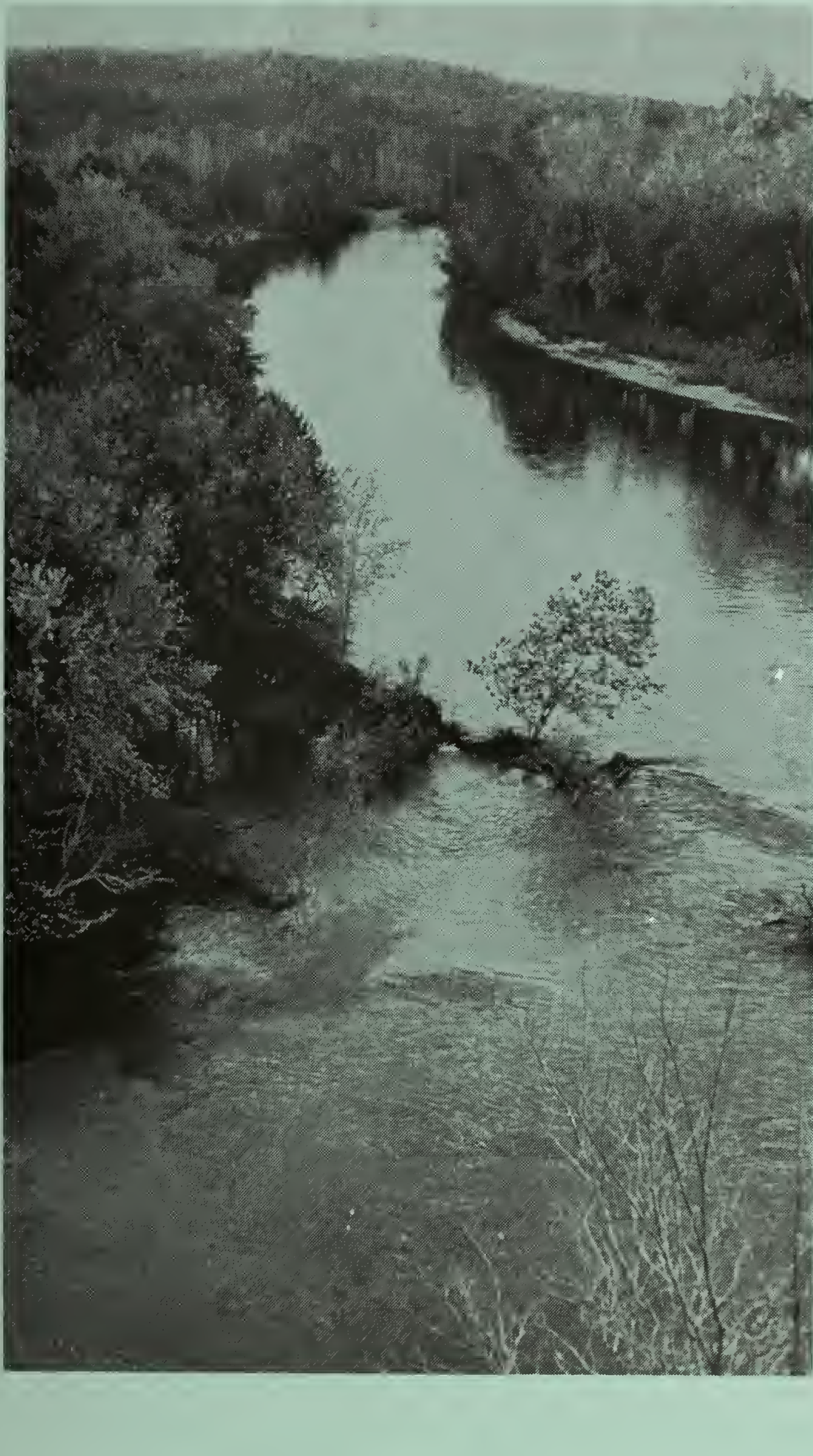

By

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WATER QUALITY of the CURRENT, JACK'S FORK, ELEVEN POINT, LITTLE BLACK and WARM FORK of SPRING RIVER BASINS of MISSOURI

Foreward

The Water Quality Survey of the Current, Jack's Fork, Eleven Point, Little Black, and Warm Fork of Spring River basins was done during 1974 as part of a continuing project designed to survey all streams in the State of Missouri. The objectives of these surveys are to determine existing water quality conditions, locate pollution sources, and obtain background information to evaluate the effects of pollution where they occur and protect against future degradation.

Financial aid was provided through the Dingell-Johnson Program (Project F-19-R, Missouri). This report is a verbatim copy of the final report required by the Dingell-Johnson Program. Copies of this report are available from the Missouri Department of Conservation, Fish and Wildlife Research Center, 1110 College Avenue, Columbia, Missouri, 65201.

The cover photograph was taken from an overlook at the confluence of the Current River with the branch from Big Spring at Van Buren, Missouri.

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Abstract

Aquatic invertebrates were collected from the Current, Jack's Fork, Eleven Point, Little Black and Warm Fork of Spring River basins to determine the water quality in these streams. Fifty-one sampling stations were established on these streams and their major tributaries. Invertebrate collections, and water samples at selected stations, were taken quarterly during 1974. The water quality conditions were evaluated by examining the invertebrate communities at each station both qualitatively and quantitatively. Qualitatively, the total number of taxa, found throughout the year, and the number of mayfly and stonefly taxa found on a seasonal and annual basis were compared to established standards for unpolluted streams in Missouri. The invertebrate community structure and presence or absence of pollution sensitive taxa were also used as indicators of water quality. Quantitatively, the diversity of the invertebrate community was evaluated by calculating species diversity index values and comparing these values to standards established for unpolluted Missouri streams. Invertebrate community structure between stations was compared by calculating coefficients of similarity for pairs of stations.

Point sources of pollution which actually or potentially discharged into these rivers and their tributaries were identified. These discharges did not appear to degrade the water quality of the rivers or their tributaries except in specific instances of localized degradation. The intensive recreational use of these rivers has not degraded the water quality of the rivers. The conversion of forest to pastureland, which occurred prior to this survey, has apparently contributed additional nutrients to the Eleven Point and Warm Fork of Spring rivers. This conversion combined with nutrients introduced by treated sewage effluent has increased the productivity

in portions of the Eleven Point River and to a lesser extent in the Warm Fork of Spring River. To date, the increased productivity has not caused serious problems, however, if the nutrient introduction is allowed to increase, future water quality degradation could occur.

Water quality parameter values usually met criteria established for unpolluted Missouri streams on a seasonal and annual basis except at stations on spring branches or where flow was influenced heavily by springs. At these stations, values were normally approached but did not meet or exceed the criteria established for Missouri streams. These stations could not be classified according to the criteria because springs and portions of streams highly influenced by spring water are naturally cooler and less productive. These natural conditions limit the establishment of warm water invertebrate populations which tend to lower the water quality parameter values slightly. The presence or absence of numerous pollution sensitive taxa was used at these stations to make a judgement about the water quality conditions. Insufficient data is available at present to establish criteria for this habitat type.

All stations not highly influenced by spring water supported invertebrate communities which are typically found in unpolluted Missouri streams. Spring branches and sections of streams influenced by spring water supported numerous pollution sensitive invertebrate types and were also considered unpolluted.

Unpolluted water quality in these rivers can only be maintained if present destructive land use practices are stopped and the problems caused by point sources of pollution are resolved.

Introduction

Intensive water quality surveys have been completed on the Meramec, Bourbeuse, and Big; Elk, James, and Spring; and North, Salt, and Cuivre river basins in Missouri since 1961 (Kuester, 1964; Duchrow, 1974; Dieffenbach and Ryck, 1976). Surveys on the Big Piney, Gasconade, Black, St. Francois, Castor, Little, and Osage river basins are in progress. When these surveys are finished, most of the river basins in the southern half of the state will have been completed. The objectives of these surveys are to be determine existing water quality conditions, locate pollution sources, and obtain background information to evaluate the present and future effects of stream pollution in these basins.

The Current, Jack's Fork, and Eleven Point rivers were chosen for this survey because they appeared to be nearly pollution free and information collected from them would apply to many similar Ozark streams.

The Current, Jack's Fork, and Eleven Point river systems are high quality recreation areas and receive heavy use throughout most of the year (Personal communication, 1976, Dr. Leo F. Marnell, Biologist, National Park Service, Van Buren, Missouri). Both Current and Jack's Fork rivers were included in the Ozark National Scenic Riverways established by the National Wild and Scenic Rivers Act, Public Law 90-542, October 2, 1968. The protection provided by this act is at least partially responsible for their relatively pollution-free status. Information collected during this survey will help to protect these rivers in the future by establishing a basis to determine if any damage has occurred by pollution or overuse. The Warm Fork of Spring and Little Black rivers were included in the survey because of their close proximity to the other river systems.

Description of the Study Area

Geology and Physiography

All five study streams flow through the Ozark Highlands, a broad, elevated peneplain. According to Sauer (1920), 33,000 of the 55,000 square miles of this formation is in southern Missouri (Fig. 0). Geologically, a majority of the drainage area of these streams is in a region classified as the Courtois Hills. This region contains sedimentary rock composed primarily of Ordovician limestone, sandstone, and shale. Cherty dolomitic limestone is the most common limestone in the stream beds of these rivers, except the lower Little Black River (discussed later). Sauer (1920) felt that the large amount of chert is very important to the physical and chemical characteristics of these streams, because it is fine textured, compact, and contains large amounts of silica which make it very resistant to physical weathering and chemical breakdown. These chert fragments vary greatly in size and shape, and are packed loosely, producing large interstitial spaces which allow large quantities of water to pass through the bed during dry periods even though there is little or no surface flow (Clifford, 1966).

The water soluble, sedimentary layers in the Courtois Hills Region results in extensive underground drainage systems and large flowing springs. Interchange of underground water occurs between these river systems as indicated by dye tracings (Personal communication, 1974, Everett Chaney, Hydrologic Technician, U. S. Forest Service, Winona, Missouri). During drought conditions, the stream flow in these rivers is maintained by the springs.

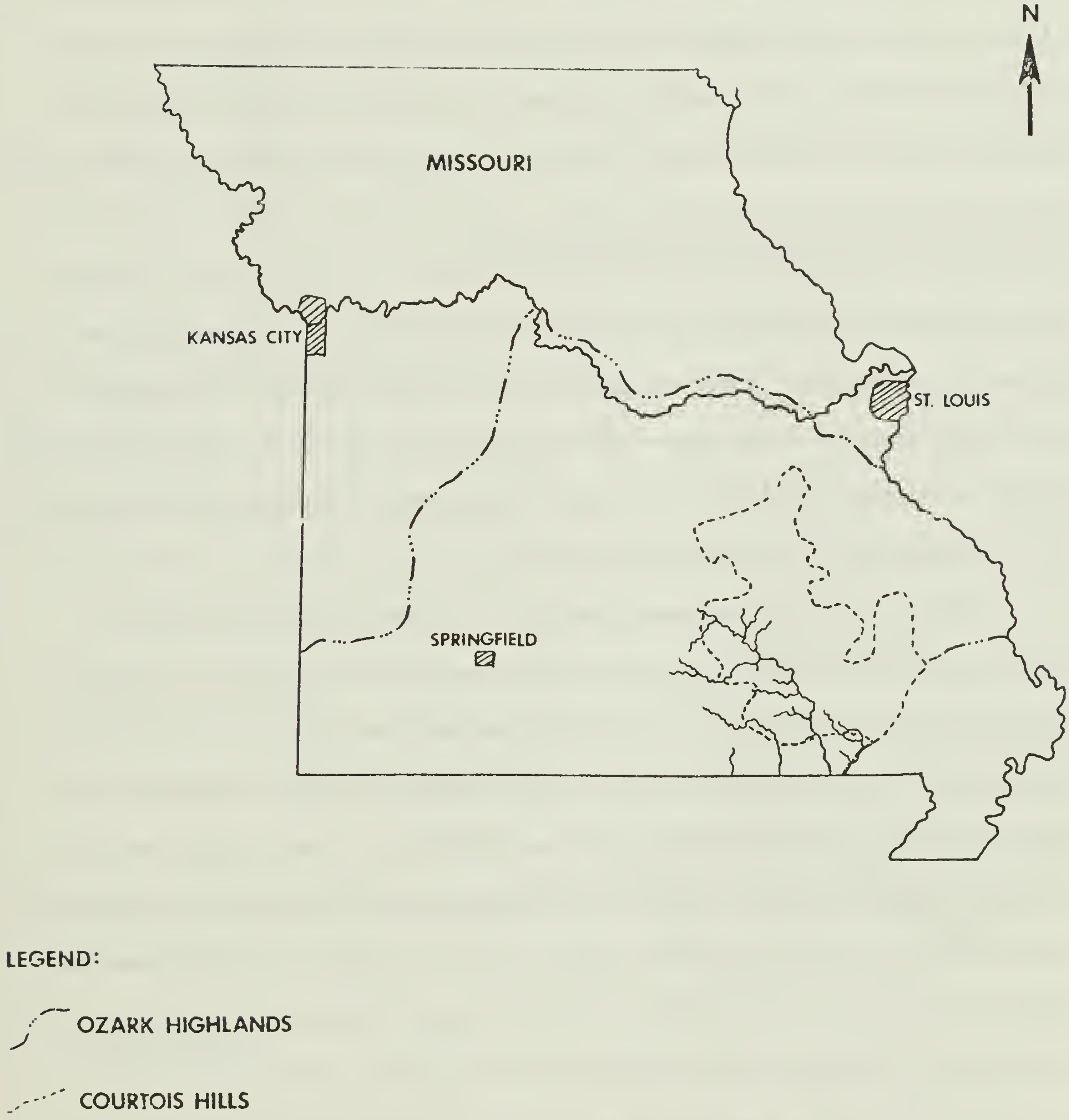


Figure 0. Location of the survey streams within the Ozark Highlands of Missouri.

Terrestrial vegetation in these basins is chiefly an oak-hickory climax association growing on poor, grey-brown podzolic soils. Steep slopes and poor soils limit municipal and agricultural development of the watershed to small areas located in the river valleys (Clifford, 1966).

Historical and Recent Land Use Practices

The Ozark Highlands of southern Missouri (Fig. 0) have not been greatly affected by man's activities. Anonymous (1889) reported the first pioneers in Texas County about 1816 and in Howell County about 1850 (Fippin and Burgess, 1902). Approximately 70% of the Ozarks were considered unimproved as late as 1910 (Watkins, et. al., 1919).

Agriculture in this area was limited, and restricted primarily to small areas of the river bottoms because of the rolling topography (Anonymous, 1889). Most of the pioneers that settled this area of the state came for mining and lumbering (Anonymous, 1894). The pine, oak, and hickory forests in this area were considered to be some of the finest in Missouri (Anonymous, 1889). Since these Ozark streams contained large quantities of sand and gravel, this area also became noted for sand and gravel production around 1900. By 1913, 20% of Missouri's output of sand and gravel came from this area of the state (Dake, 1918).

The five rivers appear to be unpolluted as indicated by the diverse aquatic and terrestrial wildlife which inhabit these rivers and their watersheds. These nearly pristine conditions prevail today for many reasons. The watersheds are forested which prevents soil erosion and problems associated with turbidity and sedimentation. The land is rolling and generally low in productivity which limits the establishment of large scale agricultural operations. Restricted agricultural activity lowers the chance of river contamination by fertilizers and pesticides (except possibly in the lower Little Black). Municipal waste problems are also limited since no large towns (over 5,000 population) or industries are located adjacent to these rivers. Since most of the flow in these river systems is contributed by springs, maintenance of high water quality in these springs by protecting the recharge basin from contamination becomes tremendously important (Bake and Fletcher, 1970). The inclusion of large acreages into state and federal ownership has also prevented potential degradation of these rivers and their watersheds by undesirable land-use practices.

The high water quality of these rivers has only been recently threatened. Conversion of hardwood forests to pasture land by herbicide spraying and bulldozing could degrade these rivers and their drainage basins if it becomes a wide spread practice. At present, the watershed of the Eleven Point River has had the largest areas cleared (Personal communication, 1974, Chuck Tryon, Watershed Scientist, U. S. Forest Service, Rolla, Missouri).

Current River

Current River begins from a series of springs known as Montauk Springs in Dent County. It flows southward for approximately 175 miles through the Courtois Hills region before entering the White River in Arkansas (Fig. 1). Current River drains 2,038 square miles and has had an average discharge of 2,709 cubic feet per second (cfs) at Doniphan Missouri during a 56 year period of record (USGS, 1974). Over 53 springs contribute to the flow of Current River during dry periods (Vineyard

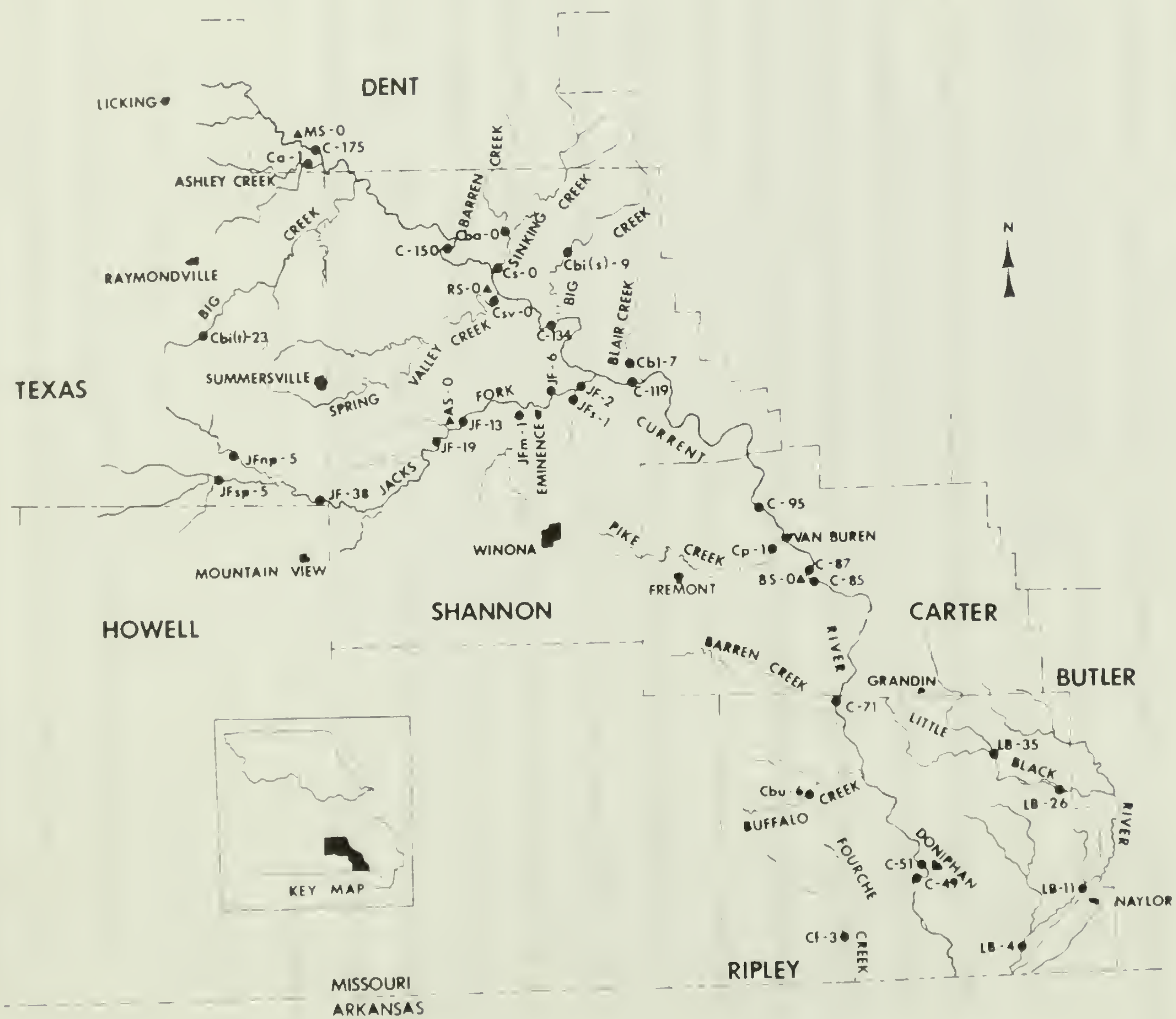


FIGURE 1. Sampling stations on the Current ,Jack's Fork ,and Little Black river systems.

and Feder, 1974). Big Spring, Missouri's largest, contributes an average discharge of 433 cfs of water to the Current just below Van Buren, Missouri (USGS, 1974). Current River is also a heavily used recreational area throughout its course (Personal communication, 1975, Dr. Leo F. Marnell, Biologist, National Park Service, Van Buren, Missouri).

Major point-source pollution discharges are limited to sewage lagoon effluent from Montauk State Park, Van Buren, Missouri (population 684), and Doniphan, Missouri (population 1,707). Gravel and agricultural operations in the watershed may also affect the water quality of Current River (Department of Natural Resources, 1976). The Missouri Department of Conservation trout hatchery at Montauk Springs also discharges nutrient rich water into the headwaters of Current River.

Jack's Fork River

Jack's Fork River, the largest tributary of Current River in Missouri, originates in Texas County and flows eastward for approximately 60 miles before entering the Current River near Eminence, Missouri (Fig. 1). The 53 year average discharge near Eminence was 442 cfs. The Jack's Fork drains 398 square miles of steep-sided limestone canyons in Texas and Shannon counties (USGS, 1974). Vineyard and Feder (1974) name nine major springs which contribute a major portion of the flow in the Jack's Fork throughout the year. Alley Spring is the largest with a 20 year average discharge of 133 cfs (USGS, 1974).

Recreation is the major use of the Jack's Fork (Personal communication, 1975, Dr. Leo F. Marnell, Biologist, National Park Service, Van Buren, Missouri). Lagoon effluent from Eminence, Missouri (population

523) and Mountain View, Missouri (population 1,313) are the only major discharges entering the river. Gravel operations and cattle grazing in the watershed may affect limited areas (Department of Natural Resources, 1976).

Little Black River

Little Black River originates in Carter County and flows through eastern Ripley County before entering Arkansas (Fig. 1). Average discharge for this river was 131 cfs at Naylor, Missouri between 1969 and 1972 (USGS, 1975). Little Black River has 35 miles of permanent flow in Missouri and drains approximately 251 square miles. One major spring (King Bee Spring) contributes to the flow of the river near Flatwoods, Missouri (Vineyard and Feder, 1974).

According to Sauer (1920), Little Black River north of Naylor, Missouri is geologically and vegetatively typical of streams flowing across the Courtois Hills region. From Naylor to the Missouri state line, the Little Black River valley is characterized by gently sloping hills and wide bottom lands. The fertile stream valleys are intensively farmed. Flow in lower Little Black River is more sluggish than other streams in the survey and the stream bed consists primarily of silt from erosion of surrounding farmlands. There are no major point-sources of pollution which discharge into Little Black River.

Eleven Point River

Eleven Point River has its headwaters in Howell County and flows for approximately 120 miles before entering the White River in Arkansas (Fig.2).

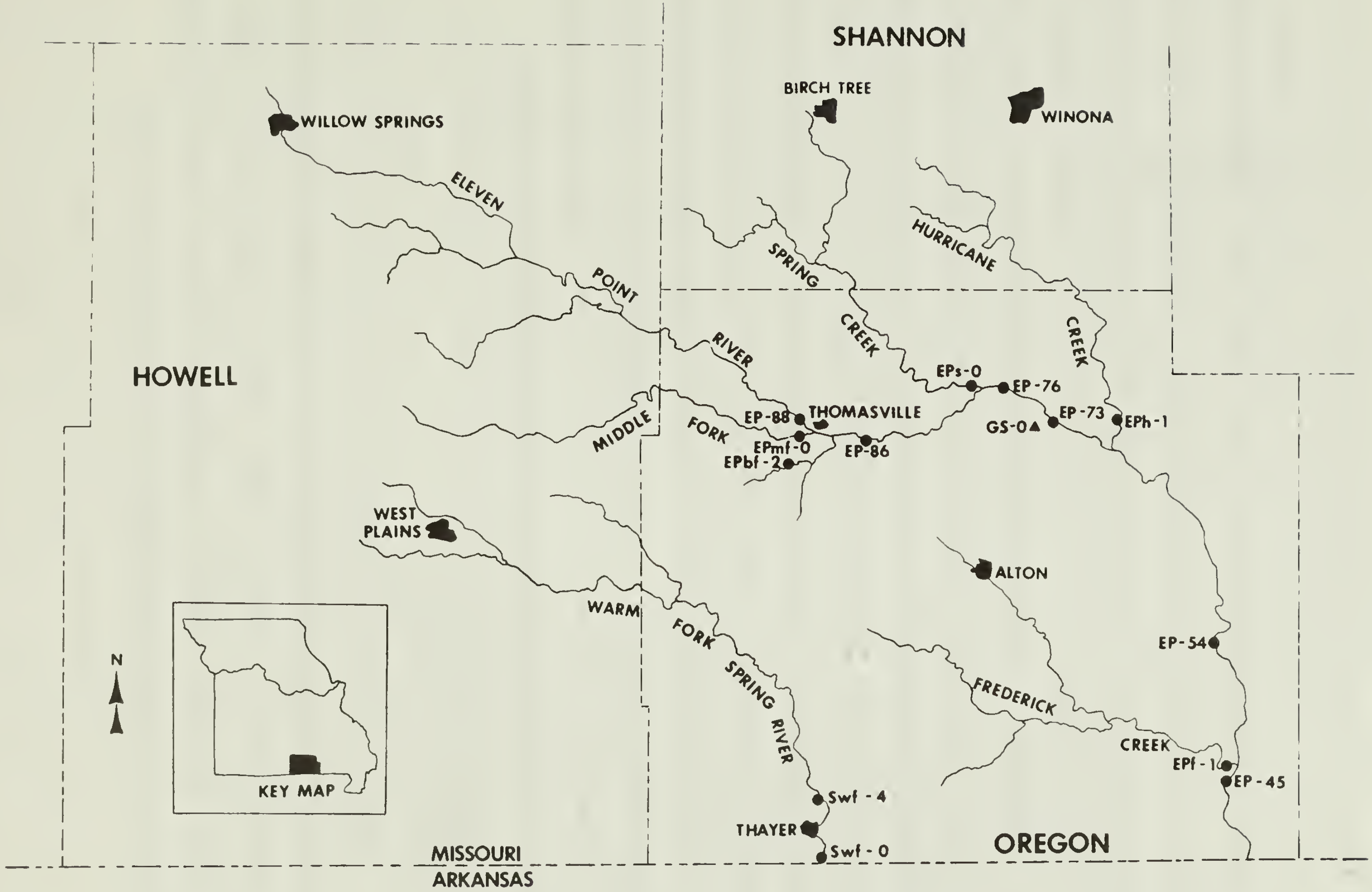


FIGURE 2. Sampling stations on the Eleven Point and Warm Fork of the Spring river systems.

It drains 793 square miles and has had a 53 year average discharge of 755 cfs near Bradley, Missouri (USGS, 1974). Sixteen major springs contribute substantially to the Eleven Point's flow (Vineyard and Feder, 1974). Missouri's second largest spring, Greer Spring (334 cfs average over 53 years), enters about half way down the river's course and more than doubles the flow of the Eleven Point River (Bake and Fletcher, 1970).

Recreation is the major use of the Eleven Point. However, large acreages of oak-hardwood forests in its headwaters have been converted to pasture land through herbicide spraying and bulldozing (Personal communication, 1973, Everett Chaney, Hydrologic Technician, U. S. Forest Service, Winona, Missouri). Treated sewage effluent from Willow Springs (population 2,015), Birch Tree (population 554), and Alton, Missouri (population 707) enter intermittent tributaries of the Eleven Point (Department of Natural Resources, 1976). A wood preserving plant and a gravel operation near Thomasville, Missouri located on Barren and Middle Forks of Eleven Point, respectively, are the only other main pollution problems.

Warm Fork of Spring River

Only 8 miles of the permanently flowing portions of this stream are in Missouri (Fig. 2). The Warm Fork has an average discharge of 59 cfs and drains 195 square miles at Thayer, Missouri (USGS, 1975). Sewage effluent from Thayer, Missouri (population 1,522) and runoff from cement plant enter the river (Department of Natural Resources, 1976).

Materials and Methods

Field and Laboratory Procedures

Water quality conditions in the Current, Jack's Fork, Eleven Point, Little Black, and Warm Fork of Spring rivers were evaluated by studying the diversity and similarity of the benthic invertebrate communities. Benthic organisms are relatively immobile and cannot quickly avoid harmful changes, therefore their presence, absence, and abundance reflect the water quality conditions of the recent past. The benthic invertebrate community structure also provided a measure of the water quality, since different invertebrates exhibit varying degrees of tolerance to pollution (Gaufin, 1958). Thus, the effect of pollutants entering a stream may be measured by sampling the invertebrate community and comparing it, qualitatively and quantitatively, with criteria established for unpolluted Missouri streams.

Bottom-dwelling invertebrates (benthic invertebrates) were collected during January, April, August and October at 51 stations; Current (23), Jack's Fork (10), Eleven Point (12), Little Black (4), and Warm Fork of Spring (2) (Figs. 1 and 2, Table 1). Sampling began in January 1974 and was completed in January 1975. Qualitative sampling for mussels was done during the spring sampling period (April-May). A list of fish species known to occur in the survey streams was compiled (Table 2). (Pflieger, 1971).

Benthic invertebrates were collected from permanent, stable riffle areas at each sampling site by disturbing the substrate with a three-pronged digging tool to a depth of 4-6 inches. Dislodged organisms were captured in a Turtox No. 105T33 heavy nylon bottom net (20 mesh to the

Table 1. Benthic invertebrate sampling station locations on the Current, Jack's Fork, Eleven Point, Little Black, and Warm Fork of Spring rivers in Missouri.

Name	Station	County	Legal Description	Sampling Method[1]	Landmarks
Current River					
Montauk Springs	MS-0	Dent	T32N R7W Sec. 23 NW¼	RN	spring branch
Current River	C-175	Dent	T32N R7W Sec. 25 NW¼	RN	near mouth of Tanvat Crk.
Ashley Creek	Ca-1	Dent	T32N R7W Sec. 35 N½	RN	below confluence of North & South Ashley creeks
Big Creek	Cbi(t)-23	Texas	T30N R8W Sec. 34 NW¼	RN	crossing at Bearclaw
Current River	C-150	Shannon	T31N R5W Sec. 34 SW¼	RN	below Pulltight campgrounds
Barren Creek	Cba-0	Shannon	T31N R4W Sec. 28 SW¼	RN	Shannon County Route CC crossing
Sinking Creek	Cs-0	Shannon	T30N R4W Sec. 7 SE¼	RN	Hyw. 19 crossing
Round Spring	Rs-0	Shannon	T30N R4W Sec. 19 NE¼	RN	spring branch
Spring Valley Creek	Csv-0	Shannon	T30N R4W Sec. 20 W½	RN	Hyw. 19 crossing
Big Creek	Cbi(s)-9	Shannon	T30N R3W Sec. 7 NW¼	RN	crossing at Map, Mo.
Current River	C-134	Shannon	T29N R4W Sec. 1 NE¼	RN	National Park Service Jerktail landing
Blair Creek	Cbl-7	Shannon	T30N R2W Sec. 31 SW¼	RN	south of Himont, Mo.
Current River	C-119	Shannon	T29N R2W Sec. 18 SW¼	RN	near Hyw. 160 below Jack's Fork
Current River	C-95	Carter	T27N R1W Sec. 3 SW¼	RN	Broccal Shoal downstream from Raftyard access
Pike Creek	Cp-1	Carter	T27N R1W Sec. 23 SE¼	RN	Carter County Route M crossing

Table 1. (Continued)

Name	Station	County	Legal Description	Sampling Method [1]	Landmarks
Current River	C-87	Carter	T27N R1E Sec. 32 SW¼	RN	Peavine Campround
Big Springs	BS-0	Carter	T26N R1E Sec. 6 Center	RN	spring branch
Current River	C-85	Carter	T26N R1E Sec. 5 SW¼	RN	Montgomery property off Carter County Route Z
Current River	C-71	Ripley	T25N R1E Sec. 21 NE¼	RN	below Hawes Campground
South Fork of Buffalo Creek	Cbu-6	Ripley	T24N R1E Sec. 29 NW¼	RN	west of Ripley County Route CC
Fourche Creek	Cf-3	Ripley	T22N R1E Sec. 22 NW¼	RN	off Ripley County Route EE crossing of a forest road
Current River	C-51	Ripley	T23N R2E Sec. 27 NE¼	RN	Hyw. 160 near Doniphan
Current River	C-49	Ripley	T23N R2E Sec. 34 NW¼	RN	Current River Dells, Doniphan
<u>Jack's Fork River</u>					
North Prong of Jack's Fork	JFnp-5	Texas	T28N R8W Sec. 11 SE¼	RN	north of Texas County Route Y
South Prong of Jack's Fork	JFsp-5	Texas	T28N R8W Sec. 22 SW¼	RN	Texas County Route Y near Clear Springs
Jack's Fork	JF-38	Texas	T28N R7W Sec. 36 SW¼	RN	Hyw. 17 bridge
Jack's Fork	JF-19	Shannon	T28N R5W Sec. 4 SW¼	RN	south of Hyw. 106, end of forest road above Alley Springs
Alley Springs	AS-0	Shannon	T29N R5W Sec. 25 SE¼	RN	spring branch
Jack's Fork	JF-13	Shannon	T29N R4W Sec. 30 NE¼	RN	1 mile below Alley Springs above Eminence

Table 1. (Continued)

Name	Station	County	Legal Description	Sampling Method[1]	Landmarks
Mahan's Creek	JFm-1	Shannon	T29N R4W Sec. 27 SW¼	RN	Hyw. 106 crossing
Jack's Fork	JF-6	Shannon	T29N R4W Sec. 24 NW¼	RN	on a forest road 2 miles southeast of Eminence
Shawnee Creek	JFs-1	Shannon	T29N R3W Sec. 20 W½	RN	1 mile north of Hyw. 106
Jack's Fork	JF-2	Shannon	T29N R3W Sec. 20 NE¼	RN	station at end of private road on Shed property
<u>Eleven Point River</u>					
Middle Fork of the Eleven Point	EPmf-0	Oregon	T24N R5W Sec. 5 NE¼	RN	Hyw. 99 bridge south of Thomasville
Eleven Point	EP-88	Oregon	T24N R5W Sec. 5 NE¼	RN	Hyw. 99 bridge south of Thomasville
Barren Fork of the Eleven Point	EPbf-2	Oregon	T24N R5W Sec. 5 SE¼	RN	Hyw. 160 south of Thomasville
Eleven Point	EP-86	Oregon	T24N R5W Sec. 3 NE¼	RN	U.S. Geological Survey Gaging Station
Spring Creek	EPs-0	Oregon	T25N R4W Sec. 22 SW¼	RN	mouth of Spring Creek
Eleven Point	EP-76	Oregon	T25N R4W Sec. 23 SE¼	RN	forest road northwest of Greer, Mo.
Greer Spring	GS-0	Oregon	T25N R3W Sec. 36 SW¼	RN	spring branch
Eleven Point	EP-73	Oregon	T25N R4W Sec. 36 NE¼	RN	below Greer Springs at Hyw. 19 bridge
Hurricane Creek	EPh-1	Oregon	T25N R3W Sec. 34 SW¼	RN	east of Hyw. 19, low water crossing of county road

Table 1. (Continued)

Name	Station	County	Legal Description	Sampling Method[1]	Landmarks
Eleven Point	EP-54	Oregon	T23N R2W Sec. 17 SE¼	RN	Hyw. 160 bridge, Riverton
Frederick Creek	EPf-1	Oregon	T22N R2W Sec. 16 NE¼	RN	½ mile west of Hyw. 160 bridge at the narrows
Eleven Point	EP-45	Oregon	T22N R2W Sec. 21 NW¼	RN	Hyw. 142 bridge
<u>Little Black River</u>					
Little Black	LB-35	Ripley	T24N R3E Sec. 10 W½	RN	Ripley County Route K
Little Black	LB-26	Ripley	T24N R4E Sec. 29 NE¼	RN	Slayton's Ford at end of Ripley County Route M
Little Black	LB-11	Ripley	T23N R4E Sec. 34 SW¼	AS	Hyw. 142 bridge West of Naylor, Mo.
Little Black	LB-4	Ripley	T22N R3E Sec. 24 SW¼	AS	Ripley County Route N bridge west of Glenn, Mo.
<u>Warm Fork of the Spring River</u>					
Warm Fork of the Spring River	Swf-4	Oregon	T22N R5W Sec. 20 S½	RN	east of Hyw. 19, crossing above Thayer, Mo.
Warm Fork of the Spring River	Swf-0	Oregon	T21N R5W Sec. 5 SE¼	RN	east of U.S. Hyw. 63, low water crossing above Mammoth Springs

1 RN - Riffle Net

AS - Artificial Substrate Sampler

Table 2. List of fishes collected in the Current, Jack's Fork, Eleven Point, Little Black, and Warm Fork of the Spring river systems (Pflieger, 1971).

Common and scientific names		Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of the Spring River
Family: Petromyzontidae - lampreys						
Chestnut lamprey	*Ichthyomyzon castaneus*	X	X			
American brook lamprey	*Lampetra lamottei*	X	X			
Least brook lamprey	*Lampetra aepyptera*	X	X	X	X	
Family: Acipenseridae - sturgeons						
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	X				
Family: Polyodontidae - paddlefishes						
Paddlefish	*Polyodon spathula*	X	X			
Family: Lepisosteidae - gars						
Shortnose gar	*Lepisosteus platostomus*	X				
Longnose gar	*Lepisosteus osseus*	X	X		X	
Family: Clupeidae - herrings						
Skipjack herring	*Alosa chrysochloris*	X				
Gizzard shad	*Dorosoma cepedianum*	X	X	X	X	
Family: Hiodontidae - mooneyes						
Mooneye	*Hiodon tergisus*	X		X		

Table 2. (Continued)

Common and scientific names		Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of the Spring River
Family: Salmonidae - trouts						
Rainbow trout	*Salmo gairdneri*	X	X	X		
Brown trout	*Salmo trutta*	X				
Family: Esocidae - pikes						
Grass pickerel	*Esox americanus*	X				
Chain pickerel	*Esox niger*	X	X	X	X	
Family: Cyprinidae - minnows and carps						
Carp	*Cyprinus carpio*	X	X	X		
Golden shiner	*Notemigonus crysoleucas*	X	X	X		
Creek chub	*Semotilus atromaculatus*	X	X	X	X	X
Pugnose minnow	*Opsopoeodus emiliae*	X	X		X	
Southern redbelly dace	*Phoxinus erythrogaster*	X	X	X	X	
Hornyhead chub	*Nocomis biguttatus*	X	X	X	X	X
Bigeye chub	*Hybopsis amblops*	X	X	X	X	X
Streamline chub	*Hybopsis dissimilis*	X	X			
Gravel chub	*Hybopsis x-punctatas*	X				
Emerald shiner	*Notropis atherinoides*	X			X	
Roseyface shiner	*Notropis rubellus*	X	X	X		
Telescope shiner	*Notropis telescopus*	X	X	X	X	X
Redfin shiner	*Notropis umbratilus*	X	X	X	X	
Ribbon shiner	*Notropis fumeus*	X			X	

Table 2. (Continued)

			Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of the Spring River
	Bleeding shiner	*Notropis zonatus*	X	X	X	X	X
	Striped shiner	*Notropis chrysocephalus*	X	X	X	X	X
	Weed shiner	*Notropis texanus*	X			X	
	Wedgespot shiner	*Notropis greenei*	X	X			
	Taillight shiner	*Notropis maculatus*				X	
	Bigeye shiner	*Notropis boops*	X	X	X	X	X
	Pallid shiner	*Notropis amnis*				X	
	Steelcolor shiner	*Notropis whipplei*	X			X	
	Blacktail shiner	*Notropis venustus*	X			X	
	Whitetail shiner	*Notropis galacturus*	X	X	X	X	X
	Ozark shiner	*Notropis ozarcanus*	X	X	X		
	Ozark minnow	*Diona nubila*	X	X	X	X	X
	Central silvery minnow	*Hybognathus nuchalis*	X				
	Bullhead minnow	*Pimephales vigilax*				X	
	Bluntnose minnow	*Pimephales notatus*	X	X	X	X	X
	Largescale stoneroller	*Campostoma oligolepis*	X	X	X	X	X
	Central stoneroller	*Campostoma anomalum*	X	X	X	X	X
Family:	Catostomidae - suckers						
	Blue sucker	*Cycleptus elongatus*	X				
	Bigmouth buffalo	*Ictiobus cyprinellus*	X				
	Black buffalo	*Ictiobus niger*	X		X		
	Smallmouth buffalo	*Ictiobus bubalus*	X				
	River carpsucker	*Carpiodes carpio*			X		

Table 2. (Continued)

		Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of the Spring River
Highfin carpsucker	*Carpiodes velifer*	X				
White sucker	*Catostomus commersoni*	X	X	X		
Northern hog sucker	*Hypentelium nigricans*	X	X	X	X	X
Black redhorse	*Moxostoma duquesnei*	X	X	X	X	
Golden redhorse	*Mosostoma erythrurum*	X	X	X	X	
Silver redhorse	*Moxostoma anisurum*	X				
Shorthead redhorse	*Moxostoma macrolepidotum*	X		X	X	
River redhorse	*Moxostoma carinatum*	X		X		
Spotted sucker	*Minytrema melanops*	X	X		X	
Lake chubsucker	*Erimyzon sucetta*	X				
Creek chubsucker	*Erimyzon oblongus*	X	X	X		X
Family: Ictaluridae - freshwater catfishes						
Black bullhead	*Ictalurus melas*	X	X		X	
Yellow bullhead	*Ictalurus natalis*	X	X	X	X	
Channel catfish	*Ictalurus punctatus*	X		X	X	
Slender madtom	*Noturus exilis*		X	X		X
Freckled madtom	*Noturus nocturnus*	X				
Ozark madtom	*Noturus albater*	X	X	X		X
Brindled madtom	*Noturus miurus*				X	
Checkered madtom	*Noturus flavater*	X	X	X		
Flathead catfish	*Pylodictus olivaris*	X				

Table 2. (Continued)

		Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of the Spring River
Family: Aphredoderidae - pirate perches						
Pirate perch	Aphredoderus sayanus	X			X	
Family: Amblyopsidae - cavefishes						
Southern cavefish	Typhlichthys subterraneus	X		X		
Family: Cyprinodontidae - killifishes						
Northern studfish	Fundulus catenatus	X	X	X		X
Starhead topminnow	Fundulus notti				X	
Blackspotted topminnow	Fundulus olivaceus	X	X	X	X	X
Family: Poeciliidae - livebearers						
Mosquitofish	Gambusia affinus	X			X	
Family: Atherinidae - silversides						
Brook silverside	Labidesthes sicculus	X	X	X	X	X
Family: Percichthyidae - temperate basses						
White bass	Morone chrysops	X				
Family: Centrarchidae - sunfishes						
Spotted bass	Micropterus punctulatus	X			X	
Smallmouth bass	Micropterus dolomieui	X	X	X	X	X
Largemouth bass	Micropterus salmoides	X	X	X	X	

Table 2. (Continued)

		Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of the Spring River
Warmouth	<u>Lepomis gulosus</u>	X	X	X	X	
Green sunfish	<u>Lepomis cyanellus</u>	X	X	X	X	X
Spotted sunfish	<u>Lepomis punctatus</u>	X	X	X	X	
Redear sunfish	<u>Lepomis microlophus</u>	X				
Orangespotted sunfish	<u>Lepomis humilis</u>				X	
Longear sunfish	<u>Lepomis megalotis</u>	X	X	X	X	X
Bluegill	<u>Lepomis macrochirus</u>	X	X	X	X	
Rock bass	<u>Ambloplites rupestris</u>	X	X	X	X	X
Black crappie	<u>Pomoxis nigromaculatus</u>	X				
White crappie	<u>Pomoxis annularis</u>	X				
Flier	<u>Centrarchus macropterus</u>	X				
Pygmy sunfish	<u>Elassoma zonatum</u>				X	
Family: Percidae - perches						
Walleye	<u>Stizostedion vitreum</u>	X	X	X		
Sauger	<u>Stizostedion canadense</u>	X	X			
Blackside darter	<u>Percina maculata</u>	X			X	
Dusky darter	<u>Percina sciera</u>				X	
Logperch	<u>Percina caprodes</u>	X		X		X
Gilt darter	<u>Percina evides</u>	X	X	X		
Stargazing darter	<u>Percina uranidea</u>	X				
Johnny darter	<u>Etheostoma nigrum</u>	X		X	X	
Bluntnose darter	<u>Etheostoma chlorosomum</u>				X	
Speckled darter	<u>Etheostoma stigmaeum</u>	X			X	
Arkansas saddled darter	<u>Etheostoma euzonum</u>	X	X			X

Table 2. (Continued)

			Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of the Spring River
	Harlequin darter	*Etheostoma histrio*				X	
	Banded darter	*Etheostoma zonale*	X	X	X	X	X
	Greenside darter	*Etheostoma blennioides*	X	X	X	X	X
	Stippled darter	*Etheostoma punctulatum*			X		
	Rainbow darter	*Etheostoma caeruleum*	X	X	X	X	X
	Orangethroat darter	*Etheostoma spectabile*	X	X	X	X	X
	Fantail darter	*Etheostoma flabellare*	X	X	X	X	X
	Slough darter	*Etheostoma gracile*				X	
	Cypress darter	*Etheostoma proeliare*	X			X	
Family:	Sciaenidae - drums						
	Freshwater drum	*Aplodinotus grunniens*	X	X	X		
Family:	Cottidae - sculpins						
	Mottled sculpin	*Cottus bairdi*	X	X	X		
	Banded sculpin	*Cottus carolinae*	X	X	X		X

inch) placed immediately below the sample site. Between 8 and 20 square feet of riffle substrate were sampled during each collection depending on the width of the riffle. Silty substrate and slow flow at the lower two stations on the Little Black River made the use of the bottom net impracticable. These stations were sampled with three "sets" of artificial substrates per station during each sampling period. A "set" included an 8 x 8 x 18-inch wire basket filled with 2 to 4-inch limestone rocks and a modified multiple plate sampler described by Hester and Dendy (1962). Both substrate types were allowed to colonize for 4 weeks before they were retrieved.

Debris and invertebrates collected in the bottom net and artificial substrates were placed into two screened pans for washing. The upper pan had ½-inch hardware cloth screen and the lower pan 40 mesh to the inch stainless steel wire screen. Debris remaining in the upper screen was checked for organisms and discarded. Organisms from the upper screened pan and all material from the lower screened pan were preserved in 10% formalin. All samples were then transported to the laboratory for final sorting and identification.

Samples to be sorted were washed with water in an U. S. No. 35 Standard Seive to remove the formalin. Most organisms were then removed from the debris by a sugar flotation method described by Anderson (1959). Debris was also systematically hand sorted to ensure removal of all invertebrates not suspended during sugar flotation. Organisms were then preserved in 70% isopropanol for identification.

Identification of invertebrates was accomplished using compound and binocular dissecting microscopes and the following references: Borror and Delong (1971); Burks (1953); de la Torre-Bueno (1937); Eddy and Hodson (1961); Frison (1935); Frison (1942); Hilsenhoff (1970); Johannsen (1934); Lewis (1974); Peterson (1960); Peterson (1962); Ross (1944); U. S. Environmental Protection Agency (1972); Usinger (1963); Ward and Whipple (1959).

Benthic organisms were identified to the following taxonomic levels:

(1) Flatworms (Platyhelminthes), roundworms (Nematoda), and segmented worms (Annelida) were identified to class.

(2) True flies (Diptera) were identified to family or genus.

(3) Mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), snails (Gastropoda), crustaceans, and other organisms were identified to genus or species.

(4) Mussels (Pelecypoda) were identified to species by Mr. Ronald D. Oesch, 9 Hill Drive, St. Louis, Missouri.

Water samples from selected stations throughout each basin, were chemically analyzed (Appendix Tables A1-A5), by the U. S. Geological Survey (Current, Jack's Fork, Little Black, Warm Fork of Spring rivers) and the U. S. Forest Service (Eleven Point River). All chemical analyses were done in accordance to procedures outlined in American Public Health Association (1971).

Assessment of water quality

Water quality at each of the 51 stations was assessed, by comparing water quality parameter values with established criteria for Missouri streams, analyzing the invertebrate community structure, examining the influence of physical and chemical features, and considering the influence of known pollution sources.

The numbers and types of invertebrates were analyzed both qualitatively and quantitatively. The number of pollution intolerant mayfly and stonefly taxa (types) and total taxa at each station were used as qualitative water quality parameter values. Seasonal and annual numbers of mayfly and stonefly taxa were used to assess water quality at a station, whereas, the total number of taxa was used strictly on an annual basis.

Quantitatively, species diversity index values were calculated for the invertebrate communities at each station. The equation for calculating species diversity index values was originally reported by Margalef (1957) and is discussed in more detail by Wilhm (1967). The equation is as follows:

$$d = \frac{s-1}{\log_e N}$$

where "s" equals the number of taxa and "N" is the total number of organisms in the sample. This index is highly correlated with both the number of taxa and the total number of organisms in the sample. It provides an excellent indicator of water quality in Missouri streams. Invertebrate samples collected from unpolluted Ozark streams usually have species diversity index values greater than 4.0, seasonally, and greater than 7.0, annually (Dieffenbach and Ryck, 1976; Duchrow, 1976a; Duchrow, 1976b; Ryck, 1974; Ryck, 1976). This index, however, has the possible disadvantage of being misinterpreted if the substrate area sampled is too small and rare species are not represented in the sample. This variable was overcome by collecting samples from a sufficient area to ensure that greater than 80% of the invertebrate types found in the riffle community were represented in the sample. A sample size of 8-20 square feet, depending on riffle width, was found to contain 80% or more of the invertebrate types in the study streams.

Coefficients of similarity (Burlington, 1962) were also used to compare benthic invertebrate communities between stations. This method defines the degree of similarity between the benthic invertebrate communities at all stations, and provides an additional indication of water quality. These coefficients provide comparisons between stations based on invertebrate community structure, whereas, species diversity indices are an indication of water quality at one station, and any comparisons between stations must be strictly on a numerical basis.

The coefficient of similarity between two stations was calculated from the equation:

$$C = \frac{200W}{a + b}$$

where "a" is the sum of the prominence values of all taxonomic levels at station 1, "b" is the sum of prominence values at station 2, and "W" is the sum of prominence values for each taxa the stations have in common. Prominence values for each taxa at any station (a or b) were calculated by multiplying the square root of the frequency of occurrence for that taxa (the percentage of stations at which it occurred) by its mean density (numbers per square foot) at that station. Coefficients of similarity greater than 60 have been found to be high and indicate that the stations being compared have similar invertebrate communities. Values less than 60 indicate varying degrees of dissimilarity (Duchrow, 1976a; Duchrow, 1976b; Dieffenbach and Ryck, 1976; Ryck, 1976). Low coefficients of similarity could be caused by differences in water quality, habitat (substrate, flow, etc.) or a combination of several factors (Dieffenbach and

Ryck, 1976). Coefficients of similarity were used as supportive information with the other water quality parameter values.

Water Quality Criteria Used in this Study

Water quality at each station was classified as polluted, moderately polluted, or unpolluted by comparing values for the following parameters; species diversity index value, number of mayfly and stonefly taxa, and total taxa; to established criteria for Missouri streams. Criteria for these water quality parameters have been developed on a seasonal and annual basis by regression analyses of data from 895 invertebrate samples collected from Missouri streams by Kuester (1964), Duchrow (1974), Duchrow (1976a), Duchrow (1976b), Ryck (1976), and Dieffenbach and Ryck (1976). These criteria are:

	Seasonal		Annual		
Water quality designation	Species diversity index value	No. of mayfly and stonefly taxa	Species diversity index value	No. of mayfly and stonefly taxa	Total taxa
Unpolluted	>3.9	>9	>6.9	>21	>56
Moderately polluted	2.2-3.9	5-9	3.8-6.9	10-21	31-56
Polluted	<2.2	<5	<3.8	<10	<31

More emphasis is placed on annual rather than seasonal parameters since the values for annual parameters are calculated by pooling information for four seasonal samples at each station. Pooling reduces some variability due to emergence, newly hatched young that are too small to be collected, temporary disturbance by floods, and the possibility of collecting a poor sample during one season.

Some difficulty was encountered in classifying water quality at stations on spring branches and streams in which springs made up most of the flow. These types of streams are naturally cooler and less productive. Cooler water limits the establishment of warm-water pollution sensitive invertebrates. The absence of these types of invertebrates tended to depress the values of the water quality parameters calculated from the samples. For this reason, stations on spring branches and stream influenced by spring water were not classified according to the criteria previously discussed. The presence or absence of cold-water pollution sensitive invertebrates was used at these stations to make a judgement about the water quality conditions. When sufficient data is available, statistically sound criteria will be developed to classify this habitat type. Prior knowledge of the amount of flow contributed by springs is imperative before the water quality of a stream can be classified according to the present criteria established for Missouri streams.

Other aids for assessing water quality

Numerous pollution sensitive invertebrate taxa other than mayflies and stoneflies are typically found in unpolluted Missouri streams (Gaufin, 1958; Roback, 1962; Kuester, 1964; Duchrow, 1974; Duchrow, 1976a; Duchrow, 1976b; Ryck, 1974; Ryck, 1976; Dieffenbach and Ryck, 1976). These organisms are good indicators of unpolluted water. The reduction of these sensitive taxa and dominance of tolerant forms also indicates moderately polluted or polluted water quality. The presence or absence of these intolerant species were also used to help classify water quality. Most of the dominant taxa listed at each station throughout this report were considered to be pollution sensitive taxa.

Coefficients of similarity and physical-chemical data were also used as an aid to assess water quality at each station in this study.

Results and Discussion

Current River

A total of 142 taxa (types) of aquatic invertebrates including 48 mayfly and stonefly types were collected from 23 stations on Current River and its tributaries (Table 3). Pollution intolerant taxa from other invertebrate groups were also well represented. Seasonal and annual water quality parameter values at stations not greatly influenced by spring water met or exceeded criteria established for unpolluted Missouri streams. Stations on spring branches or whose flow was primarily made up of spring water were also considered unpolluted since numerous pollution sensitive taxa were present. Point sources of pollution were present in the watershed of Current River (Table 4) but for the most part these sources were small and their effects, if any, were localized near the point of entry.

Mainstem

Current River originates near a series of springs known as Montauk Springs located in Montauk State Park, southwest of Salem, Missouri. The average discharge from Montauk Springs is considered the 11th largest in

Table 3. Taxonomic list of benthic invertebrates identified in samples collected from the Current, Jack's Fork, Eleven Point, Little Black, and Warm Fork of Spring River systems, 1974.

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Phylum: Arthropoda					
Class: Insecta					
Order: Plecoptera					
Family: Pteronarcidae					
Pteronarcys sp.	X	X	X		
Family: Nemouridae					
Nemoura sp.	X	X			
N. (*Amphinemura*) *delosa*			X		X
N. (*Prostoia*) sp.				X	
Family: Taeniopterygidae					
Taeniopteryx maura/*burki*	X				X
T. burki			X		
T. metequi	X			X	
T. sp.		X			
Brachyptera fasciata	X	X	X	X	X
Family: Capniidae					
Paracapnia opis				X	
Paracapnia sp.	X	X	X	X	X
Allocapnia sp.	X	X	X	X	X
Capnia sp.	X	X	X		
Family: Perlidae					
Acroneuria evoluta	X	X	X	X	X
Neoperla clymene	X	X	X		
Paragnetina media	X	X			

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Perlesta placida	X	X	X	X	X
Perlinella drymo	X	X	X		
Phasganophora capitata	X	X	X		
Paragnetina/Claassenia		X	X		
Family: Perlodidae					
Isogenus (Helopicus) natatus	X	X	X		X
Isoperla signata	X	X			
I. namata	X		X		
I. mohri	X		X		
I. clio			X		
Family: Leuctridae					
Leuctra sp.		X	X		X
Zealeuctra sp.	X				
Order: Ephemeroptera					
Family: Heptageniidae					
Heptagenia sp.	X	X	X		X
Rhithrogena pellucida (?)	X	X	X		X
Stenonema pulchellum	X	X	X	X	X
S. nepotellum	X	X	X	X	X
S. tripunctatum	X	X	X	X	X
S. (undescribed sp.)	X	X			
S. ares				X	
S. exiguum				X	
S. bipunctatum	X				
Stenacron gildersleevei	X	X	X	X	X

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
S. interpunctatum (gp.)	X	X	X		X
Family: Ephemerellidae					
Ephemerella bicolor (gp.)	X	X	X	X	X
E. bicolor	X				X
E. invaria (gp.)	X	X	X	X	X
E. needhami	X	X			
E. dorothea/excrucians			X		
E. serrata (gp.)	X	X	X	X	X
E. serratoides		X			
Family: Caenidae					
Caenis sp.	X	X	X	X	X
Family: Tricorythidae					
Tricorythodes sp.	X	X	X	X	X
Family: Siphlonuridae					
Isonychia sp.	X	X	X	X	X
Family: Baetidae					
Baetis sp.	X	X	X	X	X
B. flavistriga/cingulatus	X				
B. grondalis			X		
B. intercalaris			X	X	X
B. vagans	X	X			
Pseudocloeon sp.	X	X	X	X	X
P. myrsum (?)	X				
Callibaetis ferrugineus				X	
Neocloeon alamance				X	

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Family: Leptophlebidae					
Leptophlebia sp.	X	X	X	X	
Paraleptophlebia sp.	X	X	X	X	X
Family: Baetiscidae					
Baetisca bajkovi	X	X	X	X	
Family: Potamanthidae					
Potamanthus myops	X	X	X		X
Family: Ephemeridae					
Ephemera simulanus/varia	X	X	X		X
Hexagenia limbata	X			X	X
Family: Polymitarcidae					
Ephoron album	X		X		X
Order: Trichoptera					
Family: Hydropsychidae					
Cheumatopsyche sp.	X	X	X	X	X
Hydropsyche bifida (gp.)	X	X	X	X	X
H. betteni	X	X	X	X	
H. piatrix	X				
H. cuanis	X	X	X	X	
H. orris	X				
H. simulans				X	
Macronemum carolina				X	
Family: Hydroptilidae					
Ochrotrichia sp.	X	X	X	X	X
Oxyethira sp.	X				
Hydroptila sp.				X	

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Family: Philopotamidae					
Chimarra obscura	X	X	X	X	X
C. aterrima	X	X	X	X	
Wormaldia sp.	X		X		
Family: Polycentropodidae					
Neureclipsis sp.	X		X	X	
Polycentropus sp.	X	X	X	X	
Phylocentropus sp.			X		
Family: Helicopsychidae					
Helicopsyche sp.	X	X	X	X	X
Family: Rhyacophilidae					
Rhyacophila sp.	X				
Psychomyia flavida	X	X	X	X	X
Family: Glossosomatidae					
Agapetus sp.	X	X	X	X	X
Family: Brachycentridae					
Brachycentrus sp.	X	X	X	X	
B. numerous	X			X	
B. lateralis	X		X		
Family: Limnophilidae					
Neophylax sp.	X	X	X	X	
Pycnopsyche sp.				X	
Family: Leptoceridae					
Athripsodes sp.			X		
Oecetis sp.	X		X	X	

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Family: Lepidostomatidae					
<u>Lepidostoma</u> sp.	X	X	X	X	
Order: Odonata					
Family: Gomphidae	X	X	X	X	X
<u>Erpetogomphus</u> sp.	X		X		
<u>Gomphus</u> sp.			X		
Family: Macromiidae					
<u>Didymops</u> sp.				X	
Family: Libellulidae	X		X	X	
<u>Macormia</u> <u>pacifica</u>/<u>taeniolata</u>				X	
Family: Aeshnidae				X	
Family: Coenagrionidae	X	X	X	X	
<u>Argia</u> <u>apicalis</u>	X				
<u>A</u>. sp.				X	
Family: Calopterygidae					
<u>Hetaerina</u> <u>americana</u>	X		X		
Order: Megaloptera					
Family: Sialidae					
<u>Sialis</u> sp.	X		X	X	X
Family: Corydalidae					
<u>Corydalus</u> <u>cornutus</u>	X	X	X	X	X
<u>Nigronia</u> <u>serricornis</u>	X	X	X	X	X
Order: Coleoptera					
Family: Elmidae					
<u>Stenelmis</u> sp.	X	X	X	X	X

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
S. exiqua			X	X	
S. lateralis	X			X	
S. sexlineata			X		
Optioservus ozarkensis	X	X	X	X	X
Macronychus glabratus	X	X		X	
Dubiraphia vittata	X	X	X	X	
Ancyronyx variegata		X	X	X	
Family: Psephenidae					
Ectopria nervosa	X	X	X	X	X
Psephenus herricki	X	X	X	X	X
Family: Dryopidae					
Microcylloepus sp.	X				
M. pusillus similis				X	
Helichus lithophilus	X		X	X	X
Dryops sp.			X		
Family: Limnichidae					
Lutrochus laticeps	X	X			
Family: Gyrinidae					
Dineutus sp.	X			X	
Gyretes sinuatus				X	
Family: Curculionidae					
Onychylis sp.	X	X		X	
Stenopelmus rustinasus	X				
Family: Hydrophilidae					
Berosus sp.	X		X	X	
Hydrochus sp.				X	

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Family: Dytiscidae					
Hydaticus sp.	X				
Hydroporus niger		X		X	
H. undulatus				X	
H. pulcher				X	
Oreodytes/Deronectes				X	
Rhantus tostus				X	
Coptotomus interrogatus				X	
Family: Halipidae					
Peltodytes edentulus				X	
P. tortulosus				X	
P. lengi				X	
P. sexmaculatus				X	
P. litoralis				X	
Family: Heteroceridae				X	
Order: Diptera					
Family: Chironomidae	X	X	X	X	X
Family: Simuliidae	X	X	X	X	X
Family: Empididae	X	X	X	X	X
Family: Stratiomyidae	X	X	X	X	
Family: Ceratopogonidae					X
Bezzia/Probezzia	X	X	X	X	
Atrichopogon sp.		X			
Family: Muscidae	X	X	X		
Family: Tipulidae					
Tipula sp.	X	X	X	X	

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Eriocera/Hexatoma	X	X	X		X
Antocha sp.	X	X	X	X	X
Erioptera sp.	X		X		
Family: Tabanidae					
Chrysops/Tabanus	X	X	X	X	X
Family: Rhagionidae					
Atherix sp.	X	X	X	X	
Family: Tanyderidae					
Protoplasa sp.	X	X	X		
Order: Hemiptera					
Family: Saldidae	X				
Family: Gerridae					
Metrobates sp.	X				
Rheumatobates trulliger		X		X	
Trepobates sp.				X	
Family: Veliidae					
Microvelia sp.				X	
Rhagovelia knighti	X	X	X		X
Family: Corixidae	X	X	X		
Family: Hebridae	X			X	
Hebrus buenoi				X	
Order: Lepidoptera					
Family: Pyralidae					
Paragyractis sp.	X	X	X	X	X

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Miscellaneous Groups:					
Phylum: Annelida					
Class: Oligochaeta					
Family: Branchiobdellidae	X	X	X		X
Other Oligochaetes	X	X	X	X	X
Class: Hirudinea	X	X	X	X	
Phylum: Nemata	X	X	X	X	X
Phylum: Nematomorpha					
Class: Gordiia	X	X	X	X	X
Phylum: Platyhelminthes					
Class: Tubellaria					
Order: Tricladida					
Family: Planariidae	X	X	X	X	X
Phylum: Mollusca					
Class: Gastropoda					
Order: Basommatophora					
Family: Physidae					
Physa sp.	X		X		
Family: Lymnaeidae					
Lymnaea sp.	X			X	
Family: Planorbidae	X		X	X	X
Family: Ancylidae					
Ferrissia sp.	X	X	X	X	X
Order: Mesogastropoda	X	X	X	X	X
Family: Pleuroceridae					
Goniobasis sp.	X	X	X	X	X

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Class: Pelecypoda					
Order: Heterodonta					
Family: Sphaeriidae	X	X	X	X	X
Family: Corbiculidae					
Corbicula leana			X	X	
Order: Eulamellibranchia					
Family: Unionidae*					
Alasmidonta marginata			X	X	
Lasmigona costata			X	X	
Ptychobranchus occidentalis	X		X	X	
Strophitus f. undulatus	X		X	X	
Lampsilis brevicula	X	X	X	X	X
L. ventricosa		X	X	X	
L. teres f. teres					X
L. radiata f. luteola			X		
Fusconaia flava f. flava				X	
F. ozarkensis	X	X	X		X
Pleurobema coccineum f. coccineum	X		X	X	
P. c. f. catillus				X	
Cyclonaias tuberculata	X			X	
Amblema plicata	X			X	
Truncilla donaciformis				X	
Quadrula pustulosa				X	
Elliptio dilatatus	X	X	X	X	
Villosa lienosa			X		
V. iris	X				

Table 3. (Continued)

Classification[1]	Current River	Jack's Fork River	Eleven Point River	Little Black River	Warm Fork of Spring River
Ligumia subrostrata			X		
Toxolasm parva	X		X		
Actinonaias pleasii			X		
Phylum: Arthropoda					
Class: Crustacea					
Order: Amphipoda					
Family: Gammaridae					
Gammarus sp.	X	X	X	X	X
Family: Talitridae					
Hyalella sp.	X	X		X	
Order: Isopoda					
Family: Asellidae					
Asellus sp.	X	X		X	X
Lirceus sp.	X		X	X	X
Order: Decapoda					
Family: Astacidae					
Orconectes sp.	X	X	X	X	X
Cambarus sp.					X
Class: Arachnoidea					
Order: Acari	X	X	X	X	X

1 Classification follows Hilsenhoff (1975) and Ward & Whipple (1959).

* Identification by Ronald Oesch, St. Louis, Missouri.

Table 4. Point source pollution discharges and potential pollution sources entering Current River and its tributaries.

Facility					
Name	Legal Description	Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
Ripley County					
Doniphan, Mo.	T23N R2E Sec.24 SW¼	lagoon (3-cell)	5.8	Current River	C-49
Doniphan, Mo.	T23N R2E Sec.24 SW¼	lagoon (1-cell)	1.3	Current River	C-49
Wright Gravel Plant	T23N R2E Sec.27 SE¼	Gravel operation	--	Current River	C-49
Ripley Co. School Dist. R-1	T23N R2E Sec.21 SW¼	Septic tank & sand filter	--	Current River	C-51
Riverlawn Subdivision	T23N R2E Sec.33 S½	--	--	Current River	--
Patterson's Spring Valley Cottage	T22N R2E Sec.4 SW¼	lagoon (1-cell)	0.1	Current River	--
Robertson Laundromat	T23N R1W Sec.5 SW¼	lagoon (2-cell)	0.5	Buffalo Creek (South Fork)	Cbu-6
Ripley Co. School Dist. R-4	T23N R1E Sec.17 NE¼	septic tank & sand filter	--	Fourche Creek (East Fork)	Cf-3
Ripley Co. School	T22N R1W Sec.1 SW¼	septic tank & sand filter	--	Fourche Creek (West Fork)	--
R. E. Wilson	T22N R1E Sec.9 NW¼	lagoon (1-cell)	0.02	Fourche Creek (West Fork)	Cf-3
Doniphan Retirement Home	T23N R2E Sec.35 SE¼	lagoon (1-cell)	0.4	Current River	C-49
Carter County					
Van Buren, Mo.	T27N R1W Sec.24 NE¼	lagoon (2-cell)	2.5	Current River	C-87
Big Spring Readimix	T27N R1W Sec.24 SW¼	gravel operation	--	Current River	C-87

Table 4. (Continued)

Facility		Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
Name	Legal Description				
Arrowhead Motel	T27N R1E Sec.18 NW¼	septic tank	--	Current River	C-87
Carter Co. School Dist. R-1	T26N R2W Sec.3 NW¼	septic tank & sand filter	--	Pike Creek	Cp-1
Shannon County					
Raymond George	T27N R1W Sec.13 SE¼	lagoon (2-cell)	0.4	Pike Creek	Cp-1
Shannon Co. School Dist. R-3	Winona, Mo.	septic tank & sand filter	--	Seamen Creek	Cp-1
Pioneer Forest	T30N R4W Sec.4 NW¼	lagoon (2-cell)	0.1	Sinking Creek	Cs-0
Camp Zoe (R.S. McMahon)	T30N R4W Sec.8 SW¼	lagoon (1-cell)	0.5	Sinking Creek	Cs-0
Reorganized School Dist. R-2	T29N R6W Sec.19 NW¼	lagoon (1-cell)	0.5	Spring Valley Creek	Csv-0
Texas County					
Summersville Industrial Development Comm.	T29N R7W Sec.24 NW¼	lagoon (1-cell)	0.4	Spring Valley Creek	Csv-0
Dent County					
Bunker, Mo.	T32N R3W Sec.24 NE¼	lagoon (2-cell)	0.6	Sinking Creek	Cs-0
Reed's Cabin	T32N R7W Sec.22	septic tank & tile field	--	Ashley Creek	Ca-1
Montauk State Park	T32N R7W Sec.23	lagoon (3-cell)	1.7	Current River	C-175
Mo. Department of Conservation	T32N R7W Sec.22	trout hatchery	--	Current River	C-175

Table 4. (Continued)

Facility					
Name	Legal Description	Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
<u>Reynolds County</u>					
Bunker, Mo.	T32N R2W Sec.19 NW¼	lagoon (2-cell)	1.2	Big Creek	Cbi(s)-9
Bunker, Mo.	T32N R2W Sec.19 NE¼	lagoon (2-cell)	1.1	Big Creek	Cbi(s)-9
Southaire Mobile Home Park	T32N R2W Sec.19 SW¼	lagoon (1-cell)	0.2	Big Creek	Cbi(s)-9

1 Compiled from information obtained from Division of Environmental Quality (DNR) and Missouri Department of Conservation personnel.

Missouri (Vineyard and Feder, 1974). To date, no sources of pollution have been traced to these springs. Invertebrates were collected from a flowing branch of these springs in the northern portion of the park at MS-0 (Fig. 1).

The invertebrate community in Montauk Springs (MS-0) was dominated by three taxonomic groups:

Snails (65%)	Caddisflies (14%)	Mayflies (11%)
Goniobasis sp. 99%	Agapetus sp. 77%	Baetis vagans 88%
	Hydropsyche bifida (gp.) 13%	
	Lepidostoma sp. 6%	

Invertebrate density was higher than most of the other stations on the Current River while total taxa, mayfly and stonefly taxa and species diversity values were low (Fig. 3; Appendix Table A-6). Cold water temperatures and lower productivity in Montauk Springs were responsible for this type of invertebrate community, not pollution. Water quality in Montauk Springs was considered unpolluted since the invertebrates living in the spring branch were pollution sensitive forms.

The effects of organic pollution from the fish hatchery operated by the Missouri Department of Conservation and a three cell sewage lagoon serving the facilities at Montauk State Park (Table 4) on Current River above station C-175 were difficult to assess. Montauk Springs makes up the major portion of the flow at this station and effects of the spring water were apparent from the lower water quality parameter values. Invertebrate density at C-175 was high (327 per sq. ft.) and total taxa,

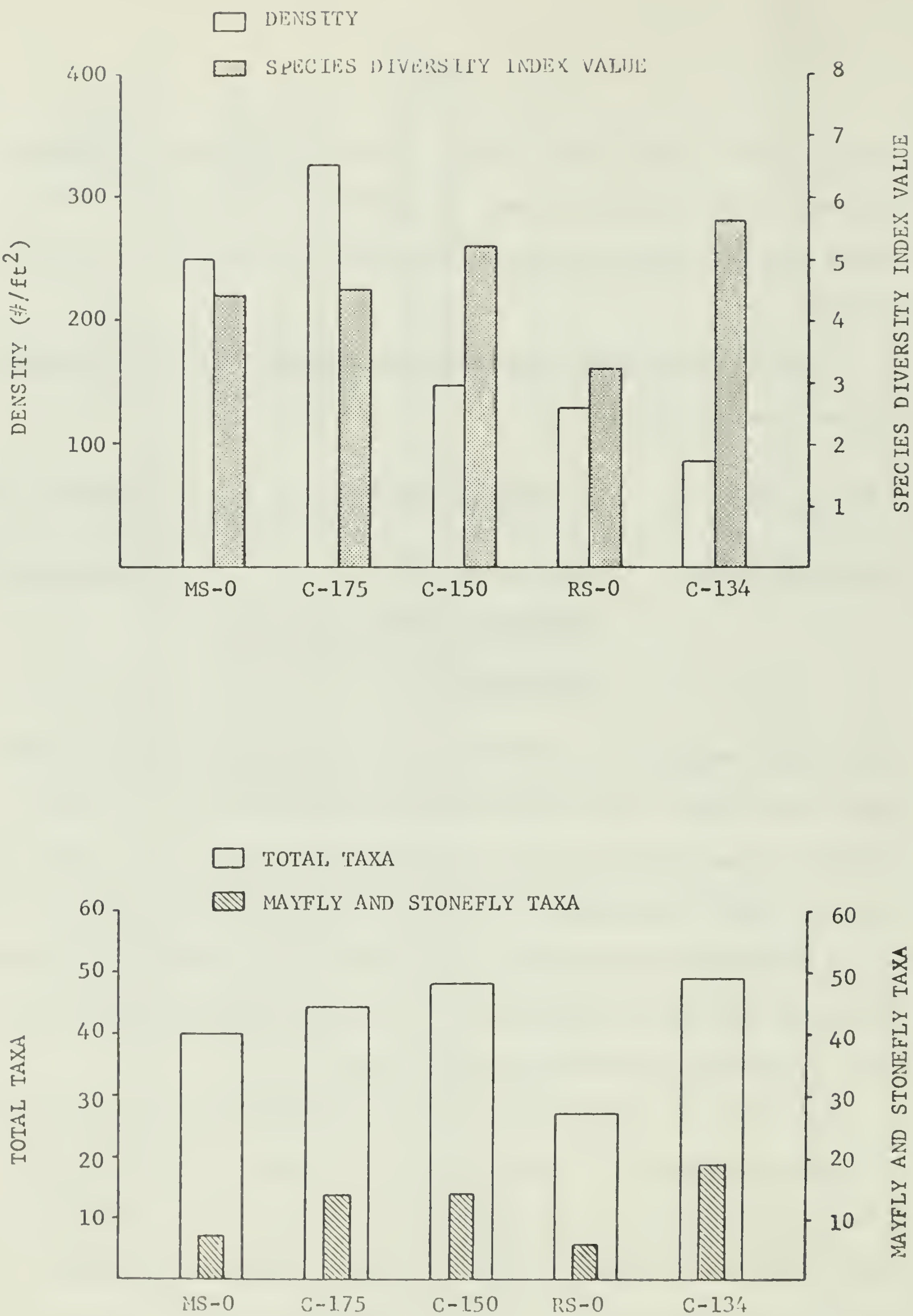


Figure 3. Summary of annual water quality parameter values for mainstem stations on upper Current River, above the mouth of Jack's Fork River.

mayfly and stonefly taxa, and species diversity were higher than at MS-0 (Fig. 3) but did not meet the criteria. Mayflies, caddisflies, and true flies comprised most of the insects found at C-175. The dominant taxa in these three groups were:

Caddisflies (57%)	Mayflies (17%)	True flies (14%)
Cheumatopsyche sp. 48%	Ephemerella serrata (gp.) 31%	Chironomidae 81%
Hydropsyche bifida (gp.) 38%	Baetis sp. 31%	Simulidae 11%
Rhyacophila sp. 12%	Pseudocloeon sp. 23%	Empididae 7%

The water quality in Current River at C-175 could not be classified. The invertebrate community at C-175 (Fig. 4) consisted of many taxa of invertebrates which are sensitive of sewage pollution. The water quality at this station was considered unpolluted based on the invertebrate taxa present. The colder water from Montauk Springs probably masked the effects, if any, of the organic wastes entering from the lagoons or fish hatchery. The effects of these pollution sources appears to be minimal.

Station C-150 was located just below Pulltight Campgrounds about 25 miles downstream from C-175 (Fig. 1, Table 1). Spring water still comprises the major portion of flow at this station and the effects of the cold, relatively infertile water on the invertebrate community was similar to those found at C-175. No major pollution sources entered the river between C-175 and C-150. Invertebrate density at C-150 was less than at C-175 (145 per sq. ft.) and the other water quality parameter values (Fig. 3) had increased slightly. Mayflies, caddisflies, and true flies were the dominant invertebrate groups. The taxa within each group were different

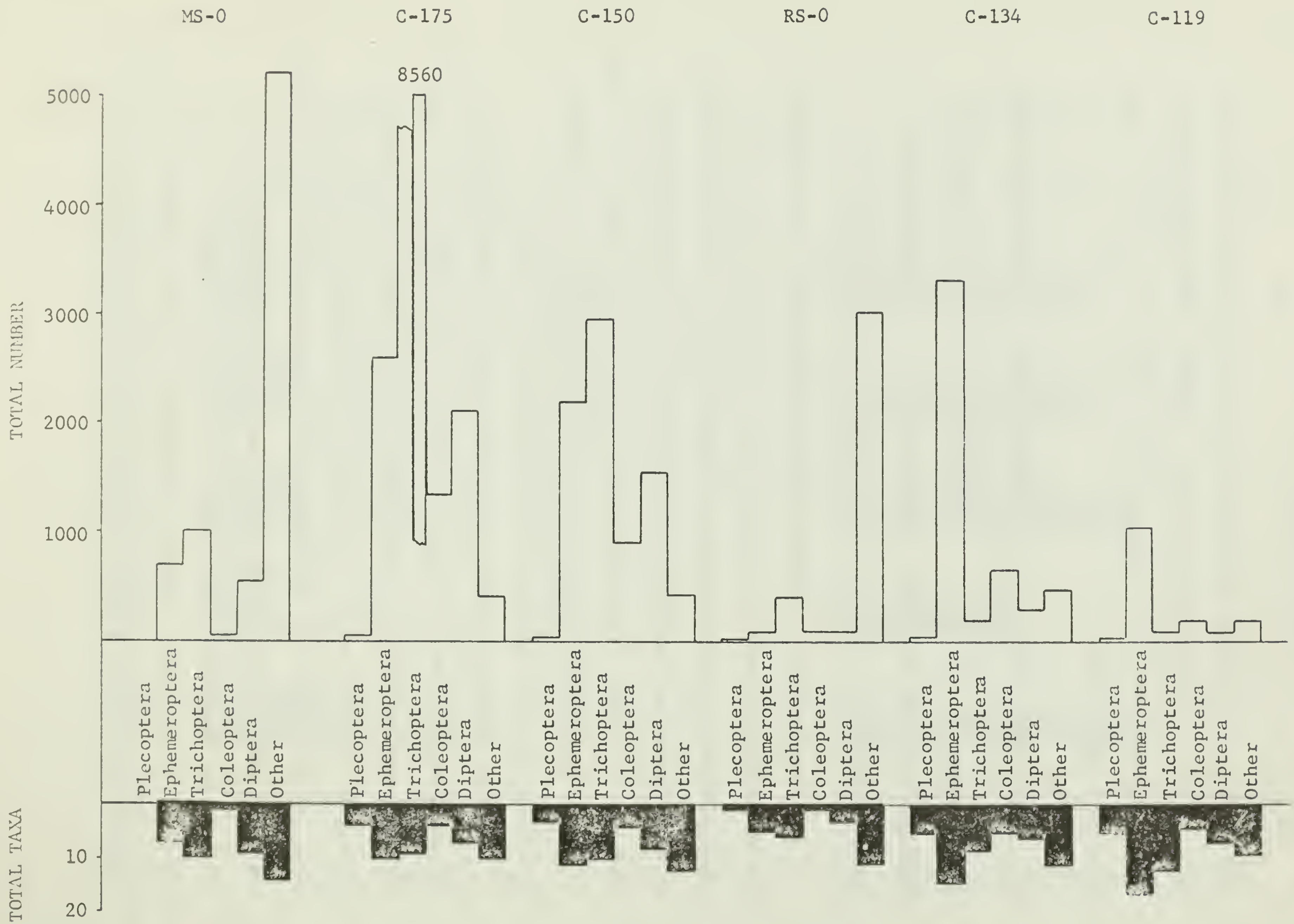


Figure 4. Community structure of benthic invertebrates from mainstem stations on upper Current River, above the mouth of Jack's Fork River.

from those at station C-175:

Caddisflies (36%)	Mayflies (27%)	True flies (19%)
Agapetus sp. 63%	*Pseudocloeon* sp. 44%	Chironomidae 79%
Hydropsyche bifida (gp.) 17%	*Rhithrogena pellucida* (?) 23%	Empididae 9%
Cheumatopsyche sp. 12%	*Baetis* sp. 15%	Simulidae 8%

The influence of spring water was primarily responsible for the water quality parameter values being depressed. Some warmer-water taxa appear to have become established. Water quality at this station was considered unpolluted because of the abundance of taxa considered to be pollution sensitive (Fig. 4).

Round Spring (RS-O) enters the Current River about 10 miles north of Eminence, Missouri (Fig. 1). According to Vineyard and Feder (1974), the discharge from this spring ranks 14th in the major springs of Missouri. To date, no pollution has been traced to Round Spring. However, Beckman and Hinchey (1944) speculated that the source of the spring included a portion of the drainage basin of Spring Valley Creek which receives the discharge from two small sewage treatment lagoons (Table 4).

The invertebrate community in the spring resembled that found in Montauk Springs in that snails (99% *Goniobasis* sp.) comprised 48% of the organisms collected at the station throughout the year. Amphipods (100% *Gammarus* sp.) accounted for 25% of the organisms and caddisflies 10% (71% *Agapetus* sp.; 15% *Lepidostoma* sp.). The coefficient of similarity comparing stations RS-0 and MS-0 (Appendix Table A-7b) was 46 which indicated that both stations had many taxa in common, however, different densities prevented the invertebrate communities from being considered similar. The only beetle collected in both spring branches was Optioservus ozarkensis.

Water quality in Round Spring was considered unpolluted since many of the taxa collected were considered pollution intolerant. Water quality parameter values (Fig. 3) were low. If pollution entering Spring Valley Creek does affect Round Spring, it was not readily apparent by examining the invertebrate community structure in the spring branch (Fig. 4); their effects, if any, were considered minimal.

Station C-134 was located 16 miles downstream from Pulltight Spring at Jerktail Landing (Fig. 1; Table 1). No pollution was known to enter the river directly, but several lagoons (Table 4) discharge into the headwaters of major tributaries (Barren, Sinking, and Spring Valley creeks). These tributaries will be discussed later. The effects of these discharges on the invertebrate community at C-134 were negligible since numerous taxa of pollution intolerant invertebrates were found. Water quality was considered unpolluted. Parameter values improved slightly at C-134 over those at C-150 (Fig. 3). The Current River at this point appeared warmer, more productive, and springs comprised less flow proportionately than at the upstream stations.

The species composition of the invertebrate community differed slightly from previous stations. Caddisflies were the most abundant taxonomic group at C-175 and C-150 but were 4th at C-134. The dominant groups were as follows:

Mayflies (65%)	Beetles (13%)	True flies (6%)
Isonychia sp. (28%)	*Optioservus ozarkensis* (95%)	Chironomidae (78%)
Stenonema pulchellum (20%)	*Psephenus herricki* (3%)	
Tricorythodes sp. (11%)		

Many of the taxa found at C-134 appeared to be more tolerate of higher temperatures than the taxa from previous stations. Some cold-water taxa found at stations C-175 and C-150 were also found at C-134 but were less abundant. The invertebrate community found at C-134 was quite similar to those sampled at lower mainstem and tributary stations which were influenced less by spring water (Appendix Table A-7). Clifford (1966) found that the average annual temperature of the Current River increased from Round Spring downstream to Doniphan. He also observed a decrease in free carbon dioxide concentration which according to the American Public Health Association (1971) shows a decrease in the influence of ground water (springs).

Jack's Fork River enters Current River between stations C-134 and C-119 (Fig. 1). Clifford (1966) sampled C-119 in 1961 and found 32 taxa which was the lowest number at the five stations he sampled. Clifford considered all five stations on Current River unpolluted based on their chemical and biological characteristics. During 1974, 58 taxa of invertebrates (48 taxa according to Clifford's taxonomic classification) were collected at C-119. Twenty-one were pollution sensitive mayfly and stonefly taxa while Clifford found only 8 taxa. Seasonal and annual species diversity index values (Fig. 5; Appendix Table A-6) also met the criteria for unpolluted Missouri streams. The decreasing influence of spring water probably accounted for the increased water quality parameter values over stations C-175, C-150

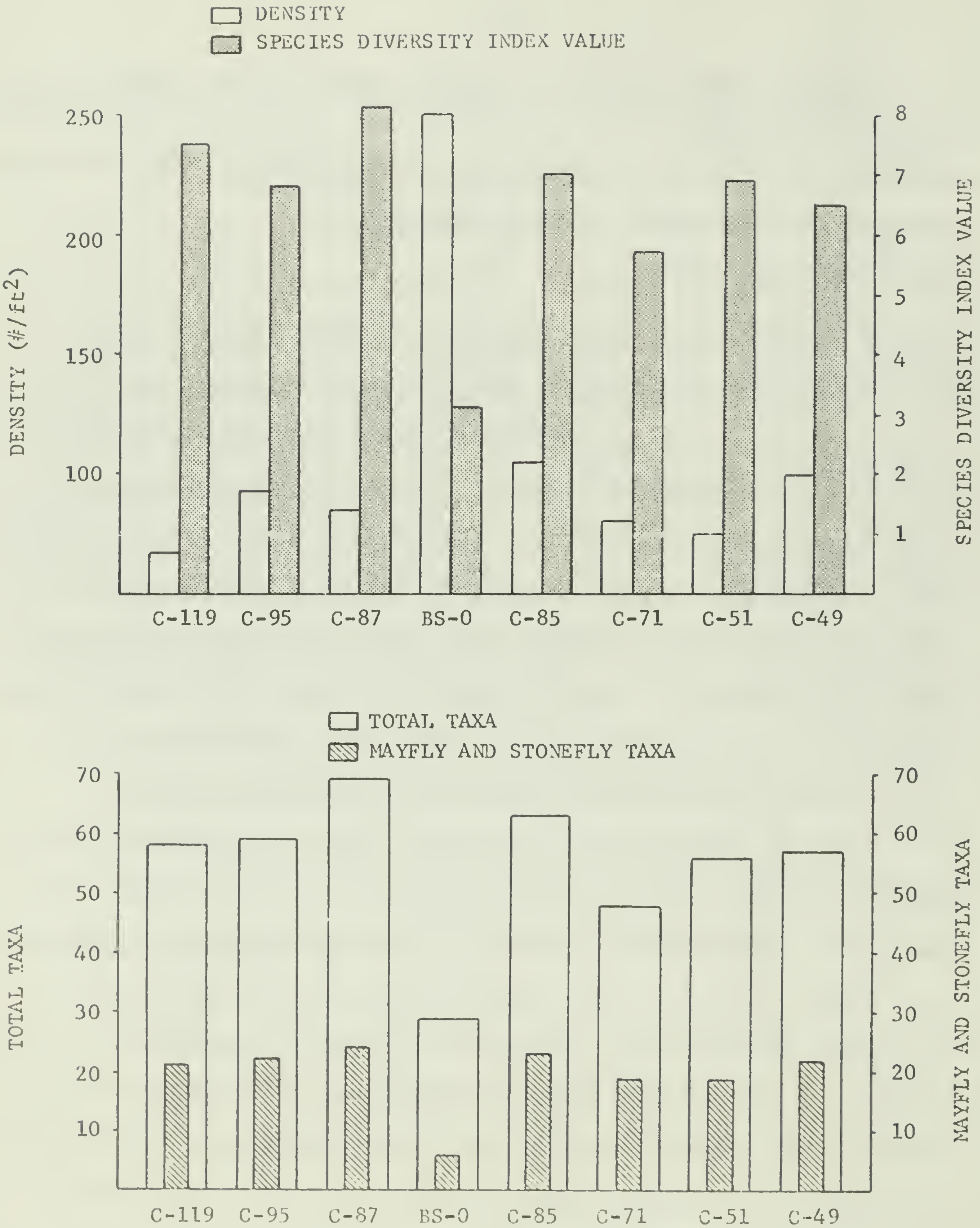


Figure 5. Summary of annual water quality parameter values for mainstem stations on lower Current River, below the mouth of Jack's Fork River.

and C-134.

The invertebrate community at C-119 was dominated by the same three major groups as at C-134. The dominant taxa within each group changed from the previous stations:

Mayflies (59%)	Beetles (12%)	True flies (9%)
Rhithrogena pellucida (?) (19%)	*Optioservus ozarkensis* (85%)	Chironomidae (81%)
Ephemerella invaria (gp.) (18%)	*Ectopria nervosa* (9%)	Empididae (6%)
Stenonema pulchellum (15%)		

Other groups; such as stoneflies (Plecoptera), crayfish (*Orconectes* sp.), and Alder-Dobsonflies (Megaloptera); were more common at C-119 than at upstream stations. Snails (primarily *Goniobasis* sp.) were prevalent but only accounted for 5% of the organisms collected in the sample.

Station C-119 had the lowest invertebrate density (34 per square foot) of all stations sampled on the Current River (Fig. 5; Appendix Table A-6). Clifford (1966) also noted this phenomena and attributed it to the poor, moderately stable substrate. In spite of the poor quality substrate, which still existed in 1974 at C-119, Current River supported a diverse invertebrate community consisting of many pollution sensitive types (Fig. 4). Water quality in this portion of Current River was classified unpolluted and the difference between Clifford's and the 1974 data was attributed to sample size. Clifford sampled only 2 square feet of riffle substrate per collection where 12-16 square feet were collected during this survey. The difference in the number of taxa found at C-119 between the two surveys emphasizes the importance of sampling an adequate area of the riffle to accurately describe the invertebrate community.

Stations C-95 and C-87 (Fig. 1, Table 1) were established to monitor the effects of pollution entering the Current River from Van Buren, Missouri (Table 4). Both stations supported very similar invertebrate communities (C=71) consisting of numerous taxa of pollution sensitive organisms (Fig. 6). Water quality parameter values (Fig. 5) for stations C-95 and C-87 exceed the criteria established for unpolluted Missouri streams. This showed that Current River was unpolluted between these sampling sites. The sewage lagoon system serving Van Buren is connected to a spray irrigation system and may account, in part, for this unpolluted condition. However, the irrigation system was not always used. When the irrigation system was not in use the quality of water in Current River immediately downstream from the lagoons was visually degraded by turbidity from large concentrations of suspended phytoplankton being discharged in the effluent (Personal communication, 1974, Thomas F. May, District Supervisor of Conservation Agents, Missouri Department of Conservation, Van Buren, Mo.). Increased turbidity has also been observed downstream from the gravel operation (Table 4), located in the floodplain, when Current River floods. The degradation, to date, has been localized and short term. If these problems are allowed to continue, the damage could become more extensive and possibly permanent.

Even though the invertebrate communities at the two stations were similar, the dominant taxonomic groups and taxa within each group varied:

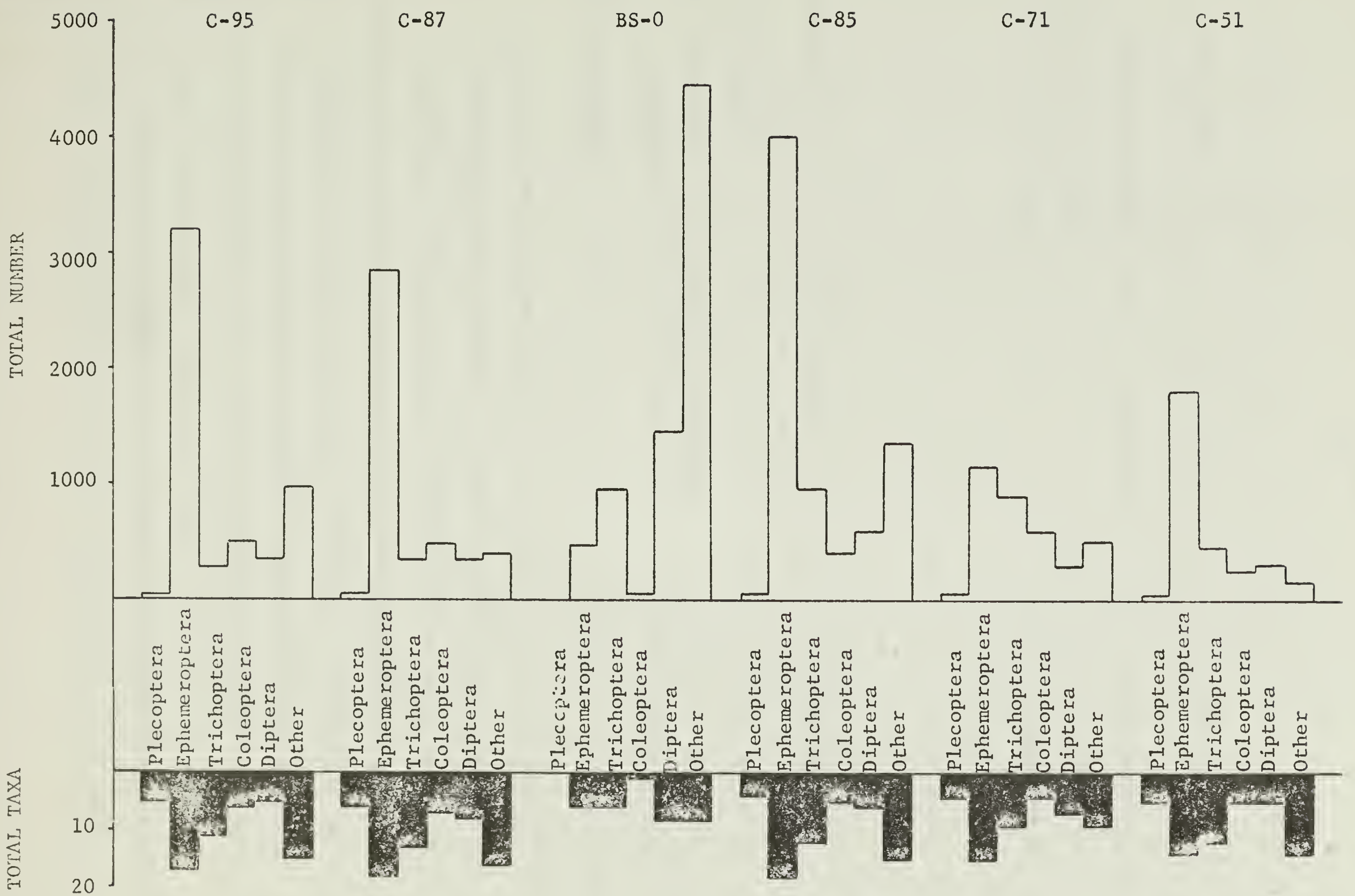


Figure 6. Community structure of benthic invertebrates from mainstem stations on lower Current River, below the mouth of Jack's Fork River.

C-95

Mayflies (60%)	Snails (15%)	Beetles (9%)
Tricorythodes sp. (23%)	*Goniobasis* sp. (98%)	*Stenelmis* sp. (64%)
Stenonema pulchellum (17%)		*Optioservus ozarkensis* (23
Heptagenia sp. (15%)		*Ectopria nervosa* (9%)
Isonychia sp. (9%)		

C-87

Mayflies (66%)	Beetles (11%)	Caddisflies (8%
Stenonema pulchellum (20%)	*Stenelmis* sp. (77%)	*Cheumatopsyche* sp.
Isonychia sp. (20%)	*Optioservus ozarkensis* (18%)	*Psychomyia flavida*
Heptagenia sp. (14%)		*Agapetus* sp. (11%)
		Hydropsyche cuanis

Missouri's largest spring, Big Spring, enters Current River just below station C-87 (Fig. 1; Table 1). Although, Big Spring usually appears to be clear and unpolluted, reports of pollution entering it from its recharge basin date back over 45 years. Bridge (1930) reported that Midcontinent Iron Company near Fremont, Missouri contaminated Big Spring by discharging chemical wastes into Davis Creek about 10 miles from the spring. The operation ceased in 1921 and the spring no longer discharged "red water". Vineyard and Feder (1974) discussed dye tracing experiments designed to identify the recharge basin of Big Spring done by the U. S. Forest Service. Nearly a dozen successful dye traces were made to Big Spring. The longest was from Mountain View, Missouri, nearly 40 miles away. The travel time was considered short and comments were made that it would be easy for viruses, bacteria, and protozoans to readily transverse this distance. The same would be true for chemical contaminants that enter the recharge basin of Big Spring.

The invertebrate community sampled in the spring branch (BS-0; Fig. 1) had some similarity to the community inhabiting Round Spring (C=47). Invertebrate density was high (246 per square foot) and the number of total taxa, mayfly and stonefly types and species diversity index values were low, but comparable to Round and Montauk springs (Figs. 3 and 5; Appendix Table A-6). Four invertebrate groups characterized the community sampled at BS-0:

Amphipods (39%)	True flies (20%)	Snails (13%)	Caddisflies (13%)
Gammarus sp. (100%)	Chironomidae (96%)	*Goniobasis* sp. (97%)	*Brachycentrus* sp.(88
	Empididae (2%)	*Physa* sp. (3%)	*Agapetus* sp. (11%)

The dominant taxa in these four groups were also well represented in samples collected from Montauk and Round springs. Even though earlier workers have shown a great potential for contamination of Big Spring, pollution has not seriously damaged the spring's inhabitants. The invertebrates collected at BS-0 were pollution sensitive and the community structure resembled that found at the previously discussed springs which were considered unpolluted (Figs. 4 and 6).

The station on Current River downstream from Big Spring was C-85 (Fig. 1, Table 1). The invertebrate community at this station was similar to those communities sampled above Big Spring at C-87 (C=62) and C-95 (C=74). Numerous taxa of pollution sensitive organisms were found and the water quality parameter values (Fig. 5) exceeded the criteria established for unpolluted streams in Missouri. Invertebrate taxa at C-85 were primarily mayflies and caddisflies with the remaining taxonomic groups being evenly represented (Fig. 6). The presence of amphipods and snails in fair numbers was probably due to the close proximity of C-85 to Big Spring. The major taxa collected in the top two groups were:

Mayflies (55%)	Caddisflies (13%)
Tricorythodes sp. (18%)	Cheumatopsyche sp. (47%
Heptagenia sp. (16%)	Agapetus sp. (38%)
Stenonema pulchellum (16%)	Psychomyia flavida (6%)
Stenacron gildersleevai (15%)	
Isonychia sp. (10%)	

Clifford (1966) collected 31 taxa of invertebrates, including 12 mayfly and stonefly taxa at this location. During the present survey, 63 taxa (53 using Clifford's classification) were collected at C-85, including 23 mayfly and stonefly types. According to Clifford's classification, 18 mayfly and stonefly types were collected. The discrepancy between the two surveys was sample size as mentioned during the discussion of C-119. The smaller sample size collected by Clifford undoubtedly accounted for the fewer taxa collected. Water quality conditions in the Current River during the 14 years between the two surveys have probably remained comparable and do not appear to have deteriorated. Pollution sensitive invertebrates were well represented at C-85 during both surveys.

Station C-71 was located on the Current River, 14 miles downstream from C-85, at Gooseneck on the Ripley-Carter county line (Fig. 1; Table 1). No point sources of pollution enter the river between C-85 and C-71. The invertebrate community sampled at C-71 was less diverse than at upstream stations on the Current River. Community structure (Fig. 6), most seasonal species diversity indices, and mayfly and stonefly taxa (Appendix Table A-6) were indicative of unpolluted conditions. However, annual water quality parameter values did not meet the criteria (Fig. 5). The substrate at C-71 had a higher percentage of sand than previous stations which made it less stable. Vineyard and Feder (1974) indicated that nine springs discharge to the Current River within 1 mile upstream from C-71. The less stable substrate and spring water were the probable reasons for the less diverse invertebrate community at C-71 (similar to those noted for upper Current River).

The invertebrate community at this station was comprised of the following major taxonomic groups:

Mayflies (32%)	Caddisflies (27%)	Beetles (18%)
Baetis sp. (32%)	*Agapetus* sp. (90%)	*Stenelmis* sp. (63%)
Heptagenia sp. (14%)	*Cheumatopsyche* sp. (4%)	*Optioservus ozarkensis* (29%)
Stenonema pulchellum (14%)	*Hydropsyche bifida* (gp.)(2%)	
Isonychia sp. (9%)	*Psychomyia flavida* (2%)	

Baetis sp. and *Agapetus* sp. were the dominant taxa in their respective groups and snails (*Goniobasis* sp.) accounted for 13% of the individuals collected at C-71. These taxa also were the dominant taxa at Montauk and Round springs. The cooler water from the springs probably inhibited the numbers of warm-water taxa enough to depress the diversity of the invertebrate community. Water quality at C-71 was considered unpolluted based on the numerous pollution sensitive taxa found at C-71.

The Doniphan sewage treatment lagoons and a gravel operation (Table 4) discharged into Current River between stations C-51 and C-49 (Fig. 1; Table 1). Numerous reports of large qualities of suspended phytoplankton and strong odors in the lagoon discharge were received during the survey (Personal communication, 1974, James Pokorny, Conservation Agent, Missouri Department of Conservation, Doniphan, Missouri). All such reports were verified and turned over to the Missouri Department of Natural Resources, Division of Environmental Quality for action.

Invertebrate communities at C-51 and C-49 were considered similar in composition (C=56) and consisted of many pollution sensitive taxa. Most seasonal and annual water quality parameter values at C-51 and C-49 (Fig. 5) met the criteria. These stations were classified unpolluted. As was true at Van Buren, the effects of the pollution problems were localized (Robinson-Wilson, 1977) and not readily apparent at C-49. Even though these problems have not yet seriously degraded the Current River, inferior quality lagoon discharges should not be tolerated in a stream such as Current River.

The invertebrate community at C-51 and C-49 were quite similar to those sampled at C-95, C-87, and C-85 (Appendix Table A-7) and were comprised mainly of the following taxonomic groups:

C-51

Mayflies (62%)	Caddisflies (15%)	True flies (11%)
Stenonema pulchellum (35%)	Cheumatopsyche sp. (80%)	Chironomidae (88%)
Baetis sp. (19%)	Hydropsyche bifida (gp.)(7%)	Simulidae (9%)
S. nepotellum (9%)	Rhyacophila sp. (5%)	Empididae (2%)

C-49

Mayflies (73%)	Caddisflies (7%)	Beetles (5%)	True flies (5%)
Stenonema pulchellum (17%)	Cheumatopsyche sp. (48%)	Stenelmis sp. (84%)	Chironomidae (91%)
Tricorythodes sp. (16%)	Psychomyia flavida (38%)	Optioservus ozarkensis (14%)	Empidiae (4%)
Heptagenia sp. (14%)	Agapetus sp. (6%)		Simulidae (3%)
S. nepotellum (10%)			

The similarity in the invertebrate communities at these two stations was also noted by Clifford (1966). Water quality has apparently remained unpolluted during the 14 years since his study because pollution sensitive taxa were well represented in samples collected during both surveys.

Major Tributaries

Ashley Creek (Ca-1)

Ashley Creek enters Current River from the west, downstream from Montauk State Park (Fig. 1, Table 1). The only known source of pollution was limited drainage from a septic tank (Table 6). The watershed of this tributary was primarily forested with some pasture land in the bottomlands. All water quality parameter values (Fig. 7) met the criteria for unpolluted Missouri streams. Ashley Creek was classified unpolluted.

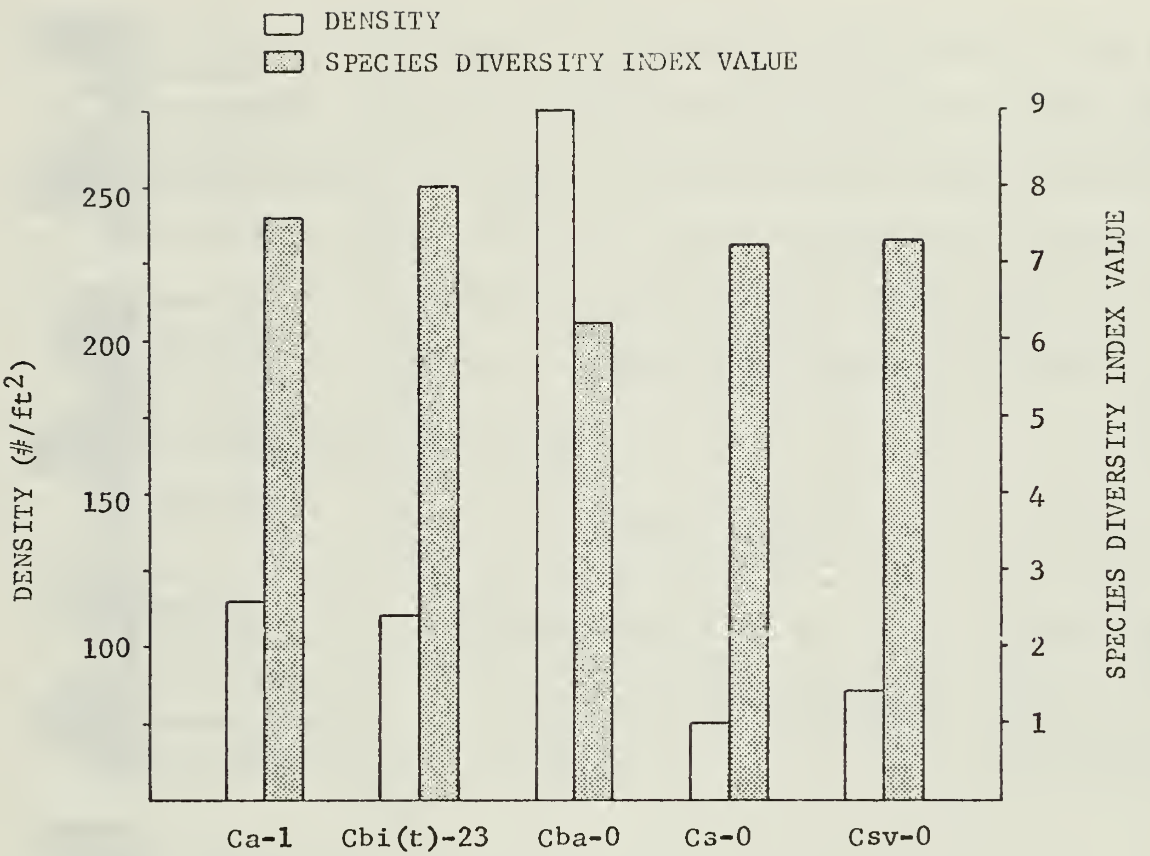
The invertebrate community in Ashley Creek consisted of numerous pollution sensitive taxa including the following major groups:

Beetles (32%)	Mayflies (25%)	Snails (17%)	Caddisflies
Optioservus ozarkensis (86%)	Stenonema pulchellum (21%)	Goniobasis sp. (99%)	Agapetus sp. (32%)
Psephenus herricki (12%)	Isonychia sp. (15%)		Cheumatopsyche (21%)
Stenelmis sp. (1%)	Tricorythodes sp. (15%)		Helicopsyche s
	S. nepotellum (13%)		Hydropsyche bi (13%)

The invertebrate community structure was quite different than that found in Current River because no single taxonomic group dominated the community inhabiting Ashley Creek (Fig. 8). At most stations on Current River, especially downstream from the mouth of the Jack's Fork, mayflies were almost twice as abundant as any other taxonomic group. This fact was not true in Ashley Creek. No explanation for this is apparent.

Big Creek, Texas County (Cbi(t)-23)

Big Creek is considered a losing stream over much of its course and becomes intermittent during periods of dry weather. The sampling station was located 23 miles above its mouth in a portion of the stream (Fig. 1; Table 1) that is not considered a losing stream (Missouri Department of Conservation, 1943). No point sources of pollution were found in the



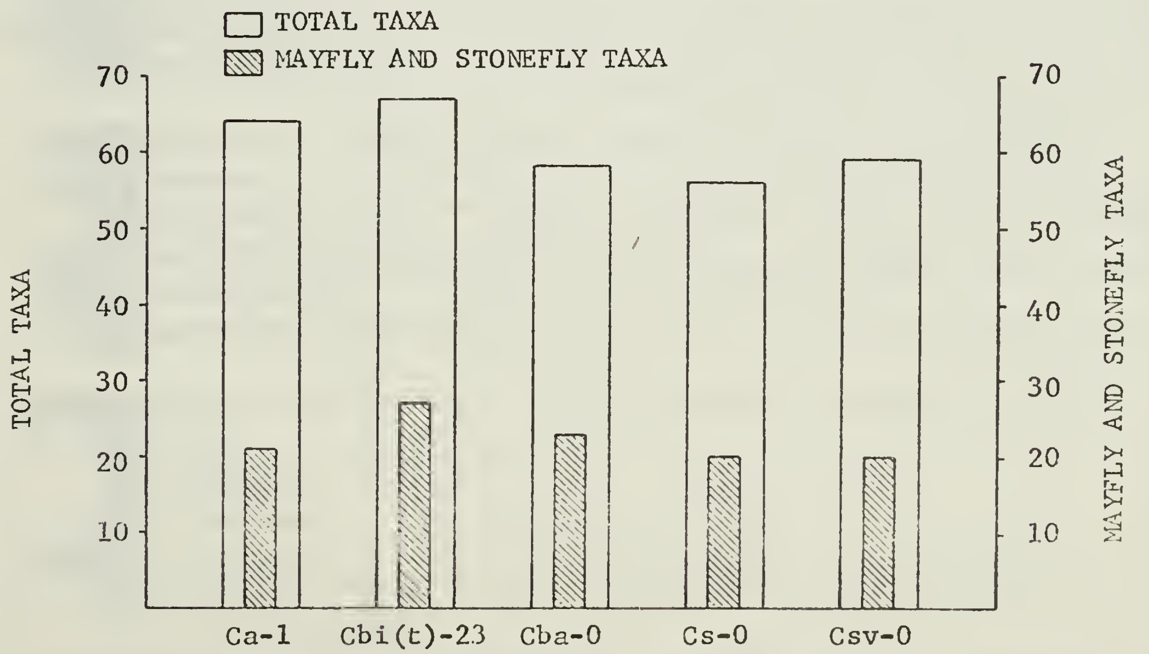


Figure 7. Summary of annual water quality parameter values for major tributaries entering upper Current River.

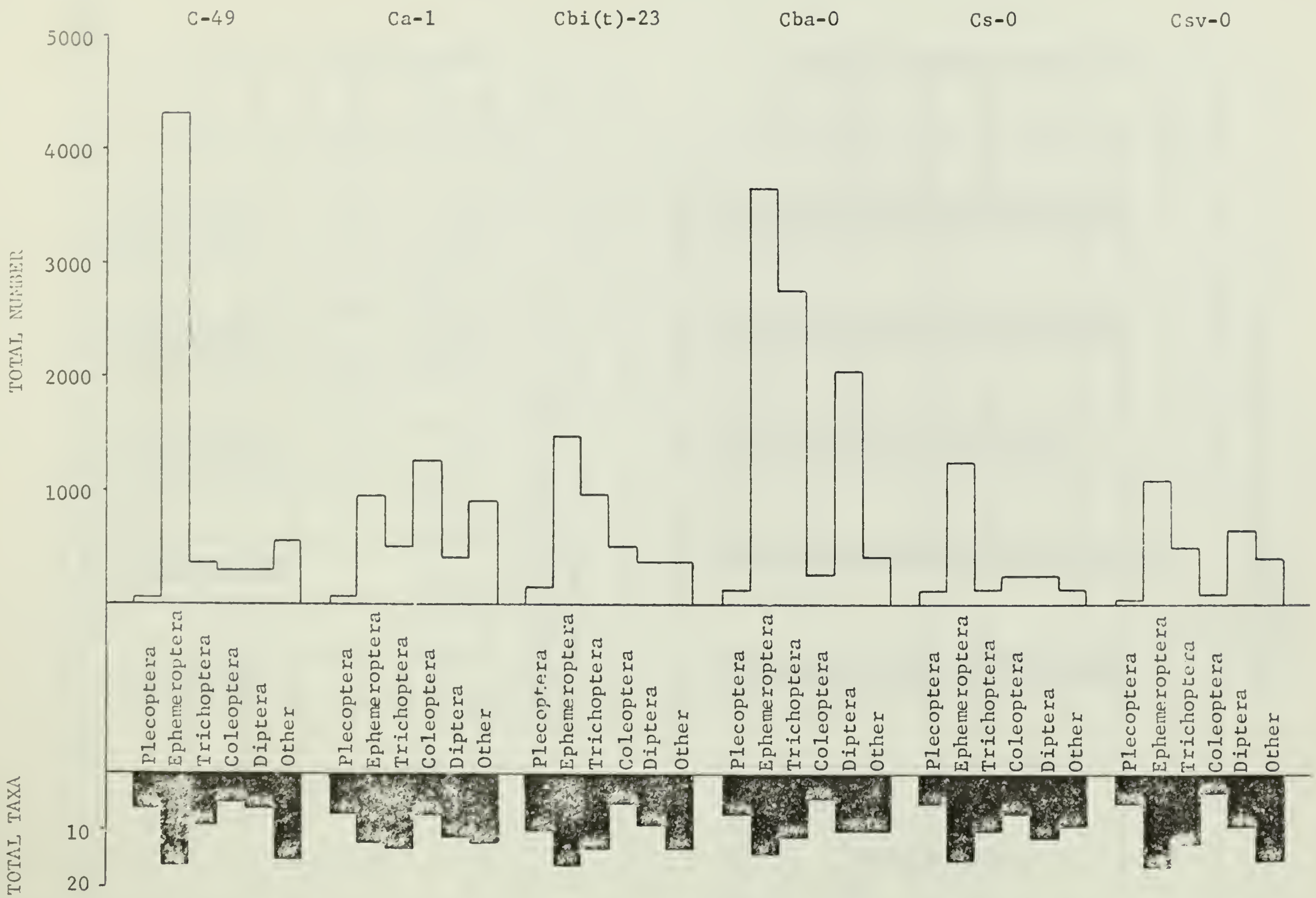


Figure 8. Community structure of benthic invertebrates from major tributaries entering upper Current River.

watershed of Big Creek. Water quality parameter values (Fig. 7) were the highest of any of the tributaries sampled in the Current River basin. The invertebrate community at Cbi(t)-23 resembled that inhabiting Ashley and Blair creeks (Appendix Table A-7). Water quality in Big Creek was classified unpolluted. Numerous pollution sensitive invertebrates were found (Fig. 8). The invertebrate community contained the following dominant taxonomic groups:

Mayflies (39%)	Caddisflies (26%)	Beetles (14%)
Pseudocloeon sp. (24%)	*Hydropsyche bifida* (gp.)(33%)	*Psephenus herricki* (61%
Isonychia sp. (19%)	*Cheumatopsyche* sp. (27%)	*Stenelmis* sp. (21%)
Stenonema pulchellum (18%)	*H. betteni* (12%)	*Optioservus ozarkensis* (15%)

Barren Creek (Cba-0)

Barren Creek, a tributary to Sinking Creek, was sampled near its mouth (Fig. 1; Table 1). No point sources of pollution were identified during the survey. Water quality in Barren Creek was classified unpolluted since numerous pollution sensitive invertebrates were collected throughout the year (Fig. 8) and most water quality parameter values, except the annual species diversity index value, (Fig. 7) exceeded criteria established for unpolluted streams. The invertebrate community was comprised of the following major groups:

Mayflies (39%)	Caddisflies (29%)	True flies (23%)
Pseudocloeon sp. (37%)	*Cheumatopsyche* sp. (58%)	Chironomidae (48%)
Baetis sp. (37%)	*Hydropsyche bifida* (gp.)(20%)	Simulidae (37%)
Isonychia sp. (11%)	*H. piatrix* (18%)	Empididae (13%)

The invertebrate community in Barren Creek resembled (C=50) the community sampled in Current River just below Montauk Springs at C-175. Large numbers of Baetid mayflies, Hydropsychid caddisflies, and high invertebrate density (272 per sq. ft) were found at both stations. This indicated that the flow in Barren Creek consists largely of ground water. Tryon (1972) reports that over 95% of the low flow in Barren Creek comes from six springs. Lower water temperatures, however, have not drastically limited some of the warm-water species and the invertebrate community in Barren Creek was found to be more diverse than that found at C-175. The most note-worthy finding at Cba-0 was the abundant population of *Hydropsyche piatrix*. This caddisfly has a very limited distribution in Missouri and has been considered rare and endangered in Missouri by Pflieger (1974). Ross (1944) described this species and noted that it has only been found in the mouth of large springs of Missouri and Arkansas. This is the first report of a large population of *Hydropsyche piatrix* outside of the range described by Ross.

Sinking Creek (Cs-0)

Sinking Creek enters Current River, from the north, just upstream from Round Spring State Park (Fig. 1; Table 1). Two small private sewage treatment lagoons discharge into the stream just upstream from Cs-0. One of the three lagoons serving Bunker, Missouri discharges into the headwaters (Table 4). Invertebrate density was low (48 per sq. ft.) and the water quality parameter values (Fig. 7) were very close to the criteria established for unpolluted Missouri streams. Sinking Creek was, classified as unpolluted. The benthic invertebrate community found in Sinking

Creek consisted of numerous pollution sensitive organisms (Fig. 8) and resembled many of the communities in the Current River and its tributaries downstream from the mouth of the Jack's Fork (Appendix Table A-7). The community in Sinking Creek consisted of the following major groups:

Mayflies (50%)	Beetles (12%)	True flies (11%)
Isonychia sp. (27%	Optioservus ozarkensis (93%)	Chironomidae (57%)
Stenonema nepotellum (18%)	Psephenus herricki (3%)	Simulidae (12%)
S. pulchellum (17%)	Stenelmis sp. (2%)	Eriocera/Hexatoma (10%)

Tryon (1972) indicated that Sinking Creek also receives much of its low flow from springs but apparently a sufficient portion of the flow was from other sources which allowed warmer water species to become established. The mayfly, Rhithrogena pellucida (?) which is considered rare and endangered (Pflieger, 1974), was found in Sinking Creek. The presence of two rare and endangered invertebrates in Barren and Sinking creeks make it imperative that the unpolluted water quality be maintained.

Spring Valley Creek (Csv-0)

Spring Valley Creek joined the spring branch from Round Spring before entering Current River (Fig. 1; Table 1). As mentioned during the discussion of Round Spring, two small sewage treatment lagoons discharge to this stream (Table 4). Annual water quality parameter values (Fig. 7) met the criteria for unpolluted Missouri streams. Spring Valley Creek was classified unpolluted and was not affected by these discharges. However, on a seasonal basis, the values for the winter and spring collection period did not meet the criteria. During this period of time, the National Park Service was engaged in constructing new campsites and a low water crossing immediately upstream from Csv-0. This involved a tremendous amount of substrate disturbance which probably accounted for the limited invertebrate community present in the stream. Upon completion of the construction work, the invertebrate community stabilized and became more representative of unpolluted conditions. The invertebrate community in Spring Valley Creek did not resemble any other stream in the Current River drainage (Appendix Table A-7). It was comprised of the following major groups:

Mayflies (40%)	True flies (25%)	Caddisflies (18%)
Pseudocloeon sp. (36%)	Chironomidae (86%)	Cheumatopsyche sp. (47%)
Baetis sp. (34%)	Empididae (9%)	Chimarra aterrima (25%)
Caenis sp. (12%)	Simulidae (2%)	Agapetus sp. (11%)

Rhithrogena pellucida (?) and Hydropsyche piatrix were sparsely represented at Csv-0, the construction work may have reduced a much larger population since they did not appear in the samples until after the construction work was completed. Some precautionary measures need to be taken in the future to ensure that these invertebrates are not eliminated.

Big Creek, Shannon County (Cbi(s)-9)

Big Creek enters Current River, from the north, several miles above the mouth of the Jack's Fork River (Fig. 1; Table 1). Three sewage treatment lagoons discharge into the headwater of this stream at Bunker, Missouri (Table 4). Although no major springs are known to discharge into

Big Creek, the invertebrate community in the river closely resembled that found in Round Spring (C=63). Most water quality parameter values met the criteria (Fig. 9) and numerous pollution sensitive invertebrates were collected (Fig. 10). This indicated that no degradation has been caused by the lagoons. Big Creek was, therefore, classified unpolluted. The following taxonomic groups were most abundant in the samples collected from Cbi(s)-9:

Snails (66%)	Beetles (12%)	Mayflies (9%)
Goniobasis sp. (100%)	*Optioservus ozarkensis* (74%)	*Stenonema nepotellum* (30%)
	Psephenus herricki (23%)	*Isonychia* sp. (17%)
	Stenelmis sp. (2%)	*Tricorythodes* sp. (14%)

Blair Creek (Cbl-7)

Blair Creek flows into Current River downstream from the confluence of the Current River with the Jack's Fork River (Fig. 1; Table 1). No point sources of pollution were known to enter this stream. The invertebrate community resembles the communities inhabiting many of the other tributaries to the Current River (Appendix Table A-7). This stream was classified unpolluted since the water quality parameter values met the criteria (Fig. 9). Numerous pollution sensitive invertebrates were represented in all samples (Fig. 10). The relatively undisturbed watershed and the inaccessibility of Blair Creek makes it one of the most aesthetic tributaries to the Current River. The major components of the invertebrate community were:

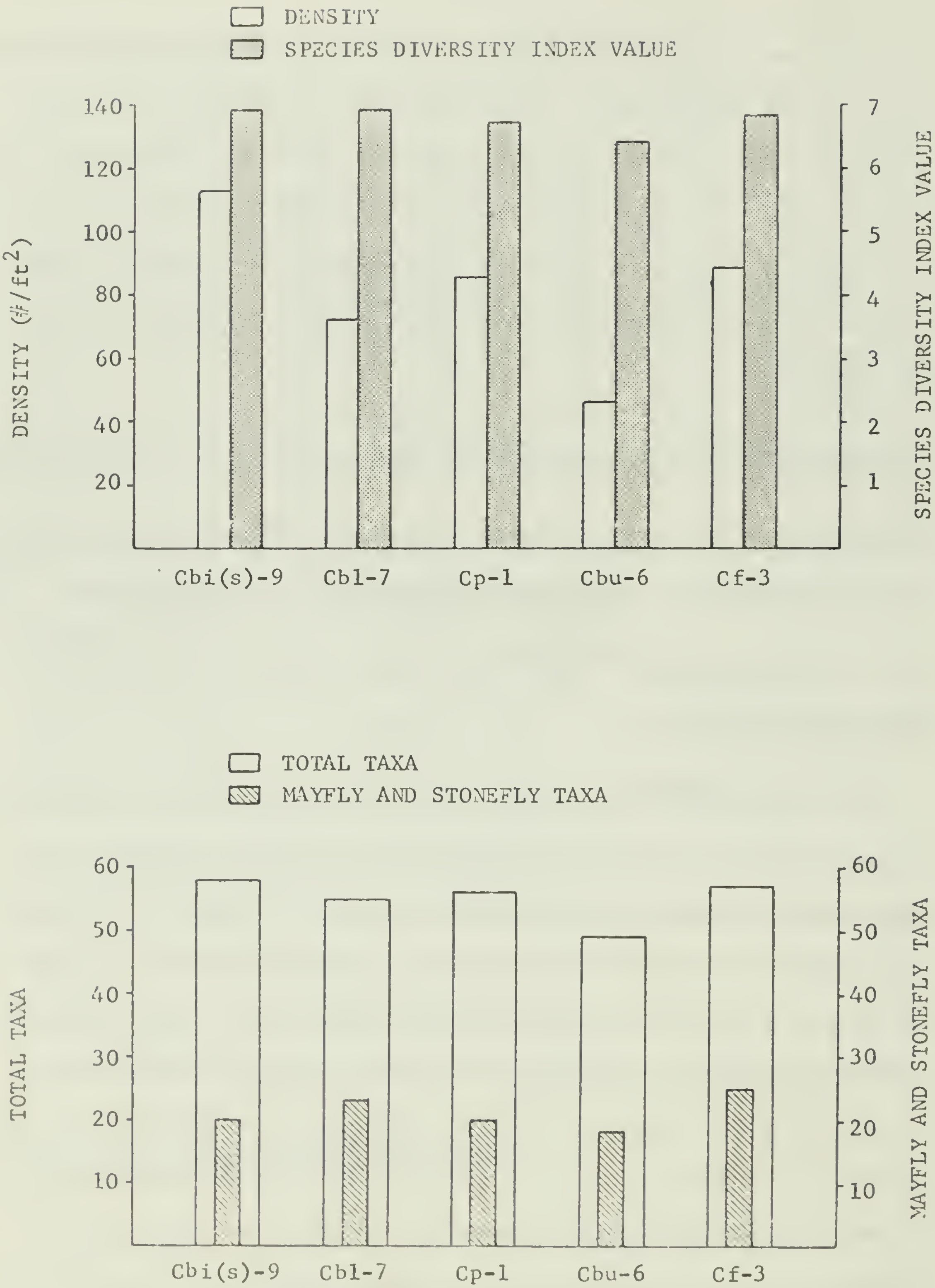


Figure 9. Summary of annual water quality parameter values for the major tributaries entering the middle and lower Current River.

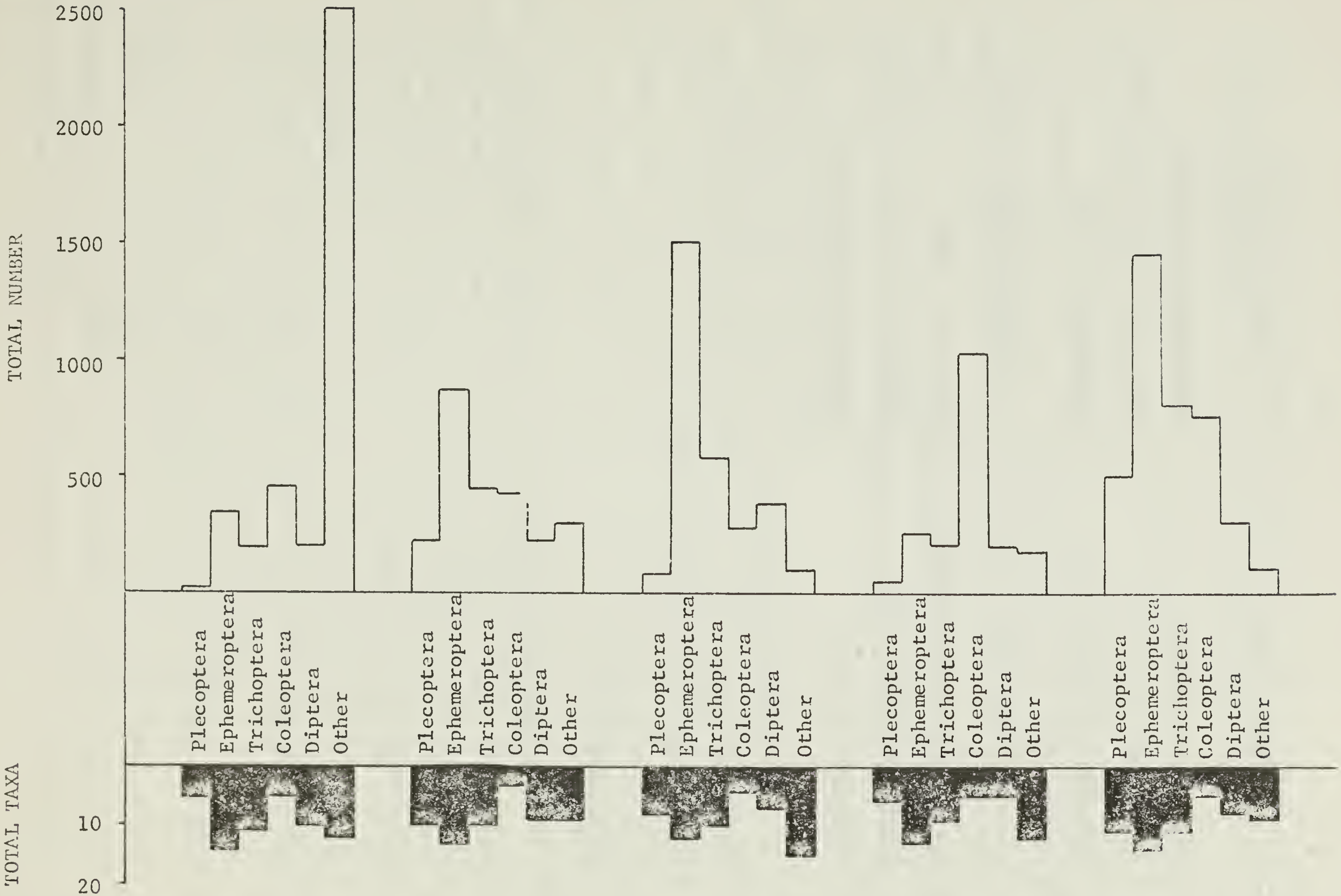


Figure 10. Community structure of benthic invertebrates from major tributaries entering the middle and lower Current River.

Mayflies (35%)	Caddisflies (18%)
Isonychia sp. (31%)	Cheumatopsyche sp. (63%)
Pseudocloeon sp. (19%)	Hydropsyche bifida (gp.) (20%)
Stenonema nepotellum (16%)	Helicopsyche sp. (6%)

Beetles (17%)	Stoneflies (9%)
Optioservus ozarkensis (60%)	Nemoura sp. (33%)
Psephenus herricki (28%)	Allocapnia sp. (25%)
Stenelmis sp. (12%)	Brachyptera fasciata (17%)

Exploitation of lead deposits in the Blair Creek watershed has been considered in the past. Such activities should be discouraged in the future to prevent degradation of this stream.

Pike Creek (Cp-1)

Pike Creek enters Current River at Van Buren, Missouri (Fig. 1; Table 1). Several small springs enter the stream along its course but probably account for only a small fraction of its total flow (Vineyard and Feder, 1974). Much of its watershed had been converted to pastureland for grazing livestock. The only sources of pollution noted in the watershed during the survey were septic tanks and a small sewage treatment lagoon (Table 4). Water quality parameter values were close but did not meet the criteria (Fig. 9; Appendix Table A-6). Therefore, water quality of Pike Creek could not be classified unpolluted but the invertebrate community inhabiting Pike Creek contained numerous pollution sensitive taxa and resembled the communities at many of the other unpolluted tributary and mainstem stations in the Current River basin (Appendix Table A-7). Pike Creek was, therefore, considered unpolluted.

The invertebrate community at Cp-1 was characterized by following major groups:

Mayflies (52%)	Caddisflies (19%)	True flies (13%)
Stenonema pulchellum (39%)	Chimarra aterrima (45%)	Simulidae (49%)
Isonychia sp. (36%)	Cheumatopsyche sp. (41%)	Chironomidae (39%)
Pseudocloeon sp. (4%)	Rhyacophila sp. (4%)	Empididae (10%)

South Fork of Buffalo Creek (Cbu-6)

One small sewage treatment lagoon discharges into the headwaters of Buffalo Creek (Table 4). The community structure of the invertebrates resembled that found in Ashley, Blair, and Pike creeks (Appendix Table A-7), however, the dominant taxonomic groups were different (Fig. 10). The abundance of beetles, especially Optioservus ozarkensis, was unusual. Numerous pollution sensitive taxa were found at Cbu-6 but their densities were low (46 per sq. ft.). Water quality parameter values (Fig. 9) did not meet the criteria (within 16%). The water quality of Buffalo Creek was not classified, but was considered unpolluted since the presence of numerous pollution intolerant taxa indicated the lagoon discharge in the headwaters was not responsible for the lower values.

The invertebrate community of the South Fork of Buffalo Creek consisted of the following major taxonomic groups:

Beetles (56%)	Mayflies (14%)
Optioservus ozarkensis (69%)	*Stenonema nepotellum* (38%)
Psephenus herricki (26%)	*Isonychia* sp. (19%)
Stenelmis sp. (5%)	*S. pulchellum* (13%)

True flies (10%)	Caddisflies (10%)
Chironomidae (86%)	*Cheumatopsyche* sp. (75%)
Empididae (5%)	*Helicopsyche* sp. (14%)
Simulidae (3%)	*Polycentropus* sp. (4%)

Fourche Creek (Cf-3)

The sampling station on Fourche Creek was located downstream from the confluence of its three main forks (Fig. 1; Table 1). The only sources of pollution noted during the survey were drainage from septic tanks and a small sewage lagoon (Table 4). The U. S. Soil Conservation Service was also in the process of implementing a Pl 566 project in the watershed. This entailed the construction of small impoundments on the headwater tributaries of Fourche Creek. The community structure of the invertebrates inhabiting Fourche Creek did not closely resemble other communities in the Current River basin (Fig. 10; Appendix Table A-7). Water quality parameter values equaled the criteria established for unpolluted streams (Fig. 9), and many pollution sensitive organisms were found in Fourche Creek. It was classified unpolluted. Little is known about the possible impacts of the Pl 566 project upon Fourche Creek. The invertebrate community in Fourche Creek during 1974 consisted of the following major groups:

Mayflies (37%)	Caddisflies (20%)
Stenonema nepotellum (42%)	*Cheumatopsyche* sp. (86%)
Isonychia sp. (15%)	*Chimarra obscura* (5%)
S. pulchellum (12%)	*C. aterrima* (4%)
Baetis sp. (12%)	

Beetles (19%)	Stoneflies (13%)
Stenelmis sp. (89%)	*Nemoura* sp. (38%)
Psephenus herricki (7%)	*Paracapnia* sp. (29%)
Optioservus ozarkensis (3%)	*Brachyptera fasciata* (11%)

Summary

Current River and its tributaries have not been seriously degraded. Pollution sources in the watershed were usually small and the effects of their discharges on the biological community were localized.

Since the Current River basin is an important recreation area, it is extremely important that the river and its tributaries do not become degraded by overuse and pollution. Very little difference could be found in the benthic invertebrate communities at selected stations when they were compared with the communities present during a similar survey done in 1961. This indicated that no detectable degradation has occurred in the drainage resulting from either intense recreational use or pollution. Care must be taken in the future to continue to protect this unpolluted environment.

The invertebrate community in portions of the Current River basin, which received a majority of their flow from springs, resembled communities inhabiting spring branches in other Ozark streams. These spring fed portions supported high densities of invertebrates with water quality parameter values lower than unpolluted Missouri streams which were not dominated by spri flow. Regression analyses comparing nutrient levels and water temperature with the water quality parameter values indicated that there was a relationship between these values and the physical and chemical water parameters. These tests indicated a direct correlation between nutrient levels and water temperature with the diversity and the abundance of various taxa, i.e. portions of Current River with lower nutrient and temperature levels generally had lower water quality parameter values than other Missouri streams. The information collected from Current River supported this hypothesis since stations with lower than normal water quality parameter values had a major portion of their flow contributed by springs. Eventhough warm-water invertebrates were poorly represented at these stations; the major portion of the invertebrate community found in these spring-fed portions consisted of pollution sensitive types which was the basis for considering them unpolluted.

Jack's Fork River

A total of 105 taxa of aquatic invertebrates including 41 mayfly and stonefly taxa were collected from the Jack's Fork and its tributaries during the survey (Table 3). Most invertebrates collected from this basin were pollution sensitive types typically found in unpolluted Missouri streams. Few point sources of pollution were found in the watershed.

The major sources were the sewage treatment facilities at Mountain View and Eminence, Missouri (Table 5).

Mainstem

Jack's Fork River originates in southeastern Texas County at the junction of the North and South Prongs (Fig. 1; Table 1). Sampling stations were established on each prong 5 miles upstream from this junction. No point sources of pollution were known to discharge into either prong.

The North Prong of the Jack's Fork (JFnp-5) receives very little of its flow from springs according to Vineyard and Feder (1974). The invertebrate community which inhabits this prong was diverse and contained many different types of pollution sensitive invertebrates (Fig. 11). All water quality parameter values exceeded the criteria established for unpolluted Missouri streams (Fig. 12; Appendix Table A-8). This prong was classified unpolluted. The invertebrate community at this station consisted at the following major taxonomic groups:

Mayflies (32%)	Caddisflies (19%)	Beetles (19%)
Stenonema nepotellum (22%)	*Cheumatopsyche* sp. (72%)	*Stenelmis* sp. (79%)
S. (undescribed sp.) (21%)	*Hydropsyche bifida* (gp.) (12%)	*Psephenus herricki* (15
S. pulchellum (10%)	*Helicopsyche* sp. (8%)	*Macronychus glabratus* (5%)

Table 5. Point source pollution discharges and potential pollution sources entering the Jack's Fork River system.[1]

Facility		Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
Name	Legal Description				
Shannon County					
Eminence, Mo.	T29N R4W Sec.26 SW¼	lagoon (2-cell)	2.4	Jack's Fork	JF-6
Butler Brothers Gravel Co.	T29N R4W Sec.26 SW¼	gravel operation	--	Jack's Fork	JF-2
Bunker Hill Ranch Restaurant	T28N R6W Sec.25 SW¼	lagoon (1-cell)	0.4	Jack's Fork	JF-19
Danny Staples	T29N R5W Sec.36 NE¼	lagoon (1-cell)	0.1	Jack's Fork	JF-13
Shannon Co. School Dist. R-1	T29N R4W Sec.34 NW¼	septic tank & sand filter	--	Jack's Fork	JF-6
Riverside Motel	T29N R4W Sec.26 NW¼	lagoon (1-cell)	0.05	no discharge	--
Howell County					
Mountain View	T27N R7W Sec.25	lagoon (3-cell)	6.0	Jam Up Creek	JF-19
Reorganized School Dist.-3	T27N R7W Sec.20 SW¼	lagoon (1-cell)	0.3	Tributary of Jack's Fork	JF-19

1 Compiled from information obtained from Division of Environmental Quality (DNR) and Missouri Department of Conservation personnel.

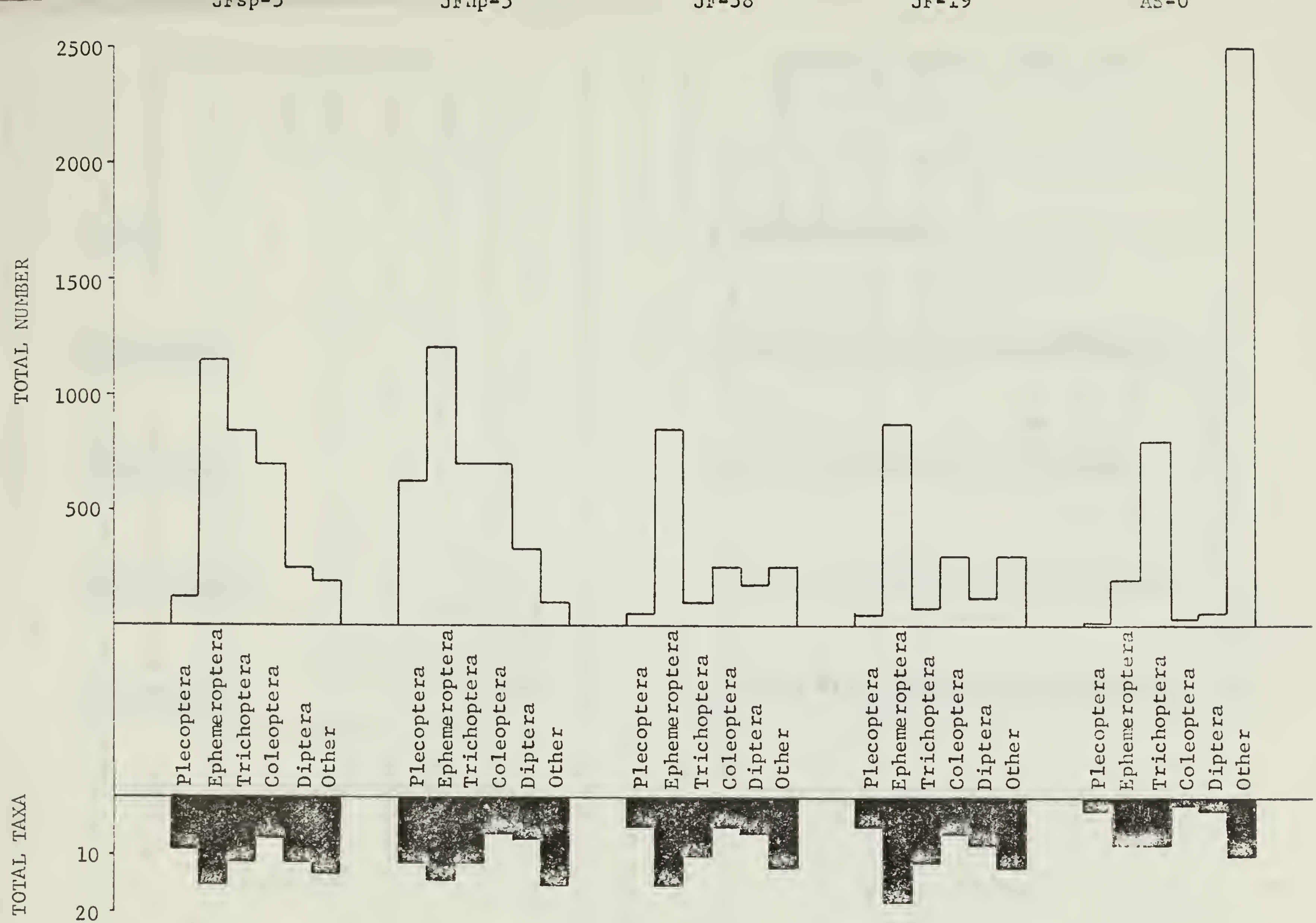


Figure 11. Community structure of benthic invertebrates from stations on upper Jack's Fork River.

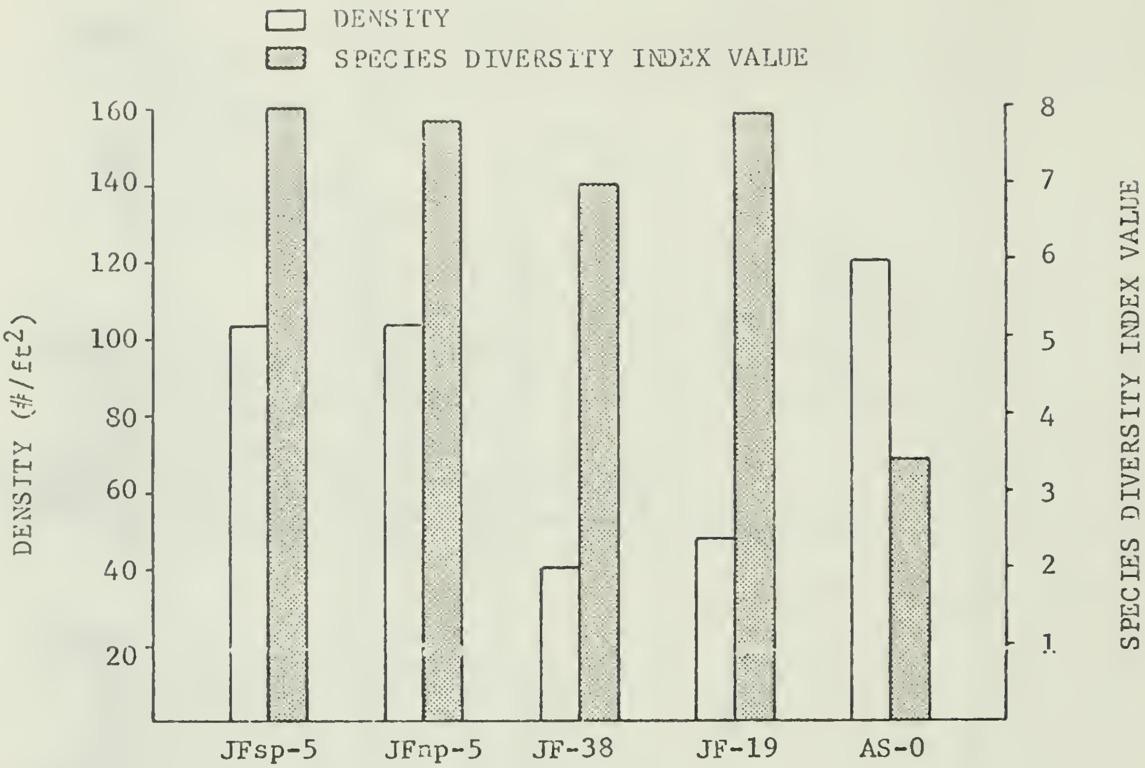


Figure 12. Summary of annual water quality parameter values for stations on upper Jack's Fork River.

Stoneflies (17%)

Isoperla namata (59%)

Neoperla clymene (13%)

I. signata (7%)

The presence of a large population of stoneflies, an undescribed mayfly species, and the beetle, Macronychus glabratus, not only indicated unpolluted water quality conditions but make special protection of this stream necessary since these invertebrate types seldom occur in large numbers in Missouri Ozark streams.

According to Vineyard and Feder (1974), the South Prong of the Jack's Fork receives flow from two small springs upstream from station JFsp-5 (Fig. 1; Table 1). Apparently, the influence of these springs is negligible since the invertebrate community at JFsp-5 resembled that found at JFnp-5 (C=53). Water quality parameter values for JFsp-5 varied slightly from those at station JFnp-5 (Fig. 12). Water quality in the South Prong of the Jack's Fork was classified unpolluted, and most invertebrate taxa present were pollution sensitive types. The structure of the invertebrate community at JFsp-5 also was not significantly different from that found at JFnp-5 (Fig. 11):

Mayflies (35%)	Caddisflies (26%)	Beetles (21%)
Stenonema nepotellum (28%)	Cheumatopsche sp. (44%)	Psephenus herricki (70%)
Isonychia sp. (22%)	Hydropsyche bifida (gp.) (33%)	Optioservus ozarkensis (21%)
Pseudocloeon sp. (20%)	Helicopsyche sp. (9%)	Stenelmis sp. (7%)

Although stoneflies and Stenonema (undescribed sp.) were not as abundant at JFsp-5 as at JFnp-5, they were still present in fair numbers. Neither of these two stations are included in the Ozark National Scenic Riverways system which makes protection from pollution and other types of degradation more difficult. The high water quality and diverse aquatic communities which inhabit these prongs should receive special efforts to ensure that they remain unpolluted.

Station JF-38 was located downstream from the junction of the North and South Prongs of the Jack's Fork (Fig. 1; Table 1). No sources of pollution were known to discharge into the Jack's Fork above this station. The substrate was not typical of that found at other stations in the survey, since it consisted of large cobble and rubble sized limestone rock. This substrate difference was probably responsible for the invertebrate density being lower than at any other station on the Jack's Fork (40 per sq. ft.). Most water quality parameter values equaled the minimum criteria for unpolluted Missouri streams (Fig. 12). Station JF-38 was classified unpolluted. Numerous pollution sensitive taxa were collected in all samples (Fig. 11).

The following taxonomic groups were dominant in the collections from JF-38:

Mayflies (51%)	Beetles (15%)	Snails (10%)
Isonychia sp. (31%)	Psephenus herricki (71%)	Goniobasis sp. (100
Stenonema nepotellum (29%)	Optioservus ozarkensis (12%)	
Pseudocloeon sp. (10%)	Stenelmis sp. (11%)	

The invertebrate taxa collected at JF-38 were less dense, but closely resembled those found in the South Prong of the Jack's Fork. The community structure in these streams was typical of those found in other unpolluted Ozark streams and is a further indication of good water quality.

Treated sewage effluent entered tributaries of the Jack's Fork River above station JF-19 from the Mountain View municipal lagoon and two other small lagoons (Table 5). All water quality parameter values for JF-19 exceeded minimum criteria established for unpolluted Missouri streams (Fig. 12). The structure of the invertebrate community was similar (C=69) to that found at JF-38 which indicated very little change in the water quality between these stations. The substrate at JF-19 was typical of that found in other Ozark streams and probably accounted for the higher density than that found at JF-38. The similar communities, presence of numerous pollution intolerant invertebrates (Fig. 11), and acceptable water quality parameter values between JF-38 and JF-19 indicated that no degradation has occurred from the pollution entering above JF-19. This section of Jack's Fork River was, therefore, classified unpolluted. The major invertebrate groups in the samples collected from this station were:

Mayflies (57%)	Beetles (14%)	Snails (11%)
Rhithrogena pellucida (?)(23%)	Psephenus herricki (14%)	Goniobasis sp. (100%)
Stenonema nepotellum (21%)	Optioservus ozarkensis (23%)	
Isonychia sp. (19%)	Stenelmis sp. (19%)	

The presence of Rhithrogena pellucida (?), considered rare and endangered in Missouri, and a small population of Stenonema (undescribed sp.), make it important to maintain the unpolluted conditions at this station.

Alley Spring is the seventh largest spring in Missouri (Vineyard and Feder, 1974). Its spring branch was sampled at AS-0, just below a dam (Fig. 1; Table 1). The substrate in Alley Spring Branch differed from the other spring branches sampled during the survey since large quantities of aquatic vegetation, primarily water milfoil (Myriophyllum heterophyllum), grew in the spring branch. No pollution sources were known to enter the spring, however, dye traces from possible sources have not been attempted. The invertebrate community living in Alley Spring was almost identical (C=75) to that inhabiting Round Spring (discussed earlier). Most invertebrates which inhabited Alley Spring were pollution sensitive taxa (Fig. 11). This indicated unpolluted water quality conditions. As discussed earlier, the cold water temperatures, typically found in spring water, have limited the taxa found in the spring branch to those tolerant of lower water temperatures. This resulted in lower water quality parameter values (Fig. 12). The invertebrate community in Alley Spring consisted of the following major groups:

Snails (49%)	Caddisflies (23%)	Amphipods (20%)
Goniobasis/Amnicola (100%)	Brachycentrus sp. (79%)	Gammarus sp. (99%)
	Agapetus sp. (19%)	Hyalella azteca (1%)
	Hydropsyche bifida (gp.)(1%)	

Station JF-13 was located about 2 miles downstream from Alley Spring (Fig. 1; Table 1). The only pollution source noted above JF-13 during the survey was the discharge from a small sewage treatment lagoon (Table 5). Water quality parameter values exceeded criteria established for unpolluted streams (Fig. 13). Neither pollution nor the influences of colder water from Alley Spring could be detected since the invertebrate community at this station resembled the communities found at most of the other stations on the Jack's Fork River (Appendix Table A-9a). Numerous types of pollution intolerant invertebrates were represented in the samples collected from this station (Fig. 14). The following taxonomic groups were the most abundant in these samples:

Mayflies (56%)	True flies (12%)
Baetis sp. (21%)	Chironomidae (88%)
Isonychia sp. (18%)	Simulidae (8%)
Pseudocloeon sp. (16%)	Empididae (4%)
Rhithrogena pellucida (?)(15%)	

Beetles (11%)	Caddisflies (10%)
Optioservus ozarkensis (76%)	*Agapetus* sp. (69%)
Stenelmis sp. (12%)	*Cheumatopsyche* sp. (12%)
Psephenus herricki (10%)	*Hydropsyche bifida* (gp.)(6%)

The major source of pollution discharging to the Jack's Fork above JF-6 (Fig. 1; Table 1) was the sewage treatment lagoons at Eminence, Missouri (Table 5). The effects of this discharge on the Jack's Fork were similar to those reported for the Current River below Van Buren and Doniphan, Missouri, i.e.; localized. The lagoons were constructed in the

Figure 13. Summary of annual water quality parameter values for stations on lower Jack's Fork River and its major tributaries.

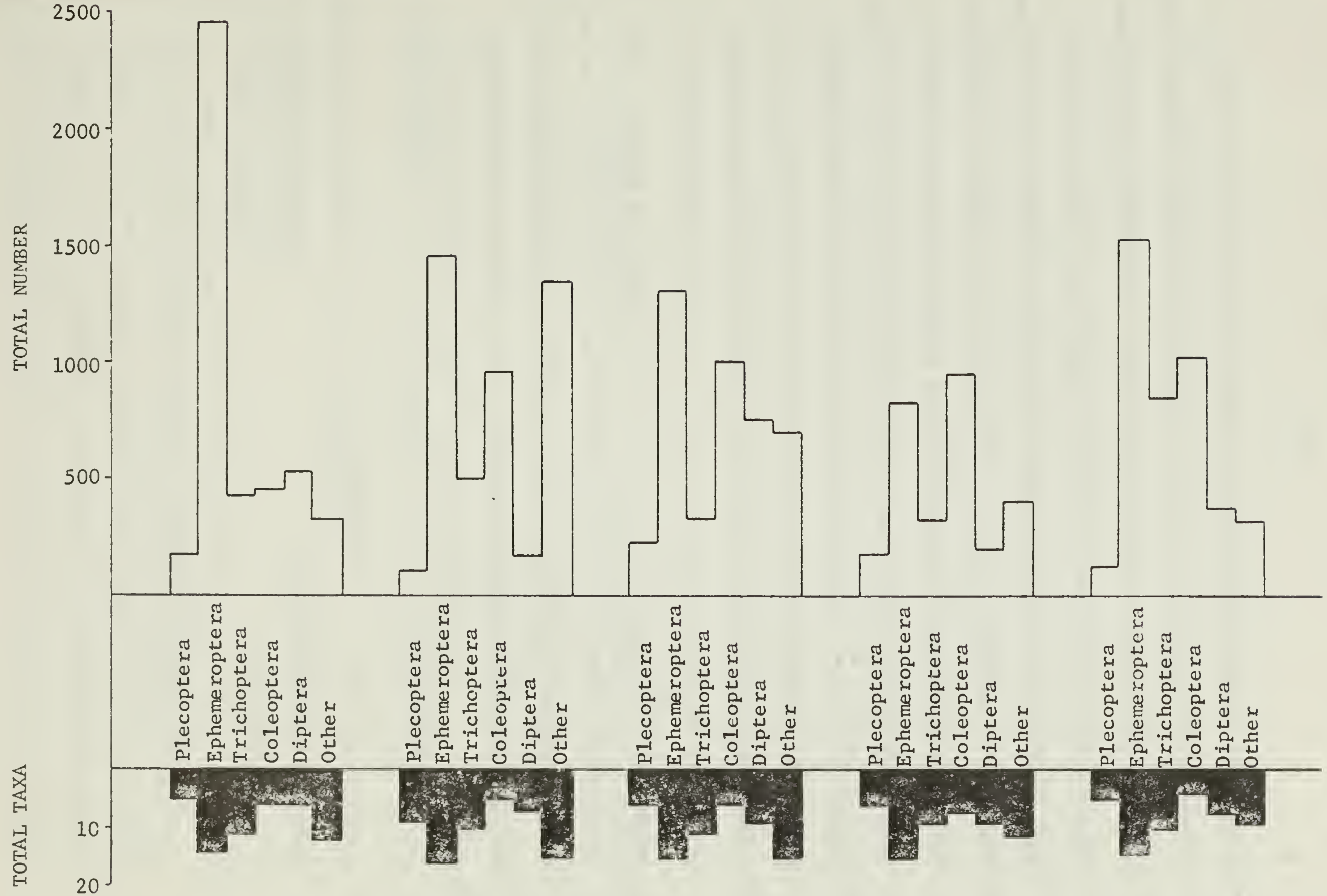


Figure 14. Community structure of benthic invertebrates from stations on lower Jack's Fork River and its major tributaries.

floodplain of the Jack's Fork and during heavy storm runoff they were occasionally inundated. When these lagoons were flooded, untreated sewage was reported to enter the Jack's Fork River. Fortunately, these lagoons were inundated infrequently (Personal communication, 1974, William R. Rogers, Conservation Agent, Missouri Department of Conservation, Eminence, Missouri). The water quality at station JF-6 was classified unpolluted since the water quality parameter values exceed the criteria (Fig. 13). Large numbers of pollution sensitive invertebrates were present in these samples (Fig. 14). The only evidence of the effects of the lagoon discharges from Eminence were excessive growths of filamentous algae on the rocks. This was the only area of the Jack's Fork River where abundant growths of algae were present. This type of growth was attributed to the excessive nutrients entering the Jack's Fork River from Eminence. The invertebrate community at JF-6 resembled that of JF-13 (C=48). The problem with the lagoon system needs to be remedied or future degradation may occur. The invertebrate community at JF-6 was characterized by the following:

Mayflies (31%)	Snails (27%)	Beetles (21%)
Isonychia sp. (34%)	Goniobasis sp. (100%)	Optioservus ozarkensis (70
Stenonema pulchellum (28%)		Psephenus herricki (27%)
S. nepotellum (14%)		Ectopria nervosa (1%)

A gravel washing operation is located upstream from station JF-2 (Table 5). The density of the filamentous algae growth on the rocks decreases markedly at JF-2 indicating that the effect of the Eminence lagoons at this site has decreased. Clifford (1966) sampled this location in 1961 and considered the invertebrate community diverse and indicative of an unpolluted Missouri stream. Although his sample size was quite small compared to the present survey, he collected 36 taxa including 12 mayfly and stonefly types. According to Clifford's taxonomic scheme, 51 taxa including 16 mayfly and stonefly types were collected during the present survey. Most water quality parameter values calculated from the samples collected during the present survey exceeded the criteria established for unpolluted Missouri streams (Fig. 13). Water quality at JF-2 was classified unpolluted and has not been degraded from pollution or intensive recreational use over the 14 years since Clifford's study. The invertebrate community sampled during the present survey contained the following dominant taxonomic groups:

Mayflies (29%)	Beetles (24%)	True flies (18%)
Ephemerella invaria (gp.)(23%)	*Optioservus ozarkensis* (88%)	Chironomidae (18%)
Pseudocloeon sp. (23%)	*Psephenus herricki* (5%)	Empididae 9%)
Rhithrogena pellucida (?)(10%)	*Ectopria nervosa* (5%)	*Chrysops*/*Tabanus* (1%)

Major Tributaries

Mahan's Creek (JFm-1)

Mahan's Creek enters the Jack's Fork from the south; west of Eminence, Missouri (Fig. 1; Table 1). No point sources of pollution were found during the survey. The Missouri Highway Department channelized Mahan's Creek immediately upstream from the sampling site during the summer of 1974. Fortunately, the sample riffle was not disturbed and the only adverse affect noted was a short term increase in turbidity. Water quality in this stream was classified unpolluted since most parameter values equaled or exceeded, the criteria established for unpolluted streams (Fig. 13; Appendix Table A-8). The invertebrate community at JFm-1 resembled those found at other stations on the Jack's Fork River downstream from Alley Spring (Appendix Table A-9a). The community consisted of the following major groups:

Beetles (33%)	Mayflies (29%)
Optioservus ozarkensis (71%)	*Pseudocloeon* sp. (31%)
Psephenus herricki (28%)	*Baetis* sp. (17%)
	Isonychia sp. (17%)

Snails (12%)	Caddisflies (10%)
Goniobasis sp. (100%)	*Helicopsyche* sp. (40%)
	Agapetus sp. (31%)
	Hydropsyche bifida (gp.)(11%)

Shawnee Creek (JFs-1)

No point sources of pollution were found in Shawnee Creek during the survey. This stream probably had the least flow of all the streams sampled during the survey, and a major portion of this flow was from Slater Spring, located upstream from the sampling station (Vineyard and Feder, 1974). The watershed was heavily grazed by livestock (Personal communications, 1974, William R. Rogers, Conservation Agent, Missouri Department of Conservation, Eminence, Missouri). The invertebrate community at JFs-1

(Fig. 1; Table 1) was not as diverse as that found at other stations on the Jack's Fork. Water quality parameter values (Fig. 13) did not meet the criteria for an unpolluted Missouri stream. The community structure of the invertebrates inhabiting Shawnee Creek was similar to that of four other stations in the survey: Big Creek (Cbi(t)-23) C=62; Pike Creek (Cp-1) C=61; Eleven Point (EP-76) C=63; and Spring Creek (EPs-0) C=60. Of the four stations, all except EPs-0 supported invertebrate communities which meet the criteria established for unpolluted Missouri streams. Water quality in Shawnee Creek was, therefore, considered unpolluted but influenced by spring water from Slater Spring. Since numerous pollution sensitive forms inhabited Shawnee Creek, it was doubtful that organic pollution was the cause (Fig. 14) of the lower values. The invertebrate community was characterized by the following major taxonomic groups:

Mayflies (37%)	Beetles (24%)	Caddisflies (20%)
Pseudocloeon sp. (27%)	*Optioservus ozarkensis* (62%)	*Cheumatopsyche* sp. (46%)
Isonychia sp. (26%)	*Psephenus herricki* (34%)	*Chimarra aterrima* (26%)
Stenonema nepotellum (15%)	*Stenelmis* sp. (3%)	*Hydropsyche bifida* (gp.) (12%)

Summary

Serious degradation by pollution was not detected in the Jack's Fork or its major tributaries during the survey. Point sources of pollution in the watershed were few and contributed little to the streams. Few differences were found in the invertebrate communities inhabiting the Jack's Fork during the survey when compared to Clifford's (1966) survey which was conducted in 1961. This was a good indication that no detectable degradation from intense recreational use, or pollution, has occurred since 1961. However, these unpolluted streams should receive maximum protection in the future.

With the exception of Shawnee Creek, all stations in the Jack's Fork basin supported invertebrate communities with water quality parameter values that equaled or exceeded criteria established for unpolluted Missouri streams. Shawnee Creek was influenced by springs similar to the streams in the upper Current River basin. Natural conditions, such as low water temperature, were the reason for the less diverse invertebrate community found in Shawnee Creek.

Little Black River

A total of 135 taxa of aquatic invertebrates including 29 mayfly and stonefly types were collected from the Little Black River during this survey (Table 3). Three point sources of pollution were identified in the watershed during this survey (Table 6). As mentioned earlier, Little Black River flows through two geologically and vegetatively different areas. The two headwater stations (Fig. 1; Table 1) were located in the portion of Little Black River which flows through the Courtois Hills region of Missouri (Sauer, 1920). From Naylor, Missouri to the Missouri-Arkansas border this river flows through the Southeastern Lowlands of Missouri (Vineyard and Feder, 1974). The lower watershed of Little Black River is intensively farmed, and the agricultural use creates more turbidity in this portion of the Little Black than in the headwaters area. None of the tributaries to Little Black River were sampled during the survey.

Point source pollution discharges and potential pollution sources entering the Little Black River system.[1]

Facility: Name	Facility: Legal Description	Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
Ripley County					
Grandin Launderette	T25N R2E Sec.11 SW¼	lagoon (1-cell)	--	Little Black River (Middle Fork)	LB-35
Current River Country Club	T23N R3E Sec.33 SE¼	lagoon (1-cell)	0.1	no discharge	--
Butler County					
Hillview Elementary	T23N R5E Sec.4 SE¼	lagoon (1-cell)	0.3	Little Black River	LB-11

1 Compiled from information obtained from Division of Environmental Quality (DNR) and Missouri Department of Conservation personnel.

Mainstem

The headwater station, LB-35, was located at the junction of the North and South Prongs of Little Black River (Fig. 1; Table 1). The stream above LB-35 is considered intermittent during extremely dry years (Missouri Department of Conservation, 1943). The various forks of the river, upstream from LB-35, flow through an undisturbed forested watershed. The only point source of pollution known to discharge into these forks is a laundromat at Grandin, Missouri, about 10 miles upstream (Table 6). Water quality at LB-35 was classified unpolluted since most water quality parameter values met the criteria established for unpolluted Missouri streams (Fig. 15) and numerous pollution sensitive taxa were collected (Fig. 16). The parameter values for seasonal and annual mayfly and stonefly taxa, however, were only within 30% of the criteria (Fig. 15; Appendix Table A-10). The reason for this remains unknown, however, there was a lack of stonefly taxa in the samples. Only 18 organisms (3 taxa) were collected during the entire year. More stonefly taxa would have brought this parameter closer to the criteria. The major groups at LB-35 were:

Mayflies (48%)	True flies (20%)	Beetles (10%)
Tricorythodes sp. (36%)	Chironomidae (83%)	*Optioservus ozarkensis* (84%)
Isonychia sp. (30%)	Simulidae (13%)	*Psephenus herricki* (7%)
Stenonema nepotellum (23%)	Empididae (2%)	*Ectopria nervosa* (5%)

Station LB-26 was located near the lower extent of the Ozark portion of Little Black River about one mile below King Bee Spring (Fig. 1; Table

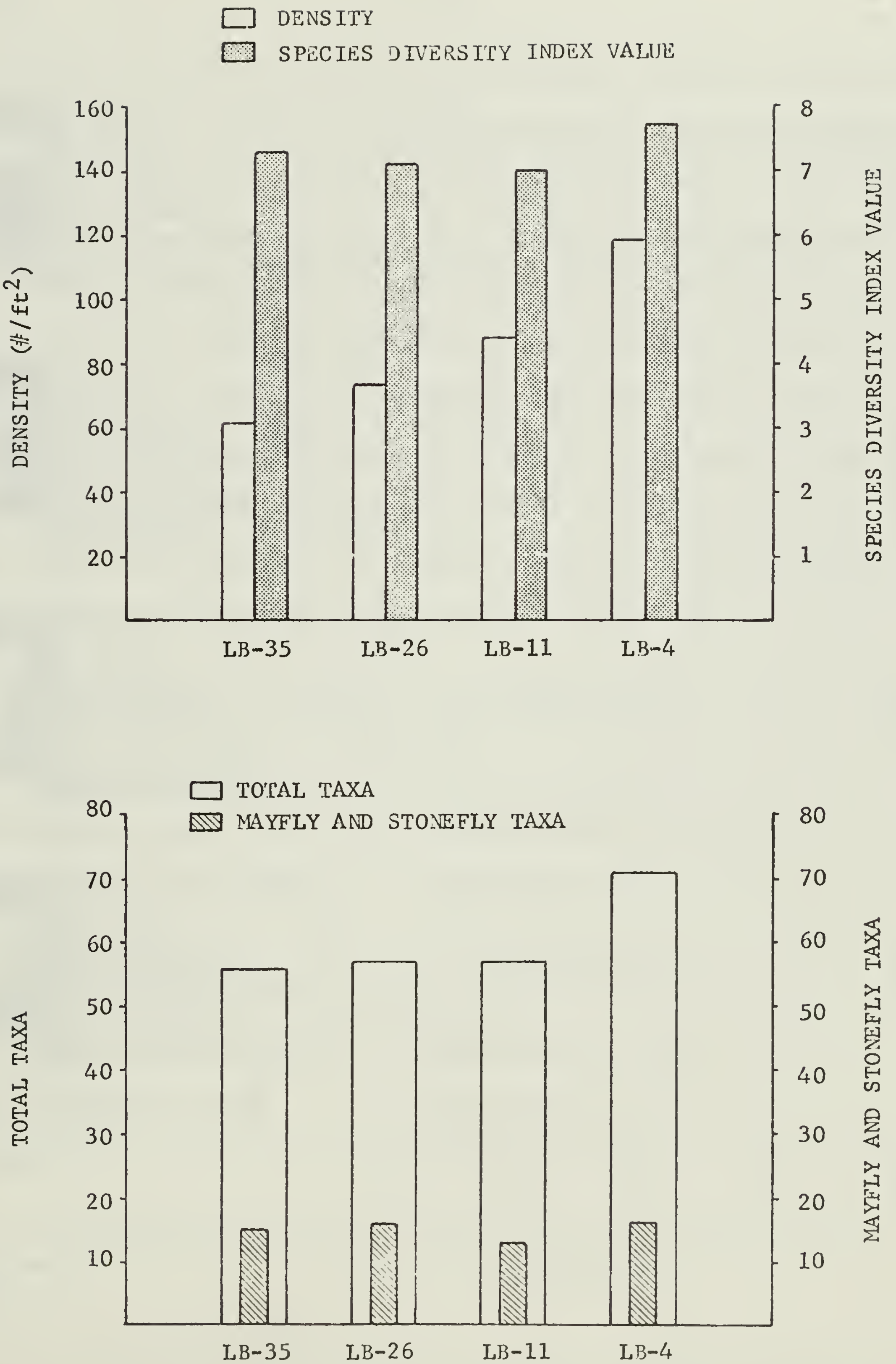


Figure 15. Summary of annual water quality parameter values for stations on Little Black River.

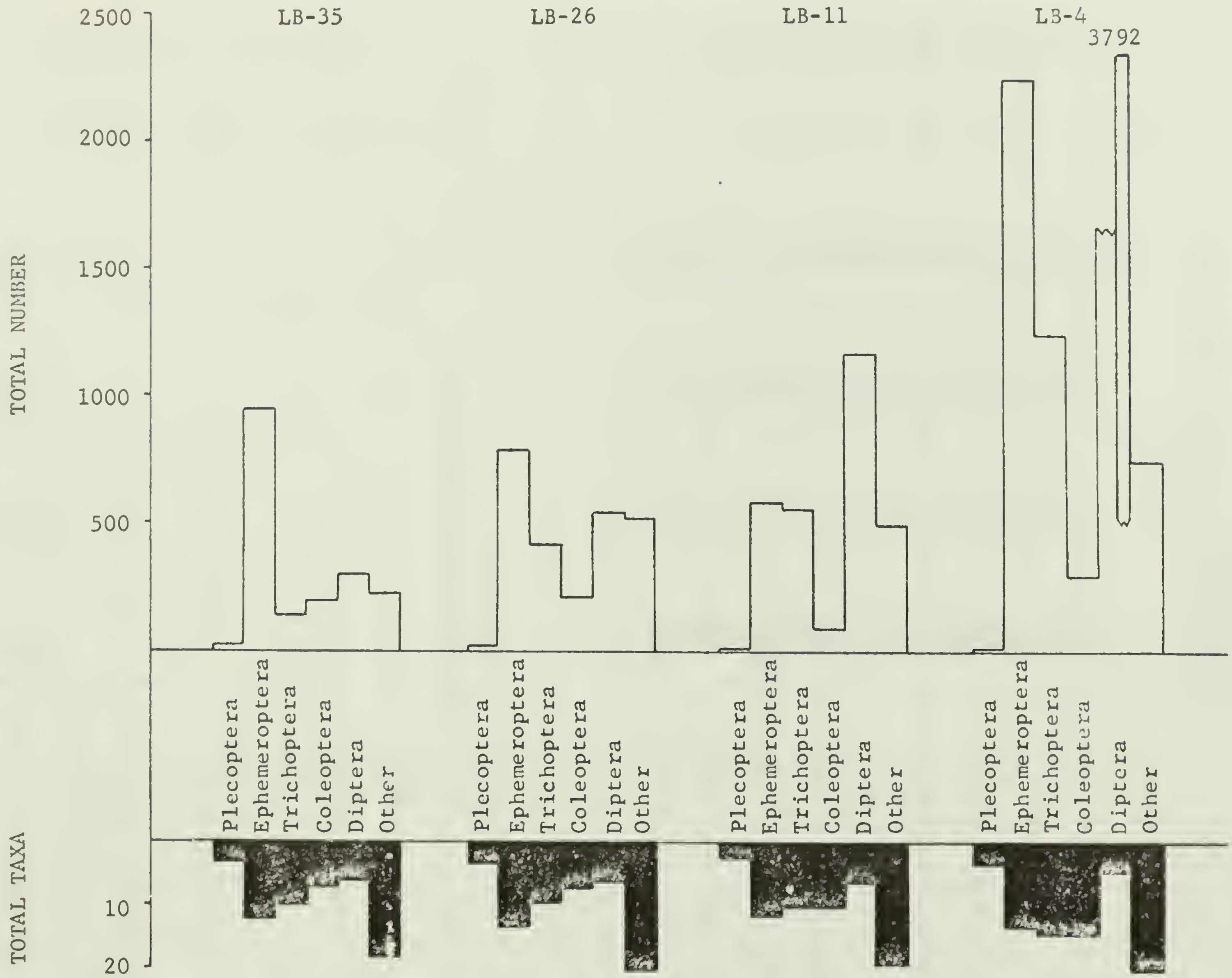


Figure 16. Community structure of benthic invertebrates from stations located on Little Black River.

1). No point sources of pollution were identified between LB-35 and LB-26. The invertebrate community inhabiting this portion of the Little Black was similar to that at LB-35 (C=68). Again, seasonal and annual mayfly and stonefly taxa were the only water quality parameter values which were less than the water quality criteria for unpolluted Missouri streams (Fig. 15). As at LB-35, there were few stonefly taxa found at LB-26 throughout the year. Since the other values at LB-26 met the established criteria and the community structure (Fig. 16) was similar to the community sampled at LB-35 this station was classified unpolluted. The lack of stonefly taxa is probably a natural occurrence unique to this portion of the Little Black. The major taxonomic groups present at LB-26 were:

Mayflies (30%)	True flies (23%)
Tricorythodes sp. (60%)	Chironomidae (88%)
Isonychia sp. (14%)	Simulidae (7%)
Stenonema nepotellum (7%)	*Antocha* sp. (2%)

Caddisflies (16%)	Snails (13%)
Hydropsyche bifida (gp.)(46%)	*Goniobasis* sp. (56%)
Cheumatopsyche sp. (25%)	*Ferrissia* sp. (42%)
Agapetus sp.	Planorbidae (2%)

The Courtois Hills portion of Little Black River was unique in other ways:

1) This was the first occurrence of snail communities which were not totally dominated by *Goniobasis* sp.

2) Mussels were present in much greater numbers and varieties than observed in the Current or Jack's Fork basins.

3) A moderate population of the Asiatic Clam, *Corbicula leana* was present at LB-26. The Little Black was the first drainage in this survey which supported this mussel of those discussed so far.

Downstream from LB-26, stream gradient became less as the Little Black flows toward the Southeastern Lowlands of Missouri. Station LB-11 is located near Naylor, Missouri in a portion of the Little Black near the western edge of these lowlands. Stream banks had a vegetated border on either side. Much of the watershed has been cultivated and is intensively farmed. The water is more turbid throughout the year than at the previous two stations, however, it does clear substantially during periods of low rainfall. Very few riffles were present at LB-11 and LB-4. The stream has deep pools with silty bottom substrates.

One small lagoon discharges into the Little Black above LB-11 (Table 6). Most pollution entering the Little Black in this area (and at LB-4) was primarily from agricultural non-point sources. Even though the habitat had changed from that of the previous two stations, water quality parameter values met the criteria and water quality at LB-11 was classified unpolluted. As before, there were few stoneflies (3 organisms, 2 taxa). Mayflies numbers were normal. Further examination of the data showed that even though the water quality parameter values for these three stations were almost identical (Fig. 15), the community structure was not (Fig. 16). Station LB-11 had a dissimilar invertebrate community when compared with stations LB-35 and LB-26 (C=27 @LB-35; C=36 @ LB-26). This difference was primarily due to habitat differences. Invertebrates such as Oligochaetes, burrowing mayflies (Hexagenia limbata), and silt tolerant caddisflies (Neureclipsis sp., Macronemum carolina, and Hydropsyche cuanis) according to Roback (1962), were well represented at LB-11 but not at LB-26 or LB-35. Beetle taxa were also more diverse at LB-11 (10 taxa) while only 6 taxa were found at LB-26 and LB-35, combined. Inspite of these structural differences, the community inhabiting the Little Black River at LB-11 was quite diverse and had numerous facilitative and intolerant taxa represented. The structure of the invertebrate community at LB-11 contained the following major groups:

True flies (38%)

Chironomidae (96%)

Empididae (3%)

Mayflies (22%)

Stenonema pulchellum (56%)

Stenacron gildersleevei (27%)

Isonychia sp. (5%)

Caddisflies (22%)

Cheumatopsyche sp. (62%)

Neureclipsis sp. (18%)

Lepidostoma sp. (12%)

Snails (5%)

Ferrissia sp. (92%)

Goniobasis sp. (7%)

Physical habitat at LB-4 (Fig. 1; Table 1) was not much different than that found at LB-11. Sand and silt were the major substrate. The vegetated borders present between the stream and croplands were not as wide in many areas as at LB-11. The invertebrate community at LB-4 was similar to that found at LB 11 (C=68). Many silt-tolerant invertebrates were collected at this station. Beetle (15 taxa), snail, and mussel populations were also well established. In addition to Corbicula leana, Sphaerid clams had also established populations. Water quality parameter values exceeded the criteria for unpolluted Missouri streams with the exception of mayfly and stonefly taxa (Fig. 15). As before, the relative absence of stoneflies (3 taxa; 11 organisms) accounted for these low values. The invertebrate community was considered diverse, even though structurally different (Fig. 16) from LB-35 (C=22) and LB-26 (C=28). The taxa which inhabited the Little Black River at LB-4 were considered facilitative or intolerant of pollution. As at LB-11, water quality was classified unpolluted and was apparently not affected by the higher turbidities and agricultural non-point pollution sources noted during the survey. The major taxonomic groups at LB-4 were:

True flies (45%)	Mayflies (28%)	Caddisflies (
Chironomidae (99%)	Stenonema pulchellum (58%)	Cheumatopsyche s
Empididae (< 1%)	Stenocron gildersleevei (25%)	Polycentropus sp
Bezzia/Probezzia,..., (< 1%)	Hexagenia limbata (6%)	Agapetus sp. (8%

Summary

Water quality in Little Black River was considered unpolluted throughout its basin in Missouri. The Courtois Hills region was virtually free of both point and non-point sources of pollution whereas the lower portion, which flows through the Southeastern Lowlands, was subject to intensive agricultural activities resulting in potential non-point pollution. Little Black River in both regions contained diverse, pollution sensitive invertebrate communities which were characterized by a conspicuous lack of stoneflies. The reason for the low numbers of stonefly taxa is unknown. The change in habitat, from the Courtois Hills region to the Southeastern Lowlands, affected the community structure of the invertebrates inhabiting Little Black River. Taxa which were more tolerant of turbid water and silty substrate became established in the lowland portions, however, the invertebrate community in each region remained diverse. This indicated that the intensive agricultural activities have not seriously degraded Little Black River in its lowland portion. Agricultural practices in these lowlands must be continued in such a manor so that the vegetative borders and other safeguards which exist to date are not destroyed. Otherwise degradation will occur in the future in the lowland areas of Little Black River.

Eleven Point River

A total of 129 taxa of aquatic invertebrates, including 42 mayfly and stonefly types were collected from Eleven Point River and its tributaries during the survey (Table 3). There were many pollution sensitive invertebrates collected in this drainage. Water quality parameter values met criteria established for unpolluted Missouri streams (Appendix Table A-11) except in portions influenced by spring water. Water samples were collected and analyzed with each invertebrate sample by the U. S. Forest Service (Appendix Table A-4). A variety of point sources of pollution were present in the watershed but they were not numerous considering the size of the

Eleven Point basin (Table 7). The major potential problem in this watershed was the spraying and clearing of forest land, which has occurred in the past, and its possible effects on the water quality of Eleven Point River and its tributaries (Personal Communication, 1974, Chuck Tryon, Watershed Scientist, U. S. Forest Service, Rolla, Missouri). Preparations are underway to include a major portion of the Eleven Point into the network of National Scenic Riverways. This inclusion would help protect this river from future clearing operations.

Mainstem

Eleven Point River is considered intermittent in Howell County during dry years and does not maintain permanent flow until it enters Oregon County near Thomasville, Missouri (Missouri Department of Conservation, 1943). Station EP-88 was the headwater station on the Eleven Point River. This portion of the river is actually one of three forks which converge about 1 mile downstream from EP-88 to make up the mainstem of the Eleven Point River (Fig. 2; Table 1). Above EP-88, Eleven Point River receives treated sewage effluent from Willow Springs and potential pollutants from a wood preserving company at Mountain View, Missouri (Table 7). Both sources were located a substantial distance from this station. Dye trace studies conducted by the U. S. Forest Service Rolla, Missouri indicated that the effluent from the Willow Springs lagoon also flowed into Greer Spring (discussed later). Therefore, depending on the amount of subterrainean flow to Greer Spring, the effluent may have very little affect on EP-88. Also, much of the waterhshed surrounding the following stations: EP-88; EPmf-0; EPbf-2, and EP-86 (Fig. 2), has been cleared and it is

Table 7. Point source pollution discharges and potential pollution sources entering the Eleven Point River system.[1]

Facility: Name	Facility: Legal Description	Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
<u>Shannon County</u>					
Birch Tree, Mo.	T27N R5W Sec.21	Oxidation ditch with final clarification	--	Birch Creek	EPs-0
<u>Howell County</u>					
Willow Springs, Mo.	T27N R9W	lagoon (2-cell)	9.2	Eleven Point	EP-88
Sahara Motel	T25N R9W Sec.36 SW¼	septic tank & dosing chamber	--	Eleven Point (Middle Fork)	EPmf-0
Ridgeview School R-4	T26N R9W Sec.22	lagoon (1-cell)	0.2	Lost Camp Creek	EP-88
Cookson Hills Christian School	T26N R8W Sec.25 NE¼	lagoon (1-cell)	0.1	no discharge	--
Peace Valley	T25N R7W Sec.17	septic tank & tile field	--	no discharge	--
Barton Tavern	T27N R7W Sec.19	lagoon (1-cell)	0.02	no discharge	--
V. Smith Lumber Co.	T27N R8W Sec.24 SW¼	Penta plant	--	Eleven Point	EP-88
<u>Oregon County</u>					
Alton, Mo.	T24N R4W Sec.34	lagoon (2-cell)	7.0	Piney Creek	EPf-1
Simmon's Slaughter	Alton, Mo.	Slaughter waste	--	no discharge	--
Couch School Dist. R-1	T22N R3W Sec.21 SW¼	septic tank & lagoon (1-cell)	--	Mill Creek	EPf-1

Table 7. (Continued)

Facility		Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
Name	Legal Description				
Doss & Harper Gravel Co.	T24N R5W Sec.6	Gravel operation	--	Eleven Point (Middle Fork)	EPmf-0
Thomasville Wood Products	T24N R5W Sec.5 SW¼	Penta plant	--	Eleven Point (Barren Fork)	EPbf-2

1 Compiled from information obtained from Division of Environmental Quality (DNR) and Missouri Department of Conservation personnel.

intensively grazed by livestock.

Water quality parameter values at EP-88 were within 6% of the minimun criteria established for unpollution streams (Fig. 18; Appendix Table A-11). The water quality at EP-88 could not be classified but was considered unpolluted since many pollution sensitive taxa (Fig. 17) were sampled. The water quality parameter values were slightly lower than those observed at EPmf-0 and EPbf-2 (discussed later) probably because of the influence of springs (Vineyard and Feder, 1974). Higher carbon dioxide values at EP-88 (Appendix Table A-4) indicated that spring water accounted for much of the flow. The dominant taxonomic groups sampled at this station were:

Caddisflies (39%)	Mayflies (36%)	Beetles (8%)
Hydropsyche bifida (gp.)(29%)	Pseudocloeon sp. (33%)	Stenelmis sp. (82%)
Cheumatopsyche sp. (28%)	Baetis sp. (31%)	Psephenus herricki (15%)
Helicopsyche sp. (19%)	Stenonema pulchellum (15%)	Optioservus ozarkensis(2

The Middle Fork of Eleven Point River was the second of the three forks sampled. Station EPmf-0 was located a short distance from the mouth of the Middle Fork of Eleven Point River (Fig. 2; Table 1). The only potential problems identified on this fork were a small sewage treatment lagoon and a gravel operation (Table 7). The invertebrate community at EPmf-0 was very diverse and had many pollution intolerant taxa (Fig. 17). There was no evidence that the gravel operation or lagoon had degraded this fork in any way. Water quality parameter values exceeded the criteria established for unpolluted Missouri streams on both a seasonal and annual basis (Fig. 18). The stream was classified unpolluted. Bake and Fletcher

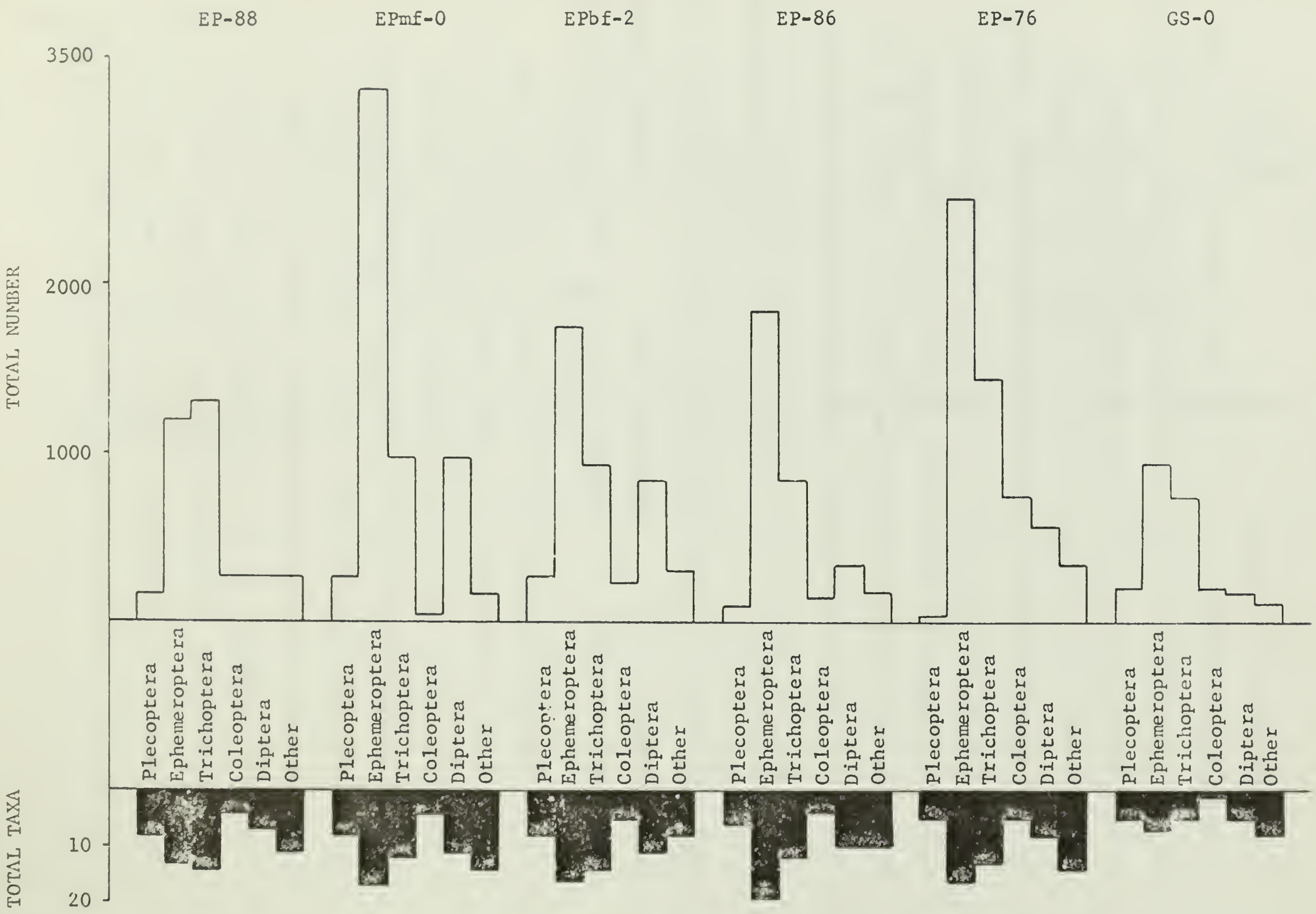


Figure 17. Community structure of benthic invertebrates from stations located on upper Eleven Point River.

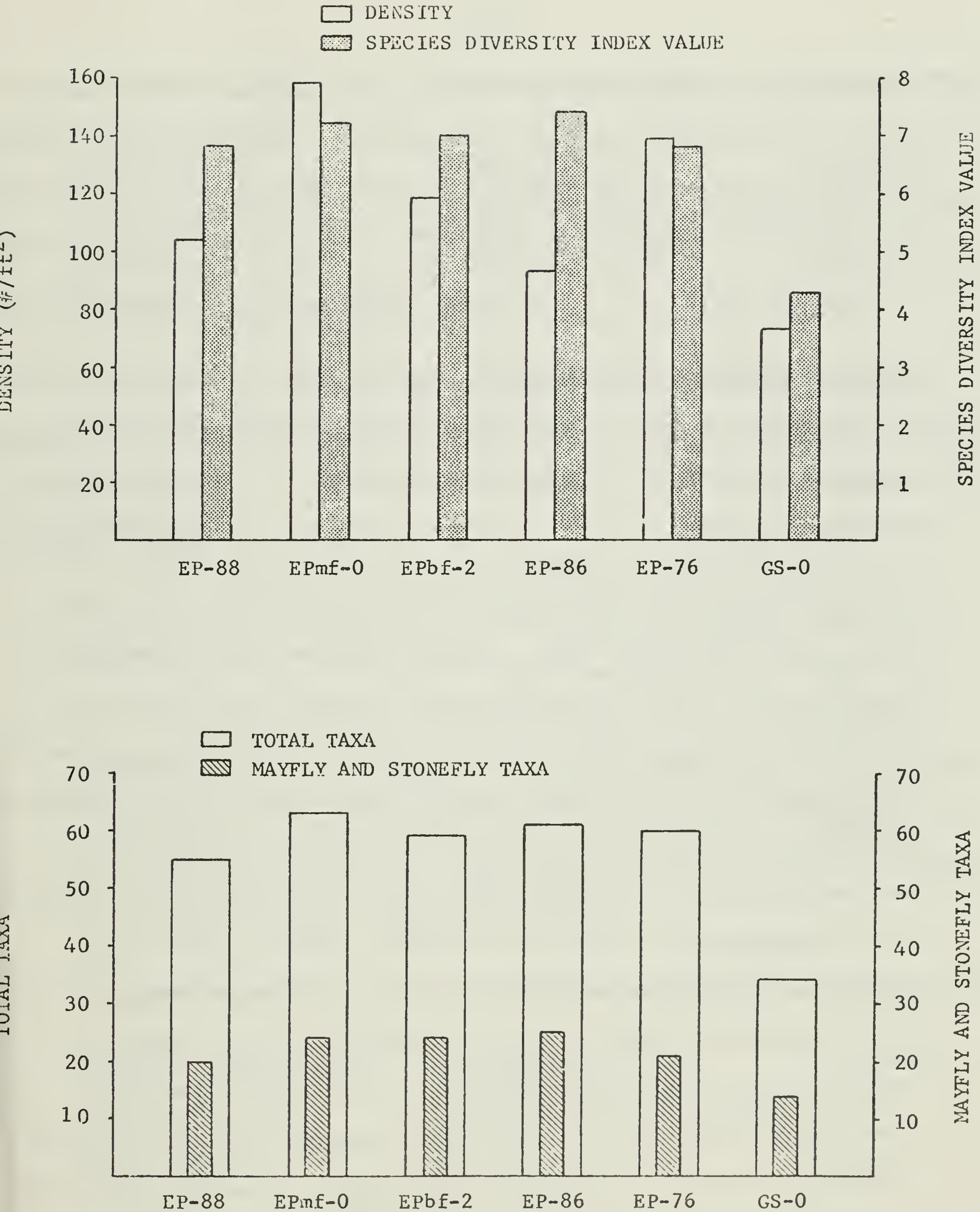


Figure 18. Summary of annual water quality parameter values for stations on upper Eleven Point River.

(1970) found the same results in 1969 when they conducted a less intensive survey of this fork for the U. S. Forest Service. The invertebrate community was similar to those found inhabiting EP-88 and EPbf-2 (Appendix Table A-9b). The invertebrate community was characterized by the following major groups:

Mayflies (57%)	Caddisflies (18%)	True flies (17%)
Stenonema nepotellem (30%)	Cheumatopsyche sp. (45%)	Chironomidae (87%)
Pseudocloeon sp. (19%)	Hydropsyche bifida (gp.)(28%)	Eriocera/Hexatoma (
Isonychia sp. (14%)	Helicopsyche sp. (9%)	Tabanus/Chrysops (2
S. pulchellum (11%)		Bezzia/Probezzia,..

The Barren Fork of Eleven Point River was the third of the headwater forks sampled during this survey. Station EPbf-2 was located immediately downstream from a wood preserving company to monitor the effects of this facility upon this fork, (Fig. 2; Tables 1 and 7). The only other potential problem was the extensive timber clearing operation which has been mentioned previously. No evidence of degradation was found in Barren Fork (Fig. 17). Bake and Fletcher (1970) reported high nitrate and fecal coliform in Barren Fork, supposedly due to cattle in the stream. However, neither fecal coliform nor nitrate concentrations were high in the water samples collected during this survey (Appendix Table A-4). The invertebrate community at EPbf-2 was similar to that inhabiting the previously discussed forks: EP-88 (C=60); EPmf-0 (C=69). Water quality parameter values exceeded the criteria established for unpolluted streams (Fig. 18), and the stream was classified unpolluted. The following invertebrate groups were dominant at this station:

Mayflies (43%)	Caddisflies (21%)	True flies (19%)
Baetis sp. (22%)	_Cheumatopsyche_ sp. (46%)	Chironomidae (84%)
Pseudocloeon sp. (21%)	_Hydropsyche bifida_ (gp.)(28%)	Empididae (4%)
Isonychia sp. (17%)	_Helicopsyche_ sp. (12%)	_Antocha_ sp. (3%)
Stenonema nepotellum (13%)		

Sample station EP-86 was on the mainstem of Eleven Point River, 1 mile downstream from the confluence of the three forks previously discussed (Fig. 2; Table 1). The invertebrate community sampled at this station was similar to that inhabiting the Middle (C=66) and Barren Fork's (C=56), but was not similar to station EP-88 (C=48). The dissimilarity was due to the effects of spring water on EP-88. The invertebrate community at EP-86 was diverse and had numerous pollution sensitive taxa (Fig. 17). Water quality parameter values exceeded the criteria established for unpolluted Missouri streams on a seasonal and annual basis (Fig. 18) and this station was classified unpolluted. No degradation had occurred from upstream pollution sources or timber clearing. The invertebrate community had the following major groups represented:

Mayflies (43%)	Caddisflies (21%)	True flies (19%)
Stenonema nepotellum (51%)	_Cheumatopsyche_ sp. (52%	Chironomidae (85%)
Isonychia sp. (14%)	_Hydropsyche bifida_ (gp.)(35%)	Simulidae (7%)
Tricorythodes sp. (10%)	_Helicopsyche_ sp. (14%)	_Antocha_ sp. (2%)

In addition, to these major taxonomic groups, stonefly taxa were also well represented, however, their numbers were usually low.

The Eleven Point was sampled above its confluence with Greer Spring at EP-76 (Fig. 2; Table 1). No point sources of pollution were found above this station. Very little of the watershed has been cleared on either side of the stream. Water quality at EP-76 was classified unpolluted because it supports a diverse community of pollution intolerant invertebrates (Fig. 17), and most seasonal and annual water quality parameter values met or exceeded criteria established for unpolluted Missouri streams (Fig. 18; Appendix Table A-11). The invertebrate community consisted of the following major groups:

Mayflies (44%)	Caddisflies (26%)	Beetles (13%)
Pseudocloeon sp. (26%)	Cheumatopsyche sp. (58%)	Optioservus ozarker
Stenonema nepotellum (22%)	Hydropsyche bifida (gp.)(31%)	Stenelmis sp. (4%)
Baetis sp. (16%)	Psychomyia flavida (4%)	Dubiraphia vittata

The community inhabiting this portion of the Eleven Point was quite similar to most of the stations discussed previously (Appendix Table A-9b), however, the dominant taxa within some of the major groups had changed.

Greer Spring, Missouri's second largest spring, entered Eleven Point River near Greer, Missouri (Fig. 2; Table 1). The spring branch, which starts with two main outlets, has a tremendous velocity and flows for about 1 mile through a steep gorge which remains in its natural, unaltered state (Vineyard and Feder, 1974; Bake and Fletcher, 1970; Beckman and Hinchley, 1944). Water from the spring branch was reported to be high in nutrients and cold (Bake and Fletcher, 1970). Chemical data collected during this survey indicated that these conditions still exist (Appendix Table A-4).

Dye traces have been made to Greer Spring from sewage treatment lagoons in Willow Springs, Mountain View, and Alton, Missouri by the U. S. Forest Service, Rolla, Missouri. Land use practices in these areas, such as the conversion of forestland to pasture were probably responsible for some of the increase in nutrient concentration in Greer Spring. The water quality of Greer Spring directly affects the water quality of the Eleven Point River below its confluence with the spring branch. The spring branch contributes about 90% of the low flow and 63% of the total flow of the river a mile below its confluence with Eleven Point River (Bake and Fletcher, 1970).

The invertebrate community inhabiting the spring branch was not similar to that found in the previously discussed springs (C=14 @MS-0; C=14 @RS-0; C=15 @BS-0; C=12 @AS-0). High nutrient concentrations probably accounted for some of this dissimilarity. The annual density in the spring branch was quite low compared to the other springs (73 organisms per sq. ft.). This low density was attributed to the rigorous environment produced by the high velocities which exist in the spring branch. Other water quality parameter values for Greer Spring were consistently higher than those calculated for the other springs (Figs. 3, 5, 12, and 18). These dissimilarities were attributed to the habitat differences which existed, of which flow and productivity were important factors. The invertebrates collected from Greer Spring were pollution sensitive types which indicate that Greer Spring was unpolluted (Fig. 17). However, with more changes in land use practices within the recharge basin, the higher productivity noted during the survey could change from a benefit to a detriment. The community at GS-0 consisted of the following dominant groups:

Mayflies (43%)	Caddisflies (34%)
Ephemerella serrata (gp.)(37%)	*Lepidostoma* sp. (48%)
Baetis sp. (36%)	*Cheumatopsyche* sp. (31%)
Pseudocloeon sp. (25%)	*Hydropsyche bifida* (gp.)(10%)

Beetles (7%)	Stoneflies (7%)
Optioservus ozarkensis (100%)	*Isoperla namata* (77%)
	Paragnetia media (17%)
	Leuctra sp. (4%)

Station EP-73 was located 1 mile downstream from the confluence of Greer Spring and the Eleven Point River (Fig. 2; Table 1). No point-source pollution discharges were identified between EP-73 and EP-76. The invertebrate community at EP-73 resembled that sampled at EP-76 (C=53), but it was not as diverse. Density of invertebrates at EP-73 was the second greatest observed at any station sampled during the survey (C-175 was higher). Water quality parameter values did not meet the criteria established for unpolluted Missouri streams (Fig. 19). This portion of the Eleven Point was not classified but considered unpolluted since numerous pollution sensitive taxa were present (Fig. 20). The major groups represented in the samples were:

Mayflies (43%)	Caddisflies (34%)
Cheumatopsyche sp. (52%	*Pseudocloeon* sp. (29%
Hydropsyche bifida (gp.)(39%)	*Ephemerella invaria* (gp.)(27%)
Psychomyia flavida (5%)	*Baetis* sp. (19%)

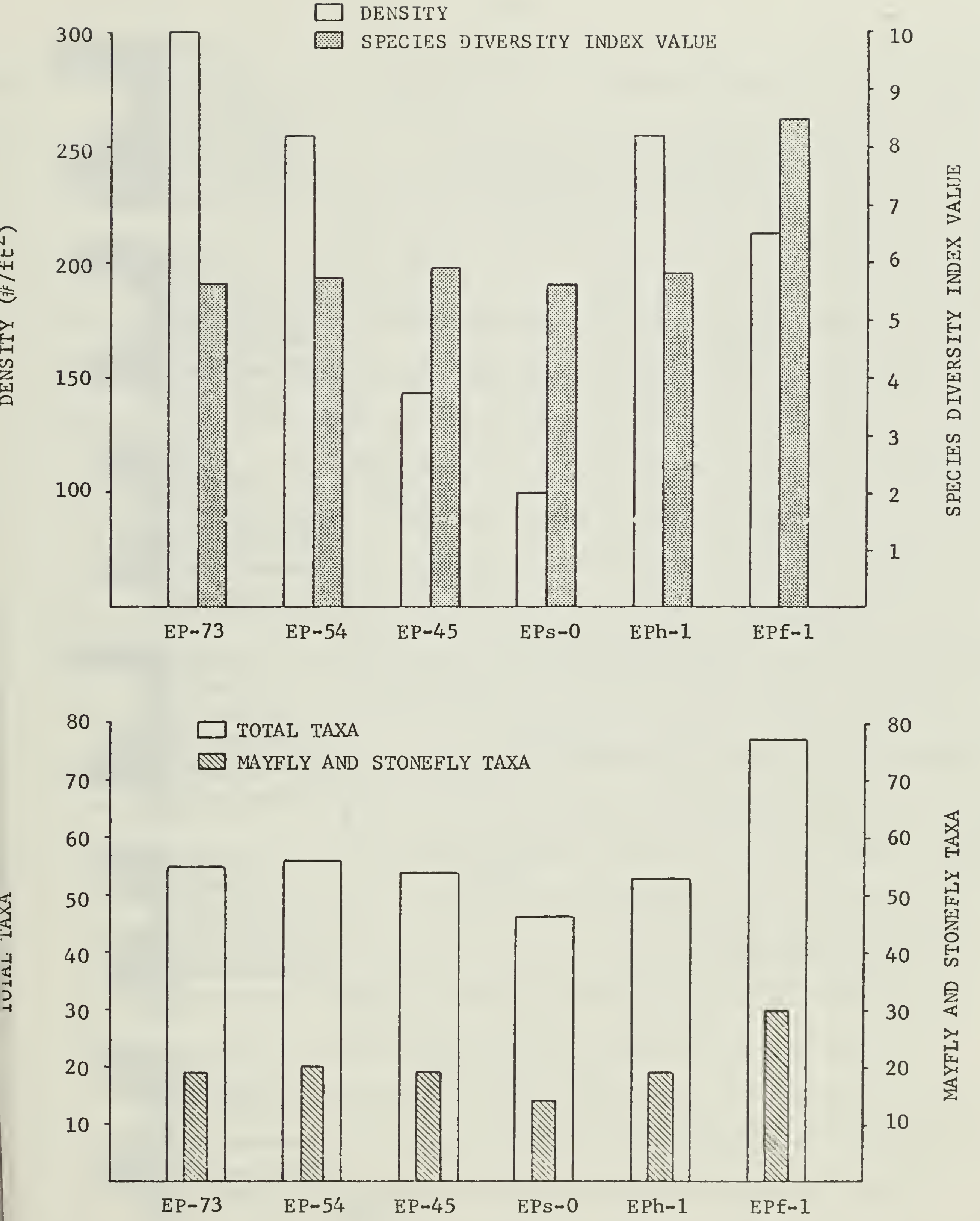


Figure 19. Summary of annual water quality parameter values for stations on lower Eleven Point River and its major tributaries.

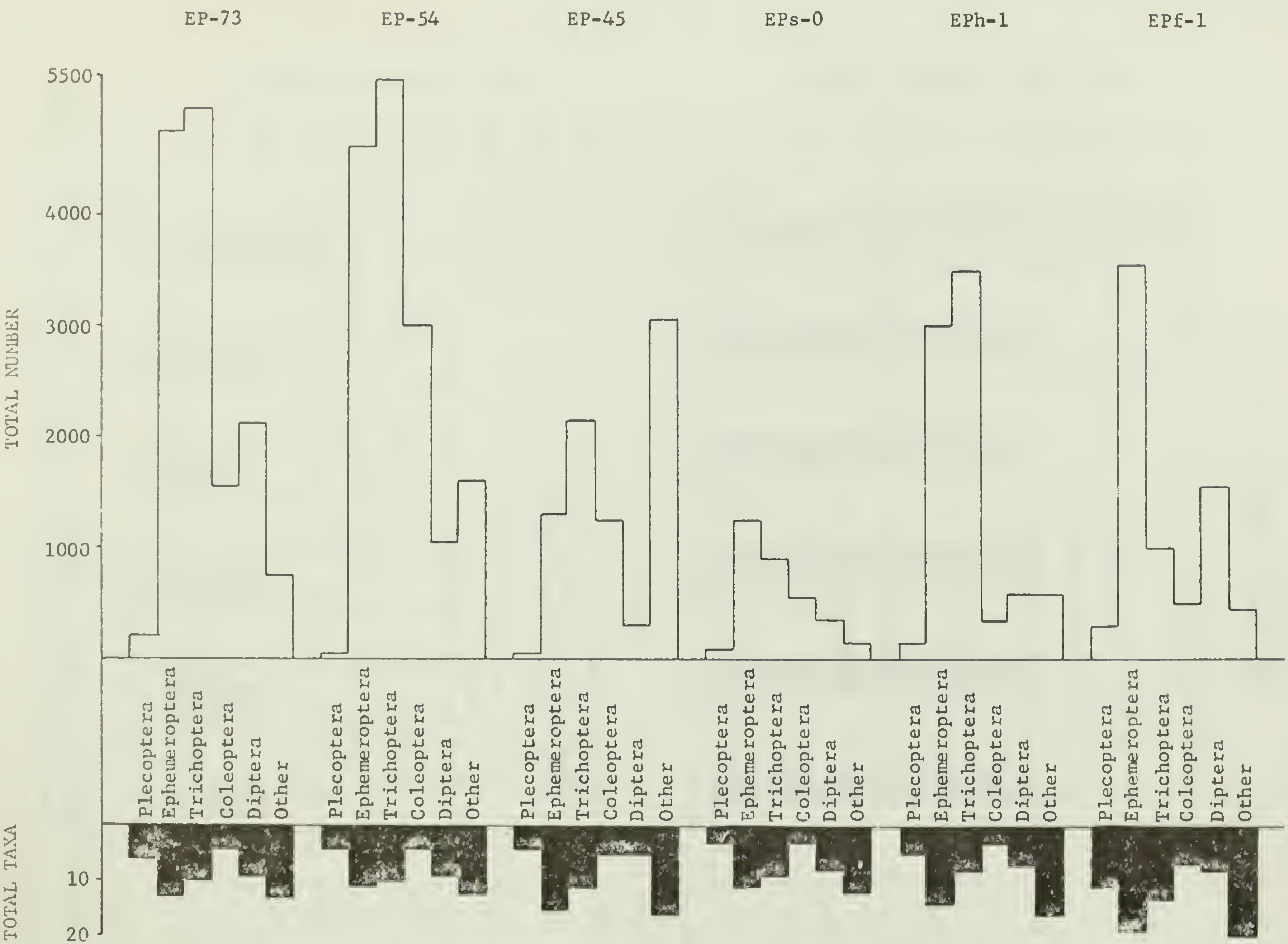


Figure 20. Community structure of benthic invertebrates from stations on lower Eleven Point River and its major tributaries.

True flies (15%)	Beetles (11%)
Chironomidae (81%)	*Optioservus ozarkensis* (98%)
Simulidae (15%)	*Stenelmis* sp. (1%)
Empididae (3%)	

The important factor noticed at EP-73 was that most of the dominant macroinvertebrate groups were also dominant at GS-0. This demonstrated the influence of Greer Spring on this portion of Eleven Point River.

No point sources of pollution or timber clearing were known to exist in the Eleven Point watershed between stations EP-73 and EP-54 (Fig. 2). Vineyard and Feder (1974) reported that many springs contributed to the flow of the Eleven Point between these two stations. The effects of the colder, low nutrient water from these springs upon the invertebrate community at EP-54 was similar to that observed at other stations highly influenced by springs. All stations on Eleven Point River below Greer Spring supported somewhat similar communities of invertebrates with coefficients of similarity equal to or greater than 50 (Appendix Table A-9b). The invertebrate community at EP-54 was diverse with a high invertebrate density noted throughout the riffle. Seasonal diversity values met the criteria established for unpolluted streams. Whereas, the annual value did not meet the criteria. The water quality at EP-54 was considered unpolluted because numerous intolerant taxa were represented (Figs. 19 and 20). The low annual species diversity index value was probably due to the high production of the organisms within each taxa present. This would tend to depress the annual diversity value because the high density was not compensated for by new taxa. The invertebrate groups which were dominant at EP-54 were:

Caddisflies (33%)	Mayflies (29%)	Beetles (19%)
Agapetus sp. (49%)	Pseudocloeon sp. (24%)	Optioservus ozarkens
Cheumatopsyche sp. (32%)	Isonychia sp. (19%)	Stenelmis sp. (< 1%)
Hydropsyche bifida (gp.)(14%)	Ephemerella invaria (gp.)(18%)	

Extensive areas of the Eleven Point watershed, between EP-54 and EP-45, have been converted to pastureland (Personal communication, 1974, Chuck Tryon, Watershed Scientist, U. S. Forest Service, Rolla, Missouri). No point sources of pollution were found during the survey. Bake and Fletcher (1970) noted localized degradation of the rivers from cabins, pastureland drainage, and cattle which had direct access to the stream in the area between EP-54 and EP-45. They considered this section of Eleven Point River unpolluted but nutrient enriched. They emphasized the need for careful land management in the watershed to ensure protection of continued good water quality in Eleven Point River.

The invertebrate community sampled at EP-45 (Fig. 2; Table 1) was diverse and seasonal water quality parameter values exceeded the criteria established for unpolluted streams (Appendix Table A-11). Annual water quality parameter values, however, did not meet the criteria (Fig. 19). The lower annual values were again due to high invertebrate production within taxa without the addition of new taxa. The presence of Morgan Spring and two smaller springs immediately above EP-45 (Vineyard and Feder, 1974) were probably responsible for the lower annual values since their colder water would restrict colonization to cold-water invertebrate taxa. Water quality at EP-45 was considered unpolluted since most parameter values met the criteria and numerous pollution sensitive forms were present

(Fig. 20). The river at EP-45 contained high concentrations of nutrients (Appendix Table A-4) and degradation from excessive nutrients could occur if careful watershed management is not practiced in the future. The invertebrate community consisted of the following dominant groups:

Snails (32%)	Caddisflies (26%)
Goniobasis sp. (99%)	*Agapetus* sp. (62%)
Ferrissia sp. (1%)	*Cheumatopsyche* sp. (19%)
	Helicopsyche sp. (8%)

Mayflies (16%)	Beetles (16%)
Stenonema pulchellum (22%)	*Optioservus ozarkensis* (97%)
Ephemerella invaria (gp.)(19%)	*Stenelmis* sp. (2%)
Tricorythodes sp. (18%)	*Psephenus herricki* (< 1%)

Major Tributaries

Spring Creek (EPs-0)

Bake and Fletcher (1970) reported that Spring Creek received much of its summer flow from springs and was considered unpolluted. Most of its watershed was forested and the only point source of pollution identified during the present survey was the treated sewage effluent from the oxidation ditch which served Birch Tree, Missouri (Table 7). This facility discharged into Birch Creek, a tributary of Spring Creek, about 20 miles above the sample station EPs-0 (Fig. 2; Table 1).

The invertebrate community at EPs-0 was not as diverse as other communities at other stations in the Eleven Point basin with the exception of GS-0. Water quality parameter values were only within 28% and did not meet the criteria established for unpolluted Missouri streams (Fig. 19). However, numerous pollution intolerant taxa were found in the samples (Fig. 20). It is doubtful that the sewage effluent entering from Birch Tree caused the reduction in parameter values at EPs-0 since coliform values were low (Appendix Table A-4). Nutrient values were not much different than those found at other stations in the Eleven Point basin. The influence of springs in Spring Creek was the probable cause for water quality parameter values being lower than the established criteria for unpolluted Missouri streams. The structure of the community was similar to that found at Pulltight Spring, C-150 (C=56) and Shawnee Creek, JFs-1 (C=60). The invertebrate community at this station included the following major groups:

Mayflies (37%)	Caddisflies (28%)	Beetles (18%)
Pseudocloeon sp. (32%)	Hydropsyche bifida (gp.) (32%)	Optioservus ozarkensis (>99%)
Stenonema nepotellum (27%)	Cheumatopsyche sp. (27%)	
Baetis sp. (18%)	Psychomyia flavida (23%)	

The mayflies, Pseudocloeon sp. and Baetis sp., and the almost total dominance of the beetle, Optioservus ozarkensis, has been typically found at stations in the survey whose flow was primarily from springs.

Hurricane Creek (EPh-1)

The summer flow in Hurricane Creek was reported to be made up almost entirely of water from springs (Bake and Fletcher, 1970). The relatively high dissolved carbon dioxide values (Appendix Table A-4) found throughout 1974, suggest that this is true. No point sources of pollution were identified during the survey. This stream appeared quite productive since density values (Fig. 19) were high during most of the sampling year (annual average = 258 per sq. ft.).

Most seasonal water quality parameter values exceeded the seasonal criteria, however, annual values did not meet the criteria (Fig. 19). Water quality was considered unpolluted since the invertebrate community was diverse with numerous pollution sensitive taxa being represented (Fig. 20). The community at this station was dissimilar to most of the other stations in the Eleven Point basin and other survey streams. The community most nearly resembled the communities at EP-54 (C=50), C-175 (C=50), and Cba-0 (C=50), which were highly influenced by springs. The community at EPh-1 consisted of the following dominant groups:

Caddisflies (43%)	Mayflies (36%)	True flies (8%)
Cheumatopsyche sp. (77%)	*Stenonema pulchellum* (64%)	Chironomidae (90%)
Agapetus sp. (15%)	*Pseudocloeon* sp. (15%)	Empididae (4%)
Hydropsyche bifida (gp.)(4%)	*Isonychia* sp. (12%)	Simulidae (3%)

Beetles were not as abundant at EPh-1 as at other stations which were influenced by springs. However, *Optioservus ozarkensis*, typically found in springs, comprised 84% of those present.

Frederick Creek (EPf-1)

Frederick Creek received treated sewage effluent from the municipal lagoons at Alton, Missouri (Table 7). It flows through an area of the Eleven Point basin which has had large forested areas converted to pastureland (Personal communication, 1974, Chuck Tryon, Watershed Scientist, U. S. Forest Service, Rolla, Missouri). These pasturelands were heavily grazed and fertilization of these lands appeared to contribute to the nutrients in the stream. Bake and Fletcher (1970) considered Frederick Creek one of most enriched streams in the Eleven Point basin. During 1974, Frederick Creek was the only stream in the basin where phytoplankton blooms were noted during summer months.

This stream, because of its higher productivity, supported an invertebrate community consisting of more total taxa and mayfly and stonelfy types than any other stream in the survey (Appendix Tables A-6, A-8, A-10, and A-11). One reason for the higher total taxa value is that Frederick Creek supported high populations of mussels and burrowing mayflies, such as Hexagenia limbata and Ephemera simulans/varia. These invertebrates were not usually found in samples from other streams. Water quality parameter values exceeded the criteria established for unpolluted streams both on a seasonal and annual basis (Fig. 19; Appendix Table A-11). Most of the taxa present were pollution sensitive indicating unpolluted water quality (Fig. 20).

Degradation could occur in the future if the land management practices in the watershed cause further increases in the nutrients in the stream. The invertebrate community at EPf-1 was comparable to that found at LB-4 (C=50) which was in a portion of the Little Black River which had intense agricultural activity. The dominant groups at EPf-1 were:

Mayflies (48%)	True flies (22%)	Caddisflies (14%)
Stenonema pulchellum (18%)	Chironomidae (91%)	*Cheumatopsyche* sp. (61%)
S. nepotellum (18%)	Simulidae (7%)	*Chimarra obscura* (25%)
Pseudocloeon sp. (18%)	Empididae (1%)	*Hydropsyche bifida* (gp.) (8%)
Isonychia sp. (12%)		
Baetis sp. (10%)		

Summary

Eleven Point River and its major tributaries were considered unpolluted and unaffected by point sources of pollution. Two large portions of the Eleven Point watershed have had extensive areas of forests cleared and converted to pastureland. No direct evidence of degradation was found to indicate that the clearing in the northwest portion of Oregon County has affected stations EP-88, EPmf-0, EPbf-2, or EP-86. The second cleared area, which Frederick Creek drained, has apparently caused this stream to be more enriched than others in the basin. The excessive nutrients were probably due to drainage from these cleared lands since other streams in the Eleven Point basin which received treated sewage effluent in their headwaters (EP-88, EPmf-0, EPs-0) did not demonstrate any effects of excessive nutrients.

Regression analyses for stations on the Eleven Point River and its tributaries showed a positive relationship between the increase in nutrients (primarily nitrates) and species diversity index values. This indicated that these enriched streams normally have higher macroinvertebrate diversities. In most instances, the streams with higher species diversity index values had watersheds in which forestlands were converted to pastureland (example: Frederick Creek and to a lesser extent Barren and Middle Forks). Bake and Fletcher (1970) observed the same results. Although these streams are now classified unpolluted, continued forest removal could cause degradation.

In general, invertebrate production in the Eleven Point River basin was much greater than observed in the other survey streams as shown by increased seasonal density of invertebrates at most stations. This increase production could partially be due to the long term effects of forest conversion to pastureland. The invertebrate communities at all stations consisted of numerous pollution sensitive taxa, however, species diversity index values varied. This variation was related to the amount of spring water discharged into the stream. Some protection will be necessary to ensure continued good water quality.

Warm Fork of the Spring River

A total of 74 taxa of aquatic invertebrates including 31 mayfly and stonefly taxa were collected from the two stations located on the Warm Fork of Spring River (Table 3). Since only 8 miles of permanent stream were located in Missouri (Missouri Department of Conservation, 1943), the two stations were located above and below Thayer, Missouri to monitor its effects on the river.

The Warm Fork was sampled above Thayer at Swf-4 (Fig. 2; Table 1). Numerous point sources of pollution discharge into two tributaries of this stream at West Plains, Missouri, about 30 miles upstream (Table 8). Approximately 70% of the watershed of the Warm Fork above Swf-4 is

Table 8. Point source pollution discharges and potential pollution sources entering the Warm Fork of Spring River system.[1]

Facility		Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
Name	Legal Description				
<u>Howell County</u>					
West Plains, Mo.	T24N R8W Sec.26 SW¼	Trickle filter with polish lagoons (2)	49.7	Howell Creek	Swf-4
West Plains, Mo.	T24N R8W Sec.33 ¼ S of city	lagoon (1-cell)	4.2	Mustion Creek	Swf-4
West Plains, Mo.	T24N R8W Sec.33 ½ S of city	lagoon (1-cell)	2.4	Mustion Creek	Swf-4
Arrowhead Estates	T23N R8W Sec.18 SE¼	lagoon (3-cell)	0.8	no discharge	--
Whispering Pines Mobile Home Park	T24N R8W Sec.30 NE¼	lagoon (2-cell)	--	Howell Creek	Swf-4
Ramada Inn	T24N R8W Sec.32 NW¼	Extended aeration	--	Mustion Creek	Swf-4
Howell Valley School	T24N R8W Sec.26 SW¼	septic tank & sand filter	--	Howell Creek	Swf-4
Foremost Dairy Co.	T24N R8W Sec.35 NW¼	lagoon (1-cell)	0.03	Mustion Creek	Swf-4
Glenwood School	T23N R8W Sec.9 SW¼	lagoon (3-cell)	0.75	Mustion Creek	Swf-4
Junction Hills R-12	T24N R8W Sec.12 SE¼	septic tank & sand filter	--	Howell Creek	Swf-4
Richard's R-5 School	T24N R8W Sec.6 NW¼	septic tank & sand filter	--	Howell Creek	Swf-4
Fairview R-2 School	T24N R9W Sec.35 NE¼	septic tank & sand filter	--	Mustion Creek	Swf-4

Table 8. (Continued)

Facility		Type of Facility	Lagoon Area (acres)	Receiving Stream	Nearest Station Downstream
Name	Legal Description				
<u>Oregon County</u>					
Thayer, Mo.	T22N R5W Sec.31	lagoon (2-cell)	8.4	Spring River (Warm Fork)	Swf-0
Poor Boy's Tavern	T22N R6W Sec.12 SW¼	lagoon (1-cell)	0.06	English Creek	Swf-4
State Line Steak House	T21N R5W Sec.5 SE¼	Sand filter	--	no discharge	--
Koshkonong High School	T22N R6W Sec.5	septic tank	--	no discharge	--
Thayer Readi-Mix	T22N R5W Sec.30 SE¼	Cement plant	--	Two Mile Creek	Swf-0

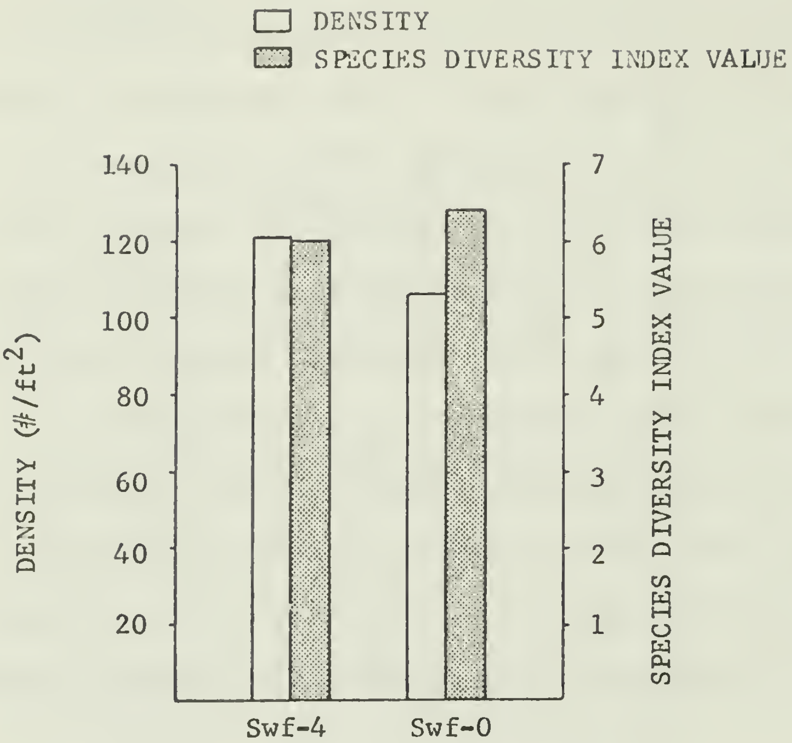
[1] Compiled from information obtained from Division of Environmental Quality (DNR) and Missouri Department of Conservation personnel.

pasture created by timber spraying and clearing (Personal communication, 1977, Gene Woolverton, District Supervisor of Conservation Agents, Missouri Department of Conservation, Thayer, Missouri). These pasturelands are heavily grazed by livestock similar to the watershed of Frederick Creek.

Stream flow in the 8 miles of permanent stream is primarily spring water. Major sources of spring water were located in T23N R5W Sec. 3 and from nearby Anthony Creek. These springs flow year round and are responsible for the Warm Fork maintaining permanent flow at this point (Personal communication, 1977, Gene Woolverton, District Supervisor of Conservation Agents, Missouri Department of Conservation, Thayer, Missouri). Above these springs, the Warm Fork is essentially dry except during periods of heavy rainfall.

The invertebrate community at Swf-4 was similar to that inhabiting Spring Creek (C=68) and Eleven Point River at EP-76 (C=67). Water quality parameter values at Swf-4 did not meet the criteria established for unpolluted Missouri streams annually (Fig. 21) but seasonal values met the criteria (Appendix Table A-12). The community was diverse with many pollution sensitive taxa represented in each sample (Fig. 22). Water quality was considered unpolluted. The dominant taxonomic groups at Swf-4 were:

Mayflies (44%)	Caddisflies (30%)	True flies (12%)
Pseudocloeon sp. (40%)	*Hydropsyche bifida* (gp.)(52%)	Chironomidae (82%)
Baetis sp. (19%)	*Psychomyia flavida* (20%)	Empididae (16%)
Tricorythodes sp. (14%)	*Cheumatopsyche* sp. (19%)	Ceratopogonidae (1%)
Stenonema nepotellum (12%)		



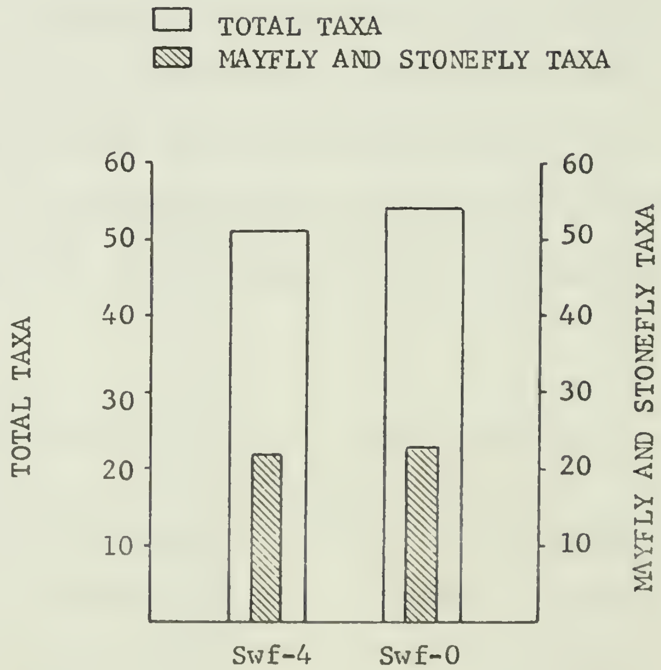


Figure 21. Summary of annual water quality parameter values for stations on Warm Fork of Spring River.

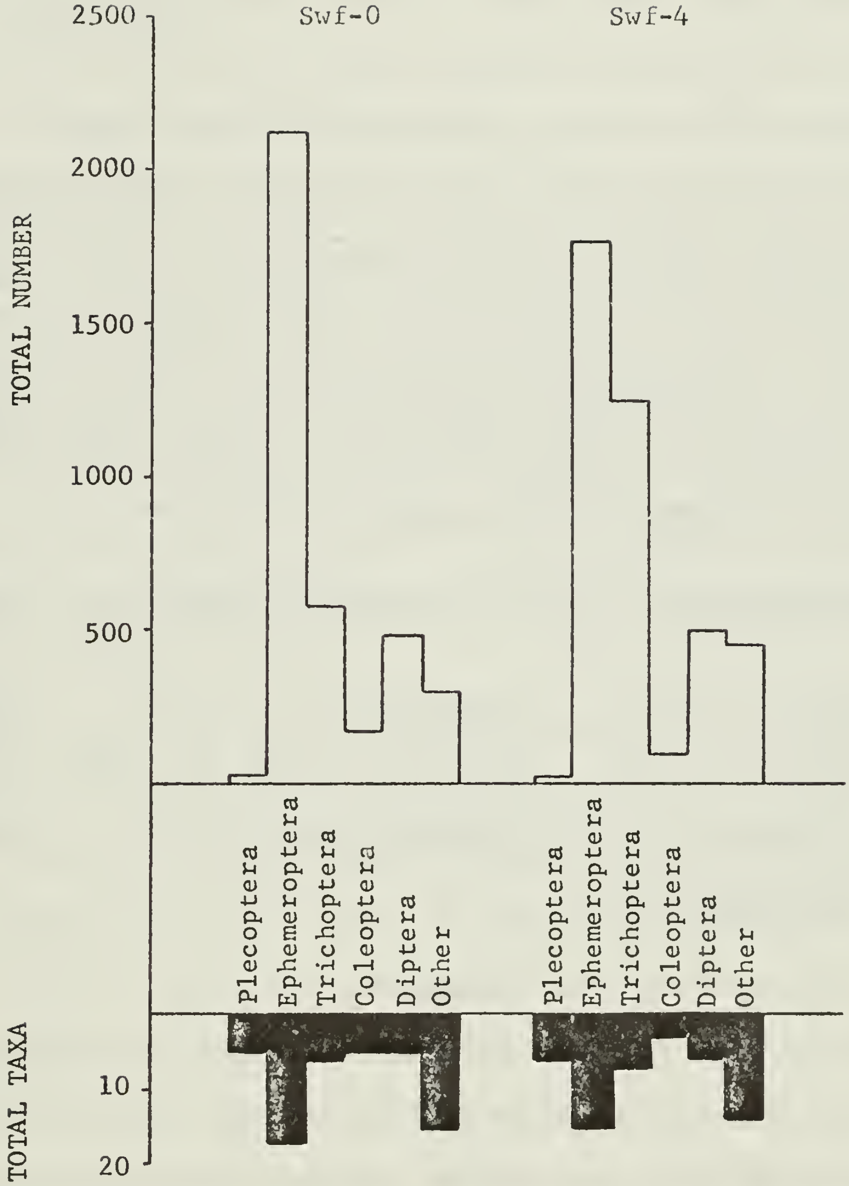


Figure 22. Community structure of benthic invertebrates from stations on Warm Fork of Spring River.

The major point source of pollution discharging into Warm Fork of Spring River above Swf-0 (Fig. 2; Table 1) was the municipal sewage treatment facility serving Thayer, Missouri (Table 8). Pollution at this station was not evident since the invertebrate community closely resembled that found at Swf-4 (C=76). Most water quality parameter values met the criteria (Fig. 21), and many pollution sensitive taxa were represented (Fig. 22). Water quality at this station was classified unpolluted. The community at Swf-0 was similar to the following stations on the Eleven Point: EPmf-0 (C=63); EPbf-2 (C=60); EPs-0 (C=63); EP-76 (C=68). The dominant taxonomic groups at Swf-0 were:

Mayflies (57%)	Caddisflies (16%)	True flies (13%)
Pseudocloeon sp. (33%)	*Cheumatopsyche* sp. (39%)	Chironomidae (85%)
Tricorythodes sp. (16%)	*Hydropsyche bifida* (gp.)(29%)	Empididae (14%)
Stenonema nepotellum (16%)	*Psychomyia flavida* (23%)	Simulidae (<1%)
Baetis intercalaris (14%)		

Summary

The Warm Fork of Spring River exhibited characteristics of an unpolluted Missouri stream which indicated that the sources of pollution in its watershed have not seriously degraded water quality. This stream receives much of its flow from springs and supports an invertebrate community typically found in such streams. There was evidence of higher productivity in this stream when compared to the Current or Jack's Fork rivers. The vast amount of pastureland and nutrients from treated sewage effluent which enter the Warm Fork of Spring River from the watershed are the probable causes for this increased productivity. Careful land use practices will have to be implemented to ensure that the Warm Fork remains unpolluted.

Conclusion

Basically, all five streams surveyed during 1974 were classified unpolluted and were not affected by point sources of pollution. When these sources discharged directly to the stream, localized degradation was noted, however, widespread degradation was not found. The invertebrate communities, dominated by pollution sensitive taxa, were typical of those inhabiting other unpolluted streams in Missouri. Water quality parameter values generally met, or exceeded, criteria established for unpolluted streams in Missouri.

Many portions of these streams were spring fed and cooler water temperatures associated with these springs generally depressed the water quality parameter values slightly by restricting the colonization of invertebrates which were tolerant of lower water temperatures. Regression analyses indicated that as water temperatures become warmer, the invertebrate communities generally become more diverse.

There was no evidence that the intense recreational pressures received by the Current, Jack's Fork, and Eleven Point rivers has degraded these streams over the years. Comparisons with a survey conducted in 1961 on the Current and Jack's Fork rivers showed no significant changes in the invertebrate communities.

Forest conversion to pastureland in the Eleven Point River basin appeared to increase the productivity of the streams affected. Additional nutrients which entered from the cleared pastureland and treated sewage effluents increased the density and number of taxa of invertebrates, especially in Frederick Creek. To date, these added nutrients have enhanced the diversity of the communities. If care is not exercised to limit the amount of nutrients entering these streams, the conditions which presently enhance the communities could cause degradation. This situation is also true in the Warm Fork of Spring River but to a lesser degree.

For these streams to sustain populations of fish and invertebrates typical of unpolluted streams, extreme care must be exercised to control the amount of pollution entering them and to resolve localized problems which presently exist. The conversion of forestland to pasture must be stopped and considered as an undesirable practice, not just to the streams, but to wildlife in general.

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APPENDIX

Appendix Table A-1. Chemical parameters analyzed at invertebrate sampling stations on Current River and its tributaries, 1974.[1]

Parameter	C-49			
Date collected	1-15-74	5-28-74	7-29-74	11-25-74
Water temperature (°F)	47.3	65.3	75.2	50.0
Discharge (cfs)	3,470	5,200	2,180	2,550
Dissolved oxygen*	11.2	8.1	7.9	10.6
pH	7.9	8.1	8.2	8.2
Specific Conductance (µmhos/cm)	270	255	325	292
Fecal Coliform (colonies/100ml)	5	25	2	80
Streptococci (colonies/100ml)	4	27	23	66
Turbidity (JTU)	--	--	--	--
Chemical Oxygen Demand*	2	6	1	3
Alkalinity as $CaCO_3$*	139	138	171	148
Hardness (Ca, Mg)*	150	140	180	150
Nitrate Nitrogen as N*	0.24	0.22	0.00	0.37
Ammonia Nitrogen as N*	0.02	0.00	0.04	0.02
Total Phosphorus as P*	0.03	0.01	0.02	0.01
Ortho Phosphorus as P*	0.03	0.01	0.01	0.01
Calcium*	30	29	36	30
Magnesium*	17	16	21	17
Sodium*	2.1	1.5	2.1	2.0
Potassium*	0.8	0.8	0.9	0.9
Sulfate*	4.3	4.5	3.7	4.3
Chloride*	1.9	1.7	3.0	2.3
Iron*	0.06	0.03	0.02	0.01
Manganese*	0.02	0.02	0.01	
Copper*	--	--	--	--
Lead*	--	--	--	--
Zinc*	--	--	--	--
Aluminum*	--	--	--	--

Appendix Table A-1. (Continued)

Parameter	Cf-3 (Downstream in Arkansas)			
Date collected	1-15-74	5-28-74	7-29-74	11-25-74
Water temperature (^{o}F)	45.5	68.9	79.7	48.2
Discharge (cfs)	183	136	20	220
Dissolved oxygen*	11.4	7.5	6.5	10.6
pH	8.0	8.1	8.1	8.1
Specific Conductance (µmhos/cm)	187	213	249	318
Fecal Coliform (colonies/100ml)	30	92	120	1,600
Streptococci (colonies/100ml)	110	92	180	3,100
Turbidity (JTU)	--	--	--	--
Chemical Oxygen Demand*	2	11	1	21
Alkalinity as CaCO3*	187	213	249	166
Hardness (Ca, Mg)*	190	210	240	170
Nitrate Nitrogen as N*	0.17	0.18	0.08	0.17
Ammonia Nitrogen as N*	0.03	0.07	0.05	0.04
Total Phosphorus as P*	0.03	0.06	0.03	0.03
Ortho Phosphorus as P*	0.03	0.01	0.02	0.01
Calcium*	40	44	50	36
Magnesium*	23	25	29	19
Sodium*	1.8	2.0	2.5	1.9
Potassium*	0.8	0.9	1.1	1.2
Sulfate*	5.4	5.3	11.0	4.8
Chloride*	2.1	2.0	2.4	1.9
Iron*	0.06	0.05	0.02	0.04
Manganese*	0.02	0.01	0.18	0.01
Copper*	--	--	--	--
Lead*	--	--	--	--
Zinc*	--	--	--	--
Aluminum*	--	--	--	--

Appendix Table A-1. (Continued)

Parameter	C-71			
Date collected	1-17-74	4-18-74	7-10-74	10-23-74
Water temperature (°F)	51.8	56.3	72.5	55.4
Discharge (cfs)	2,900	3,840	2,160	1,500
Dissolved oxygen*	9.1	9.2	8.8	9.7
pH	7.9	8.0	8.1	7.9
Specific Conductance (μmhos/cm)	280	273	316	339
Fecal Coliform (colonies/100ml)	3	10	--	8
Streptococci (colonies/100ml)	6	17	--	22
Turbidity (JTU)	1	2	1	1
Chemical Oxygen Demand*	3	6	24	0
Alkalinity as $CaCO_3$*	144	141	162	180
Hardness (Ca, Mg)*	150	150	160	190
Nitrate Nitrogen as N*	0.18	0.23	0.23	0.00
Ammonia Nitrogen as N*	0.05	0.03	0.03	0.01
Total Phosphorus as P*	0.03	0.03	0.01	0.01
Ortho Phosphorus as P*	0.03	0.00	--	0.01
Calcium*	31	30	34	38
Magnesium*	17	17	19	22
Sodium*	2.0	2.5	1.2	1.7
Potassium*	0.9	0.8	1.0	0.7
Sulfate*	5.8	4.9	4.4	5.8
Chloride*	2.7	1.7	2.2	2.3
Iron*	0.04	0.02	0.02	0.01
Manganese*	0.01	0.00	0.00	0.00
Copper*	<0.01	<0.01	<0.01	<0.01
Lead*	0.10	<0.10	<0.10	<0.10
Zinc*	0.03	0.21	0.30	0.07
Aluminum*	--	--	--	--
Pesticides & Herbicides	neg.	neg.	neg.	neg.

Appendix Table A-1. (Continued)

Parameter	C-134			
Date collected	1-18-74	4-17-74	7-10-74	10-22-74
Water temperature (°F)	51.8	56.3	70.7	53.6
Discharge (cfs)	1,820	2,420	1,260	850
Dissolved oxygen*	8.2	10.8	8.2	10.2
pH	8.0	8.2	8.1	8.1
Specific Conductance (μmhos/cm)	292	285	318	341
Fecal Coliform (colonies/100ml)	14	1	--	2
Streptococci (colonies/100ml)	7	3	--	11
Turbidity (JTU)	1	1	1	1
Chemical Oxygen Demand*	5	20	24	0
Alkalinity as $CaCO_3$*	151	143	162	177
Hardness (Ca, Mg)*	150	150	160	190
Nitrate Nitrogen as N*	0.21	0.24	0.42	0.00
Ammonia Nitrogen as N*	0.05	0.01	0.03	0.00
Total Phosphorus as P*	0.03	0.03	0.02	0.02
Ortho Phosphorus as P*	0.03	0.00	--	0.01
Calcium*	32	30	34	38
Magnesium*	18	17	19	22
Sodium*	1.6	2.0	1.4	1.7
Potassium*	1.0	0.8	1.1	0.7
Sulfate*	5.1	4.8	7.8	3.4
Chloride*	2.4	1.7	3.0	2.3
Iron*	0.10	0.20	0.40	0.02
Manganese*	0.00	0.00	0.01	0.00
Copper*	< 0.01	< 0.01	< 0.01	< 0.01
Lead*	< 0.10	< 0.10	< 0.10	< 0.10
Zinc*	0.03	0.23	0.30	0.05
Aluminum*	--	--	--	--
Pesticides & Herbicides	neg.	neg.	neg.	neg.

Appendix Table A-1. (Continued)

Parameter	C-175			
Date collected	1-18-74	4-17-74	7-9-74	10-21-74
Water temperature (°F)	56.3	52.7	59.9	54.5
Discharge (cfs)	160	204	146	109
Dissolved oxygen*	11.6	10.4	10.2	9.4
pH	8.0	7.8	7.4	7.3
Specific Conductance (μmhos/cm)	242	205	272	292
Fecal Coliform (colonies/100ml)	< 2	24	--	30
Streptococci (colonies/100ml)	6	20	--	37
Turbidity (JTU)	1.0	3.0	1.0	1.0
Chemical Oxygen Demand*	5	3	23	2
Alkalinity as $CaCO_3$*	118	97	126	141
Hardness (Ca, Mg)*	120	100	140	94
Nitrate Nitrogen as N*	0.46	0.51	0.66	0.80
Ammonia Nitrogen as N*	0.06	0.04	0.09	0.04
Total Phosphorus as P*	0.04	0.04	0.03	0.13
Ortho Phosphorus as P*	0.03	0.01	0.04	0.13
Calcium*	26	22	30	13
Magnesium*	14	12	16	15
Sodium*	2.3	2.4	2.3	2.4
Potassium*	1.0	0.9	1.2	1.4
Sulfate*	5.2	13.0	4.9	3.9
Chloride*	3.1	2.2	2.8	0.1
Iron*	0.03	0.06	0.02	0.39
Manganese*	0.00	0.02	0.02	0.09
Copper*	< 0.01	< 0.01	< 0.01	< 0.01
Lead*	< 0.10	< 0.10	< 0.10	< 0.10
Zinc*	0.03	0.48	0.01	0.06
Aluminum*	--	--	--	--
Pesticides & Herbicides	neg.	neg.	pos. (2,4,5-T;2,4-D)	neg.

Appendix Table A-1. (Continued)

Parameter	C-87	Cp 1	BS-0	C-85
Date collected	10-18-73	10-18-73	10-18-73	10-18-73
Water temperature (^{o}F)	57.2	54.5	57.2	57.2
Discharge (cfs)	1,930	--	441	1,940
Dissolved oxygen*	9.4	8.5	9.0	9.6
pH	8.1	7.7	7.4	8.1
Specific Conductance (µmhos/cm)	320	429	348	321
Fecal Coliform (colonies/100ml)	20	260	10	13
Streptococci (colonies/100ml)	160	140	32	62
Turbidity (JTU)	--	--	--	--
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	167	249	180	167
Hardness (Ca, Mg)*	--	--	--	
Nitrate Nitrogen as N*	0.38	0.18	0.38	0.38
Ammonia Nitrogen as N*	0.00	0.01	0.04	0.04
Total Phosphorus as P*	0.09	0.06	0.10	0.05
Ortho Phosphorus as P*	0.00	0.00	0.00	0.00
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	--	--	--	--
Potassium*	--	--	--	--
Sulfate*	--	--	--	--
Chloride*	--	--	--	--
Iron*	--	--	--	--
Manganese*	--	--	--	--
Copper*	--	--	--	--
Lead*	--	--	--	--
Zinc*	--	--	--	--
Aluminum*	--	--	--	--

Appendix Table A-1. (Continued)

Parameter	Cs-0	C-150	RS-0	C-119
Date collected	10-16-73	10-15-73	10-16-73	10-17-73
Water temperature (°F)	59.9	60.8	57.2	59.9
Discharge (cfs)	146	761	71	1,490
Dissolved oxygen*	8.8	10.0	8.1	10.1
pH	7.8	7.9	7.3	8.1
Specific Conductance (μmhos/cm)	324	324	273	322
Fecal Coliform (colonies/100ml)	39	82	32	10
Streptococci (colonies/100ml)	160	180	91	38
Turbidity (JTU)	--	--	--	--
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	172	167	148	167
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	0.17	0.55	0.37	0.33
Ammonia Nitrogen as N*	0.12	0.18	0.01	0.03
Total Phosphorus as P*	0.00	0.01	0.02	0.10
Ortho Phosphorus as P*	0.00	0.00	0.00	0.00
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	--	--	--	--
Potassium*	--	--	--	--
Sulfate*	--	--	--	--
Chloride*	--	--	--	--
Iron*	--	--	--	--
Manganese*	--	--	--	--
Copper*	--	--	--	--
Lead*	--	--	--	--
Zinc*	--	--	--	--
Aluminum*	--	--	--	

1 - Water samples collected and analyzed by the U.S. Geological Survey reported in U.S. Geological Survey (1974, 1975).

* - Expressed as mg/l.

Appendix Table A-2. Chemical parameters analyzed at invertebrate sampling stations on Jack's Fork River and its tributaries, 1974.[1]

Parameter	JF-2			
Date collected	1-18-74	4-17-74	7-10-74	10-22-74
Water temperature (°F)	50.9	55.4	69.8	54.5
Discharge (cfs)	560	680	326	233
Dissolved oxygen*	10.8	11.3	7.9	9.6
pH	7.9	8.2	8.0	8.0
Specific Conductance (µmhos/cm)	305	295	338	346
Fecal Coliform (colonies/100ml)	21	2	--	12
Streptococci (colonies/100ml)	16	12	--	13
Turbidity (JTU)	1.0	1.0	1.0	1.0
Chemical Oxygen Demand*	0	1	2	2
Alkalinity as $CaCO_3$*	157	148	169	185
Hardness (Ca, Mg)*	160	150	170	190
Nitrate Nitrogen as N*	0.25	0.23	0.36	0.35
Ammonia Nitrogen as N*	0.07	0.00	0.03	0.01
Total Phosphorus as P*	0.03	0.03	0.01	0.02
Ortho Phosphorus as P*	0.00	0.00	--	0.01
Calcium*	32	31	35	40
Magnesium*	19	18	21	23
Sodium*	1.5	1.8	1.3	1.6
Potassium*	0.9	0.8	1.0	0.7
Sulfate*	4.7	4.6	4.0	3.2
Chloride*	2.5	1.7	2.2	2.3
Iron*	0.04	0.03	0.01	0.02
Manganese*	0.01	0.00	0.00	0.00
Copper*	< 0.01	< 0.01	< 0.01	< 0.01
Lead*	< 0.10	< 0.10	< 0.10	< 0.10
Zinc*	0.03	0.26	0.02	0.24
Aluminum*	--	--	--	--
Pesticides & Herbicides	neg.	neg.	neg.	neg.

Appendix Table A-2. (Continued)

Parameter	JFs-1	JF-6	JF-13
Date collected	10-17-73	10-17-73	10-16-73
Water temperature (°F)	58.1	56.3	61.7
Discharge (cfs)	8.4	435	443
Dissolved oxygen*	9.5	9.2	9.5
pH	8.0	7.8	7.9
Specific Conductance (μmhos/cm)	550	318	306
Fecal Coliform (colonies/100ml)	59	110	76
Streptococci (colonies/100ml)	230	220	170
Turbidity (JTU)	--	--	--
Chemical Oxygen Demand*	--	--	--
Alkalinity as $CaCO_3$*	287	162	154
Hardness (Ca, Mg)*	--	--	--
Nitrate Nitrogen as N*	0.41	0.46	0.47
Ammonia Nitrogen as N*	0.01	0.08	0.08
Total Phosphorus as P*	0.09	0.00	0.00
Ortho Phosphorus as P*	0.02	0.00	0.00
Calcium*	--	--	--
Magnesium*	--	--	--
Sodium*	--	--	--
Potassium*	--	--	--
Sulfate*	--	--	--
Chloride*	--	--	--
Iron*	--	--	--
Manganese*	--	--	--
Copper*	--	--	--
Lead*	--	--	--
Zinc*	--	--	--
Aluminum*	--	--	--

Appendix Table A-2. (Continued)

Parameter	JFm-1	AS-0	
Date collected	10-16-73	10-16-74	7-10-74
Water temperature (^{o}F)	63.5	57.2	57.2
Discharge (cfs)	15	201	169
Dissolved oxygen*	8.5	8.1	8.4
pH	8.0	7.4	7.4
Specific Conductance (μmhos/cm)	410	260	273
Fecal Coliform (colonies/100ml)	41	210	--
Streptococci (colonies/100ml)	210	360	--
Turbidity (JTU)	--	--	--
Chemical Oxygen Demand*	--	--	--
Alkalinity as $CaCO_3$*	226	135	135
Hardness (Ca, Mg)*	--	--	
Nitrate Nitrogen as N*	0.22	0.78	0.70
Ammonia Nitrogen as N*	0.03	0.01	0.03
Total Phosphorus as P*	0.00	0.02	0.03
Ortho Phosphorus as P*	0.00	0.00	--
Calcium*	--	--	--
Magnesium*	--	--	--
Sodium*	--	--	--
Potassium*	--	--	--
Sulfate*	--	--	--
Chloride*	--	--	--
Iron*	--	--	--
Manganese*	--	--	--
Copper*	--	--	--
Lead*	--	--	--
Zinc*	--	--	--
Aluminum*	--	--	--

Appendix Table A-2. (Continued)

Parameter	JF-38		JF-19
Date collected	10-16-73	7-9-74	10-16-73
Water temperature (^{o}F)	62.6	79.7	64.4
Discharge (cfs)	156	56	242
Dissolved oxygen*	9.2	8.2	8.5
pH	8.1	8.2	8.1
Specific Conductance (μmhos/cm)	341	402	323
Fecal Coliform (colonies/100ml)	100	--	13
Streptococci (colonies/100ml)	240	--	97
Turbidity (JTU)	--	--	--
Chemical Oxygen Demand*	--	--	--
Alkalinity as $CaCO_3$*	177	192	177
Hardness (Ca, Mg)*	--	--	--
Nitrate Nitrogen as N*	0.36	0.22	0.30
Ammonia Nitrogen as N*	0.05	0.03	0.06
Total Phosphorus as P*	0.00	0.00	0.01
Ortho Phosphorus as P*	0.00	--	0.01
Calcium*	--	--	--
Magnesium*	--	--	--
Sodium*	--	--	--
Potassium*	--	--	--
Sulfate*	--	--	--
Chloride*	--	--	--
Iron*	--	--	--
Manganese*	--	--	--
Copper*	--	--	--
Lead*	--	--	--
Zinc*	--	--	--
Aluminum*	--	--	--

1 - Water samples collected and analyzed by the U.S. Geological Survey reported in U.S. Geological Survey (1974, 1975).

* - Expressed as mg/1.

Appendix Table A-3. Chemical parameters analyzed at the lower invertebrate sampling stations on Little Black River, 1974.[1]

Parameter	LB-4			
Date collected	1-15-74	5-28-74	7-29-74	11-25-74
Water temperature (°F)	40.1	67.1	80.6	49.1
Discharge (cfs)	243	219	48	320
Dissolved oxygen*	11.6	6.0	4.9	8.8
pH	7.5	7.5	7.8	7.6
Specific Conductance (µmhos/cm)	123	136	290	134
Fecal Coliform (colonies/100ml)	46	290	230	3,600
Streptococci (colonies/100ml)	550	180	240	5,200
Turbidity (JTU)	--	--	--	--
Chemical Oxygen Demand*	6	11	5	14
Alkalinity as $CaCO_3$*	49	59	148	57
Hardness (Ca, Mg)*	61	62	150	68
Nitrate Nitrogen as N*	0.16	0.16	0.21	0.10
Ammonia Nitrogen as N*	0.04	0.10	0.13	0.04
Total Phosphorus as P*	0.04	0.06	0.06	0.07
Ortho Phosphorus as P*	0.03	0.02	0.02	0.02
Calcium*	13	12	31	16
Magnesium*	7	8	17	7
Sodium*	2.1	2.0	2.7	1.6
Potassium*	0.9	0.9	1.2	1.8
Sulfate*	5.9	4.8	3.9	4.8
Chloride*	2.4	2.0	3.1	3.0
Iron*	0.12	0.13	0.05	0.09
Manganese*	0.05	--	0.13	0.04
Copper*	--	--	--	--
Lead*	--	--	--	--
Zinc*	--	--	--	--
Aluminum*	--	--	--	--

1 - Water samples collected and analyzed by the U.S. Geological Survey reported in U.S. Geological Survey (1974, 1975).

* - Expressed as mg/l.

Appendix Table A-4. Chemical parameters analyzed at invertebrate sampling stations on Eleven Point River and its tributaries, 1974.[1]

Parameter	EP-88			
Date collected	1-11-74	4-19-74	8-16-74	10-24-74
Water temperature (°F)	51.0	58.0	69.5	58.0
Discharge (cfs)	--	33.2	--	--
Dissolved oxygen*	--	10.5	7.2	8.1
Dissolved Carbon Dioxide*	15.4	13.7	91.0	13.0
pH	7.7	7.5	8.0	7.7
Specific Conductance (µmhos/cm)	268	320	340	382
Fecal Coliform (colonies/100ml)	2	4	~ 75	12
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	4.5	2.2	2.1	1.8
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	170	184	187	208
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.75	0.33	0.23
Ammonia Nitrogen as N*	--	0.02	0.02	<0.01
Total Phosphorus as P*	--	0.011	0.015	0.009
Ortho Phosphorus as P*	--	< 0.001	0.010	0.007
Calcium*	--	31	32	38
Magnesium*	--	19	19	22
Sodium*	--	1.2	1.3	1.3
Potassium*	--	1.0	1.2	1.1
Sulfate*	--	1.8	2.8	3.0
Chloride*	--	1.5	1.5	2.0
Iron*	--	0.12	0.16	< 0.05
Manganese*	--	0.02	0.02	< 0.01
Copper*	--	0.02	< 0.01	< 0.01
Lead*	--	<0.025	< 0.025	< 0.025
Zinc*	--	0.05	0.03	0.02
Aluminum*	--	0.10	0.40	< 0.10

Appendix Table A-4. (Continued)

Parameter	EP-86			
Date collected	1-22-74	4-19-74	8-15-74	10-24-75
Water temperature (°F)	50.0	59.0	70.0	58.0
Discharge (cfs)?	330	117	59	
Dissolved oxygen*	10.8	10.6	7.8	8.4
Dissolved Carbon Dioxide*	27.0	11.7	69.0	5.0
pH	7.4	7.6	8.0	7.4
Specific Conductance (µmhos/cm)	260	318	337	374
Fecal Coliform (colonies/100ml)	9	7	~ 100	90
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	4.0	1.4	1.6	2.0
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	143	176	191	215
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	0.60	0.70	0.35	0.21
Ammonia Nitrogen as N*	0.04	0.05	0.05	< 0.01
Total Phosphorus as P*	0.018	0.011	0.013	0.018
Ortho Phosphorus as P*	0.006	< 0.001	0.009	0.007
Calcium*	28	31	32	40
Magnesium*	18	18	19	21
Sodium*	1.0	1.0	1.5	0.3
Potassium*	1.0	1.0	1.2	1.1
Sulfate*	3.4	2.0	3.0	1.5
Chloride*	2.3	1.6	1.6	2.0
Iron*	0.22	0.16	0.10	< 0.05
Manganese*	0.05	0.01	< 0.01	< 0.01
Copper*	< 0.01	0.03	< 0.01	< 0.01
Lead*	< 0.025	< 0.025	< 0.025	< 0.025
Zinc*	0.07	0.05	0.03	0.01
Aluminum*	0.32	0.13	< 0.10	0.10

Appendix Table A-4. (Continued)

Parameter	EPbf-7			
Date collected	1-22-74	4-19-74	8-16-74	10-24-74
Water temperature (^{o}F)	50.0	55.0	81.0	59.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	--	10.6	8.5	10.6
Dissolved Carbon Dioxide*	18.0	12.5	64.0	10.5
pH	7.6	7.7	8.1	7.6
Specific Conductance (µmhos/cm)	270	312	340	332
Fecal Coliform (colonies/100ml)	16	78	--	32
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	2.7	1.1	0.6	1.1
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	143	196	178	205
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.75	0.40	0.35
Ammonia Nitrogen as N*	--	0.04	0.27	< 0.01
Total Phosphorus as P*	--	0.007	0.020	0.004
Ortho Phosphorus as P*	--	< 0.001	0.009	< 0.001
Calcium*	--	37	35	44
Magnesium*	--	17	17	20
Sodium*	--	1.2	1.6	1.7
Potassium*	--	0.9	1.3	1.1
Sulfate*	--	2.2	3.8	2.8
Chloride*	--	2.4	2.4	2.6
Iron*	--	0.06	0.42	< 0.05
Manganese*	--	< 0.01	< 0.01	< 0.01
Copper*	--	0.02	< 0.01	< 0.01
Lead*	--	< 0.025	< 0.025	< 0.025
Zinc*	--	0.12	0.03	< 0.01
Aluminum*	--	< 0.10	0.30	< 0.10

Appendix Table A-4. (Continued)

Parameter	EPmf-0			
Date collected	1-22-74	4-19-74	8-16-74	10-24-74
Water temperature (^{o}F)	49.5	55.5	73.5	60.0
Discharge (cfs)	--	--	14.2	--
Dissolved oxygen*	--	10.6	9.1	10.2
Dissolved Carbon Dioxide*	9.6	10.4	69.0	12.0
pH	7.8	7.5	8.2	7.4
Specific Conductance (µmhos/cm)	228	280	315	338
Fecal Coliform (colonies/100ml)	35	9	15	61
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	3.6	0.9	0.7	1.5
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	120	170	174	185
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.75	0.32	0.17
Ammonia Nitrogen as N*	--	0.03	0.02	< 0.01
Total Phosphorus as P*	--	0.011	0.011	0.003
Ortho Phosphorus as P*	--	< 0.001	0.011	< 0.001
Calcium*	--	30	32	38
Magnesium*	--	17	18	20
Sodium*	--	1.1	1.4	1.4
Potassium*	--	1.1	1.2	1.1
Sulfate*	--	2.0	2.0	6.5
Chloride*	--	1.6	1.6	2.0
Iron*	--	0.05	0.10	< 0.05
Manganese*	--	< 0.01	< 0.01	< 0.01
Copper*	--	0.02	< 0.01	< 0.01
Lead*	--	< 0.025	< 0.025	< 0.025
Zinc*	--	0.06	0.03	< 0.01
Aluminum*	--	0.13	0.30	< 0.10

Appendix Table A-4. (Continued)

Parameter	EPs-0			
Date collected	1-22-74	4-19-74	8-15-74	10-24-74
Water temperature (^{o}F)	55.0	62.0	62.5	60.0
Discharge (cfs)	--	--	50.6	--
Dissolved oxygen*	--	10.7	9.3	10.3
Dissolved Carbon Dioxide*	6.4	9.2	79.0	7.0
pH	7.7	7.6	8.0	7.4
Specific Conductance (μmhos/cm)	280	322	341	355
Fecal Coliform (colonies/100ml)	2	0	12	12
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	3.6	2.4	1.4	3.0
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	162	194	193	205
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.85	0.49	0.46
Ammonia Nitrogen as N*	--	0.03	0.13	<0.01
Total Phosphorus as P*	--	0.009	0.024	0.025
Ortho Phosphorus as P*	--	< 0.001	0.008	< 0.001
Calcium*	--	32	32	37
Magnesium*	--	19	20	22
Sodium*	--	1.0	1.3	1.6
Potassium*	--	0.8	1.0	0.9
Sulfate*	--	0.8	2.8	1.2
Chloride*	--	1.3	1.3	1.8
Iron*	--	0.08	0.10	< 0.05
Manganese*	--	0.01	< 0.01	< 0.01
Copper*	--	< 0.01	< 0.01	< 0.01
Lead*	--	< 0.025	< 0.025	< 0.025
Zinc*	--	0.05	0.03	0.01
Aluminum*	--	< 0.10	0.30	< 0.10

Appendix Table A-4. (Continued)

Parameter	EP-76			
Date collected	1-22-74	4-19-74	8-15-74	10-24-74
Water temperature (^{o}F)	--	63.0	68.0	59.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	--	11.3	8.8	11.2
Dissolved Carbon Dioxide*	--	9.9	58.0	10.5
pH	--	7.6	8.1	7.8
Specific Conductance (μmhos/cm)	--	338	341	376
Fecal Coliform (colonies/100ml)	--	3	29	5
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	--	1.9	1.9	1.1
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	--	182	185	198
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.75	0.47	0.28
Ammonia Nitrogen as N*	--	0.03	0.09	< 0.01
Total Phosphorus as P*	--	0.010	0.016	0.007
Ortho Phosphorus as P*	--	< 0.001	0.010	0.007
Calcium*	--	32	31	40
Magnesium*	--	19	20	22
Sodium*	--	1.2	1.4	1.3
Potassium*	--	0.9	1.1	1.0
Sulfate*	--	2.2	3.0	3.8
Chloride*	--	1.6	1.8	1.8
Iron*	--	0.08	0.10	< 0.05
Manganese*	--	<0.01	0.02	< 0.01
Copper*	--	0.03	< 0.01	< 0.01
Lead*	--	< 0.025	< 0.025	< 0.025
Zinc*	--	0.06	0.04	0.01
Aluminum*	--	< 0.10	0.46	< 0.10

Appendix Table A-4. (Continued)

Parameter	GS-0			
Date collected	2-12-74	4-18-74	8-14-74	10-25-74
Water temperature (^oF)	57.5	57.6	57.0	58.0
Discharge (cfs)	99	121	62	--
Dissolved oxygen*	9.6	11.2	8.7	9.0
Dissolved Carbon Dioxide*	7.3	20.5	141.0	32.5
pH	7.8	7.6	7.6	7.3
Specific Conductance (μmhos/cm)	278	292	344	360
Fecal Coliform (colonies/100ml)	17	0	3	6
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	6.3	3.3	2.5	2.9
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	144	186	182	192
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	1.06	1.00	0.64	0.73
Ammonia Nitrogen as N*	0.05	0.08	0.16	< 0.01
Total Phosphorus as P*	0.021	0.020	0.011	0.018
Ortho Phosphorus as P*	0.019	0.020	0.009	0.013
Calcium*	29	30	32	36
Magnesium*	18	18	20	21
Sodium*	1.1	1.1	1.4	1.4
Potassium*	1.0	1.0	1.1	0.9
Sulfate*	3.6	2.1	3.0	1.0
Chloride*	2.2	1.7	1.5	1.8
Iron*	0.22	0.11	0.10	< 0.05
Manganese*	< 0.01	< 0.01	< 0.01	0.01
Copper*	< 0.01	0.02	< 0.01	< 0.01
Lead*	< 0.025	< 0.025	< 0.025	< 0.025
Zinc*	0.06	0.06	0.03	0.01
Aluminum*	0.20	< 0.10	0.65	< 0.10

Appendix Table A-4. (Continued)

Parameter	EP-73			
Date collected	2-12-74	4-18-74	8-14-74	10-25-74
Water temperature (°F)	51.0	59.0	62.0	60.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	--	11.5	9.7	12.1
Dissolved Carbon Dioxide*	12.5	11.2	70.0	13.5
pH	7.9	7.5	7.9	7.3
Specific Conductance (μmhos/cm)	262	300	350	330
Fecal Coliform (colonies/100ml)	9	2	6	2
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	3.0	1.9	1.7	2.1
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	160	170	183	200
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.78	0.67	0.58
Ammonia Nitrogen as N*	--	0.08	0.05	< 0.01
Total Phosphorus as P*	--	0.012	0.018	0.009
Ortho Phosphorus as P*	--	< 0.001	0.013	0.008
Calcium*	--	31	32	36
Magnesium*	--	18	20	22
Sodium*	--	1.1	1.4	1.3
Potassium*	--	1.0	1.1	1.0
Sulfate*	--	1.1	2.0	2.5
Chloride*	--	1.6	1.5	1.8
Iron*	--	0.10	0.11	< 0.05
Manganese*	--	0.01	0.01	< 0.01
Copper*	--	0.02	< 0.01	< 0.01
Lead*	--	< 0.025	< 0.025	< 0.025
Zinc*	--	0.06	0.04	0.01
Aluminum*	--	0.20	0.30	< 0.10

Appendix Table A-4. (Continued)

Parameter	EPh-1			
Date collected	1-23-74	4-18-74	8-14-74	10-25-74
Water temperature (^{o}F)	51.0	60.0	66.0	63.0
Discharge (cfs)	--	--	10.2	--
Dissolved oxygen*	11.2	10.4	9.1	10.0
Dissolved Carbon Dioxide*	21.8	12.3	85.0	15.5
pH	7.5	7.7	8.0	7.9
Specific Conductance (µmhos/cm)	280	366	370	374
Fecal Coliform (colonies/100ml)	40	14	--	20
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	1.4	1.2	0.7	1.3
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	152	178	210	167
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	0.34	0.27	0.13	0.10
Ammonia Nitrogen as N*	< 0.01	0.07	0.11	0.10
Total Phosphorus as P*	0.007	0.010	0.012	0.017
Ortho Phosphorus as P*	< 0.001	< 0.001	< 0.001	< 0.001
Calcium*	33	35	34	42
Magnesium*	21	21	23	24
Sodium*	0.8	0.9	1.2	1.0
Potassium*	0.6	0.7	0.9	0.9
Sulfate*	3.5	2.6	2.8	2.0
Chloride*	1.5	1.0	1.8	1.5
Iron*	0.14	0.14	0.10	< 0.05
Manganese*	0.02	< 0.01	< 0.01	< 0.01
Copper*	< 0.01	0.01	< 0.01	< 0.01
Lead*	< 0.025	< 0.025	< 0.025	< 0.025
Zinc*	0.05	0.07	0.03	0.01
Aluminum*	0.40	< 0.10	< 0.10	< 0.10

Appendix Table A-4. (Continued)

Parameter	EP-54			
Date collected	2-12-74	4-18-74	8-14-74	10-25-74
Water temperature (°F)	52.0	57.5	64.0	58.0
Discharge (cfs)	1,100	1,220	807	1,060
Dissolved oxygen*	10.6	9.2	9.5	8.3
Dissolved Carbon Dioxide*	5.2	16.3	73.0	17.0
pH	7.7	7.7	8.1	7.6
Specific Conductance (μmhos/cm)	300	320	334	378
Fecal Coliform (colonies/100ml)	7	6	1	36
Streptococci (colonies/100ml)	14	16	54	70
Turbidity (JTU)	3.0	3.4	1.2	1.8
Chemical Oxygen Demand*	8	9	0	6
Alkalinity as $CaCO_3$*	164	170	187	251
Hardness (Ca, Mg)*	170	150	190	170
Nitrate Nitrogen as N*	0.78	0.90	0.54	0.47
Ammonia Nitrogen as N*	<0.01	0.08	0.20	<0.01
Total Phosphorus as P*	0.006	0.011	0.027	0.007
Ortho Phosphorus as P*	0.005	<0.001	0.007	<0.001
Calcium*	30	31	32	38
Magnesium*	19	18	20	22
Sodium*	1.0	1.1	1.5	1.4
Potassium*	0.9	0.9	1.1	1.0
Sulfate*	2.4	4.4	2.8	2.4
Chloride*	2.2	1.5	1.5	2.0
Iron*	0.10	0.70	0.10	<0.05
Manganese*	<0.01	<0.01	<0.01	<0.01
Copper*	<0.01	0.04	<0.01	<0.01
Lead*	<0.025	<0.025	<0.025	<0.025
Zinc*	0.09	0.06	0.03	<0.01
Aluminum*	0.20	0.18	0.56	<0.10

Appendix Table A-4. (Continued)

Parameter	EPf-1			
Date collected	2-12-74	4-18-74	8-14-74	10-25-75
Water temperature (°F)	47.0	58.0	73.0	58.0
Discharge (cfs)	--	--	15.7	--
Dissolved oxygen*	--	11.7	6.6	12.2
Dissolved Carbon Dioxide*	9.2	9.1	43.0	15.5
pH	7.8	7.6	8.2	7.3
Specific Conductance (µmhos/cm)	322	338	335	390
Fecal Coliform (colonies/100ml)	7	6	~ 200	28
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	2.2	2.3	2.2	3.2
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	170	186	180	218
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.65	0.34	0.02
Ammonia Nitrogen as N*	--	0.08	0.05	< 0.01
Total Phosphorus as P*	--	0.019	0.019	0.012
Ortho Phosphorus as P*	--	< 0.001	0.010	0.011
Calcium*	--	33	32	42
Magnesium*	--	19	19	23
Sodium*	--	1.1	1.4	1.5
Potassium*	--	1.0	1.3	1.6
Sulfate*	--	2.8	3.5	4.5
Chloride*	--	2.4	1.4	2.5
Iron*	--	0.18	0.16	< 0.05
Manganese*	--	0.02	0.02	< 0.01
Copper*	--	0.02	< 0.01	< 0.01
Lead*	--	< 0.025	< 0.025	< 0.025
Zinc*	--	0.07	0.03	0.01
Aluminum*	--	0.10	0.40	< 0.10

Appendix Table A-4. (Continued)

Parameter	EP-45			
Date collected	2-12-74	4-18-74	8-14-74	10-25-74
Water temperature (°F)	52.5	58.0	64.0	58.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	--	10.4	6.6	8.3
Dissolved Carbon Dioxide*	9.1	11.5	80.0	17.0
pH	8.0	7.7	7.9	7.6
Specific Conductance (μmhos/cm)	310	310	358	378
Fecal Coliform (colonies/100ml)	3	6	20	6
Streptococci (colonies/100ml)	--	--	--	--
Turbidity (JTU)	3.0	5.6	1.3	1.8
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	178	191	201	251
Hardness (Ca, Mg)*	--	--	--	--
Nitrate Nitrogen as N*	--	0.70	0.48	0.47
Ammonia Nitrogen as N*	--	0.12	0.31	<0.01
Total Phosphorus as P*	--	0.019	0.030	0.006
Ortho Phosphorus as P*	--	0.005	<0.001	0.005
Calcium*	--	33	33	42
Magnesium*	--	19	21	23
Sodium*	--	1.1	1.4	1.4
Potassium*	--	0.9	1.1	1.0
Sulfate*	--	2.8	3.0	1.8
Chloride*	--	1.7	1.5	2.0
Iron*	--	0.10	0.20	<0.05
Manganese*	--	0.02	< 0.01	<0.01
Copper*	--	<0.01	< 0.01	<0.01
Lead*	--	<0.025	<0.025	<0.025
Zinc*	--	0.05	0.02	< 0.01
Aluminum*	--	< 0.10	0.80	< 0.10

1 - Water samples collected and analyzed by the U.S. Forest Service, Region 9 Water Quality Laboratory, Ely, Minnesota.

2 - Discharge for EP-86 from U.S. Geological Survey (1974, 1975).

* - Expressed as mg/l.

Appendix Table A-5. Chemical parameters analyzed at the lower invertebrate sampling stations on Warm Fork of Spring River, 1974.[1]

Parameter	S f-0			
Date collected	1-15-74	5-28-74	7-29-74	11-25-74
Water temperature (^{o}F)	50.0	64.4	70.7	49.1
Discharge (cfs)	131	231	92	46
Dissolved oxygen*	11.2	8.4	7.6	11.2
pH	8.0	8.1	8.0	8.3
Specific Conductance (μmhos/cm)	417	400	435	475
Fecal Coliform (colonies/100ml)	52	160	200	56
Streptococci (colonies/100ml)	44	130	180	88
Turbidity (JTU)	--	--	--	--
Chemical Oxygen Demand*	5	2	4	7
Alkalinity as $CaCO_3$*	225	217	205	213
Hardness (Ca, Mg)*	230	220	230	250
Nitrate Nitrogen as N*	0.53	0.02	0.40	0.51
Ammonia Nitrogen as N*	0.02	0.05	0.05	0.02
Total Phosphorus as P*	0.02	0.03	0.03	0.02
Ortho Phosphorus as P*	0.01	0.03	0.02	0.01
Calcium*	51	47	50	52
Magnesium*	26	25	26	29
Sodium*	2.0	3.7	2.0	2.0
Potassium*	1.3	1.3	1.4	1.4
Sulfate*	3.2	3.5	14.0	3.8
Chloride*	2.7	2.4	3.3	3.2
Iron*	0.05	0.02	0.04	0.0[illegible]
Manganese*	0.02	1.9	0.17	0.01
Copper*	--	--	--	--
Lead*	--	--	--	--
Zinc*	--	--	--	--
Aluminum*	--	--	--	--

1 - Water samples collected and analyzed by the U.S. Geological Survey reported in U.S. Geological Survey (1974, 1975).

* - Expressed as mg/l.

Appendix Table A-6. Summary of water quality parameter values for Current River and its tributaries, 1974.

Station	Density (organisms/ft^2)					Number of taxa					Number of mayfly & stonefly taxa					Margalef's diversity index				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
C-49	90	95	136	71	98	27	33	38	38	57	13	16	13	12	22	3.6	4.5	4.8	5.3	6.5
C-51	18	24	36	111	49	24	24	24	45	56	9	11	12	16	19	4.2	4.0	3.6	5.9	6.9
C-71	12	24	128	69	61	17	26	35	36	48	8	9	15	15	19	3.1	4.3	4.5	5.0	5.7
C-85	80	104	153	109	110	33	37	39	43	63	16	16	13	16	23	4.3	5.0	4.9	5.6	7.0
C-87	19	41	115	79	67	27	36	48	46	69	14	12	18	16	24	4.6	5.5	6.1	6.3	8.1
C-95	39	100	118	88	86	25	32	44	40	59	12	13	14	12	22	3.7	4.3	5.7	5.4	6.8
C-119	23	54	7	56	34	19	29	20	49	58	7	17	9	16	21	3.2	4.3	4.1	7.1	7.5
C-134	35	103	116	77	87	22	31	36	33	49	10	15	12	10	19	3.5	4.2	4.5	4.6	5.6
C-150	22	188	159	209	145	15	21	43	30	48	5	8	12	8	14	2.7	2.7	5.3	3.8	5.2
C-175	166	250	479	618	327	23	27	35	22	44	7	12	8	6	14	3.2	3.4	3.9	2.5	4.5
Ca-1	111	54	162	118	117	35	33	45	25	64	11	13	13	7	21	5.2	5.3	5.8	3.5	7.6
Cba-0	53	137	441	320	272	23	32	39	38	58	9	13	14	13	23	3.8	4.4	4.4	4.7	6.2
Cbi(s)-9	18	27	218	114	113	19	29	40	33	58	8	13	10	7	20	3.8	5.2	5.0	4.7	6.9
Cbi(t)-23	118	35	226	100	110	38	34	42	32	67	10	16	14	10	27	5.6	5.5	5.5	4.6	8.0
Cbl-7	27	75	76	95	72	22	40	37	29	55	10	19	10	7	23	4.1	6.1	5.3	4.2	6.9
Cbu-6	47	45	55	45	46	21	18	34	24	49	6	7	13	7	18	3.5	2.9	5.1	3.9	6.4
Cf-3	26	65	265	71	88	29	25	34	29	57	15	9	12	11	25	4.9	3.8	4.3	4.4	6.8
Cp-1	49	59	140	58	85	31	26	39	35	56	14	10	10	11	20	5.3	4.1	5.1	5.5	6.7

Appendix Table A-6. (Continued)

Station	Density (organisms/ft^2)					Number of taxa					Number of mayfly & stonefly taxa					Margalef's diversity index				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
Cs-0	20	32	92	62	48	16	18	42	31	56	9	8	13	9	20	3.0	3.1	5.9	4.8	7.2
Csv-0	4	116	124	41	70	14	17	46	24	59	5	7	14	6	20	3.9	2.3	6.2	4.0	7.3
BS-0	341	229	322	119	246	14	18	21	19	29	3	2	4	3	6	1.7	2.3	2.6	2.6	3.1
RS-0	217	90	129	102	129	12	17	17	12	27	1	6	1	2	6	1.5	2.4	2.3	1.6	3.2
MS-0	253	479	162	109	250	18	26	28	19	40	3	5	5	2	7	2.3	3.0	3.8	2.7	4.4

Appendix Table A-7. Coefficient of similarity matrix for invertebrate sampling stations on Current River and its tributaries (A) and major springs (B).

(A)	C-175	Ca-1	Cbi(t)-23	C-150	Cba-0	Cs-0	Csv-0	C-134	Cbi(s)-9	C-119	Cbl-7	C-95	Cp-1	C-87	C-85	C-71	Cbu-6	C-51	C-49	Cf-3
C-175	--																			
Ca-1	29	--																		
Cbi(t)-23	26	47	--																	
C-150	38	42	41	--																
Cba-0	50	29	39	42	--															
Cs-0	10	41	42	24	23	--														
Csv-0	24	41	46	46	33	29	--													
C-134	19	49	43	36	29	56	31	--												
Cbi(s)-9	11	47	24	22	16	42	24	31	--											
C-119	8	29	29	24	15	60	27	47	23	--										
Cbl-7	32	52	57	32	31	62	38	49	36	41	--									
C-95	12	41	46	22	21	47	34	54	23	43	46	--								
Cp-1	19	47	48	32	30	47	32	65	29	32	57	40	--							
C-87	12	41	53	23	25	57	36	60	23	44	50	71	49	--						
C-85	15	42	45	28	26	37	37	51	20	33	42	74	38	62	--					
C-71	13	40	39	40	21	40	43	35	29	42	43	42	29	50	40	--				
Cbu-6	15	48	35	31	14	37	26	38	34	35	51	31	45	30	23	29	--			
C-51	13	36	45	27	22	48	43	50	20	47	43	54	48	63	49	44	33	--		
C-49	15	39	47	27	25	45	36	60	18	37	39	77	43	68	75	37	24	56	--	
Cf-3	17	35	42	20	25	39	34	34	17	25	49	44	40	47	41	34	27	45	45	--

Appendix Table A-7. (Continued)

(B)	MS-0	RS-0	BS-0	C-175	Ca-1	Cbi(t)-23	C-150	Cba-0	Cs-0	Csv-0	C-134	Cbi(s)-9	C-119	Cbl-7	C-95	Cp-1	C-87	C-85	C-71	Cbu-6	C-51	C-49	Cf-3
MS-0	--			17	23	14	33	21	8	23	10	48	8	11	10	6	11	15	24	6	11	10	8
RS-0	46	--		9	33	17	21	13	15	21	19	63	14	18	15	12	15	26	30	14	11	15	10
BS-0	30	47	--	24	24	15	19	25	8	26	12	24	7	10	10	7	12	19	17	6	10	13	9

Appendix Table A-8. Summary of water quality parameter values for the Jack's Fork River system, 1974.

Station	Number of organisms/ft^2					Number of taxa				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
JF-2	125	17	71	77	74	33	21	42	38	61
JF-6	155	111	59	97	101	40	39	40	35	63
JF-13	126	37	69	83	82	40	25	37	39	58
JF-19	50	31	54	56	47	29	29	40	32	61
JF-38	41	17	70	55	40	27	21	26	35	53
JFnp-5	72	41	218	97	103	36	27	45	35	65
JFsp-5	95	43	111	166	103	37	40	38	38	66
JFm-1	111	37	83	67	79	34	24	40	28	57
JFs-1	62	65	177	240	136	16	36	36	29	49
AS-0	218	117	95	76	120	13	16	19	15	29

Appendix Table A-8. (Continued)

	Number of mayfly & stonefly taxa					Margalef's diversity index				
Station	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
JF-2	12	7	14	10	21	4.2	3.6	5.9	5.3	7.2
JF-6	12	17	15	13	26	5.5	5.3	5.9	4.8	7.4
JF-13	16	13	13	15	24	5.1	3.9	5.4	5.5	6.8
JF-19	12	10	14	9	23	4.7	4.7	6.0	4.9	7.9
JF-38	10	10	10	10	20	4.5	3.9	4.0	5.4	7.0
JFnp-5	19	13	13	14	26	5.2	4.5	5.9	5.1	7.8
JFsp-5	14	15	11	11	23	5.7	6.4	5.5	5.2	8.0
JFm-1	10	9	14	8	21	4.6	4.0	6.0	4.3	7.1
JFs-1	6	14	10	6	19	2.5	5.4	4.8	3.7	5.7
AS-0	2	7	7	2	10	1.7	2.2	2.7	2.2	3.4

Appendix Table A-9. Coefficient of similarity matrix for invertebrate sampling stations on Jack's Fork River, including Alley Spring, (A), Eleven Point River, including Greer Springs, (B), and Little Black River (C).

(A)	JFnp-5	--									
	JFsp-5	53	--								
	JF-38	38	48	--							
	JF-19	36	44	69	--						
	AS-0	5	10	8	11	--					
	JF-13	35	49	44	49	12	--				
	JFm-1	29	47	41	40	17	50	--			
	JF-6	29	42	41	39	37	48	60	--		
	JFs-1	43	63	38	35	9	49	58	53	--	
	JF-2	28	38	35	39	16	58	65	51	46	--
		JFnp-5	JFsp-5	JF-38	JF-19	AS-0	JF-13	JFm-1	JF-6	Jfs-1	JF-2

(B)	EP-88	--											
	EPmf-0	52	--										
	EPbf-2	60	69	--									
	EP-86	48	66	56	--								
	EPs-0	52	50	54	50	--							
	EP-76	55	63	62	60	70	--						
	GS-0	49	31	40	28	45	39	--					
	EP-73	41	42	43	27	44	53	25	--				
	EPh-1	34	41	40	26	32	43	24	49	--			
	EP-54	41	46	40	30	44	57	27	55	50	--		
	EPf-1	45	69	59	46	42	61	29	50	45	46	--	
	EP-45	27	23	28	27	43	36	25	43	31	50	25	--
		EP-88	EPmf-O	EPbf-2	EP-86	EPs-O	EP-76	GS-O	EP-73	EPh-1	EP-54	EPf-1	EP-45

Appendix Table A-9. (Continued)

(C)	LB-35	--			
	LB-26	68	--		
	LB-11	27	36	--	
	LB-4	22	28	68	--
		LB-35	LB-26	LB-11	LB-4

Appendix Table A-10. Summary of water quality parameter values for the Little Black River system, 1974.

Station	Number of organisms/ft^2					Number of taxa				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
LB-4	130	68	186	88	118	39	34	52	43	71
LB-11	*	89	75	201	88	*	41	41	26	57
LB-26	92	39	76	78	74	39	32	30	38	57
LB-35	118	23	54	64	61	41	24	26	28	56

Station	Number of mayfly & stonefly taxa					Margalef's diversity index				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
LB-4	9	6	11	9	16	4.9	4.6	6.3	5.7	7.7
LB-11	*	13	10	5	13	*	5.6	5.6	4.2	7.0
LB-26	9	6	6	11	16	5.4	5.4	4.5	5.8	7.1
LB-35	8	7	7	8	15	6.1	4.4	4.1	4.3	7.3

* - samples missing

Appendix Table A-11. Summary of water quality parameter values for the Eleven Point River System, 1974.

	Number of organisms/ft^2					Number of taxa				
Station	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
EP-45	189	162	102	114	139	39	37	36	38	54
EP-54	400	139	211	238	259	44	33	38	38	56
EP-73	281	328	330	307	313	39	39	33	31	55
EP-76	118	119	130	180	139	41	36	30	35	60
EP-86	71	26	87	174	93	39	26	28	43	61
EP-88	134	122	113	75	110	36	37	27	28	55
EPbf-2	28	162	127	112	118	22	50	32	33	59
EPmf-0	142	124	141	240	158	32	45	36	35	63
EPf-1	144	352	187	202	213	52	51	36	48	77
EPh-1	224	400	95	234	258	36	41	33	30	53
EPs-0	116	143	75	75	102	23	38	26	27	46
GS-0	105	114	35	47	73	20	23	19	22	34

Appendix Table A-11. (Continued)

Station	Number of mayfly & stonefly taxa					Margalef's diversity index				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
EP-45	12	13	11	13	19	4.8	4.8	4.7	4.9	5.9
EP-54	14	12	12	12	20	4.8	4.3	4.6	4.5	5.7
EP-73	13	14	10	8	19	4.8	4.6	3.9	3.7	5.6
EP-76	13	14	10	10	21	5.8	4.8	4.2	4.4	6.8
EP-86	14	12	11	16	25	5.8	4.7	4.2	5.6	7.4
EP-88	11	13	8	8	20	5.2	5.2	3.8	4.2	6.8
EPbf-2	11	20	9	10	24	4.1	6.5	4.5	4.7	7.0
EPmf-0	12	21	13	12	24	4.6	6.0	5.0	4.5	7.2
EPf-1	22	23	14	17	30	6.8	6.3	4.8	6.4	8.5
EPh-1	11	13	9	6	19	4.5	5.1	4.7	3.9	5.8
EPs-0	6	14	8	10	14	3.4	5.3	3.9	4.1	5.6
GS-0	7	8	7	7	14	3.0	3.2	3.2	3.5	4.3

Summary of water quality parameter values for the Warm Fork of Spring River system, 1974.

Station	Number of organisms/ft^2					Number of taxa				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
Swf-0	58	159	109	99	106	32	35	37	26	54
Swf-4	36	184	98	112	121	24	37	26	30	51

Station	Number of mayfly & stonefly taxa					Margalef's diversity index				
	Wi	Sp	Su	Fa	Annual	Wi	Sp	Su	Fa	Annual
Swf-0	11	14	13	10	23	5.1	4.8	5.0	3.8	6.4
Swf-4	11	17	11	10	22	4.3	4.7	3.8	4.3	6.0