Comparison of the Fish Populations and the Abiotic Characteristics of a Channelized and Unchannelized Stream in the Delta Area of Arkansas

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ABSTRACT

The physical, chemical and biological characteristics of a channelized and an unchannelized stream in the delta area of eastern Arkansas were compared through intensive sampling during the week of July 30 through August 3, 1984. Physiographic location, size of watershed and measured flows were similar in Brushy Creek and Second Creek. In contrast, Brushy Creek exhibits severe channelization, removal of instream and riparian vegetation and cultivation to the edge of the stream channel; whereas Second Creek demonstrates very little channel alteration or instream and riparian cover removal. Over 95% of the drainage area of Brushy Creek is in intensive agriculture operations; land uses in the Second Creek watershed are about 65% agriculture. Water quality measured during low flow did not exhibit great differences between the streams, although higher levels of turbidity, TDS, sulfates, alkalinity, hardness, maximum dissolved oxygen and dissolved oxygen percent saturation were noted in Brushy Creek. The fish populations in Brushy Creek and Second Creek were distinctively different as a result of the absence of instream habitat in Brushy Creek and the abundance of such habitat in Second Creek. The total fish biomass, number of species, total relative abundance value and diversity index were higher in the unchannelized stream than in the channelized stream, and the fish species in Brushy Creek were characteristic of high-turbidity and sparce instream cover habitats. It was apparent in the physical characteristics

as well as in the deteriorated fish populations that channelization has adversely affected the biotic and abiotic character of Brushy Creek.

INTRODUCTION

The Water Division of the Arkansas Department of Pollution Control and Ecology (ADPC&E) initiated a program in early 1983 to develop area-specific water quality standards for selected waters of the state to protect their existing uses. With a grant from the U.S. Environmental Protection Agency, 205(j), the project was designed to reclassify the streams of the state according to their existing physical, chemical and biological characteristics. The least disturbed streams within each physiographic region were established as reference streams and are being intensively sampled to establish baseline data.

Considerable difficulity was encountered in locating least-disturbed reference streams in the highly agriculturalized delta area of eastern Arkansas. However, the opportunity existed to compare one of the reference streams in the delta with a similar size and closely related stream of that area which has been channelized for agriculture drainage. Second Creek in St. Francis County and tributary to the L'Anguille River was selected as one of the least-disturbed reference streams. For comparison the channelized Brushy Creek in Cross and Poinsett Counties was selected. It is also a tributary to the L'Anguille River (Fig. 1).

Description of Study Area

Brushy Creek originates in Poinsett County near Weiner, Arkansas, flows southward through the highly agriculturalized sections of Poinsett and Cross Counties and enters the L'Anguille River west of Wynne, Arkansas. Watershed land uses are 95.8% agriculture and 4.2% forestland (ASWCC, Non-point Source Pollution Assessment Summaries for St. Francis River Basin, 1979). Most of the forestland is located below the sample site and near the confluence with L'Anguille River. Channel modification of the upper 90% of Brushy Creek was completed prior to 1974 and was probably accomplished on a segment by segment basis by local interest. Channel maintenance and clean-out is a local landowner responsibility and appears to be very active. The sample site was at Highway 42 bridge approximately 5.6 km east of Hickory Ridge, Arkansas (Fig.1).

Second Creek begins near the Woodruff-Cross County line and meanders southwesterly then southeasterly across the western part of St. Francis County entering the L'Anguille River about 8.1 km northwest of Forrest City, Arkansas. Land uses in the watershed are 64.5% agriculture and 35.5% forest,most of which is bottomland type forest. This stream was sampled at county road crossing between Palestine and Horton in Section 17, Township 5 N, Range 2 E.

Materials and Methods

Standard sampling procedures have been established for each reference stream investigation. The investigation program requires sampling over a one week period (Monday through Friday) for each stream site. Two streams in close proximity were sampled concurrently. The established standard methodology was used to sample both Brushy Creek and Second Creek during the week of July 30 through August 3, 1984.

Physical characteristics of the stream site to be sampled were determined by establishing a stream reach which includes a length of the stream that was 15 times the stream width where stream flow measurements were taken. Stream flow measurements were made on a transect of the stream which was not widened by a pool or narrowed by a riffle. Ten transects were evenly spaced within the stream reach and taped measurements made along each transect for stream channel width, stream width, substrate type, instream cover and riparian cover. Stream depth and flow velocity were measured at 0.6 m intervals across this transect. Velocity was measured with a Marsh-McBirney, Model 201, portable water current meter. Mean stream flow velocity was measured using tracer dye over a representative reach of stream to determine time of travel.

Water quality was determined from the average of three grab samples. Samples were iced and returned to ADPC&E water lab for

analysis. Analytical procedures followed were as described in Standard Methods, 14th Edition. Parameters measured include: pH, turbidity, total suspended solids, total dissolved solids, BOD_5, BOD_{20}, total phosphorus, PO_4-phosphorus, NO_2 + NO_3-nitrogen, NH_3-nitrogen, chlorides, sulfates, total iron, conductivity, alkalinity, total hardness, fecal coliform and total manganese.

Two continuous recording dissolved oxygen and temperature meters (YSI Model 56) were installed at each site on the first day of the sample period and were operated continuously until the end of the period. Meters were calibrated daily using the Winkler Azide method.

Fish population sampling was accomplished by treating approximately 0.16 ha of each stream with approximately 2 ppm powdered rotenone containing 7% active ingredient. Block nets were used at the lower end of the sample area to block movements of fish out of the sample area and to collect dead and dying fish drifting downstream. Rotenone was detoxified with potassium permanganate immediately below the sample area. Fishes were dipped from the water by workers with hand held dip nets. All small fish were preserved in 10% formalin for laboratory indentification and large fishes were identified, counted and weighed in the field. Each species of fish was given a relative abundance value based on observations and subjective judgement of experienced fishery workers in the collecting crew and based on

final enumeration of preserved specimens. Values ranged from four for abundant species to one for rare species and are assigned in one-half unit increments. Values were also given for each age group for each species. Age groups included adult, intermediate and young. The maximum relative abundance value for a species was 12 with a minimum value of one. The Shannon-Wiener dominance diversity index (Shannon, C.E. and W. Weaver, The Mathematical Theory of Communication, University of Illinois Press, 1963) and other comparative parameters such as percent primary feeders, secondary feeders, top carnivores, Percidae, etc. are calculated using relative abundance values instead of numbers of individuals. It is felt that the relative abundance values more adequately reflect the abundance of a species than do actual numbers of individuals collected. In typical populations some fish species exist in very large numbers whereas other fishes, particularly predator species, exist in comparatively low numbers though they may be saturating their existing ecological niche.

RESULTS AND DISCUSSION

Brushy Creek and Second Creek offer an excellent opportunity to compare the physical, chemical and biological characteristics of two physiographically similar streams. One has been relatively undisturbed for a delta area stream and the other has had severe channel realignment and straightening, removal of riparian

vegetation and cultivation to the edge of the stream channel.

Physical Characteristics

Brushy Creek drains 164 square km^2 above the sample site. Stream gradient was 0.35 m/km, channel width was 14.8 m with a stream width on the sample date of 8.3 m. Average depth was approximately 0.6 m with a flow velocity of 0.15 m/sec and a calculated flow of 0.2 m^3/sec. The flow noticably varied each day in response to drainage of irrigation water. The stream substrate was 90% mud and silt; some gravel and large rocks were present, but most likely were from road and bridge construction materials. Instream cover existed in only 2% of the area and was composed of brush, logs and debris which had collected beneath the highway bridge. There was no stream canopy and the riparian ground cover was predominantly grasses and bare ground, but the banks appeared to be moderately stable.

One hundred fifty-six km of watershed exist above the sample site on Second Creek. Stream gradient was 0.14 m/km. Channel width at the sample site was 19.3 m and mean stream width was 12.9 m. Estimated mean water depth was 0.76 m with a stream velocity of 0.09 m/sec and a calculated flow volume of 0.2 m^3/sec. Instream substrate types were predominantly mud and silt. Cover was measured as 0.4% undercut banks; 35% brush, logs and debris; 6.4% overhanging vegetation and 0.9% innundated vegetation. The sample

reach was 70% moderate pools and 30% shallow pools. Stream canopy was 55% and was predominantly bottomland hardwood and some wetland type timber. The bank was 80% stable. The water was relatively clear, but a shallow layer of fine silt covered much of the bottom and was easily dispersed into the water column by bottom disturbances. Resettling of silt and clearing of water could be observed over a short period of time. Flow fluctuations as a result of irrigation water drainage was apparent.

Water Quality

Table 1 compares selected water quality parameters from Brushy Creek and Second Creek. This data is the mean of the three grab samples taken at each site on the sample date, except the dissolved oxygen and D.O. saturation data are the extremes measured from a continuous 72 hour recording. Higher values of turbidity, total suspended solids, total dissolved solids, sulfates, alkalanity and total hardness in Brushy Creek are reflective of greater levels of agriculture drainage. Stream flows during the sample period were predominantly from drainage of irrigation water and therefore are not indicative of moderate or heavy rainfall runoff. There is no doubt that significant increases in turbidity occurs in Brushy Creek following heavy rainfall. It is suspected that the higher TDS, sulfates, alkalinity and hardness in Brushy Creek may have resulted from crop fertilization and/or the use of ground water for irrigation.

A 72 hour continuous recording of dissolved oxygen, temperature and D.O. saturation at two stations on both streams was made. Diurnal fluctuation of D.O. is apparent on both streams although Brushy Creek D.O. fluctuated approximately 7 mg/l daily from a maximum of 12 mg/l to a minimum of 4.6 mg/l. Second Creek varied about 4 mg/l per day and ranged from 8.1 mg/l to 3.5 mg/l. Dissolved Oxygen saturation levels approached 100% in the afternoon and dropped to near 15% just before daylight on Second Creek. In contrast D.O. saturation ranged from about 25% to highly supersaturated during the same time periods on Brushy Creek. Although not readily apparent, a short-strand, brownish-green filamentous algae was attached to the stream bottom on Brushy Creek. Much of this was broken loose during fish sampling and was trapped in the block nets. Second Creek had a noticeable population of long-strand, green filamentous algae; however the absence of a stream canopy on Brushy Creek may have increased D.O. production by photosynthesis thereby causing D.O. supersaturation during daylight hours.

Fish Populations

Distinctive fish population differences existed between Brushy Creek and Second Creek. These differences resulted primarily from the absence of instream fish habitat in Brushy Creek; however the dominant fish species in Brushy Creek were those more tolerant of high turbidity levels. Table 2 compares some general parameters

and indices (using relative abundance values) from the two populations. Total number of species, standing crop, total relative abundance value and diversity index were substantially higher in Second Creek than Brushy Creek. Although the difference in the diversity indices from the two creeks was only 0.95 units, this difference is substantial. The use of relative abundance values instead of number of individuals produces diversity indices which are higher and numerically more similar; however their comparisons are valid and the relation of the two populations is accurately reflected. The total fish biomass in Second Creek was 56% higher than in Brushy Creek. The Brushy Creek population was dominated by one species in five different families whereas the Second Creek population had seven species of Centrarchids totaling 22.4% of the total relative abundance value; six species of Cyprinids with 12.9% of the value and four species of Percids composing 15.3% of the total (Figure 2).

The trophic feeding structure of the two populations is also notably different. Primary feeders composed of detritivores, planktavores and omnivores which feed on a substantial amount of plant material comprised 12.9% of the Brushy Creek population, but only 5% of the Second Creek fishes. In contrast, top carnivores (fish and crayfish feeders) comprised only 2.2% of the Brushy Creek population and 14.6% of the Second Creek population (Figure 3). High or notably increasing populations of primary feeders often indicate habitat and/or water quality deterioration while

strong populations of top carnivores indicate a healthy diverse community (Karr, J. Fisheries, 6(6): 21-27, 1981).

The Jaccard Index of qualitative similarity between the Brushy Creek and Second Creek population was calculated to be 0.56. This indicates approximately an equal level of similarity and dissimilarity among the species of both samples. The range of values calculated from this index is from 0 to 1. Values closest to zero indicate little similarity among the comparative populations while values near one indicate structurally similar populations (Jaccard, P. New Phytol., 11:37, 1912).

Of the 36 species of fish collected in the two samples only 20 species occurred in both samples. Table 3 list all species collected with the relative abundance value assigned to each species and the number of individuals collected. The species are listed in numerical order of relative abundance value in Second Creek. The most abundant species collected in Second Creek were pirate perch (Aphredoderus sayanus), bluegill (Lepomis macrochirus), largemouth bass (Micropterus salmoides) and bluntnose darter (Etheostoma chlorosomum). Other species common to this sample were several species of sunfishes (Centrarchidae), two additional species of darters (Percidae), topminnows (Fundulus spp.), yellow bullhead (Ictalurus natalis) and mosquitofish (Gambusia affinis). In Brushy Creek the mosquitofish, blacktail

shiner (Notropis venustus), channel catfish (Ictalurus punctatus), drum (Aplodinotus grunniens) and gizzard shad (Dorosoma cepedianum) were the dominant species. Of the ten most abundant species in both samples, only the mosquitofish was abundant or common at both sites (Table 4).

The fish population in Second Creek was a diverse, healthy and typical population of a lowland delta stream characterized by species of relatively fertile waters which associate with instream cover. In contrast, the Brushy Creek population had a comparatively low species diversity. Eight of the 21 species were represented by only one or two individuals and the dominant species were typical of turbid water habitats and sparce instream cover.

Table 1. Comparison of Water Quality Parameters of Brushy Creek and Second Creek on July 31, 1984.*

Parameter	Brushy Creek	Second Creek
Flow - m^3/sec.	0.2	0.2
Temp - ^oC	25.5	24.7
pH	7.6	7.5
Turbidity - NTU	26.7	7.5
TSS - mg/l	36.3	11.3
TDS - mg/l	342.7	247.5
T.-Phos.-mg/l	0.11	0.10
NO_2-NO_3-N-mg/l	0.08	0.12
NH_3-N-mg/l	0.05	0.07
SO_4-mg/l	24.3	8.0
Alkalinity-mg/l	248	163
T. Hardness-mg/l	248.7	181.3
Dissolved Oxygen mg/l(min-max)**	4.5-12.1	3.4-8.2
D.O. saturation-% (min-max)**	53->100	39-100

* Average of three samples taken on same date.

** Taken from continuous recording meters at two stations over a 3-day period at each site.

Table 2. Comparison of Fish Population Data from Brushy Creek and Second Creek August 1-2, 1984.

	Brushy Creek	Second Creek
Area sampled (hectares)	0.13	0.19
Total wt. of fish (kg)	21.6	51.1
Standing crop (kg/ha)	171.9	268.6
Total species	21	35
Total Relative Abundance Value	89	209.5
Dominance Diversity Index (R.A. Value)	3.85	4.79
Primary feeders	12.9	5.0
Secondary feeders	84.8	80.4
Top Carnivors	2.2	14.6
Percidae	2.2	15.3
Cyprinidae *	21.9	12.9
Catostomidae	1.7	1.9
Centrarchidae **	13.5	22.4
Ictaluridae	19.7	8.4

* Excludes Carp

** Excludes Black Basses and Crappies

Table 3. Comparison of Relative Abundance Values and Number of Individual Fishes Collected in Brushy Creek and Second Creek.

Species	Brushy Creek R.A.	Brushy Creek No.	Second Creek R.A.	Second Creek No.
Aphredoderus sayanus	-	-	12	107
Lepomis macrochirus	2	27	12	381
Micropterus salmoides	2	2	12	72
Etheostoma chlorosomum	1	2	12	226
Lepomis megalotis	2	25	10.5	233
Gambusia affinis	12	150	10.5	75
Ictalurus natalis	5	27	9	30
Fundulus notatus	-	-	9	25
Fundulus olivaceous	-	-	9	19
Lepomis gulosus	-	-	9	86
Lepomis punctatus	1	1	9	70
Pomoxis nigromaculatus	-	-	9	62
Etheostoma asprigene	-	-	9	80
Etheostoma proeliare	-	-	9	67
Notropis fumeus	-	-	8	47
Notropis atherinoides	5.5	14	7.5	37
Notropis emiliae	-	-	7.5	33
Lepisosteus oculatus	-	-	7	35
Noturus gyrinus	6	15	6	25
Aplodinotus grunniens	8.5	59	4.5	19
Lepomis cyanellus	2	5	4	23
Dorosoma cepedianum	8	431	3	44
Ictalurus punctatus	11.5	746	2.5	7
Notropis venustus	12	309	2	7
Ictiobus bubalus	1.5	4	2	4
Ictiobus niger	-	-	2	4
Elassoma zonatum	-	-	2	3
Etheostoma gracile	1	1	2	3
Cyprinus carpio	1	1	1.5	2
Lepomis microlophus	-	-	1.5	4
Pomoxis annularis	3.5	8	1.5	2
Hybognathus hayi	1	1	1	1
Notemigonus crysoleucas	1	1	1	2
Lepomis symmetricus	-	-	1	1
Micropterus punctulatus	-	-	1	1
Centrarchus macropterus	1	1	-	-

Table 4. Comparison of Dominant Species from Brushy Creek and Second Creek Fish Population Samples.

Species	Relative Abundance Value	
	Brushy Creek	Second Creek
A. sayanus	-	12
L. macrochirus	2	12
M. salmoides	2	12
E. chlorosomum	1	12
L. megalotis	2	10.5
G. affinis	12	10.5
N. venustus	12	2
I. punctatus	11.5	2.5
A. grunniens	8.5	4.5
D. cepedianum	8	3

Figure 1. Brushy Creek and Second Creek Area Map and Sample Sites.

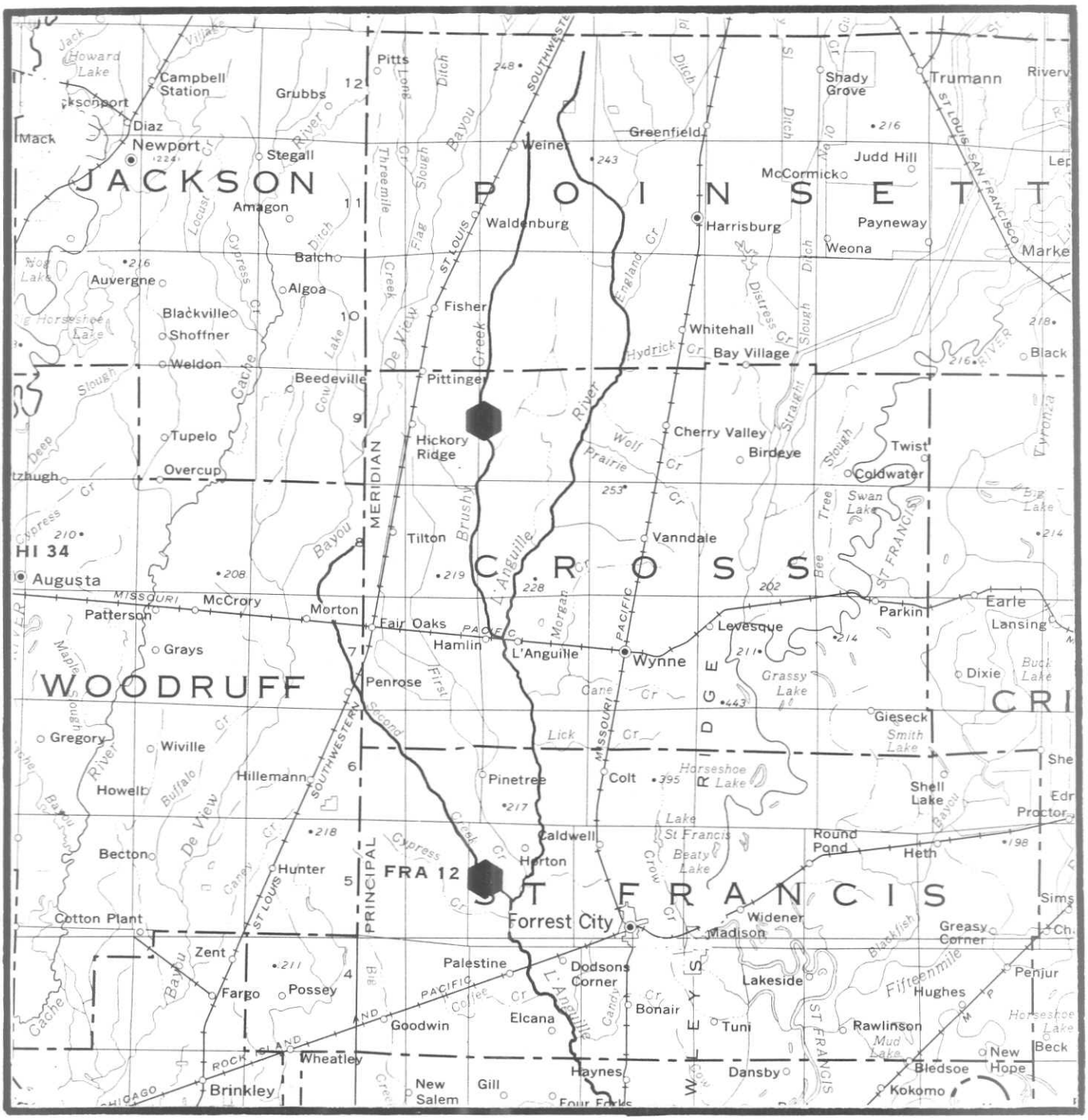
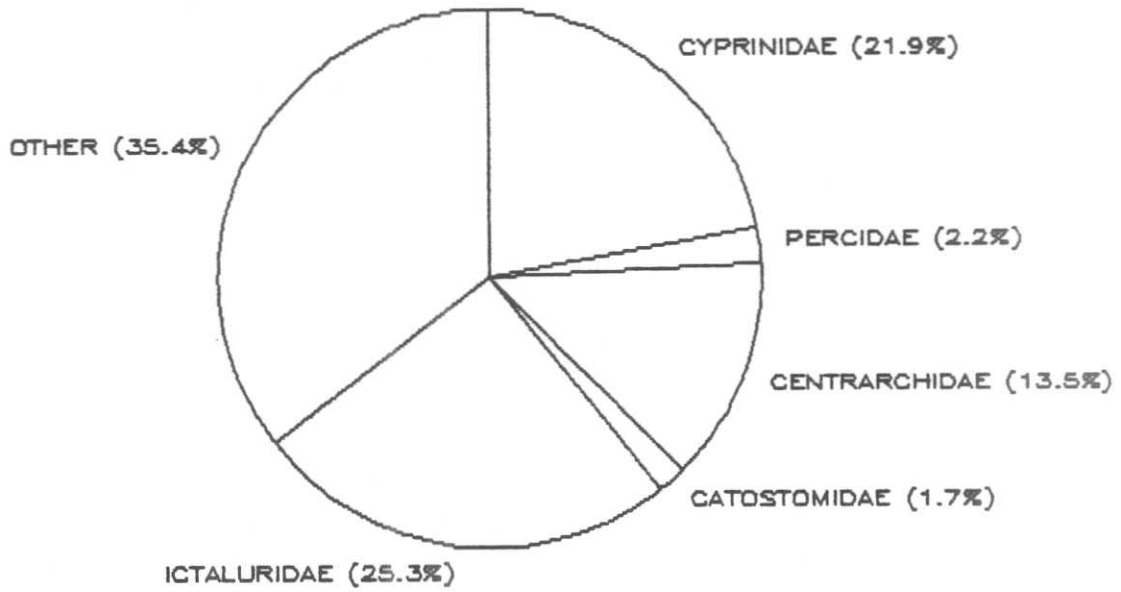


Figure 1. : Brushy Creek and Second Creek Area Map and Sample Sites

Sample Sites

Figure 2. Comparison of Fish Families Collected from Brushy and Second Creeks, 1984.

BRUSHY CR



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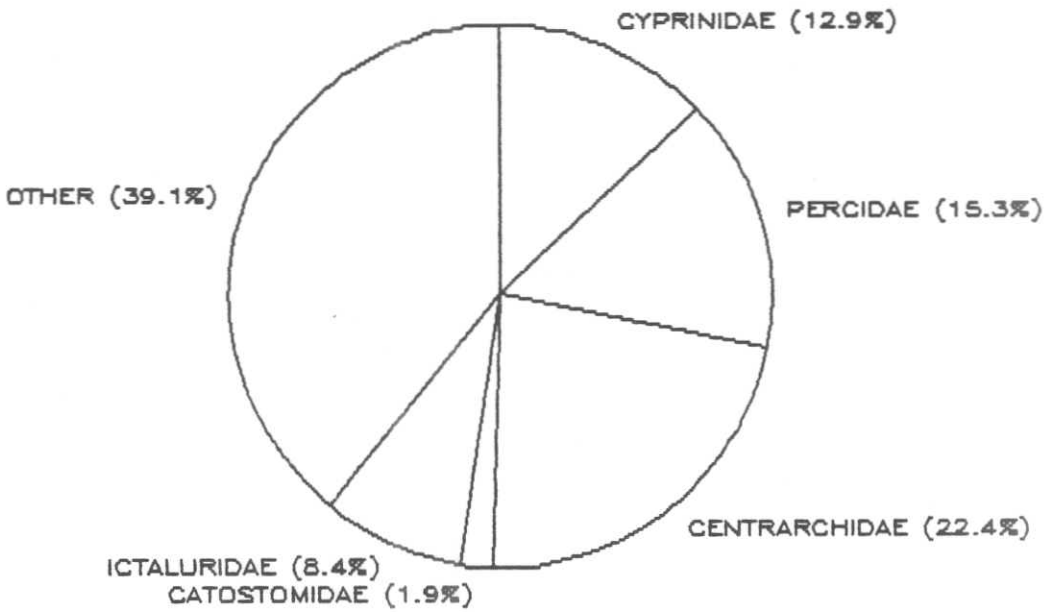

Figure 3. Comparison of Trophic Feeding Levels of Fishes Collected from Brushy and Second Creeks, 1984.

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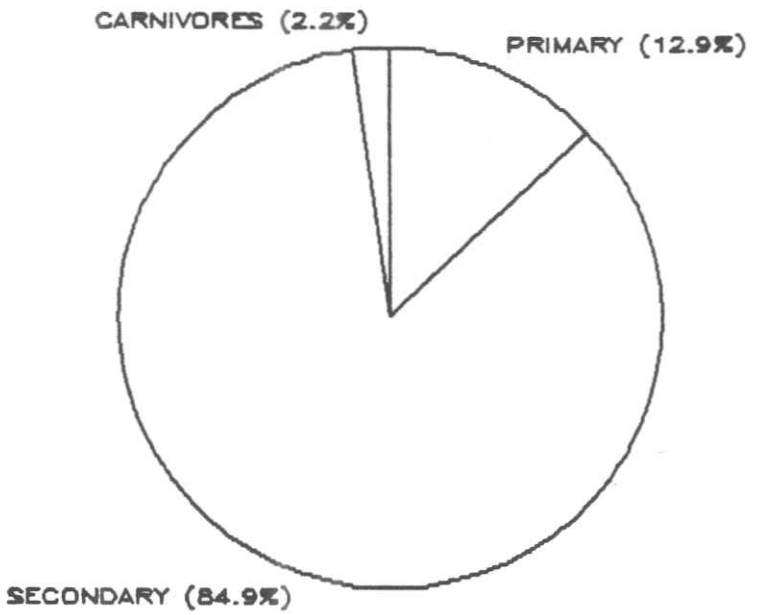

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