Journal of the Arkansas Academy of Science

Volume 41 Article 16

1987

Distribution of Fishes in Reference Streams Within Arkansas' Ecoregions

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DISTRIBUTION OF FISHES IN REFERENCE STREAMS WITHIN ARKANSAS' ECOREGIONS

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ABSTRACT

The State of Arkansas has been subdivided into six ecoregions based on the homogeneity of land surface forms, potential natural vegetation, soil types and land uses. Reference streams of various sizes, excluding the large rivers, and with the least amount of point source and non-point source disturbances were selected for intensive physical, chemical and biological sampling. These data are to be used to characterize the streams and establish water quality criteria which will protect all stream uses. Fish communities of the reference streams were distinctively different among the ecoregions and can easily be used to characterize the waters of different ecoregions. Although composed of different species, the composition of trophic feeding levels of the fish community was very similar among the ecoregions. The average number of species collected per sample site was similar among the ecoregions; however, the Arkansas River Valley and the Gulf Coastal ecoregions had the greatest species richness and the Delta ecoregion was the lowest in species richness. Species of fish sensitive to environmental change comprised near 50% or more of the community relative abundance in the Boston Mountains, Ozark Highlands and Ouachita Mountains ecoregions. Delta ecoregion fish populations contained less than 1% sensitive species. Comparisons of the ten most abundant species from each ecoregion by use of a similarity index shows very little similarity among the ecoregions. The Ouachita Mountains and Boston Mountains communities were most similar and the Ozark Highlands community versus Delta and Ozark Highlands versus Gulf Coastal were least similar.

INTRODUCTION

The delineation of regions that are distinctly homogeneous has been done by resource managers for decades in an effort to more efficiently manage a variety of natural resources. Many of the early attempts established physiographic regions based on geographic characteristics, regions of similar vegetation type and regions of various land use patterns. These were all single character classifications with specific needs in mind. Later, in an attempt to characterize ecological relationships, several workers incorporated various combinations of multiple characteristics such as soils, climate, water resource, vegetation, land uses and others into ecoregions classifications (USDA Soil Conservation Service, 1981; Bailey, 1976; Warren, 1979).

Most recently, Hughes and Omernik (1981) and Omernik *et al.* (1982) proposed methods for development and uses for ecoregions. The potential uses of these ecoregions include: (1) comparisons of land/water relationships within a region; (2) establish realistic water quality standards for regional rather than a large scale application; (3) location of monitoring and reference sites; (4) extrapolate from site specific studies; and (5) predict effects and monitor environmental changes resulting from pollution control activities (Omernik and Gallant, 1986).

The ecoregions of Omernik (1987) were developed from four small-scale maps of interrelated land characteristics. These include: land uses, land surface forms, potential natural vegetation and soil types. The regions are delineated as the areas of greatest homogeneity. Within each region, the areas which share all of the characteristics that typify the ecoregion are distinguished as the most typical area. Areas which share most but not all of the similar characteristics are designated as generally typical of the region.

The ecoregions within Arkansas and surrounding areas were developed for the U.S. Environmental Protection Agency, Region VI, Dallas and for the Arkansas Department of Pollution Control and Ecology to assist with Arkansas' stream reclassification project. The ecoregions in Arkansas include six distinct regions: (1) Ozark Highlands; (2) Boston Mountains; (3) Arkansas River Valley; (4) Ouachita Mountains; (5) West Gulf Coastal Plains; and (6) Mississippi Alluvial Plain (Delta). These regions are very similar to the natural divisions and sub-divisions of Arkansas as described in *Arkansas Natural Area Plan* (Foti, 1974) and further refined by Pell (1983). The natural divisions of Foti were developed from factors such as: primary vegetation, topography, surface geology, soils and surface hydrology.

Ground reconnaissance and field investigations have resulted in a slight modification of the western segment of the ecoregion boundary between the Arkansas River Valley and the Ouachita Mountains from that purposed by Omernik (1987).

MATERIALS AND METHODS

In order to characterize the physical, chemical and biological features of the biotic environments within each of Arkansas' ecoregions, the Arkansas Department of Pollution Control and Ecology selected a series of streams of varying sizes within each ecoregion for detailed investigation. These reference streams were selected, where possible, within the most typical area of the ecoregion, and only streams with the least amount of point and non-point source disturbances were chosen. A sample site on each stream was established, and both low-flow, high-temperature summertime and steady-state flow, springtime sampling was done. The sampling included detailed measurements of the physical features of the stream, analysis of 18 water quality parameters, a 72-hour continuous record of dissolved oxygen and water temperature, intensive sampling of the stream macroinvertebrate population and a comprehensive fish population sample.

The summer fish population sampling was done with the fish toxicant rotenone or with electrofishing devices. Most of the spring sampling was done with trammel nets of mesh sizes from 2.5 to 8.9 cm. Spring fish sampling was to identify migratory fishes in the area and verify fish spawning activities. The summer sampling identified the total resi-

dent fish population and established the relative abundance of each species.

Sample sites with very small or no flow, with reduced visibility into the water and with numerous instream obstructions were sampled with rotenone. If flow existed at these sites, a block net was utilized at the downstream limit of the sample area and the rotenone was detoxified with potassium permanganate below the sample area. Areas sampled ranged from about 0.1 to 0.4 ha.

Electrofishing gear was used at sites which had substantial flow, high visibility into the water and where much of the stream could be waded by workers in chest-waders. A gasoline powered generator with 3500 watt A.C. output was used as a power source. The electrodes were energized directly from the generator. Swift flowing riffle areas were blocked with a seine and stunned fish were allowed to drift into the seine. Sampling was done in an upstream direction and the sample areas were usually from 0.4 to 1.6 km in length. All areas that could be efficiently worked were sampled until it became apparent that all existing habits had been sampled and the fish species and their relative abundance was well established by the sample.

All fishes possible were dipped from the water and preserved in 10% formalin for later identification and enumeration. When large numbers of the same species were observed while electrofishing, only an occasional "dip" sub-sample was made but notes on the species abundance were recorded. Each fish species from all summer samples was given a relative abundance value as described below:

4 — Abundant — Species or age group collected easily in a variety of habitats where species expected; numerous individuals seen with consideration of sampling gear limitations and expected abundance of such species; a dominant species of the species group.

3.5 — Common to Abundant

3 — Common — Species or age group collected in most areas where such species would exist; individuals frequently seen and apparently well established in the population; one of the more frequent species of the species group.

2.5 — Present to Common

2 — Present — Species or age group collected with enough frequency to indicate the likely presence of an established population but definitely a subordinate species in the species group.

1.5 — Rare to Present

1 — Rare — Species or age group represented by only one or very few individuals in the population; more than likely a remnant, migrant or a displaced species.

Values are assigned to the adult, intermediate and young age group of each species; therefore, the maximum value for a species is 12 and the minimum is 1.

These values were determined from the number of fish in each species size group, field observations of fishes which were not collected, general knowledge of fish species life history, selectivity of the sample gear and limitations existing at the sample site. Extensive efforts were not made to determine an accurate separation of the young and intermediate age groups of each species. These determinations were based on the presence or absence of a variety distinctive size groups. All calculations of percent of the total community were made with the relative abundance values.

RESULTS AND DISCUSSION

General location of each sample site on the selected reference streams within Arkansas' six ecoregions are shown in Figure 1. A list of the reference streams with the size of the watershed and the stream gradient at the sample site is given in Table 1. Also included are the

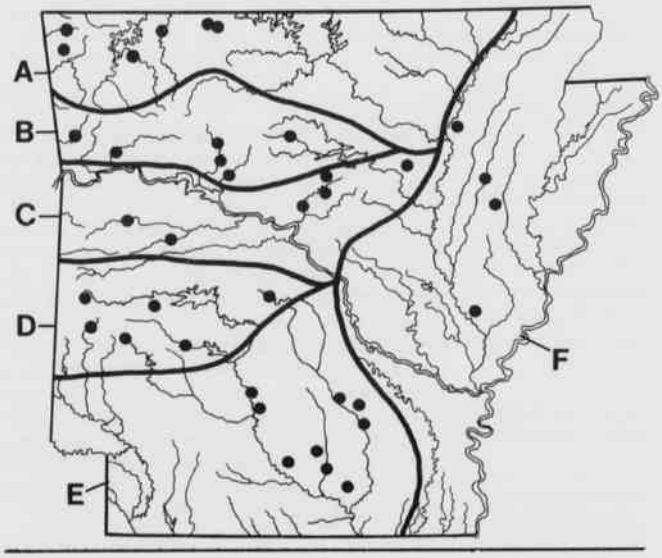

Figure 1. Reference stream sample sites within Arkansas Ecoregions with locations of sample sites on reference streams.
A - Ozark Highlands;
B - Boston Mountains;
C - Arkansas River Valley;
D - Ouachita Mountains;
E - Gulf Coastal Plains;
F - Mississippi Alluvial Plains (Delta)

Table 1. List of reference streams within each ecoregion with watershed size, stream gradient and flows at sample sites.

Stream	Watershed Size (km^2)	Stream Gradient(m/km)	Summer Flow(M^3/s)	Spring Flow(M^3/s)
OZARK HIGHLAND ECOREGION				
South Ford Spavinaw	46.8	4.8	0.04	0.51
Flint Creek	49.4	3.7	0.14	0.81
Yocum Creek	143.0	3.4	0.16	4.86
Long Creek	478.4	1.3	0.29	5.49
War Eagle Creek	683.8	0.8	0.75	3.06
Kings River	1367.6	0.9	1.46	7.56
BOSTON MOUNTAINS ECOREGION				
Indian Creek	122.2	6.1	T	0.57
Hurricane Creek	130.0	6.3	T	0.90
Archey Creek	278.2	2.7	0.02	3.66
Illinois Bayou	325.0	2.4	0.03	4.41
Lee Creek	436.8	2.9	0.11	9.00*
Mulberry River	969.8	2.6	0.19	9.00*

ARKANSAS RIVER VALLEY ECOREGION				
Mill Creek	44.2	2.6	0	0.30
No. Cadron Creek	54.6	1.9	T	0.30
Ten Mile Creek	127.4	1.5	T	3.15
Dutch Creek	286.0	0.7	0.02	2.10
Petit Jean River	626.6	0.7	0.09	9.00*
Cadron Creek	800.8	0.1	0.45	15.00*
OUACHITA MOUNTAINS ECOREGION				
Board Camp Creek	49.4	5.3	0.08	0.59
Little Missouri River	78.0	5.5	0.12	0.77
South Fork Quachita	119.6	1.3	0.20	1.01
Cossatot River	312.0	7.6	0.52	2.92
Caddo River	756.6	2.5	4.02	15.00*
Saline River	938.6	0.8	1.59	12.00*
GULF COASTAL ECOREGION				
E. Fork Tulip Creek	119.6	0.7	0.16	1.68
Cypress Creek	189.8	0.8	0.32	4.50
Whitewater Creek	59.8	0.5	0	0.07
Big Creek	153.4	0.5	0	0.02
Derrieusseaux Creek	384.8	0.7	0	6.00
Freeo Creek	405.6	0.6	0	0.48
Hudgins Creek	486.2	0.3	0	9.00*
L'Aigle Creek	603.2	0.5	0	5.66
Moro Creek	1172.6	0.3	0	10.50
DELTA ECOREGION				
Boat Gunwale Slash	59.8	0.1	0.09	6.90
Second Creek	156.0	0.2	0.23	4.95
Village Creek	504.4	0.1	4.01	1.05
Bayou DeView	1196.0	0.1	5.73	15.00*

T = Less than 0.01

*Flow estimated

stream flows which existed during the spring and summer sample periods. The range of watershed sizes among all sites is from 44.2 to 1367.6 km². Stream gradients are from 0.095 to 7.6 m/km.

Fish habitat was measured at each site during the summer sampling along numerous stream transects. Instream fish cover such as brush, logs, debris, undercut banks, aquatic vegetation and low-overhanging vegetation was measured directly along each transect and converted to percent of stream width. Stream substrate was also measured along each transect. Both the Delta and Gulf Coastal ecoregions are dominated by instream fish habitat such as brush, logs and debris. The Arkansas River Valley is highly variable in the type of fish habitat; however, from all sample sites, approximately 30% of the fish habitat is similar to that of the Delta and Gulf Coastal region and about 70% is dominated by substrate types which provide desirable fish cover. The Boston Mountains, Ozark Highlands and Ouachita Mountains ecoregion streams are heavily dominated by fish habitat provided by substrate. These differences in fish habitat among the ecoregions produce distinctly different fish communities.

The distribution of fishes within the five major fish families of the State are shown for each ecoregion in Figure 2. The Delta and Gulf

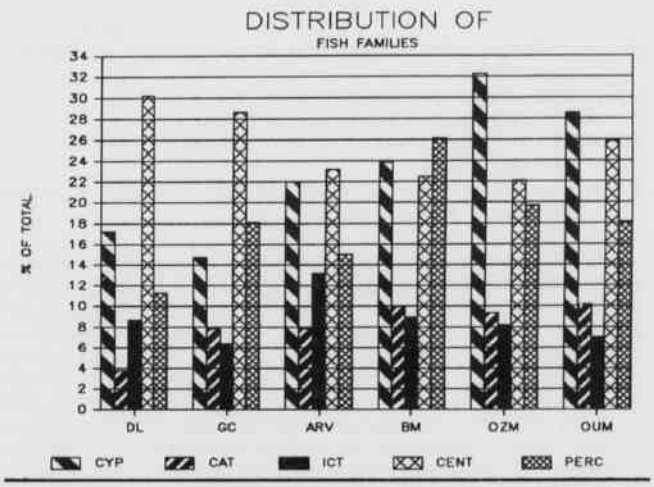

Figure 2. Distribution of fishes within the fish families of Cyprinidae (CYP), Catostomidae (CAT), Ictaluridae (ICT), Centrarchidae (CENT) and Percidae (PERC) for reference streams within each ecoregion.

Coastal ecoregions are distinctively dominated by the Centrarchidae. The Arkansas River Valley is also dominated by Centrarchidae but Cyprinidae is only slightly sub-dominant. Percidae dominates the Boston Mountains fishes but are followed closely by Cyprinidae and Centrarchidae. The Ozark Highlands are strongly dominated by Cyprinidae followed by Centrarchidae and Percidae. Similarly the Ouachita Mountains communities are dominated by Cyprinidae although not as distinctively as in the Ozark Highlands.

The secondary trophic feeding level (marcroinvertebrate feeding fishes) dominates the fish communities of all regions. These comprise 70 to 80% of the relative abundance values. Primary feeders normally make up less than 10% of the community and carnivores constitute 10 to 15% of the community. Primary feeding fishes are least abundant in the Gulf Coastal ecoregion where two samples contained no primary feeders. They are most abundant in the Ozark Highlands. This region also contains the highest levels of nitrogen in the water of the reference streams.

A list of Arkansas fishes which are sensitive to slight to moderate environmental changes were developed from a concensus of knowledgeable ichthyologist. These species make up less than 0.2% of the relative abundance value of all Delta ecoregion communities. Gulf Coastal and Arkansas River Valley fish communities contain approximately 10 to 15% sensitive species. In contrast, sensitive species make up about 50% or more of the communities in the Ozark Highlands, Boston Mountains and Ouachita Mountains ecoregions. Over 66% of the Ozark Highlands fishes are sensitive species.

The average number of species collected per site is very similar among the ecoregions. However, the total number of species collected per ecoregion was as follows: Arkansas River Valley 75, Gulf Coastal 66, Ouachita Mountains 61, Boston Mountains 60, Ozark Highlands 60, and Delta 51. Although it is realized that not all species present within each ecoregion were collected, it is felt that the majority of the more common species within the least-disturbed streams were identified. Areas inadequately sampled within the ecoregions were the large rivers.

The relative abundance value for each species was added for all reference streams where it occurred within each ecoregion and the species were listed in descending order of abundance within the region (ADPC&E 1987). The similarity index from Odum (1971) was modified

to use these relative abundance values as follows:

$$SI = \frac{C}{A+B+D} \times 1000$$

SI = similarity index (range from 0 to 100; 100 = identical populations)
A = total relative abundance value of sample A
B = total relative abundance value of sample B
C = sum of relative abundance values of species common to both samples
D = sum of difference in relative abundance values of species common to both samples

Only the ten most abundant species from each ecoregion were subjected to the index for comparison, but all possible comparisons among the six ecoregions were made. The results are shown in Table 2. The greatest similarity exist between the Ouachita Mountains and the Boston Mountains fishes. The least similarity is between the Ozark Highland versus Gulf Coastal and between the Ozark Highlands versus Delta fishes. It is apparent from the similarity indices that there is very little similarity of the 10 most abundant fishes from each of the six ecoregions within the State. This substantiates the distinctiveness of these ecoregions as reflected in the fish communities of the least-disturbed streams.

Table 2. Similarity indices from comparisons of relative abundance values of the ten most abundant fish species of all ecoregions.

	ECOREGIONS				
	BOSTON MTNS.	OZARK HIGHLAND	AR RIVER VALLEY	DELTA	GULF COASTAL PLAINS
OUACHITA MTNS.	62	32	21	11	11
BOSTON MTNS.		39	40	10	10
OZARK HIGHLAND			19	9	9
AR RIVER VALLEY				36	29
DELTA					58

CONCLUSIONS

Fish communities of least-disturbed reference streams within Arkansas' six ecoregions are distinctive and can be used to characterize a segment of the biota of each region. The ten most abundant species from each ecoregion are substantially dissimilar and the relative abundance of fishes within the major fish families is characteristically different among the ecoregions. The greatest species diversity was found in the Arkansas River Valley ecoregion and was a result of a great diversity of stream types. The Delta ecoregion showed the lowest fish species richness. The composition and proportion of sensitive fishes within the ecoregions is distinctive, particularly between the upland and lowland type regions. It is apparent that fish communities are sufficiently distinctive to be used to characterize waters of the various ecoregions, to establish specific communities to be protected and to monitor for environmental changes.

ACKNOWLEDGEMENT

This project was part of a wide scope project funded under Section 205(j) of the Clean Water Act and administered through the Environmental Protection Agency, Dallas Region. The field work was performed by numerous members of the Water Division of the Arkansas Department of Pollution Control and Ecology and assisted by Fisheries Biologist from the Arkansas Game and Fish Commission.

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