -0.02 | 0.84 | **-0.28** | **-0.52** | **-0.05** | -0.02 | -0.04 | 0.00 | | | | **-0.45** | **-0.83** | **-0.07** |
| %Cropland | | | | | | | | | | | | | | | | | | |
| %Developed | 0.08 | -0.03 | 0.18 | | | | | | | 0.02 | 0.00 | 0.04 | 0.25 | -0.22 | 0.72 | | | |
| %Grassland | | | | | | | | | | | | | | | | | | |
| %Woodland | 0.09 | -0.02 | 0.20 | -0.36 | -0.90 | 0.19 | | | | | | | | | | | | |
| %Wetland | | | | 0.29 | -0.26 | 0.85 | | | | -0.01 | -0.03 | 0.01 | | | | | | |
| Landscape Edge | | | | | | | -0.16 | -0.37 | 0.04 | -0.01 | -0.04 | 0.01 | 0.27 | -0.20 | 0.74 | **-0.55** | **-1.00** | **-0.09** |

# CHAPTER 4: MOTIVATIONS FOR ENROLLMENT INTO THE CONSERVATION RESERVE ENHANCEMENT PROGRAM IN SOUTH DAKOTA

*This chapter is being prepared for submission in the Journal of Human Dimensions of Wildlife.*

## Abstract

The Conservation Reserve Enhancement Program (CREP) targets high-priority conservation needs (e.g., water quality, wildlife habitat) by paying landowners an annual rental rate to remove environmentally sensitive or agriculturally unproductive lands from rowcrop production, and then implement conservation practices on these lands. This study examined motivations of South Dakota landowners for enrolling in the James River Basin CREP. All 517 newly-enrolled landowners were mailed a questionnaire in 2014 measuring demographics, behaviors, opinions, and motivations (60% response rate). Cluster analysis of 10 motivations for enrolling identified three motivation groups (wildlife=40%, financial=35%, environmental=25%). The financial group had the youngest mean age (62 years), followed by the wildlife (65) and environmental groups (68). Among respondents, 43% favored the public access requirement of this CREP with the environmental group most in favor. Understanding landowner enrollment motivations and decision criteria will assist in strategies (e.g., financial incentives, increasing yield via habitat restoration) for increasing future participation.

**Keywords:** Conservation Reserve Enhancement Program, CREP, grassland management, landowner motivations

## Introduction

Increasing demand for lower-cost foods and alternative energy production is threatening critical wildlife habitats (Green, Cornell, Scharlemann, & Balmford, 2005). Natural resource conservation programs are designed to maintain, improve, or reclaim important wildlife habitats, but are mostly dependent on voluntary participation by landowners. The success of these programs depends, in part, on understanding agricultural producer motivations toward these conservation programs and wildlife habitats. Motivations describe why people select and participate in various activities to meet their goals or satisfy their needs (Manning, 2011). Understanding agricultural producer motivations for enrollment may lead to improved conservation programs with increased adoption and program satisfaction among landowners (Selinske, Coetzee, Purnell, & Knight, 2015).

Agricultural producer motivations toward conservation throughout the Great Plains and the Midwest are complex and offer no unified strategy to increase participation in conservation programs (Smith, Peterson, & Leatherman, 2007). Agricultural producers may react to an individual situation or conservation program in a number of ways. For example, studies of agricultural producers have shown that conservation compliance requirements, age, education, organization affiliation, and attitudes toward wildlife and conservation are all influential factors affecting conservation decision making (Allen & Vandever, 2003; Beedell & Rehman, 1999, 2000; Hua, Zulauf, & Sohngen, 2004; Knowler & Bradshaw, 2007; Poudyal & Hodges, 2009; Sorice & Conner, 2010). A survey of Conservation Reserve Program (CRP) participants in Missouri, for example, found that 49% of respondents denoted some importance of benefiting wildlife as influencing their decision to enroll land into the CRP (Kurzejeski, Burger, Monson, & Lenkner, 1992). However, Kurzejeski et al. (1992) found that in ranking the most important factors for landowners enrolling land in the CRP, concerns about soil erosion (23%) ranked the highest, whereas providing wildlife habitat ranked fifth out of seven variables (12%). These studies highlight an inherent variability among individuals and regions. Moreover, these studies detail the overarching vulnerability of conservation programs that are implemented on a national scale or programs that fail to consider landowner desires.

Even among farmers who characterize themselves as dedicated to natural resources, there is a distinct separation in conservation priorities as a result of variable definitions of "conservation." Does conservation mean tiling practices for "best" water management, maintaining waterways for runoff benefits, implementing cover crops for erosion or minimizing air/water quality impacts, maintaining wildlife habitat with agriculture practices, or implementing a combination of practices depending on their view of conservation (Ahnström et al., 2009)? These definitions are also influenced by the social-economic pressures that can alter a farmer's perspective. The term "conservation," therefore, is truly in the eye of the beholder.

In South Dakota, a Conservation Reserve Enhancement Program (CREP) project was initiated for the James River Basin in November 2009, with a goal of enrolling 100,000 acres in 10-15 year contracts. This CREP has been valuable for grassland and wetland conservation by forming federal partnerships (i.e., Natural Resource Conservation Service [NRCS]) with state agencies (i.e., South Dakota Game, Fish and Parks) in an effort to address specific regional conservation priorities. This program was intended not only to benefit water quality and stabilize stream-channels, but also to increase habitat available to game and non-game fish and wildlife. This CREP is administered similar to the Conservation Reserve Program (CRP) through local NRCS offices. Furthermore, the South Dakota CREP project is unique in that all lands under contract were required to allow public access through South Dakota’s Walk-in Area Program and all enrolled landowners were required to comply with aquatic and terrestrial monitoring. Coupling the CREP with the State Walk-in Area Program provides landowners an additional 40% over the financial incentive for other CRP’s in the state (USDA, 2009, 2011).

This research focused on the human dimensions aspects of a comprehensive project to evaluate the successes of the James River CREP. The objective of this study was to gain a better understanding of the motivations for landowner enrollment into the South Dakota CREP. This research note addressed three main questions: (a) what are the characteristics and demographics of CREP enrollees and how is age related to enrollment, (b) how do CREP enrollees feel about the requirement to provide public access, and (c) what are the most important motivational factors for enrollment and can these be grouped into clusters? This research provides additional insight into the value of landowner characteristics and motivations for informing future conservation and program expansion efforts.

## Methods

This research involved a census of 517 landowners with land that was newly enrolled (January 2010 – November 2012) in the South Dakota CREP. In other words, properties in this study were not re-enrolled from previous grassland conservation programs. Packages containing a cover letter describing the study details and purpose, a questionnaire, and a postage-paid business-reply envelope were mailed to each landowner in November 2014. Follow-up mailings included a: (a) postcard reminder; (b) second mailing of a cover letter, questionnaire, and postage-paid business-reply envelope; and (c) final postcard reminder. A 60% useable response rate was achieved (*n* = 338; after removal of non-deliverables). The limited project budget prohibited a non-response bias check.

The questionnaire was a 12-page booklet with 10 pages of questions including one page for optional comments about how the CREP can be improved. The questionnaire included descriptive questions about farming and ranching practices, various evaluations of their CREP enrollment, and motivations for enrolling land into the CREP. This analysis included 10 motivational variables based on a literature review of peer-review articles (e.g., Ahnström et al., 2009; Allen & Vandever, 2003; Kurzejeski et al., 1992; Smith, et al., 2007). The 10 motivations (Figure 1) were measured on a scale from 1 “no influence” to 5 “highly influential” on their decision to enroll land into the CREP. The questions, topics of discussion, and format were formulated specifically for the CREP, but similarity to other studies (e.g., Allen & Vandever, 2003) was maintained for ease of comparison, if applicable.

Data were evaluated using descriptive statistics via frequency tables and means among associated variables. Cluster analysis (K-means solved for three clusters with pairwise exclusion of cases) was used for classifying CREP enrollment based on evaluation of the 10 motivations. Significant differences among cluster groups were assessed using ANOVA ($p \leq .05$) and post hoc multiple comparisons tests. Effect sizes were assessed using eta values (Vaske, 2008).

## Results

The average age of CREP enrolled landowners (64.8 years) was 8.9 years older than the average landowner in South Dakota (55.9 years; USDA, 2014a, 2014b). Among respondents, 92% were owners of the enrolled land, with 46% of respondents being active agricultural operators and 46% non-operators (4% were renters, 3% were trustees). Most respondents (87%) were current South Dakota residents, 10% were non-residents who had lived in South Dakota in the past, and 3% were non-residents who had never lived in South Dakota. Respondents primarily elected for the shortest CREP contract length of 10 years (77%), followed by 15-year (17%) and 11-year (6%) contracts. The average respondent had 1.9 CREP contracts and averaged 183 enrolled acres. Forty-two percent of respondents had participated in a previous conservation program within the past five years.

The 10 motivational variables evaluated for landowner enrollment in the CREP ranged from financial incentive ($M = 3.9 \pm 0.1$) rated as the highest motivation to air quality ($M = 2.2 \pm 0.2$) having the lowest overall rating (Table 1, Figure 1). Cluster analysis of these 10 variables identified three types of landowners based on how they rated the importance of each variable in their decision to enroll land in the CREP. Landowner types were named “wildlife,” “financial,” and “environmental” based on each group’s motivations. Of the total respondents, 40% were classified in the wildlife group, 35% in the financial group, and 25% in the environmental group. The financial group rated the financial incentive motivation slightly higher than the other two groups and rated the other nine motivations relatively low in influence (Figure 2). In addition to rating financial incentives relatively high, the wildlife group also rated four additional motivations (fish / wildlife populations, wildlife viewing, public access, personal hunting / fishing) relatively high, indicating the importance of wildlife and hunting / fishing opportunities as additional reasons influencing enrollment in the CREP. The environmental group rated all 10 motivations quite high in importance and rated five motivations (soil erosion, local water quality scenic quality, national water quality, air quality) measuring general environmental parameters much higher than the other two groups .The financial group had the youngest mean age of 61.8 (± 2.3) years, followed by the wildlife group (64.7 ± 2.4) and the environmental group (67.8 ± 3.1) ($F(2, 262) = 4.76$, $p = .009$, $\eta = .19$). This eta effect size indicates a minimal to typical relationship (Vaske, 2008).

Forty-three percent of respondents were favorable (10% slightly, 19% moderately, 14% strongly) toward the requirement for enrolled land to be open for public access, with 34% neutral and 23% disliking the requirement (11% slightly, 5% moderately, 7% strongly). Several respondents commented on the importance of providing outdoor recreation areas for the next generation. Based on a scale of 1 “strongly dislike” to 7 “strongly like,” the environmental landowner group was significantly more in favor of the requirement ($M = 5.3 \pm 0.4$) than the wildlife ($M = 4.3 \pm 0.3$) and financial ($M = 4.1 \pm 0.4$) groups, ($F(2, 267) = 11.10$, $p < .001$, $\eta = .28$). This eta effect size indicates a typical relationship (Vaske, 2008).

## Discussion

Despite continued grassland and wetland habitat loss in the continental United States, some progress has been made in recent decades to offset these losses through grassland, wetland, and conservation cover restoration efforts across the Midwest and the Great Plains (Rashford, Walker, & Bastian, 2011; Wright & Wimberly, 2013). Further advancement of grassland and wetland conservation programs will require studies such as this to gain a better understanding of agricultural producer beliefs toward environmental conservation and their motivations for program enrollment to ensure program success. Results here identified different groups of motivations for enrolling in conservation programs.

A number of variables have been documented as influential to landowner enrollment in a conservation program. For example, some studies have identified environmental variables (e.g., soil erosion, improvement of water quality) as most influential to landowner enrollment (Allen & Vandever, 2003; Reimer & Prokopy, 2014). In contrast, much of the previous research has demonstrated economic incentives to be the most influential factor (Gustafson & Hill, 1993; Hodur, Leistritz, & Bangsund, 2002; Wachenheim, Lesch, & Dhingra, 2014; Yeboah, Lupi, & Kaplowitz, 2015). Results from this study were consistent with the majority of these studies, which documented direct or intrinsic benefits (i.e., financial incentives, benefiting fish and wildlife populations, soil erosion) to be the most important motivations for enrollment. In comparison, all large-scale or altruistic motivational variables (e.g., nationwide water quality and air quality) ranked lowest of all 10 motivation variables (Greiner & Gregg, 2011).

The older age of the CREP enrollees suggests that CREP and other conservation programs may serve as a buffer for landowners entering retirement (Hodur et al., 2002; Janssen, Klein, Taylor, Opoku, & Holbeck, 2008). Future research is needed to confirm if this association is consistent across all programs. Age was also found to differ significantly among the three respondent clusters (wildlife, financial, environmental concern). Although all three clusters rated financial incentive as a high motive for enrollment, older landowners rated non-financial motivations higher compared to younger landowners. This significance of age may result from a recognition by older landowners of the need to conserve wildlife and other natural resources; portraying older landowners' recognition of land alterations throughout recent decades or the result of younger landowners having greater financial needs.

The requirement to provide public access through the South Dakota Walk-in program is unique to the South Dakota CREP and was favored by 43% of the enrolled landowners; only 23% disliked the public access requirement. This requirement of providing public access was a unique strategy for simultaneously offering additional financial benefit to landowners (i.e., 40% higher than on CRPs in South Dakota), increasing access to lands for public recreation (i.e., over 81,000 acres), and promoting habitat for fish and wildlife (i.e., requiring contract minimum of 40 acres; USDA, 2009, 2011). Future research is needed to evaluate environmental, social, and economical differences and benefits of large-scale and holistic (i.e., >40 acres, public access, unique or additional financial incentives) conservation programs, such as the South Dakota CREP, in comparison to detailed environmentally focused programs (i.e., water quality improvement, Iowa CREP; USDA, 2001). Such research may prove vital to evaluating cost-benefit in times of economic strain and deterioration of funding caps.

It is intuitive that most landowners wanted to maximize their financial profit, but with budget shortages, agencies must be able to identify new financial incentives for all stakeholders. Yeboah et al. (2015) indicated that one-time payments, such as a signing bonus, may not yield a significant increase in landowner participation. Although some landowners are solely motivated by the financial benefit of participating in conservation programs, it appears that emphasizing wildlife and environmental benefits may provide effective, additional incentives for some landowners to participate. Identifying innovative ways for advancing financial and non-financial incentives for landowners will be key to promoting conservation programs in the future and ensuring program enrollment, relevance, and success (Morzillo & Needham, 2015; Sorice & Conner, 2010; Wachenheim et al., 2014). Even though all landowner clusters in this study desired to maximize financial gain for their effort, this research also identified that non-financial incentives were important to a majority of landowners.

**Note**

The use of trade names or products does not constitute endorsement by the U.S. Government.

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Table 1. Identified cluster groups of landowners' evaluation (ranging from 1, no influence, to 5 being highly influential) of the importance of each motivation to their enrollment in the James River Conservation Enhancement Program in South Dakota.

| Motivation | Cluster Group | Mean Rating[1] | 95% C.I. | *F (df)* | *p*-value | Eta (*η*) |
|---|---|---|---|---|---|---|
| Financial incentive | Wildlife | $3.6^{a}$ | ± 0.2 | 13.22 (2, 267) | < .001 | .300 |
| | Financial | $4.4^{b}$ | ± 0.2 | | | |
| | Environmental | $3.7^{a}$ | ± 0.3 | | | |
| Fish/Wildlife populations | Wildlife | $4.0^{a}$ | ± 0.2 | 107.16 (2, 256) | < .001 | .675 |
| | Financial | $2.5^{b}$ | ± 0.3 | | | |
| | Environmental | $4.7^{c}$ | ± 0.2 | | | |
| Wildlife viewing | Wildlife | $3.5^{a}$ | ± 0.2 | 154.58 (2, 250) | < .001 | .744 |
| | Financial | $1.5^{b}$ | ± 0.2 | | | |
| | Environmental | $4.1^{c}$ | ± 0.3 | | | |
| Soil erosion | Wildlife | $2.5^{a}$ | ± 0.2 | 64.56 (2, 256) | < .001 | .579 |
| | Financial | $2.4^{a}$ | ± 0.3 | | | |
| | Environmental | $4.2^{b}$ | ± 0.2 | | | |

Table continued on next page

Table 1 (continued).

| Motivation | Cluster Group | Mean Rating[1] | 95% C.I. | *F (df)* | *p*-value | Eta ($\eta$) |
|---|---|---|---|---|---|---|
| Public access | Wildlife | $3.1^{a}$ | ± 0.2 | 67.67 (2, 251) | < .001 | .592 |
| | Financial | $1.8^{b}$ | ± 0.2 | | | |
| | Environmental | $3.8^{c}$ | ± 0.3 | | | |
| Personal hunting/fishing | Wildlife | $3.1^{a}$ | ± 0.3 | 64.56 (2, 254) | < .001 | .581 |
| | Financial | $1.6^{b}$ | ± 0.2 | | | |
| | Environmental | $3.7^{c}$ | ± 0.4 | | | |
| Local water quality | Wildlife | $2.3^{a}$ | ± 0.2 | 141.40 (2, 244) | < .001 | .733 |
| | Financial | $1.7^{b}$ | ± 0.2 | | | |
| | Environmental | $4.2^{c}$ | ± 0.2 | | | |
| Scenic quality | Wildlife | $2.4^{a}$ | ± 0.2 | 65.70 (2, 244) | < .001 | .592 |
| | Financial | $1.4^{b}$ | ± 0.2 | | | |
| | Environmental | $3.4^{c}$ | ± 0.3 | | | |

Table continued on next page

Table 1 (continued).

| Motivation | Cluster Group | Mean Rating[1] | 95% C.I. | *F (df)* | *p*-value | Eta ($\eta$) |
|---|---|---|---|---|---|---|
| National water quality | Wildlife | $2.0^a$ | ± 0.2 | 172.10 (2, 245) | < .001 | .764 |
| | Financial | $1.4^b$ | ± 0.2 | | | |
| | Environmental | $4.1^c$ | ± 0.2 | | | |
| Air quality | Wildlife | $1.8^a$ | ± 0.2 | 150.15 (2, 247) | < .001 | .741 |
| | Financial | $1.4^b$ | ± 0.1 | | | |
| | Environmental | $3.8^c$ | ± 0.3 | | | |

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[1] For each motivation, means with different superscripts for the cluster groups are significant at $p < .05$ based on Tamhane's T2 method when Levene's test for equality of variances was significant and Scheffé's S test when Levene's test for equality of variances was not significant.

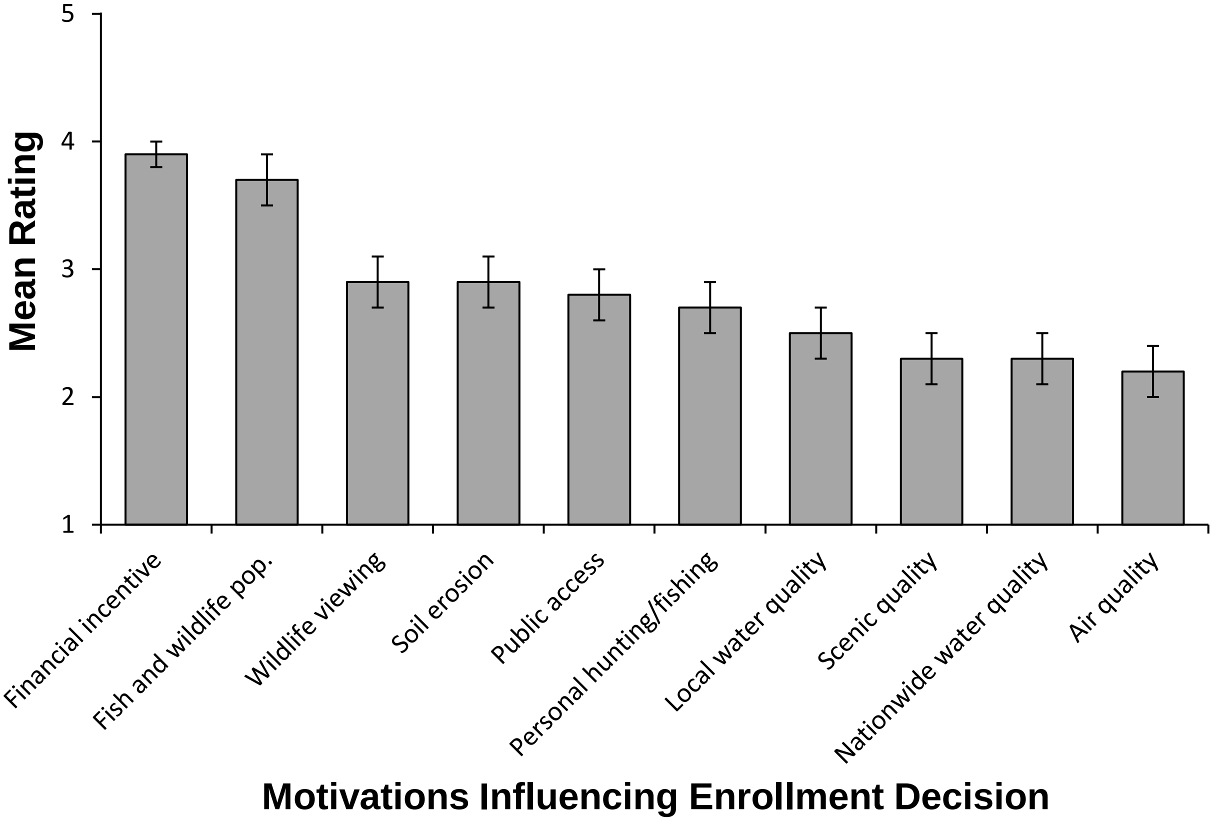

Figure 1. Mean evaluations (1 “no influence” to 5 “highly influential”) with 95% confidence intervals of motivations influential to landowner enrollment in the James River Conservation Reserve Enhancement Program in South Dakota.

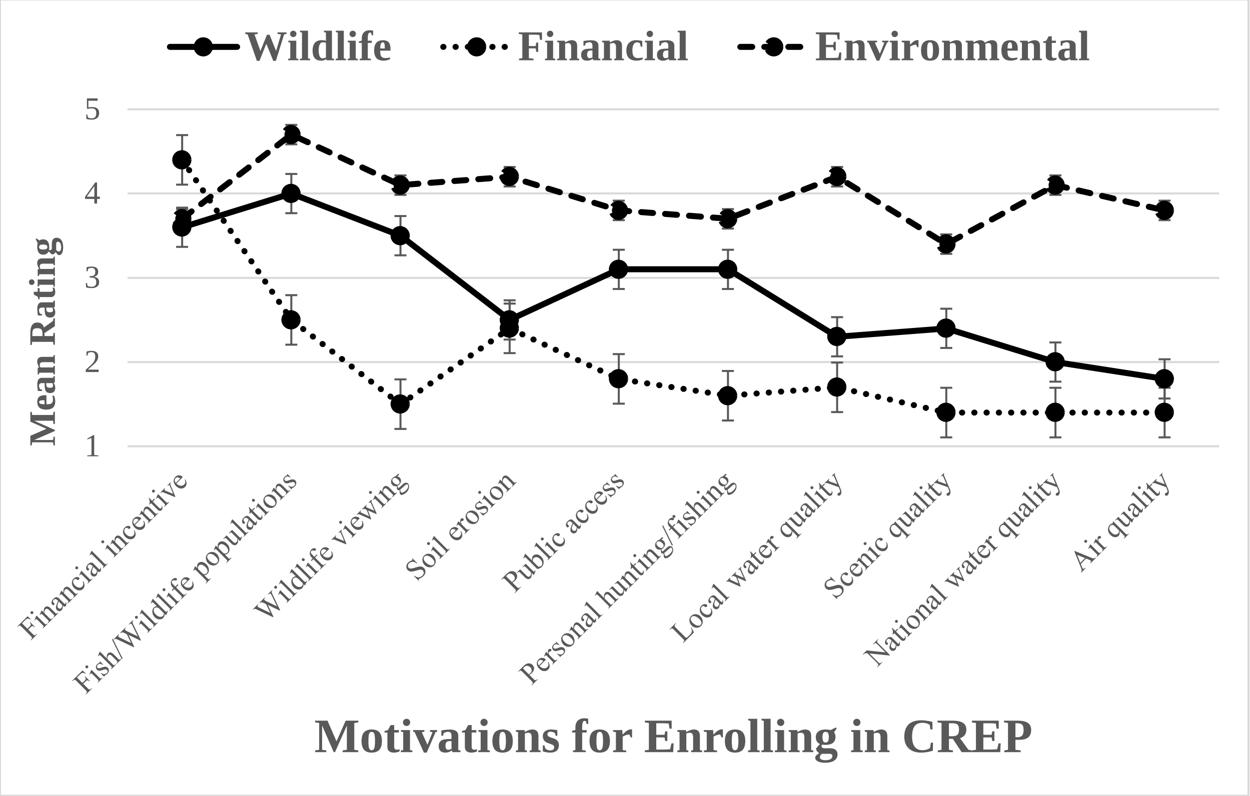

Figure 2. Comparison of cluster groups (wildlife, financial, environmental) for landowner evaluations (1 "no influence" to 5 "highly influential") of the importance of motivations to enrolling in the James River Conservation Enhancement Program in South Dakota.

# CHAPTER 5: INTEGRATED EVALUATION OF CONSERVATION PROGRAMS: SUMMARY AND CONCLUSIONS

Restoration of grassland and wetland complexes are widely advocated practices through various conservation programs (Allen 2005, Teels et al. 2006). Recent focus on these restorations have emphasized improving watersheds that have been deemed particularly environmentally and economically important (Goodwin et al. 1997, Allen 2005, USDA 2011). Recognizing that ecosystems cannot be fully restored to native states (Kauffmann et al. 1997, Gray and Teels 2006, Teels et al. 2006), future platforms must determine how best to maximize system potential in working landscapes.

Assessment and improvement of restoration success of ecological systems for environmental variables and wildlife populations will be less effective and efficient without integration of the social-economic impacts of these programs. The complexity and variability of landowner attitudes throughout the U.S. (Leatherman et al. 2007) has led to revealing conflicting needs of diverse interest groups (Sear et al. 1998, Cole et al. 2010, Shanahan et al. 2010, Kroll et al. 2014). With approximately 72% of the U.S. land privately owned (Vincent et al. 2014), and the demand for lower-cost foods and environmental sustainability at an all-time high (Godfray et al. 2010), it is a crucial time to understand agricultural producers’ environmental beliefs.  Thus, effective conservation program planning and implementation must incorporate a multi-scale comprehensive biological and human dimensions assessment (Meyerson et al. 2005, Palmer and Bernhardt 2006; Heneghan et al. 2008; Dallimer & Strange, 2015; Selinske, Coetzee, Purnell, & Knight, 2015; Velasco, García-Llorente, Alonso, Dolera, Palomo, Iniesta-Arandia, & Martin-López, 2015).

# RESEARCH ASSESSMENT

## Biological

Through my integrated, stepwise evaluation, 2 concepts became apparent: 1) both field and landscape scale variables were important in predicting avian parameters and, thus, meeting CREP program goals and understanding the interconnected ecological network, and; 2) implementing conservation programs with broad and non-cooperative objectives may result in undesired outcomes (McCoy et al. 1999, Fletcher et al. 2006).

My evaluation documented positive associations of grassland avifauna to landscapes with increased grassland and decreased cropland cover, with density of edge (i.e., field and landscape scale fragmentation) having the most meaningful, negative influence on daily survival rate of nests (Schmidt and Whelan 1999, Ribic and Sample 2001, Koper and Schmiegelow 2006, Askins et al. 2007, Renfrew and Ribic 2008). These results highlight the need for contract evaluations to focus on areas with increased grassland abundance at larger and less fragmented scales, which will minimize grassland islands that are cross-sectioned and interconnected by travel corridors that allow for ease of predator movements. Partners in Flight Regional Conservation Score (Prairie Pothole Region) modeling of all breeding birds emphasized the significance of incorporating landscape variables for species of greatest conservation concern and confirmed the need for a multi-scale approach (Vickery and Herkert 2001, Ribic et al. 2009). Landscape level models also better predicted nest density and nest species richness of waterfowl species group and nest survival of the other species group than field scale models.

Increasing patch size has been advocated in avian research as a technique to benefit spatially sensitive species (Davis 2004, Renfrew and Ribic 2008, Ribic et al.

2009). My study of 4 avian species groups documented no substantial influence of field size on abundance or species richness of breeding birds and no influence on daily survival rate of nesting avifauna. Conversely, nest density and species richness were negatively and positively associated with patch size, respectively, potentially highlighting the importance of area sensitivity for species of conservation concern in restored grasslands (i.e., CREP focal species; Herkert et al 2003, Bollinger and Gavin 2004, Skagen et al. 2005).

Evaluation of percent woody cover at field and landscape levels resonated with previous research. Our study depicted that presence of woody species generally portrays a negative influence; however, results represented a positive influence of percent woody cover at the field level on species richness of 2 groups of nesting avifauna (i.e., other and song bird species groups). Prior research has shown that additional species tend to be generalist, edge preference species of lesser conservation concern (Coppedge et al. 2008, Koford 2002, Bakker 2003, Fletcher and Koford 2003, Grant et al. 2004, Stephens et al. 2004). Woody cover presence is a key example of how an integrated stepwise platform can be tailored for obtainable objectives (i.e., goal of increasing avian abundance and species richness or obligate species focus).

Percent forb cover and mean visual obstruction readings (VOR; Robel et al. 1970) had variable associations with different species groups. Percent forb cover was present in competitive models for all avian groups, excluding nest survival of CREP focal species; which advocates the importance of seed mix design to achieving program objectives (McIntyre and Thompson 2003, Bakker et al. 2006, Bakker and Higgins 2009, Riffell et al. 2010). For example, percent forb supported a positive influence on the breeding and nesting song bird species groups. Percent forb depicted a negative association to the waterfowl and the other species groups; however, these results may have been an indirect result due to false influence between timing of nest initiation and percent forb cover (Dzus and Clark 1998, Arzel et al. 2014). Variability of visual obstruction was illustrated by species groups' ecological preferences (i.e., nest site characteristics; Jungers et al. 2015, Fisher and Davis 2010). Mean visual obstruction had a negative influence on breeding and nesting demographics of the song bird, CREP, and other species groups, which may have been driven by general nest preferences for mid-vegetation nesting species and open vegetation for ground nesting species (DeCasare et al. 2013). Breeding and nesting demographics of the waterfowl species group portrayed a positive association with mean visual obstruction, which may be due to early season nest initiation influencing selection of fields and nesting locations with increased visual obstruction for nest concealment (Hines and Mitchell 1983, Borgo and Conover 2016).

Given my study area lies in the heart of the Prairie Pothole region, it was crucial that I included variables in my models that accounted for percent wetland cover and type of wetland present. Type of wetland and percent wetland cover within fields represented a positive association across all breeding and nesting avian species groups, excluding the negative influence of present wetland on nest species richness of the other and CREP species groups. This suggests that assessing potential enrollment locations based solely on wetland presence is likely inadequate for the species groups we evaluated (Homan et al. 2000, Higgins et al. 2002, Reynolds et al. 2006).

### Human Dimensions

The enthusiasm of CREP enrollees for the program was positive and impressive. My study highlighted 4 themes of motivation for CREP enrollment. First, the requirement of providing public access with CREP enrollment offered additional financial incentive for enrollees, and many respondents detailed their enthusiasm to “pay it forward” and provide recreational opportunities for future generations. Although all three respondent clusters (financial incentive, wildlife oriented, and environmental concern) rated financial incentive as a strong motivation for enrollment, older individuals demonstrated higher levels of motivation to provide benefits to the non-financial variables (e.g., environmental). Second, based on demographic data, landowner age represented a potential shift of producers towards retirement and decisions to reduce active production (Hodur, Leistritz, & Bangsund 2002, Hua et al. 2004, Leatherman et al. 2007, Janssen, Klein, Taylor, Opoku, & Holbeck 2008). Mean age of CREP landowners ($\bar{x}$ = 64.8 years) was approximately 9 years older than the average South Dakota producer ($\bar{x}$ = 55.9 years; USDA 2014). Third, because this CREP targeted the James River Basin, landowners may have conceptualized their own personal motivations with the program to benefit the local community and wildlife. For example, of the ten motivational variables for enrollment, local impact variables (e.g., financial incentive and benefit to fish and wildlife populations) rated higher than large-scale influence variables (e.g., nationwide water quality and air quality; Allen & Vandever 2003, Reimer & Prokopy 2014).  I believe this result suggests motivation by landowners to provide greater benefit to their family, community, and local fish and wildlife (Gustafson & Hill, 1993; Hodur et al., 2002; Wachenheim, Lesch, & Dhingra, 2014; Yeboah, Lupi, & Kaplowitz, 2015).

# MANAGEMENT IMPLICATIONS

Although competitive field models tended to include more meaningful variables across species groups than competitive landscape models (Cunningham and Johnson 2006), it was also apparent that the landscape level was in some instances more influential (e.g., daily survival rate of the other species group) to breeding and nesting bird groups than the field level (Ribic and Sample 2001). Thus, I suggest taking a top-down approach to an integrated stepwise conservation program design and implementation. My integrated evaluation identified a design which assesses potential variability of landscape aspects (i.e., could be evaluated by zones within program regions) to compute a prospective species suite (i.e., focal species group) suitable for greatest potential success (e.g., Best et al. 1997, Naugle et al. 1999, Fletcher and Koford 2002, Fletcher and Koford 2003, Pretelli et al. 2015). A collection of suitable species will allow for tailored assessment options based on field scale attributes (e.g., contract site selection and seed mixture) for desired focal species. Such an approach would permit managers to focus implementation and management plans to best capitalize restoration success and meet program goals. I recommend conservation managers conduct further research into the ecology of focal avifauna to tailor integrated conservation program platforms for game and non-game bird species alike. Despite continued grassland and wetland habitat loss in the continental United States, some progress has been made in recent decades to overcome such losses through restoration efforts across the Midwest and the Great Plains. Further advancement will require better understanding of agricultural producers’ beliefs towards environmental conservation to ensure program success.

It is intuitive that most landowners wanted to maximize their financial profit; however, with the continued budget shortages, agencies must be able to identify solutions for all stakeholders (Wachenheim et al. 2014). Advancing innovative financial and non-financial incentives for landowners will be key to advancing conservation programs for the future. Coupling public access through the Walk-in program with the CREP in South Dakota was a unique strategy for offering additional financial benefit to landowners, increasing access to lands for public recreation, and promoting habitat for fish and wildlife. Developing and presenting non-financial incentives may offer improved concepts to attract and maintain landowner enrollment in future platforms. For example, multiple landowners suggested they would take up to a 25% rental payment cut during management years if they were allowed to hay their lands. This option could not only maintain financial expenditures of the agency implementing the conservation program, but potentially provide additional financial savings for agencies to place additional grass on the landscape. Research has shown that haying management regimes can provide benefits to a variety of grassland breeding birds, including many species of conservation concern (McMaster et al. 2005).

## CONCLUSION

There are still many gaps in the knowledge of avian response to the establishment and management of grassland conservation programs in agricultural landscapes. I believe that a multi-scaled evaluation framework and proper vegetation composition and management could significantly influence the success of restoration programs, thereby providing additional useable space for breeding and nesting birds. Targeted conservation research in Illinois has demonstrated that programs, such as CREP, have the potential to increase cost-effectiveness for environmental variables (Yang et al. 2005, Riffell et al. 2010). My research supports the notion that the contract selection process should be more thorough. However, emphasis should be based on a stepwise approach that accentuates district conservation priorities within the program region and implements success within districts based on tailored contract level detail. More importantly, management of natural resources is making strides into a new era of conservation on a working landscape. Identifying of the successes of implemented programs begins and ends with landowners. With that, evaluating and understanding stakeholder motivations and beliefs is key to conservation advancement.

I encourage resource managers and policy makers to incorporate an integrated program evaluation of current and future platforms based on a comprehensive approach emphasizing biological and human dimension factors. Although difficult, comprehensive frameworks have the potential to minimize program constraints throughout the design, delivery, and management processes.

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