Final Report
Prepared for the USDA Farm Services Agency

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Assessment of Environmental Services of CREP Wetlands in Iowa and the Midwestern Corn Belt

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EXECUTIVE SUMMARY

This final project report is a compendium of 3 previously submitted progress reports and a 4th report for work accomplished from August – December, 2009.

Our initial primary objective (Progress Report I) was prediction of environmental services provided by the 27 Iowa Conservation Reserve Enhancement Program (CREP) wetland sites that had been completed by 2007 in the Prairie Pothole Region of north-central Iowa. The sites contain 102.4 ha of wetlands and 377.4 ha of associated grassland buffers. Mass balance models were constructed for each of the 27 wetlands and used to simulate nitrate removal performance across a representative range in hydraulic loading rate and temperature. Models predicted that nitrate mass removal could range from 200 – 3,000 kg/ha/y, depending on hydraulic and nitrate loading rates. The greatest benefit of wetlands for mass nitrate reduction will be found in those extensively row-cropped and tile-drained areas where the nitrate concentrations and loading rates are highest. With respect to wildlife habitat value, USFWS models predicted that the 27 wetlands would provide habitat for 136 pairs of 6 species of ducks, 48 pairs of Canada Geese, and 839 individuals of 5 grassland songbird species of special concern. Wildlife Habitat Relational Models developed by the Iowa Gap Analysis program predicted that the existing CREP wetlands would provide habitat for 192 wildlife species, including 13 species of amphibians, 115 species of birds, 41 species of mammals and 23 species of reptiles. Approximately 30% of these species are listed in the Iowa Wildlife Action Plan as Species of Greatest Conservation Need. Seed mixtures in planted buffers surrounding the wetlands had slight variances but were dominated by 5 native grasses and 10 native forbs from local ecotypes. Field assessment in 2007 of community vegetation in the buffers of a sample of the sites suggested that the first few years after seeding provided an environment suitable for opportunistic annuals, mostly native but not originally seeded. After the initial emergence of these ruderal species, evidence suggests seeded natives became established, providing greater canopy cover. Average canopy cover of seeded and not-seeded grasses varied between fields from 44% greater cover by seeded grasses to 35% greater cover from not-seeded grasses.

Our focus in the 2nd phase of the project (Progress Report II and III) shifted to comparative pre- versus post-construction analysis of potential wildlife habitat value in alternative CREP wetland sites within a watershed. Specifically, the 4 hypothesized position types were: tile-zone (TZ), breakpoint (BP), upstream floodplain (USFP), and downstream floodplain (DSFP). (Existing CREP sites would be classified as BP position type.) We used several metrics of predicted wildlife response: species richness, cumulative species habitat value (CHSV), grassland bird density, and waterfowl breeding success, to compare potential habitat value in the 4 landscape positions. We constrained our analysis by considering only bird, mammal, amphibian, and reptile species that were classified as Species of Greatest Conservation Need (SGCN) in the Iowa DNR Wildlife Action Plan. Average species richness generally increased significantly as landscape position moved lower in the watershed, but the largest predicted increases between pre- to post-construction occurred in TZ and BP locations. Average differences in a metric of site habitat value (CSHV) among position types and between pre- and post-construction times were significant for all taxonomic groups. CSHV increased significantly for all taxonomic groups as the landscape position moved lower in the drainage area. For all taxonomic groups except mammals, there were also significant differences among position types in the net change in CHSV between pre- and post-construction. Bird and reptile habitat increased significantly only in USFP and DSFP sites, and there were no significant net changes in mammal habitat in any position type. A significant increase in amphibian habitat occurred only in DSFP sites. For all species combined, there were significant average increases in habitat in USFP and DSFP sites, no significant increase in BP sites, and a marginally significant increase in TZ sites. The total increase in habitat value was about the same in USFP and DSFP sites, and the smallest increase was in BP sites. The majority of increased habitat value was associated with bird species. Predicted densities of 3 of 4 modeled grassland bird species tended to increase as position type moved lower in the watershed. For all position types, post-project average densities of 3 of 4 species also were greater than the corresponding pre-project average, but smallest increases were consistently in BP sites. The predicted number of breeding waterfowl pairs and recruits differed by landscape position for mallards, blue-winged teal, and total ducks. Floodplain sites had about twice the number of breeding pairs and recruits of each species as TZ and BP sites. However, because wetland size had to increase to maintain the desired watershed: wetland size ratio as projects were moved lower in the watershed, recruits/ha was at least 50% greater on TZ and BP sites.

In the final phase of the project (Progress Report IV) we extended the empirical wetland performance model developed for a set of 27 Iowa CREP wetlands (FSA Progress Report I, 2008) to assess the potential of restored wetlands to reduce nitrate loadings from tile-drained agricultural watersheds throughout the Midwestern Corn Belt region of North America. Extending the general Iowa CREP wetland performance model to the Upper Mississippi Region (UMR) and Ohio River basins required estimating hydrologic and nitrate loads for potential wetland sites throughout the region. We developed a grid of long term FWA nitrate concentration for UMR and Ohio River basins based on the percent row crop and tile drainage grids. We then estimated annual nitrate load each year using a 100 ha grid covering the UMR and Ohio River basins, and corresponding estimates of nitrate mass removal that could be achieved using wetland restorations. Results indicate that a 30% reduction in the total nitrate load exported from the UMR and Ohio River basins could be achieved with approximately 2270 km^2, 2680 km^2 or 3350 km^2 of <u>wetland area</u> restored at wetland:watershed area ratios of 1%, 2% or 3% , respectively. Similarly, results indicate that a 30% reduction in the total nitrate load could be achieved by treating approximately 227,000 km^2, 134,000 km^2, or 112,000 km^2 <u>of watershed</u> area for wetland:watershed area ratios of 1%, 2% or 3% respectively. Our results assume that wetlands could be located so as to intercept water from the highest nitrate load contributing areas. If wetlands are instead restored in areas with lower nitrate concentrations and loads, then the wetlands would be expected to remove less nitrate than estimated here.

Progress Report I
Prepared for the USDA Farm Services Agency

February 20, 2008

Assessment of Environmental Services of CREP Wetlands in Iowa and the Midwestern Corn Belt

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BACKGROUND

The report is organized into sections that present results generated by each of the 4 Principal Investigator teams for Project Objective 1, i.e., assessment of environmental services provided by completed or approved Iowa Conservation Reserve Enhancement Program (CREP) wetland sites in a 37 county region of north-central Iowa (Fig. 1). The approved sites have resulted in the creation of 253.0 acres (102.4 ha) of wetlands and 932.6 acres (377.4 ha) of associated grassland buffers.

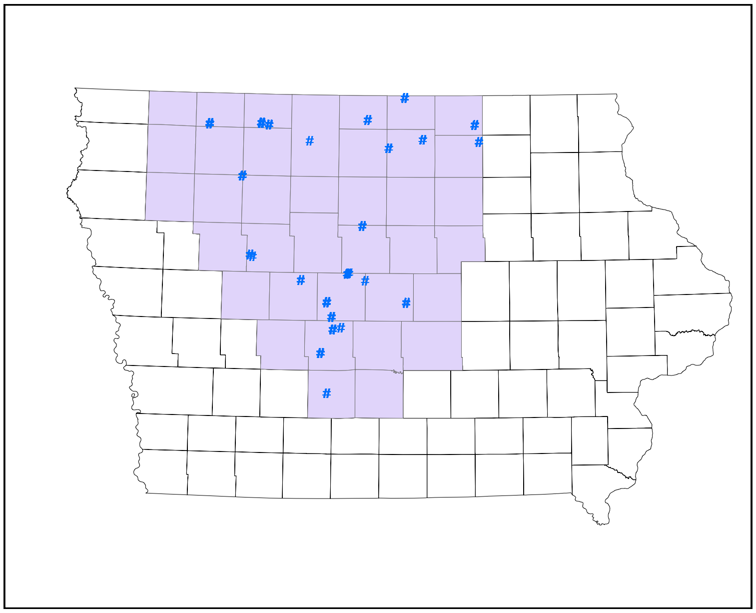

Figure 1. Location of 27 CREP wetland sites in the 37 CREP eligible counties in the Prairie Pothole Region of Iowa.

NITRATE REMOVAL

Introduction

We were tasked with evaluating the long-term potential for nitrate removal of the existing 27 Iowa CREP wetlands over a broad range of hydrological conditions. Mass balance models were developed for each constructed wetland for the period 1980 through 2005, and modeled nitrate loss rates compared with loss rates observed for monitored CREP wetlands. The preliminary results of these analyses are presented here.

Methods

Mass balance models were constructed for each of the 27 existing CREP wetlands and used to simulate nitrate removal performance across a representative range in hydraulic loading rate and temperature. Forcing functions included inflow rates, inflow concentrations, and temperature. Inflow rates and temperature were estimated from a selected subset of United States Geological Survey (USGS) stream gages and National Weather Service (NWS) Climate Cooperative Network (COOP) climate monitoring stations within the Des Moines Lobe (DML) region of Iowa. After examining the range in annual water yields for DML stream gage stations over the 26 year period from 1980 through 2005, we selected the USGS gauging station, Squaw Creek at Ames, Iowa as the station from which daily water yield was estimated for wetland modeling. The range in annual water yield for this station spans the water yield for stations across the DML region over the period of analysis. Daily surface water inflows to each wetland were estimated as the product of the calculated daily water yield from the Squaw Creek gauging station and the contributing watershed area above each wetland. Water temperature for each wetland was estimated as the average of the observed daily minimum and maximum air temperature from nearby COOP climate stations, constrained to a minimum of $4^{o}C$. Inflow nitrate concentrations for all wetlands were held at a constant value of 14.3 mg N L^{-1} over the entire length of simulation for all models. This is based on the observed flow weighted average nitrate concentration of monitored CREP wetlands, and for the purpose of this project, is treated as an approximation of long-term, flow weighted average nitrate concentration entering CREP wetlands. Daily nitrate mass loading was modeled as the product of the daily hydrologic inflow and nitrate concentration. Each wetland was modeled as a tanks-in-series system in which mass loss rates were calculated using a temperature-dependent first-order areal loss function (Crumpton 2001, Crumpton, et. al 2006; Kadlec and Knight 1995). Wetland outflow was modeled using the equation for flow over a rectangular broad-crested weir (a minor simplification of the primary outflow structure of CREP wetlands). Only surface inflows and outflows were included in the mass balance. Mass nitrate exported was determined as the product of simulated nitrate concentration output and wetland outflow. Model simulations used 4^{th} order Runge-Kutta with an adaptive time step and daily output.

Results and Discussion

Wetland performance is a function of hydraulic loading rate, hydraulic efficiency, nitrate concentration, temperature, and wetland condition. Of these, hydraulic loading rate and nitrate concentration are especially important for CREP wetlands. The range in hydraulic loading rates expected for CREP wetlands is significantly greater than would be expected based on just the four fold range in wetland/watershed area ratio approved for the Iowa CREP. In addition to spatial variation in precipitation (average precipitation declines from southeast to northwest across Iowa), there is tremendous annual variation in precipitation. The 25 year period of analysis covers significant variations in seasonal and annual hydrologic conditions, ranging from the regional low-flow years of 1981 and 2000, and the regional high-flow year of 1993.

The combined effect of these factors means that loading rates to CREP wetlands can be expected to vary by more than an order of magnitude, and will to a large extent determine nitrate loss rates for individual wetlands. The effect of variability in forcing functions is illustrated by considering the patterns in hydraulic loading rate and percent nitrate removal expected for the existing CREP wetlands based on hindcast modeling over the period from 1980 through 2005 (Figure 2). For comparison, the percent nitrate removal measured for wetlands monitored as part of the Iowa CREP is also presented and illustrates reasonably good correspondence between observed and modeled performance. Percent nitrate removal is clearly a function of hydraulic loading rate (Figure 2).

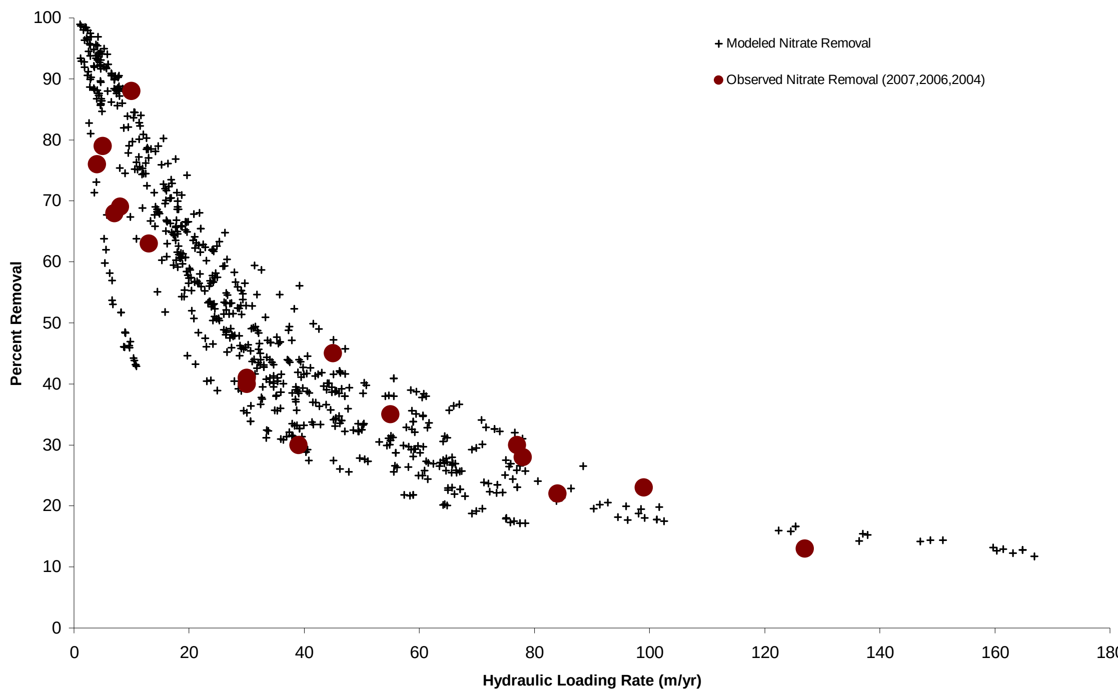

Figure 2. Modeled and observed nitrate removal efficiencies for CREP qualifying wetlands versus Hydraulic Loading Rate.

Mass nitrate removal is a function of percent nitrate removal, hydraulic loading rate, and flow-weighted average nitrate concentration. Figure 3 illustrates the patterns in hydraulic loading rate and mass nitrate removal expected for the existing CREP wetlands based on hindcast modeling over the period from 1980 through 2005 at an inflow concentration of 14.3 mg N L^{-1}.

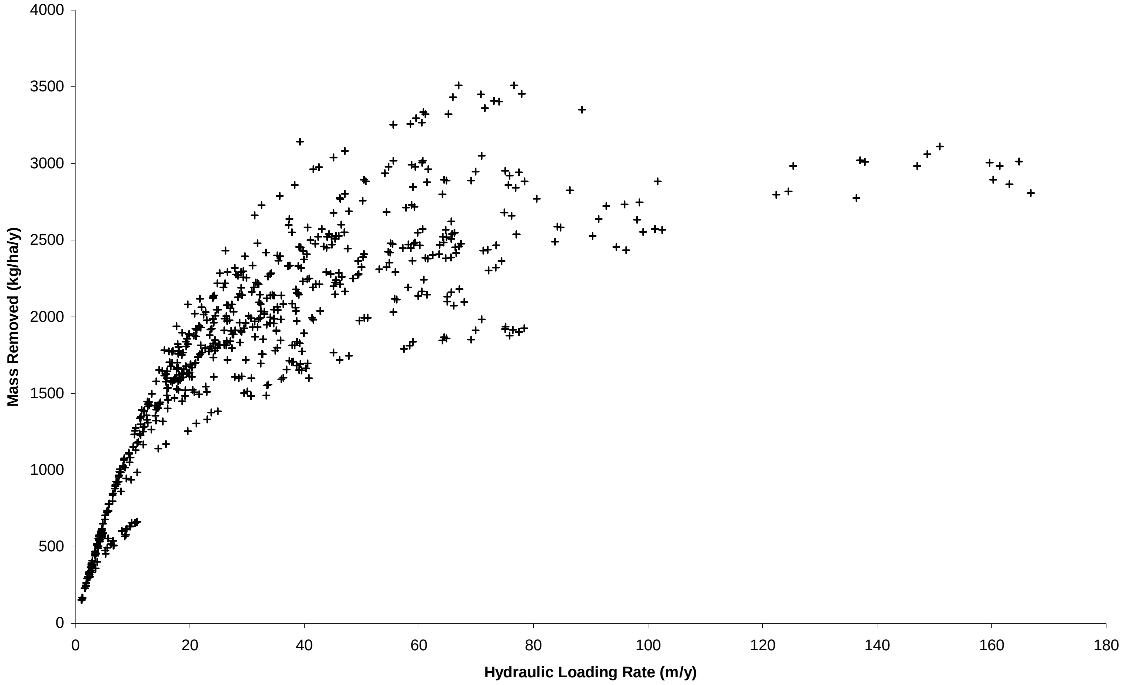

Figure 3. Modeled nitrate mass removal in CREP wetlands versus Hydraulic Loading Rate (assumes a flow-weighted average nitrate concentration of 14.3 mg N L^{-1}).

The greatest benefit of wetlands for mass nitrate reduction will be found in those extensively row-cropped and tile-drained areas where the nitrate concentrations and loading rates are highest. Crumpton et al. (2006) demonstrated significant potential for nitrate reductions if wetland restorations were targeted to areas with the highest nitrate concentrations and loads. The actual mass and percent nitrate reductions that can be achieved will depend on our ability to identify and achieve desirable hydraulic and nitrate loading rates.

Literature Cited

Crumpton, W.G. 2001. Using wetlands for water quality improvement in agricultural watersheds: the importance of a watershed scale perspective. Water Science and Technology. 44: 559-564.

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MIGRATRORY BIRD ABUNDANCE

Introduction

The first phase of the U.S. Fish and Wildlife Service task was to evaluate the contribution of the 27 approved sites to migratory birds breeding in the Prairie Pothole Region of Iowa. To date, evaluation has been completed for 7 species of waterfowl and 5 species of grassland birds. All evaluations were completed using existing models that relate landscape composition to bird populations. As such, the first objective was to develop a current land cover geographic information system (GIS) that reflected current landscape conditions including the incorporation of habitat restored through the CREP program. The second objective was to input landscape variables from our land cover GIS into models to estimate various migratory bird population parameters (i.e. the number of pairs, individuals, or recruits) for each site.

Methods

GIS Land Cover Development

A GIS-based land cover developed from the interpretation of 2002-03 Landsat imagery was acquired from the Iowa Department of Natural Resources (Monica Ulman, Iowa DNR, pers. com. 2008). The land cover was a raster-based, grid coverage with a 15-m^2 pixel size. The coverage contained 17 land cover classes that were combined into a simplified 8 land cover class system (Table 1). Similar classes were combined based on variables required for the predictive bird models. The modified 2002 land cover layer was further updated by adding the CREP wetlands and associated grass buffers for the 27 approved sites. Polygon coverages of the CREP wetlands and buffers were acquired from the Iowa Department of Agriculture and Land Stewardship (Shawn Richmond, IDALS, unpublished data 2007). These coverages were converted to raster coverages and then added to the 2002 land cover using the "reclassify" and "raster calculator" tools in the spatial analyst extension of ArcGIS (ESRI 2008).

Waterfowl Pair and Recruitment Estimates

Canada Geese (*Branta canadensis*) pair estimates were calculated by multiplying the 1998-2005 average pair density (0.19 pairs/acre; Dan Hertel, USFWS, unpublished data 2007) for Canada Geese on Iowa semi-permanent wetlands by wetland size for each CREP wetland. Number of duck pairs per site was estimated for 6 species of ducks: Mallard (*Anas platyrhynchos*), Blue-winged Teal (*Anas discors*), Northern Shoveler (*Anas clypeata*), Gadwall (*Anas strepera*), Northern Pintail (*Anas acuta*), and Wood Duck (*Aix sponsa*), using models developed by Cowardin et al. (1995). Pair abundance was based on wetland class (i.e., temporary, seasonal, semi-permanent, lake, or river), wetland size, and a set of species specific regression coefficients. All CREP wetlands were considered semi-permanent for this analysis; therefore only coefficients associated with the semipermanent wetland pair model were used in calculations. The general equation used to estimate the pairs per wetland was:

Pairs = $e^{(a + bx + \alpha)} * p$ where,

e = mathematical constant ≈ 2.718,
a = species specific regression coefficient a (Table 2),
b = species specific regression coefficient b (Table 2),
x = the natural log of wetland size,
α = species specific alpha value (Table 2), and
p = proportion of the basin containing water (assumed to be 0.90 for this analysis)

Recruitment for the 27 sites was estimated for Mallards, Blue-winged Teal, Northern Shoveler, Gadwall, and Northern Pintail according to recruitment models presented by Cowardin et al. (1995). Recruitment was not estimated for Canada Geese and Wood Ducks because recruitment models do not exist for these species. Variables used to estimate recruitment included the number of pairs, the composition of the landscape in a 4-square mile area around the CREP wetland, species-specific habitat preferences, and species- and habitat-specific clutch success rates. Recruitment estimates were derived using the following equations:

Recruits = 2*R*n where,

2 = constant based on the assumption of equal sex ratio at hatch,
n = number of breeding pairs estimated using the pairs equation previously outlined,
R = Recruitment rate as defined by Cowardin and Johnson (1979) where,

R = H*Z*B/2 where,

H = hen success (see Cowardin et al. (1995) for methods used to calculate H, which is related to land cover types in the 4-mile^2 landscape around each wetland),
Z = proportion of broods that survived to fledge at least 1 recruit (= 0.74 based on Cowardin and Johnson 1979),
B = average brood size at fledging (= 4.9 based on Cowardin and Johnson 1979).

Grassland Bird Estimates

The migratory bird benefits of the 27 CREP sites were predicted for Bobolink (*Dolichonyx oryzivorus*), Grasshopper Sparrow (*Ammodramus savannarum*), Sedge Wren (*Cistothorus platensis*), Savannah Sparrow (*Passerculus sandwichensis*), and Dickcissel (*Spiza Americana*). Population estimates for these species were calculated using models developed by Quamen (2007) for the Prairie Pothole Region of Iowa (Table 3). The "neighborhood analysis" tool in the spatial analysis extension of ArcGIS (2008) was used to create landscape composition variables (grass400, grass3200, hay400, hay3200, tree400) needed for model input (see Table 3 for variable definitions). Values for the species-specific relative abundance (bbspath) variable were acquired from Diane Granfors, USFWS HAPET office. The equations for each model were used to calculate bird density (birds/ha) for each 15-m^2 pixel of the land coverage. Next, the "zonal statistics" tool in the spatial analyst extension of ArcGIS (ESRI 2008) was used to calculate the average bird density for each CREP buffer. A population estimate for each site was then calculated by multiplying the average density by the buffer size.

Results

Waterfowl Pair and Recruitment Estimates

The CREP wetlands created will provide habitat for a predicted 136 pairs of 6 species of ducks and 48 pairs of Canada Geese (Table 4). Duck pair estimates ranged from 2.9 to 8.3 pairs per wetland, while estimated goose pairs ranged from 0.6 to 4.0 pairs per wetland (Table 4). A predicted 135 recruits will be produced on the sites (Table 4). Recruitment estimates for the 5 species of ducks analyzed ranged from 3 to 8 recruits produced per wetland, with estimates highest for Mallards and Blue-winged Teal (Table 4). Recruit estimates showed a strong relationship ($r^2 = 0.79$) with CREP buffer size (Fig. 4).

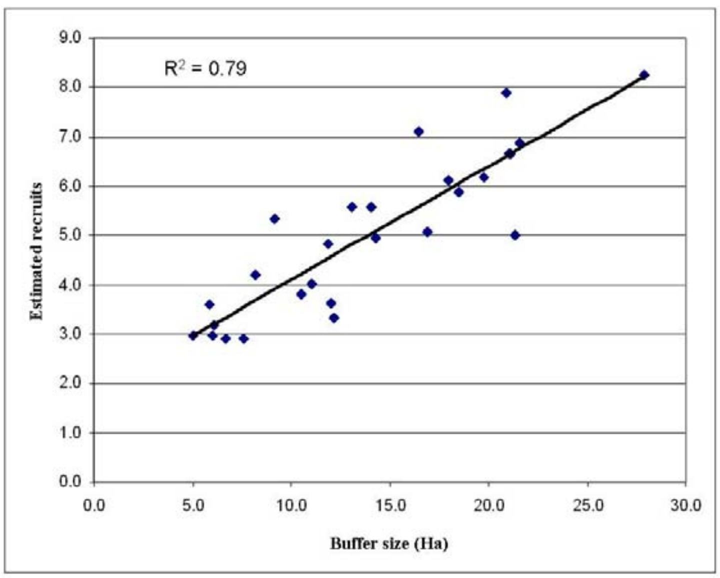

Figure 4. Relationship between CREP buffer size and the predicted number of waterfowl recruits for 27 CREP sites in the Prairie Pothole Region of Iowa.

Grassland Bird Estimates

The CREP buffers will provide habitat for an estimated 839 grassland birds for the 5 species analyzed, with Sedge Wrens and Bobolinks have the highest overall predicted numbers (Table 5). Estimated birds per site ranged from a low of 9 birds to a high of 69 birds (Table 5). Total birds per site showed a strong relationship ($r^2 = 0.84$) to CREP buffer size (Fig. 5).

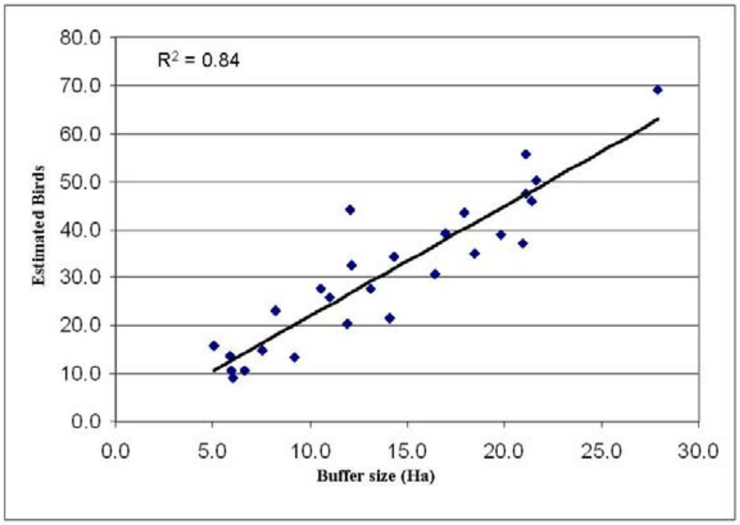

Figure 5. Relationship between CREP buffer size and the predicted number of grassland birds for 27 CREP sites in the Prairie Pothole Region of Iowa.

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Quamen, F.R. 2007. A landscape approach to grassland bird conservation in the Prairie Pothole Region of the Northern Great Plains. Ph.D. Dissertation, University of Montana, Missoula, MT. 150pp.

Table 1. Original land cover classes and combined land cover classes based on a 2002 land cover analysis completed by the Iowa Department of Natural Resources.

Old Code	**Original Class**	**New Code**	**New Class**
1	Open Water	1	Wetland
2	Wetland	1	Wetland
3	Wet Forest	2	Woodland
4	Coniferous Forest	2	Woodland
5	Deciduous Forest	2	Woodland
6	Ungrazed Grassland	3	Grassland
7	Grazed Grassland	3	Grassland
8	CRP	3	Grassland
9	Alfalfa, lush grass	4	Hayland
10	Corn	5	Cropland
11	Soybeans	5	Cropland
12	Other Agriculture	5	Cropland
13	Roads	6	Developed
14	Commercial/Industrial	6	Developed
15	Residential	6	Developed
16	Barren	7	Barren
17	Missing Data	8	Missing Data

Table 2. Species specific coefficients used to estimate pairs on CREP wetlands in the Prairie Pothole Region of North Dakota.

Species	**a**	**b**	**α**
Mallard	-0.444	0.606	0.322
Blue-winged Teal	-0.915	0.551	-0.063
Northern Shoveler	-2.517	0.632	0.053
Gadwall	-4.517	0.700	0.168
Northern Pintail	-4.940	0.561	-0.057
Wood Duck	-1.356	0.532	0.023

Table 3. Models used to estimate density (birds/ha) of 4 species of grassland birds for the Prairie Pothole Region of Iowa.

Species	Model*
BOBO	density = $e^{(-0.8696546 + 0.0180943 * grass400)}$
GRSP	density = $e^{(-2.554612 + 0.0246975 * grass400 – 0.1032461 * trees400)}$
SEWR	density = $1-1/1+e^{(-0.8015652 + 0.08500569 * grass400)} * e^{(-0.7982511 + 0.0285891 * bbspath + 0.0105094 * grass400)}$
DICK	density = $1-1/1+e^{(-6.811334 + 1.889878 * bbspath)} * e^{(-1.831015 + 0.0312571 * hay400)}$
SASP	density = $e^{(-1.581362 + 0.0229603 *bbspath + 0.01024* grass3200 + 0.0255867 * hay3200)}$

* Variable definitions: grass400 = percentage of the 400-m radius surrounding landscape that is in grass; trees400 = percentage of the 400-m radius surrounding landscape that is in trees; hay400 = the percentage of the 400-m radius surrounding landscape that is in hay; grass3200 = percentage of the 3200-m radius surrounding landscape that is in grass; hay3200 = the percentage of the 3200-m radius surrounding landscape that is in hay; and bbspath = species-specific relative abundances as determined from 1992-2003 BBS data.

Table 4. Estimated waterfowl pairs and recruits * for 27 CREP sites in the Prairie Pothole Region of Iowa.

	Mallard		*Blue-winged Teal*		*N. Shoveler*		*Gadwall*		*Northern Pintail*		*Wood Duck*	*Total Duck*		*C. Goose*
Site ID	**Pairs**	**Recruits**	**Pairs**	**Recruits**	**Pairs**	**Recruits**	**Pairs**	**Recruits**	**Pairs**	**Recruits**	**Pairs**	**Pairs**	**Recruits***	**Pairs**
Boo822729D	2.964	3.515	1.117	1.320	0.067	0.084	0.053	0.066	0.021	0.027	0.752	4.973	5.012	1.646
Boo832824B	4.703	5.490	1.699	2.124	0.108	0.137	0.090	0.112	0.031	0.041	1.128	7.759	7.903	3.528
Boo852602B	2.119	2.525	0.823	0.982	0.047	0.059	0.036	0.043	0.015	0.018	0.560	3.599	3.627	0.946
Boo852603C	1.941	2.325	0.760	0.894	0.043	0.054	0.032	0.039	0.014	0.017	0.518	3.308	3.329	0.818
Boo852603D	3.950	4.722	1.450	1.709	0.090	0.113	0.074	0.088	0.027	0.032	0.967	6.557	6.665	2.644
Cal873421C	2.862	3.393	1.082	1.276	0.064	0.080	0.051	0.062	0.020	0.025	0.729	4.808	4.836	1.554
Cal873427D	1.718	1.969	0.680	0.836	0.038	0.047	0.028	0.036	0.012	0.016	0.466	2.942	2.904	0.669
Cer962220C	3.630	3.490	1.343	1.651	0.082	0.076	0.067	0.084	0.025	0.028	0.898	6.045	5.329	2.301
Cer971931C	1.788	2.025	0.705	0.837	0.039	0.048	0.030	0.036	0.013	0.015	0.482	3.057	2.962	0.714
Dal792828C	2.136	2.504	0.829	0.980	0.047	0.059	0.036	0.045	0.015	0.019	0.564	3.627	3.607	0.958
Dal812619C	3.808	4.305	1.402	1.605	0.087	0.103	0.071	0.087	0.026	0.031	0.937	6.330	6.131	2.489
Dal812718C	3.296	3.930	1.230	1.457	0.075	0.094	0.060	0.073	0.023	0.028	0.825	5.509	5.583	1.962
Dic983729C	3.982	4.717	1.460	1.698	0.091	0.113	0.075	0.090	0.027	0.032	0.974	6.608	6.649	2.680
Emm983229C	3.473	4.102	1.290	1.574	0.079	0.099	0.064	0.082	0.024	0.032	0.864	5.793	5.889	2.139
Emm983322C	3.031	3.542	1.140	1.343	0.068	0.080	0.054	0.066	0.021	0.025	0.767	5.082	5.056	1.708
Emm983327B	2.946	3.476	1.110	1.312	0.066	0.080	0.053	0.064	0.020	0.025	0.748	4.943	4.957	1.629
Flo961502D	2.394	2.787	0.920	1.084	0.053	0.066	0.041	0.051	0.017	0.021	0.623	4.049	4.009	1.157
Gre853026B	1.679	1.980	0.666	0.830	0.037	0.047	0.027	0.036	0.012	0.017	0.457	2.878	2.911	0.644
Ham892406C	4.186	4.935	1.528	1.904	0.096	0.122	0.079	0.103	0.028	0.038	1.018	6.935	7.101	2.911
Kos962903D	2.440	2.956	0.936	1.101	0.054	0.069	0.042	0.051	0.017	0.021	0.634	4.124	4.199	1.194
Mad752802B	2.354	2.606	0.906	1.066	0.052	0.063	0.041	0.049	0.017	0.019	0.614	3.983	3.803	1.125
Mit981528A	4.160	4.764	1.520	1.844	0.095	0.117	0.078	0.099	0.028	0.036	1.012	6.894	6.860	2.881
Poc933406C	3.689	4.246	1.362	1.712	0.084	0.096	0.068	0.087	0.025	0.034	0.911	6.140	6.175	2.362
Sto832121A	3.339	3.860	1.244	1.532	0.076	0.095	0.061	0.076	0.023	0.030	0.835	5.577	5.593	2.004
Sto852430B	1.870	2.174	0.734	0.890	0.041	0.052	0.031	0.040	0.013	0.018	0.502	3.191	3.173	0.769
Win982409D	1.706	2.033	0.676	0.829	0.037	0.048	0.028	0.036	0.012	0.017	0.463	2.922	2.963	0.661
Wor1002115C	5.060	5.821	1.816	2.142	0.117	0.141	0.098	0.118	0.034	0.039	1.202	8.327	8.261	3.981
Total	81.223	94.191	30.428	36.534	1.833	2.241	1.469	1.820	0.559	0.700	20.450	135.962	135.487	48.077

* Recruits not estimated for Wood Ducks and Canada Geese.

Table 5. Estimated densities (birds/ha) and number of grassland birds for 27 CREP sites in the Prairie Pothole Region of Iowa.

		Bobolink		*Grass. Sparrow*		*Sedge Wren*		*Dickcissel*		*Savannah Sparrow*		*Total Birds*[3]
Site	**Area[1] (Ha)**	**Density**	**Estimate[2]**	**Density**	**Estimate[2]**	**Density**	**Estimate[2]**	**Density**	**Estimate[2]**	**Density**	**Estimate[2]**	**Estimate**
Boo822729D	21.38	0.89	18.97	0.21	4.59	0.66	14.05	0.16	3.43	0.24	5.03	46.07
Boo832824B	20.92	0.73	15.35	0.17	3.45	0.55	11.40	0.16	3.43	0.30	3.59	37.23
Boo852602B	12.06	1.67	20.18	0.51	6.20	1.01	12.22	0.18	2.14	0.27	3.27	44.01
Boo852603C	12.15	1.02	12.41	0.26	3.17	0.74	8.97	0.18	2.15	0.28	5.87	32.57
Boo852603D	21.10	1.19	25.03	0.32	6.71	0.82	17.28	0.17	3.56	0.26	3.10	55.67
Cal873421C	11.91	0.72	8.57	0.16	1.90	0.54	6.42	0.16	1.91	0.25	1.68	20.47
Cal873427D	6.67	0.57	3.79	0.12	0.77	0.36	2.40	0.16	1.07	0.27	2.51	10.54
Cer962220C	9.19	0.64	5.84	0.02	0.17	0.46	4.27	0.17	1.54	0.28	1.70	13.52
Cer971931C	5.99	0.68	4.10	0.14	0.86	0.52	3.09	0.19	1.14	0.27	1.61	10.80
Dal792828C	5.88	0.67	3.95	0.14	0.82	0.48	2.82	0.16	0.96	0.29	5.26	13.81
Dal812619C	17.98	1.07	19.16	0.26	4.58	0.76	13.64	0.16	2.89	0.26	3.35	43.64
Dal812718C	13.11	0.76	9.92	0.17	2.28	0.56	7.35	0.17	2.21	0.29	6.04	27.80
Dic983729C	21.08	0.94	19.78	0.23	4.82	0.70	14.67	0.16	3.43	0.25	4.68	47.37
Emm983229C	18.49	0.74	13.76	0.17	3.11	0.56	10.35	0.16	2.99	0.28	4.80	35.01
Emm983322C	16.92	0.96	16.31	0.23	3.97	0.72	12.12	0.16	2.71	0.28	4.02	39.13
Emm983327B	14.30	1.03	14.71	0.21	2.97	0.75	10.76	0.17	2.36	0.31	3.45	34.25
Flo961502D	11.04	1.03	11.42	0.23	2.48	0.76	8.41	0.17	1.90	0.23	1.74	25.95
Gre853026B	7.57	0.67	5.04	0.14	1.06	0.48	3.65	0.16	1.21	0.24	3.97	14.94
Ham892406C	16.44	0.78	12.90	0.18	3.01	0.60	9.80	0.16	2.67	0.28	2.32	30.69
Kos962903D	8.20	1.13	9.26	0.29	2.39	0.81	6.65	0.17	1.38	0.34	3.54	23.22
Mad752802B	10.53	0.94	9.94	0.23	2.45	0.69	7.31	0.18	1.88	0.29	6.23	27.82
Mit981528A	21.60	0.96	20.73	0.23	5.00	0.72	15.65	0.19	4.12	0.24	4.81	50.30
Poc933406C	19.80	0.82	16.18	0.18	3.52	0.62	12.27	0.16	3.17	0.26	3.65	38.79
Sto832121A	14.07	0.65	9.21	0.14	2.01	0.46	6.52	0.16	2.31	0.25	1.54	21.59
Sto852430B	6.07	0.59	3.57	0.12	0.73	0.38	2.32	0.17	1.04	0.27	1.36	9.01
Win982409D	5.06	0.61	3.07	0.13	0.65	0.42	2.11	0.16	0.79	0.33	9.12	15.75
Wor1002115C	27.90	1.09	30.43	0.21	5.90	0.80	22.32	0.18	5.04	0.25	5.29	68.97
Total			**343.58**		**79.58**		**248.81**		**63.42**		**103.52**	**838.92**

[1] Size of CREP buffer; [2] Estimate calculated by multiplying density (birds/ha) by buffer size; [3] Total birds calculated by summing estimates for 5 bird species

WILDLIFE SPECIES OCCURRENCE

Introduction

The objective of the USGS/ISU task was to predict, for each of these 27 CREP sites, the presence/absence of wildlife species whose range distributions include some portion of the 37 eligible counties of the Iowa Conservation Reserve Enhancement Program.

Methods

GIS Land Cover Development

A GIS land cover dataset was developed from two sets of polygon shapefiles for the 27 CREP easements and wetlands. Shape files were acquired from the Iowa Department of Agriculture and Land Stewardship (Shawn Richmond, IDALS, unpublished data 2007). The land cover is a raster dataset with a 15 m^2 pixel size and only 2 land cover classes: wetland and grassland. These shape files were converted to raster datasets using the Features to Raster command in the Spatial Analyst extension of ArcGIS 9.2 (ESRI 2008). They were then manipulated into one raster in several steps using the "Reclassify" and "Raster Calculator" tools, also in Spatial Analyst. Metadata was created for the final dataset using ArcCatalog.

Prediction of Wildlife Species Presence

Using the EMAP hexagon species range maps developed by the Iowa Gap Analysis Project (Kane et al. 2004), the list of all wildlife species occurring in Iowa was reduced to include only those species whose ranges overlapped the counties that contain the 27 approved CREP wetland and associated grassland buffer sites. Kane et al. (2004) developed a Wildlife Habitat Relational Model (WHRM) for each species based on their GIS land cover classification (Table1). These WHRMs predict species presence in a pixel based on cover type and a suite of auxiliary variables. For the current exercise, we adapted the Iowa GAP WHRMs to the simplified 2002 land cover class system used by the USFWS migratory bird project (Table 6). These simplified WHRMs simply predicted species presence as a function of land cover type, i.e., a species was predicted to be present if the site was within the species range and the WHRM contained either wetland or grassland cover type.

Results

Prediction of Wildlife Species Presence

The existing CREP wetlands were predicted to provide habitat for 192 species (Table 7), including 13 species of amphibians, 115 species of birds, 41 species of mammals and 23 species of reptiles (Fig. 6). Of these, 66.7% were found at all 27 CREP sites, 17.7% were found at 10-26 sites, and 15.6% were found in 1-10 sites. Of the predicted 192 species, 30.7% are listed in the Iowa Wildlife Action Plan as Species of Greatest Conservation Need (Zohrer 2005; Fig. 7), included 14 species that are listed as endangered, threatened or of special concern. When stratified by land cover class, 19.8% of the predicted species required only wetland habitat, 47.9% required only grassland habitat and 32.3% of all predicted species required both wetland and grassland habitat types.

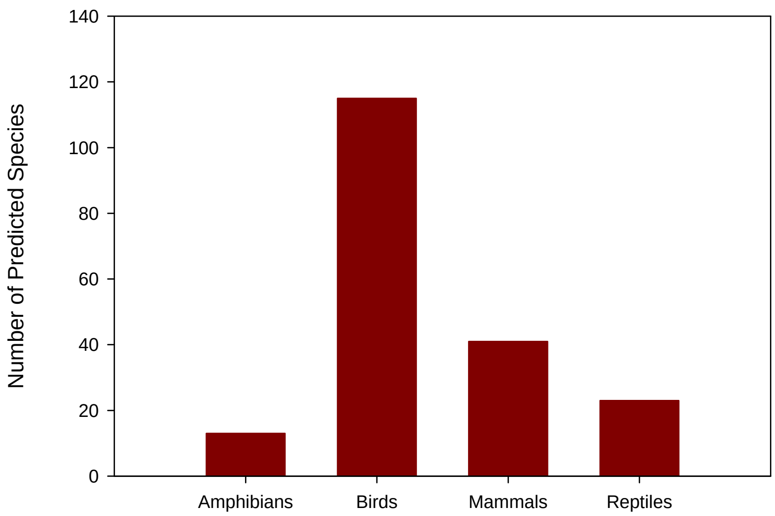

Figure 6. Number of wildlife species per taxon predicted for 27 CREP sites.

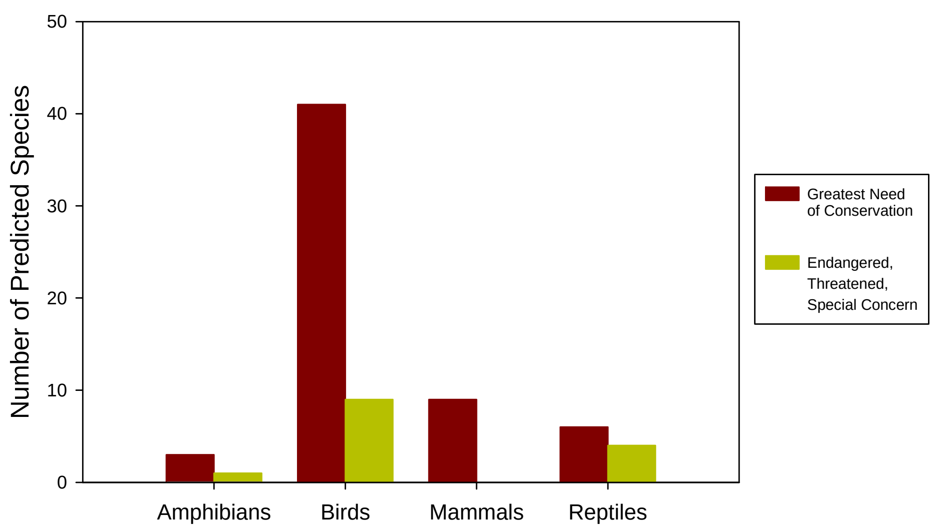

Figure 7. Number of wildlife species of special concern per taxon predicted for 27 CREP sites.

These results suggest that the CREP wetlands can provide habitat that will contribute to keeping common species common as well as benefiting species of concern. They also highlight the wildlife benefits of both wetland and upland habitats.

<u>Literature Cited</u>

Kane, K. L., E. E. Klaas, K. L. Anderson, P. D. Brown, and R. L. McNeely. 2004. The Iowa Gap Analysis Project. Final Report. Iowa State University, Ames, IA. 655 pp.

Zohrer, J. L. 2005. Securing a Future for Fish and Wildlife: A Conservation Legacy for Iowans. Iowa Wildlife Action Plan. Iowa Department of Natural Resources. 344pp.

Table 6. Original land cover classes used by Iowa Gap Analysis Project and simplified land cover classes based on a 2002 land cover analysis completed by the Iowa Department of Natural Resources.

Old Code	Original GAP Analysis Class	New Code	New Class
110	Open Water	1	Wetland
71	Temporarily Flooded Wetland	1	Wetland
72	Seasonally Flooded Wetland	1	Wetland
73	Semi-permanently Flooded Wetland	1	Wetland
74	Saturated Wetland	1	Wetland
75	Permanently Flooded Wetland	1	Wetland
12	Eastern Red Cedar Forest	2	Woodland
17	Pine Forest	2	Woodland
18	Evergreen Forest	2	Woodland
19	Upland Deciduous Forest	2	Woodland
20	Temporarily Flooded Forested Wetland	2	Woodland
24	Seasonally Flooded Forested Wetland	2	Woodland
30	Mixed Evergreen/ Deciduous Forest	2	Woodland
41	Eastern Red Cedar Woodland	2	Woodland
42	Upland Deciduous Woodland	2	Woodland
44	Mixed Evergreen/ Deciduous Woodland	2	Woodland
51	Upland Shrub	2	Woodland
52	Temporarily Flooded Shrub	2	Woodland
53	Seasonally Flooded Shrub	2	Woodland
54	Semi-permanently Flooded Shrub	2	Woodland
55	Saturated Shrub	2	Woodland
61	Warm Season Grass/ Perennial Forb	3	Grassland
66	Cool Season Grass	3	Grassland
67	Grassland With Sparse Shrubs and Trees	3	Grassland
90	Cropland	5	Cropland

101	Artificial/High Vegetation	6	Developed
102	Artificial/Low Vegetation	6	Developed
80	Sparsely Vegetated/Barren	7	Barren
82	Barren/Mixed Vegetation	7	Barren
9999	No Data	8	Missing Data

Table 7. List of predicted wildlife species occurring in the CREP wetland sites.

AMPHIBIANS

Northern Cricket Frog	*Acris crepitans blanchardi*
Smallmouth Salamander	*Ambystoma texanum texanum*
Tiger Salamander	*Ambystoma tigrinum tigrinum*
American Toad	*Bufo americanus americanus*
Cope's Gray Treefrog	*Hyla chrysoscelis*
Gray Treefrog	*Hyla versicolor*
Mudpuppy	*Necturus maculosus*
Spring Peeper	*Pseudacris crucifer*
Western Chorus Frog	*Pseudacris triseriata triseriata*
Plains Leopard Frog	*Rana blairi*
Bullfrog	*Rana catesbeiana*
Green Frog	*Rana clamitans melanota*
Northern Leopard Frog	*Rana pipiens*

BIRDS

Spotted Sandpiper	*Actitis macularia*
Western Grebe	*Aechmophorus occidentalis*
Red-Winged Blackbird	*Agelaius phoeniceus*
Wood Duck	*Aix sponsa*
Henslow's Sparrow	*Ammodramus henslowii*
Grasshopper Sparrow	*Ammodramus savannarum*
American Wigeon	*Anas americana*
Northern Shoveler	*Anas clypeata*
Green-Winged Teal	*Anas crecca*
Blue-Winged Teal	*Anas discors*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Great Blue Heron	*Ardea herodias*
Short-Eared Owl	*Asio flammeus*
Long-Eared Owl	*Asio otus*
Burrowing Owl	*Athene cunicularia*
Redhead	*Aythya americana*
Ring-Necked Duck	*Aythya collaris*
Canvasback	*Aythya valisineria*
Upland Sandpiper	*Bartramia longicauda*
Cedar Waxwing	*Bombycilla cedrorum*
American Bittern	*Botaurus lentiginosus*
Canada Goose	*Branta canadensis*
Red-Tailed Hawk	*Buteo jamaicensis*
Swainson's Hawk	*Buteo swainsoni*

Green Heron	*Butorides virescens*
Northern Cardinal	*Cardinalis cardinalis*
American Goldfinch	*Carduelis tristis*
House Finch	*Carpodacus mexicanus*
Turkey Vulture	*Cathartes aura*
Belted Kingfisher	*Ceryle alcyon*
Killdeer	*Charadrius vociferous*
Black Tern	*Chlidonias niger*
Lark Sparrow	*Chondestes grammacus*
Common Nighthawk	*Chordeiles minor*
Northern Harrier	*Circus cyaneus*
Marsh Wren	*Cistothorus palustris*
Sedge Wren	*Cistothorus platensis*
Black-Billed Cuckoo	*Coccyzus erythropthalmus*
Northern Flicker	*Colaptes auratus*
Northern Bobwhite	*Colinus virginianus*
Eastern Wood-Pewee	*Contopus virens*
Blue Jay	*Cyanocitta cristata*
Yellow Warbler	*Dendroica petechia*
Bobolink	*Dolichonyx oryzivorus*
Gray Catbird	*Dumetella carolinensis*
Willow Flycatcher	*Empidonax traillii*
Horned Lark	*Eremophila alpestris*
American Kestrel	*Falco sparverius*
American Coot	*Fulica Americana*
Common Snipe	*Gallinago gallinago*
Common Moorhen	*Gallinula chloropus*
Common Yellowthroat	*Geothlypis trichas*
Sandhill Crane	*Grus Canadensis*
Blue Grosbeak	*Guiraca caerulea*
Bald Eagle	*Haliaeetus leucocephalus*
Cliff Swallow	*Hirundo pyrrhonota*
Barn Swallow	*Hirundo rustica*
Yellow-Breasted Chat	*Icteria virens*
Baltimore Oriole	*Icterus galbula*
Orchard Oriole	*Icterus spurious*
Least Bittern	*Ixobrychus exilis*
Loggerhead Shrike	*Lanius ludovicianus*
Hooded Merganser	*Lophodytes cucullatus*
Red-Headed Woodpecker	*Melanerpes erythrocephalus*
Wild Turkey	*Meleagris gallopavo*
Swamp Sparrow	*Melospiza Georgiana*
Song Sparrow	*Melospiza melodia*
Northern Mockingbird	*Mimus polyglottos*
Brown-Headed Cowbird	*Molothrus ater*

Great Crested Flycatcher	*Myiarchus crinitus*
Black-Crowned Night-Heron	*Nycticorax nycticorax*
Eastern Screech-Owl	*Otus asio*
Ruddy Duck	*Oxyura jamaicensis*
Savannah Sparrow	*Passerculus sandwichensis*
Indigo Bunting	*Passerina cyanea*
Gray Partridge	*Perdix perdix*
Wilson's Phalarope	*Phalaropus tricolor*
Ring-Necked Pheasant	*Phasianus colchicus*
Rose-Breasted Grosbeak	*Pheucticus ludovicianus*
Eastern Towhee	*Pipilo erythrophthalmus*
Eared Grebe	*Podiceps nigricollis*
Pied-Billed Grebe	*Podilymbus podiceps*
Vesper Sparrow	*Pooecetes gramineus*
Sora	*Porzana Carolina*
Purple Martin	*Progne subis*
Great-Tailed Grackle	*Quiscalus mexicanus*
Common Grackle	*Quiscalus quiscula*
King Rail	*Rallus elegans*
Virginia Rail	*Rallus limicola*
Bank Swallow	*Riparia riparia*
Eastern Phoebe	*Sayornis phoebe*
American Woodcock	*Scolopax minor*
Louisiana Waterthrush	*Seiurus motacilla*
Eastern Bluebird	*Sialia sialis*
Dickcissel	*Spiza Americana*
Chipping Sparrow	*Spizella passerine*
Field Sparrow	*Spizella pusilla*
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*
Forster's Tern	*Sterna forsteri*
Eastern Meadowlark	*Sturnella magna*
Western Meadowlark	*Sturnella neglecta*
Tree Swallow	*Tachycineta bicolor*
Brown Thrasher	*Toxostoma rufum*
House Wren	*Troglodytes aedon*
American Robin	*Turdus migratorius*
Eastern Kingbird	*Tyrannus tyrannus*
Western Kingbird	*Tyrannus verticalis*
Barn Owl	*Tyto alba*
Blue-Winged Warbler	*Vermivora pinus*
Bell's Vireo	*Vireo bellii*
Yellow-Throated Vireo	*Vireo flavifrons*
White-Eyed Vireo	*Vireo griseus*
Yellow-Headed Blackbird	*Xanthocephalus xanthocephalus*
Mourning Dove	*Zenaida macroura*

MAMMALS

Northern Short-Tailed Shrew	*Blarina brevicauda, (Say)*
Elliot's Short-Tailed Shrew	*Blarina hylophaga, Elliot*
Coyote	*Canis latrans, Say*
Virginia Opossum	*Didelphis virginiana, Kerr*
Big Brown Bat	*Eptesicus fuscus, (Beauvois)*
Plains Pocket Gopher	*Geomys bursarius, (Shaw)*
Flying Squirrel	*Glaucomys volans, (Linnaeus)*
Silver-Haired Bat	*Lasionycteris noctivagans, (Le Conte)*
Red Bat	*Lasiurus borealis, (Muller)*
Hoary Bat	*Lasiurus cinereus, (Beauvois)*
White-Tailed Jackrabbit	*Lepus townsendii, Bachman*
River Otter	*Lutra canadensis, (Schreber)*
Woodchuck	*Marmota monax, (Linnaeus)*
Striped Skunk	*Mephitis mephitis, (Schreber)*
Prairie Vole	*Microtus ochrogaster, (Wagner)*
Meadow Vole	*Microtus pennsylvanicus, (Ord)*
Ermine	*Mustela erminea, Linnaeus*
Long-Tailed Weasel	*Mustela frenata, Lichtenstein*
Least Weasel	*Mustela nivalis, Linnaeus*
Mink	*Mustela vison, Schreber*
Little Brown Bat	*Myotis lucifugus, (Le Conte)*
White-Tailed Deer	*Odocoileus virginianus, (Zimmermann)*
Muskrat	*Ondatra zibethicus, (Linnaeus)*
Northern Grasshopper Mouse	*Onychomys leucogaster, (Wied-Neuwied)*
White-Footed Mouse	*Peromyscus leucopus, (Rafinesque)*
Deer Mouse	*Peromyscus maniculatus, (Wagner)*
Raccoon	*Procyon lotor, (Linnaeus)*
Western Harvest Mouse	*Reithrodontomys megalotis, (Baird)*
Eastern Mole	*Scalopus aquaticus, (Linnaeus)*
Masked Shrew	*Sorex cinereus, Kerr*
Hayden's Shrew	*Sorex haydeni, Baird*
Franklin's Ground Squirrel	*Spermophilus franklinii, (Sabine)*
Thirteen-Lined Ground Squirrel	*Spermophilus tridecemlineatus, (Mitchill)*
Spotted Skunk	*Spilogale putorius, (Linnaeus)*
Eastern Cottontail	*Sylvilagus floridanus, (J.A. Allen)*
Southern Bog Lemming	*Synaptomys cooperi, Baird*
Eastern Chipmunk	*Tamias striatus, (Linnaeus)*
Badger	*Taxidea taxus, (Schreber)*
Gray Fox	*Urocyon cinereoargenteus, (Schreber)*
Red Fox	*Vulpes vulpes, Linnaeus*
Meadow Jumping Mouse	*Zapus hudsonius, (Zimmermann)*

REPTILES

Smooth Softshell Turtle	*Apalone mutica*
Spiny Softshell Turtle	*Apalone spinifera*
Snapping Turtle	*Chelydra serpentina*
Western Painted Turtle	*Chrysemys picta belli*
Wood Turtle	*Clemmys insculpta*
Racer	*Coluber constrictor*
Ringneck Snake	*Diadophis punctatus arnyi*
Fox Snake	*Elaphe vulpina vulpina*
Blanding's Turtle	*Emydoidea blandingii*
Northern Prairie Skink	*Eumeces septentrionalis septentrionalis*
Eastern Hognose Snake	*Heterodon platirhinos*
Milk Snake	*Lampropeltis triangulum*
Northern Water Snake	*Nerodia sipedon sipedon*
Smooth Green Snake	*Opheodrys vernalis*
Bull Snake	*Pituophis melanoleucus sayi*
Graham's Crayfish Snake	*Regina grahamii*
Brown Snake	*Storeria dekayi*
Northern Redbelly Snake	*Storeria occipitomaculata*
Western Ribbon Snake	*Thamnophis proximus*
Plains Garter Snake	*Thamnophis radix*
Eastern Garter Snake	*Thamnophis sirtalis*
Northern Lined Snake	*Tropodiclonion lineatum*
Smooth Earth Snake	*Virginia valeriae elegans*

INVENTORY OF BUFFER VEGETATION

Introduction

The task assigned to the USGS Fort Collins Science Center was to document CREP wetland buffer vegetation and quantify wildlife habitat quality to support wildlife models and establish baselines for longer-term assessment and modeling of vegetative management and succession.

Methods

Assessment of community vegetation and initial site visitation to 22 sites occurred in October, 2007. Due to inclement weather, only 7 of the 16 sites were sampled. Vegetation sampling was conducted using 0.5-m^2 Daubenmire (1959) quadrat frames to measure percent coverage of 4 variables: bare ground, litter, residual standing cover, and cover by species. Exposed ground was defined as bare mineral soil devoid of live vegetation, vegetation debris, or litter. Robel poles were used to measure visual obstruction readings for vegetation density. Data were averaged to yield a single value for each variable per site. Transects were placed perpendicularly across buffers from edge of pool to the outermost edge to capture spatial variability of species cover and density. Visual assessments included percent of basin in wetland vegetation and percent of basin under water.

Vegetation recorded in plots was categorized as seeded, not seeded, and native, non-native. Seeded vegetation was classified as being part of the original seeding mixture recommended by the Natural Resources Conservation Service. Plant species that were not contained in the original seed mixture were classified as not seeded. Vegetation recognized as native to the lower 48 states according to the National Plants database (USDA 2004) was recorded as native; otherwise the species was classified as non-native.

Species richness (vegetation diversity) and evenness (equity of distribution) have not yet been fully analyzed.

Results

Of the 7 buffers sampled, age of buffer varied from 6 months to 3 years. Prior to seeding, buffers were planted on land previously in crops, pasture or existing Conservation Reserve Program (CRP). Seed mixtures have slight variances but are dominated by 5 native grasses and 10 native forbs from local ecotypes. One sampled buffer was not planted and was dominated by smooth brome, an introduced grass, which was the previous existing CRP cover. Season of seeding varied: 8 of the 22 planted buffers were seeded in the spring and the other 14 during the fall.

Although the small sample size prevented in-depth statistical analysis, at this juncture it appears that the canopy cover of grass increases with age of stand (Fig. 8). Average forb cover decreased with age of stand (Fig. 9) most likely due to a flush of annual forbs emerging after the soil was disturbed for seeding. Annual forbs typically have longer seed viability in the soil than perennial grasses, and forbs are more likely to dominate composition in viable seed banks (Felix and Owen 2001; Rice 1989). Average litter depth increased and percent bare ground decreased as detritus accumulated throughout successive growing seasons (Figs. 10,11). Visual obstruction readings (vegetation density) increased with age of buffer (Fig. 12). Number of forb and grass species recorded per site varied from 5 in a 3-year-old field to 19 in a 1-year-old field (Fig. 13).

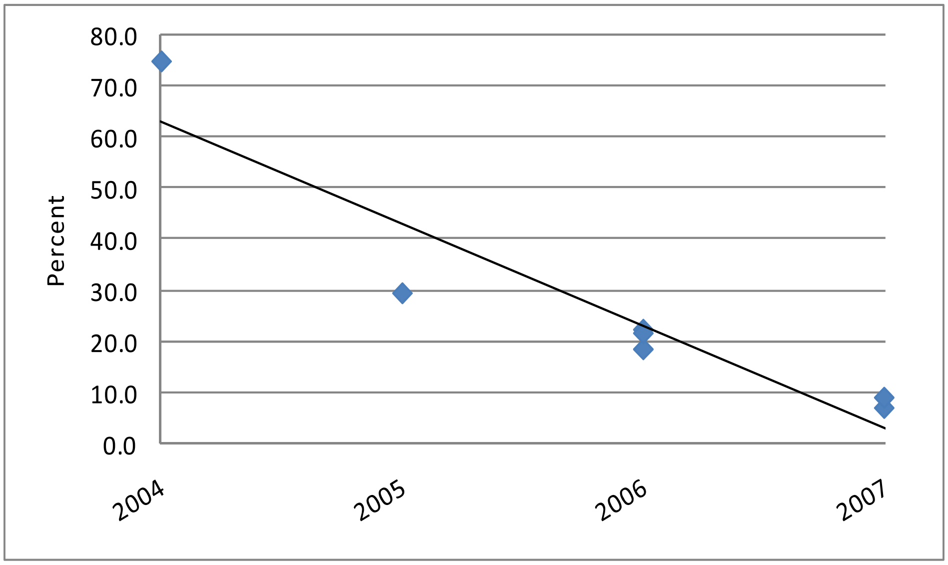

Figure 8. Average canopy cover of grass in Iowa Conservation Reserve Enhancement Program buffers (*n* = 7).

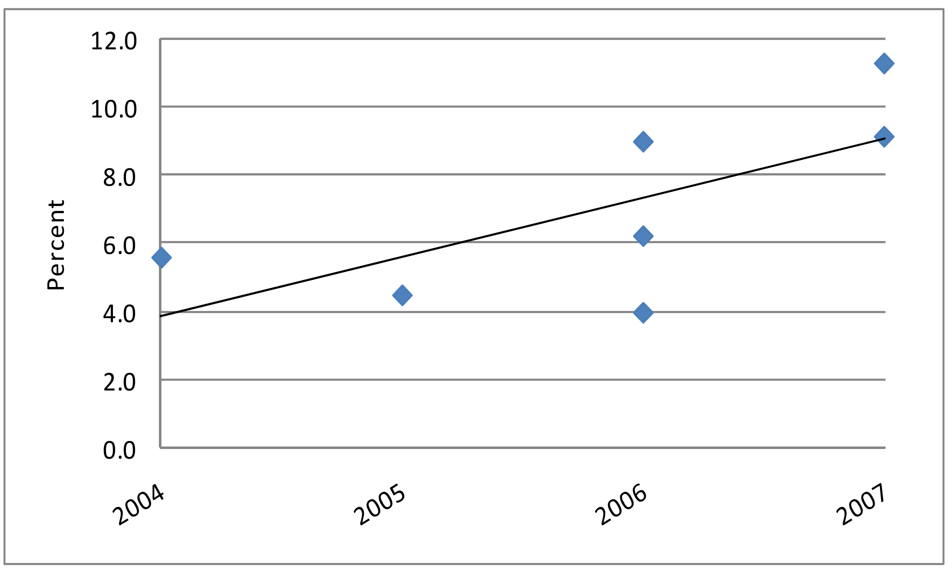

Figure 9. Average canopy cover of forbs in Iowa Conservation Reserve Enhancement Program buffers (n = 7).

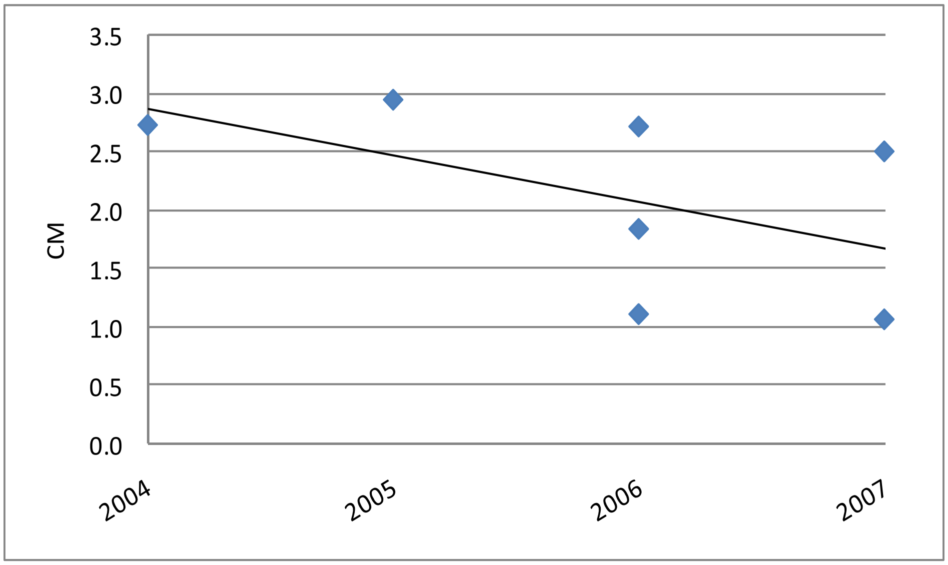

Figure 10. Average litter depth in Iowa Conservation Reserve Enhancement Program buffers (n = 7).

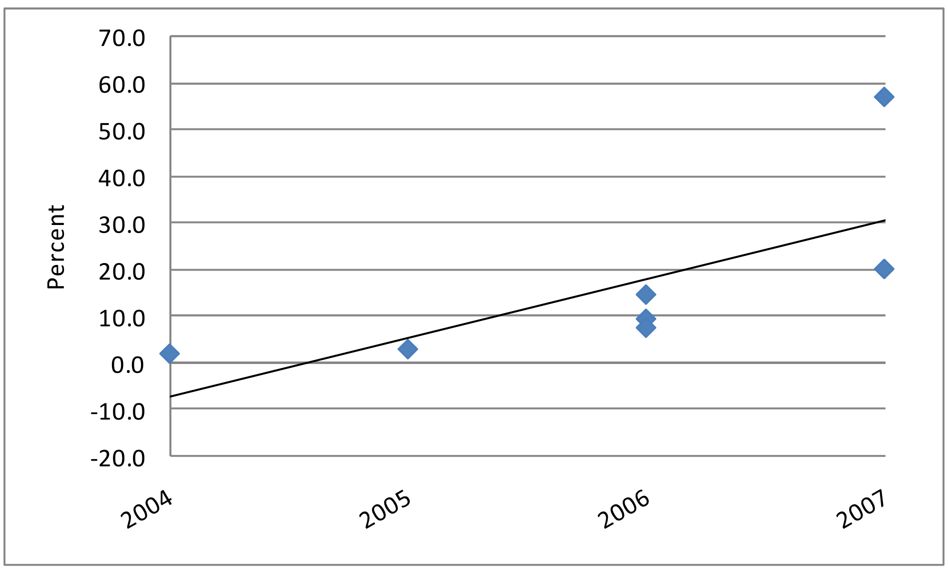

Figure 11. Average percent bare ground in Iowa Conservation Reserve Enhancement Program buffers (n = 7).

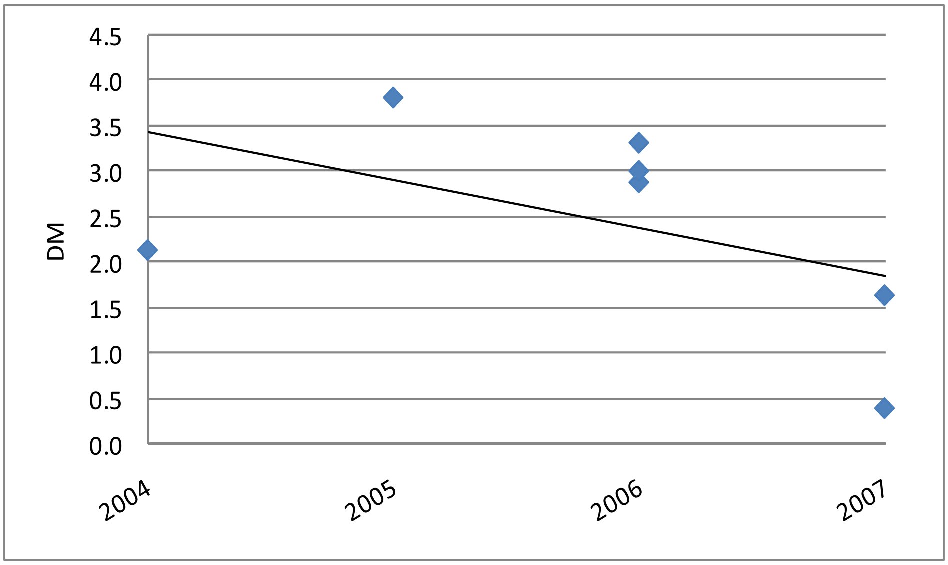

Figure 12. Average visual obstruction reading in Iowa Conservation Reserve Enhancement Program buffers (n = 7).

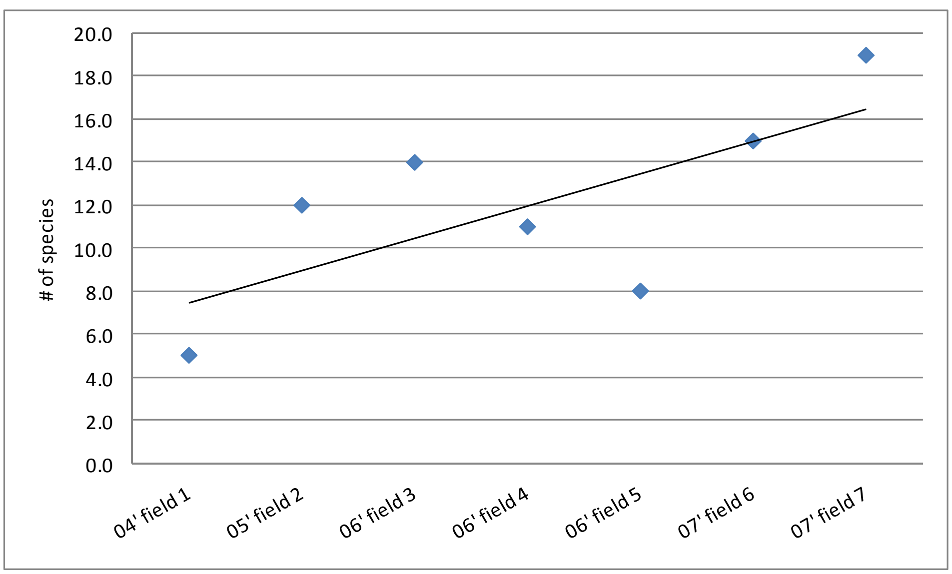

Figure 13. Number of forb and grass species (species richness) in Iowa Conservation Reserve Enhancement Program buffers (n = 7).

It appears that the first few years after seeding provided an environment suitable for opportunistic annuals, mostly native but not originally seeded. After the initial emergence of these ruderal species, evidence suggests seeded natives became established, providing greater canopy cover. Average canopy cover of seeded and not-seeded grasses varied between fields from 44% greater cover by seeded grasses to 35% greater cover from not-seeded grasses (Fig. 14). The oldest field sampled (2004) poses a unique situation whereas the buffer was not seeded due to adequate existing non-native CRP cover. Excluding the oldest field, only one of the 6 fields had greater canopy cover of non-native vs. native grasses. However, the difference is not statistically significant (Fig. 15).

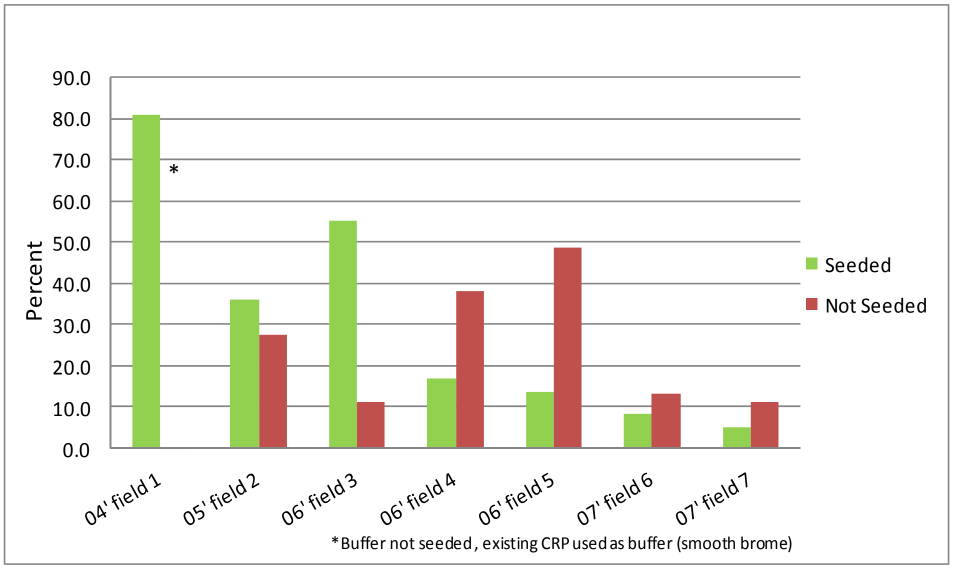

Figure 14. Average grass canopy cover/plot in seeded vs. not-seeded Iowa Conservation Reserve Enhancement Program buffers (n = 7).

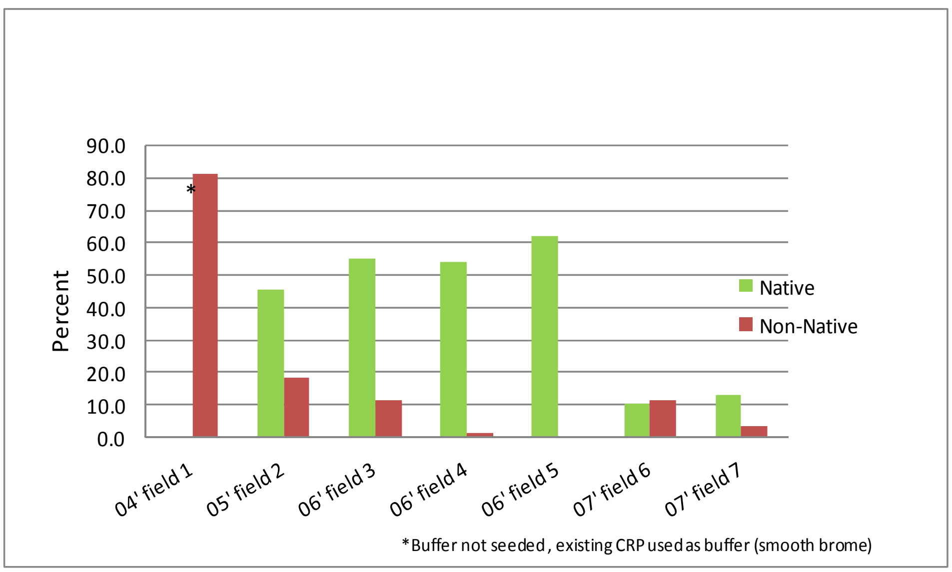

Figure 15. Average grass canopy cover/plot in native vs. non-native Iowa Conservation Reserve Enhancement Program buffers (n = 7).

Wetland Vegetation Characteristics

Observational data was collected on wetland vegetation. Dominant obligate wetland species consisted of cattail (*Typha* L.), duckweed (*Lemma* L.), and rushes (*Juncus* L.). Some annual upland grasses such as foxtail (*Alopecurus* L.) and reed canarygrass (*Phalaris arundinacea* L.) were present. Percent basin covered in vegetation varied from 0 % to 80 % and varied across years (Fig. 16). Fifteen of the 16 wetlands observed were at full pool (100% of the basin full), the other at 80% capacity.

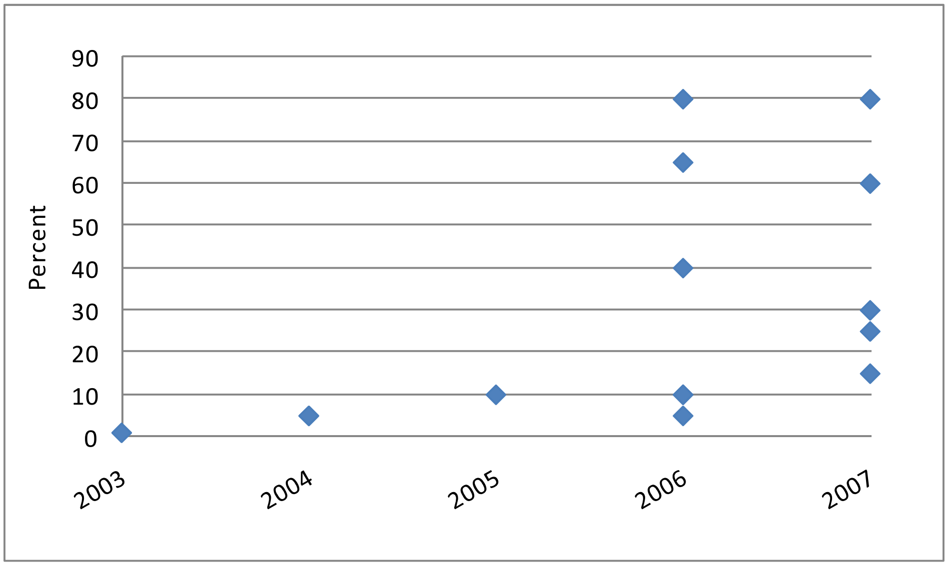

Figure 16. Percent of basin in wetland vegetation in Iowa Conservation Reserve Enhancement Program buffers (*n* = 13).

Discussion

Although the existing CREP buffers represent a relatively small area (< 500 hectares), the potential of this program to enhance wildlife habitat within agriculturally dominated landscapes appears promising. Buffers may provide provisions to waterfowl and shorebirds and year-round habitat for resident species of wildlife in intensively farmed landscapes. Conditions that might affect success of buffer establishment include precipitation, soil structure, management, and temporal changes.

Vegetative characteristics of seeded CRP grasslands change through time (Cade et al. 2005; Baer et al. 2002). Annual forbs typically have a longer seed life in the soil than perennial grasses, which allow forbs to dominate composition in the early years on disturbed sites (Rice 1989; Felix and Owen 2001). As seeded sites respond to disturbance annual forbs and grasses typically exhibit rapid increase in population followed by gradual decline. Within established CRP grasslands, abundance and distribution of forbs are likely to diminish after years of domination by planted grasses (Felix and Owen 2001; Baer et al. 2002). Recently planted buffers may provide diverse vegetation but lack in canopy cover of seeded vegetation. More inclusive documentation of buffer management (i.e., mowing, herbicide), another year's growing season, and a larger sample size are needed to assess the effects of temporal changes in vegetation structure, diversity, and provision of wildlife habitat.

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NEXT STEPS

We are currently obtaining spatial information for an additional enrolled 30 CREP sites within the designated 37 county region. This increase in sample size to 57 sites should provide adequate representation of environmental services provided in the current Iowa CREP program. For each of the sites, we will model the nitrate removal and wildlife habitat benefits, using approaches similar to those described in this report. A second round of buffer vegetation sampling will be conducted in late spring, 2008.

Progress Report II
Prepared for the USDA Farm Services Agency

August 18, 2008

Assessment of Environmental Services of CREP Wetlands in Iowa and the Midwestern Corn Belt

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BACKGROUND

This progress report presents additional results of our assessment of the potential environmental services provided by constructed wetlands enrolled in the USDA Iowa Conservation Reserve Enhancement Program (CREP). Specifically, we present analyses of potential wildlife values and an update on a field assessment of buffer vegetation.

LANDSCAPE POSITION COMPARISON OF WILDLIFE VALUE

Introduction

Habitat selection decisions by wildlife species occur within a hierarchy of geographical scales, i.e., beginning at range-wide and regional scales, and continuing through landscape and local site scales. Thus, the wildlife habitat value of a CREP site depends not only on the composition of the land cover within the site boundary, but also on the larger scale landscape context in which the site is located. Although Iowa CREP projects to date have been sited at breakpoint positions within the tile-drainage system, a comparison of the relative wildlife habitat value provided by alternative site placement strategies could help inform design of future CREP programs that are driven by a goal of optimizing cumulative environmental services.

Objectives

Our objectives were to 1) use several wildlife species and community metrics to compare wildlife value of CREP wetlands in 4 different landscape position types, and 2) to estimate the change in grassland bird density and waterfowl production due to establishment of existing CREP wetland sites.

Position Types and Site Selection

We chose to compare wildlife response at 4 different position types within a drainage area. Position types were chosen based on the presumption that land cover composition and complexity will change significantly as location moves from the upper reaches of the drainage area that are dominated by cropland use, to the lower downstream floodplain reaches with increased pasture and woody components . Thus, wildlife response to establishment of a CREP wetland site could be significantly affected by differences in the attributes of the surrounding landscape.
Specifically, the 4 landscape position types were:

> Tile-zone (TZ): These were located in the farthest upland reaches of the landscape in tile drained areas planted primarily to corn and soybean. Where possible, existing depressions were selected in close proximity to the tile infrastructure and sufficiently down-slope from tile drained agricultural areas to facilitate the diversion of water from tiles to the wetlands.

Breakpoint (BP): Breakpoint wetlands were existing CREP wetlands. These wetlands were located at the topographic transition from lower relief areas with subsurface tile drainage to higher relief areas with more surface drainage.

Upstream Floodplain (USFP): Upstream floodplain wetlands were located either within existing stream channels or along the floodplains of first order streams or the upstream reaches of second-order streams. Upstream floodplain sites were only located directly within stream channels in a small number of cases and only if the channel was small enough, the over-bank areas directly upstream flat enough to allow sufficient ponding, and if other placement options were exhausted. These sites occupied positions in the floodplain that were either in row-crop production or preferably pasture. Site criteria required for the placement of upstream sites included: sufficiently small location grade, close proximity to a stream channel (to reroute flow from the channel through the wetland) or to the outlet of a drainage tile main, in addition to the general CREP pool and buffer size requirements listed below.

Downstream Floodplain (DSFP): Downstream floodplain wetlands were located using, generally, the same placement and land-use requirements as those discussed for upstream floodplain sites. However, downstream floodplain sites were positioned within the historic floodplains of the downstream reaches of second-order streams or the up-stream reaches of third-order streams.

We defined three, 4 - county regions in the northwestern, south-central, and northeastern Des Moines Lobe (Figure 1). Within each region, we used the previously described criteria to choose 6 sites for each of the TZ, USFP, and DSFP position types, for a total of 54 potential CREP wetland sites. We used the existing 27 CREP wetlands as the breakpoint (BP) sites.

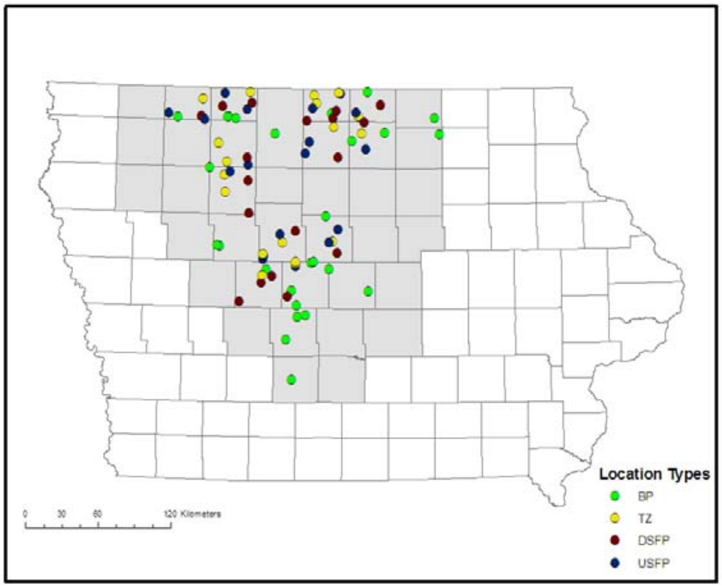


Figure 1. Locations of 81 CREP wetlands used in a landscape position comparison study. Gray shading indicates Iowa counties that are eligible for CREP participation.

CREP Site Attributes

All aforementioned selected sites and their respective GIS representations were aggregated into a single GIS shapefile to aid in comparative analysis. In all wetlands, approximate pool size was determined in accordance with general CREP requirements, and was included as an attribute in the shapefile. Approximate pool size for all site types was determined from the estimated contributing area for each site, and was restricted to be between 0.5% and 2 % of the contributing area. The DNR 2002 land-use and land-classification grid described in Progress Report I was used to identify desired land-use characteristics for proper site placement. We attempted to locate sites in either cultivated cropland or in grazed or ungrazed grassland.

We merged the shapefile containing the point locations of the 81 CREP project sites with the modified 2002 Iowa DNR land cover. At each site, we created a polygon centered on a circle with area equal to the value in the site attribute file, and then added a circular buffer around the center circle, using the ratio of 3.89:1, which is the average buffer to pool size ratio in existing CREP wetlands (S. Richmond, IDALS, Pers. Comm.). The combined area was considered the experimental site in subsequent analyses. The composition of the DNR land cover types within the experimental site boundary defined the pre-project state of the site. The post-project land cover of the site was obtained by converting the center circle to wetland cover type and its surrounding buffer to grassland cover type.

Analyses

We used 4 metrics of wildlife response, i.e., species richness, habitat value, grassland bird density, and waterfowl production, to compare wildlife value in the 4 landscape positions.

Species Richness
We used a pre- vs. post-site construction (project) approach to estimate the net change in species richness and then compared this change among the 4 position types. However, we were concerned about the potential for bias in the results due to inclusion of sites that had a significant percentage of their land cover in non-CREP eligible agricultural use, i.e., cropland and grassland. This situation was most likely to occur in USFP and DSFP sites because some degree of expert judgment was required when tradeoffs were necessary in the desired hydrological and land cover attributes. To reduce this potential source of bias, we tabulated the percentage of cropland and grassland in the pre-project BP sites, and then excluded from the analysis any sites in the other position types that did not satisfy this land cover criterion. Although in reality the current BP sites must be 100% agricultural, we assumed that errors in land cover classification and our forcing the wetland shape to be circular could result in < 100% coverage. All BP sites except one had > 89% agricultural landcover, and use of this criterion resulted in exclusion of 3 of the 18 USFP sites. Eleven of the 18 DSFP sites also did not satisfy the criterion, and therefore we chose to eliminate this position type from the analysis.

We constrained our analysis by considering only bird, mammal, amphibian, and reptile species that were classified as Species of Greatest Conservation Need (SGCN) in the Iowa DNR Wildlife Action Plan (Zohrer 2005). Next we used the EMAP hexagon species range maps developed by the Iowa Gap Analysis Project (Kane et al. 2004) to further constrain the list to include only species whose range overlapped the 37 county CREP -eligible region. This process resulted in a list of 79 species: 52 birds, 15 mammals, 3 amphibians, and 9 reptiles (Table 1).

Kane et al. (2004) developed a Wildlife Habitat Relational Model (WHRM) for each species in their Gap Analysis, based on their GIS land cover classification. These WHRMs predict species presence in a pixel based on cover type and one or more auxiliary variables that depend on attributes of the surrounding landscape (Table 2). Our method for adapting the Iowa GAP WHRMs to the 2002 DNR land cover class system was described in Progress Report I.

Table1. List of Iowa DNR Species of Greatest Conservation Need used in landscape position comparison of species richness and habitat value.

AMPHIBIANS

Northern Cricket Frog	*Acris crepitans blanchardi*
Smallmouth Salamander	*Ambystoma texanum texanum*
Mudpuppy	*Necturus maculosus*

BIRDS

Henslow's Sparrow	*Ammodramus henslowii*
Grasshopper Sparrow	*Ammodramus savannarum*
Northern Pintail	*Anas acuta*
Short-Eared Owl	*Asio flammeus*
Long-Eared Owl	*Asio otus*
Redhead	*Aythya americana*
Canvasback	*Aythya valisineria*
Upland Sandpiper	*Bartramia longicauda*
Ruffed Grouse	*Bonasa umbellus*
American Bittern	*Botaurus lentiginosus*
Broad-Winged Hawk	*Buteo platypterus*
Swainson's Hawk	*Buteo swainsoni*
Whip-Poor-Will	*Caprimulgus vociferus*
Veery	*Catharus fuscescens*
Black Tern	*Chlidonias niger*
Lark Sparrow	*Chondestes grammacus*
Common Nighthawk	*Chordeiles minor*
Northern Harrier	*Circus cyaneus*
Sedge Wren	*Cistothorus platensis*
Yellow-Billed Cuckoo	*Coccyzus americanus*
Black-Billed Cuckoo	*Coccyzus erythropthalmus*
Northern Bobwhite	*Colinus virginianus*
Cerulean Warbler	*Dendroica cerulea*
Bobolink	*Dolichonyx oryzivorus*
Willow Flycatcher	*Empidonax traillii*
Acadian Flycatcher	*Empidonax virescens*
Common Moorhen	*Gallinula chloropus*
Sandhill Crane	*Grus Canadensis*
Bald Eagle	*Haliaeetus leucocephalus*
Wood Thrush	*Hylocichla mustelina*
Yellow-Breasted Chat	*Icteria virens*
Least Bittern	*Ixobrychus exilis*
Loggerhead Shrike	*Lanius ludovicianus*
Red-Headed Woodpecker	*Melanerpes erythrocephalus*
Northern Mockingbird	*Mimus polyglottos*
Black-Crowned Night-Heron	*Nycticorax nycticorax*
Kentucky Warbler	*Oporornis formosus*
Wilson's Phalarope	*Phalaropus tricolor*

Eastern Towhee	*Pipilo erythrophthalmus*
Prothonotary Warbler	*Protonotaria citrea*
King Rail	*Rallus elegans*
American Woodcock	*Scolopax minor*
Louisiana Waterthrush	*Seiurus motacilla*
Dickcissel	*Spiza Americana*
Field Sparrow	*Spizella pusilla*
Forster's Tern	*Sterna forsteri*
Eastern Meadowlark	*Sturnella magna*
Barn Owl	*Tyto alba*
Blue-Winged Warbler	*Vermivora pinus*
Bell's Vireo	*Vireo bellii*
White-Eyed Vireo	*Vireo griseus*
Hooded Warbler	*Wilsonia citrina*

MAMMALS

Elliot's Short-Tailed Shrew	*Blarina hylophaga, Elliot*
Flying Squirrel	*Glaucomys volans, (Linnaeus)*
White-Tailed Jackrabbit	*Lepus townsendii, Bachman*
River Otter	*Lutra canadensis, (Schreber)*
Bobcat	*Lynx rufus*
Prairie Vole	*Microtus ochrogaster, (Wagner)*
Woodland Vole	*Microtus pinetorum*
Northern Myotis	*Myotis septentrionalis*
Indiana Bat	*Myotis sodalis*
Evening Bat	*Nycticeius humeralis*
Hayden's Shrew	*Sorex haydeni, Baird*
Franklin's Ground Squirrel	*Spermophilus franklinii, (Sabine)*
Spotted Skunk	*Spilogale putorius, (Linnaeus)*
Southern Bog Lemming	*Synaptomys cooperi, Baird*
Red Squirrel	*Tamiasciurus hudsonicus*

REPTILES

Western Worm Snake	*Carphophis amoenus vermis*
Wood Turtle	*Clemmys insculpta*
Timber Rattlesnake	*Crotalus horridus*
Blanding's Turtle	*Emydoidea blandingii*
Northern Prairie Skink	*Eumeces septentrionalis septentrionalis*
Speckled Kingsnake	*Lampropeltis getula holbrooki*
Smooth Green Snake	*Opheodrys vernalis*
Bull Snake	*Pituophis melanoleucus sayi*
Smooth Earth Snake	*Virginia valeriae elegans*

Table 2. List of auxiliary variables in Wildlife Habitat Relationship Models developed by the Iowa Gap Analysis Project to predict species presence.

Auxiliary Variable	**Description**
Lake Buffer	Lakes buffered 120 meters
Stream Order Buffer	Buffer width based on stream order
Wetlands Buffer	Herbaceous and shrubland wetlands buffered 120 meters
All Wetlands Buffer	All wetlands buffered 120 meters
All Water Buffer	Merge of lake buffer and water buffer to get all open water
Forest/Crop Ecotone	Intersection of forest and crop classes, each buffered 90 meters
Forest/Grass Ecotone	Intersection of forest and grass classes, each buffered 90 meters
Crop/Grass Ecotone	Intersection of crop and grass classes, each buffered 90 meters
Grass Core Area	Grass classes shrunk to 60 meters
Forest Core Area	Forest classes shrunk to 60 meters

We ran the WHRM for each species in Table 1 and recorded predicted presence or absence at each site for both pre- and post- project land coverages. We tabulated pre- and post-species richness at each site and calculated difference as a metric of net change. Results indicated that richness increased as the position moved lower in the drainage area, and averaged about 30 species post-project (Figure 2a). However, richness of the sites in the TZ position increased from pre- to post-project by an average of 7.9 species (SD = 3.6) , while richness in USFP positions was essentially unchanged (Figure 2b; $\bar{x}$ = -1.0, SD = 4.7).

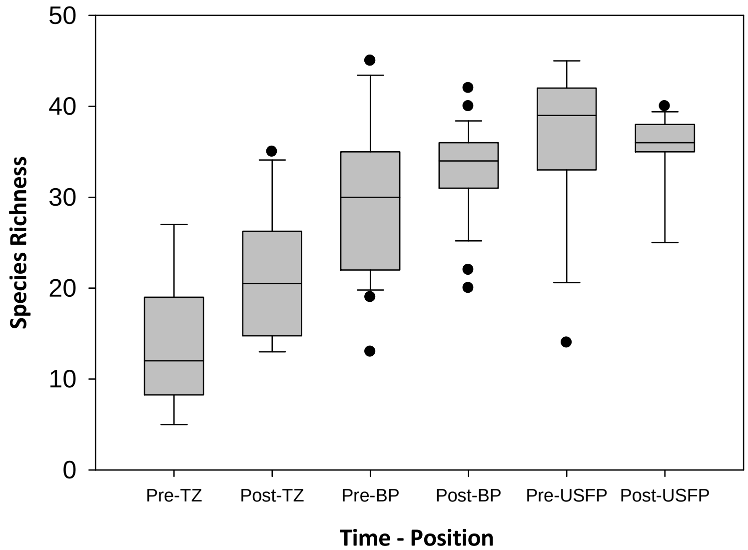


Figure 2a. Box plot of species richness pre- and post-project in each wetland position type.

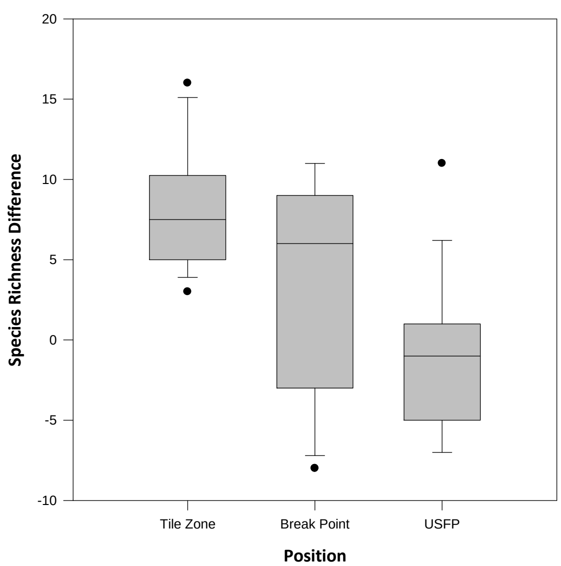
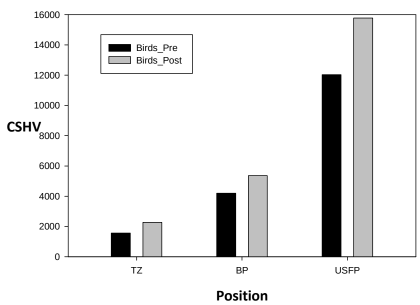


Figure 2b. Box plot of species richness difference pre- and post-project in each wetland position type.

Although we did not include 3 of the USFP sites or the DSFP sites in the above comparison, we did calculate post-project species richness for all sites in all 4 landscape positions. Average species richness was roughly the same in BP ($\bar{x}$ = 36.3, SD = 5.1), USFP ($\bar{x}$ = 35.1, SD = 4.5), and DSFP ($\bar{x}$ = 38.4, SD = 2.6) sites, and nearly double that in TZ sites ($\bar{x}$ =21.4, SD = 6.9).

Habitat Value

We used the same set of sites and species model runs described for the species richness analysis to record, for each species, the number of 30 m^2 pixels within the site boundary that were classified as useable habitat. We then tabulated an index of the cumulative species habitat value (CSHV) for each site and taxonomic group by summing the number of useable habitat pixels over all species within the taxon and dividing by the respective number of position sites. For all taxonomic groups, CSHV increased as the position moved lower in the drainage area, and habitat increased from pre- to post-project for all position types (Figure 3). The large majority of the habitat was for birds. The greatest absolute increase in CSHV was in USFP sites, but percentage increase was twice as large in TZ sites (61.5%) than in either BP (31.6%) or USFP (31.8%) sites.



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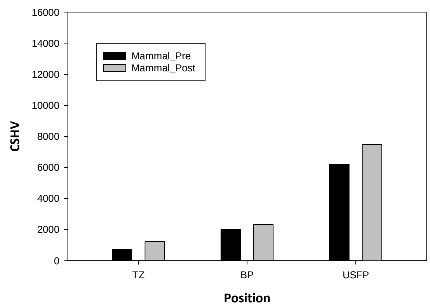

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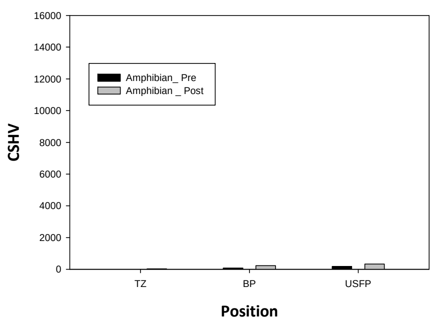

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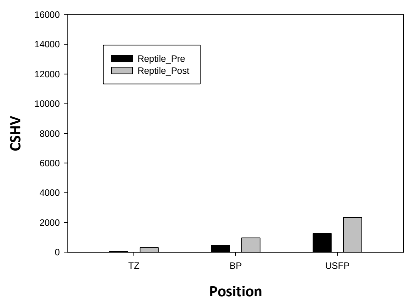

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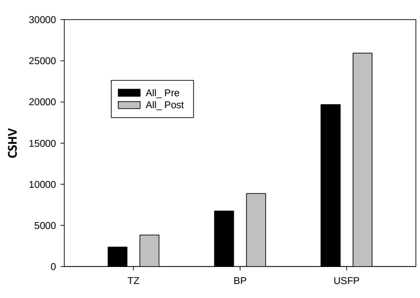

e.

Figure 3. Cumulative Species Habitat Value (CSHV) of position types for a) birds, b) mammals, c) amphibians, d) reptiles, e) all species combined.

Post-project average CSHV values for all taxa for all sites and position types increased as landscape position moved lower in the drainage. The greatest increase in habitat value occurred between the BP and the USFP and DSFP flood plain position types (Figure 4). There is not an appreciable difference between the 2 flood plain position types.

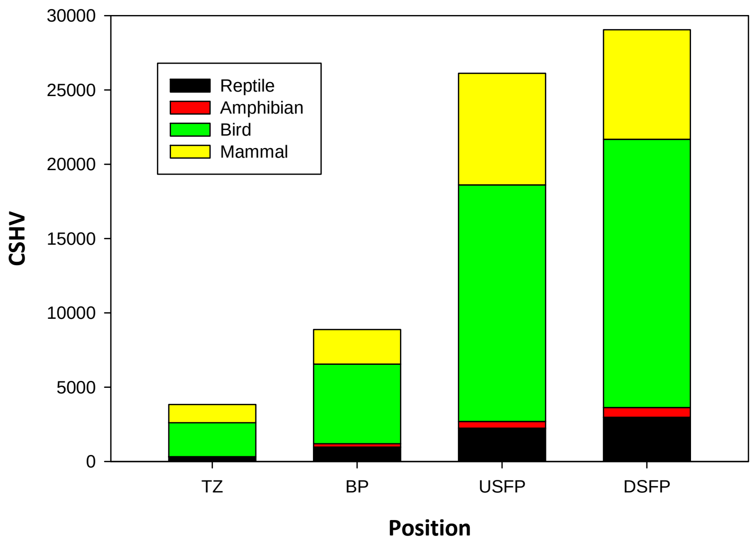

Figure 4. Post-project Cumulative Species Habitat Value (CSHV) of all position types.

Grassland Bird Density

We calculated predicted post-project grassland bird densities for the 18 sites in each of the alternate landscape positions (TZ, USFP, and DSFP) and the 27 actual BP sites using the Quamen (2007) models (Table 3). Predicted densities of bobolinks, grasshopper sparrows, sedge wrens, and savanna sparrows were then compared using ANOVA. We used a post-hoc test (Bonferonni's Test) to make pair-wise comparisons when there was a significant F-statistic from ANOVA. Statistical tests were considered significant when $p < 0.05$.

Predicted densities varied significantly by landscape position for the 4 species of grassland birds. Sedge wrens ($F = 27.3$; $p < 0.001$) had the highest density on DSFP and USFP sites (Figure 5). Grasshopper sparrows ($F = 6.5$; $p = 0.001$) had similar densities for BP, DSFP, and USFP sites (Figure 6). Savanna Sparrow ($F = 7.5$; $p < 0.001$) densities were highest on BP and DSFP sites (Figure 7). Bobolinks ($F = 20.6$; $p < 0.001$) had the highest density for DSFP sites, with moderate densities for BP and USFP sites (Figure 8). TZ sites had the lowest predicted density for all 4 species.

Table 3. Models used to estimate density (birds/ha) of 4 species of grassland birds for the Des Moines Lobe region of Iowa.

Species	Model*
BOBO	density = e (-0.8696546 + 0.0180943 * grass400)
GRSP	density = e (-2.554612 + 0.0246975 * grass400 – 0.1032461 * trees400)
SEWR	density = 1-1/1+e (-0.8015652 + 0.08500569 * grass400) *e (-0.7982511 + 0.0285891 * bbspath + 0.0105094 * grass400)
DICK	density = 1-1/1+e (-6.811334 + 1.889878 * bbspath) * e (-1.831015 + 0.0312571 * hay400)
SASP	density = e (-1.581362 + 0.0229603 *bbspath + 0.01024* grass3200 + 0.0255867 * hay3200)

* Variable definitions: grass400 = percentage of the 400-m radius surrounding landscape that is in grass; trees400 = percentage of the 400-m radius surrounding landscape that is in trees; hay400 = the percentage of the 400-m radius surrounding landscape that is in hay; grass3200 = percentage of the 3200-m radius surrounding landscape that is in grass; hay3200 = the percentage of the 3200-m radius surrounding landscape that is in hay; and bbspath = species specific relative abundances as determined from 1992-2003 BBS data.

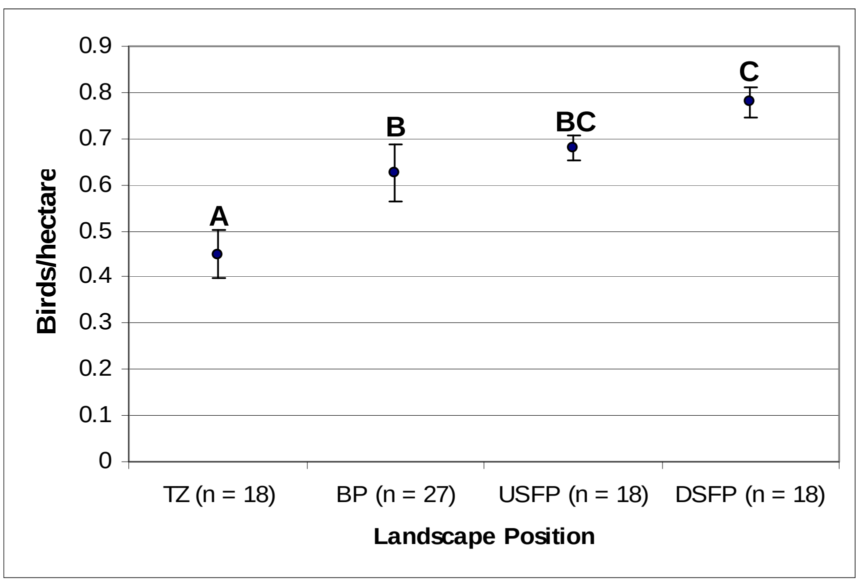

Figure 5. Mean density (birds/ha) and 95% confidence interval for sedge wrens at sites located in four different landscape positions in north central Iowa. Means with different letters are significantly different at the p <0.05 level.

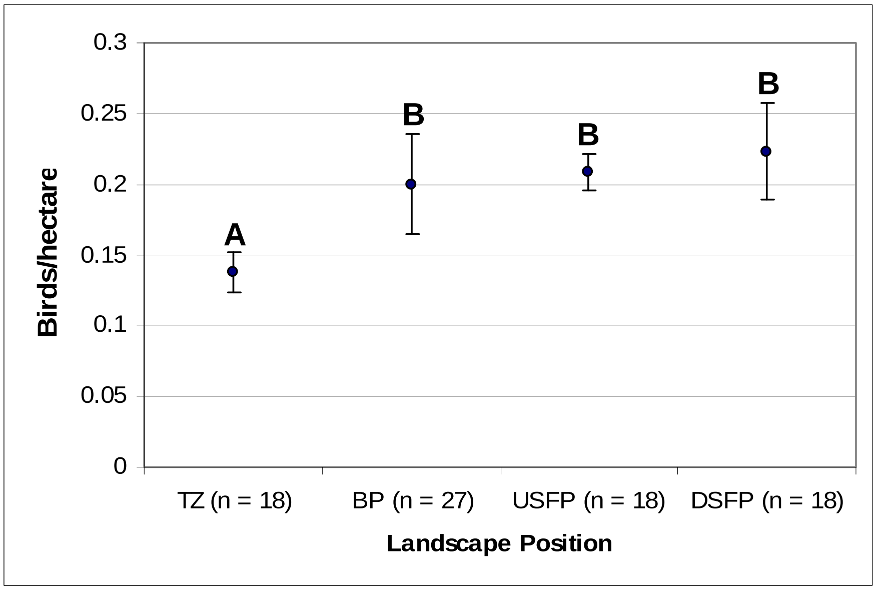

Figure 6. Mean density (birds/ha) and 95% confidence interval for grasshopper sparrows at sites located in four different landscape positions in north central Iowa. Means with different letters are significantly different at the $p < 0.05$ level.

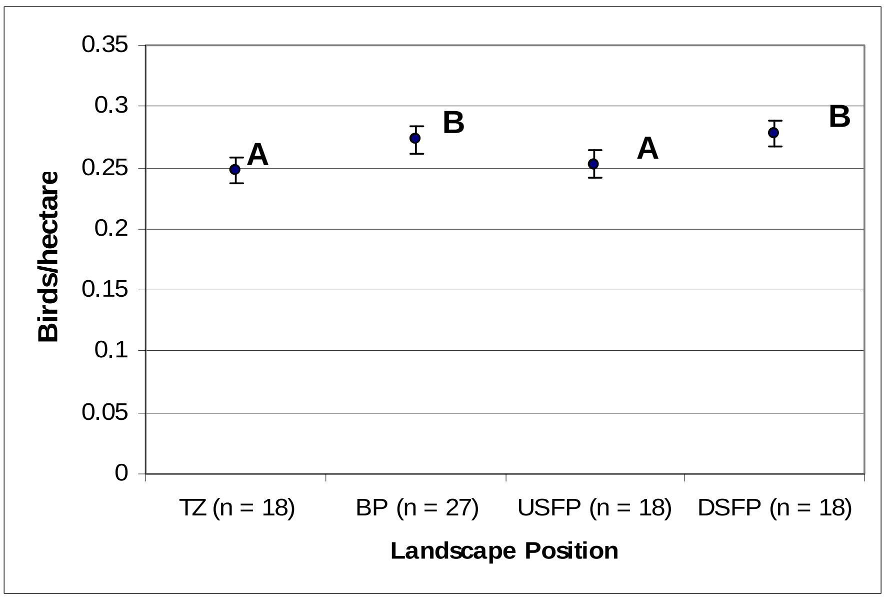

Figure 7. Mean density (birds/ha) and 95% confidence interval for savanna sparrows at sites located in four different landscape positions in north central Iowa. Means with different letters are significantly different at the $p < 0.05$ level.

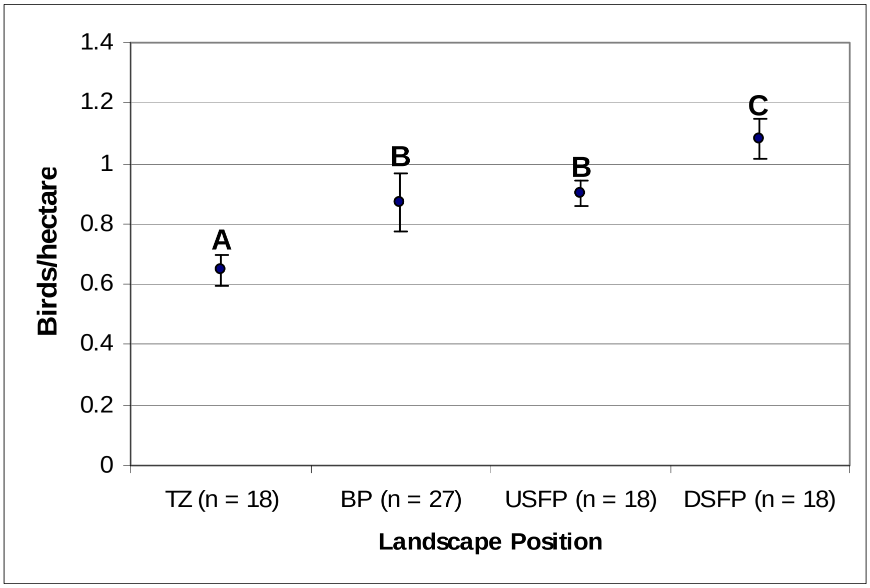

Figure 8. Mean density (birds/ha) and 95% confidence interval for bobolinks at sites located in four different landscape positions in north central Iowa. Means with different letters are significantly different at the $p < 0.05$ level.

Waterfowl Production

We used methods described in Progress Report I to estimate the number of recruits produced for each site within the TZ, USFP, and DSFP landscape positions. Recruitment estimates were calculated for mallards, blue-winged teal, gadwall, northern pintail, and northern shoveler. For the BP sites, we used the number of recruits estimated from Progress Report I for each enrolled site. We used ANOVA to test for differences in the estimated number of recruits produced between the 4 landscape positions (TZ, BP, USFP, and DSFP) for mallards, blue-winged teal, and total ducks. Analysis was not conducted for gadwall, northern pintail, and northern shoveler because estimated recruitment for these species in Iowa was very small. A post-hoc test (Bonferonni's Test) was used to make pair-wise comparisons if there was a significant F-statistic. All statistical tests were considered significant when $p < 0.05$.

The estimated number of recruits differed by landscape position for mallards ($F = 42.9$; $p < 0.001$), blue-winged teal ($F = 43.1$; $p < 0.001$), and total recruits ($F = 43.2$; $p < 0.001$). The mean number of recruits estimated for USFP and DSFP sites was approximately double the mean for BP and TZ sites (Table 4).

Table 4. Mean number of recruits (95% confidence interval) estimated for CREP projects located in 4 different landscape positions in Iowa (different letters within each group indicates a significant difference between means at the $p \leq 0.05$ level).

	Landscape Position			
Group	$\bar{x}$ Break Point (n = 27)	$\bar{x}$ Tile Zone (n = 18)	$\bar{x}$ US Floodplain (n = 18)	$\bar{x}$ DS Floodplain (n = 18)
Mallard	3.5 (3.0-3.9) A	2.9 (2.5-3.2) A	7.2 (6.1-8.2) B	6.3 (5.6-7.1) B
BW Teal	1.4 (1.2-1.5) A	1.2 (1.0-1.3) A	2.6 (2.3-2.9) B	2.3 (2.1-2.6) B
Total[1]	5.0 (4.4-5.7) A	4.2 (3.7-4.7) A	10.2 (8.7-11.6) B	9.0 (8.0-10.0) B

[1] Includes estimated total number of recruits for mallards, blue-winged teal, northern shoveler, gadwall, and northern pintail.

WILDLIFE VALUE OF EXISTING CREP SITES

Introduction

In Progress Report I we presented several analyses of wildlife value provided by 27 existing CREP wetland sites in Iowa. In this report, we present 2 additional analyses that strengthen this evaluation. The first analysis estimates the net change in grassland bird density pre- and post- CREP site construction of the 27 sites. The second analysis repeats a species occurrence analysis from Progress Report I, using a larger set of CREP sites made possible by the addition of 32 more recently contracted or constructed CREP sites.

Grassland Bird Density

We estimated pre-project grassland bird densities for the 27 enrolled CREP sites using the GIS coverages described above and the grassland bird models for 5 species of grassland birds nesting in Iowa: bobolinks, grasshopper sparrows, sedge wrens, savanna sparrows, and dickcissels. Post-project estimates were taken from Progress Report I. Pre- and post-project densities for each species were compared using t-tests; tests were considered significant if $p < 0.05$.

Estimated sedge wren ($t = 2.4$; $df = 52$; $p = 0.019$) density increased and dickcissel density decreased significantly ($t = -2.4$; $df = 52$; $p = 0.017$) between pre- and post-project (Table 5). Although not significant, bobolink ($t = 1.8$; $df = 52$; $p = 0.076$), savanna sparrow ($t = 1.24$; $df = 52$; $p = 0.218$), and grasshopper sparrow ($t = 1.7$; $df = 52$; $p = 0.089$) densities increased (Table 5). Predicted dickcissel density decreased for many sites because hayland (a primary variable in the dickcissel model) that occurred on enrolled CREP sites prior to habitat restoration was replaced by grassland or wetland as part of CREP restoration activities. Densities decreased for other species on some individual sites (i.e., Boo852602B) because grassland in the pre-project land cover GIS was replaced by wetland in the post-project land cover GIS (Table 5).

Table 5. Predicted density (birds/ha) for 5 species of grasslands birds at 27 CREP sites located in north central Iowa pre- and post-project.

	Bobolink		G. Sparrow		S. Sparrow		Sedge Wren		Dickcissel	
Site	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Boo822729D	0.56	0.89	0.11	0.21	0.24	0.25	0.34	0.66	0.16	0.16
Boo832824B	0.55	0.73	0.11	0.17	0.23	0.24	0.33	0.55	0.17	0.16
Boo852602B	1.78	1.67	0.56	0.51	0.29	0.30	1.05	1.01	0.18	0.18
Boo852603C	0.75	1.02	0.17	0.26	0.26	0.27	0.56	0.74	0.20	0.18
Boo852603D	0.88	1.19	0.21	0.32	0.27	0.28	0.66	0.82	0.28	0.17
Cal873421C	0.60	0.72	0.12	0.16	0.25	0.26	0.40	0.54	0.16	0.16
Cal873427D	0.56	0.57	0.11	0.12	0.25	0.25	0.34	0.36	0.16	0.16
Cer962220C	0.53	0.64	0.01	0.02	0.26	0.27	0.32	0.46	0.17	0.17
Cer971931C	0.62	0.68	0.13	0.14	0.27	0.28	0.45	0.52	0.20	0.19
Dal792828C	0.63	0.67	0.12	0.14	0.26	0.27	0.43	0.48	0.16	0.16
Dal812619C	0.89	1.07	0.17	0.26	0.28	0.29	0.66	0.76	0.16	0.16
Dal812718C	0.52	0.76	0.11	0.17	0.25	0.26	0.29	0.56	0.18	0.17
Dic983729C	0.88	0.94	0.21	0.23	0.28	0.29	0.66	0.70	0.18	0.16
Emm983229C	0.73	0.74	0.16	0.17	0.25	0.25	0.54	0.56	0.17	0.16
Emm983322C	1.00	0.96	0.20	0.23	0.28	0.28	0.74	0.72	0.16	0.16
Emm983327B	1.03	1.03	0.20	0.21	0.27	0.28	0.75	0.75	0.17	0.17
Flo961502D	0.85	1.03	0.15	0.23	0.30	0.31	0.65	0.76	0.24	0.17
Gre853026B	0.51	0.67	0.10	0.14	0.23	0.23	0.28	0.48	0.16	0.16
Ham892406C	0.62	0.78	0.12	0.18	0.24	0.24	0.43	0.60	0.16	0.16
Kos962903D	1.06	1.13	0.27	0.29	0.27	0.28	0.78	0.81	0.17	0.17
Mad752802B	0.91	0.94	0.22	0.23	0.32	0.34	0.67	0.69	0.19	0.18
Mit981528A	0.70	0.96	0.14	0.23	0.28	0.29	0.52	0.72	0.28	0.19
Poc933406C	0.64	0.82	0.13	0.18	0.24	0.24	0.45	0.62	0.16	0.16
Sto832121A	0.53	0.65	0.11	0.14	0.25	0.26	0.30	0.46	0.24	0.16
Sto852430B	0.53	0.59	0.10	0.12	0.24	0.25	0.30	0.38	0.17	0.17
Win982409D	0.58	0.61	0.12	0.13	0.26	0.27	0.38	0.42	0.16	0.16
Wor1002115C	0.70	1.09	0.06	0.21	0.31	0.33	0.53	0.80	0.34	0.18
Mean	0.75	0.87	0.16	0.20	0.26	0.27	0.51*	0.63*	0.19*	0.17*

* Indicates a significant difference at $P < 0.05$

Species Occurrence

In Progress Report I we predicted that the 27 constructed CREP wetlands could provide habitat for 192 wildlife species, including 13 species of amphibians, 115 species of birds, 41 species of mammals and 23 species of reptiles. We used the same modeling procedures to tabulate how many new species would be added to this list by inclusion of an additional 32 CREP sites (Figure 9) that are now constructed or contracted (S. Richmond, IDALS, Pers. Comm.).

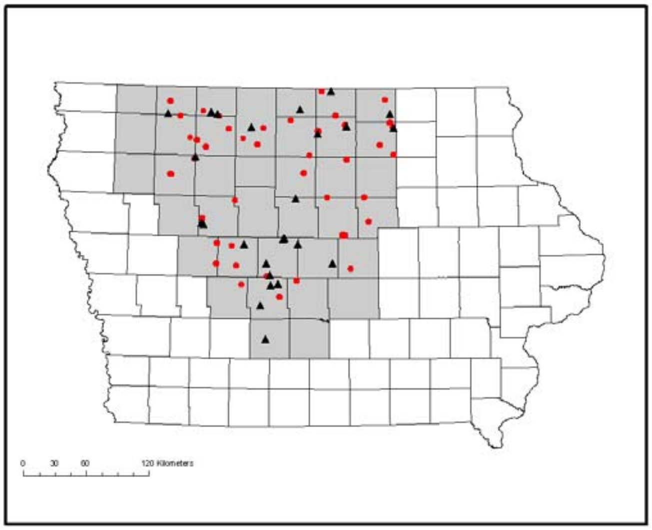

Figure 9. Locations of 69 constructed or contracted CREP wetland sites in Des Moines Lobe region of Iowa. Sites include those used in analyses reported in Progress Report I (Δ) and additional sites (•) used in the current analysis.

Cumulative results from all 69 CREP wetlands predicted that 197 wildlife species could use 1 or more sites (Figure 10) . The additional 5 species were: central newt (*Notopthalmus viridescens*), false map turtle (*Graptemys pseudogeographica*), massasauga (*Sistrurus catenatus*), cattle egret (*Bubulcus ibis*), and ring-billed gull (*Larus delawarensis*). Of the predicted 197 species, 30.5% are listed in the Iowa Wildlife Action Plan as Species of Greatest Conservation Need (Figure 11), included 15 species that are listed as endangered, threatened or of special concern. When stratified by land cover class, 20.3% of the predicted species required only wetland habitat, 46.7% required only grassland habitat and 33.0% of all predicted species required both wetland and grassland habitat types. Predicted species richness per wetland ranged from 143 to 167 with an average of 155.

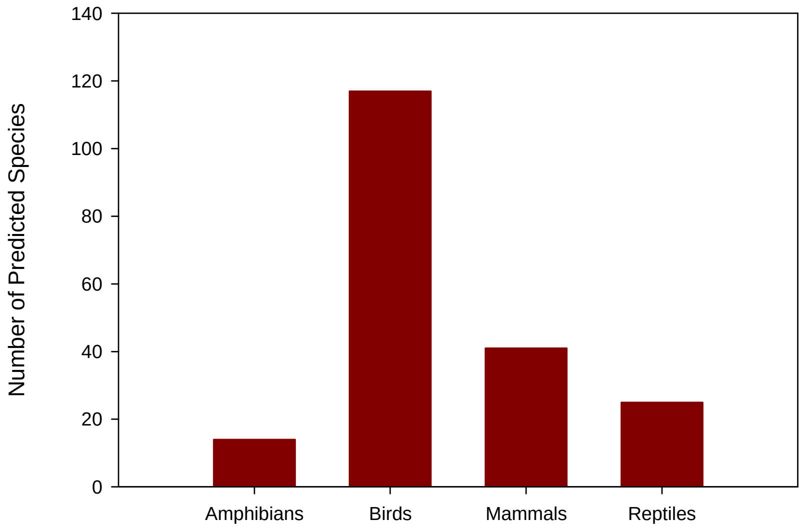

Figure 10. Number of wildlife species predicted in 69 CREP sites in the Des Moines Lobe region of Iowa.

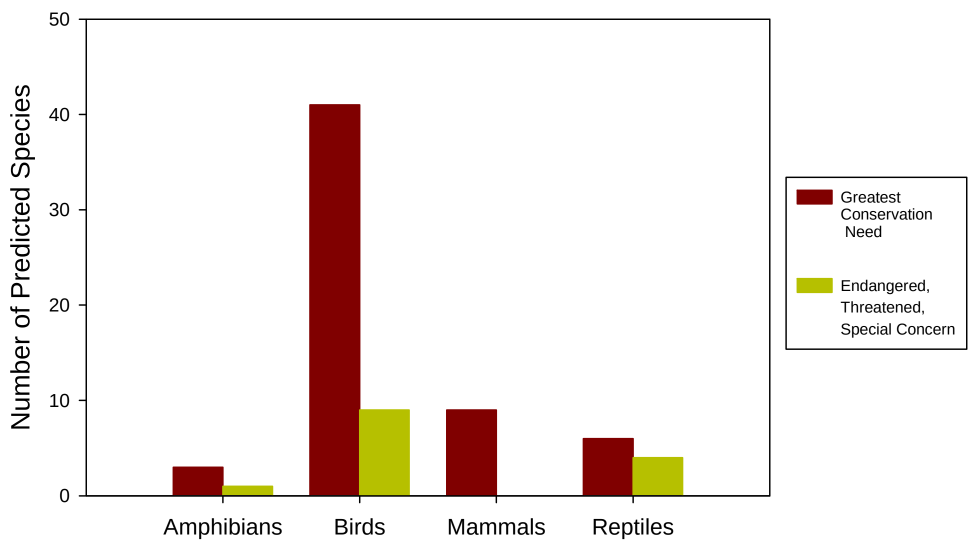

Figure 11. Number of wildlife species of special conservation status predicted in 69 CREP sites in the Des Moines Lobe region of Iowa.

These results suggest only a marginal increase in predicted species occurrence as a result of more than doubling the number of CREP sites modeled. This exercise provides support for use of the currently available set of sites to predict potential wildlife value of hypothetical increases in the number of CREP sites within the Des Moines Lobe.

DISCUSSION

Our results consistently demonstrate the influence of landscape context on the potential wildlife value of a CREP wetland project. As site location moved from the tile-zone areas at the top of a drainage area to the floodplains in the bottom of the drainage, there tended to be increased habitat diversity and complexity and decreased dominance of cropland, both of which generally increase wildlife diversity and abundance. In addition, potential maximum pool size will increase for sites lower in the drainage area because CREP requirements specify that pool size must be between 0.5% and 2% of the upslope contributing drainage area. With increased pool size, grassland buffer size will also increase because the buffer to pool ratio for CREP sites average about 3:1. Thus, quantity as well as quality of potential wildlife habitat is influenced by landscape position.

Managers must still account for fine-scale habitat requirements when determining the best placement of future CREP sites. For example, the models for savanna and grasshopper sparrows predicted that the highest densities for both species would occur at DSFP sites based strictly on landscape variables (see Table 3) that entered into the models. Due to increased moisture at DSFP sites, grassland habitat would probably be tall and dense. However, previous research from Iowa reported that these species selected sites with shorter, sparser vegetation (Fletcher and Koford 2002). On the contrary, Fletcher and Koford (2002) found that bobolinks and sedge wrens both preferred tall, dense vegetation and, therefore, would likely benefit from CREP sites placed in lower landscape positions. As another example, managers should evaluate the frequency of flooding in lower topographic positions (i.e. DSFP and USFP sites) before deciding on future CREP project placement. If CREP projects are placed in locations with frequent spring flooding, they may not be available for ground-nesting waterfowl or grassland birds.

A primary goal of the 2008 Gulf Hypoxia Plan (2008) is to achieve a 45% reduction in nitrogen loads in tile-drained regions of the Upper Midwest. One plausible scenario for moving toward this goal is scaling up of the Iowa CREP program. However, given the rapidly evolving economic influences on Midwestern agriculture, a significant expansion of the program will require more reliance on sites out of the tile-zone and breakpoint regions, i.e., sites that tend to be lower in the drainage areas and devoted to non-crop agricultural use such as pasture. Thus, we propose that a primary focus of the next phase of the project involve a more detailed and comprehensive case study analysis in a major Iowa river drainage. We will compare the environmental services provided by different sets of sites within the river drainage that are generated by alternative site selection criteria. All sets would achieve target nitrogen reduction levels, but may vary significantly in number, size, and landscape position. This exercise could help inform future determination of CREP program enrollment parameters that could increase the probability of success in achieving program goals.

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INVENTORY OF BUFFER VEGETATION

Introduction

The task assigned to the USGS Fort Collins Science Center was to document CREP wetland buffer vegetation and quantify wildlife habitat quality to support wildlife models and establish baselines for longer-term assessment and modeling of vegetative management and succession.

Vegetation sampling in Fall, 2007 established baseline conditions and provided information for prediction of thermal/wintering cover that will be available for the winter and spring months. Unfortunately, spring vegetation sampling to measure pre-greenup residual buffer vegetation was not done in 2008 because of an extended harsh winter and an extremely wet spring. However, the most informative time to sample is shortly after the growing season to see how the grasses and forbs responded to another year in the ground, and therefore sites will be sampled again in September, 2008. Vegetation monitoring is expected to be continued for several years, in order to better understand vegetation succession of these buffers and how and when to incorporate management to help accelerate plant succession.

Progress Report III
Prepared for the USDA Farm Services Agency

July 24, 2009

Assessment of Environmental Services of CREP Wetlands in Iowa and the Midwestern Corn Belt

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Background

This progress report presents additional results of our assessment of the potential environmental services provided by constructed wetlands in the USDA Iowa Conservation Reserve Enhancement Program (CREP). Specifically, we present additional analyses of the comparison of potential wildlife habitat values of CREP wetlands in alternative landscape positions within the watershed.

Introduction

Habitat selection decisions by wildlife species occur within a hierarchy of geographical scales, i.e., beginning at range-wide and regional scales, and continuing through landscape and local site scales. Thus, the wildlife habitat value of a CREP site depends not only on the composition of the land cover within the site boundary, but also on the larger scale landscape context in which the site is located. Although Iowa CREP projects to date have been sited at breakpoint positions within the tile-drainage system, a comparison of the relative wildlife habitat value provided by alternative site placement strategies could help inform design of future CREP programs that are driven by a goal of optimizing cumulative environmental services.

Objectives

In our Progress Report II, we presented an analysis that used several wildlife species and community metrics to compare habitat value of CREP wetlands in 4 different landscape position types. Our report demonstrated the potential of our approach for informing future CREP program site criteria, but we believed that our methodology and analyses could be significantly improved and strengthened. Two primary weaknesses in the original analysis were 1) potential wetland sites were identified only by a point location that served as the center of an assumed circular pool size area, which in turn determined a fixed ratio circular grassland buffer area, and 2) filtering of the base GIS land cover only assured that land use of the point location was cropland, CRP, or pasture, and therefore eligible for CREP enrollment. Our improved approach involved additional modeling of landscape attributes to provide site-specific wetland and buffer polygons, and we assured that the resulting entire site was CREP-eligible. This refined approach leads to a larger, balanced and more realistic set of wetlands, and hence a more comprehensive analysis of comparative wildlife habitat values.

Methods

Position Types and Site Selection

We compared wildlife response at 4 different position types within a drainage area (watershed). Position types were chosen based on the presumption that land cover composition and complexity will changed significantly as position moves from the upper reaches of the drainage area that are dominated by cropland use, to the lower downstream floodplain reaches that contain increased pasture and woody components. Thus, wildlife response to establishment of a CREP wetland site could be significantly affected by changes in both the attributes of the project site and its surrounding landscape.

Specifically, the 4 landscape position types were:

Tile-zone (TZ): These were located in the farthest upland reaches of the landscape in tile drained areas planted primarily to corn and soybean. Where possible, existing depressions were selected in close proximity to the tile infrastructure and sufficiently down-slope from tile drained agricultural areas to facilitate the diversion of water from tiles to the wetlands. The TZ sites satisfy NRCS criteria for delineation of Farmed Wetlands.

Breakpoint (BP): We used existing CREP wetlands constructed prior to 2009 as our breakpoint sites. These wetlands were located at the topographic transition from lower relief areas with subsurface tile drainage to higher relief areas with more surface drainage. A requirement for CREP enrollment is that the site is currently under agricultural production (i.e., row crop, pasture) or enrolled in CRP.

Upstream Floodplain (USFP): Upstream floodplain wetlands were located either within existing stream channels or along the floodplains of first- and second- order streams or the upstream reaches of third-order streams. Upstream floodplain sites were only located directly within stream channels in a small number of cases and only if the channel was small enough, the over-bank areas directly upstream flat enough to allow sufficient water accumulation, and if other placement options were exhausted. Site criteria required for the placement of upstream sites included: sufficiently small location grade, close proximity to a stream channel (to reroute flow from the channel through the wetland) or to the outlet of a drainage tile main, in addition to the general CREP pool and buffer size requirements listed below.

Downstream Floodplain (DSFP): Downstream floodplain wetlands were located using, generally, the same placement and land-use requirements as those discussed for upstream floodplain sites. However, downstream floodplain sites were positioned within the historic floodplains of the downstream reaches of third-order or greater stream channels.

Our analysis was based on 24 sets of each of the 4 landscape position types. For each set, we first identified an existing BP site and then, for each of the other 3 position types, we identified the nearest landscape location that met the respective selection criteria.

CREP Site Attributes

All sites were located in areas qualifying for CREP program inclusion: actively farmed and/or grazed areas or land that is enrolled in CRP (Fig. 1). Land-use was determined from the originally classified Iowa Department of Natural Resources (IDNR) 2002 Land-use and Land-cover GIS raster dataset. Floodplain sites are, in all cases, situated within the historical flood plain, as indicated by the IDNR GIS file.

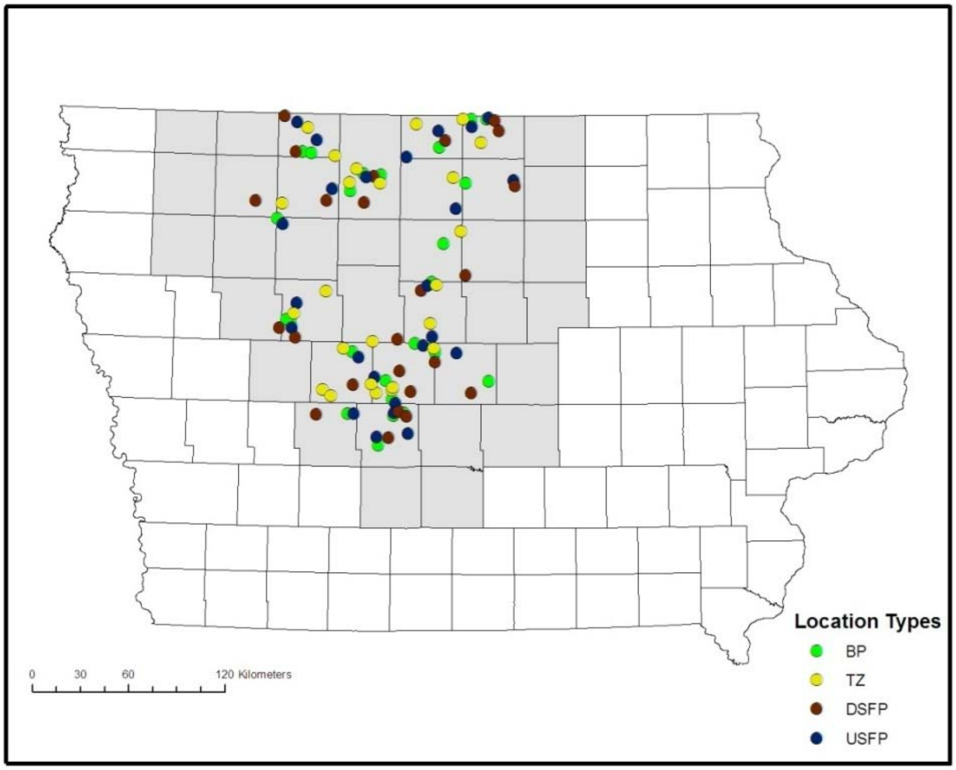

Figure 1. Locations of 96 CREP wetlands used in a landscape position comparison study. Gray shading indicates Iowa counties that are eligible for CREP participation.

Wetland pool area was constrained to between 0.5 and 2.0 percent of the upstream contributing area if the wetland was to be situated in-channel, and was assigned an area of approximately 1.0 percent of the upstream contributing area if the wetland was to be situated stream-side. This area assignment assumed that sufficient flow equal to that which would be contributed by between 0.5 and 2.0 percent of the upstream contributing area could be diverted to the wetland. For most sites, pool areas were specified by following natural landscape contours and land-use patterns. For a few locations, however, pool shapes were delineated not by contours but by landscape patterns and stream proximity, and thus, may appear to be arbitrarily formed. Grassland buffers surrounding each wetland were created by buffering around the wetland perimeter to achieve an approximate wetland:buffer ratio of 1:4, which is the target criteria used in the Iowa CREP. Wetland:buffer ratios for existing CPEP (BP) sites actually range from about 1:3 to 1:7, and therefore we allowed ratios for our hypothetical sites to vary within the same range.

We merged the wetland and buffer shapefiles containing the 96 sites with the modified 2002 Iowa DNR land cover described in Progress Report I. The composition of the DNR land cover types within the experimental site boundary defined the pre-project state of the site. The post-project land cover of the site was created by converting the polygons within the designated pool area to the wetland cover type and the polygons with the associated modeled buffer polygon to the grassland cover type.

Analyses

We used several metrics of predicted wildlife response: species richness, cumulative species habitat value (CHSV), grassland bird density, and waterfowl breeding success, to compare potential habitat value in the 4 landscape positions.

We constrained our analysis by considering only bird, mammal, amphibian, and reptile species that were classified as Species of Greatest Conservation Need (SGCN) in the Iowa DNR Wildlife Action Plan (Zohrer 2005). Next we used the EMAP hexagon species range maps developed by the Iowa Gap Analysis Project (Kane et al. 2004) to further constrain the list to include only species whose range overlapped the 37 county CREP -eligible region. This process resulted in a set of 79 species: 52 birds, 15 mammals, 3 amphibians, and 9 reptiles (Table 1).

For each metric except waterfowl breeding parameters, we calculated the pre- and post-project values at each site and conducted a 2-way randomized block with repeated measures ANOVA to test for overall differences 1) among position types averaged over pre- and post- periods, 2) between pre- and post- project times averaged over all position types and 3) among position types in the pre- and post-project average net change. We were particularly interested in the last comparison because it compares the net gain in habitat value among position types. We used a post-hoc test (Tukey's Test) for individual comparisons when there was a significant F-statistic from ANOVA. Statistical tests were considered significant when $P < 0.05$.

Species Richness

Kane et al. (2004) developed a Wildlife Habitat Relational Model (WHRM) for each species in their Gap Analysis, based on their GIS land cover classification. These WHRMs predict species presence in a 30-m x 30-m pixel based on cover type and one or more auxiliary variables that depend on attributes of the surrounding landscape (Table 2). We adapted the Iowa GAP WHRMs to a simplified 2002 land cover class system (Table 3). If the site was within the predicted species range, we then predicted potential pre-project species presence at a site if any pixel within the site satisfied the WHRM criteria for land cover type and all pertinent auxiliary variables. We predicted potential post-project species presence at a site using the same approach, after converting the original site to the appropriate areas of wetland and grassland cover type. Species richness for each time period was obtained by counting the number of species predicted to be present.

Table1. List of Iowa DNR Species of Greatest Conservation Need used in landscape position comparison of species richness and habitat value.

AMPHIBIANS	
Northern Cricket Frog	*Acris crepitans blanchardi*
Smallmouth Salamander	*Ambystoma texanum texanum*
Mudpuppy	*Necturus maculosus*
BIRDS	
Henslow's Sparrow	*Ammodramus henslowii*
Grasshopper Sparrow	*Ammodramus savannarum*
Northern Pintail	*Anas acuta*
Short-Eared Owl	*Asio flammeus*
Long-Eared Owl	*Asio otus*
Redhead	*Aythya americana*
Canvasback	*Aythya valisineria*
Upland Sandpiper	*Bartramia longicauda*
Ruffed Grouse	*Bonasa umbellus*
American Bittern	*Botaurus lentiginosus*
Broad-Winged Hawk	*Buteo platypterus*
Swainson's Hawk	*Buteo swainsoni*
Whip-Poor-Will	*Caprimulgus vociferus*
Veery	*Catharus fuscescens*
Black Tern	*Chlidonias niger*
Lark Sparrow	*Chondestes grammacus*
Common Nighthawk	*Chordeiles minor*
Northern Harrier	*Circus cyaneus*
Sedge Wren	*Cistothorus platensis*
Yellow-Billed Cuckoo	*Coccyzus americanus*
Black-Billed Cuckoo	*Coccyzus erythropthalmus*
Northern Bobwhite	*Colinus virginianus*
Cerulean Warbler	*Dendroica cerulea*
Bobolink	*Dolichonyx oryzivorus*
Willow Flycatcher	*Empidonax traillii*
Acadian Flycatcher	*Empidonax virescens*
Common Moorhen	*Gallinula chloropus*
Sandhill Crane	*Grus Canadensis*
Bald Eagle	*Haliaeetus leucocephalus*
Wood Thrush	*Hylocichla mustelina*
Yellow-Breasted Chat	*Icteria virens*
Least Bittern	*Ixobrychus exilis*
Loggerhead Shrike	*Lanius ludovicianus*
Red-Headed Woodpecker	*Melanerpes erythrocephalus*
Northern Mockingbird	*Mimus polyglottos*
Black-Crowned Night-Heron	*Nycticorax nycticorax*
Kentucky Warbler	*Oporornis formosus*

Wilson's Phalarope	*Phalaropus tricolor*

Table 1 (cont).

Eastern Towhee	*Pipilo erythrophthalmus*
Prothonotary Warbler	*Protonotaria citrea*
King Rail	*Rallus elegans*
American Woodcock	*Scolopax minor*
Louisiana Waterthrush	*Seiurus motacilla*
Dickcissel	*Spiza Americana*
Field Sparrow	*Spizella pusilla*
Forster's Tern	*Sterna forsteri*
Eastern Meadowlark	*Sturnella magna*
Barn Owl	*Tyto alba*
Blue-Winged Warbler	*Vermivora pinus*
Bell's Vireo	*Vireo bellii*
White-Eyed Vireo	*Vireo griseus*
Hooded Warbler	*Wilsonia citrina*
MAMMALS	
Elliot's Short-Tailed Shrew	*Blarina hylophaga, Elliot*
Flying Squirrel	*Glaucomys volans, (Linnaeus)*
White-Tailed Jackrabbit	*Lepus townsendii, Bachman*
River Otter	*Lutra canadensis, (Schreber)*
Bobcat	*Lynx rufus*
Prairie Vole	*Microtus ochrogaster, (Wagner)*
Woodland Vole	*Microtus pinetorum*
Northern Myotis	*Myotis septentrionalis*
Indiana Bat	*Myotis sodalis*
Evening Bat	*Nycticeius humeralis*
Hayden's Shrew	*Sorex haydeni, Baird*
Franklin's Ground Squirrel	*Spermophilus franklinii, (Sabine)*
Spotted Skunk	*Spilogale putorius, (Linnaeus)*
Southern Bog Lemming	*Synaptomys cooperi, Baird*
Red Squirrel	*Tamiasciurus hudsonicus*
REPTILES	
Western Worm Snake	*Carphophis amoenus vermis*
Wood Turtle	*Clemmys insculpta*
Timber Rattlesnake	*Crotalus horridus*
Blanding's Turtle	*Emydoidea blandingii*
Northern Prairie Skink	*Eumeces septentrionalis septentrionalis*
Speckled Kingsnake	*Lampropeltis getula holbrooki*
Smooth Green Snake	*Opheodrys vernalis*
Bull Snake	*Pituophis melanoleucus sayi*
Smooth Earth Snake	*Virginia valeriae elegans*

Table 2. List of auxiliary variables in Wildlife Habitat Relationship Models developed by the Iowa Gap Analysis Project to predict species presence.

Auxiliary Variable	Description
Lake Buffer	Lakes buffered 120 meters
Stream Order Buffer	Buffer width based on stream order
Wetlands Buffer	Herbaceous and shrubland wetlands buffered 120 meters
All Wetlands Buffer	All wetlands buffered 120 meters
All Water Buffer	Merge of lake buffer and water buffer to get all open water
Forest/Crop Ecotone	Intersection of forest and crop classes, each buffered 90 meters
Forest/Grass Ecotone	Intersection of forest and grass classes, each buffered 90 meters
Crop/Grass Ecotone	Intersection of crop and grass classes, each buffered 90 meters
Grass Core Area	Grass classes shrunk to 60 meters
Forest Core Area	Forest classes shrunk to 60 meters

Table 3. Original land cover classes used by Iowa Gap Analysis Project and simplified land cover classes based on a 2002 land cover analysis completed by the Iowa DNR.

Old Code	Original GAP Analysis Class	New Code	New Class
110	Open Water	1	Wetland
71	Temporarily Flooded Wetland	1	Wetland
72	Seasonally Flooded Wetland	1	Wetland
73	Semi-permanently Flooded Wetland	1	Wetland
74	Saturated Wetland	1	Wetland
75	Permanently Flooded Wetland	1	Wetland
12	Eastern Red Cedar Forest	2	Woodland
17	Pine Forest	2	Woodland
18	Evergreen Forest	2	Woodland
19	Upland Deciduous Forest	2	Woodland
20	Temporarily Flooded Forested Wetland	2	Woodland
24	Seasonally Flooded Forested Wetland	2	Woodland
30	Mixed Evergreen/ Deciduous Forest	2	Woodland
41	Eastern Red Cedar Woodland	2	Woodland
42	Upland Deciduous Woodland	2	Woodland
44	Mixed Evergreen/ Deciduous Woodland	2	Woodland
51	Upland Shrub	2	Woodland
52	Temporarily Flooded Shrub	2	Woodland
53	Seasonally Flooded Shrub	2	Woodland
54	Semi-permanently Flooded Shrub	2	Woodland
55	Saturated Shrub	2	Woodland
61	Warm Season Grass/	3	Grassland

	Perennial Forb		
66	Cool Season Grass	3	Grassland
67	Grassland With Sparse Shrubs and Trees	3	Grassland
90	Cropland	5	Cropland
101	Artificial/High Vegetation	6	Developed
102	Artificial/Low Vegetation	6	Developed
80	Sparsely Vegetated/Barren	7	Barren
82	Barren/Mixed Vegetation	7	Barren
9999	No Data	8	Missing Data

Habitat Value

We used the WHRM models to tabulate, for each species, the predicted number of 15 m^2 pixels within the site boundary that was classified as useable habitat. We then tabulated an index of the cumulative species habitat value (CSHV) for each site and taxonomic group by summing the number of useable habitat pixels over all species within the taxon and converting this number to hectares.

Grassland Bird Density

We calculated predicted pre- and post-project grassland bird densities of bobolinks (*Dolichonyx oryxiivorous*), grasshopper sparrows (*Ammoddramus savannarum*), sedge wrens (*Cistothorus platensis*), and savanna sparrows (*Passerculus sandwichensis*) for each of the 4 position types (TZ, BP, USFP, and DSFP) in each of the 24 watersheds using the Quamen (2007) models (Table 4). Dickcissels (*Spiza townsendi*) were not included in the final analysis because the only independent variable in their model was the amount of hayland in the landscape, and not grassland or wetland that is affected by CREP.

Table 4. Models used to estimate density (birds/ha) of 4 species of grassland birds for the Des Moines Lobe region of Iowa.

Species	Model*
BOBO	density = e (-0.8696546 + 0.0180943 * grass400)
GRSP	density = e (-2.554612 + 0.0246975 * grass400 – 0.1032461 * trees400)
SEWR	density = 1-1/1+e (-0.8015652 + 0.08500569 * grass400) *e (-0.7982511 + 0.0285891 * bbspath + 0.0105094 * grass400)
SASP	density = e (-1.581362 + 0.0229603 *bbspath + 0.01024* grass3200 + 0.0255867 * hay3200)

* Variable definitions: grass400 = percentage of the 400-m radius surrounding landscape that is in grass; trees400 = percentage of the 400-m radius surrounding landscape that is in trees; hay400 = the percentage of the 400-m radius surrounding landscape that is in hay; grass3200 = percentage of the 3200-m radius surrounding landscape that is in grass; hay3200 = the percentage of the 3200-m radius surrounding landscape that is in hay; and bbspath = species specific relative abundances as determined from 1992-2003 BBS data.

Waterfowl Breeding

Because waterfowl are obligate wetland species, we assumed that all sites in all position types did not contain pre-project breeding pairs or recruits. We used ANOVA to test for differences among the 4 landscape positions (TZ, BP, USFP, and DSFP) in the estimated number of mallard (*Anas platyrhynchos*) and blue-winged teal (*Anas discors*) breeding pairs and recruits (Cowardin and Johnson 1979, Cowardin et al. 1995). Analysis was not conducted for gadwall (*Anas strepera*), northern pintail (*Anas acuta*), and northern shoveler (*Anas clypeata*) because estimated recruitment for these species in Iowa was very small. A post-hoc test (Bonferonni's Test) was used to make pair-wise comparisons if there was a significant F-statistic. All statistical tests were considered significant when $P < 0.05$.

Results

Site Attributes

Average wetland pool size of TZ and BP sites was very similar ($\bar{X}$=3.3 ha; Fig. 2a) and significantly less (Kruskal-Wallis ANOVA; $P < 0.05$) than the average size of USFP and DSFP sites ($\bar{X}$= 10.9 ha). Similarly, average size of grassland buffer in TZ and BP sites was very similar ($\bar{X}$=15.6 ha; Fig. 2b) and significantly less (Kruskal-Wallis ANOVA; $P < 0.05$) than the average buffer size of USFP and DSFP sites ($\bar{X}$= 48.6 ha).

Species Richness

Average species richness increased significantly ($P < 0.001$) as landscape position moved lower in the drainage area (Fig. 3), ranging from $\bar{X}$ = 12 in TZ sites to $\bar{X}$ = 41 in DSFP sites. All pairwise comparisons between position types were significant except BP vs.USFP. There was a significant ($P < 0.001$) difference among position types in the magnitude and direction of the change in pre- and post-project richness. The trend in these changes was again directly related to the position of the site in the drainage elevation gradient. Average richness moderately increased in TZ ($\bar{X}$ = 5.6) and BP ($\bar{X}$ = 2.1) sites, was unchanged in USFP sites, and decreased substantially in DSFP sites ($\bar{X}$ = -7.8).

Habitat Value

Average differences in CHSV among position types and between pre- and post-construction times were significant ($P < 0.001$) for all taxonomic groups. CSHV increased significantly for all taxonomic groups as the landscape position moved lower in the drainage area (Fig.4 a-4e). For all taxonomic groups except mammals, there were also significant differences among position types in the net change in CHSV between pre- and post-construction. Bird and reptile habitat increased significantly ($P < 0.001$) only in USFP and DSFP sites (Fig. 4a,4d). There were no significant net changes in mammal habitat in any position type (Fig. 4b). A significant increase ($P < 0.001$) in amphibian habitat occurred only in DSFP sites (Fig. 4c). For all species combined, there were significant ($P < 0.001$) average increases in habitat in USFP and DSFP sites, no significant increase in BP sites, and a marginally significant ($P = 0.070$) increase in TZ sites (Fig. 4e). The total increase in habitat value was about the same in USFP and DSFP sites, and the smallest increase was in BP sites (Fig. 5). The majority of increased habitat value was associated with bird species.

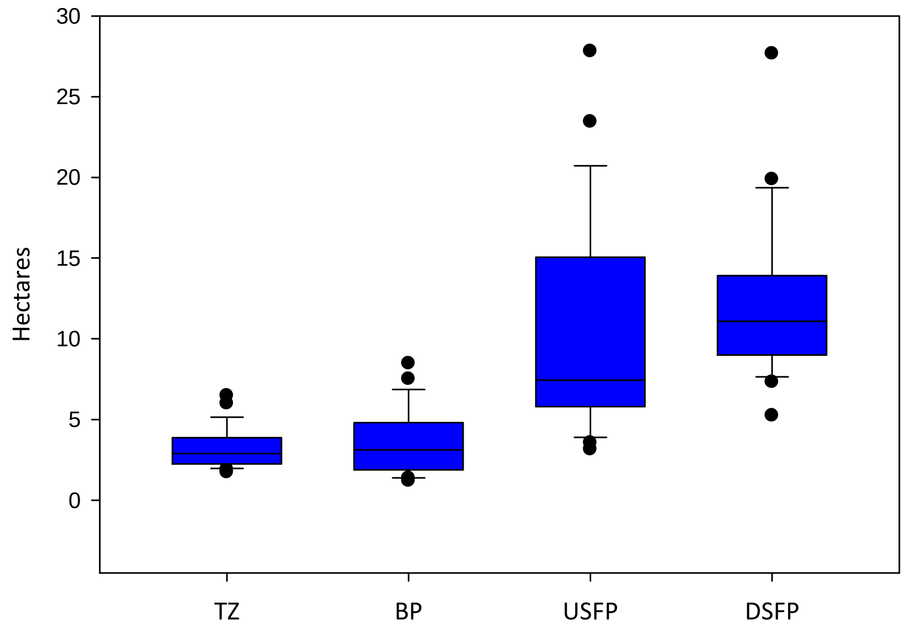

Figure 2a. Box plot of wetland site area by landscape position type.

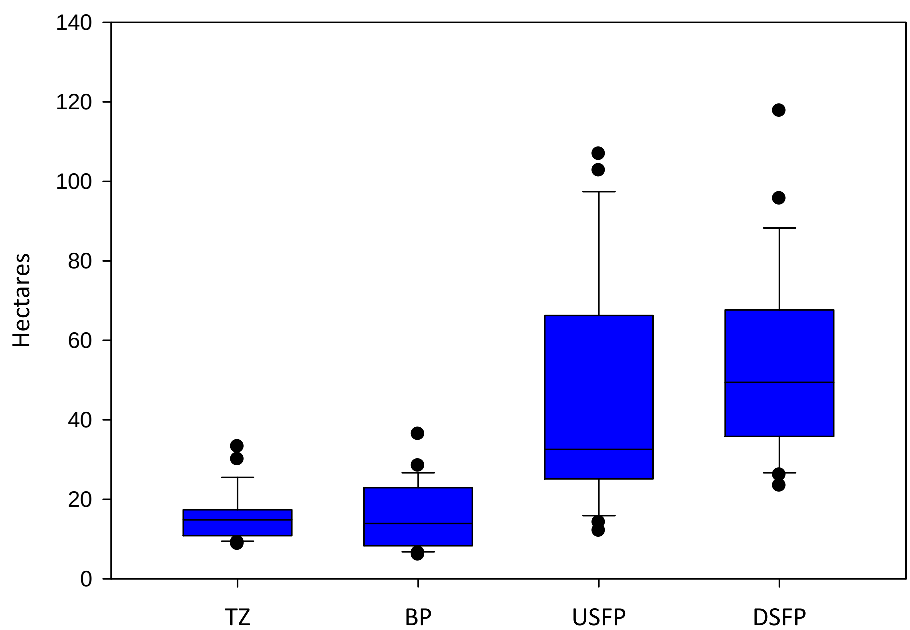

Figure 2b. Box plot of grassland buffer area by landscape position type.

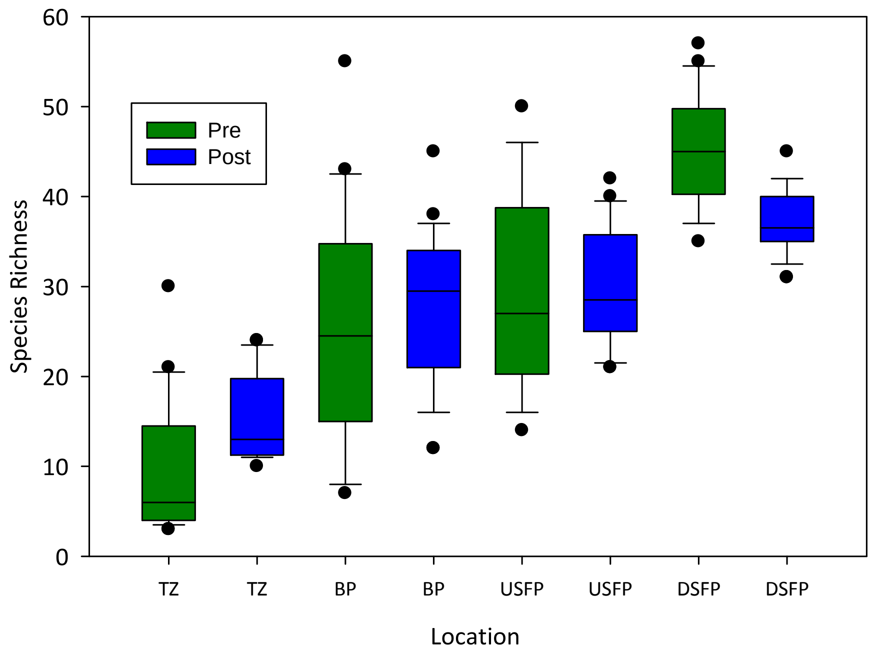

Figure 3. Box plot of species richness pre- and post-project by landscape position type.

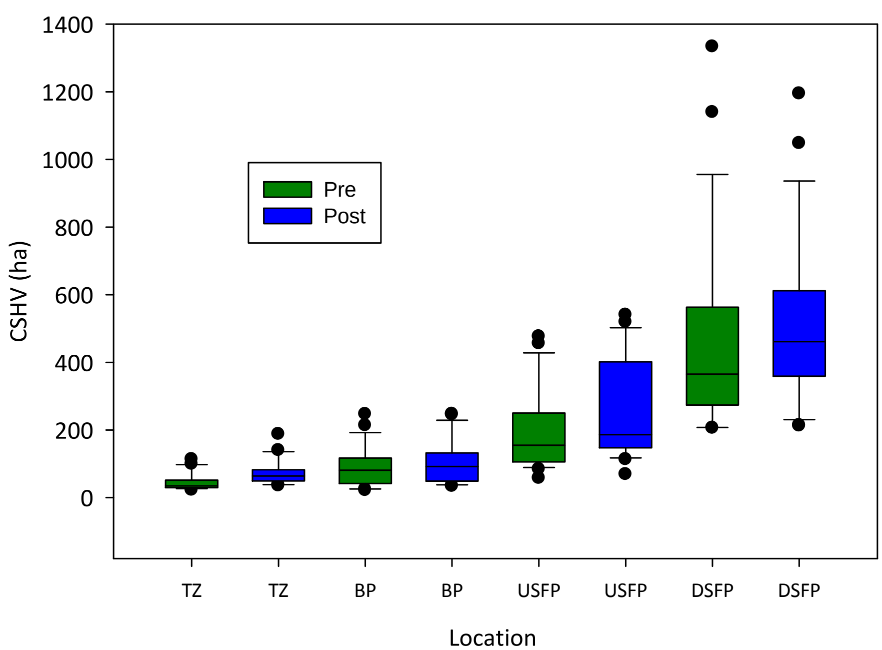

Figure 4a. Box plot of Cumulative Species Habitat Value (CSHV) for birds pre- and post-project by landscape position type.

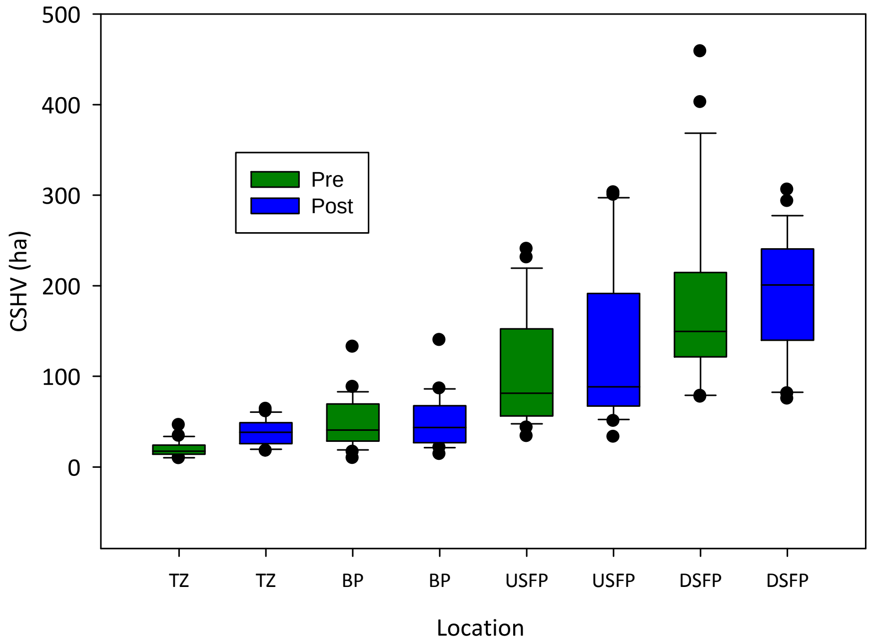

Figure 4b. Box plot of Cumulative Species Habitat Value (CSHV) for mammals pre- and post-project by landscape position type.

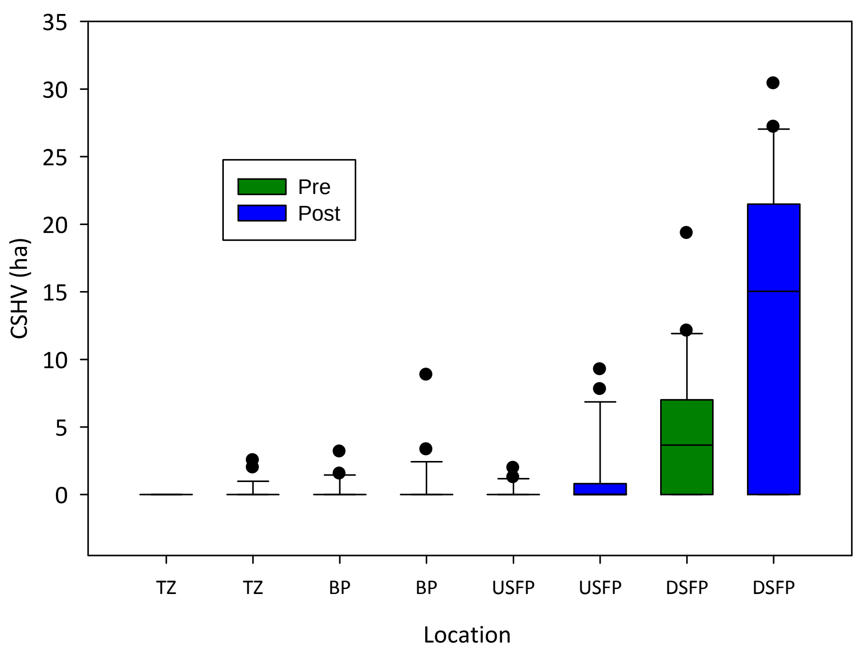

Figure 4c. Box plot of Cumulative Species Habitat Value (CSHV) for amphibians pre- and post-project by landscape position type.

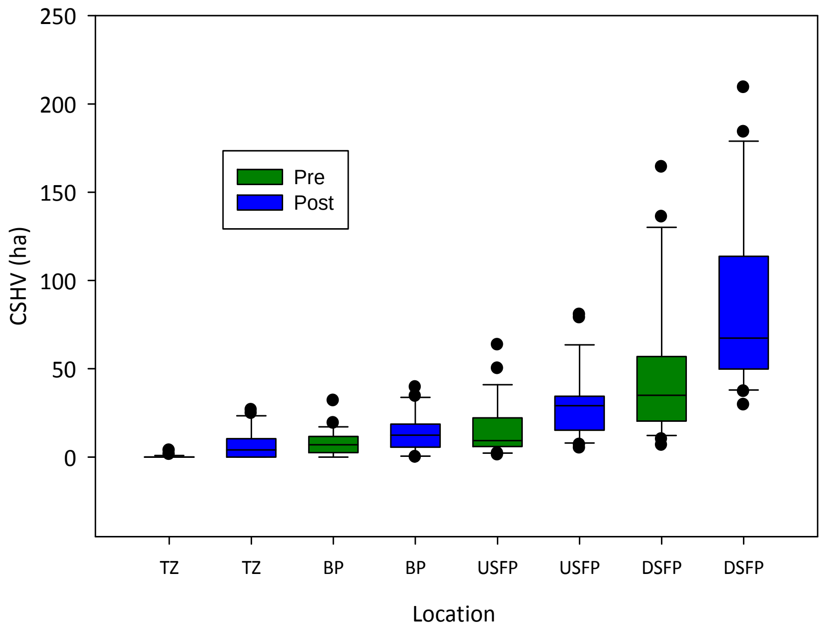

Figure 4d. Box plot of Cumulative Species Habitat Value (CSHV) for reptiles pre- and post-project by landscape position type.

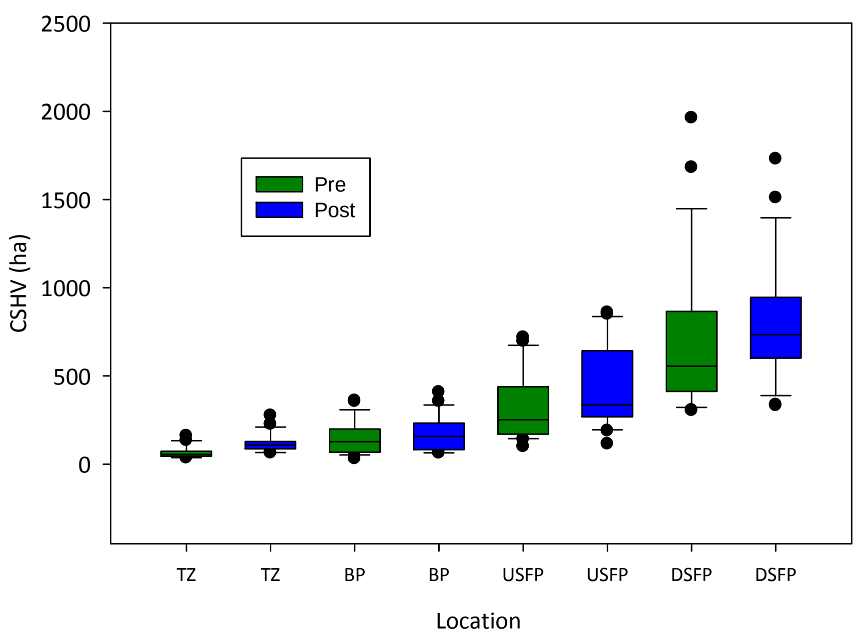

Figure 4e. Box plot of Cumulative Species Habitat Value (CSHV) for all taxonomic groups pre- and post-project by landscape position type.

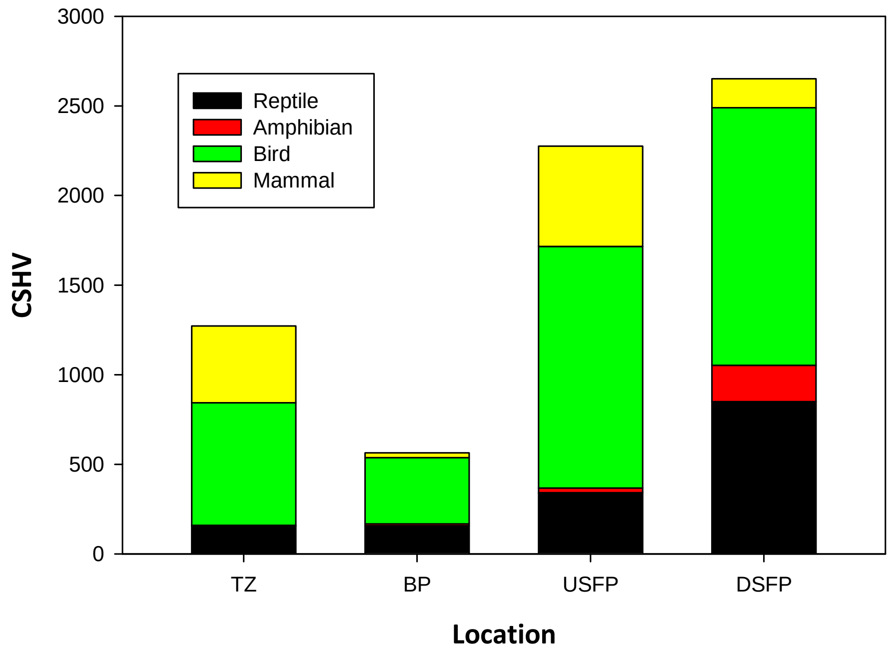

Figure 5. Net change in Cumulative Species Habitat Value (CSHV) for each taxonomic group for all position types.

Grassland Bird Density

There was a significant difference in average bobolink density among position types ($P < 0.001$), and all pairwise difference among types were significant except BP vs. USFP. Averages increased monotonically as position moved lower in the drainage (Fig. 6a). For all position types, post-project averages were greater than the corresponding pre-project average, but there were significant differences in the magnitude of the increase. The greatest increase ($\overline{X} = 0.45$) was in DSFP sites, and the smallest increase ($\overline{X} = 0.10$) was in BP sites.

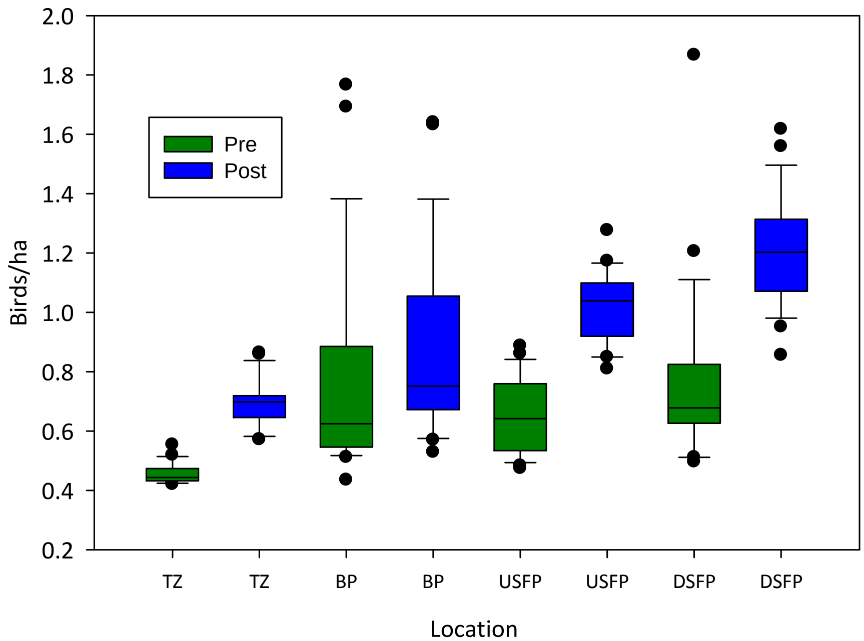

Figure 6a. Box plot of bobolink density pre- and post-project by landscape position type.

There was a significant difference in average grasshopper sparrow density among position types ($P < 0.002$), and all pairwise difference among types were significant except TZ vs. DSFP and BP vs. USFP. Averages were greatest in BP and USFP sites (Fig. 6b). For all position types, post-project means were greater than the corresponding pre-project mean, but there were significant differences ($P < 0.001$) in the magnitude of the increase. The greatest increase ($\bar{X} = 0.11$) was in USFP and DSFP sites, and the smallest increase ($\bar{X} = 0.03$) was in BP sites.

There was a significant difference in savannah sparrow density among position types ($P < 0.001$), and all pairwise difference among types were significant except BP vs. USFP. Although averages tended to increase as position moved lower in the drainage (Fig. 6c), there was no overall difference ($P = 0.283$) between pre- and post-project average density.

There was a significant difference in average sedge wren density among position types ($P < 0.001$); TZ site averages were smaller than all other positions, and BP sites were smaller than DSFP sites. Averages increased monotonically as position moved lower in the drainage (Fig. 6d). For all position types, post-project means were greater than the corresponding pre-project mean, but there were significant differences ($P < 0.001$) in the magnitude of the increase. Increase in TZ, USFP and DSFP sites was about equal ($\bar{X} = 0.30$), and the smallest increase ($\bar{X} = 0.11$) was in BP sites.

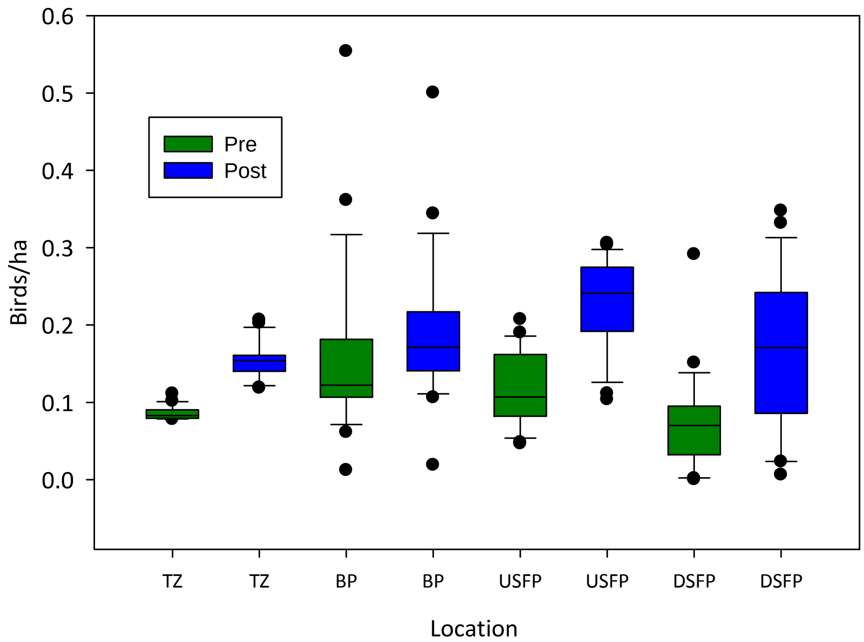

Figure 6b. Box plot of grasshopper sparrow density pre- and post-project by landscape position type.

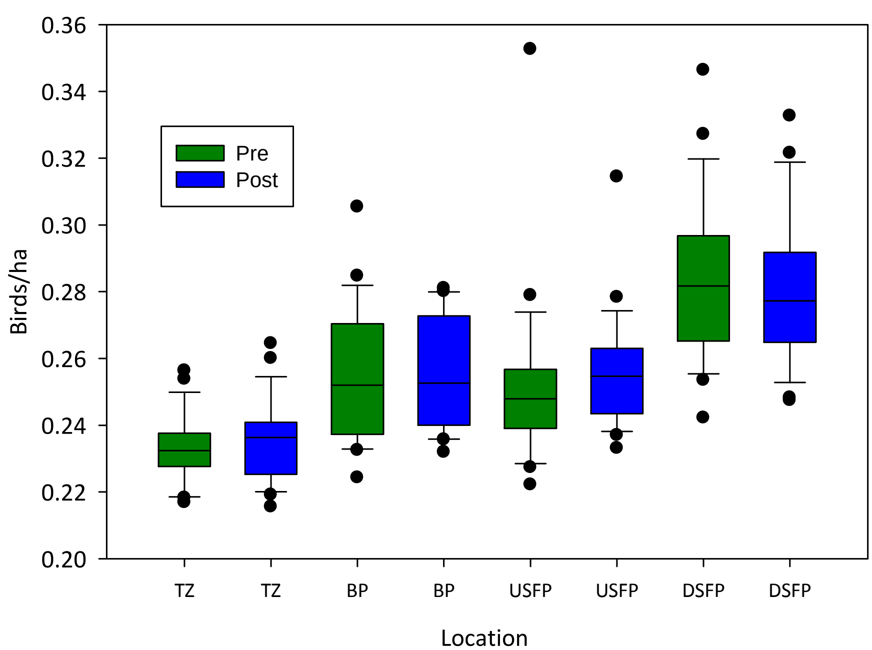

Figure 6c. Box plot of savannah sparrow density pre- and post-project by landscape position type.

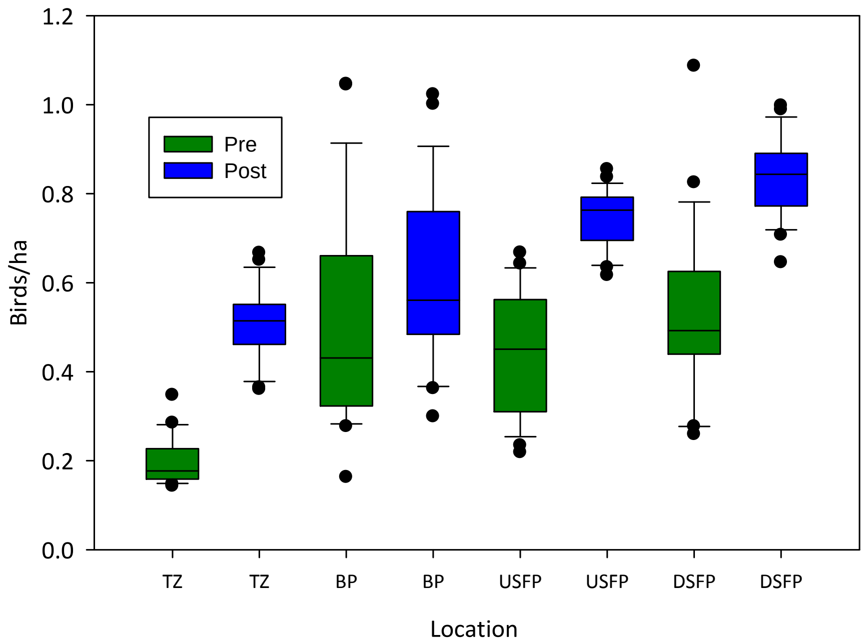

Figure 6d. Box plot of sedge wren density pre- and post-project by landscape position type.

Waterfowl
The estimated number of breeding pairs and recruits differed by landscape position for mallards (P <0.001), blue-winged teal (P <0.001), and total ducks (P <0.001; Table 5). Floodplain sites had about twice the number of breeding pairs and recruits of each species as TZ and BP sites. However, because wetland size had to increase to maintain the desired watershed: wetland size ratio as projects were moved lower in the watershed, recruits/ha was at least 50% greater on TZ and BP sites (Table 5). This phenomenon of observing higher per capita recruitment on smaller wetlands is well known for upland nesting waterfowl.

Discussion

A primary goal of the 2008 Gulf Hypoxia Plan (2008) is to achieve a 45% reduction in nitrogen loads in tile-drained regions of the Upper Midwest. One plausible scenario for moving toward this goal is scaling up of the Iowa CREP program. However, given the rapidly evolving economic influences on Midwestern agriculture, a significant expansion of the program may require more reliance on sites out of the tile-zone and breakpoint regions, i.e., sites that tend to be lower in the drainage areas and devoted to non-crop agricultural use such as pasture. Thus, comparison of the relative environmental services provided by constructed wetlands in these alternative watershed positions becomes relevant to informed decision making about the future design of the CREP program design. In particular, our study has addressed one component, wildlife habitat

Table 5. Effects of watershed position (N= 24 for each) on predicted mallard, blue-winged teal, and total upland nesting duck pair densities, recruits produced, and recruits produced per hectare (ha) of CREP wetland (different letters within a row indicate a significant difference at *P*<0.05).

Species	TZ	BP	USFP	DSFP
Mean Wet Hectares	3.2	3.5	9.9	12.0
Mallard				
Pairs	2.8a	2.9a	5.3b	6.4b
Recruits	3.2a	3.3a	6.3b	6.8b
Recruits/ha	0.17a	0.17a	0.11b	0.09c
Blue-winged Teal				
Pairs	1.0a	1.1a	1.9b	2.2b
Recruits	1.3a	1.3a	2.3b	2.6b
Recruits/ha	0.07a	0.07a	0.04b	0.04b
Total Ducks				
Pairs	4.6a	4.8a	8.8b	10.4b
Recruits	4.7a	4.8a	8.9b	9.8b
Recruits/ha	0.25a	0.25a	0.17b	0.13b

value, within the collection of environmental services provided by CREP projects. With few exceptions, our results suggest that although habitat value is increased by construction of a CREP project at any of the landscape position sites we considered, the net gains in value consistently increase as site location moves from the more intensively tile zoned region at the top of the drainage area into floodplains lower in the drainage. This result is generally due to the concomitant increase in the physical area of the wetland and associated grassland buffer, and the increase in diversity and complexity of the habitat in the surrounding landscape.

However, we encourage the reader to use caution in making inferences about the predicted changes of any one species or taxonomic group, or in extrapolating our results to larger regional scales. We note that the national GAP analysis program and its associated models were focused only on prediction of species richness at landscape scales. Accuracy assessment of wildlife habitat models, i.e., comparison of model predictions with actual field surveys, such as those developed in the Iowa GAP analysis is notoriously difficult, and is relatively rare, especially at small scales (Boone and Krohn 1999). Thus, we have admittedly employed these models in an application for which they were not designed. Our derived CHSV metric is subject to similar criticism.

Similarly, our estimates of waterfowl breeding success should be interpreted cautiously. Models used to generate these estimates were developed from data on natural semipermanent and permanent wetlands which routinely have a watershed:wetland area ratio of less than a 20:1. Thus, it is unreasonable to assume that created CREP wetlands with mean watershed:wetland ratios of 50:1 to 200:1 will function as natural wetlands, and although CREP wetland flora and fauna were not assessed as part of this study, our estimates of changes in bird populations are probably inflated. Additionally, further consideration of finer-scale biological processes that are not captured by large-scale models also suggests the potential for misleading inferences. For example, because ducks may nest in excess of 3.2 km from wetlands, proximity of other habitat, while desirable, is not as essential. Because natural wetlands in TZ areas are shallow, they tend to warm up faster providing invertebrate food to female birds that require lipids and proteins for egg production. Because they are small, they provide breeding pairs with isolation from conspecifics. In many cases, these same benefits accrue even from farmed or partially drained wetlands as long as they hold water. In fact, a general rule of thumb is that the density of ponded, small shallow wetlands determines the annual population of ducks that breed locally, and that breeding waterfowl abundance may be maximized, while removing the least amount of land from agriculture, by restoring small, shallow wetlands.

Our estimates of increasing density of grassland birds in the lower reaches of watersheds (USFP and DSFP) are attributable to landscape context, i.e., some streams have remnant grasslands or other habitats within the floodplain or as part of the actual channel, while wildlife habitat in CREP projects in the upper reaches of watersheds (TZ and BP sites) was almost always minimal. Another primary factor that limits the success of wetlands and/or grasslands protected or restored as wildlife habitat is isolation. Juxtaposition of CREP wetlands with existing suitable habitat will generally increase the predicted value of restored wildlife habitat. However, previous studies have demonstrated a negative relationship between trees and grassland bird density (Grant et al. 1994, Bakker et al. 2002), and thus the potential value of floodplain sites as grassland bird habitat may be mediated by the increased presence of woodlands in lower reaches of the watershed.

Managers should also consider fine-scale species habitat requirements when determining the best placement of future CREP sites. For example, the savanna sparrow model predicted that the highest density would occur at DSFP sites, based strictly on landscape scale variables in the model. However, because of increased moisture at DSFP sites, grassland habitat would probably be tall and dense. Previous research from Iowa reported that this species selected sites with shorter, sparser vegetation (Fletcher and Koford 2002), but bobolinks and sedge wrens both preferred tall, dense vegetation and, therefore, would likely benefit from CREP sites placed in lower landscape positions. As another consideration, managers should evaluate the frequency of flooding in lower topographic positions (i.e. DSFP and USFP sites) before deciding on future CREP project placement. If CREP projects are placed in locations with frequent spring flooding, they may not be available for ground-nesting waterfowl or grassland birds.

Despite the several cautions articulated above, we believe our study has value when considered as an initial course filter assessment of the potential tradeoffs in wildlife value as a function of landscape position within drainage areas in the Iowa CREP program. We have adapted available pre-existing models for making predictions about a large and diverse suite of wildlife species within a large region that has not historically been intensively studied with respect to wildlife – habitat relationships. If future design of the Iowa CREP program is deemed of sufficient priority, we suggest that the next logical step in providing policy makers with useful information will involved field studies that evaluate specific hypotheses about wildlife responses to wetland construction in this region. Our results should be informative and relevant to the design and objectives of such efforts.

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Progress Report IV
Prepared for the USDA Farm Services Agency

March 31, 2010

Assessment of Environmental Services of CREP Wetlands in Iowa and the Midwestern Corn Belt

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Introduction

For this project we extended the empirical wetland performance model developed for a set of 27 Iowa CREP wetlands (FSA Progress Report I, 2008) to assess the potential of restored wetlands to reduce nitrate loadings from tile-drained agricultural watersheds throughout the Midwestern Corn Belt region of North America. The implementation of this model to the larger region required the estimating potential hydrologic and nitrate loadings throughout the study region. The project required:
1) Developing a regression model to predict flow-weighted average (FWA) nitrate concentrations as a function of the land use and drainage characteristics of contributing areas,
2) Developing basin-wide estimates of annual water yield and estimating annual nitrate loadings for the 26-year period encompassing 1980 through 2005, and
3) Estimating the annual nitrate reduction that could be achieved using targeted wetland restorations throughout the Upper Mississippi and Ohio River basins

Methods

Estimating Nitrate Loadings

Extending the general Iowa CREP wetland performance model to the UMR and Ohio River basins required estimating hydrologic and nitrate loads for potential wetland sites throughout the region. Hydrologic and nitrate loads vary considerably both spatially within the basins and from year to year for a particular location. Analyses of regional hydrological and mass loadings must take into account the inherent variability in environmental conditions expected to occur over the entire region. For the current analysis, we used water yield (derived from selected USGS gauging stations) and FWA nitrate concentrations (estimated from land use and soils data) to account for variability in hydrologic and nitrate loads (as in Crumpton et al. 2006). We extended the regression developed by Crumpton et al. (2006) to estimate FWA nitrate concentrations as a function of both the relative extent of agricultural lands and the estimated extent of tile drainage.

We estimated annual hydrologic and nitrate loads for the period 1980 to 1993 for 48 stream sampling stations in the UMR and Ohio River basins from measured nitrate concentrations and measured daily discharge. Data were obtained from the USGS National Stream Quality Accounting Network (NASQAN) and the USGS National Water Information System (NWIS). Nitrate loads were determined from NASQAN data and subsequently divided by discharge at each station to obtain flow-weighted average (FWA) nitrate concentrations (Refer to Crumpton et al. 2006 for additional information).

A percent row crop grid was derived for the UMR and Ohio River basins based on a land use and land cover grid developed from 1992 LANDSAT Thematic Mapper data. A tile drainage grid was derived based on the land use and land cover grids and on soils grids obtained from the Natural Resources Conservation Service (NRCS) Soil Survey Geographical Database (SSURGO). Grid cells classified as row crop and having a soil drainage classification of somewhat poor or wetter were assumed to be tile drained. For each of the NASQAN stations, the row crop and tile drained land grids were used to estimate the percent of row cropped and tile drained land within the contributing area for each of the NASQAN stations. Per cent row crop, per cent tile drainage, and FWA nitrate concentrations for the 48 sites were used to derive a relationship between FWA nitrate concentration, land use, and extent of tile-drainage (Figure 1; $R^2 = 0.93$).

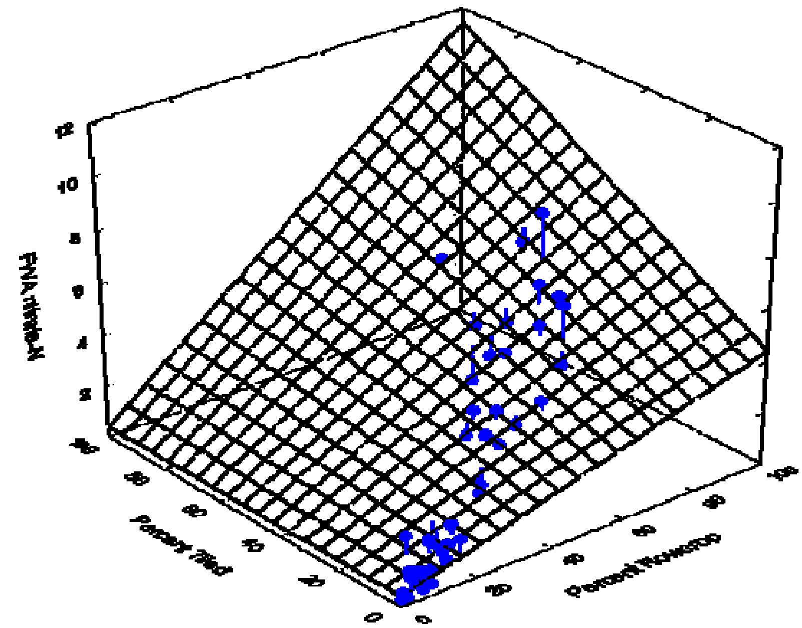

Figure 1. Relationship between percent tile-drained lands, percent row-cropped lands, and flow-weighted average nitrate concentrations. Extended from Crumpton et al. (2006).

We used the relationship in Figure 1 to develop a grid of long term FWA nitrate concentration for UMR and Ohio River basins based on the percent row crop and tile drainage grids. Spatial patterns in mapped results are similar to FWA nitrate concentrations estimated from the U.S. Environmental Protection Agency STORET and individual state databases (Figure 2: refer to Crumpton et al. 2006 for additional information).

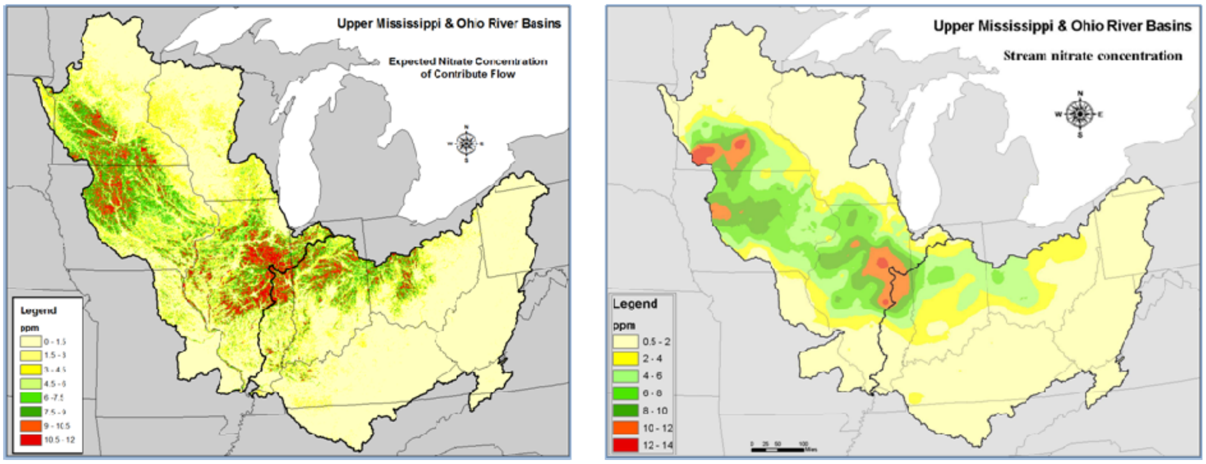

Figure 2. FWA nitrate concentrations predicted based on land use and tile drainage (left panel), and FWA nitrate concentrations estimated using USEPA & state STORET data (right panel).

We estimated annual nitrate load each year from 1980 through 2005 using a 100 ha grid covering the UMR and Ohio River basins. Nitrate yield for each grid cell was calculated as the product of nitrate concentration (Figure 2; left panel), water yield and grid cell area. The annual water yield for each grid cell was estimated by interpolation of annual water yields from USGS stream monitoring stations with less than 1000 mi^2 watersheds selected to encompass the UMR and Ohio River basins (Crumpton et al 2006). Discharge and nitrate loading were estimated through summation over the grid areas of the analysis space.

Estimating Potential Nitrate Removal by Wetlands in the UMR and Ohio River Basins

Estimates of nitrate mass removal that could be achieved using wetland restorations were derived for the same grid used for water and nitrate yield estimates for each year over the period 1980 through 2005. As shown in Figure 3, wetland performance is strongly dependent upon hydraulic loading rate, which is a function of water yield and the wetland:watershed area ratio. We assessed the potential nitrate reductions that could be achieved by wetlands at three different wetland:watershed area ratios, specifically for wetlands occupying 1%, 2%, and 3% of their upland contributing area. These percentages were chosen in part based upon results from Iowa CREP monitoring. For each year and for each wetland:watershed area ratio, we estimated the potential mass reduction of nitrate on the basis of the expected annual nitrate loads and water yields obtained from the previously mentioned analyses, and the percent removal expected based on the generalized performance model relating percent nitrate removal and hydraulic loading rate (Figure 3). This allows comparison of the potential nitrate mass reduction for each year for each wetland:watershed area ratio including how the cumulative area of wetlands restored would affect cumulative mass removal.

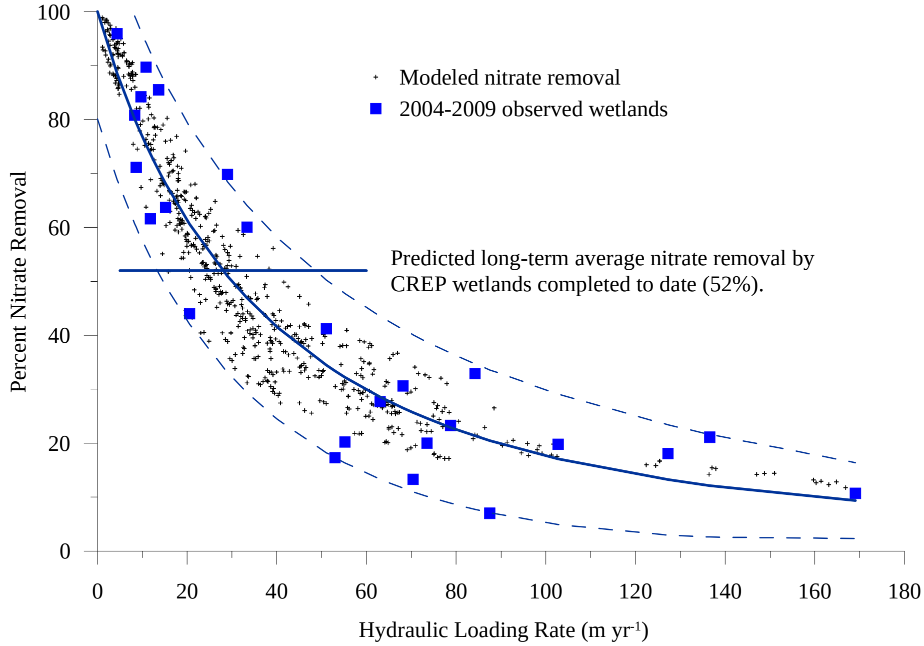

Figure 3. Modeled nitrate removal efficiency of CREP wetlands based on 1980 to 2006 model input conditions and measured nitrate removal efficiency based on wetland monitoring from 2004-2009.

Results

The pattern of average nitrate yield across the UMR and Ohio River basins for 1980-2005 is shown in Figure 4 in kg nitrate-N km^{-2} of watershed $year^{-1}$. As could be expected, mass loads are highest in those areas with extensive row-crop and tile drainage. The majority of the combined nitrate load from the UMR and Ohio River basins can be attributed to the intensively row cropped and tile drained lands of the Corn Belt.

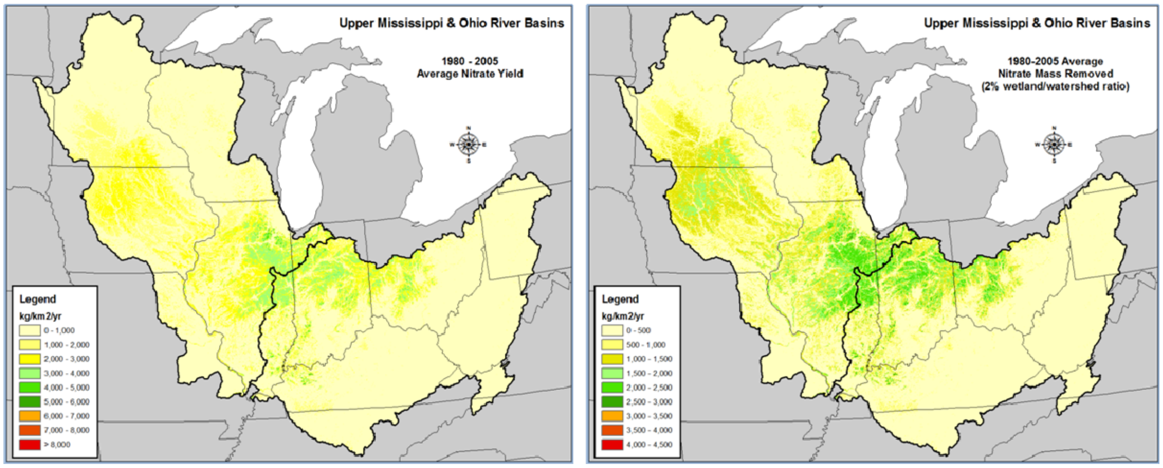

Figure 4. Left Panel: Average nitrate loadings for the period 1980 through 2005. Right Panel: Average nitrate removal for the period 1980 through 2005 for the 2% wetland:watershed area ratio.

The pattern in long term average nitrate mass removal by wetlands is shown in Figure 4 in kg nitrate-N ha^{-1} of wetland $year^{-1}$ for a wetland:watershed area ratio of 2%. The spatial pattern in mass removal was similar for all restoration scenarios. However, nitrate mass removal in kg nitrate-N km^{-2} <u>of watershed</u> $year^{-1}$ are highest for the 3% wetland:watershed area ratio and lowest for the 1% ratio. The 3% scenario of course has three times more wetland area than the 1% scenario. In contrast, nitrate mass removal rates in kg nitrate-N ha^{-1} <u>of wetland</u> $year^{-1}$ are highest for the 1% wetland:watershed area ratios and lowest for the 3% ratio. Percent mass removal is inversely related to wetland:watershed area ratios (for the same watershed area, hydraulic loading rate is lower and percent mass removal higher at a 3% wetland to watershed ratio than at a 1% wetland:watershed area ratio). However, the relationship is not linear and while wetlands with a 1% wetland:watershed area ratio remove a lower percent of the load received than at 3% ratio, they remove a greater mass per wetland area. Restoration strategies will need to balance percent reduction goals and mass load reduction goals.

Cumulative nitrate reduction is shown in Figure 5 as a function of total wetland area restored for 1%, 2% and 3% wetland:watershed area ratios. In this figure, the results are arrayed to sum removal across grids summing from grids with the highest removal rates to those with the lowest removal rates for each scenario. The horizontal line represents a 30% reduction of cumulative nitrate loads. The vertical lines represent the wetland area that would need to be restored to achieve a 30% reduction in nitrate loads for wetland:watershed area ratios of 1%, 2% and 3%. Results indicate that a 30% reduction in the total nitrate load exported from the UMR and Ohio River basins could be achieved with approximately 2270 km^2, 2680 km^2 or 3350 km^2 of wetland area restored at wetland:watershed area ratios of 1%, 2% or 3% respectively (Figure 5).

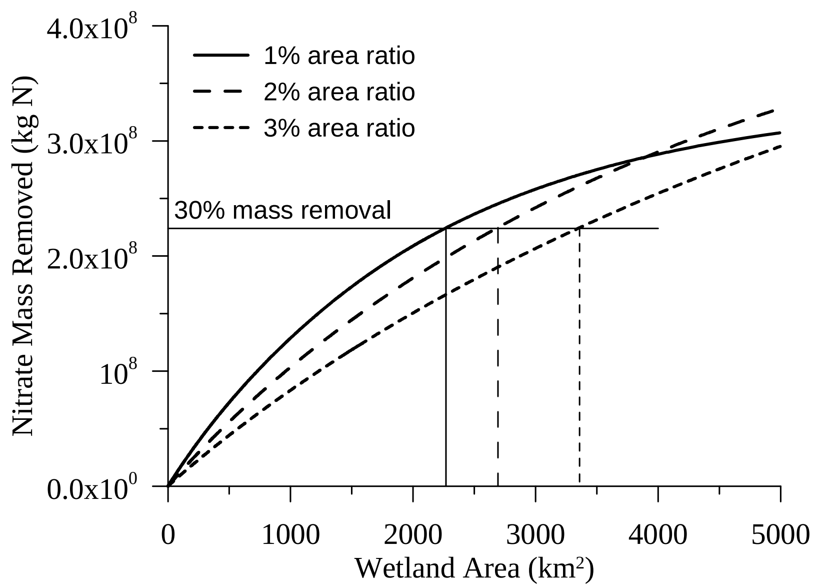

Figure 5. Cumulative nitrate reduction as a function of wetland area restored for targeted wetland restorations with wetland:watershed area ratios of 1%, 2%, or 3%. The horizontal line represents 30% of the average mass load from the UMR and Ohio River basins. The vertical lines indicate the watershed area treated to achieve a 30% in nitrate load from the basins for each scenario.

Cumulative nitrate reduction is shown in Figure 6 as a function of total watershed area treated for the 1%, 2% and 3% wetland:watershed area ratios. As in Figure 5, results are arrayed to sum removal across grids summing from grids with the highest removal rates to those with the lowest removal rates for each scenario. The horizontal line again represents a 30% reduction of cumulative nitrate loads. The vertical lines represent the watershed areas that would need to be treated to achieve a 30% reduction in nitrate loads for wetland:watershed area ratios of 1%, 2% and 3%. Results indicate that a 30% reduction in the total nitrate load exported from the UMR and Ohio River basins could be achieved by treating approximately 227,000 km^2, 134,000 km^2, or 112,000 km^2 of watershed area for wetland:watershed area ratios of 1%, 2% or 3% respectively (Figure 6).

Our results assume that wetlands could be located so as to intercept water from the highest nitrate load contributing areas. If wetlands are instead restored in areas with lower nitrate concentrations and loads, then the wetlands would be expected to remove less nitrate than estimated here.

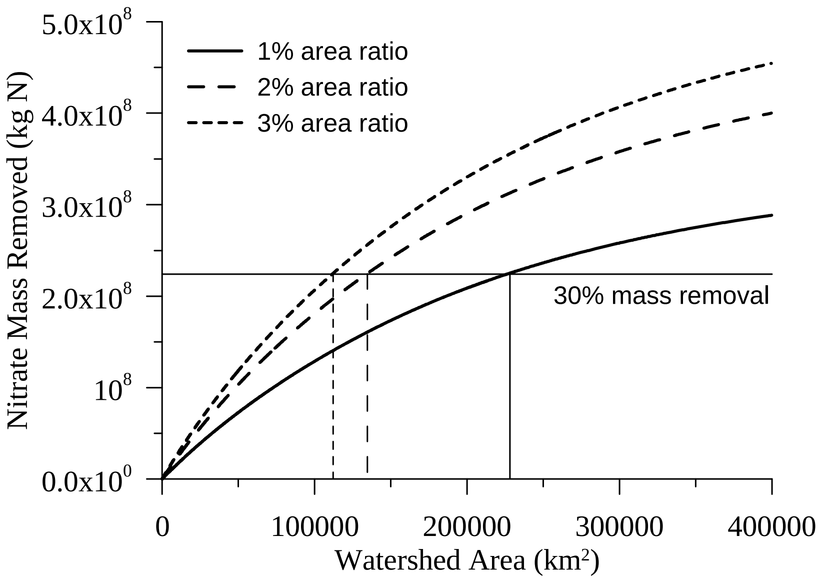

Figure 6. Cumulative nitrate reduction as a function of watershed treated at 1%, 2% and 3% wetland:watershed area ratios. The horizontal line represents 30% of the average mass load from the UMR and Ohio River basins. The vertical lines indicate the watershed area treated to achieve a 30% in nitrate load from the basins for each scenario.

Literature Cited

Crumpton, W.G., G.A. Stenback, B.A. Miller, and M.J. Helmers. 2006. Potential Benefits of Wetland Filters for Tile Drainage Systems: Impact on Nitrate Loads to Mississippi River Sub-basins. Project Report to the U.S. Department of Agriculture, Project Number IOW06682