THE EFFECTS OF STREAM ALTERATION AND ASSOCIATED LAND USE CHANGES ON RIPARIAN AVIFAUNA IN SOUTHCENTRAL OKLAHOMA

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Problem Background

Stream Alteration in Relation to the Riparian Environment

There is considerable evidence that stream alteration activities directly and indirectly cause the draining of wetlands, destruction of hardwood forests, obliteration of oxbows and meanders, lowered water tables, elimination of fish and wildlife habitat, increased erosion and sedimentation, poor water quality, increased flooding downstream, and increased construction on, and development of, the floodplain (Committee on Government Operations 1973).

Streams are a valuable economic and social resource (Ellis 1976). Streams and their associated wooded swamps and overflow lands are viewed by some people as attractive, interesting, and productive parts of the environment. They constitute the source of the floodplain ecological type which is disappearing at an alarming rate (Martin 1969).

Numerous corridors of bottomland hardwood forest extend westward along rivers and streams from the eastern deciduous forest into the grasslands of southcentral United States. In this region where forests are scarce and water limited, riparian habitat is recognized as highly important to many furbearers, waterfowl, and songbirds (National Academy of Science 1970).

Riparian habitat is recognized as critical for the survival of many species of birds. The highest population densities for non-colonial nesting birds in North America are recorded for this vegetation type (Johnson 1970). Carothers and Johnson (1975a) have documented that over 50% of the species breeding in homogeneous cottonwood stands along the Verde River and its tributaries are exclusively dependent upon this habitat for reproduction. Some avian species are essentially restricted to riparian habitats while others are dependent on them for such life cycle functions as reproduction, protection, or feeding. Sprunt (1975) emphasizes that riparian woodlands can be of extreme importance to migrants. River valleys are frequently used as major migration routes. In areas of the arid and semi-arid west, where many rivers are oriented across the path of most migrants, the strips of riparian woodland can be vital to migrating passerines. They constitute havens of refuge and potential food sources to break the journey across unfavorable terrain, allowing many forest species to successfully cross grasslands and deserts.

The presence of naturally flowing streams in grasslands acts as a powerful attraction to birds. Plant communities in these moist low-lying areas usually provide rich bird habitat. Odum (1950) states that moist, fertile areas consistently show higher bird densities than more xeric sites. Gill et al. (1974) observed that moist areas are usually quite productive of birdlife, serving as primary centers of activity. Mesic vegetation types supply more diverse foliage strata and a greater number of potential niches for nesting birds (Fawver 1950; Tramer 1968).

Stream alteration often facilitates the drainage of swamps and wetlands for agricultural purposes, resulting in loss of riparian habitat important to wildlife (Ellis 1976). By 1969, channelization had resulted in the drainage of over 56 million ha of land in 39 states. Over 37 million ha of land were to be drained in 1972 alone (U.S. Dept. of Commerce 1973). Between 1959 and 1966 an average of 57,500 ha were drained each year in the three major waterfowl production states, the Dakotas and Minnesota (Aus 1969). In southern states, such as Tennessee and North Carolina, channelization has resulted in the drainage and destruction of valuable hardwood swamps. Barstow (1971), who studied stream alteration impact on wetland habitat in the Obion-Forked Deer Basin of Tennessee, found that in the channelized sections of the basin approximately 60% of the existing woodland had been cleared, aquatic habitat had been all but eliminated, and edge habitat had been reduced. In the Hawk Creek Watershed of Minnesota, 9 times as much wetland area was drained in the channelized portion as in the unchannelized portion of the watershed (Choale 1972).

As large acreages of wetlands do not exist over most of the southcentral grasslands, the most obvious channelization affect is degradation of riparian habitat. In this region, with its intensively farmed floodplains, the existing wildlife habitat is often restricted to the stream and its adjacent vegetation. Where reductions in quality and quantity of riparian habitat in this region leave wildlife with little remaining suitable habitat, population numbers can be expected to decline accordingly.

The Need for Stream Alteration Impact Information

A congressional decision to approve or disapprove any federally funded stream alteration project is based on the results of a cost-benefit analysis (CBA). The CBA evaluates the project on 4 accounts. These are: (1) national economic development; (2) regional economic development; (3) social well-being; and (4) environmental quality. If the projected benefits derived from the project outweigh the cost of construction, maintenance, and operation, congressional approval is usually granted.

Environmentalists and some resource agencies argue that many stream alteration projects have been approved without adequate consideration given to adverse environmental effects. Project benefits to national economic development, regional economic development, and social well-being can usually be evaluated in terms of dollars. Environmental quality, on the other hand, remains an extremely difficult parameter to evaluate economically. Consequently, environmental qualtiy is often disregarded in the planning stages due to the difficulty and time required to quantify the biological effects of stream alteration.

The recent emphasis on environmental quality has created considerable concern over the need for channelization. However, with the world's population placing greater demands on American agriculture, and changes in farming practices to large clean fields coupled with the farmer's desire to increase drainage and reduce flood risks, it seems likely that economic pressures for channelization will continue. Now, at a time of shrinking wildlife habitat, it must be determined which projects are necessary and which are not. In order to make intelligent and knowledgeable decisions concerning stream alteration effects, scientific studies must be completed to document environmental effects attributed to these projects.

The Soil Conservation Service (SCS) and the U.S. Army Corps of

Engineers (COE) are obligated by statutes in Public Law 566 to pay one-half of the cost of fisheries and wildlife mitigation features included in a project. If these agencies are to meet these requirements they must first be made aware of the environmental changes they are inflicting and secondly be shown the extent of this damage. The U.S. Fish and Wildlife Service (FWS), in recognition of its statutory obligation to evaluate environmental effects of stream alteration projects, established the National Stream Alteration Study Team to coordinate and oversee stream alteration impact studies funded by the FWS. The present study is one of many stream alteration studies subsidized and coordinated through the above agency.

The environmental effects of channelization had not been closely studied previously, and there has been little quantitative evaluation of these effects on the riparian plant and animal communities. But, the ability to predict and simulate the response of ecological communities to land use changes and management disturbances is a prerequisite for effective resource planning and reducing adverse environmental effects (Cox and Blacke 1974).

Unfortunately, few of the many ecological studies concerning wildlife response to forest disturbance have included nongame birds (Webb 1973). Birds offer good potential as being sensitive indicators of environmental quality. North American birds are highly diversified, possessing more species than other terrestrial vertebrate classes. Birds are largely diurnal, vocal, highly territorial, and many are brightly colored. These factors make them convenient subjects for audio-visual counts. Since many species have evolved to fill highly specialized niches, any alteration of their life requisites will effect their population numbers and overall species composition. Thus it appears that birds can serve as convenient indicators of environmental conditions associated with stream alteration projects.

The purpose of this study, therefore, was to obtain quantitative information that can be used with confidence to predict the consequences of stream alteration and its associated land use changes on riparian avian communities in the southern grasslands of the United States.

The specific objective was to determine the impact of stream alteration and associated land use changes on the avifauna in selected riparian habitats along portions of altered and unaltered streams in southcentral Oklahoma.

Literature Review

There are many recent studies in the literature pertaining to the impact of stream alteration on aquatic and fishery resources (Bayless and Smith 1964, Bruna 1969, Bulkley et al. 1976, Cederholm 1972, Kelley 1975, Tarplee et al. 1971, and Trautman and Gartman 1974). Ghongdon (1971) and Funk and Ruhr (1971) studied impacts of stream alteration on aquatic resources in the Midwest. However, little information is available in the formal literature on the effects of such alterations on terrestrial wildlife (Henegar and Harmon 1971). Even more scarce is information dealing specifically with stream alteration impact on avifauna in the southern grasslands of the United States.

Studies done by Carothers et al. (1974) and Carothers and Johnson (1975a) probably have the most direct applicability to the present study. They emphasized the importance of riparian habitat to avian populations in regions where forest vegetation types are scarce. They found riparian habitat along the Verde River in Arizona to contain the highest densities of non colonial nesting birds in North America. Fifty percent of these species are so exclusively dependent on the riparian habitat that they would face local extirpation should water salvage and flood control practices continue to deplete vegetation along rivers in that region. The authors report that such practices have been directly responsible for the reduction of quantity and density of riparian forests. A direct linear correlation was found between riparian forest density and bird density.

Possardt (1975) studied the impact of stream alteration on aquatic and riparian wildlife in the White River Watershed of Vermont. Mist netting results showed species diversity to be significantly less in channelized areas for fall, early summer, and spring. Lower numbers of birds were collected at channelized sites. Unaltered sites produced higher numbers of Parulids and thrushes especially in fall and spring. Swallows and sandpipers were more numerous on channelized sites.

Ellis (1976), using spot-map and line transect count methods, found the number of birds seen during winter to be significantly higher on channelized sites as compared to unchannelized sites. Old channelization sites were found to contain a higher average number of birds seen per hour than did the more recently channelized sites. Ellis credits the higher abundances at older channelized sites to a greater complexity of the vegetation. Species richness and bird species diversity during the breeding season increased with increasing age of channelization recovery to a high on the unchannelized sites. This same trend was observed for the breeding bird densities.

Parulids appeared to be most affected by channelization. Positive linear relationships between percent canopy closure and breeding bird densities, and foliage height diversity and breeding bird species diversity led Ellis to conclude that bird diversity and density during the breeding season are greatly affected by removal of tree and shrub layers along the stream.

Rice (1976) studied the effects of channelization on vegetation, mammals and birds on Gordon Creek, Ohio. Time-area counts of birds were conducted from bridges in the various control and channelized sites. In general, bird species diversity indices and species richness were greatest in the wooded channelized sites as compared to unchannelized wooded sites during spring, summer, and fall sampling periods. These same avian population parameters were slightly higher for wooded edge channelized sites as compared to wooded unchannelized sites for the same 3 seasons. Grass-channelized sites proved to have significantly fewer species when statistically tested against wooded unchannelized sites.

New (1972) conducted a qualitative study on nongame birds along selected portions of natural and channelized streams in Indiana. His results indicated the total number of birds, total number of resident birds, number of birds per species, and species indigenous to riparian habitats were lower on the channelized streams as compared to natural portions. However, he concluded that, although a shift in species composition did occur, channelization had little effect on the total number of species using the area.

The implementation of channelization projects often enables adjacent wetlands to be drained. When wetlands drainage accompanies channelization work the impact on the native avifauna can be immense. Bonnema (1972) studied the wildlife losses following stream alteration of 217 km of Ten Mile Creek in central Minnesota. His results indicated that 82% of the adjacent wetlands were drained resulting in an annual loss of 12,000 ducks and 8,000 pheasants. The Alabama Department of Conservation reported an 86% reduction in the number of wood ducks nesting along Crow Creek after the completion of an SCS project involving extensive channelization (Anon n.d.).

Considering the available stream alteration literature, several factors that are evident on the short term basis seem to be negatively affecting riparian avifauna. First, the clearing of riparian habitat adjacent to the stream channel for passage of large dredging machinery eliminates valuable streamside habitat. Secondly, reduced flooding along channelized streams allows farmers to clear riparian habitat and drain wetlands over large areas. The subsequent utilization of the bottomlands for monocultural crop or forage production may likewise be viewed as detrimental to avifauna. These habitat alterations, associated with stream channelization, set back succession and create ecotones quite dissimilar to natural conditions.

Gill et al. (1974) reported that the primary habitat characteristic controlling bird density and diversity, and greatly affected by land management practices, is vegetation structure. An appreciation of the effects of modification of the forest structure is thus essential if watershed managers are to understand forest bird habitat requirements.

As the successional stages of riparian habitat are shifted back by habitat alterations created by channelization and subsequent land use change, the avian species composition and bird species diversity can be expected to change. Bird species diversity is likely to decrease as succession is reduced to early stages. Species composition would be expected to shift toward grasslands oriented species and more edge species in situations where riparian habitat is broken up in a patchy arrangement.

Numerous authors report that bird species diversity increases as succession advances (Karr 1968, Karr and Roth 1971, MacArthur 1964, and Odum 1950). These authors report that in some cases, bird species diversity and, usually, bird density will decrease slightly from subclimax to mature climax stages. Karr (1971) reports that this relationship is most likely a function of foliage density. Foliage height diversity and foliage density are generally considered to be the parameters associated with succession that account for the change in bird species diversity (Karr 1968, Willson 1974). Willson (1974) found that in a series of sites with increasing complexity of vegetational structure, the addition of trees in the series has the greatest impact on the addition of avian species. The increase may not be due to an increase in productivity of resources, but rather of environmental patchiness in 3 dimensions. Removal of understory reduces habitat diversity and eliminates niches for lower to mid-level foragers and nesters (Curtis and Ripley 1975, Dambach 1944).

Habitat selection can be viewed as a system designed to provide the species with all requisites for survival and reproduction (Balda 1975). These requisites, termed ultimate factors (after Baker 1938), encompass food, shelter, and correct physiognomy (Hilden 1965). Lack (1933) was first to show that on successional areas where rapid revegetation is occurring, a drastic change in avifauna can occur in a relatively short time. Lack viewed the major factors, most responsible for the composition of the existing population, to be suitable nesting requirements and a correct set of psychological characters. Lack stressed the psychological aspects of habitat selection rather than the ultimate factors. He viewed an important psychological factor to be height of vegetation, irrespective of the use of these heights for nesting or feeding.

Land and water management activities eliminate original forest habitat niches, replacing them with new and often quite dissimilar ones (Hooper 1967). Habitat alteration affects bird community diversity and the degree of change is often correlated to the alteration magnitude (Ambrose 1973). Bird species vary considerably in their tolerance to forest disturbance. Some bird species tolerate little alteration while others are found only on severely disturbed forest sites (Curtis and Ripley 1975). Clearly, certain bird species benefit from forest habitat changes while others are unfavorably affected, depending in each case upon the creation or destruction of the required niche (Stewart and Robbins 1958).

DESCRIPTION OF STUDY AREA

The study was conducted on portions of Rush Creek, Wildhorse Creek, Lake Creek, and Cobb Creek, all of which occur in southcentral and westcentral Oklahoma (Fig. 1). Rush Creek and Wildhorse Creek, which are parallel and have adjoining watersheds, were used to study channelization impact. Above and below impoundment effects were studied upstream and downstream of Ft. Cobb Reservoir along Cobb Creek and 1 of its tributaries, Lake Creek. All creeks are tributaries of the Washita River which enters Oklahoma along the western border and drains southeasterly into the Red River midway along the southern border of Oklahoma (Fig. 1). The confluence of Cobb Creek with the Washita River is approximately 130 km upstream from the confluence of Rush Creek and the Washita River.

The relative location of each Rush and Wildhorse creek study site is shown in Figure 2. The relative location of each Cobb and Lake creek study site appears in Figure 3. The physical description of the 4 creeks selected for study appears in Table 1. The physical description of each study site appears in Table 2.

Climate

The annual growing seasons for the study areas average 212 days (Rush and Wildhorse Creeks) and 207 days (Cobb Creek). The average annual precipitation is 86 cm for Rush and Wildhorse Creeks and 75 cm for Cobb Creek. May is the wettest month, receiving 18% of the annual

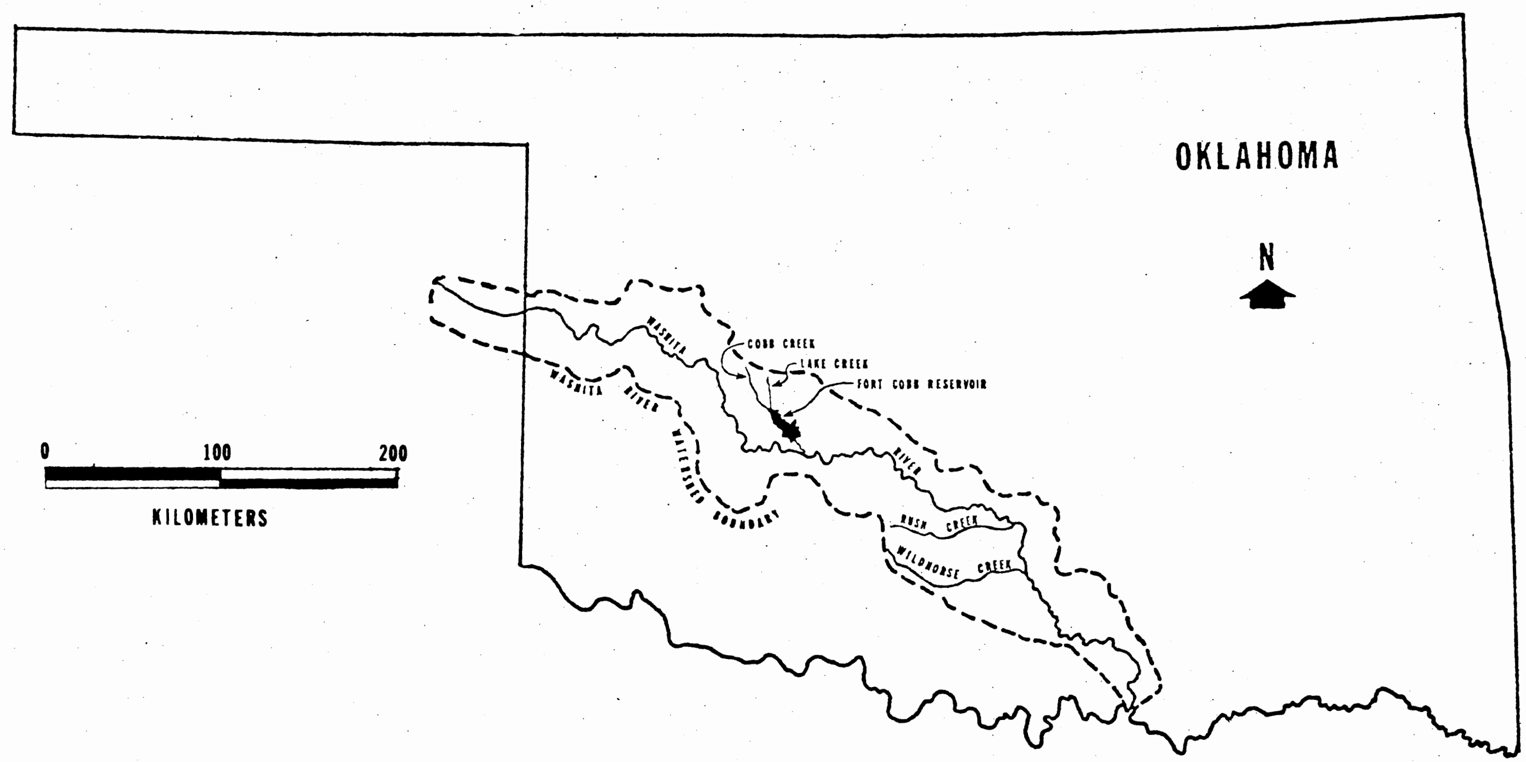


Fig. 1. Relative location of the 3 streams selected for study of alteration effect in Oklahoma.

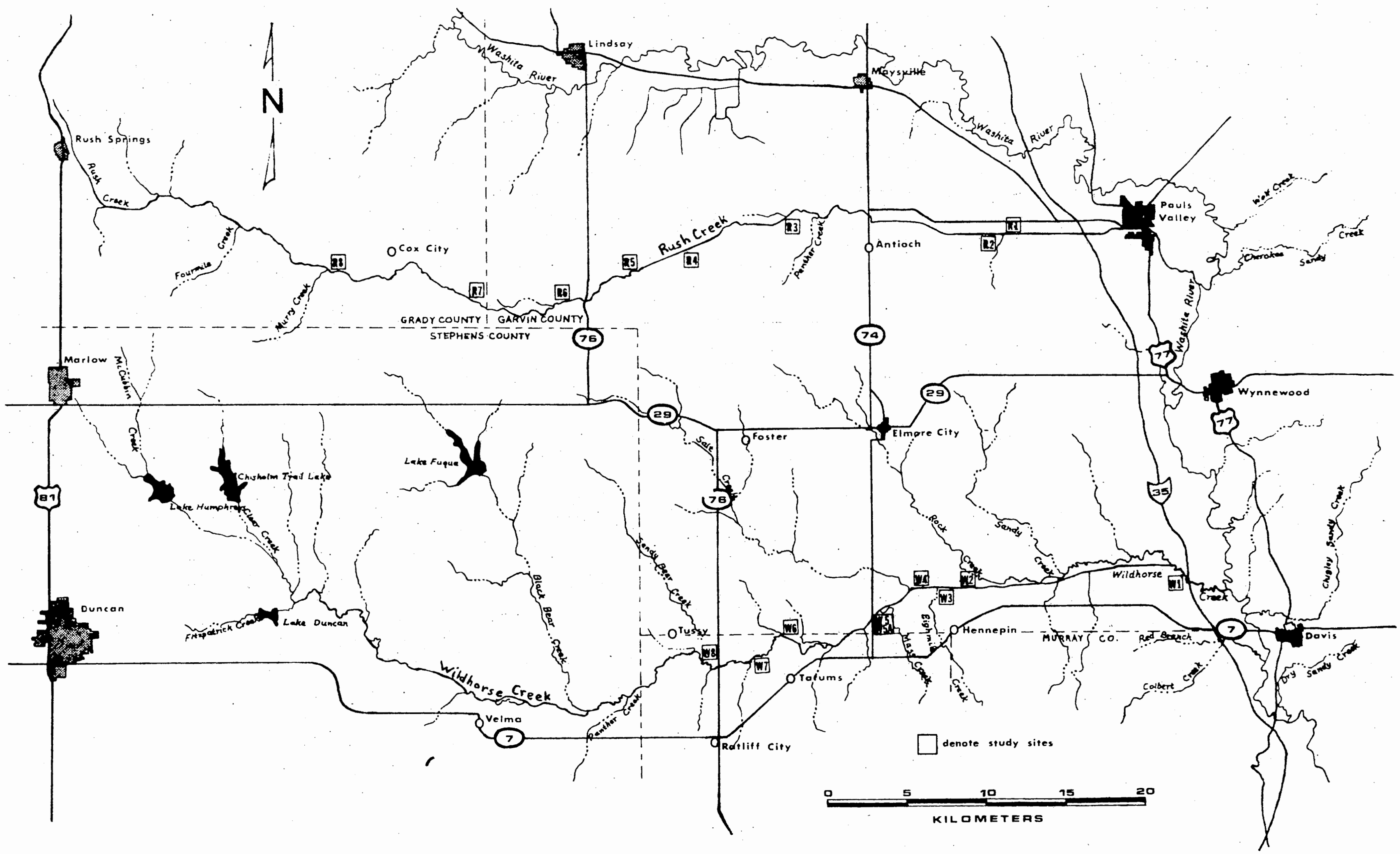


Fig. 2. Location of study sites on Rush and Wildhorse creeks.

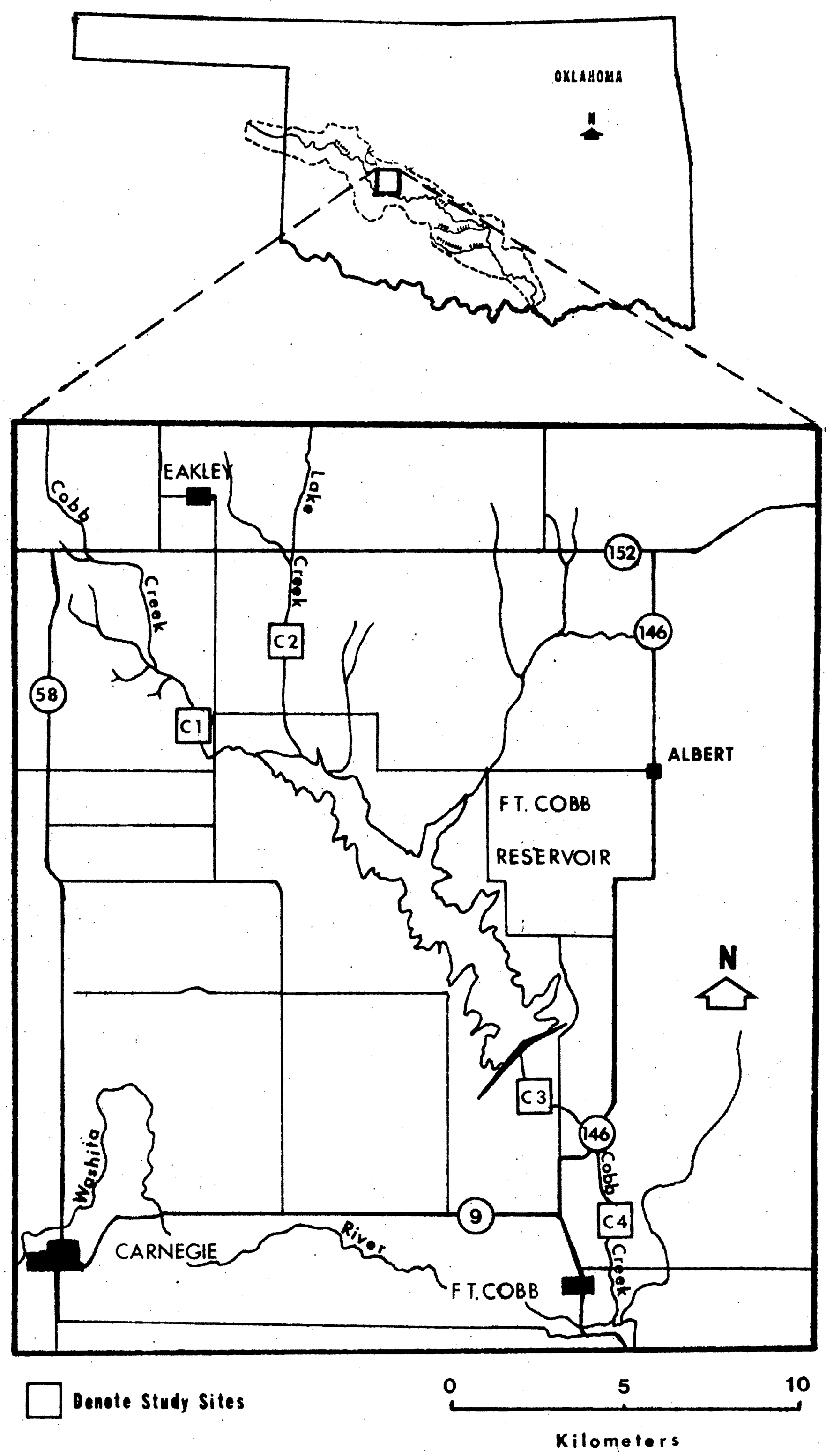


Fig. 3. Location of study sites on Cobb and Lake creeks.

Table 1. Location and physical description of creeks selected for study.

Creeks	Origin (km and dir. from nearest town and part of county)	General direction of flow	Length (km)	Loc. of confluence with the Washita River or Ft. Cobb Res. (km and dir. from nearest town and part of county)	Area of watershed (ha)	Okla. counties included in watershed	Area of flood plain (ha)	Year of channel or impoundment work	No. of P.L. 566 upstream retarding structures
Rush	3 N and 1 W of Rush Springs, SE Grady Co.	E	74	4 E and 4 S of Pauls Valley, E Garvin Co.	77,580	Grady Garvin Stephens	5,760	1922 1923	46
Wildhorse	1 E and 1 S of Marlow, NW Stephens Co.	E	92	2 W of Davis, SE Garvin Co.	104,600	Garvin Carter Murray Stephens	13,600	1931 1933 1968 1971	92
Cobb, upstream from Res.	8 S of Weatherford, SE Custer Co.	SE	33	7 S of Eakley, W Caddo Co.	83,836	Custer Washita Caddo	—	Res. built 1959	6
Lake, upstream from Res.	10 E of Eakley, N Caddo Co.	S	23	15 N of Ft. Cobb, Cent. Caddo Co.	—	Caddo	—	"	0
Cobb, downstream from Res.	Dam 6 N of Ft. Cobb, Cent. Caddo Co.	SE	8	1 E and 1 S of Ft. Cobb, Cent. Caddo Co.	—	Caddo	—	"	4

Table 2. Characteristics of selected riparian study sites on Rush, Wildhorse, Cobb, and Lake creeks.

Site No.	Channelization status	Habitat type	Transect length (m)	Location or km W. of I-35	Legal description County	R	T	S	Grazed[1]	Flood zone[2] vegetation
Rush Creek study sites										
R1	Channelized	Cropland	300	3.6	Garvin	3N	1W	15	No	Yes
R2	Channelized	Pecan grove with tame grass	300	4.4	Garvin	3N	1W	16	Yes	Yes
R3	Unchannelized	Bottomland forest "island	100	15.2	Garvin	3N	2W	8	Yes	No
R4	Channelized	Tame grass	300	18.4	Garvin	3N	3W	12	Yes	No
R5	Unchannelized	Native grass	225	26.4	Garvin	3N	4W	24	Yes	Yes
R6	Unchannelized	Bottomland forest island	100	29.6	Garvin	3N	4W	29	Yes	Yes
R7	Unchannelized	Bottomland forest (control)	300	38.4	Grady	3N	5W	26	Yes	Yes
R8	Unchannelized	Bottomland forest (control)	300	44.2	Grady	3N	5W	19	Yes	Yes
Wildhorse Creek study sites										
W1	Unchannelized	Bottomland forest (control)	300	0.4	Garvin	1N	1E	23	Yes	Yes
W2	Channelized	Cropland	300	12.8	Garvin	1N	1W	29	Yes	Yes
W3	Channelized	Pecan grove with tame grass	300	19.2	Garvin	1N	2W	26	Yes	Yes
W4	Channelized	Pecan grove with tame grass	300	20.0	Garvin	1N	2W	26	Yes	Yes
W5A	Channelized	Bottomland forest regrowth	300	20.9	Garvin	1N	2W	34	No	No
W5	Channelized	Bottomland forest	300	20.8	Garvin	1N	2W	34	Yes	No
W6	Channelized	Tame grass	300	28.0	Carter	1S	3W	1	Yes	Yes
W7	Channelized	Cropland	300	28.8	Carter	1S	3N	2	Yes	Yes
W8	Unchannelized	Bottomland forest (control)	300	32.2	Carter	1S	2W	3	Yes	Yes
Ft. Cobb Reservoir study sites										
C1	Control (above reservoir)	Narrow wooded strip with alfalfa border	300	Cobb Cr.	Caddo	9N	13W	22	Yes	Yes
C2	"	Bottomland forest	300	Lake Cr.	Caddo	9N	13W	12	Yes	Yes
C3	Below tail water	Wide wooded strip with alfalfa border	300	Cobb Cr.	Caddo	8N	12W	22	No	No
C4	Downstream	Narrow wooded strip with alfalfa border	300	Cobb Cr.	Caddo	7N	12W	12	No	No

1 Indicates grazed at least part of the time in which study occurred.

2 Indicated flood zone vegetation occurring below berm or top of stream bank parallel to stream.

precipitation. Lake evaporation is 160 cm annually. The mean annual temperature is 16.6°C with mean ranges from about 3.8°C in January to 28.4°C for the month of August (both study areas).

Topography, Soils and Geology

The study areas are classified as rolling to gently rolling prairie and savannah (Soil Conservation Service 1954). The study areas vary in elevation from 274-426 m above sea level (Gray and Galloway 1959). The gradient of the 3 streams is 3.1 m/km within 8 km of their confluence with the Washita River. Upper reaches of the creeks have gradients of 6.2 m/km (Oklahoma Water Resources Board 1968).

Chief soil associations of the Rush and Wildhorse Creek basins include the Darnell-Stephenville, Durant-San Saba-Tarrant, and Renfrow-Zaneis-Vernon. Part-Gracemont-Pulaski and Dougherty-Eufaula are the major soil associations found in the Ft. Cobb study area (Soil Conservation Service 1973).

Geologic formations underlying the Rush Creek and Wildhorse Creek study areas include the Garber Sandstones, Hennessey Shales, and El Reno Groups. Ft. Cobb Reservoir lies in the Western Sandstone Hills geologic area. The chief geological formation underlying Ft. Cobb Reservoir is the Rush Springs Sandstone of the Permian age (Gray and Galloway 1959).

Vegetation

According to Bailey (1976) the Rush and Wildhorse Creek area is included in the Oak + Bluestem Parkland ecoregion, while Ft. Cobb Reservoir lies in the Bluestem + Grama Prairie ecoregion. The Rush and Wildhorse Creek area lies in the Postoak-Blackjack Forest and Tallgrass Prairie vegetation types (Duck and Fletcher 1943). The Ft. Cobb area lies in the Mixedgrass Eroded Plains, Postoak-Blackjack Forest, and Tallgrass Prairie vegetation types.

Climax dominant plant species vary considerably among range sites within the study areas. Sand bluestem (scientific names appear in Appendix A., p. 127), big bluestem, little bluestem, indiangrass, switchgrass, side-oats grama and blue grama are usually among the dominant grasses found at range sites in good condition (Soil Conservation Service 1973). However, as a result of intensive grazing, poor range conditions persist over most of the areas and vegetation is typified by such species as broom sedge, annual three-awn, ragweed, windmillgrass, sand dropseed, fall witchgrass, and mat sandbur.

Stream courses are characterized by woody species such as ash, elm, burr oak, hackberry, pecan, black walnut, cottonwood, and willow (Soil Conservation Service 1973).

METHODS AND MATERIALS

Study Site Selection

Thirteen Oklahoma grassland streams with various extents of channelization were considered as potential study areas. Seven Oklahoma reservoirs were considered as potential impoundment impact (upstream and downstream of reservoir) study sites. The streams and reservoirs were evaluated by aerial and ground reconnaissance. A stream and reservoir selection matrix was subsequently developed to evaluate the usefulness and compatibility of each area to the present study (see Table 3).

The selection matrix was used to rank each area in respect to the following broad parameters: (1) physical, (2) hydrologic, (3) informational, (4) proximal, and (5) access. Each subdivision of the major parameters was assigned a value of 0-5 based on its applicability to the needs of this study. The values were summed, and the total ratings indicated that 3 streams, Rush Creek, Wildhorse Creek and Sugar Creek, showed high usefulness to the channelization impact portion of the study. Sugar Creek was eliminated due to its deficiency of unchannelized control sites and other uncontrollable variables. Ft. Cobb Reservoir was selected over Salt Plains Reservoir because the former was closer to our summer base camp at Foster, Oklahoma, occurred in the Washita River drainage system as did Rush and Wildhorse Creeks, and posed fewer potential access and ecological problems than did the areas

Table 3. Study stream and reservoir selection matrix, Stream Alteration Impact Study, Oklahoma.

Parameters	Bear-Hybarger Cr.	Canyon View Cr.	Cavalry Cr.	Fast Runner Cr.	Four Mile Cr.	Kickapoo Sandy Cr.	Lambert Cr.	Rush Cr.	Sandstone Cr.	Squaw Cr.	Sugar Cr.	Tonkawa Cr.	Wildhorse Cr.	Canton Res.	Carl Blackwell Res.	Ellsworth Res.	Ft. Cobb Res.	Foss Res.	Kaw Res.	Salt Plains Res.
Physical:																				
Soil index	4	1	3	3	4	2	4	2	4	1	2	2	3	3	1	4	4	4	2	3
Game type	2	2	3	2	2	4	2	4	1	1	1	4	4	4	2	2	2	4	4	4
Land use	2	3	3	4	1	4	3	4	4	3	3	3	5	5	3	3	5	1	2	5
Hydrologic:																				
Miles channel	2	1	1	2	2	2	2	5	1	2	5	2	2	-	-	-	-	-	-	-
Type flow	3	2	3	2	3	3	3	2	3	2	3	3	3	4	3	4	3	4	4	4
Type channel	4	4	4	4	4	4	4	4	4	5	4.5	4.5	3.7	-	-	-	-	-	-	-
Type channel	1	3	3	3	3	2.5	3	2	3	1	3	3	2	-	-	-	-	-	-	-
(Bef. project)	2	1	4	1	1	3	1	5	4	1	5	2	5	5	1	2	2	4	5	5
Drain. area	2	1	4	1	1	3	1	5	4	1	5	2	5	5	1	2	2	4	5	5
Informational:																				
Soil survey	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	0	1	1
Stream gauge	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1
Topo. map																				
1940	1	1	1	1	1	0	1	1	0	0	1	1	1	1	0	0.5	1	1	1	1
1970	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Proximal:																				
From OSU	2	3	2	2	4	2	2	2	1	1	2	2	1	2	5	2	2	1	4	3
To control	3	3	2	3	2	2	3	1	3	1	3	2	2	3	3	3	3	3	3	3
To Wh. Cr.	5	2	2	3	3	5	1	5	1	3	3	3	5	1	1	3	2	1	1	1
Access:																				
Public own.	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5
Access pts	4	2	4	3	5	5	5	5	4	5	5	3	5	5	5	5	5	5	5	5
No. sites	2	2	0	4	1	2	0	3	0	0	3	2	3	0	0	1	1	0	0	0
TOTALS	39	33	38	40	39	43	37	47	37	29	47	39	46	39	31	38	39	36	39	40

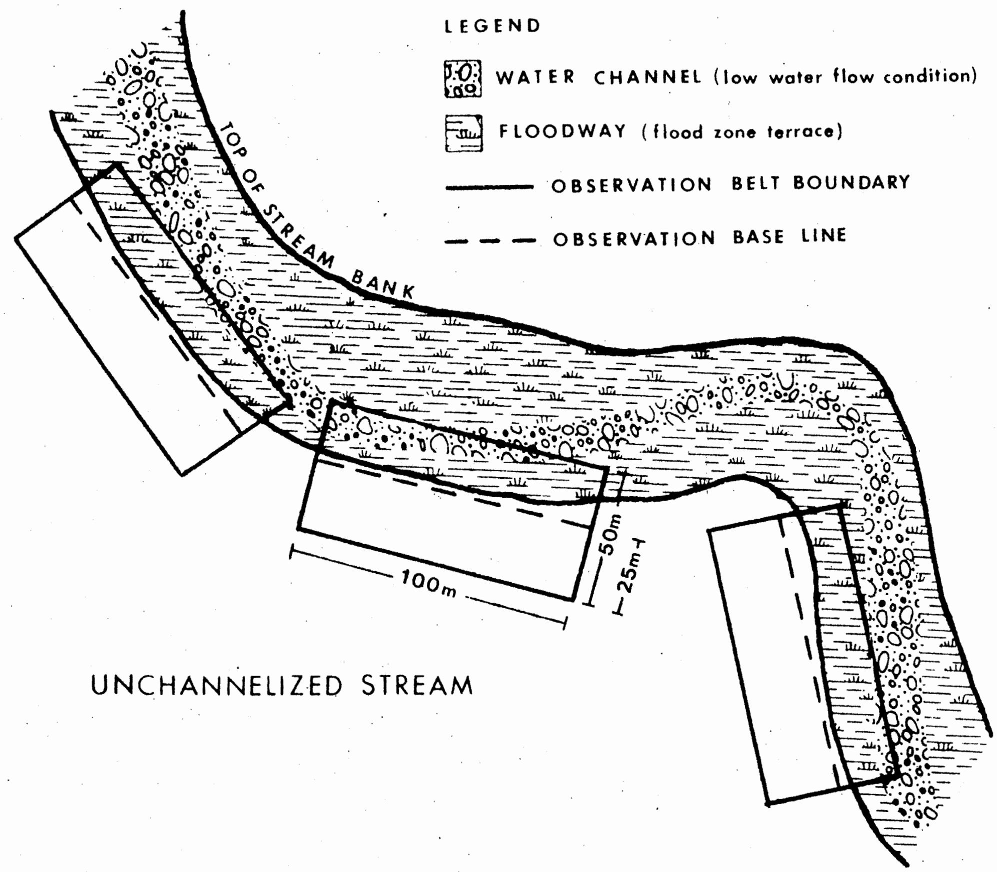
above and below the Salt Plains Reservoir.

Another intensive aerial survey of the 3 selected study areas was conducted. Potential study sites and their nearest access points were photographed and plotted on maps. Landowner maps were acquired, and an intensive landowner interview program was conducted. Specific study sites were then selected if they met needed size, habitat, and alteration criteria and if the landowner was willing to grant access permission. The habitat at each site had to be homogeneous, at least 100 X 500 m in area, and accompanied by the same habitat on the other side of the stream.

Seventeen sites, 9 on Wildhorse Creek and 8 on Rush Creek, were ultimately selected for the channelization study. Four sites, 2 above and 2 below Ft. Cobb Reservoir, were selected to study the upstream and downstream effects of reservoir impoundment.

Bird Census Techniques

An observation base line was established parallel to the stream channel at each site (Fig. 4). Due to the meandering nature of the stream on unaltered study sites it was impossible to establish a single straight base line 300 m in length. In these cases the base line was broken into 100 or 200 m lengths to fit the curve of the stream. The count areas of these smaller segments did not overlap. The base line was situated in 1 homogeneous vegetative cover type, and started and ended at least 100 m from the nearest differing cover type to minimize the possibility of edge effect. All study sites were composed of approximately equal areas of land and water. A narrow path was cleared of dense vegetation along the base line on wooded sites to reduce noise



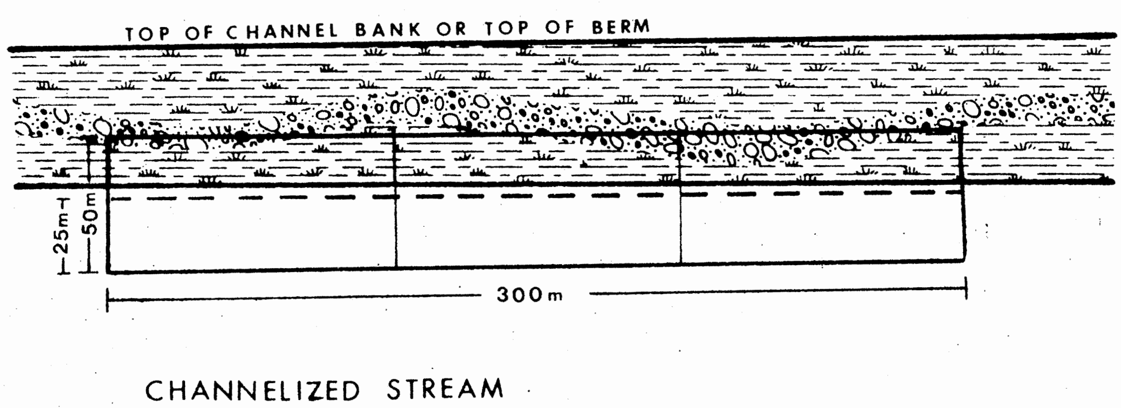


Fig. 4. Placement of observation belts on stretches of unaltered and altered streams.

made by observers as they advanced along the line.

Steel measuring tapes and brightly colored plastic flagging were used to mark the base lines at 25 m intervals. Markers were also placed at distances 25 m landward from the base line. The markers allowed observers to make accurate lateral distance judgements and to accurately record bird locations on grid maps of each study site.

Progress along each base line and recording methods were like those described by Emlen (1971). All birds detected at each site were recorded on the grid map, but only those in the 300 X 50 m observation belt were used to make comparisons between sites. Weather conditions and time were recorded at the start and finish of each count.

Following each count, data were transferred to computer card format data sheets. All data were transferred from data sheets to standard computer cards when the field work was completed.

Emlen (1971) pointed out that a major source of error in bird census work is observation bias, influenced by such variables as observer experience, weather, and time of day. To minimize biases caused by weather, human disturbance, and daily activity patterns of birds, the following conditions were met before a count would be taken: (1) wind speed less than 25 M.P.H.: (2) no precipitation occurring; (3) no human disturbance occurring during or previous to count, and (4) count taken during the first 3 h of daylight.

Due to the man-power needed to conduct an adequate number of counts at each of the 21 sites it was necessary to employ 2 technicians in addition to the author. The technicians were selected on the basis of their bird identification ability plus other criteria. The team members spent 2 weeks synchronizing and improving their observation acuity prior to the initiation of the study. The 3 observers conducted test counts along the same observation base lines, separated by 5 minute intervals. Test count results were very similar for each observer. Observational biases were also minimized during the regular survey by having each site sampled an equal number of times by each observer.

Data Analysis

Each study site was censused approximately 10 times during the summer 1976, and on the average of 3 times each during the fall 1976, winter 1976-77 and spring 1977. Seasons were defined as follows: (1) summer-June, July and August; (2) fall-September, October and November; (3) winter-December, January and February; and (4) spring-March, April and May. All data on parameters of the avian populations, with the exception of the life forms analysis, were calculated and compared on the seasonal basis.

Parameters used to describe the avian community at each site and used to make comparisons between sites included:

1. Bird species diversity (BSD)
2. Equitability or evenness coefficients of the population
3. The average number of species seen per visit in the 300 X 50 m observation belt (species richness)
4. The average number of birds (individuals) seen per hectare per visit in the 300 X 50 m belt (density)
5. The total number of different species seen in the observation belt per season
6. The average number of individuals seen per species

7. Species composition

8. Life forms composition

The computations for density and species richness per site for each visit and for each season, plus the density per species per visit, were conducted using the IBM 370 computer and standard Fortran programs (McCracken 1974).

The currently most popular index of species diversity is derived from the information theory and is calculated by the "Shannon and Weaver formula" (Shannon and Weaver 1963). This index was used in the present study to facilitate the communication of avian community parameters and to make our data comparable to a large number of studies that have also used the index. The formula is defined as:

$$H' = -\Sigma p_i \log_e p_i$$

where p_i is the proportion of the total population represented by the i^{th} species. This proportion (p_i) is estimated from the samples by n_i/N, where n_i is the number of individuals observed of the i^{th} species, and N is the total number of individuals observed. Natural logs were used because diversity indices are asymptotically normal in distribution when natural logs are used (Hutcheson 1969).

The formula is influenced by 2 factors. The first factor, species richness (S), is the total number of species present in the sample. The second factor, the relative abundance or the evenness of each species in the community, referred to as the equitability component (J') (Pielou 1966a), is defined as:

$$J' = H'/H'max.$$

H' is the species diversity value, and H' max is the maximum diversity possible for the sample which is calculated by taking the natural log of the number of species in the sample (S). J' varies from a minimum of 0 to a maximum of 1 when all species have equal densities in the sample.

Tramer (1969) showed that in birds, species diversity (H') was highly correlated with species richness ($r = 0.972$). His studies dealt with breeding bird communities where evenness (J') between species is high due to territoriality. In addition to breeding bird diversity, the present study deals with bird species diversity (BSD) in the fall, winter and spring, where dispersion due to territoriality is generally lacking, and J' values do influence the H' value considerably.

Importance values were calculated for all bird species per study site per season. The importance value was defined as the relative density per count plus the relative frequency (number of counts on which the species appeared). The maximum importance value that a species could have was 200.

Similarity between the bird communities of various study sites was expressed as the coefficient of community similarity (C), $C=2W/A+B$, where W is the sum of the importance values for species shared by 2 study sites; A is the sum of importance values for all species on the first study site; and B is the sum of the importance values for all species occurring on the second study site (Bray and Curtin 1957). Increasing similarity in species composition and relative abundance of the various species between the 2 compared communities will be reflected by corresponding increasing in the C value toward 1.0.

Communities having all species in common and relative abundances of all species the same will have C values of 1.0 (Kricher 1975).

Coefficients of community similarity (C) (Bray and Curtin 1957) were calculated between each site and each of the 4 Rush and Wildhorse Creek control sites during each of the 4 seasons. The bird species composition and relative abundance at the control sites were considered to be representative of natural riparian bottomland forests. Species composition and relative abundance at the altered sites were compared to those at control sites for the purpose of determining to what extent the effect of channelization and various intensities of subsequent land use changes had on alteration of the native riparian avifauna composition. Coefficients of community similarity were calculated, comparing every study site to each of the 4 control sites. The mean C value for each site was determined by averaging its C value from each of the 4 control sites.

Species composition tables showing seasonal densities for each species were constructed for each site (Appendix C and D). Species from the summer counts were grouped into life forms, fashioned after classifications used by Thomas (c. a. 1979) and Haapanen (1965). The life forms are categories that reflect combinations of habitat requirements for reproduction and for feeding. For example, life form 8 is any bird that excavates its own cavity in a tree for nesting and feeds in bushes and trees. The purpose of the life forms analysis is to relate the composition of the avian community to vegetation structure and successional stages.

The high number of bird species, many of which have different life requisites, makes it difficult for land managers and biologists to consider each species in land and water management planning processes. The 84 species of breeding bird species observed on study sites in the present study have been reduced to a more manageable level of 18 life forms. Definitions of all life forms and the species contained in each appear in Appendix B, p. 132.

In order to preserve native riparian avifauna we must first identify what combinations of general characteristics of the vegetation are responsible for their existence. Life forms analyses are useful in identifying the vegetation forms, lost in alteration activities, that result in avian community changes away from the natural state. Further, of major importance to resource managers and biologists, the life forms displays can be used to predict the response of avian communities to alterations of the plant community. Thus, through the use of life forms analyses various agencies may be facilitated in meeting their statutory obligations to environmental impact statements and cost-benefit analyses.

Statistical Analysis

T-tests were used to test for significant differences between class means for BSD, equitability coefficients, total species richness per season, mean species richness per visit and density per visit (Sokal and Rohlf 1969). T-tests were also used to test for significant differences among seasons within classes for the above parameters. The observed T-values and significance levels for all tests conducted appear in Appendix F. As the number of counts used to calculate parameter means for each site numbered at least 10 in the summer, these means may be considered to be normally distributed by use of the central limit theorem. However, statistical tests of data taken during the fall, winter, and spring should be interpreted with caution as parameter means were calculated from a maximum of 4 counts and may not be normally distributed.

A one-way analysis of variance was used to test for significant differences in each avian parameter between the two streams being studied for channelization effects (Sokal and Rohlf 1969).

ABBREVIATIONS AND DEFINITIONS

altered	=	channelized or downstream from impoundment
BSD	=	bird species diversity
C	=	coefficient of community similarity value
control site	=	unaltered bottomland forest site
ChBotFor	=	channelized bottomland forest
ChBotForReg	=	channelized bottomland forest regrowth
ChCrop	=	channelized cropland
ChPecGroTaGr	=	channelized pecan grove with tame grass
ChTaGr	=	channelized tame grass
cm	=	centimeter
forest "island"	=	a small remnant patch of bottomland forest which is surrounded by a differing cover type
H'	=	bird species diversity value
ha	=	hectare
J'	=	equitability coefficient value
km	=	kilometer
m	=	meter
site class	=	all sites with the same cover type and channel type
UnBotFor	=	unaltered bottomland forest
UnBotForIs	=	unchannelized bottomland forest "island"
UnNatGr	=	unchannelized native grass

RESULTS

A total of 412 bird counts were conducted during the course of the study. Each of the 17 study sites being investigated for channelization effects were sampled at least 10 times each in the summer and an average of 3 times each during the fall, winter and spring. Each of the 4 sites being studied for the effect of impoundment were sampled 10 times each in the summer, 2 times each during the winter, and 3 times each during the spring. No bird counts were conducted on these 4 sites during the fall due to the occurrence of inclement weather on days when fall counts were scheduled. The exact number of counts taken at each of the various sites is included in Appendix C and D.

Analysis of variance (ANOVA) tests were conducted for each avian parameter to determine if the sites on the two creeks being studied for channelization effects were comparable to each other. ANOVA tests showed that differences in each avian parameter were nonsignificant between the two creeks when site data from each stream were pooled.

Survey maps drawn in 1871 indicate that all selected study sites were once natural riparian bottomland forest (National Archives 1977). Therefore, avian parameters from sites altered through channelization and land use change as a result of channelization were compared to the unchannelized bottomland forest sites to determine the degree of change away from the natural condition.

Due to the voluminous amount of data and the large number of sites that are to be compared, each of the avian parameters studied is presented as a separate section. Findings under each parameter section are further divided into annual, summer, winter, migration priods, and seasonal trends subsections.

The Effects of Channelization: Rush and Wildhorse Creeks

Species Richness

The mean number of avian species seen per visit at each Rush and Wildhorse creek study site is shown in Table 4. The total number of avian species seen per season on each Rush and Wildhorse creek study site appears in Table 5.

Annual. The total number of bird species seen on the ChPecGroTaGr (definitions of site abbreviations occur on p. 31), UnBotForIs, ChBotFor, ChCrop and ChTaGr sites was significantly lower than the total species seen on the control sites (UnBotFor) (Appendix F, Table 3). The total number of species seen during the entire year was higher on the ChBotForReg site (39) than on the control sites ($\bar{X}$ = 36.2 ± 2.04, $\bar{X}$ = mean ± s.d.).

Summer. The total number of bird species seen during the summer was lower on the ChCrop, ChTaGr, ChBotFor, and UnBotForIs sites than on the control sites. However, only the ChCrop and UnBotForIs sites supported significantly lower total summer bird species when compared to the control sites (Appendix F, Table 3). The total number of species seen during the summer on the ChPecGroTaGr ($\bar{X}$ = 26.3 ± 1.24), ChBotFor-Reg (24) and UnNatGr (24) sites were similar to that observed on the

Table 4. Mean number of avian species seen per visit on the Rush and Wildhorse creek study sites during summer, fall, winter 1976, and spring 1977.

Season	Unaltered bottomland forest				Channelized pecan grove tame grass			Unaltered bottomland forest island		Channel-ized bottomland forest regrowth	Channel-ized bottomland forest	Channelized cropland			Channelized tame grass		Unaltered native grass
	W1	W8	R7	R8	R2	W3	W4	R3	R6	W5A	W5	W2	W7	R1	R4	W6	R5
Summer	7.3	6.9	4.4	8.0	8.7	6.9	5.0	5.4	4.5	8.0	5.0	1.9	2.5	4.2	3.1	4.2	3.1
	X=7.05[1] s=.721				X=6.68 s=1.51			X=4.95 s=.450				X=2.86 s=.970			X=3.65 s=.550		
Fall	6.0	6.0	7.3	8.5	7.5	1.0	1.5	1.0	2.3	5.0	2.3	4.0	1.5	2.0	1.6	2.5	1.6
	X=6.95 s=1.04				X=3.33 s=2.95			X=1.65 s=.650				X=2.50 s=1.08			X=2.05 s=.202		
Winter	6.0	5.3	6.3	7.0	2.5	1.5	3.0	2.3	1.5	5.0	5.5	0.3	2.3	1.5	1.0	3.0	1.0
	X=6.15 s=.610				X=2.33 s=.623			X=1.90 s=.400				X=1.36 s=.820			X=2.00 s=1.00		
Spring	6.0	8.0	8.5	7.2	4.6	4.5	5.0	2.0	4.7	5.0	5.5	1.5	2.0	1.0	3.0	2.0	3.0
	X=7.42 s=.940				X=4.70 s=.216			X=3.35 s=1.35				X=1.50 s=.400			X=2.50 s=.500		
Overall mean and standard deviation	X=6.89 s=.463				X=4.30 s=1.69			X=2.96 s=1.31		X=5.75 s=1.68	X=4.57 s=1.32	X=2.05 s=.639			X=2.55 s=.441		X=2.17 s=.810

[1] X denotes the mean; s denotes the standard deviation.

Table 5. Total number of bird species seen per season on the Rush and Wildhorse creek study sites during 1976-1977.

Season	Unaltered bottomland forest				Channelized pecan grove tame grass			Unaltered bottomland forest island		Channel-ized bottomland forest regrowth	Channel-ized bottomland forest	Channelized cropland			Channelized tame grass		Unaltered native grass
	W1	W8	R7	R8	R2	W3	W4	R3	R6	W5A	W5	W2	W7	R1	R4	W6	R5
Summer	23	24	13	24	28	26	25	15	11	24	18	9	16	14	19	20	24
	$\bar{X}$=21				$\bar{X}$=26.3			$\bar{X}$=13				$\bar{X}$=13			$\bar{X}$=19.5		
	s=4.63				s=1.24			s=2.0				s=2.94			s=.50		
Fall	6	10	17	12	14	2	3	3	6	13	6	4	3	4	4	5	10
	$\bar{X}$=11.2				$\bar{X}$=6.3			$\bar{X}$=4.5				$\bar{X}$=3.66			$\bar{X}$=4.5		
	s=3.96				s=5.43			s=1.5				s=.471			s=.50		
Winter	16	13	13	13	3	6	9	7	5	16	14	1	4	3	3	9	9
	$\bar{X}$=13.7				$\bar{X}$=6.0			$\bar{X}$=6.0				$\bar{X}$=2.66			$\bar{X}$=6.0		
	s=1.3				s=2.44			s=1.0				s=1.24			s=3.0		
Spring	9	16	21	16	10	8	10	6	15	8	9	3	3	4	7	2	5
	$\bar{X}$=15.5				$\bar{X}$=9.33			$\bar{X}$=10.5				$\bar{X}$=3.33			$\bar{X}$=4.5		
	s=4.27				s=.942			s=4.5				s=.471			s=2.5		
Total	33	36	38	38	33	30	30	21	23	39	28	15	18	19	22	19	33
	$\bar{X}$=36.2				$\bar{X}$=31			$\bar{X}$=22				$\bar{X}$=17.3			$\bar{X}$=20.5		
	s=2.04				s=1.41			s=1.0				s=1.7			s=1.5		

control sites ($\bar{X} = 21 \pm 4.63$).

The mean number of bird species seen per summer visit on the UnNatGr, ChCrop, ChTaGr, UnBotForIs sites was significantly lower than on the control sites (Appendix F, Table 1). The mean numbers of avian species seen per visit on the ChBotFor and ChPecGroTaGr sites, although lower, were not significantly lower than the control sites.

Winter. Differences in species richness between control sites and the altered sites became more pronounced in the winter. All site classes (except the ChBotFor and ChBotForReg classes) supported significantly fewer total numbers of species and numbers of species seen per visit than did the control class (Appendix F, Table 3). The channelized sites with intensive land use changes (e.g., ChPecGroTaGr, ChTaGr and ChCrop sites) were utilized by only 43% of the total number of species that utilized control sites.

Migration Periods. All sites (except the ChBotForReg site) supported fewer total number of species seen during the fall than did the control sites. However, only the ChCrop sites supported significantly lower total species seen in the fall than the control sites (Appendix F, Table 3). In the fall, all sites (except the ChBotForReg site) were found to support a significantly lower mean number of species seen per visit than the control sites (Appendix F, Table 1).

Although all sites supported a lower total number of species seen during spring than did the control sites, only the ChCrop, ChTaGr and ChPecGroTaGr sites supported significantly lower total spring species than did the control sites (Appendix F, Table 3). All sites (except the ChBotForReg and ChBotFor sites) supported a significantly lower mean number of species seen per visit in the spring than did the control sites (Appendix F, Table 1).

Seasonal Trends. Figure 5 shows that the mean number of species seen per visit throughout the year on the control sites was very high (overall $\bar{X} = 6.89 \pm .463$) and varied least of any site class from season to season. The control sites supported 34% fewer total species in winter than in summer. Total species seen on these sites during migration periods was 36% lower than in the summer. The total number of species seen on control sites in fall, winter and spring was significantly lower than in summer (Appendix F, Table 3). However, differences in the total number of species seen on the various sites between summer, fall, winter and spring should be interpreted with caution as sampling intensities varied considerably between the summer and fall, winter and spring. The higher number of visits to each site in the summer gave rarer species a higher probability of being seen then than in the fall, winter or spring.

Figure 5 shows that the mean number of species seen per visit on the ChPecGroTaGr sites decreased noticeably from summer through winter. The mean for these sites was significantly lower in winter and spring when compared to summer (Appendix F, Table 2).

The ChPecGroTaGr sites supported an average of 70% fewer total species in the fall, winter and spring than in the summer. The total number of bird species seen in fall, winter and spring on the ChPecGroTaGr sites was significantly lower than in the summer (Appendix F, Table 4).

Trends in seasonal variation of species richness for the ChTaGr and UnBotForIs sites approximated that of the ChPecGroTaGr sites

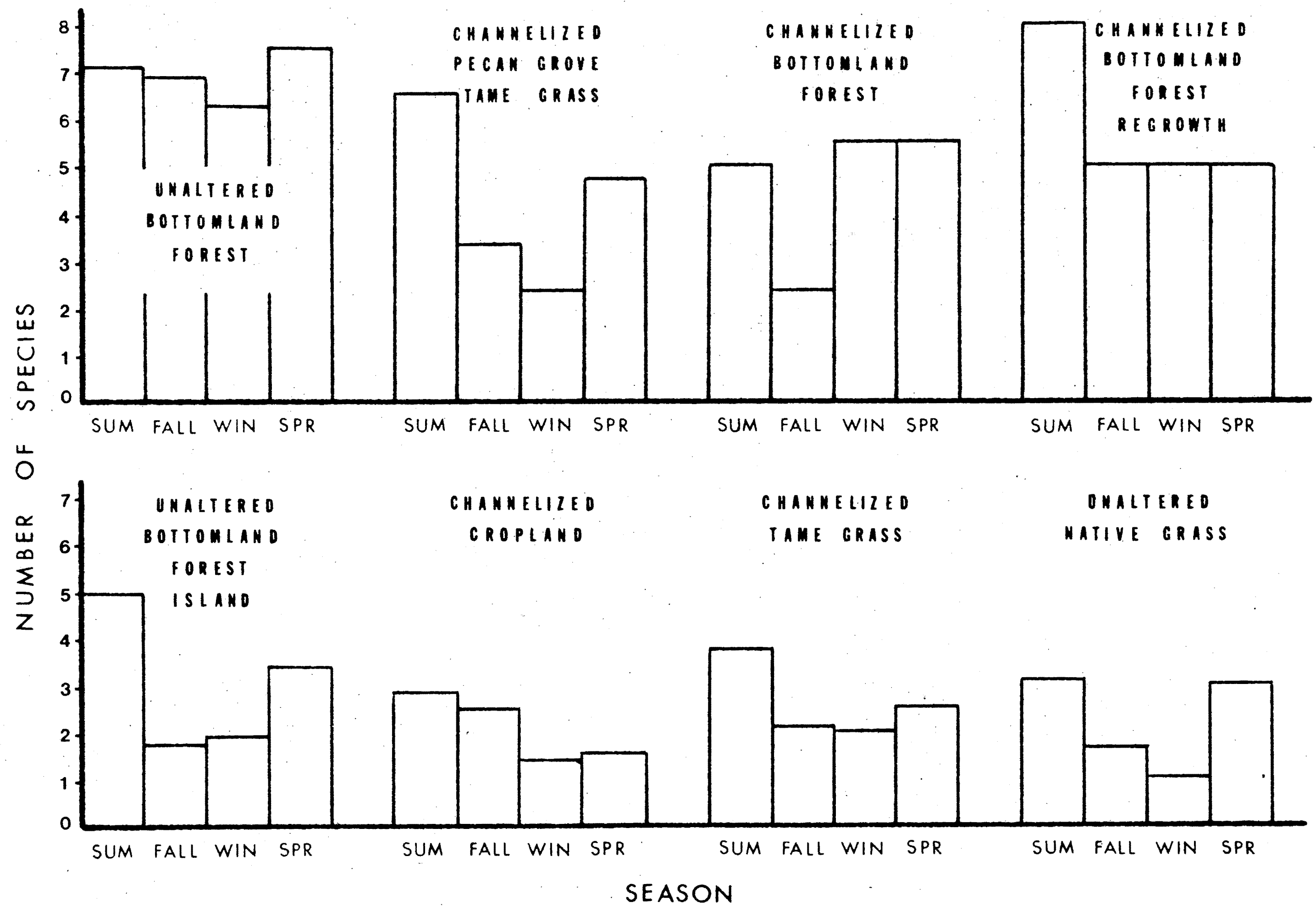


Fig. 5. Mean number of species seen per visit on each Rush and Wildhorse creek site class during summer, fall, winter 1976, and spring 1977.

(Fig. 5). The mean number of species seen per visit in winter and fall was significantly lower on both the ChTaGr and UnBotForIs sites when compared to the summer (Appendix F, Table 2).

The total number of species seen on ChTaGr sites was significantly lower in the fall, winter and spring when compared to summer (Appendix F, Table 4). The total number of species seen on the UnBotForIs sites was significantly lower in the fall and winter when compared to summer.

The mean number of species seen per visit on the ChCrop sites was consistently low for all seasons (overall $\bar{X} = 2.05 \pm .630$). Total species richness per season for the ChCrop sites was significantly lower in fall, winter and spring than in summer (Appendix F, Table 4).

Bird Density

The average number of birds seen per ha per visit for each Rush and Wildhorse creek study site is shown in Table 6.

Annual. The overall mean number of birds seen per ha per visit (mean for the entire year) ranged from 13.38 on control sites (UnBotFor) to 4.23 on ChTaGr sites. All site classes (except the ChBotForReg) supported a significantly lower overall mean number of birds seen per ha per visit than the control class (Appendix F, Table 5).

Summer. The ChPecGroTaGr, ChBotFor, ChCrop, ChTaGr and UnNatGr sites supported lower bird densities per visit than did the control sites. However, only the ChTaGr sites supported significantly lower densities than the control sites (Appendix F, Table 5). Summer bird densities per visit on the ChBotForReg and UnBotForIs sites were similar to those observed on control sites (Table 6).

Table 6. Average number of birds seen per hectare per visit on the Rush and Wildhorse creek study sites during summer, fall, winter 1976, and spring 1977.

	Unaltered bottomland forest				Channelized pecan grove tame grass			Unaltered bottomland forest island		Channel-ized bottomland forest regrowth	Channel-ized bottomland forest	Channelized cropland			Channelized tame grass		Unaltered native grass
Season	W1	W8	R7	R8	R2	W3	W4	R3	R6	W5A	W5	W2	W7	R1	R4	W6	R5
Summer	9.33	9.38	6.06	12.8	10.3	7.86	4.40	12.8	6.40	12.0	5.16	1.83	6.77	9.46	3.81	4.86	5.81
	$\bar{X}$=9.39 [1] s=2.38				$\bar{X}$=7.53 s=2.43			$\bar{X}$=9.60 s=3.20				$\bar{X}$=6.02 s=2.73			$\bar{X}$=4.33 s=.525		
Fall	7.33	8.66	20.4	12.6	11.6	0.66	1.00	2.00	8.66	6.88	2.00	8.00	2.33	7.55	2.44	5.66	5.92
	$\bar{X}$=12.2 s=5.09				$\bar{X}$=4.44 s=5.10			$\bar{X}$=5.33 s=3.33				$\bar{X}$=5.96 s=2.57			$\bar{X}$=4.05 s=1.61		
Winter	25.1	34.0	12.8	11.7	0.99	2.83	6.16	8.66	4.00	12.8	11.9	1.33	4.22	4.65	3.77	5.83	4.00
	$\bar{X}$=20.9 s=9.20				$\bar{X}$=3.32 s=2.13			$\bar{X}$=6.33 s=2.32				$\bar{X}$=3.39 s=1.48			$\bar{X}$=4.80 s=1.03		
Spring	10.6	12.6	10.6	10.3	6.00	3.66	5.00	7.33	18.5	4.66	6.00	3.33	3.33	2.66	3.55	4.00	1.33
	$\bar{X}$=11.0 s=.930				$\bar{X}$=4.88 s=.950			$\bar{X}$=12.9 s=5.58				$\bar{X}$=3.10 s=.315			$\bar{X}$=3.77 s=.225		
Overall mean and standard deviation	X=13.3 s=4.45				X=5.04 s=1.54			X=8.54 s=2.97		X=9.10 s=3.43	X=6.27 s=3.50	X=4.61 s=1.37			X=4.23 s=.380		X=4.26 s=1.85

[1] $\bar{X}$ denotes the mean; s denotes the standard deviation.

Winter. During this season the contrast in bird density per visit between the control sites and the various channelized sites became more evident. The ChPecGroTaGr, ChCrop and ChTaGr sites supported significantly lower densities per visit when compared to control sites (Appendix F, Table 5). The inability to establish significant differences between the control sites and other altered sites resulted from the extremely high standard deviation (s = 9.20) on the control sites.

Migration Periods. All site classes supported lower bird densities per visit than the control sites in fall. However, none of these sites proved to be significantly lower than the control sites (Appendix F, Table 5). This was mainly due to the high standard deviation (s = 5.09) found between control sites.

In the spring, all site classes (except the UnBotForIs class) proved to have significantly lower bird densities per visit than the control class (Appendix F, Table 5).

Seasonal Trends. Figure 6 shows the mean bird density per visit for each site class during the 4 seasons. Mean bird density on the control sites increased significantly (Appendix F, Table 6) from summer through winter, then decreased in the spring.

Both the ChBotFor and ChBotForReg sites showed decreases in density from summer to fall, followed by an increase in winter and another decrease in spring (Fig. 6).

The ChPecGroTaGr and ChCrop sites generally supported slightly lower densities of birds during fall, winter, and spring than in the summer (Fig. 6). The ChPecGroTaGr sites showed a significant

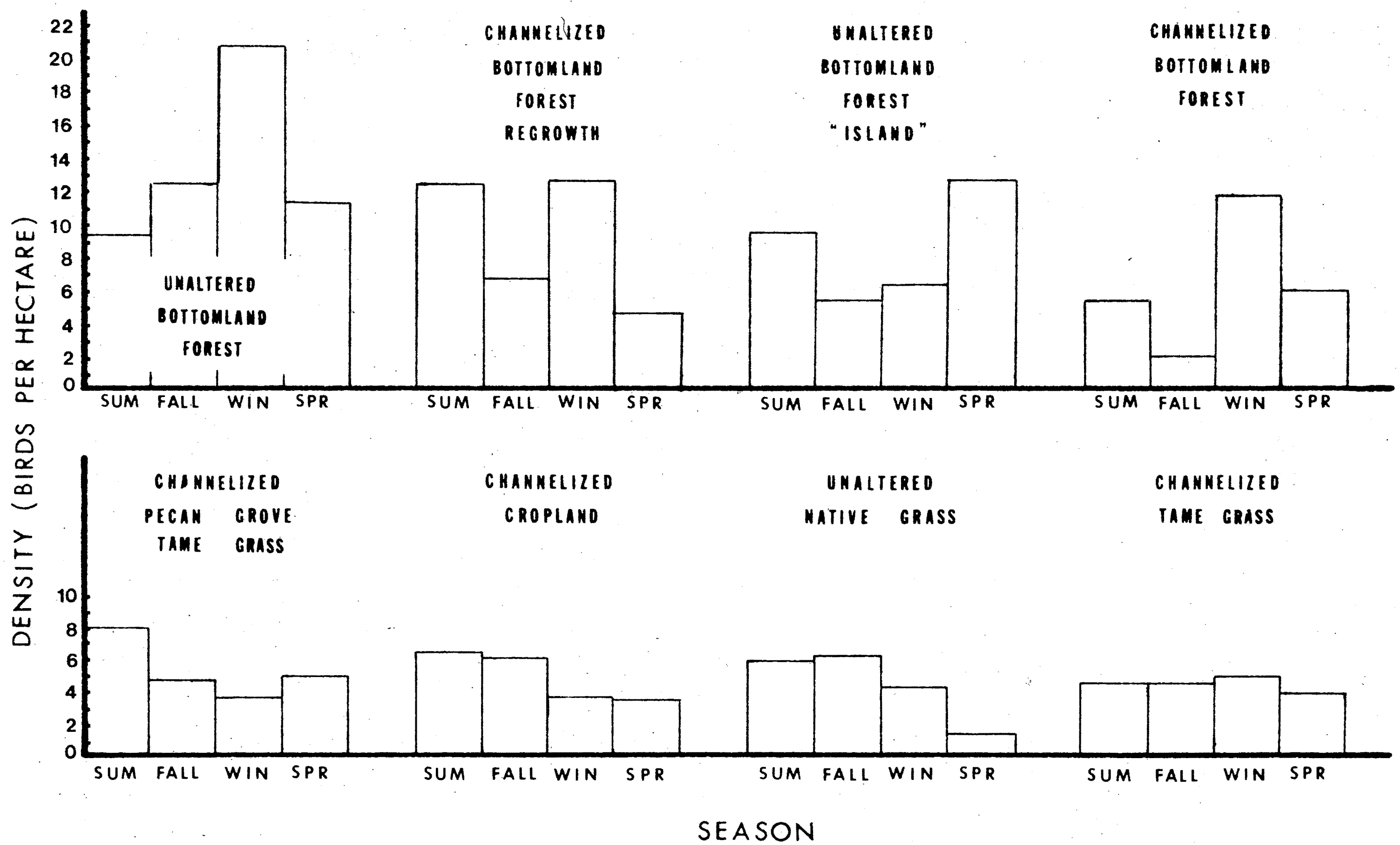


Fig. 6. Mean number of birds seen per hectare on Rush and Wildhorse creek study sites during summer, fall, winter 1976, and spring 1977.

decrease in density from summer to winter (Appendix F, Table 6). The ChTaGr sites supported low densities of birds throughout all seasons (overall $\bar{X}$ = 4.27 ± .380) and varied little from season to season.

Species Diversity

Bird species diversity (BSD) and evenness coefficients for each site are shown in Table 7.

Annual. The overall BSD (mean for the 4 seasons) ranged from a high of 2.30 on the control class (UnBotFor) to a low of 0.74 on the ChCrop class. The overall BSD was significantly lower on all site classes (except the ChBotForReg class) when compared to the control class (Appendix F, Table 7).

Summer. During the breeding season, BSD ranged from 2.61 on the ChBotForReg class to 1.03 on the ChCrop class. The control class ($\bar{X}$H' = 2.36 ± .276) ranked third highest in BSD behind the ChBotForReg class (H' = 2.61) and the ChPecGroTaGr class ($\bar{X}$H' = 2.42 ± .250). However, differences in summer BSD among these 3 site classes proved to be nonsignificant (Appendix F, Table 7). The ChCrop, ChTaGr and UnBotForIs classes were found to have significantly lower summer BSD when compared to the control class (Appendix F, Table 7). In general the wooded sites showed higher summer BSD values, while more intensively altered sites produced lower summer BSD values.

Winter. BSD ranged from 1.97 on the control class to 0.43 on the ChCrop class. All site classes (except the ChBotFor and ChBotForReg classes) supported significantly lower BSD than the control class

Table 7. Bird species diversity values (H') and equitability coefficients (J') for the Rush and Wildhorse creek study sites and site classes during summer, fall, winter 1976, and spring 1977.

		Unaltered bottomland forest				Channelized pecan grove tame grass			Unaltered bottomland forest island	
Season		W1	W8	R7	R8	R2	W3	W4	R3	R6
Summer	H'	2.56	2.37	1.91	2.61	2.69	2.50	2.09	1.69	1.04
	J'	.92	.85	.90	.88	.92	.91	.87	.75	.67
		$\bar{X}H'=2.36$			1	$\bar{X}H'=2.42$			$\bar{X}H'=1.36$	
		$sH'=.276$			2	$sH'=.250$			$sH'=.325$	
		$\bar{X}J'=.88$			3	$\bar{X}J'=.90$			$\bar{X}J'=.71$	
		$sJ'=.020$			4	$sJ'=.026$			$sJ'=.056$	
Fall	H'	2.48	2.24	2.22	2.72	2.54	0.50	0.79	0.52	0.64
	J'	.95	.89	.84	.87	.87	.49	.49	.33	.24
		$\bar{X}H'=2.41$				$\bar{X}H'=1.24$			$\bar{X}H'=.580$	
		$sH'=.203$				$sH'=.900$			$sH'=.060$	
		$\bar{X}J'=.88$				$\bar{X}J'=.68$			$\bar{X}J'=.28$	
		$sJ'=.046$				$sJ'=.268$			$sJ'=.063$	

		Channelized bottomland forest regrowth	Channelized bottomland forest	Channelized cropland			Channelized tame grass		Unaltered native grass
Season		W5A	W5	W2	W7	R1	R4	W6	R5
Summer	H'	2.61	1.95	0.74	0.92	1.45	1.32	1.76	1.82
	J'	.91	.81	.53	.55	.69	.75	.90	.78
				$\bar{X}H'=1.03$			$\bar{X}H'=1.54$		
				$sH'=.301$			$sH'=.155$		
				$\bar{X}J'=.59$			$\bar{X}J'=.82$		
				$sJ'=.087$			$sJ'=.106$		
Fall	H'	1.95	1.14	1.85	0.45	0.55	0.48	0.95	1.38
	J'	.86	.94	.92	.45	.27	.30	.40	.55
				$\bar{X}H'=.950$			$\bar{X}H'=.710$		
				$sH'=.637$			$sH'=.233$		
				$\bar{X}J'=.54$			$\bar{X}J'=.35$		
				$sJ'=.380$			$sJ'=.070$		

Table 7. (Continued)

Season		Unaltered bottomland forest				Channelized pecan grove tame grass			Unaltered bottomland forest island		Channel-ized bottomland forest regrowth	Channel-ized bottomland forest	Channelized cropland			Channelized tame grass		Unaltered native grass
		W1	W8	R7	R8	R2	W3	W4	R3	R6	W5A	W5	W2	W7	R1	R4	W6	R5
Winter	H'	1.97	1.51	2.01	2.39	1.29	0.40	1.07	0.97	0.45	1.56	1.87	0.00	0.63	0.68	0.12	0.91	0.92
	J'	.79	.79	.75	.86	.99	.20	.64	.63	.44	.77	.81	.00	.44	.43	.12	.45	.45
		$\bar{X}H'=1.97$				$\bar{X}H'=0.92$			$\bar{X}H'=0.71$				$\bar{X}H'=0.43$			$\bar{X}H'=0.51$		
		$sH'=.312$				$sH'=.378$			$sH'=.260$				$sH'=.309$			$sH'=.395$		
		$\bar{X}J'=.79$				$\bar{X}J'=.61$			$\bar{X}J'=.53$				$\bar{X}J'=.29$			$\bar{X}J'=.28$		
		$sJ'=.045$				$sJ'=.395$			$sJ'=.134$				$sJ'=.250$			$sJ'=.233$		
Spring	H'	2.25	2.42	2.66	2.61	1.89	2.09	1.51	0.68	1.88	2.20	1.98	0.38	1.14	0.21	1.17	0.65	0.50
	J'	.86	.82	.89	.91	.90	.96	.47	.55	.83	.94	.95	.37	.88	.21	.58	.64	.49
		$\bar{X}H'=2.48$				$\bar{X}H'=1.83$			$\bar{X}H'=1.28$				$\bar{X}H'=0.57$			$\bar{X}H'=0.91$		
		$sH'=.162$				$sH'=.240$			$sH'=.600$				$sH'=.404$			$sH'=.260$		
		$\bar{X}J'=.87$				$\bar{X}J'=.77$			$\bar{X}J'=.56$				$\bar{X}J'=.480$			$\bar{X}J'=.87$		
		$sJ'=.039$				$sJ'=.267$			$sJ'=.147$				$sJ'=.349$			$sJ'=.074$		

Table 7. (Continued)

Season	Unaltered bottomland forest (W1, W8, R7, R8)	Channelized pecan grove tame grass (R2, W3, W4)	Unaltered bottomland forest island (R3, R6)	Channelized bottomland forest regrowth (W5A)	Channelized bottomland forest (W5)	Channelized cropland (W2, W7, R1)	Channelized tame grass (R4, W6)	Unaltered native grass (R5)
Overall mean and standard deviation	$\bar{X}H'=2.30$ $sH'=.198$ $\bar{X}J'=.85$ $sJ'=.043$	$\bar{X}H'=1.60$ $sH'=.573$ $\bar{X}J'=.74$ $sJ'=.125$	$\bar{X}H'=0.98$ $sH'=.341$ $\bar{X}J'=.55$ $sJ'=.198$	$\bar{X}H'=1.73$ $sH'=.345$ $\bar{X}J'=.87$ $sJ'=.078$	$\bar{X}H'=2.08$ $sH'=.381$ $\bar{X}J'=.87$ $sJ'=.074$	$\bar{X}H'=0.74$ $sH'=.250$ $\bar{X}J'=.47$ $sJ'=.131$	$\bar{X}H'=0.91$ $sH'=.386$ $\bar{X}J'=.51$ $sJ'=.247$	$\bar{X}H'=1.15$ $sH'=.494$ $\bar{X}J'=.56$ $sJ'=.147$

1 $\bar{X}H'$=mean bird species diversity value.
2 sH'=standard deviation of bird species diversity value.
3 $\bar{X}J'$=mean coefficient of equitability.
4 sJ'=standard deviation of equitability coefficient.

(Appendix F, Table 7).

Migration Periods. BSD during the spring and fall was highest on the control sites. During the fall and spring BSD was found to be significantly lower on all site classes (except the ChBotForReg class) when compared to the control class (Appendix F, Table 7).

Seasonal Trends. The control class maintained high BSD throughout the year (overall $\bar{X}H' = 2.30 \pm .198$) and varied less than any other site class among the 4 seasons. It is interesting to note that although BSD on the control class was somewhat different between summer and winter, species richness was very similar. The low J' value in winter (.79), caused by uneven distribution of individuals among species, was responsible for the lower winter BSD.

BSD and equitability on the ChPecGroTaGr class decreased significantly from summer through winter, then increased significantly in spring (Appendix F, Table 8). BSD varied more (s = .573) among the 4 seasons on the ChPecGroTaGr class than on any other class.

BSD on the UnBotForIs and ChBotFor classes decreased from summer to fall, increased from fall to winter and increased again in spring. BSD on ChBotForReg, ChCrop and ChTaGr classes decreased significantly from summer through winter then increased in spring (Appendix F, Table 8). BSD on the UnNatGr class decreased steadily from summer through spring.

Species Composition

Table 8 shows the mean coefficients of commonly similarity (C) values for summer, fall, winter and spring, 1976-1977, for all Rush and

Table 8. Mean coefficients of community similarity (C) for Rush and Wildhorse creek study sites during summer, fall, winter 1976, and spring 1977.

	Unaltered bottomland forest				Channelized pecan grove tame grass			Unaltered bottomland forest island		Channelized bottomland forest regrowth	Channelized bottomland forest	Channelized cropland			Channelized tame grass		Unaltered native grass
Season	W1	W8	R7	R8	R2	W3	W4	R3	R6	W5A	W5	W2	W7	R1	R4	W6	R5
Summer	.937	.898	.907	.927	.784	.512	.746	.874	.764	.939	.916	.023	.241	.397	.079	.330	.732
Fall	.564	.621	.651	.637	.454	.056	.433	.192	.377	.451	.572	.033	.000	.138	.081	.015	.357
Winter	.782	.766	.735	.657	.377	.566	.504	.493	.419	.640	.732	.000	.340	.242	.000	.449	.442
Spring	.699	.710	.792	.742	.375	.359	.439	.525	.625	.522	.612	.044	.000	.081	.015	.169	.491

Wildhorse creek study sites. The species composition for each site, plus the importance value, density and relative abundance of each species seen on the site during each season, appears in Appendix C.

Summer. Mean C values for the 4 control sites (UnBotFor) ranged from .937 (W1) to .898 (W8). These high values indicate that species compositions were very similar among the control sites. Species considered to be characteristic to the native riparian community by virtue of their occurrence on all 4 of the control sites include the cardinal, carolina chickadee, tufted titmouse, brown-headed cowbird, red-bellied woodpecker, painted bunting, yellow-billed cuckoo, indigo bunting, carolina wren and American goldfinch.

The 6 most abundant species comprised 66% of the total birds seen on control sites in the summer (Fig. 7). Species considered to be exclusively limited to native riparian bottomland forests by virtue of their occurrence only on control sites included the parula warbler and Louisiana waterthrush. Sixty-six percent of the total birds seen were permanent residents while 30% were summer residents (Fig. 8).

The ChBotFor and ChBotForReg sites had C values of .916 and .939, respectively. Although these sites are channelized, the high C values indicate that the remaining bottomland forest has an avian community composition very similar to that of the control sites. Four of the 6 most abundant species on each ChBotFor and ChBotForReg sites were also among the 6 most abundant on the control sites (Fig. 7).

Seventy-two percent of the total birds seen on ChBotFor sites were permanent residents while 25% were summer residents. However, the ChBotFor site supported 2.55 less permanent residents and 1.56 less summer residents per ha than did the control sites (Fig. 8).

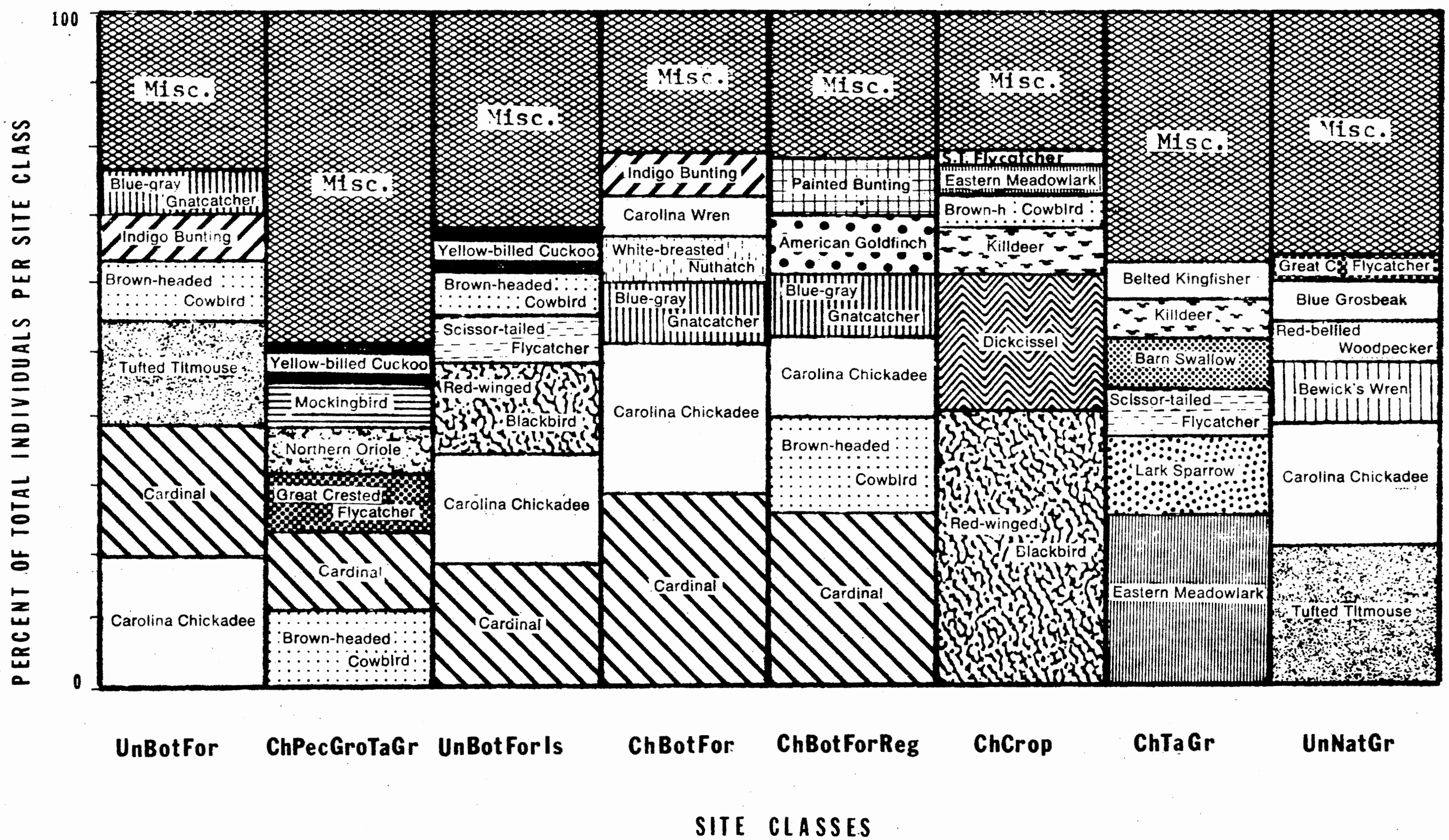


Fig. 7. Relative abundance of dominant avian species per site class on Rush and Wildhorse creeks during the summer 1976.

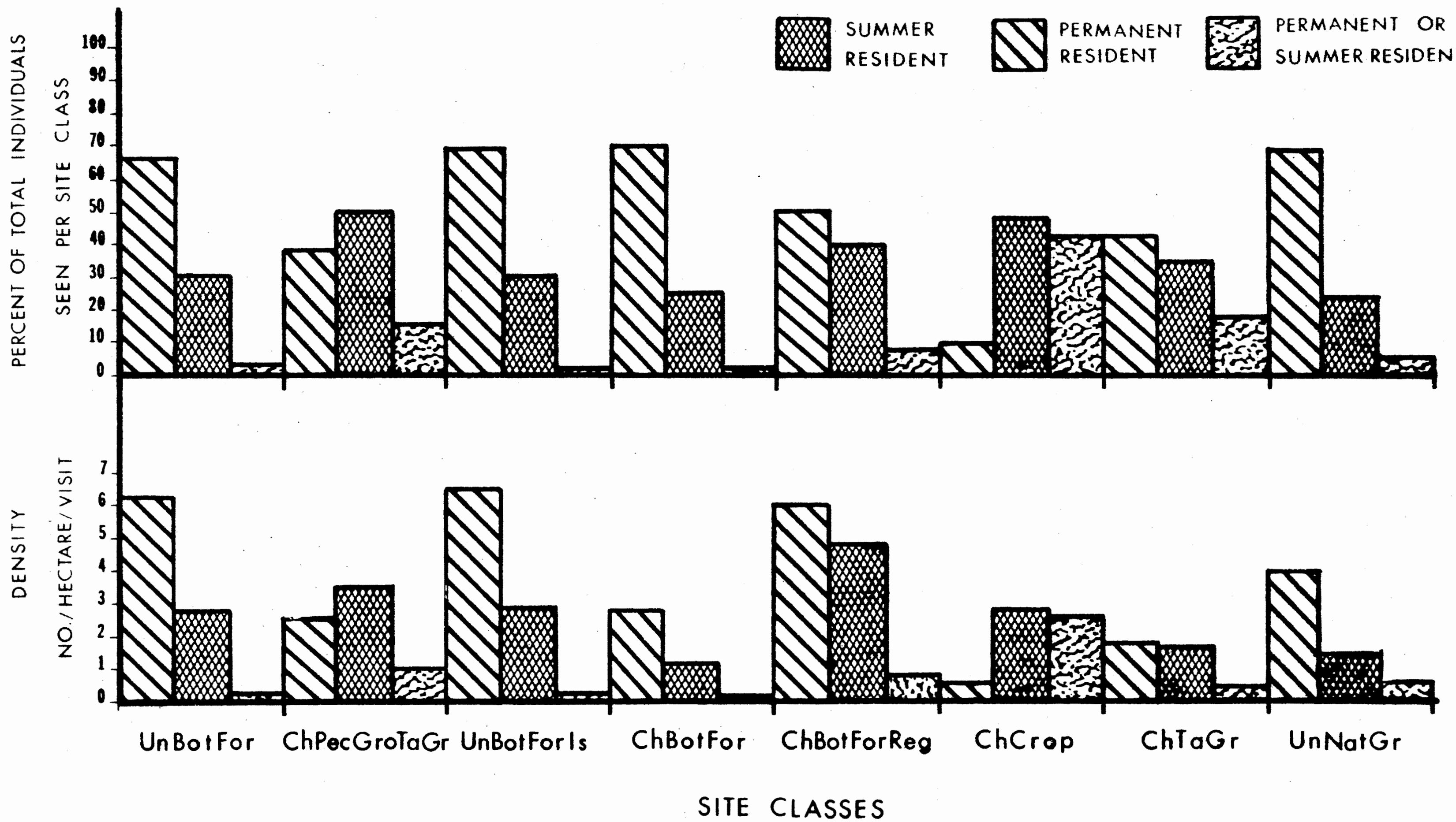


Fig. 8. Density and relative abundance of permanent and summer resident avian species per site class on Rush and Wildhorse creeks during summer 1976.

Stenoecious forest species such as the pileated woodpecker, eastern wood pewee, red-eyed vireo and white-eyed vireo occurred only on the ChBotFor and control sites.

The ChBotForReg site had similar densities of permanent residents when compared to control sites (Fig. 8). However, the ChBotForReg site supported 2.09 more summer residents per ha than did the control sites.

Mean C values for the 2 UnBotForIs sites averaged .819, indicating that species composition and relative abundance were similar to control sites. The 6 most abundant species comprised 62% of the total individuals seen on UnBotForIs sites during the summer (Fig. 7). Three of these species were among the 6 most abundant species seen on control sites during summer. Sixty-nine percent of the total summer birds seen on the UnBotForIs sites were permanent residents while 30% were summer residents (Fig. 8). Densities of permanent and summer resident species were very comparable to control sites (Fig. 8). However, the UnBotForIs sites supported 6 fewer summer resident species than did the control sites.

C values for the 3 ChPecGroTaGr sites averaged .680, indicating that species composition and relative abundance differed considerably from that on control sites. The 6 most abundant species comprised 44% of the total birds seen on ChPecGroTaGr sites (Fig. 7). Only 2 of 6 most abundant species on ChPecGroTaGr sites were among the 6 most abundant species on control sites (Fig. 7). Densities of summer residents were comparable between ChPecGroTaGr sites and control sites. However, the ChPecGroTaGr sites supported 3.57 fewer permanent residents per ha than did control sites (Fig. 8). Species with narrow forest niches were absent from ChPecGroTaGr sites. The decrease in forest species was accompanied by an increase in species that typically utilized edge, grassland or savannah habitats.

The intensively altered sites, ChTaGr and ChCrop sites, were typified by very low C values (Table 8), indicating that there was little similarity in species composition and relative abundance between these sites and control sites. The 6 most abundant species comprised 60 and 79% of the total birds seen on ChTaGr and ChCrop sites, respectively. Only 1 (the brown-headed cowbird) of the 6 most abundant species on the ChCrop sites were among the 6 most abundant on control sites. The ChTaGr and control sites shared none of the 6 most abundant species in common.

The ChCrop sites supported 5.72 fewer permanent residents per ha than did control sites (Fig. 8). The ChCrop and control sites supported equal numbers of summer residents but species comprising summer residents on these 2 site classes were vastly different (Appendix C). The ChTaGr sites supported 3.57 less permanent residents and 1.72 less summer residents per ha than did control sites. Stenoecious forest species were completely absent from all of the ChTaGr and ChCrop sites. The majority of species that did utilize the highly altered sites were those showing grasslands or edge preferences or those with high degrees of adaptability.

It is only logical that species with forest requisites will be more numerous in the forest and species with grasslands requisites will be more numerous in the open country. In the present study the bird species composition at each site appeared to be governed by the type of and quality of habitat present.

It is useful to note the relative abundance of species that feed in or very near the water. Herons occurred in approximately equal numbers on both channelized and unchannelized sites. However, killdeers and belted kingfishers were over 4 times as abundant on channelized sites as on the unchannelized sites. Swallows were found to be twice as numerous on the channelized sites.

Winter. Coefficients of community similarity were consistantly lower on all sites in winter when compared to summer. C values at control sites ranged from .657 (R8) to .782 (W1) (Table 8). The 6 most abundant winter species comprised 76% of the total birds seen on control sites (Fig. 9). Twenty-six percent of the total birds seen were permanent residents (Fig. 10). However, densities of permanent resident species were similar to summer densities (5.1 vs 6.26 per ha). Sixty-six percent of the total birds seen on the control sites were winter residents (Fig. 10). Densities of winter residents on control sites (18.8 per ha) were higher than on any other sites.

C values from the ChBotFor (.732) and ChBotForReg (.640) sites indicated that species composition and relative abundance on these sites were as similar to those on control sites as control sites were to each other. The 6 most abundant species comprised 85 and 75% of the total birds seen on the ChBotFor and ChBotForReg sites, respectively (Fig. 9). Four of the 6 most abundant species on the ChBotFor site were among the 6 most abundant on the control sites (Fig. 9). Three of the 6 most abundant species on the ChBotForReg site were among the 6 most abundant on the control sites. Permanent residents on the ChBotForReg site occurred in lower densities when compared to control sites. ChBotFor and ChBotForReg sites supported 6.81 and 10.0 fewer

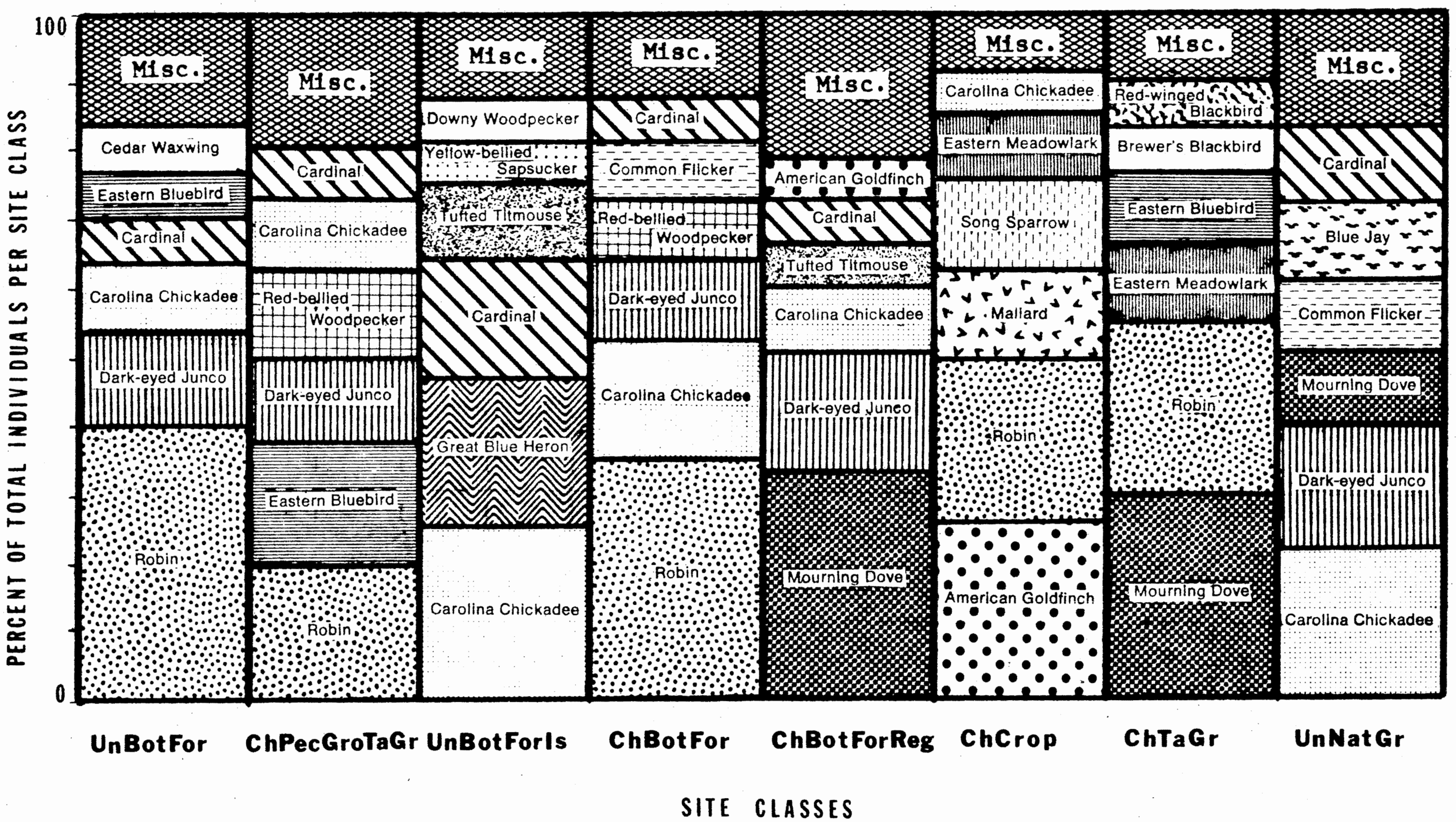


Fig. 9. Relative abundance of dominant avian species per site class on Rush and Wildhorse creeks during the winter 1976-1977.

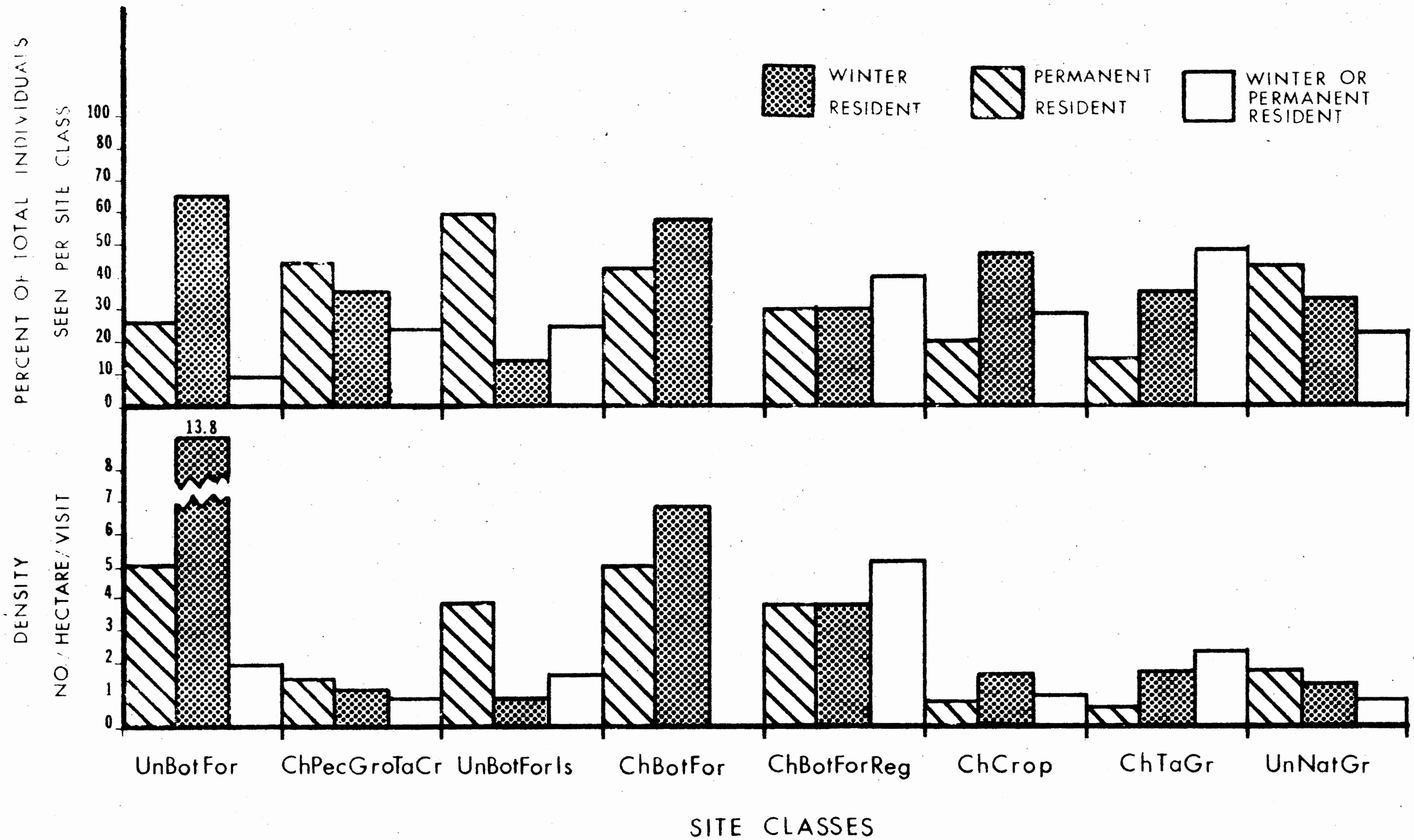


Fig. 10. Density and relative abundance of permanent and winter resident avian species per site class on Rush and Wildhorse creeks during winter 1976-1977.

winter residents per ha respectively than did the control sites (Fig. 10).

C values for UnBotForIs sites averaged .456 indicating that species composition and relative abundance of various species differed considerably from those on control sites (Table 8). Only 2 of the 6 most abundant species on UnBotForIs sites were among the 6 most abundant on the control sites (Fig. 9). The UnBotForIs sites supported 1.27 fewer permanent residents and 12.89 fewer winter residents per ha than control sites (Fig. 10).

C values averaging .482 indicated that winter species composition and relative abundance on ChPecGroTaGr sites had little similarity to that on control sites. Six of the most abundant species comprised 75% of the total species seen on ChPecGroTaGr sites. Five of these 6 most abundant species were also among the 6 most common species on control sites. The ChPecGroTaGr sites supported 3.62 fewer permanent residents and 12.59 fewer winter residents than control sites (Fig. 10).

Species composition and relative abundance of winter avian communities on ChCrop and ChTaGr sites were the least similar to those of control sites (Table 8). Only 2 of the 6 most abundant species on ChCrop sites were among the 6 most abundant on control sites. The ChTaGr class had only 1 of its 6 most abundant species held in common with the 6 most abundant seen on control sites (Fig. 9). Densities of permanent residents on the ChCrop and ChTaGr sites averaged 4.4 less per ha when compared to control sites (Fig. 10). ChCrop and ChTaGr sites supported an average of 12.8 fewer winter residents per ha when compared to control sites.

Migration Periods. When avian species composition and relative abundance on control sites were compared among themselves, C values averaged .618 in the fall and .735 in the spring. Six of the most abundant species comprised 55% of the total birds seen on control sites during the fall (Fig. 11). Thirty-five percent of the total birds (4.4 per ha) seen on control sites during the fall were migrants (Fig. 12). Permanent residents comprised 52% (6.3 per ha) of the total birds seen on control sites during the fall (Fig. 12).

Six of the most abundant species comprised 67% of the total birds seen on control sites during the spring (Fig. 13). Fifty-one percent of the total birds seen on control sites (5.64 per ha) in the spring were permanent residents. Species classified as migrants or summer residents comprised 45% (4.98 per ha) of the total birds seen. Spring species composition on the control sites strongly resembled that of the summer community but species classified as summer residents were present in higher densities. The high spring densities of summer resident species were probably composed of individuals that would remain to nest as well as those that would migrate further north before nesting.

Five species of parulids (i.e., parula warbler, Louisiana waterthrush, yellow warbler, Nashville warbler and American redstart), whose niches are closely restricted to forest habitats, comprised 4% of the total birds seen on control sites during the spring. None of these species were observed on any of the altered sites during the spring.

Fall C values of .451 and .572, for ChBotFor and ChBotForReg sites respectively, were comparable to those from control sites (Table 8). However, only 11% (.22 per ha) and 29% (1.9 per ha), of the total number of birds seen on ChBotFor and ChBotForReg sites respectively were

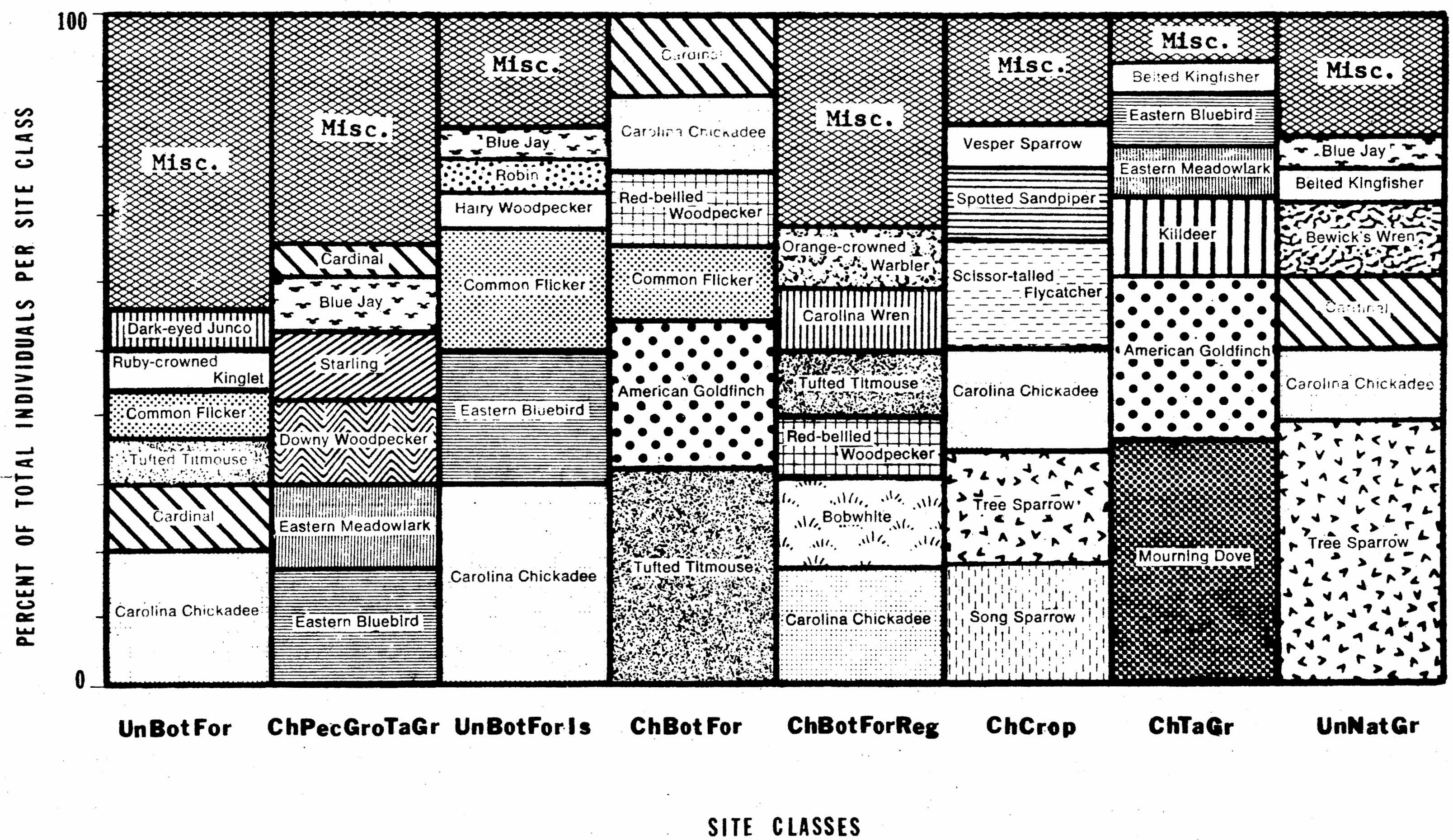


Fig. 11. Relative abundance of dominant avian species per site class on Rush and Wildhorse creeks during the fall 1976.

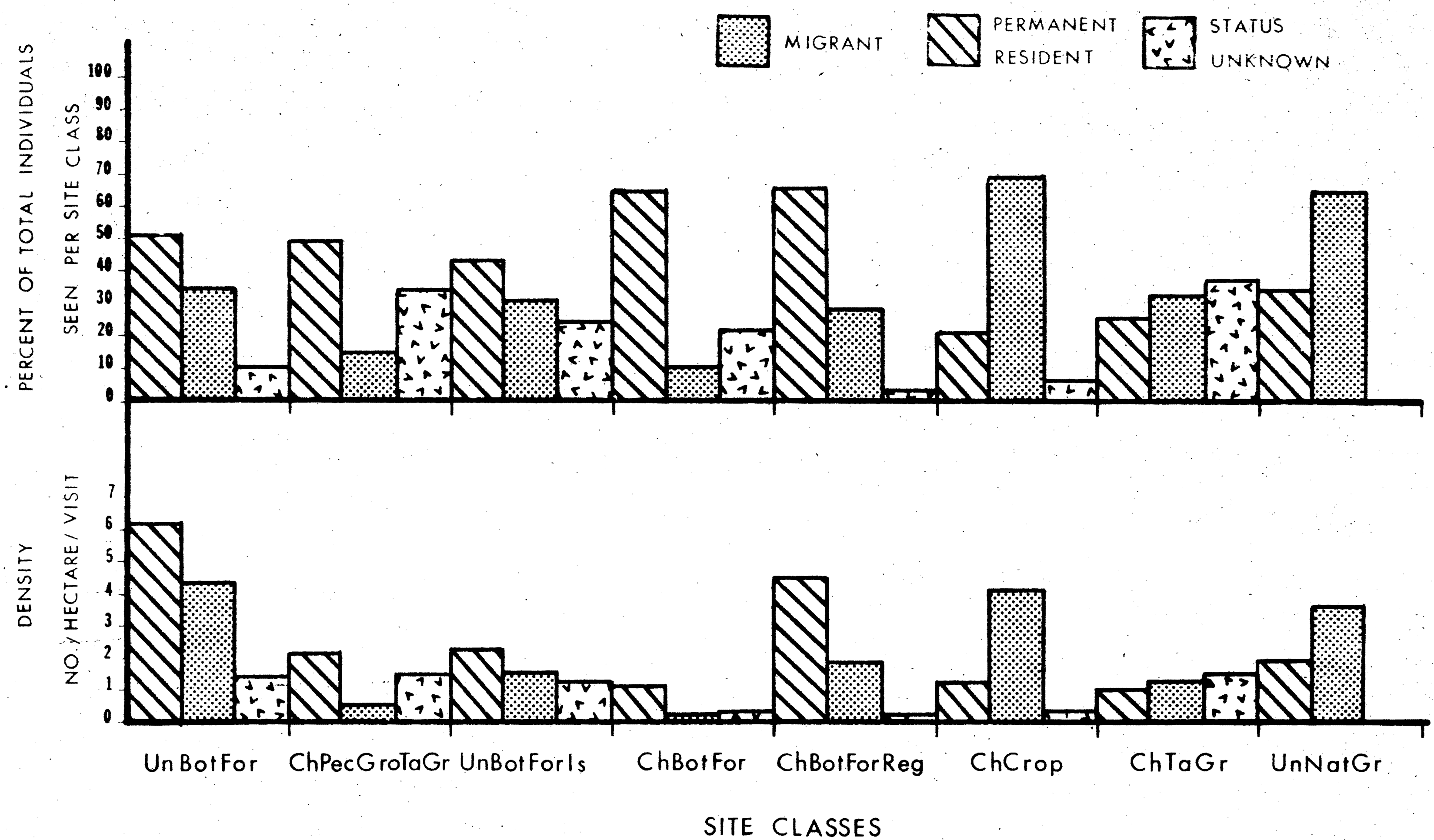


Fig. 12. Density and relative abundance of permanent resident and migrant avian species per site class on Rush and Wildhorse creeks during the fall 1976.

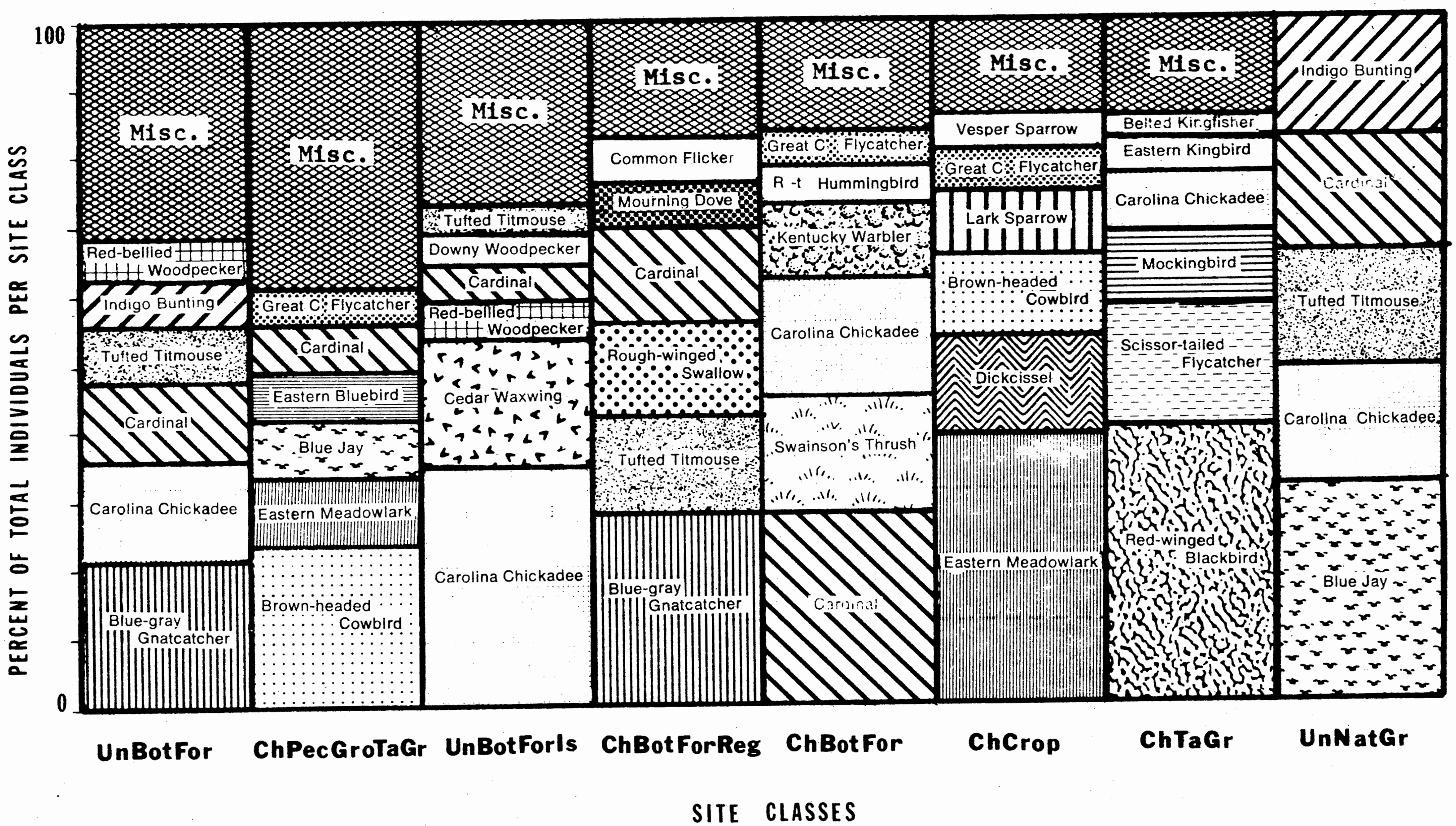


Fig. 13. Relative abundance of dominant avian species per site class on Rush and Wildhorse creeks during the spring 1977.

migrants (Fig. 11). Compared to 4.90 migrants per ha for the control sites, these altered forest sites seemed to be considerably less valuable to migrating species. Densities of permanent residents were considerably less on the ChBotFor site (1.32 per ha) when compared to the control sites (6.3 per ha) (Fig. 12).

Spring C values for the ChBotFor and ChBotForReg sites indicated the bird communities were similar to those on control sites (Table 8). However, these sites, again, supported lower densities of migrants and species classified as summer residents or migrants than did control sites (Fig. 14). Only 2 of the 6 most abundant species on the ChBotForReg site and 3 of the 6 most abundant species on the ChBotFor site were among the 6 most abundant on control sites (Fig. 13).

The absence of many permanent resident species from the UnBotForIs sites in the fall produced relatively low C values of .192 and .377 for sites R3 and R6 respectively (Table 8). UnBotForIs sites also supported 2.75 fewer fall migrants per ha than did control sites (Fig. 12). The 6 most abundant species comprised 87% of the total birds seen on UnBotForIs sites during the fall (Fig. 11). Four of these species were among the 6 most abundant seen on control sites.

In the spring, permanent resident and summer resident species on the UnBotForIs sites were evident in numbers comparable to those of the summer (Fig. 14). C values for these two sites averaged .575, indicating that the avian community was more like those of control sites than those of any of the altered sites.

C values on ChPecGroTaGr sites averaged .314 in the fall and .391 in the spring (Table 8). Fall migrants occurred in very low densities (.66 per ha) and comprised only 15% of the total birds observed on the

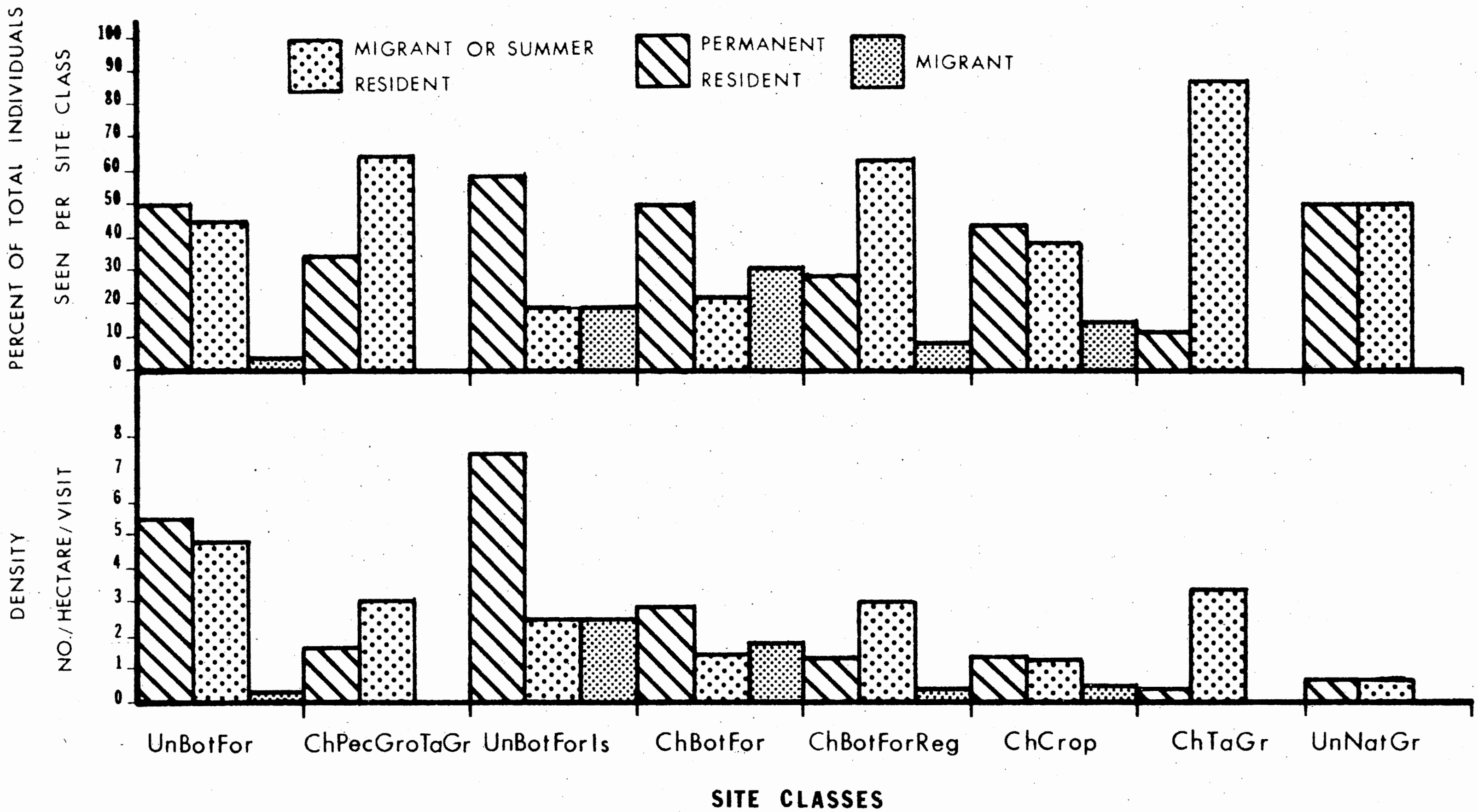


Fig. 14. Density and relative abundance of permanent residents, summer residents, and migrant avian species per site class on Rush and Wildhorse creeks during the spring 1977.

ChPecGroTaGr sites (Fig. 12). The ChPecGroTaGr sites also supported low densities of permanent residents (2.30 per ha) which was 4.1 fewer than observed on control sites (Fig. 12). Only 1 of the 6 most abundant species on the ChPecGroTaGr sites was among the 6 most abundant species on control sites (Fig. 11).

Densities of permanent resident species (1.7 per ha) were again low on ChPecGroTaGr sites in the spring and were 3.94 per ha lower than on the control sites (Fig. 14). Species classified as summer residents or spring migrants comprised 64% of the total birds seen on ChPecGroTaGr sites. Their densities were only 1.68 birds per ha lower than on the control sites. The 6 most abundant species comprised 66% of the total birds seen on ChPecGroTaGr sites during the spring (Fig. 13). Only 1 of those species was among the 6 most abundant species seen on the control sites.

C values for the ChCrop sites were the lowest of all sites and averaged .041 and .057 for the fall and spring respectively. Densities of fall migrants on ChCrop sites were very similar to those observed on control sites (Fig. 12). ChCrop sites supported 5.0 fewer permanent residents per ha when compared to control sites (Fig. 12). Six of the most abundant species comprised 81% of the total birds seen on ChCrop sites during the fall (Fig. 11). Only 1 of these species was among the 6 most abundant species seen on control sites.

In the spring, ChCrop sites supported 4.31 less permanent residents per ha than control sites (Fig. 14). Species classified as summer residents or spring migrants occurred in lower densities on the ChCrop sites (1.62 per ha) than on control sites (4.98 per ha) (Fig. 14). None of the 6 most abundant species on ChCrop sites were among the 6 most abundant on the control sites (Fig. 13).

Avian communities on the ChTaGr sites showed little similarity to control sites during migration periods. C values averaged .103 in the fall and .092 in the spring. These sites supported 5.2 less permanent residents and 3.0 less fall migrants per ha than control sites (Fig. 12). The 6 most abundant species comprised 93% of the total species seen on ChTaGr sites in the fall. None of these species were among the 6 most abundant species seen on control sites (Fig. 11).

In the spring, ChTaGr sites supported 5.2 less permanent residents per ha than did control sites (Fig. 14). Densities of species classified as summer residents or spring migrants were comparable to control sites although many of the species were different (Appendix C). Only 1 of the 6 most abundant species seen on ChTaGr sites during spring was among the 6 most abundant on control sites (Fig. 13).

Life Forms

The number of species and number of birds seen per life form on each Rush and Wildhorse creek study site is shown in Appendix E. The mean number of species and individuals per life form per site class appear in Table 9. The total number of life forms per site class ranged from 7 on the ChBotFor class to 13 on the ChTaGr class. In general, the wooded sites contained fewer life forms than the intensively altered sites.

An average of 7.75 life forms occurred on each control site (UnBotFor). Eighty-four percent of the total species and 89% of the total individuals seen on the control sites were contained in life forms 3, 4, 5, 7, and 8. This indicates that over 80% of the avian

Table 9. Mean number of species and mean number of individuals seen per life form for each Rush and Wildhorse creek site class during the summer 1976.

	Unaltered bottomland forest				Channelized pecan grove - tame grass				Unaltered bottomland forest islands				Channelized bottomland forest regrowth			
Life form	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals
1	0.7	3.0	2.7		1.6	6.0	1.7	-	-	-	-	-	-	-	-	-
2	-	-	-	-	0.6	3.0	3.0	3.0	0.5	4.0	1.0	1.0	-	-	-	-
3	3.2	15.0	12.7	8.0	4.3	16.0	22.0	19.0	1.0	8.0	1.5	3.0	4.0	17.0	17.0	9.0
4	2.2	10.0	8.0	5.0	1.6	6.0	7.6	8.0	1.0	8.0	2.5	5.0	4.0	17.0	8.0	4.0
5	4.5	21.0	39.2	26.0	5.0	19.0	22.3	20.0	3.5	27.0	13.0	27.0	5.0	21.0	85.0	47.0
6	0.2	1.0	1.2	1.0	-	-	-	-	-	-	-	-	-	-	-	-
7	5.5	26.0	66.0	44.0	5.0	19.0	19.6	17.0	4.0	31.0	14.0	29.0	6.0	29.0	34.0	19.0
8	2.5	12.0	9.7	6.0	3.0	11.0	7.3	6.0	2.0	15.0	9.0	19.0	3.0	13.0	4.0	7.0
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	0.2	1.0	0.5	0.1	0.3	1.0	0.3	0.1	-	-	-	-	-	-	-	-
15	-	-	-	-	2.3	9.0	14.6	13.0	-	-	-	-	-	-	-	-
16	-	-	-	-	0.6	3.0	1.3	1.0	-	-	-	-	-	-	-	-
17	0.7	3.0	0.7	0.3	0.6	3.0	1.0	1.0	0.5	1.0	2.0	4.0	1.0	4.0	6.0	3.0
18	1.0	5.0	10.7	7.0	1.0	4.0	11.3	10.0	0.5	4.0	3.0	6.0	1.0	4.0	24.0	13.0
Total	21.0	100.0	151.5	100.0	26.3	100.0	113.0	100.0	13.0	100.0	48.0	100.0	24.0	100.0	181.0	100.0
Total life forms	10				12				8				7			

Table 9 (Continued)

Life form	Channelized bottomland forest				Channelized cropland				Channelized tame grass				Unaltered native grass			
	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals	Mean No. of species	% of total species	Mean No. of individuals	% of total individuals
1	-	-	-	-	0.3	3.0	0.6	1.0	1.5	8.0	3.0	4.0	2.0	8.0	2.0	3.0
2	-	-	-	-	1.0	8.0	3.6	4.0	2.5	13.0	7.5	13.0	-	-	-	-
3	1.0	6.0	5.0	8.0	1.3	11.0	4.6	5.0	2.5	8.0	7.0	10.0	2.0	8.0	4.0	6.0
4	1.0	6.0	1.0	2.0	0.6	6.0	0.6	1.0	-	-	-	-	1.0	4.0	1.0	1.0
5	5.0	28.0	25.0	40.0	3.0	25.0	7.0	7.0	1.0	5.0	1.5	2.0	5.0	21.0	11.0	15.0
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	6.0	33.0	24.0	39.0	0.6	6.0	2.6	3.0	1.5	8.0	5.0	7.0	5.0	21.0	37.0	37.0
8	3.0	17.0	4.0	6.0	0.3	3.0	0.3	0.1	1.0	5.0	1.5	2.0	3.0	13.0	7.0	10.0
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	2.5	13.0	6.0	9.0	2.0	8.0	2.0	3.0
11	-	-	-	-	1.3	11.0	45.0	45.0	1.0	5.0	2.5	4.0	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	0.6	6.0	18.6	19.0	1.0	5.0	1.0	1.0	2.0	8.0	4.0	6.0
15	-	-	-	-	2.0	17.0	5.3	5.0	2.5	13.0	25.5	38.0	2.0	8.0	4.0	6.0
16	-	-	-	-	1.0	8.0	6.0	6.0	1.0	5.0	3.5	5.0	-	-	-	-
17	1.0	6.0	1.0	2.0	0.3	3.0	0.3	0.1	1.0	5.0	3.5	5.0	-	-	-	-
18	1.0	6.0	2.0	3.0	0.3	3.0	4.0	4.0	0.5	3.0	2.5	4.0	-	-	-	-
Total	18.0	100.0	62.0	100.0	12.0	100.0	99.0	100.0	19.5	100.0	68.0	100.0	24.0	100.0	72.0	100.0
Total life forms	7				13				13				9			

community primarily utilized the tree and shrub vegetation for feeding and reproduction. Life form 6 was represented only on the control sites. Life form 7 comprised 26% of the total species and 44% of the total individuals seen on the control sites. The high number of species and individuals utilizing either natural cavities or abandoned woodpecker cavities for nesting emphasizes the importance of maintaining riparian forests in a mature climax condition so that an abundance of dead trees and limbs will be present. Only 1 ground nesting species was recorded during the entire summer on control sites.

An average of 10.3 life forms was observed on each of the ChPecGroTaGr sites. These sites contained all of the life forms that occurred on the control sites (except life form 6) (Table 9). Seventy percent of the total species and 71% of the total individuals seen on the ChPecGroTaGr sites were contained in life forms 3, 4, 5, 7, and 8. Avifauna of the ChPecGroTaGr sites contained an average of 1 more species and 10 more individuals in life form 3 than the control sites. Of the species that typically utilize the smaller trees and shrubs (life form 5), an average of 17 fewer individuals were seen on ChPecGroTaGr sites when compared to control sites. All natural understory vegetation has been removed from beneath the pecan groves, consequently; the presence of an average of 5 species and 22.3 individuals of life form 3 on ChPecGroTaGr sites was attributed to the presence of flood zone vegetation. The number of species in life form 7 on ChPecGroTaGr sites was comparable to that on control sites. However, the ChPecGroTaGr sites contained 72% fewer individuals of life form 7.

In addition to having the 9 life forms characteristic of control sites, the ChPecGroTaGr sites supported life forms 2, 15, and 16

(Table 9). Twelve percent of the total species and 14% of the total individuals seen on ChPecGroTaGr sites were contained in life forms 14, 15, and 16, indicating that the installation of the planted tame grass pasture makes this altered habitat usable to species that generally nest on the ground and feed in open areas. Life form 2 was probably not represented on the control sites due to the preference of these species for very open tree stands for nesting and open grassland areas for feeding. The conversion of riparian forests into pecan groves by clearing all trees except pecans and replacing understory vegetation with tame grass stands has in most cases produced artificial savannah-like vegetation suitable to species in life form 2.

The life form composition on the UnBotForIs sites was much like that on control sites, with 89% of the total species and 83% of the total individuals occurring in life forms 3, 4, 5, 7, and 8 (Table 9). The major difference between control sites and UnBotForIs sites was the absence of life forms 1, 6 and 14 from the UnBotForIs sites and the addition of life form 2. The addition of life form 2 occurred due to nesting opportunities in the island stand of trees and opportunities for open area feeding in agricultural fields which surrounded the UnBotForIs sites.

The ChBotForReg site supported only 7 life forms, all of which were present on the control sites. As on other wooded study sites, the vast majority, 93 and 83% of the total species and total individuals respectively, were contained in life forms 3, 4, 5, 7 and 8. No ground nesting species were observed. The numbers of species and individuals in life forms 3 and 4 were comparable to the control sites. However, the ChBotForReg site supported more than twice as many individuals (85) in life form 5 than did the control sites. Life form 7 on the ChBotForReg site contained only about half the number of individuals as it did on the control sites.

The ChBotFor site supported 7 life forms, all of which were included on the control sites (Table 9). Again, virtually all of the total species (90%) and total individuals (95%) were contained in life forms 3, 4, 5, 7 and 8. However, actual densities of individuals within all life forms were considerably less on the ChBotFor sites than on control sites. Life forms 1, 6 and 14, which were present on control sites, were absent on the ChBotFor sites.

The ChCrop sites supported more life forms (13, $\bar{X}$ = 8/site) than the wooded sites (Table 9). Life forms 3, 4, 5, 7 and 8 contained only 51% of the total species and only 17% of the total individuals seen on ChCrop sites. Life forms 14, 15 and 16 contained approximately 30% of the total species and individuals seen on ChCrop sites. Rank herbaceous vegetation and readily available food created by crop plantings afforded life form 11 with acceptable feeding and nesting requisites.

The ChTaGr sites supported 5 life forms that the control sites did not support (Table 8). Birds preferring savannah type habitats (life form 2) and open grassland habitats (life form 15) comprised 51% of the total individuals seen on ChTaGr sites. The ChTaGr sites were void of birds in life form 4.

The UnNatGr site supported only 9 life forms (Table 8). The extensive flood zone vegetation accounted for the utilization of the UnNatGr site by life forms 3, 4, 5, 7 and 8 which comprised 89% of the total individuals seen. The grass portion of the study site was utilized very sparingly by life form 15 which accounted for only 6%

of the total individuals seen.

The Effects of Impoundment: Cobb and Lake Creeks

Species Richness

The mean number of avian species seen per visit on the Cobb and Lake creek study sites during each season is shown in Table 10. The total number of species seen on each Cobb and Lake creek site per season appears in Table 11. Data for the fall season were not obtained. The occurrence of inclement fall weather made bird counts impossible on days for which they were scheduled.

During the summer the mean number of species seen on study sites upstream from the reservoir (C1 and C2, hereafter referred to as the upstream sites) was very similar to the mean for the sites downstream from the reservoir (C3 and C4, hereafter referred to as the downstream sites). However, downstream sites supported significantly fewer total species seen during the summer when compared to upstream sites (Appendix F, Table 9). Differences in species richness per visit were found to be statistically nonsignificant (Appendix F, Table 9).

During the winter, marked differences in total species richness and species richness per visit was observed between upstream and downstream sites. The number of species seen per visit on upstream sites averaged 6 species lower than on downstream sites. Upstream sites averaged 9 fewer total number of species seen during the winter. However, these differences were nonsignificant statistically (Appendix F, Table 9).

In the spring, the average number of species seen per visit on

Table 10. Average number of avian species seen per visit on Cobb and Lake creek study sites during summer, winter 1976, and spring 1977.

	Upstream study sites			[1]	Downstream study sites			
Season	C1	C2	Mean ($\bar{X}$)	St. Dev. (s)	C3	C4	Mean ($\bar{X}$)	St. Dev. (s)
Summer	6.50	5.80	6.15	0.35	6.30	5.70	6.00	0.30
Winter	3.50	7.50	5.50	2.00	14.00	9.00	11.50	2.50
Spring	5.33	6.67	6.00	0.67	5.33	7.00	6.16	0.84
Overall Mean	5.11	6.65	5.88	0.77	8.54	7.23	7.88	0.65
Overall St. Dev.	1.23	0.69	0.27		3.87	1.35	2.55	

[1] St. Dev. denotes standard deviation.

Table 11. Total number of avian species seen on Cobb and Lake creek study sites during summer, winter 1976, and spring 1977.

	Upstream study sites			[1]	Downstream study sites			
Season	C1	C2	Mean ($\bar{X}$)	St. Dev. (s)	C3	C4	Mean ($\bar{X}$)	St. Dev. (s)
Summer	21	22	21.5	0.50	19	18	18.5	0.50
Winter	5	12	8.5	3.50	21	14	17.5	3.50
Spring	12	15	13.5	1.50	10	14	12	2.00
Overall Mean	12.6	16.3	14.4	1.90	16.6	15.3	15.9	0.60
Overall St. Dev.	6.5	4.19	5.35		4.78	1.88	2.85	

[1] St. Dev. denotes standard deviation.

upstream and downstream sites again appeared to be very similar (Table 10). The total number of avian species on upstream sites ($\bar{X}$ = 13.5 ± 1.5) averaged only 1.5 higher than the total seen on sites downstream ($\bar{X}$ = 12.0 ± 2.0).

The overall mean number of species seen per visit and the overall mean total number of species seen per season were slightly less on upstream sites. These differences were nonsignificant statistically (Appendix F, Table 9).

Little variation between seasons was observed in the mean number of species seen per visit on the upstream sites (s = 0.27). However, the seasonal variation in mean number of species seen per visit was considerably higher on the downstream sites (s = 2.55). The mean number of species seen per visit on downstream sites was significantly lower in summer when compared to winter (Appendix F, Table 9).

Seasonal variation in the total number of species seen per season was higher on the upstream sites (s = 5.35). The total number of species seen during the winter and spring was significantly lower when compared to the summer (Appendix F, Table 10). The total number of species seen per season varied less (s = 2.85) on the downstream sites and averaged 15.9 species per season (Table 11). Total species richness on downstream sites was significantly lower in the spring when compared to the summer (Appendix F, Table 10). Differences in total number of species seen per season should be viewed with caution as sampling intensity varied considerably during each season.

<u>Bird Density</u>

The average number of birds seen per ha during each season on the

Cobb and Lake creek study sites is shown in Table 12. In general, downstream sites were characterized by slightly higher bird densities when compared to sites upstream from Ft. Cobb Reservoir. However, differences in density between upstream and downstream sites proved to be nonsignificant in all seasons (Appendix F, Table 9).

In summer, downstream sites supported a mean of 8.33 birds per ha which was quite comparable to the mean of 7.99 observed per ha on the upstream sites (Table 12). Density increased from summer to winter on all sites but increases were greatest on downstream sites which supported an average of 14.6 more birds per ha than upstream sites. Spring densities closely resembled those of summer with upstream sites supporting 6.77 birds per ha and downstream sites supporting 7.9 birds per ha. Bird densities during the winter were significantly higher than spring and summer bird densities for both upstream and downstream site classes (Appendix F, Table 10).

Density on upstream sites averaged 9.53 birds per ha per season which was 5.37 (36%) fewer birds than on the downstream sites (14.9 birds per ha). Seasonal variation was lowest on the upstream sites ($s = 3.08$). The similarity in density between seasons on upstream sites was largely due to the small increase in density from summer to winter. On the other hand, density on the downstream sites varied noticably with seasons ($s = 9.56$). The dramatic increase in density from summer (8.33 birds per ha) to winter (28.49 birds per ha) accounted for this high variation.

Species Diversity

The BSD values (H') and equitability coefficients (J') for each

Table 12. Average number of individuals seen per hectare per visit on Cobb and Lake creek study sites during summer, winter 1976, and spring 1977.

	Upstream study sites				Downstream study sites			
Season	C1	C2	Mean ($\bar{X}$)	St. Dev.[1] (s)	C3	C4	Mean ($\bar{X}$)	St. Dev. (s)
Summer	7.93	8.06	7.99	0.07	9.20	7.46	8.33	0.87
Winter	12.33	15.33	13.83	2.00	20.66	36.33	28.49	7.84
Spring	4.66	8.88	6.77	2.11	8.22	7.59	7.90	0.31
Overall Mean	8.30	10.75	9.53	0.92	12.69	17.12	14.90	2.22
Overall St. Dev.	3.14	3.25	3.08		5.64	13.50	9.56	

[1] St. Dev. denotes standard deviation.

Cobb and Lake creek study site during summer, winter and spring appear in Table 13. During the summer, BSD on upstream ($\bar{X}H'$ = 2.33 ± .08) and downstream ($\bar{X}H'$ = 2.21 ± .03) sites was very similar. The slightly higher BSD on upstream sites was the result of both higher species richness and greater equitability in the avian community. BSD was also found to be very similar on upstream ($\bar{X}H'$ = 2.24 ± .02) and downstream ($\bar{X}H'$ = 2.32 ± .25) sites during spring.

During the winter, BSD on upstream sites ($\bar{X}H'$ = 1.81 ± .78) was considerably lower than that observed on downstream sites ($\bar{X}H'$ = 2.98 ± .54). However, neither this difference nor differences observed in summer and spring BSD between upstream and downstream sites proved to be significant (Appendix F, Table 9).

The overall mean BSD for downstream sites averaged 2.50. This was slightly higher than the overall mean of 2.12 observed on the upstream sites. Seasonal variation in mean BSD was slightly higher on downstream sites (s = .32) than on upstream sites (s = .22). Seasonal differences in BSD among sites and site means were all nonsignificant (Appendix F, Table 9).

Overall J' values for the upstream (.87) and downstream (.86) sites were very similar. However, in the summer, J' values were significantly lower on downstream sites than on upstream sites (Appendix F, Table 9).

Species Composition

Coefficients of community similarity were calculated for all possible combinations of Cobb and Lake creek study sites. Coefficients of community similarity (C) for each pair of sites during summer,

Table 13. Bird species diversity values (H') and equitability coefficients (J') for Cobb and Lake creek study sites during summer, winter 1976, and spring 1977.

Season and value (H') or coefficient (J')	Upstream study sites				Downstream study sites			
	C1	C2	Mean (X)	St. Dev.[1] (s)	C3	C4	Mean (X)	St. Dev. (s)
Summer								
H'	2.42	2.25	2.33	0.08	2.24	2.18	2.21	0.03
J'	0.90	0.92	0.91	0.01	0.84	0.86	0.85	0.01
Winter								
H'	1.04	2.59	1.81	0.78	3.52	2.44	2.98	0.54
J'	0.67	0.89	0.78	0.11	0.92	0.72	0.82	0.03
Spring								
H'	2.27	2.22	2.24	0.02	2.08	2.57	2.32	0.25
J'	0.96	0.89	0.92	0.03	0.89	0.91	0.90	0.01
Overall mean								
H'	1.91	2.35	2.12	0.23	2.61	2.39	2.50	0.11
J'	0.84	0.90	0.87	0.03	0.88	0.83	0.86	0.02
Overall St. Dev.								
H'	0.61	0.16	0.22		0.64	0.16	0.32	
J'	0.12	0.01	0.06		0.03	0.01	0.02	

[1] St. Dev. denotes standard deviation.

winter and spring appear in Table 14.

Summer. Upstream sites, when compared to each other, produced a summer C value of .911, which showed that these sites are quite similar in species composition and relative abundance of species. Downstream sites (C = .867) showed less resemblance to each other. Comparisons of C1 to sites C3 and C4 produced higher C values than either of the within class comparisons. Comparisons of downstream sites with C2 produced C values of .916 and .842 which were slightly lower than downstream comparisons with C1. Sites C1 and C4 had a narrower strip on woodland habitat along the stream than did C2 and C3. Consequently, the number of species and density of birds that have edge or open-country habitat preferences were higher on sites C1 and C4 (Appendix D). When sites with narrow woodland strips were compared to a site with a wide wooded strip, species not held in common by both sites usually consisted of stenoecious woodland interior species or edge species.

In the summer, the 8 most abundant species comprised 70% of the total birds seen on upstream sites (Fig. 15). Six of the 8 most abundant species on upstream sites were also among the 8 most abundant species on downstream sites. Upstream and downstream sites also show a marked similarity in densities of permanent and summer residents during the summer (Fig. 16). Downstream sites supported on average of 1.1 more permanent residents per ha and .67 fewer summer residents per ha per visit when compared to upstream sites (Fig. 16).

Winter. C values for all site comparisons were considerably lower in the winter, indicating that less similarity existed among the sites than in the summer (Table 14). During the winter, upstream sites

Table 14. Coefficients of community similarity (C) between pairs of Cobb and Lake creek study sites during summer, winter 1976, and spring 1977.

	Upstream sites	Downstream sites	Upstream sites vs. downstream sites			
Season	(C1 vs. C2)	(C3 vs. C4)	(C1 vs. C4)	(C2 vs. C3)	(C1 vs. C3)	(C2 vs. C4)
Summer	.911	.867	.927	.916	.951	.842
Winter	.592	.776	.663	.673	.507	.737
Spring	.766	.733	.769	.846	.794	.709

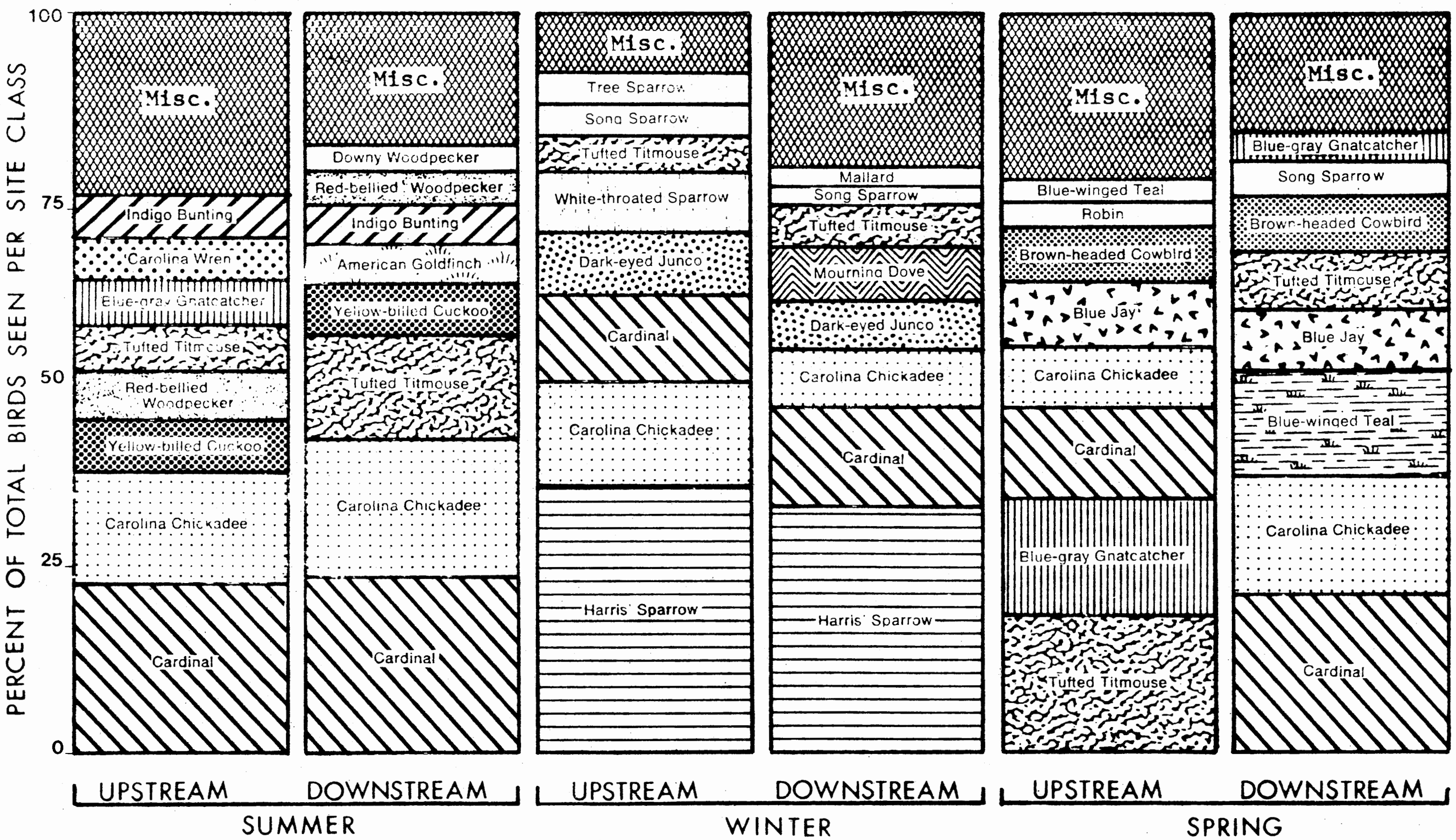


Fig. 15. Relative abundance of dominant avian species during summer, winter 1976, and spring 1977, on study sites upstream and downstream from Ft. Cobb Reservoir.

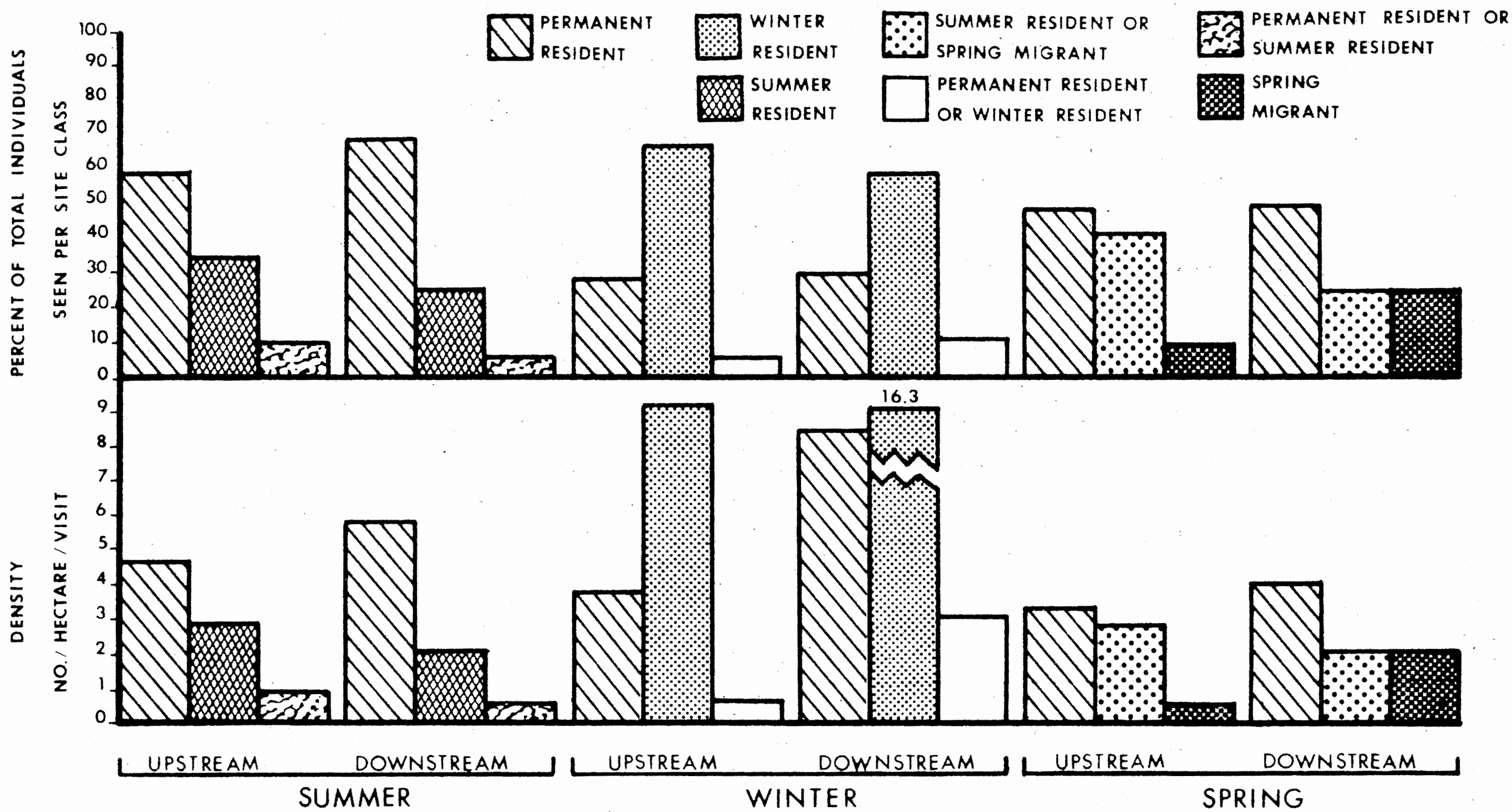


Fig. 16. Density and relative abundance by residence status of birds seen on study sites upstream and downstream from Ft. Cobb Reservoir during the summer, winter 1976-1977, and spring 1977.

showed only moderate similarity to each other (C = .592). Downstream sites were more similar with a C value of .776. Comparisons of site C2 to C3 and C4 resulted in C values of .673 and .737 respectively. C values from comparisons of C1 with C3 and C4 were somewhat lower (.507 and .633 respectively).

The 8 most abundant species comprised 91% of the total individuals seen on upstream sites during the winter (Fig. 15). The 8 most abundant species comprised 80% of the total species seen on downstream sites during the winter. Six of these species were also among the 8 most abundant on upstream sites. The relative abundance values for permanent and winter residents were very similar between upstream and downstream sites (Fig. 16). However, downstream sites supported 4.7 more permanent residents and 7 more winter residents per ha than upstream sites (Fig. 16).

Spring. C values for the various pairs of sites were generally intermediate between winter and summer values (Table 14). In general, coefficients of community similarity indicated that spring species composition and relative abundance was as similar for sites between classes as it was for sites within classes. Variation between C values for the various pairs of sites was very low (s = .043).

In the spring, the 8 most abundant species comprised 73 and 81% of the total species seen on upstream and downstream sites respectively. Seven of the 8 most abundant on species on upstream sites were among the 8 most abundant on downstream sites.

Life Forms

The number of species and density of birds contained in each life form for the Cobb and Lake creek study sites during the summer appear in Table 15. The upstream sites supported an average of 9.5 and a total of 11 life forms. Downstream sites supported an average of 8 and a total of 11 life forms.

Life forms 3, 5, 7, 8, 16, 17, and 18 were observed on both the upstream and downstream sites. Life forms 1, 13, and 15 were unique to upstream sites, while life forms 2, 10, and 14 were seen only on downstream sites. However, the density of these unique life forms was very low, indicating that they were not a numerically significant part of the avifauna on the sites.

The mean density of birds on both the upstream and downstream sites was highest in life form 5. This life form contained 38 and 37% of the total birds seen on upstream and downstream sites respectively. The mean density of birds that utilized the lower vegetation strata for feeding and nesting (life forms 4 and 5) were very similar on both upstream and downstream sites, 3.66 and 3.76 per ha respectively. This would seem to indicate that vegetation in the lower zones on downstream sites has not been altered by reduced flooding in a way which appreciably affected avifauna utilizing this zone.

Mean densities of birds in life form 8 were very comparable between upstream (.63 per ha) and downstream (.59 per ha) sites. Mean densities of life form 7 were slightly higher on downstream sites (2.4 vs. 3.1 per ha), and comprised 33 and 38% of the total birds seen on upstream and downstream sites respectively. Mean densities of life forms 16 and 19 were equal on upstream and downstream sites. Mean

Table 15. Number of species and density of birds in each life form for Cobb and Lake creek study sites during the summer 1976.

	Upstream sites						Downstream sites					
	C1		C2		Mean		C3		C4		Mean	
Life forms	No. species	Density[1]	No. species	Density	No. species	Density	No. species	Density	No. species	Density	No. species	Density
1	-	-	1.0	0.2	0.5	0.1	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	1.0	0.1	0.5	0.1
3	2.0	0.4	2.0	1.0	2.0	0.1	-	-	1.0	0.2	0.5	0.1
4	1.0	0.7	1.0	0.4	1.0	0.5	2.0	0.8	2.0	0.5	2.0	0.7
5	6.0	3.6	5.0	2.6	5.5	3.1	5.0	3.8	5.0	2.4	5.0	3.1
6	-	-	-	-	-	-	-	-	-	-	-	-
7	6.0	2.2	5.0	2.6	5.5	2.4	6.0	3.2	4.0	3.0	5.0	3.1
8	2.0	0.5	4.0	0.7	3.0	0.6	3.0	0.8	2.0	0.3	2.5	0.6
9	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	1.0	0.1	0.5	0.1
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	1.0	0.1	0.5	0.1	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	1.0	0.3	0.5	0.2
15	1.0	0.1	1.0	0.1	1.0	0.1	-	-	-	-	-	-
16	1.0	0.1	-	-	0.5	0.1	1.0	0.1	-	-	0.5	0.1
17	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	-	-	0.5	0.1
18	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.2	1.0	0.3	1.0	0.2
Total	21.0	7.9	22.0	8.1	21.5	7.9	19.0	9.2	18.0	7.4	18.5	8.3
Total life forms	9		10		9.5		7		9		8	

[1] Density denotes number of birds per hectare.

densities of life form 18 were twice as high on downstream sites.

Differences between upstream and downstream sites in mean number of species and mean density of birds within each life form all proved to be nonsignificant (Appendix F, Table 11). Again, these results indicate that the effects of alteration (impoundment) upon the downstream riparian habitat and associated avifaunal life forms could not be detected at statistically significant levels.

DISCUSSION

The Effects of Channelization: Rush and Wildhorse Creeks

A minimun of 43 years has passed (except for sites W6 and W7) since the channelization on Rush and Wildhorse Creeks was completed (Table 1). Presumably, the amount of time needed for stream beds and banks to recover from the immediate disturbances of construction activity has been sufficient. Therefore, any of the differences observed in this study between channelized and unchannelized sites should reflect the long term effects of stream channelization.

Species Richness

The control sites (UnBotFor), with few exceptions, supported more species of birds in all seasons than did the altered sites. The number of avian species present on the study sites was inversely related to the intensity of land use change that followed channelization. Species richness on sites where riparian bottomland forest was left intact following channelization was generally the most comparable to that on control sites. The absence of certain native riparian species from all altered sites indicated that channelization and subsequent land use changes significantly reduce the requisites needed to support all species which naturally occur on control sites.

Species richness on the ChBotForReg and ChPecGroTaGr sites in a few instances exceeded that observed on control sites. First, it should be noted that although the total number of species seen per month on ChBotForReg sites exceeded that observed on control sites during summer, fall and winter, the mean number of species seen per visit was usually higher on control sites. This information indicates that although higher numbers of species were seen on the ChBotForReg site per season, they were not seen consistently on each site visit, unlike the control sites. The inconsistency of sightings of various species on this altered site suggests that these species were unable to satisfy all of their requisites at this site.

Two factors which were unique to the ChBotForReg site are believed to account for the high number of species observed there. First, selective logging of some of the mature trees has created a patchy distribution of foliage in the canopy and mid-story layers. Secondly, the absence of grazing for many years and increased sunlight reaching the understory through the thinned canopy has resulted in an undisturbed and dense understory not found on any of the other study sites. Tramer (1968) concluded that forest thinning increased the number of potential spatial niches and, consequently, the number of bird species by increasing the physical heterogeneity of the habitat. Other investigators (Preston and Norris 1947) have found that ungrazed woodlands are characterized by a higher species richness than are grazed woodlands. Preston and Norris believed that the higher species richness on ungrazed woodlands was the result of reduced disturbance to the wood land nesting species, 50% of which nest lower than 2 m from the ground.

The ChPecGroTaGr sites also had higher total species richness in the summer than did the control sites. The presence of a strip of flood zone vegetation, dominated by shrubs and saplings on ChPecGroTaGr sites, created an ecotone along most of the observation belt. The presence of ecotone species plus the addition of species that utilize the pecan trees and/or the planted tame grass are factors believed to have been responsible for the high species richness observed at the ChPecGroTaGr sites. Lay (1938) in a summer study in Texas, found that wooded margins supported 41% more bird species than did corresponding areas of homogeneous woodland.

The seasonal trends in species richness on control sites best exemplify the high value of these sites to avifauna. Species richness per visit was very high ($\bar{X} = 6.89 \pm .49$) and varied very little from season to season, indicating that the control sites provided avian requisites for a high number of species throughout the year. Channelized sites varied considerably from season to season in their ability to support various avian species. The intensively altered sites (i.e., ChTaGr and ChCrop sites) consistently exhibited low species richness throughout all seasons.

The UnBotForIs sites supported a significantly lower number of species when compared to the control sites. It appears that the size (area) of riparian forests must be maintained above some lower limit in order for the forest tract to support a full complement of naturally occurring riparian avian species. Below this size limit, the number of species that a track of forest can support decreases significantly. These findings are in agreement with those of Whitcomb (1975), who, in a Maryland study, concluded that many of the neotropical migratory species that were once dominant in the eastern deciduous forest interior tended to disappear from fragmented forests and were not replaced by other species.

Plant succession and vegetation structure are site characteristics usually recognized as determining what bird species are present and in what numbers (Hamilton and Noble 1975). Bird species richness usually increases as succession advances and vegetative structure becomes more complex (MacArthur 1961). Karr (1968), studying succession on stripmined areas in Illinois, showed that bird species richness increased from bare ground through shrub stages to bottomland forest. Johnson and Odum (1956), studying breeding bird populations in relation to old-field succession, also found positive correlations between species richness and increasing successional stages. Activities associated with channelization, such as clearing of stream bank vegetation and secondary effects such as conversion of remaining riparian forests to pastures and croplands, all serve to set back succession. In the present study increases in vegetation structure among the various study sites was accompanied by increases in bird species richness. While tame grass pastures and croplands do not represent natural seral stages in a riparian forest successional sere, the vegetation structure in these habitats are much like early grass-forb seral stages. Both are structurally simple and 1-layered. Vegetation on the ChPecGroTaGr areas is like that of early tree seral stages in that both are basically 2-layered. Most studies indicate it is the life form of the vegetation rather than the precise species of plants involved that determine the presence of the various avian species (Pitelka 1946, Bond 1957, James 1971, Whitmore 1975).

Various authors (MacArthur and MacArthur 1961, MacArthur 1964, Tramer 1968) attribute the increase in species richness which accompanies advances in succession to the increase of vegetational layering which in turn creates more spatial niches. Stream channelization and especially, subsequent land use changes convert or alter natural riparian vegetation so that the resulting vegetation is structurally more simple and vertically less stratified. In the present study, decreases in vertical vegetation zonation and vegetation complexity, as the result of stream alteration and subsequent land use change, were usually accompanied by decreases in bird species richness.

Bird Density

The density of birds, regardless of species, was generally higher on control sites during all seasons than on any of the altered sites. The summer was the only season when any of the altered sites supported higher bird densities than control sites. The ChBotForReg and UnBotForIs sites supported slightly more birds per ha than control sites. The high amounts of ecotone on the UnBotForIs sites were believed to have been responsible for the high densities observed there. Beecher (1942) compared bird densities in a large block of forest habitat with an equivalent acreage composed of small blocks. He found that bird densities increased with the increase in relative amounts of edge. The heterogeneity of the thinned forest and the extremely dense ungrazed understory are believed to have been responsible for the high bird densities on the ChBotForReg site. Kendeigh (1947) found the highest bird densities in early forest seral stages where shrubs were still very dense. He attributed the high bird density to the presence of dense vegetation under the trees. Johnson (1970) found a density of approximately 800 pairs of birds per 40.4 ha

(100 acres) in selectively thinned upland forest; he attributed the high bird density to a densely foliated understory and openness in the canopy which created a relatively large amount of edge.

Possardt (1975), in Vermont, and Ellis (1976) in Virginia, found breeding bird densities to be higher on unaltered sites than on channelized sites. Carothers and Johnson (1975), in Arizona, also found that breeding bird density decreased as the degree of habitat manipulation resulting from stream channelization increased.

The value of the control sites to a large number of birds was most evident during the winter. During this season the control sites supported approximately twice as many birds as in the summer. Survival of resident and wintering birds is mainly influenced by availability of food and cover (Ellis 1976). Many species that reproduce in northern latitudes migrate to warmer southern wintering grounds and concentrate there in high densities. The survival of the wintering birds is determined to a large extent by the quality and extent of the required wintering habitat. The high densities of birds on the control sites in the present study indicates that riparian forests support more birds per ha than any of the altered habitats. Diminished quality and quantity of the native riparian forests as a result of channelization and subsequent land use changes may seriously limit the usefulness of these altered habitats to wintering birds that depend on riparian forests for survival in winter. These results contrast with Ellis' (1976) findings which indicated higher bird densities occurred on older channelized sites than on unchannelized sites or recently channelized sites.

During both fall and spring migration periods all altered sites supported lower bird densities than did the control sites. These results support Possardt's (1975) findings which showed significantly lower fall and spring densities on channelized sites when compared to unaltered sites. In the southcentral grasslands, the presence of strips of riparian forest along the stream courses is essential to the provision of requisites for migrating forest species (Sprunt 1975). Stevens et al. (1977) has shown that riparian forest plots contained up to 10.6 times the numbers of migrants per ha found on adjacent non-riparian plots. Extensive destruction or reduction in quality of riparian vegetation could indirectly limit populations of migrants with no changes having occurred in their preferred nesting or wintering habitats.

An increase in avian density through a progression of successional communities has been documented by Saunders (1936) in New York, Kendeigh (1948) in Michigan, Odum (1950) in North Carolina, Johnson and Odum (1966) in Georgia, Haapanen (1965) in Finland, Karr (1968) in Illinois, Karr (1971) in Panama, and Shugart and James (1973) in Arkansas. These findings, drawn from diverse regions, are in general agreement. In the present study the most intensely altered sites (e.g., the ChCrop and ChTaGr sites), whose vegetation is essentially 1-layered and structurally simple, had the lowest bird densities. ChPecGroTaGr sites which supported bird densities intermediate between intensively altered sites and control sites are essentially 2-layered and are structurally less complex than vegetation on the control sites which represent a climax condition. Tureek (1951) and Oelke (1966) have noted that increased stratification of vegetation in various habitats will generally result in higher breeding bird densities. In the present study, increases in the intensity of land use change following channelization resulted in decreases in vegetation zonation and complexity. Consequently, the intensity of habitat alteration which has occurred on a site was inversely related to the site's bird density.

Results of the present study confirm a high density utilization of natural riparian forests by birds during all seasons in the south-central grasslands region. The data also indicate that when this habitat is altered due to channelization and subsequent land use changes the ability of these altered habitats to support high densities of resident, migrating and wintering birds decreases drastically.

Species Diversity

During the summer, BSD was higher on control sites than on all altered sites except the ChPecGroTaGr and ChBotForReg sites. Wooded sites consistently had higher BSD than did the intensively altered sites where woody vegetation had largely been removed.

Two primary factors, foliage height diversity (foliage measure of cover, usually at 3 heights in a stand corresponding to herb, shrub and canopy layers) and horizontal diversity within a foliage level, seem to account for variations in BSD (MacArthur and MacArthur 1961). Since the number of levels and, as a consequence, the foliage height diversity tend to increase as succession advances, avian species diversity also tends to increase. Maximum BSD is usually achieved at or near vegetative climax (Karr 1971, Shuggart and James 1973).

The high BSD observed on the ChBotForReg site may be explained by the increased horizontal and vertical vegetation diversity created in the herb and shrub layers as the result of the selective thinning and lack of grazing. All other wooded sites received grazing by livestock during some time of the year.

The practice of cutting all riparian forest trees except pecan and totally replacing understory vegetation with tame grass obviously reduces foliage height diversity. However, BSD on the ChPecGroTaGr sites was higher than on the control sites. Both components (species richness and equitability) of the species diversity index appear to have been responsible for this anomally. Encroachment by avian species which utilized the tame grass pasture, incidental use by transients, and presence of edge species which utilized the ecotones between the flood zone vegetation and the pecan grove appears to have offset the number of species lost by eliminating most of the natural forest vegetation. Territoriality plus interspecific competition among the higher number of species may have created finer habitat partitioning which resulted in higher equitability among species.

Stream alteration practices coupled with land use changes which reduce or eliminate foliage height diversity or horizontal diversity generally caused significant reductions in BSD as well as in factors previously considered. Channelization had the least effect on BSD when riparian forest vegetation was left intact. Activities which increased foliage height diversity or horizontal foliage diversity and created ecotones tended to increase BSD in the summer.

Summer BSD data from the present study compare favorably to those from other stream alteration studies. Ellis (1976) found that summer BSD increased through successional stages on altered stream sites to a high of 2.40 on the control sites. Summer BSD values averaged 2.36 from the control sites in the present study. Possardt (1975) found

BSD values for breeding birds to be significantly less on the channelized areas.

The high value of native riparian forest to birds was most noticeable during the winter when all altered sites supported less diverse avian communities than did control sites. These results support Ellis' (1976) findings which showed winter BSD to be lower on channelized sites when compared to unchannelized sites. Foliage height diversity is considerably less in winter due to leaf-fall. Because of cold weather, the greatly reduced availability of insects must minimize insectivor niche effectiveness in the winter. For both of these reasons a reduced BSD would be expected in winter. All sites exhibited a considerable decrease in BSD in the winter except the control sites which decreased only slightly. The apparent explanation for comparable summer and winter BSD on control sites is the narrowing of previous summer feeding strategies and the opening up of new winter feeding opportunities. The new opportunities are presumably centered around the reservoirs of edible biomass produced above the ground in summer then concentrated on or near the ground during winter due to dormancy or death of plants plus gravitational action (Hamilton and Noble 1975). Other potential trophic niches are associated with food matter protected by favorable microclimates in the litter layer of the soil. Many of the overwintering birds subsist on these food sources while a few others may still be able to subsist on overwintering insects and their larvae. Stream alteration and subsequent land use changes apparently alter vegetation and biomass production to a point where winter food and associated winter niches are considerably reduced from levels present in natural riparian forests.

The control sites again demonstrated their value to birds during spring and fall migration periods when they exhibited higher BSD values than any of the altered sites. The significantly lower BSD values on the majority of channelized sites indicates that channelization and, especially, subsequent land use changes significantly reduce the ability of these altered sites to support diverse bird populations during migration periods. Stevens et al. (1977) in Arizona showed that stop-over habitat selection is evident in migrating passerines. He found that migrant passerine species diversity was significantly higher on riparian woodland areas than on adjoining areas of nonriparian woodlands.

It is important to note that while BSD showed considerable seasonal variation for most of the channelized sites, it was consistently high through all seasons on the control sites. This trend reflects the high value of unaltered riparian forests to a high diversity of birds throughout all seasons and supports the theory that BSD is lowest and more unstable in habitats with structurally simple vegetation and vice versa.

Species Composition

Coefficients of community similarity (C) indicated that species composition was very similar among the control sites during the summer. Summer C values indicated that species composition became more unlike that on control sites, as the intensity of land use change increased. Altered sites characterized by woody vegetation produced higher C values than sites where woody vegetation had been removed.

It is important to note that the more intensively altered sites with higher C values (e.g., sites R2 and W3) were those with the most extensive flood zone vegetation. The vegetation of the flood zones resembled early seral stages of bottomland forests, and it was the occurrence of characteristic forest species in this zone that resulted in the high C values.

Species with very narrow niches are usually among those most affected by habitat alterations (Balda 1975). The stenoecious forest species, parula warbler and Louisana waterthrush, were found only on control sites. Possardt (1975) and Ellis (1976) both found parulids to be significantly more abundant on unchannelized sites. However, other stenoecious forest species such as the pileated woodpecker, eastern wood pewee, red-eyed vireo and white-eyed vireo were found only on control and ChBotFor sites. The occurrence of some stenoecious forest species on both the control and ChBotFor sites suggests that over a prolonged recovery period channelization alone appears to have little effect on avian species composition. However, the absence of a few stenoecious forest species from the ChBotFor site that did occur on control sites indicates that a few avian niches may be altered or eliminated by channelization alone. The occurrence of no stenoecious forest species on sites where extensive land use change has followed channelization indicates that the value of these altered sites to natural riparian avifauna has been significantly reduced.

Densities of permanent resident species on control sites were slightly lower than those on ChBotForReg and UnBotForIs sites, but were considerably higher than those on other channelized sites.

Five of the 10 channelized study sites supported densities of summer residents which were comparable to those observed on control sites. However, summer resident species which were characteristic of forested habitats were consistently observed in the flood zone vegetation. The other summer residents on intensively altered sites were typically grassland or savannah species, representing a shift in species composition away from the original condition. These open country species generally have broad niches and show a high degree of adaptability (e.g., red-winged blackbird, mockingbird, starling, common grackle, northern oriole).

Densities of birds that feed in or very near water were higher on the channelized sites. The occurrence of higher densities of killdeers is probably due to this species' preference for more open habitats and the greater quantities of exposed substrate along channelized streams. Belted kingfishers typically excavate their nest and roost holes in the sides of steep earth banks. The sheer walls caused by extensive bank erosion along the channelized portions of the streams provided an abundance of potential nest and roost sites. The absence of meanders in the channelized stretches of stream has created long shallow pools of water where minnows are very accessible to kingfishers. The increase in available nest sites and increased availability of food is probably responsible for the higher kingfisher populations along the channelized stretches of the streams. Rough-winged swallows also build their nests in or on the sides of the steep cut banks. The high availability of these nesting requisites probably accounted for the higher swallow densities along channelized stretches of the streams. Possardt (1975) also found swallows plus sandpipers (with feeding stratigies similar to the killdeer) to be more abundant in channelized stretches of his study streams.

Coefficients of community similarity were consistently lower on all sites during the winter than in the summer. The general absence of territoriality and the lower sampling intensity during winter were believed to account for lower C values and increased variance respectively. Although C values from all sites were lower in winter than in the summer, the ranking of study sites in terms of their C values was generally the same as it was in the summer. The ChBotFor and ChBotForReg sites, where riparian forest vegetation was left intact following channelization, showed the most similarity to control sites. Wooded sites had higher C values than did sites where land use changes had occurred, i.e., intensity of land use change was inversely related to the coefficient of community similarity.

In the winter, densities of permanent residents on all sites were very comparable to what they were in the summer. However, densities of winter residents on control sites were over twice that observed on any of the other sites, indicating that stream alteration and subsequent land use changes noticeably reduced the altered sites' ability to provide requisites to wintering birds.

Low sampling intensity, lack of territoriality and the high mobility of migrants were probably responsible for the unusually low C values for all sites during the fall. Slightly higher spring C values on all sites probably reflects the initiation of territorial activity.

During the spring and fall, C values indicated that the similarity of species composition on altered sites to control sites was inversely related to the intensity of habitat alteration. Species composition on sites where riparian forests were left intact following channelization was most similar to control sites.

Control sites supported higher densities of both permanent residents and migrants than did any of the channelized sites in the fall. During the spring, all altered sites (except the UnBotForIs sites) supported at least 50% lower densities of permanent residents than did control sites. All altered sites supported lower densities of species classified as summer residents or spring migrants than did the control sites. These data reflect the high value of natural riparian forests to avifauna during migration periods.

Five species of wood warblers whose niches are closely restricted to forest habitats were seen on control sites during the spring. None of these species were observed on any of the altered sites during the spring. Their occurrence on only the control sites indicates their sensitivity to habitat alteration and emphasizes the importance of natural riparian bottomland forests to birds that depend on this habitat during migration.

Five species of fall migrants (song sparrow, tree sparrow, spotted sandpiper, long-billed dowitcher and vesper sparrow) were seen only on the intensively altered sites. Although these migrant species are not considered to be typical riparian forest migrants, their occurrence on the highly altered sites indicates that these sites are of use to at least some migrating species in the fall. Only intensively altered sites were utilized by migrating shorebirds during the fall.

It is important to note that the control sites consistently supported high densities of permanent residents throughout all seasons. Although some of the altered sites supported high densities of permanent residents in the summer, their ability to sustain these populations throughout the year was noticeably lacking.

Land and water management activities eliminate original forest habitat niches, replacing them with new and often quite dissimilar ones (Hooper 1967). Coefficients of community similarity from the present study clearly show that avian species composition and relative abundance in natural riparian forests are altered proportional to the intensity of habitat alteration. Ambrose (1973) found that habitat alteration affected bird community composition and the degree of change was correlated to the alteration magnitude.

Bird species vary widely in their tolerance to forest disturbance (Curtis and Ripley 1975). Some birds, usually stenoecious species, tolerate little alteration, while others, euryoecious species, occur in a wide variety of altered habitats. Whitcomb (1977) emphasized that certain bird species such as forest-interior warblers and vireos disappear from fragmented forests. He also found that severe forest fragmentation may in some regions cause regional extinction to these species. Some species are found only in severely disturbed forest situations (Webb 1973). Clearly, certain bird species benefit from forest habitat changes while others are unfavorably affected, depending in each case upon the creation or destruction of habitat essential to the required niche (Stewart and Robbins 1958).

In addition to destroying some habitat types which are important to certain stenoecious species, some management practices and land use changes are accompanied by rapid habitat changes which favor genetically labile or colonizing species that are preadapted for fluctuating habitats. Those forms that are less elastic in their requirements will probably be selected against (Hamilton and Noble 1975). In the present study, intensively altered sites like the channelized cropland, where habitats varied from dense stands of crops to bare ground, were where the majority of genetically labile species (e.g., red-winged blackbird, lark sparrow, killdeer) occurred. The stenoecious forest species (e.g., parula warbler, red-eyed vireo, yellow warbler, Louisiana waterthrush, Swainson's thrush, Nashville warbler, orange-crowned warbler, ovenbird) were limited more to the naturally vegetated forest sites.

Garber and Garber (1963) compared the bird populations of Illinois in 1956-1958 with populations found there earlier. They noted both a decrease in total number of birds and in diversity. There had been a recent trend of increasing bird numbers confined to a few species associated with managed habitats. They found numbers of many forest species to be dwindling as forest habitats were converted to other land uses.

The same phenomena has occurred in the floodplains of Rush and Wildhorse creeks, and probably over much of the southcentral grasslands where channelization activities are prevalent. The majority of channelization was accomplished in the early 1920's and 1930's for Rush and Wildhorse creeks respectively. Hedrick (c.a. 1978) reported that 11,053 ha of bottomland forest existed in the Rush and Wildhorse floodplains in 1871. He determined that only 1529 ha of bottomland forest existed in the two floodplains in 1969. In 98 years 9524 ha of highly productive riparian bird habitat had been destroyed.

Assuming that species composition and species' densities on control sites of the present study are similar to what existed in the bottomland forests of Rush and Wildhorse creeks in 1871 and 1969, the reduction of stenoecious forest species has been drastic. Considering only those species that occurred exclusively on bottomland forest sites in summer, the loss of this habitat probably resulted in the destruction of breeding habitat for an estimated 1253 parula warblers, 4388 red-eyed vireos, 951 eastern wood pewees, and 2381 wood ducks. The effect of habital destruction on wintering and migrant forest birds, although more difficult to assess, has probably been equally dramatic. Habitat survey information from various counties in Oklahoma indicate that the rate of decline of bottomland forest is considerably less where channelization activities have been absent (Oklahoma Department of Wildlife Conservation 1976).

Life Forms

The number of avian life forms that occurred on the study sites was directly related to the intensity of habitat alteration. The creation of habitat other than riparian forest as a result of land use changes allowed more birds of various life forms to utilize the altered study sites. At the same time many of the life forms that were characteristic of riparian forests were able to utilize the altered study sites in limited numbers due to the presence of flood zone vegetation.

Eighty-nine percent of the birds that were found to typify control sites (UnBotFor) were contained in life forms 3, 4, 5, 7, and 8, indicating that the majority of riparian forest birds depend on the shrub and tree vegetation layers for feeding and nesting. The control sites supported higher densities of birds in life form 7 than did any of the other sites. The high number of species and individuals utilizing cavities for nesting emphasizes the importance of maintaining riparian forests in a mature condition so that an abundance of dead trees and limbs will be present. Balda (1975) studied the number of cavity nesting species in relation to the density of snags in a ponderosa pine forest. He found that the species richness, density, and BSD of cavity nesters increased as the number of snags increased.

The absence of flooding on the channelized sites may reduce tree mortality caused by physical damage from floating debris, heavy siltation, root death caused by waterlogging, oxygen poor soils and prolonged inundation. A paucity of dead trees and limbs would reduce the potential for natural cavities and abandoned woodpecker cavities that are necessary for reproduction and roosting of birds in life form 7. All woodpeckers that occur in southcentral Oklahoma excavate their cavities in dead trees. Consequently, the same factors that may be limiting the abundance of life form 7 may also account for lower densities of life form 8 on all of the channelized sites.

Only 2 sightings of a ground nesting species (Louisiana waterthrush and black and white warbler) were recorded during the summer for the control sites. Several factors may explain the paucity of ground nesting species on control sites. First, very few species that nest on forest floors nest in southcentral Oklahoma. Secondly, disturbance of low vegetation as a result of livestock grazing and trampling was evident on all control sites. A lack of sufficient ground cover may make ground nesters too vulnerable. Finally, of the ground nesting species that do nest in the deciduous forest of Oklahoma, many may discriminate against riparian forests due to the possibility of flooding.

When streams are channelized and riparian forests converted to pecan groves the number of individuals that require low tree and shrub vegetation (life forms 4 and 5) is reduced. An increase in the number of species and individuals preferring savannah (life form 2) and ground habitats is observed due to the wide spatial distribution of the pecan trees and the introduction of the tame grass beneath the trees.

The reduction of large expanses of riparian forest to small blocks or islands of forest altered the life form composition very little. However, the islands of trees were utilized by birds that prefer savannah type vegetation. Selective thinning of mature trees from the riparian forests encouraged development of dense and diverse understory vegetation which was accompanied by an increase in life form 5. Channelization followed by no land use change altered the life form composition very little. However, densities within the various life forms were slightly lower.

Elimination of all riparian forest vegetation followed by the planting of agricultural crops or tame grass decreased the number of species and individuals in life form 3, 4, 5, 6, 7 and 8 but increased species and numbers of life forms 11, 16 and 15. Flood zone vegetation, if allowed to develop, increased bird numbers in life forms 4 and 5.

The Effects of Impoundment: Cobb and Lake Creeks

Study sites located upstream from the reservoir are still subject to occasional flooding. Sites downstream from the reservoir do not flood due to the controlled water release from the dam. Periodic flooding appears to be essential for the reproduction of many floodplain plant species.

Flooding can have adverse effects on riparian vegetation. Riparian vegetation can be killed due to heavy siltation (Sigafoos 1964, Harper 1937), root death caused by water-logged and oxygen-poor soils (Kramer 1951), prolonged inundation (Hall and Smith 1955) and physical damage caused by floating debris in flood waters. The result of this periodic damage and regrowth of riparian vegetation would seemingly produce a habitat consisting of a mixture of early and late successional vegetation; which in turn would create a very patchy vegetative structure, plus an abundance of dead or dying trees. Since habitat patchiness has been shown to be positively correlated to bird species diversity and richness (Roth 1976, MacArthur 1962), one would expect to find higher numbers of species upstream from reservoirs. The abundance of dead trees would facilitate nesting and feeding by woodpeckers and nesting by secondary cavity nesters.

The upstream sites were both periodically grazed and one (C1) was burned during the winter. Downstream sites were neither grazed nor burned. It appears that the effect of grazing and burning confounded interpretation of the data. As studies have shown that grazing generally destroys habitat for a number of species (Overmire 1963, Owens and Myers 1973, Smith 1940), an absence of grazing and fire on all sites may have made differences between upstream and downstream sites more evident. Also, the low number of available study sites above and below (2 each) the reservoir tended to make statistical comparisons less sensitive.

Species Richness

Bird species richness data from sites upstream and downstream of

Ft. Cobb Reservoir did not convincingly indicate that impoundment has any appreciable effect on riparian avifauna. Bird species richness during the summer was higher on upstream sites than on downstream sites. Species richness was considerably higher on downstream sites during the winter. Upstream and downstream sites supported virtually equal numbers of species during the spring.

The lower number of species seen on upstream sites during the winter was believed to have been the result of a burn that occurred on site C1 during early December 1976, and intensive grazing and trampling on site C2. Both the burn and the grazing and trampling served to destroy the majority of the vegetation from ground level up to 2 m. The absence of grazing, burning or flooding on the downstream sites allowed understory vegetation to remain intact and probably provided food and cover to a greater variety of bird species.

In the spring, understory plants on the upstream sites began to refoliate. This was accompanied by an increase in species richness which made upstream and downstream sites very comparable.

Bird Density

The density data indicate that no significant differences existed in the ability of upstream and downstream sites to support numbers of birds in summer, winter and spring. Bird densities on both upstream and downstream sites were very similar in the summer and spring, suggesting that impoundment had very little effect on riparian avifauna during these seasons. Lower winter densities on the upstream sites probably reflects the disturbed nature of these sites due to grazing and burning as discussed previously. The absence of adequate understory and brushy vegetation would be most limiting to high concentrations of wintering fringillids which chiefly utilize low level vegetation and the ground when searching for food.

Species Diversity

BSD indices and equitability coefficients from the present study suggest that no significant differences in avian species diversity existed between upstream and downstream sites during the 3 seasons. Therefore, the reduction of flooding downstream from the reservoir apparently had little detectable effect on BSD or equitability of bird communities in the streamside habitats. Although winter H' and J' values were noticeably different between the upstream and downstream sites, we strongly believe that the differences were due to land use practices rather than the effects of the reservoir.

BSD on C1 was abnormally low during the winter. Burning and grazing during winter largely destroyed understory and brushy vegetation at this site. Reduction in the number of vegetation strata and unevenness of apportionment among strata has been shown to reduce BSD (MacArthur and MacArthur 1961, MacArthur 1964, Tramer 1969).

Species Composition

Coefficients of community similarity indicated that the likeness of bird species composition and relative abundance between upstream and downstream sites was greatest during the summer. Sites C1 and C4 had a narrower strip of woodland habitat along the stream than did C2 and C3. Consequently, the numbers of species and the density of birds that exhibit edge or open-country habitat preferences were higher on sites C1 and C4 (Appendix D). When sites with narrow woodland strips were compared to sites with wide wooded strips, species not held in common by both sites were usually stenoecious woodland interior species or edge species. During the summer, the densities and relative abundance of permanent and summer residents on upstream and downstream sites were comparable.

The lack of territoriality, high mobility of wintering bird populations (Kricher 1975) and lower sampling intensity were viewed as major factors which reduced C values during the winter. The highest source of dissimilarity came from site comparisons involving site C1. The abnormal species composition on this site was believed to have been caused by the burn which rendered the site temporarily unsuitable to many species that probably should have occurred there.

Densities of both permanent and winter residents were noticeably lower on upstream sites than downstream sites during the winter; however, the difference was most evident among the wintering species. Wintering fringillids depend chiefly on seeds for survival during the rigorous winter season (Bent 1937, Davis 1973). Consequently, the majority of their requisites (food and cover) are met in the areas where seeds collect on the ground and lower zones of vegetation provide cover. Of the 113 winter resident individuals that were recorded on downstream sites, 80% were fringillids that typically utilize lower vegetation zones. These fringillids were noticeably less in evidence on upstream sites, with only 53 observed. The burn and severe grazing on the upstream sites is believed to have altered lower vegetation zones and ground litter enough to make the sites considerably less useful to these wintering species. Since upstream and downstream sites both supported many of the same species (Fig. 15), but bird densities were much higher on downstream sties where lower zone vegetation was undisturbed; it appears that disturbance of lower zone vegetation on upstream sites most effects the site's carrying capacity.

The refoliation of the lower zone vegetation and the resumption of some territorial activity are believed to have been responsible for the overall increase in C values of all sites in spring over winter. During the spring, species composition was very similar between upstream and downstream sites.

In conclusion, impoundment seemed to have little detectable effect on species composition during summer, winter, and spring. The reduction of flooding downstream from the reservoir apparently has not altered riparian habitat in a manner which could be detected. Noticeable differences in winter species composition between upstream and downstream sites were attributed to grazing and burning rather than effects of impoundment.

Life Forms

The life forms composition on downstream sites was extremely similar to that observed on upstream sites. The only life forms that did not occur on both upstream and downstream sites comprised a miniscule portion of the avian population. The similarity of life form composition and densities of birds within each life form between upstream and downstream sites suggests that reduced flooding downstream from the reservoir has no detectable effect on birds in any of the 18 life forms.

SUMMARY AND CONCLUSIONS

From June 1976 to May 1977, 2 streams in southcentral Oklahoma and 1 stream and its tributary in westcentral Oklahoma were studied to determine the impact of stream alteration and associated land use changes on riparian avifauna in a southcentral grasslands region of the United States. A study stream selection matrix was used to select 2 streams (Rush and Wildhorse Creeks) along which 17 study sites representing various combinations of vegetation cover types and channel conditions were designated. Two sites above and 2 sites below Ft. Cobb Reservoir were selected to study impoundment effects.

All 21 study sites were sampled at least 10 times each in summer and an average of 3 times each during fall (excluding impoundment sites), winter and spring using a fixed-width line count method. Avifauna on the various sites were described and compared using the following parameters: 1) species richness, 2) density, 3) species diversity, 4) species composition, and 5) life forms.

The effects of channelization on riparian avifauna should be viewed as long term effects as all sites (except sites W6 and W7) were channelized at least 43 years ago. Not all possible parameters of avian populations were measured and some effects of stream alteration on riparian avifauna were probably not detected with techniques used in the present study.

The overall results of the present study indicate that channelization significantly effects the avian community. The avian community is least effected when riparian forest vegetation is left intact following channelization. Significant changes occurred in the avian community when channelization and subsequent land use changes caused decreases in species richness, bird density, species diversity and shifts in the species composition away from the natural condition. After a minimum of 43 years recovery time, channelized sites failed to support avian populations comparable to unaltered sites. The data indicated that impoundment had no significant effect on avian communities in the stream side habitat downstream from the reservoir.

The Effects of Channelization: Rush and Wildhorse Creeks

Species Richness

The mean number of bird species seen per visit, when averaged over the entire year, was significantly lower on all channelized sites (except ChBotForReg site) when compared to the control sites (UnBotFor). The mean number of bird species seen per visit was higher on control sites than on any altered sites during fall, winter and spring and was second highest during summer. The control sites supported a significantly higher mean number of species per visit than did the ChCrop, ChTaGr, UnBotForIs and UnNatGr sites in summer; the ChBotFor, UnBotForIs, ChCrop, ChTaGr and UnNatGr sites in fall; the ChPecGroTaGr, UnBotForIs, ChCrop, ChTaGr and UnNatGr sites in winter and spring.

The total number of bird species seen per season during the fall, winter and spring was significantly lower on all sites (except the ChBotForReg site--falla and winter, ChBotFor site--winter) when compared to the control sites. The total number of species seen during the entire year was significantly lower on the ChPecGroTaGr, UnBotForIs, ChCrop and ChTaGr sites when compared to the control sites. Bird species richness decreased as the intensity of habitat alteration increased.

Conclusions. 1) Channelization significantly reduces annual bird species richness (mean number of species seen per visit and total number of species seen per season averaged over the entire year). 2) Channelization significantly reduces bird species richness in the fall. 3) Intensive land use changes associated with stream channelization significantly reduce bird species richness in all seasons. 4) Channelization not accompanied by riparian forest alteration has no detectable significant effect on bird species richness during the summer, winter and spring.

Bird Density

The results show a high density of birds using control sites during all seasons. Bird density per visit, averaged over the entire year, was significantly lower on all altered sites (except the ChBotForReg site) when compared to the control sites. During the spring, mean bird density per visit was significantly lower on all channelized sites when compared to control sites. In the summer, mean bird density per visit was significantly lower on the ChTaGr sites when compared to control sites. The ChPecGroTaGr, ChTaGr and ChCrop sites supported significantly lower bird densities per visit in winter when compared to the control sites.

Conclusions. 1) Channelization significantly reduces annual bird density (mean number of birds per ha per visit averaged over the entire year). 2) Channelization significantly reduces bird density during the spring. 3) Channelization alone has no apparent significant long term effect on bird density during the summer, winter and fall. 4) Intensive land use change (i.e., conversion of riparian forest to cropland or tame grass pasture) significantly reduces bird densities during the summer, winter and spring.

Species Diversity

BSD values reflected the intensity of habitat alteration on the various sites. During spring and fall, BSD was found to be significantly lower on all channelized sites (except the ChBotForReg sites) when compared to control sites. During the winter, BSD was significantly lower on all channelized sites (except the ChBotFor and ChBotForReg sites) when compared to control sites. During summer, BSD on the ChCrop, UnBotForIs, and ChTaGr sites proved to be significantly lower than on the control sites. Overall BSD was found to be significantly lower on all altered sites (except the ChBotForReg site) when compared to the control sites.

Conclusions. 1) Channelization significantly reduces annual BSD (BSD values averaged over the entire year). 2) Channelization significantly reduces BSD in the fall and spring. 3) Intensive land use changes associated with channelization significantly reduce BSD during all seasons.

Species Composition

Coefficients of community similarity clearly show that species composition and relative abundance were altered proportionally with the intensity of habitat alteration. Species with savannah or grasslands preferences comprised larger proportions of the avian population when habitat alteration subsequent to channelization resulted in primarily 1 or 2-layered vegetation structures.

Species composition of each site indicated that species with stenoecious forest habitat requirements (e.g., parula warbler, red-eyed vireo and pileated woodpecker) appear to be particularly affected by channelization and subsequent land use change. Kingfishers, killdeers and swallows benefited from channelization and subsequent land use changes.

Conclusions. 1) Channelization effects the species composition very little after a prolonged recovery period if riparian forest vegetation is allowed to remain intact. 2) Land use changes associated with channelization noticeably alter species composition by eliminating native riparian avian species and replacing them with species that show ecotone, savannah and grasslands preferences. 3) Stenoecious forest species are those most effected by channelization and subsequent land use change.

Life Forms

Densities of life forms 7 and 8 were higher on control sites than on any other sites. The high numbers of life forms 7 and 8 on control sites emphasizes the importance of dead trees and cavities to riparian forest avifauna. Eighty-nine percent of the total number of individuals seen on control sites were contained in life forms 3, 4, 5, 7 and 8. Sites characterized by land use changes were occupied by an increased number of individuals in life forms 2, 15 and 16. The presence of flood zone vegetation on intensively altered sites was accompanied by increases in life forms 4 and 5.

Conclusions. 1) The vast majority of birds in natural riparian forests depend on the shrub and tree layers for feeding and nesting requisites. 2) Channelization and subsequent land use changes tend to reduce the density of cavity nesting species.

The Effects of Impoundment: Cobb and Lake Creeks

Species Richness

No significant differences in mean species richness per visit were found between upstream and downstream sites in any season. Total species richness per season was significantly lower on downstream sites during the summer but was nonsignificant between upstream and downstream sites in the fall and winter.

Conclusion. These data do not conclusively demonstrate that impoundment has any significant effect on species richness of riparian avifauna downstream from the reservoir.

Bird Density

No significant differences in bird density were found between upstream and downstream sites in any season.

Conclusion. Impoundment has no significant effect on density of riparian avifauna downstream from the reservoir.

Species Diversity

No significant differences in BSD were found between upstream and downstream sites in any season.

Conclusion. Impoundment has no significant effect on BSD of avian communities downstream from the reservoir.

Species Composition

No significant differences in species composition attributed to the effects of impoundment were found between upstream and downstream sites. Coefficients of community similarity indicated that species composition and relative abundance on the 2 downstream sites were as similar to upstream sites as they were to each other.

Conclusion. Impoundment has no detectable effects on species composition of riparian avifauna downstream from the reservoir.

Life Forms

Very few differences occurred between upstream and downstream sites in mean number of species and mean number of birds within each life form.

Conclusion. Impoundment has little effect on the life forms composition of avifauna downstream from the reservoir.

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APPENDIXES

APPENDIX A

SCIENTIFIC NAMES FOR PLANTS AND ANIMALS MENTIONED IN THE TEXT OR NOTED IN THE DATA TAKEN DURING THE STUDY

Scientific Name	Common Name
Flora (Alphabetical Order by Common Name)	
Medicago sativa	Alfalfa
Fraxinus spp.	Ash
Hordeum vulgare	Barley
Cynodon dactylon	Bermuda grass
Andropogon gerardii	Bluestem, big
Andropogon scoparius	Bluestem, little
Andropogon hallii	Bluestem, sand
Andropogon virginicus	Broomsedge
Populus spp.	Cottonwood
Sporobolus cryptandrus	Dropseed, sand
Ulmus spp.	Elm
Bouteloua gracilis	rama, blue
Bouteloua curtipendula	Grama, side-oats
Celtis spp.	Hackberry
Sorghastrum nutans	Indiangrass
Quercus macrocarpa	Oak, bur
Carya illinoinsis	Pecan
Pinus ponderosa	Pine, ponderosa
Ambrosia spp.	Ragweed
Cenchrus pauciflorus	Sandbur
Sorghum spp.	Sorghum
Panicum virgatum	Switchgrass
Aristida spp.	Three-awn
Juglans nigra	Walnut, black
Citrullus spp.	Watermelon
Triticum spp.	Wheat
Salix spp.	Willow
Chloris verticillata	Windmill grass
Panicum capillare	Witchgrass, fall
Avifauna (In Taxonomic Order)	
Anas platyrhynchos	Mallard
Anas discors	Teal, blue-winged
Anas crecca	Teal, green-winged
Aix sponsa	Wood duck
Cathartes aura	Vulture, turkey
Ictinia mississippiensis	Kite, Mississippi
Accipiter striatus	Hawk, sharp-shinned
Circus cyaneus	Hawk, marsh
Buteo lagopus	Hawk, rough-legged
Buteo jamaicensis	Hawk, red-tailed
Haliaeetus leucocephalus	Eagle, bald
Falco sparverius	Kestrel, American

Colinus virginianus	Bobwhite
Ardea herodias	Heron, great blue
Florida caerulea	Heron, little blue
Butorides striatus	Heron, green
Nyctanassa violacea	Night heron, yellow-crowned
Charadrius vociferus	Killdeer
Bartramia longicauda	Sandpiper, upland
Tringa solitaria	Sandpiper, solitary
Actitis macularia	Sandpiper, spotted
Limnodromus scolopaceus	Dowitcher, long-billed
Capella gallinago	Snipe, common
Zenaida macroura	Dove, mourning
Coccyzus americanus	Cuckoo, yellow-billed
Geococcyx californianus	Roadrunner
Bubo virginianus	Owl, great horned
Strix varia	Owl, barred
Caprimulgus carolinensis	Chuck-will's-widow
Archilochus colubris	Hummingbird, ruby-throated
Megaceryle alcyon	Kingfisher, belted
Colaptes auratus	Flicker, common
Dryocopus pileatus	Woodpecker, pileated
Melanerpes carolinus	Woodpecker, red-bellied
Melanerpes erythrocephalus	Woodpecker, red-headed
Sphyrapicus varius	Sapsucker, yellow-bellied
Picoides villosus	Woodpecker, hairy
Picoides pubescens	Woodpecker, downy
Muscivora forfic	Flycatcher, scissor-tailed
Tyrannus tyrannus	Kingbird, eastern
Tyrannus verticalis	Kingbird, western
Myiarchus crinitus	Flycatcher, great crested
Sayornis phoebe	Phoebe, eastern
Contopus virens	Pewee, eastern wood
Eremophila alpestris	Lark, horned
Hirundo rustica	Swallow, barn
Petrochelidon pyrrhonota	Swallow, cliff
Stelgidopteryx ruficollis	Swallow, rough-winged
Cyanocitta cristata	Jay, blue
Corvus brachyrhynchos	Crow, common

Parus carolinensis	Chickadee, carolina
Parus bicolor	Titmouse, tufted
Sitta carolinensis	Nuthatch, white-breasted
Certhia familiaris	Creeper, brown
Troglodytes aedon	Wren, house
Thryomanes bewickii	Wren, Bewick's
Thryothorus ludovicianus	Wren, carolina
Mimus polyglottos	Mockingbird
Dumetella carolinensis	Catbird, gray
Taxostoma rufum	Thrasher, brown
Turdus migratorius	Robin, American
Catharus ustulata	Thrush, Swainson's
Catharus guttata	Thrush, hermit
Sialia sialis	Bluebird, eastern
Polioptila caerulea	Gnatcatcher, blue-gray
Regulus satrapa	Kinglet, golden-crowned
Regulus calendula	Kinglet, ruby-crowned
Bombycilla cedrorum	Waxwing, cedar
Lanius ludovicianus	Shrike, loggerhead
Sturnus vulgaris	Starling
Vireo solitarius	Vireo, solitary
Vireo griseus	Vireo, white-eyed
Vireo bellii	Vireo, Bell's
Vireo olivaceus	Vireo, red-eyed
Vireo gilvus	Vireo, warbling
Mniotilta varia	Warbler, black and white
Vermivora peregrina	Warbler, Tennessee
Vermivora celata	Warbler, orange-crowned
Vermivora ruficapilla	Warbler, Nashville
Parula american	Warbler, parula
Dendroica petechia	Warbler, yellow
Dendroica coronata	Warbler, yellow-rumped
Seiurus aurocapillus	Ovenbird
Seiurus motacilla	Waterthrush, Louisiana
Geothlypis trichas	Yellowthroat, common
Oporornis formosus	Warbler, Kentucky
Wilsonia pusilla	Warbler, Wilson's
Setophaga ruticilla	Redstart, American
Passer domesticus	Sparrow, house

Sturnella magna	Meadowlark, eastern
Sturnella neglecta	Meadowlark, western
Agelaius phoinicius	Blackbird, red-winged
Euphagus carolinus	Blackbird, rusty
Euphagus cyanocephalus	Blackbird, Brewer's
Quiscalus quiscula	Grackle, common
Molothrus ater	Cowbird, brown-headed
Icterus spurius	Oriole, orchard
Icterus galbula	Oriole, northern
Piranga rubra	Tanager, summer
Cardinalis cardinalis	Cardinal
Guiraca cairulea	Grosbeak, blue
Passerina cyania	Bunting, indigo
Passerina ciris	Bunting, painted
Carduelis tristis	Goldfinch, American
Spiza americana	Dickcissel
Pipilo erythrophthalmus	Towhee, rufous-sided
Passerculus sandwichensis	Sparrow, savannah
Ammodramus savannarum	Sparrow, grasshopper
Pooecetes gramineus	Sparrow, vesper
Chondestes grammacus	Sparrow, lark
Junco hyemalis	Junco, dark-eyed
Spizella pusilla	Sparrow, field
Zonotrichia ouerula	Sparrow, Harris'
Zonotrichia leucophrys	Sparrow, white-crowned
Zonotrichia albicollis	Sparrow, white-throated
Passerella iliaca	Sparrow, fox
Melospiza lincolnii	Sparrow, Lincoln's
Melospiza melodia	Sparrow, song

APPENDIX B

DEFINITIONS OF AVIAN LIFE FORMS AND THE SOUTHCENTRAL OKLAHOMA BREEDING BIRDS CONTAINED IN EACH

Life form	Reproduces	Feeds	Species
1	In trees (usually in canopy)	In or near water	Great blue heron Little blue heron Green heron Great egret Cattle egret Yellow-crowned night heron
2	In trees (usually in savannah situations)	In air or on ground (usually in open areas)	Mississippi kite Red-tailed hawk Swainson's hawk Great horned owl Eastern kingbird Western kingbird Scissor-tailed flycatcher
3	In trees	In trees, shrubs, and on the ground	Cooper's hawk Red-shouldered hawk Broad-winged hawk Blue jay Blue-gray gnatcatcher Parula warbler Northern oriole Summer tanager Loggerhead shrike Robin Mockingbird Common crow Eastern wood pewee
4	In small trees and shrubs	In small trees and shrubs	Yellow-billed cuckoo Ruby-throated hummingbird White-eyed vireo Bell's vireo Orchard oriole Red-eyed vireo
5	In small trees and shrubs	In small trees, shrubs and on the ground	Painted bunting Indigo bunting Blue Grosbeak Warbling vireo Mourning dove Brown thrasher Gray catbird American goldfinch
6	In tree cavity (natural or evacuated woodpecker's)	In or near water	Wood duck

Life forms	Reproduces	Feeds	Species
7	In tree cavity (natural or evacuated woodpecker's)	In trees, shrubs, and on ground	Barred owl American kestrel Carolina chickadee Tufted titmouse White-breasted nuthatch Bewick's wren Carolina wren Starling Eastern bluebird Great crested flycatcher
8	In self-excavated cavity	Predominately in trees (occasionally in shrubs and on ground	Common flicker Red-bellied woodpecker Pileated woodpecker Hairy woodpecker Downy woodpecker Red-headed woodpecker
9	In caves, cliffs, rims, or talus	On ground	Turkey vulture Black vulture
10	On cliffs, cut-banks, or man-made structures	In air, or on ground	Barn swallow Cliff swallow Rough-winged swallow Purple martin Rock dove House sparrow Eastern phoebe
11	Predominately in rank vegetation, usually near water (occasionally in trees and shrubs)	Predominately on ground (occasionally in trees and shrubs)	Red-winged blackbird Common grackle
12	On ground or very low shrubs	Predominately in trees (occasionally in shrubs or on ground)	Black and white warbler
13	On ground	In air	Chuck-will's-widow
14	On ground or very low shrubs	In shrubs and on ground	Dickcissel Field sparrow Common yellowthroat Louisiana waterthrush Roadrunner

Life forms	Reproduces	Feeds	Species
15	On ground	On ground	Upland sandpiper Eastern Meadowlark Grasshopper sparrow Lark sparrow Bobwhite
16	On ground	In water or on ground	Killdeer
17	In self-excavated subterranean burrow	In water	Belted kingfisher
18	In trees, shrubs, or on ground (a nest parasite)	Predominately on ground (occasionally in shrubs and trees)	Brown-headed cowbird

APPENDIX C

TOTAL NUMBERS, RELATIVE ABUNDANCE, DENSITY,

AND IMPORTANCE VALUES OF AVIAN SPECIES

SEEN ON EACH RUSH AND WILDHORSE

CREEK SITE DURING SUMMER,

FALL, WINTER 1976,

AND SPRING 1977.

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W1 - Summer (N = 10)				
Carolina chickadee	23	16.4	1.53	62.5
Cardinal	23	16.4	1.53	119.5
Tufted titmouse	21	15.0	1.40	76.6
Blue-gray gnatcatcher	14	10.0	0.93	21.8
Carolina wren	9	6.4	0.60	15.9
Indigo bunting	7	5.0	0.46	21.2
Yellow-billed cuckoo	5	3.5	0.33	19.1
Downy woodpecker	4	2.8	0.26	19.1
White-breasted nuthatch	4	2.8	0.26	3.4
Green heron	3	2.1	0.20	10.5
Red-bellied woodpecker	3	2.1	0.20	6.6
Hairy woodpecker	3	2.1	0.20	12.1
Great crested flycatcher	3	2.1	0.20	7.3
Bewick's wren	3	2.1	0.20	4.7
Summer tanager	3	2.1	0.20	11.0
American goldfinch	3	2.1	0.20	13.2
Little blue heron	2	1.4	0.13	5.0
Parula warbler	2	1.4	0.13	4.9
Ruby-throated hummingbird	1	0.7	0.06	1.3
Belted kingfisher	1	0.7	0.06	1.3
Eastern wood pewee	1	0.7	0.06	1.3
Brown-headed cowbird	1	0.7	0.06	2.4
Painted bunting	1	0.7	0.06	1.3
Total	140	100	9.33	442
Total species	23	100		
W1 - Fall (N = 1)				
Carolina chickadee	3	27.2	2.00	127
Hairy woodpecker	2	18.1	1.33	118
Tufted titmouse	2	18.1	1.33	118
White-breasted nuthatch	2	18.1	1.33	118
Yellow-billed cuckoo	1	9.0	0.66	109
Cardinal	1	9.0	0.66	109
Total	11	100	7.33	699
Total species	6			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W1 - Winter (N = 3)				
Robin	62	54.8	13.77	144
Cardinal	8	7.0	1.77	150
Dark-eyed junco	7	6.1	1.55	160
Carolina chickadee	7	6.1	1.55	48
Yellow-bellied sapsucker	4	3.5	0.88	115
Common crow	4	3.5	0.88	19
Cedar waxwing	4	3.5	0.88	12
Red-bellied woodpecker	3	2.6	0.66	12
Downy woodpecker	3	2.6	0.66	46
Tufted titmouse	3	2.6	0.66	45
Common flicker	2	1.7	0.44	11
Hairy woodpecker	2	1.7	0.44	46
Blue jay	1	0.8	0.22	11
Eastern bluebird	1	0.8	0.22	11
Yellow-rumped warbler	1	0.8	0.22	11
American goldfinch	1	0.8	0.22	11
Total	113	100	25.11	650
Total species	16			
W1 - Spring (N = 2)				
Carolina chickadee	9	28.1	3.00	135
Blue-gray gnatcatcher	9	28.1	3.00	135
Tufted titmouse	3	9.3	1.00	109
American goldfinch	3	9.3	1.00	34
Red-bellied woodpecker	2	6.2	0.66	31
Parula warbler	2	6.2	0.66	31
Indigo bunting	2	6.2	0.66	31
Wood duck	1	3.1	0.33	28
Painted bunting	1	3.1	0.33	28
Total	32	100	10.66	562
Total species	9			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W2 - Summer (N = 12)				
Killdeer	11	33.3	0.61	71.4
Scissor-tailed flycatcher	8	24.2	0.44	23.7
Eastern meadowlark	5	15.1	0.27	35.2
Loggerhead shrike	3	9.0	0.16	6.5
Green heron	2	6.0	0.11	7.5
Red-tailed hawk	1	3.0	0.05	1.5
Bobwhite	1	3.0	0.05	4.8
Belted kingfisher	1	3.0	0.05	2.3
Red-winged blackbird	1	3.0	0.05	1.5
Total	33	100	1.83	154
Total species	9			
W2 - Fall (N = 1)				
Scissor-tailed flycatcher	4	33.3	2.66	133
Common crow	4	33.3	2.66	133
Spotted sandpiper	3	25.0	2.00	125
Long-billed dowitcher	1	8.3	0.66	108
Total	12	100	8.00	499
Total species	4			
W2 - Winter (N = 3)				
Mallard	6	100	1.3	43
Total	6	100	1.3	43
Total species	1			
W2 - Spring (N = 2)				
Eastern meadowlark	7	70.0	2.33	68
Vesper sparrow	2	20.0	0.66	36
Great crested flycatcher	1	10.0	0.33	75
Total	10	100	3.33	179
Total species	3			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W3 - Summer (N = 10)				
Mockingbird	18	15.2	1.20	99
Bobwhite	14	11.8	0.93	16
Brown-headed cowbird	12	10.1	0.80	45
Yellow-billed cuckoo	9	7.6	0.60	22
Lark sparrow	9	7.6	0.60	31
Scissor-tailed flycatcher	8	6.7	0.53	14
Mourning dove	6	5.0	0.40	20
Eastern meadowlark	6	5.0	0.40	30
Carolina chickadee	5	4.2	0.33	21
Orchard oriole	5	4.2	0.33	8.3
Cardinal	4	3.3	0.26	21
Blue grosbeak	3	2.5	0.20	2.6
Green heron	2	1.6	0.13	5.5
Red-bellied woodpecker	2	1.6	0.13	7.3
Hairy woodpecker	2	1.6	0.13	7.9
Downy woodpecker	2	1.6	0.13	2.4
Northern oriole	2	1.6	0.13	5.1
Great blue heron	1	0.8	0.06	1.5
Killdeer	1	0.8	0.06	1.5
Ruby-throated hummingbird	1	0.8	0.06	1.4
Belted kingfisher	1	0.8	0.06	2.0
Great crested flycatcher	1	0.8	0.06	2.4
Blue jay	1	0.8	0.06	2.0
Loggerhead shrike	1	0.8	0.06	1.8
Indigo bunting	1	0.8	0.06	1.4
American goldfinch	1	0.8	0.06	1.4
Total	118	100	7.86	367
Total species	26			
W3 - Fall (N = 2)				
Mourning dove	1	50.0	0.33	100
Downy woodpecker	1	50.0	0.33	100
Total	2	100	0.66	200
Total species	2			
W3 - Winter (N = 4)				
Carolina chickadee	6	35.2	1.00	19.7
Red-bellied woodpecker	4	23.5	0.66	31.2
White-breasted nuthatch	2	11.7	0.33	10.7
Robin	2	11.7	0.33	31.2
Cardinal	2	11.7	0.33	10.7
Yellow-bellied sapsucker	1	5.8	0.16	8.5
Total	17	100	2.83	112
Total species	6			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W3 - Spring (N = 2)				
Brown-headed cowbird	4	36.3	1.33	136
Bobwhite	1	9.0	0.33	33
Ruby-throated hummingbird	1	9.0	0.33	33
Belted kingfisher	1	9.0	0.33	35
Great crested flycatcher	1	9.0	0.33	33
Tufted titmouse	1	9.0	0.33	35
Eastern meadowlark	1	9.0	0.33	35
Cardinal	1	9.0	0.33	33
Total	11	100	3.66	373
Total species	8			
W4 - Summer (N = 10)				
Cardinal	12	18.1	0.80	79
Blue jay	5	7.5	0.33	17
Bewick's wren	5	7.5	0.33	15
Indigo bunting	5	7.5	0.33	14
Carolina chickadee	4	6.0	0.26	8.3
Yellow-billed cuckoo	3	4.5	0.20	13
Carolina wren	3	4.5	0.20	7.2
Mockingbird	3	4.5	0.20	7.6
Brown-headed cowbird	3	4.5	0.20	7.6
Blue grosbeak	3	4.5	0.20	15.4
Green heron	2	3.0	0.13	6.4
Red-bellied woodpecker	2	3.0	0.13	6.5
Hairy woodpecker	2	3.0	0.13	3.8
Downy woodpecker	2	3.0	0.13	8.3
Lark sparrow	2	3.0	0.13	7.1
Great blue heron	1	1.5	0.06	3.0
Barred owl	1	1.5	0.06	2.2
Great crested flycatcher	1	1.5	0.06	2.4
Eastern wood pewee	1	1.5	0.06	11.0
White-breasted nuthatch	1	1.5	0.06	2.1
Eastern bluebird	1	1.5	0.06	2.1
Loggerhead shrike	1	1.5	0.06	3.0
Eastern meadowlark	1	1.5	0.06	2.1
Painted bunting	1	1.5	0.06	2.1
American goldfinch	1	1.5	0.06	2.4
Total	66	100	4.4	250
Total species	25			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W4 - Fall (N = 2)				
Common flicker	1	33.3	0.33	41
Carolina chickadee	1	33.3	0.33	41
Cardinal	1	33.3	0.33	41
Total	3	100	1.00	124
Total species	3			
W4 - Winter (N = 4)				
Eastern bluebird	11	29.7	1.83	85
Robin	10	27.0	1.66	28
Dark-eyed junco	8	21.6	1.33	52
Blue jay	2	5.4	0.33	11
Cardinal	2	5.4	0.33	12
Common flicker	1	2.7	0.16	8.7
Downy woodpecker	1	2.7	0.16	9.2
Bewick's wren	1	2.7	0.16	9.2
Field sparrow	1	2.7	0.16	9.1
Total	37	100	6.16	226
Total species	9			
W4 - Spring (N = 2)				
Eastern bluebird	3	20.0	1.00	36
Carolina chickadee	2	13.3	0.66	32
Mockingbird	2	13.3	0.66	32
Brown-headed cowbird	2	13.3	0.66	75
Mourning dove	1	6.6	0.33	28
Downy woodpecker	1	6.6	0.33	28
Great crested flycatcher	1	6.6	0.33	28
Cardinal	1	6.6	0.33	28
Blue grosbeak	1	6.6	0.33	28
Indigo bunting	1	6.6	0.33	28
Total	15	100	5.00	346
Total species	10			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W5A - Summer (N = 10)				
Cardinal	47	25.9	3.13	128
Brown-headed cowbird	24	13.2	1.60	59
Carolina chickadee	20	11.0	1.33	45
Blue-gray gnatcatcher	14	7.7	0.93	41
American goldfinch	13	7.1	0.86	41
Painted bunting	13	7.1	0.86	54
Indigo bunting	11	6.0	0.73	42
Tufted titmouse	7	3.8	0.46	11
Belted kingfisher	6	3.3	0.40	11
Yellow-billed cuckoo	4	2.2	0.26	17
Red-bellied woodpecker	4	2.2	0.26	17
White-breasted nuthatch	3	1.6	0.20	12
Downy woodpecker	2	1.1	0.13	4.9
Great crested flycatcher	2	1.1	0.13	7.1
Red-eyed vireo	2	1.1	0.13	4.5
Ruby-throated hummingbird	1	0.5	0.06	1.4
Pileated woodpecker	1	0.5	0.06	1.4
Eastern wood pewee	1	0.5	0.06	1.6
Common crow	1	0.5	0.06	1.4
Bewick's wren	1	0.5	0.06	1.4
Carolina wren	1	0.5	0.06	1.6
Gray catbird	1	0.5	0.06	1.4
White-eyed vireo	1	0.5	0.06	6.0
Summer tanager	1	0.5	0.06	1.5
Total	181	100	12.06	517
Total species	24			
W5A - Fall (N = 3)				
Carolina chickadee	5	16.1	1.11	53
Bobwhite	4	12.9	0.88	37
Red-bellied woodpecker	3	9.6	0.66	52
Tufted titmouse	3	9.6	0.66	17
Carolina wren	3	9.6	0.66	20
Orange-crowned warbler	3	9.6	0.66	17
Ruby-crowned kinglet	2	6.4	0.44	15
Nashville warbler	2	6.4	0.44	15
Cardinal	2	6.4	0.44	17
Belted kingfisher	1	3.2	0.22	17
Indigo bunting	1	3.2	0.22	14
American goldfinch	1	3.2	0.22	14
Ovenbird	1	3.2	0.22	14
Total	31	100	6.88	306
Total species	13			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W5A - Winter (N = 4)				
Mourning dove	26	33.7	4.33	27
Dark-eyed junco	13	16.8	2.16	14
Carolina chickadee	6	7.7	1.00	34
Tufted titmouse	5	6.4	0.83	9.2
Cardinal	4	5.1	0.66	43
American goldfinch	4	5.1	0.66	8.7
Rufous-sided towhee	4	5.1	0.66	22
Common crow	3	3.9	0.50	8.0
White-breasted nuthatch	3	3.9	0.50	27
Yellow-bellied sapsucker	2	2.6	0.33	7.5
Golden-crowned kinglet	2	2.6	0.33	18
Common flicker	1	1.3	0.16	6.7
Red-bellied woodpecker	1	1.3	0.16	6.7
Blue jay	1	1.3	0.16	6.7
Bewick's wren	1	1.3	0.16	6.7
Robin	1	1.3	0.16	7.5
Total	77	100	12.8	255
Total species	16			
W5A - Spring (N = 2)				
Blue-gray gnatcatcher	4	28.5	1.33	126
Tufted titmouse	2	14.2	0.66	114
Rough-winged swallow	2	14.2	0.66	41
Cardinal	2	14.2	0.66	37
Mourning dove	1	7.1	0.33	33
Common flicker	1	7.1	0.33	33
Indigo bunting	1	7.1	0.33	31
Eastern wood pewee	1	7.1	0.33	31
Total	14	100	4.66	446
Total species	8			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W5 - Summer (N = 8)				
Cardinal	18	29.0	1.50	83
Carolina chickadee	13	20.9	1.08	96
Blue-gray gnatcatcher	5	8.0	0.41	18
White-breasted nuthatch	3	4.8	0.25	10
Carolina wren	3	4.8	0.25	18
Indigo bunting	3	4.8	0.25	18
Red-bellied woodpecker	2	3.2	0.16	7.8
Great crested flycatcher	2	3.2	0.16	2.7
Tufted titmouse	2	3.2	0.16	7.8
Brown-headed cowbird	2	3.2	0.16	8.6
Blue grosbeak	2	3.2	0.16	9.6
Yellow-billed cuckoo	1	1.6	0.08	3.5
Belted kingfisher	1	1.6	0.08	2.1
Pileated woodpecker	1	1.6	0.08	2.5
Hairy woodpecker	1	1.6	0.08	3.2
Bewick's wren	1	1.6	0.08	2.8
Painted bunting	1	1.6	0.08	3.5
American goldfinch	1	1.6	0.08	2.8
Total	62	100	5.16	302
Total species	18			
W5 - Fall (N = 3)				
Tufted titmouse	3	33.3	0.66	74
American goldfinch	2	22.2	0.44	27
Common flicker	1	11.1	0.22	22
Red-bellied woodpecker	1	11.1	0.22	27
Carolina chickadee	1	11.1	0.22	19
Cardinal	1	11.1	0.22	27
Total	9	100	2.00	288
Total species	6			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W5 - Winter (N = 4)				
Robin	27	36.4	4.50	104
Carolina chickadee	13	17.5	2.16	78
Dark-eyed junco	9	12.1	1.50	11
Red-bellied woodpecker	6	8.1	1.00	113
Common flicker	5	6.7	0.83	9
Cardinal	4	5.4	0.66	74
Hairy woodpecker	3	4.0	0.50	9.7
Red-tailed hawk	1	1.3	0.16	7.2
Downy woodpecker	1	1.3	0.16	11.2
Blue jay	1	1.3	0.16	7.2
Tufted titmouse	1	1.3	0.16	6.7
White-breasted nuthatch	1	1.3	0.16	6.7
Bewick's wren	1	1.3	0.16	6.7
Golden-crowned kinglet	1	1.3	0.16	6.7
Total	74	100	11.93	400
Total species	14			
W5 - Spring (N = 2)				
Cardinal	5	27.7	1.66	137
Swainson's thrush	3	16.6	1.00	34
Carolina chickadee	3	16.6	1.00	131
Kentucky warbler	2	11.1	0.88	31
Ruby-throated hummingbird	1	5.5	0.33	28
Great crested flycatcher	1	5.5	0.33	28
Tufted titmouse	1	5.5	0.33	31
Blue-gray gnatcatcher	1	5.5	0.33	28
Brown-headed cowbird	1	5.5	0.33	28
Total	18	100	6.00	476
Total species	9			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W6 - Summer (N = 10)				
Eastern meadowlark	25	34.2	1.66	94
Lark sparrow	13	17.8	0.86	53
Scissor-tailed flycatcher	5	6.8	0.33	13
Brown-headed cowbird	5	6.8	0.33	16
Red-winged blackbird	4	5.4	0.26	18
Green heron	3	4.1	0.20	7.2
Great blue heron	2	2.7	0.13	6.4
Bobwhite	2	2.7	0.13	6.3
Killdeer	2	2.7	0.13	8.1
Carolina chickadee	2	2.7	0.13	3.0
Mississippi kite	1	1.3	0.06	2.6
Belted kingfisher	1	1.3	0.06	1.8
Eastern phoebe	1	1.3	0.06	2.6
Rough-winged swallow	1	1.3	0.06	2.1
Barn swallow	1	1.3	0.06	2.1
Mockingbird	1	1.3	0.06	4.3
Eastern bluebird	1	1.3	0.06	4.3
Loggerhead shrike	1	1.3	0.06	1.9
Cardinal	1	1.3	0.06	2.0
Field sparrow	1	1.3	0.06	2.7
Total	73	100	4.86	254
Total species	20			
W6 - Fall (N = 2)				
Mourning dove	7	41.1	2.33	45
American goldfinch	6	35.2	2.00	42
Eastern bluebird	2	11.7	0.66	30
Sharp-shinned hawk	1	5.8	0.33	22
Belted kingfisher	1	5.8	0.33	22
Total	17	100	5.66	173
Total species	5			
W6 - Winter (N = 4)				
Robin	15	42.8	2.50	28
Eastern meadowlark	6	17.1	1.00	86
Eastern bluebird	5	14.2	0.83	42
Red-winged blackbird	4	11.4	0.66	20
Bald eagle	1	2.8	0.16	7.5
Common flicker	1	2.8	0.16	9.7
Carolina chickadee	1	2.8	0.16	9.7
Cardinal	1	2.8	0.16	9.7
American goldfinch	1	2.8	0.16	9.7
Total	35	100	5.83	223
Total species	9			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W6 - Spring (N = 1)				
Red-winged blackbird	5	83.3	3.33	183
Carolina chickadee	1	16.6	0.66	116
Total	6	100	4.00	299
Total species	2			
W7 - Summer (N = 12)				
Red-winged blackbird	76	62.3	4.22	57
Dickcissel	10	8.2	0.55	44
Mockingbird	8	6.5	0.44	12
Eastern meadowlark	6	4.9	0.33	11
Killdeer	5	4.1	0.27	10
Blue grosbeak	5	4.1	0.27	11
Grasshopper sparrow	2	1.6	0.10	7.9
Eastern kingbird	2	1.6	0.10	3.0
Bobwhite	1	0.8	0.05	4.3
Downy woodpecker	1	0.8	0.05	2.4
Brown thrasher	1	0.8	0.05	2.2
Loggerhead shrike	1	0.8	0.05	1.6
Orchard oriole	1	0.8	0.05	1.6
Cardinal	1	0.8	0.05	2.0
Indigo bunting	1	0.8	0.05	1.6
Painted bunting	1	0.8	0.05	2.4
Total	122	100	6.77	177
Total species	16			
W7 - Fall (N = 2)				
Vesper sparrow	4	57.1	1.33	116
Red-winged blackbird	2	28.5	0.66	83
Eastern meadowlark	1	14.2	0.33	150
Total	7	100	2.33	178
Total species	3			
W7 - Winter (N = 3)				
Robin	11	57.89	2.44	37
Eastern meadowlark	4	21.0	0.88	71
Downy woodpecker	3	15.7	0.66	144
Red-winged blackbird	1	5.2	0.22	13
Total	19	100	4.22	265
Total species	4			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W7 - Spring (N = 2)				
Eastern meadowlark	5	50.0	1.66	145
Dickcissel	4	40.0	1.33	147
Red-winged blackbird	1	10.0	0.33	32
Total	10	100	3.33	324
Total species	3			
W8 - Summer (N = 13)				
Carolina chickadee	32	17.4	1.64	97
Cardinal	20	10.9	1.02	74
Blue-gray gnatcatcher	19	10.3	0.97	59
Carolina wren	17	9.2	0.86	44
Tufted titmouse	16	8.7	0.82	46
Brown-headed cowbird	13	7.1	0.66	30
Red-eyed vireo	9	4.9	0.46	29
Red-bellied woodpecker	7	3.8	0.35	17
White-breasted nuthatch	7	3.8	0.35	11
Green heron	6	3.2	0.30	13
Wood duck	5	2.7	0.25	3.5
Downy woodpecker	5	2.7	0.25	2.0
Indigo bunting	5	2.7	0.25	18
Yellow-billed cuckoo	3	1.6	0.15	5.3
Ruby-throated hummingbird	3	1.6	0.15	10
Great-crested flycatcher	3	1.6	0.15	5.2
American goldfinch	3	1.6	0.15	6.3
Eastern wood pewee	2	1.0	0.10	1.6
Summer tanager	2	1.0	0.10	2.6
Parula warbler	1	0.5	0.04	1.6
Total	183	100	9.38	494
Total species	24			
W8 - Fall (N = 2)				
White-throated sparrow	7	26.9	2.33	43
Carolina chickadee	5	19.2	1.61	126
Tufted titmouse	4	15.3	1.33	119
Common crow	3	11.5	1.00	32
Common flicker	2	7.6	0.66	30
Barred owl	1	3.8	0.33	27
Pileated woodpecker	1	3.8	0.33	27
Eastern wood pewee	1	3.8	0.33	27
Ruby-crowned kinglet	1	3.8	0.33	27
Total	26	100	8.66	490
Total species	10			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
W8 - Winter (N = 3)				
Robin	87	55.4	19.33	31
Dark-eyed junco	20	13.0	4.44	15
Eastern bluebird	13	8.5	2.88	14
Starling	10	6.5	2.22	13
Cedar waxwing	7	4.5	1.55	12
Carolina chickadee	6	3.9	1.33	79
Downy woodpecker	2	1.3	0.44	61
White-breasted nuthatch	2	1.3	0.44	18
Cardinal	2	1.3	0.44	48
Pileated woodpecker	1	0.6	0.22	11
Yellow-bellied sapsucker	1	0.6	0.22	11
Tufted titmouse	1	0.6	0.22	14
American goldfinch	1	0.6	0.22	11
Total	153	100	34.00	342
Total species	13			
W8 - Spring (N = 3)				
Blue-gray gnatcatcher	23	40.3	5.10	136
Cardinal	6	10.5	1.33	55
Red-bellied woodpecker	5	8.7	1.10	54
Red-eyed vireo	3	5.2	0.66	50
Indigo bunting	3	5.2	0.66	14
Wood duck	2	3.5	0.44	15
Blue jay	2	3.5	0.44	18
White-breasted nuthatch	2	3.5	0.44	47
Parula warbler	2	3.5	0.44	47
Brown-headed cowbird	2	3.5	0.44	48
Summer tanager	2	3.5	0.44	13
Belted kingfisher	1	1.7	0.22	12
Pileated woodpecker	1	1.7	0.22	13
Downy woodpecker	1	1.7	0.22	12
Tufted titmouse	1	1.7	0.22	13
American goldfinch	1	1.7	0.22	12
Total	57	100	12.66	562
Total species	16			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R1 - Summer (N = 10)				
Red-winged blackbird	52	36.62	3.46	116.1
Dickcissel	46	32.39	3.06	118.8
Brown-headed cowbird	12	8.45	0.80	5.8
Common grackle	6	4.23	0.40	3.1
Indigo bunting	5	3.52	0.33	20.5
Great crested flycatcher	4	2.82	0.26	11.4
Carolina chickadee	4	2.82	0.26	5.9
Blue grosbeak	3	2.11	0.20	11.4
Cardinal	3	2.11	0.20	10.9
Killdeer	2	1.41	0.13	5.3
Northern oriole	2	1.41	0.13	4.7
Bell's vireo	1	0.70	0.06	2.0
Eastern meadowlark	1	0.70	0.06	4.3
Painted bunting	1	0.72	0.06	1.4
Total	142	100	9.46	321.6
Total species	14			
R1 - Fall (N = 3)				
Song sparrow	14	41.18	3.10	87.3
Tree sparrow	13	38.24	2.88	27.6
Cardinal	4	11.76	0.88	73.6
American goldfinch	3	8.8	0.66	14.6
Total	34	100	7.55	209
Total species	4			
R1 - Winter (N = 2)				
American goldfinch	8	57.14	2.66	53.5
Song sparrow	4	28.57	1.33	39.0
Carolina chickadee	2	14.29	0.66	32.0
Total	14	100	4.65	124
Total species	3			
R1 - Spring (N = 4)				
Brown-headed cowbird	7	43.75	1.16	31.25
Lark sparrow	5	31.25	0.83	24.00
Savannah sparrow	2	12.50	0.33	13.20
Song sparrow	2	12.50	0.33	31.25
Total	16	100	2.66	99.00
Total species	4			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R2 - Summer (N = 10)				
Great crested flycatcher	22	14.19	1.41	46.2
Northern oriole	19	12.26	1.26	57.7
Brown-headed cowbird	19	12.26	1.26	57.4
Cardinal	17	10.97	1.13	93.2
Blue jay	11	7.10	0.70	31.8
Painted bunting	10	6.45	0.66	69.1
Eastern meadowlark	9	5.81	0.60	39.9
Carolina chickadee	7	4.52	0.46	24.9
Yellow-billed cuckoo	5	3.23	0.33	18.4
Downy woodpecker	5	3.23	0.33	21.4
Red-bellied woodpecker	4	2.58	0.26	18.6
Bobwhite	3	1.94	0.20	4.8
Killdeer	3	1.94	0.20	10.2
Tufted titmouse	3	1.94	0.20	5.8
Belted kingfisher	2	1.29	0.13	5.6
Carolina wren	2	1.29	0.13	1.6
Eastern bluebird	2	1.29	0.13	2.4
Loggerhead shrike	2	1.29	0.13	4.9
Little blue heron	1	0.65	0.06	1.4
Mourning dove	1	0.65	0.06	1.5
Hairy woodpecker	1	0.65	0.06	1.7
Western kingbird	1	0.65	0.06	1.4
Bewick's wren	1	0.65	0.06	1.5
Robin	1	0.65	0.06	1.7
Summer tanager	1	0.65	0.06	1.5
Blue Grosbeak	1	0.65	0.06	1.5
Indigo bunting	1	0.65	0.06	1.4
Dickcissel	1	0.65	0.06	1.9
Total	155	100	10.33	529.4
Total species	28			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R2 - Fall (N = 2)				
Eastern bluebird	7	20.0	2.33	46.5
Eastern meadowlark	5	14.2	1.66	38.0
Starling	4	11.4	1.33	35.5
Downy woodpecker	4	11.4	1.33	111.5
Blue jay	3	8.5	1.00	32.5
Red-headed woodpecker	2	8.5	0.66	31.0
Brown-headed cowbird	2	5.7	0.66	30.0
American goldfinch	2	5.7	0.66	31.0
Belted kingfisher	1	2.8	0.33	27.5
Carolina chickadee	1	2.8	0.33	27.5
Tufted titmouse	1	2.8	0.33	28.0
Loggerhead shrike	1	2.8	0.33	27.5
Cardinal	1	2.8	0.33	27.5
Total	35	100	11.66	522.0
Total species	14			
R2 - Winter (N = 2)				
Red-bellied woodpecker	2	40.0	0.66	141.5
Carolina chickadee	2	40.0	0.66	141.5
Starling	1	20.0	0.33	41.5
Total	5	100	1.65	649
Total species	3			
R2 - Spring (N = 3)				
Brown-headed cowbird	7	25.9	1.55	126.6
Eastern meadowlark	5	18.5	1.10	68.6
Blue jay	5	18.5	1.10	58.6
Northern oriole	3	11.1	0.66	23.0
Red-bellied woodpecker	2	7.4	0.44	16.3
Mourning dove	1	3.7	0.22	14.6
Common crow	1	3.7	0.22	14.6
Tufted titmouse	1	3.7	0.22	13.6
Common grackle	1	3.7	0.22	14.6
Cardinal	1	3.7	0.22	13.6
Total	27	100	6.00	364.0
Total species	10			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R3 - Summer (N = 10)				
Cardinal	12	18.7	2.40	87.7
Red-bellied woodpecker	11	17.1	2.20	52.5
Carolina chickadee	7	10.9	1.40	9.5
Scissor-tailed flycatcher	6	9.3	1.20	16.8
Downy woodpecker	4	6.2	0.80	7.6
Yellow-billed cuckoo	4	6.2	0.80	14.7
Bewick's wren	4	6.2	0.80	8.2
Tufted titmouse	3	4.6	0.60	12.7
Carolina wren	3	4.6	0.60	8.7
Hairy woodpecker	2	3.1	0.40	6.4
Blue-gray gnatcatcher	2	3.1	0.40	5.7
Indigo bunting	2	3.1	0.40	6.6
Painted bunting	2	3.1	0.40	3.0
American goldfinch	1	1.5	0.20	3.5
White-breasted nuthatch	1	1.5	0.20	6.8
Total	64	100	12.80	250.1
Total species	15			
R3 - Fall (N = 3)				
Common flicker	1	33.3	0.66	22.0
Blue jay	1	33.3	0.66	22.0
Robin	1	33.3	0.66	22.0
Total	3	100	2.00	66.0
Total species	3			
R3 - Winter (N = 3)				
Great blue heron	4	30.8	2.66	33.0
Cardinal	3	23.0	2.00	43.3
Carolina chickadee	2	15.3	1.34	22.0
Yellow-bellied sapsucker	1	7.6	0.66	19.3
Downy woodpecker	1	7.6	0.66	19.3
Tufted titmouse	1	7.6	0.66	19.3
Brown creeper	1	7.6	0.66	19.3
Total	13	100	8.66	176
Total species	7			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R3 - Spring (N = 3)				
Carolina chickadee	6	54.5	4.00	36.0
Red-bellied woodpecker	1	9.0	0.66	27.6
Downy woodpecker	1	9.0	0.66	15.0
Blue jay	1	9.0	0.66	27.6
Tufted titmouse	1	9.0	0.66	15.0
Cardinal	1	9.0	0.66	44.3
Total	11	100	7.33	165.5
Total species	5			
R4 - Summer (N = 11)				
Eastern meadowlark	10	15.8	0.60	27.7
Starling	7	11.1	0.42	4.2
Barn swallow	7	11.1	0.42	5.0
Belted kingfisher	6	9.5	0.36	22.9
Loggerhead shrike	6	9.5	0.36	28.2
Killdeer	5	7.9	0.30	15.3
Scissor-tailed flycatcher	5	7.9	0.30	24.9
Eastern kingbird	3	4.7	0.18	4.9
Mourning dove	2	3.1	0.12	1.8
Red-headed woodpecker	2	3.1	0.12	6.0
House sparrow	2	3.1	0.12	5.3
Little blue heron	1	1.5	0.06	1.3
Red-tailed hawk	1	1.5	0.06	3.0
Red-bellied woodpecker	1	1.5	0.06	3.0
Mockingbird	1	1.5	0.06	2.0
Northern oriole	1	1.5	0.06	2.2
Common grackle	1	1.5	0.06	1.3
Dickcissel	1	1.5	0.06	1.3
Lark sparrow	1	1.5	0.06	2.0
Total	63	100	3.81	179.0
Total species	15			
R4 - Fall (N = 3)				
Killdeer	4	36.3	0.88	110.0
Mourning dove	3	27.2	0.66	25.0
Eastern meadowlark	3	27.2	0.66	25.0
Cardinal	1	9.0	0.22	15.6
Total	11	100	2.44	176.0
Total species	4			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R4 - Winter (N = 3)				
Mourning dove	13	76.4	2.88	41.6
Brewer's blackbird	3	17.6	0.66	44.3
Mockingbird	1	5.8	0.22	13.6
Total	17	100	3.77	99.0
Total species	3			
R4 - Spring (N = 3)				
Scissor-tailed flycatcher	6	37.0	1.33	69.3
Mockingbird	4	25.0	0.88	61.3
Eastern kingbird	2	12.5	0.44	20.3
Mourning dove	1	6.2	0.22	15.0
Belted kingfisher	1	6.2	0.22	15.6
Rough-winged swallow	1	6.2	0.22	44.3
Northern oriole	1	6.2	0.22	15.6
Total	16	100	3.55	241.0
Total species	7			
R5 - Summer (N = 11)				
Tufted titmouse	14	19.5	1.13	43.9
Carolina chickadee	13	18.1	1.57	50.1
Bewick's wren	6	8.4	0.48	18.5
Red-bellied woodpecker	4	5.6	0.32	17.1
Blue grosbeak	4	5.6	0.32	12.4
Great crested flycatcher	3	4.2	0.24	5.7
Northern oriole	3	4.2	0.24	12.8
Cardinal	3	4.2	0.24	13.2
Field sparrow	3	4.2	0.24	2.1
Bobwhite	2	2.8	0.16	14.3
Downy woodpecker	2	2.8	0.16	5.8
Eastern meadowlark	2	2.8	0.16	7.2
Painted bunting	2	2.8	0.16	1.8
Great blue heron	1	1.4	0.08	1.9
Green heron	1	1.4	0.08	3.8
Mourning dove	1	1.4	0.08	2.2
Yellow-billed cuckoo	1	1.4	0.08	1.2
Hairy woodpecker	1	1.4	0.08	2.2
Eastern phoebe	1	1.4	0.08	1.8
Barn swallow	1	1.4	0.08	3.8
Blue jay	1	1.4	0.08	1.8
Eastern bluebird	1	1.4	0.08	2.2
Indigo bunting	1	1.4	0.08	1.8
Dickcissel	1	1.4	0.08	1.8
Total	72	100	5.81	230.0
Total species	24			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R5 - Fall (N = 3)				
Tree sparrow	8	40.0	2.37	33.0
Carolina chickadee	2	10.0	0.59	19.3
Bewick's wren	2	10.0	0.59	28.6
Cardinal	2	10.0	0.59	16.3
Belted kingfisher	1	5.0	0.29	15.0
Blue jay	1	5.0	0.29	15.0
Ruby-crowned kinglet	1	5.0	0.29	15.0
Orange-crowned warbler	1	5.0	0.29	15.0
Nashville warbler	1	5.0	0.29	15.0
Dark-eyed junco	1	5.0	0.29	15.0
Total	20	100	5.92	186.0
Total species	10			
R5 - Winter (N = 4)				
Carolina chickadee	4	22.3	0.88	12.7
Dark-eyed junco	3	16.7	0.66	11.2
Mourning dove	2	11.2	0.44	9.5
Common flicker	2	11.2	0.44	34.7
Blue jay	2	11.2	0.44	9.5
Cardinal	2	11.2	0.44	22.7
Bewick's wren	1	5.6	0.22	7.7
Carolina wren	1	5.6	0.22	7.7
Song sparrow	1	5.6	0.22	7.7
Total	18	100	4.00	123.0
Total species	9			
R5 - Spring (N = 4)				
Blue jay	2	33.4	0.44	31.2
Carolina chickadee	1	16.7	0.22	18.7
Tufted titmouse	1	16.7	0.22	18.7
Cardinal	1	16.7	0.22	18.7
Indigo bunting	1	16.7	0.22	18.7
Total	6	100	1.33	106.0
Total species	5			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R6 - Summer (N = 10)				
Carolina chickadee	7	21.8	1.40	45.0
Brown-headed cowbird	6	18.7	1.20	33.6
Belted kingfisher	4	12.5	0.80	17.4
Cardinal	4	12.5	0.80	18.9
Painted bunting	4	12.5	0.80	21.5
Tufted titmouse	2	6.2	0.40	9.9
Yellow-billed cuckoo	1	3.1	0.20	6.0
Barred owl	1	3.1	0.20	4.3
Red-bellied woodpecker	1	3.1	0.20	6.0
Northern oriole	1	3.1	0.20	1.9
Indigo bunting	1	3.1	0.20	1.9
Total	32	100	6.40	166.0
Total species	11			
R6 - Fall (N = 3)				
Carolina chickadee	5	38.4	3.33	24.6
Eastern bluebird	3	23.0	2.00	14.3
Common flicker	2	15.3	1.33	80.0
Barred owl	1	7.6	0.66	24.6
Hairy woodpecker	1	7.6	0.66	24.6
Brown creeper	1	7.6	0.66	24.6
Total	13	100	8.66	198.0
Total species	6			
R6 - Winter (N = 4)				
Carolina chickadee	4	50.0	2.00	58.7
Red-bellied woodpecker	1	12.5	0.50	18.7
Tufted titmouse	1	12.5	0.50	11.2
Eastern bluebird	1	12.5	0.50	31.2
Golden-crowned kinglet	1	12.5	0.50	31.2
Total	8	100	4.00	151.0
Total species	5			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R6 - Spring (N = 4)				
Carolina chickadee	10	27.0	5.00	86.0
Cedar waxwing	10	27.0	5.00	25.2
Cardinal	2	5.4	1.00	10.7
Indigo bunting	2	5.4	1.00	31.2
American goldfinch	2	5.4	1.00	30.7
Red-bellied woodpecker	2	5.4	1.00	13.2
Green heron	1	2.7	0.50	9.7
Belted kingfisher	1	2.7	0.50	9.7
Downy woodpecker	1	2.7	0.50	10.2
Scissor-tailed flycatcher	1	2.7	0.50	8.0
Blue jay	1	2.7	0.50	9.7
Tufted titmouse	1	2.7	0.50	8.5
Carolina wren	1	2.7	0.50	10.2
Eastern bluebird	1	2.7	0.50	9.7
Painted bunting	1	2.7	0.50	8.5
Total	37	100	18.50	256.0
Total species	15			
R7 - Summer (N = 10)				
Carolina chickadee	20	21.9	1.33	69.4
Tufted titmouse	20	21.9	1.33	66.0
Cardinal	14	15.3	0.93	51.2
Indigo bunting	13	14.2	0.86	56.2
Brown-headed cowbird	9	9.8	0.60	46.3
American goldfinch	5	5.4	0.33	13.7
Blue grosbeak	3	3.2	0.20	7.3
Bewick's wren	2	2.1	0.13	6.0
Yellow-billed cuckoo	1	1.0	0.06	2.1
Red- bellied woodpecker	1	1.0	0.06	2.1
Great crested flycatcher	1	1.0	0.06	1.5
Carolina wren	1	1.0	0.06	2.1
Painted bunting	1	1.0	0.06	3.0
Total	91	100	6.06	326.0
Total species	13			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R7 - Fall (N = 3)				
Carolina chickadee	19	20.6	4.22	70.3
Dark-eyed junco	14	15.2	3.10	17.3
Cardinal	14	15.2	3.10	118.0
Common flicker	10	10.8	2.22	55.6
Ruby-crowned kinglet	8	8.6	1.77	14.3
Eastern bluebird	8	8.6	1.77	14.3
Red-bellied woodpecker	4	4.3	0.88	49.3
Tufted titmouse	3	3.2	0.66	12.3
Nashville warbler	3	3.2	0.66	23.3
Fox sparrow	2	2.1	0.44	11.6
Pileated woodpecker	1	1.0	0.22	11.3
Yellow-bellied sapsucker	1	1.0	0.22	14.0
Blue jay	1	1.0	0.22	11.3
Carolina wren	1	1.0	0.22	11.3
Robin	1	1.0	0.22	11.3
Purple finch	1	1.0	0.22	11.3
Rufous-sided towhee	1	1.0	0.22	14.0
Total	92	100	20.40	472.0
Total species	17			
R7 - Winter (N = 3)				
Carolina chickadee	15	25.8	3.33	123.0
Robin	10	17.2	2.22	25.0
Song sparrow	8	13.7	1.77	31.3
Red-winged blackbird	6	10.3	1.33	19.6
Cardinal	4	6.8	0.88	50.6
Tufted titmouse	4	6.8	0.88	49.3
Red-bellied woodpecker	3	5.1	0.66	50.7
Bewick's wren	2	3.4	0.44	13.6
Downy woodpecker	2	3.4	0.44	46.6
Roadrunner	1	1.7	0.22	12.3
Common flicker	1	1.7	0.22	12.3
Eastern bluebird	1	1.7	0.22	13.3
Cedar waxwing	1	1.7	0.22	12.3
Total	58	100	12.80	460.0
Total species	13			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R7 - Spring (N = 4)				
Carolina chickadee	18	28.1	3.00	123.0
Cardinal	8	12.5	1.33	65.7
Indigo bunting	7	10.9	1.16	31.7
Tufted titmouse	5	7.8	0.83	69.7
Blue-gray gnatcatcher	4	6.2	0.66	67.5
Brown-headed cowbird	3	4.6	0.50	27.5
Downy woodpecker	2	3.1	0.33	26.7
Great crested flycatcher	2	3.1	0.33	26.7
White-breasted nuthatch	2	3.1	0.33	8.2
Yellow-rumped warbler	2	3.1	0.33	10.7
Barred owl	1	1.5	0.16	8.5
Red-bellied woodpecker	1	1.5	0.16	10.2
Carolina wren	1	1.5	0.16	7.2
Swainson's thrush	1	1.5	0.16	7.0
Eastern bluebird	1	1.5	0.16	8.5
Warbling vireo	1	1.5	0.16	7.0
Nashville warbler	1	1.5	0.16	7.0
Louisiana waterthrush	1	1.5	0.16	8.5
American redstart	1	1.5	0.16	7.0
Painted bunting	1	1.5	0.16	8.5
American goldfinch	1	1.5	0.16	7.0
Total	64	100	10.60	544.0
Total species	21			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R8 - Summer (N = 10)				
Cardinal	42	21.8	2.80	123.8
Carolina chickadee	34	17.7	2.26	80.8
Tufted titmouse	25	13.0	1.66	75.5
Brown-headed cowbird	20	10.4	1.33	33.1
Bewick's wren	15	7.8	1.00	72.1
Red-bellied woodpecker	12	6.2	0.08	54.6
Painted bunting	6	3.1	0.04	28.8
Yellow-billed cuckoo	5	2.6	0.33	10.9
Indigo bunting	5	2.6	0.33	11.4
Red-eyed vireo	4	2.0	0.26	11.2
Carolina wren	4	2.0	0.26	11.8
White-breasted nuthatch	3	1.5	0.20	10.0
American goldfinch	3	1.5	0.20	2.5
Summer tanager	2	1.0	0.13	1.7
Eastern wood pewee	2	1.0	0.13	4.7
Downy woodpecker	2	1.0	0.13	4.8
Belted kingfisher	1	0.5	0.06	1.9
Hairy woodpecker	1	0.5	0.06	1.5
Eastern bluebird	1	0.5	0.06	1.3
Loggerhead shrike	1	0.5	0.06	1.7
White-eyed vireo	1	0.5	0.06	1.5
Louisiana waterthrush	1	0.5	0.06	1.3
Northern oriole	1	0.5	0.06	1.5
Blue grosbeak	1	0.5	0.06	1.3
Total	192	100	12.80	549.0
Total species	24			
R8 - Fall (N = 2)				
Starling	8	21.0	26.00	39.0
Robin	8	21.0	26.00	39.0
Carolina chickadee	7	18.4	23.00	115.0
Blue jay	3	7.8	1.00	111.0
Red-headed woodpecker	3	7.8	1.00	111.0
Ruby-crowned kinglet	2	5.2	0.66	106.0
Common flicker	2	5.2	0.66	106.0
Golden-crowned kinglet	1	2.6	0.33	26.0
Tufted titmouse	1	2.6	0.33	30.0
Downy woodpecker	1	2.6	0.33	30.0
Hairy woodpecker	1	2.6	0.33	30.0
Red-bellied woodpecker	1	2.6	0.33	26.0
Total	38	100	12.60	772.0
Total species	12			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
R8 - Winter (N = 3)				
Dark-eyed junco	21	39.6	4.66	128.0
Robin	7	13.2	1.55	53.0
Red-headed woodpecker	5	9.4	1.11	112.0
Red-bellied woodpecker	4	7.5	0.88	57.0
Carolina chickadee	4	7.5	0.88	38.0
Song sparrow	4	7.5	0.88	53.0
Common flicker	2	3.7	0.44	12.6
Blue jay	1	1.8	0.22	14.6
Tufted titmouse	1	1.8	0.22	14.3
Bewick's wren	1	1.8	0.22	11.6
Carolina wren	1	1.8	0.22	11.6
Cardinal	1	1.8	0.22	14.6
Field sparrow	1	1.8	0.22	11.6
Total	53	100	11.77	532.0
Total species	13			
R8 - Spring (N = 4)				
Cardinal	16	25.8	2.60	128.0
Tufted titmouse	9	14.5	1.50	70.0
Carolina chickadee	7	11.2	1.10	67.0
Red-headed woodpecker	6	9.6	1.00	65.5
Brown-headed cowbird	5	8.0	0.83	31.2
Indigo bunting	3	4.8	0.50	30.0
Blue-gray gnatcatcher	2	3.2	0.33	8.2
Eastern bluebird	2	3.2	0.33	11.2
Carolina wren	2	3.2	0.33	29.5
Great crested flycatcher	2	3.2	0.33	8.2
Hairy woodpecker	2	3.2	0.33	9.0
Red-bellied woodpecker	2	3.2	0.33	28.0
Northern oriole	1	1.6	0.16	7.2
Yellow warbler	1	1.6	0.16	7.2
Barred owl	1	1.6	0.16	7.5
Downy woodpecker	1	1.6	0.16	7.2
Total	62	100	10.30	516.0
Total species	16			

APPENDIX D

TOTAL NUMBER, RELATIVE ABUNDANCE, DENSITY, AND IMPORTANCE VALUES OF AVIAN SPECIES SEEN ON EACH COBB AND LAKE CREEK STUDY SITE DURING SUMMER, WINTER 1976, AND SPRING 1977.

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
C1 - Summer (N = 10)				
Cardinal	23	19.3	1.53	81.8
Carolina chickadee	21	17.6	1.40	82.3
Yellow-billed cuckoo	11	9.2	.73	45.8
Indigo bunting	10	8.4	.66	57.1
Mourning dove	8	6.7	.53	15.4
American goldfinch	8	6.7	.53	13.9
Red-bellied woodpecker	7	5.8	.46	42.5
Carolina wren	5	4.2	.33	13.2
Tufted titmouse	4	3.3	.26	12.2
Northern oriole	4	3.3	.26	7.6
Painted bunting	4	3.3	.26	12.4
Belted kingfisher	2	1.6	.13	5.4
Great crested flycatcher	2	1.6	.13	5.1
Eastern wood pewee	2	1.6	.13	5.8
Brown-headed cowbird	2	1.6	.13	2.2
Killdeer	1	0.8	.06	2.2
Downy woodpecker	1	0.8	.06	1.7
Bewick's wren	1	0.8	.06	1.7
Eastern bluebird	1	0.8	.06	2.0
Blue grosbeak	1	0.8	.06	2.4
Lark sparrow	1	0.8	.06	1.7
Total	119	100	7.93	414.0
Total species	21			
C1 - Winter (N = 2)				
Harris' sparrow	25	67.5	8.33	125.0
Cardinal	5	13.5	1.66	281.0
Carolina chickadee	3	8.1	1.00	231.0
Tree sparrow	3	8.1	1.00	59.0
Song sparrow	1	2.7	0.33	53.0
Total	37	100	12.33	374.0
Total species	5			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
C1 - Spring (N = 3)				
Carolina chickadee	4	19.0	.88	182.0
Brown-headed cowbird	3	14.2	.66	345.0
Cardinal	3	14.2	.66	180.0
Blue jay	2	9.5	.44	73.0
Robin	2	9.5	.44	61.0
Yellow-billed cuckoo	1	4.7	.22	44.0
Red-bellied woodpecker	1	4.7	.22	44.0
Downy woodpecker	1	4.7	.22	53.0
Tufted titmouse	1	4.7	.22	44.0
Blue-gray gnatcatcher	1	4.7	.22	44.0
Eastern meadowlark	1	4.7	.22	44.0
Summer tanager	1	4.7	.22	44.0
Total	21	100	4.66	386.0
Total species	12			
C2 - Summer (N = 10)				
Cardinal	29	23.9	1.93	105.0
Blue-gray gnatcatcher	12	9.9	.80	23.5
Carolina chickadee	12	9.9	.80	33.2
Tufted titmouse	11	9.0	.73	33.3
Great crested flycatcher	9	7.4	.60	26.3
Red-bellied woodpecker	8	6.6	.53	21.8
Carolina wren	7	5.7	.46	32.6
Yellow-billed cuckoo	6	4.9	.40	12.7
Summer tanager	4	3.3	.26	6.7
Green heron	3	2.4	.20	8.1
Indigo bunting	3	2.4	.20	13.4
Painted bunting	3	2.4	.20	1.8
Bobwhite	2	1.6	.13	2.6
Mourning dove	2	1.6	.13	2.3
Brown-headed cowbird	2	1.6	.13	1.5
American goldfinch	2	1.6	.13	5.2
Chuck-wills-widow	1	0.8	.06	1.2
Belted kingfisher	1	0.8	.06	1.6
Red-headed woodpecker	1	0.8	.06	1.6
Hairy woodpecker	1	0.8	.06	1.6
Downy woodpecker	1	0.8	.06	1.7
Bewick's wren	1	0.8	.06	1.7
Total	121	100	8.06	339.0
Total species	22			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
C2 - Winter (N = 2)				
Carolina chickadee	8	17.3	2.66	115.0
Dark-eyed junco	7	15.2	2.33	34.0
White-throated sparrow	7	15.2	2.33	34.0
Harris' sparrow	6	13.0	2.00	33.0
Tufted titmouse	4	8.7	1.33	47.0
Blue jay	3	6.5	1.00	108.0
Cardinal	3	6.5	1.00	108.0
Song sparrow	3	6.5	1.00	29.0
Common flicker	2	4.3	.66	22.0
Common snipe	1	2.1	.33	30.0
Red-winged blackbird	1	2.1	.33	30.0
Tree sparrow	1	2.1	.33	26.0
Total	46	100	15.33	623.0
Total species	12			
C2 - Spring (N = 3)				
Tufted titmouse	10	25.0	2.22	134.0
Blue-gray gnatcatcher	8	20.0	1.77	60.0
Cardinal	4	10.0	.88	51.0
Blue jay	3	7.5	.66	49.0
Blue-winged teal	2	5.0	.44	14.0
Wood duck	2	5.0	.44	15.6
Black and white warbler	2	5.0	.44	120.3
Yellow-rumped warbler	2	5.0	.44	14.0
Belted kingfisher	1	2.5	.22	12.0
Hairy woodpecker	1	2.5	.22	13.0
Downy woodpecker	1	2.5	.22	13.0
Carolina chickadee	1	2.5	.22	12.0
Carolina wren	1	2.5	.22	12.0
Brown-headed cowbird	1	2.5	.22	12.0
Song sparrow	1	2.5	.22	12.0
Total	40	100	8.88	450.0
Total species	15			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
C3 - Summer (N = 10)				
Cardinal	39	28.2	2.60	128.0
Carolina chickadee	26	18.8	1.66	65.0
Tufted titmouse	15	18.8	1.00	44.0
American goldfinch	12	8.7	.80	47.0
Yellow-billed cuckoo	10	7.2	.66	21.0
Red-bellied woodpecker	8	5.8	.53	55.0
Indigo bunting	5	3.6	.33	11.0
Downy woodpecker	4	2.9	.26	18.0
White-breasted nuthatch	3	2.1	.20	11.0
Brown-headed cowbird	3	2.1	.20	4.9
Ruby-throated hummingbird	2	1.4	.13	1.8
Belted kingfisher	2	1.4	.13	4.2
Great crested flycatcher	2	1.4	.13	2.0
Carolina wren	2	1.4	.13	5.8
Killdeer	1	0.7	.06	2.6
Hairy woodpecker	1	0.7	.06	1.6
Bewick's wren	1	0.7	.06	2.6
Brown thrasher	1	0.7	.06	2.6
Painted bunting	1	0.7	.06	1.4
Total	138	100	9.20	433.0
Total species	19			
C3 - Winter (N = 2)				
Harris' sparrow	14	22.5	4.66	121.0
Carolina chickadee	7	11.2	2.33	101.0
Dark-eyed junco	5	8.0	1.66	107.0
Tufted titmouse	4	6.4	1.33	30.0
Cardinal	4	6.4	1.33	106.0
Mourning dove	3	4.8	1.00	104.0
Song sparrow	3	4.8	1.00	30.0
Mallard	2	3.2	.66	27.0
Belted kingfisher	2	3.2	.66	27.0
Carolina wren	2	3.2	.66	102.0
Robin	2	3.2	.66	27.0
American goldfinch	2	3.2	.66	28.0
Rufous-sided towhee	2	3.2	.66	28.0
White-crowned sparrow	2	3.2	.66	102.0
Great blue heron	1	1.6	.66	28.8
Common flicker	1	1.6	.33	26.0
Red-bellied woodpecker	1	1.6	.33	26.0
Downy woodpecker	1	1.6	.33	26.0
Purple finch	1	1.6	.33	26.0
Tree sparrow	1	1.6	.33	26.0
Total	62	100	20.66	760.0
Total species	21			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
C3 - Spring (N = 3)				
Blue-winged teal	10	27.0	2.22	25.0
Cardinal	9	24.3	2.00	128.0
Blue jay	5	13.5	1.11	53.0
Carolina chickadee	3	8.1	.66	58.0
Blue-gray gnatcatcher	3	8.1	.66	58.0
Tufted titmouse	2	5.4	.44	49.0
Field sparrow	2	5.4	.44	18.0
Belted kingfisher	1	2.7	.22	12.0
Brown-headed cowbird	1	2.7	.22	12.0
American goldfinch	1	2.7	.22	14.0
Total	37	100	8.22	429.0
Total species	10			
C4 - Summer (N = 10)				
Carolina chickadee	23	20.5	1.53	66.0
Cardinal	22	19.6	1.46	124.0
Tufted titmouse	18	16.0	1.20	26.0
Indigo bunting	9	8.0	.60	44.0
Yellow-billed cuckoo	5	4.4	.33	22.0
Brown-headed cowbird	5	4.4	.33	11.0
Dickcissel	5	4.4	.33	7.2
Carolina wren	4	3.5	.26	19.0
Mourning dove	3	2.6	.20	7.5
Ruby-throated hummingbird	3	2.6	.20	7.5
Downy woodpecker	3	2.6	.20	13.0
Northern oriole	3	2.6	.20	5.8
Red-bellied woodpecker	2	1.7	.13	6.8
Scissor-tailed Flycatcher	2	1.7	.13	5.4
Blue	2	1.7	.13	3.6
Cliff swallow	1	0.8	.06	1.4
Eastern bluebird	1	0.8	.06	2.6
Painted bunting	1	0.8	.06	1.4
Total	112	100	7.46	377.0
Total species	18			

Species, site, season and number of counts (N)	Total No. seen	Percent of total birds seen	Density (No./ha)	Importance value
C4 - Winter (N = 2)				
Harris' sparrow	45	41.2	15.00	277.0
Cardinal	18	16.5	6.00	70.0
Mourning dove	10	9.1	3.33	61.0
Dark-eyed junco	9	8.2	3.00	237.0
Tree sparrow	7	6.4	2.33	57.0
Carolina chickadee	6	5.5	2.00	223.0
Tufted titmouse	5	4.5	1.66	217.0
Mallard	2	1.8	.66	52.0
Starling	2	1.8	.66	52.0
Belted kingfisher	1	0.9	.33	55.0
Loggerhead shrike	1	0.9	.33	51.0
Red-winged blackbird	1	0.9	.33	51.0
Rufous-sided towhee	1	0.9	.33	51.0
Song sparrow	1	0.9	.33	55.0
Total	109	100	36.33	754.0
Total species	14			
C4 - Spring (N = 3)				
Carolina chickadee	8	21.6	1.77	123.0
Cardinal	6	16.2	1.33	115.0
Tufted titmouse	4	10.8	.88	111.0
Brown-headed cowbird	4	10.8	.88	55.0
Song sparrow	4	10.8	.88	19.0
Barred owl	2	5.4	.44	18.0
Harris' sparrow	2	5.4	.44	15.0
Yellow-billed cuckoo	1	2.7	.22	13.0
Scissor-tailed flycatcher	1	2.7	.22	13.0
Blue jay	1	2.7	.22	13.0
Indigo bunting	1	2.7	.22	13.0
Dickcissel	1	2.7	.22	13.0
Rufous-sided towhee	1	2.7	.22	13.0
Lincoln's sparrow	1	2.7	.22	13.0
Total	37	100	7.95	551.0
Total species	14			

APPENDIX E

THE NUMBER OF SPECIES AND NUMBER OF INDIVIDUALS SEEN PER LIFE FORM AT EACH RUSH AND WILDHORSE CREEK STUDY SITE DURING THE SUMMER 1976

Number of species and number of individuals seen per life form at each Rush and Wildhorse creek study site during the summer 1976.

	UnBotFor[1] (Control) sites								ChPecGroTaGr sites						UnBotForIs sites			
	W1		W8		R7		R8		R2		W3		W4		R3		R6	
Life form [2]	No. species	No. individuals	No. species	No. individuals	No. species	No. individuals	No. species	No. individuals	No. species	No. individuals	No. species	No. individuals	No. species	No. individuals	No. species	No. individuals	No. species	No. individuals
1	2	5	1	6	-	-	-	-	1	1	2	3	2	3	-	-	-	-
2	-	-	-	-	-	-	-	-	1	1	1	8	-	-	1	6	-	-
3	4	20	5	25	-	-	4	6	5	34	4	22	4	10	1	2	1	1
4	2	6	3	15	1	1	3	10	1	5	3	15	1	3	1	4	1	1
5	4	34	4	30	5	36	5	57	5	30	5	15	5	22	4	17	3	9
6	-	-	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	6	63	5	75	5	44	6	82	6	37	2	6	7	16	5	18	3	10
8	3	10	3	13	1	1	3	15	3	10	3	6	3	6	3	17	1	1
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	2	12	3	29	2	3	-	-	-	-
16	-	-	-	-	-	-	-	-	1	3	1	1	-	-	-	-	-	-
17	1	1	1	1	-	-	1	1	1	2	1	1	-	-	-	-	-	-
18	1	1	1	13	1	9	1	20	1	19	1	12	1	3	-	-	1	6
Total	23	140	24	183	13	92	24	192	28	155	25	118	25	66	15	64	11	32
Total life forms	8		9		6		8		12		11		8		6		7	

[1] Definitions of site class abbreviations appear on p. 31.
[2] Definitions of life formes appear on pp. 132-134.

Life forms	ChBotForReg site W5A No. species	No. individuals	ChBotFor site W5 No. species	No. individuals	ChCrop sites W2 No. species	No. individuals	W7 No. species	No. individuals	R1 No. species	No. individuals	ChTaGr sites R4 No. species	No. individuals	W6 No. species	No. individuals	UnNatGr site R5 No. species	No. individuals
1	–	–	–	–	1	2	–	–	–	–	1	1	2	5	2	2
2	–	–	–	–	2	9	1	2	–	–	3	9	2	6	–	–
3	4	17	1	5	1	3	2	9	1	2	3	8	2	6	2	4
4	4	8	1	1	–	–	1	1	1	1	–	–	–	–	1	1
5	5	85	5	25	–	–	5	9	4	12	1	2	1	1	5	11
6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7	6	34	6	24	–	–	–	–	2	8	1	7	2	3	5	37
8	3	7	3	4	–	–	1	1	–	–	2	3	–	–	3	7
9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–	–	2	9	3	3	2	2
11	–	–	–	–	1	1	1	76	2	58	1	1	1	4	–	–
12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14	–	–	–	–	–	–	1	10	1	46	1	1	1	1	2	4
15	–	–	–	–	2	6	3	9	1	1	2	11	3	40	2	4
16	–	–	–	–	1	11	1	5	1	2	1	5	1	2	–	–
17	1	6	1	1	1	1	–	–	–	–	1	6	1	1	–	–
18	1	24	1	2	–	–	–	–	1	12	–	–	1	5	–	–
Total	24	181	18	62	9	33	16	122	14	142	19	63	20	73	24	72
Total life forms	7		7		7		9		9		12		12		9	

APPENDIX F

RESULTS OF STATISTICAL TESTS

Table 1. Observed t-values for comparisons of mean number of avian species seen per visit between the various altered site classes and the control class on Rush and Wildhorse creeks, by season.

Class comparisons (degrees of freedom)	Observed t-value per season				
	Summer	Fall	Winter	Spring	Annual
Control vs. ChPecGroTaGr[1] (5)	0.437	2.33*	8.12	4.80**	4.14**
Control vs. UnBotForIs (4)	4.37**	7.67**	8.68**	4.40**	9.38**
Control vs. ChBotFor (3)	2.20	3.46*	0.82	1.60	3.31*
Control vs. ChBotForReg (3)	1.02	1.45	1.46	1.50	1.55
Control vs. ChCrop (5)	5.29*	5.50**	8.93**	10.05**	15.26**
Control vs. ChTaGr (4)	4.98**	6.24**	6.58**	6.67**	10.07**
Control vs. UnNatGr (3)	4.24*	3.98*	6.53**	3.60*	6.90**

[1] Definitions of abbreviations appear on p. 31.

* Denotes $P \leq 0.05$; ** denotes $P \leq 0.01$.

Table 2. Observed t-values for within class comparisons of mean number of avian species seen per visit between summer 1976 and fall, winter, and spring 1976-1977.

Seasonal comparisons	t-values for site classes				
	Control[2] (6)[1]	ChPecGroTaGr (4)	UnBotForIs (2)	ChCrop (4)	ChTaGr (2)
Summer vs. fall	0.15	1.75	5.90*	0.42	3.86*
Summer vs. winter	1.90	4.61**	7.16**	2.04	3.16*
Summer vs. spring	0.62	2.24*	1.59	2.24*	2.18

[1] Degrees of freedom denoted parenthetically.

[2] Definitions of abbreviations appear on p. 31.

* Denotes $P \leq 0.05$; ** denotes $P \leq 0.01$.

Table 3. Observed t-values for comparisons of total number of avian species seen per season between the various altered site classes and the control class on Rush and Wildhorse creeks, by season.

Class comparisons (degrees of freedom)	Observed t-value per season				
	Summer	Fall	Winter	Spring	Annual
Control vs. ChPecGroTaGr[1] (5)	1.89	1.39	5.47**	2.40*	3.75**
Control vs. UnBotForIs (4)	2.23*	2.20*	5.89**	1.33	7.73**
Control vs. ChBotFor (3)	0.57	1.01	0.22	1.20	3.11*
Control vs. ChBotForReg (3)	0.50	0.35	1.58	1.36	1.06
Control vs. ChCrop (5)	2.59*	3.20*	11.32**	4.01	12.94**
Control vs. ChTaGr (4)	0.43	2.24*	5.01**	3.25*	7.65**
Control vs. UnNatGr (3)	0.50	0.28	2.80*	1.90	1.21

[1] Definitions of abbreviations appear on p. 31.

* Denotes $P \leq 0.05$; ** denotes $P \leq 0.01$.

Table 4. Observed t-values for within class comparisons of total number of avian species seen per season between summer 1976 and fall, winter, and spring 1976-1977.

Seasonal comparisons	t-values for site classes				
	Control (6)[1]	ChPecGroTaGr[2] (4)	UnBotForIs (2)	ChCrop (4)	ChTaGr (2)
Summer vs. fall	3.21**	6.21**	4.80*	5.43*	30.00**
Summer vs. winter	3.03*	6.48**	4.42*	5.61*	6.27*
Summer vs. spring	1.74	18.87**	0.71	5.62*	8.32**

[1] Degrees of freedom denoted parenthetically.

[2] Definitions of abbreviations appear on p. 31.

* Denotes $P \leq 0.05$; ** dentoes $P \leq 0.01$.

Table 5. Observed t-values for comparisons of mean number of birds seen per hectare per visit between the various altered site classes and the control class on Rush and Wildhorse creeks, by season.

Class comparisons (degrees of freedom)	Observed t-values per season				
	Summer	Fall	Winter	Spring	Annual
Control vs. ChPecGroTaGr[1] (5)	1.01	1.99	3.17*	8.54**	6.79**
Control vs. UnBotForIs (4)	0.12	1.68	2.08	0.84	3.75**
Control vs. ChBotFor (3)	1.37	1.55	0.75	4.16*	3.34*
Control vs. ChBotForReg (3)	0.84	1.03	0.71	6.81**	2.02
Control vs. ChCrop (5)	1.26	1.59	3.18*	13.83**	7.96**
Control vs. ChTaGr (4)	2.81*	2.10	2.32*	10.51**	7.93**
Control vs. UnNatGr (3)	1.16	1.21	1.42	8.05**	4.28*

[1] Definitions of abbreviations appear on p. 31.

* Denotes P ≤ 0.05; ** denotes P ≤ 0.01.

Table 6. Observed t-values for within class comparisons of mean number of birds seen per hectare per visit between summer 1976 and fall, winter, and spring 1976-1977.

Seasonal comparisons	t-values for site classes				
	Control (6)[1]	ChPecGroTaGr[2] (4)	UnBotForIs (2)	ChCrop (4)	ChTaGr (2)
Summer vs. fall	1.00	0.94	1.30	0.02	0.03
Summer vs. winter	2.42*	2.25*	1.21	1.46	0.34
Summer vs. spring	1.26	1.75	0.72	1.84	1.38

[1] Degrees of freedom denoted parenthetically.

[2] Definitions of abbreviations appear on p. 31.

* Denotes P ≤ 0.05; ** denotes P ≤ 0.01.

Table 7. Observed t-values for comparisons of mean bird species diversity values between the various altered site classes and the control class on Rush and Wildhorse creeks, by season.

Class comparisons (degrees of freedom)	Observed t-values per season				
	Summer	Fall	Winter	Spring	Annual
Control vs. ChPecGroTaGr[1](5)	0.29	2.59*	4.04**	4.32**	3.53**
Control vs. UnBotForIs (4)	3.99**	11.84**	4.85**	4.18**	10.26**
Control vs. ChBotFor (3)	1.15	4.84**	0.64	2.38*	2.58*
Control vs ChBotForReg (3)	0.70	1.75	1.01	1.40	0.99
Control vs. ChCrop (5)	6.08**	4.42**	8.50**	19.64**	15.31**
Control vs. ChTaGr (4)	3.76**	9.30**	5.03**	9.47**	6.83**
Control vs. UnNatGr (3)	1.32	3.93*	2.60*	9.46**	5.20**

[1] Definitions of abbreviations appear on p. 31.

* Denotes P $\leq$ 0.05; ** denotes P $\leq$ 0.01.

Table 8. Observed t-values for within class comparisons of mean bird species diversity values between summer 1976 and fall, winter, and spring 1976-1977.

Seasonal comparisons	t-values for site classes				
	Control (6)[1]	ChPecGroTaGr[2] (4)	UnBotForIs (2)	ChCrop (4)	ChTaGr (2)
Summer vs. fall	0.07	2.18*	3.33*	0.19	4.19*
Summer vs. winter	1.86	4.68**	2.20	2.40*	3.43*
Summer vs. spring	0.74	2.94*	0.16	1.58	2.94*

[1] Degrees of freedom denoted parenthetically.

[2] Definitions of abbreviations appear on p. 31.

* Denotes P $\leq$ 0.05; ** denotes P $\leq$ 0.01

Table 9. Observed t-values for various avian parameters compared between study sites upstream and downstream from Ft. Cobb Reservoir, by season.

Season	Observer t-values for parameters tested (upstream vs. downstream)				
	Mean species richness (no. of species seen per visit)	Total species richness (total no. of species seen per season)	Density (no. of birds seen per hectare per visit)	Bird species diversity (H')	Equitability coefficient (J')
Summer	0.46	6.00*	0.55	1.98	6.00*
Winter	2.65	2.47	2.55	1.74	0.49
Spring	0.21	0.84	0.74	0.45	0.89
Annual	2.80	1.06	3.16	2.10	0.39

* Denotes $P \leq 0.05$.

Table 10. Observed t-values for various avian parameters compared within classes among seasons for study sites upstream and downstream from Ft. Cobb Reservoir.

	Observed t-values for parameters tested				
Class and season compared	Mean species richness (no. of species seen per visit)	Total species richness (total no. of species seen per season)	Density (no. of birds seen per hectare per visit)	Bird species diversity (H')	Equitability coefficient (J')
Upstream					
Summer vs. winter	0.45	5.20*	4.12*	0.93	0.13
Summer vs. spring	0.28	7.15*	0.81	1.54	0.44
Winter vs. spring	0.33	1.85	3.43*	0.77	1.73
Downstream					
Summer vs. winter	3.08*	0.40	3.61*	2.01	0.40
Summer vs. spring	0.25	0.49	0.65	0.61	5.00*
Winter vs. spring	2.86	4.45*	3.71*	1.56	3.57*

* Denotes $P \leq 0.05$.

VITA

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Master of Science

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