Final Report for:

Solicitation Number: FSA-R-28-04DC Estimating Wildlife Response to the Conservation Reserve Program, Department of Agriculture, Farm Service Agency, Acquisition Management Branch, Special Projects Section

Title: Estimating Wildlife Response to the Conservation Reserve Program: Bobwhite and Grassland Birds

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EXECUTIVE SUMMARY

We provided retrospective analysis of correlative relationships among land use/land cover types, Conservation Reserve Program habitats and indices of grassland bird populations in response to FSA's request for "national and regional estimates of per acre CRP effects on wildlife populations for CRP conservation practices (RFP for FSA-R-28-04DC)." Although robust per acre estimates of the real effect of CRP on wildlife species can only be derived from an ongoing monitoring program based on probabilistic sampling design, correlative analyses are the only possibility with retrospective data.

We conducted two different analyses with different CRP databases at different spatial extents, and we also set up a probabilistic monitoring program for CP33 that will allow robust estimates of per acre CRP effects. Our major outcomes are described below:

***Project #1: Retrospective analysis of range-wide response of bobwhite and grassland birds to the conservation reserve program*.**

We conducted retrospective analyses with two different datasets: NRI data which was available at broad spatial scales but restricted to generic classifications of CRP, and CLU data which contained information about practice, configuration and age but was restricted to 3 states. We discovered relevant information from both.

Conclusions from regional analysis using NRI data:

- Across 7 Bird Conservation Regions (circa 1997), CRP habitat was overwhelmingly associated with higher abundance of grassland birds (both obligate and facultative species). However, these relationships varied among region, and we caution that these are correlative relationships only.
- Significant CRP relationships were more prevalent in ecological regions where the majority of the landscape was covered by forest and there was little cropland. This suggests a hypothesis for future work - that CRP has its greatest effects on grassland birds where grassland habitats are relatively scarce.
- Northern bobwhite was associated with both tree- and grass-based conservation practices.

Conclusions from spatially-explicit, CLU analysis data from Nebraska, Kansas and Missouri:

- Northern bobwhite was positively related to the density (# patches / km^2) of grass CRP ≤ 4 year old. Thus, bobwhite would benefit from increasing the density of grass CRP patches in the landscape and from mid-contract management on existing contracts in this region (i.e., Kansas, Nebraska, Missouri).
- The final model for northern bobwhite was:

$$\text{sqrt}(\text{nobo} + 0.5) = 1.1153 + 0.2405 \text{ Forest Patch Density} - 0.1726 \text{ Grassland Patch Density} + 0.0449 \text{ Grassland Edge Density} + 16.3036 \text{ Young Grass CRP Patch Density} - 3.7948 \text{ Northing}$$

- Effects of CRP on other species were predominantly positive.
- Practice type, configuration and age of the contract were all more important than simple, generic classifications of CRP. Recommendations for particular combinations of these characteristics will vary depending on the target species.

Project #2: Development of spatial data for future monitoring of a select new CRP practice, CP33.

Notice CRP-479 specified that "a monitoring and evaluation plan must provide the ability to establish baseline data on quail populations and estimate increasing quail populations and impact on other upland bird populations as a result of practice CP-33, Habitat Buffers for Upland Birds….." One of the critical steps in this monitoring program was cross-referencing CRP contract numbers in the FSA national database with physical files housed in USDA-FSA county offices. To obtain number of fields, field-specific acreage, location, buffer configuration, and landowner contact information (and other information required for the monitoring program), we visited the individual county offices. Arkansas, Georgia, Indiana, Iowa, Kentucky, Mississippi, Nebraska, Tennessee, Texas, and South Carolina have been completed. State natural resource management agencies from Illinois, Missouri, and Ohio elected to collect CP-33 contract information themselves, however, the contract information collected by these states will be collated into the national monitoring program. Florida, Alabama and Louisiana will not be visited because they did not enroll enough CP-33 contracts to conduct monitoring this year. If these 3 states meet enrollment standards, we will visit them in the future. Data will not be collected from Kansas and Oklahoma because they elected to use a different monitoring protocol.

Due in part to these efforts, CP33 monitoring is now underway. The CP33 monitoring project will permit "national and regional estimates of per acre CRP effects on wildlife populations for CRP conservation" in a statistically robust fashion.

INTRODUCTION

One of the objectives of the Conservation Reserve Program (CRP) is to provide for wildlife habitat within agricultural landscapes. Since the initiation of CRP with the 1985 Farm Bill, millions of acres of cropland have been converted to grassland, shrubland and forest habitats. Benefits of the CRP to wildlife populations have been widely documented (see Hohman and Halloum 2000, Haufler 2005 for reviews), but research has focused primarily on individual fields or local-scales. However, the success of the CRP at providing wildlife habitat will be ultimately judged by whether regional, national or range-wide increases in wildlife populations occur (Ryan 2000). Unfortunately, few quantitative assessments of the CRP at regional scales exist.

The few existing regional-scale assessments of wildlife response to the CRP have several short-comings. First, some of them are restricted to small regions that are politically-defined, like a single state, rather than examining a species' entire range or ecologically-based region(s) (e.g., Reynolds et al. 1994; Roseberry and David 1994). Studies that have assessed CRP over an entire species range (e.g., Herkert 1998) or a large ecological region (e.g., Murphy 2003) share a second shortcoming by treating all CRP-enrolled lands as a single habitat type. Doing this may mask CRP effects because different CRP practices can vary greatly in habitat quality. For example, tree planting and existing tree stands (CP3, CP11, etc.) comprise over 60% of the CRP-enrolled acres in the Southeast (Burger 2000). Clearly, compared to grass practices (like CP2 - native warm-season grasses), CP3 trees will be of lower habitat quality for some species (like grassland birds), but will be higher quality for others (i.e., forest birds). Also, native warm season grasses (CP2) may be better habitat that cool-season CP1 for some species (see McCoy et al. 2001a for a discussion). Third, the spatial arrangement of contracts and the landscape context in which they occur has rarely been considered. CRP plantings that are contiguous to each other or within a few kms may be more or less productive quail habitat than the same acreage widely dispersed within a county. The landscape context (proportional composition and structure of the remainder of the landscape) may influence the relative value of CRP as wildlife habitat (Roseberry and David 1994). Fourth, the age of the CRP planting can influence habitat quality. Burger et al. (1990) and McCoy et al. (2001b) demonstrate that vegetation communities in CRP fields are not static but change over the life of the contract, and the wildlife habitat of CRP may vary with time since establishment. For example, CP1 and CP2 plantings are most suitable for bobwhite during the first 3 years of the enrollment (Burger et al. 1990). During the remaining years of the enrollment, succession renders the habitat less suitable unless appropriate management activities (planned disturbance regimes) take place.

Ideally, FSA would like to receive "*national and regional estimates of per acre CRP effects on wildlife populations for CRP conservation practices (RFP for FSA-R-28-04DC).*" Robust estimates of the real effect of CRP on wildlife species should come from ongoing monitoring of wildlife populations at a random sample of contracts selected from a pool of all national contracts (based on a probabilistic sampling design). Such a design would allow inferences to the national population of CRP contracts, however such an analysis is more expensive and will take years to obtain results. Insofar as this has not been done, FSA has requested a ***retrospective analysis of correlative relationships*** among land use/land cover change and indices of populations. However, the existing land use databases (NRI, Census of Agriculture, etc.) have one or more of the following deficiencies: they lack information about the specific conservation practice or age of the contract, lack the spatial distribution of CRP contracts; or are collected at spatial scales (e.g. county or state level) that do not correspond to biological datasets (e.g. route level). Without this information, estimates of wildlife population response cannot account for the effects of practice, succession, and habitat configuration which all influence the number of individual birds actually produced. The FSA common land unit data (CLU), which are field level and include specific conservation practice information, were available for three states within the northern bobwhite range.

To provide a retrospective analysis of correlative bird-CRP relationships, we modeled abundance of northern bobwhite and 14 grassland birds over the bobwhite breeding range. These are key wildlife to assess because these species have exhibited declining national trends (Brennen and Kulvesky 2005, Brady and Flather 1998a, b), and these declines have been attributed to habitat fragmentation and agricultural intensification across their breeding habitats in North America (Brennen 1991, Peterjohn 2003). The early successional grassland habitat the CRP often provides should directly benefit these species, and thus ***grassland birds are an appropriate indicator for measuring wildlife benefits of CRP***.

For this solicitation, we completed two projects. Project #1 produced the most comprehensive, regional assessment of the effects of the CRP on bobwhite and grassland birds permitted by the constraints of the available databases (CLU data and NRI data). Project #2 developed and implemented a robust sampling design/protocol that would permit inferences to the true effects of a single new CRP conservation practice (CP33 – Habitat Buffers for Upland Birds) from its inception.

PROJECT #1: RETROSPECTIVE ANALYSIS OF RANGE-WIDE RESPONSE OF BOBWHITE AND GRASSLAND BIRDS TO THE CONSERVATION RESERVE PROGRAM.

Our original intent for this project was to use the spatially-explicit Farm Service Agency database of CRP contracts (hereafter referred to as the CLU database) to model response of northern bobwhite and other grassland birds to CRP. However, CLU data was available for only three states within the range of the northern bobwhite (Nebraska, Kansas and Missouri). Because CLU data was restricted to such a narrow geographic area, we conducted additional analyses at broader (and more ecologically-relevant) scales using data from the National Resources Inventory (hereafter NRI). Below we present results from two sub-projects: *Sub-project A - Regional assessment using NRI data* and *Sub-project B - Exploratory analyses using CLU data.*

SUB-PROJECT A - REGIONAL ASSESSMENT USING NRI DATA

Materials and Methods

Temporal and Geographic Extent of Study. Because we used 1997 NRI data, we used bird data from a 5-year window (1995 - 1999) centered on 1997. Geographically, we restricted our analysis to 7 Bird Conservation Regions (hereafter BCRs) that comprise the majority of the current breeding range of the northern bobwhite - eastern tallgrass prairie, prairie-hardwood transition, central hardwoods, southeastern coastal plain, Appalachian mountains, piedmont, and the

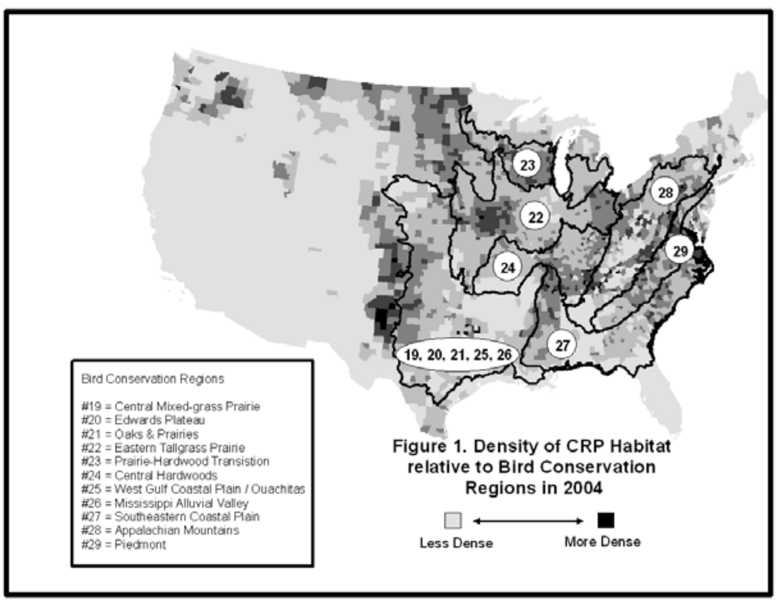

Figure 1. Density of CRP Habitat relative to Bird Conservation Regions in 2004

southwest region of the bobwhite range (Figure 1 above). The southwest region was a combination several smaller BCRs (Central Mixed-grass Prairie, Edwards Plateau, Oaks and Prairies, West Gulf Coast Plain, and Mississippi Alluvial Valley) with densities of Breeding Bird Survey routes too low to allow us to construct models for this part of the bobwhite range. BCRs are ecologically-distinct regions in North America with similar bird communities, habitats, and resource management issues that were developed by the North American Bird Conservation Initiative (http://www.nabci-us.org/bcrs.html). Because BCRs are ecologically-based, population responses to CRP should be consistent within a BCR (but not necessarily among BCRs). Additionally, BCRs represent the fundamental planning unit used in NABCI and the Northern Bobwhite Conservation Initiative (NBCI).

Focal Bird Species. Our focal species was the northern bobwhite (*Colinus virginianus*). We also constructed predictive models for 14 other species that: (a) were abundant enough to facilitate analysis and (b) had breeding ranges that roughly overlapped that of the northern bobwhite. We also selected these species to represent different, ecological groups of species.

- 5 obligate grassland species: horned lark (*Eremophila alpestris)*, grasshopper sparrow (*Ammodramus savannarum)*, dickcissel (*Spiza americana*), eastern meadowlark (*Sturnella magna*), and western meadowlark (*Sturnella neglecta*).
- 7 facultative grassland species: mourning dove (*Zenaida macroura*), eastern kingbird (*Tyrannus tyrannus*), loggerhead shrike (*Lanius ludovicianus*), common yellowthroat (*Geothlypis trichas*), lark sparrow (*Chondestes grammacus*), red-winged blackbird (*Agelaius phoeniceus*), and eastern bluebird (*Sialia sialis*).
- 1 nest-parasite: brown-headed cowbird (*Molothrus ater*).
- 1 representative edge species: indigo bunting (*Passerina cyanea*).

Breeding Bird Data. The Breeding Bird Survey (BBS) is a long-term monitoring program that was initiated in 1966 (Robbins et al. 1986) with over 4,000 routes in North America that are censused annually during the summer breeding season. Routes are located along secondary roads (< 1-2 vehicles / min), and routes do not usually include interstate, federal, state highways, or busy county roads (Robbins and Van Velzen 1967). Each route is 39.4 km long and consists of 50 stops (0.8-km intervals). Trained observers record all birds seen or heard at each stop during a 3-min period. The survey was ideally suited to our objectives because of the abundance of routes, long route lengths, and a wide geographic distribution of routes.

We calculated the mean abundance of each species over the 5-year window (1995 - 1999) for all routes which were sampled in ≥ 3 of the 5 years. We omitted any route-year combinations that had unacceptable runs (inappropriate weather, first-time observer, etc.) as defined by Sauer et al. (2003).

Landuse, Agriculture and CRP variables. To describe the landscape surrounding each BBS route, we used National Resources Inventory data (USDA 1997, Nusser et al. 1998) from 1997. NRI raw data consists of points (800,000 nationwide) where agricultural information is recorded. Each point is identified with a unique landscape composition classification. *We intentionally chose this point in time because 1997 estimates of CRP acreage are cumulative estimates as no contract would yet have expired. We would not have this assurance with other dates or other data sources.* The NRI data is collected independently of the Conservation Reserve Program.

We constructed 25-km, circular buffers on the center of each BBS route and estimated land use, agriculture and CRP-related variables within each circular buffer. We chose 25-km radius buffers for two reasons. First, this approximates the mean maximum natal dispersal distances (Sutherland et al. 2002) of our focal species (northern bobwhite ≈ 28.5 km, all species average ≈ 24 km); hence, these species should respond to landscape characteristics at this scale (C. Flather, *personal communication)*. Second, 25-km buffers provided at least 300 NRI sample points for the majority of the BBS routes (S. Brady, *personal communication*). We then derived estimates of agricultural land composition based on NRI-points (Daryl Lund and Dean Oman, USDA Natural Resources Conservation Service, Resource Inventory and Assessment Division, *personal communication*).

We used the following NRI-derived ***landscape composition variables***:

Cultivated cropland	= % of 25-km buffer in cultivated cropland
Noncultivated cropland	= % of 25-km buffer in noncultivated cropland
Pasture	= % of 25-km buffer in pasture lands
Rangeland	= % of 25-km buffer in range lands
Forest	= % of 25-km buffer in forest lands
Rural transportation	= % of 25-km buffer in rural transportation
Other	= % of 25-km buffer in other types of rural land uses
Urban	= % of 25-km buffer in urban and built-up land uses
Small water	= % of 25-km buffer in small water
Large water	= % of 25-km buffer in large water
Federal	= % of 25-km buffer in federal land

We used the following NRI-derived ***generic CRP variables***:

Total CRP	= % of 25-km buffer in CRP lands
Grass-legume CRP	= % of CRP lands in grass and legumes
Tree CRP	= % of CRP lands in tree-based CRP practices

Because tree-based CRP practices are prevalent primarily in the southeastern United States, we only included this variable for regions where it occurred within enough buffers to permit analysis (entire study region, southeastern coastal plain, prairie-hardwood transition, and piedmont). NRI data also classifies CRP habitat as "CRP-Wildlife" (percent of land in CRP wildlife and components like CP4, CP4d), but this CRP habitat type did not occur frequently enough to permit including it in analyses.

To assure the quality of NRI-derived estimates, we did not use routes that had < 300 NRI points within the associated circular buffer, routes where the estimated number of acres differed from the actual area of the buffer by > 6%, and routes with buffers that were not full circles (i.e., coastal areas, D. Lund and D. Oman, *personal communication*).

Statistical Techniques. Because we wanted to model CRP effects in a manner that also accounted for surrounding land use, we included all landscape composition variables and CRP variables in our group of potential explanatory variables. We then built linear regression models using a stepwise selection process (α-to-enter = 0.20; α-to-stay = 0.05) to build predictive models of grassland bird abundance (see also discussion of stepwise procedures on page 23). Because a high proportion of zero data on BBS routes created difficulties in satisfying assumptions of linear regression for some species in some regions, we used logistic regression for species that were present on < 70 % of the BBS routes. We did not construct any models when a species was present on < 10 % of the BBS routes. For each species, we built regression models for each of the 7 BCRs and for the study region as a whole.

Spatial autocorrelation occurs when observations from routes that are close to each other are more similar to each other than to more distant routes (Lichstein et al. 2002). This autocorrelation may result from spatial patterns in environmental conditions, social organization of birds, and a myriad of other factors. Autocorrelation in model residuals is a problem because this violates the independent-errors assumption of least-squares and logistic regression and can lead to biased estimates of the effects of explanatory variables (Littell et al. 2006). To account for spatial autocorrelation in our models, we took several steps.

First, we corrected for broad-scale spatial trends (*sensu* Lichstein et al. 2002). We centered the easting (east-west coordinate) and northing (north-south coordinate) for each route by subtracting the mean easting and northing. Coordinates were divided by 1,000,000 to ensure that all polynomial terms were of relatively similar magnitudes as other explanatory variables. We then included third-order polynomial terms of the centered site coordinates (E, N, E^2, N^2, EN, E^2N, EN^2, E^3, N^3, where E = easting and N = northing) and included these terms in our pool of potential explanatory variables (K. Gutzwiller, *personal communication*). Including these terms both accounts for broad-scale spatial trends in our data and assures that we meet the stationarity assumption for correcting for spatial autocorrelation (next paragraph).

Second, we inspected the residuals from each regression model by calculating robust estimates of the semivariogram. Using parameter estimates from the robust semivariogram as starting values, we used Proc Mixed and the Glimmix macro (Littell et al. 2006) to test for the presence of spatial covariance structures (exponential, Gaussian, etc.). If a -2 log likelihood test indicated the spatial term improved the fit of the model, we retained that particular spatial covariance structure in the model.

We did not automatically transform our abundance estimates, but we inspected residual plots to ensure that residuals were normally-distributed and that residual variance was reasonably constant. We applied $\log_{10}$ or square-root transformations only when necessary to meet assumptions. Because our data were means of 3 - 5 yearly counts, most of our bird variables tended towards a normal distribution (e.g., central limit theorem) and satisfied assumptions without transformations.

RESULTS & DISCUSSION

We built 109 regression models for 15 species, and 61 of these contained significant CRP effects (Table 1). ***All 61 significant CRP effects were positive***. Significant CRP effects are summarized in Table 1, and full model descriptions are in Appendix A. Our results are robust in that we met the assumptions of regression analysis and accounted for effects of landscape

Table 1. Summary of bird-CRP relationships using NRI-derived CRP variables by bird conservation region.

Species	ETP[1] *n* = 132	PHT *n* = 55	CH *n* = 71	SCP *n* = 88	APS *n* = 154	PDT *n* = 57	SWR *n* = 79	Entire Range *n* = 636	% +[4]
Northern bobwhite	ns[2]	ns	+ total	+ trees	ns	+ total	+ grsleg	+ grsleg + trees	57 %
Horned lark	+ total	ns	ns	ns	ns	ns	ns	+ grsleg	14 %
Grasshopper sparrow	+ total + grsleg	ns	ns	ns	+grsleg	+ total	+ total	+ grsleg + trees	57 %
Dickcissel	+ total	ns	+ total	+ total	--	--	+ total	+ trees	80 %
Eastern meadowlark	+ total	+ total	+ total	+ total	+ total	+ total	+ total	+ total	100 %
Western meadowlark	ns	ns	-- [3]	--	--	--	ns	ns	0 %
Mourning dove	ns	ns	+ total	+ trees	ns	+ total	+ total	+ grsleg + trees	57 %
Eastern kingbird	+ total	+ trees	ns	+ trees	+ total	+ total	+ total	+ total + trees	86 %
Loggerhead shrike	ns	--	+ total	ns	--	+ total	ns	ns	40 %
Common yellowthroat	+ total	ns	+ grsleg	ns	+ grsleg	+ total + trees	ns	+ total + grsleg	71 %
Lark Sparrow	ns	--	ns	--	--	--	ns	+ total	0 %
Red-winged blackbird	+ total	ns	ns	+ trees	+ grsleg	ns	ns	ns	43 %
Eastern bluebird	ns	+ grsleg	+ grsleg	+ total	ns	+ total	ns	+ grsleg + trees	57 %
Brown-headed cowbird	ns	ns	+ grsleg	ns	+ grsleg	ns	+ grsleg	+ grsleg	43 %
Indigo bunting	ns	+ grsleg	ns	+ trees	+ grsleg	ns	ns	+ grsleg + trees	43 %

[1] ETP = Eastern tallgrass prairie, PHT = Prairie-hardwood transition, CH = Central hardwoods, SCP = Southeast coastal plain, APS = Appalachian mountains, PDT = Piedmont, SWR = Central mixedgrass prairie, Edwards plateau, Oaks & Prairies, West gulf coast plain, and Mississippi alluvial valley.
[2] ns = no CRP variables were selected.
[3] Model not fit because species was present on < 10 % of the routes.
[4] (number regional models containing significant CRP variable) / (number regional models developed).

composition (to the extent of the variables provided by the NRI dataset). By including broad-scale spatial trends, we likely accounted for much of the effects of climate and other potentially important environmental variables that we did not measure. By adjusting for spatial autocorrelation when appropriate, we ensured that our standard errors and associated *P*-values were not inflated.

Northern Bobwhite. Across our study area, northern bobwhite was positively related to both grass-legume CRP and tree-based CRP (Table 1, Appendix A) and negatively related to forest cover, urban land uses and federally-owned land (Appendix A). Because northern bobwhite use both wooded and grassy habitats to meet seasonally varying life-history requirements, it is not surprising ***that both types of CRP conferred distinct and separate benefits to quail***. The fact that both grass and tree CRP variables occurred in the same model indicates that each type of CRP represents a distinct and different type of landscape modification. Bobwhite-CRP relationships were not consistent across individual BCRs. Northern bobwhite was positively associated with grass-legume CRP in the southwestern part of its range, positively associated with tree CRP in the southeastern coastal plain, and with total CRP in the central hardwoods and piedmont. No significant effects of CRP were detected in the other BCRs.

Other Grassland Birds. Seven of the other 14 species were positively related to CRP in ½ or more of the BCRs in which they were modeled. Six of these 7 species - eastern meadowlark (100%), dickcissel (80%), eastern kingbird (86%), common yellowthroat (71%), mourning dove (57%) and eastern bluebird (57%) - are species which prefer late-successional (i.e., mature grasslands with some woody vegetation) which is likely the condition of the majority of the CRP habitat in the United States. ***Eastern kingbird*** - as expected - was often associated with tree CRP because they use woody cover for singing perches and cover. In contrast, ***common yellowthroat*** and ***eastern bluebird*** were associated with grass-legume CRP habitat, but these species also prefer grasslands with either dense shrubs or some scattered woody cover (much of the grass-legume CRP is likely old enough to contain woody cover). ***Grasshopper sparrow*** is the lone short-grass specialist in this group of species, and CRP habitats likely become less suitable for them as the contracts age (Herkert 1998). However, CRP (in particular grass-legume practices) seem to have benefited grasshopper sparrows in most of its range, and this is consistent with other studies at smaller scales (Herkert 1998).

The remaining seven species were less often related to CRP. Two species - lark sparrow and western meadowlark - were not related to CRP in any BCR (although lark sparrow was related to CRP over our entire study area). ***Lark sparrow*** prefers shrubby, open areas and heavily-grazed habitats. Martin and Parrish (2000) report that due to "current emphasis on native grasses without rehabilitation of historic woody plant species, CRP mimics land-use patterns of the 1850s, precluding shrub- and edge-preferring species such as the Lark Sparrow." ***Western meadowlarks*** use a variety of grassland habitats, and CRP would be expected to benefit them. Others have similarly detected no relationship between western meadowlarks (Johnson and Schwarz 1993), due perhaps in part because they are most common further west than the majority of CRP habitat.

Horned lark nest in cultivated fields or in very short-grass habitats with patches of open, bare ground, and often respond positively to heavy grazing that can create short-grass habitats they require (Saab et al. 1995). Because others have documented their preference for cultivated lands (see Best et al. 1997, Ryan et al. 1998, Hohman and Halloum 2000 for reviews) and heavily grazed habitats (Saab et al. 1995, Ryan et al. 1998) over CRP, we did not expect to find positive relationships between CRP and horned larks. Horned larks were related to cultivated cropland in all 7 BCRs, but we also found positive relationships to CRP in the eastern tallgrass prairie. This BCR covered the core area of horned lark range in the eastern and midwestern United States (they are most common in the western US). A possible explanation for this apparent contradiction to other studies (e.g., Best et al. 1997, Ryan et al. 1998, Hohman and Halloum 2000) is that while horned larks may prefer cultivated and/or grazed habitats for nesting and foraging at local scales, increased amounts of CRP in the broader landscape may confer other benefits to horned larks.

Loggerhead shrike and red-winged blackbird were both related to CRP in less than half of the BCRs (40% and 43%, respectively), and it is unclear whether these species can be considered "CRP species". ***Loggerhead shrikes*** prefer a variety of open habitats, especially grazed pastures with available woody perches or abundant fencerows (Yosef 1996), and they are threatened by decreasing pastureland and increasing human activities. We see this reflected in the negative relationships with urban and forest landcover in our range-wide model for loggerhead shrike (Appendix A). We observed positive associations between CRP and shrikes in the central hardwoods and piedmont regions. Although CRP may not provide preferable habitat for loggerhead shrikes, CRP may be a mechanism for slowing urban development and retaining agricultural lands in the landscape which would benefit shrikes. ***Red-winged blackbirds*** were consistently related to cropland (a food source). Because they adapt readily to a variety of habitats, broad effects of CRP are not necessarily expected, but we did find them for eastern tallgrass prairie (total CRP), southeastern coastal plain (tree CRP) and Appalachian mountains (grass-legume CRP). In the heavily-forested Appalachian mountains, CRP may represent additional breeding habitat in a region where breeding habitat is scarce. Explanations for the other BCRs are not as apparent.

Our edge species - indigo bunting and brown-headed cowbird - were also related to CRP in less than 50% of the BCRs (43 % each). ***Indigo buntings*** are generally abundant across their range and favor weedy, brushy edge habitats (Payne 1992). We would expect them to do well in CRP-dominated landscapes, and they were positively related to CRP the prairie-hardwood transition, southeastern coastal plain, and Appalachian mountains. ***Brown-headed cowbird*** is of concern because it is a nest parasite that threatens populations of many grassland and forest breeding birds, and they are often associated with pasturelands and fragmented landscapes with lots of field-forest ecotone (Lowther 1993). The only cowbird-CRP relationships we observed were with grass-legume CRP in the Appalachian mountains, central hardwoods and in the western region. Two possible explanations are that CRP may contribute to landscape heterogeneity in these regions (e.g., increases the amount of field-forest ecotone), and/or grass-legume CRP habitat may provide nesting habitat for cowbird hosts.

Differences among BCRs. Clearly, our results indicate that ***bird responses to CRP vary considerably from one ecological region to another***. Although this regional variation makes predicting response to CRP more complex, it is not surprising. Among BCRs, there is considerable variation in topography, climate, land cover, and composition of the avian community (and indeed this is our major justification for creating BCR-specific models of bird-CRP relationships). In an attempt to generate some hypotheses about how and why responses vary across BCR's, we examined the possibility that regional differences in land cover might influence bird responses. We calculated (from 1992 NCLD data) the percent of each BCR that was comprised of major land cover types (water, urban, barren, forest, grassland, pasture, cropland, etc.) and looked for correlations between these variables and the % of species (that we modeled) that exhibited significant CRP relationships. ***We caution that our sample size for these investigations is only 7, and these results should be considered preliminary***.

We found significantly more bird-CRP relationships in BCRs that were comprised mostly of forest ($r = 0.801$, $P = 0.030$) and had little cropland ($r = - 0.750$, $P = 0.052$). There were fewer bird-CRP relationships in BCRs that were predominantly cropland and had little forest (see Figure 2 below). A possible explanation for this is that CRP has a greater impact on grassland bird populations in areas (like the Appalachian mountains region) where native grasslands, croplands and other habitats for grassland birds are more scarce. In these regions, CRP could be either creating new habitat for grassland birds and/or providing additional economic revenues that prevents agricultural landscapes in primarily forested regions from reverting to forest cover. These ideas are merely hypotheses, but represent a needed line of future research.

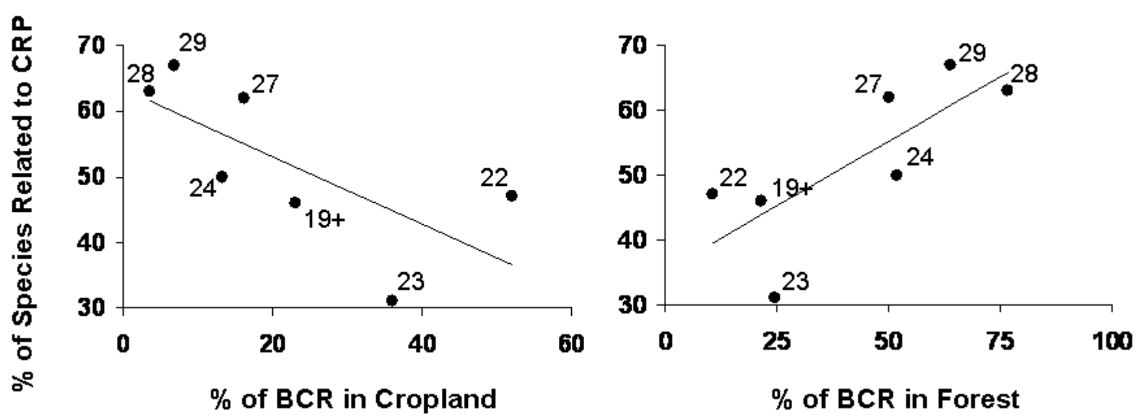

Figure 2. Relationships between the prevalence of significant bird-CRP relationships (% of species in a region with significant CRP effects, on y-axis) and regional land cover composition of each BCR (% of region comprised of a particular land cover, on x-axis). Each point represents one of the seven bird conservation regions, and model results for each region are in Table 1.

Weakness of NRI-derived analyses. NRI-derived estimates suffer from some limitations. First, landscape variables include only composition metrics. Aspects of landscape configuration like edge density, patch size, patch density, contagion are often important predictors of bird abundance, sometimes more important than composition metrics. Without these, we cannot rule out the possibility that CRP metrics are correlated to aspects of landscape configuration that the NRI database does not measure. Thus, CRP may not be the causal factor behind observed relationships. Second, the NRI database only provides a basic (grass vs. tree) distinction among the myriad of practice types, and does not provide any configuration information about CRP contracts. We know from literature (e.g., Burger et al. 1990, Herkert 1994, Johnson and Igl 2001, Herkert et al. 2003) and our analyses presented below that CRP practice type, configuration and age can all affect the response of grassland birds. The generic classification of CRP in the NRI database means that it is possible that other effects (both positive and negative) of specific types of CRP may have gone undetected. Third, using 1997 CRP data limits analysis to the early years of the CRP. After 1997, modifications to the Environmental Benefits Index (EBI) used to rank and award contract were revised such that wildlife benefits were emphasized in the award process. Thus, it is possible that CRP effects on grassland birds have been even more pronounced since then.

Major Conclusions

- In and around 1997, ***CRP habitat was overwhelmingly associated with higher abundance of grassland birds*** (both obligate and facultative species). However, we caution that these are correlative relationships only, that that CRP may be merely correlated with some underlying, unmeasured factor that is actually responsible for the effects we observed.
- Among species, ***significant CRP relationships were more prevalent in ecological regions where the majority of the landscape was covered by forest and there was little cropland***. This suggests a hypothesis for future work - that CRP has its greatest effects on grassland birds where grassland habitats are relatively scarce.

SUB-PROJECT B - EXPLORATORY ANALYSES USING CLU DATA

Materials and Methods

Temporal and Geographic Extent of Study. Availability of the CLU data limited both the temporal and geographic extent of our analyses. Because the CLU was based on contract information circa 2003 – 2004, we were restricted to modeling bird abundance from 2000 - 2004 only. Dates of individual contracts were part of the database, but some contracts likely expired or were withdrawn from the CRP were not included. Thus, accurate data about CRP contract acreage prior to 2003 – 2004 did not exist within this database.

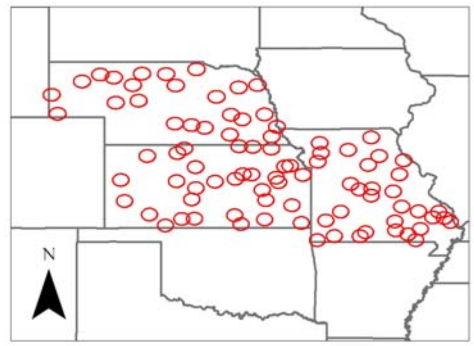

Figure 3. Location of 87 BBS routes used for sub-Project B.

We were geographically restricted to a 3-state region consisting of Nebraska, Kansas and Missouri (see Figure 3 above) because this was the extent of FSA-CLU contract data that was available within the breeding range of the northern bobwhite.

Focal Bird Species. We used the same focal bird species described in the methods for *sub-Project A* above.

Breeding Bird Data. We calculated the mean abundance of each species over the 5-year window (2000 - 2004) for all routes which were sampled in ≥ 3 of the 5 years. We omitted any route-year combinations that had unacceptable runs (inappropriate weather, first-time observer, etc.). Breeding Bird Survey methodology is described in *Sub-Project A* above.

Landuse, Agriculture and CRP variables. We used USGS National Land cover-Land use dataset (built around 1992 data) to estimate landscape characteristics. Although the dates did not correspond exactly to the CRP (≈ 2004) and bird data, this is the best (and only) large-scale landcover data source available for such analysis. To estimate landscape composition and to quantify the amount and configuration of CRP in the surrounding landscape, we used the FSA-CLU database to mask the USGS National Land cover-Land use dataset. Masking ensured that the NLCD-derived variables were mutually-exclusive of CLU-derived CRP variables (e.g., NLCD grassland did not include any CRP grassland). We positioned 25-km radius, circular buffers on the center of each BBS route and estimated land use, agriculture and CRP-related variables within each circular buffer. For justification of the 25-km radius buffer, see *Sub-Project A; Landscape, Agriculture, and CRP Variables* above.

We calculated the following ***landscape variables*** for use in analyses:

Contagion	= landscape contagion metric for entire landscape
Area_Water	= area of water: 11 (open water) + 12 (ice/snow)
Area_Urban	= residential land, commercial land, urban/recreational grasses (classes 21 + 22 + 23 + 85)
Area_Barren	= bare rock, clay, sand, quarries (classes 31 + 32)
Area_Forested	= deciduous, evergreen and mixed upland forest (classes 41 + 42 + 43)
MPS_Forested	= mean patch size forested land
PD_Forested	= patch density (#/km^2) of forested land
ED_Forested	= edge density (m/km^2) of forested land
Cohesion_Forested	= cohesion metric for forested land
Area_Grassland	= grasslands (classes 33 + 51 + 71; see text below)
MPS_Grassland	= mean patch size of grassland
PD_Grassland	= patch density (#/km^2) of grassland
ED_Grassland	= edge density (m/km^2) of grassland
Cohesion_Grassland	= cohesion metric for grassland
Area_Pasture/Hay	= pasture and hay (class 81)
Area_RowCrops	= rowcrops and small grains (classes 82 = 83)
Area_Fallow	= fallow land (class 84)
Area_Wetlands	= emergent and forested wetlands (classes 91 + 92)

Grassland habitats include USGS land cover class 33 (barren transitional) because this land cover class had enough grassland cover to be considered potential breeding habitat for many of the species we worked with. We also included land cover class 51 (shrublands) because NLCD metadata indicated that the USGS classification algorithm did not sufficiently distinguish 51 – shrublands from 71-grasslands.

We also calculated ***CRP variables*** as follows:

Generic CRP Variables (all contracts in database)

Total CRP Area	= % of the 25-km buffer in CRP
Grass CRP Area	= % of the 25-km buffer, grass-based practices only
Tree CRP Area	= % of the 25-km buffer, tree-based practices only

Practice-specific CRP Variables (all contracts in database)

Native Grass (CP2) Area	= % of the 25-km buffer, CP2 (native grasses)
Exotic Grass (CP1) Area	= % of the 25-km buffer, CP1 (exotic grasses)
Grass Strip CRP Area	= % of the 25-km buffer, grass-based strip practices: (CP8 + CP8A+ CP13 + CP13A + CP13C + CP15 + CP15A + CP15B + CP21 +CP24 + CP29)
Woody Strip CRP Area	= % of the 25-km buffer, tree-based strip practices: (CP4A + CP4B + CP5 + CP5A + CP13B + CP13D + CP16 + CP16A + CP17 + CP17A + CP22)

NOTE: All practices are included in the generic variables, but practice-specific variables included only those practices that can be clearly classified. For example, CP10 – existing grasses is included in Grass CRP Area, but is excluded from the Native Grass (CP2) and Exotic Grass (CP1) variables because either native or exotic grasses can be re-enrolled into CP10. Thus, CP10 cannot be clearly classified and is omitted from practice-specific variables.

Configuration Variables (all contracts in database)

Total CRP Patch Density	= patch density (#/km^2) of all CRP contracts
Total CRP Patch Size	= mean patch size of all CRP contracts
Grass CRP Patch Density	= patch density (#/km^2) of grass-based practices
Native Grass Patch Density	= patch density (#/km^2) of all CP2 contracts
Exotic Grass Patch Density	= patch density (#/km^2) of all CP1 contracts

Young CRP Variables (contracts initiated after 2000 only)

Young Total CRP Area*
Young Grass CRP Area
Young Native Grass (CP2) Area
Young Exotic Grass (CP1) Area
Young Total CRP Patch Density
Young Total CRP Patch Size
Young Grass CRP Patch Density
Young Native Grass Patch Density
Young Exotic Grass Patch Density

* Variables calculated as above, except that calculation was restricted to only those contracts in an early successional stage (initiated after 2000). CP10 and

CP11 were omitted because these practices are re-enrollments of existing grass and trees, and thus, are not early successional habitats.

Statistical Techniques. Because this dataset (although restricted spatially) provided more detail about practice type, configuration and age, we constructed our analysis in a way that allowed us to compare the relative importance of these components to the generic CRP variables (total, grass-legume and trees) that we used in the NRI-based analysis.

We constructed bird-CRP models using a two-stage stepwise selection process (α-to-enter = 0.20 but α-to-stay = 0.05) to build landscape models for grassland bird abundance. First, we included the landscape variables and the CRP variables in a stepwise selection. Then, we conducted a second stepwise selection where the third-order polynomial terms (E, N, E^2, etc.) were the potential explanatory variables, but landscape and CRP variables retained from the first stepwise selection were forced in first. We made this modification for this analysis because many of the CRP variables were correlated to the broad-scale spatial trend variables. We needed to ensure that broad-scale trends were accounted for to meet the stationarity assumption for testing for spatial autocorrelation, but we did not want to preclude CRP variables from entering into the model. After fitting landscape, CRP and broad-scale trend variables, we inspected for spatial autocorrelation and included terms as indicated (following the procedures described for the previous analysis).

For each bird species, we built two of these models -- a "Generic CRP model" that included only generic CRP variables (e.g., total, grass, and tree CRP) and a "Specific CRP model" that contained all the practice-, configuration- and young-age CRP variables.

Because we had many potential explanatory variables, many of which were correlated, we were concerned about the effects of multi-collinearity on our standard errors and associated statistical tests. We computed variance-inflaction factors (VIFs) for each model (Neter et al. 1989) to identify pairs of highly-correlated explanatory variables. In models that were unduly influenced by mulit-collinearity (VIF > 10; Neter et al. 1989:409), we removed one of the correlated variables.

Stepwise regression allowed us to sort out multiple sets of potentially explanatory variables, and we wanted to do so in a hierarchical fashion (sensu Lichstein et al. 2002). We minimized potential problems associated with stepwise procedures (e.g., Whittingham et al. 2006) in the following ways. We carefully selected candidate predictors based on known and theorized bird-landscape relationships to reduce the number of potential predictors. We used a liberal entry criterion ($\alpha = 0.20$) to increase the number of potential predictor combinations that were evaluated, but we used a stringent criterion to retain predictors ($\alpha = 0.05$) to prevent over-fitting in the final model and recognize that a single model often contained multiple predictors (and hence multiple hypotheses). We investigated variance inflation factors to ensure that the final model was not unduly affected by multi-collinearity. We inspected residuals to assure that assumptions of regression were met and preformed appropriate transformations or included terms for spatial correlation when indicated. In short, we did not blindly rely on the stepwise algorithm, but employed careful thought to possible predictors and critically examined the models at each step (Draper and Smith 1998).

Results and Discussion

Northern Bobwhite. Northern bobwhite demonstrated no generic response to CRP, but ***northern bobwhite were positively related to patch density of native grasses ≤ 4 yrs old*** (Table 2). Based on this model, ***a 10% increase in the density of CP2 patches would be associated with an estimated 2.94% increase in northern bobwhite abundance*** (Table 3).

It is commonly accepted that bobwhite populations flourish when there is a high degree of interspersion in the landscape - high habitat heterogeneity providing the multiple habitats require by bobwhite in close proximity (Baxter and Wolfe 1972, although see Guthery 1999). Thus, bobwhite should be more abundant in landscape with greater patch densities and more edge (e.g., Roseberry and Sudkamp 1998, Smith 2004), and ***this configuration effect was apparent*** in the specific model for bobwhite. Bobwhite was more abundant in landscapes with greater forest and grassland edge density and with greater density of native grass CRP patches (Appendix B). We observed an ***effect of young-aged CRP*** on bobwhite quail, and this highlights the importance of mid-contract management to inhibit ecological succession in CRP habitat. (Burger et al. 1990, McCoy et al. 2001b, Greenfield et al. 2003). In summary, CRP in Kansas, Missouri, and Nebraska seems to most benefit bobwhite when it is comprised of a high density of patches of native grass that is less than < 4 years old. Mid-contract management would help maintain the benefits of native grass CRP over the course of the contract.

Table 2. Summary of significant CRP responses by grassland birds in Kansas, Nebraska and Missouri (2000 - 2004) from general and specific CRP models based on CLU data

Species	Generic CRP Model Effects	Specific CRP Model Effects	Type of Response
Northern bobwhite	ns[1]	+ Young Grass CRP Patch Density	Configuration Young-aged
Horned Lark	ns	+ Native Grass (CP2) Area	Practice
Grasshopper sparrow	+ Grass CRP	+ Native Grass (CP2) Area	Generic Practice
Henslow's Sparrow	ns	ns	No Response
Dickcissel	+ Grass CRP	ns	Generic
Eastern meadowlark	ns	ns	No Response
Western meadowlark	ns	ns	No Response
Mourning dove	ns	ns	No Response
Eastern kingbird	ns	+ Native Grass (CP2) Patch Density	Practice Configuration
Loggerhead shrike	ns	+ Total CRP Patch Density	Configuration
Common yellowthroat	ns	+ Young Grass CRP Area	Young-aged
Lark Sparrow	ns	+ Total CRP Patch Density	Configuration
Red-winged blackbird	ns	ns	No Response
Eastern bluebird	ns	ns	No Response
Brown-headed cowbird	ns	ns	No Response
Indigo bunting	ns	- Total CRP Patch Size	Configuration

[1] No CRP variables selected.

Table 3. Estimated response (% increase in abundance) of bird species to significant CRP variables in Kansas, Nebraska and Missouri (2000 - 2004) from general and specific CRP models based on CLU data.

			Response to a 10% change in CRP variables	
CRP Variable	units	Mean value of CRP variable	10% change in CRP variable (mean + 10%)	Predicted bird abundance (% change)
Northern bobwhite				
Young Grass CRP Patch Density	#/km^2	0.037	0.040	2.94 %
Horned Lark				
Native Grass (CP2) Area	% of buffer area	0.917	1.008	3.15 %
Grasshopper Sparrow				
Grass CRP Area (general model)	% of buffer area	2.554	2.809	5.60 %
Native Grass (CP2) Area (specific model)	% of buffer area	0.917	1.008	4.67 %
Dickcissel				
Grass CRP Area	% of buffer area	2.554	2.809	1.63 %
Eastern Kingbird				
Native Grass (CP2) Patch Density	#/km^2	0.085	0.094	1.33 %
Loggerhead Shrike				
Total CRP Patch Density	#/km^2	0.405	0.445	3.36 %
Common Yellowthroat				
Young Grass CRP Area	% of buffer area	0.255	0.281	3.92 %
Lark Sparrow				
Total CRP Patch Density	#/km^2	0.405	0.445	2.80 %
Indigo Bunting				
Total CRP Patch Size	ha	11.399	12.538	-2.03 %

Other Grassland Birds. We examined bird-CRP relationships for 15 other species of grassland birds (Henslow's sparrow was abundant enough to include in this analysis). Eight of the other 15 species were related to CRP variables (Tables 2 & 3). Models and results for these species are in Table 2 (general vs. specific effects), Table 3 (associated increases), and Appendix B (complete list of models). Rather than discuss each species separately, we will discuss the responses by birds to CRP in 5 general classes: practice-specific responses, configuration responses, young CRP responses, generic responses, and no response. Readers interested in model specifications and results for individual species, these are listed in Appendix B.

Practice-specific responses. In addition to northern bobwhite, 3 other species exhibited practice-specific responses. Greater abundance of horned lark, grasshopper sparrow, and eastern kingbird was associated with native grass (CP2) practices. Grasshopper sparrow is traditionally associated with native prairies and prefers open grasslands with interspersed bare ground and few shrubs (Vickery 1996, Herkert 1998), conditions that CP2 plantings are likely to contain. Although most documented responses of horned lark to CRP have been negative (Best et al. 1997, Ryan et al. 1998 and references therein), Johnson and Schwarz (1993) documented horned lark preference for native grass CRP. Few responses to CRP (positive or negative) have been reported for eastern kingbird. However, rarely have studies examined practice-specific aspects of CRP habitats, and our results highlight the importance of considering specific aspects of CRP habitats (such as practice type) when evaluating the program's effect on wildlife.

Configuration responses. In addition to northern bobwhite, we observed configuration effects for five other species. Northern bobwhite, eastern kingbird, loggerhead shrike, indigo bunting and lark sparrow were related to CRP variables in ways that were consistent with their affinity for habitat edges (i.e., negatively related to patch size or positively related to patch density). All five are known edge denizens, so they likely prefer CRP that is configured in many, small patches rather than a few large patches. Management of CRP should strive to maintain a mosaic of large (for area-sensitive species) and small (for edge species) CRP patches in the landscape.

Young-age responses. In addition to northern bobwhite (discussed above), common yellowthroat was also positively associated with CRP habitat < 4 years old. Although common yellowthroat are traditionally considered a wetland species (Guzy and Ritchison 1999), they often breed in CRP habitats (Johnson and Igl 1995). However, little quantitative information about their habitat requirements (both generally and specifically in CRP habitat) is known (Guzy and Ritchison 1999).

Generic response. Grasshopper sparrow and dickcissel were the only species to show a general response to CRP (i.e., relationship with one of the generic variables), and both grasshopper sparrow (Herkert 1998) and dickcissel (Ryan et al. 1998 and references therein) have been generally associated with CRP. In our study area, grass CRP comprised 2.554 % of the 196,250-ha landscapes associated with BBS routes. Using the general models (Appendix B) and mean values for the landscape and CRP variables, **increasing the % native grass CRP in the landscape by 1% (0.9% to 1.9%) is associated with an 23.6% increase in grasshopper sparrow abundance and a similar increase in total grass CRP (2.6% to 3.6%) is associated with a 6.5% increase in dickcissel abundance**. However, for both species, the specific model had a substantially lower AIC_c (Burnham and Anderson 2002) indicating that the Specific CRP Model may be a better explanation for bird abundance. This, and the fact that only 2 of 16 species even had a significant CRP effect in the Generic Models, underscores the importance of considering practice type, configuration and mid-contract management in the evaluation and design of CRP.

No response. Seven species were not related to CRP variables, but we stress that this does not mean that CRP does not benefit these species. Indeed, positive associations with CRP have been widely-documented for some of these species (e.g., eastern meadowlark in our NRI-analyses). Responses to CRP can vary from region to region within a species, and it is quite possible that these species could be related to CRP in other ecological regions. Also, our small available sample size may decrease our ability to detect CRP-bird relationships.

Strengths and Weaknesses of the CLU-based Analysis. Using the spatially-explicit CLU database ameliorates many of the weaknesses of other available data about CRP because it provides practice-specific information, configuration metrics can be calculated and the age of the contract can be estimated. This represents a substantial improvement in the ability to detect effects of CRP on wildlife. Also, we were able to combine it with spatially-explicit land use data which allowed us to also account for the effects of landscape configuration in our models.

However, our current analysis was limited to only a small geographic area. Thus, we cannot make any broad-scale conclusions about CRP effects, and our results should be applied beyond the states of Kansas, Missouri and Nebraska. Other relationships might be expected in other physiographic regions with a differing landscape context. A second weakness is that we had to match the CLU data (2004) to the 1992 NCLD data. This problem will be partially rectified when the 2001 NCLD data becomes available in the near future.

Major Conclusions

In the region in which we worked:

- Northern bobwhite were positively related to young grass CRP patch density. Thus, ***bobwhite would benefit from increasing the density of grass CRP patches in the landscape and from mid-contract management on existing contracts***.
- ***Effects of CRP on other species were predominantly positive***.
- ***Practice type, configuration and age of the contract were all generally more important that simple, generic classifications of CRP***. Recommendations for particular combinations of these characteristics will vary depending on the target species.

PROJECT #2: DEVELOPMENT OF SPATIAL DATA FOR FUTURE MONITORING OF A SELECT NEW CRP PRACTICE, CP33.

BACKGROUND OF PROJECT

USDA-FSA Notice CRP-479 provides policy for CRP continuous signup practice CP-33, Habitat Buffers for Upland Wildlife, thus ***providing a perfect opportunity to implement an ideal monitoring scheme***. Notice CRP-479 specifies that "a monitoring and evaluation plan must provide the ability to establish baseline data on quail populations and estimate increasing quail populations and impact on other upland bird populations as a result of practice CP-33, Habitat Buffers for Upland Birds, including the following:

- verification that suitable Northern Bobwhite quail cover is established;
- verification that appropriate cover management practices are implemented on a timely basis;
- states must control acreage within their allocation;
- implementing a statewide sampling process that will provide reliable estimates of the number of quail per acre (or some other appropriate measure) before practice CP-33 is implemented."

Implementation of the national CP33 monitoring required 5 critical steps:

1) selection of statistically-representative, random sample of contracts, stratified by state;
2) collection of CP33 contract information from county USDA service centers in the 20 states to be sampled;
3) development, award and execution of subcontracts to state agencies for sampling;
4) training of state agency personnel in field selection and bird monitoring protocol; and
5) execution of actual monitoring.

Project #2 of our proposal was to accomplish critical step #2 - collecting CP33 contract information from county USDA service centers. A random sample of contracts, stratified by state, was drawn from the national database. However, ***the individual county offices had to be***

visited to collect information regarding number of fields, individual field size, landowner contact information, and spatial data.

Of the total CP-33 allocation of 250,000 acres, 95% (235,700 ac) occurs in 20 states. The remaining 5% of the acreage is distributed among 15 states that are outside of the core range of the bobwhite. Intensive monitoring in the 20 states that received 95% of the CP-33 allocation would characterize the national impact of CP-33 on northern bobwhite populations. We proposed to send teams of 2 persons to visit county offices in the 20 states receiving CP33 allotments to collect the needed contract information.

To obtain number of fields, location, and landowner contact information (and other information required for the monitoring program), these contract numbers had to be cross-referenced to physical files housed in USDA-FSA county offices. Information on individual CRP contracts is protected by the privacy provisions of the 2002 Farm Act, and access to this information required special permission by USDA-FSA national office. On 15 December 2005, FSA National released Notice CRP-508 (Confidentiality of Information and Monitoring of Practice CP33, Habitat Buffers for Upland Birds) which enabled access to CP33 contract information by Mississippi State University and respective State Wildlife Agency researchers. Upon issuance of CRP-508, we assembled technician teams to visit county offices to collect CP33 contract information.

Completed Data Collection

USDA service centers in Arkansas, Georgia, Indiana, Iowa, Kentucky, Mississippi, Nebraska, Tennessee, Texas, and South Carolina have been visited and contract information collected. Illinois, Missouri, and Ohio elected to collect CP-33 contract information themselves. Arkansas and Nebraska intend to start monitoring fall 2006, thus county offices in these states were visited in July 2006. Florida, Alabama and Louisiana will not be visited because they did not enroll enough CP-33 contracts to conduct monitoring this year. If these 3 states meet enrollment standards, we may visit them in the future. Data will not be collected from Kansas, and Oklahoma because they are using a different monitoring protocol.

Connection to Continuing Monitoring

This project was instrumental in securing $707,000 in additional funding to support CP33 monitoring funding through the IAFWA 2006 Multistate Conservation Grants Program. These funds will be distributed through subcontracts to individual states to direct and support CP33 sampling. Currently, instructional sampling packets have been assembled and were distributed to State CP-33 Coordinators in Georgia, Indiana, Iowa, Kentucky, Mississippi, Tennessee, Texas, and South Carolina. Ohio, Illinois, and Missouri assembled their own sampling packets. Because Arkansas, Nebraska, North Carolina, and Virginia will not be monitoring until Fall 2006, sampling packets will be assembled and distributed during August 2006.

Major Outcomes

The Project funded the selecting and design of the monitoring scheme, ***and that monitoring is now underway.*** The CP33 monitoring project will permit "*national and regional estimates of per acre CRP effects on wildlife populations for CRP conservation*" in a statistically robust fashion.

SUMMARY & RECOMMENDATIONS

Our results are the first to quantify the positive associations between Conservation Reserve Program lands and northern bobwhite (and other grassland birds) across a broad geographic region. Although our analyses were correlative and retrospective, results consistently pointed towards widespread positive effects of CRP on grassland birds. Additionally, we demonstrated that simple classifications of CRP that ignore issues of contract age, configuration and practice type may not allow many benefits of CRP to be detected.

Robust estimates of the real effect of CRP on wildlife species should come from ongoing monitoring of wildlife populations at a random sample of contracts selected from a pool of all national contracts (based on a probabilistic sampling design). Our results represent a first step in that direction, but current availability of data sources limits the extent of inferences. Fortunately, forthcoming datasets will alleviate many of these hurdles. First, completion of the entire, national CLU database will permit future CRP assessments that explicitly consider effects of specific practice type, spatial configuration and successional stage (i.e., contract age) at large spatial scales. Our results underscore the need for completion and availability of the entire CLU database. Secondly, the pending availability of the 2001 National Land Use Land Cover Dataset will provide landuse data that is a better temporal match to the CLU data (circa 2004) than the currently available 1992 NLCD. Finally, the initiation of biological monitoring of CP33 (randomized, paired-sample design, see *Project #2: Development of Spatial Data for Future Monitoring of a Select New CRP Practice, CP33* above) will provide robust inferences about the national population of CRP contracts.

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Appendix A. Results of models for grassland birds species derived from NRI data. All models are linear models except those denoted by †, which were logistic regressions on presence-absence data. Any additional spatial covariance structure is described in parentheses.

Northern bobwhite

Eastern Tallgrass Prairie (sqrt):	– 0.7391 Rural transportation – 2.6182 E – 9.8519 Northing – 17.1604 N^2 (gaussian)
Prairie-hardwood Transition †:	– 11.4766 N
Central Hardwoods:	+ 0.1883 Cultivated cropland **+ 1.8246 Total CRP** – 87.4253 E^3
Southeastern Coastal Plain:	**+ 0.0534 Tree CRP** – 23.5825 E^2 + 97.5317 E^2N
Appalachian Mountains †:	+ 0.1553 Noncultivated cropland – 5.5549 N + 9.3669 E^2
Piedmont:	+ 0.1476 Forest + 0.7097 Large water + 0.2586 Pasture **+ 4.2746 Total CRP** (spherical)
Southwest Regions:	**+ 0.1471 Grass-legume CRP** – 34.2752 E – 40.7689 N^2 (exponential)
Range-wide:	– 0.0637 Forest – 0.1311 Urban – 0.1468 Federal **+ 0.0311 Grass-legume CRP + 0.0350 Tree CRP** – 24.3221 E^2N (exponential)

Horned lark

Eastern Tallgrass Prairie ($\log_{10}$):	+ 0.0195 Cultivated cropland **+ 0.0326 Total CRP** + 0.9089 E – 1.0883 N – 1.4027 E^2
Prairie-hardwood Transition:	+ 0.2051 Cultivated cropland – 528.31 N^3
Central Hardwoods †:	+ 0.1387 Cultivated cropland
Southeastern Coastal Plain †:	+ 0.0910 Cultivated cropland + 7.4210 E^2
Appalachian Mountains †:	+ 0.2507 Cultivated cropland – 0.1549 Urban + 0.6848 Large water – 37.4668 E^2
Piedmont †:	+ 0.1148 Cultivated cropland
Southwest Regions †:	+ 0.0939 Cultivated cropland

Appendix A. Continued.

Range-wide †:	+ 0.0838 Cultivated cropland **+ 0.0092 Grass-legume CRP** - 1.6828 Northing (exponential)
Grasshopper sparrow	
Eastern Tallgrass Prairie ($\log_{10}$):	**+ 0.0661 Total CRP + 0.0021 Grass-legume CRP** – 1.7716 N + 8.7398 N^3 (exponential)
Prairie-hardwood Transition †:	+ 0.1448 Pasture
Central Hardwoods †:	+ 0.0870 Cultivated cropland – 0.3522 Urban
Southeastern Coastal Plain †:	+ 0.2512 Pasture + 2.9522 Rural transportation + 20.8124 N – 31.5207 E^2N
Appalachian Mountians †:	+ 0.0892 Cultivated cropland **+ 0.0132 Grass-legume CRP** - 13.8800 E^2
Piedmont ($\log_{10}$):	+ 0.0436 Non-cultivated cropland + 0.0416 Pasture + 0.2197 Rural transportation **+ 0.1819 Total CRP**
Southwest Regions †:	**+ 2.0567 Total CRP** – 12.9794 E + 9.6010 N – 35.5810 N^3 + 142.65 E^2N
Range-wide †:	**+ 0.0119 Grass-legume CRP** + 0.0090 Tree CRP + 1.9075 N – 4.4827 N^2 – 2.1039 E^3 (gaussian)
Dickcissel	
Eastern Tallgrass Prairie:	**+ 1.6490 Total CRP** – 57.6394 E – 89.8590 N + 56.8070 E^2 (exponential)
Prairie-hardwood Transition †:	– 0.0909 Forest – 67.8558 E^3
Central Hardwood:	**+ 4.4888 Total CRP** – 463.26 E^3 + 854.70 E^2N (spherical)
Southeastern Coastal Plain †:	**+ 0.2828 Total CRP** + 25.2910 N – 86.6829 E^2N
Southwest Regions:	+ 0.9380 Cultivated cropland + 5.0611 Non-cultivated cropland **+ 2.7099 Total CRP** + 101.45 N – 253.24 E^2 – 297.55 N^3
Range-wide ($\log_{10}$) †:	– 0.0464 Forest – 0.0827 Federal **+ 0.0223 Tree CRP** – 6.3191 E – 8.7022 N^2

Appendix A. Continued.

Eastern meadowlark

Eastern Tallgrass Prairie:	+ 0.5648 Pasture **+ 1.3528 Total CRP** – 69.3914 N - 191.88 E^2N
Prairie-hardwood Transition:	+ 0.9240 Non-cultivated cropland **+ 1.4536 Total CRP** + 495.89 N^2 + 820.31 N^3 + 364.67 EN
Central Hardwoods:	+ 18.3963 Rural transportation **+ 4.1792 Total CRP** + 424.76 E^2 - 201.00 EN
Southeastern Coastal Plain (log_{10}):	+ 0.0437 Pasture **+ 0.0341 Total CRP** + 1.0231 N
Appalachian Mountains (log_{10}):	+ 0.0378 Non-cultivated cropland + 0.0356 Pasture **+ 0.1476 Total CRP** - 4.8065 E^3 (exponential)
Piedmont:	+ 0.1806 Forest + 1.2241 Pasture **+ 3.8021 Total CRP** (gaussian)
Southwest Regions:	+ 0. 7568 Pasture – 0.3734 Forest **+ 2.9499 Total CRP** + 191.04 EN^2 (exponential)
Range-wide (log_{10}):	0.0155 Non-cultivated cropland + 0.0157 Pasture – 0.0079 Forest – 0.0149 Federal **+ 0.0327 Total CRP** – 0.8094 N – 0.7266 E^2 + 1.5309 N^3 + 0.7789 EN (spherical)

Western meadowlark

Eastern Tallgrass Prairie †:	– 0.1039 Urban – 4.9235 E + 28.3988 N – 69.9683 E^2N
Prairie-hardwood Transition †:	+ 0.0723 Cultivated cropland – 10.9157 E
Southwest Regions †:	– 1.1496 Small water + 4.9841 N (gaussian)
Range-wide †:	+ 0.0703 Cultivated cropland – 5.4586 E + 8.4982 N + 4.6984 E^2 (exponential)

Mourning dove

Eastern Tallgrass Prairie:	+ 50.9262 E^2
Prairie-hardwood Transistion (log_{10}):	– 0.0056 Forest + 0.3975 E

Appendix A. Continued.

Central Hardwoods:	+ 0.5404 Cultivated cropland + 0.2719 Pasture + 4.2404 Other **+ 2.2921 Total CRP**
Southeastern Coastal Plain:	+ 1.1241 Cultivated cropland + 0.8271 Pasture **+ 0.1127 Tree CRP** + 153.61 E^3 – 260.63 N^3
Appalachian Mountains:	+ 1.0496 Cultivated cropland + 0.4666 Pasture + 0.4646 Urban – 13.5489 E
Piedmont:	– 0.4869 Forest **+ 10.4850 Total CRP** (exponential)
Southwest Regions:	– 0.7484 Forest **+ 2.1992 Total CRP** + 108.25 E^2
Range-wide ($\log_{10}$):	– 0.0077 Forest – 0.0122 Federal **+ 0.0006 Grass-legume CRP + 0.0014 Tree CRP** + 0.3429 E – 0.1446 N – 0.2939 E^3 (gaussian)
Eastern kingbird	
Eastern Tallgrass Prairie:	**+ 0.3025 Total CRP** – 8.8133 E + 9.9062 E^2 – 49.1271 E^2N + 58.0141 EN^2
Prairie-hardwood Transition:	+ 0.1802 Pasture **+ 0.0622 Tree CRP** + 7.9821 E – 28.9626 E^2 + 58.5269 N^2 – 451.91 EN^2
Central Hardwoods:	+ 0.1162 Pasture (spherical)
Southeastern Coastal Plain:	**+ 0.0178 Tree CRP** – 17.0473 N^2
Appalachian Mountains:	+ 0.1287 Pasture + **0.4436 Total CRP** + 18.4666 E^2
Piedmont:	– 0.0981 Cultivated cropland + 0.2773 Pasture – 0.1453 Federal **+ 0.7888 Total CRP** + 155.63 E^2 + 158.25 N^2 – 299.55 EN
Southwest Regions:	+ 0.8505 Non-cultivated cropland **+ 0.5178 Total CRP** – 27.8406 E^2 + 35.1628 N^3
Range-wide ($\log_{10}$):	- 0.0126 Pasture - 0.0054 Federal **+ 0.0168 Total CRP + 0.0012 Tree CRP** + 0.7168 E^2N (gaussian)

Appendix A. Continued.

Loggerhead shrike

Eastern Tallgrass Prairie †:	– 6.3844 E – 8.7888 N + 38.0417 EN^2
Central Hardwoods †:	**+ 0.5413 Total CRP** – 50.7768 E^2N
Southeastern Coastal Plain:	– 0.0633 Forest – 0.0658 Federal – 33.2724 N^3 + 9.0436 EN (gaussian)
Piedmont †:	**+ 1.1561 Total CRP** – 8.6210 N
Southwest Regions †:	– 0.0377 Forest
Range-wide †:	– 0.0614 Forest – 0.0750 Urban – 0.1021 Federal – 9.3611 N + 2.4011 E^2 – 8.5720 N^2 – 8.3163 N^3 + 5.7341 E^2N – 3.8803 EN (exponential)

Common yellowthroat

Eastern Tallgrass Prairie:	**+ 1.0739 Total CRP** – 5.3599 E – 50.4351 EN (exponential)
Prairie-hardwood Transition:	+ 279.25 N^2 + 1473.78 N^3
Central Hardwoods ($\log_{10}$):	– 0.0067 Pasture **+ 0.0027 Grass-legume CRP** + 0.5236 E
Southeastern Coastal Plain ($\log_{10}$):	+ 0.0079 Forest + 0.0195 Federal + 1.0932 E^2 + 6.5347 N^3 – 2.4431 EN
Appalachian Mountains:	+ 0.1406 Forest **+ 0.0929 Grass-legume CRP** – 24.5420 E + 32.4046 N (exponential)
Piedmont:	**+ 2.2109 Total CRP + 0.0294 Tree CRP** + 15.7106 N^2 + 46.6561 N^3
Southwest Regions ($\log_{10}$):	+ 0.0512 Non-cultivated cropland + 0.0069 Forest + 0.0387 Large water + 0.9070 E + 2.2360 N^3
Range-wide ($\log_{10}$):	+ 0.0059 Forest **+ 0.0147 Total CRP + 0.0017 Grass-legume CRP** + 0.4901 N + 0.3727 E^3 (exponential)

Appendix A. Continued.

Lark sparrow

Eastern Tallgrass Prairie †: + 0.0830 Forest – 0.9599 Other – 5.6638 E

Central Hardwoods †: - 0.5623 Urban – 3.1901 E

Southwest Regions (log_{10}): – 0.0103 Cultivated cropland – 0.0076 Forest – 0.0238 Urban – 0.0139 Federal – 1.4763 E + 2.1622 E^2 – 0.6131 N^2 + 1.3772 EN – 2.9780 E^2N

Range-wide †: **+ 0.1799 Total CRP** – 5.2492 E – 4.7808 N^2 – 5.5841 E^2N

Red-winged blackbird

Eastern Tallgrass Prairie (log_{10}): + 0.0045 Cultivated cropland **+ 0.0171 Total CRP** – 0.8503 E^2 (exponential)

Prairie-hardwood Transition: – 2.2024 Cultivated cropland – 4.0261 Forest – 75.8976 Small water

Central Hardwoods: + 2.5244 Cultivated cropland + 1.2097 Pasture

Southeastern Coastal Plain (log_{10}): + 0.0203 Cultivated cropland + 0.0848 Non-cultivated cropland **+ 0.0028 Tree CRP** - 0.6528 E

Appalachian Mountains: + 2.9373 Non-cultivated cropland + 16.2951 Small water **+ 0.1315 Grass-legume CRP** (spherical)

Piedmont (log_{10}): - 0.0168 Urban – 0.0276 Forest + 3.0854 N^2

Southwest Regions (log_{10}): + 0.0199 Cultivated cropland + 2.6876 E^2

Range-wide (log_{10}): + 0.0045 Cultivated cropland + 0.0137 Non-cultivated cropland – 0.0134 Forest – 0.0065 Urban – 0.0179 Federal – 0.1710 E + 0.2354 N – 0.6261 E^2 + 0.9989 E^2N + 0.5387 EN (exponential)

Eastern bluebird

Eastern Tallgrass Prairie (log_{10}): – 0.0141 Cultivated cropland – 0.0189 Urban – 0.4138 N + 1.0834 E^3

Prairie-hardwood Transition (log_{10}): – 0.0134 Cultivated cropland **+ 0.0019 Grass-legume CRP** + 6.8506 N^2

Central Hardwoods:	- 0.1712 Cultivated cropland – 0.1491 Federal **+ 0.0453 Grass-legume CRP**
Southeastern Coastal Plain:	+ 3.5907 Rural transportation **+ 0.3954 Total CRP** + 88.9224 N^3
Appalachian Mountains:	+ 4.1446 Rural transportation + 73.2564 E^2 – 82.5825 E^2N – 62.5779 EN (exponential)
Piedmont:	**+ 2.2893 Total CRP** – 11.6986 N (exponential)
Southwest Regions:	– 0.1098 Cultivated cropland + 0.1418 Pasture – 0.2393 Federal (gaussian)
Range-wide ($\log_{10}$):	- 0.0137 Cultivated cropland – 0.0054 Forest – 0.0129 Urban – 0.0139 Federal **+ 0.0010 Grass-legume CRP** – 0.6415 N – 0.6275 N^2 + 0.4228 E^3 + 0.8421 N^3 – 0.6592 EN^2 – 0.3646 EN (exponential)

Brown-headed cowbird

Eastern Tallgrass Prairie:	– 6.6704 Rural transportation – 8.844 Small water – 30.6216 E (exponential)
Prairie-hardwood Transition:	(exponential)
Central Hardwoods:	+ 0.8649 Non-cultivated cropland **+ 0.0495 Grass-legume CRP** – 164.30 E^3
Southeastern Coastal Plain:	+ 0.3702 Pasture + 30.4206 E^2N
Appalachian Mountains ($\log_{10}$):	- 0.0049 Forest – 0.0149 Federal **+ 0.0014 Grass-legume CRP**
Piedmont:	- 0.0878 Forest
Southwest Regions:	**+ 0.1751 Grass-legume CRP** – 71.1726 E^2 + 50.6555 N^2
Range-wide ($\log_{10}$):	+ 0.0047 Pasture – 0.0637 Rural transportation - 0.0098 Federal **+ 0.0010 Grass-legume CRP** – 0.3055 E + 00.2310 N (exponential)

Indigo bunting

Eastern Tallgrass Prairie ($\log_{10}$):	+ 0.0118 Forest + 0.4755 E – 1.0871 N – 0.9439 E^2 (spherical)

Appendix A. Continued.

Prairie-hardwood Transition:	+ 0.5076 Forest – 0.7948 Non-cultivated cropland + 1.5240 Other **+ 0.0711 Grass-legume CRP** + 458.30 N^2 + 199.57 EN
Central Hardwoods:	– 20.0706 Rural transportation + 15.2812 Small water
Southeastern Coastal Plain (sqrt):	+ 0.0252 Forest + 0.6693 Small water **+ 0.0105 Tree CRP** – 2.1065 E + 6.9380 N (exponential)
Appalachian Mountains ($\log_{10}$):	- 0.0106 Urban **+ 0.0016 Grass-legume CRP** – 1.7856 EN^2 - 1.2922 N^2
Piedmont:	– 0.2359 Forest – 0.7660 Urban – 199.17 N^2 + 187.83 EN
Southwest Regions:	– 0.2283 Cultivated cropland – 4.9496 Rural transportation + 41.8032 E + 18.5625 N – 41.6428 N^2 – 119.12 EN^2 (spherical)
Range-wide ($\log_{10}$):	+ 0.0063 Pasture + 0.0065 Forest + 0.0169 Other – 0.0056 Urban – 0.0651 Rural transportation **+ 0.0018 Tree CRP + 0.0014 Grass-legume CRP** – 0.4291 N – 0.5732 E^2 – 1.2361 N^2 + 0.5290 E^3 + 0.8713 N^3 – 0.9348 EN^2 + 0.2222 EN (exponential)

‡ Omitted 2 extreme outliers.

Appendix B. Bird-CRP models derived from CLU data for Kansas, Missouri, and Nebraska., including base models, total-CRP models, practice-specific models, configuration. Any additional spatial covariance structure is described in parentheses.
CRP variables in bold.

Northern bobwhite

General CRP Model (square-root transformed):

– 0.0878 Contagion - 34.1613 N^3 (exponential)

Specific CRP Model (square-root transformed):

+ 0.2405 Forest Patch Density – 0.1726 Grassland Patch Density + 0.0449 Grassland Edge Density **+ 16.3036 Young Grass CRP Patch Density** - 3.7948 N

Horned lark

General CRP Model ($\log_{10}$ transformed):

– 0.0112 Forest Area + 4.6998 E^2 – 3.1277 E^3 + 4.0527 EN

Specific CRP Model ($\log_{10}$ transformed):

– 0.0171 Forest Area - 0.0220 Grassland Patch Density **+ 0.1251 Native Grass (CP2) Area** + 3.2786 E^2 (spherical)

Grasshopper sparrow

General CRP Model ($\log_{10}$ transformed):

+ 0.0192 Grassland Area + 0.0210 Rowcrop Area **+ 0.0858 Grass CRP Area**

Specific CRP Model ($\log_{10}$ transformed):

+ 0.0171 Forest Edge Density + 0.0185 Grassland Area + 0.0385 Grassland Cohesion + **0.2002 Native Grass (CP2) Area**

Appendix B. Continued.

Henslow's sparrow (logistic regression)

General CRP Model:

+ 0.0437 Forest Edge Density – 64.5380 N^2

Specific CRP Model:

+ 0.0437 Forest Edge Density – 64.5380 N^2

Dickcissel

General CRP Model (square-root transformed):

– 0.0606 Forest Area + 0.0260 Grassland Edge Density + 0.0613 Pasture-Hay Area + **0.1994 Grass CRP Area** – 10.8427 E^2 - 36.7398 E^2N

Specific CRP Model (square-root transformed):

– 0.0976 Forest Area + 0.0558 Pasture-Hay Area – 13.3541 E^2 – 37.9842 E^2N (spherical)

Eastern meadowlark

General CRP Model ($\log_{10}$ transformed):

– 0.0372 Forest Patch Density + 0.0206 Grassland Area + 0.0115 Rowcrop Area + 4.4590 E - 2.6289 N - 1.7721 E^2 - 8.0560 E^3 - 14.4540 EN^2 (exponential)

Specific CRP Model ($\log_{10}$ transformed):

– 0.0372 Forest Patch Density + 0.0206 Grassland Area + 0.0115 Rowcrop Area + 4.4590 E - 2.6289 N - 1.7721 E^2 - 8.0560 E^3 - 14.4540 EN^2 (exponential)

Appendix B. Continued.

Western meadowlark (logistic regression)

General CRP Model:

+ 0.2694 Grassland Cohesion + 0.03185 Rowcrop Area (spherical)

Specific CRP Model:

+ 0.2694 Grassland Cohesion + 0.03185 Rowcrop Area (spherical)

Mourning dove

General CRP Model ($\log_{10}$ transformed):

+ 0.3570 Barren Area – 0.0113 Forest Area + 0.0032 Rowcrop Area + 1.06587 E^2 – 3.4586 E^3 (exponential)

Specific CRP Model ($\log_{10}$ transformed):

+ 0.3570 Barren Area – 0.0113 Forest Area + 0.0032 Rowcrop Area + 1.06587 E^2 – 3.4586 E^3 (exponential)

Eastern kingbird

General CRP Model (square-root transformed):

- 4.80001 E^2 + 2.4034 N + 11.7617 E^3 - 1.7836 E

Specific CRP Model (square-root transformed):

+ 0.1127 Grassland Cohesion **+ 2.6060 Native Grass (CP2) Patch Density** + 2.5121 N + 11.5396 E^3

Loggerhead shrike (logistic regression)

General CRP Model:

– 0.0359 Forest Area

Specific CRP Model:

+ 2.8573 Total CRP Patch Density + 3.8991 N

Appendix B. Continued.

Common yellowthroat

General CRP Model ($\log_{10}$ transformed):

+ 0.0092 Area Rowcrop + 1.8678 E + 17.8571 N^3 (spherical)

Specific CRP Model ($\log_{10}$ transformed):

+ 0.0263 Forest Cohesion + 0.0051 Rowcrop Area **+ 0.3471 Young Grass CRP Area** + 1.3903 N + 1.2294 E

Lark sparrow

General CRP Model ($\log_{10}$ transformed):

– 0.0083 Contagion + 0.0153 Grassland Area – 0.0322 Fallow Area

Specific CRP Model ($\log_{10}$ transformed):

+ 0.0147 Grassland Area – 0.0321 Fallow Area **+ 0.2276 Total CRP Patch Density**

Red-winged blackbird

General CRP Model ($\log_{10}$ transformed):

– 0.0113 Contagion + 0.0111 Rowcrop Area + 0.0668 Wetland Area (exponential)

Specific CRP Model ($\log_{10}$ transformed):

– 0.0113 Contagion + 0.0111 Rowcrop Area + 0.0668 Wetland Area (exponential)

Appendix B. Continued.

Eastern bluebird

General CRP Model (log_{10} transformed):

+ 0.0232 Forest Cohesion + 0.0069 Grassland Edge Density + 0.0097 Pasture-Hay Area - 0.0056 Rowcrop Area + 0.9959 E

Specific CRP Model (log_{10} transformed):

+ 0.0232 Forest Cohesion + 0.0069 Grassland Edge Density + 0.0097 Pasture-Hay Area - 0.0056 Rowcrop Area + 0.9959 E

Brown-headed cowbird

General CRP Model:

- 94.9001 E^2 (exponential)

Specific CRP Model:

- 94.9001 E^2 (exponential)

Indigo bunting

General CRP Model (log_{10} transformed):

+ 0.0238 Forest Cohesion + 3.7545 E^3 (spherical)

Specific CRP Model (log_{10} transformed):

– 0.0115 Contagion - 0.0010 Rowcrop Area - **0.0070 Total CRP Patch Size** +2.3650 E^3 (gaussian)