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Breeding Birds of the Upper Mississippi River Floodplain Forest: One Community in a Changing Forest, 1994 to 1997

Scientific Investigations Report 2020–5114

Version 1.1, February 2021

U.S. Department of the Interior

U.S. Geological Survey

Front cover. Photograph of a Prothonotary Warbler (*Protonotaria citrea*), taken by Tim Fox, Upper Midwest Environmental Sciences Center, U.S. Geological Survey.

Back cover. Photograph of the Upper Mississippi river floodplain forest, taken by Jules Black, Upper Midwest Environmental Sciences Center, U.S. Geological Survey.

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Eileen M. Kirsch

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square meter (m^2)	10.76	square foot (ft^2)
hectare (ha)	0.003861	square mile (mi^2)

Abbreviations

ANOSIM	analysis of similarity
CCA	canonical correspondence analyses
GIS	geographic information system
NMS	nonmetric multidimensional scaling
PCA	principal components analysis
UMR	Upper Mississippi River
UMRCC	Upper Mississippi River Conservation Committee

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Eileen M. Kirsch

Abstract

Floodplain forest on the upper Mississippi River (UMR), a unique habitat in the Midwest that is important for many bird species, has been reduced and is undergoing continued reduction and changes in structure and species diversity because of river engineering and invasive species. Hydrological changes are causing tree diversity to decline favoring *Acer saccharinum* (silver maple) and *Fraxinus pennsylvanica* (green ash). Invasive *Phalaris arundinacea* (reed canary grass, *Phalaris*) threatens tree regeneration, and recent *Agrilus planipennis* (emerald ash borer) arrival threatens to decimate the important ash component of the forest canopy. During the 1990s, virtually no information was available about breeding songbird species and abundances on the UMR floodplain forest from along many river miles and a broad range of forest situations (for example, mainland, island, edge, interior). From 1994 to 1997, we surveyed breeding birds and sampled vegetation at 391 random points on UMR floodplain forest along a latitudinal gradient from Red Wing, Minnesota, to Clinton, Iowa, to characterize bird assemblages and associations with gradients in forest structure at survey points (local scale) and land cover composition within a 200-meter radius of survey points (landscape scale).

Eighty-six bird species were detected during the study, but 28 species comprised 90 percent of all detections. Species that are typically associated with woodland edge or are tolerant of fragmentation were the most common: *Setophaga ruticilla* (American Redstart), *Troglodytes aedon* (House Wren), *Turdus migratorius* (American Robin), *Quiscalus quiscula* (Common Grackle), and *Vireo gilvus* (Warbling Vireo). Species typically associated with large forest patches—*Setophaga cerulea* (Cerulean Warbler), *Hylocichla mustelina* (Wood Thrush), and *Dryocopus pileatus* (Pileated Woodpecker)—were rare. Principal components analyses consistently described local habitat gradients related to canopy cover and *Phalaris* presence and described landscape gradients related to forest area and areas of open land cover types. However, nonmetric multidimensional scaling revealed no pattern in bird assemblages. Canonical correspondence analyses with local habitat variables for each year revealed that bird assemblages were affected by canopy cover, the presence of *Phalaris,* and the number of tree species. Four bird species were consistently associated with *Phalaris* presence or negatively with canopy cover, and no species were associated with the number of tree species variable. Although landscape variables were significantly related to the bird assemblage in canonical correspondence analyses, no bird species were consistently related to any landscape variable. These results indicate that there is one assemblage of forest birds on the UMR composed mainly of edge-tolerant species. Species associated with lower canopy cover and *Phalaris* presence may be favored to increase in abundance as canopy cover opens as trees die and *Phalaris* becomes more prevalent.

Introduction

Riparian areas support great diversity and abundance of avifauna, and breeding bird assemblages in floodplain forest can differ greatly from assemblages in uplands even in the mesic Midwest and Eastern United States (Stauffer and Best, 1980; Knutson and others, 1996). The upper Mississippi River (UMR) between St. Paul, Minnesota, and Cairo, Illinois (Fremling, 2005) is a Globally Important Bird Area recognized by the American Bird Conservancy (Chipley and others, 2003). Forest is the most prevalent semiterrestrial habitat on the UMR, and UMR floodplain forest is important to birds because this forest habitat forms a nearly contiguous connection between northern and southern forest ecoregions through the largely agricultural heart of the Midwest (Emlen and others, 1986; Grettenberger, 1991). Not only does bird species composition in UMR forests differ from adjacent upland forest, abundance of breeding birds is almost twice as high (Knutson and others, 1996; Knutson and others, 1999). Several bird species such as *Protonotaria citrea* (Prothonotary Warbler), *Setophaga ruticilla* (American Redstart), *Certhia americana* (Brown Creeper), and *Sphyrapicus varius* (Yellow-bellied Sapsucker) are more abundant in UMR floodplain forest compared to nearby upland forests (Knutson and others, 1996).

Floodplain forest on the UMR particularly in the upper impounded reach between St. Paul, Minn., and St. Louis, Missouri, has been greatly reduced and altered since the 1800s (Knutson and Klaas, 1998). Logging for fuel and building material and clearing for agriculture and town sites began with European settlement along the river. The UMR also has a long history of channel development, which culminated at the completion of the lock and dam system that created a 3-meter (m) navigation channel in the early 1940s. This lock and dam system permanently flooded one-third to one-half of the historical floodplain between the successive dams (Theiling, 1999). Knutson and Klaas (1998) estimate that floodplain forest on the UMR formerly occupied 50–70 percent of the floodplain before European settlement but now occupies 22–25 percent of the floodplain.

The lock and dam system and its management have changed the hydrology of the system (Sparks, 1995; Wlosinski and others, 1995) which continues to affect floodplain forest composition and structure. Although the *Acer saccharinum* (silver maple) community—which includes *Fraxinus pennsylvanica* (green ash), elm (primarily *Ulmus americana*), *Betula nigra* (river birch), and *Populus deltoides* (cottonwood) as codominants or part of the subcanopy and understory—is considered late successional in this system, dominance of silver maple has increased (Knutson and Klaas, 1998; Romano, 2010). Historically, *Quercus palustris* (pin), *Q. bicolor* (swamp white), *Q. rubra* (red) and *Q. velutina* (black) oaks were present on terrace and higher island areas, and river birch, cottonwoods and *Salix nigra* (black willow) occurred in many areas, but these species are declining (Yin and Nelson, 1995; Knutson and Klaas, 1998; Upper Mississippi River Conservation Committee [UMRCC], 2002; Romano, 2010). Mast trees can no longer survive on lower elevations because of elevated water levels, and pioneering species are declining because deposition of new alluvium is rare and even more rarely timed to coincide with seed dispersal (Yin and Nelson, 1995; Yin and others, 1997, Yin, 1999; Knutson and Klaas, 1998; UMRCC, 2002; Romano, 2010).

Furthermore, severe reduction in forest area and conversion to more grassland/savannah habitat is possible (Yin and others, 1997; Yin, 1999; UMRCC, 2002; Romano, 2010). Much of the forest canopy is composed of even-aged silver maple trees established in the 1930s and 1940s, and life expectancy of silver maple is about 130 years (Gabriel 2004). There are few saplings and older seedlings of silver maple and other species in the understory (Yin, 1999; UMRCC, 2002) because many floodplain species are intolerant or only moderately tolerant of shade. In some areas, large silver maples and cottonwoods have been blown down or have died, leaving gaps in the canopy (Fox and others, 2000; UMRCC 2002). Without management intervention an aggressive grass, *Phalaris arundinacea* (reed canary grass; hereafter *Phalaris*), often colonizes these gaps preventing germination and growth of any tree seedlings (Knutson and Klaas, 1998; UMRCC, 2002). As the even-aged silver maple forest senesces, *Phalaris* may take over the ground cover, further retarding tree regeneration, resulting in a savannah-like habitat and eventually to losses of large areas of forest. The recent invasion by emerald ash borer (*Agrilus planipennis*) in 2008 threatens to decimate the large component of ash in this forest as well, potentially allowing faster *Phalaris* invasion.

A large part of the UMR floodplain forest in Pools 4 through 14 (just northwest of Red Wing, Minn., to Cordova, Ill.) is in public ownership (U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and State lands). Resource managers are interested in maintaining floodplain forest to benefit breeding migratory songbirds. My field crew and I gathered data on features of the forest that are changing or are known to affect bird communities at two scales. On a local scale, I looked for relations to canopy cover, the relative amount of vertical vegetation structure, number of tree species present, and *Phalaris* presence because of the threat it poses to UMR floodplain forest. On a moderate landscape scale, I examined forest area, amounts of nonforested areas, and length of forest edge because some species are sensitive to patch size and proximity to forest edge (Ambuel and Temple, 1983; Robbins and others, 1989; Flaspohler and others, 2001). The literature about bird relations to forest patch size and proximity to edge is large, and there are many inconsistencies among studies even for the same species. Our aim was to explore relations of bird assemblages to variation in these features that may indicate possible changes in these assemblages as the forest changes. Breeding songbird and habitat surveys were done during the summers of 1994–1997, at a random sample of floodplain forest locations in several navigation pools of the UMR lock and dam system. This was the first broad-scale study on the UMR to document breeding bird assemblages in the full range of floodplain forest situations, including from closed to more open canopy areas and from small islands to large forest tracts.

Study Area

The UMR flows from north to south from Hastings, Minn., to St. Louis, Mo., through a 1.2- to 8-kilometer (km) wide floodplain, bounded throughout most of its length by 100–150 m bluffs. The floodplain forest in this reach is interspersed with other terrestrial and aquatic habitats to different degrees. Other terrestrial habitats in this reach include shrub thickets of willow (*Salix interior* and *S. nigra*) and cottonwood, emergent wetlands, wet meadows, and agricultural and urban areas. This study was done in Pools 8 and 13 from 1994 through 1997, Pool 4 from 1995 through 1997, and Pools 5, 7, and 12 in 1997 (fig. 1). "Pools" are delimited by locks and dams and named for the number of the downstream lock and dam. In general, the upper part of pools is a complex of floodplain forest and backwater sloughs, with relatively small ponds, lakes, and streams (Fremling and Claflin 1984). The lower part of pools typically has large open expanses of water, with scattered small wooded islands (Fremling and Claflin, 1984). The study reach encompasses approximately 444 river km (274 river miles), all within the Driftless Area physiographic region (Martin, 1965). As measured along the main channel, pool lengths are: Pool 4, 71 km; Pool 5, 24 km;

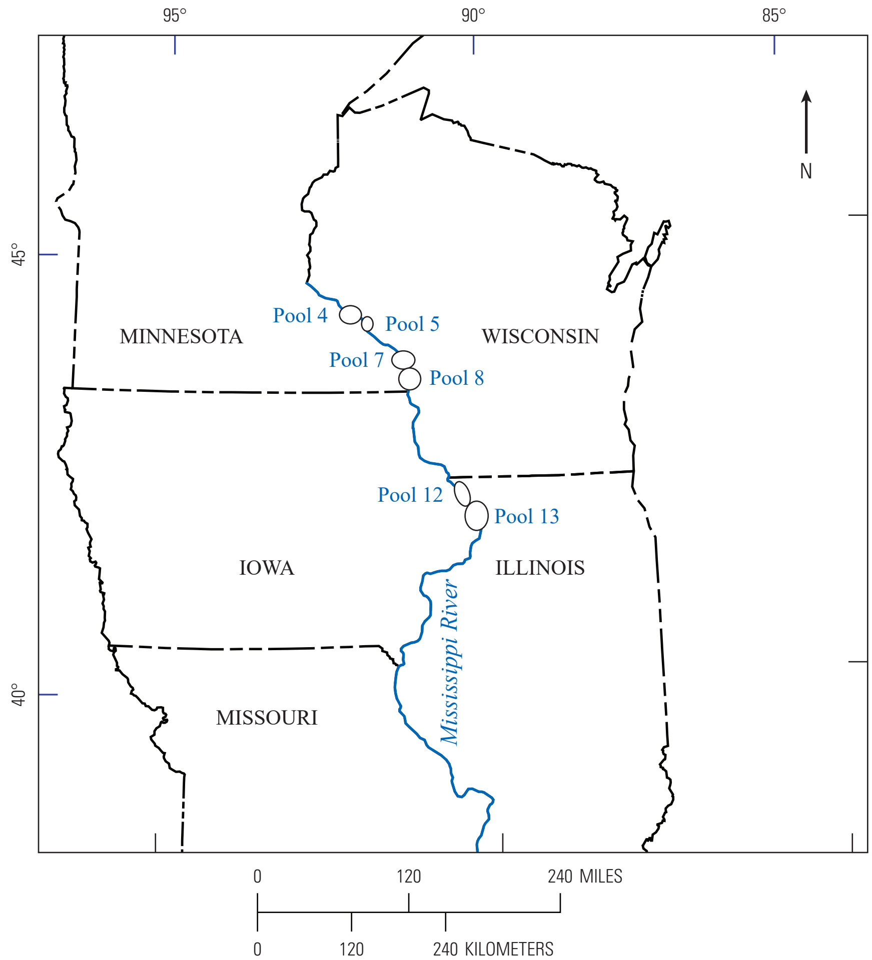

Figure 1. Location of pools on the upper Mississippi River where breeding birds in forest habitat were sampled, 1994 –1997.

Pool 7, 19 km; Pool 8, 37 km; Pool 12, 42 km; and Pool 13, 53 km. The study area is between 44°36’15” and 41°56”15” North latitudes.

Methods

The methods used in this study from 1994 to 1997 are described in this section of the report. Specifically, this section describes the selecting of sample points and methods for bird surveys, measuring habitat features, and data analyses. All data collected for this study is available in a companion data release (Kirsch, 2019).

Selecting Sample Points

Detailed geographic information system (GIS) coverages digitized from 1:15,000 color infrared aerial photos taken in 1989 were available for each pool (Upper Mississippi River Restoration Program, 2015), and survey points were randomly selected using Arc/Info (version 7). First a 50- by 50-m grid was overlaid on the GIS coverage of floodplain forest in each pool, numbers were assigned to each node, and nodes were selected with computerized random number generator. A random set of alternate points was also generated for each pool to replace original random points that were not accessible. Eighty-nine to 112 random points were placed in forest habitat in Pools 4, 8, and 13. The number of points in forest reflected the proportion of forest relative to other habitats sampled in a pool. Pools 8 and 13 were sampled in 1994, and Pools 4, 8, and 13 were sampled in 1995 and 1996. Pools 4, 8, and 13 are considered “Key Pools” by the Upper Mississippi River Restoration Program where extensive and intensive ecological monitoring has taken place since the late 1980s. To increase the spatial distribution of points beyond the Key Pools, in 1997 we sampled 33 to 41 random forest points in Pools 5, 7, and 12, and a random subset of 44 to 48 points from each of Pools 4, 8, and 13.

Occasionally random points were not accessible because of logistical constraints or the area was no longer considered suitable habitat for breeding birds (covered by water or washed away completely). When this occurred, either: (1) an alternate point, close to the original point was chosen from the list and map of alternate points, or (2) the survey was done as close as possible to the original random location. In both cases, the GIS point coverage was updated to reflect changes. We used Rockwell military grade global positioning system units and traditional orienteering techniques to navigate to and locate points (with approximately10 m accuracy).

Bird Surveys

We conducted 10-minute, 50-m fixed-radius point counts (Ralph and others, 1993) to survey birds during the breeding period between May 30 and July 10 in all years. We sampled the southernmost pool (13) first and then progressed to each pool in succession northward, finishing in Pool 4, sampling each point once a season (table 1). Surveys were done from 30 minutes before to 5 hours after local sunrise. We recorded all birds seen and heard within a 10-minute sampling period and mapped location data within and beyond 50 m from the observer (as determined by visual estimation) on sheets. Observers were experienced birders or field biologists with ornithological training. All underwent a week-long training period with the study director and were trained to estimate distances and to identify birds by sight and sound. Birds were noted as singing, calling, flying over, or detected visually (seen but not vocalizing), and we also recorded observation of pairs, nests, and fledglings. We recorded survey start time and weather conditions and did not do surveys when wind speed exceeded 25 km per hour, in moderate to heavy rain, or in thick fog.

Habitat Features — Local

We recorded vegetation cover using a *relevé* (Mueller-Dombois and Ellenberg, 1974) within a 10-m radius surrounding the survey point immediately after each bird survey. We estimated cover classes (less than 5 percent, 5–25 percent, 26–50 percent, 51–75 percent, 76–95 percent, and 95–100 percent) for tree canopy and ground cover. We enumerated the number of vegetation layers present (canopy, subcanopy, understory, and ground) but not all layers were present at all sites (tables 2 and 3). We identified up to three tree species with the most cover in the canopy and subcanopy each. We estimated canopy height (m) using a clinometer and visually estimated ground layer height (m). Beginning in 1995, the number of standing dead trees (snags) greater than 10-centimeter diameter at breast height within the 50-m radius were counted as seen from center of the survey circle.

Habitat features — Landscape

Within 200-meter buffers of each sample point, I estimated the area (square meters) of forest, marsh, grassland/forb, developed, agricultural, and open water habitats, and length of forest edge (m) extracted from 1:15,000 scale GIS coverages of study pools (Upper Mississippi River Restoration Program, 2015) using ARC/INFO (version 7, circa 1994). These variables and a summary of their values are presented in table 2. A 200-m radius was the largest possible buffer size around points to avoid including areas outside of the floodplain where no comparable GIS coverage existed in the late 1980s and early 1990s.

Data Analyses

Gradients in local and landscape habitat data were characterized separately with principal components analysis (PCA) using variance-covariance cross products matrices in CANOCO (Ter Braak and Smilauer 2012). I excluded the number of snags variable because its inclusion decreased the amount of variance accounted for by PCA and number of snags were not recorded in 1994. Cover class categories were converted to class midpoint values. I standardized variables before running PCA. Because this analysis was exploratory, I did not relate bird data to estimated axes. I used all seven

Table 1. Numbers of sites sampled by pool and year on the upper Mississippi River during the breeding season, 1994–1997.

[--, not surveyed]

	Year			
Pool	1994	1995	1996	1997
4	--	103	105	47
5	--	--	--	33
7	--	--	--	41
8	92	84	75	46
12	--	--	--	37
13	97	101	97	43
All	189	288	277	247

Table 2. Numeric local and landscape variables for upper Mississippi River forest points. 1994–1997. Local variables were measured in a 10-meter radius area at each bird survey point (n=1,000) immediately after the 10-minute point count survey was completed. All heights are in meters. Landscape variables were estimated from 1989 1:15,000 geographic information system coverages (Upper Mississippi River Restoration Program, 2015) of the upper Mississippi River within 200-meter radius (n=787) of bird survey point locations recorded with a military grade global positioning system (approximately 10-meter accuracy). All areas are 1,000 meters-squared and all lengths are in 1,000 meters.

[SE, standard error; Min., minimum; Max., maximum]

Type	Variable	Abbreviation	Mean	SE	Min.	Max.
Local	Number of tree species	#treesp	2.4	0.98	1	6
	Canopy height	Canopyht	24.4	6.88	5	50
Landscape	Forest area	Forest	77.1	29.3	0.88	125.7
	Grass/forb area	Grass	0.8	2.9	0	26.1
	Emergent wetland area	Marsh	17.5	17.20	0	122.7
	Area of residential or commercial development	Devel	1.3	5.93	0	62.5
	Area of agricultural development	Ag	1.0	5.53	0	58.3
	Forest edge	Forest edge	1.4	0.69	0	3.5

Table 3. Local categorical habitat variables from upper Mississippi River forest points, 1994–1997 (n=1,000 samples) and percent of these points falling with each category. Local variables were measured in a 10-meter radius area at each bird survey point immediately after the 10-minute point count survey was completed.

[For the PHAL variable, "0" indicates not present and "1" indicates present. For the remaining variables 0 = less than 5 percent cover, 1 = 6–25 percent cover, 2 = 26–50 percent cover, 3 = 51–75 percent cover, 4 = 76–95 percent cover and 5 = greater than 95 percent cover; -, no data]

Variable	Abbreviation	Category					
		0	1	2	3	4	5
Presence of reed canary grass in the ground vegetation layer	PHAL	78	22	-	-	-	-
Canopy cover	Cancovr	-	1	3	9	25	62
Ground cover	Grdcovr	3	7	8	12	13	57
Number vegetation layers (1 through 4 only)	Veglayer	-	0[a]	2	16	82	-

[a]Three observations.

landscape variables, which were also standardized before running PCA. I ran PCA and subsequent analyses for local and landscape data separately because the landscape variables were not available for many sample points in different years where location information was inaccurate because the global position system technology was not available to all field personnel the first 2 years or it could not get an accurate fix because of dense canopy. I estimated principal components for data from each year separately because we visited most sites more than 1 year.

I used nonmetric multidimensional scaling (NMS) in PRIMER-E (Clark and Gorley, 2006) to look for bird assemblage groupings of forest- and woodland-edge-associated species (51 of 86 species detected in surveys) independent of habitat variables. I square-root transformed the bird counts to down-weight abundant species slightly and ran NMS on Bray Curtis similarity values among samples. I evaluated stress of the two- and three-dimensional solutions by running NMS for 100 simulations, and PRIMER-E reported the number of runs that yielded the lowest stress value. The stress value is a measure of the amount of multidimensional variability among samples. The stress value reflects how well the ordination summarizes the observed distances among the samples. I used the entire dataset because I could examine the effects of year and pool on bird assemblages with analysis of similarities (ANOSIM) and depict sites by year and pool in the NMS plot. I examined whether bird assemblages differed among pools because pools occur along a latitudinal gradient which affects bird and tree species occurrence and abundance (Emlen and others, 1986; Burns and Honkala, 1990). In PRIMER-E, the ANOSIM test statistic rho indicates similarity among *a priori* defined groups where smaller values of rho indicate greater similarity and larger values of rho indicate greater differences among those a priori groups. To test if rho differs significantly (P-value less than 0.05) from zero, I used 1,000 random permutations of the data in PRIMER-E. However, a small and biologically trivial value of rho can be significant when power is large (Clark and Gorley, 2006).

I ran canonical correspondence analyses (CCA, in CANOCO; Ter Braak and Smilauer, 2012) to discern patterns in bird associations related to habitat gradients. Canonical correspondence analysis is a constrained ordination where only bird community structure related to measured habitat variables are considered. Because most sites within a pool were sampled more than 1 year, I ran CCAs for each year separately. While I did not expect relations of bird assemblages with any gradients to differ among years, CCA requires independent samples and the method does not account for repeated visits to virtually the same sites among years.

The CCA for local variables included canopy and ground cover, canopy height, number of tree species in the canopy and subcanopy combined, number of vegetation layers present (minimum 1, maximum 4), and *Phalaris* presence, which was coded as categories (1 = present, 0 = absent). For the cover variables, I used the midpoint values for each class, and for vegetation layers, I used the four classes as numeric values. I used all the landscape variables in landscape CCAs. I included northing coordinates with landscape variables because some species differ in abundance from north to south. The set of local and set of landscape habitat variables were not strongly correlated within each set (absolute value of Spearman correlation coefficients: local variables less than 0.41; landscape variables less than 0.44).

I ran CCA on species found in 10 percent or more of sites. Although CCA results are not affected much by rare species because their weights are very low (Ter Braak and Verdonschot, 1995; Greenacre, 2013), rare species are often depicted as outliers in biplots, which gives the impression of importance and compresses the plots making it more difficult to see relations of the more common species with habitat variables. Significance (P-value less than 0.05 for an F-ratio test) of the relation between the bird assemblage and response variables of the first constrained axis and the four calculated constrained axes (the default number of axes in CANOCO) was assessed using 500 unrestricted Monte Carlo permutations. Along with model output statistics in tables, I present biplot graphs using biplot scaling, focusing on response variable distances, which allows examination of positions of species and habitat variables relative to each other (Ter Braak and Smilauer, 2012). I assessed species relations with habitat vectors using t-value plots. These plots depict positive and negative Van Dobbin circles for a habitat variable, which corresponds to the ±2 t-value of that vector. Bird species are depicted as arrows. Significant relations of a species with a habitat vector are indicated with species arrows that are entirely contained in a Van Dobben circle (Ter Braak and Smilauer, 2012).

Breeding Birds of the Upper Mississippi River Floodplain Forest

This section of the report describes the results of the study regarding habitat features and bird community features. A discussion of the results also is presented.

Habitat Features

For the local habitat variables each year the first three PCA axes accounted for 64.4 to 67.4 percent of the total variation in each dataset. For the landscape habitat variables each year the first three PCA axes accounted for 63.0 to 67.6 percent of the total variance in each dataset. Regressions of some variables with principal components were particularly strong (regression coefficient greater than 0.5; table 4). Although regression coefficients of variables with principal components differed each year, plots of variable vectors maintained similar positions relative to one another for both variable sets (figs. 2*A*–*D*, 3*A*–*D*). For the local variables for all years, the first principal component described a gradient from greater canopy cover and no *Phalaris* to less canopy cover with *Phalaris* present. The second principal component described a gradient from greater number of tree species, greater ground cover and vegetation layers to less habitat complexity. For the landscape variables for all years the first principal component described a gradient from mostly forest to mostly open water or marsh and increased forest edge within 200 m of a site (fig. 3*A*–*D*). The second principal component described a gradient from more open water to more marsh cover within 200 m of a site. A high correlation of marsh with forest edge indicates that sites with marsh had complex forest edges and open water edges with forest were simple. The depiction of sample sites in the principal component plots of landscape variables demonstrate that our sites encompassed those that were mostly forest to sites with only small forest areas with different open land cover types in the remainder of the 200-m circle.

Bird Community Features

Eighty-six species were identified in 18,755 detections during the study (Kirsch, 2019). An average of about 19 individual birds (range 12.8 to 23.0 by pool and year) and 10 species of birds (range 8.8 to 12.4 by pool and year) were detected at survey points (table 5). Standard deviations reveal

Table 4. Explained variation and regression coefficients of local and landscape variables with principal components for data from each year (1994–1997) collected on survey sites in floodplain forest of the upper Mississippi River.

[PC, principal component]

Local variables	1994			1995			1996			1997		
	PC 1	PC 2	PC 3	PC1	PC 2	PC 3	PC 1	PC 2	PC 3	PC1	PC 2	PC 3
Cumulative explained variation	27.0	48.4	65.4	25.5	47.6	63.8	29.3	51.6	66.8	24.4	47.5	63.7
Canopy height (CANHT)	-0.500	-0.498	-0.114	0.364	-0.404	0.553	-0.229	-0.607	0.574	-0.512	0.289	0.538
Canopy cover (CANCOVR)	-0.574	-0.102	-0.623	0.485	-0.471	-0.349	0.308	-0.582	-0.374	-0.590	0.260	0.343
Ground cover (GRDCOVR)	0.755	-0.221	-0.272	-0.714	-0.432	0.093	-0.846	0.018	-0.021	0.209	-0.663	0.474
Number of vegetation layers (VEGLAYER)	0.397	-0.579	-0.465	-0.513	-0.512	0.318	-0.780	-0.159	0.110	-0.452	-0.674	-0.302
Phalaris presence (PHAL)	0.523	0.498	-0.272	-0.621	0.333	-0.301	-0.364	0.651	-0.184	0.681	-0.112	0.480
Number tree species (#treesp)	0.269	-0.626	0.501	-0.017	-0.621	-0.584	-0.394	-0.428	-0.628	-0.452	-0.571	0.141
Landscape Variables												
Cumulative explained variation	31.4	50.9	67.6	29.8	47.8	63.0	29.6	47.9	64.1	25.5	47.4	64.0
Area forest (Forest)	0.960	0.058	-0.248	-0.927	-0.253	0.018	-0.929	0.197	-0.159	0.912	0.144	-0.093
Area open water (Open water)	-0.771	-0.329	0.391	0.596	0.767	-0.045	0.653	-0.683	0.245	-0.782	-0.542	-0.064
Area grass/forb (Grass)	-0.107	0.714	0.161	0.048	-0.184	0.610	0.040	0.493	0.533	0.023	0.220	0.655
Area marsh (Marsh)	-0.675	0.086	-0.564	0.664	-0.588	-0.209	0.642	0.463	-0.425	0.320	0.798	-0.273
Area developed (Devel)	0.025	-0.044	0.627	0.003	0.158	0.734	0.041	0.273	0.739	-0.189	0.034	0.689
Area agriculture (Ag)	0.037	0.739	0.333	-0.153	0.064	-0.286	0.053	-0.060	-0.105	0.176	0.027	0.415
Length of forest edge (Forest edge)	-0.460	0.440	-0.323	0.635	-0.448	0.158	0.606	0.492	-0.153	-0.418	0.726	0.024

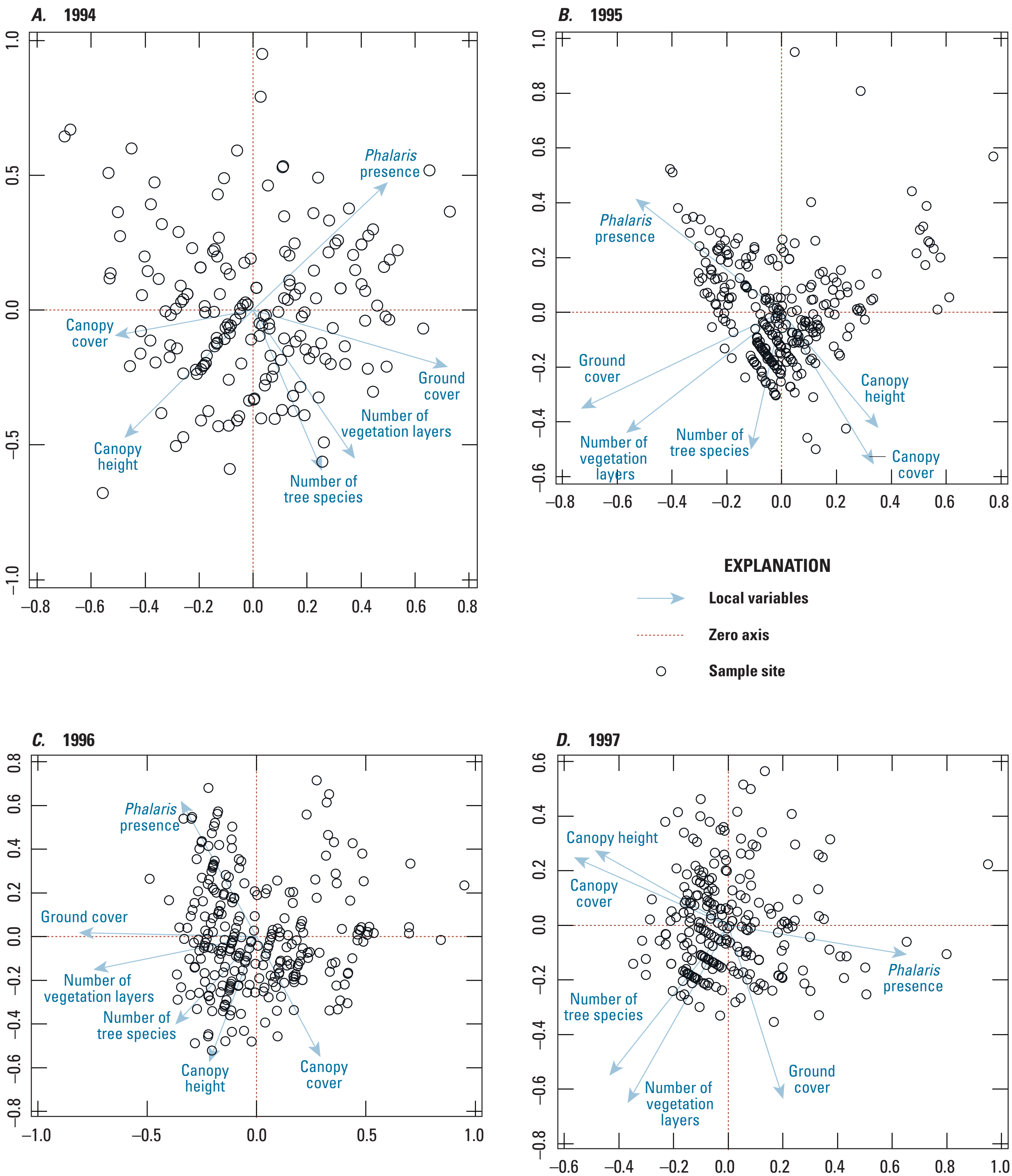

Figure 2. Plots of local habitat variable correlations with the first two principal components from data collected in floodplain forest sample sites on the upper Mississippi River from years *A*, 1994, *B*, 1995, *C*, 1996, and *D*, 1997. Open circles are sample sites plotted in ordination space. Variable names can be found in tables 1 and 2.

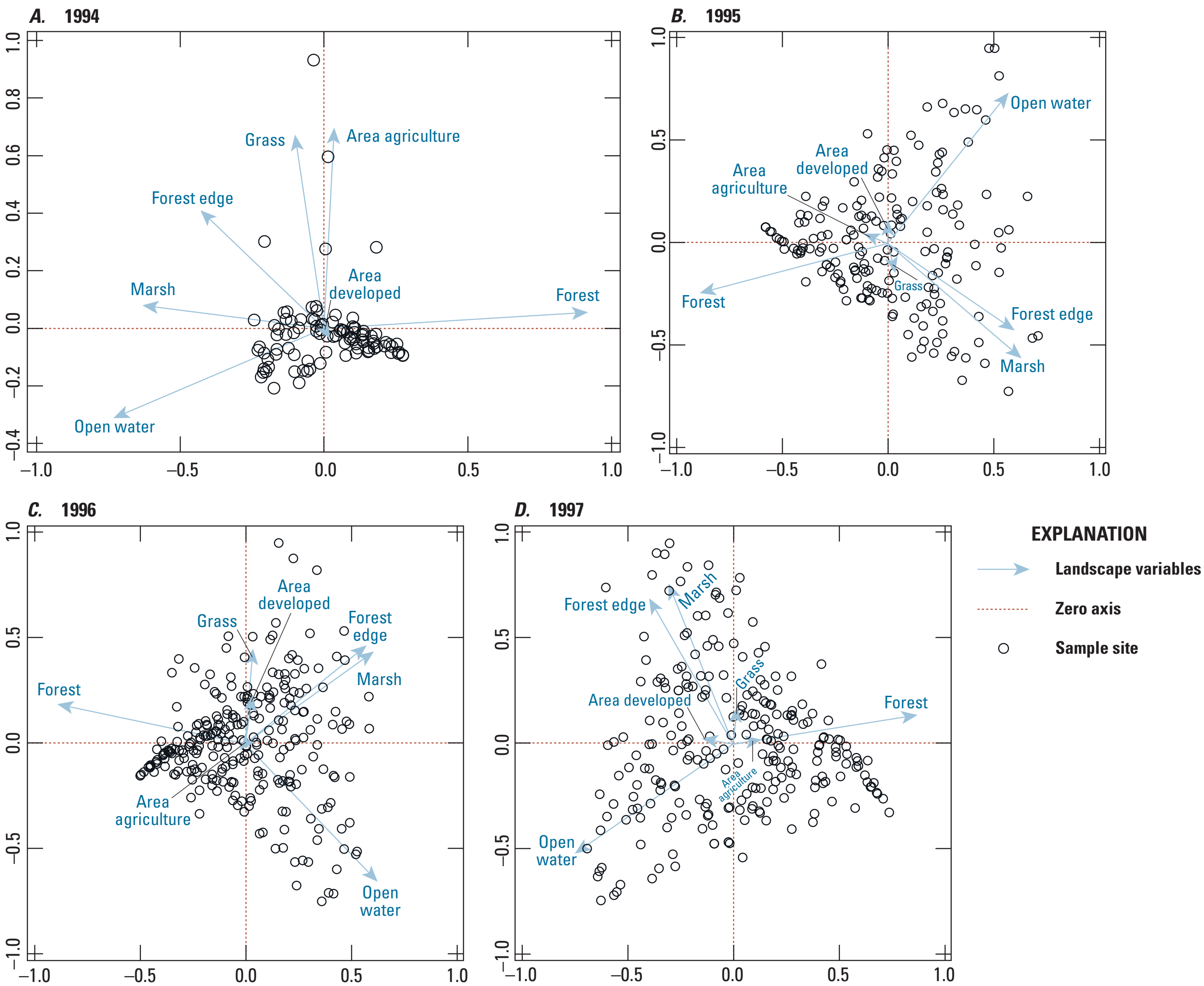

Figure 3. Plots of landscape habitat variable (estimated from 200-meter buffers around survey points) correlations with the first two principal components from data collected in floodplain forest sample sites on the upper Mississippi River from years *A*, 1994, *B*, 1995, *C*, 1996, and *D*, 1997. Open circles are sample sites plotted in ordination space. Variable names can be found in tables 1 and 2.

that numbers from individual surveys were highly variable and that estimates were consistently lower in 1997 than other survey years

American Redstarts dominated the forest bird community followed by *Troglodytes aedon* (House Wren), *Turdus migratorius* (American Robin), *Quiscalus quiscala* (Common Grackle), and *Vireo gilvus* (Warbling Vireo; table 6). Several species of concern for the U. S. Fish and Wildlife Service and Partners in Flight—*Setophaga cerulea* (Cerulean Warbler), *Hylocichla mustelina* (Wood Thrush), *Toxostoma rufum* (Brown Thrasher), *Empidonax virescens* (Acadian Flycatcher), *E. traillii* (Willow Flycatcher), *Melanerpes erythrocephalus* (Red-headed Woodpecker), and *Colaptes auratus* (Northern Flicker)—were rare, but Prothonotary Warbler was common. Because most of the floodplain forest is less than 100 m from any edge (Kirsch and Gray, 2017), we also occasionally detected species within 50 m that are not typically associated with forested habitats (for example, *Botaurus lentiginosus* [American Bittern], *Cistothorus platensis* [Sedge Wren], *Cistothorus palustris* [Marsh Wren], *Melospiza georgiana* [Swamp Sparrow], and *Charadrius vociferus* [Killdeer]).

Nonmetric multidimensional scaling revealed no distinct groupings of sites based on bird assemblages. Two-dimensional NMS minimum stress of 0.32 occurred on 54 percent of runs, and three-dimensional minimal stress was 0.25 and occurred in 51 percent of runs. Such high stress

Table 5. Average (standard deviation) number of individual birds and species detected within 50-meter radius at survey points in floodplain forest on the upper Mississippi River during the breeding season, 1994–1997.

[--, no surveys]

Pool	Number of detections per point				Number of species detected per point			
	Year				Year			
	1994	1995	1996	1997	1994	1995	1996	1997
4	--	20.2 (7.43)	17.5 (5.77)	14.8 (5.78)	--	11.0 (3.58)	9.5 (3.01)	9.4 (2.14)
5	--	--	--	14.5 (8.56)	--	--	--	8.3 (2.47)
7	--	--	--	12.8 (4.87)	--	--	--	8.6 (3.16)
8	18.2 (6.68)	23.0 (8.44)	21.2 (7.72)	13.9 (5.49)	11.0 (3.46)	12.4 (3.56)	10.9 (3.55)	8.8 (2.57)
12	--	--	--	17.0 (5.72)	--	--	--	9.9 (2.52)
13	17.7 (6.17)	21.4 (11.81)	22.5 (8.24)	17.1 (4.41)	10.3 (2.94)	11.2 (3.91)	11.7 (3.46)	11.0 (2.61)
All	17.9 (6.41)	21.5 (9.56)	20.3 (7.56)	15.0 (5.97)	10.6 (3.21)	11.5 (3.73)	10.6 (3.45)	9.4 (2.71)

Table 6. Frequency of occurrence and average number of detections per point (total number of detections out of 1,001) of bird species during the breeding season at points along the upper Mississippi River, 1994–1997 (n=1,001). Birds with a frequency of occurrence of less than 1 percent are not presented. Species codes are standard four-letter alpha codes used by the U.S. Geological Survey Bird Banding Lab.

Common name	Scientific name	Species alpha code	Percent frequency of occurrence	Average detections per point
American Redstart	*Setophaga ruticilla*	AMRE	78.9	2.87
House Wren	*Troglodytes aedon*	HOWR	68.0	1.31
American Robin	*Turdus migratorius*	AMRO	66.9	1.32
Common Grackle	*Quiscalus quiscula*	COGR	57.2	1.36
Warbling Vireo	*Vireo gilvus*	WAVI	56.2	0.96
Baltimore Oriole	*Icterus galbula*	BAOR	52.4	0.70
Song Sparrow	*Melospiza melodia*	SOSP	47.4	0.82
Great Crested Flycatcher	*Myiarchus crinitus*	GCFL	41.0	0.55
Downy Woodpecker	*Dryobates pubescens*	DOWO	37.7	0.44
Eastern Wood-Pewee	*Contopus virens*	EAWP	36.3	0.44
Prothonotary Warbler	*Protonotaria citrea*	PROW	34.1	0.53
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL	31.3	0.86
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	31.3	0.40
Brown-headed Cowbird	*Molothrus ater*	BHCO	29.1	0.38
Northern Cardinal	*Cardinalis cardinalis*	NOCA	27.4	0.35
Blue-gray Gnatcatcher	*Polioptila caerulea*	BGGN	26.1	0.32
Gray Catbird	*Dumetella carolinensis*	GRCA	24.6	0.32
Red-bellied Woodpecker	*Melanerpes carolinus*	RBWO	21.9	0.25
American Goldfinch	*Spinus tristis*	AMGO	21.3	0.29
Common Yellowthroat	*Geothlypis trichas*	COYE	21.1	0.31
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA	20.6	0.25
Yellow-throated Vireo	*Vireo flavifrons*	YTVI	20.2	0.23
Black-capped Chickadee	*Poecile atricapillus*	BCCH	18.5	0.27
Yellow Warbler	*Setophaga petechia*	YEWA	17.7	0.33
Red-eyed Vireo	*Vireo olivaceus*	REVI	14.3	0.15
Tree Swallow	*Tachycineta bicolor*	TRES	12.5	0.27
Blue Jay	*Cyanocitta cristata*	BLJA	11.5	0.15
Yellow-billed Cuckoo	*Coccyzus americanus*	YBCU	10.1	0.11
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	10.2	0.12
Mourning Dove	*Zenaida macroura*	MODO	9.6	0.13
Brown Creeper	*Certhia americana*	BRCR	9.7	0.11
Cedar Waxwing	*Bombycilla cedrorum*	CEDW	7.0	0.16
Indigo Bunting	*Passerina cyanea*	INBU	6.7	0.08
Northern Flicker	*Colaptes auratus*	NOFL	6.5	0.07
Wood Duck	*Aix sponsa*	WODU	6.0	0.12
Red-headed Woodpecker	*Melanerpes erythrocephalus*	RHWO	6.1	0.06
Hairy Woodpecker	*Dryobates villosus*	HAWO	5.7	0.06
American Crow	*Corvus brachyrhynchos*	AMCR	5.4	0.07
European Starling	*Sturnus vulgaris*	EUST	4.7	0.08
Wood Thrush	*Hylocichla mustelina*	WOTH	3.7	0.04

Table 6. Frequency of occurrence and average number of detections per point (total number of detections out of 1,001) of bird species during the breeding season at points along the upper Mississippi River, 1994–1997 (n=1,001). Birds with a frequency of occurrence of less than 1 percent are not presented. Species codes are standard four-letter alpha codes used by the U.S. Geological Survey Bird Banding Lab.—Continued

Common name	Scientific name	Species alpha code	Percent frequency of occurrence	Average detections per point
Tufted Titmouse	*Baeolophus bicolor*	ETTI	3.6	0.04
Least Flycatcher	*Empidonax minimus*	LEFL	3.0	0.04
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	2.6	0.03
Cerulean Warbler	*Setophaga cerulea*	CERW	2.5	0.03
Veery	*Catharus fuscescens*	VEER	1.9	0.03
Scarlet Tanager	*Piranga olivacea*	SCTA	1.2	0.01
Willow Flycatcher	*Empidonax traillii*	WIFL	1.2	0.01
Eastern Pheobe	*Sayornis phoebe*	EAPH	1.1	0.01
Eastern Kingbird	*Tyrannus tyrannus*	EAKI	1.0	0.01
Brown Thrasher	*Toxostoma rufum*	BRTH	0.9	0.01

indicated that the ordinations were largely arbitrary. Bird assemblages also did not differ by pool (ANOSIM rho = 0.115, P-value = 0.001) or by year (ANOSIM rho = 0.046, P-value = 0.001; fig. 4). Although these P-values are statistically significant, these ANOSIM rhos were so small they are biologically meaningless.

CCA revealed that the bird and local and landscape variable matrices were significantly related (table 7). The first three CCA axes using local habitat variables accounted for 4.8–6.7 percent of variation in bird data and the first three axes using landscape habitat variables accounted for 5.0–10.2 percent of the variation in the bird data.

Biplots from CCAs using the local habitat variables depicted centroids for most bird species either close to plot origins or shifting every year relative to habitat variable vectors (fig. 5). Variable relations to each other in biplots were similar for each year. Details of the strength of predictor variables are in table 8, but in general the strongest variables were *Phalaris* presence, canopy cover, and number of tree species. *Phalaris* presence and canopy cover vectors were negatively correlated in all biplots. The number of tree species was not related to this gradient except in the 1996 dataset where it was positively correlated with canopy cover. Few bird species were consistently associated with habitat vectors. *Geothlypis trichas* (Common Yellowthroat), *Melospiza melodia* (Song Sparrow), and *Agelaius phoeniceus* (Red-winged Blackbird) were associated with *Phalaris* presence three of the years. Song Sparrow (4 years) and *Setophaga petechia* (Yellow Warbler; 3 years) were negatively associated with greater canopy cover.

The biplots with landscape variables generally depicted the same gradient as the PCAs, from greater amounts of forest to greater amounts of open habitats (fig. 6). Again, most bird species centroids were close to the plot origin or shifted position relative to habitat vectors each year. No bird species were related to any habitat vector more than two of the years.

Discussion of Results

Floodplain forest sites of the UMR exhibited moderate gradients in local and landscape variables as indicated by PCA However, the NMS of bird assemblages at sites revealed no structure in the bird assemblage and subsequent ANOSIM tests also indicated no differences by pool or year. The CCAs for each year revealed that most bird species were not associated with habitat gradients, which indicated that virtually the same suite of bird species can be expected in any UMR forest location (from Pools 4–13). Abundance of a few species was associated with the presence of *Phalaris* or lower canopy cover but no species were associated with changes in landscape composition metrics. Although CCAs accounted for a small percent of variation in bird abundance, this is typical for noisy ecological response data (Ter Braak and Smilauer, 2012).

One apparent explanation for a lack of pattern is the dominance of only a few species of birds in this community. However, there are at least two possible and not mutually exclusive reasons for finding homogeneous (that is, similar) bird assemblages and no strong patterns of bird species abundance related to habitat gradients throughout floodplain forest on the UMR during 1994–1997: (1) fine spatial scale variation in forest structure and floristics, and (or) (2) dominance of forest edge. Not only is the forest dominated by silver maple-elm-ash forest type (Yin and others, 1997; Yin, 1999), relative dominance of tree species, tree species composition,

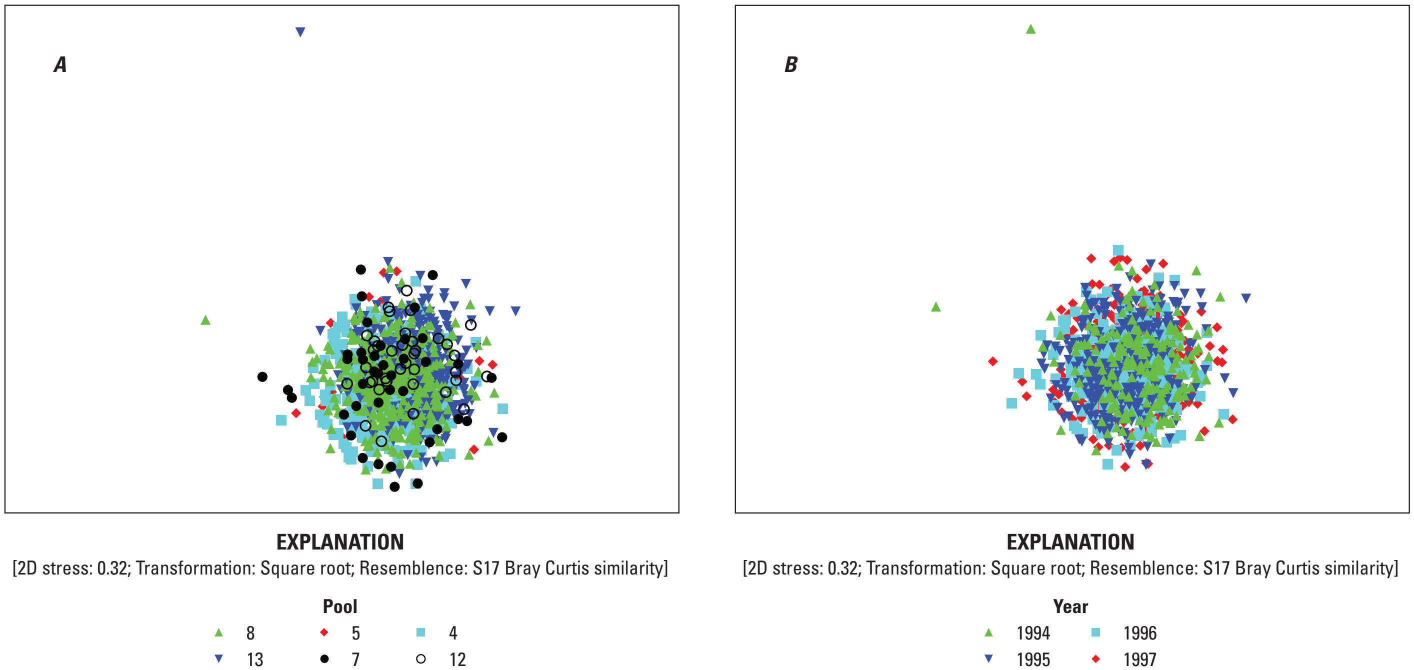

Figure 4. Two-dimensional (2D) plots of nonmetric multidimensional scaling results based on bird assemblages at sample points: *A*, points labeled by pool and *B*, points labeled by year.

Table 7. Eigenvalues and tests of significance from canonical correspondence analyses of habitat variables with bird assemblage composition, from data collected in floodplain forest of the upper Mississippi River 1994–1997.

[Data were analyzed using CANOCO (version 5; Ter Braak and Smilauer, 2012); --, not applicable]

Local variables	1994			1995			1996			1997		
	Value	F-ratio	P-value	Value	F-ratio	P-value	Value	F-ratio	P-value	Value	F-ratio	P-value
Sum all eigenvalues (4)	2.308	--	--	2.396	--	--	2.380	--	--	2.537	--	--
Sum all canonical eigenvalues	0.179	2.545	0.002	0.138	2.868	0.002	0.160	3.220	0.002	0.160	2.682	0.002
First eigenvalue	0.098	8.112	0.002	0.062	7.492	0.002	0.069	8.079	0.002	0.084	8.172	0.002
Landscape variables												
Sum all eigenvalues	2.302	--	--	2.293	--	--	2.293	--	--	2.529	--	--
Sum all canonical eigenvalues	0.304	1.674	0.016	0.248	2.601	0.002	0.176	2.662	0.002	0.177	2.197	0.002
First eigenvalue	0.125	50322	0.040	0.075	5.215	0.010	0.098	11.49	0.002	0.070	6.657	0.002

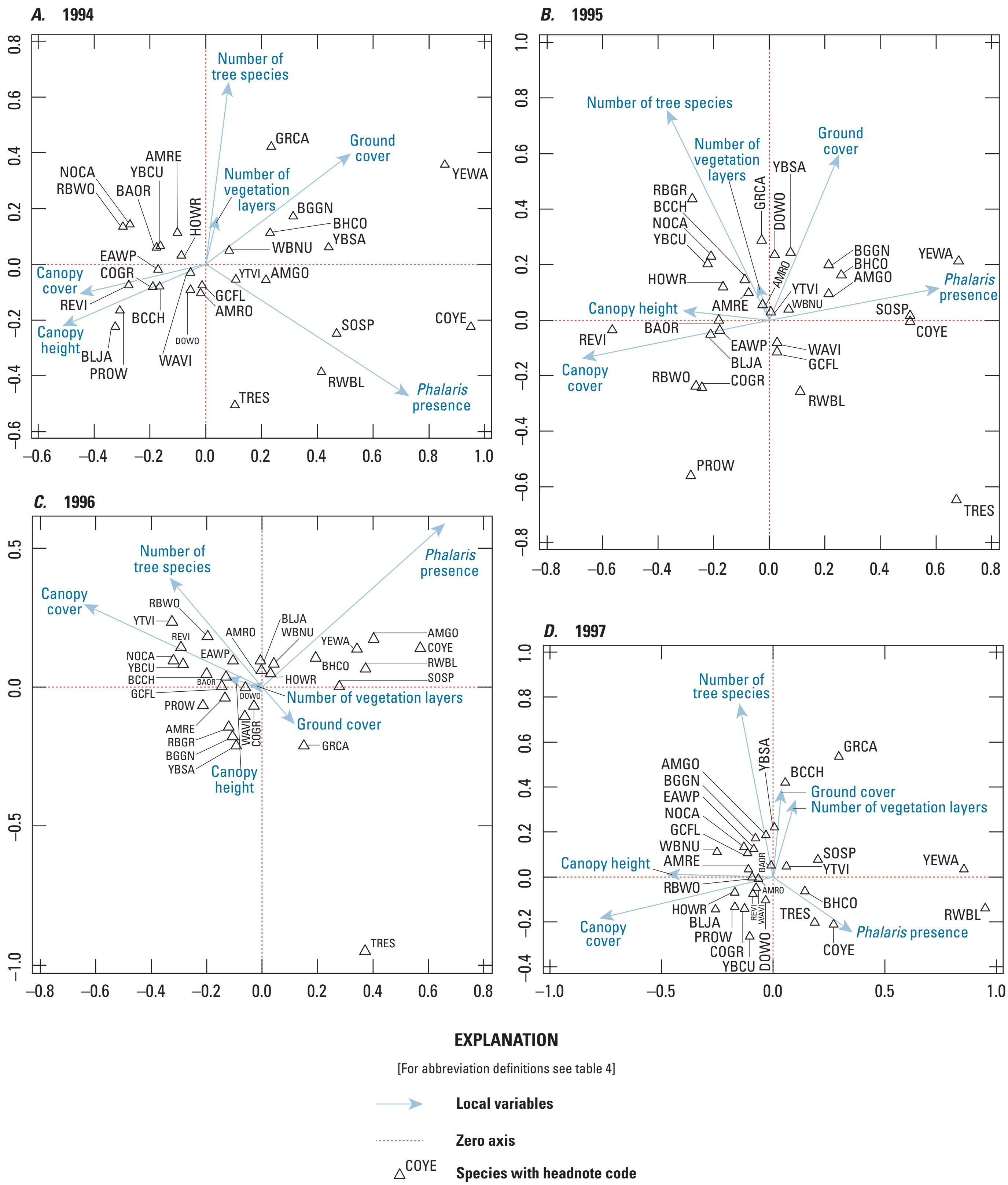

Figure 5. Canonical correspondence analysis biplots (axes 1 and 2) of bird species as related to local habitat variables at sample sites in floodplain forest along the upper Mississippi River from years *A*, 1994, *B*, 1995, *C*, 1996, and *D*, 1997. Variable names can be found in table 1. Bird species codes are found in table 4.

Table 8. Summary results for canonical correspondence analyses of bird community responses to local and landscape variables from data collected in floodplain forest of the upper Mississippi River, 1994–1997.

[Canonical coefficients are listed for each variable for the first three axes. Data were analyzed using CANOCO (version 5; Ter Braak and Smilauer, 2012). Pool 13 was the reference variable and set to 0 in analyses.]

Local Variables	1994			1995			1996			1997		
	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3
Eigenvalues	0.098	0.039	0.017	0.062	0.039	0.013	0.069	0.032	0.027	0.084	0.025	0.019
Cumulative percent variance in response explained	4.3	5.9	6.7	2.6	4.2	4.8	2.9	4.3	5.4	3.3	4.3	5.1
Canopy height (Canopyht)	-0.329	-0.316	-0.311	-0.181	0.064	0.568	-0.001	0.069	-0.317	-0.397	0.023	0.344
Canopy cover (Cancovr)	-0.314	0.044	-0.715	-0.541	-0.239	-0.677	-0.565	0.395	-0.420	-0.742	-0.284	-0.421
Ground cover (Grdcovr)	0.311	0.452	-0.669	0.246	0.525	0.030	0.143	-0.575	0.372	-0.116	0.384	-0.796
Number of vegetation layers (Veglayer)	-0.040	-0.013	0.009	-0.158	-0.027	-0.334	-0.188	0.159	-0.215	0.222	0.098	-0.194
Phalaris presence (PHAL)	0.613	-0.600	-0.211	0.488	0.009	-0.480	0.592	0.838	-0.201	0.275	-0.317	-0.106
Number tree species (#treesp)	0.094	0.615	0.028	-0.328	0.767	-0.024	-0.363	0.512	0.792	-0.124	0.758	0.390
Landscape Variables												
Eigenvalues	0.125	0.070	0.040	0.075	0.064	0.039	0.098	0.025	0.019	0.070	0.029	0.027
Cumulative percent variance in response explained	5.4	8.5	10.2	3.3	6.1	7.8	4.3	5.7	6.2	2.8	3.9	5.0
Area forest (Forest)	1.280	2.528	-2.534	-1.199	-2.690	-1.915	-0.128	0.180	-0.821	-0.022	-0.588	-1.031
Area open water (Open water)	1.717	1.910	-2.581	-1.411	-1.506	-2.276	0.344	0.360	-1.425	0.712	-0.621	-0.945
Area grass/forbs (Grass)	0.362	-0.003	-0.328	-0.099	-0.194	-0.137	0.038	0.058	-0.195	-0.079	0.434	0.051
Area marsh (Marsh)	1.254	0.756	-0.833	-2.119	-1.113	-1.083	0.989	-0.139	-0.204	0.393	-0.602	0.346
Area developed (Devel)	0.723	0.470	-0.601	-0.209	-0.439	-0.351	-0.021	0.022	0.052	-0.050	0.199	-0.226
Area agriculture (Ag)	0.101	0.200	-0.132	-0.363	-0.588	-0.606	0.100	0.234	0.087	-0.038	-0.271	0.157
Length of forest edge (Forest edge)	-0.150	0.736	-0.701	0.232	-0.158	0.032	-0.332	0.467	-0.247	0.254	-0.077	-0.414
Northing	-0.422	-0.603	-0.538	-0.260	-0.149	-0.521	0.151	-0.825	-0.428	0.391	0.668	-0.004

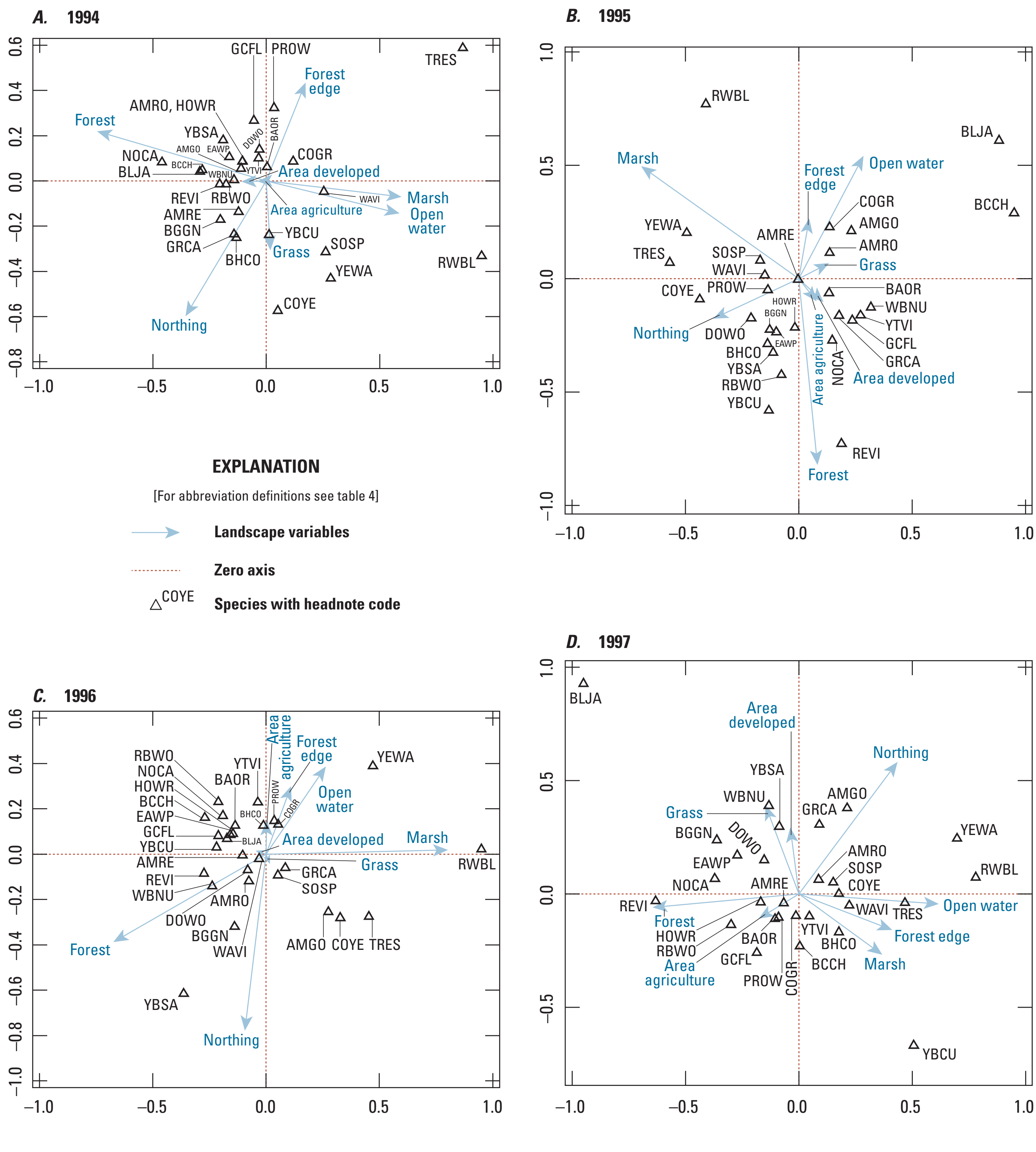

Figure 6. Canonical correspondence analysis biplots (axes 1 and 2) of bird species as related to landscape habitat variables within a 200-meter buffer of floodplain forest sample sites on the upper Mississippi River from years *A*, 1994, *B*, 1995, *C*, 1996, and *D*, 1997. Bird species codes are found in table 4.

tree height, basal area, and vertical stratification and species composition of the subcanopy through the ground cover layers can shift within relatively small spatial scales (U.S. Army Corps of Engineers, St. Paul and Rock Island Districts, written commun., 2014, forest inventory data for Pools 4 through 14). These fine-scale differences in forest structure and floristics are because of (1) slight differences in flood regimes caused by elevation changes over small distances, as well as a gradual differences in water levels within a pool from the upstream dam to the downstream dam (Knutson and Klaas, 1998); (2) presence and distance from canopy openings from trees that have died or fallen over (Fox and others, 2000); and (3) past management history that affects forest age (for example, logging or agriculture; Turner and others, 2004). Furthermore, edge is a dominant feature of floodplain forest of the UMR because of the degree to which forest is interspersed with other land cover types. Although some sample points fell hundreds of meters within forest, 90 percent sampling points were less than or equal to 100 m from an adjacent habitat. Kirsch and Gray (2017) report that only 4 or 5 percent of floodplain forest in Pools 4, 8, and 13 is farther than 100 m from open water, emergent wetland, or wet meadow.

Knutson (1995) and Knutson and Klaas (1997) sampled in Pools 6–10, including many of the same places I and my crew sampled, but Knutson (1995) concluded that some bird species were associated with three types of forest plots that were defined in cluster analysis of her suite of habitat and landscape variables. However, the sampling scheme used in those studies targeted areas with different amounts forest and then placed a grid of points in each “stand.” My PCA results indicated no clear groupings of sites based on habitat variables. Knutson and Klaas (1997) examined responses to a major flood in 1993, but the songbirds and woodpecker species they detected, and their abundances, are similar to ours.

Unlike Emlen and others (1986) and Miller and others (2004), the effect of latitude on the bird assemblage was not clear and no species were associated with the northing vector (table 8). The effect of latitude on species distribution and abundance was demonstrated in Emlen and others (1986) along the Mississippi River from St. Paul, Minn., to Cairo, Ill., and in Miller and others (2004) along the Wisconsin River from Stevens Point to Blue River, Wisconsin. Emlen and others (1986) found that while habitat structure was similar among their 12 plots, abundance of bird species that have more northern or southern distributions differed accordingly with latitude. Miller and others (2004) found that northing (in other words, latitudinal position), distance from the Mississippi River, and the abundance of flood tolerant trees (for example, silver maple) were highly correlated and affected bird assemblages. In my analyses, northing was an important variable associated with the bird assemblage and usually orthogonal to the gradient from mostly forest to mostly open habitat area gradient. However, no bird species were associated with northing, perhaps because I sampled a narrower range of latitudes represented by the Pools 4–13, versus the range sampled in Emlen and others (1986). Because northing was highly correlated with two other variables in Miller and others (2004), species responses to each of these variables could not be distinguished. However, in a separate analysis they found that species richness and abundance increase with lower latitudes (Miller and others, 2004).

The breeding bird species assemblage of the UMR floodplain forest is unique in the upper Midwest and differs from those described in two other major midwestern rivers, the Wisconsin and Missouri Rivers. Although Thogmartin and others (2009) report on only the most common mature floodplain forest species and Cerulean Warbler and *Buteo lineatus* (Red-shouldered Hawk) because they are species of concern, their most common species were House Wren, *Cardinalis cardinalis* (Northern Cardinal), *Melanerpes carolinus (*Red-bellied Woodpecker), and *Pheucticus ludovicianus* (Rose-breasted Grosbeak). The most common species in Wisconsin River forests were Song Sparrow, *Poecile atricapillus (*Black-capped Chickadee), *Contopus virens* (Eastern Wood-Pewee), *Vireo olivaceus* (Red-eyed Vireo), and *Myiarchus crinitus* (Great Crested Flycatcher; Miller and others, 2004).

Changes to floodplain forest on the UMR are expected to continue if contemporary hydrological conditions remain in place with no active management. Tree diversity will continue to decrease; trees will become old and senesce, then fall or blow down; and regeneration will not be strong because of *Phalaris* invasion in forest openings and edges (Knutson and Klaas; 1998, UMRCC, 2002; Thomsen and others, 2012). The invasion of emerald ash borer on the UMR will only hasten these changes. Furthermore, as canopy cover decreases *Phalaris* is likely to increase.

Although the bird assemblage seems homogeneous, CCAs indicated four bird species were associated with relatively more open canopy and (or) *Phalaris* presence. These species would likely increase in abundance if UMR floodplain forests follow the predicted trajectory of losing trees and *Phalaris* preventing regeneration. Kirsch and Gray (2017) reported that *Phalaris* cover and not canopy cover was most associated with slight differences in bird assemblage composition on Pools 3 and 4, with increased *Phalaris* cover associated with greater abundance of Common Yellowthroat, Black-capped Chickadee, and Rose-breasted Grosbeak and lower abundance of American Redstart, Great Crested Flycatcher, and *Icterus galbula* (Baltimore Oriole). Abundance and occurrence of species averse to dense ground cover such as Prothonotary Warbler (Petit, 2020) and American Robins (Vanderhoff and others, 2020) may also decline. Red-eyed Vireos and Red-bellied Woodpeckers may also decline because they are associated with greater canopy cover (Cimprich and others, 2020; Shackelford and others, 2020). Species of management concern such as Acadian Flycatcher, Cerulean Warbler, and Red-shouldered Hawk would become even more scarce as forest cover and the number of mature trees decreases (Allen and others, 2020; Buehler and others, 2020; Dykstra and others, 2020). Figure 7 provides a simple summary of these potential shifts in species abundance.

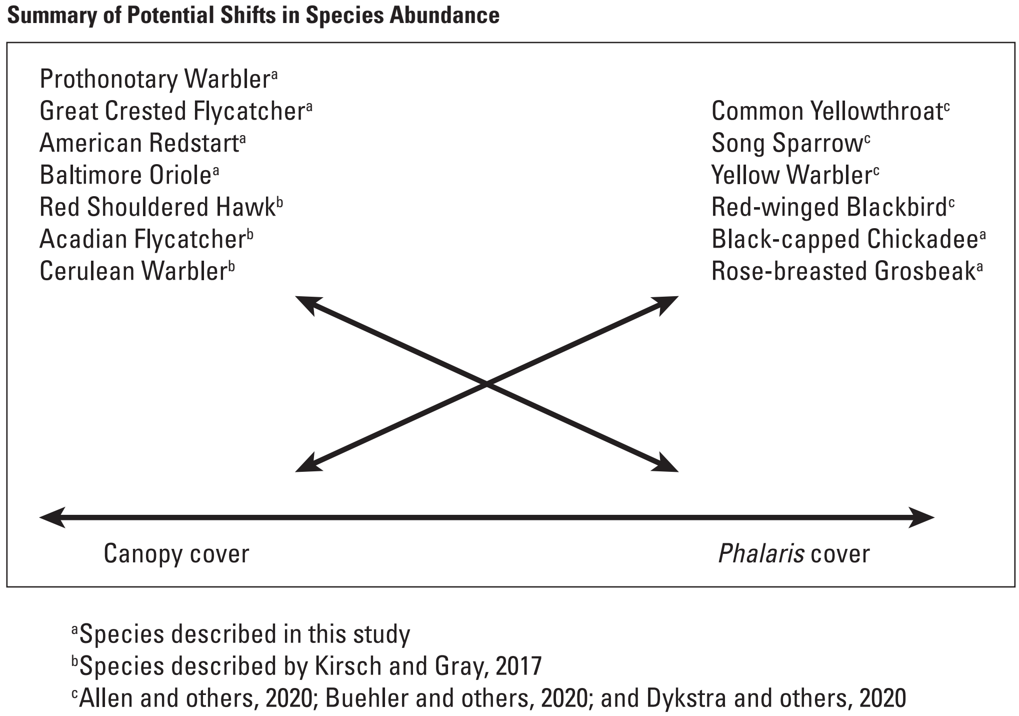

Figure 7. Potential trends in species abundance associated with a habitat gradient between closed canopy forests with no *Phalaris* to open canopy areas with greater *Phalaris* cover. Species associated with this gradient are described in upper Mississippi River floodplain forest by, *A,* this study and, *B,* Kirsch and Gray (2017). *C,* Other species that potentially could respond to this gradient are based on known habitat preferences reported in the literature (Allen and others 2020, Buehler and others 2020, Dykstra and others 2020).

Change in the bird assemblage may be gradual as the results from associations with canopy cover presence of *Phalaris* gradient indicate. Relative and absolute abundance of individual species will reflect the degree to which required nesting substrate and cover changes. Even common open woodland birds like Warbling Vireo (Gardali and Ballard, 2020) and Eastern Wood-Pewee (Watt and others, 2020) along with Baltimore Oriole would eventually become less numerous as the number of trees declines. Alternatively, Red-headed Woodpecker (Frei and others, 2020) and other woodpeckers tolerant of open canopies and forest fragmentation—*Dryobates pubescens* (Downy Woodpecker) and Northern Flicker (Jackson and Ouellet, 2020; Wiebe and Moore, 2020)—may increase while there is an abundance of standing snags.

The UMR from Pool 4 to 13 provides approximately 226,500 ha of floodplain forest habitat. Management to encourage mixed age forests or a mosaic of forest ages could improve diversity in habitat structure along spatial and temporal gradients. Planting species likely to survive the current water levels at sites and selective harvesting may improve habitat in some areas. However, intensive management may be necessary to provide habitat and ensure propagation for pioneering and mast producing tree species. This will be very costly to do at a large scale without the aid of flow management that mimics a historical flow regime. One less costly option would be to use dredge spoil to elevate some sites (change the hydrology, and in some scenarios, bury *Phalaris*) or deposit dredge spoil next to forest areas, to provide mineral soil required for establishment of pioneering species but also ideal for germination of other tree species. In canopy openings caused naturally or by timber management, getting ahead of *Phalaris* establishment will be the challenge (Knutson and Klaas, 1997; UMRCC, 2002; Thomsen and others, 2012). Unfortunately, arrival of emerald ash borer on the UMR in 2008, and the insipient devastation of ash tree component of this forest will only make management to maintain adequate forest cover and prevent rapid spread of *Phalaris* more difficult.

The extensive UMR floodplain forest habitat supports greater densities of breeding birds than in upland forests (Knutson and others, 1996). Even though the bird assemblage is very similar throughout UMR floodplain forests surveyed in this study, it is unique in the upper Midwest. If a large amount of this habitat is substantially changed in the next 50 years, although changes may be gradual and almost imperceptible at a local scale, the effects will be tremendous.

Summary

Floodplain forest in the upper Mississippi River (UMR) supports an abundant, diverse and unique assemblage of breeding birds. Riverine systems in the eastern half of the United States support greater breeding bird abundance and diversity than adjacent uplands and perhaps especially so in areas dominated by agricultural land use. An average of 19 detections and 10 species per survey (50-meter radius, 0.79 hectares) in this study from 1994 to 1997 demonstrated high abundance and species richness on a per point basis. However, rarity of forest interior species and a community dominated by forest edge and generalist species seems a common theme for linear and naturally fragmented riverine forest.

UMR floodplain forest was severely reduced when the navigation system was completed in the early 1940s. Although a great deal still exists, this forest is less diverse than before the 1900s. Silver maple has become overdominant as oaks and pioneering species have become less frequent. The forest is mature and still responding to hydrological changes. The sustainability and health of UMR floodplain forest is also threated by invasive species, especially *Phalaris* and emerald ash borer.

The breeding bird assemblage is dominated by a few species and is essentially homogeneous. That is, the chances of finding a particular species in a particular location is probably related more to its overall abundance than to any habitat feature present or absent at the site. Nonetheless, a few open woodland tolerant birds seem to be associated with habitat variables that may increase as forests are thinned and lost because of continuing threats. These data are important as a historical record of the bird assemblage and abundances of breeding birds and of forest habitat conditions during the 1990s.

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