WOOD DUCK DISTRIBUTION AND PRODUCTION IN OKLAHOMA

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PREFACE

An effective understanding of the needs and requirements of wood ducks is necessary to manage and coordinate research efforts. This study is designed to provide baseline information on the habitat requirements and distribution of wood ducks utilizing riverine and reservoir systems in Oklahoma. I sincerely hope the results and conclusions will spark interest into further research concerning waterfowl and the preservation of wetlands in Oklahoma.

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I wish to express my sincerest appreciation to my major adviser, Dr. Frank Schitoskey, Leader, Oklahoma Cooperative Wildlife Research Unit. I also wish to thank Dr. Paul A. Vohs, former Leader, and Dr. John A. Bissonette, former Assistant Leader, Oklahoma Cooperative Wildlife Research Unit, for assistance in project development. A special thanks to Mrs. Judy Gray for her irreplaceable secretarial help, to Eugene Maughan and Larry Talent for reviewing this manuscript, and to Diane Love and Lem Due of the Oklahoma

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Finally, I wish to especially thank the Graduate Students of Life Sciences West (there are just too many to name) for making a "Yankee" feel at home.

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CHAPTER I

This thesis is composed of 2 manuscripts (Chapter II and III) written in formats suitable for submission to national scientific journals. Chapter II, "Factors Affecting Wood Duck Populations and Productivity on Oklahoma Streams" was written in JOURNAL OF WILDLIFE MANAGEMENT format. Chapter III, "Wood Duck Use of Impounded and Natural Flowing Rivers" was written in SOUTHWESTERN NATURALIST format. Appendices A and B contain information referenced in both chapters, but will not be submitted for publication.

CHAPTER II

FACTORS AFFECTING WOOD DUCK POPULATIONS AND PRODUCTIVITY ON OKLAHOMA STREAMS[1]

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ABSTRACT: River float counts were conducted on 17 rivers to obtain information on wood duck (*Aix sponsa*) abundance, distribution, production, and habitat requirements in Oklahoma. An estimated 10,146 wood ducks were present in spring 1981. Highest densities occurred in the northeast region of the state and lowest densities in the west (Duncan, $P<0.05$). Most nesting occurred in late March but some early nesting occurred in February. Duckling survival was estimated to be 19%. While on rivers, wood ducks selected for log jams and flooded shrub/scrub habitats and avoided swift moving water, open areas, and eroded banks. The occurrence of log jams was positively correlated ($R^2 = 0.33$) with wood duck densities but the presence of marsh and swamp

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habitat around rivers was negatively correlated with densities. Cover and nesting habitat were considered to be limiting factors to productivity.

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Key words: Aix sponsa, float counts, habitat, Oklahoma, productivity, riverine, survival, wood duck.

Oklahoma is on the western fringe of North America's interior wood duck population range (Bellrose 1976). Current research shows them to be the most prolific breeding species of waterfowl in the state (Heitmeyer 1980). Despite extensive studies on wood duck conducted in other states (Stewart 1957, Grice and Rogers 1965) little information has been generated on life history strategies or habitat requirements in regions of marginal habitat. Oklahoma provides an opportunity to investigate these parameters in just such habitat. The objectives of this study were to identify major wood duck breeding areas as they relate to riverine systems in Oklahoma, and to identify riverine characteristics that influence breeding density and duckling survival.

I wish to thank L.A. Colten, M.N. Dillard, and D.H. Latham for helping collect and compile data; O.E. Maughan, L. Talent and especially F. Schitoskey for providing editorial assistance; J.M. Gray and F. Schitoskey for logistical support; and W.D. Warde for providing statistical advice and assistance in writing computer programs. I especially acknowledge fellow wildlifers at Oklahoma State

University along with Mya and E. Joe for their time and support.

METHODS

River Float Counts

Partially flooded bottomland forest is considered to be some of the most suitable habitat for wood ducks (Bellrose 1953, McGilvrey 1968). Therefore, bottomland forest was used as the criterion for selection of rivers. The percentage of bottomland forest in each of Oklahoma's 77 counties was calculated from Soil Conservation Service (SCS) cover maps. Forest habitats in the northeastern counties were classified as mixed forest, so SCS Prime Farmland cover maps were used to provide better estimates of bottomland forest (Appendix Fig. 1). Rivers in counties containing greater than 2.50% bottomland forest were divided into non-overlapping 14.5 km (9.0 miles) sampling units. Sixteen sampling units were randomly selected for float counts from Oklahoma's 6 physiographic provinces in 1980. Stratification by province was designed to reduce high count variation (for a detailed description of the provinces see Heitmeyer 1980). An additional river was added in 1981. More rivers were floated in those provinces where wood duck densities were predicted to be higher (Fig. 1).

River float counts via canoe were conducted during spring and summer 1980 and 1981. Single morning and evening counts were conducted on all rivers during spring 1980

(12 April - 11 May). Single morning brood counts were conducted during summer 1980 (1 June - 20 June). We attempted to float each river 3 times during spring 1981 (27 March - 11 May) and summer 1981 (18 May - 28 June).

During spring counts the missing female of a pair was assumed to be present when a single male was observed (Stewart 1958). All flushed birds were followed until out of sight to reduce duplication in counts. Number, sex, and flushing time were noted. If similar numbers and sex were observed within 10 minutes, these birds were assumed to be duplicates and not included in the totals.

All broods were aged following the methodology of Dries (1954). Overall duckling survivorship was calculated assuming an initial clutch size of 12.2 (Bellrose 1976:188) and little or no mortality after 7 weeks of age. Nesting chronology was determined by back-dating the age of broods, assuming a 30 day incubation period and a 14 day egg laying period. Province and statewide estimates of breeding wood ducks were generated for 1981 by multiplying the average number of wood ducks observed/km during spring counts by the km of permanent stream present in each province (Heitmeyer 1980:22).

Count variation between morning and evening floats were compared using paired t-tests. Analysis of Variance (AOV) and Duncan's Multiple Range test (Duncan) were used to test for differences in wood duck density between floats and provinces.

Riverine Habitat Evaluation

Riverine shoreline characteristics and wood duck habitat selection were evaluated using the non-mapping technique of Marcum and Loftsgaarden (1980). We recorded the predominant shoreline habitat each time a wood duck was encountered (Table 1). Riverine habitat features were tallied during the return trip following each float count by stopping at systematic time intervals and recording the predominant shoreline feature present along both shores of the river. A minimum of 100 shoreline observations/river were made. Time intervals between observations were determined by dividing the time (in minutes) required to complete the morning float count by 50, thereby generating a minimum of 100 (50 x 2) shoreline observations.

Chi-square test of homogeneity has been used to determine randomness of occurrence of wood ducks in particular habitats. If habitat preference is non-random (significant P-value), preference or avoidance of habitats can be indicated using simultaneous confidence intervals following the Bonferroni approach (Marcum and Loftsgaarden 1980). A 98.4% confidence interval is calculated for each habitat type using the following equation:

$$(P_{H1} - P_{D1}) \pm Z_{.984}[P_{H1}(1 - P_{H1})/n_H + P_{D1}(1 - P_{D1})/n_D]^{1/2}$$

where: n_H = total number of habitat observations

P_{H1} = proportion of habitat observations categorized as habitat type 1

n_D = total number of wood duck sightings

P_{D1} = proportion of wood duck sightings in habitat type 1

$Z_{.984}$ = 98.4th percentile for a standard normal curve = 2.145

Confidence intervals that do not include zero indicate preference (negative values) or avoidance (positive values) of a particular habitat.

Nesting and brood rearing habitat is critical for successfully reproducing populations. Nesting habitat was qualitatively examined for each river by developing a simple index for potential nesting sites. No tree cavities were examined, but the presence or absence of large overmature trees along the river bank were noted while shoreline habitat was evaluated. Overmature trees were considered trees with a diameter breast height (dbh) greater than 51 cm (20 inches). Since river length and number of observations/river varied, the index was calculated in terms of average number of trees per observation.

All wetlands within 0.80 km (1/2 mile) of the rivers were identified from topographic maps and categorized as either marsh, lake or pond according to size and topographic map symbol. Wetland data and riverine habitat features were combined in regression models for predicting wood duck density and productivity for the state. All analysis was completed using packaged programs of the Statistical Analysis System (Barr et al. 1979).

RESULTS

Float Counts

Concurrent morning and evening float counts down 16 rivers in 1980 showed that more wood ducks could be observed during morning hours (Table 2). No measure of variation was possible since only single counts were conducted.

In spring 1981, 3 surveys were completed on each of 17 rivers (Appendix Table 1). Surveys were spaced at approximately 10 - 12 day intervals, and all totals were converted to the number of ducks/km. No difference was present in densities observed between surveys (AOV, $\underline{P}$ = 0.14). Count variation ranged from 7.8% - 173.2% on the different rivers (Table 3). By province, variation ran from 23.1% - 131.4% (Table 4). Count variation remained constant in provinces 1, 2, and 3, but became progressively more variable in the southeastern and western provinces. Significant differences were present in densities between rivers (AOV, $\underline{P}$ = 0.001) and between provinces (AOV, $\underline{P}$ = 0.001). Province 1 maintained the highest density in the state (2.16 ducks/km) while province 6 maintained the lowest (0.12 ducks/km). Both densities were significantly different from the other provinces (Duncan, $\underline{P} < 0.05$).

Sixteen brood counts were completed during the summer of 1980 and forty-four were completed in 1981. Forty-five broods were observed over the 2 year period (Appendix Tables 2 and 3) Brood density/river in 1981 was determined by summing the total number of broods observed during the surveys and dividing by the number of counts/river. Province 1 had the highest productivity in 1981 although East Cache Creek in province 5 had the single highest productivity, producing an average of 0.24 broods/km over the 9.9 km surveyed.

Linear regression comparing spring density with summer production showed little correlation in 1980 when single counts were conducted (Fig. 2). When 3 counts were run during spring and summer 1981 a positive relationship existed between spring breeding density and summer productivity (Fig. 3).

Population Estimates and Brood Survival

An estimated 10,146 wood ducks were present on Oklahoma streams during spring 1981 (Table 5). The greatest numbers were present in provinces 1 and 4. In province 5, 2 distinctly different riverine types were floated. East Cache Creek possessed characteristics of rivers in the eastern provinces being predominately mud channels and classified as lower perennial with an unconsolidated mud bottom, permanently flooded, fresh, and circumneutral (Cowardin et al. 1979, Heitmeyer 1980). The Washita River possessed characteristics comparable to province 6 rivers: numerous mud and sand bars, lower perennial, unconsolidated bottom/ unconsolidated shore of sand, permanently flooded/seasonally flooded, oligosaline, and alkaline. These differences in riverine characteristics were exemplified in differences in wood duck density and productivity. Spring wood duck density averaged 1.11 ducks/km on East Cache Creek and 0.02 ducks/km on the Washita River. Consequently, population estimates were calculated separately for the 2 riverine types in this province.

The 1st broods were observed on 1 May 1980 and 26 April 1981. Backdating the age of broods to the time of nesting showed most nests were initiated during late March - early April although some nesting occurred as early as late February (Fig. 4).

Brood survivorship can only be approximated since it was not possible to account for instances in which entire broods were lost, and no data were available on initial clutch size in Oklahoma. Assuming an initial clutch size of 12.2, an average of 2.3 ducklings/brood survived to 7 weeks of age. This approach yields a survival rate of 19% (Table 6).

Habitat Selection

Examination of riverine habitat selection during spring using chi-square analysis suggests that wood ducks are not randomly utilizing different habitat types (Table 7). Instead there is strong preference (98.4% probability) for log jams and flooded shrub/scrub type habitat, and selective avoidance of exposed stream beds, eroded banks, rapids, and open water type habitats. While the probability of preference or avoidance of a particular habitat feature may be as high as 98.4%, the relatively high number of habitat types examined

(9 in all) lowers the probability to 71% that all confidence intervals simultaneously are correct (Miller 1966:67).

The excessively high chi-square values for flooded shrub/scrub, exposed stream bed, and log jams in particular, suggests a direct association between wood duck density and these habitat types. In contrast simple linear regression models show little direct relationship between spring wood duck density and percent occurrence of flooded shrub/scrub or exposed stream bed (R^2 = 0.021 and 0.047, respectively). However, a fairly good positive relationship exists between density and percent occurrence of log jams (Fig. 5).

When hectares of marsh per km of river are plotted against wood duck densities, a negative correlation is found to exist (Fig. 6). Rivers where natural wetlands abound tend to have lower densities. Assuming wood ducks occurred in equal densities over a specific area, wood ducks seem to prefer natural marsh habitat over rivers.

There is also a significant positive relationship between the average productivity (number of broods/km) per river and the density of potential nesting trees (Fig. 7). For example, East Cache Creek (province 5) had the highest average productivity as well as the highest index for overmature trees. If hectares of marsh is included in the regression model, the relationship improves (R^2 = 0.67, $\underline{P}$ = 0.007). The effect of marsh habitat, however, is to reduce the number of broods likely to be seen on the rivers.

DISCUSSION

Most other investigators recommend initiation of river float counts early in the morning as was done in this study. In contrast, Stewart (1957) found the least variation in counts conducted in the evening, but concluded that small sample size limited the validity of his results. In support of early morning counts, incubating wood ducks are generally off their nests during early morning, although nest attentiveness varies between individuals (Breckenridge 1956). Our data showed that 11 of 13 river counts were higher in the morning. Therefore, these data seem to support the contention of most researchers that morning float counts are most effective at revealing wood duck population density.

Float count variation continues to remain a concern when monitoring wood duck populations. Our data seems to agree with the conclusion of other workers who found that float counts were unsuitable to detect small population changes (Stewart 1957, Martin 1959, Hein 1962). Similarly, the problem of double counting birds may remain a weakness. Hein (1962) points out the possibility of herding large numbers of wood ducks ahead of the boat. Generally, it is hoped that birds added to counts from duplication are offset by ducks overlooked. The technique of recording time of sighting, number, sex of flushed birds, and birds returning upriver was designed to minimize the number of birds double counted. Since densities were never very great (maximum observed was 40 ducks over 14.6 km) and the same technique was maintained through all counts, comparisons made between rivers and provinces should remain valid, because no significant differences were observed in number of ducks seen between surveys.

Bellrose (1976) estimated a statewide breeding wood duck population of 5000. Heitmeyer (1980) projected a population estimate of 7568 adults based on sampling 1/4-section wetlands with the highest populations in provinces 3, 4, and 5. My estimate of 10,146 was based on ducks observed and 76% of the population was found in provinces 1 and 4. The greatest disparity between these estimates occurs in province 1. Heitmeyer (1980) did not observe any wood ducks on 1/4-sections in this province and therefore concluded that very low numbers breed in this area of the state. I attribute the difference between our estimates to a differential use of habitat.

Natural wetlands (e.g., sloughs, oxbows) are rarely found in province 1 (Heitmeyer 1980). Consequently, riverine systems provide the majority of available habitat in this province and float counts encounter a majority of the population in this area of the state. Conversely, in provinces 3 and 4 the greatest number of natural wetlands occur. Since wood ducks also utilize natural wetlands, rivers float counts in these areas encounter only a fraction of the population. However, considering that Oklahoma was going through a prolonged drought during the study period, it is possible that rivers provided the most acceptable habitat present at the time for all regions of the state. Heitmeyer (1980) and other investigators (Black 1976, Mitsch et al. 1979) point out the dynamic nature of wetlands, particularly natural wetlands. With little or no precipitation to recharge them, natural wetlands quickly diminish in size. This reduction in habitat could easily force wood ducks to utilize riverine systems to a much greater degree, and in the process improve the integrity of the counts. For example, I noted that spring counts 1 and 2, conducted in province 4 in 1981, were approximately equal. Prior to the 3rd spring count heavy rains fell in that region of the state and recharged most wetlands. The subsequent count was considerably lower than counts 1 and 2.

The use of river float counts for generating population estimates has been heavily criticized since the inventory generally reaches only a portion of the total population (Martin 1959). In those provinces where count variability remains small, relatively few bottomland wetlands occur and float counts may provide reliable estimates of population size. Where bottomland wetlands are numerous, sampling 1/4-section wetlands (Stewart and Kantrude 1972, Heitmeyer 1980) in addition to rivers would perhaps give more repeatable results. Closer examination of wetlands around natural waterways could help explain the variation observed in productivity.

Martin (1959) found limited effectiveness of float counts but concluded that satisfactory estimates of breeding wood duck populations could be achieved on tree bordered streams where there were few subsiduary ponds and oxbows. The inference that available sloughs and oxbows provide habitat preferable to rivers is not inconsistent with other research already completed. Heitmeyer (1980) found the greatest spring populations and productivity of wood ducks on natural bottomland wetlands, although these wetlands comprise less than 4% of the wetland basins in Oklahoma. My data showed a negative trend for number of wood ducks observed around rivers where marsh habitat was common. In spite of these difficulties I was able to observe a definite correlation between spring adult densities and summer productivity when 3 float counts were conducted in both spring and summer. A correlation of this type would generally be expected; however, similar counts in other states, namely Ohio (Stewart 1957) and Indiana (Mumford 1952), failed to produce any correlation. In these states the effects of marsh and swamp habitat adjacent to rivers probably functions to reduce riverine wood duck populations by drawing ducks away from rivers (Hein 1962). Furthermore, when suitable brood rearing habitat is lacking or unavailable on rivers, rivers serve as travel lanes to more suitable rearing habitat (Hardister et al. 1962, Hepp and Hair 1977).

The distribution of natural wetlands in Oklahoma undoubtedly affects local wood duck distribution patterns (their presence or absence on rivers) as well as the broods produced. However, other factors directly influence wood duck densities and productivity. The lack of available nesting habitat has traditionally been cited as a limiting factor to wood duck production. The correlation observed between productivity and the frequency of overmature trees indirectly exemplifies the restrictions placed on productivity due to limited nesting habitat. Trees with a dbh of 41 cm (16 inches) or greater provide the greatest proportion of natural cavities for nesting (Grice and Rogers 1965, Weier 1966). The likelihood of cavities is about 50% in trees with a dbh greater than 51 cm (Gilmer et al. 1978). Studies have demonstrated increased production in local populations when natural cavities are supplemented with nest boxes (McLaughlin and Grice 1957). In some cases nest boxes are preferred over natural cavities (Bellrose et al. 1964, Strange et al. 1971). Transplanting juvenile wood ducks and erecting nest boxes in areas totally lacking nesting habitat established breeding populations in areas of North Dakota where no production occurred previously (Doty and Kruse 1972).

Cover is considered an important requirement for attracting wood ducks and for successfully rearing broods. Log jams and flooded shrub/scrub habitat along riverine systems were frequently selected by wood ducks while open areas were avoided. Flooded shrub/scrub habitat most likely affords only temporary cover when water levels are high. Log jams, conversely, are a relatively common habitat along rivers and continue to remain after water levels drop.

Minser (1968) found wood duck pairs in Tennessee concentrated along river sections thickly bordered with forest vegetation and containing numerous tree snags. The importance of tree snags as loafing sites was also noted by Webster and McGilvrey (1966) and similarly described for dabbling ducks (Hochbaum 1944) and prairie ducks (Sowls 1955).

Prior to nesting, loafing sites receive considerable use by wood ducks (Beard 1964, Minser 1968), and felling trees along water edges is a suggested management practice for improving wood duck habitat along lakes and rivers (Minser 1968, Watts 1968). In Oklahoma, log jams provide not only important cover when water levels are low, but may serve as a source of food.

Bilby and Likens (1980) point out that organic debris dams (log jams) function to trap small bits of woody vegetation and leaves which become a habitat for numerous shredding invertebrates. In this study I observed many invertebrates clinging to these debris dams which may provide a protein source for nesting hens and broods (Cook 1964, Drobney and Fredrickson 1979). In support of the hypothesis of higher productivity near log jams, Burges and Bider (1980) found higher levels of invertebrate production along stream sections improved by constructing small rock and log dams. It is possible that organic debris dams may be analagous to aquatic macrophytes in palustrine systems (Arner et al. 1974).

With little habitat in the form of sloughs and oxbows, rivers become a major source of breeding and brood rearing habitat for wood ducks in Oklahoma. With these conditions cover and nesting habitat may be the most critical factors limiting production and duckling survival. Log jams provide the most consistent form of habitat utilized along rivers, but do not occur frequently enough to provide good rearing habitat. The limited available cover, in the form of log jams, may be expressed in low duckling survival (19%).

There are inherent problems in determining duckling survival from the techniques used in this study. Poor visibility reduces the number of young ducks observed versus the number actually present (Minser 1968), resulting in underestimation of survivorship. Assuming a hatching rate of about 12 young per nest could also underestimate survival. The inability to account for entire brood loss, conversely, would over estimate duckling survival possibly as high as 30% (Gilmer et al. 1978). These factors are partially overcome by the design of this study.

Since little cover was present, broods of all ages were easily counted; thus underestimating survivorship according to visibility does not seem to be important in this study. Age specific survival was calculated as mean brood size, limiting accuracy primarily as a function of sample size. Assuming an overestimation of survival due to entire brood loss, actual survivorship on rivers may range from 12 - 15%. This estimate of survival seems to show excessively low survival when other states show survival rates of 52%

(Mississippi, Baker 1970), 47% (Maryland, McGilvrey 1969), and 32% (Georgia, Odum 1970). However, in Texas, Ridelhuber (1980) observed 8% survival in areas considered poor rearing habitat compared to 48% in good rearing habitat. McGilvrey (1968) considers optimum rearing habitat 75% cover and 25% open water with a minimum of 1/3 cover and 2/3 open water. Most of Oklahoma's mud channeled rivers fall well below these minimum conditions and 19% survival is not inconsistent with the habitat conditions found on the rivers.

CONCLUSION

The predominant factors limiting wood duck distribution and productivity in Oklahoma relate to poor nesting habitat and little available cover. Natural bottomland wetlands provide preferred nesting and brood rearing habitat when available. However, since these important wetlands are confined to southeastern Oklahoma, river systems provide the most habitat throughout the state. In western Oklahoma natural wetlands are rare, nesting habitat is sparse and river systems dominated by sand and mud flats provide low quality habitat. Wood duck densities reflect these conditions; productivity proves to be negligible. Some riparian habitat in these regions of the state stand out by providing the only available habitat for wood ducks. East Cache Creek is one example where large overmature trees occur in thin strips along the river in areas dominated by pasture and farmland. All nesting and brood rearing are confined to these rivers so float counts encounter most of the local population.

When rivers provide most of the habitat, the integrity of float counts improves and good estimates of wood duck populations may be determined. Counts would be especially effective if conducted in triplicate during April for estimating spring densities and June for monitoring summer production. In most states river float counts prove to be unreliable due to wood duck interaction with adjacent wetlands, poor visibility due to increased cover, and high wood duck densities that enhance the problem of duplication. Oklahoma shows few of these problems so float counts remain a viable technique.

The most consistent form of cover available for wood ducks on rivers appears to be log jams. In addition to cover, log jams may provide a food source in the form of invertebrates utilizing these structures as substrate. As useful as log jams appear, they do not provide cover in sufficient quantity to allow for high brood survival. The initiation of nest box programs may increase nesting across the state. However, due to limited brood rearing habitat, duckling survival in western Oklahoma could not be expected to increase.

Rivers and bottomland wetlands continue to provide the primary habitat for wood ducks. Sound management and research is needed to protect these wetlands not only for maintenance of Oklahoma's wood duck population, but also for their extensive use by wintering species of waterfowl.

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Table 1 . Description of shoreline habitat types used for evaluating riverine habitat features and wood duck habitat selection. Most descriptions follow those of Cowardin et al. (1979) .

Habitat Type	Description
Flooded Timber	woody vegetation, alive or dead, 6m (20 ft) tall or taller, has an estimated dbh of 20 cm (8 in), and is completely or partially submerged
Flooded Shrub/Scrub	partially or totally flooded areas dominated by woody vegetation less than 6m tall and has a dbh less than 20cm
Emergent Vegetation	any flooded erect rooted herbaceous hydrophyte
Exposed Stream Bed	irregularly exposed portions of the river channel composed of unconsolidated material
Eroded Bank	eroded portions of the river bank frequently occurring on the concave side of the river channel
Rapids	swift moving water usually accompanied with shallow water and a rocky substrate
Open Water	areas along the stream bank completely devoid of vegetation and lacking any kind of exposed stream bed
Log Jam	any combination of uprooted woody vegetation entangled in or along the river shoreline

Table 2 . Paired t-test comparing number of wood ducks observed during morning and evening float counts on Oklahoma rivers[a] during spring 1980 .

River	Adult Wood Ducks Present AM	PM
Caney	6	2
Verdigris	13	4
Illinois	11	11
Deep Fork I	9	6
Deep Fork II	13	4
Poteau	19	12
Kiamichi I	9	6
Kiamichi II	6	3
Blue	3	0
Muddy Boggy I	2	4
Muddy Boggy II	6	10
Cache Creek	14	6
totals	116	68

t-value = 3.3
12 d.f.
P = 0.01

[a]16 rivers were floated but only those rivers with wood ducks are represented here .

Table 3 . Mean density of wood ducks, standard deviation, and coefficient of variation from 3 float counts/river conducted during spring 1981 .

River	Mean Density	S.D.	C.V.
Caney	2.07	0.484	23.4
Illinois	1.68	0.241	14.3
Big Cabin Creek	2.73	0.213	7.8
Deep Fork I	0.89	0.117	13.1
Deep Fork II	0.83	0.289	34.6
Poteau	1.08	0.270	25.0
Poteau (below Wister Dam)	1.17	0.142	12.1
Kiamichi I	0.84	0.195	23.3
Kiamichi II	0.79	0.305	38.4
Little	0.78	0.118	14.9
Blue	1.03	0.735	71.6
Muddy Boggy I	1.64	1.032	63.0
Muddy Boggy II	0.39	0.144	36.7
East Cache Creek	1.11	0.505	45.4
Washita	0.02	0.035	173.2
North Fork of Red	0.10	0.179	173.2
Wolf Creek	0.13	0.167	124.9

Table 4 . Total number of float trips, mean density of wood ducks, standard deviation, and coefficient of variation for each province in Oklahoma during spring 1981.

Province	Number of Floats	Mean Density	S.D.	C.V.
1	9	2.16	0.544	25.2
2	6	0.86	0.200	23.1
3	12	0.97	0.262	27.0
4	12	0.96	0.721	75.1
5	6	0.57	0.679	119.8
6	6	0.12	0.155	131.4

Table 5 . Wood duck population estimates according to kilometers of permanent stream present in each province during spring, and mean wood duck density (with 95% confidence interval in parenthesis) during spring 1981 .

Province	Permanent Streams[a] (km)	Mean Number of Wood Duck/km	Population Estimates	Range
1	2201	2.16 (± 0.42)	4754	3830 - 5679
2	1122	0.86 (± 0.21)	965	729 - 1201
3	558	0.97 (± 0.17)	541	446 - 636
4	3035	0.96 (± 0.46)	2914	1518 - 4310
5[b]	811	1.11 (± 1.25)	900	0 - 1914
	2333	0.02 (± 0.37)	47	0 - 910
6	211	0.12 (± 0.12)	25	0 - 59
		Totals	10,146	6,523 - 14,709

[a]taken from Heitmeyer 1980.

[b]2 distinctly different riverine systems were floated in province 5. East Cache Creek possessed characteristics equivalent to rivers in the eastern provinces being predominately mud channels with an average duck density of 1.11. The Washita River possessed characteristics comparable to province 6 rivers having numerous mud and sand bars and an average of 0.02 ducks/km. Consequently, population estimates were calculated seperately for these river types.

Table 6. Estimate of age specific duckling survival on Oklahoma rivers for 1980 and 1981 combined[1]. Duckling age was estimated according to Dries (1954).

Brood Age (weeks)	Sample Size	Brood Size	Percent Survival
Initial Clutch	-	12.2[2]	-
1	17	7.2	59
2-3	20	4.3	35
4-5	11	3.6	30
6-7	8	2.3	19

[1]5 brood sightings were provided by the Oklahoma Department of Wildlife Conservation; 2 additional broods were observed on rivers not included in the study.

[2]initial clutch size is taken from Bellrose (1976).

Table 7 . Chi-square analysis and 98.4% simultaneous confidence intervals showing the non-random utilization of certain riverine habitat types. Confidence intervals that do not include zero indicate preference (negative values) or avoidance (positive values) of a particular habitat by adult wood ducks for spring 1980 and 1981 combined .

Habitat Type	Observed	Expected	Chi-Square	98.4% Confidence Interval
Flooded Timber	39	34.3	0.7	-0.022 - 0.010
Flooded Shrub/Scrub	222	152.9	31.2	-0.122 - -0.055*
Flooded Herbaceous	44	45.3	0.0	-0.015 - 0.019
Exposed Stream Bed	103	230.4	70.5	0.136 - 0.188**
Eroded Bank	20	34.6	6.2	0.007 - 0.031**
Rapids	3	16.7	11.2	0.012 - 0.023**
Open Water	181	240.6	14.8	0.045 - 0.108**
Log Jam	233	86.0	251.2	-0.222 - -0.155*
Other	11	15.1	1.1	-0.004 - 0.014
totals	856	855.9	424.1	
			$\underline{P}$ = 0.0001	

*preference

**avoidance

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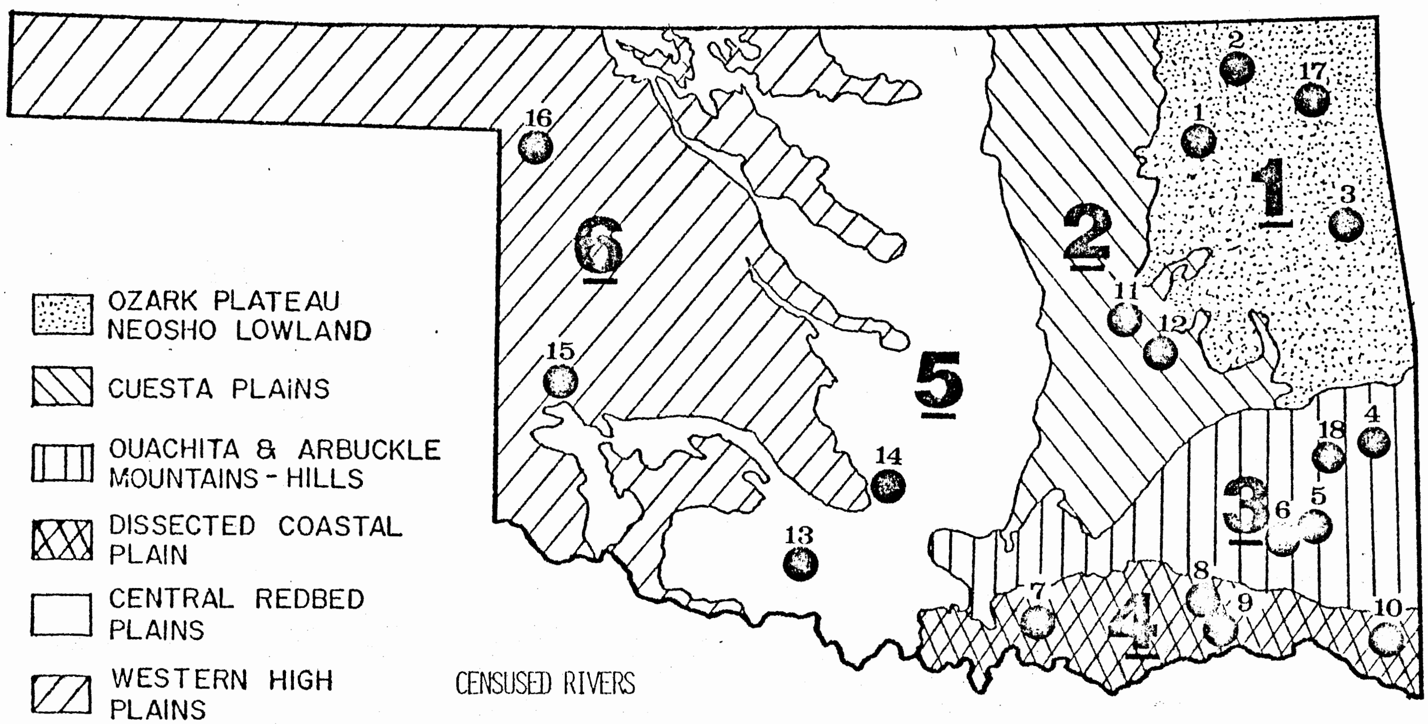


CENSUSED RIVERS

1. Caney
2. Verdigris
3. Illinois
4. Poteau
5. Kiamichi (I)
6. Kiamichi (II)
7. Blue
8. Muddy Boggy (I)
9. Muddy Boggy (II)
10. Little
11. Deep Fork (I)
12. Deep Fork (II)
13. East Cache Creek
14. Washita
15. North Fork of Red
16. Wolf Creek
17. Big Cabin Creek
18. Poteau (below Wister Dam)

Fig. 1. Oklahoma's 6 physiographic provinces (underlined) and the distribution of rivers censused for breeding wood ducks and broods.

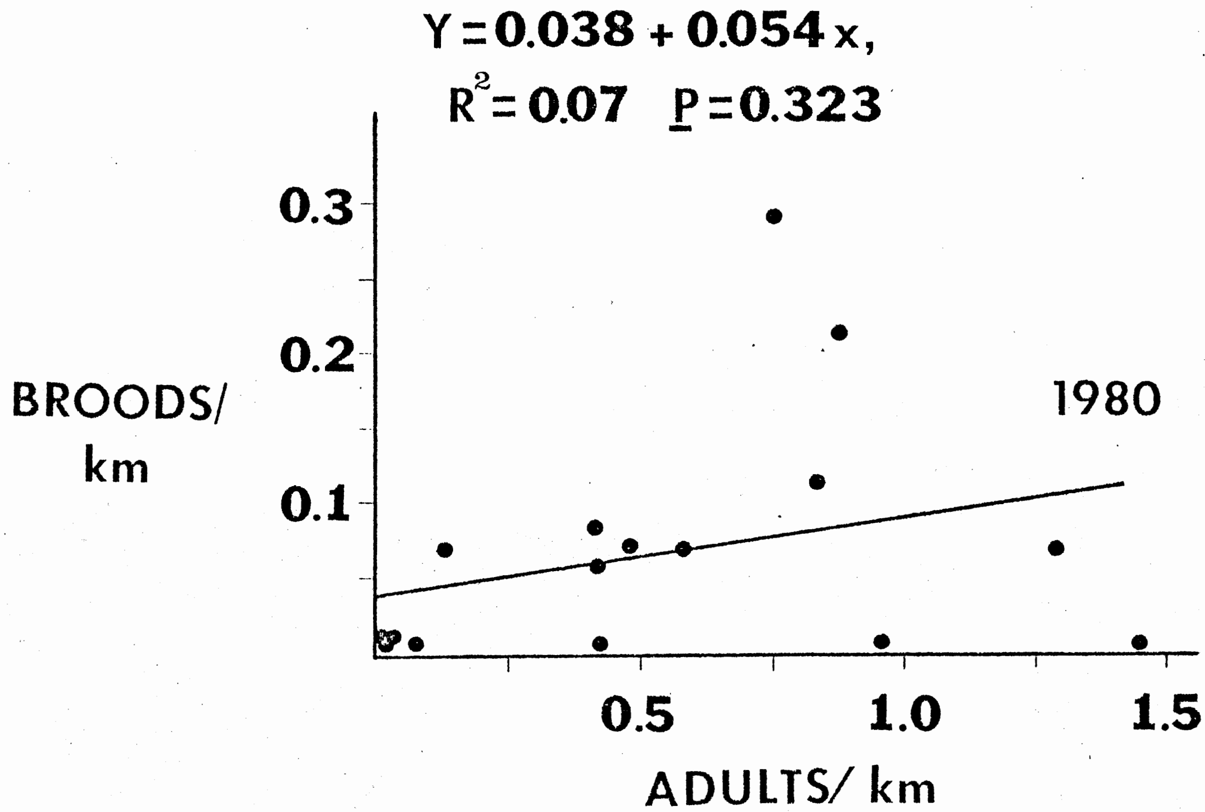
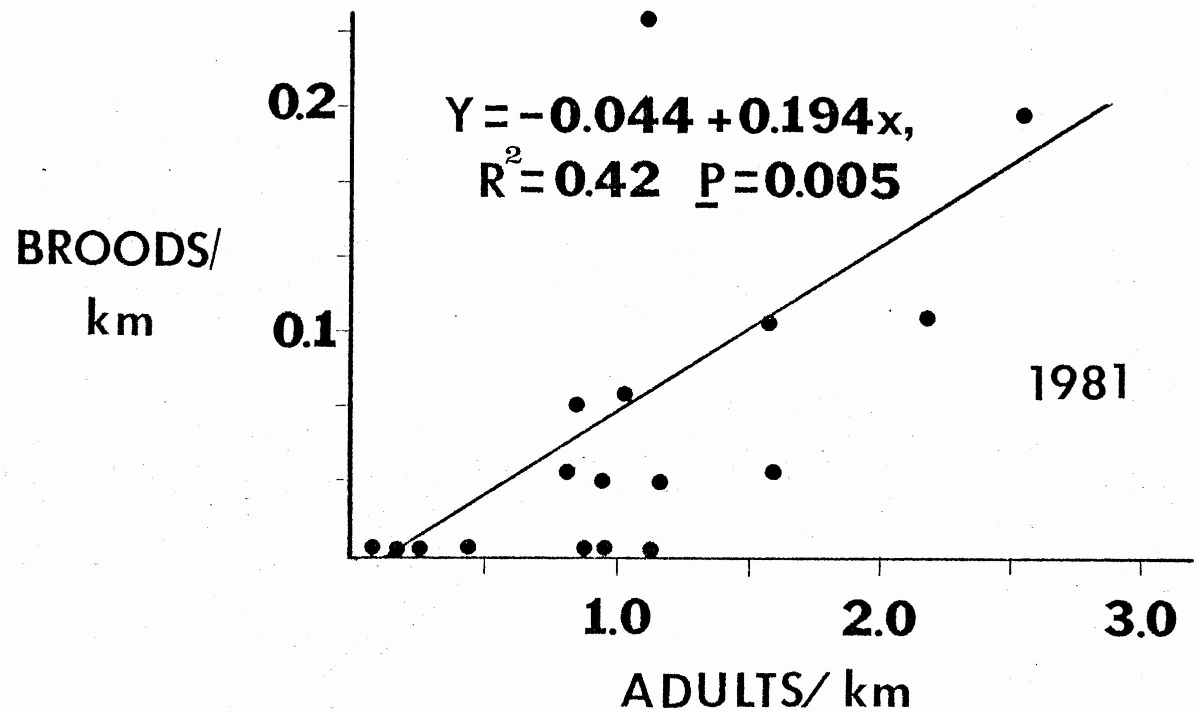


Fig. 2. Correlation between spring adult wood duck densities and summer productivity for 16 rivers in Oklahoma during 1980.



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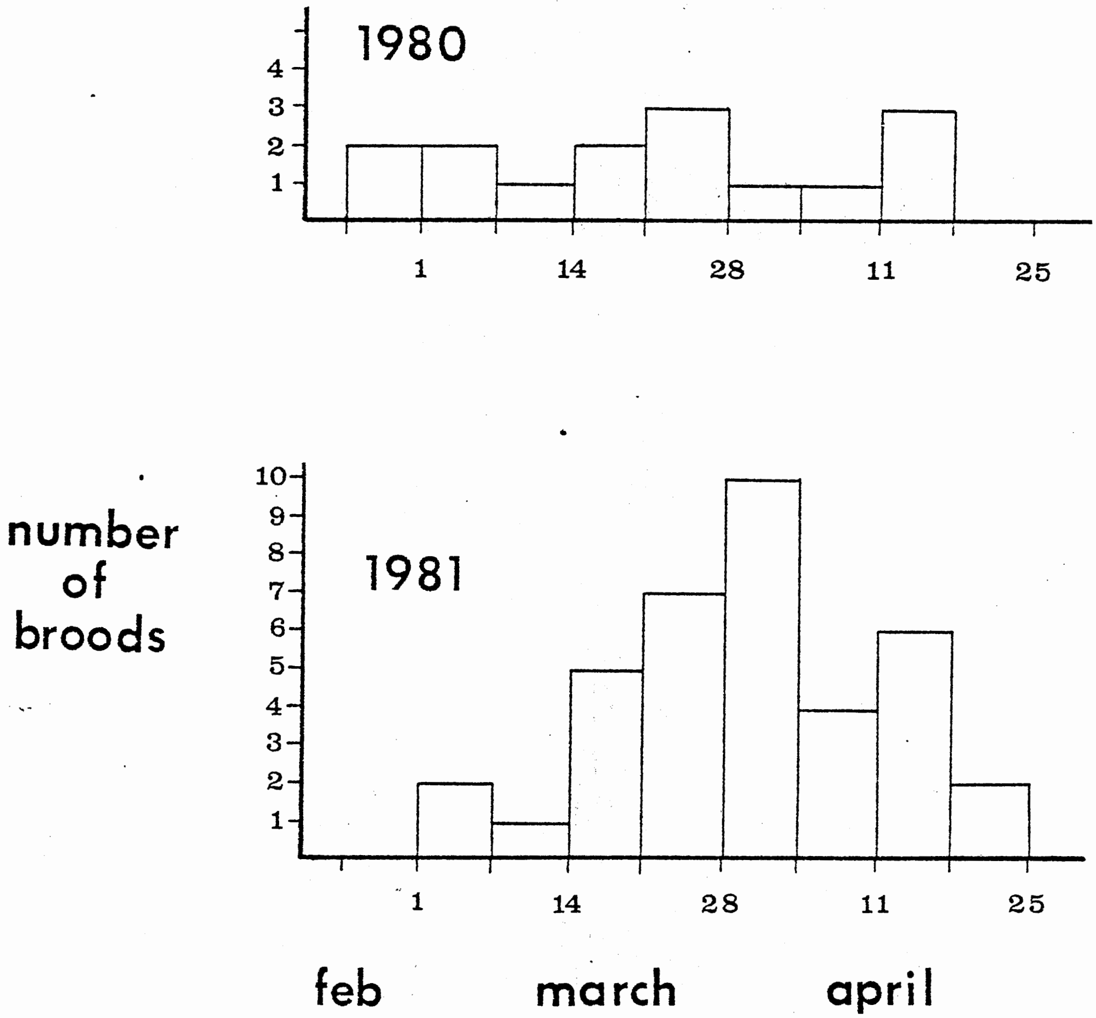

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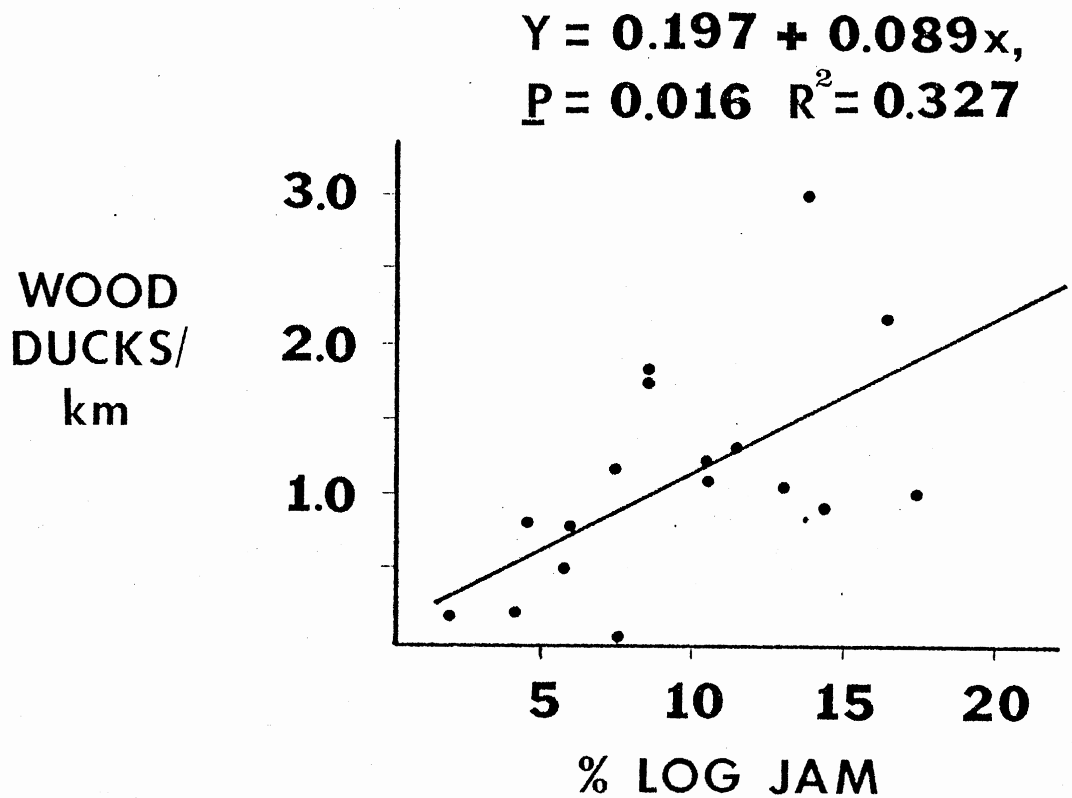

Fig. 5. Correlation between spring wood duck density and percent of shoreline habitat observations categorized as log jams on 17 Oklahoma rivers during 1981.

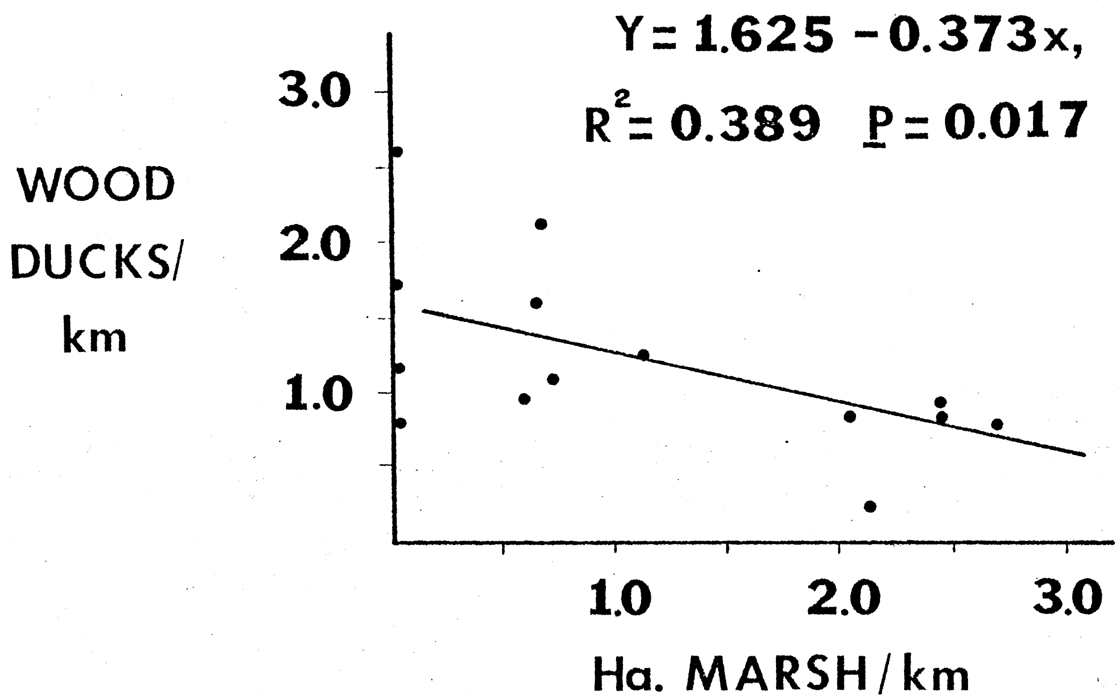

Fig. 6. Correlation between wood duck density on Oklahoma rivers and ha. of marsh/km within 0.80 km of the river for spring 1981.

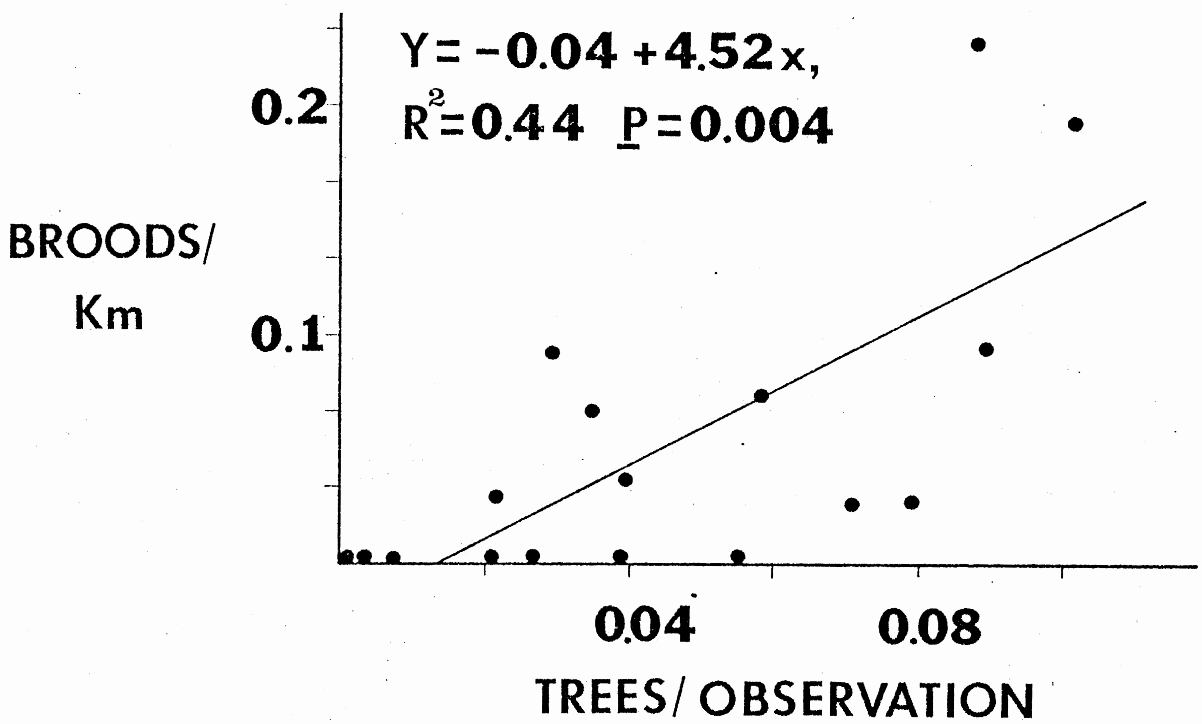

Fig. 7. Correlation between average wood duck brood density and overmature tree index during summer 1981.

CHAPTER III

WOOD DUCK USE OF IMPOUNDED AND NATURAL FLOWING RIVERS IN OKLAHOMA[1]

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ABSTRACT.-Wood duck (*Aix sponsa*) densities on impounded river systems equaled densities on unaltered streams. In summer when river flow is low, impounded rivers may provide the greatest proportion of available wood duck habitat. In reservoirs wood ducks concentrate in secluded coves off the main river channel. Limited cover and deep water may be responsible for limiting distribution in some impounded river systems. Adjacent wetlands may be responsible for reducing wood duck use on some rivers.

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[2] Oklahoma Department of Wildlife Conservation, Oklahoma State University, US Fish and Wildlife Service, and Wildlife Management Institute cooperating.

The wood duck is the most abundant species of waterfowl nesting in Oklahoma (Heitmeyer 1980). However, wood duck habitat is gradually being reduced or altered due to vast water retention projects. Large multi-purpose reservoirs have created potential habitat for migrating waterfowl (Hintz and Bartlett 1975, Barclay 1976), but have resulted in the loss of highly productive bottomland waterfowl habitat (White and Malaher 1964, Gorham 1975).

The objective of this study is to assess the impact of reservoirs on wood duck breeding populations in Oklahoma. To accomplish this objective, comparisons of abundance and distribution patterns between natural flowing and impounded rivers were made using river float counts. Habitat requirements of wood ducks associated with large impoundments were also evaluated.

STUDY AREA.-An intensive study site was established along Lake Wister, A U.S. Army Corps of Engineers flood control impoundment, located in LeFlore county, 3.2 km south of Wister, Oklahoma (Appendix Fig. 2). Lake Wister was constructed in 1949 to provide flood protection and serve as regional water supply for the Poteau Valley (Oklahoma Water Resource Board 1976). The lake has a surface area of 1619 ha. and a total shoreline length of 185 km. Average water depth is 2.3 m with a maximum depth of 13.1 m. The Fourche Maline and Poteau (above dam) rivers are the main contributing streams to the reservoir, and are permanently inundated through much of their length. All water entering the reservoir is discharged into the Poteau river (below dam). The downstream area of the river was considered a naturally flowing river for the purpose of this study.

METHODS.-River float counts were conducted along 18.9 km of the Fourche Maline, 22.1 km of the Poteau (above dam), and 12.9 km of the Poteau (below dam). Counts were run during spring (21 March - 28 May) and summer (9 June - 1 August) 1980. Each river was floated 3 times during spring (27 March - 11 May) and summer (18 May - 28 June) 1981 and the data used for a comparison with 3 flowing rivers found in the same region of the state. The comparison data was from 14.8 km on the Poteau River, 50 km below Lake Wister, and 2 areas along the Kiamichi River in Pushmataha county. The two areas in the Kiamichi included approximately 15.5 km just east of Clayton, Oklahoma, and 16.4 km south of the town of Kiamichi. Coefficients of variation were calculated for wood duck counts on each river and breeding bird density between flooded and natural riverine systems were compared using Analysis of Variance (AOV) and Duncan's Multiple Range test (Duncan).

Rivers at Lake Wister were divided into equal 0.40 km (1/4 mile) sections and all sections identified by numbered styrofoam buoys or flagging. Presence or absence of ducks on each section was determined using float counts. Sightings believed to be repeats were not included. River sections were classified into 3 categories: flooded riverine, natural riverine, or cove. A cove was defined as any recessed area not part of the main river channel and surrounded on 3 sides by land. Most coves had been semi-permanent streams or creeks prior to river inundation. The persistence of flowing water was the criterion for classifying them as flooded or natural riverine.

Forty-seven 0.40 km sections were established along the Fourche Maline (Appendix Table 4). Twenty-nine of the sections were classified as flooded and 18 sections were classified as coves. No natural flowing sections were present. The Poteau (above dam) was floated far enough up river so that the final 4.12 km (7 sections) consisted of natural flowing stream. The remaining sections were classified as flooded (37) and coves (11). All 32 sections of the Poteau (below dam) were considered natural flowing stream.

A Poisson method for measuring intrapopulation dispersion was used to evaluate wood duck distribution patterns throughout the Lake Wister system (Andrewartha and Birch 1954). A variance to mean ratio ($s^2/\overline{x}$) was calculated according to the frequency of wood duck observations on each 0.40 km river section. Mean number of sightings/section was calculated along with a measure of variance, since the number of sightings/section can vary from 0 to the total number of visits made to each section. For a clumped distribution, the sample will contain many values much larger and smaller than the mean so the variance will be high.

For a random dispersion pattern, the variance and mean tend to be equal. When the variance is divided by the mean ($s^2/\overline{x}$), an index of aggregation is calculated. Values greater than 1.0 indicate a clumped distribution pattern while values close to 1.0 suggest a random distribution. A level of significance that measures the probability of the ratio varying from 1.0 is determined by t-test. Clumped populations were further analyzed using Duncan's Multiple Range test to determine the type of river section most heavily used.

Habitat features were also measured for each 0.40 km section. Acetate overlays placed over aerial photographs of the rivers were used to mark the length of shoreline in flooded timber and 3 other predominant shoreline features. (For a description of shoreline habitat types see Prokop 1981:24). A numonics Model 1224 electronic digitizer was used to calculate the percent of shore covered by the 4 habitat types. River width/section was calculated by determining the area occupied by each section. Total forested area within 0.80 km (1/2 mile) of the river section was measured by centering a scaled 1.61 km (1 mile) diameter circle over each section. The total forested area within each circle was also measured. Total area of wetlands within 0.80 km of the section was determined in a similar fashion. All wetlands were classified as either natural wetlands (e.g., sloughs, oxbows), ponds or reservoir associated. Student's t-test was used to compare the differences in habitat features of sections that had a minimum of 1 wood duck with those sections that had no wood ducks.

RESULTS.-Float Count Comparison. Thirty-five float counts were completed at Lake Wister during the springs of 1980 and 1981 (Table 1). Counts were initialized to number of ducks/km for ease in comparisons. Densities between rivers were not significantly different in 1980 than in 1981 (AOV, P = 0.17). Fewer ducks were observed on the Poteau (above dam) in 1981 (AOV, P = 0.015; Duncan, P<0.05) than on the other rivers. Variability remained constant on the rivers between years but was lower in 1981 than in 1980.

During the summers of 1980 and 1981, 28 counts were conducted on these same rivers (Table 1). A significant reduction in density was apparent between spring and summer for both years (AOV, P = 0.003, 0.001 for 1980 and 1981, respectively). Although densities decreased on all rivers at this time, counts were more consistent (less variable) on the 2 impounded rivers. Variability exceeded 100% on the natural flowing Poteau (below dam) during summer for both years (Table 1).

Results from float counts on the Poteau, Kiamichi I, and Kiamichi II conducted during the same time periods show trends similar to those observed at Lake Wister (Table 2). Counts were highest in spring and variability remained constant between rivers. In summer, however, densities dropped considerably and variation increased well over 100%.

Overall, flooded rivers were not significantly different in density from natural rivers during spring (Table 3). Float counts also tended to be less variable on natural rivers at this time. During summer there is a significant decline in density in both riverine systems (AOV, natural $P = 0.0001$; flooded $P = 0.011$), but flooded rivers maintain both higher wood duck densities and less variable counts than natural rivers.

Dispersion Patterns. Wood duck dispersion patterns along Lake Wister rivers were analyzed using a Poisson method. Along the 2 impounded rivers, Fourche Maline and Poteau (above dam), the calculated ratios ($s^2/\bar{x}$) were 2.25 and 2.01, respectively (Appendix Table 5). These values both differed significantly from 1.0 (t-test: Fourche Maline, d.f. = 46, $P<0.005$; Poteau (above dam), d.f. = 55, $P<0.005$). However, for the Poteau (below dam), the ratio did not differ significantly from 1.0 ($s^2/\bar{x} = 1.001$: t-test, d.f. = 31, $P>0.50$). According to this Poisson test, wood duck populations appear clumped along the 2 impounded rivers, but are randomly distributed along the natural river. Analysis of variance comparing number of wood ducks seen/ section per visit show the same trend. The probability that wood ducks use flooded sections equally is also very low (Fourche Maline, $P = 0.002$; Poteau, above dam, $P = 0.0001$) but on the natural flowing Poteau (below dam) there was no significant difference in use of the 32 river sections (P = 0.13).

In spring wood ducks were found more often in coves than on the main river channel along the Fourche Maline (Duncan, $P<0.05$). On the Poteau (above dam), most wood ducks bypassed the first 18 km of the impounded river to concentrate on the final 4.12 km (Duncan, $P<0.05$). These river sections were classified as natural flowing. Mean density for natural river sections on this river was 0.67 ducks/section compared to 0.10 for impounded sections.

During summer, wood ducks continued to use coves rather than flooded riverine sections on the Fourche Maline, but the lower densities and fewer observations resulted in a reduced level of significance (AOV, P = 0.06). On the Poteau (above dam), wood ducks totally ab ndoned the natural river sections to concentrate on the impounded areas. Mean wood duck density/section was 0.17 for flooded sections and 0.10 for coves. However, the differences in density estimates were not significant (Duncan, $P>0.05$).

Habitat Features. Habitat features were measured and comparisons made between sections that had wood ducks and those that did not. Student's t-tests were used to compare all differences (Table 4). Wood duck distribution appeared random between sections on the Poteau (below dam) and there were no significant differences in any variables. This would be expected if wood ducks were utilizing sections indiscriminately, and agrees with the random distribution of ducks hypothesized earlier.

On the rivers where populations were clumped along particular sections, certain differences among sections were apparent. Wood ducks favored areas on the Fourche Maline with a greater proportion of the shore composed of flooded timber, but less in proportions of exposed stream bed, and heavily surrounded by forest (Table 4). On the Poteau (above dam), significant differences were present for percent of shoreline in flooded timber, mean river width, area of natural wetlands, and total wetland area. Wood ducks favored a high percent of flooded timber on the Fourche Maline but low percent on the Poteau (above dam). This discrepancy may be explained in terms of river width. Few wood ducks were seen along the Poteau (above dam) where it enters Lake Wister. The river is very wide in this area and the flooded timber, although present along most of the shore, is in deep water with little more than erect stems protruding from the water. The wide open areas and deep water may negate the limited cover these trees afford.

River sections where wood ducks were common also had fewer wetlands within 0.80 km of the section. When sections for all rivers are combined according to presence or absence of wood ducks, total wetland area averaged 6.02 ha. for those sections where wood ducks were observed, and 15.16 ha. where no ducks were seen. No tests were run to determine if this difference was significant, but an inverse relationship appears to exist between adjacent wetland area and occurrence of wood ducks.

DISCUSSION AND CONCLUSION.-River impoundments may have provided a haven for wood ducks in eastern Oklahoma during part of the year. Some impounded river systems have the potential for maintaining spring wood duck populations that are equal to densities observed on unaltered streams. In fact, some reservoirs may provide the majority of available habitat during summer months, although most of this available habitat is not utilized. Instead wood ducks concentrate in secluded coves that branch off the main river channel. Higher wood duck densities observed in these coves may compensate for the infrequent use of the remaining habitat.

Higgins (1979) found adult wood ducks selected a small bay in an east Texas impoundment. Water depth was shallow (24.4 cm) and cover in the form of woody stems was considered dense in the bay. Logs and shoreline habitat were often utilized for loafing.

The presence of shallow water and cover are considered critical habitat for wood ducks (Grice and Rogers 1965, McGilvrey 1968, Drobney and Fredrickson 1979). Similarly, the use of logs and fallen trees as loafing sites is critical (Webster and McGilvrey 1966, Minser 1968) and it has been suggested that felling trees along the shore of lakes and rivers would improve wood duck habitat (Watts 1968).

Coves provide a majority of the preferred habitat in flooded riverine systems. Impounded rivers are generally steep banked with very little shoreline along the edge of the previously existing river bank. Available cover is often limited to erect tree trunks protruding from the water. Wood ducks bypass this habitat to concentrate in coves where a gradual transition from land to water exists. As a result of this less abrupt transition, water is shallow and cover is often plentiful in the form of flooded trees, shrubs, and fallen logs. In natural rivers wood duck distribution appears to be random among areas, but is strongly correlated with the distribution of flooded shrubs and log jams (Prokop 1981). Such an observation indicates that distribution was not random, but rather followed the distribution of available cover.

If such cover becomes limited in river systems, their suitability as wood duck habitat undoubtedly decreases. This decrease in cover probably occurs on Oklahoma rivers during summer when lack of precipitation results in a reduction of river flow which in turn results in exposure of the stream bed. This decrease in riverine habitat quality corresponds with the lower observed wood duck densities.

In summer the need for dense cover becomes critical as wood ducks initiate their summer molt. Johnsgard (1975) notes that drakes desert incubating hens and move to secluded woodland swamps where they begin their summer molt.

Bellrose (1976) and Grice and Rogers (1965) noted the post-breeding emigration of both drakes and hens to wooded marshes where cover is abundant and dense. In the safety of thick cover, wood ducks molt their nuptial plummage and become flightless for approximately 3 weeks. The obvious reduction in wood duck densities observed on both flooded and natural rivers coincides with the period of their expected summer molt. The abandonment of natural rivers should not be unexpected since cover is drastically reduced due to low river flow. Impounded rivers, conversely, maintain high water levels throughout the year. At Lake Wister, water levels are raised 2 meters at the onset of summer to accomodate recreational activities. During this time, thousands of hectares are inundated with shallow water. Not surprisingly, wood ducks may seek the shelter of flooded rivers during their molt.

Natural wetlands (e.g., sloughs, oxbows) have been considered the most important wood duck habitat in Oklahoma (Heitmeyer 1980). This hypothesis seems to be supported by the data since few wood ducks were observed on river sections where wetlands were common. It must be realized, however, that natural wetlands are dynamic in their ability to maintain water levels (Heitmeyer 1980). During dry years they are not sufficiently recharged and it is during these times that impounded and natural rivers provide an important source of wood duck habitat in Oklahoma.

Dry periods would appear to be the best time to conduct river float counts. Our data indicates that counts made at this time would be less variable since most of the population would continuously be present. During spring 1981 Oklahoma was going through a prolonged drought and float counts at Lake Wister were considerably less variable than counts conducted the previous year.

It has generally been concluded that rivers provide poor brood rearing habitat. Hepp and Hair (1977) conclude that the primary function of rivers to wood ducks was as travel lanes. Higgins (1979) considered poor wood duck rearing habitat to characteristically have deep water and little available cover. Most reservoirs in Oklahoma fit these characteristics and therefore, lack the requirements for good rearing habitat: 75% cover, 25% open water (McGilvrey 1968). Our data seems to support the conclusion that reservoirs provide poor brood rearing habitat. Despite 20 summer float counts on impounded rivers at Lake Wister, only 2 broods were observed. Productivity is either very low or broods are seeking rearing habitat in the wetlands surrounding these impounded rivers. Further research on the ability of reservoirs to fulfill all wood duck needs is needed.

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Table 1 . Comparison of spring and summer wood duck river float counts at Lake Wister during 1980 and 1981 according to number of floats, mean number of ducks/km, standard deviation, and coefficient of variation.

Year	River	Number of Floats	$\bar{x}$	S.D.	C.V.
Spring					
	Fourche Maline	11	1.04	0.44	42.5
1980	Poteau (above dam)	5	0.62	0.27	44.3
	Poteau (below dam)	10	0.88	0.44	50.2
	Fourche Maline	3	1.39	0.29	20.8
1981	Poteau (above dam)	3	0.68	0.17	24.4
	Poteau (below dam)	3	1.17	0.14	12.1
Summer					
	Fourche Maline	7	0.39	0.30	75.0
1980	Poteau (above dam)	7	0.29	0.27	91.0
	Poteau (below dam)	5	0.65	1.02	156.6
	Fourche Maline	3	0.44	0.12	27.6
1981	Poteau (above dam)	3	0.45	0.16	35.2
	Poteau (below dam)	3	0.26	0.32	123.8

Table 2 . Mean number of ducks/km, standard deviation, coefficient of variation, and number of floats for natural flowing rivers during spring and summer 1981.

Season	River	Number of Floats	$\bar{x}$	S.D.	C.V.
	Poteau	3	1.08	0.27	25.0
Spring	Kiamichi I	3	0.84	0.20	23.3
	Kiamichi II	3	0.79	0.31	38.4
	Poteau	3	0.04	0.08	173.2
Summer	Kiamichi I	2[a]	0.19	0.32	123.8
	Kiamichi II	2[a]	0.04	0.07	173.2

[a] a third float was not completed so missing values were generated (Snedecor and Cochran 1967:317).

Table 3 . Number of float trips, mean number of ducks/km, standard deviation, coefficient of variation, and probability of means being equal between permanently flooded and natural riverine systems floated during spring and summer 1981 .

System	Number of Floats	$\bar{x}$	S.D.	C.V.	*P*[a]
Spring					
Natural	12	0.97	0.26	27.0	0.70
Flooded	6	1.04	0.44	43.1	
Summer					
Natural	10	0.13[b]	0.18	135.1	0.002
Flooded	6	0.45	0.13	28.4	

[a]based on analysis of variance.

[b]two float counts were not completed on the Kiamichi river. This mean includes 2 missing values generated (Snedecor and Cochran 1967:317).

Table 4. Student's t-test comparing habitat variable means between river sections having wood ducks versus those sections lacking any wood duck sightings for each river at Lake Wister during spring 1980 .

Habitat Variable	$\bar{x}_{(absent)}$	$\bar{x}_{(present)}$	P
Fourche Maline			
% flooded timber	36.00	58.29	0.0004*
% flooded shrub/scrub	15.15	13.14	0.62
% eroded bank	20.96	11.33	0.068
% exposed stream bed	19.19	4.48	0.014*
river width (ha.)	2.07	1.63	0.106
area natural wetlands (ha.)	1.19	1.11	0.911
total wetland area (ha.)	9.22	7.53	0.341
area forested (ha.)	98.33	121.50	0.01*
Poteau (above dam)			
% flooded timber	44.95	32.08	0.01*
% flooded shrub/scrub	6.30	22.50	0.10
% eroded bank	13.86	9.67	0.48
% exposed stream bed	4.04	4.25	0.95
river width (ha.)	2.34	1.35	0.0001*
area natural wetlands (ha.)	3.96	0.71	0.0001*
total wetland area (ha.)	23.41	2.67	0.0001*
area forested (ha.)	111.54	124.55	0.13
Poteau (below dam)			
% flooded timber	45.57	57.60	0.171
% flooded shrub/scrub	29.71	23.32	0.447
% eroded bank	5.86	3.56	0.478
% exposed stream bed	0.71	0.72	0.995
river width (ha.)	1.61	1.50	0.38
area natural wetlands (ha.)	4.63	6.00	0.53
total wetland area (ha.)	12.85	7.86	0.17
area forested (ha.)	89.25	76.48	0.27

*significant at the 0.05 level.

APPENDIX A

WOOD DUCK NUMBERS AND BROOD SIZES OBSERVED DURING FLOAT COUNTS

Table 1 . Number of wood ducks observed during each river float count and total km floated/river during spring 1981 .

River	Km Floated	Ducks Observed/Float 1	2	3
Caney	14.48	35	33	22
Illinois	14.50	24	21	28
Big Cabin Creek	10.09	26	27	28
Deep Fork I	12.71	13	10	11
Deep Fork II	15.93	16	8	16
Poteau	14.85	16	20	12
Poteau (below Wister Dam)	12.87	16*	13	16
Kiamichi I	15.53	13	10	16
Kiamichi II	16.41	18	13	8
Little	13.21	12	9	10
Blue	14.27	15	25	4
Muddy Boggy I	14.64	22	40	10
Muddy Boggy II	15.93	5	5	9
East Cache Creek	9.90	16	11	6
Washita	15.45	1	0	0
North Fork of Red	12.71	4	0	0
Wolf Creek	12.39	0	1	4
totals	235.87	252	246	202

*missing value generated (Snedecor and Cochran 1967:317) .

Table 2 . Number and size of broods observed during float counts during summer 1980.

River	Number of Broods	Brood Size(s)
Caney	1	1
Illinois	3	6,8,3
Verdigris	0	-
Deep Fork I	4	1,2,2,7
Deep Fork II	2	10,1
Poteau	1	7
Kiamichi I	1	4
Kiamichi II	0	-
Little	1	7
Blue	1	5
Muddy Boggy I	0	-
Muddy Boggy II	1	3
East Cache Creek	0	-
Washita	0	-
North Fork of Red	0	-
Wolf Creek	0	-
Total Broods	15	

Table 3 . Total number and size of broods observed during each river float count during summer 1981 .

River	Number of Broods	Brood Size(s)/Float 1	2	3
Caney	4	11[a],1,9	3	-
Illinois	6	2	7,5	6,4
Big Cabin Creek	6	10	3,5	3,3,3
Deep Fork I	0	-	-	-
Deep Fork II	0	-	-	-
Poteau	0	-	-	-
Poteau (Below Wister Dam)	1	5	-	-
Kiamichi I	2	-	1,7	-
Kiamichi II	1	7	-	-
Little	0	-	-	-
Blue	3	-	7	7,3
Muddy Boggy I	0	-	-	-
Muddy Boggy II	0	-	-	-
East Cache Creek	7	11[a],5,4,2	10,4	3
Washita	0	-	-	-
North Fork of Red	0	-	-	-
Wolf Creek	0	-	-	-
Total Broods	30			

[a]broods observed during spring counts.

APPENDIX A

LIST OF FIGURES

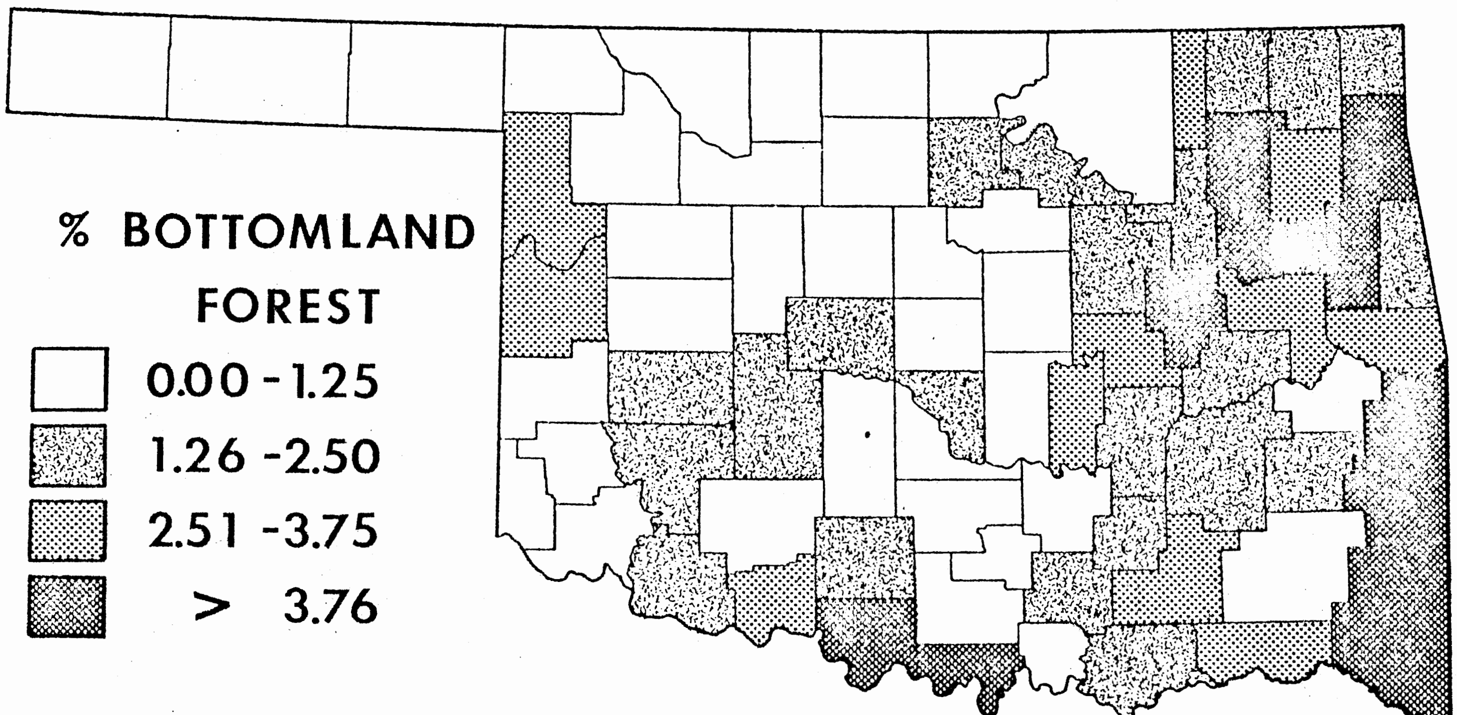

Fig. 1. Percent composition by area of bottomland forest for each county in Oklahoma as determined from Soil Conservation cover maps.

APPENDIX B

CLASSIFICATION OF RIVER SECTIONS

AND POISSON ANALYSIS FOR

LAKE WISTER RIVERS

Table 4. Classification and number of 0.80km river sections for each of the rivers floated at Lake Wister during 1980.

River	Total Distance Floated (km)	0.80km River Sections Flooded	Natural	Coves	Total
Fourche Maline	18.90	29	0	18	47
Poteau (above dam)	22.12	37	7	11	55
Poteau (below dam)	12.87	0	32	0	32
					134

Table 5. Analysis of wood duck distribution patterns along Lake Wister rivers using a Poisson test for randomness. Variance to mean ratios exceeding 1.0 indicate a clumped distribution, values equal to 1.0 suggest random distribution.

River	$s^2/\bar{x}$	Poisson t-value	df	P*
Fourche Maline	2.249	5.990	46	0.005
Poteau (above dam)	2.010	3.322	54	0.005
Poteau (below dam)	1.001	0.004	31	0.500

*probability of the ratio differing from 1.0.

APPENDIX B

LIST OF FIGURES

Fig. 1. Location of Lake Wister, situated in LeFlore County Oklahoma.

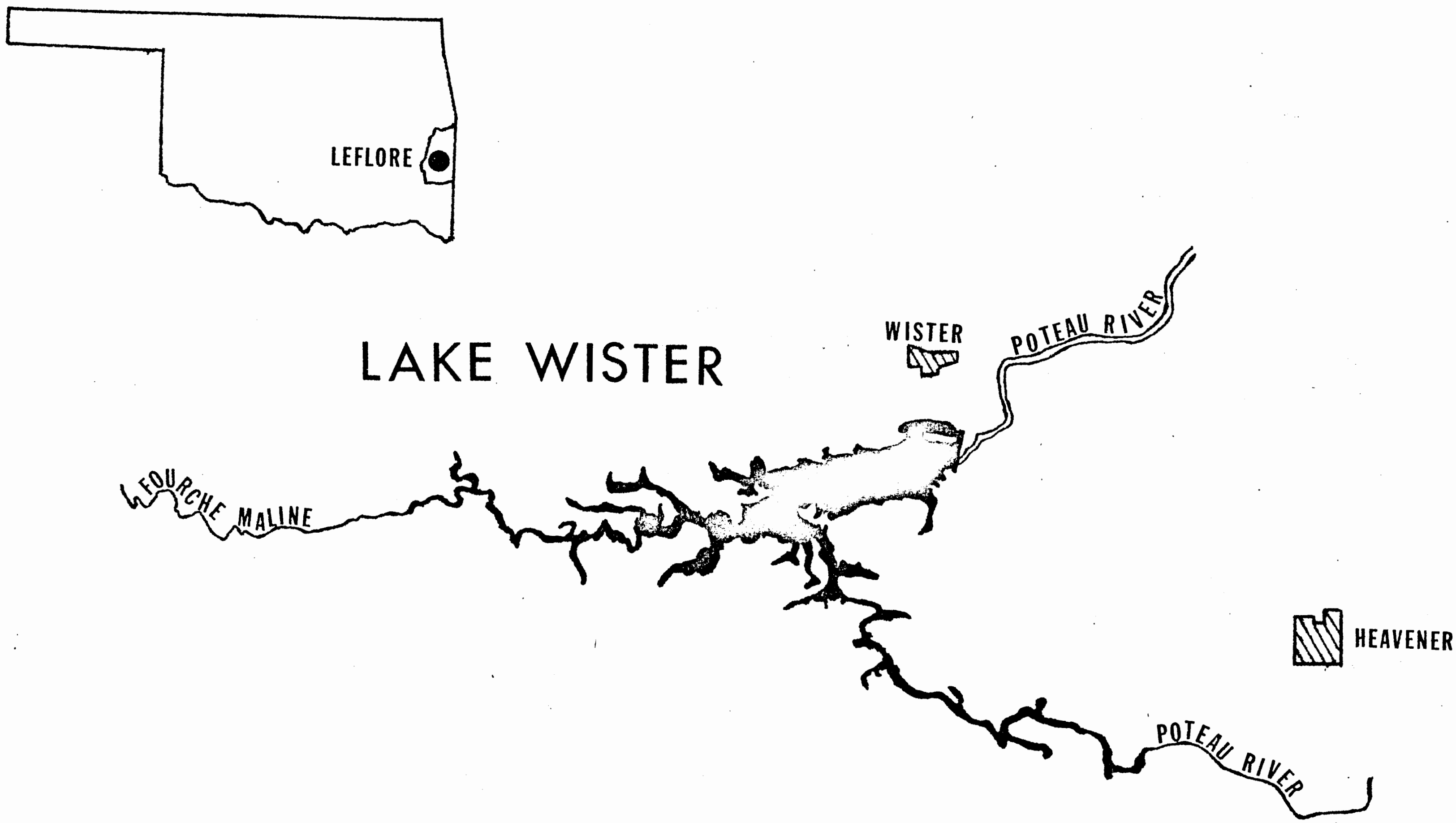

Fig. 1. Location of Lake Wister, situated in LeFlore County, Oklahoma.

VITA

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