Prairie Pothole Joint Venture

Assessing the Biological Benefits of the USDA-Conservation Reserve Program (CRP) for Waterfowl and Grassland Passerines in the Prairie Pothole Region of the United States:

Spatial analyses for targeting CRP to maximize benefits for migratory birds

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The mission of the Prairie Pothole Joint Venture is to implement conservation programs that sustain populations of waterfowl, shorebirds, other waterbirds and prairie landbirds at objective levels through targeted wetland and grassland protection, restoration and enhancement programs. These activities are based on science and implemented in collaboration with multiple stakeholders.

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Our understanding of the ever-dynamic Prairie Pothole Region (PPR) landscape spans multiple generations of conservation science and continues to evolve. We have relied directly upon past work conducted by Ron Reynolds, Mike Estey, Terry Shaffer, Neal Niemuth, Brian Wangler, Rex Johnson, Johann Walker, Dan Hertel, Diane Granfors, David Naugle, and Frank Quamen.

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Disclaimer

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

Executive Summary

The Conservation Reserve Program (CRP), administered by the U.S. Department of Agriculture–Farm Service Agency (USDA–FSA), provides annual, cost-share, and in some cases incentive payments to landowners to establish perennial cover in place of agricultural production on marginal agricultural lands. Following the establishment of the program in 1985, CRP acres peaked nationally in 2007 with approximately 36.8 million acres enrolled (roughly equivalent in area to the U.S. state of Georgia), approximately 8.2 million acres of which were located within the Prairie Pothole Region (PPR) of the United States. Since 2007, a sharp decline in CRP acres has occurred as contracts, typically enrolled for 10 or 15 years, expired alongside marked increases in agricultural commodity prices. As of September 2013, total CRP acreage declined nationally to 26.8 million acres, with approximately 5.2 million acres of CRP remaining in the PPR. Over 1.7 million acres have left the CRP between 2011 and 2013, marking the steepest decline in CRP acreage in the PPR since the program commenced (USDA 2013).

The benefits of CRP for migratory birds have previously been documented for portions of the PPR (e.g., Johnson and Igl 1995, Reynolds et al. 2006; 2007, Niemuth et al. 2007) and elsewhere (e.g., McLachlan et al. 2007). However, widespread landcover change has occurred throughout the PPR in recent years, including losses of wetland and grassland habitat alongside extensive CRP reversion to row crop agriculture (Wright and Wimberly 2013, Doherty et al. 2013, Dahl et al. 2014). As of 2011, CRP grasslands encompassed approximately 4.8% of the study area. A decline in CRP enrollments is expected to continue until current Farm Bill cap of 24 million acres is reached (Claassen 2014, Stubbs 2014).

We used spatially explicit landscape-scale models of species-habitat relationships to estimate the benefits of CRP grasslands for waterfowl and grassland passerine birds in the PPR of the United States. Building on past work conducted by Reynolds et al. (2007), we assessed waterfowl carrying capacity and annual recruitment for five of the most common upland-nesting breeding duck species (i.e., mallard, gadwall, blue-winged teal, northern shoveler, and northern pintail) in the PPR, from 2005 to 2011. Our results indicate that CRP grasslands increased the carrying capacity of associated PPR wetlands for breeding waterfowl by approximately 200,000 pairs—5% of the study area's waterfowl carrying capacity. Annual waterfowl recruitment models, applied to the Dakotas/Montana portion of the PPR, indicate that an additional 1.5 million waterfowl recruits—approximately a 23% increase on average, for all species—were produced per year, with an estimated 12.3 million waterfowl recruits produced from 2005 to 2011, due to CRP grasslands. Average percent increases in production resulting from CRP were observed, as follows: 27% mallard, 17% gadwall, 23% blue-winged teal, 21% northern shoveler, 21% northern pintail, and 23% for these five species combined—values that are approximately 10% lower than those reported for the peak CRP years by Reynolds et al. (2007). We also developed and applied waterfowl brood models to estimate brood abundance and spatial distribution of broods in response to CRP; however, no statistically significant outcomes for brood abundance could be distinguished in response to CRP.

We applied spatially explicit models to estimate breeding pair abundance for 10 grassland passerines species (i.e., Baird's sparrow, bobolink, chestnut-collared longspur, clay-colored sparrow, dickcissel, grasshopper sparrow, horned lark, Le Conte's sparrow, savannah sparrow, and sedge wren) to evaluate the biological benefits and related spatial patterns of CRP benefits for a subset of migratory grassland songbirds. The benefits provided by CRP were variable across species and ecoregions, ranging from supporting over 34% of the population of Le

Conte's sparrow to supporting 6% of the grasshopper sparrow population in PPR. Within the tallgrass ecoregion of the PPR, approximately 50% of the Le Conte's sparrow population was found to be dependent on CRP grasslands. Savannah sparrow exhibited the greatest number of total birds supported by CRP (1.6 million pairs; 12% of the total PPR population), followed by bobolink (1.2 million pairs; 11% of the total PPR population). Baird's sparrow, clay-colored sparrow, and sedge wren also exhibited CRP-related benefits, with 12%, 15%, and 15% of their populations supported by CRP, respectively. For all seven passerine species that exhibited CRP-related benefits, our models indicated that, as of 2011, approximately 4.8 million pairs (9.6 million individuals) of grassland birds were dependent on CRP in the tallgrass and mixed grass ecoregions of the PPR. We estimated both the direct (on-CRP), and the indirect (off-site; i.e., "landscape context") benefits of CRP for grassland bird populations. Indirect (off-site) benefits from CRP grasslands were found to extend beyond the CRP parcels for most species, indicating extensive value-added landscape context benefits for grassland birds provided by CRP.

CRP cover is declining alongside other habitat losses in the PPR. The biological value of CRP for migratory birds is substantial though spatially variable. We applied the results from spatially explicit biological models to develop a conceptual framework for strategically targeting CRP to maximize multiple benefits for waterfowl and grassland birds throughout the mixed grass and tallgrass ecoregions of the PPR. The associated spatial data, provided to USDA–FSA, can be customized to evaluate policy alternatives, including explicit project or program objectives, focal areas, prioritizations among species, and/or specific population targets that could further refine map-based decision support tools.

Introduction

The Prairie Pothole Joint Venture (PPJV) is a partnership of federal, state and non-governmental organizations focused on bird conservation in the Prairie Pothole Region (PPR) of the United States. The PPJV was established in 1987, through the North American Waterfowl Management Plan, as one of the first bird habitat Joint Ventures in the United States. The PPJV partnership works to sustain abundant populations of waterfowl, shorebirds, waterbirds, and landbirds through the long-term protection, restoration, and management of wetland and grassland habitats throughout the PPR (PPJV 2005).

The PPR encompasses one of the most biologically productive grassland-wetland ecosystems on Earth, with millions of depressional wetlands serving as "the backbone of North America's 'duck factory'" alongside large tracts of native prairie and other grasslands that support a diverse array of migratory bird species and other resident wildlife (PPJV 2005). However, the PPR is also a predominantly privately owned and highly altered agricultural landscape, throughout which private lands conservation programs make up an important component of the conservation estate. The widespread conversion of remaining grassland and wetland habitats to row crop agriculture continues to be detrimental to many migratory bird populations and other wildlife (Doherty et al. 2013, Wright and Wimberly 2013).

The U.S. Department of Agriculture–Farm Service Agency (USDA–FSA) administers the largest private lands conservation program in the United States: the Conservation Reserve Program (CRP). The CRP was created in 1985 in response to decreasing agricultural commodity prices driven by commodity surpluses, resulting in landowners returning millions of acres of cropland back to grassland and wetland cover. The CRP provides annual, cost-share, and in some cases incentive payments to landowners in exchange for agreeing to temporarily remove marginal land from agricultural production by re-establishing perennial vegetation and thereby promoting soil protection and a variety of other environmental benefits. Contracts typically last 10 or 15 years and provide water quality and wildlife benefits on otherwise marginal agricultural lands. The biological benefits associated with CRP for both waterfowl (e.g., Reynolds et al. 2001, Reynolds et al. 2007) and grassland birds (e.g., Johnson 2005, Niemuth et al. 2007) have been well documented for portions of the PPR and elsewhere (e.g., McLachlan et al. 2007). Recent advances in landcover and spatial biological modeling capacity for priority migratory birds in the PPR allow for improved accounting of the benefits of CRP, evaluating scenarios of changes of biological outcomes associated with losses of CRP acres, and exploring the associated spatial patterns of changes in landcover and their respective biological outcomes. Understanding the biological benefits of CRP can inform strategic responses to declines in CRP enrollment.

Economic trends and agricultural policy decisions will continue to combine to drive net change in both CRP and non-CRP grassland and wetland area throughout much of the PPR. Acreage of CRP enrollment has declined by over 3 million acres in the PPR since 2007 as funding for CRP has decreased concurrent with increases in agricultural commodity prices (USDA 2013). The result has been a decline in wildlife habitat and an ongoing fragmentation of habitat throughout the PPR, the biological implications of which can be difficult to monitor. In response to recent and anticipated future conservation challenges, we used a combination of landcover (Habitat and Population Evaluation Team [HAPET] unpublished), U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory data, USDA–FSA CRP Common Land Unit data, and spatially explicit waterfowl and grassland bird models to evaluate the biological benefits of CRP and to provide tools for the strategic targeting of CRP to maximize the benefits for migratory birds. Our objectives were to:

1. Estimate the population-level biological benefits of CRP for priority breeding waterfowl and grassland migratory bird populations using spatial models;
2. Estimate and portray spatial patterns in the biological benefits (and potential losses) for breeding wetland and grassland migratory birds associated with CRP; and
3. Develop spatially explicit tools to inform future decisions for targeting CRP to maximize benefits for breeding populations of waterfowl and grassland-dependent passerines in the PPR.

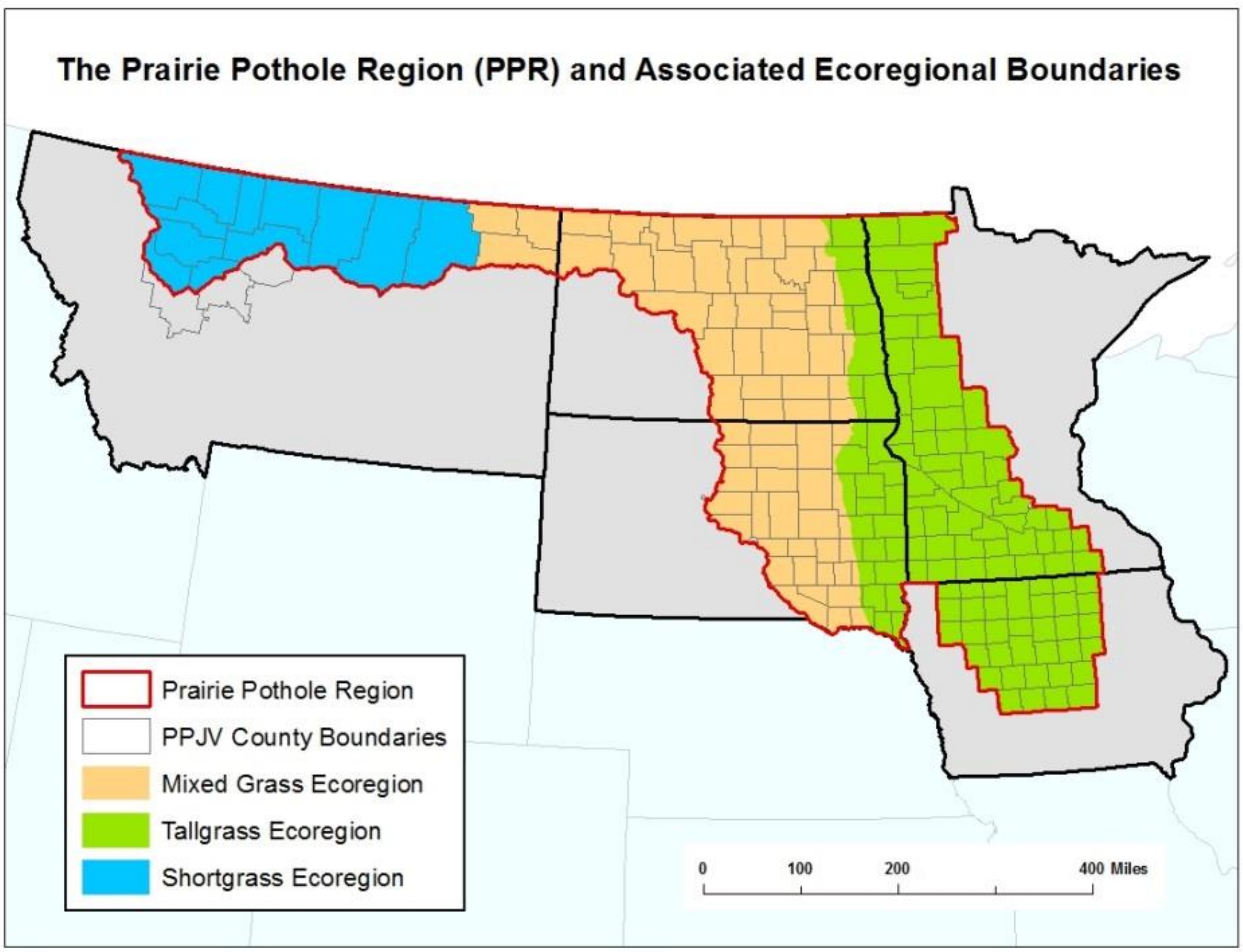
The PPJV partnership has worked for over two decades to develop and advance landscape conservation science to strategically target the most effective and efficient conservation of wetland and grassland habitats throughout the PPR. FWS–HAPET has worked with many other PPJV partners to provide a foundational capacity for spatial biological modeling and decision support tool development for strategic habitat conservation. The following analyses were conducted by HAPET, with direct support from USDA–FSA. Brood modeling work was conducted by Ducks Unlimited, in partnership with HAPET and the PPJV. The primary intent of this work is to increase the effectiveness of conservation delivery, to maximize the biological benefits of future USDA–FSA enrollment strategies for CRP. A secondary intent of this work is to inform USDA, the PPJV Management Board, and other policy makers.

Background

Study Area Overview

The PPR encompasses portions of Iowa, Minnesota, North Dakota, South Dakota, and Montana (Figure 1), west of the Mississippi River, east of the Rocky Mountains, and north of the Missouri River. This region is the product of extensive glaciation during the late Pleistocene epoch, which left millions of depressional "pothole" wetlands scattered throughout the tallgrass, mixed grass, and shortgrass prairie ecosystems (PPJV 2005). The PPR encompasses approximately 118 million acres; the tallgrass ecoregion portion of the PPR encompasses approximately 51 million acres, while the mixed grass ecoregion encompasses approximately 46 million acres, and the shortgrass ecoregion of the PPR encompasses approximately 21 million acres.

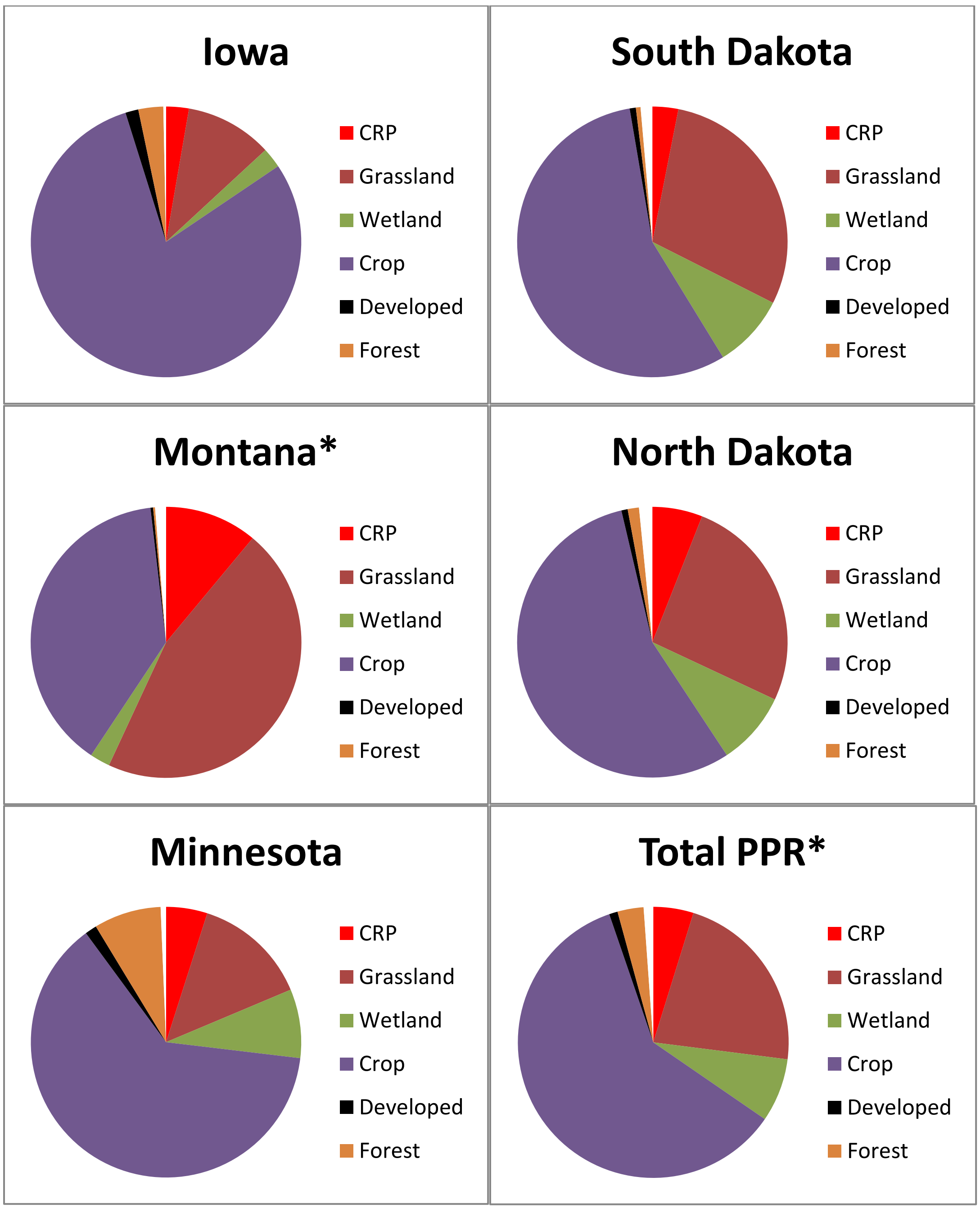
Figure 1. The U.S. Prairie Pothole Region (PPR) and associated ecoregions.



Our study focuses primarily on the tallgrass and mixed grass ecoregions of the PPR (unpublished data, HAPET; Figure 2; Appendix A) due to the consistent availability of spatial data over time and the consistency of spatial models directly applicable to these geographies.

Figure 2. Landcover summary for the tallgrass and mixed grass ecoregions of the PPR (HAPET 2011). Conservation Reserve Program (CRP) landcover includes all Conservation Practice (CP) types described in Appendix A. “Grassland” includes grassland-herbaceous and undisturbed grassland landcover (excluding CRP grasslands); “Wetland” includes all wetlands mapped by the FWS National Wetlands Inventory plus any additional water identified during the classification process.

*Totals presented for Montana and the PPR do not include the shortgrass ecoregion of Montana.



The Benefits of CRP for Waterfowl in the PPJV (Review)

Past research suggests that wetlands are the primary determinant of breeding waterfowl pair distribution and carrying capacity in the PPR (Johnson and Grier 1988, Kantrud et al. 1989). The number of waterfowl settling and breeding in the PPR is largely driven by the annual availability of water-filled wetland basins, which can vary greatly over time (Niemuth et al. 2014). It is important to note that relatively small temporary and seasonal basins are known to contribute disproportionately to total waterfowl carrying capacity despite encompassing less area (i.e., 69% of breeding pair capacity attributed to 59% of the total wetland area; Reynolds et al. 2007).

Upland cover near wetlands is also an important driver of waterfowl population levels in the PPR, specifically because it influences nest success, which has been demonstrated to be the single most important lifecycle factor influencing mallard population levels (Hoekman et al. 2002). Nest success for upland nesting waterfowl in the PPR has been found to be positively associated with perennial cover and negatively associated with cropland in the nearby landscape (Reynolds et al. 2001, Greenwood et al. 1995). Declining nest success in the PPR has coincided with the conversion of perennial grassland cover to cropland, which has effectively increased habitat fragmentation, resulting in more edges that predators utilize, thereby concentrating nesting ducks in nesting cover that is at greater risk to predation (Cowardin et al. 1983, Greenwood et al. 1995, Reynolds et al. 2001).

Reynolds et al. (2001) evaluated the importance of CRP cover for 5 upland-nesting waterfowl species (i.e., mallards [MALL; *Anas platyrhynchos]*, gadwall [GADW; *A. strepera*], blue-winged teal [BWTE; *A. discors]*, Northern shoveler [NSHO; *A. clypeata*], and Northern pintail [NOPI; *A. acuta*]) in ND, SD, and northeast MT, searching over 30,000 acres of CRP to determine the fate of >10,000 duck nests. Their results indicated that CRP was preferred over all other cover types for all species studied and that nest success in CRP was higher than for any other cover types. Further, they found that CRP contributed disproportionately (30%) to successful nests compared to the area that CRP encompassed (only 7% of the total area during the study period), concluding that CRP contributed a 30% increase in duck productivity in the PPR. An estimated additional 2 million ducks per year were produced in the PPR portions of North Dakota, South Dakota, and northeast Montana, from 1992–2004, due to CRP (Reynolds et al. 2007).

Biological Benefits of CRP for Grassland Birds in the PPJV (Review)

The CRP is known to support a variety of species of grassland birds in the PPR. For example, studies have generally found higher densities of many grassland bird species in CRP grasslands (e.g., Johnson and Schwartz 1993, Johnson and Igl 1995, Best et al. 1997, Herkert 1998) and comparisons with Breeding Bird Survey (BBS) data have illustrated positive population-level responses of grassland birds to CRP grasslands (Herkert 1998, Veech 2006).

Niemuth et al. (2007) evaluated the biological benefits of CRP for a suite of grassland birds in the PPR of North Dakota and South Dakota, for 1995–1997, using landscape-scale spatial models. Their results indicated that CRP benefits ranged from 2% to 52%, varying by species, or an estimated contribution of >900,000 individuals of the four grassland bird species per state included in their analyses. Extrapolating over the PPR of the Dakotas, they estimated >1.8

million birds were dependent on CRP landcover. Species such as sedge wren and bobolink, known to utilize dense grassland cover, showed the greatest proportional population dependencies on CRP. Their results further emphasized that the location of CRP grasslands, the composition of the surrounding landscape, and that the conservation/management practice applied on CRP and nearby grasslands all play an important role in determining the biological benefits of CRP at any particular site (Niemuth et al. 2007). Other studies have emphasized that CRP benefits can vary greatly from year to year in response to climatic variation, succession of vegetation communities, and fluctuations in the total population and distributions of birds (Delisle and Savidge 1997, Johnson et al. 1997, Igl and Johnson 1999).

BBS annual trend data for all PPJV grassland bird species indicates long-term and ongoing declines for many species (Appendices B and C), though many grassland bird species are relatively poorly covered, regionally and nationally, by the BBS, and population trends exhibit substantial variability from year to year (Sauer et al. 2014).

Habitat Change and CRP Trends in the PPR (Review)

Changes in the extent and spatial distribution of landcover in the PPR are important because long-term and continued declines of grassland landcover and wetlands in the PPR result in the direct loss of wildlife habitat. Subsequent fragmentation and degradation of remaining habitat (Johnson et al. 2010, Anteau 2011, Hill et al. 2014) can exacerbate region-wide declines in waterfowl population levels (Reynolds 2007, Loesch et al. 2012), declines for most grassland bird species populations (e.g. Herkert et al. 2003, Niemuth et al. 2007), and impacts to other wildlife populations including amphibians (Mushet et al. 2014) and pollinators (Potts et al. 2010). Additionally, habitat losses negatively impact many other ecosystem services (Fargione et al. 2009) and may result in a long-term functional loss of resilience to climate change (Johnson et al. 2010). Ongoing habitat losses may further fuel increased risk for future wetland and grassland losses on unprotected lands (Wright and Wimberly 2013), and may constrain practical options for future ecological restoration efforts (Dahl 2014).

The conversion of grassland and wetland habitat to row crop agriculture throughout the PPR geography has been well documented in recent years (e.g., Dahl 1990, Euliss et al. 2006, Oslund et al. 2010, Doherty et al. 2013, Dahl 2014). Land use and vegetative cover are changing constantly throughout the PPR, though the availability of comprehensive landcover data is limited to periodic snapshots in time (e.g., National Landcover Data is typically published every five years, and HAPET landcover products have been developed at similar time intervals) due to the cost and workload required to attain, process, and ground truth remotely sensed imagery. Thus snapshots of status and trends of landcover change, and their subsequent biological outcomes, are periodic and inherently retrospective.

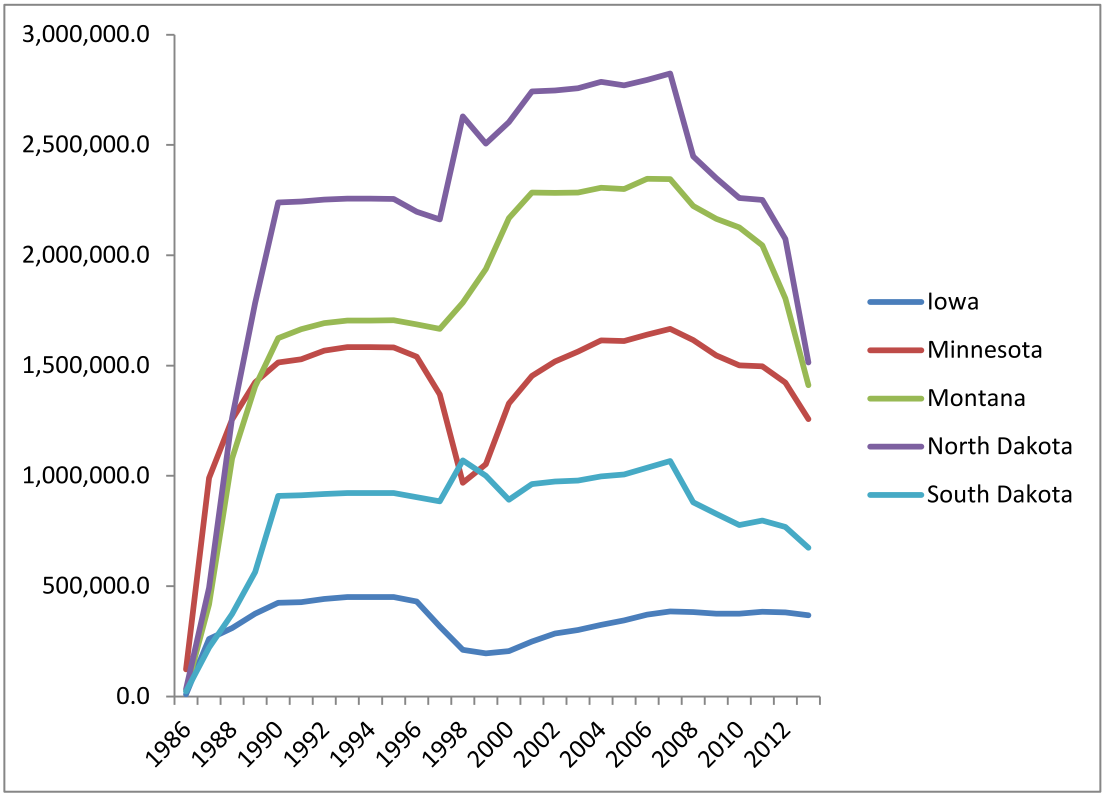
CRP and Other Grassland Trends in the PPR

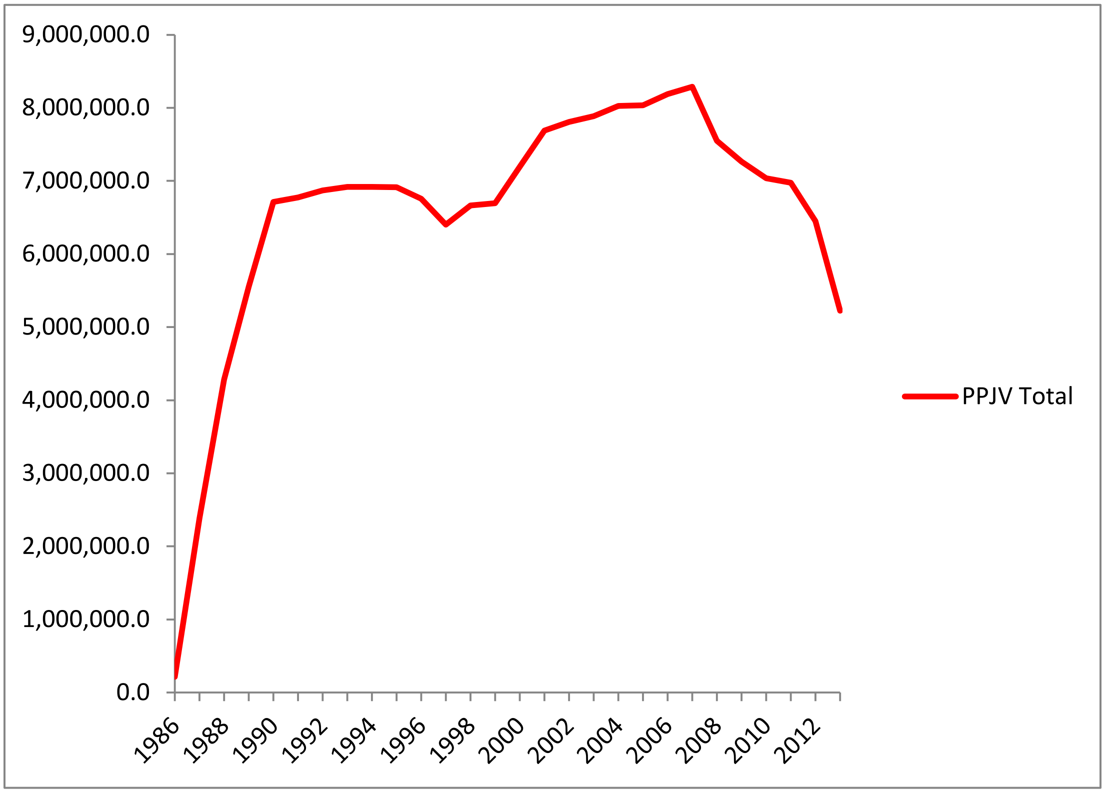
Euliss et al. (2006) estimated that wetlands encompassed upwards of 20% of the total PPR land area prior to European settlement, with the remaining 80% of the area having been predominantly grasslands. Grassland losses have exceeded rates of all other biome losses throughout North America since 1830 (Samson and Knopf 1994). U.S. grasslands west of the Mississippi River declined by an estimated 260 million acres between 1850 and 1950, with an additional loss of over 27 million acres of grasslands occurring from 1950–1990 (Conner et al. 2001). From 2006–2011, Wright and Wimberly (2013) found grassland conversion rates were comparable to deforestation rates in Brazil, Malaysia, and Indonesia—rates of grassland declines that have not been observed in this region since the rapid agricultural industrialization expansion period of the 1920s and 1930s. Dahl (2014) estimated that as of 2009, grassland landcover, including native prairie and planted grassland cover like CRP and domestic pasture, covered approximately 22% of the PPR landscape, noting a 2.6% loss of grassland landcover (approximately 568,000 acres) in the PPR from 1997–2009, 95% of which was attributed to agricultural conversion. Niemuth et al. (2014) found that the PPR exhibited the greatest increases in corn and soybean acreage in the nation during their analysis period of 1997–2007.

Grassland conversion, including changes in both remnant native prairie and other planted, non-native grasslands like CRP, has been spatially heterogeneous. The eastern PPR (i.e., the tallgrass prairie and eastern portion of the mixed grass prairie ecoregion) currently contains relatively low amounts of grassland due to the extensive conversion of native prairie to row crop agriculture. Modest increases in grassland landcover were observed in Minnesota and Iowa from 1997–2009 (i.e., an increase of approximately 237,000 acres), likely due to conservation work done on publicly managed lands combined with gains in CRP grasslands (Dahl 2014). Conversely, relatively dramatic losses were observed in the western portions of the PPR, where Montana, North Dakota, and South Dakota exhibited grassland losses of 805,000 acres, the majority of which occurred in South Dakota. During the same period, CRP acre totals within all PPJV counties increased from 6.2 million acres in 1997 to 7.2 million acres in 2009 (USDA 2013). However, declines in CRP acreage have since ensued, alongside record agricultural commodity prices that have driven habitat conversion throughout the PPR that has yet to be fully accounted for (Faber et al. 2012, Wright and Wimberly 2013).

Enrollment in CRP peaked nationally in 2007, with approximately 36.8 million acres enrolled and approximately 8.2 million acres enrolled within the PPR (USDA 2013). Of the 31.1 million acres of CRP enrolled nationally in September 2011, approximately 6.9 million acres (22.2% of all CRP acres nationally) fell within the PPJV (Figure 3; USDA 2013). As of September 2013, total CRP acreage including all CRP CP Types (Appendix D) had declined nationally to 26.8 million acres, with approximately 5.2 million acres of CRP remaining in the PPR; over 1.7 million acres left the CRP between 2011 and 2013, marking the steepest decline in CRP acreage in the PPR since the program commenced in 1986 (USDA 2013). Considered alongside other landcover changes, the implications for many wildlife species of recent and ongoing CRP losses are cause for concern (Wright and Wimberly 2013, Doherty et al. 2013, Mushet et al. 2014).

Figure 3. Conservation Reserve Program (CRP) acres for Prairie Pothole Joint Venture counties 1986–2013. Acres include all CRP parcels for all Conservation Practice Types (USDA 2013).





Wetland Trends in the PPR

Trends for wetlands in the PPR are equally concerning. As of 2009, approximately 61% of the estimated 17 million acres of historical wetlands in the PPR had been lost. Recent wetland losses totaling approximately 1.1% of the total PPR area (or 4% of the total number of wetlands basins) occurred from 1997–2009. Ninety-five percent of the total area of wetland losses was attributed to agricultural conversion (Dahl 2014). Extensive losses have been observed for temporary and seasonal wetlands, while semipermanent wetlands and lakes have increased, possibly due to smaller wetland drainage and consolidation processes associated with landcover conversion to cropland (Dahl 2014), as well as generally wetter than average conditions in recent years.

Of particular concern, temporary wetlands losses totaled approximately 133,000 acres between 1997 and 2009 (Dahl 2014). Though small and often considered nuisance wetlands by agricultural producers, temporary wetlands are important features that provide multiple ecological functions in the PPR (Gibbs 1993, Krapu et al. 1997, Fairbairn and Dinsmore 2001) encompassing 49% of remaining wetland basins in 2009 (Dahl 2014). The trend in temporary wetland losses is particularly troubling for waterfowl because these wetlands, along with seasonal wetlands, are known to be utilized by breeding ducks at higher densities than other wetland classes and thus greatly influence the carrying capacity of waterfowl in the PPR (Reynolds et al. 2006, Loesch et al. 2012). Increasingly widespread subsurface tile drainage networks also pose new challenges as the impact of their use increasingly affects regional hydrology (Galatowitsch and van der Valk 1994, Dahl 2011) and limits the potential for the “successful” restoration of wetland hydrology in many areas (Dahl 2014). Further, remaining wetlands in predominantly agricultural landscapes may be at increased risk of becoming functionally degraded due to an influx of sediment and agricultural pesticides and subsequent toxicity for invertebrate populations upon which waterfowl and other wildlife depend (Beyersbergen et al. 2004).

Ultimately, grassland and wetland losses in this landscape can be viewed as an interwoven problem, the trajectory of which is inherently tied to agricultural policy, national and global agricultural economic conditions, and climate. The loss of CRP, other grasslands, and wetlands are each problematic when considered in isolation; when combined, the resulting fragmentation and degradation of remaining habitat complexes may be greater than the sum of the parts and could result in threshold responses at local or regional scales, particularly when stressed by extreme weather events or climate change (Johnson et al. 2010, Niemuth et al. 2014).

Methods

Landcover, Wetland Basin, and CRP Common Land Unit Data

We used landcover derived from Landsat imagery and wetlands mapped in the PPR by the FWS National Wetlands Inventory (NWI) using aerial photography as the foundation for these analyses.

Landcover

We used landcover data for the PPR developed for two time periods (2005 and 2011). In 2005, a 28.5-meter landcover classification grid for the PPR, excluding central and western Montana, was developed from Landsat images collected during 2002–03 (unpublished data, HAPET, Bismarck, ND; and Fergus Falls, MN; Appendix E). In 2013, a 30-meter landcover dataset was completed for the entire PPR (unpublished data, HAPET). Again Landsat images were used for the classification and all scenes were collected during 2011 (Appendices E and F). For both landcover datasets, extensive field data was collected and used both to inform the classification process and to perform assessments of classification accuracy. For both landcover datasets, Common Land Units (CLUs) enrolled in the CRP were distinguished in the final product as the “CRP” cover class; for modeling purposes, CRP grasslands were treated as “undisturbed grassland” cover (Appendices D and G). Additionally, basins created using wetlands mapped by NWI were embedded into the final landcover as wetland basins (see Johnson and Higgins 1997).

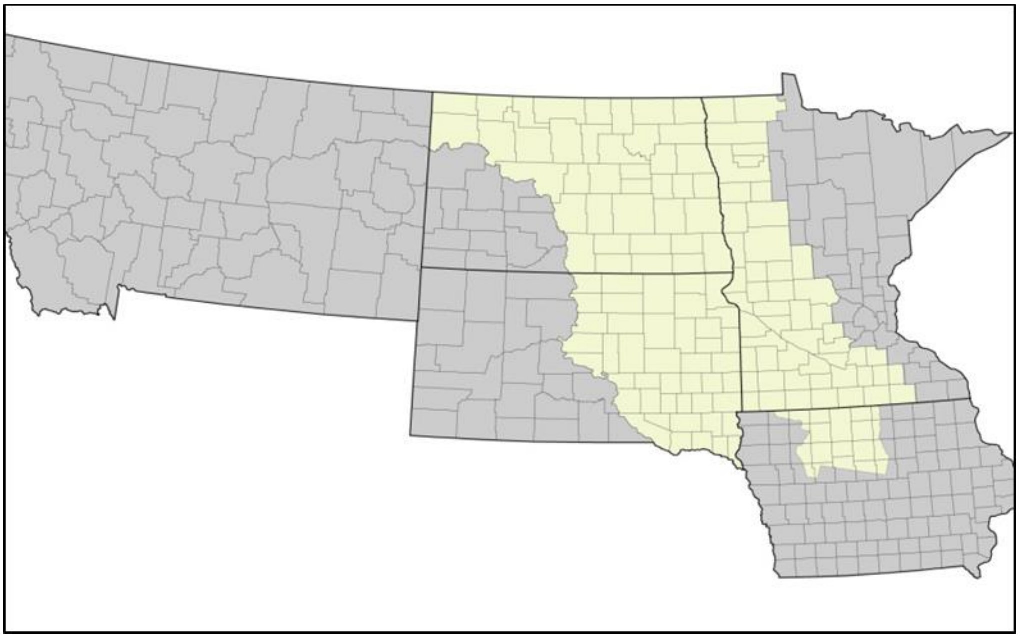
<u>Landcover (2005):</u> For 2005, both the CRP and landcover data was restricted to the northern portion of the Des Moines Lobe, Iowa; Minnesota, northeast Montana, North Dakota, and South Dakota (Figure 4). One wetland and 10 upland classes were combined into five classes for identifying wetland-upland associations (Appendix H).

<u>Landcover (CRP):</u> Spatial data for all CRP tracts within the PPR were secured from USDA–FSA for 2005 and 2011. All CRP Types were reviewed and only CP types interpreted to be “undisturbed grassland” cover (i.e., those highlighted in Appendix D*)* were directly incorporated into the 2005 or 2011 HAPET landcover data. This was done to maximize the accuracy of CRP grassland landcover locations. Similar to the 2005 landcover, one wetland and 10 upland classes were combined into five classes for the purpose of identifying wetland-upland associations.

While USDA (2013) data indicates that approximately 6.4 million acres of CRP are enrolled in the mixed grass and tallgrass ecoregions of the PPR, only approximately 4.7 million acres were treated as undisturbed grassland cover within the 2011 HAPET landcover data. Once rasterized into 30-meter pixels this equated to approximately 4.3 million acres (or 4.8% of the total PPR area; Appendix G). The landcover classes for all other non-grassland CP types were determined by the default landcover classification process described above.

<u>Landcover (No CRP Scenario):</u> For purposes of evaluating the biological benefits of CRP, we reclassified all CRP grassland pixels to cropland.

Figure 4. The geographic extent of 2005 HAPET Landcover data.



Wetland Basins

During the late-1970s to mid-1980s, aerial photography was collected by NWI to map and classify wetlands in the PPR. The wetlands were converted to digital representations beginning in the early 1990s and continue to be the foundation wetland data set used to apply habitat models for wetland-dependent wildlife in the PPJV. Oslund et al. (2010) and Loesch et al. (unpublished data, Bismarck, ND) conducted similar assessments of wetland change and loss relative of NWI mapped wetlands to evaluate the appropriateness of continued use of the wetland data. The results suggest that although changes have occurred, most frequently in the eastern third of the PPJV, NWI mapped wetlands continue to be a valuable resource for landscape analyses and species-habitat modeling.

We used a modified version of NWI data where wetlands were converted from the Cowardin et al. (1979) wetland classification to a “basin” classification (i.e., temporary, seasonal, semipermanent, lake, riverine) following processing rules described by Cowardin et al. (1995) and Johnson and Higgins (1997). In general, simple basins were reclassified to the associated water regime (Cowardin et al. 1979), and complex wetlands were consolidated and reclassified to the deepest water regime.

Waterfowl Carrying Capacity Methods

We updated the results of Reynolds et al. (2007) to estimate the waterfowl response to CRP for 2005–2011. We applied the same pair-wetland relationships to estimate CRP benefits to breeding waterfowl populations and subsequent recruitment (see pages 21–37, Table 1-2 *in Reynolds et al. [2007]*).We used updated pair-wetland relationship models and incorporated spatial context in building on the previous breeding population analysis.

Reynolds et al. (2007) reported an increased abundance of breeding duck pairs on wetlands associated with CRP relative to other upland land covers (see Figures 4-9 *in Reynolds et al. 2007*). There was positive association with CRP by species (i.e., BWTE, GADW, MALL, NOPI, NSHO), wetland basin class (i.e., temporary, seasonal, semipermanent), and adjacent upland class (i.e., cropland, CRP, grassland, other). We calculated CRP-related benefits by incorporating standardized adjustment factors, which varied by species and wetland class, according to the specific responses identified in Reynolds et al. (2007). The analysis conducted by Reynolds et al. (2007) included the PPR region of North Dakota and South Dakota, and the northeastern portion of the PPR in Montana. We assumed the relationship between pair abundance and associated upland landcover was applicable for both the western and eastern portions of the PPR, given that the sampling design did encompass the agriculture-dominated tallgrass portions of the eastern Dakotas.

We estimated the contribution of CRP cover to breeding duck pairs for three time intervals (scenarios), two historic landcover years (2005 and 2011) with CRP present, and one future landcover scenario with no CRP. Landcover and CRP location data were different for the two historic time periods.

Cultivated haylands were considered cropland when estimating the abundance of breeding pairs relative to surrounding uplands. For the 2005 Landcover, all hayland was reclassified to cropland. To differentiate between hayed native cover and planted alfalfa in the 2011 landcover, we used overlays of the USDA National Agricultural Statistics Survey (NASS) Cultivated Land Cover Data (Boryan et al. 2012) and HAPET landcover to identify areas with a recent cropping history; hayland with a cropping history was grouped with the cropland class and hayland without a recent cropping history was grouped with the grassland/herbaceous class. The eight upland and five wetland classes (Appendix E) were consolidated into five classes (i.e., water, cropland, CRP, grassland, other) for the purpose of identifying wetland-upland associations.

Breeding Pair Abundance, Wetland Basins, and Basin Wetness

We estimated the average breeding duck pair abundance for the five species on each wetland mapped by NWI in the PPR using models similar to those published in Reynolds et al. (2006). Waterfowl estimation within the PPR follows similar processes within each of the three ecoregions of the PPR. We used four different suites of waterfowl models across the PPR because duck pair survey data availability and model development for the five duck species varied geographically (Table 1). These models included two suites for Iowa and Minnesota (EPPR), another for northeast Montana (i.e., Daniels, Roosevelt, and Sheridan Counties), North Dakota and South Dakota (CPPR) (Reynolds et al. 2006), and a fourth for the remainder of Montana (WPPR) (Fields 2011).

Wetland size is an important parameter for estimating pair abundance (Reynolds et al. 2006). The inundated area of individual wetland basins is dynamic and changes in response to the temporal and spatial variation in temperature and precipitation in the PPR. We used a model of average percent full to adjust the wetland size mapped by NWI before applying the pair abundance models for Montana and the Dakotas (see Reynolds et al. [2006]; Table 1). For the remainder of the PPR, we used either wetland class-specific constants of an estimated percent full, or considered the basin 100 percent full (Table 1).

Table 1. Differences in data and process used to generate waterfowl pair abundance estimates throughout the ecoregions of the U.S. PPR.

	Eastern PPR[a]		Central PPR	Western PPR
Item	MN	IA	ND, SD, Northeast MT[b]	MT
NWI imagery dates	1980's	2002	1980's	1980's
Wetland basin percent full	MALL, BWTE = 100% NOPI, NSHO, GADW = Temporary = 0.6303 Seasonal = 0.7118 Semipermanent = 0.8148 Lake = 0.9242 River = 0.7814		Modeled from wetland condition data[b]	100%
Pair-wetland abundance model data years	MALL, BWTE = 1987-2008 NOPI, NSHO, GADW = 1987-1998		1987-2011[c]	2008-2011[d]

[a]Unpublished data, FWS, HAPET, Fergus Falls, MN

[b]Includes Daniels, Sheridan, and Roosevelt Counties

[c]Reynolds et al. (2006)

[d]Fields (2011)

Wetland-Upland Associations

We used geospatial polygon-intersect rules for polygon representations of both landcover and wetland basins to determine the upland classes that wetlands were embedded in or adjacent to. Processing rules were assembled into an ArcGIS toolbox (ESRI 2011) using Model Builder to create a sequence of four models that were used to manipulate table structure and attribution of features for wetland basin and landcover feature classes. The models facilitated the standardization, automation, and repeatability of the spatial overlays to determine the upland class (i.e., cropland, grassland, CRP, other) that each individual wetland was associated with.

The upland association for wetlands completely embedded (i.e., intersecting only one upland class) in one of the four upland classes was assigned the respective upland class. For wetland basins that shared a perimeter with multiple upland classes, we used a hierarchical set of rules in the sequence of Other:Grassland:Cropland:CRP to determine upland association (Appendix H).

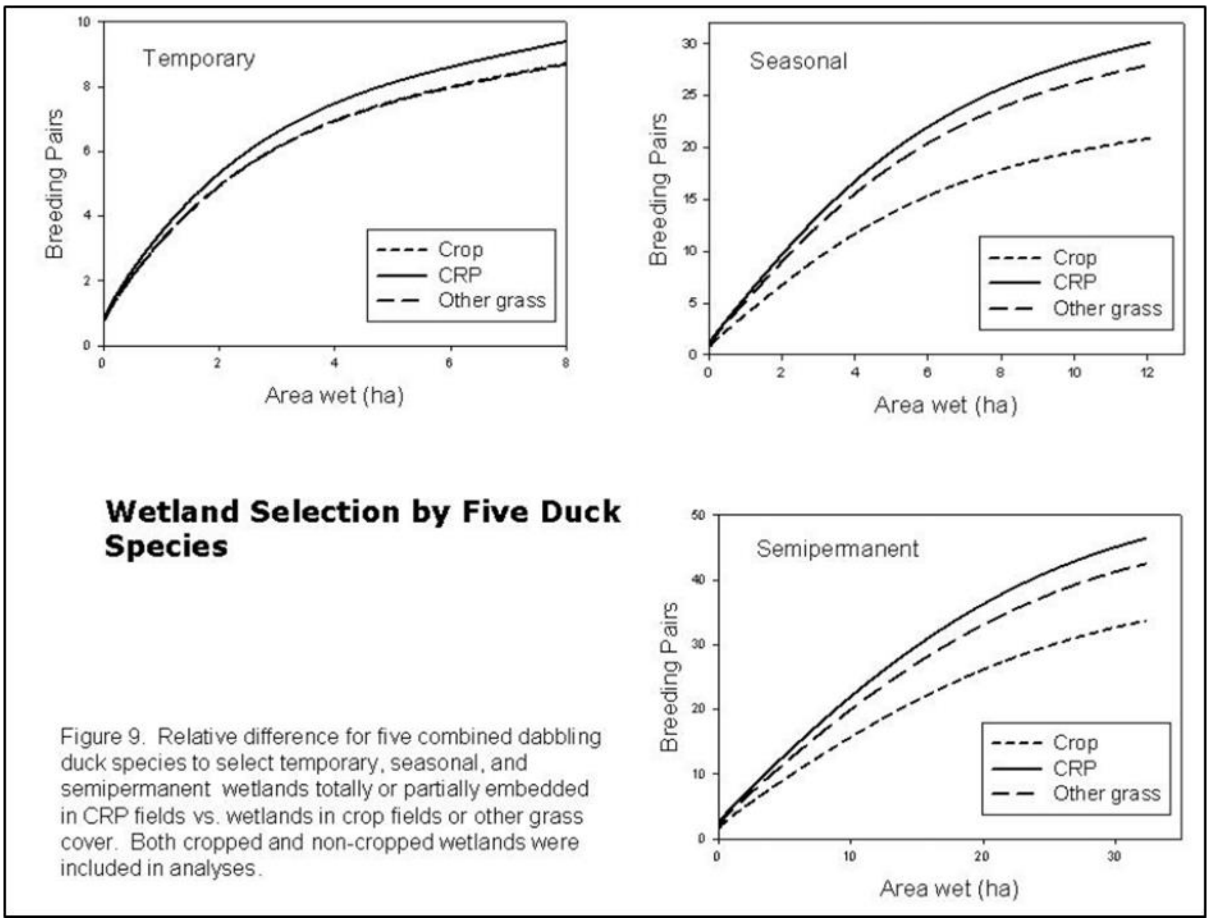
Some examples of wetland-update associations:

1. A basin embedded in Grassland = Grassland association
2. A basin perimeter touching both Grassland and Cropland = Cropland association
3. A basin perimeter touching Grassland, Cropland, and CRP = CRP association
4. A basin perimeter touching Other and Grassland = Grassland association
5. A basin perimeter touching Grassland and CRP = CRP association

Differential Pair Abundance

We used the differences in breeding duck pair abundance and landcover relative to 20 species:basin class combinations reported in Reynolds et al. (2007; see Figures 4–9) to estimate the contribution of CRP to breeding pair carrying capacity in the PPR. For each year scenario, the average, basin-specific breeding pair estimates for wetlands associated with CRP were multiplied by both the Cropland and CRP proportional difference values (Table 2, Figure 5). The differences between the two resulting values were summed for all wetlands associated with CRP cover to represent the estimated pair carrying capacity benefits of the CRP (Appendix I).

Figure 5. Wetland selection for five duck species (Figure 9 in Reynolds et al. [2007]), by wetland class, and respective upland-association adjustment factor.



Waterfowl Annual Breeding Population and Recruitment Modeling Methods

We estimated the annual breeding population and productivity for five dabbling duck species using the methods described in Reynolds et al. (2007; pages 25–28; also see Cowardin et al. 1995). Estimates were generated for 2005–2012 and were limited to the same geography of Reynolds et al. (2007). We did this to allow a direct comparison with the previous report. Breeding populations for the five species are primarily a function of annual wetland habitat conditions and influence subsequent production estimates (Table 3). We estimated production annually with respect to population size for two landcover scenarios. First, we estimated production with CRP intact on the landscape and then repeated the estimation process with CRP represented as cropland as dictated by year, based on CRP contract expiration dates. The difference between the two estimates represents the estimated number of recruits expected to be added to the fall population as a result of CRP (Table 4; Appendices I and J).

Table 2. Proportional differences, presented as a multiplier, in the abundance of breeding duck pairs based on wetland-upland associations. Estimates are presented for wetlands in the PPR portion of northeast Montana, North Dakota, and South Dakota relative to the uplands that the wetlands are associated with. Positive (i.e., values > 1.0) and negative (i.e., values < 1.0) deviations are relative to abundance estimated for wetlands associated with the native grassland cover data from the habitat files maintained to support the FWS Four Square Mile Survey (unpublished data, FWS Habitat and Population Evaluation Team, Bismarck, ND; unpublished from Reynolds et al. 2007).

	Wetland Class							
	Temporary		Seasonal		Semipermanent		Lake	
Species	Cropland	CRP	Cropland	CRP	Cropland	CRP	Cropland	CRP
Mallard	1.0358	1.3638	0.7811	1.1249	0.7254	1.2301	0.8310	0.9018
Blue-winged Teal	1.0000	1.0000	0.6633	1.0704	0.7854	1.1270	0.5911	0.7126
Gadwall	1.0000	1.0000	0.6578	1.0258	0.7260	1.1125	0.9267	0.8844
Northern Shoveler	1.0000	1.0000	0.9488	1.2433	0.6954	1.1948	2.7652	0.7867
Northern Pintail	0.9387	1.1941	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 3. Estimated number of breeding pairs for five duck species and those species combined in the PPR of North Dakota, South Dakota, and northeastern Montana, 2005–2012.

	Breeding Pairs											
	MALL		GADW		BWTE		NSHO		NOPI		Species Combined	
Year	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
2005	749,967	40,229	458,693	26,235	734,666	45,707	236,280	12,936	191,280	11,486	2,370,885	130,442
2006	731,563	36,779	476,128	30,311	785,628	54,536	197,757	9,967	160,588	8,724	2,351,664	134,816
2007	1,131,730	63,330	576,360	37,837	1,258,582	74,350	344,652	19,258	293,054	16,761	3,604,378	201,750
2008	865,941	57,301	461,348	32,735	832,279	50,102	343,055	19,166	203,333	13,056	2,705,957	163,850
2009	1,195,098	45,765	730,946	29,373	1,853,292	77,459	714,593	32,079	532,127	23,067	5,026,056	199,766
2010	1,113,022	44,970	634,338	27,252	1,799,714	78,654	659,681	29,281	505,693	22,758	4,712,448	196,694
2011	1,521,338	58,858	838,779	34,208	2,374,182	92,277	787,413	40,088	747,658	34,852	6,269,370	250,922
2012	1,408,653	61,703	830,991	43,826	2,232,152	99,364	627,937	33,337	509,442	25,902	5,609,174	255,844
Average	1,089,252	44,013	625,522	27,676	1,483,501	59,004	488,684	20,220	392,796	16,074	4,079,755	161,361

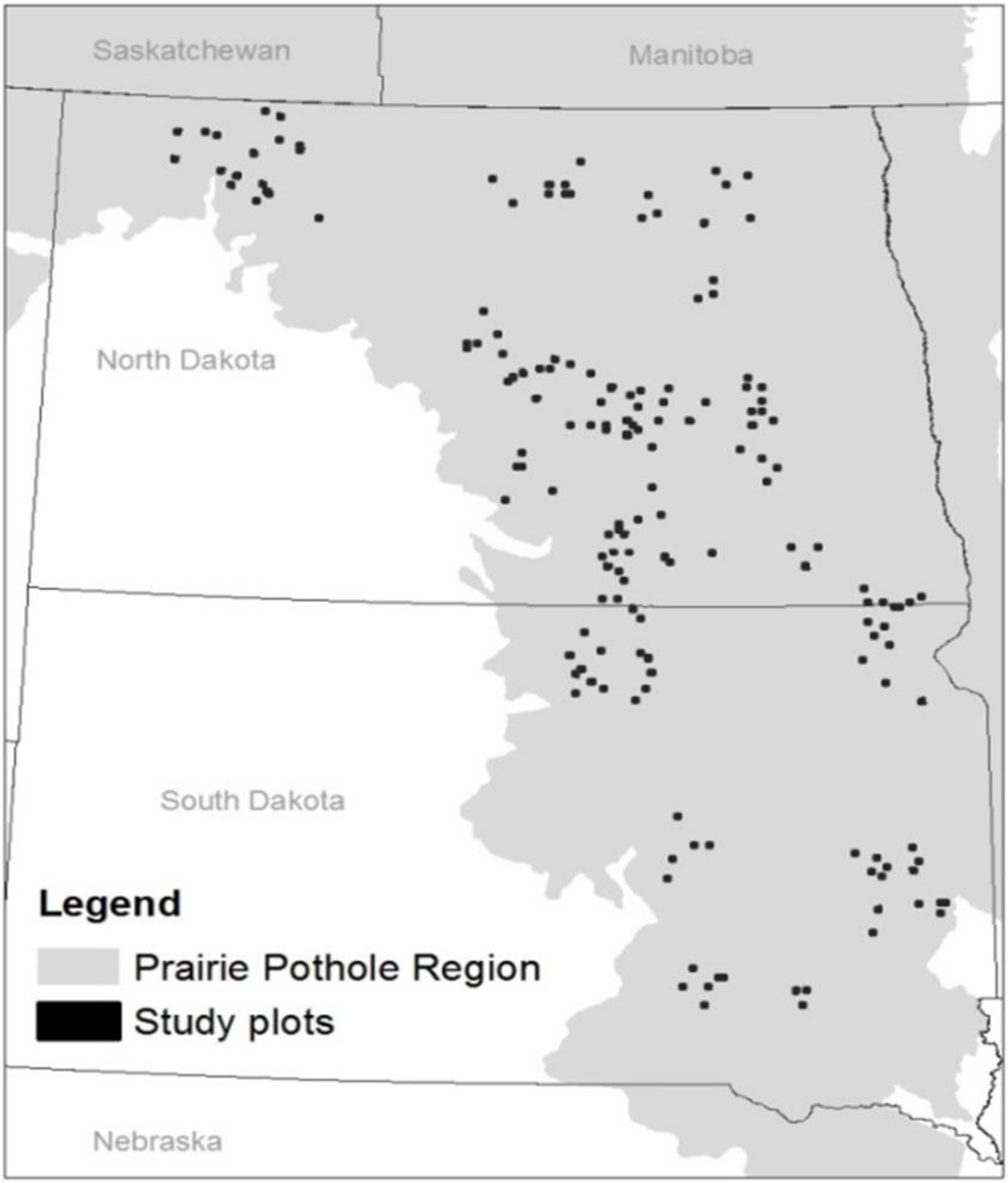
Table 4. Estimated number of combined mallard, blue-winged teal, gadwall, northern shoveler, and northern pintail recruits produced with and without CRP cover in the PPR of North Dakota, South Dakota, and northeastern Montana, 2005–2012.

	Recruits					
	Without CRP		With CRP		Difference	
Year	Estimate	SE	Estimate	SE	Estimate	SE
2005	2,038,034	113,350	2,650,131	161,116	612,098	60,631
2006	2,208,628	127,231	2,870,506	191,704	661,878	79,016
2007	4,336,611	224,172	5,760,601	314,227	1,423,990	109,720
2008	2,494,169	136,730	3,330,596	185,974	836,427	61,697
2009	7,294,216	282,371	9,423,433	369,596	2,129,217	120,480
2010	6,703,484	294,264	8,867,504	385,536	2,164,019	119,118
2011	10,481,418	410,162	13,411,889	505,369	2,930,472	142,753
2012	5,295,743	218,493	6,849,092	276,508	1,553,349	86,089
Average	5,105,580	181,560	6,644,552	239,365	1,538,972	81,220

CRP Brood Abundance Analysis Methods

We used brood count data from a four-year survey (i.e., 2007–2010) in the PPR of North Dakota and South Dakota to estimate brood abundance and detection probabilities for the five duck species used above with regards to CRP (Walker et al. 2013). Brood data consisted of counts of feathered broods (age classes 2–3) from 167 plots and 3,565 wetland basins (Figure 6). We only included counts of feathered broods (i.e., Class II or higher; Bellrose 1980) because we expected them to be most likely to survive to fledging and contribute to overall duck recruitment (Krapu et al. 2000). Walker et al. (2013) provides a description of the study area and methods regarding the collection of brood data.

Figure 6. Location of 2 mi x 2 mi (n = 167 sample plots), surveyed from 2007–2010, used to develop brood models.



CRP and landcover data for North Dakota and South Dakota were available for the years 2005 and 2011 while CRP and landcover data for Minnesota and Iowa were available for 2011. While brood surveys were conducted during 2008 and 2009 in the eastern PPR, insufficient brood data were collected in Minnesota and Iowa to include in this analysis of brood abundance. Prior to developing any models, we created separate CRP representations for each year of the brood study (2007–2010). We assumed that any CRP in 2005 that expired before 2011 but that was still present in the 2011 CRP CLU data was maintained as CRP during the interim period. We also assumed that if CRP CLU in 2005 data expired before 2011 and did not persist in the 2011 dataset it was converted to cropland the year of its expiration date. We then summarized the amount of upland cover in each survey plot that consisted of CRP and incorporated the resulting proportion into the brood models.

In addition to CRP, other covariates considered in the abundance models included:

PE, PE^2: quadratic representation of the amount of emergent cover on an individual basin

PC: the percent of the upland portion of the four-square mile plot classified as perennial cover (this includes CRP)

JWA: wet acres within each plot in July

PropSeas: the proportion of seasonal basins within each plot that was wet in May

LogWA: the log of a basin's wet area

Regime (SEAS, TEMP, SEMI): basin regime

Covariates considered in the detection models included:

WA: basin wet area

PE: percent of basin covered in emergent vegetation

time,time^2*:* time of day the visit took place

logDate: log transformed Julian date

Before running the models, we scaled all quantitative parameters to zero for ease of parameter interpretation.

We used Royle's (2004) N-mixture models to generate predictions of brood abundance with a zero-inflated Poisson distribution. These models have a hierarchical structure and can be described as follows:

$$N_i = pres_i \times K_i$$

$$pres_i \sim Bernoulli(\delta_i)$$

$$K_i \sim Poisson(\lambda_{i,})$$

$$y_{ij} \sim Binomial(N_i, p_{ij})$$

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

$$logit(p_{ij}) = \gamma + \gamma_1 x_{ij1} + \cdots + \gamma_V x_{ijV}$$

Where N_i is wetland-level abundance at site *i* and K_i is the realized abundance given presence ($pres_i$), which is a binary variable indicating whether or not the species is present at site *i*. The observation process is then modeled using a binomial distribution where y_{ij} is the observed count at site *i* and survey *j* and p_{ij} is the probability of detecting an individual given the true abundance N_i is greater than zero. The probability of abundance and detection can then be modeled as functions of covariates using a log and logit link function respectively.

The described hierarchical model assumes that the abundance of broods on a wetland remains constant across visits and that broods are independent of each other and equally detectable. These assumptions were addressed in the study design. With regard to the first assumption, the first and third visits were within a 24–36 hour period. The second assumption was also met in the study design as observers spent at least two minutes at each wet basin visit.

Using a remove-one approach, we assessed the support for each covariate listed above within an information theoretic framework (Burnham and Anderson 2002). We assessed lack-of-fit at the basin level using a parametric bootstrap procedure (MacKenzie and Bailey 2004). We assessed lack-of-fit at a larger scale through a comparison of plot level predictions to actual observed data. We considered low levels of correlation between the two (R^2 <=0.5) as proof of poor model fit.

The covariates from the most supported model were used to generate PPR-wide predictions of brood abundance per basin across North Dakota, South Dakota, Minnesota, and Iowa. We generated predictions for Minnesota and Iowa basins separately as limited brood data were collected in these states, thus it should be noted that application of the model to these states is beyond the scope of the original sampling design. In calculating these predictions, we held all parameters except *Regime, PC*, and *CRP* constant at their average values. We produced predictions for three different CRP scenarios: brood abundance at 2005 CRP levels (North Dakota, South Dakota), brood abundance at 2011 CRP levels (North Dakota, South Dakota, Minnesota, Iowa), and brood abundance assuming total CRP loss from 2011 levels (North Dakota, South Dakota, Minnesota, Iowa). We only included semipermanent, seasonal and temporary basins in these predictions. Although basin size and inundation is highly variable in the PPR, for the purposes of these predictions we considered all basins in the PPR within North Dakota, South Dakota, Minnesota, and Iowa 100 percent full. For scenarios 1 and 2, every basin had a scaled covariate representing the percent of the upland portion of the surrounding four-square miles was classified CRP or PC at the relevant time step (2005 or 2011). We summed basin-level predictions to obtain a PPR-wide prediction and predicted confidence intervals using a bootstrapping method.

Grassland Bird Model Development Methods

Grassland Bird Sampling and Survey Design

We developed grassland bird models using 3,185 100-meter fixed-radius point counts conducted throughout the PPJV during May/June 2003–2005 (Quamen 2007). Points were selected using a stratified random sampling design, spatially allocated for equal distribution throughout the FWS Wetland Management Districts of the PPJV. Points were also apportioned among the various landcover types as follows: 15% on cropland, 70% on grassland, and 15% on hayland. To increase the range of variation in predictor variables, points were further stratified to encompass a range of low–high grassland abundance within 8 km^2 of each survey location (Quamen 2007). Preliminary Monte Carlo simulations (Quamen 2007) indicated that, on average, detection rates increased <5% for rare species and 9–11% for more abundant grassland bird species when sites were visited twice instead of once. Thus to increase sample size, each point was surveyed only once and a new sample of survey locations was selected each year. Each survey point was located >1.6 km from neighboring points to reduce dependence among observations (Hurlbert 1984) and reduce spatial autocorrelation problems (Legendre 1993). Observers recorded the distance to each bird detected, recording singing males for all species except bobolink, for which all males were counted regardless of whether they were actively singing. Quamen (2007) describes details of the sampling design and bird survey protocol.

We analyzed survey data in association with 2005 landcover data and developed grassland bird models separately for the tallgrass and mixed grass ecoregions of the PPR (see Figure 1) due to the ecological differences in landuse and landcover, climate, and breeding range for some species. In addition to the biological basis for the geographic distinction, the different ecoregions also reflect decisions by the PPJV to evaluate species population objectives and conservation priorities for each ecoregion to inform impending PPJV Implementation Plan updates (PPJV 2005).

Landcover Classification and Focal Analyses for Grassland Bird Modeling

We combined cover classes and created binary grids, resulting in 10 “combined” cover classes (cropland, developed, grassland-herbaceous, grassland-undisturbed, hay, trees, temporary wetlands, seasonal wetland, semipermanent wetland, and lake wetlands), based on HAPET landcover classification values (Appendix F). Focal mean analyses (ArcGIS 10.1; ESRI) were conducted for each binary grid to evaluate the proportion of each combined landcover class within a circular radius of 400, 800, 1600, and 3,200 meters. Results from these focal mean analyses were used as input variables for the various grassland bird models.

Adjusting Density Estimates Using Detection Functions

Raw survey results were adjusted using program DISTANCE (Buckland et al. 2001, Thomas et al. 2005) to account for unequal detection probabilities that may vary across distance, habitat types, by species and environmental conditions. We plotted frequency histograms of raw detection data by habitat type to evaluate detection patterns for evasive bird movement, heaping, or outliers (Buckland et al. 2004). We observed no anomalies requiring further adjustment. We stratified detection data by landcover type to improve precision and reduce bias associated with detection patterns among cover types. We fit detection functions with cosine and simple polynomial expansions, and half-normal and hazard-rate model forms with cosine expansions. We used Akaike’s Information Criteria (AIC) values to select among competing candidate models. The model with the lowest AIC value for each species was considered the most parsimonious and best approximation of information contained in the data (Burnham and Anderson 2002). We then used the best model, respectively, for each species in each of the two ecoregions, to adjust raw count data to account for detection probability to make valid estimates of density for use as a dependent variable in spatial modeling of species-habitat relationships.

Incorporation of Climate Variables

Autocorrelation in spatial distribution and abundance of grassland birds can result when environmental variables influencing the niche of a species are, themselves, spatially structured (Legendre 1993). An initial step of the model-building process was to compare models using latitude/longitude to models using climate variables. Models with latitude/longitude generally had lower AIC values, though it was determined that interpretation was more difficult and that the practical implications and biological justifications for incorporate climate variables (e.g., evaluating implications of climate change) out-weighed practical reasons for relying on latitude/longitude variables. Thus we considered a suite of spatially explicit broad-scale climate variables created using spline regressions applied to weather station data from 1961–1990 (Rehfeldt et al. 2006; Crookston and Rehfeldt, unpublished). In addition to avoiding some spatial autocorrelation problems, directly incorporating climate variables within spatial models allows for the exploring the biological outcomes of future climate change scenarios. Given a high degree of spatial correlation between many of the climate variables developed by Rehfeldt et al. (2006), we chose a subset where correlations were ≤0.65 that we believed were the most ecological meaningful for grassland bird biology in the PPR.

We selected the number of degree-days > 5° C (*dd5*), annual moisture index (*ami*), and the summer/spring precipitation balance (*smrsprpb*) to encompass a range of values representing temperature, moisture, and precipitation—which, along with soil characteristics and landcover context, drive broad-scale ecological patterns. We tested quadratic functions (*dd5_2, ami_2, smrsprpb_2*) for all climatic variables, assuming *a priori* that many species prefer an intermediate range of climatic gradients.

Grassland Bird Model Development

We developed spatially explicit landscape-scale models for 12 grassland bird species: Baird's sparrow (*Ammodramus bairdii* [*BAIS]*), bobolink (*Dolichonyx oryzivorus* [BOBO]), chestnut-collared longspur (*Calcarius ornatus* [*CCLO]*), clay-colored sparrow (Spizella pallida [*CCSP]*), dickcissel (*Spiza americana* [*DICK]*), grasshopper sparrow (*Ammodramus savannarum* [*GRSP]*), horned lark (*Eremophila alpestris [HOLA]*), Le Conte's sparrow (*Ammodramus leconteii* [*LCSP]*), savannah sparrow (*Passerculus sandwichensis* [*SAVS]*), sedge wren (*Cistothorus platensis* [*SEWR]*), Sprague's pipit (*Anthus spragueii* [*SPPI]*), and western meadowlark (*Sturnella neglecta [WEME]*; Appendices K and L). Variable selection for the final models was a systematic process that followed several discrete steps. First, for each species we identified the most predictive scale of each variable. Better model results can be obtained for a general linear model when variables are integrated at the scale at which they make the highest contribution to the explained variance in univariate models (Graf et al. 2005). We selected the best scale for each landcover class based upon AIC. The comparison of scales for all species' models also included an intercept-only (null) model. If the variable was not more predictive (based on AIC) than the null model, the variable was excluded from all subsequent analyses. We then assessed the level of correlations among retained landscape variables using Pearson's r statistic. Variables with correlations ≥ |0.65| were compared using AIC and the variable with the lowest AIC was retained if there was no clear biological reason to retain one over the other. Highly correlated variables were not included in the same model.

We computed all possible combinations of models with the retained (non-correlated) variables. We used the resulting matrix of model coefficients to assess consistency in the direction of β-estimates. We dropped all models that included unstable β-estimates that switched from positive to negative effects or vice versa, because AIC has been shown to sometimes spuriously include uninformative variables (Arnold 2010), which tend to manifest as variables with β-estimates centered around zero with confidence intervals including both positive and negative effects (Smith et al. 2009).

Our bird survey results included a large proportion of no-occurrence (zero) data, resulting in a "zero-inflated" dataset that does not satisfy standard distribution assumptions associated with many common statistical modeling techniques. Failure to account for zero-inflation when selecting a modeling approach can lead to bias in parameter estimates and their associated error rates (MacKenzie et al. 2002), resulting in poor inference (Barry and Welsh 2002) and could misdirect conservation actions (Martin et al. 2005).

We used zero-inflated Poisson regression (ZIP) techniques to explicitly account for the large proportion of zeros in our survey results. We applied a two-step heuristic modeling approach (Barry and Welsh 2002; Welsh et al. 1996). First, we modeled occupancy (presence/absence) as a binary logistic regression (LOGIT; STATA ver. 12.0) using climatic and multi-scaled habitat variables. Habitat variables were assessed as a proportion of each landcover class (including temporary [*temp*], seasonal [*seas*], and semipermanent [*semi*] wetlands, grassland-herbaceous [*grassherb*], undisturbed grassland/CRP [*und_crp*], hay [*hay*], and trees [*tree*]) within a 400, 800, 1600, and 3200 meter radius associated with each survey point. We then held variables from the top LOGIT model(s) constant in the inflation portion of the ZIP model (STATA version 12.0). The same model selection process was used to develop both the LOGIT and ZIP models. We replicated these steps for each of the species, for both the tallgrass and mixed grass ecoregions of the PPJV.

Candidate models were then ranked based on their respective AIC values and we used AIC weights (w_i) to assess the strength of evidence that a particular model was the best option to select from a candidate set of models, given the data. We generated model weights for all models then selected all models that comprised 90% of the variation. We generated new model weights based on the top 90% subset and calculated model-averaged coefficients and standard errors based on the relative weight of each model within the top 90% (Burnham and Anderson 2002). If a ZIP model would not converge, we developed only a LOGIT (occupancy) model for that species.

Models outputs were clipped to their respective range boundaries using BBS range maps (Sauer et al. 2014). Lastly we removed lake and urban areas from the model outputs; final population estimates reported did not include any contributions from urban or lake landcover classes.

Grassland Bird Model Validation

As a preliminary validation step, we calculated occupancy rates by landcover type as the number of survey locations where a species was detected, divided by total number of survey locations. We then compared occupancy rates with adjusted densities and confirmed that the landcover types that were most commonly occupied indeed contained the highest densities of birds.

We then used BBS data (Sauer et al. 2014) as an independent dataset to validate the grassland bird models. We mapped all BBS stop points within the PPJV by digitizing each stop point (50 points per route) according to the best available data. We started with published BBS route line data (Sauer et al. 2014) and manually digitizing stop points using written BBS stop point descriptions in consultation with actual surveyors, when available, to locate points as accurately as possible. We used simple GIS-based equal interval line-segmenting techniques when no other stop-point descriptions were available. We used survey results within the study area from 2006–2011, to validate our models. A total of 5,153 BBS points were surveyed (*n* = 2,006 for the mixed grass ecoregion; *n* = 3,147 points in the tallgrass ecoregion) within the study area.

For all BBS points, we considered a point “occupied” for a species if that species was detected at least once at the point over the six-year period. We compared model outputs for abundance estimates versus observed occupancy from BBS points using a Resource Selection Function (RSF) based on a use-availability design (Johnson et al. 2006). Boyce et al. (2002) describe how RSFs can be evaluated using *k*-fold cross validation. For each data fold, an independent dataset can be assessed against the model predictions using bin ranks of the RSF values and the frequency of independent observations in the same bin rank standardized for area (Johnson et al. 2006).

We used the equal-area slice tool in ArcGIS (ESRI ArcGIS 10.1) to create 20 data bins of habitat suitability based on the final model abundance estimate (LOGIT/ZIP model outputs) for each species; the resulting index provides a 1–20 classification index of habitat suitability for each species, within each ecoregion of the PPJV, each standardized for area. In cases where the equal-area slice process produced bins of unequal area, we applied a 10-bin classification using natural breaks (jenks), and thus similarly standardized expected occurrences to account for differences in total area associated with each bin. We then calculated the utilization $U(x_i)$ value for each bin *i* according to the formula:

$$U(x_i) = w(x_i)A(x_i) / \sum_j (w(x_j)A(x_j)$$

where $w(x_i)$ is the midpoint RSF of bin *i* and $A(x_i)$ is the area of bin *i* (Boyce and McDonald 1999). We then summed the number of occupied BBS points, and compared to an estimate of the expected number of validation observations within each bin (N_i) such that,

$$N_i = N \times U(x_i)$$

where N is the total number of testing-data validation observations used and $U(x_i)$ is calculated from the utilization function above.

We then compared the expected number, N_i, from our model estimates for each species/ecoregion, with the observed number of occupied BBS points using linear regression (Appendix M). A model that was proportional to probability of use would have a slope of 1, an intercept of 0, with an R^2 value of 1 indicating a perfect fit between expected and observed values (Johnson et al. 2006).

Last, we also used the BBS data to validate the non-linearity of species-habitat relationships by comparing the proportion of the model-based population estimates falling within in each equal-area 20-bin class, for each species/ecoregion, to the observed BBS distribution of occurrences by bin, as a proportion of the total occurrences for each species. This approach allowed us to estimate the percent of a population falling within a given portion of the total study area and further validate the models based on the convergence of these curves when compared to BBS observations.

We developed models for 12 grassland bird species (11 species in the mixed grass ecoregion; 9 species in the tallgrass ecoregion)—Baird's sparrow, bobolink, chestnut-collared longspur, clay-colored sparrow, dickcissel, grasshopper sparrow, horned lark, Le Conte's sparrow, savannah sparrow, sedge wren, Sprague's pipit, and western meadowlark.

Grassland Bird CRP Analysis

To assess the benefits of CRP lands for grassland birds, we digitally converted all CRP pixels, for all relevant grassland CP types (Appendix D), to cropland and re-ran the spatial models for each species using 2011 Landcover and CRP data.

Grassland birds do occur on cropland pixels, although typically in much lower abundance compared to grassland pixels, depending on the amount of grass in the surrounding landscape—the scale of which can vary among species. The impact of CRP conversion to cropland at a particular location will vary by species and landscape context; in most cases conversion of CRP to cropland will result in much lower abundance estimates on those pixels, but the estimates will tend to remain above zero. We refer to the birds estimated as persisting on post-conversion pixels as "lingerers." Due to lingerers, it is not possible to simply sum populations on CRP and subtract those from the total population to estimate the benefits of CRP for these species. Further, the influence of CRP extends beyond each CRP tract. Landscape context influences model outputs such that the conversion of CRP affects estimates on nearby non-CRP pixels. We assessed the total population impacts of CRP and further explored the on-CRP versus off-site CRP benefits by evaluating population changes, following conversion of all CRP pixels to cropland, after accounting for post-conversion lingerers.

CRP Prioritization Decision Support Tool Methodology

We developed a process for integrating the results of waterfowl and grassland bird abundance models to produce a prototype decision support tool for informing CRP enrollment and re-enrollment decision to maximize benefits for multiple migratory bird species. Our objective was to develop a relatively simple tool for ranking priority (focal) areas of shared importance for waterfowl and passerine birds, while simultaneously maintaining the underlying model outputs to ensure results could be interpreted in a meaningful way.

We integrated spatial data from Waterfowl Breeding Pair Accessibility Maps (i.e., FWS "Thunderstorm" maps, Reynolds et al. 1996, Reynolds et al. 2007) with spatial abundance models for five species of grassland passerines. The resulting tool is designed to:

1. Identify locations where both waterfowl and grassland birds are benefiting the most from CRP grasslands (i.e., re-enrollment priorities);
2. Identify strategic opportunities for targeting new CRP grasslands to maximize benefits for waterfowl and grassland birds (i.e., new enrollment priorities).

Waterfowl Breeding Pair Accessibility Maps (commonly referred to as "Thunderstorm Maps") are produced from long-term waterfowl survey data (Cowardin et al. 1995, Reynolds et al. 2007) in the PPR. Thunderstorm maps display predictions of the number of upland nesting duck pairs (mallards, blue-winged teal, gadwall, northern pintail, and northern shoveler) that could potentially nest in the upland habitats of every 40-acre block throughout the PPR. These predictions are based on the known travel distances of hens from core wetlands to their nest sites, along with statistical abundance models created from field survey data to predict the number of duck pairs that utilize individual wetland basins (see Johnson and Higgins 1997) in the PPR during the breeding season (see Reynolds et al. 2007).

Thunderstorm maps have been used widely by PPJV partners to identify priority sites for the protection or restoration of grassland habitat for nesting waterfowl. Additionally, these maps have also been used to help guide CRP targeting efforts in the past to maximize benefits for breeding waterfowl (e.g., CRP Conservation Practice: CP37—Duck Nesting Habitat).

To demonstrate the potential use of this approach for a customizable decision support tool, we identified subjective proportional priority population level thresholds for breeding waterfowl pairs, and four tallgrass and five mixed grass passerine species. For waterfowl, we used GIS processes to identify the geographic distribution of top 25%, 50%, and 75% of the cumulative abundance of breeding pair accessibility; we also identified the top 25% of the cumulative population for each of the passerines (i.e., the smallest footprint of the total study area that contains the respective proportion of each species' population). Grassland passerine species in the mixed grass prairie included bobolink, grasshopper sparrow, savannah sparrow, sedge wren; tallgrass prairie species were similar but also included Le Conte's sparrow. Grassland passerine species selection was a function of available abundance models and documented affinity to CRP grassland habitat. The species also represent a range of site and landscape conditions (e.g., wet to dry soils, moderate to high vegetation height/density preferences).

Analyses were run separately for each ecoregion, completed at a spatial resolution of approximately 40 acres per pixel. Overlay functions within ArcGIS were used to combine the priority population layers. The number of grassland passerine species that were common to a location within the priority waterfowl population was summed and a value of 0–5 was attributed to the location.

The resulting decision support tool consists of a value that represents the number of species in addition to waterfowl that would benefit from conservation actions at that location, based on pre-defined population thresholds. Higher values indicate greater overlap in benefits for breeding waterfowl and one or more passerine species populations. Actual waterfowl pair accessibility values and grassland bird abundance estimates are maintained within the data structure. Doing so allows a simple ranking of locations while simultaneously ensuring that the underlying information is readily available to inform decisions related to population objectives. Abundance estimates can also be used to discern trade-offs among species, such that users of the tool can understand the data underlying any particular location(s) and consider whether a portfolio of CRP options will adequately encompass the full suite of species of concern.

Results

Results: Waterfowl Carrying Capacity Estimates

In 2005, 10% of the temporary, seasonal, and semipermanent wetland basins, 23% of the wetland acres, and 17% of the breeding pairs (Appendix H) were either embedded in or adjacent to a CRP CLU. In 2011 the percent of temporary, seasonal, and semipermanent wetlands basins, percent of wetland acres, and the percent of breeding pairs associated with CRP all declined slightly to 8%, 22%, and 16%, respectively.

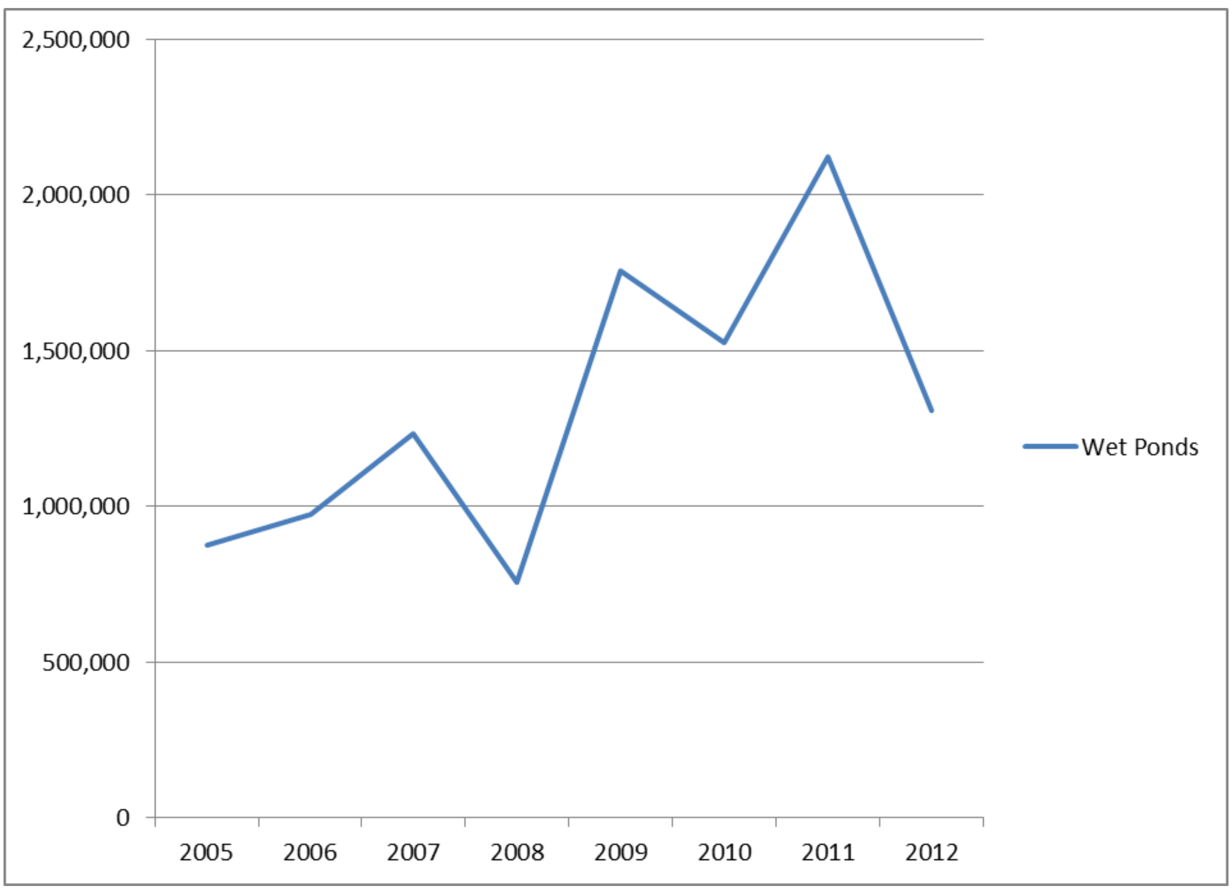
During the 2005 time period, the positive relationship between CRP and breeding duck pairs resulted in an increase in the carrying capacity of 194,947 pairs (5.1%) for the PPR in North Dakota, South Dakota, and north-eastern Montana. The positive impact of CRP to breeding pairs during the 2011 time period was similar (198,125 pairs, including a larger portion of Iowa), with a 4.9% increase in the breeding population attributed to CRP. It should be noted that the analysis area differed in size between the 2005 and 2011 because the earlier landcover version did not have data for the entire PPR (see Figure 4). However, the difference was modest, with the added pair carrying capacity for 2011 when limited to the 2005 analysis extent equivalent to 189,557 pairs.

Not surprisingly, the spatial distribution of the contribution of CRP to attracting and supporting additional breeding duck pairs is closely aligned to the distribution of CRP during the time periods. However, changes in the contribution of CRP over time are related not only to the distribution of CRP but also to the size, location, and class of wetlands associated with CRP grasslands.

Duck Production and CRP

During the period 2005–2012 duck production varied annually (see Table 3), by species, primarily reflecting changes in numbers of wet ponds, breeding pairs and CRP acreage (Figure 3, Table 3). Recruits produced were lowest—approximately 2.7 million—in 2005 and 2006 when pond numbers (Figure 7) and breeding population levels (see Table 3) were relatively low. Recruits increased dramatically beginning in 2009 and peaked during 2011 at over 13 million, coinciding with high pond numbers and high breeding population levels. Across the PPR study area production of recruits with CRP averaged 6.6 million ducks per year. We estimated that for the five duck species, an average ~1.5 million (range = 0.6–2.9 million) additional recruits were produced annually as the result of CRP compared to the same period when we simulated the scenario with cropland in place of CRP (see Table 4; Appendix J). Average percent increases in production resulting from CRP were: 27% for mallard, 17% for gadwall, 23% for blue-winged teal, 21% for northern shoveler, 21% for northern pintail, and 23% for these five species combined. These estimates are approximately 10% lower than those reported for the peak CRP years by Reynolds et al. (2007).

Figure 7. Estimated wet pond numbers for the Prairie Pothole Region of North and South Dakota and northeast Montana derived from the annual Four Square Mile Waterfowl Survey (2005-2012).



CRP Brood Modeling Results

The most supported model indicated that the amount of perennial cover and CRP on the landscape benefited brood numbers. However, wetland type, area, and conditions were more influential to average brood abundance estimates. Parameter estimates indicated that broods were most numerous on seasonal basins, followed by semipermanent and temporary basins, and that these conditions varied as overall wetland conditions changed (Figure 8). Statistical tests for model fit indicated high levels of over-dispersion at the basin level (P<0.01), suggesting that we were unable to capture all of the environmental variation at this scale in our model. The highly inconsistent and often difficult to predict climate and hydrological conditions within the PPR (Euliss et al. 2004, Niemuth et al. 2010, Loesch et al. 2012) are likely two of the main underlying contributors to this variation. Predicted abundance at the plot level, however, correlated with observed numbers of broods (R^2=0.61). Thus, we believe the most supported brood model from our analysis was appropriate for use in comparing relative changes in brood abundance at the four-square mile scale and larger.

Despite the appropriateness of these models for use in making landscape scale predictions, the inherent variability in the data still caused a high degree of uncertainty in our predictions for North Dakota, South Dakota, Minnesota, and Iowa. Predictions of PPR-wide abundance for 2005, 2011, and CRP loss scenarios differed by less than 200,000 broods and confidence intervals overlapped in all cases indicating that the predictions were not significantly different from each other (Tables 5 and 6, Figures 9 and 10).

Figure 8. Predicted number of broods within the PPR of ND and SD for three CRP scenarios: 2005 CRP levels, 2011 CRP levels, and total CRP loss from 2011 levels.

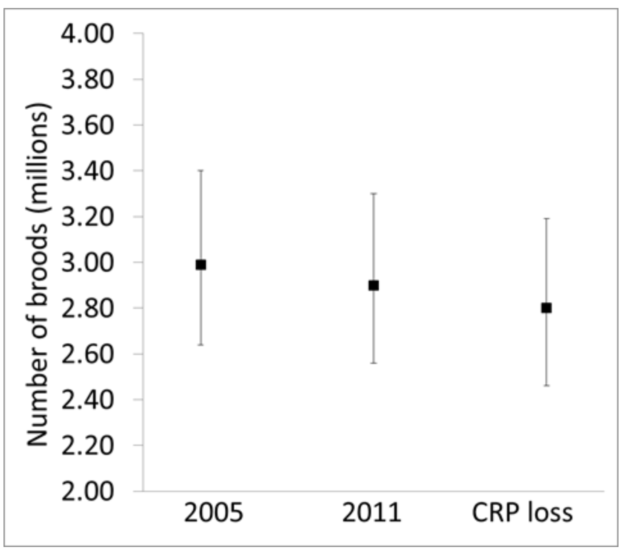


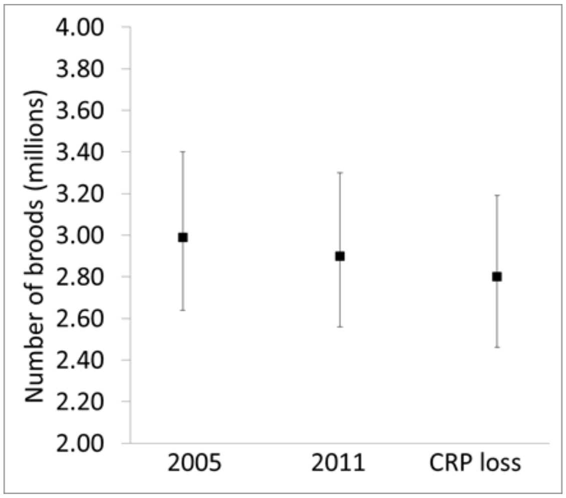
Table 5. Predicted number of broods within the PPR of North Dakota and South Dakota for three CRP scenarios: 2005 CRP levels, 2011 CRP levels, and total CRP loss from 2011 levels. Predictions were calculated using the most supported brood abundance model. Ninety-five percent confidence intervals were calculated using a bootstrap procedure. Predictions calculated from these models indicated that differences between the three CRP scenarios were very small for both the North Dakota and South Dakota area of the PPR (see Table 1, Figures 2-3).

CRP scenario	Estimated # broods (millions)	95% LCL	95% UCL
2005	2.99	2.64	3.40
2011	2.90	2.56	3.30
No CRP	2.80	2.46	3.19

Table 6. Predicted number of broods within the PPR of Iowa and Minnesota for two CRP scenarios: 2011 CRP levels, and total CRP loss from 2011 levels. Predictions were calculated using the most supported brood abundance model. Ninety-five percent confidence intervals were calculated using a bootstrap procedure.

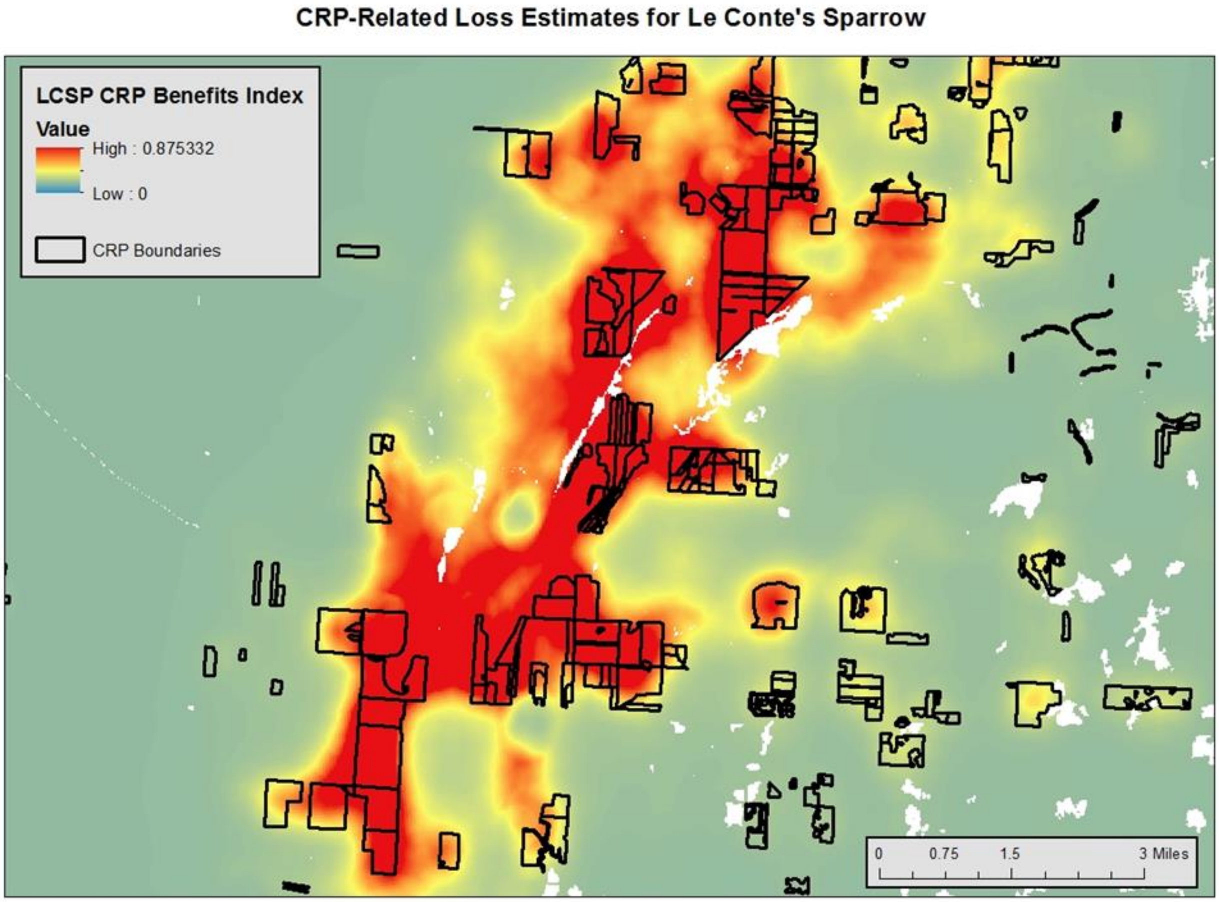
CRP scenario	Estimated # broods (millions)	95% LCL	95% UCL
2011	0.28	0.25	0.32
No CRP	0.26	0.23	0.30

Figure 9. Predicted number of broods within the PPR of IA and MN for two CRP scenarios: 2011 CRP levels, and total CRP loss from 2011 levels.



The assumptions made when calculating the CRP coverage for each plot-year combination in the candidate models added additional uncertainty to our predictions. The brood data that were used to develop the model were collected each year including and between 2007 and 2010.

Figure 10. An example of the spatial heterogeneity of CRP benefits for Le Conte's Sparrow. Values indicate the relative change in abundance estimates (0–1 scale) when the spatial model was re-run after digitally converting all CRP pixels to cropland landcover; white pixels indicate lake or developed landcover where the models do not apply. Results illustrate the spatially heterogeneous patterns of on-CRP and off-site CRP benefits.



Grassland Bird Model Selection Results

We produced spatial models for 12 passerine species, including species in the mixed grass ecoregion (Baird's sparrow, bobolink, chestnut-collared longspur, clay-colored sparrow, grasshopper sparrow, horned lark, Le Conte's sparrow, savannah sparrow, sedge wren, Sprague's pipit, and western meadowlark) and nine species in the tallgrass ecoregion (bobolink, clay-colored sparrow, dickcissel, grasshopper sparrow, horned lark, Le Conte's Sparrow, savannah sparrow, sedge wren and western meadowlark). ZIP (abundance) models were created for all species with the exception of LOGIT (occupancy) models for Sprague's pipit and western meadowlark (Appendices K and L).

Grassland Bird Model Validation Results

Grassland passerine model validation results, using BBS data as an independent validation dataset, indicated a high degree of variation amongst species and between the two ecoregions. In some cases (e.g., clay-colored sparrow, Le Conte's sparrow), models performed well in one ecoregion but poorly in the other, as indicated by the R^2 values from the *k*-fold validation analyses (Table 7 and Appendix M; Johnson et al. 2006). Resulting R^2 values should be considered alongside the BBS precision ratings (i.e., the color codes in Appendix B). While a low R^2 value from this independent dataset validation exercise may be cause for concern, a low value does not necessarily prove poor model performance but rather may reflect a lack of BBS samples being surveyed in areas with relatively high amounts of grassland cover.

Table 7. R2 values from linear regression results comparing model abundance estimates to BBS point occurrence data.

Grassland Bird *k*-fold Model Validation Results		
Species	Tallgrass R^2	Mixed Grass R^2
BAIS		0.32
BOBO	0.86	0.31
CCSP	-0.23	0.72
CCLO		0.54
DICK	-0.68	
GRSP	0.71	0.60
HOLA	0.53	0.37
LCSP	0.89	-0.42
SAVS	0.76	0.34
SEWR	0.83	0.58
SPPI		0.65
WEME	0.00	0.26

As an additional validation step, we compared our modeled population estimates for each species with Partners in Flight (PIF 2013) population estimates for Bird Conservation Region (BCR) 11 (Appendix N), which effectively encompasses the same boundary as the PPJV in the United States. We doubled the HAPET pair estimates to compare our model outputs with individual bird estimates provided by PIF. Results indicate that HAPET models consistently predict a greater number of birds for all species, with the exception of horned lark and clay-colored sparrow, where HAPET models estimated 66% and 68% of the PIF totals, respectively, and dickcissel, which was only modeled in a portion of its range. All remaining species population estimates were less than double the PIF estimates, with the notable exception of bobolink, which was estimated to be nearly 500% of the PIF population estimate.

Grassland Bird Population Estimates and CRP Benefits Results

Our results indicate that CRP grasslands provide substantial benefits for many grassland bird species. As of 2011, CRP grasslands encompassing approximately 4.8% of the study area were estimated to provide disproportionately large benefits for several grassland bird populations (Table 8; Appendix O). The benefits provided by CRP were variable across species and ecoregions, ranging from supporting over 34% (340,000 pairs) of the population of Le Conte's sparrow to supporting 6% (480,000 pairs) of the grasshopper sparrow population in the study area. Within the tallgrass ecoregion, we estimated that approximately 50% of the Le Conte's sparrow population was dependent on CRP. Savannah sparrow exhibited the greatest number of total birds supported by CRP (1.6 million pairs; 12% of the total PPR population), followed by bobolink (1.2 million pairs; 11% of the total PPR population). Baird's sparrow (88,000 pairs; 12% of the total PPR population), clay-colored sparrow (590,000 pairs; 15% of the total PPR population), and sedge wren (475,000 pairs; 15% of the PPR population) also exhibited benefits due to CRP grasslands. For all seven passerine species that exhibited CRP-related benefits, our models indicated that, as of 2011, approximately 4.8 million pairs (9.6 million individuals) of grassland birds were dependent on CRP in the tallgrass and mixed grass portion of the PPR.

Table 8. Population (pair) estimates for grassland bird species for the tallgrass and mixed grass portions of the PPR and the resulting percent change in population levels predicted if all CRP is converted to cropland.

Species	Pair Total (PPR)	PPR Total Change (No CRP)
Baird's Sparrow	750,320	-11.69%
Bobolink	11,060,548	-10.84%
Chestnut-collared Longspur	1,260,031	+21.09%
Clay-colored Sparrow	3,999,747	-14.80%
Dickcissel	818,668	+6.23%
Grasshopper Sparrow	7,275,888	-6.65%
Horned Lark	5,095,463	+11.51%
LeConte's Sparrow	998,728	-34.06%
Savannah Sparrow	13,493,776	-12.10%
Sedge Wren	3,072,148	-15.45%

Chestnut-collared longspur, dickcissel, and horned lark populations all exhibited negative associations with CRP, exhibiting population increases of 21%, 6%, and 12% respectively when all CRP was converted to cropland landcover.

For the seven grassland bird species benefiting from CRP, population impacts were estimated to extend beyond CRP tract (Figure 10) due to the influence of CRP grasslands to the broader landscape context. Changing CRP to cropland typically reduced grassland bird abundance estimates at particular locations and also affected estimates associated with nearby non-CRP habitats; the scale of influence varied by species and ecoregion according to each species' model parameters. Similarly, the surrounding (non-CRP) landscape within which CRP grasslands were embedded influenced the estimated changes in abundance associated with converting any CRP pixel to cropland landcover. A proportion of each species' population was estimated to persist on locations that were converted from CRP to cropland, therefore population-level impacts of CRP were distinguished as a combination of on-CRP and off-site CRP changes in abundance following the simulated conversion of CRP grasslands to cropland landcover (Table 9). Offsite benefits of CRP were generally comparable to on-site benefits, in terms of the proportional combined impact for each species' population, with approximately half of the estimated total population benefits occurring on-CRP versus off-site CRP. For two species, Le Conte's sparrow (16% on-CRP and 18% off-site CRP population benefit) and savannah sparrow (5% on-CRP and 7% off-site CRP population benefit), the landscape context (offsite) benefits of CRP were estimated to exceed the direct (on-CRP) population benefits.

Table 9. Percentages of grassland bird populations benefiting from CRP, directly on CRP landcover in comparison to benefits provided to nearby non-CRP landcover.

Species	Directly supported on CRP lands (% of total PPR population)	Off-site CRP "bonus" from CRP lands (% of total PPR)
Baird's Sparrow	8.87%	2.82%
Bobolink	6.07%	4.77%
Clay-colored Sparrow	7.68%	7.12%
Grasshopper Sparrow	3.65%	3.00%
LeConte's Sparrow	16.47%	17.59%
Savannah Sparrow	5.34%	6.75%
Sedge Wren	8.27%	7.18%

Discussion

Waterfowl Carrying Capacity Discussion

In the PPR, the most widely recognized benefit of CRP grasslands for upland nesting waterfowl is that they function as high quality nesting cover. Additionally, the perennial cover provided by CRP may also influence nest success in other nearby cover types (Reynolds et al. 2001, 2006, 2007; Greenwood et al. 1995). An added benefit is the increased carrying capacity of wetlands adjacent to or embedded in CRP for breeding pairs (Reynolds et al. 2007). Our models suggest that, as of 2011, CRP increased the carrying capacity of wetlands in the PPR by roughly 5% or 200,000 breeding pairs. While the underlying biological cause of the increased response of pair settlement preference to wetlands near CRP, relative to wetlands in cropland, is uncertain, it may be related to improved water storage, reduced sedimentation and nutrient loading, and increased plant diversity or invertebrate abundance associated with wetlands in CRP (Gleason et al. 2011). Additionally, wetlands embedded in grasslands have lower mean concentrations of some pesticides (Anson et al. 2014). Consequently, increased benefits to breeding pair abundance and carrying capacity can be accomplished by targeting CRP enrollment in high wetland density areas in the PPR.

While we did not conduct an assessment of wetland drainage relative to CRP, though the security of wetlands embedded in CRP is likely higher than wetlands in cropland. Higher rates of surface drainage impacts in crop fields, compared to grasslands, were documented in North Dakota and South Dakota (C. Loesch, FWS, Bismarck, ND, unpublished data). Additionally, wetlands restored by conservation organizations in CRP CLUs generally were subject to contract lengths that match the CRP contract and can be re-drained when no longer in CRP. The resulting carrying capacity estimates assume that CRP benefits only apply to wetlands that are directly adjacent to CRP. Wetlands nearby, but not adjacent to CRP, may also benefit (though likely to a lesser degree), and thus our carrying capacity estimates attributed to CRP may be conservative. Furthermore, waterfowl estimates are primarily driven by wetland area—particularly area contributed by relatively small temporary and seasonal wetlands. For our analyses, wetlands were held constant (i.e., there were no changes in the area encompassed by wetlands due to climate or wetland drainage). In reality, if losses of CRP grasslands contribute to increased risk of wetland drainage to wetlands adjacent to or otherwise nearby CRP, the existing benefits of CRP for waterfowl could be substantially greater than what we have estimated.

Waterfowl Annual Recruitment Modeling Discussion

The contribution of CRP as both preferred and more secure nesting cover for upland nesting waterfowl in the PPR is well documented (Reynolds et al. 2001, Reynolds et al. 2007). The magnitude of the CRP program in the PPR resulted in a substantial increase in recruitment for the five species (i.e., ~20%). The change in the annual number of estimated recruits is a function of the amount and distribution of CRP, proximity to other perennial cover, annual wetland conditions, and subsequent breeding populations. The estimated increase in recruits resulting from CRP reported in Reynolds et al. (2007) was larger (i.e., ~30% vs ~20%) than we estimated even though the total acres of CRP were comparable. Differences are likely the result of a lower estimated breeding population for 2005–2012 (mean = 4.08 million) than during 1992–2004 (mean = 5 .02 million). Additionally, changes to the geographic distribution of CRP may also have contributed to the decline.

Waterfowl Brood Modeling Discussion

While the importance of perennial cover to nesting success has been thoroughly studied and is well documented in the literature, the relationship of this landscape factor to brood abundance is less clear. Results from previous studies are ambiguous as some have found a positive effect of perennial cover on broods (Walker et al. 2013) while others found a negative (Amundson and Arnold 2011, Bloom et al. 2012) or neutral (Krapu et al. 2000) effect. Although we did see a weak positive relationship between brood abundance, perennial cover, and CRP, this relationship was overshadowed by covariates describing wetland type, size, and condition. These results are consistent with previous investigations that placed strong emphasis on wetland-related factors and their influence on brood ecology and survival (Krapu et al. 2000, Raven et al. 2007, Amundson and Arnold 2011, Walker et al. 2013).

Grassland Bird Discussion

Grassland Bird CRP Benefits

We estimated substantial benefits from CRP grasslands for many grassland bird species populations in the PPR. As of 2011, CRP grasslands encompassed approximately 4.8% of the study area but appeared to provide disproportionately larger benefits for some grassland bird populations. Further, CRP-related benefits for many species were found to extend to the surrounding landscape, indicating a value-added nature of CRP when targeted in close proximity to non-CRP wildlife habitat.

These results are consistent with past research documenting positive relationships between many grassland bird species and CRP grasslands (e.g., Johnson and Schwartz 1993, Herkert 1998, Johnson 2005, Niemuth 2007, etc.)—in particular, bobolink (Koford 1999), grasshopper sparrow (Herkert 1998, Dechant et al. 2003a), Le Conte’s Sparrow (Igl and Johnson 1995, Dechant et al. 2002, Lowther 2005), savannah sparrow (Swanson 2003), and sedge wren (Herkert et al. 2001, Dechant et al. 2003b). In some cases, CRP grasslands have been documented as providing habitat that is comparable or better than public lands managed for waterfowl or other wildlife species (Koford 1999, Cunningham 2000).

However, different species respond differently to the presence and/or loss of CRP grasslands and the magnitude of responses may further vary throughout the geography of a species’ range (Johnson 2005). Management of CRP grasslands, or lack thereof, will affect vegetation structure and composition, which will ultimately influence which species benefit. Further, local occurrence and abundance is subject to considerable variation among species resulting from varying natural histories, migration and wintering factors, breeding ranges, and annual population levels. Consequently, the relative importance of CRP grasslands will likely also fluctuate annually in response to annual weather patterns, succession of vegetation communities, and fluctuations in the numbers and distributions of birds relative to climate change (Johnson 2005). Other studies have emphasized the importance of evaluating the biological benefits of CRP at a variety of spatial and temporal scales (Quamen 2007, Riffell et al. 2008).

For example, we estimated that approximately 34% of the Le Conte sparrow population in the PPR is dependent on CRP grasslands. However, Igl and Johnson (1995) found dramatic increases of Le Conte’s sparrows in CRP grasslands during wet conditions, suggesting that the proportion of the population may shift in response to climate and that during drier years CRP may be less utilized by Le Conte's sparrow populations. Given that Le Conte's sparrow also appeared to benefit indirectly (due to off-site CRP benefits extending from CRP grasslands), this may further support conservation strategies that focus on providing broader grassland-wetland complexes, including a mosaic of grassland structure and wetland classes, within which CRP can play an integral component. While the proportion of the population that exists on CRP in a given year will vary, the importance of CRP for long-term population resilience and general carrying capacity should not be discounted.

For species that are known to be positively associated with cropland (i.e., horned lark; Beason 1995), known to prefer grazed or mowed structure (i.e., chestnut-collared longspur; Hill and Gould 1997), or simply known to be highly variable each year (i.e., dickcissel; Temple 2002), our results confirm that not all species will benefit from the dense vegetation structure and non-native species composition common to CRP grasslands. The conservation of native prairie, grazing and other disturbance (i.e., occasional fire, haying, and/or mowing) of both native and non-native grasslands, will continue to be important to maintaining desired population levels of grassland songbirds and the overall diversity of grassland-dependent wildlife throughout the PPR. CRP grasslands under current management conditions contribute one important component to the broader dynamic landscape mosaic of variable grassland and wetland types.

Grassland Bird Population Estimates

In nearly all cases, our passerine population estimates were substantially larger than those published by Partners in Flight (PIF 2013; Appendix N) using BBS data. However, the BBS survey protocol was designed to assess trends in population numbers and not designed to produce detection functions or quantitative abundance estimates. The grassland bird data (Quamen 2007) used to develop HAPET grassland bird abundance models were sampled to maximize the range of variation in the amount of grassland in the nearby landscape. This helps to ensure that the resulting models are interpolating within the range of observed variation, thereby allowing stronger inferences about grassland bird populations across a gradient of landscape conditions, whereas the BBS was designed to assess relative trends in species' population change over time at the continental/regional scale using a representative sample. The PIF (2013) population estimates are based on BBS survey data—adjusted by area surveyed and non-statistical "detection adjustments" (Blancher et al. 2007). BBS data and related PIF estimates can provide a useful validation mechanism though caution is warranted when using these data for abundance estimation purposes beyond their intended design.

Grassland Bird Model Validation

For all ZIP models, validation options were limited to comparing the observed occupancy of BBS points with modeled abundance estimates at those points. While each ZIP model includes an occupancy (logistic regression) component, their ultimate output is an abundance estimate (pairs per 30-m pixel). This means models were validated in terms of the relationship between abundance predicted by our models and occupancy observed from BBS data. For models with moderate to high R^2 values, we believe this implies confidence in spatial predictions as a good index of relative habitat quality. Further, our validation process confirmed, in most cases, a high degree of correlation between the proportion of the BBS-observed population and the resulting k-fold habitat bins (see Table 7 and Appendix M), indicating the spatial distribution of species populations can be considered valid relative to the R^2 value reported; estimates of percent population change in response to CRP can thus also be considered valid.

We consider the results of this validation process, for those models ultimately selected for further use, to imply reasonable confidence in the spatial distribution and habitat relationships, as well as their proportional spatial distribution. Comparisons can be made using the outputs of selected models, as a relative index of population change, in response to alternative landcover change scenarios applied at regional (e.g., ≥ multi-county) scales. However, actual quantitative population estimates should be used with caution until they are further validated. Further, site-level estimates should be expected to exhibit substantial variability in comparison with field-observed data, due in part to underlying variability of vegetative structure and composition not captured in broad-scale landcover data, along with local climate factors, and more general landcover classification errors.

Interpretation of the Spatial Prioritization Tool for CRP Targeting

The value and usefulness of spatial decision support tools are directly related to the quality of the models used to estimate species demographics and the spatial resolution and quality of the landscape metrics the models are subsequently dependent upon (e.g., the landcover data input). Often, when the area is as large as the PPR, the landscape data tends to be more generalized in nature. As a result, the model predictions are general and useful at broad scales but become more tenuous when examined at local scales. These tools are particularly valuable for identifying areas within large landscapes that are likely to be of higher biological value for target species than other locations. When data for multiple species is available, identification of areas with potential for multiple species benefits can be identified and conservation actions can be prioritized accordingly. We developed a framework for a customizable decision support tool for the PPR using multi-species benefits that can be utilized to identify focal areas for informing CRP re-enrollment or new enrollment decisions relative to breeding waterfowl and grassland passerine outcomes. This tool can be used in combination with other CRP targeting criteria, such as water quality improvements or other ecosystem services.

In addition to the spatial priorities identified for maximizing CRP benefits in areas where both waterfowl and grassland birds will benefit, various additional guidelines might also be considered. For example, Reynolds et al. (2007) provided the following recommendations to maximize benefits for waterfowl, which remain highly relevant:

1. CRP cover should be located near areas where sufficient wetlands exist that attract moderate to high numbers of breeding hens that have access to the cover for nesting;
2. CRP cover should be planted in relatively large blocks to reduce edge;
3. Conservation Practices targeting wetlands in the PPR should allow whole field enrollment to reduce fragmentation and edge around wetlands (e.g., CP37); and
4. CRP enrollment criteria should, if possible, encourage CRP contracts in areas near other CRP cover, or other forms of existing perennial grassland cover, to avoid isolated patches.

Additionally, our results suggest that individual CRP enrollments may extend grassland bird benefits to other CRP lands nearby—and thus it is advisable to concentrate CRP in strategic focal areas. It may also be biologically advantageous to prioritize CRP near other high-quality permanently protected areas, to ensure some perpetual landscape context benefits persist, thus minimizing the potential for extensive loss or fragmentation of nearby habitat over the duration of the CRP contract.

Many grassland birds will benefit from these criteria, with a particular emphasis on creating large areas of predominantly grassland cover, nesting within broader grassland-wetland mosaics of varying structure and composition (i.e., combined alongside native prairie, pasture, and other actively managed grassland areas that contribute a diversity of structure within a landscape of approximately 2–4 square miles in area) and/or as components of wetland complexes. Most grassland birds of concern will also benefit by locating CRP grasslands away from trees (Grant et al. 2004, Kelsey et al. 2006). While many grassland bird species can benefit by targeting CRP in areas that will also provide nesting cover for waterfowl, additional focus will likely need to be dedicated to xeric grasslands to ensure sufficient habitat persists for grassland-dependent species (e.g., grasshopper sparrow) that respond positively to CRP grassland cover but which are otherwise not strongly associated with wetland habitats that are highlighted when simultaneously pursuing waterfowl benefits.

The population priority thresholds we used to prioritize CRP (e.g., the top 25%, 50%, or 75% for waterfowl and the top 25% for passerines) are an admittedly subjective example of how this "multi-dimensional" information can be integrated to prioritize CRP grasslands to provide multiple benefits for wildlife (Appendix P). The results highlight locations where:

1. Existing CRP provides important multi-species migratory bird benefits;
2. Areas where additional CRP grasslands would likely be beneficial for both breeding waterfowl and grassland passerines; and
3. Existing CRP overlaps with few migratory bird benefits (and thus could be considered as candidates to let expire and shift resources elsewhere).

Changing both the priority population thresholds and species of interest will result in changes to the targeted areas identified. Ultimately, identifying thresholds used for spatial prioritization can be a situation-specific process that considers a number of factors including species priorities, habitat considerations alongside population objectives, and the contributions of other public and private lands conservation programs throughout the PPR. Additional species models or other ecosystem services prioritizations could be incorporated in the future. HAPET will continue to work with USDA–FSA to customize these tools, as needed, to guide strategic habitat conservation efforts in the PPR.

Implications for PPJV Planning

Recent assessments suggest ongoing declines in grassland and wetland habitat are occurring throughout the PPR and will likely continue for some time (Doherty et al. 2013, Wright and Wimberly 2013, Dahl 2014), translating to long-term declines for some wildlife species populations. The biological outcomes of ongoing agricultural conversion may not be immediately apparent due to a combination of climate variability (e.g., an ongoing period of above average wetness), inadequate monitoring activities, lag time and error associated with landcover processing, and the many technical challenges associated with accurately estimating biological outcomes. The implications for wildlife population declines may not be fully realized for several years and could be exacerbated by future changes in climate.

The CRP provides important benefits for wildlife amidst a landscape of constant change. Resilience of the PPR landscape depends fundamentally on the availability of wetland and grassland habitat (Niemuth et al. 2014) and CRP grasslands remain a critical component of the conservation estate in the PPR. In addition to providing millions of acres of direct contributions to habitat, CRP provides connectivity in an increasingly fragmented landscape, effectively providing value-added “landscape context” benefits for many wildlife species. In the context of ongoing habitat fragmentation, the biological benefits provided by CRP may be disproportionally important in the future.

It should also be reiterated that many species of concern will continue to depend on untilled native prairie and that some important grassland birds and other wildlife species will rarely utilize cropland or CRP fields under current management practices (e.g., Sprague’s pipit and Baird’s sparrow; Johnson 2005). However, management activities that affect the structure and composition of vegetation on CRP grassland can greatly influence the resultant wildlife benefits. The CRP provides an important tool in the conservation toolbox for the PPR, which can be best utilized as part of a comprehensive strategy that leverages fee-title acquisitions of native prairie and wetland habitats alongside other federal and state conservation programs.

The rate and ultimate lower limit to which CRP and other habitat will decline remains unclear, particularly as agricultural commodity prices fluctuate, genetic modification of crops continues, and agricultural conversion extends further into increasingly marginal agricultural lands throughout this dynamic landscape. Since the 2011 study period, roughly 2 million additional acres of CRP have expired, concurrent with other grassland and wetland habitat losses throughout the PPR. The future will undoubtedly hold many challenges for conservation in the PPR. Spatial analyses of wildlife habitat and population outcomes can help account for the importance of CRP and can be applied to maximize the contributions of future CRP enrollments for wildlife through strategically targeting the best opportunities; however, these benefits will need to be considered alongside other ecosystem services models to truly demonstrate the full ecological and economic benefits of CRP to society.

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Appendix

In this appendix:

<u>Appendix A</u>*. *2011 Landcover classes of the PPR by state/ecoregion (total acres). *Acres are summed for the mixed grass (MG) and tallgrass (TG) ecoregions, by state, based on HAPET 2011 Landcover data.*

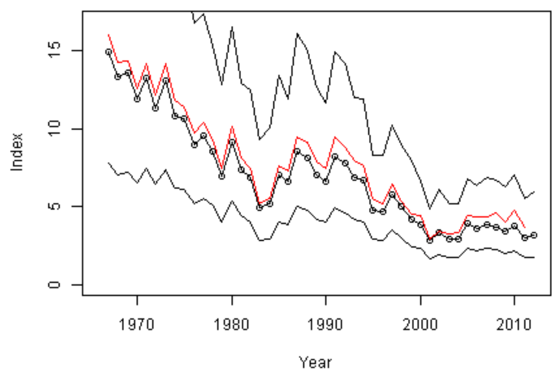
	Total Acres of Each Landcover Class by Ecoregion/State Within the PPJV							
2011 Landcover Class	**MT (MG)**	**ND (MG)**	**SD (MG)**	**IA (TG)**	**MN (TG)**	**SD (TG)**	**ND (TG)**	**Total**
Unclassified	32,289	38,880	51,516	25,235	20,268	22,167	669	191,024
NDWI water	6,074	437,788	123,609	15,083	82,702	113,713	20,972	799,941
NLCD Developed, Open Space	6,913	88,773	32,258	276	155,905	35,389	34,364	353,878
NLCD Developed, Low Intensity	3,064	48,804	24,649	129,911	139,250	30,491	34,343	410,513
NLCD Developed, Medium Intensity	885	15,940	13,779	48,423	53,496	20,196	16,054	168,772
NLCD Developed, High Intensity	97	3,630	4,000	14,835	16,421	6,040	5,317	50,341
Barren	0	0	0	1,506	904	0	0	2,411
Forest	8,157	281,731	36,017	374,601	2,084,291	90,382	160,872	3,036,051
Shrub	7,233	18,625	4,901	0	88,785	0	1,507	121,051
Grassland / Herbaceous	1,184,312	4,168,296	2,640,224	640,746	588,089	624,762	81,066	9,927,495
CRP	388,111	1,749,736	422,897	342,627	1,278,871	277,508	215,946	4,675,696
Undisturbed Grassland	333,002	3,124,316	1,932,137	563,466	2,013,658	730,800	354,890	9,052,269
Hay	93,526	712,269	557,819	104,624	955,849	153,430	68,916	2,646,433
Cropland	1,363,306	14,326,188	7,949,271	10,007,817	16,303,046	4,736,676	3,898,228	58,584,532
FWS Temporary Wetland	12,619	278,517	253,348	45,617	96,607	86,044	34,127	806,879
FWS Seasonal Wetland	17,402	802,507	374,727	71,971	380,371	114,486	55,639	1,817,101
FWS Semipermanent Wetland	15,677	782,286	400,294	48,602	443,155	276,100	48,018	2,014,133
FWS Lake Wetland	32,449	796,209	255,927	90,558	1,125,451	182,544	28,541	2,511,680
FWS Riverine Wetland	6,226	29,717	33,075	47,820	84,609	16,105	15,688	233,239
Total:	3,511,340	27,704,213	15,110,448	12,573,719	25,911,725	7,516,835	5,075,159	97,403,438

<u>Appendix B</u>. National and regional Breeding Bird Survey (BBS) annual grassland bird population trends. *Breeding Bird Survey (BBS) trends in Bird Conservation Region 11 (BCR 11; Prairie Pothole Region; Sauer et al. 2014). Values in parentheses indicate the upper and lower 95% credible intervals. Colors indicate relative sampling precision (red = "very low" precision, black = "low" precision, blue = "moderate" precision), illustrating generally poor BBS coverage for most grassland birds regionally and nationally.*

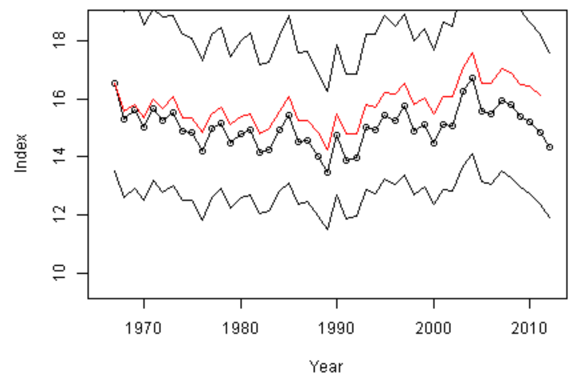
	BBS Annual Trends (1966–2012) (95% CI)		BBS Annual Trends (1982–2012) (95% CI)	
	BCR 11	**National**	**BCR 11**	**National**
Baird's Sparrow	-3.39 (-4.99, -1.73)	-1.10 (-7.63, 7.83)	-0.57 (-5.67, 5.11)	-2.96 (-4.70, -0.70)
Bobolink	-0.3 (-0.9, +0.2)	-1.14 (-1.54, -0.77)	-0.50 (-2.10, 0.87)	-0.82 (-2.03, 0.41)
Chestnut-collared Longspur	-4.47 (-5.51, -3.40)	-3.76 (-4.75, -2.74)	-3.86 (-5.74, -1.75)	-2.33 (-4.57, 0.17)
Clay-colored Sparrow	-0.90 (-1.37, -0.44)	0.10 (-0.88, 0.92)	0.17 (-0.91, 1.33)	0.41 (-1.09, 1.89)
Dickcissel	0.83 (-0.35, 1.95)	-0.55 (-1.05, -0.12)	9.00 (5.20, 13.07)	1.10 (0.15, 2.10)
Grasshopper Sparrow	-2.20 (-3.13, -1.17)	-2.82 (-3.46, -2.32)	-0.62 (-3.18, 2.05)	-1.49 (-2.82, -0.12)
Horned Lark	-3.61 (-4.34, -2.93)	-1.57 (-1.97, -1.24)	-2.05 (-3.49, -0.53)	-1.28 (-2.02, -0.59)
Le Conte's Sparrow	0.29 (-1.20, 1.76)	2.23 (0.13, 4.28)	2.88 (-0.83, 7.22)	2.46 (-2.42, 7.31)
Savannah Sparrow	0.36 (-0.05, 0.74)	-1.21 (-1.63, -0.84)	-0.63 (-1.70, 0.34)	-1.77 (-2.67, -0.81)
Sedge Wren	5.11 (3.30, 6.57)	1.88 (0.92, 2.70)	5.95 (2.47, 9.45)	3.60 (1.21, 5.97)
Sprague's Pipit	-3.40 (-4.78, -1.97)	-0.12 (-2.26, 1.99)	-3.11 (-6.53, 0.81)	0.09 (-6.57, 7.31)
Western Meadowlark	-2.02 (-2.39, -1.62)	-1.31 (-1.54, -1.03)	-0.91 (-1.64, -0.12)	-1.17 (-1.56, -0.75)

<u>Appendix C</u>. Breeding Bird Survey (BBS) annual plots (1967–2012) for selected grassland passerines in Bird Conservation Region (BCR) 11. *Breeding Bird Survey (BBS) Trend Plots (Sauer et al. 2014), for Bird Conservation Region 11 (BCR 11, Prairie Pothole Region) for 12 grassland birds. Red lines indicate "adjusted" model estimates; outer bounds indicate the 95% credible intervals associated with relative population estimates. Colors associated with each species in Appendix B should also be considered with regard to BBS sampling coverage and model validity.*

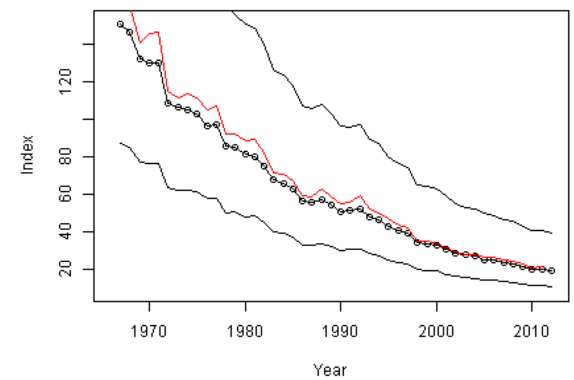
<u>Baird's Sparrow:</u>



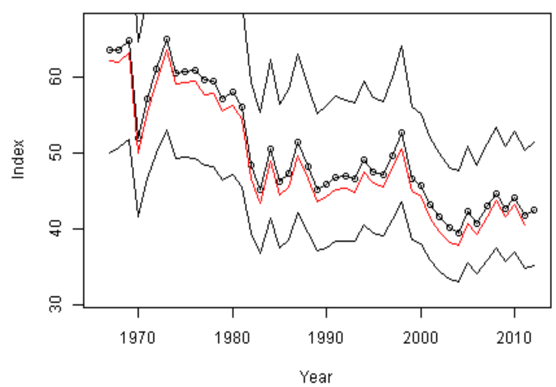
<u>Bobolink:</u>



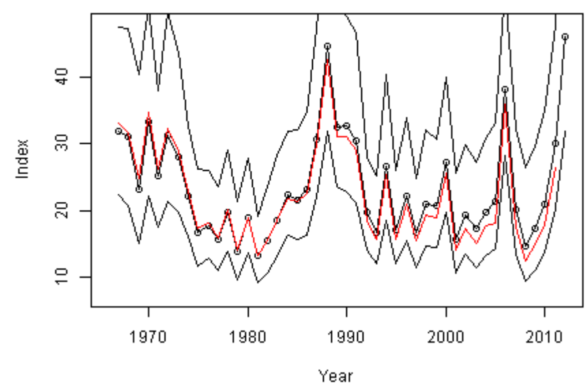
<u>Chestnut-collared Longspur:</u>



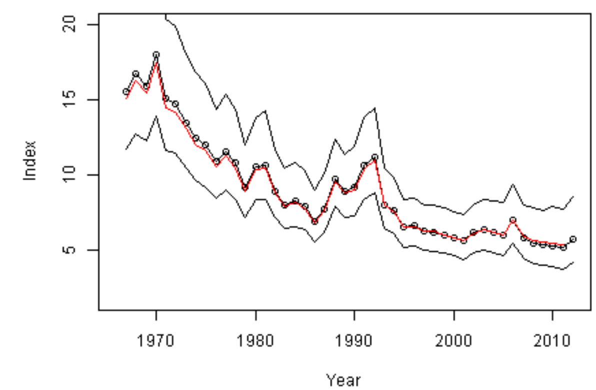
<u>Clay-colored Sparrow:</u>



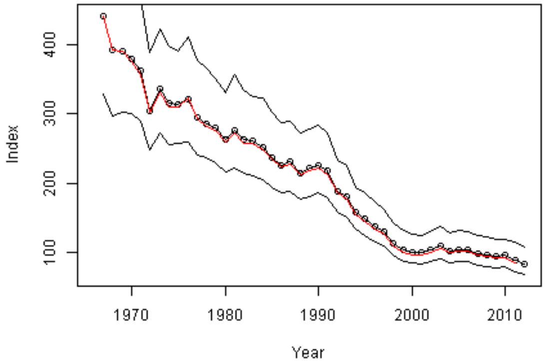
<u>Dickcissel:</u>



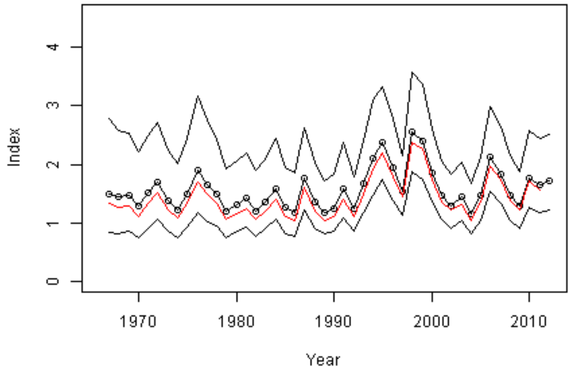
<u>Grasshopper Sparrow:</u>



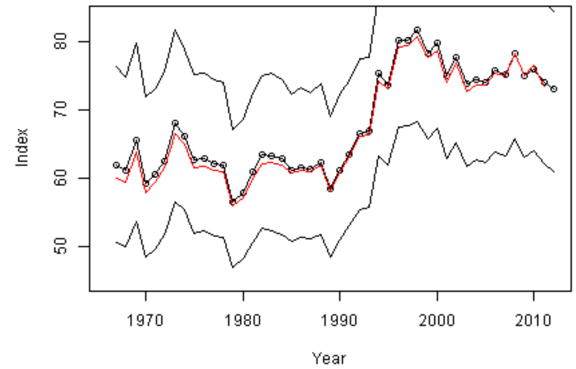
Horned Lark:



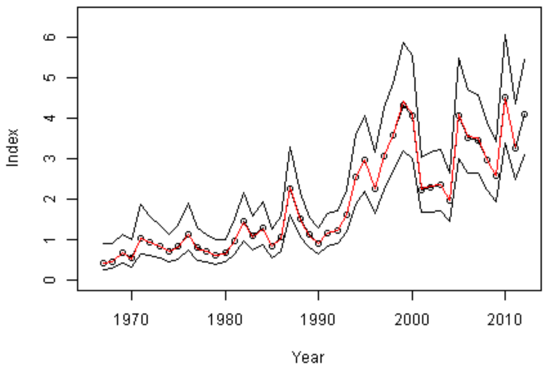
LeConte's Sparrow:



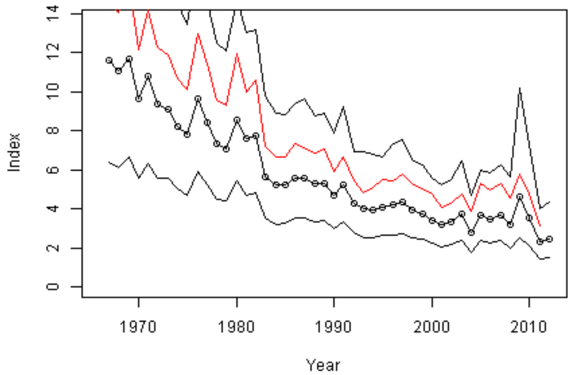
Savannah Sparrow:



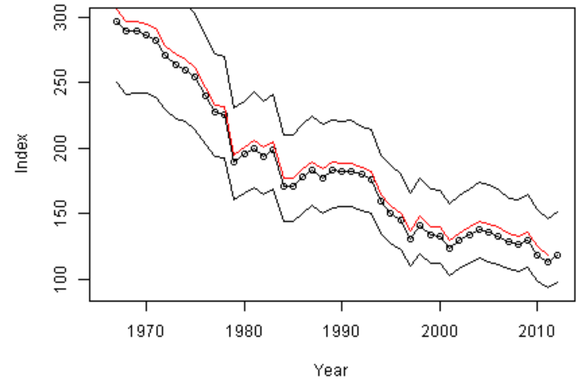
Sedge Wren:



Sprague's Pipit:



Western Meadowlark:



***Appendix D*. Conservation Reserve Program (CRP) Conservation Practice (CP) Types classified as perennial grassland landcover.** *Yellow highlights indicate those CP types that were classified as "undisturbed grassland" in the HAPET 2011 Landcover spatial dataset (Estey et al. 2014); all other CP types were classified according to remote imagery classification processing regardless of CRP enrollment status.*

Practice	Conservation Practice (CP) Type Description
<null>	<None specified>
CP1	Establishment of permanent introduced grasses and legumes
CP10	Vegetative cover – grass – already established
CP11	Vegetative cover – trees – already established
CP12	Wildlife food plot
CP13	Vegetative filter strips
CP13A	Vegetative filter strips (grass)
CP13C	Vegetative filter strips (grass), noneasement
CP14	Bottomland timber established on wetlands
CP15	Establishment of permanent vegetative cover (contour grass strips)
CP15A	Establishment of permanent vegetative cover (contour grass strips), noneasement
CP15B	Marginal pastureland (contour grass strips) on terraces
CP16	Shelterbelt establishment
CP16A	Shelterbelt establishment, noneasement
CP17	Living snow fence
CP17A	Living snow fence, noneasement
CP18	Establishment of permanent vegetation to reduce salinity
CP18A	Establishment of permanent salt tolerant vegetative cover
CP18B	Establishment of permanent vegetation to reduce salinity, noneasement
CP18C	Establishment of permanent salt tolerant vegetative cover, noneasement
CP19	Alley cropping
CP2	Establishment of permanent native grasses
CP20	Alternate perennial
CP21	Filter strips
CP22	Riparian buffer
CP23	Wetland Restoration
CP23A	Wetland Restoration, nonflood plain
CP24	Cross Wind Trap Strips
CP25	Rare and Declining Habitat
CP26	Sediment retention
CP27	Farmable Wetland Pilot Wetland
CP28	Farmable Wetland Pilot Buffer
CP29	Marginal pastureland wildlife habitat buffer
CP3	Tree planting
CP30	Marginal pastureland wetland buffer

CP31	Bottomland timber established on wetland
CP32	Expired hardwood tree planting
CP33	Habitat for upland birds
CP34	Flood Control System
CP35A	Emergency Forestry – Longleaf Pine, New
CP35E	Emergency Forestry – Bottomland Hardwood, New
CP36	Continuous Longleaf Pine
CP37	Duck Nesting Habitat
CP38A	SAFE – Buffers
CP38B	SAFE – Wetlands
CP38C	SAFE – Trees
CP38D	SAFE – Longleaf Pine
CP38E	SAFE – Grass
CP39	Constructed Wetland
CP3A	Hardwood tree planting
CP4	Permanent wildlife habitat
CP40	Farmable Wetlands Aquaculture Wetland Restoration
CP41	Farmable Wetlands Flooded Prairie Wetland
CP42	Pollinator Habitat
CP4A	Permanent wildlife habitat (corridors)
CP4B	Permanent wildlife habitat (corridors), noneasement
CP4C	Permanent wildlife habitat
CP4D	Permanent wildlife habitat, noneasement
CP5	Field windbreak establishment
CP5A	Field windbreak establishment, noneasement
CP6	Diversions
CP7	Erosion control structure
CP8	Grass waterways
CP8A	Grass waterways, noneasement
CP9	Shallow water areas for wildlife
CP9A	Shallow water areas for wildlife
Easmt	Unspecified Easement (?)
"None"	<None specified>

<u>Appendix E</u>. Landcover class descriptions for 2005 and 2011 HAPET Landcover datasets used in the assessment of CRP benefits for breeding ducks. *"Reclass Code" indicates attribute values associated with HAPET landcover datasets.*

2011 HAPET Landcover

Original NLCD Code	Reclass Code	Description
10	1	Water/Wetland – all areas of open water and/or wetland vegetation. Includes Temporary, Seasonal, Semipermanent, Lake, and Riverine wetlands.
11	1	NDWI water from first cloud free LandSat of 2011. Open Water – All areas of open water, generally with less than 25% cover of vegetation or soil.
12	1	NLCD Perennial Ice/Snow – All areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
21	7	NLCD Developed, Open Space – Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes
22	7	NLCD Developed, Low Intensity – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.
23	7	NLCD Developed, Medium Intensity – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50–79% of the total cover. These areas most commonly include single-family housing units.
24	7	NLCD Developed, High Intensity – Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to 100% of the total cover.
31	10	Barren Land (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
40	6	Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover.

41	6	NLCD Deciduous Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42	6	NLCD Evergreen Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
43	6	NLCD Mixed Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
52	9	Shrub/Scrub – Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
71	2	Grassland/Herbaceous – Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for grazing.
72	2	Grassland/Forbe/Legume – Similar to 71 but with a legume component probably sweet clover. These areas are not subject to intensive management such as tilling but can be utilized for grazing. Developed by CLoesch by reclassifying Class 80 where it intersected with non-cultivated locations identified in the 2012 NASS Cultivated Land Dataset.
75	3	CRP – Areas enrolled in the USDA Conservation Reserve program and the Conservation Practice resulted in plantings of perennial, non-woody vegetation.
76	2	Undisturbed Grassland – Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to grazing or intensive management such as tilling. These areas commonly include CRP and WPAs.
80	5	Hay – Areas of grasses, legumes, or grass-legume mixtures planted for hay crops, or areas of grammanoid or herbaceous vegetation typically hayed on a perennial cycle. NOTE: This definition may be changed to include only tame hay with an alfalfa threshold depending on how the classification process distinguishes this class.
81	2	NLCD Pasture/Hay – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.

82	5	Crop / Cultivated Crops – Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
84	5	Hay – Areas of grasses, legumes, or grass-legume mixtures planted for hay crops, or areas of grammanoid or herbaceous vegetation typically hayed on a perennial cycle. Developed by C. Loesch by reclassifying Class 80 where intersected with cultivated locations identified in the 2012 NASS Cultivated Land Dataset.
90	1	NLCD Woody Wetlands – Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95	1	NLCD Emergent Herbaceous Wetlands – Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
111	11	FWS Temporary Wetlands
112	12	FWS Seasonal Wetlands
113	13	FWS Semipermanent Wetlands
114	14	FWS Lake Wetlands
115	15	FWS Riverine Wetlands
116	16	FWS Intermittent Riverine Wetlands

1995 and 2006 Landcover Classification

Code	Description
1	Water – Water present at the time satellite imagery was collected that was not present when NWI data were collected. This is an artifact of recent unusually wet periods and is most evident around large water bodies in the eastern portion of the region
2	Grassland – Mix of native grass, forb, or scattered, low shrub species on untilled prairie; typically grazed or hayed annually.
3	Undisturbed Grass – Mix of cool-season grass and forb species planted on previously cropped land; generally undisturbed but may be hayed or grazed intermittently.
4	Hay – Mix of alfalfa and cool-season grass species hayed once or twice annually.
5	Cropland – Tilled and planted with small grains or row crops that are harvested annually; includes fallow fields.
6	Forest – Trees and forest cover; rarely includes small patches or shelterbelts.

7	Urban – Urban lands identified using digital mask of incorporated areas.
8	Cloud – Areas where clouds prevented collection of TM data.
9	Shrub/Grass - GAP landcover data used to fill cloud-related gaps in Montana. Treat as grassland.
10	Barren – Large mines, gravel pits, alkali flats, and sand bars.
11	Temporary Wetland – Wetland basins[a] in which surface water is present for brief periods during the growing season but the water table is otherwise well below the soil surface.
12	Seasonal Wetland – Wetland basins[a] in which surface water is present for extended periods, especially early in the growing season, but is absent by the end of the season in most years.
13	Semipermanent Wetland – Wetland basins[a] in which surface water persists throughout the growing season in most years. When surface water is absent, the water table is at or near the soil surface.
14	Lake – Wetland basins[a] in which surface water is present throughout the year in all years. Includes permanent wetlands and lakes.
15	River – All wetlands and deepwater habitats contained within a channel.
16	FWS Intermittent Riverine Wetlands.
17	Enrolled CRP.

FWS Region 3 Landcover Crosswalk (2005)

Value	Reclass Code	Description
1	1	Water – Water present at the time satellite imagery was collected that was not present when NWI data were collected. This is an artifact of recent unusually wet periods and is most evident around large water bodies in the eastern portion of the region
2	1	Wetlands – Not on NWI not listed below
3	1	Bog not delineated on NWI
4	1	Cattails not on NWI
11	4	Hayland
12	5	Cropland
13	10	Barren
14	9	Shrub
15	7	Urban/developed
21	14	Permanent wetland
22	15	Riverine
23	12	Seasonal wetland
24	13	Semi-permanent wetland

25	11	Temporary wetland
26	14	Forested wetland
27	14	Scrub – shrub wetland
99	6	All forest
100	2	All grass
n/a	16	Enrolled CRP from layer provided by DHertel (1997)

***Appendix F*. Grassland Passerine Models Landcover Input Classification.**

Value	Cover Class	Grassland Bird Model Inputs
0	Unclassified	N/A
10	Decision Tree Modeled Water	N/A
11	NDWI water from first cloud free LandSat of 2011	N/A
12	NLCD Perennial Ice / Snow	N/A
21	NLCD Developed, Open Space	*Developed**
22	NLCD Developed, Low Intensity	*Developed**
23	NLCD Developed, Medium Intensity	*Developed**
24	NLCD Developed, High Intensity	*Developed**
31	Barren	N/A
40	forest	tree
41	NLCD Deciduous Forest	tree
42	NLCD Evergreen Forest	tree
43	NLCD Mixed Forest	tree
52	Shrub	N/A
71	Grassland / Herbaceous	grass_herb
75	CRP	und_crp
76	Undisturbed Grassland	und_crp
80	Hay	hay
81	NLCD Pasture / Hay	hay
82	Cropland	crop
90	NLCD Woody Wetlands	tree
95	NLCD Emergent Herbaceous Wetlands	seas
111	FWS Temporary Wetlands	temp
112	FWS Seasonal Wetlands	seas
113	FWS Semipermanent Wetlands	semi
114	FWS Lake Wetlands	*Lake**
115	FWS Riverine Wetlands	N/A
116	FWS Intermittent Riverine Wetlands	N/A

** Developed and Lake cover classes were not used directly as model inputs. For all lake and developed pixels, abundance estimates were reclassified to zero.*

***Appendix G*. Conservation Reserve Program (CRP) Conservation Practice (CP) Types acres, by state, within the PPJV for 2011.** *Yellow highlights indicate those CP types that were classified as CRP (grassland) landcover in the HAPET 2011 Landcover spatial dataset (Estey et al. 2014).*

Practice	IA	MN	ND (Mixed)	ND (Tall)	SD (Mixed)	SD (Tall)	MT (Mixed)	MT (Short)	SUM All PPJV States	% of Total CRP Acres
<null>	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.00%
CP1	15,262.5	150,063.3	155,224.8	10,652.5	7,194.8	4,504.7	69,540.6	242,583.1	655,026.3	10.23%
CP10	22,871.4	126,612.6	585,678.7	31,117.5	42,968.2	34,319.8	215,676.8	490,462.0	1,549,707.1	24.20%
CP11	1,305.0	11,759.7	731.6	134.3	200.1	341.0	83.4	400.9	14,955.9	0.23%
CP12	658.6	2,659.8	562.2	16.7	739.7	361.7	202.0	1,700.8	6,901.5	0.11%
CP13	124.7	10.2	104.7	0.0	0.0	9.6	13.7	0.0	263.0	0.00%
CP13A	1.3	80.0	9.1	0.0	0.0	0.0	0.0	0.0	90.5	0.00%
CP13C	29.0	8.9	2.0	12.0	0.8	0.0	0.0	0.0	52.7	0.00%
CP14	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	4.0	0.00%
CP15	29.3	0.0	0.0	0.0	49.3	15.0	0.0	0.0	93.6	0.00%
CP15A	2,250.1	31.8	8.0	36.3	32.2	22.6	0.0	0.0	2,381.0	0.04%
CP15B	16.4	87.1	0.0	0.0	0.0	0.0	0.0	0.0	103.4	0.00%
CP16	10.3	6.0	13.0	0.8	550.3	107.3	3.0	11.4	702.1	0.01%
CP16A	1,289.8	47.9	3,537.2	493.5	8,006.6	3,042.0	28.9	67.2	16,513.2	0.26%
CP17	0.9	3,760.1	5.9	6.2	29.7	0.0	0.0	0.0	3,802.9	0.06%
CP17A	417.4	219.8	167.2	107.3	223.6	106.9	84.6	25.0	1,351.8	0.02%
CP18	0.7	3,375.1	19.2	40.1	234.1	55.3	676.9	1,521.7	5,923.1	0.09%
CP18A	5.3	120.4	0.0	0.0	2.9	0.0	0.0	17.6	146.3	0.00%
CP18B	0.0	52.5	1,976.9	0.0	1,079.9	139.5	240.5	46,623.5	50,112.7	0.78%
CP18C	0.0	7.2	25,840.4	65,237.4	10,166.8	1,119.0	154.8	2,705.6	105,231.1	1.64%
CP19	13.9	6,193.9	76.1	0.0	0.0	4.9	0.0	1,434.7	7,723.4	0.12%
CP2	26,105.0	0.0	39,727.3	10,672.2	40,399.6	46,712.4	76,713.5	395,642.4	635,972.4	9.93%
CP20	188.9	89,895.3	4.0	4.4	5.3	21.7	166.4	36.6	90,322.7	1.41%
CP21	85,693.0	171.2	4,581.5	4,977.5	3,167.0	5,985.7	131.8	68.7	104,776.5	1.64%
CP22	13,242.3	142,874.1	1,231.6	294.9	3,325.0	1,848.7	428.5	403.0	163,648.0	2.56%

CP23	32,977.3	34,880.4	547,588.1	22,147.7	135,135.4	75,987.8	0.0	1,270.1	849,986.8	13.27%
CP23A	5,111.2	283,288.0	13,092.3	3,837.8	38,862.3	11,057.8	0.0	0.0	355,249.4	5.55%
CP24	20.7	55,874.9	35.1	0.0	0.0	168.1	11.0	453.6	56,563.4	0.88%
CP25	21,519.2	106.6	1,913.2	7,766.6	12,618.1	6,845.8	23,799.3	145,611.5	220,180.3	3.44%
CP26	16.3	138,640.5	7.9	17.4	59.0	1.1	0.0	0.0	138,742.3	2.17%
CP27	16,636.1	0.0	3,605.8	911.6	7,229.9	3,637.3	46.8	3.3	32,070.7	0.50%
CP28	50,922.3	14,848.5	51,089.1	16,633.5	42,073.1	23,472.7	83.3	6.6	199,128.9	3.11%
CP29	2,658.4	27,055.7	0.0	0.0	2,042.6	107.2	0.0	0.0	31,863.8	0.50%
CP3	70.5	764.5	19.8	0.0	0.0	65.8	96.9	0.0	1,017.5	0.02%
CP30	760.9	6,095.8	110.4	0.0	6,943.9	12,920.1	0.0	0.0	26,831.2	0.42%
CP31	437.3	5,163.9	86.9	0.0	0.0	5.2	0.0	0.0	5,693.3	0.09%
CP32	284.7	289.3	95.4	0.0	0.0	0.0	0.0	0.0	669.4	0.01%
CP33	10,343.0	1,509.8	62,392.3	0.0	644.7	638.5	0.0	0.0	75,528.3	1.18%
CP34	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2.0	0.00%
CP35A	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	6.6	0.00%
CP35E	104.9	70.9	159.0	0.0	9.5	10.4	0.0	152.2	506.9	0.01%
CP36	0.0	168.2	51.3	3.0	121.5	2.5	0.0	0.0	346.4	0.01%
CP37	594.5	3.1	17,159.7	3,916.4	62,266.9	30,252.6	0.0	0.0	114,193.1	1.78%
CP38A	0.9	8,282.6	230.5	64.5	0.0	39.3	0.0	0.0	8,617.7	0.13%
CP38B	305.5	0.8	0.0	0.0	187.8	200.8	0.0	75.7	770.5	0.01%
CP38C	0.0	3.3	0.0	35.9	0.0	0.0	0.0	0.0	39.2	0.00%
CP38D	68.6	2.0	0.0	15.7	0.0	177.7	0.0	0.0	263.9	0.00%
CP38E	7,415.5	12.4	0.0	5,637.4	11,521.3	23,482.1	295.3	6,159.3	54,523.3	0.85%
CP39	24.8	25,400.5	0.0	0.0	0.0	0.0	0.0	0.0	25,425.2	0.40%
CP3A	1,787.7	10.0	0.0	26.2	4.7	10.1	0.0	0.0	1,838.9	0.03%
CP4	137.4	18,725.8	3,612.4	0.0	3,975.5	213.8	120.9	78.1	26,863.9	0.42%
CP40	86.9	3,119.7	616.7	19.8	130.2	0.0	0.0	0.0	3,973.3	0.06%
CP41	5.8	125.5	2,096.2	192.5	528.0	331.3	0.0	68.4	3,347.7	0.05%
CP42	85.7	186.6	49.2	15.3	26.8	13.7	0.0	0.0	377.3	0.01%
CP4A	0.0	46.0	64.9	0.0	226.9	0.0	0.0	0.0	337.7	0.01%

CP4B	313.3	89.0	5.1	0.0	0.0	5.5	0.0	22.1	435.0	0.01%
CP4C	0.0	203.6	194.0	70.9	4.5	0.0	0.0	210.2	683.2	0.01%
CP4D	35,415.4	16.3	324,310.1	41,676.7	38,115.8	13,176.5	52.3	12,029.7	464,792.8	7.26%
CP5	24.8	231,405.1	37.7	1.7	573.2	102.2	0.0	2.4	232,147.1	3.63%
CP5A	3,860.9	397.3	3,181.0	679.6	12,240.5	3,273.6	74.5	20.6	23,728.1	0.37%
CP6	3.9	7,667.3	0.0	4.1	0.0	0.0	0.0	0.0	7,675.4	0.12%
CP7	0.0	1,353.5	0.0	0.0	6.6	0.0	0.0	0.0	1,360.0	0.02%
CP8	61.5	0.3	11.2	0.0	12.2	12.3	6.9	0.0	104.4	0.00%
CP8A	12,442.1	31.4	47.6	41.5	490.4	490.6	12.4	47.1	13,603.0	0.21%
CP9	3,365.4	3,004.6	146.7	0.0	54.3	15.7	194.2	78.8	6,859.6	0.11%
CP9A	7.3	286.3	0.0	0.0	0.0	0.0	0.0	0.0	293.5	0.00%
Easmt	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.00%
"None"	37.5	96.0	6.8	3.2	410.6	581.5	0.0	0.0	1,135.5	0.02%
Total PPJV:	**377,426.7**	**1,407,267.8**	**1,851,519.7**	**227,522.6**	**494,896.0**	**306,023.9**	**388,939.1**	**1,349,993.9**	**6,403,589.7**	**100.00%**

Appendix H*. *Wetland-upland associations derived for waterfowl carrying capacity modeling.

Number of temporary, seasonal, and semipermanent wetlands associated with Conservation Reserve Program (CRP) and other upland land cover[a] in 2005[b] and 2011[b] that provide increased function for breeding ducks as a result of the CRP.

		2005					2011				
State	Wetland Class	CRP	Grass	Crop	Other	Total	CRP	Grass	Crop	Other	Total
Iowa	Temp, Seas, Semi	5,848	9,256	12,917	5,060	33,081	5,508	11,788	10,178	5,607	33,081
	Other	452	1,140	1,811	472	3,875	448	1,494	1,408	525	3,875
Minnesota	Temp, Seas, Semi	49,637	69,728	220,183	77,836	417,384	44,738	89,920	209,826	72,900	417,384
	Other	4,941	6,168	13,978	3,778	28,865	4,734	8,496	12,539	3,097	28,866
Montana	Temp, Seas, Semi	-	-	-	-	-	14,136	148,959	52,335	14,560	229,990
	Other	-	-	-	-	-	599	18,380	661	2,454	22,094
North Dakota	Temp, Seas, Semi	178,963	453,128	1,030,517	13,266	1,675,874	158,371	418,903	1,075,052	23,548	1,675,874
	Other	1,158	2,542	2,910	85	6,695	1,343	1,990	3,203	159	6,695
South Dakota	Temp, Seas, Semi	62,930	384,038	493,444	1,724	942,136	56,866	280,292	600,216	4,762	942,136
	Other	554	1,371	1,568	56	3,549	650	768	2,033	98	3,549
Total	Temp, Seas, Semi	297,378	916,150	1,757,061	97,886	3,068,475	279,619	949,862	1,947,607	121,377	3,298,465
% of Total		10%	30%	57%	3%		8%	29%	59%	4%	
Total All Wetlands		304,483	927,371	1,777,328	102,277	3,111,459	287,393	980,990	1,967,451	127,710	3,363,544

[a]Landcover class CRP = USDA FSA Common Land Unit Data; Grass = grassland and undisturbed grassland classes; Crop = cropland; Other = all other upland classes.
[b]Derived from Landsat Satellite images collected during 2001–2003 (2005 version) and 2011 (2011 version) (FWS, HAPET, unpublished data).

Acres of temporary, seasonal, and semipermanent wetlands associated with Conservation Reserve Program (CRP) and other upland land cover[a] in 2005[b] and 2011[b] that provide increased function for breeding ducks as a result of the CRP.

		2005					2011				
State	Wetland Class	CRP	Grass	Crop	Other	Total	CRP	Grass	Crop	Other	Total
Iowa	Temp, Seas, Semi	42,021	16,615	40,397	7,577	106,610	40,114	23,299	34,684	8,513	106,610
	Other	88,883	7,560	24,193	965	121,601	88,274	5,933	26,339	1,055	121,601
Minnesota	Temp, Seas, Semi	268,411	92,251	540,487	69,567	970,716	250,358	135,484	535,255	49,618	970,716
	Other	612,449	63,594	814,841	31,578	1,522,462	606,911	128,167	768,578	18,807	1,522,462
Montana	Temp, Seas, Semi	-	-	-	-	-	68,285	228,562	153,346	19,475	469,668
	Other	-	-	-	-	-	8,663	81,798	85,814	4,106	180,381
North Dakota	Temp, Seas, Semi	527,558	468,511	1,190,894	9,902	2,196,866	519,149	367,969	1,290,449	19,298	2,196,866
	Other	441,337	122,203	395,422	617	959,579	545,225	41,935	370,353	2,066	959,579
South Dakota	Temp, Seas, Semi	284,401	454,819	919,966	1,601	1,660,788	308,691	253,039	1,095,587	3,470	1,660,788
	Other	241,910	38,209	208,570	41	488,731	297,257	10,475	180,860	139	488,731
Total	Temp, Seas, Semi	1,122,391	1,032,196	2,691,745	88,648	4,934,980	1,186,598	1,008,353	3,109,322	100,374	5,404,648
% of Total		23%	21%	55%	2%		22%	19%	58%	2%	
Total All Wetlands		2,506,970	1,263,761	4,134,773	121,849	8,027,353	2,732,929	1,276,661	4,541,266	126,547	8,677,402

[a]Landcover class CRP = USDA FSA Common Land Unit Data; Grass = grassland and undisturbed grassland classes; Crop = cropland; Other = all other upland classes.
[b]Derived from Landsat Satellite images collected during 2001–2003 (2005 version) and 2011 (2011 version) (FWS Habitat and Population Evaluation Team, unpublished data).

<u>Appendix I</u>. Breeding Duck Pair Estimates (2005 and 2011), by Wetland Class and Wetland-Upland Association.

Estimated number of breeding duck pairs using temporary, seasonal, and semipermanent wetlands associated with Conservation Reserve Program (CRP) and other upland land cover[a] in 2005[b] and 2011[b] that provide increased function for breeding ducks as a result of the CRP.

		2005					2011				
State	Wetland Class	CRP	Grass	Crop	Other	Total	CRP	Grass	Crop	Other	Total
Iowa	Temp, Seas, Semi	10,160	8,103	11,878	3,945	34,085	9,625	10,937	9,603	4,381	34,546
	Other	3,976	2,297	5,083	743	12,099	3,871	3,118	4,287	824	12,099
Minnesota	Temp, Seas, Semi	79,682	51,271	174,057	40,898	345,908	74,471	69,474	167,548	36,306	347,799
	Other	64,051	9,031	48,412	6,365	127,859	62,960	15,942	44,951	4,006	127,859
Montana	Temp, Seas, Semi	-	-	-	-	-	33,529	170,473	85,563	11,343	300,907
	Other	-	-	-	-	-	2,139	22,277	16,076	2,001	42,493
North Dakota	Temp, Seas, Semi	419,680	708,888	1,114,553	14,311	2,257,432	396,732	621,324	1,190,104	27,000	2,235,160
	Other	71,094	49,296	85,898	446	206,734	85,588	24,726	95,112	1,308	206,734
South Dakota	Temp, Seas, Semi	174,467	579,723	625,897	1,413	1,381,501	174,245	369,315	793,602	3,595	1,340,757
	Other	31,879	16,519	38,633	42	87,073	37,573	5,846	43,529	125	87,073
Total	Temp, Seas, Semi	683,990	1,347,985	1,926,385	60,567	4,018,927	688,602	1,241,523	2,246,419	82,625	4,259,169
% of Total		17%	34%	48%	2%		16%	29%	53%	2%	
Total All Wetlands		854,990	1,425,128	2,104,410	68,164	4,452,692	880,733	1,313,430	2,450,374	90,890	4,735,427

[a]Landcover class CRP = USDA FSA Common Land Unit Data; Grass = grassland and undisturbed grassland classes; Crop = cropland; Other = all other upland classes.
[b]Derived from Landsat Satellite images collected during 2001–2003 (2005 version) and 2011 (2011 version) (FWS, HAPET, unpublished data).

<u>Appendix J</u>. Waterfowl annual recruitment estimates (2005–2011) for the PPR portion of North Dakota, South Dakota, and Montana, with and without CRP.

Estimated number of mallard recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 2005-2012.

	Recruits without CRP		Recruits with CRP		Difference	
Year	Estimate	SE	Estimate	SE	Estimate	SE
2005	449,018	27,092	589,111	36,748	140,093	12,807
2006	497,229	27,939	652,731	38,726	155,502	14,083
2007	1,015,518	55,529	1,378,694	79,583	363,176	29,530
2008	591,076	35,930	817,194	48,443	226,118	16,082
2009	1,251,614	45,113	1,652,277	61,607	400,663	24,705
2010	1,148,324	52,086	1,565,369	71,001	417,044	26,771
2011	1,877,475	77,078	2,498,862	100,757	621,388	36,663
2012	834,271	34,398	1,104,982	45,659	270,711	17,804
Average	957,871	36,768	1,282,183	49,403	324,313	18,628

Estimated number of gadwall recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 2005–2012.

	Recruits without CRP		Recruits with CRP		Difference	
Year	Estimate	SE	Estimate	SE	Estimate	SE
2005	587,920	32,189	784,867	45,087	196,947	15,320
2006	646,265	39,567	864,658	59,356	218,393	22,562
2007	776,483	50,411	1,046,428	73,150	269,945	25,780
2008	565,632	35,631	785,547	53,505	219,915	20,680
2009	1,315,258	52,550	1,708,118	68,182	392,860	20,388
2010	1,056,840	47,822	1,406,842	64,100	350,002	20,396
2011	1,659,131	71,096	2,144,883	90,488	485,752	25,153
2012	1,309,899	66,684	1,703,842	86,828	393,943	24,735

Average	989,187	41,408	1,305,106	56,773	315,920	18,940

Estimated number of blue-winged teal recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 2005–2012.

	Recruits without CRP		Recruits with CRP		Difference	
Year	Estimate	SE	Estimate	SE	Estimate	SE
2005	779,251	49,031	1,024,725	72,902	256,332	28,667
2006	947,786	61,928	1,269,464	96,671	328,726	40,037
2007	2,032,914	167,712	2,792,306	240,837	771,144	78,726
2008	1,221,587	83,400	1,721,833	120,083	503,387	40,711
2009	3,113,793	122,998	4,067,635	162,001	983,736	51,941
2010	3,116,423	168,494	4,222,050	231,478	1,116,003	73,563
2011	4,924,933	216,321	6,368,392	280,184	1,507,446	82,017
2012	2,402,473	104,391	3,168,856	139,996	793,916	45,993
Average	2,317,208	97,597	3,079,856	134,144	782,998	44,548

Estimated number of northern shoveler recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 2005–2012.

	Recruits without CRP		Recruits with CRP		Difference	
Year	Estimate	SE	Estimate	SE	Estimate	SE
2005	204,515	12,534	238,465	15,004	41,455	3,727
2006	176,384	9,472	214,792	12,070	42,046	3,609
2007	378,321	27,191	480,603	37,144	106,737	11,128
2008	315,999	19,271	410,283	26,023	99,448	7,957
2009	1,116,487	51,595	1,300,303	60,993	222,644	15,443
2010	968,515	50,272	1,170,345	59,657	214,962	15,736
2011	1,457,301	74,173	1,651,633	81,153	257,339	18,004
2012	580,368	27,670	679,539	33,366	116,381	8,609
Average	649,707	27,257	768,784	32,709	137,932	8,879

Estimated number of northern pintail recruits produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 2005–2012.

	Recruits without CRP		Recruits with CRP		Difference	
Year	Estimate	SE	Estimate	SE	Estimate	SE
2005	126,298	8,959	80,171	11,074	9,451	2,133
2006	100,910	6,538	66,407	7,637	10,070	2,330
2007	205,498	13,247	175,398	16,875	31,222	4,130
2008	114,059	7,943	109,912	9,952	21,690	2,127
2009	565,078	23,984	365,154	34,134	54,654	7,348
2010	470,593	24,052	355,344	36,983	72,787	9,999
2011	854,241	42,279	620,657	61,814	101,350	15,175
2012	354,003	17,882	196,392	21,216	31,674	4,384
Average	348,836	14,505	271,725	23,048	52,555	10,373

Estimated number of recruits for five combined species (mallard, gadwall, blue-winted teal, northern shoveler and northern pintail) produced with and without Conservation Reserve Program (CRP) cover in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, 2005–2012.

	Recruits without CRP		Recruits with CRP		Difference	
Year	Estimate	SE	Estimate	SE	Estimate	SE
2005	2,147,003	121,159	2,717,340	167,701	570,337	60,845
2006	2,368,574	136,212	3,068,052	202,233	699,479	79,594
2007	4,408,734	295,495	5,873,430	420,741	1,464,696	139,352
2008	2,808,353	168,370	3,844,769	236,277	1,036,416	78,692
2009	7,362,230	280,883	9,093,486	358,641	1,731,257	115,688
2010	6,760,696	330,203	8,719,950	439,450	1,959,255	136,037
2011	10,773,081	457,886	13,284,428	571,941	2,511,347	177,189
2012	5,481,014	238,234	6,853,611	302,580	1,372,597	93,900
Average	5,262,808	206,310	6,681,000	274,572	1,418,192	91,413

Appendix K. Final statistical models selected for grassland birds in the mixed grass ecoregion of the PPR.

Baird's Sparrow (BAIS) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1.0 - (1.0 / (1.0 + Exp(-1.0 * (74.1284 + (ami * -4.660423) + (smrsprpb * -107.9069) + (smrsprpb_2 * 58.67785) + (grassherb800 * -12.98912) + (hay3200 * -73.71837) + (seas3200 * -2.009829) + (temp1600 * -575.1261) + (tree400 * -329.6288)))))) * (Exp(-22.56196 + (dd5 * 0.0291295) + (dd5_2 * -0.00000937) + (seas3200 * -34.34073) + (tree400 * -44.51024) + (temp800 * -36.86265) + (und_crp400 * 1.161008) + (grassherb3200 * -0.1782774)))) * 0.09)

Bobolink (BOBO) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1.0 - (1.0 / (1.0 + Exp(-1.0 * (32.82501 + (ami * 2.000906) + (dd5 * -0.0370981) + (dd5_2 * 0.00000779) + (hay400 * -87.71432) + (und_crp400 * -5.724778) + (crop400 * -3.866156)))))) * (Exp(-8.847913 + (ami * 0.308901) + (ami_2 * -0.0720677) + (dd5 * 0.007372) + (dd5_2 * -0.00000165) + (seas400 * -1.03044) + (tree400 * -3.61367) + (und_crp400 * 1.077387) + (crop400 * -1.112249)))) * 0.09)

Chestnut-collared Longspur (CCLO) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (44.20932 + (ami * -6.75443) + (ami_2 * 0.5204053) + (smrsprpb * -36.28447) + (smrsprpb_2 * 15.36765) + (temp800 * 4.957465) + (tree1600 * 99.25933) + (und_crp800 * 1.580491) + (grassherb400 * -2.970659) + (hay3200 * -10.88685)))))) * (Exp(-0.4145372 + (hay3200 * -12.33203) + (und_crp3200 * -2.156621) + (temp3200 * 3.466374) + (tree400 * -115.2409) + (crop3200 * 1.057898)))) * 0.09)

Clay-colored Sparrow (CCSP) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (62.78448 + (dd5 * -0.030444) + (dd5_2 * 0.00000737) + (smrsprpb * -82.39436) + (smrsprpb_2 * 38.31814) + (crop400 * 14.39715) + (tree400 * 18.49651) + (und_crp400 * -167.5681) + (seas400 * -9.30892)))))) * (Exp(-21.92463 + (dd5 * 0.01275) + (dd5_2 * -0.0000037) + (smrsprpb * 15.6789) + (smrsprpb_2 * -6.211363) + (hay3200 * 0.7580583) + (crop400 * -0.4514295) + (tree400 * 2.589651) + (und_crp400 * 0.6929123)))) * 0.09)

Grasshopper Sparrow (GRSP) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (-52.17748 + (ami * 23.7939) + (ami_2 * -2.694174) + (grassherb400 * -2.686895) + (hay3200 * -21.21282) + (seas3200 * 1.709326) + (temp3200 * -3.918521) + (tree400 * 3.12489) + (crop400 * 1.747158)))))) * (Exp(-8.701949 + (ami * 1.858408) + (ami_2 * -0.1849988) + (smrsprpb * -0.276924) + (dd5 * 0.0036875) + (dd5_2 * -0.000000795) + (grassherb1600 * 0.3216321) + (seas800 * -6.417057) + (temp3200 * -8.720204) + (tree400 * -4.299875) + (crop400 * -0.6046171)))) * 0.09)

Horned Lark (HOLA) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (-1175.856 + (ami * -19.59386) + (dd5 * 1.199538) + (dd5_2* -0.0002842) + (crop400 * -7.372573) + (hay400 * 91.74285) + (tree800 * -294.6837)))))) * (Exp(-3.906917 + (crop400 * 3.575445) + (tree3200 * -45.17539) + (temp400 * 1.788885)))) * 0.09)

LeConte's Sparrow (LCSP) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (42.00098 + (ami * -17.3112) + (ami_2 * 2.018997) + (dd5 * 0.0014315) + (smrsprpb * -2.984067) + (und_crp400 * -1.268434) + (hay800 * 31.23518) + (seas800 * -4.746699)))))) * (Exp(2.295132 + (ami * 0.3301866) + (smrsprpb * -5.692512) + (smrsprpb_2 * 2.477182) + (grassherb400 * 1.868847) + (temp800 * -11.93341) + (tree3200 * -59.67677)))) * 0.09)

Savannah Sparrow (SAVS) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (50.46933 + (dd5 * -0.0560161) + (dd5_2 * 0.0000132) + (grassherb400 * 7.832499) + (seas3200 * -128.6847) + (tree400 * 9.291534) + (und_crp400 * 8.252281)))))) * (Exp(-5.011873 + (dd5 * 0.0053277) + (dd5_2 * -0.00000174) + (smrsprpb * 0.2971463) + (tree400*-6.697022) + (und_crp400 * 1.345024) + (hay400 * 1.711038)))) * 0.09)

Sedge Wren (SEWR) Zero-Inflated Poisson (Mixed Grass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (-53.27608 + (ami * 53.99743) + (ami_2 * -6.699259) + (dd5 * -0.0535809) + (dd5_2 * 0.000012) + (smrsprpb * 3.297418) + (temp400 * 11.8891) + (und_crp400 * -12.12245) + (grassherb800 * 5.386445) + (hay400 * 15.86368) + (seas800 * -33.03315)))))) * (Exp(-10.67303 + (ami * 2.836528) + (ami_2 * -0.465483) + (dd5 * 0.0045035) + (dd5_2 * -0.000000941) + (smrsprpb * 0.6181462) + (grassherb3200 * -1.644393) + (crop400 * -1.379594) + (seas3200 * -2.919801)))) * 0.09)

Sprague's Pipit (SPPI) Logistic Regression (Mixed Grass PPJV) Model

((Exp(-60.5099 + (ami * 0.2222248) + (smrsprpb * 94.88957) + (smrsprpb_2 * -40.28817) + (temp1600 * -65.66966) + (grassherb400 * 3.279442) + (seas3200 * -2.644417))) / (1 + (Exp(-60.5099 + (ami * 0.2222248) + (smrsprpb * 94.88957) + (smrsprpb_2 * -40.28817) + (temp1600 * -65.66966) + (grassherb400 * 3.279442) + (seas3200 * -2.644417)))))

Western Meadowlark (WEME) Logistic Regression (Mixed Grass PPJV) Model

((Exp(-2.274162 + (dd5 * 0.0005093) + (grassherb400 * 1.777282) + (hay3200 * 7.798499) + (seas400 * -0.2497139) + (smrsprpb * -0.3043711) + (tree400 * -6.87374) + (und_crp400 * -0.5031669))) / (1 + (Exp(-2.274162 + (dd5 * 0.0005093) + (grassherb400 * 1.777282) + (hay3200 * 7.798499) + (seas400 * -0.2497139) + (smrsprpb * -0.3043711) + (tree400 * -6.87374) + (und_crp400 * -0.5031669))

***Appendix L*. Final statistical models selected for grassland birds in the tallgrass ecoregion of the PPR.**

Bobolink (BOBO) Zero-Inflated Poisson (Tallgrass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (-1.615024 + (dd5 * -0.0080536) + (dd5_2 * 0.00000322) + (seas800 * -1.017296) + (tree400 * 3.510486) + (und_crp400 * 0.9788015) + (crop400 * 2.859455)))))) * (Exp(0.3298629 + (ami * -0.2593224) + (und_crp400 * 0.7152657) + (seas1600 * 1.065933) + (temp400 * -3.626515) + (tree3200 * -4.712846)))) * 0.09)

Clay-colored Sparrow (CCSP) Zero-Inflated Poisson (Tallgrass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (-20.43864 + (ami * 24.2636) + (ami_2 * -6.220076) + (hay400 * -7.423093) + ((seas3200) * -205.7695) + (temp3200 * 95.39822) + (crop400 * 32.08815) + (grassherb400 * 22.43422)))))) * (Exp(-0.6207247 + (dd5*0.0088171) + (dd5_2 * -0.00000285) + (smrsprpb * -9.141556) + (smrsprpb_2 * 3.416907) + (seas3200 * 0.4264235) + (temp3200 * 2.130661) + (crop3200 * -1.018371) + (hay800 * -8.858228)))) * 0.09)

Dickcissel (DICK) Zero-Inflated Poisson (Tallgrass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (1.079501 + (smrsprpb * -6.260898) + (smrsprpb_2 * 4.718195) + (tree400 * 15.97616) + (und_crp3200 * 4.356852) + (grassherb800 * -3.413042) + (hay400 * -2.503049) + (seas400 * 7.760141)))))) * (Exp(-0.8857303 + (ami * -0.3115876) + (smrsprpb * 9.533826) + (smrsprpb_2 * -8.522974) + (grassherb1600 * 0.8650596) + (hay1600 * 9.004399) + (tree1600 * 9.294695) + (und_crp400 * 0.535959)))) * 0.09)

Grasshopper Sparrow (GRSP) Zero-Inflated Poisson (Tallgrass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (1.682288 + (grassherb800 * -8.914181) + (temp3200 * 23.2273) + (tree800 * -1.303381) + (und_crp400 * -1.324729)))))) * (Exp(-0.2384877 + (tree400 * -7.946376) + (crop400 * -0.9351358) + (grassherb400 * 0.2268799)))) * 0.09)

Horned Lark (HOLA) Zero-Inflated Poisson (Tallgrass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (1.191958 + (ami * 5.366151) + (ami_2 * -1.285555) + (crop400 * -4.055634) + (grassherb1600 * 3.372382) + (hay400 * -16.73649) + (seas400 * 2.935577)))))) * (Exp(-2.914712 + (crop400 * 1.278313) + (hay400 * 0.9567243) + (seas400 * -5.175869) + (und_crp400 * -1.183709)))) * 0.09)

LeConte's Sparrow (LCSP) Zero-Inflated Poisson (Tallgrass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (2.009394 + (ami * 0.6022285) + (crop800 * 1.341732) + (grassherb3200 * 3.020093) + (seas400 * 4.606205) + (temp3200 * -18.32668) + (und_crp3200 * -3.459813)))))) * (Exp(-0.1650752 + (ami * 0.4403281) + (grassherb800 * -4.537737) + (hay400 * -0.1079245) + (und_crp400 * 1.167525)))) * 0.09)

Savannah Sparrow (SAVS) Zero-Inflated Poisson (Tallgrass PPJV) Model

(((1 - (1 / (1 + Exp(-1 * (-0.703953 + (dd5 * -0.0972295) + (dd5_2 * 0.0000245) + (smrsprpb * 148.2225) + (smrsprpb_2 * -58.65169) + (tree400 * 1.80166) + (und_crp3200 * -1.089383) + (crop400 * -3.966928) + (hay400 * -5.167714)))))) * (Exp(-0.811623 + (smrsprpb * -0.393182) + (smrsprpb_2 * 0.2836034) + (tree400 * -3.070665)+ (und_crp3200 * 2.154574) + (crop400 * -0.6825326) + (hay400 * 1.204299) + (grassherb3200 * -0.8652877)))) * 0.09)

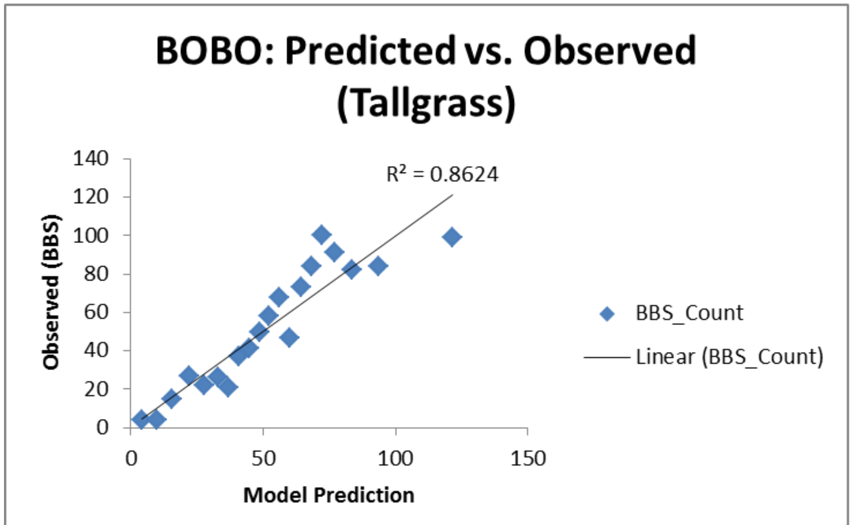
Sedge Wren (SEWR) Zero-Inflated Poisson (Tallgrass PPJV) Model

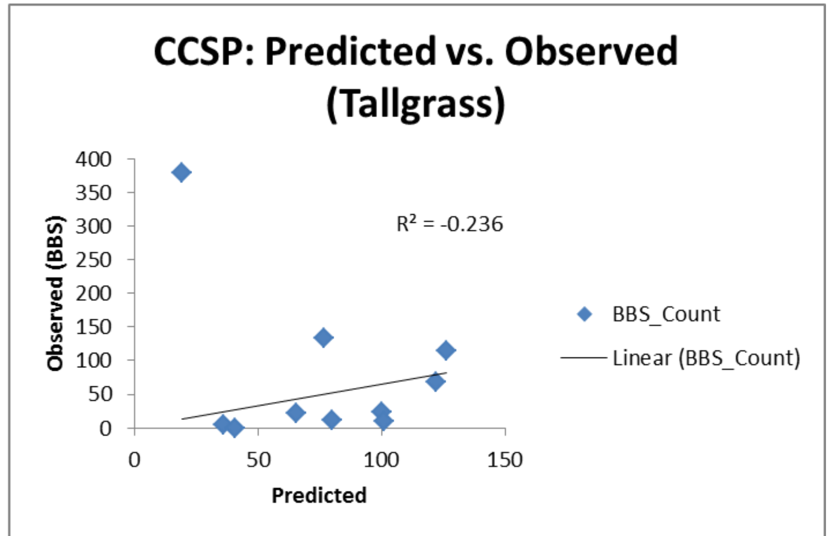
(((1 - (1 / (1 + Exp(-1 * (-1.123289 + (ami * -0.1852601) + (crop400 * 2.893067) + (grassherb400 * 2.747191) + (hay400 * 2.731749) + (seas400 * -1.142048) + (temp3200 * -5.532846) + (tree800 * 10.13602)))))) * (Exp(0.2347713 + (ami * -0.2057145) + (smrsprpb * -2.29905) + (smrsprpb_2 * 1.362245) + (crop400 * -0.1656039) + (temp3200 * 1.413917) + (grassherb3200 * -0.1507843) + (und_crp400 * 0.6244673)))) * 0.09)

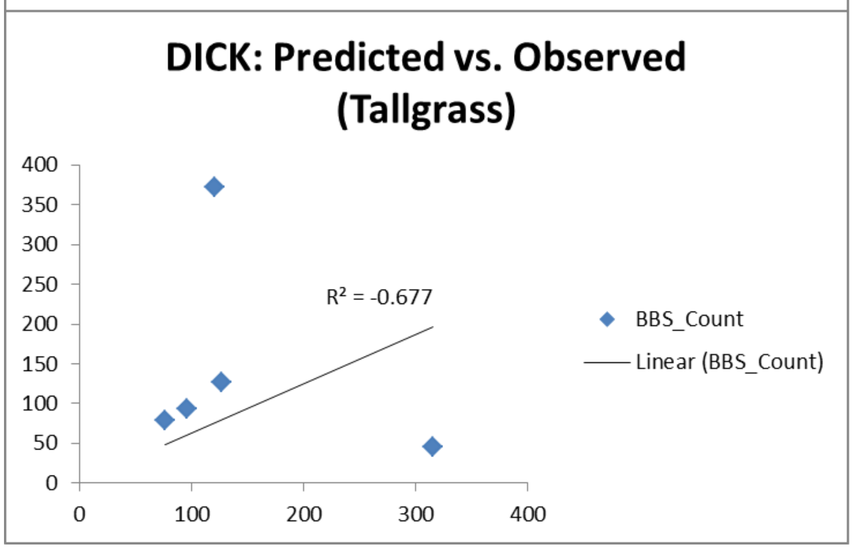
Western Meadowlark (WEME) Logistic Regression (Tallgrass PPJV) Model

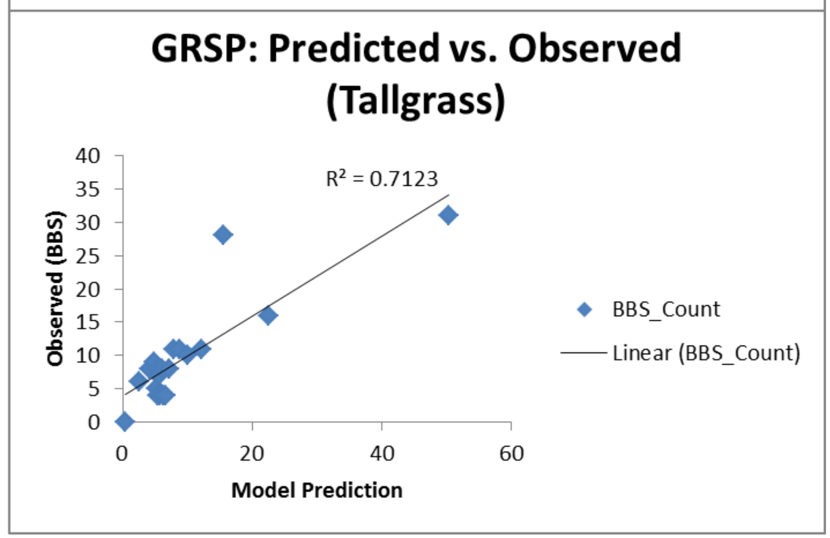
((Exp(-1.690349 + (smrsprpb * -0.0021155) + (smrsprpb_2 * 0.00000095) + (tree400 * 2.995367) + (und_crp3200 * 8.521252) + (grassherb800 * -4.162899) + (hay400 * -8.614397) + (seas400 * -0.7856803))) / (1 + (Exp((-1.690349 + (smrsprpb * -0.0021155) + (smrsprpb_2 * 0.00000095) + (tree400 * 2.995367) + (und_crp3200 * 8.521252) + (grassherb800 * -4.162899) + (hay400 * -8.614397) + (seas400 * -0.7856803))))))

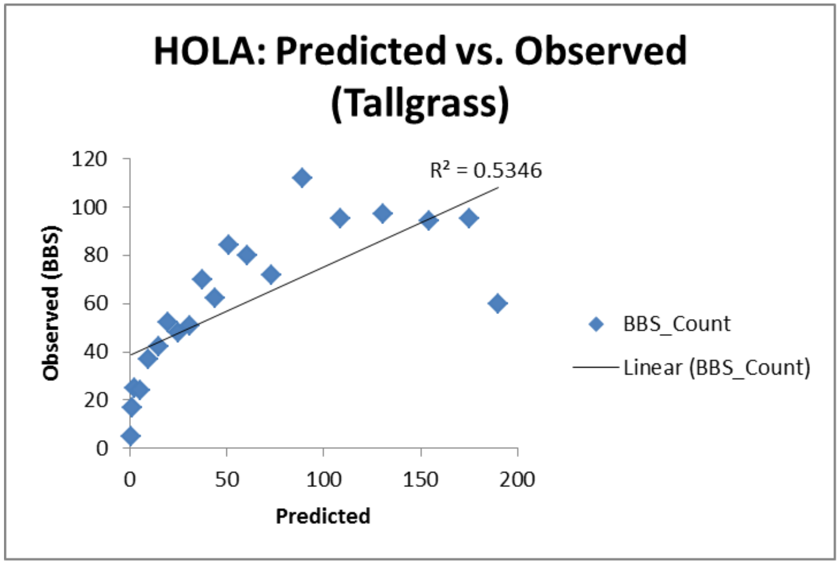
***Appendix M*. Grassland bird model validation regression plots comparing expected abundance versus observed occupancy, using Breeding Bird Survey (BBS) points as an independent validation dataset.**

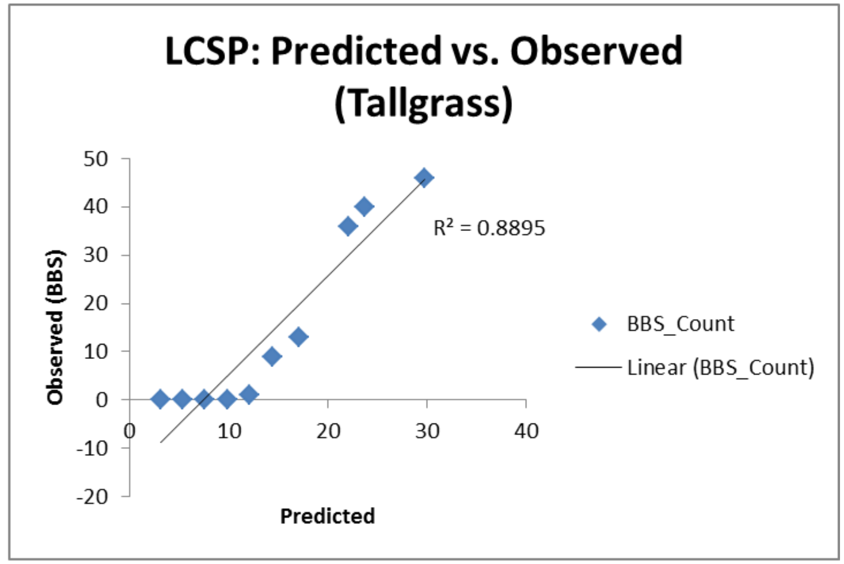


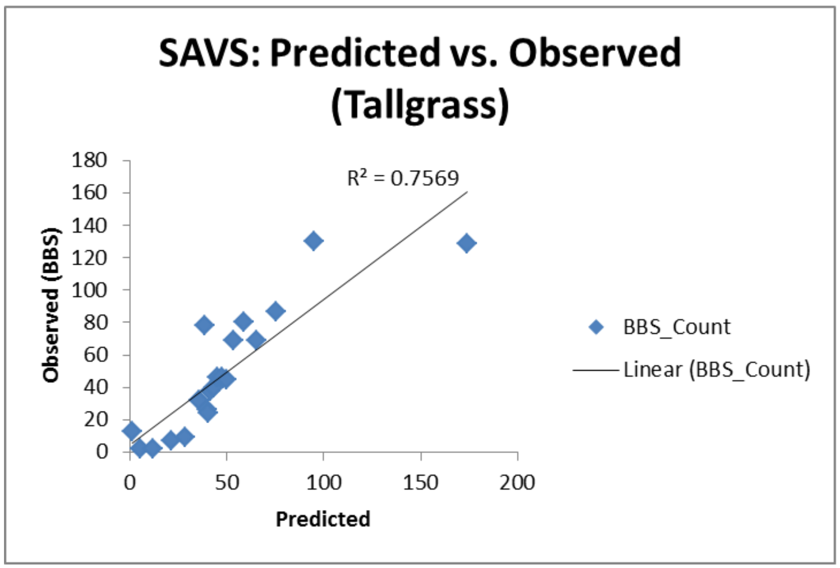


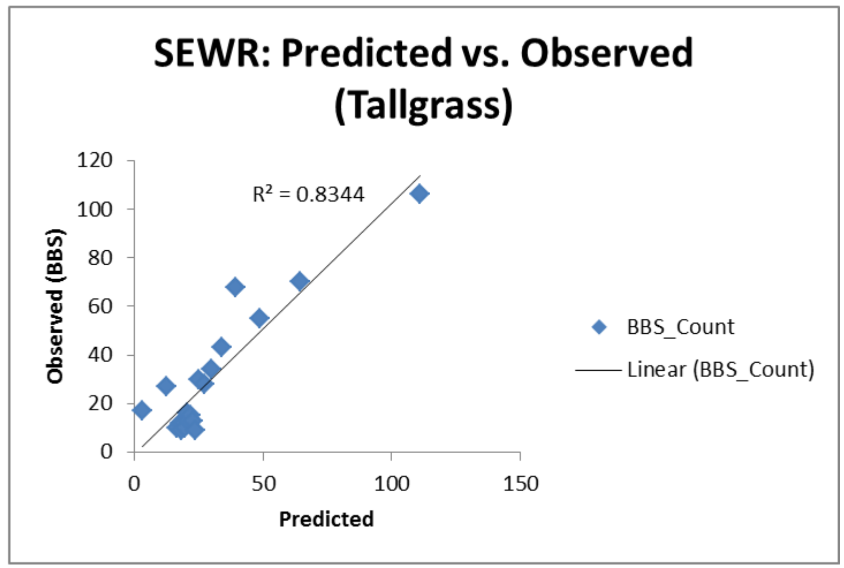


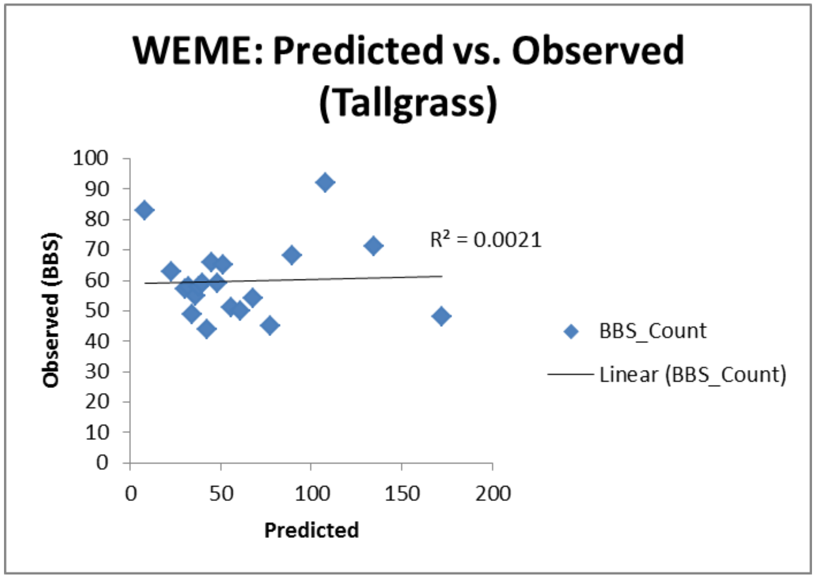


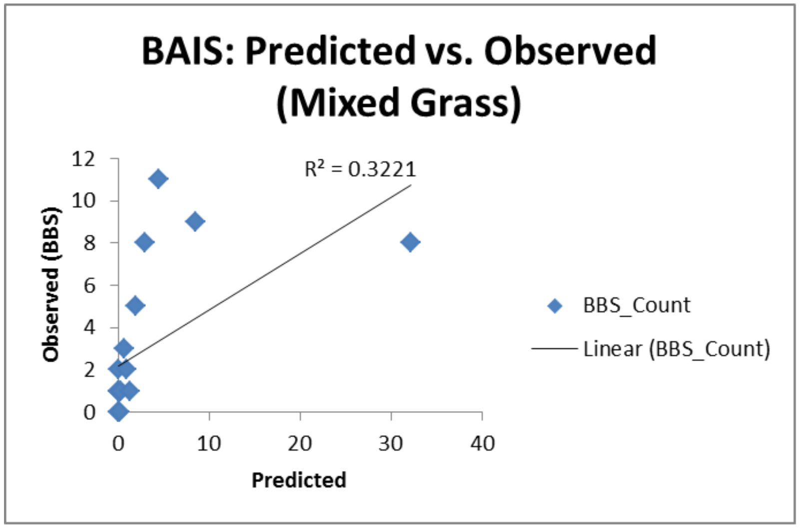

HOLA: Predicted vs. Observed (Tallgrass)
R² = 0.5346
Observed (BBS)
Predicted
BBS_Count
Linear (BBS_Count)
120
100
80
60
40
20
0
0
50
100
150
200

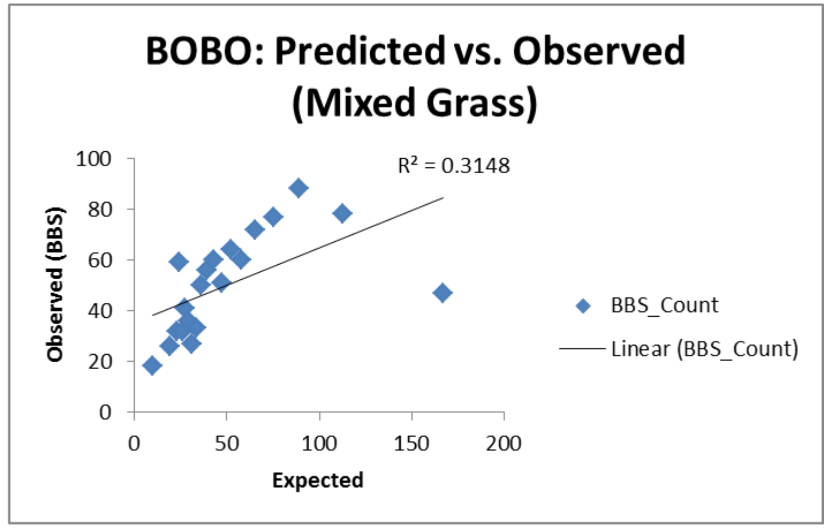

LCSP: Predicted vs. Observed (Tallgrass)
R² = 0.8895
Observed (BBS)
Predicted
BBS_Count
Linear (BBS_Count)
50
40
30
20
10
0
-10
-20
0
10
20
30
40

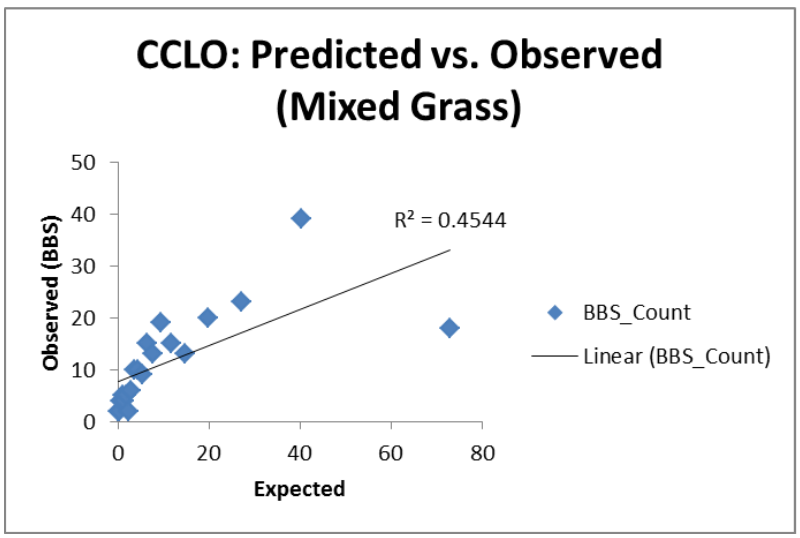

SAVS: Predicted vs. Observed (Tallgrass)
R² = 0.7569
Observed (BBS)
Predicted
BBS_Count
Linear (BBS_Count)
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200

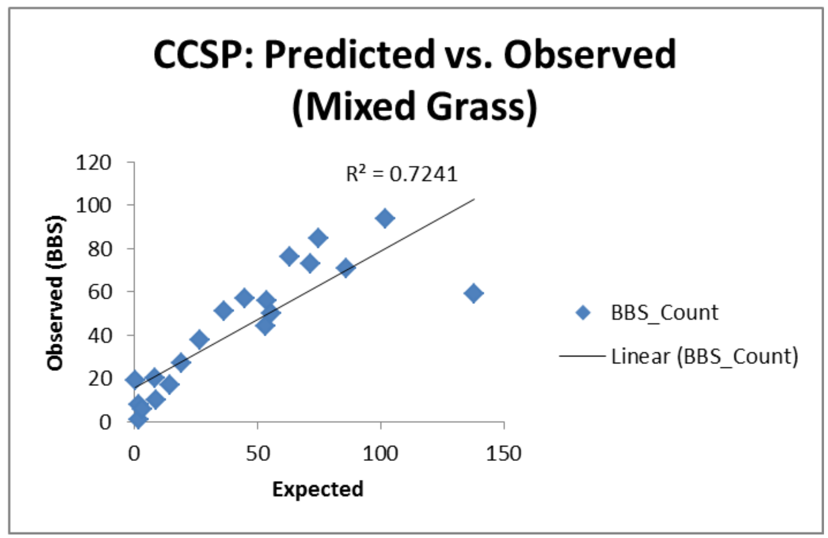

SEWR: Predicted vs. Observed (Tallgrass)
R² = 0.8344
Observed (BBS)
Predicted
BBS_Count
Linear (BBS_Count)
120
100
80
60
40
20
0
0
50
100
150

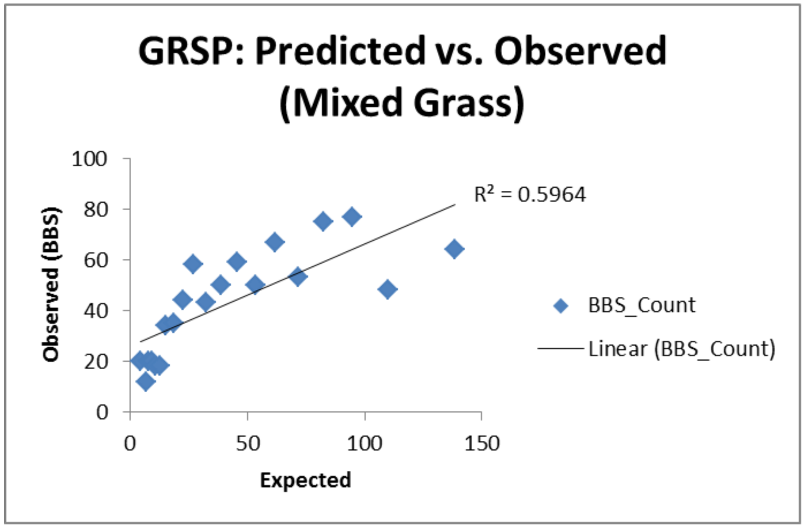

WEME: Predicted vs. Observed (Tallgrass)
Observed (BBS)
Predicted
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
R² = 0.0021
BBS_Count
Linear (BBS_Count)

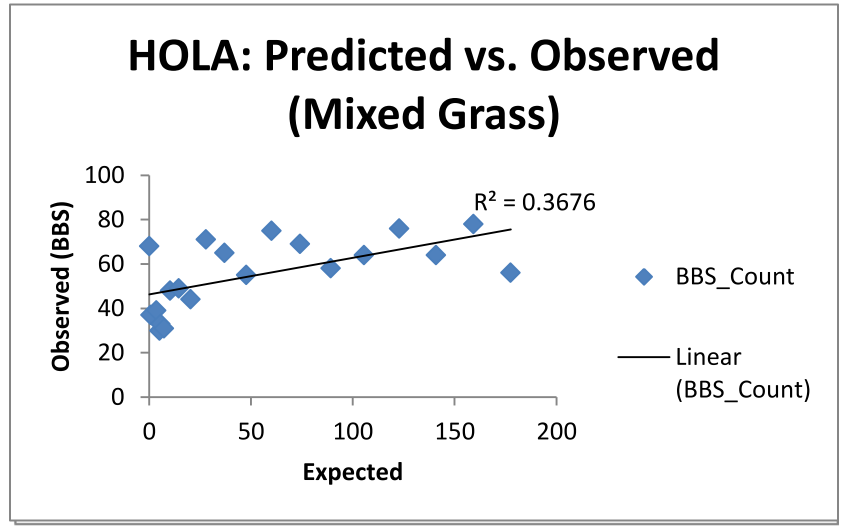

BAIS: Predicted vs. Observed
(Mixed Grass)
R² = 0.3221
Observed (BBS)
Predicted
0
2
4
6
8
10
12
0
10
20
30
40
BBS_Count
Linear (BBS_Count)

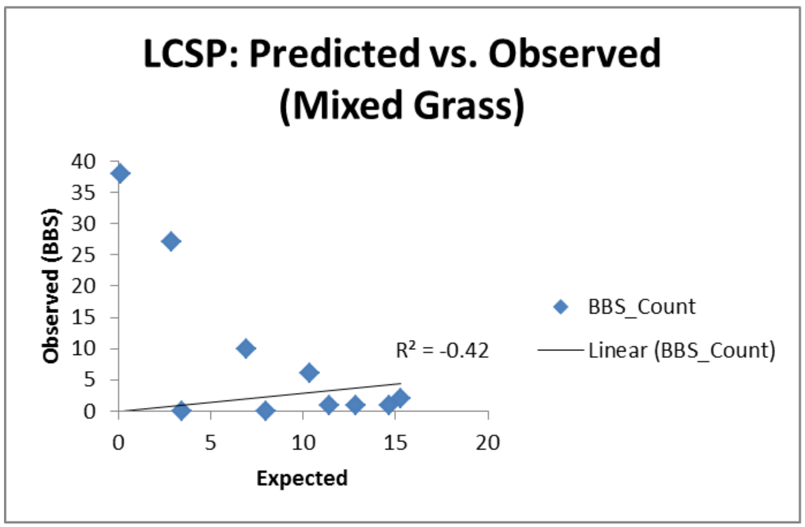

BOBO: Predicted vs. Observed
(Mixed Grass)
R² = 0.3148
Observed (BBS)
Expected
0
20
40
60
80
100
0
50
100
150
200
BBS_Count
Linear (BBS_Count)

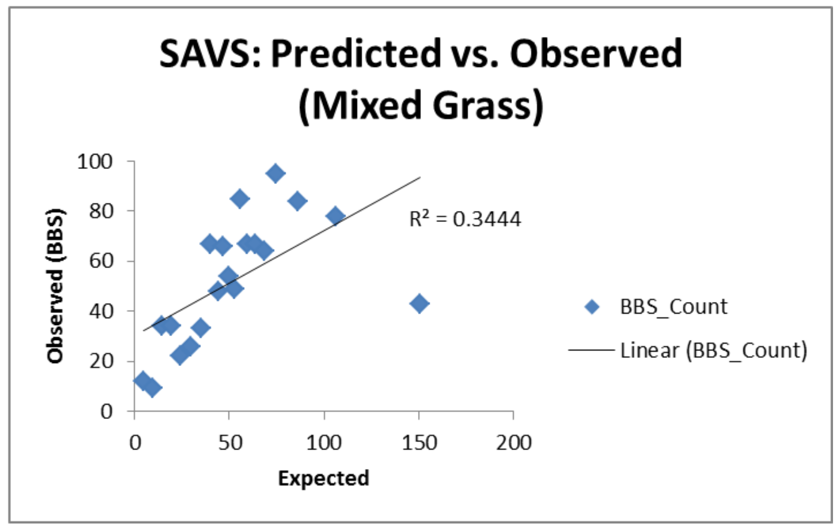

CCLO: Predicted vs. Observed
(Mixed Grass)
R² = 0.4544
Observed (BBS)
Expected
0
10
20
30
40
50
0
20
40
60
80
BBS_Count
Linear (BBS_Count)

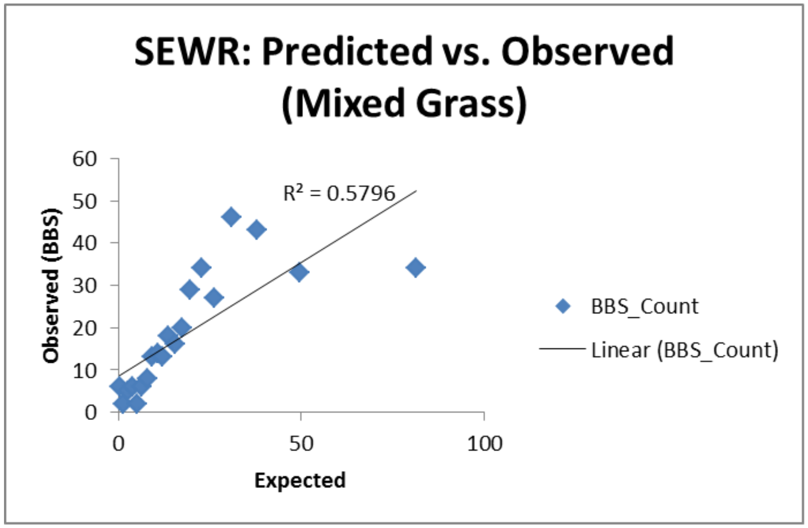

CCSP: Predicted vs. Observed
(Mixed Grass)
R² = 0.7241
Observed (BBS)
Expected
0
20
40
60
80
100
120
0
50
100
150
BBS_Count
Linear (BBS_Count)

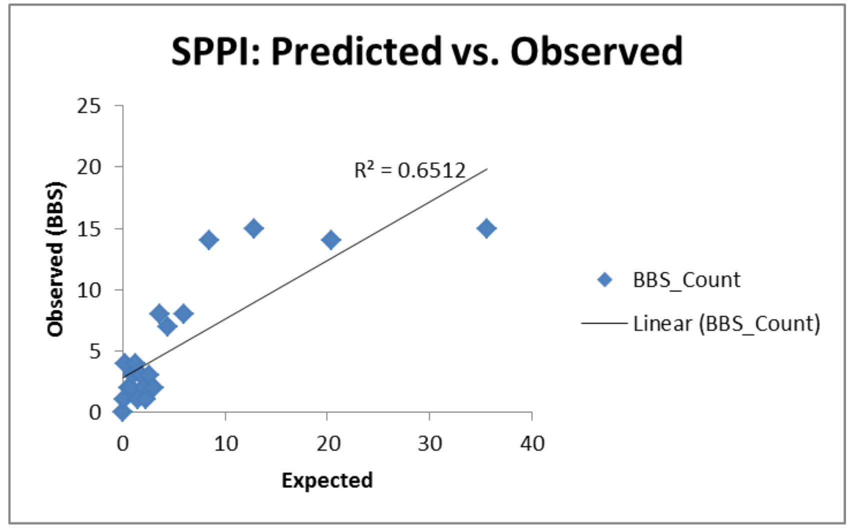

GRSP: Predicted vs. Observed
(Mixed Grass)
Observed (BBS)
Expected
R² = 0.5964
BBS_Count
Linear (BBS_Count)
0
20
40
60
80
100
0
50
100
150

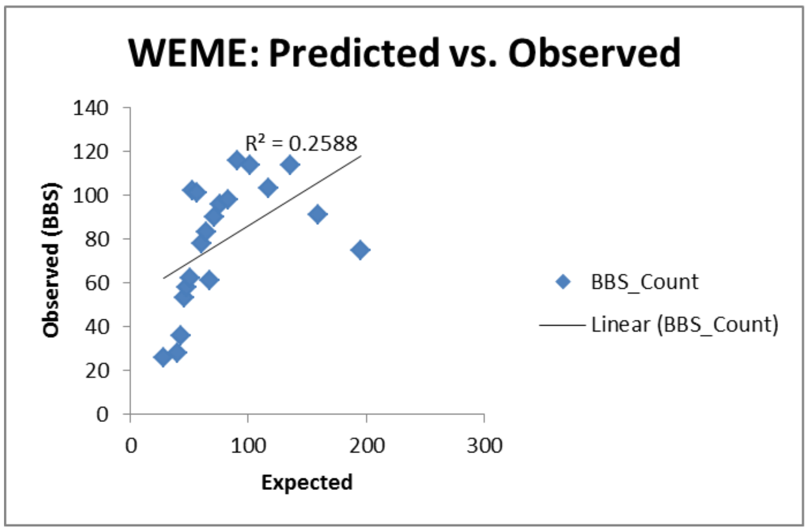

HOLA: Predicted vs. Observed
(Mixed Grass)
Observed (BBS)
Expected
R² = 0.3676
BBS_Count
Linear
(BBS_Count)
0
20
40
60
80
100
0
50
100
150
200


LCSP: Predicted vs. Observed
(Mixed Grass)
Observed (BBS)
Expected
R² = -0.42
BBS_Count
Linear (BBS_Count)
0
5
10
15
20
25
30
35
40
0
5
10
15
20


SAVS: Predicted vs. Observed
(Mixed Grass)
Observed (BBS)
Expected
R² = 0.3444
BBS_Count
Linear (BBS_Count)
0
20
40
60
80
100
0
50
100
150
200


SEWR: Predicted vs. Observed (Mixed Grass)
R² = 0.5796
Observed (BBS)
60
50
40
30
20
10
0
0
50
100
Expected
BBS_Count
Linear (BBS_Count)


SPPI: Predicted vs. Observed
R² = 0.6512
Observed (BBS)
25
20
15
10
5
0
0
10
20
30
40
Expected
BBS_Count
Linear (BBS_Count)


WEME: Predicted vs. Observed
R² = 0.2588
Observed (BBS)
140
120
100
80
60
40
20
0
0
100
200
300
Expected
BBS_Count
Linear (BBS_Count)

<u>Appendix N</u>. A comparison of HAPET grassland population estimates with Partners in Flight (PIF) population estimates for Bird Conservation Region (BCR) 11, by state. *Totals from PIF estimates are summarized for each state's portion of Bird Conservation Region (BCR) 11. Note that (*) HAPET estimates only include the mixed grass ecoregion of Montana; the HAPET Dickcissel (DICK) model only applies to the tallgrass ecoregion.*

	Partners in Flight BBS-Based Population Estimate (Total Birds)					
Species	**PIF- IA**	**PIF- MN**	**PIF- MT***	**PIF-ND**	**PIF-SD**	**BCR11 (PIF)**
Baird's Sparrow			200,000	200,000	700	400,700
Bobolink	50,000	500,000	80,000	1,300,000	400,000	2,330,000
Chestnut-collared Longspur			500,000	400,000	100,000	1,000,000
Clay-colored Sparrow		600,000	600,000	4,000,000	500,000	5,700,000
Dickcissel	180,000	100,000	300	90,000	800,000	1,170,300
Grasshopper Sparrow	30,000	90,000	1,100,000	1,600,000	1,400,000	4,220,000
Horned Lark	90,000	600,000	4,000,000	3,000,000	500,000	8,190,000
Le Conte's Sparrow		200,000	1,800	300,000	1,000	502,800
Savannah Sparrow	30,000	2,000,000	3,000,000	4,200,000	500,000	9,730,000
Sedge Wren	90,000	600,000		900,000	700,000	2,290,000

	HAPET Grassland Bird Model Population Estimates (Total Birds)						Population Estimate Comparison (% of PIF)
Species	**IA**	**MN**	**MT***	**ND**	**SD**	**Full PPJV**	
Baird's Sparrow			711,212	789,428		1,500,640	374.50%
Bobolink	1,503,472	6,500,220	502,460	8,385,219	5,229,726	22,121,097	949.40%
Chestnut-collared Longspur			659,251	1,016,598	844,212	2,520,061	252.01%
Clay-colored Sparrow	941	1,598,048	630,479	4,921,539	848,487	7,999,495	140.34%
Dickcissel (Tallgrass only)	820,389	378,623		18,210	420,114	1,637,336	139.91%
Grasshopper Sparrow	818,332	1,433,520	1,627,129	5,708,301	4,964,494	14,551,776	344.83%
Horned Lark	265,677	1,053,259	521,945	5,073,272	5,595,218	10,190,925	124.43%
Le Conte's Sparrow		943,878	10,711	963,416	79,452	1,997,456	397.27%
Savannah Sparrow	1,223,466	6,513,198	1,459,878	7,973,076	9,432,954	26,987,551	277.36%
Sedge Wren	756,511	2,026,976	26,795	2,083,058	1,250,956	6,144,297	268.31%

<u>Appendix O</u>. A detailed summary of grassland bird species populations by state/ecoregion and their associated benefits attributed to CRP.

<u>Baird's Sparrow (BAIS) CRP Benefits Results</u>

MIXED-GRASS MODEL				
	ND	**SD**	**MT**	**PPJV Mixed-grass Sum**
BAIS (Baseline 2011)	394,714	0	355,606	750,320
BAIS – No CRP	367,212	0	295,414	662,626
% Change (No CRP	-6.97%	0	-16.93%	-11.69%

<u>Bobolink (BOBO) CRP Benefits Results</u>

TALLGRASS MODEL					
	ND	**SD**	**MN**	**IA**	**PPJV Tallgrass Sum**
BOBO (Baseline 2011)	770,678	919,210	3,250,110	751,736	5,691,734
BOBO – No CRP	736,179	869,307	3,043,603	705,782	5,354,870
% Change (No CRP)	-4.48%	-5.43%	-6.35%	-6.11%	-5.92%

MIXED-GRASS MODEL					
	ND	**SD**	**MT**		**PPJV Mixed-grass Sum**
BOBO (Baseline 2011)	3,421,931	1,695,653	251,230		5,368,814
BOBO – No CRP	2,781,240	1,560,085	165,354		4,506,679
% Change (No CRP)	-18.72%	-8.00%	-34.18%		-16.06%

<u>BOBO</u>	**Sum**	**% Change (No CRP):**
PPJV Pair Total	11,060,548	
No-CRP PPJV Total	9,861,549	-10.84%
No-CRP Difference	-1,199,000	

Chestnut-collared Longspur (CCLO) CRP Benefits Results:

MIXED-GRASS MODEL				
	ND	SD	MT	PPJV Mixed-grass Sum
CCLO (Baseline 2011)	508,299	422,106	329,626	1,260,031
CCLO – No CRP	609885.4	456139.9	459697	1,525,722
% Change (No CRP)	+19.99%	+8.06%	+39.46%	+21.09%

Clay-colored Sparrow (CCSP) CRP Benefits Results:

TALLGRASS MODEL					
	ND	SD	MN	IA	PPJV Tallgrass Sum
CCSP (Baseline 2011)	231,278	205,645	799,024	470	1,236,417
CCSP – No CRP	198,051	180,707	591,991	274	971,022
% Change (No CRP)	-14.37%	-12.13%	-25.91%	-41.83%	-21.46%

MIXED-GRASS MODEL					
	ND	SD	MT		PPJV Mixed-grass Sum
CCSP (Baseline 2011)	2,229,492	218,599	315,240		2,763,331
CCSP – No CRP	1,973,928	206,040	256,951		2,436,919
% Change (No CRP)	-11.46%	-5.75%	-18.49%		-11.81%

CCSP	Sum	% Change (No CRP):
PPJV Pair Total	3,999,747	
No CRP PPJV Total	3,407,941	-14.80%
Difference	-591,806	

Dickcissel (DICK) CRP Benefits Results:

TALLGRASS MODEL					
	ND	**SD**	**MN**	**IA**	**PPJV Tallgrass Sum**
DICK (Baseline 2011)	9,105	210,057	189,312	410,195	818,668
DICK – No CRP	10,188	222,017	203,449	433,991	869,645
% Change (No CRP)	+11.90%	+5.69%	+7.47%	+5.80%	+6.23%

Grasshopper Sparrow (GRSP) CRP Benefits Results:

TALLGRASS MODEL					
	ND	**SD**	**MN**	**IA**	**PPJV Tallgrass Sum**
GRSP (Baseline 2011)	142,143	425,600	716,760	409,166	1,693,669
GRSP – No CRP	125,031	395,155	619,272	383,306	1,522,763
% Change (No CRP)	-12.04%	-7.15%	-13.60%	-6.32%	-10.09%

MIXED-GRASS MODEL					
	ND	**SD**	**MT**		**PPJV Mixed-grass Sum**
GRSP (Baseline 2011)	2,712,008	2,056,647	813,565		5,582,220
GRSP – No CRP	2,514,826	1,999,693	754,431		5,268,950
% Change (No CRP)	-7.27%	-2.77%	-7.27%		-5.61%

GRSP	Sum	% Change (No CRP):
PPJV Pair Total	7,275,888	
No CRP PPJV Total	6,791,714	-6.65%
Difference	-484,175	

Horned Lark (HOLA) CRP Benefits Results:

TALLGRASS MODEL					
	ND	**SD**	**MN**	**IA**	**PPJV Tallgrass Sum**
HOLA (Baseline 2011)	258,151	246,263	526,629	132,839	1,163,882
HOLA – No CRP	275,309	264,559	584,681	143,089	1,267,639
% Change (No CRP)	+6.65%	+7.43%	+11.02%	+7.72%	+8.91%

MIXED-GRASS MODEL					
	ND	SD	MT		PPJV Mixed-grass Sum
HOLA (Baseline 2011)	2,278,485	1,392,123	260,973		3,931,581
HOLA – No CRP	2,583,650	1,486,250	344,663		4,414,563
% Change (No CRP)	+13.39%	+6.76%	+32.07%		+12.28%

HOLA	Sum	% Change (No CRP):
PPJV Pair Total	5,095,463	
No CRP PPJV Total	5,682,201	+11.51%

LeConte's Sparrow (LCSP) CRP Benefits Results:

TALLGRASS MODEL					
	ND	SD	MN	IA	PPJV Tallgrass Sum
LCSP (Baseline 2011)	88,236	27,575	471,939	0	587,751
LCSP – No CRP	49626.9	17056.28	222692.8	0	289,376
% Change (No CRP)	-43.76%	-38.15%	-52.81%	0	-50.77%

MIXED-GRASS MODEL					
	ND	SD	MT		PPJV Mixed-grass Sum
LCSP (Baseline 2011)	393,472	12,150	5,355		410,977
LCSP – No CRP	353,036	11,474	4,673		369,183
% Change (No CRP)	-10.28%	-5.57%	-0.13%		-10.17%

LCSP	Sum	% Change (No CRP):
PPJV Pair Total	998,728	
No CRP PPJV Total	658,559	-34.06%
Difference	-340,169	

Savannah Sparrow (SAVS) CRP Benefits Results:

TALLGRASS MODEL					
	ND	**SD**	**MN**	**IA**	**PPJV Tallgrass Sum**
SAVS (Baseline 2011)	687,461	860,971	3,256,599	611,733	5,416,765
SAVS – No CRP	579,245	760,232	2,675,877	580,677	4,596,030
% Change (No CRP)	-15.74%	-11.70%	-17.83%	-5.08%	-15.15%

MIXED-GRASS MODEL					
	ND	**SD**	**MT**		**PPJV Mixed-grass Sum**
SAVS (Baseline 2011)	6,209,755	1,137,317	729,939		8,077,011
SAVS – No CRP	5,543,498	1,084,158	638,017		7,265,673
% Change (No CRP)	-10.73%	-4.67%	-12.59%		-10.05%

SAVS	**Sum**	**% Change (No CRP):**
PPJV Pair Total	13,493,776	
No CRP Total	11,861,703	-12.10%
Difference	-1,632,072	

Sedge Wren (SEWR) CRP Benefits Results:

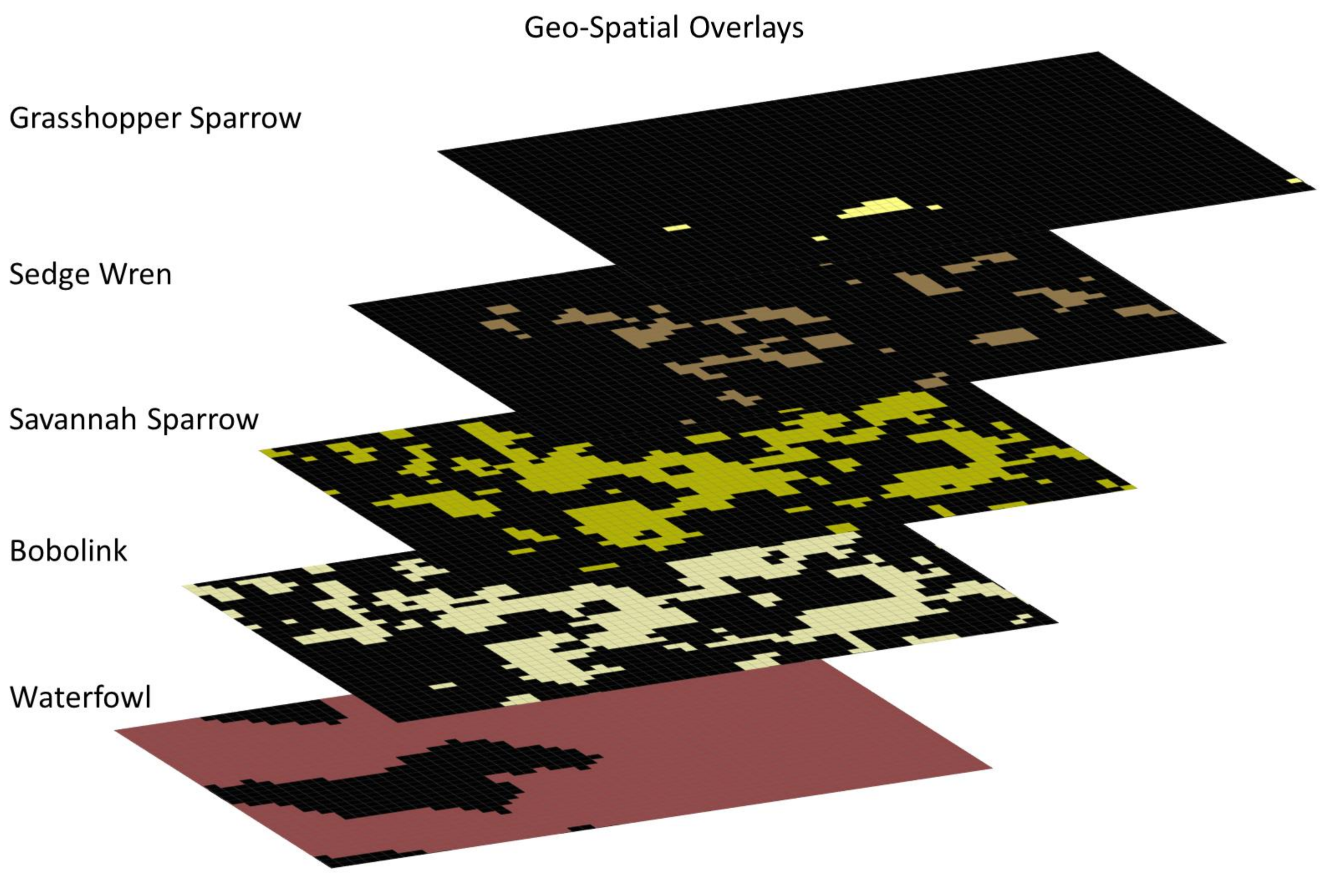
TALLGRASS MODEL					
	ND	**SD**	**MN**	**IA**	**PPJV Tallgrass Sum**
SEWR (Baseline 2011)	204,090	300,775	1,013,488	378,256	1,896,608
SEWR – No CRP	173,708	268,619	829,974	343,293	1,615,593
% Change (No CRP)	-14.89%	-10.69%	-18.11%	-9.24%	-14.82%

MIXED-GRASS MODEL					
	ND	**SD**	**MT**		**PPJV Mixed-grass Sum**
SEWR (Baseline 2011)	837,439	324,704	13,398		1,175,540
SEWR – No CRP	666,588	304,446	10,994		982,028
% Change (No CRP)	-20.40%	-6.24%	-17.94%		-16.46%

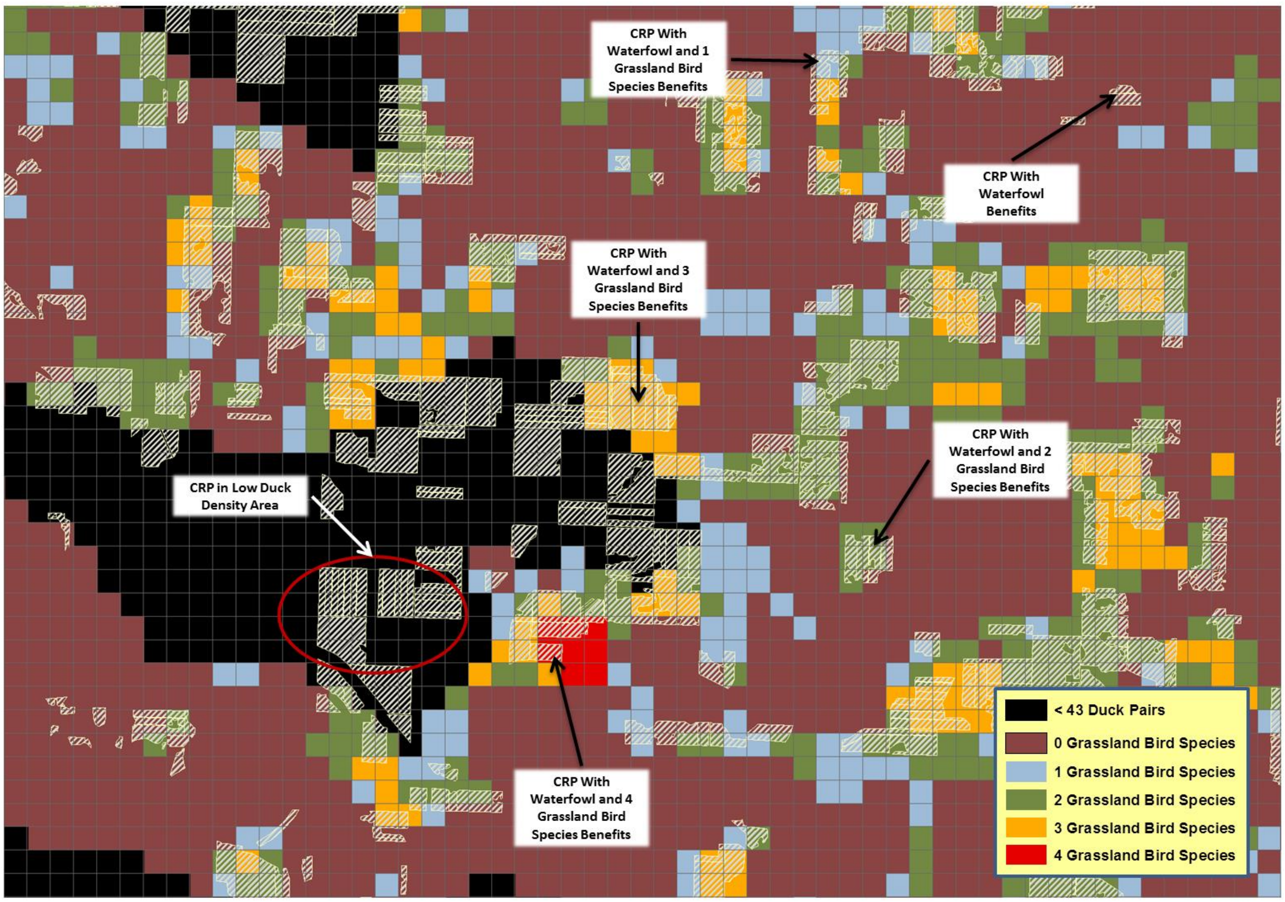
SEWR	Sum	% Change (No CRP):
PPJV Pair Total	3,072,148	
No CRP PPJV Total	2,597,621	-15.45%
Difference	-474,527	

Appendix P. **Example applications of a spatial prioritization tool for targeting CRP to maximize benefits for breeding waterfowl and grassland passerine populations.**

Each layer (mask) can be defined based on the minimum "footprint" possible to contain a specified percentage of a species' population—for example, we have identified the habitat accessible by the top 75% of five waterfowl species, along with the habitat associated with the top 25% of each grassland passerine population. We can use this information to identify areas of priority for multiple species within an explicit population threshold. Changing the population thresholds or the species under consideration can dramatically alter the resulting priorities.



Multiple species layers, based on population thresholds, can be stacked to identify areas of shared priorities as a simple ranking index. Underlying model estimates can be maintained within the data structure, allowing for transparency and encouraging exploration of the data to ensure broad-scale tradeoffs can be accounted for. In this example, CRP parcels (indicated by white hash marks) exhibit a wide range of value for waterfowl and grassland birds; some existing CRP tracts appear to provide limited multi-species benefits. Other opportunities for targeting unprotected lands for new enrollments are also apparent.



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