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Avian Distribution Patterns Across the Cache River Floodplain, Arkansas

by James S. Wakeley, Thomas H. Roberts

September 1994 – Final Report

Wetlands Research Program

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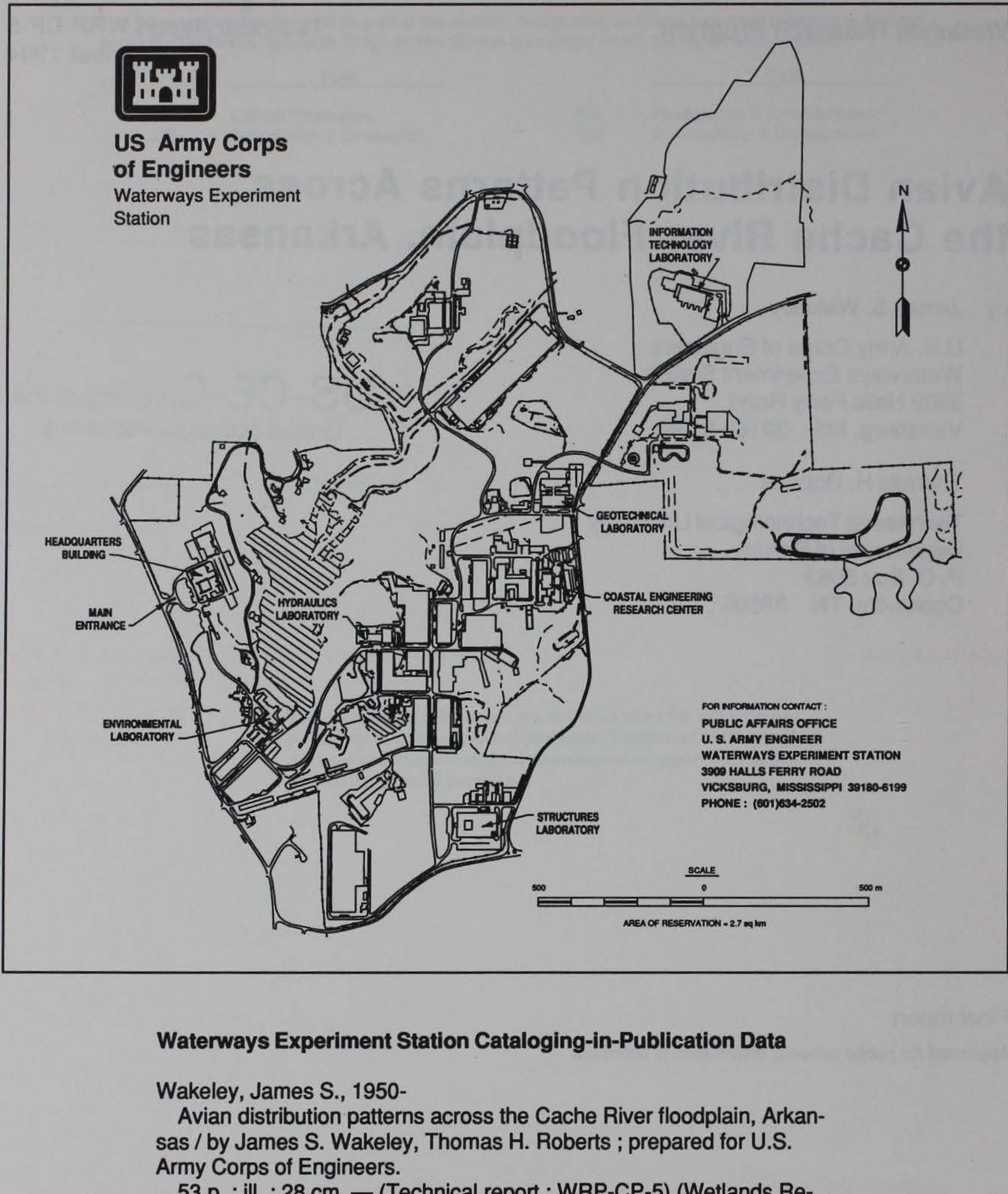

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Corps of Engineers Research Report Summary, Sep. 1994

Birds in Bottomland Hardwoods

Avian Distribution Patterns Across the Cache River Floodplain, Arkansas (WRP-CP-5)

ISSUE:

Southeastern bottomland hardwood wetlands provide habitat for a diverse community of wild birds, but relatively little is known of factors affecting their distribution and abundance. Information is needed to facilitate development of functional evaluation models for forested wetlands.

RESEARCH:

Birds were sampled in summer and winter along two transects across the broad, forested floodplain of the Cache River in Arkansas. Objectives were to compare bird diversity and abundance among floodplain forest zones, identify habitat characteristics affecting the distribution of both breeding and wintering species, and determine effects of the hydrology gradient on habitat use by birds.

SUMMARY:

Forest zones differed in structural characteristics, flooding regime, and use by birds. The tupelo/baldcypress zone, in particular, provided habitat unlike that in the higher oak-dominated zones and supported a number of bird species that were much less abundant elsewhere. To maintain diversity of bottomland bird communities, it is important to maintain intact systems including all elevational forest zones.

AVAILABILITY OF REPORT:

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About the Authors:

Dr. James S. Wakeley is a research wildlife biologist, and Dr. Thomas H. Roberts was a wildlife biologist at the WES Environmental Laboratory. Dr. Roberts now works at the Tennessee Technological University. Point of contact is Dr. Wakeley at (601) 634-3702.

Contents

Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Critical Processes Task Area of the Wetlands Research Program (WRP). The work was performed under Work Unit 32807, "Field Investigations of Wetlands," for which Ms. Barbara A. Kleiss, Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES) was Technical Manager. Mr. John Bellinger (CECW-PO) was the WRP Technical Monitor for this work.

Mr. Dave Mathis (CERD-C) was the WRP Coordinator at the Directorate of Research and Development, HQUSACE; Dr. William L. Klesch (CECW-PO) served as the WRP Technical Monitor's Representative; Dr. Russell F. Theriot, WES, was the Wetlands Program Manager; and Mr. Jack Davis, WES, was the Task Area Manager.

This work was performed at WES by Drs. James S. Wakeley and Thomas H. Roberts, Wetlands Branch, EL, under the general supervision of Mr. E. Carl Brown, Chief, Wetlands Branch; Dr. Conrad J. Kirby, Chief, Ecological Research Division; and Dr. John W. Keeley, Director, EL. Dr. Roberts currently works for Tennessee Technological University, Cookeville, TN.

We thank Mr. R. Dan Smith, WES, who, along with several field assistants, sampled vegetation along the transects and performed the TWINSPAN and DECORANA analysis. Dr. L. Jean O'Neil, WES, helped plan the Cache River wildlife and vegetation sampling. Mr. Robert P. Ford of the Tennessee Conservation League assisted in bird surveys. Suggestions on the manuscript were provided by Mr. Robert P. Ford, Dr. Paul B. Hamel (U.S. Department of Agriculture Forest Service, Southern Hardwoods Laboratory), Dr. K. C. Jensen, WES, Dr. O'Neil, and Mr. Smith.

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1 Introduction

More than half of all wetland acreage existing in the conterminous United States in the 1780s has been converted to nonwetland, primarily because of drainage for agriculture (Dahl 1990). Losses of southeastern forested wetlands have continued to the present day; between 1940 and 1980, more than 2 million hectares were converted, mostly since 1960 (Abernethy and Turner 1987). Wetlands today are recognized as important for the many beneficial functions they perform, including flood abatement, water quality improvement, food chain support, and the provision of habitat for both plants and animals (e.g., Sather and Smith 1984; Wilkinson et al. 1987).

Bottomland hardwood swamps are complex mosaics of plant and animal associations, primarily because of spatial variations in the frequency, duration, and timing of flooding (Klimas, Martin, and Teaford 1981; Wharton et al. 1982). Bottomland hardwood wetlands in the Southeast support a rich avifauna, particularly in the higher elevation, oak-dominated zones (Wharton et al. 1982); densities of breeding and wintering birds are often higher than in nearby upland forests (Dickson 1978a; James and Neal 1986). Wintering populations in some areas can be particularly high, as the resident population is swelled by the arrival of migrants from northern breeding areas (Dickson 1978b).

As bottomland hardwood forests continue to disappear and remaining tracts become smaller and more fragmented, there is increasing concern for the many species that depend upon these systems (Harris and Gosselink 1990). To aid in management of existing tracts or in mitigation for further losses, recent attempts have been made to develop evaluation methods for bottomland hardwood wetlands, including their wildlife habitat functions (e.g., Schroeder, O'Neil, and Pullen, in preparation).[1] However, development of these methods has been hampered by the scarcity of literature on wildlife use of these systems.

The purpose of this study was to investigate factors affecting the distribution of both breeding and wintering birds across an extensive bottomland

[1] For another example, see Adamus, P. R., Smith, R. D., and Miur, T. (1990). "Manual for assessment of bottomland hardwood functions — Operational draft," Unpublished Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

hardwood forest subject to frequent winter and early spring flooding. Specific objectives were to compare avian abundance and species richness among floodplain vegetation zones, identify habitat variables related to the distribution of both breeding and wintering species, and examine the influence of hydrologic gradients on habitat use by birds.

2 Methods

Study Area

Study sites were located in the broad floodplain of the Cache River in Woodruff County, Arkansas (Figure 1). The floodplain in this area is covered by an extensive tract (>30 km^2) of relatively mature and continuous bottomland hardwood forest, forming a forested corridor >2 km wide within a predominantly agricultural landscape. Study sites were located within the Arkansas Game and Fish Commission's Rex Hancock Wildlife Management Area and the Cache River National Wildlife Refuge.

Vegetation in the study area was distributed in elevational zones typical of southeastern bottomland hardwood swamps (Wharton et al. 1982). Water tupelo (*Nyssa aquatica*) and baldcypress (*Taxodium distichum*) were the dominant trees in the lowest portions of the floodplain. Proceeding up the gradient, the next zone was dominated by overcup oak (*Quercus lyrata*), water hickory (*Carya aquatica*), and green ash (*Fraxinus pennsylvanica*), followed by areas dominated by Nuttall oak (*Q. nuttallii*), willow oak (*Q. phellos*), and sweetgum (*Liquidambar styraciflua*). Sweetgum, water oak (*Q. nigra*), and pignut hickory (*C. ovalis*) dominated at the highest elevations in the floodplain. Formerly forested, adjacent uplands had been converted to agriculture. Major crops in the area included soybeans, rice, and cotton. The study area receives approximately 130 cm of rainfall annually, with the highest monthly totals from November to May (U.S. Department of Agriculture (USDA) Soil Conservation Service 1968). Water levels in the Cache River commonly fluctuate >3 m annually.

The study sites consisted of two belt transects (A and C) that originated approximately 40 m inside the woods at the agricultural edge of the forested floodplain and extended to the Cache River. Transects A and C were 1,620 and 1,740 m long, respectively, and were separated by approximately 8 river km. Each transect was 160 m wide and was divided into two parallel lines of bird sampling plots (A1, A2, C1, and C2) (Figure 2). Each plot measured 80 by 60 m (0.48 ha). There were a total of 110 plots, 52 along transect A and 58 along transect C. Elevational profiles of each transect are shown in Figure 3. At both transect locations, floodplain forest on the opposite bank of the river was ≥1 km wide. Therefore, transects were situated within the

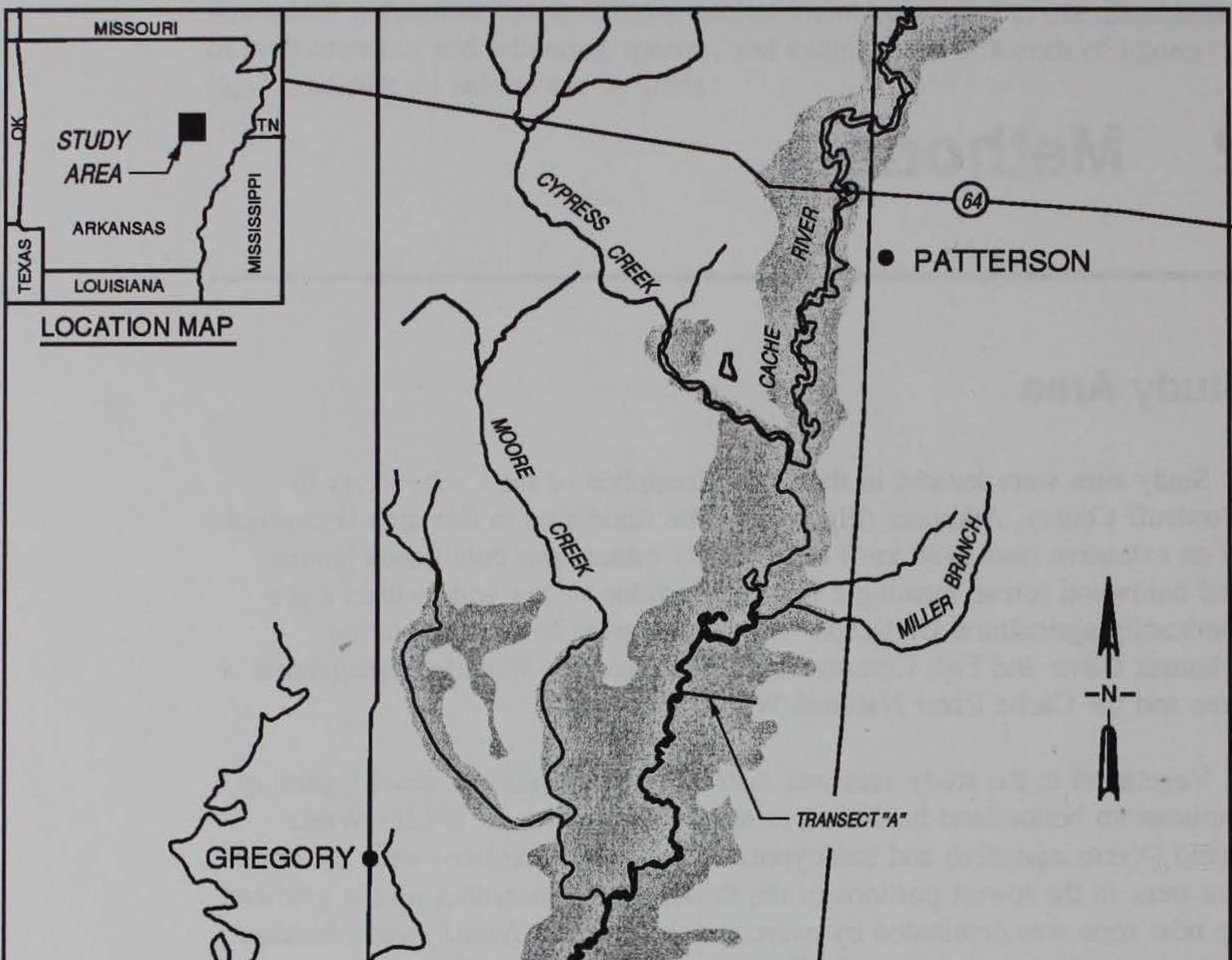

Figure 1. Cache River study areas

Transect A

Plot	A1	A2	Plot
2	O	O	27
3	S	S	28
4	N	N	29
5	O	O	30
6	O	N	31
7	O	O	32
8	O	S	33
9	S	S	34
10	S	S	35
11	S	N	36
12	N	N	37
13	N	O	38
14	O	N	39
15	O	N	40
16	O	N	41
17	O	O	42
18	N	N	43
19	N	N	44
20	N	N	45
21	N	O	46
22	O	O	47
23	T	O	48
24	T	N	49
25	T	N	50
26	N	T	51
		N	52
		T	53

Transect C

Plot	C1	C2	Plot
73	O	O	102
74	N	O	103
75	O	O	104
76	O	N	105
77	O	O	106
78	O	T	107
79	O	T	108
80	O	O	109
81	O	O	110
82	O	O	111
83	O	O	112
84	O	O	113
85	O	O	114
86	O	N	115
87	O	O	116
88	O	O	117
89	O	O	118
90	O	O	119
91	O	O	120
92	O	O	121
93	O	O	122
94	O	O	123
95	O	O	124
96	O	N	125
97	T	O	126
98	T	O	127
99	T	O	128
100	T	T	129
101	T	T	130

Figure 2. Arrangement of bird sampling plots on transects A and C. Transects extended from floodplain forest edge (top) to Cache River (bottom). Letters indicate TWINSPAN classification of cover types: T = tupelo/baldcypress (TUPELO), O = overcup oak/water hickory (OVERCUP), N = Nuttall oak/willow oak/sweetgum (NUTTALL), and S = sweetgum/water oak/pignut hickory (SWEETGUM)

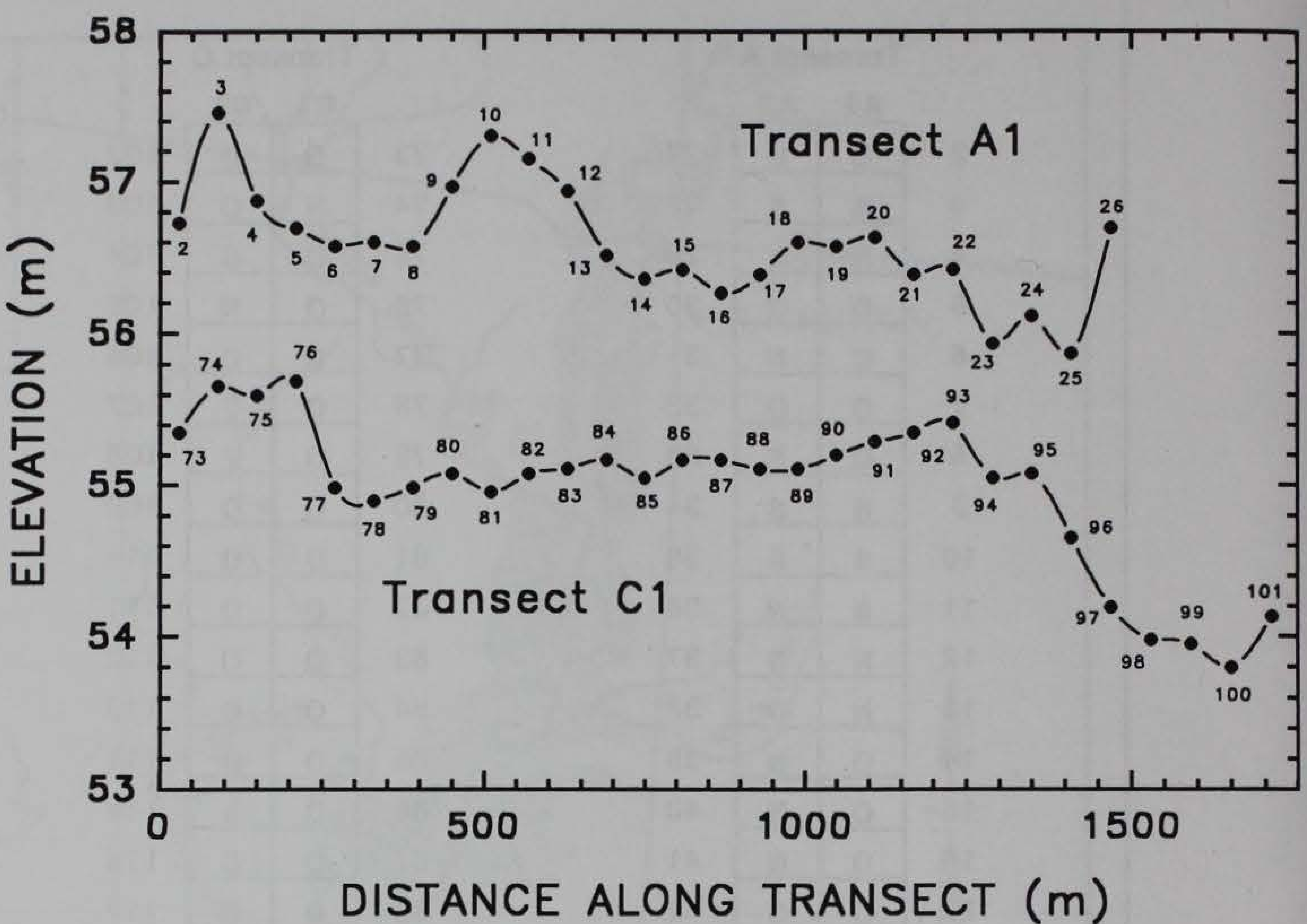

Figure 3. Elevation profiles of surveyed transect lines A1 and C1

extensive hardwood wetland, and only the head of each transect was near a large, agricultural opening. Additional information about the study area was presented by Kleiss (1993).

Habitat Sampling

Habitat characteristics (Table 1) were measured within 0.04-ha circular sampling plots centrally located within each bird sampling plot. All trees (≥5 cm dbh) on each plot were identified and their diameters measured. Standing dead trees (snags) were counted in the tree plot. Canopy heights were measured with a clinometer; average canopy height was equal to the mean height of the five tallest trees in the plot. Saplings (<5 cm dbh and ≥1.4 m tall) were identified and counted within two 0.004-ha subplots, and seedlings (<1.4 m tall) within two 0.0004-ha subplots. Canopy vines were defined as those reaching the average canopy height and were counted in the tree plot. Subcanopy vines were tallied in the sapling plots. Percent cover of herbaceous plants was estimated visually in the two seedling plots. Number of species in the ground layer equaled the total number of seedling and herbaceous species identified in the seedling plots.

Estimates of percent cover of leaf litter, woody debris, and woody cover in various strata (0 to 1, 1 to 3, 3 to 5, 5 to 15, and >15 m) were based on point-intercept sampling at 40 sampling points; 10 points were located at 1-m intervals along each of four lines starting at plot center and extending in the cardinal compass directions. Vegetation above 3 m was sampled with a sighting tube containing cross hairs. Most of the habitat measurements were made in May 1988, although trees, snags, saplings, and vines were tallied on some plots in the fall of 1987. Presence of flood waters on sampling plots was noted during bird surveys.

Total percent vegetative cover, an index to total volume of vegetation, was calculated by summing percent cover estimates for the five strata (Willson 1974). Foliage height diversity, expressing the evenness with which vegetation was distributed among layers, was calculated with the Shannon-Wiener formula using percent cover estimates for each stratum (MacArthur and MacArthur 1961).

The computer program TWINSPAN (Hill 1979a) was used to classify plots into cover types based on species composition and dominance (basal area) of trees. Four major community types were identified, which corresponded with the vegetation zones described previously. The types were designated as (a) tupelo/baldcypress (14 plots), (b) overcup oak/water hickory (63 plots), (c) Nuttall oak/willow oak/sweetgum (25 plots), and (d) sweetgum/water oak/pignut hickory (8 plots) (Figure 2). Hereafter, cover types are designated by their principal dominant: TUPELO, OVERCUP, NUTTALL, and SWEETGUM, respectively.

Three variables (Table 1) provided information on the hydrologic regime of study plots. First, elevation at plot center (ELEV) was determined by standard surveying techniques. Only one line of plots along each transect (A1 and C1) was surveyed. Second, a link-node surface-water model for the Cache River (Walton et al., in preparation) was used to estimate the average annual cumulative flooding duration (DURFLOOD) at each plot. The model used continuous water-level data available at U.S. Geological Survey gauges located upstream at Patterson and downstream at Cotton Plant, Arkansas, and was calibrated using water-level measurements made during water year 1990 (1 October 1989 to 30 September 1990). The model was used to calculate flooding durations on surveyed plots during the 1988, 1989, 1990, and 1991 water years. Third, detrended correspondence analysis (DECORANA) (Hill 1979b) was used to ordinate plots based on the same data matrix used by TWINSPAN. The first DECORANA axis ordered plots from those dominated by baldcypress and tupelo to those dominated by white oak (*Q. alba*), pignut hickory, water oak, and sweetgum. This axis was interpreted as a moisture gradient, and plot scores (DECWET) were used in subsequent analyses.

Bird Sampling

Breeding season

The bird sampling procedure was similar to that for a fixed-width transect (e.g., Franzreb 1981; Wakeley 1987) except that each transect was divided into a series of rectangular plots (n = 110) (Figure 2). Birds were sampled by walking each line of plots (A1, A2, C1, and C2) and recording all individuals seen or heard. Each line was sampled twice, once each by two independent observers. Sampling was done between sunrise and approximately 10:00 a.m. or when activity noticeably declined. The goal was to identify most of the species and individuals present on a plot. Studies of point counts in forested habitats (Scott and Ramsey 1981; Smith et al. 1993) have shown that a count duration of 15 min or more is needed to detect most of the species and individuals that would eventually be detected in a count lasting 30 min or more. Therefore, each plot was sampled for about 15 min, occasionally spending longer to confirm some detections visually. Sampling dates (first count from 3-12 April and second from 10-27 May 1988) were scheduled to coincide with early and late nesting periods.

Wide-ranging species (e.g., hawks, crows, and waterfowl) were not included in statistical analyses. The remaining species were categorized as breeding residents or migrants according to James and Neal (1986). Two guilds of birds were identified based on observed use of major habitat layers. For all species observed and categorized by habitat layer at least 10 times, those with >50 percent of detections within 3 m of the ground surface were designated as understory users; those with >50 percent of samples above 3 m were designated canopy users. Neotropical migratory species were identified from Finch (1991).

Winter

Winter birds were sampled only along transect A (lines A1 and A2) (Figure 2). Each plot (n = 52) was sampled twice by the same observer, first during 17-20 December 1988 and second during 8-11 March 1989. In December, flood waters up to 1.2 m deep completely covered more than half the plots and partially covered many others. Flooding was even more extensive during March, and some sampling had to be done by boat.

Data Analysis

Habitat characteristics

Analysis of variance was used to identify differences in means of individual habitat variables among cover types. Analysis of variance was performed on ranked data whenever variables were not normally distributed. For all tests, significance was determined at $P < 0.05$. Unless specified otherwise, all analyses were performed with PC/SAS software (SAS Institute Inc., Cary, NC).

Avian community and guild analyses

The number of bird species (RICHNESS) and average number of individuals (ABUNDANCE) detected per plot were calculated for the entire avian community, breeding residents, migrants, understory users, and canopy users. Analysis of variance was used to detect differences in RICHNESS or ABUNDANCE among cover types, and multiple regression was used to examine relationships between community or guild attributes and individual habitat variables.

Problems because of collinearity in the regression analyses were reduced by examining a correlation matrix of habitat variables and eliminating one of each pair of highly correlated ($|r| \geq 0.50$) variables. Variables dropped from regression analyses are indicated in Table 1. In addition, the derived variables FHD (foliage height diversity) and PCVC (total percent vegetation cover) were highly correlated with one or more of their constituent variables COVER0 to COVER15. FHD and PCVC were used in community-level analyses, and measured percent cover values for each stratum were used in analyses involving guilds and individual species. Ground-layer variables measured during May (e.g., HERBCOV and LITTER) were not used in analyses of winter bird distributions because subsequent flooding had reduced ground-layer vegetation and rearranged leaf litter and woody debris.

DECWET, which was based on tree species composition and basal area, was used in the regression analyses as the sole index to the hydrologic regime of sampling plots. Unlike ELEV and DURFLOOD, which were available only for surveyed plots, DECWET values could be calculated for all plots. Furthermore, DECWET was highly correlated ($P < 0.001$) with both ELEV ($r = 0.94$ for transect A and $r = 0.87$ for transect C) and DURFLOOD ($r = -0.93$ for transect A and $r = -0.87$ for transect C).

Avian species analyses

Analysis of variance was used to test for differences in abundance of individual bird species among cover types. Stepwise logistic regression was then used to identify habitat variables affecting the distribution of birds based on presence or absence of the species on each plot. Breeding season regressions were performed for all species present on ≥20 plots; winter regressions were done for species present on ≥10 plots. Finally, canonical correspondence analysis (Ter Braak 1986; Ter Braak and Prentice 1988; Palmer 1993) was used to investigate the distribution of selected breeding bird species across the Cache River floodplain in relation to major habitat gradients. Canonical correspondence is a form of multivariate direct gradient analysis that examines relationships between a number of species and environmental variables. Stepwise selection was used to identify habitat variables that had the most influence on bird species distributions. Only breeding resident species detected on ≥20 plots were considered; there was no evidence that winter bird distributions were affected by the moisture gradient.

3 Results

Habitat Characteristics

Most habitat variables were not normally distributed (Table 2), necessitating nonparametric methods of analysis. Analysis of variance by ranks (Kruskall-Wallis tests) identified many variables that differed among cover types ($P < 0.05$) (Table 3). Most of the differences were between the TUPELO type and one or more of the other three cover types.

Tupelo/baldcypress stands contained higher densities of large trees than did other stands, but had lower densities of vines and seedlings, lower percent cover values in all layers, and fewer plant species of all types. In general, water tupelo and baldcypress stands were characterized by large trees with relatively little understory development. Stands were flooded an average of nearly 300 days per year (Table 3), preventing establishment of all but a few highly flood-tolerant species.

Plots of the SWEETGUM cover type, occupying the highest parts of the floodplain, had significantly greater coverage of herbaceous plants, more ground-layer species, and greater coverage of leaf litter and woody debris than did OVERCUP plots, which were more regularly flooded. SWEETGUM plots also had higher densities of foliage in the 5- to 15- and >15-m strata.

Avian Community and Guild Analysis

Approximately 3,000 individuals of 59 species of birds were detected during spring sampling, excluding a small number of hawks (Falconiformes), crows (*Corvus brachyrhynchos*), and waterfowl (Anatidae). Forty-three species were breeding residents, and sixteen were migrants (Appendix A). For those species that were observed ≥10 times, 9 were classified as primarily understory users and 16 as primarily canopy users. Carolina chickadees and tufted titmice used both layers about equally and were not included in either guild (see Appendix A for scientific names of bird species used in the analysis). More than 1,000 individuals of 24 species were detected during winter sampling, not counting nearly 600 mallards (*Anas platyrhynchos*), 30 Canada geese

(*Branta canadensis*), and 11 wood ducks (*Aix sponsa*) observed on flooded plots (Appendix B).

Community and guild distributions across cover types

During the breeding season, there were no overall differences in abundance of birds across cover types, although TUPELO plots contained significantly ($P < 0.05$) fewer species than did NUTTALL plots (Table 4). Among breeding residents, there were no differences in species richness among cover types, but OVERCUP stands contained fewer individuals than TUPELO stands. The TUPELO cover type supported fewer migrants, both in terms of number of species and number of individuals.

Average species richness of the understory guild was lowest in TUPELO stands because of the relative scarcity of ground-level cover. Analysis of variance indicated that the abundance of understory users also differed across cover types, but the Tukey tests failed to identify any significant differences between pairs of cover types. There were also fewer species of canopy users in TUPELO stands than in OVERCUP or NUTTALL stands. However, there were no differences in overall abundance of canopy users across cover types (Table 4).

For winter samples, there were no differences ($P > 0.05$) in number of species or overall abundance among cover types (Table 4). Furthermore, there were no differences (Mann-Whitney tests, $P > 0.05$) in either richness or abundance between sampling dates (December versus March), even though flooding was much more extensive in March. Thus, there was no evidence that birds abandoned the floodplain during highest water.

Relationships between community measures and habitat variables

During the breeding season, total foliage density (PCVC) was directly related to overall bird species richness, richness of breeding species, and both richness and abundance of migrants (Table 5). Mean canopy height (MEANCAN) had a positive influence on abundance of all birds and species richness of migrants. The wetness gradient (reflected by DECWET) affected the abundance of both breeding residents and migrants, but in opposite directions. Other habitat variables that helped to explain the richness or abundance of residents, migrants, or all birds included DEBRIS, SEEDLDEN, TREDEN5, and FHD.

Both species richness and overall abundance of the canopy-using guild were positively related to the amount of foliage in the 3- to 5-m stratum and to mean canopy height (Table 5). Understory bird species richness was related to position on the moisture gradient (DECWET) and the density of saplings. Abundance of understory species was also related to DECWET and to the coverage of herbaceous plants. Despite the number of significant relationships between bird community measures and habitat variables, model R^2 values were generally low ($R^2 \leq 0.18$).

For winter samples, both the number of species and number of individuals were positively related to FHD (Table 5), despite the fact that leaves were off at that time. Species richness was also negatively related to canopy height. For the canopy-using guild, none of the measured habitat variables was related to species richness, and only the density of large vines was related to the abundance of that guild.

Avian Species Analysis

Bird species distributions across cover types

Twelve species of birds showed significant differences in abundance among cover types during the breeding season (Table 6). Of those, all but the gray-cheeked thrush and Swainson's thrush were breeding residents.

Chimney swifts, eastern wood pewees, great crested flycatchers, and prothonotary warblers were all more abundant in the TUPELO community than in one or more of the higher elevation cover types (Table 6). In contrast, gray-cheeked thrushes, ovenbirds, and Swainson's thrushes were more common in the SWEETGUM community than in one or more of the wetter types. Acadian flycatchers were more abundant in NUTTALL than in OVERCUP areas; cardinals were more common in OVERCUP than in TUPELO; indigo buntings were more numerous in OVERCUP than in TUPELO or NUTTALL stands; northern parulas were more abundant in NUTTALL than in SWEETGUM; and summer tanagers were more common in OVERCUP and NUTTALL than in TUPELO communities.

During winter, there were no significant differences in the abundance of each species across cover types (Table 6).

Relationships between bird species and habitat variables

Logistic regressions relating the presence or absence of bird species to habitat variables revealed significant relationships for 19 species during the breeding season (Table 7). Position on the moisture gradient (DECWET) affected the presence of five species; chimney swifts, great crested flycatchers, prothonotary warblers, and white-breasted nuthatches were more abundant on wetter plots, whereas Swainson's thrush was more abundant on drier plots. Distributions of five species (blue-gray gnatcatcher, brown-headed cowbird, Carolina wren, northern waterthrush, and yellow-billed cuckoo) were not associated with any of the habitat variables.

During winter, most species showed no affinity for the measured habitat variables (Table 7). Only the presence of cardinals was related to the density of subcanopy vines. There was also no evidence that individual species avoided flooded areas. For both December and March samples, contingency tables comparing the presence or absence of each species on flooded (>50 percent coverage of water) versus unflooded plots revealed no significant differences (Fisher's exact tests, $P > 0.05$).

Breeding bird distributions in relation to major habitat gradients

Canonical correspondence analysis revealed only one significant axis that explained 13.1 percent of the variance in the distributions of 20 resident bird species. Stepwise selection of habitat variables indicated that position on the moisture gradient (DECWET) was the most influential variable on that axis, followed by seedling density (SEEDLDEN) and number of tree species (TREESPEC). The axis was interpreted primarily as a wetness gradient, with higher scores reflecting relatively drier sites with greater tree species richness and more seedlings in the understory.

An ordination of common resident bird species was produced by plotting their scores on the first canonical correspondence axis (Figure 4). Chimney swifts had the greatest affinity for wet sites in the study area, followed by prothonotary warblers. Great crested flycatchers, eastern wood pewees, and white-breasted nuthatches also were more common in relatively wet woods. Drier sites were used more regularly by summer tanagers and red-eyed vireos. Species indicated in the central portion of the ordination tended to be widely distributed across the floodplain; thus, their average occurrences fell in the middle of the gradient. Blue-gray gnatcatchers, for example, were present on 108 of the 110 sampling plots and did not show any preference for the middle of the moisture gradient.

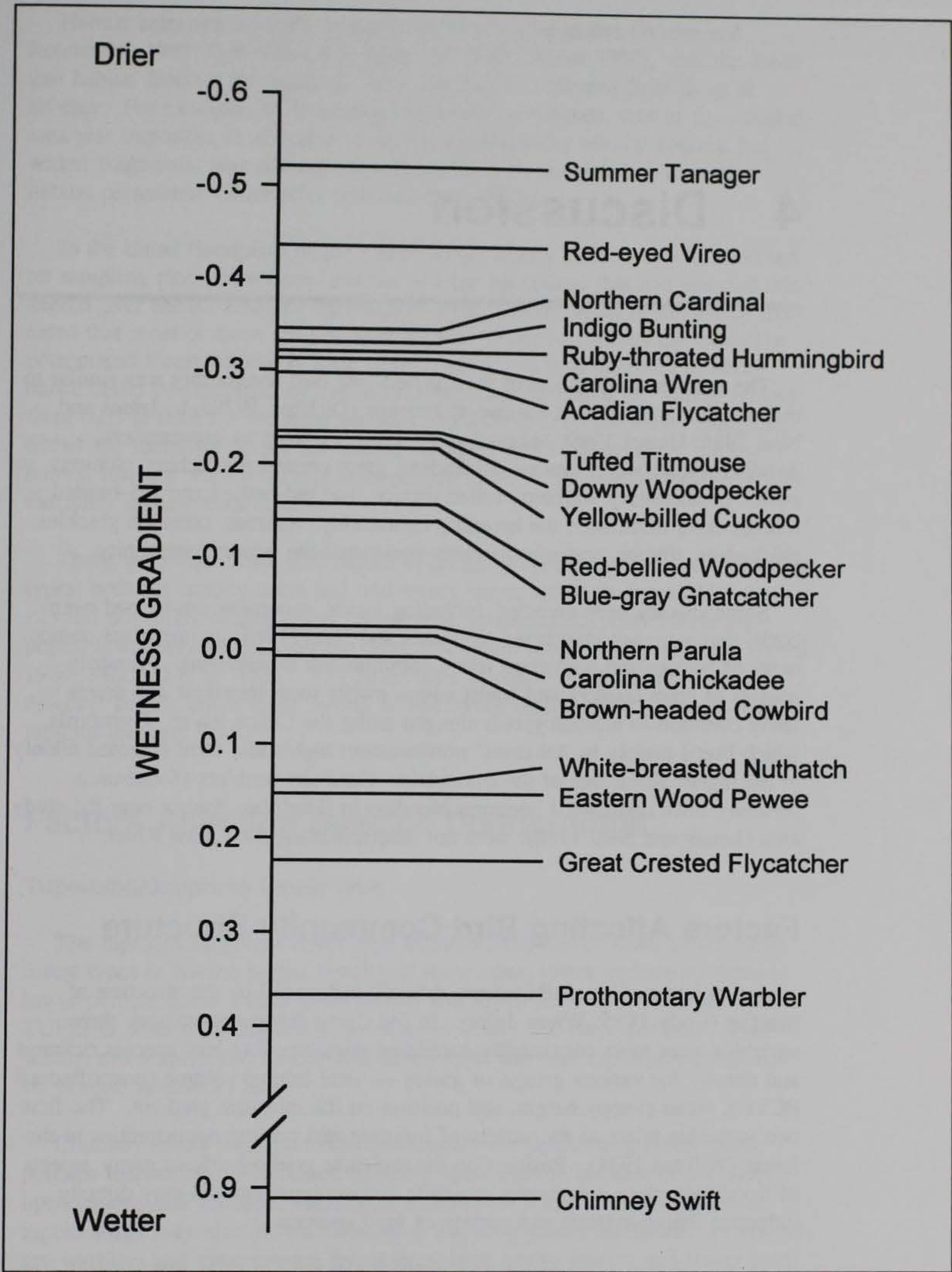

Figure 4. Ordination (location of centroids) of 20 common breeding bird species on first canonical correspondence axis, which reflected wetness gradient in study area. Species that were distributed widely across floodplain had centroids that fell in middle of gradient

4 Discussion

The species composition of the Cache River bird community was similar to that of other southeastern hardwood swamps (Dickson 1978a, b; James and Neal 1986; Hamel 1989; Mitchell et al. 1989). Blue-gray gnatcatchers, Acadian flycatchers, Carolina chickadees, great crested flycatchers, chimney swifts, prothonotary warblers, tufted titmice, and red-bellied and red-headed woodpeckers dominated the breeding community; whereas, common grackles, chickadees, titmice, and woodpeckers dominated the winter community.

Some species were detected, including swifts, mourning doves, and ovenbirds, that were not mentioned by James and Neal (1986) as important components of bottomland hardwood forest communities in Arkansas. Primarily species of open country and forest edges, swifts were abundant and doves fairly common in tupelo/cypress sloughs along the Cache River. Ovenbirds, which breed mainly in Arkansas' northwestern highlands, were detected mainly in the higher elevations of the floodplain. Cerulean warblers (*Dendroica cerulea*), once considered common breeders in floodplain forests near the study area (James and Neal 1986), were not detected along the Cache River.

Factors Affecting Bird Community Structure

Avian community attributes are strongly influenced by the structure of habitats (Cody 1985; Wiens 1989). In the Cache River bottomland, three variables were most consistently correlated with breeding bird species richness and density for various groups or guilds — total foliage volume (quantified as PCVC), mean canopy height, and position on the moisture gradient. The first two variables relate to the variety of foraging and nesting opportunities in the forest (Willson 1974). Position on the moisture gradient affects many aspects of floodplain plant community structure and composition and may directly influence the abundance and variety of food sources.

For winter samples, foliage height diversity, canopy height, and vine density entered the models predicting bird richness and density. However, none of the regression coefficients were significantly different from zero. Apparently the distributions of wintering species within the floodplain were not influenced by the variables measured.

Habitat selection by birds occurs at various spatial scales (Wiens and Rotenberry 1981; Gutzwiller and Anderson 1987; Wiens 1989), with the result that habitat features important at one scale may be different from those at another. For example, in Wyoming streamside woodlands, size of the wooded area was important in selection of habitat fragments by several species, but within fragments, nest site selection appeared to be unrelated to measured habitat parameters (Gutzwiller and Anderson 1987).

In the broad floodplain of the Cache River, nearly all bird species detected on sampling plots were forest interior or edge specialists that had selected this habitat over the surrounding agricultural areas, where casual observations indicated that most of these species were absent. However, within the extensive bottomland forest, relatively little of the variance in bird diversity or abundance could be explained by the habitat variables measured (R^2 values ranged from 0.03 to 0.18 for breeding samples and 0.05 to 0.10 for winter samples). Either the sampling design for habitat variables was inadequate, or microhabitat features were relatively unimportant to bird community structure within the fairly mature woodland.

There were significant differences in breeding species richness among cover types, both for canopy users and understory users, although overall bird density did not differ among types. In general, tupelo/baldcypress stands supported fewer species than did the other floodplain forest zones (see also Hamel 1989; Mitchell et al. 1989). No differences in community attributes were detected among cover types during winter, when many species formed wide-ranging foraging flocks.

Factors Affecting Species Distributions

Tupelo/baldcypress forest type

The tupelo/baldcypress cover type differed from one or more of the other forest types in having higher density of large trees, lower understory density, lower percent cover values in all layers, and fewer plant species of all types. TUPELO plots were flooded an average of nearly 300 days per year. This wetter, more open, and less diverse forest type was also an important habitat for several species of birds.

Chimney swifts were particularly abundant on tupelo/baldcypress plots, perhaps responding to increased foraging opportunities because of the more open canopy and probable abundance of insects. Large, hollow cypress or tupelo snags may also provide nesting or roosting places for swifts. Prothonotary warblers and great crested flycatchers, both cavity nesters and insect feeders, also achieved highest densities on TUPELO plots. Mourning doves were only found in open tupelo sloughs. The tupelo/baldcypress cover type was an important component of the floodplain forest, because it provided habitat unlike that of the higher elevation oak- and sweetgum-dominated zones and supported a number of bird species that were much less abundant elsewhere.

Distributions of bird species along the wetness gradient

A unique feature of the Cache River study area, compared with upland sites at which studies of birds in eastern deciduous forests have been conducted, is the pronounced wetness gradient. Responses of plants to differences in the frequency, duration, and seasonality of flooding result in the zonation of communities typical of bottomland hardwood forests (Fredrickson 1978; Wharton et al. 1982). Animals may respond directly to the presence of water (e.g., waterfowl and wading birds) or indirectly to flooding-induced variations in structure and species composition of the forest. In other regions, Smith (1977), Swift, Larson, and DeGraaf (1984), and Douglas et al. (1992) showed that bird distributions were influenced by variations in habitat wetness.

This study suggests that to maintain the diversity of bottomland hardwood bird communities, it is important to maintain intact systems including all elevational forest zones. These analyses revealed a number of bird species whose distributions (reflected by their centroids on the canonical correspondence axis) were skewed either toward the wetter or drier ends of the moisture gradient. The apparent preference of chimney swifts, prothonotary warblers, and great crested flycatchers for the tupelo/baldcypress zone has already been noted. In addition, white-breasted nuthatches and eastern wood pewees were distributed toward the wetter end of the gradient.

The distributions of a number of species (summer tanager, red-eyed vireo, northern cardinal, indigo bunting, ruby-throated hummingbird, Carolina wren, and Acadian flycatcher) on average were skewed toward drier sites. Some species (e.g., summer tanager) apparently avoided the TUPELO habitats, but were more evenly distributed in the higher zones. Others (e.g., Swainson's thrush) gradually increased in density from the wettest to driest forest cover types. Ovenbirds and gray-cheeked thrushes were abundant only in the highest elevation SWEETGUM habitat type.

Many species (e.g., blue-gray gnatcatcher, Carolina chickadee, tufted titmouse, and downy woodpecker) were widely distributed across the floodplain and showed no particular affinity for specific cover types or hydrologic regimes. The establishment of breeding territories may have served to spread individuals out among all available forest types. However, logistic regressions identified a number of structural variables (e.g., mean canopy height and density of large trees) that may have affected habitat use by some of these species.

Relevance to Forest Fragmentation

There is increasing concern that fragmentation of eastern deciduous forests is causing declines in regional forest bird diversity (Whitcomb et al. 1981; Robbins, Dawson, and Dowell 1989). Habitat fragmentation produces more "edge" habitats where the risks of predation and parasitism are greater (Temple and Cary 1988; Yahner and Scott 1988), reduces "core" area resulting in the loss of interior forest specialists (Temple 1986; Blake and Karr 1987), and increases the isolation of patches (Noss 1987). In bottomland hardwood areas, agricultural expansion has tended to reduce the width and area of remaining forest fragments and totally eliminate the higher elevation zones.

The Cache River study area is part of an extensive bottomland hardwood forest. During spring sampling, 59 bird species were detected (not counting hawks, crows, and waterfowl) of which 43 were known to breed in the area. Hamel (1989) found similar numbers of breeding species in South Carolina's Congaree Swamp. Thirty-two of the breeding residents at the Cache River were considered by Whitcomb et al. (1981) to be either forest interior or interior/edge specialists (Appendix A). Nineteen were also considered to be sensitive to forest tract size and are often lacking from small fragments (Temple 1986; Robbins, Dawson, and Dowell 1989). On the other hand, as mentioned previously, cerulean warblers were absent from the study area, perhaps indicating that the 2- to 3-km width of the forested floodplain was still too narrow to prevent the loss of certain sensitive species.

A number of species commonly thought of as field and edge specialists (e.g., brown-headed cowbird, common grackle, and indigo bunting) were detected over the entire length of each transect, and mourning doves were found in open tupelo/baldcypress sloughs >1 km from the nearest field/forest edge. Strelke and Dickson (1980) did not find cowbirds >100 m into the woods in Texas, although other studies (Robbins, Dawson, and Dowell 1989; Robinson 1990) have shown deeper penetration into the forest interior. Brood parasitism by cowbirds and nest predation by blue jays and other predators are thought to occur primarily within about 100 m of the forest edge (e.g., Gates and Gysel 1978; Temple 1986). However, this and other studies show that avian parasites and predators penetrate deeply into large forest tracts with unknown risks to forest interior species.

The number of species detected may approach the maximum species richness that can be expected in large, relatively unfragmented bottomland forests in the Southeast. Therefore, the Cache River area could be a valuable reference site against which to evaluate the effects of forest fragmentation and the success of bottomland hardwood restoration.

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Table 1
Habitat Variables

Abbreviation	Definition and Units
Measured Variables	
MEANCAN	Mean canopy height, m
MAXCAN[1]	Maximum canopy height, m
TREDEN5	Density of trees between 5 and 30 cm dbh, /ha
TREDEN30	Density of trees >30 cm dbh, /ha
SNAGDEN5	Density of snags between 5 and 30 cm dbh, /ha
SNAGDEN30	Density of snags >30 cm dbh, /ha
SAPLDEN	Density of saplings, /0.1 ha
CANVDEN	Density of canopy vines, /0.1 ha
SUBVDEN	Density of subcanopy vines, /0.1 ha
SEEDLDEN	Density of seedlings, /0.01 ha
TREESPEC	Number of tree species
SAPLSPEC[1]	Number of sapling species
CANVSPEC[1]	Number of species of canopy vines
SUBVSPEC[1]	Number of species of subcanopy vines
GRNDSPEC[1]	Number of species in the ground layer
HERBCOV	Percent cover of herbaceous plants
LITTER[1]	Percent cover of leaf litter
DEBRIS	Percent cover of woody debris
COVER0	Percent cover of woody plants, 0- to 1-m stratum
COVER1	Percent cover of woody plants, 1- to 3-m stratum
COVER3	Percent cover of woody plants, 3- to 5-m stratum
COVER5	Percent cover of woody plants, 5- to 15-m stratum
COVER15	Percent cover of woody plants, >15-m stratum
ELEV[1]	Elevation at plot center, m
Derived Variables	
FHD	Foliage height diversity
PCVC	Total percent vegetative cover
TWINSPAN	TWINSPAN cover type classification

(Continued)

[1] Variables eliminated from regression analyses because of correlations ($|r| \geq 0.50$) with other habitat variables.

Table 1 (Concluded)

Abbreviation	Definition and Units
DECWET	Plot score on the wetness gradient defined through detrended correspondence analysis (DECORANA) of tree species composition and basal area
DURFLOOD[1]	Mean number of days per year that a plot was inundated, according to hydraulic model

Table 2
Summary Statistics for Habitat Variables at Cache River

Variable	Minimum	25%ile	Median	75%ile	Maximum	Mean	CV[1]
MEANCAN	12.2	21.3	24.4	25.9	29.0	23.41	14.37
MAXCAN	18.3	25.9	27.4	29.0	36.6	27.67	10.37
TREDEN5[2]	0.0	400.0	625.0	725.0	1,400.0	596.59	43.29
TREDEN30	0.0	75.0	100.0	150.0	450.0	115.00	60.79
SNAGDEN5	0.0	0.0	25.0	50.0	275.0	29.77	136.73
SNAGDEN30	0.0	0.0	0.0	25.0	75.0	8.64	181.55
SAPLDEN	0.0	87.5	137.5	250.0	750.0	180.23	81.74
CANVDEN	0.0	0.0	5.0	10.0	112.5	9.70	188.91
SUBVDEN	0.0	0.0	25.0	75.0	1,162.5	68.30	201.39
SEEDLDEN	0.0	325.0	675.0	1,275.0	3,887.5	878.75	82.90
TREESPEC	2.0	7.0	8.0	9.0	12.0	7.64	25.99
SAPLSPEC	0.0	2.0	4.0	5.0	10.0	3.76	54.81
CANVSPEC	0.0	0.0	1.0	2.0	5.0	1.20	108.74
SUBVSPEC	0.0	0.0	1.0	2.0	7.0	1.34	109.77
GRNDSPEC	0.0	4.0	8.0	11.0	20.0	7.98	56.18
HERBCOV	0.0	0.0	1.0	6.5	62.5	5.72	190.30
LITTER	0.0	17.5	50.0	72.5	97.5	45.45	69.16
DEBRIS	0.0	7.5	17.5	27.5	57.5	19.20	66.33
COVER0	0.0	2.5	10.0	17.5	67.5	13.52	100.12
COVER1	0.0	12.5	22.5	32.5	55.0	23.95	58.47
COVER3[2]	0.0	35.0	45.0	57.5	95.0	46.66	43.86
COVER5	7.5	32.5	45.0	70.0	95.0	49.48	44.90
COVER15	0.0	10.0	20.0	37.5	97.5	26.34	89.38
ELEV	53.8	55.1	55.6	56.6	57.5	55.73	1.67
FHD	0.54	1.26	1.41	1.49	1.58	1.35	14.38
PCVC[2]	35.0	120.0	165.0	195.0	275.0	159.95	34.02
DECWET	0.0	228.0	286.5	350.0	629.0	288.22	46.90
DURFLOOD	1.0	28.0	86.0	102.0	365.0	96.07	100.76

[1] Coefficient of variation.
[2] Distribution does not differ from a normal distribution (Shaprio-Wilk statistic, $P > 0.05$).

Table 3
Means of Habitat Variables by Cover Types and Results of Analysis of Variance by Ranks

Variable	Cover Type			
	TUPELO	OVERCUP	NUTTALL	SWEETGUM
MEANCAN	23.95a	23.13a	23.59a	24.19a
MAXCAN[1]	28.52a	27.21a	28.59a	26.86a
TREDEN5	471.42a	633.73a	600.00a	512.50a
TREDEN30[1]	200.00c	92.86a	118.00b	131.25abc
SNAGDEN5	73.21a	23.81a	20.00a	31.25a
SNAGDEN30	5.36a	9.92a	6.00a	12.50a
SAPLDEN	178.57a	184.33a	180.00a	151.56a
CANVDEN[1]	0.36a	13.49b	5.20b	10.31b
SUBVDEN[1]	1.79a	91.47b	59.50b	29.69ab
SEEDLDEN[1]	392.86a	1,047.62b	744.50ab	818.75ab
TREESPEC[1]	5.00a	7.97b	8.20b	7.88b
SAPLSPEC[1]	2.21a	3.76b	4.32b	4.75b
CANVSPEC[1]	0.07a	1.52b	1.04b	1.13b
SUBVSPEC[1]	0.14a	1.67b	1.28b	1.00ab
GRNDSPEC[1]	2.21a	8.49b	8.60bc	12.13c
HERBCOV[1]	0.43a	5.87b	4.04bc	19.13c
LITTER[1]	1.43a	46.39b	56.50bc	80.63c
DEBRIS[1]	8.75a	21.91b	21.10bc	10.31ac
COVER0[1]	3.57a	13.65b	14.20b	27.81b
COVER1[1]	10.18a	25.36b	28.10b	24.06ab
COVER3[1]	20.36a	46.98b	61.80c	42.81ab
COVER5[1]	38.75a	46.43ab	57.50bc	67.19c
COVER15[1]	13.75a	23.10ab	29.00b	65.63c
ELEV[1]	54.75a	55.56a	56.54b	57.22b
FHD[1]	1.07a	1.38b	1.40b	1.45b
PCVC[1]	86.61a	155.52b	190.60c	227.50c
DECWET[1]	50.50a	278.49b	366.00c	537.75d
DURFLOOD[1]	297.38c	77.15b	28.00a	2.75a

[1] Analysis of variance by ranks (Kruskal-Wallis test) indicated significant differences among cover types ($P < 0.05$). Significant differences between cover types are indicated by different letters (Tukey tests, $P < 0.05$) (Zar 1984).

Table 4
Means of Bird Community Variables by Cover Types and Results of Analysis of Variance

Group or Guild	Variable	Cover Type: TUPELO	OVERCUP	NUTTALL	SWEETGUM
Breeding Season					
All birds	RICHNESS[1] ABUNDANCE	12.43a 14.18a	14.63ab 12.90a	15.60b 14.32a	13.38ab 12.44a
Breeding residents	RICHNESS ABUNDANCE[1]	11.71a 13.75b	12.46a 11.44a	13.48a 12.82ab	10.88a 10.31ab
Migrants	RICHNESS[1] ABUNDANCE[1]	0.71a 0.43a	2.17b 1.46b	2.12b 1.50b	2.50b 2.13b
Understory users[2]	RICHNESS[1] ABUNDANCE	2.64a 2.39a	3.90b 3.17a	4.20b 3.40a	3.88ab 3.63a
Canopy users[2]	RICHNESS[1] ABUNDANCE	5.57a 5.36a	6.94b 6.17a	7.08b 6.54a	5.38ab 5.25a
Winter					
All birds	RICHNESS ABUNDANCE	6.80a 5.50a	7.28a 13.39a	6.57a 7.91a	7.88a 8.31a
Canopy users[2]	RICHNESS ABUNDANCE	5.40a 4.80a	5.89a 6.75a	5.57a 7.24a	5.75a 7.00a

[1] Significant differences among cover types ($P < 0.05$). Values of RICHNESS were not normally distributed; therefore, analysis of variance was performed on ranked data. Significant differences between cover types are indicated by different letters (Tukey tests, $P < 0.05$).
[2] Only includes species detected ≥10 times. Breeding season figures exclude Carolina chickadees and tufted titmice, which were evenly split between habitat layers. The understory guild is not presented in winter because only one species (common grackle) had ≥10 sightings.

Table 5
Results of Multiple Regressions of Bird Species Richness and Overall Abundance on Habitat Variables

Group or Guild	Variable	Habitat Variables in the Final Regression Model[1]				R^2
Breeding Season						
All birds	RICHNESS	+PCVC				0.087
	ABUNDANCE	-DEBRIS	+MEANCAN	(-SEEDLDEN)		0.102
Breeding residents	RICHNESS	(+PCVC)				0.026
	ABUNDANCE	-DECWET	-DEBRIS	(-SEEDLDEN)	(-TREDEN5)	0.153
Migrants	RICHNESS	+PCVC	(+FHD)	(+MEANCAN)		0.164
	ABUNDANCE	+PCVC	(+DECWET)			0.177
Understory users	RICHNESS	+DECWET	+SAPLDEN			0.122
	ABUNDANCE	+DECWET	(+HERBCOV)			0.110
Canopy users	RICHNESS	+COVER3	+MEANCAN			0.108
	ABUNDANCE	+COVER3	+MEANCAN			0.130
Winter						
All birds	RICHNESS	(-MEANCAN)	(+FHD)			0.104
	ABUNDANCE	(+FHD)				0.045
Canopy users	RICHNESS	No variables entered the model				--
	ABUNDANCE	(+CANVDEN)				0.067

[1] Variables are listed in the order in which they entered the model; "+" and "-" indicate the sign of the regression coefficient. Variables in parentheses were not significant ($P > 0.05$), but were retained in the final model and contributed to the reported R^2.

Table 6
Average Count of Birds per Plot (number/0.48 ha) by Species and Cover Type

Bird Species	Cover Type			
	TUPELO	OVERCUP	NUTTALL	SWEETGUM
Breeding Season				
Acadian flycatchers[1]	0.39ab	0.51a	0.84b	0.69ab
American goldfinch	0.00	0.02	0.04	0.06
American redstart	0.04	0.08	0.06	0.19
Bay-breasted warbler	0.00	0.11	0.04	0.06
Black-and-white warbler	0.04	0.00	0.00	0.00
Blackburnian warbler	0.00	0.03	0.06	0.06
Black-throated green warbler	0.00	0.06	0.08	0.06
Blue-gray gnatcatcher	1.61	1.49	1.76	1.81
Blue jay	0.04	0.03	0.10	0.06
Brown-headed cowbird	0.43	0.31	0.48	0.25
Canada warbler	0.00	0.02	0.00	0.06
Carolina chickadee	1.00	0.97	1.06	0.75
Carolina wren	0.11	0.17	0.26	0.25
Chestnut-sided warbler	0.11	0.18	0.26	0.06
Chimney swift[1]	3.86b	0.87a	1.20a	0.13a
Common grackle	0.07	0.16	0.02	0.00
Common yellowthroat	0.00	0.01	0.00	0.00
Downy woodpecker	0.39	0.71	0.64	0.69
Eastern kingbird	0.00	0.01	0.00	0.00
Eastern wood pewee[1]	0.25b	0.07a	0.36b	0.00a
Empidonax (unidentified)	0.04	0.06	0.02	0.00
Golden-winged warbler	0.00	0.02	0.00	0.00
Gray catbird	0.00	0.02	0.00	0.00
Gray-cheeked thrush[1]	0.00a	0.08ab	0.06ab	0.31b
Great crested flycatcher[1]	1.04b	0.54a	0.58ab	0.31a
Hairy woodpecker	0.00	0.03	0.00	0.06

(Sheet 1 of 4)

[1] Analysis of variance by ranks (Kruskal-Wallis test) indicated significant differences among cover types ($P < 0.05$). Significant differences between cover types are indicated by different letters (Tukey tests, $P < 0.05$).

Table 6 (Continued)

Bird Species	Cover Type			
	TUPELO	OVERCUP	NUTTALL	SWEETGUM
Breeding Season				
Hooded warbler	0.00	0.01	0.02	0.00
Indigo bunting[1]	0.11a	0.53b	0.26a	0.25ab
Kentucky warbler	0.00	0.07	0.04	0.13
Magnolia warbler	0.04	0.06	0.00	0.00
Mourning dove	0.25	0.02	0.00	0.00
Mourning warbler	0.00	0.02	0.00	0.00
Northern cardinal[1]	0.07a	0.44b	0.18ab	0.13ab
Northern oriole	0.04	0.00	0.02	0.00
Northern parula[1]	0.14ab	0.17ab	0.42b	0.00a
Northern waterthrush	0.04	0.12	0.10	0.06
Ovenbird[1]	0.04a	0.03a	0.04a	0.31b
Philadelphia vireo	0.00	0.01	0.00	0.00
Pileated woodpecker	0.04	0.07	0.02	0.13
Prothonotary warbler[1]	1.21c	0.65b	0.74bc	0.06a
Red-bellied woodpecker	0.75	0.83	0.84	0.75
Red-eyed vireo	0.07	0.25	0.22	0.25
Red-headed woodpecker	0.00	0.05	0.06	0.06
Red-winged blackbird	0.00	0.02	0.00	0.00
Rose-breasted grosbeak	0.00	0.05	0.10	0.00
Ruby-throated hummingbird	0.43	0.48	0.52	0.88
Scarlet tanager[1]	0.00	0.06	0.08	0.19
Summer tanager[1]	0.04a	0.40b	0.38b	0.25ab
Swainson's thrush[1]	0.04a	0.19a	0.44ab	1.00b
Tennessee warbler	0.21	0.47	0.36	0.44
Tufted titmouse	0.68	0.63	0.78	1.37
Veery	0.00	0.03	0.00	0.00
White-breasted nuthatch	0.36	0.31	0.24	0.13
White-eyed vireo	0.00	0.08	0.18	0.00
White-throated sparrow	0.00	0.02	0.00	0.00

(Sheet 2 of 4)

Table 6 (Continued)

Bird Species	Cover Type			
	TUPELO	OVERCUP	NUTTALL	SWEETGUM
Breeding Season				
Wood thrush	0.04	0.08	0.10	0.00
Yellow-billed cuckoo	0.11	0.11	0.14	0.06
Yellow-breasted chat	0.00	0.01	0.00	0.00
Yellow-throated vireo	0.07	0.07	0.12	0.13
Yellow-throated warbler	0.04	0.00	0.00	0.00
Winter				
American robin	0.00	0.03	0.00	0.00
Blackbirds (unidentified)	0.00	0.19	0.00	0.00
Blue jay	0.00	0.06	0.02	0.25
Brown creeper	0.00	0.33	0.29	0.25
Brown-headed cowbird	0.00	0.03	0.00	0.00
Carolina chickadee	0.70	1.03	0.93	0.75
Carolina wren	0.10	0.08	0.02	0.19
Common grackle	0.00	5.83	0.00	0.13
Downy woodpecker	0.60	0.75	0.71	0.44
Eastern bluebird	0.00	0.06	0.10	0.31
Eastern phoebe	0.00	0.08	0.00	0.19
European starling	0.00	0.00	0.57	0.00
Golden-crowned kinglet	0.40	0.47	0.45	0.69
Hermit thrush	0.00	0.08	0.00	0.00
Northern cardinal	0.20	0.03	0.21	0.13
Northern flicker	0.30	0.00	0.05	0.13
Red-bellied woodpecker	0.90	0.67	1.00	1.06
Red-breasted nuthatch	0.00	0.00	0.02	0.00
Red-headed woodpecker	1.30	2.19	1.95	2.06
Ruby-crowned kinglet	0.00	0.08	0.14	0.00
Tufted titmouse	0.40	0.94	0.88	1.50

(Sheet 3 of 4)

Table 6 (Concluded)				
	Cover Type			
Bird Species	**TUPELO**	**OVERCUP**	**NUTTALL**	**SWEETGUM**
Winter				
White-breasted nuthatch	0.50	0.22	0.38	0.06
Winter wren	0.10	0.08	0.10	0.00
Yellow-bellied sapsucker	0.00	0.14	0.07	0.19

(Sheet 4 of 4)

Table 7
Results of Logistic Regressions of Bird Species Presence Versus Habitat Variables

Bird Species	Variables in Final Model[1]		
Breeding Season			
Acadian flycatcher	+COVER15	+SAPLDEN	
Blue-gray gnatcatcher	No variables entered the model		
Brown-headed cowbird	No variables entered the model		
Carolina chickadee	-COVER15	(-SNAGDEN5)	
Carolina wren	No variables entered the model		
Chestnut-sided warbler	+COVER1	+MEANCAN	
Chimney swift	-TREESPEC	-DECWET	
Downy woodpecker	-TREDEN30		
Eastern wood pewee	-COVER15		
Great crested flycatcher	-TREDEN5	-DECWET	-DEBRIS
Indigo bunting	+CANVDEN		
Northern cardinal	+SEEDLDEN	-TREDEN30	
Northern parula	+COVER3	-COVER15	
Northern waterthrush	No variables entered the model		
Prothonotary warbler	-COVER15	-SEEDLDEN	-DECWET
Red-bellied woodpecker	-HERBCOV	+COVER5	
Red-eyed vireo	+COVER0		
Ruby-throated hummingbird	+TREESPEC		
Summer tanager	+COVER3		
Swainson's thrush	+DECWET	+SAPLDEN	
Tennessee warbler	+TREESPEC		
Tufted titmouse	+MEANCAN		
White-breasted nuthatch	-DECWET	-SNAGDEN5	-COVER1
Yellow-billed cuckoo	No variables entered the model		
Winter			
Brown creeper	No variables entered the model		
Carolina chickadee	No variables entered the model		

(Continued)

[1] Variables are listed in the order in which they entered the model; "+" and "-" indicate sign of the regression coefficient. Variables in parentheses were not significant (P > 0.05), but were retained in the final model.

Table 7 (Concluded)	
Bird Species	**Variables in Final Model**[1]
Winter	
Downy woodpecker	No variables entered the model
Golden-crowned kinglet	No variables entered the model
Northern cardinal	+SUBVDEN
Red-bellied woodpecker	No variables entered the model
Red-headed woodpecker	No variables entered the model
Tufted titmouse	No variables entered the model
White-breasted nuthatch	No variables entered the model
Yellow-bellied sapsucker	No variables entered the model

Appendix A
Scientific Names, Breeding Status, Guild Assignment, Major Habitat Affinity, Neotropical Migrant Status, and Area Sensitivity of Bird Species Detected During Spring Sampling

Common Name	Scientific Name	Breeding Status[1]	Guild[2]	Habitat Affinity[3]	Neotropical Migrant[4]	Area Sensitive[5]
Acadian flycatcher	*Empidonax virescens*	R	U	I	Yes	Yes
American goldfinch	*Carduelis tristis*	R		FE		
American redstart	*Setophaga ruticilla*	R	C	I	Yes	Yes
Bay-breasted warbler	*Dendroica castanea*	M	C		Yes	
Black-and-white warbler	*Mniotilta varia*	R		I	Yes	Yes
Black-throated green warbler	*Dendroica virens*	M			Yes	
Blackburnian warbler	*Dendroica fusca*	M			Yes	
Blue jay	*Cyanocitta cristata*	R		IE		
Blue-gray gnatcatcher	*Polioptila caerulea*	R	C	IE	Yes	Yes
Brown-headed cowbird	*Molothrus ater*	R	C	FE		
Canada warbler	*Wilsonia canadensis*	M			Yes	Yes
Carolina chickadee	*Parus carolinensis*	R	CU	IE		

(Sheet 1 of 5)

Note: References cited in this appendix are located at the end of the main text.

[1] R = breeding resident; M=migrant (James and Neal 1986).

[2] Based on observed use of major habitat layers by species observed ≥ 10 times: C = canopy user, U = understory user, CU = used both layers about equally (in statistical analyses, these species were not included in either guild).

[3] I = interior forest species; IE = forest interior/edge species; FS = forest edge/scrub; FE = field/edge species (Whitcomb et al. 1981).

[4] Neotropical migratory species (Finch 1991).

[5] Species sensitive to forest tract size (Temple 1986; Robbins, Dawson, and Dowell 1989).

(Continued)

Common Name	Scientific Name	Breeding Status[1]	Guild[2]	Habitat Affinity[3]	Neotropical Migrant[4]	Area Sensitive[5]
Carolina wren	*Thryothorus ludovicianus*	R	U	IE		
Chestnut-sided warbler	*Dendroica pensylvanica*	M	C		Yes	Yes
Chimney swift	*Chaetura pelagica*	R			Yes	
Common grackle	*Quiscalus quiscula*	R	C	FE		
Common yellowthroat	*Geothlypis trichas*	R		IE	Yes	
Downy woodpecker	*Picoides pubescens*	R	C	IE		
Eastern kingbird	*Tyrannus tyrannus*	R		FE	Yes	
Eastern wood-pewee	*Contopus virens*	R		IE	Yes	
Flycatcher (unidentified)	*Empidonax* sp.	R			Yes	
Golden-winged warbler	*Vermivora chrysoptera*	M			Yes	
Gray catbird	*Dumetella carolinensis*	R		IE	Yes	
Gray-cheeked thrush	*Catharus minimus*	M	U		Yes	
Great crested flycatcher	*Myiarchus crinitus*	R	C	IE	Yes	Yes
Hairy woodpecker	*Picoides villosus*	R		I		Yes
Hooded warbler	*Wilsonia citrina*	R		I	Yes	Yes

(Sheet 2 of 5)

(Continued)

Common Name	Scientific Name	Breeding Status[1]	Guild[2]	Habitat Affinity[3]	Neotropical Migrant[4]	Area Sensitive[5]
Indigo bunting	*Passerina cyanea*	R	U	FE	Yes	
Kentucky warbler	*Oporornis formosus*	R		I	Yes	Yes
Magnolia warbler	*Dendroica magnolia*	M			Yes	
Mourning dove	*Zenaida macroura*	R		FE		
Mourning warbler	*Oporornis philadelphia*	M			Yes	Yes
Northern cardinal	*Cardinalis cardinalis*	R	U	IE		
Northern oriole	*Icterus galbula*	R		FE	Yes	
Northern parula	*Parula americana*	R	C	IE	Yes	Yes
Northern waterthrush	*Seiurus noveboracensis*	M	U		Yes	Yes
Ovenbird	*Seiurus aurocapillus*	R		I	Yes	Yes
Philadelphia vireo	*Vireo philadelphicus*	M			Yes	
Pileated woodpecker	*Dryocopus pileatus*	R		I		Yes
Prothonotary warbler	*Protonotaria citrea*	R	U	IE	Yes	
Red-bellied woodpecker	*Melanerpes carolinus*	R	C	IE		Yes
Red-eyed vireo	*Vireo olivaceus*	R	C	IE	Yes	Yes

(Sheet 3 of 5)

(Continued)

Common Name	Scientific Name	Breeding Status[1]	Guild[2]	Habitat Affinity[3]	Neotropical Migrant[4]	Area Sensitive[5]
Red-headed woodpecker	*Melanerpes erythrocephalus*	R		FS		
Red-winged blackbird	*Agelaius phoeniceus*	R		FE	Yes	
Rose-breasted grosbeak	*Pheucticus ludovicianus*	M	C		Yes	Yes
Ruby-throated hummingbird	*Archilochus colubris*	R	U	IE	Yes	
Scarlet tanager	*Piranga olivacea*	R		I	Yes	Yes
Summer tanager	*Piranga rubra*	R	C	IE	Yes	Yes
Swainson's thrush	*Catharus ustulatus*	M	U		Yes	
Tennessee warbler	*Vermivora peregrina*	M	C		Yes	
Tufted titmouse	*Parus bicolor*	R	CU	IE		Yes
Veery	*Catharus fuscescens*	M		I	Yes	Yes
White-breasted nuthatch	*Sitta carolinensis*	R	C	I		Yes
White-eyed vireo	*Vireo griseus*	R		IE	Yes	
White-throated sparrow	*Zonotrichia albicollis*	M				
Wood thrush	*Hylocichla mustelina*	R		IE	Yes	Yes
Yellow-billed cuckoo	*Coccyzus americanus*	R	C	IE	Yes	

(Sheet 4 of 5)

(Concluded)

Common Name	Scientific Name	Breeding Status[1]	Guild[2]	Habitat Affinity[3]	Neotropical Migrant[4]	Area Sensitive[5]
Yellow-breasted chat	*Icteria virens*	R		FE	Yes	
Yellow-throated vireo	*Vireo flavifrons*	R		IE	Yes	Yes
Yellow-throated warbler	*Dendroica dominica*	R		I	Yes	

(Sheet 5 of 5)

Appendix B
Scientific Names and Guild Assignments of Bird Species Detected During Winter Sampling

Common Name	Scientific Name	Guild[1]
American robin	*Turdus migratorius*	
Blackbirds (unidentified)		
Blue jay	*Cyanocitta cristata*	
Brown creeper	*Certhia americana*	C
Brown-headed cowbird	*Molothrus ater*	
Carolina chickadee	*Parus carolinensis*	C
Carolina wren	*Thryothorus ludovicianus*	
Common grackle	*Quiscalus quiscula*	U
Downy woodpecker	*Picoides pubescens*	C
Eastern bluebird	*Sialia sialis*	
Eastern phoebe	*Sayornis phoebe*	
European starling	*Sturnus vulgaris*	C
Golden-crowned kinglet	*Regulus satrapa*	C
Hermit thrush	*Catharus guttatus*	
Northern cardinal	*Cardinalis cardinalis*	
Northern flicker	*Colaptes auratus*	
Red-bellied woodpecker	*Melanerpes carolinus*	C

(Continued)

[1] Based on observed use of major habitat layers by species observed and categorized by layer ≥10 times: C = canopy user; U = understory user.

(Concluded)		
Common Name	**Scientific Name**	**Guide[1]**
Red-breasted nuthatch	*Sitta canadensis*	
Red-headed woodpecker	*Melanerpes erythrocephalus*	C
Ruby-crowned kinglet	*Regulus calendula*	
Tufted titmouse	*Parus bicolor*	C
White-breasted nuthatch	*Sitta carolinensis*	C
Winter wren	*Troglodytes troglodytes*	
Yellow-bellied sapsucker	*Sphyrapicus varius*	C

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13. ABSTRACT *(Maximum 200 words)*

During spring of 1988 and winter of 1988-89, songbirds were sampled along two belt transects extending across the broad, forested floodplain of the Cache River, Arkansas. Objectives were to compare avian abundance and species richness among floodplain forest zones, identify habitat variables related to the distribution of both breeding and wintering species, and examine the influence of the hydrologic gradient on habitat use by birds. Forest zones differed in structure, flooding regime, and use by birds. The tupelo/cypress zone, in particular, provided habitat unlike that in the higher oak-dominated zones and supported a number of bird species that were much less abundant elsewhere. Distributions of chimney swifts, prothonotary warblers, and great crested flycatchers were skewed toward wetter sites, whereas summer tanagers, red-eyed vireos, and others were skewed toward drier sites. To maintain diversity of bottomland bird communities, it is important to maintain intact systems including all elevational forest zones.

14. SUBJECT TERMS

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