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AVIAN DIVERSITY AND ABUNDANCE ALONG A GRADIENT OF BAYOU DEVELOPMENT IN HOUSTON

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ABSTRACT.—Different species of water birds were recorded during 18 sampling sessions along three different Houston bayou transects (two along Buffalo Bayou, and one along Brays Bayou), representing gradients of channelization. Of 15 recorded guilds and species, 11 were observed at the site that had been channelized most extensively (Brays), nine were observed at the completely unchannelized site (Arboretum) and seven were observed at the moderately channelized site (Allen). Bird abundance was highest along Brays (mean = 34 individuals; r = 10–59), and lowest at Allen (mean = 5 individuals; r = 0–14). Little Blue Heron (*Egretta caerulea*) was the only species shared among all three sites, suggesting strong differences in species composition due to variation in extent of channelization. The species accounting for highest abundance at Brays were shorebirds due to the similarity of this habitat to Texas Coastal flats. In contrast, ardeids represented a high proportion of the community at Arboretum, reflecting the pristine nature of this wooded riverine segment. The moderately channelized site is an inadequate substitute for the natural riparian system as it does not resemble any other natural ecosystem and exhibits low water bird abundance and diversity. The composition of the aquatic bird communities studied are likely attributed to habitat and channelization differences rather than abiotic weather events, as the latter were for the most part statistically insignificant.

INTRODUCTION

As human urbanization extends into natural environments, it changes them, thereby creating an entirely new set of ecosystems. The effects of human activity on fundamental natural resources are becoming so widespread that completely pristine areas are increasingly difficult to find. The environments that take their places are mosaics of urban and rural characteristics: gardens, parks, and urban streams are a few examples. Because these systems have developed quite recently, both they and their effects on native species remain largely uncharacterized (Gilbert 1991).

A classic example of an area in which human intervention has modified the ecosystem so dramatically that it has reshaped the environment is Houston's Bayou systems. Since the establishment of the City of Houston, channelization of the Bayou has completely transformed it from a riparian ecosystem into a series of very different environments. The implications of this differentiation upon the Bayou's ecology, however, are not yet completely evident. In order to further understand and address them, we studied the effects of channelization, water level, and season upon water bird diversity and abundance along a development gradient of bayou stems. Because water birds are directly affected by changes in biotic and abiotic factors, they are ideal subjects for this study.

In order for several species to coexist, each must adapt to utilize a particular set of local resources.

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Thus, if an ecosystem is disturbed through human intervention, the biotic and abiotic factors to which organisms have adapted in the natural environment can change drastically. This may ultimately eliminate many of the niches in a certain environment and can therefore lead to the disappearance of certain species (Brooks 1998).

The abundance of many species fluctuates seasonally with local and long-distance migration (Brooks 1997). Seasonal changes, however, do not reflect human influence on the bayou system. It is important to measure seasonality because it could bias data, leading to a misrepresentation of the effects of human interference.

Changing water levels reflect a significant change in the bayou environment and should certainly be considered in relation to bird diversity and abundance. Changes in the weather (e.g., heavy rain), however, can also cause changes in water level and lead to flooding, or influence bird behavior otherwise (Childs 1988). This provides another example of how the effects of a natural factor could be wrongly attributed to human influence. Additionally, weather can strongly influence bird movement, and some species are constrained to association with precise water levels (Hayes and Fox 1991).

METHODS

We examined three areas representing a gradient from complete to lack of channelization. Brays Bayou (hereafter Brays) was completely channelized with concrete banks and landscaped on top. Buffalo Bayou along Allen Parkway (hereafter Allen) represented a natural riverine situation along the banks but more heavily landscaped on the land surrounding the Bayou. Buffalo Bayou bordering the Houston Arboretum (hereafter Aboretum) represented a 'pristine' bayou system.

Each transect was 3 km in length. The Brays transect ran along Braeswood Blvd. from Greenbriar to Braes Blvd., the Allen transect ran along Allen Parkway from downtown to Shepherd St., and the Arboretum transect ran along Buffalo Bayou from loop 610 to the vicinity of River Oaks Country Club.

Transects were sampled weekly (eight times/site) at Brays and Allen. Sampling at Brays took place on March 2, 18, 26, April 1, 9, 15, 29, and May 6. Sampling along Allen took place on February 26, March 17, 24, 31, April 7, 16, 23, and May 5. Two samples were accomplished April 8 and 23 at the Arboretum site.

All surveys took place 07:00–09:00. For Brays and Allen, strip transects were walked along the bayou lip. Canoe sampling was used at the Arboretum since continuous bank access for transects was not possible. DM

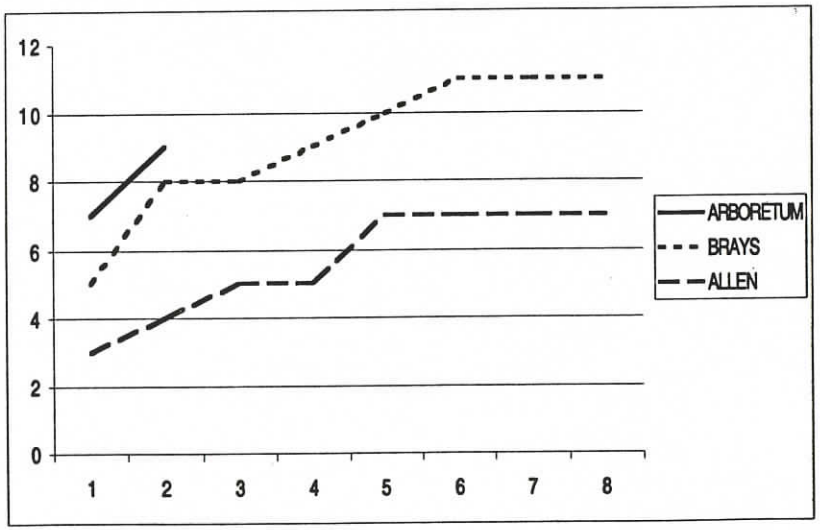

Figure 1. Species accumulation curves. The Y-axis represents cumulative species richness, and the X-axis represents successive sample numbers.

visually recorded numbers of species restricted to aquatic systems (Table 1), using unlimited distance contacts (Ralph 1981). Unknown species were identified using Peterson (1947) and Rappole and Blacklock (1985, 1994). Cloud cover was recorded, and ranked using the following scale: clear = 0, slightly cloudy = 1, partly cloudy = 2, moderately cloudy = 3, overcast = 4. Temperature data were obtained from the Hobby Airport website (srh.noaa.gov), and water level data were obtained from Harris' County Flood Control District's website (hcoem.org).

Abundance values (Table 1) were computed following Brooks (2000), where Abundance = total number of individuals recorded during study / number of sampling sessions. Species pervasiveness was measured using standard deviation computations with a TI-35X statistical calculator (Fowler and Cohen n.d.). Using the computer program SPSS (1996), Pearson product-moment correlations were used to test for significance with temperature and water-level pairings, and non-parametric Spearman rank correlations were used to test for significance with cloud cover pairings.

RESULTS AND DISCUSSION

Diversity

Fifteen guilds and species of water birds were recorded during this study; 11 were observed at Brays, nine at the Arboretum site, and seven at Allen (Table 1). Similarly, individual bird abundance was highest along Brays (mean = 34 individual/sample; r = 10—59) and lowest at Allen (mean = 5 individuals/sample; r = 0–14), with the Arboretum site again in the middle of the distribution (mean = 14 individuals/sample; r = 9–19).

Though lower in richness than Brays, the unchannelized Arboretum site may actually have proven more diverse if it were sampled more intensively. Indeed, the species accumulation curves (Fig. 1) were higher during the first two sampling dates at Arboretum than the other two sites (1st and 2nd samples at Arboretum = 7 and 9 species respectively, Brays = 5 and 8, Allen = 3 and 4). This supports the hypothesis that a more natural environment creates more niches and therefore higher diversity. Observations from Brays and Allen however, suggest an unexpected pattern of differentiation. Although Brays is more channelized than Allen, diversity is much higher at Brays.

Channelization

The only species that was present at all three sites was the Little Blue Heron (*Egretta caerulea*). The low number of species shared among sites indicates high species turnover due to extremely different habitats. This suggests strong variation in species composition due to differences in degree of channelization.

Table 1. Values of species abundance and fluctuations

		Abundance			Fluctuations	
Common Name	Latin Name	Brays	Allen	Arbor.	Brays	Allen
Wood Duck	*Aix sponsa*	0.25		**3.5**[1]	0.18	
Belted Kingfisher	*Megaceryle alcyon*		0.12	0.5		0.13
Shorebirds	+	**13.75**[1]		0.5	**7.01**	
Killdeer	*Charadrius vociferus*	**4.37**[3]	**0.62**[2]		**2.04**	0.42
Ring-billed Gull	*Larus delawarensis*	**2.87**[4]	**1.5**[1]		**1.9**	**4.47**
Laughing Gull	*L. atricilla*	1.25	0.12		0.65	0.13
Osprey	*Pandion hcoastal*		**0.37**[3]			0.23
Cormorant	*Phalacrocorax sp.*	1.87	**0.25**[4]		0.76	0.73
Little Blue Heron	*Egretta caerulea*	1.12	0.12	**3**[2]	0.72	0.13
Snowy Egret	*E. thula*	0.75		1	0.37	
Great Blue Heron	*Ardea herodias*	0.12		1	0.13	
Cattle Egret	*Bubulcus ibis*	**7.62**[2]			**5.71**	
Green Heron	*Butorides virescens*	0.25		**1.5**[4]	0.18	
Yellow Cr. Night Heron	*Nycticorax violacea*			**1.5**[3]		
White Ibis	*Eudocimus albus*			0.5		
TOTAL SPP. GROUPS		**11**	**7**	**9**		

Species showing the strongest patterns are represented in **bold**; superscripts represent order of abundance.
+Least Sandpiper (*Calidris minutilla*) and Greater Yellowlegs (*Tringa melanoleuca*) are dominant species.

Brays resembles coastal flats in many crucial ways, and this has perhaps created a niche ideally suited to birds that frequent Texas coastline. The most abundant group along the completely channelized Brays site was shorebirds (Table 1). The reason for these species abundance is likely attributed to optimal foraging opportunities: the flat concrete bank being covered with algae, combined with shallow water level, provide high prey abundance for the birds, and simulate coastal flats that shorebirds are frequently associated with. With the exception of Killdeer (*Charadrius vociferus*), which were associated with the open, grassy banks at Allen, shorebirds were completely absent or extremely rare at the other two sites, most likely due to water being too deep, and the presence of vegetation along the water.

Next to the Wood Duck (*Aix sponsa*), a species strongly associated with wooded riverine tributary, five species of ardeids (i.e., herons and egrets) accounted for the most abundant species at the pristine Arboretum site (Table 1). The pristine, wooded riverine tributary at the Arboretum provides an ideal environment for several species of ardeids that are often associated with this type of habitat.

The low abundance of ardeids at Allen (moderately channelized) is rather unexpected, and can probably be traced to the type of channelization that this area of the bayou has undergone. Although this habitat has a few characteristics in common with the riparian forest, it is also different in many ways. The species that were most abundant at Allen are not necessarily associated with beach or riverine forest, but rather are associated with a variety of habitats. Interestingly however, Belted Kingfisher (*Megaceryle alcyon*) was absent from Brays, likely due to the completely open nature of Brays and lack of adequate perching sites. Although Osprey (*Pandion haliaetus*) was not recorded at the other sites during the actual study, its presence was noted at Brays before sampling began, while delineating transects in February.

Seasonality

Species with standard deviation values exceeding 1.00 (Table 2) were considered to have significant fluctuations in abundance. Four out of 11 species (36%) at Brays showed significant fluctuations in abundance, whereas only one out of seven (14%) at Allen showed significant fluctuations in abundance (Table 2). These fluctuations were most apparent in shorebirds at the Brays site, and Ring-billed Gull (*Larus delawarensis*) represented the only species shared between the two sites with significant fluctuations in abundance (Table 2). These results reinforce that little seasonality was observed when considering all species in this study. The fluctuations in Ring-billed Gull abundance for example were likely influenced by water level (see below).

Correlation analysis revealed rather little significance between various abiotic weather parameters and avian diversity and abundance. For Allen and Brays, or both sites combined, no significant relationships were found between diversity and cloud cover or temperature, and only one significant relationship between an individual species and cloud cover or temperature. This exception is Killdeer, which was encountered more with increased temperature at Allen ($r = 0.765$, $P = 0.027$). This may be an artifact of Killdeer activity increasing during warmer temperature. The relationship between water level and avian diversity and abundance was negative for all correlations at Allen. However, at Brays diversity increased with lower water level ($r = -0.712$, $P = 0.048$), and Ring-billed Gull abundance increased with higher water level ($r = 0.747$, $P = 0.033$). Diversity increasing is likely due to increased shorebird abundance when the algal mats are exposed along the banks during lower water levels. Ring-billed Gull abundance increasing during higher water levels may be tied to optimal foraging conditions, with preferred fish prey being more abundant with higher water levels.

ACKNOWLEDGMENTS

This project was done by DM as part of her Research Problems Course, where she was co-advised by DB (HMNS) and Alan Thornhill (Rice Univ.). We thank Mark Bersche (Houston Arboretum), Jennifer Drummond and Nick Block (Rice Univ.) for help in the field, and to Ron Howell for computing standard deviation values in Table 2. We also wish to thank Bob Behrstock and Bob Honig for preliminary insights of Houston's Bayou avifauna, and to these two individuals and Fred Collins for commenting on the shorebird guild, and/or the species list in Table 1. Thanks to Keith Arnold and Jack Eitniear for their helpful comments.

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SHORT COMMUNICATIONS

OBERHOLSER'S BIBLIOGRAPHY OF TEXAS BIRDS

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It was the intent of H.C. Oberholser that his monograph on Texas birds would include a bibliography of all pertinent literature from earliest times through 1945. Inclusion in the bibliography was based on the criterion that a publication must furnish "definite Texas information regarding some bird or birds." Oberholser believed that the observations of sportsmen were of "considerable value" and, in addition to citations of technical literature, his original bibliography (Oberholser n.d.) also includes a large number of articles published in sport magazines.

Oberholser arranged his bibliography to reflect the historical development of ornithology in Texas. This was accomplished by listing entries by year of publication rather than alphabetically by author. A brief annotation naming the species discussed or the conclusions of the paper accompanied each entry.

The typescript of *The Bird Life of Texas* is archived in The Center For American History at the University of Texas in Austin. Both the typescript and a microfilm copy are available on site to researchers. Microfilm copies (6 rolls) may also be purchased from The Center. This note describes the differences between the bibliography of the typescript and the published monograph. The comparison is limited to those references published before 1900 since they represent the early formative period of ornithology in Texas.

REVISION OF THE BIBLIOGRAPHY

Edgar B. Kincaid, Jr. was placed in charge of revising the typescript following Oberholser's death on 25 December 1963. The major challenge facing Kincaid and his assistants was reducing the typescript from three million to one million words. Editing and updating of the 572 page bibliography was assigned to Rose Ann Rowlett (Oberholser 1974:xvii).

Rowlett faced a daunting task. In order to include recent literature, there would need to be a severe pruning of the older entries. This was accomplished by the deletion of 83% (1,223 entries) of all articles published before 1900 (Table 1). Articles in sport magazines such as *American Field, Chicago Field* and *Forest and Stream* were, for the most part, deleted as were entries from ephemeral journals such as *The Curlew, Naturalist and Fancier, The Osprey,* and *Random Notes on Natural History*. All references to articles in *Gefiederte Welt* were removed (Table 2). The majority of the annotations were deleted and it was also decided to list articles alphabetically by author rather than by year of publication.

SIGNIFICANCE OF THE REVISIONS

Deletions of most of the annotations and over 80% of the pre-1900 literature helped achieve the goal of reducing the length of the typescript while, at the same time, allowing for the inclusion of recent literature. However, attainment of this goal worked contrary to Oberholser's vision of a comprehensive bibliography. Elimination of most articles from sport magazines (Table 2) sent a clear signal that information from these sources was of lesser value. Removal of titles published in *Gefiederte Welt* and *Zoologische Garten* effectively obscured much of the work of one of the most productive ornithologists in early Texas, i.e., Henry Nehrling who, in 1883, was elected a fellow of the American Ornithologist Union based primarily on work done in Texas (Stone 1932).

Oberholser's arrangement of articles by their year of publication provided a means by which the year-by-year development of Texas ornithology could be followed. The revised arrangement makes this process much more difficult. Perhaps more significant, at least to the historians, was the deletion of articles from ephemeral journals and sport magazines (Table 2). These publications were often the only outlets though which amateurs could publish their observations. And, while the information from these sources is often trivial, it does provide a unique view of Texas bird life and how it was perceived by observers of the 19th century.

Oberholser's career as an ornithologist spanned the latter part of the 19th century and much of the 20th. His bibliography of Texas birds was a relatively complete but, in many ways, an uncritical record of the past. It can be argued that the deleted entries contained information of only minimal value and that their removal was necessary to focus attention on more recent and relevant research. However, it can also be argued that when a discipline loses or cannot readily access its literature, it also loses contact with its origins. Being aware of this potential loss, Kincaid and the advisory committee overseeing the revision wisely chose to preserve the unedited typescript and to make it available to future generations.

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AN UNUSUALLY LARGE NUMBER OF EGGS LAID BY A BREEDING RED-COCKADED WOODPECKER FEMALE

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The Red-cockaded Woodpecker (*Picoides borealis*) is a cooperatively breeding species that typically uses a single cavity for nesting (Ligon 1970, Walters et al. 1988). A single tree, or aggregation of cavity trees, termed the cluster, is inhabited by a group of woodpeckers that includes a single breeding pair and up to several helpers, which are typically male offspring of previous breeding seasons (Ligon 1970, Lennartz et al. 1987). Each group of Red-cockaded Woodpeckers usually produces one nest per breeding season, but will

Table 1. Numbers of articles cited in the typescript and published version of *The Bird Life of Texas* for the years 1820 through 1899.

Years	Number of Articles Cited in Typescript	Number of Articles Cited in Monograph	Difference
1820–1829	1	1	0
1830–1839	4	3	1
1840–1849	12	4	8
1850–1859	54	19	35
1860–1869	30	7	23
1870–1879	229	38	191
1880–1889	593	122	471
1890–1899	550	56	494
TOTALS	1,473 (100%)	250 (17%)	1,223 (83%)

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