The Prairie Naturalist 44:79–97; 2012

AVIAN DIVERSITY AND HABITAT USE ON WETLAND RESERVE PROGRAM LANDS IN THE LOWER MISSOURI RIVER VALLEY

ERIC C. HOPPS[1]

657 South 29 Road, Syracuse, NE, 68446 USA

ABSTRACT A primary objective of the Wetland Reserve Program (WRP) is to provide habitat for migratory birds throughout all seasons of the year. Comprehensive avian assessments are lacking and limit our ability to evaluate the benefits of the WRP to continental bird populations. I investigated avian species occurrence on WRP lands within the Lower Missouri River Valley (LMRV), Nebraska, USA, from March 2010 to February 2011. Ten WRP habitat types are described based on plant community assemblages and observed hydrological regimes. Estimates of avian species richness were greatest in lowland forest (n = 115), lowland woodland (n = 83) and upland forest (n = 77) habitats. Taxonomic measures of avian diversity differed between habitat types but was similar in respect to season. Ecological habitat types ranked according to avian preference revealed forest and wetland communities to be significantly utilized across the entire species assemblage as compared to grassland habitats. Ordination displayed similarity within grouped ecological habitat types and was supportive of a high dimensional community structure. Approximately one-half of all species documented met breeding level criteria, with 64 species confirmed as breeding. Taxonomic structure of breeding birds did not differ from the total WRP avian assemblage. I conclude that the regional and historical species pool within the LMRV remains largely intact and that WRP restorations exhibit the full complement of avian assemblage.

KEY WORDS avian diversity, habitat use, Lower Missouri River Valley, species richness, taxonomic distinctness, Wetland Reserve Program, WRP

The Wetland Reserve Program (WRP) represents a substantial investment by the United States (U.S.) government and constitutes a major effort aimed at restoring and protecting wetland habitats in the U.S. Between the years 1992 – 2011, ≥1,000,000 ha of land were enrolled in program agreements with projects represented in all 50 states. In Nebraska (NE), 127 million U.S. dollars were allocated between the years 1993 – 2011 to conserve approximately 35,000 ha of wetland and associated upland habitats (R. Epperson, Natural Resources Conservation Service, personal communication).

The WRP is administered by the Natural Resources Conservation Service (NRCS) under the direction of the U.S. Department of Agriculture (USDA). Initially authorized as a programmatic component of the 1990 Food Agriculture, Conservation and Trade Act, the WRP has several targeted objectives including an emphasis on restoring, creating or enhancing wetland habitat for migratory birds (Natural Resources Conservation Service 2010). Quantitative information, however, linking the environmental benefits of the WRP to fish and wildlife species is limited (Gray 2005). In particular, avian response to restoration efforts has thus far been limited to qualitative descriptions with few analytical measures (Rewa 2005). King et al. (2006) provide a detailed overview of the role and status of the WRP in the Mississippi Alluvial Valley, but acknowledge that a lack of scientific research has limited evaluation of the program's impact on wildlife populations. Recent information derived from the USDA Conservation Effects Assessment Project provides regional inferences to avian use of WRP habitats but quantitative data appears mixed (Frazier and Galat 2009, Faulkner et al. 2010, Duffy et al. 2011, Steven and Gramling 2011). Additionally, more localized investigations such as Summers (2010) thesis regarding avifaunal use of bottomland forests are needed to more adequately evaluate WRP restorations. In contrast, the grassland equivalent USDA Conservation Reserve Program, has received considerable attention and its benefits to a suite of biotic and abiotic factors have been largely documented (Haufler 2005, Gleason et al. 2008). Thus without more detailed investigations relating the degree of association between WRP restoration activities and biological responses, a more complete measure of the programs merit cannot be gained.

A fundamental interpretation of ecological health generally includes some type of measurement regarding biological diversity (see Niemi and McDonald 2004). Avian communities in particular provide a mechanism for evaluation of environmental variables and correlations to conservation objectives (Canterbury et al. 2000). Of all avian diversity measures, species richness dominates the literature and indeed entire treatises have been devoted to the subject (e.g. Adams 2009). Derivations of species richness have been supplemented in recent decades by the application of predictive estimators (see Hortal et al. 2006) increasing the use of species richness as a surrogate measurement of biological diversity (Gaston and Spicer 2004). In addition, new branches of biological measurement have emerged that are less reliant on species equitability but take account of such aspects as taxonomic, phylogenetic, genetic or functional relationships (see Magurran 2004). Not surprisingly, Schweiger et al. (2008) recommend a complimentary use of both species

[1] Corresponding author email address: eric.hopps@ne.usda.gov

richness and phylogenetic measurements that more detailed mechanistic relationships between the two may be gained. Because WRP restorations within the LMRV encompass a variety of habitat types, the application of multiple diversity measures may provide insight into avian community structure and complement future restoration objectives.

Furthermore, habitat selection in birds is motivated by numerous external and internal causations and is expressed in a variety of adaptations, both physiologically and behaviorally (Cody 1985). Correlating the role of specific or even broad habitat types to avian selection, however, requires among other things, a measurement of availability and use before measures of preference can be ascertained (Johnson 1980). Therefore, conservation, restoration, and management of naturalized habitats is inextricably linked to those species or suites of species targeted for assembly. Consequently, if avian assessments of the WRP are to be determined, baseline information as to the availability and use of specific habitat types associated with program restorations must be quantified.

Here I use two principle measures of diversity (species richness and taxonomic distinctness) to investigate avian assemblages on WRP lands within the LMRV. Specifically, my objective was to: (1) measure the relative contributions of categorized WRP habitat types to overall avian species richness and taxonomic structure, (2) determine habitat preferences across the entire species assemblage based on availability and use, and (3) examine seasonal variations in avian diversity. Two ancillary measures also are explored; comparisons of regional and historical species lists to WRP avian taxonomic structure and documentation of WRP avian breeding activity relative to described WRP habitat types.

STUDY AREA

My study area consisted exclusively of individual WRP easement sites ($n = 67$) within a 334 km stretch of the LMRV (Fig. 1). All study sites were west of the Missouri River channel and located between Thurston County, NE (river mile 703) and Richardson County, NE (river mile 495; U.S. Army Corp of Engineers 2009). I selected study sites from a pool of approximately 110 WRP easements based on existing or established habitat types associated with WRP restorations. I selected sites across the entire floodplain, from easements immediately adjacent to the Missouri River, across first and second bottom land, and terminating on lateral bluffs. Size or anthropogenic influences (management, levees) were not considered in the selection process; however, age of restoration was considered in respect to development of grassland and wetland plant communities. Average age of study sites post-restoration was five years. All but five sites were in private ownership with 22 sites being riverward of constructed levees or otherwise directly influenced by Missouri River flood waters. Climatic conditions were characterized by above normal temperatures (avg. 11.1° C + 1.3) and above normal precipitation (883.9 mm + 118.9 mm; National Weather Service 2011). The Missouri River exceeded flood stage south of the Platte River on three occasions between 16 March and 9 October. Flood waters were restricted to areas riverward of constructed levees.

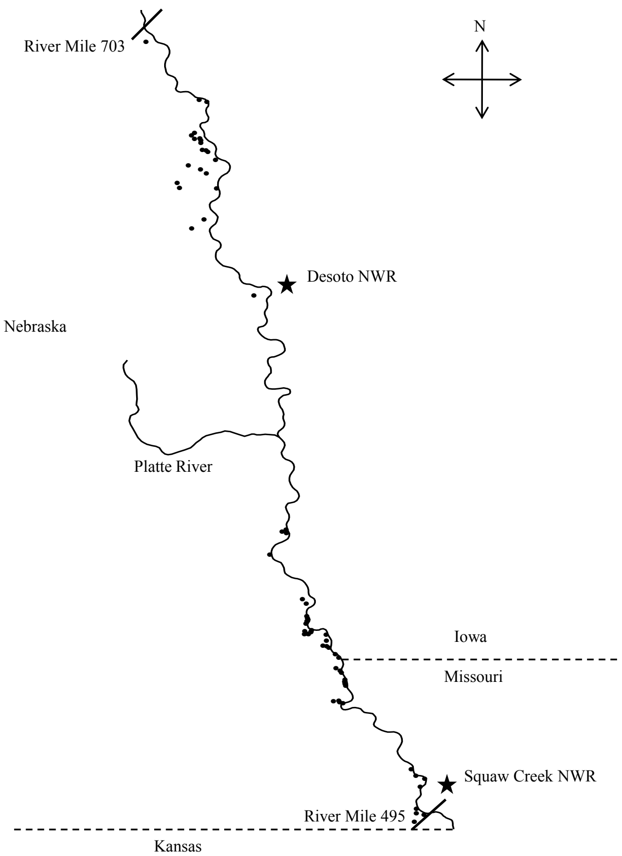

Figure 1. Map indicating site locations and approximate 334 km length of study area between river mile 703 and 495 along the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011.

Vegetation Characteristics of WRP Sites

Because this study was restricted to WRP lands, I utilize site-specific ecological data collected during July and August 2008 and 2009 (E. C. Hopps and T. P. Janke, The Nature Conservancy, unpublished data). Eight distinct plant communities: wetland emergent, wet meadow, moist-soil, lowland grassland, lowland herbaceous, lowland forest, lowland woodland and upland forest and two classified habitat types: open water and wetland bare soil were described based on plant community assemblages and observed hydrologic regimes (Table 1). Plant community assemblages were determined by species compositions resulting from similar environmental influences (e.g., soils and hydrology). Spatial

Table 1. Wetland Reserve Program habitat descriptions in the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011.

Habitat Type	Habitat Description	Diagnostic Species[a]
Open Water	Wetland areas with water depths ≤ 2.0 meters exhibiting ≤ 10% cover by submergent, floating leaved or emergent vegetation.	None
Wetland Emergent	Plant assemblages' growing in saturated or flooded conditions through most of the growing season.	Cattail (*Typha* spp.), bulrush (*Scirpus* spp., *Schoenoplectus* spp.), arrowhead (*Sagittaria latifolia*) and swamp milkweed (*Asclepias incarnata*).
Wet Meadow	Plant assemblages' growing in areas that are saturated early in the growing season or after heavy rains, but dry out or are damp by midsummer.	Sedges (*Carex* spp.), spikerush (*Eleocharis* spp.), rushes (*Juncus* spp.) and prairie cordgrass (*Spartina pectinata*).
Moist Soil	Plant assemblages' established during midsummer on saturated to damp soil following inundation during the early growing season.	Millet (*Echinochloa crusgalli*), ammannia (*Ammannia coccinea*), pigweed (*Amaranthus rudis*) and sedges (*Cyperus* spp.).
Wetland Bare Soil	Non-vegetated exposed soil, left after flood waters recede or ponded water evaporates.	None
Lowland Grassland	Plant assemblages' characteristic of wet-mesic areas infrequently flooded but subject to saturation after heavy rains and snowmelt.	Wildrye (*Elymus* spp.), big bluestem (*Andropogon gerardii*), western wheatgrass (*Pascopyrum smithii*) and Illinois bundleflower (*Desmanthus illinoensis*).
Lowland Herbaceous	Plant assemblages' characteristic of frequently flooded areas, often near the river channel, but not retaining water after flood events subside.	Canarygrass (*Phalaris arundinacea*), foxtail (*Setaria* spp.), sunflower (*Helianthus annuus*) and cocklebur (*Xanthium strumarium*).
Lowland Woodland	Stands of immature woody floodplain vegetation generally displaying a singular woody vegetation layer, often growing as monocultures of similar age trees and shrubs.	Cottonwood, willow (*Salix* spp.) and roughleaf dogwood (*Cornus drummondii*).
Lowland Forest	Stands of relatively diverse and mature woody floodplain vegetation, displaying a distinct tree canopy confined to the upper 1/3 of stem and understory layers of shade tolerant shrubs and herbs of varying densities.	Cottonwood (*Populus deltoides*), mulberry (*Morus* spp.), sycamore (*Platanus occidentalis*) and silver maple (*Acer saccharinum*).
Upland Forest	Stands of diverse and mature woody upland vegetation, displaying a distinct tree canopy confined to the upper 1/3 of stem and understory layers of shade tolerant shrubs and herbs of varying densities.	Oak (*Quercus spp*.), hickory (*Carya* spp.), walnut (*Juglans nigra*) and basswood (*Tilia americana*).

[a]All common and scientific plant nomenclature follows that described in Rolfsmeier and Steinauer (2010).

division of habitat types on each study area was conducted in-field with backpack Global Positioning Systems (GARMIN GPSMAP 76S) and data downloaded into a Geographic Information System (ArcGIS 9.2; ESRI, Inc., Redlands, CA, USA) for analysis. Any changes in plant community extent or hydrological expression between ecological data collection and study period were noted and adjustments to spatial analysis determined. All common and scientific plant nomenclature follows that described in Rolfsmeier and Steinauer (2010).

METHODS

Bird Surveys

I collected bird data during 600 surveys ($\bar{x}$ = 50.0/mo., SD = 14.5) on 67 individual easement areas. Survey sites ranged in size from small to large ($\bar{x}$ = 54.9 ha, range 2.4 – 293.8 ha, SD = 47.2 ha). I initiated surveys at sunrise and continued until 1200 hours CST; data collection began on 10 March 2010 and continued through 28 February 2011. Seasonal periods were established as: spring (Mar – May), summer (Jun – Aug), fall (Sep – Nov) and winter (Dec – Feb). Selection of daily site surveys was conducted randomly throughout the length of study area, but was differentiated between north and south of the Platte River due to travel time (Fig. 1). I recorded all species observed or heard within the WRP easement boundary in a binary data format (presence-absence) and placed in one of 10 predefined habitat categories (Table 1). A requisite for inclusion in a specified habitat type included visual or auditory confirmation as to the precise habitat association of the bird. Species such as raptors and swallows observed in flight were only categorized if actively hunting or foraging within a specific habitat type.

Due to known multiplicity in habitat types across and within individual study sites and because the temporal range of study would include large variations in avian behavioral and physiological change (e.g., migration, breeding, wintering), use of traditional avian sampling techniques (e.g., point counts, line transects) were precluded on the following basis. First, seasonal and habitat related deficiencies in species detectability from fixed area sampling protocol (Pagen et al. 2002, Selmi and Boulinier 2003, Nichols et al 2008, Simons et al. 2009) necessitated a sampling technique optimal to species detection during a limited one year period (see Watson 2003, Rompre et al. 2007). Second, more intensive search methods have been shown to yield more information on avian habitat associations as compared to more passive methods (Bart and Earnst 2002). Third, avoidance of multiple methodologies and subsequent comparative issues regarding analytical performance across divergent environmental and temporal variables (Hortal et al. 2006). Finally, the decision to collect and interpret information at the site (patch analog) and study area (landscape analog) scale, rather than from fixed areas within sites (Watson 2004), influenced sampling technique selection.

Therefore, I adopted the "*Standardized Search*" (SS) described by Watson (2003). The SS allows for entire sites, rather than points, transects or quadrants within sites, to be freely sampled and directly compared. A further benefit of the SS approach is its independence of habitat types within and across sites and performance in estimating species richness and sampling completeness modeled on results-based stopping rules (Watson 2004). Results-based stopping rules likewise remove time constraints associated with standard sampling measures and focus more on precision of results rather than effort expended (Peterson and Slade 1998). I applied stopping rules only after all habitat types within each study area were thoroughly search. Stopping rules were then interpreted to have been met following a final observation period of approximately 10 – 20 minutes when no new species were recorded. Stopping rules were not applied in the strict sense associated with repeated sampling periods or use of same-day extrapolation methods (Peterson and Slade 1998, Watson 2004, Rompre et al 2007). Consequently, the SS was conducted on all habitat types within each study site on each site visit. The site survey is therefore analogous to sample, and was established as the measurement of unit effort. Because all WRP study sites exhibited a degree of habitat heterogeneity and variance in total area, duration of surveys were correspondingly different. However effort expended (duration) is unimportant as long as survey method and sampling completeness are equivalently applied (Watson 2003). Here survey duration is approximately defined as sites ≤50 ha = 1 hr and sites ≥51 ha = 2 hrs. All surveys were conducted on foot as well as utilization of visually strategic vantage points where available (Watson 2010). To increase efficiency, I employed an All-Terrain Vehicle (ATV) during searches of large grasslands and to access dense emergent wetlands. I observed periods of stoppage throughout searches enabling aural detection or visual confirmation. An ancillary benefit of ATV use was the elicitation of territorial and nesting behaviors (e.g., scolding, flushing) thereby assisting in documenting breeding status.

Breeding Bird Survey—I followed the protocol outlined in the Nebraska Breeding Bird Atlas Project (Mollhoff 2001) to document the level of avian breeding activity on WRP lands. Four levels of breeding effort are described: observed, possible, probable and confirmed. I located nests opportunistically based on known habitat preferences, referenced initiation dates and observing species exhibiting breeding behavior. Information related to this particular aspect of the study, other than taxonomic measures, is provided in proportional attributes and was not designed for rigorous statistical testing.

Data Analysis

Species Richness.—In order to measure sample completeness and compare observed species richness with estimated richness, I applied three non-parametric estimators, CHAO 2 (Chao 1987), JACKKNIFE 2 (Smith and van Belle 1984) and the incidence-based coverage estimator (ICE; Chazdon 1998) to calculate *estimated species richness* (S_{est}) relative to both *observed species richness* (S_{obs}) and the largely known regional S_{True} value. Because S_{obs} never exceeds S_{True} involving sampling measures (Longino et al. 2002), the use of predictive estimators provides a means to extrapolate the approximate S_{True} value. CHAO 2 and JACKKNIFE 2 incorporate two active parameters based on the number of *unique* (species denoted in a single sample) and *duplicate* (species denoted in exactly two samples) in their estimate of S_{True}. The ICE estimates species richness within a slightly broader mathematical equation based on the number of *infrequent species* (species denoted in ≤10 samples) and the number of *frequent species* (species denoted in >10 samples). In effect, all three estimators operate by using the number of rare or uncommon species in a sample or aggregate of samples as a way of calculating the number of species not yet found, thus an estimate of S_{True}. Rarefaction curves are mere graphical representations of the data plotted against sampling effort (pooled and randomized). As the curve reaches an asymptote and begins trending towards infinity, S_{True} has been estimated. Use of non-parametric estimators also provided a statistical means to compensate for variable species detection or occupancy rates (Gotelli and Colwell 2011). I generated all richness estimators and associated accumulation curves in Program ESTIMATES v8.2 (Colwell 2009) set at 500 randomizations, founded on an incidence and sample based matrix. I also determined species richness measures for seasonal variance based on individual monthly lists.

Taxonomic Distinctness.—To determine the taxonomic structure of the entire WRP avian assemblage, I applied three measures of analysis based on *Total Taxonomic Distinctness*, the average taxonomic distance apart of any randomly selected species to all other species in an assemblage (Warwick and Clarke 1995), *Average Taxonomic Distinctness*, the average taxonomic distance apart of any randomly selected pair of species in an assemblage (Clarke and Warwick 1998), and *Variation in Taxonomic Distinctness*, the variance in taxonomic distance between every pair of randomly selected species in an assemblage (Clarke and Warwick 2001*a*). High values of taxonomic distinctness represent assemblages more distantly related whereas low values represent assemblages more closely related. All species were categorized in four recognized levels of avian taxonomy; species, genus, family and order (American Ornithologists' Union 1998). I derived measures of taxonomic distinctness by comparing habitat and seasonal assemblages to the entire species assemblage documented during the study (e.g., master species list). To determine whether the WRP *Average Taxonomic Distinctness* is representative of the regional and historical species pool, I compare bird checklists from U.S. Fish and Wildlife Service, National Wildlife Refuges, Squaw Creek (SCNWR) and DeSoto (DNWR) to the documented WRP master species list. Both SCNWR and DNWR are located within the LMRV, east of the river channel proper (Fig. 1) and were established in 1935 and 1958 respectively. I reduced total species lists for SCNWR and DNWR by excluding accidental and rare (observed 2 – 5 yr interval) species unless indexed in the WRP master list. I generated all taxonomic diversity tests in the TAXDTEST routine of Program PRIMER v6 (Clarke and Gorley 2006) set at 100,000 random permutations and equal step lengths between each level in the taxonomic hierarchy (e.g., 25, 50, 75, 100).

Habitat Preference.—Because categorized habitat types were expressed disproportionately in total area, a degree of measurement was required that quantified habitat availability versus usage in order to arrive at a measure of habitat preference. To determine the relative importance of individual and grouped ecological (forest, wetland, and grassland) habitat types to the documented species pool, I applied the method described by Johnson (1980). I generated analysis of habitat preference by Program PREFER (Johnson 1980) based on an incidence and sample based matrix. The critical value for the Waller-Duncan procedure was $W = 2.50$ using a K ratio of 500, alpha approximating 0.01. I compared pooled species occurrences against available habitat for each independent study site and across the three ecological groups. I converted total binary occurrence data ($n = 4{,}730$) and habitat area (3,562 ha) to percentages for analyses (i.e. percent available habitat within and across study sites and percent use of all pooled species). Due to their contiguous proximity, I consolidated 13 study sites into five independent sampling locations during analysis. Total numbers, mean size (ha), spatial range (ha) and standard deviation of habitat types sampled across all 67 study sites are listed in Table 2.

To test for differences between avian assemblages and discrete WRP habitat types, I applied the Bray-Curtis coefficient of similarity adjusted for binary data to derive the necessary metric inclusive to nonmetric multidimensional scaling (MDS) and clustering techniques. I used hierarchical agglomerative clustering sorted by group, including associated similarity profile (SIMPROF) permutation test, to determine relationships between avian communities and habitat types (Clarke and Warwick 2001*b*). SIMPROF tests the null hypothesis that all samples are *a priori* unstructured (e.g., that habitat types are unstructured regarding avian assemblages). To compare the accuracy of cluster analysis and further measure the similarity-dissimilarity of avian community structure, I applied ordination by MDS. The goal of MDS is to graphically place different objects far apart in ordination space while similar objects are placed close together, here only the rank ordering of the original dissimilari-

Table 2. Sample size, mean size (ha), spatial range (ha) and standard deviation of habitat types sampled across all 67 study sites in the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011.

Habitat Type	*N*	Size (ha)	Range (ha)	SD
Lowland Forest	33	15.2	0.5–66.7	18.8
Lowland Woodland	34	4.6	0.2–45.8	5.1
Upland Forest	4	11.4	3.5–22.2	7.5
Open Water	52	2.6	0.1–16.1	3.1
Wetland Emergent	38	7.8	0.2–49.3	9.8
Wet Meadow	6	2.2	0.4–3.4	1.2
Moist-Soil	26	9.5	0.1–21.8	15.8
Wetland Bare Soil	23	2.5	0.2–9.6	2.7
Lowland Grassland	39	30.0	0.8–139.5	31.2
Lowland Herbaceous	41	22.6	0.1–105.6	27.2

ties is preserved (Gotelli and Ellison 2004). Significance of MDS ordination is measured in terms of stress value. Stress values < 0.05 indicate a highly accurate representation of a high-dimensional assemblage structure (Clarke and Warwick 2001*b*). I performed cluster (including associated SIMPROF permutation test) and MDS analysis in Program PRIMER v6 (Clarke and Gorley 2006). MDS analysis was set at 10,000 iterations and a minimum stress value of 0.01. Cluster analysis was set at 100,000 mean and 999 simulation permutations and a significance value of 0.01.

RESULTS

Species Richness

A total of 212 species were documented during the study (Appendix). Species richness was greatest during peak periods of migration, May and September (Fig. 2). Observed species richness varied by plant community type but was greatest in lowland forest and least in wet meadow.

The nonparametric estimators ICE, CHAO 2 and JACKKNIFE 2 plotted against unit of effort (samples) demonstrate stability and attainment of an asymptote reductive of peak estimates (Fig. 3). The sample based rarefaction curve S_{obs} (Mao Tau) displayed asymptotic behavior but had not trended to zero (S_{obs} = 212, SD = 3.67). Overall estimates of S_{True} for CHAO 2 ($\bar{x}$ = 225.1, SD = 7.13) and ICE ($\bar{x}$ = 224.8) were nearly identical and provides inference to the likely S_{True} value for the study area. The estimated value of JACKKNIFE 2 ($\bar{x}$ = 239.9) is closely aligned to the S_{True} value representative of the larger regional species pool. The performance of the three estimators as predictors of S_{True} was evaluated on attainment of 95% of the total estimated value. JACKKNIFE 2 displayed asymptotic behavior in the fewest samples (s) but at the greatest standard deviation (s = 195, *S* = 227.02, SD = 14.44). CHAO 2 followed at (s = 259, *S* = 213.08, SD = 11.57) and ICE at (s = 312, *S* = 212.99, SD = 7.22). Overall, S_{obs} accounted for 94.2%, 94.3%, and 88.4% of the estimated S_{True} value for CHAO 2, ICE and JACKKNIFE 2 respectively.

Based on attainment of asymptotic behavior, rarefaction curves for all 10 WRP habitat types (Fig. 4) demonstrate that few species were undetected or sampling of species was consistent during the study. Observed species richness, 95% confidence intervals and standard deviations on all WRP habitat types are listed in Table 3. Seasonal periods as represented by cumulative number of site surveys on both Figs. 3 and 4 can be separated accordingly, spring (0 – 168), summer (169 – 286), fall (287 – 481) and winter (482 – 600).

Taxonomic Distinctness

A total of 17 taxonomic orders were recorded (Appendix). Three orders: Passeriformes, Charadriiformes and Anseriformes were dominant across the entire species pool and accounted for 52.8%, 13.2% and 11.3% of all species respectively. The remaining 14 orders contributed between 0.5 – 4% of total taxonomic structure.

Distributions around the mean *Average Taxonomic Distinctness* value for six habitat types conform to the 95% CI for the full WRP species assemblage despite reductive *Total Taxonomic Distinctness* and *S* values (Fig. 5a). In contrast, lowland forest, lowland woodland, upland forest and lowland herbaceous fell below the lower bound 95% CI during analysis of *Average Taxonomic Distinctness*. These lower bound values suggest that forest and woodland communities are drawing upon a taxonomically restricted portion of the available species pool. The low value for lowland herbaceous habitat may have been influenced by its close spatial affiliation with forest and woodland habitats.

Interestingly, mean *Average Taxonomic Distinctness* values ranked from most disparate (highest value) to those most closely related (lowest value) fits the hypothetical expectation of plant community assembly, Wetland (= 90.12, SD = 1.51), Grassland (= 86.37, SD = 1.74), and Forest (= 84.15, SD = 0.75). Conversely, four wetland habitat types and lowland herbaceous fell above the upper bound 95% CI in examination of *Variation in Taxonomic Distinctness* (Fig. 5b). It appears that the avian taxonomic structure of open water, wetland emergent, moist-soil, wetland bare soil and lowland herbaceous show a greater imbalance, leading to increased *Variation in Taxonomic Distinctness*, with a higher number of species-rich genera within some families (or families within orders) and a sparser representation of species within other families (or families within orders), than is shown by taxa from the other five habitat types, which consequently have greater balance and lower *Variation in Taxonomic Distinctness* values.

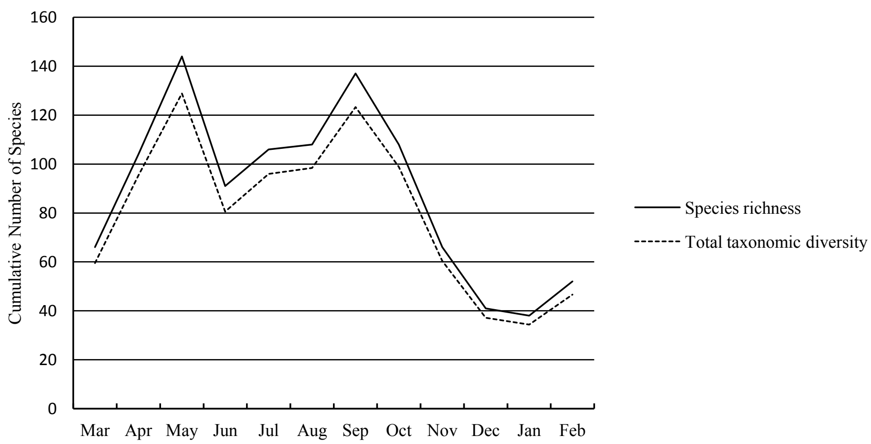

Figure 2. Monthly observed species richness and total taxonomic diversity on studied Wetland Reserve Program sites along the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011. Total taxonomic diversity values reduced for comparison by a factor of 10^{-2}.

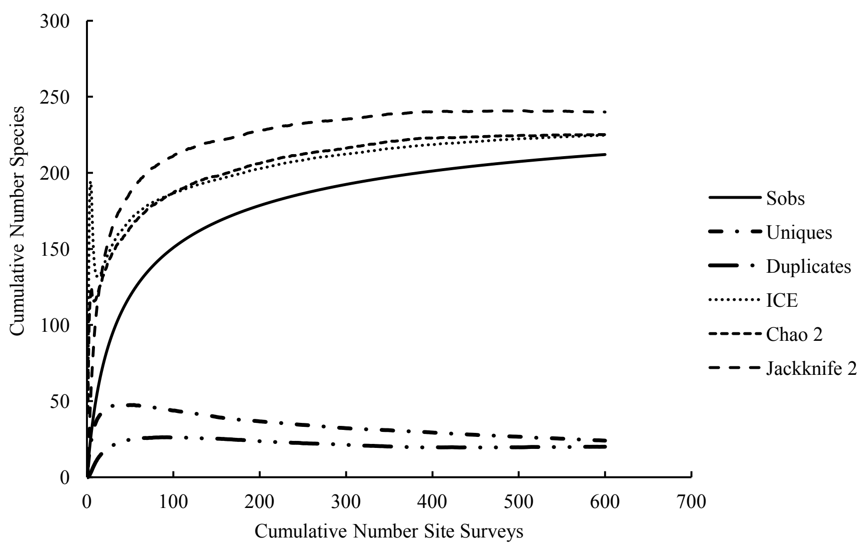

Figure 3. Performance of three non-parametric estimators of species-richness plotted against the sample-based rarefaction curve of observed species-richness including the cumulative number of unique and duplicate species for an empirical data set of avian diversity associated with the Wetland Reserve Program (WRP) along the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011. Total taxonomic diversity values reduced for comparison by a factor of 10^{-2}.

Monthly *Total Taxonomic Distinctness* closely tracked *S* as expected (Fig. 2). *Total Taxonomic Distinctness* and *S* relative to habitat type and seasonality were again in synchrony. Species richness and *Total Taxonomic Distinctness* were greatest in lowland forest (*S* = 115, *TTD* = 9,745) and least diverse in wet meadow (*S* = 30, *TTD* = 2,709). Seasonal *Average Taxonomic Distinctness* was uniform with a slight reduction during fall and seasonal difference in *Variation in Taxonomic Distinctness* was pronounced only during winter (Figs. 6a, b). Comparisons of *Average Taxonomic Distinctness* and *Variation in Taxonomic Distinctness* between the WRP master list and that calculated for SCNWR and DNWR conformed to the 95% probability limits for both locations albeit displaying a modestly low *Average Taxonomic Distinctness* and a slightly elevated *Variation in Taxonomic Distinctness* respectively.

Table 3. Observed species richness, 95% confidence intervals and standard deviations on WRP habitat types in the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011.

Habitat Type	S_{obs}	CI	SD
Lowland Forest	115	111.7–118.3	1.7
Lowland Woodland	83	80.6–85.4	1.2
Upland Forest	77	74.3–79.7	1.4
Open Water	66	62.7–69.3	1.7
Lowland Herbaceous	63	59.2–66.8	1.9
Moist-Soil	59	58.2–59.8	0.4
Wetland Emergent	51	48.1–53.9	1.5
Wetland Bare Soil	49	44.5–53.5	2.3
Lowland Grassland	42	39.6–44.4	1.2
Wet Meadow	30	29.0–31.0	0.5

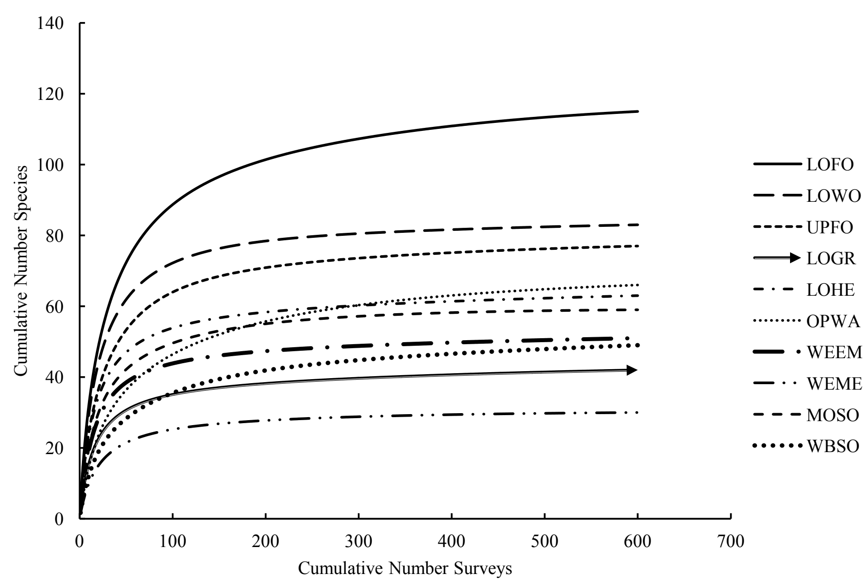

Figure 4. Sample-based rarefaction curves of observed species richness for an empirical data set of avian diversity correlated to 10 categorized WRP habitat types along the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011. Categorized WRP habitat types: Open Water (OPWA), Lowland Woodland (LOWO), Lowland Forest (LOFO), Upland Forest (UPFO), Wetland Bare Soil (WBSO), Wet Meadow (WEME), Wetland Emergent (WEEM), Moist-Soil (MOSO), Lowland Herbaceous (LOHE) and Lowland Grassland (LOGR).

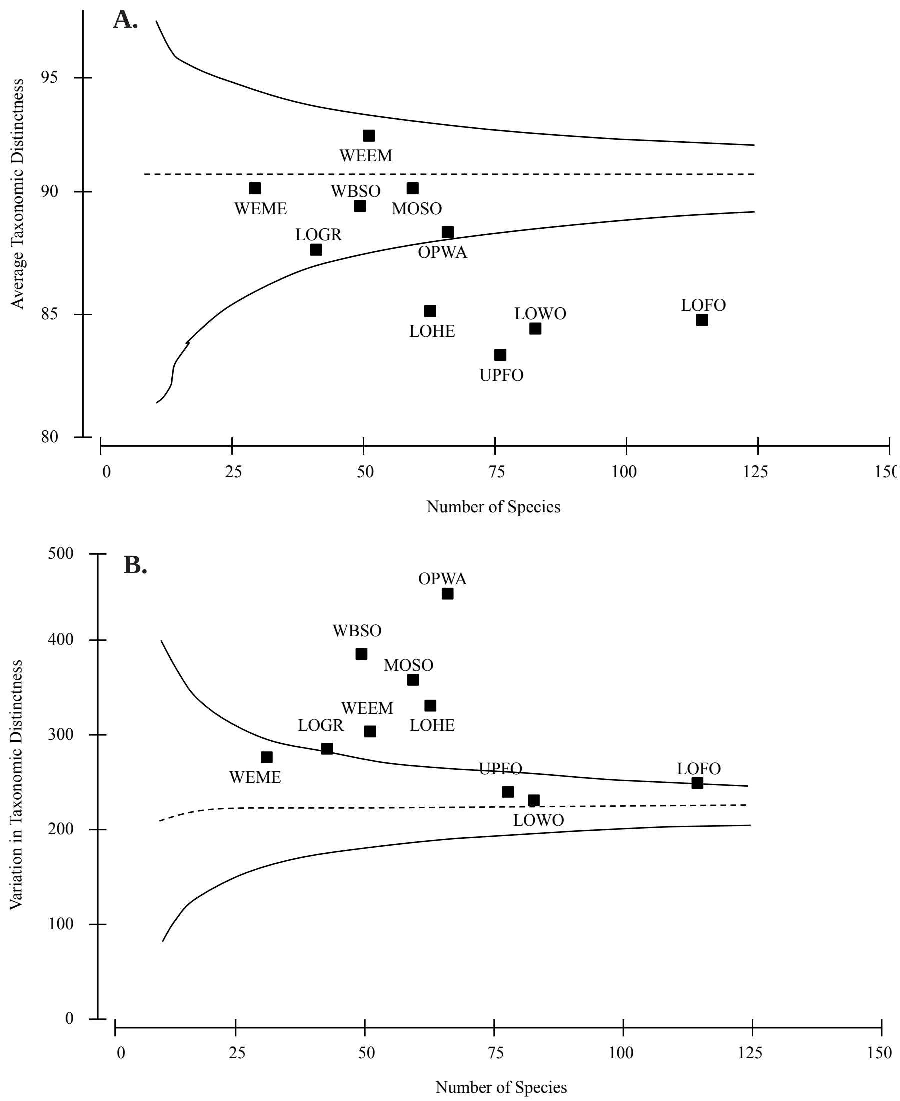

Figure 5. Average Taxonomic Distinctness (a; AvTD) and Variation in Taxonomic Distinctness (b; VarTD) of 10 Wetland Reserve Program (WRP) habitat types plotted against the number of species in each list. Horizontal dashed line represents mean AvTD and VarTD for the entire 212 avian species list. Solid funnel lines represent 95% confidence limits of AvTD and VarTD from 100,000 random selections of subsets drawn from the full WRP list. Categorized WRP habitat types: Open Water (OPWA), Lowland Woodland (LOWO), Lowland Forest (LOFO), Upland Forest (UPFO), Wetland Bare Soil (WBSO), Wet Meadow (WEME), Wetland Emergent (WEEM), Moist-Soil (MOSO), Lowland Herbaceous (LOHE) and Lowland Grassland (LOGR).

Habitat Preference

Avian use ranked according to habitat availability did not parallel spatial constraints with the exception of the ubiquitous lowland herbaceous and lowland grassland communities (Table 4.). The null hypotheses of H_0: habitat types are equally utilized across the entire species assemblage was rejected at ($F_{9, 49}$ = 8.68, P < 0.001). Mean pair-wise comparisons demonstrated preference for open water habitat across all habitat types at ($F_{1, 30}$ = 29.07, P < 0.001), except in comparison with lowland woodland ($F_{1, 25}$ = 0.25, P = 0.38) and lowland forest ($F_{1, 27}$ = 0.16, P = 0.31) communities. Overall, forest and woodland communities tend to support higher species richness and subsequent use across all ecological habitat types (Table 4.) but did not differ in grouped ecological comparison with wetland communities ($F_{1,40}$ = 0.85, P = 0.64). Preference for forest and wetland ecological groups was pronounced over grassland and herbaceous habitats at ($F_{1, 45}$ = 31.35, P < 0.001 and $F_{1, 50}$ = 41.56, P < 0.001) respectively.

Avian similarity between habitat types displayed a substantial degree of mixing within the entire species pool, as evidenced by no single habitat being mutually exclusive of the other. Performance of cluster analysis and associated similarity permutation test differentiated avian assemblages

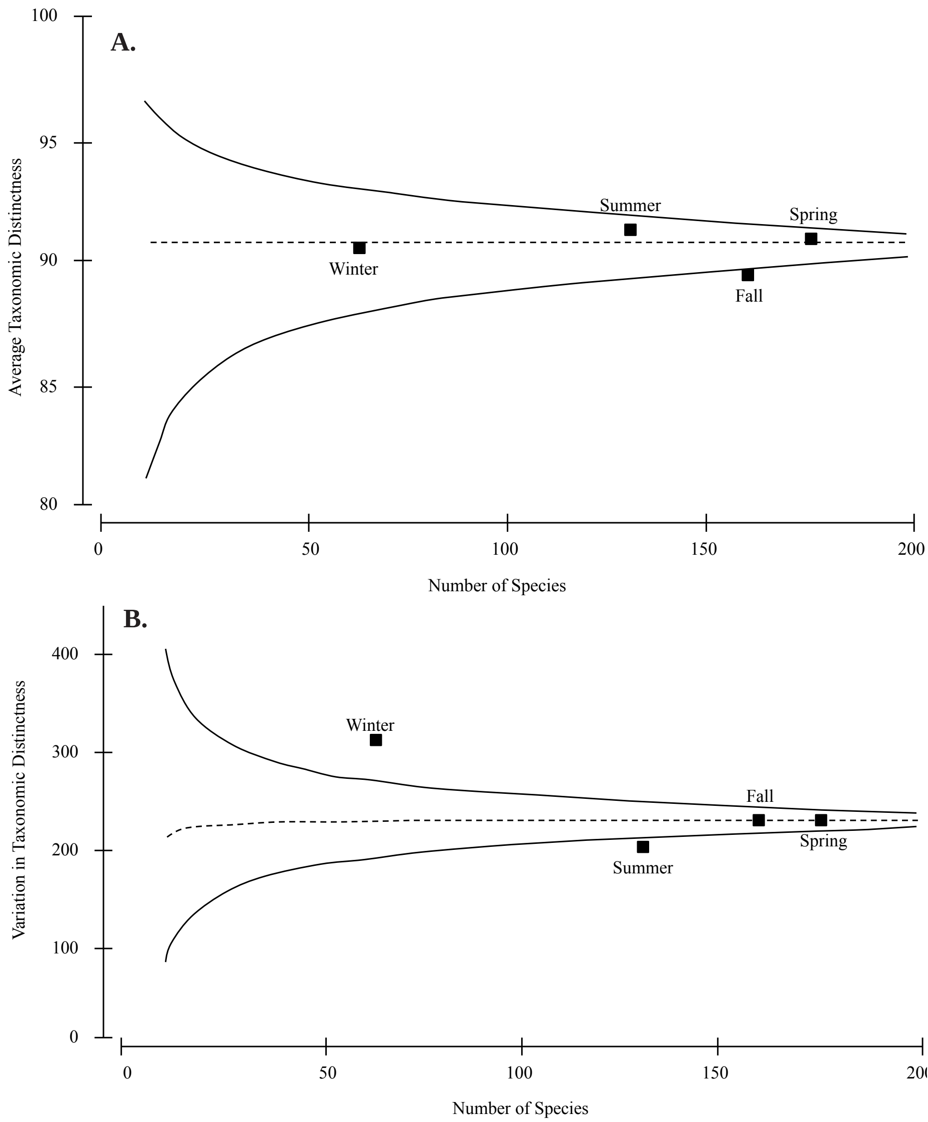

Figure 6. Average Taxonomic Distinctness (a; AvTD) and Variation in Taxonomic Distinctness (b; VarTD) of four Wetland Reserve Program (WRP) seasonal periods plotted against the number of species in each list. Horizontal dashed line represents mean AvTD and VarTD for the entire 212 avian species list. Solid funnel lines represent 95% confidence limits of AvTD and VarTD from 100,000 random selections of subsets drawn from the full WRP list.

across grouped habitat types at (SIMPROF, $Pi = 11.73$, $P < 0.001$). Additionally, forest, wetland, and grassland ecological groups fused together precisely as might be expected prior to assimilating with more ecologically dissimilar habitat types. Location of fusion between the three forested habitats occurred at 68% similarity, between the two grassland habitats at 57% similarity and at 36% similarity between the five wetland habitat types. Forested and grassland habitats then fused at 35% level of similarity prior to assimilating with all wetland habitats at 22%. MDS was supportive of cluster analysis and demonstrates a strong high-dimensional structure (2D stress = 0.04, 3D stress = 0.02) between avian community assemblages and distributed habitat types (Fig. 7). Wet meadow appears to be an outlier as compared to the other wetland habitat types and should be interpreted with caution due to its limited spatial availability and species composition.

Breeding Birds

A total of 103 species met breeding level criteria. 64 were confirmed as nesting, 12 listed as probable, 11 as possible and 16 observed but not believed to be breeding within study sites. Of the 87 species listed as confirmed, probable and possible, I found the following habitat relationships: forest/woodland ($n = 64$; 74%), wetland ($n = 15$; 17%), and grass-

Table 4. WRP avian habitat preference ranked according to use and availability in the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011.

Ecological Type[a]	Tbar[b]	Rank	Habitat Type[c]	Availability[d] (%)	Usage[e] (%)	Tbar	Rank[f]
Forest	−0.45689	1	OPWA	3.80	31.1	−1.13793	1
Wetland	−0.38793	2	LOWO	4.37	39.2	−0.78448	2
Grassland	0.84483	3	LOFO	14.05	54.2	−0.55172	3
			UPFO	1.36	36.3	−0.33620	4
			WBSO	1.65	23.1	−0.32758	5
			WEME	0.37	14.2	−0.19827	6
			WEEM	8.29	24.1	0.31034	7
			MOSO	7.08	27.8	0.68103	8
			LOHE	26.14	29.7	1.03448	9
			LOGR	32.90	19.8	1.31034	10

[a] Grouped (Ecological) WRP habitat types; [b] Mean difference in rank between habitat types. Negative values represent preferred ($P < 0.001$) habitats (Johnson 1980); [c] Categorized WRP habitat types: Open Water (OPWA), Lowland Woodland (LOWO), Lowland Forest (LOFO), Upland Forest (UPFO), Wetland Bare Soil (WBSO), Wet Meadow (WEME), Wetland Emergent (WEEM), Moist-Soil (MOSO), Lowland Herbaceous (LOHE) and Lowland Grassland (LOGR); [d] Percent area for individual habitat types available to species; [e] Percent of total individual species occurrence ($n = 212$); [f] Relative preference rank, 1 = most preferred, 10 = least preferred.

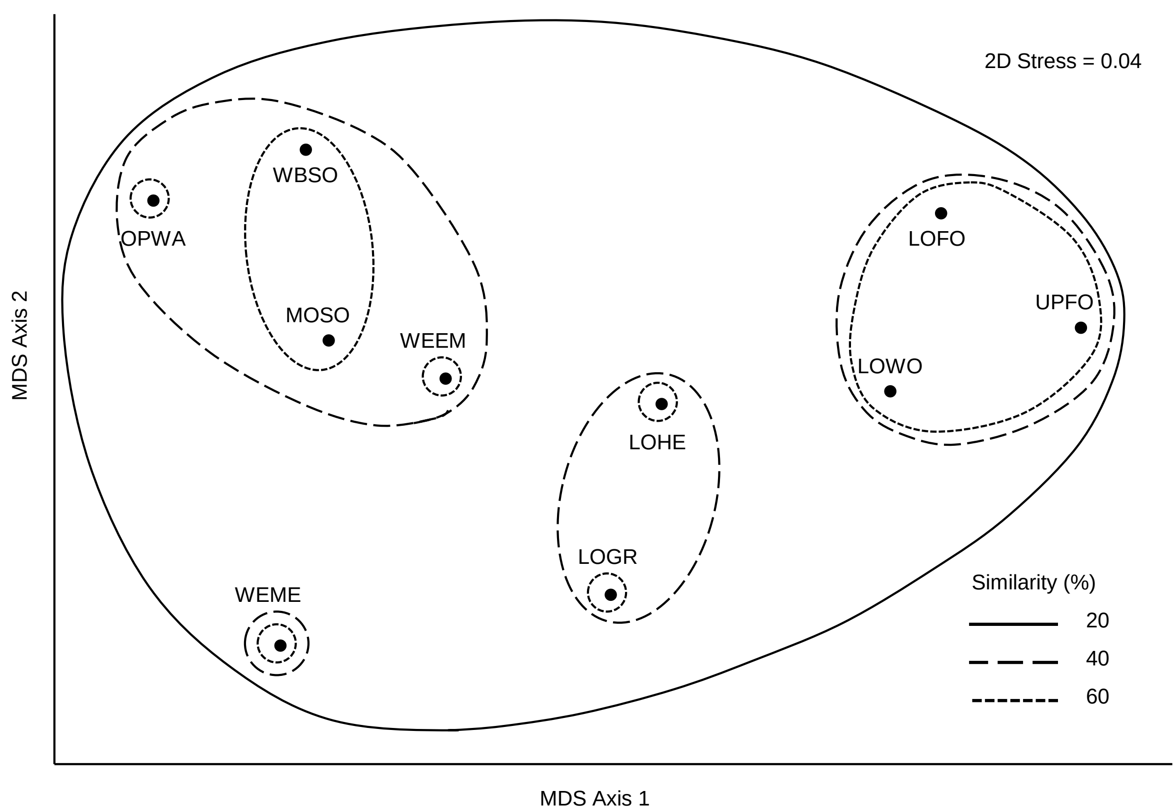

Figure 7. Nonmetric multidimensional scaling ordination based on Bray-Curtis coefficient of similarities between WRP avian assemblages and habitat community types in the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011.

land/herbaceous (n = 15; 17%). Habitat groupings are based on individual habitat types filling similar ecological roles. Nest detection peaked in June but was documented from early March through late September. Taxonomic structure of the avian breeding assemblage did not depart from the 95% CI for *Average Taxonomic Distinctness* and *Variation in Taxonomic Distinctness* compared to the full WRP data set.

DISCUSSION

Species richness varied broadly across the 10 WRP habitat types but displayed ecological similarity when applied to clustering and ordination techniques. The most species rich habitats within the three ecological groups (forest, wetland, and grassland) were lowland forest, open water and lowland herbaceous. In turn, taxonomic structure across individual habitat types varied as a function of species relatedness. The most diverse habitats in terms of *Average Taxonomic Distinctness* within the three ecological groups were lowland forest, wetland emergent and lowland grassland. These findings provided a relevant example for the use of mixed diversity measures. That is, based on species richness, open water and herbaceous habitats may be a priority for WRP restorations and management however, based on taxonomic diversity, wetland emergent and grassland habitats may be of greater value. Variance in seasonal diversity was marked by fluid species richness and stable taxonomic distinctness. Species richness was greatest in May and least in January. *Average Taxonomic Distinctness* was greatest in April and least in June. Collectively, my results supported the findings of Schweiger et al. (2008) that *Average Taxonomic Distinctness* in combination with species richness is the preferred method for comparing temporally and spatially independent communities.

A number of avian studies have applied predictive estimators to determine sample completeness (Watson 2003, Rompre et al. 2007, Watson 2010), and derive measures of species richness (Herzog et al. 2002, Hughes et al. 2002, O'Dea et al. 2006). My use of predictive estimators was characterized by asymptotic behavior (i.e. few species were left undetected) providing a strong measure as to sampling completeness and the current and likely true richness of WRP lands. These estimates were closely aligned with the largely known regional and historic avifauna (SCNWR and DNWR bird checklists), thus I concluded that avian diversity on WRP lands is representative of the annual species pool within the LMRV.

Forested communities associated with the WRP were identified as the single greatest contributors to avian diversity based on findings of habitat preference (including nest site selection), species richness and total taxonomic diversity. High species richness associated with riparian and floodplain forests have been documented throughout the U.S (e.g. Knopf et al. 1988, Knutson 1995, Miller et al. 2004) and on a global scale (e.g. Remsen and Parker 1983, Robertson et al. 1998, Palmer and Bennett 2006). Specific to the Missouri River, riparian and floodplain forests are known to exhibit greater avian diversity as compared to other habitat types (Zimmerman and Tatschl 1975, Scott and Auble 2002, Thogmartin et al. 2009).

In Nebraska, the Missouri River marks the eastern most terminus of the Great Plains and as longitude increases westward into this region the importance of forested habitats to avian communities becomes more pronounced. Johnsgard (1979) noted that although forest and woodland habitats comprised a mere 15% of the surface area of the Great Plains, these habitat types supported more than 50% of the total breeding avifauna. More than 70% of the WRP breeding bird assemblage was associated with forest and woodland communities. However, sampled lowland forest and upland forest habitats were not consequential of WRP restoration activities but were intact at the time of enrollment. Restoration of upland forest was not an active component of the WRP in the LMRV. Conversely, recruitment of similarly diverse lowland forest communities directly resultant of restoration efforts may take decades to achieve and to date has been limited to areas of natural regeneration.

I found avian diversity within wetland habitats to be marginally less than forested communities. Indeed, based on *Average Taxonomic Distinctness*, wetland bird assemblages were actually more genetically diverse (per observed number of species) than either forest or grassland communities. Further, avian preference for open water habitat across the entire WRP species pool demonstrated the attractiveness of this ecological feature. Annual variation in WRP avian diversity however is likely to be more pronounced for wetland communities along the LMRV as a direct result of altered hydrological regimes. During this study, a major and extended flood event occurred on the Missouri River. Direct inundation of WRP study sites riverward of constructed levees combined with elevated water tables and heavy precipitation, substantially increased hydroperiods for many wetlands within the study reach. These events unquestionably provided optimum conditions for the use and occurrence of wetland dependent bird species.

Of the three ecological habitat types defined for the WRP only grassland habitat appeared significantly disproportionate to its combined contribution to avian diversity. For example, only the spatially restricted wet meadow displayed less species richness than lowland grassland. Further, only 16 of 212 species displayed preference for lowland grassland and lowland herbaceous habitats despite their spatial dominance across WRP sites. The low *Average Taxonomic Distinctness* value for lowland herbaceous may be a reflection of its conditional food supply and close landscape association to forest and woodland communities, resulting in the assimilation of similar species within the phylogenetic pool. This is in part evidenced by an examination of shared species between forest and woodland communities and lowland herbaceous habitat. Based on analysis of similarity however, it appeared that grassland and herbaceous habitats may have acted as links between more species rich forest communities and more genetically diverse (per number of observed species) wetland communities. Therefore, although grassland habitats may be relatively species poor, they may provide a mechanism for species exchange between the three ecological groups. Thogmartin et al. (2009) noted that early successional forest had a species composition intermediate to mature forest and wet prairie in the LMRV, potentially in response to a successional gradient. Conversely, I found grassland and herbaceous habitats to be intermediate to forest and wetland communities and apparently unrelated to successional gradients.

I found species of conservation concern to be notable among the entire WRP avian assemblage (Appendix). In all, 19 species in the North American Landbird Conservation Plan (Rich et al. 2004) were documented, with 13 confirmed as breeding. Six species listed in the U.S. Shorebird Conservation Plan (Brown et al. 2001) as of high conservation concern and five species listed in the North American Waterbird Conservation Plan (Kushlan et al. 2002) were recorded utilizing WRP lands. Birds listed in the Nebraska Natural Legacy Project (Schneider et al. 2005) as Tier I and Tier II included 32 species, with nine confirmed as breeding. According to the North American Breeding Bird Survey (Sauer et al. 2011), 34 species were experiencing population declines in Bird Conservation Region 22. Of these, 32 were found utilizing WRP sites including 15 confirmed as breeding. Relating grouped WRP habitat affiliations with species of conservation concern yields the percentages, 50% Forest, 39% Wetland and 11% Grassland. Consequently, WRP restoration and management based solely on species of concern, rather than overall avian diversity, would remain consistent with findings of this study.

MANAGEMENT IMPLICATIONS

Restoration and management of forest and woodland communities should be a priority of the WRP within the LMRV. In addition to passive actions such as natural tree regeneration, proactive measures such as direct and diverse tree plantings would be complementary of avian assemblages associated with this ecological community. Based on current spatial expressions (i.e. amount, distribution), grassland and herbaceous habitats appear to be adequately represented in relation to associated avian diversity. Restoration and management of wetland habitats are innate to WRP goals and objectives.

ACKNOWLEDGEMENTS

I thank K. R. Clarke and D. H. Johnson for their helpful suggestions on a previous version of this manuscript. I thank Ducks Unlimited, the Nebraska Game and Parks Commission and the Nebraska Natural Resources Conservation Service for their support during this project. Appreciation is extended to all landowners who allowed access to their properties throughout this study.

LITERATURE CITED

Adams, J. 2009. Species Richness: patterns in the diversity of life. Praxis Publishing, Chichester, United Kingdom.

American Ornithologists' Union. 1998. Check-list of North American birds. Seventh edition. Washington, D.C., USA. <http://www.aou.org/checklist/north/results.php>. Accessed 12 February 2012.

Bart, J., and S. Earnst. 2002. Double sampling to estimate density and population trends in birds. Auk 119:36–45.

Brown, S., C. Hickey, B. Harrington, and R. Gill. 2001. The U.S. Shorebird Conservation Plan. Second edition. Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.

Canterbury, G. E., T. E. Martin, D. R. Petit, L. J. Petit, and D. F. Bradford. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. Conservation Biology 14:544–558.

Chao, A. 1987. Estimating the population size for capture-recapture data with unequal catchability. Biometrics 43:783–791.

Chazdon, R. L., R. K. Colwell, J. S. Denslow, and M. R. Guariguata. 1998. Statistical methods for estimating species richness of woody regeneration in primary and secondary rain forests of northeastern Costa Rica. Pages 285–309 *in* F. Dallmeier and J. A. Comiskey, editors. Forest biodiversity research, monitoring and modeling: conceptual background and old world case studies. Parthenon Publishing, Paris, France.

Clarke, K. R., and R. N. Gorley. 2006. Primer Version 6: user manual/tutorial. PRIMER-E, Plymouth Marine Laboratory, Plymouth, United Kingdom.

Clarke, K. R., and R. M. Warwick. 1998. A taxonomic distinctness index and its statistical properties. Journal of Applied Ecology 35:523–531.

Clarke, K. R., and R. M. Warwick. 2001*a*. A further biodiversity index applicable to species lists: variation in taxonomic distinctness. Marine Ecology Progress Series 216:265–278.

Clarke, K. R., and R. M. Warwick. 2001*b*. Change in marine communities: an approach to statistical analysis and interpretation. Second edition. PRIMER-E, Plymouth Marine Laboratory, Plymouth, United Kingdom.

Cody, M. L. 1985. Habitat Selection in birds. Academic Press, San Diego, California, USA.

Colwell, R. K. 2009. EstimateS: statistical estimation of species richness and shared species from samples. <http://viceroy.eeb.uconn.edu/estimates>. Accessed 11 March 2011.

Duffy, W. G., S. N. Kahara, and R. M. Records. 2011. Conservation Effects Assessment project, wetlands assessments in California's central valley and upper Klamath basin. U.S. Geological Survey – open file report. 2011–1296.

Faulkner, S., M. Baldwin, W. Barrow, H. Waddle, B. Keeland, S. Walls, D. James, and T. Moorman. 2010. Regional estimates of ecological services derived from U.S. Department of Agriculture conservation programs in the Mississippi Alluvial Valley. Final Report. U.S. Geological Survey, National Wetlands Research Center. Lafayette, Louisiana, USA.

Frazier, S., and D. L. Galat. 2009. Analysis of Missouri Wetlands Reserve Program easement monitoring data. Final report to Natural Resources Conservation Service, resource inventory and assessment division, Conservation Effects Assessment Project. University of Missouri, Columbia, USA.

Gaston, K. J., and J. I. Spicer. 2004. Biodiversity an introduction. Second edition. Blackwell Publishing, Malden, Massachusetts, USA.

Gleason, R. A., M. K. Laubhan, and N. H. Euliss Jr. 2008. Ecosystem services derived from wetland conservation practices in the U.S. prairie pothole region with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs. U.S. Geological Professional Paper 1745.

Gotelli, N. J., and R. K. Colwell. 2011. Estimating species richness. Pages 39–54 *in* A. E. Magurran, and B. J. McGill, editors. Biological diversity: frontiers in measurement and assessment. Oxford University Press, Oxford, United Kingdom.

Gotelli, N. J., and A. M. Ellison. 2004. A primer of ecological statistics. Sinauer Associates Inc., Sunderland, Massachusetts, USA.

Gray, R. L. 2005. Wetland Reserve Program: a partnership to restore wetlands and associated habitat. USDA, Forest Service, General Technical Report PSW-GTR-191, Albany, California, USA.

Haufler, J. B. 2005. Fish and wildlife benefits of Farm Bill conservation programs: 2000–2005 update. The Wildlife Society Technical Review 05-2, Bethesda, Maryland, USA.

Herzog, S. K., M. Kessler, and T. M. Cahill. 2002. Estimating species richness of tropical bird communities from rapid assessment data. Auk 119:749–769.

Hortal, J., P. A. V. Borges, and C. Gaspar. 2006. Evaluating the performance of species richness estimators: sensitivity to sample grain size. Journal of Animal Ecology 75:274–287.

Hughes, J. B., G. C. Daily, and P. R. Ehrlich. 2002. Conservation of tropical forest birds in countryside habitats. Ecology Letters 5:121–129.

Johnsgard, P. A. 1979. Birds of the Great Plains, breeding species and their distribution. University of Nebraska Press, Lincoln, USA.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65–71.

King, S. L., D. J. Twedt, and R. R. Wilson. 2006. The role of the Wetland Reserve Program in conservation efforts in the Mississippi Alluvial Valley. Wildlife Society Bulletin 34:914–920.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, and R. C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100:272–284.

Knutson, M. G. 1995. Birds of large floodplain forests: local and regional habitat associations on the Upper Mississippi River. Dissertation. Iowa State University, Ames, USA.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas. Washington, D.C., USA.

Longino, J. T., J. Coddington, and R. K. Colwell. 2002. The ant fauna of a tropical rainforest: estimating species richness three different ways. Ecological Society of America 83:689–702.

Magurran, A. E. 2004. Measuring Biological Diversity. Blackwell Publishing, Malden, Massachusetts, USA.

Miller, J. R., M. D. Dixon, and M. G. Turner. 2004. Response of avian communities in large-river floodplains to environmental variation at multiple scales. Ecological Applications 14:1394–1410.

Mollhoff, W. J. 2001. The Nebraska Breeding Bird Atlas 1984–1989. Nebraska Game and Parks Commission, Lincoln, USA.

National Weather Service. 2011. Annual Climatological Report. Omaha, Nebraska, USA.<http://www.weather.gov/climate/index.php>. Accessed 15 March 2011.

Natural Resources Conservation Service. 2010. Wetland Reserve Program Manual, Part 514.United States Department of Agriculture, Natural Resources Conservation Service, Washington D.C., USA.

Nichols, J. D., L. Thomas, and P. B. Conn. 2008. Inferences about landbird abundance from count data: recent advances and future directions. Pages 201–235 *in* D. L. Thomson,E. G. Cooch, and M. J. Conroy, editors. Modeling demographic processes in marked populations. Springer, New York, New York, USA.

Niemi, G. J., and M. E. McDonald. 2004. Application of ecological indicators. Annual Review of Ecology, Evolution, and Systematics 35:89–111.

O'Dea, N., R. J. Whittaker, and K. I. Ugland. 2006. Using spatial heterogeneity to extrapolate species richness: a new method tested on Ecuadorian cloud forest birds. Journal of Applied Ecology 43:189–198.

Pagen, R. W., F. R. Thompson III, and D. E. Burhans. 2002. A comparison of point-count and mist-net detections of songbirds by habitat and time-of-season. Journal of Field Ornithology 73:53–59.

Palmer, G. C., and A. F. Bennett. 2006. Riparian zones provide for distinct bird assemblages in forest mosaics of south-east Australia. Biological Conservation 130:447–457.

Peterson, A. T., and N. A. Slade. 1998. Extrapolating inventory results into biodiversity estimates and the importance of stopping rules. Diversity and Distributions 4:95–105.

Remsen, J. V. Jr., and T. A. Parker III. 1983. Contribution of river-created habitats to bird species richness in Amazonia. Biotropica 15:223–231.

Rewa, C. 2005. Wildlife benefits of the Wetlands Reserve Program. Pages 133–146 *in* J. B. Haufler, editor. Fish and wildlife benefits of Farm Bill conservation programs: 2000–2005 update. The Wildlife Society Technical Review 05-2, Bethesda, Maryland, USA.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Inigo-elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology, Ithaca, New York, USA.

Robertson, A., A. M. Jarvis, C. J. Brown, and R. E. Simmons. 1998. Avian diversity and endemism in Namibia: patterns from the southern Africa bird atlas project. Biodiversity and Conservation 7:495–511.

Rolfsmeier, S. B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska. Nebraska Game and Parks Commission, Lincoln, USA.

Rompre, G., W. D. Robinson, A. Desrochers, and G. R. Angehr. 2007. Environmental correlates of avian diversity in lowland Panama rainforests. Journal Biogeography 34:802–815.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski Jr., and W. A. Link. 2011. The North American Breeding Bird Survey, results and analysis, 1966–2009. Version 3.23.2011. USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Schneider, R., M. Humpert, K. Stoner, and G. Steinauer. 2005. The Nebraska Natural Legacy Project. Nebraska Game and Parks Commission, Lincoln, USA.

Schweiger, O., S. Klotz, W. Durka, and I. Kuhn. 2008. A comparative test of phylogenetic diversity indices. Oecologia 157:485–495.

Scott, M. L., and G. T. Auble. 2002. Conservation and restoration of semiarid riparian forests: a case study from the upper Missouri River, Montana. Pages 145–190 *in* B. Middleton, editor. Flood pulsing in wetlands: restoring the natural hydrological balance. John Wiley and Sons, New York, New York, USA.

Selmi, S., and T. Boulinier. 2003. Does time of season influence bird species number determined from point-count data? A capture-recapture approach. Journal of Field Ornithology 74:349–356.

Simons, T. R., K. H. Pollock, J. M. Wettroth, M. W. Alldredge, K. Pacifici, and J. Brewster. 2009. Sources of measurement error, misclassification error, and bias in auditory avian point count data. Pages 237–254 *in* D. L. Thomson, E. G. Cooch, and M. J. Conroy, editors. Modeling demographic processes in marked populations. Environmental and Ecological Statistics 3, Springer Science and Business Media. New York, New York, USA.

Smith, E. P., and G. van Belle. 1984. Nonparametric estimation of species-richness. Biometrics 40:119–129.

Steven, D. D., and J. M. Gramling. 2011. Assessing wetland restoration practices on southern agricultural lands: the Wetland Reserve Program in the southeastern coastal plain. Final Report. U.S. Department of Agriculture Forest Service, Southern Research Station, Asheville, North Carolina, USA.

Summers, E. A. 2010. Evaluating ecological restoration in Tennessee hardwood bottomland forests. Thesis. University of Tennessee, Knoxville, USA.

Thogmartin, W. E., M. Gallagher, N. Young, J. J. Rohweder, F. Durbian, and M. G. Knutson. 2009. Avian assemblages in the lower Missouri River floodplain. Wetlands 29:552–562.

U.S. Army Corps of Engineers. 2009. Aerial photography and maps of the Missouri River. Omaha, Nebraska, USA.

Warwick, R. M., and K. R. Clarke. 1995. New biodiversity measures reveal a decrease in taxonomic distinctness with increasing stress. Marine Ecology Progress Series 129:301–305.

Watson, D. M. 2003. The standardized search: an improved way to conduct bird surveys. Austral Ecology 28:515–525.

Watson, D. M. 2004. Comparative evaluation of new approaches to survey birds. Wildlife Research 31:1–11.

Watson, D. M. 2010. Optimizing inventories of diverse sites: insights from Barro Colorado Island birds. Methods in Ecology and Evolution 1:280–291.

Zimmerman, J. L., and J. L. Tatschl. 1975. Floodplain birds of Weston Bend, Missouri River Wilson Bulletin 87:196–206.

Submitted 1 March 2012. Accepted 20 November 2012.
Associate Editor was C. Lehman.

Appendix. Taxonomic list[a] of avian species documented on Wetland Reserve Program lands in the Lower Missouri River Valley, Nebraska, Mar 2010 to Feb 2011.

Order	Scientific Name	Common name
Anseriformes	*Anser albifrons*	Greater white-fronted goose
	Chen caerulescens	Snow goose
	Chen rossii[1]	Ross' goose
	Branta canadensis[†]	Canada goose
	Cygnus buccinator#	Trumpeter swan
	Aix sponsa[†]	Wood duck
	Anas strepera	Gadwall
	Anas americana[#]	American wigeon
	Anas rubripes[1]	American black duck
	Anas platyrhynchos	Mallard
	Anas discors	Blue-winged teal
	Anas cyanoptera[#1]	Cinnamon teal
	Anas clypeata	Northern shoveler
	Anas acuta	Northern pintail
	Anas crecca	Green-winged teal
	Aythya valisineria[#]	Canvasback
	Aythya americana	Redhead
	Aythya collaris	Ring-necked duck
	Aythya affinis[#]	Lesser scaup
	Bucephala albeola	Bufflehead
	Bucephala clangula	Common goldeneye
	Lophodytes cucullatus	Hooded merganser
	Mergus merganser[2]	Common merganser
	Oxyura jamaicensis	Ruddy duck
Galliformes	*Colinus virginianus*[^]	Northern bobwhite
	Phasianus colchicus[†^]	Ring-necked pheasant
	Meleagris gallopavo	Wild turkey
Podicipediformes	*Podilymbus podiceps*[†]	Pied-billed grebe
Suliformes	*Phalacrocorax auritus*	Double-crested cormorant
Pelecaniformes	*Pelecanus erythrorhynchos*	American white pelican
	Botaurus lentiginosus	American bittern
	Ixobrychus exilis[†#]	Least bittern
	Ardea herodias[†]	Great blue heron
	Ardea alba	Great egret
	Bubulcus ibis[2]	Cattle egret
	Butorides virescens[^]	Green heron
	Nycticorax nycticorax[•#1]	Black-crowned night-heron
	Plegadis chihi[#]	White-faced ibis
Accipitriformes	*Cathartes aura*	Turkey vulture
	Pandion haliaetus[2]	Osprey
	Haliaeetus leucocephalus[†#*]	Bald eagle
	Circus cyaneus	Northern harrier
	Accipiter cooperii	Coopers hawk
	Buteo swainsoni[#*1]	Swainsons hawk
	Buteo jamaicensis[†]	Red-tailed hawk
	Buteo lagopus	Rough-legged hawk
	Aquila chrysaetos[#1]	Golden eagle
Falconiformes	*Falco sparverius*	American kestrel
	Falco columbarius[#]	Merlin
	Falco peregrinus[#1]	Peregrine falcon
Gruiformes	*Rallus elegans*[#]	King rail
	Rallus limicola[1]	Virginia rail

Order	Scientific Name	Common name
	Porzana carolina	Sora
	Fulica americana[†]	American coot
Charadriiformes	*Pluvialis squatarola*	Black-bellied plover
	Pluvialis dominica[◊]	American golden plover
	Charadrius semipalmatus	Semipalmated plover
	Charadrius vociferus[†]	Killdeer
	Actitis macularius	Spotted sandpiper
	Tringa solitaria[◊]	Solitary sandpiper
	Tringa melanoleuca	Greater yellowlegs
	Tringa semipalmata	Willet
	Tringa flavipes	Lesser yellowlegs
	Bartramia longicauda[◊^]	Upland sandpiper
	Limosa fedoa[◊2]	Marbled godwit
	Calidris pusilla	Semipalmated sandpiper
	Calidris minutilla	Least sandpiper
	Calidris fuscicollis[2]	White-rumped sandpiper
	Calidris bairdii[2]	Baird’s sandpiper
	Calidris melanotos	Pectoral sandpiper
	Calidris alpina[2]	Dunlin
	Calidris himantopus[2]	Stilt sandpiper
	Tryngites subruficollis[#◊]	Buff-breasted sandpiper
	Limnodromus scolopaceus	Long-billed dowitcher
	Gallinago gallinago	Common snipe
	Phalaropus tricolor[◊]	Wilson’s phalarope
	Chroicocephalus philadelphia[•]	Bonaparte’s gull
	Leucophaeus pipixcan[•2]	Franklin’s gull
	Larus delawarensis	Ring-billed gull
	Larus argentatus[1]	Herring gull
	Chlidonias niger[•#]	Black tern
	Sterna forsteri[•#]	Forster’s tern
Columbiformes	*Columba livia*[^]	Rock pigeon
	Zenaida macroura[†^]	Mourning dove
Cuculiformes	*Coccyzus americanus*[†^]	Yellow-billed cuckoo
	Coccyzus erythropthalmus[^2]	Black-billed cuckoo
Strigiformes	*Megascops asio*[1]	Eastern screech owl
	Bubo virginianus[†]	Great horned owl
	Strix varia	Barred owl
Caprimulgiformes	*Chordeiles minor*[^1]	Common nighthawk
Apodiformes	*Chaetura pelagica*[^2]	Chimney swift
	Archilochus colubris[†#]	Ruby-throated hummingbird
Coraciiformes	*Megaceryle alcyon*	Belted kingfisher
Piciformes	*Melanerpes erythrocephalus*[†*^]	Red-headed woodpecker
	Melanerpes carolinus[†*]	Red-bellied woodpecker
	Sphyrapicus varius[2]	Yellow-bellied sapsucker
	Picoides pubescens[†]	Downy woodpecker
	Picoides villosus[†]	Hairy woodpecker
	Colaptes auratus[†^]	Northern flicker
	Dryocopus pileatus[#]	Pileated woodpecker
Passeriformes	*Contopus cooperi*[*2]	Olive-sided flycatcher
	Contopus virens[†]	Eastern wood-pewee
	Empidonax flaviventris[1]	Yellow-bellied flycatcher
	Empidonax virescens[#1]	Acadian flycatcher
	Empidonax traillii[†*]	Willow flycatcher
	Empidonax minimus	Least flycatcher
	Sayornis phoebe[†]	Eastern phoebe

Order	Scientific Name	Common name
	Myiarchus crinitus[†]	Great crested flycatcher
	Tyrannus verticalis[^2]	Western kingbird
	Tyrannus tyrannus[†^]	Eastern kingbird
	Tyrannus forficatus[#1]	Scissor-tailed flycatcher
	Lanius ludovicianus[^1]	Loggerhead shrike
	Vireo Bellii[†*#]	Bell's vireo
	Vireo flavifrons[*#]	Yellow-throated vireo
	Vireo solitarius	Blue-headed vireo
	Vireo gilvus[†]	Warbling vireo
	Vireo olivaceus[†]	Red-eyed vireo
	Cyanocitta cristata[†^]	Blue jay
	Corvus brachyrhynchos	American crow
	Eremophila alpestris[^]	Horned lark
	Progne subis[2]	Purple martin
	Tachycineta bicolor[†]	Tree swallow
	Stelgidopteryx serripennis	Northern rough-winged swallow
	Riparia riparia	Bank swallow
	Petrochelidon pyrrhonota	Cliff swallow
	Hirundo rustica[†]	Barn swallow
	Poecile atricapillus[†^]	Black-capped chickadee
	Baeolophus bicolor[†#]	Tufted titmouse
	Sitta carolinensis[†]	White-breasted nuthatch
	Certhia americana[#]	Brown creeper
	Thryothorus ludovicianus[#]	Carolina wren
	Troglodytes aedon[†]	House wren
	Troglodytes hiemalis	Winter wren
	Cistothorus platensis[†#]	Sedge wren
	Cistothorus palustris[†]	Marsh wren
	Polioptila caerulea[†#]	Blue-gray gnatcatcher
	Regulus satrapa	Golden-crowned kinglet
	Regulus calendula	Ruby-crowned kinglet
	Sialis sialis[†]	Eastern bluebird
	Catharus ustulatus	Swainsons thrush
	Catharus guttatus	Hermit thrush
	Hylocichla mustelina[†*]	Wood thrush
	Turdus migratorius[†]	American robin
	Dumetella carolinensis[†]	Gray catbird
	Toxostoma rufum[†*^]	Brown thrasher
	Sturnus vulgaris[†]	European starling
	Anthus rubescens	American pipit
	Bombycilla cedrorum[†]	Cedar waxwing
	Oreothlypis peregrina	Tennessee warbler
	Oreothlypis celata	Orange-crowned warbler
	Oreothlypis ruficapilla	Nashville warbler
	Setophaga americana	Northern parula
	Setophaga petechia[†]	Yellow warbler
	Setophaga magnolia[2]	Magnolia warbler
	Setophaga caerulescens[1]	Black-throated blue warbler
	Setophaga coronata	Yellow-rumped warbler
	Setophaga virens	Black-throated green warbler
	Setophaga fusca[1]	Blackburnian warbler
	Setophaga dominica[#1]	Yellow-throated warbler
	Setophaga palmarum[1]	Palm warbler
	Setophaga striata[1]	Blackpoll warbler
	Mniotilta varia[#]	Black-and-white warbler

Order	Scientific Name	Common name
	Setophaga ruticilla[†]	American redstart
	Protonotaria citrea[#]	Prothonotary warbler
	Seiurus aurocapilla	Ovenbird
	Parkesia noveboracensis	Northern waterthrush
	Parkesia motacilla[#]	Louisiana waterthrush
	Geothlypis philadelphia[2]	Mourning warbler
	Geothlypis trichas[†^]	Common yellowthroat
	Setophaga citrina[1]	Hooded warbler
	Cardellina pusilla	Wilson's warbler
	Cardellina canadensis[*]	Canada warbler
	Pipilo erythrophthalmus[†*]	Eastern towhee
	Spizella arborea	American tree sparrow
	Spizella passerina	Chipping sparrow
	Spizella pallida[1]	Clay-colored sparrow
	Spizella pusilla[^]	Field sparrow
	Pooecetes gramineus[^2]	Vesper sparrow
	Chondestes grammacus	Lark sparrow
	Passerculus sandwichensis[#^]	Savannah sparrow
	Ammodramus savannarum[†*^]	Grasshopper sparrow
	Ammodramus leconteii	Le Conte's sparrow
	Ammodramus nelsoni[*]	Nelson's sparrow
	Passerella iliaca	Fox sparrow
	Melospiza melodia[†]	Song sparrow
	Melospiza lincolnii	Lincoln's sparrow
	Melospiza georgiana[#]	Swamp sparrow
	Zonothrichia albicollis	White-throated sparrow
	Zonothrichia querula[*]	Harris's sparrow
	Zonothrichia leucophrys	White-crowned sparrow
	Junco hyemalis[#]	Dark-eyed junco
	Piranga rubra[†#]	Summer tanager
	Piranga olivacea[†]	Scarlet tanager
	Cardinalis cardinalis[†]	Northern cardinal
	Pheucticus ludovicianus[†]	Rose-breasted grosbeak
	Passerina caerulea[1]	Blue grosbeak
	Passerina cyanea[†*]	Indigo bunting
	Spiza americana[†*^]	Dickcissel
	Dolichonyx oryzivorus[^]	Bobolink
	Agelaius phoeniceus[†^]	Red-winged blackbird
	Sturnella magna[^]	Eastern meadowlark
	Sturnella neglecta[†^]	Western meadowlark
	Xanthocephalus xanthocephalus[†*]	Yellow-headed blackbird
	Euphagus carolinus[*]	Rusty blackbird
	Quiscalus quiscula[†^]	Common grackle
	Molothrus ater[†^]	Brown-headed cowbird
	Icterus spurius[†]	Orchard oriole
	Icterus galbula[†]	Northern oriole
	Carpodacus purpureus[2]	Purple finch
	Spinus pinus[#2]	Pine siskin
	Spinus tristis[†]	American goldfinch
	Passer domesticus[^1]	House sparrow

[a]Avian taxonomic nomenclature follows American Ornithologist's Union (1998); [†] Designates confirmed breeding status on WRP lands; [#] Nebraska Natural Legacy Project Tier I and II species (Schneider et al. 2005); [◊] Species of high conservation concern in U.S. Shorebird Conservation Plan (Brown et al. 2001); [•] Species of conservation concern in N.A. Waterbird Conservation Plan (Kushlan et al. 2002); [*] Watch list species in N.A. Landbird Conservation Plan (Rich et al. 2001); [^] Species in decline Bird Conservation Region 22 (Sauer et al. 2011); [1,2] Designates species observed on one (unique) and two (duplicate) occasions.