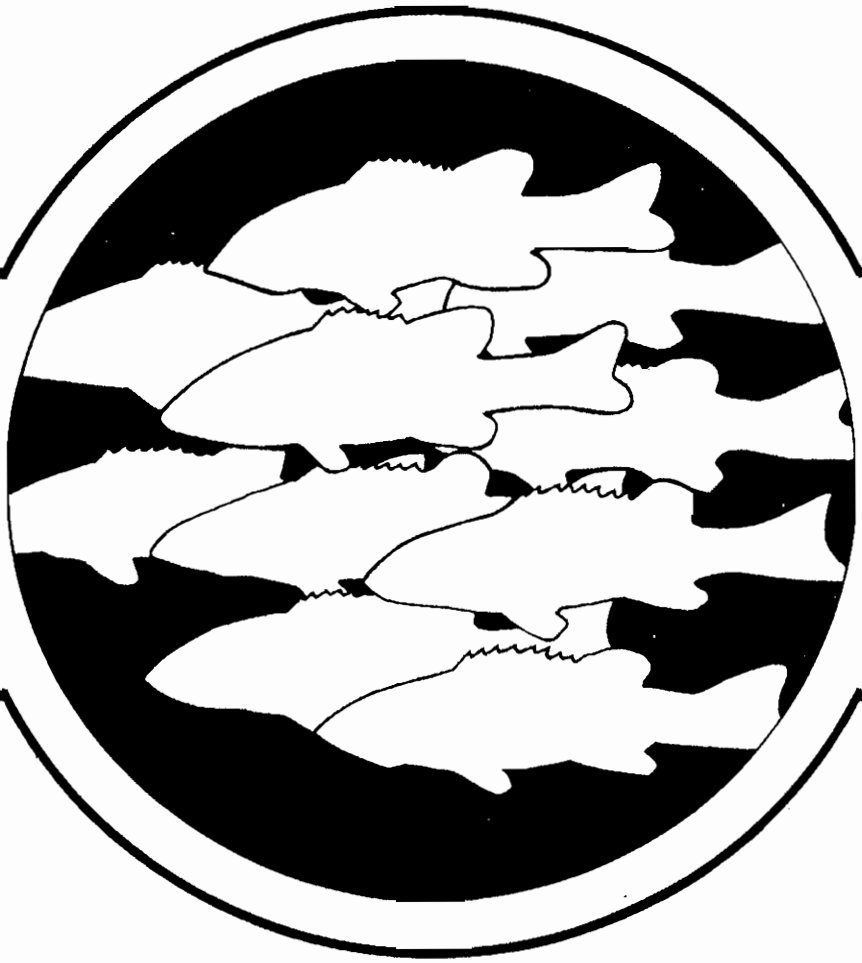

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Muskellunge Streams Investigation in the Middle Fork and North Fork Kentucky River Drainages and Upper Licking River

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ABSTRACT

Electrofishing studies were conducted on the upper Licking River, Middle Fork Kentucky River, North Fork Kentucky River, and Troublesome Creek in order to evaluate existing and potential muskellunge habitat. All stations were sampled in 1982 and 1983, with the exceptionof those on Troublesome Creek, which were sampled in 1984. Eight pools were electrofished on the upper Licking River from the headwater to Cave Run Lake. Area sampled totaled 5.44 stream miles. Two muskellunge were captured in 1982, and 0.4 fish/hour and 0.4 fish/mile in 1983. Dominant species by number wer gizzard shad, white sucker, golden redhorse, and carp. A total of 32 fish species were collected in 1982 and 30 species in 1983. The main limiting factor to good muskellunge habitat in this river above Cave Run Lake was found to be siltation. Twelve pools were electrofsihed in the Middle Fork Kentucky River from the headwater area to the mouth excluding Buckhorn Lake. In 1982, 13.62 stream miles were electrofished; in 1983, 12.72 stream miles were electrofished. Four muskellunge were collected in 1982; 11 muskellunge were captured in 1983. The catch rate in 1982 was 0.2 fish/hour and 0.3 fish/mile; the catch rate in 1983 was 0.6 fish/hour and 1.6 fish/mile. A total of 38 fish species were collected in 1982 and 1983. The limiting factor to good muskellunge habiatat in this stream was siltation above Buckhorn Lake and the presence of Buckhorn Lake, which prevents muskellunge from spawning in the headwaters. Enough muskellunge are escaping below the lake from fish stocked above the dam to provide good numbers of fish for angling downstream. Ten pools were sampled on the North Fork Kentucky River in 1982 and nine pools were sampled in 1983. A total of 17.65 stream miles were sampled during a total of 20.98 hours of electrofishing in 1982; 9.55 miles were sampled during 7.30 hours of electrofishing in 1983. No muskellunge were collected or seen. A total of 32 fish species were collected in 1982, with 39 species collected in 1983. Siltation was determined to be the main limiting factor to good muskellunge habitat as with the other study streams. Troublesome Creek, tributary to North Fork Kentucky River, was electrofsihed in 1984 and contained eight sampling stations. No muskellunge were found. A total of 3.3 stream miles were electrofished during a total of 4.5 hours. Siltation was the main limiting factor to good fish habitat. Water quality determinations indicated no major problems other than periodic high turbidity levels. Benthic macroinvertebrate populations appeared to be most influenced by seasonal variations. Population indices for benthic macroinvertebrates in all four study streams ranged from levels indicating degradation to levels indicating unimpacted conditions. Dominant benthic macroinvertebrates were Corbicula fluminea and Cheumatopsyche sp. Recommendations were made for stocking advanced fingerling muskellunge in the North Fork Kentucky River once sedimentation in the stream has been sufficiently reduced as a result of better control of watershed disturbances that cause severe sedimentation. Muskellunge should then be stocked at the rate of one 7-9 inch fish per 2 miles of pool habiatat from Hazard to Beattyville for 4 years and alternating years thereafter to re-establish the species.

INTRODUCTION

Muskellunge Esox masquinongy are found in a number of streams throughout eastern Kentucky. Remaining native populations are primarily found in the northeastern and southeastern part of the state where their stream habitat has not been heavily altered by mining, petroleum, or logging industries. Muskellunge are found, or were historically found, in all the major drainages in eastern Kentucky. This study deals with work done in the eastern region of the state where major streams such as the Big Sandy system, the Middle Fork and North Fork Kentucky River, and the upper Licking River (above Cave Run Lake) are located. Until recent years, what could be considered native populations of muskellunge were present in the upper Licking River and the Middle Fork Kentucky River. Native fish may still be present in these streams. According to local residents knowledgeable of the North Fork Kentucky River, this river once supported a native population. This population has probably been extirpated for several decades, however. This study deals with these three rivers as well as a major tributary, Troublesome Creek, of the North Fork Kentucky River. This stream was probably a spawning site for muskellunge inhabiting the North Fork.

Native muskellunge populations in eastern Kentucky have been exposed to adverse conditions such as heavy siltation of spawning and feeding areas since the middle of the nineteenth century. This area could be considered the heart of the eastern coal field where exploitation of natural resources has been occurring for the longest period of time. The study of these former native muskellunge streams was conducted in conjunction with studies on existing native muskellunge streams in order to compare fish populations, water quality, habitat, and macroinvertebrate populations. Similar studies previously conducted were done in northeast Kentucky by Kornman (1983) and in southeast Kentucky by Jones (1984). Kornman researched some additional streams in the northeast region which is in press at the time of this writing. The initial study of muskellunge in Kentucky was done by Brewer (1980) on 11 streams in northeast and southeast Kentucky. Neither the Middle Fork or North Fork Kentucky River were included in these studies, as their muskellunge populations were considered non-existant or in very low numbers. Brewer did, however, sample the upper Licking River near Salyersville in Magoffin County. His studies were designed to determine the size and structure of muskellunge populations, the minimum size of musky at maturity, spawning information, survival of young, growth rate, and any physical, chemical, or biological factors which would limit muskellunge populations in streams. Much knowledge was gained concerning native muskellunge populations during these initial studies. Valuable data concerning muskellunge populations were obtained, some of which was information on habitat, forage, spawning requirements, and stocking rates. Prior to studies done by Brewer, only records from general stream inventory studies were available. Such studies were done by Clark (1941), Clay (1962), Turner (1967), and Jones (1970 and 1973).

Brewer was concerned about the impact of flood control projects upon muskellunge streams. Both the Middle Fork Kentucky River and the Licking River have major impoundments on their main stem-

Buckhorn Lake on the former river and Cave Run Lake on the latter. There are a total of about 700 miles of muskellunge streams in Kentucky. Due to increasing encroachment on quality stream conditions as well as other factors, Brewer recommended supplementally stocking one larger muskellunge fingerling (6-8 inches) per two acres of pool habitat. A list of muskellunge stocked in the study streams is presented in Table 1.

Stream studies were initiated in 1982 as part of D-J Project F-50 in order to study previous, existing, or potential muskellunge habitat. Eleven goals were developed for this study: (1) to be a pilot study for developing future stream studies, classification, and management plans per drainage, sub-drainage, or stream, (2) identify species associations and other descriptions in musky streams to determine habitat preference of muskellunge, (3) determine extent of muskellunge distribution in each stream and other streams not known to have any or a few muskellunge, (4) learn about black bass composition in these streams and their habitat requirements in association with muskellunge, (5) identify characteristics of muskellunge streams required to protect the streams as habitat for muskellunge and other fish associated with the muskellunge, (6) determine stream requirements for muskellunge and other species such as spotted bass in order to duplicate stream conditions where migitation from stream alteration is planned, (7) document stream alteration and other habitat loss or change, (8) determine productivity from bottom fauna data, water quality, and the fish population structure in order to detect any past or future impacts on the stream and provide a basis for measuring stream quality, (9) refine a supplemental stocking program for muskellunge in streams, (10) describe public access sites and additional access needs, and (11) recognize future research needs.

STUDY AREA

The four streams involved in this study lie in the eastern Kentucky coal fields (Fig. 1). The Licking River above Cave Run Lake is entirely contained in Magoffin County and is the only drainage in that county. The stream begins in the southeast corner of the county and flows northwesterly to Morgan County and the headwater of Cave Run Lake. This portion of the watershed is heavily forested and hilly. The steep terrain promotes erosion and stream siltation from land usages such as both deep and strip mining, oil and gas acquisition, silviculture, and agriculture. During the course of these studies, precipitation quickly caused heavy stream turbidities, after which there was a slow clearing of the water. The Licking River is a moderate-gradient stream with relatively good pool and riffle development. The pools are long and shallow, becoming narrow and deep in the lower reaches of most pools. The riffle substrate is composed of mostly rubble and gravel, while the pool substrate is primarily gravel and finer material (sand and clay). The bedrock consists of sandstone, siltstone, coal, and minor limestone from the Breathitt Formation. The coarse fraction consists chiefly of sandstone with lesser amounts of shale, siltstone, and coal pebbles (Kentucky Nature Preserves Commission 1979). The mean gradient of the section studied above Cave Run Lake is 2.6 ft/mi. Major tributaries are Elk Fork, Burning Fork, and Middle Fork.

The Middle Fork Kentucky River begins with the headwaters in Leslie County, flowing north-northwest through portions of Perry County and Breathitt County, and through Lee County where it joins the North Fork Kentucky River just upstream and east of Beattyville. One major impoundment, Buckhorn Lake, is located on the Middle Fork and is operated as a flood control reservoir by the U.S. Army Corps of Engineers. The reservoir is characterized by short water retention time and a winter-summer pool fluctuation level of about 25 feet. About 25 miles of stream habitat was lost to muskellunge when this lake was impounded in 1961. A small water-supply dam is also located on the main stem at Hyden. Though this is a low-level dam, it is an effective fish barrier. This drainage is mountainous with high, sharp-crested ridges, narrow valleys, and few level, upland areas. The combined drainage basin of the Kentucky River in eastern Kentucky comprises about 28% of the Appalachian Province. The Middle Fork has a drainage area of about 543 square miles and a total length of about 45 miles. It has a mean gradient of 2.5 ft/mi. Land usages include mining, silviculture, gas and oil well operations and agriculture. Major tributaries are Greasy Creek and Cutshin Creek (Kentucky Nature Preserves Commission 1979).

The North Fork Kentucky River originates in Letcher County and flows northwest through Perry and Breathitt counties into Lee County where it meets the Middle Fork and South Fork at Beattyville. The North Fork is the longest of the three forks with a length of about 153 mi and a drainage area of about 1,300 square mi. The mean gradient of the area studied is 2.9 ft/mi. The headwater region is mountainous, with steep ridges and narrow valleys. Topography in the lower region of the stream is characterized by undulating hills with

slightly wider valleys. Hillsides are heavily forested. Land usage is composed of mining, silviculture, oil and gas acquisition, and agriculture. Major tributaries are Frozen Creek, Troublesome Creek, Quicksand Creek, Carr Fork, Rockhouse Creek, and Line Fork. Carr Fork contains the only major impoundment in the North Fork drainage. This is a 710-acre flood control reservoir operated by the U.S. Army Corps of Engineers. The lake has a pool fluctuation level of about 10 feet. A low level dam is located on the main stem of North Fork in Hazard and was constructed to create a recreational pool adjacent to the city. Though it is a low-level dam, it is an effective fish barrier. There are no major impoundments on the main stem.

Troublesome Creek is the largest eastern tributary to North Fork Kentucky River. It originates in eastern Knott County and flows northwest for more than 104 miles to join the North Fork. Data collected by the Kentucky Nature Preserves Commission in 1978 indicated the stream bottom contained high amounts of rubble and gravel in the pools and riffles. They also reported that the pools were generally underlain by deep deposits (up to 1.5 ft) of sand, silt, and clay. They describe Troublesome Creek as underlain by the Breathitt Formation of the Pennsylvanian age. The stream has a mean gradient of 5.1 ft/mi. Major tributaries are Lost Creek, Buckhorn Creek, and Balls Fork. Land usages in the drainage are typical of the Kentucky River headwater drainage in that coal mining, gas and oil exploitation, silviculture, and agriculture are the primary enterprises.

METHODS

Location of pools for electrofishing in each study stream was determined by accessability to pool areas. If a pool could be reached with a four-wheel-drive vehicle, studies were conducted. Most fish sampling sites were accessible by old fording sites or riffle areas (Tables 2-5). The fish populations were sampled for 2 consecutive years (1982 and 1983) in the Licking River, Middle Fork Kentucky River, and North Fork Kentucky River. Troublesome Creek was sampled for 1 year (1984). Boat-mounted electrofishing gear were used to sample fish populations. Gear consisted of a 16-foot aluminum jon-boat rigged with bow-mounted booms and three electrodes. The electrodes were extended about 8 feet in front of the boat. Power was obtained from a gasoline-operated 5,000 watt Homelite generator and controlled by a Chenault booster control box. Current (AC) was maintained at about 8 amps and 275 volts.

The total fish population structure was obtained by electrofishing the upper and lower ends of each study pool for 30 minutes. These samples involved the entire shoreline of the pool when the length of the pool could be covered in 30 minutes or less. If the pool was larger than this, electrofishing was conducted for only muskellunge until the end of the pool was reached. Repeated circuits of the pool were conducted if a muskellunge was seen or captured during the first round. Fish collected during the general fish sample were identified and measured. Fish that could not be identified in the field were preserved in formalin for identification in the laboratory. Captured muskellunge were measured to the nearest 0.1 in and weighed to

the nearest 0.01 lb. Muskellunge under 30 in long were marked by clipping one of the pelvic fins to enable determinations of possible recapture. Muskellunge equal to or more than 30 in were tagged with a monel self-piercing jaw tag on the anterior basal edge of the dorsal fin. These tags were numbered and identified as belonging to the Kentucky Department of Fish and Wildlife Resources. Scale samples were taken from each muskellunge to facilitate age and growth determination. Self-addressed postage-paid scale envelopes were made available to fishermen by conservation officers and at general stores and tackle shops in the study area. Upon catching a legal-size muskellunge, fishermen were asked to fill out the questionnaire on the envelopes, remove five scales from a designated location on the fish, and place them in the envelope. If the fish was tagged, anglers were asked to provide the number. Successful fishermen were sent a certificate and/or a clutch-back pin upon receipt of the envelope.

Age and growth determinations were made by placing moistened scales from fish between two glass slides. The slides were placed on a Bausch and Lomb Microprojector to be enlarged and projected. Back-calculations of growth were determined by utilizing a modification of the Lee Method (Lagler 1956, Everhart and Youngs 1981), whereby, a correction factor of 4.5, as determined by Brewer, was used. This correction factor was substituted into the formula $L' = C + \frac{s'}{s}(L-C)$ where:

L' = length of fish at annulus
C = correction factor (4.5)
s' = length of scale radius at annulus
s = length of total scale radius
L = total length of fish at capture

Length-weight relationships were not calculated for muskellunge due to the low number of fish captured.

Fish identified in the laboratory were measured and recorded. Identifications were made with the use of the following fish keys: Clay (1975), Pfleiger (1975), Eddy (1974), and Trautman (1981). Preserved specimens were placed in the fish collections of the Eastern Fishery District Office at Prestonsburg, Kentucky; Fisheries Division Museum at Frankfort, Kentucky; or Southern Illinois University at Carbondale, Illinois.

Measurement of the study pools was done directly in the field when possible or by topographical maps and a cartometer in the laboratory. Pool length, when measured in the field, was measured by vehicle odometer. Average width was ascertained with a 100-ft plastic tape measure. Depths were recorded at 5-ft intervals along the same line that widths were taken in order to obtain mean depth values. Depth was measured with a calibrated pole or a Tom Mann Bird Trap depth finder. Sediment depth on the stream bottom was measured and recorded. General physical characteristics were recorded on stream survey forms for each pool sampled. Such characteristics were amount of fish shelter and type, amount of shade over stream and width of stream-side

vegetation, bottom type in riffles and pools, riffle-pool ratio, pollution, and land usage. Gradient was measured by reading elevation and measuring stream length on topography maps.

Water quality and benthic macroinvertebrates were taken once during the spring, summer, and fall from a lower, middle, and upper stream site, except at Troublesome Creek where benthic sampling was conducted only at an upper and lower section. Benthic sampling was done at the Licking River, Middle Fork Kentucky River, and North Fork Kentucky River in 1982 and 1983. Sampling was conducted at Troublesome Creek in 1984. Water quality and benthic macroinvertebrate sampling were conducted at the following sites on the Upper Licking River: lower - at ford off Highways 460 and 7 just below mile marker 22 in Morgan County; middle - at ford one-eighth of a mile above the mouth of Oakley Creek, 0.25 mi off Highway 7 at Sublett in Magoffin County; upper - 0.9 mi below Gunlock, Kentucky Post Office off Highway 7 in Magoffin County. Water quality and benthic macroinvertebrate sampling were done at the following sites on the Middle Fork Kentucky River: lower - at Highway 708 bridge just off Highway 52 in Lee County; middle - at Highway 28 bridge over Buckhorn Lake tailwater in Breathitt County; upper - at low-water bridge at junction of county roads 1780 and 1850 at Warbranch, Kentucky in Leslie County. Water quality and benthic macroinvertebrate sampling were done at the following sites on the North Fork Kentucky River: lower - at Mt. Carmel road low-water bridge in Breathitt County; middle - at Hazard, Kentucky at junction of Highways 1440, 476, and 1088 in Perry County; upper - off Highway 119 about 1 mi upstream from Whitesburg in Letcher County. Water quality and benthic macroinvertebrates were sampled at the following sites on Troublesome Creek: lower - at ford between Clayhole, Kentucky and Flintville, Kentucky off Highway 476 in Breathitt County; upper - at the mouth of Ogden Branch just below Hindman, Kentucky in Knott County. Water quality determinations consisted of surface temperature, dissolved oxygen, pH, total alkalinity, salinity, specific conductivity, and turbidity. Temperature and dissolved oxygen were taken with a Yellow Springs Instruments Model 54 oxygen meter; temperature was also taken with a hand-held mercury thermometer. Hydrogen ion concentration (pH) was measured with a Hach Colorimeter and a Leeds and Northrup pH meter. Total alkalinity was measured with a Hach field kit. Salinity and conductivity were measured with a Yellow Springs Instrument Model SCT-33 meter. Turbidity was measured with a HF Instrument's turbidity meter.

Benthic macroinvertebrates were collected by using a hand-held D-frame net. Mesh size of the net was 34 mesh per in. Two square meter samples were taken in riffle areas at each site once during the spring, summer, and fall. Samples were taken by dislodging the substrate and allowing the detritus to flow into the net. The filtrate from the two square meters was then placed in glass containers, preserved in 60% ethanol, and labeled. In the laboratory, samples were picked for organisms that were prepared for identification. Organisms were then identified by an experienced benthic macroinvertebrate specialist, Mr. Cliff Schneider, Principle Biologist with the Division of Water, Kentucky Department of Natural Resources, Frankfort, Kentucky. Specimens were identified to species, if possible, using the following keys and references: Pennak (1953); Oliver, McClymont, and

Roussel (1978); Merritt and Cummins (1978); Needham and Westfall (1954); Usinger (1956); Simpson and Bode (1980); Bringham, Brigham, and Gnilka (1982); Bednarik and McCafferty (1979); and five USEPA contract publications: 18050 ELDO5/72, USEPA - 600/3-82-026, USEPA 600/4-78-060, Biota of Freshwater Ecosystems Identification Manual No. 6, and EPA 670/4-74-006. Two formulas were utilized to analyze the quality of the benthic macroinvertebrate community in each stream at each collection site. First, the diversity index ($\bar{d}$) was calculated using the formula as illustrated by Lloyd, Zar, and Karr (1968). This formula is presented as follows:

$$\bar{d} = \frac{C}{N} (N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where C is a constant (3.321928), N is the total number of individuals, and Ni is the total number of individuals in the ith species. From the diversity index, the equitability value (e) was calculated. The formula was devised by Lloyd and Ghelardi (1964) and is expressed by the following equation: $e = \frac{s'}{s}$.

Creel surveys of anglers fishing the streams was attempted by utilizing a self-addressed postage-paid questionnaire. These forms were handed out to anglers while fishing who were to fill out the form at the conclusion of the fishing trip. Questions asked were: stream fished, date, starting and ending time, number of anglers, species sought, method, species caught and released and their size. A space was also provided for comments.

RESULTS

Fish Population Surveys

Upper Licking River

Eight pools representing 5.4 mi of stream were electrofished in both 1982 and 1983. Diurnal electrofishing of pool shoreline in 1982 resulted in the capture of two muskellunge on May 18. Both fish were approximately the same size and were collected from the same pool (Tables 6, 8, and 10). One other muskellunge of about the same size was seen but not captured. These fish measured 21.2 and 21.8 in and weighed 2.18 lb and 2.63 lb, respectively. A total of 3.3 hours was spent electrofishing the Upper Licking River study pools in 1982. Muskellunge captured in 1982 were located in Pool 7. Fish shelter was considered abundant in this pool, with the substrate being composed of bedrock, large rubble (6-12 in), silt, and muck. This section of stream was described as having a 40-60 pool-riffle ratio, with water willows Justica sp. being the common aquatic vegetation. No other muskellunge were seen or boated in 1982 (Table 11).

Electrofishing studies on the same pools in 1983 were conducted for a total of 3.8 hours. One muskellunge was captured in pool 1 after a total of 1.5 hours diurnal electrofishing on November 21 (Tables 7, 9, and 10). This fish was 30.2 in long,weighed 8.04 lb, and

was tagged. This fish was found in shallow, swift water in close proximity with numerous redhorse. This area of the pool was also considered the boundary between Cave Run Lake and the riverine habitat of Licking River. Fish shelter was considered to be medium in availability, consisting of boulders, ledges, logs, and brush. Bottom composition in the pool area was silt and muck, which was measured to be 1.5 to 2.0 ft in depth. The riffle areas were also silt and much. The pool-riffle ratio in this section was 95-5. Aquatic macrophytes were not present at the time of sampling (Table 11).

Age and growth determinations were conducted on the three muskellunge collected from the upper licking River during the 2-year study (Tables 12 and 13). The two fish collected in 1982 in the 22 inch-group were both aged at 2 years old. These 1980 year-class fish had a mean length of 12.1 in at the end of their first year and 18.6 in at the end of their second year. The fish captured in 1983 was age 4, reaching harvestable size (30 in) between its fourth and fifth year. This 1979 year class fish was 10.9, 13.8, 20.9, and 25.9 in long at the end of each year of growth. Mean growth rates of these three muskellunge collected was 11.5 at age 1, 16.2 at age 2, 20.9 at age 3, and 25.9 at age 4 (Table 15).

A total of 38 species of fish were collected from the upper Licking River by electrofishing. Of the species collected, one was listed by the Endangered Species Committee of the Kentucky Academy of Science and the Kentucky Nature Preserves Commission to be considered for classification. This was the Ohio muskellunge, which was given "special concern" status. This description indicates a species should be continually monitored because (a) it exists in a limited geographic area, (b) it may become threatened or endangered due to modification or destruction of habitat, (c) certain characteristics or requirements make it especially vulnerable to specific pressures, or (d) experienced researchers have identified other factors (Branson et al. 1981). The streamline chubs that were collected represented a new drainage record for the species. The identification was confirmed by Melvin Warren and Brooks M. Burr, Southern Illinois University, Carbondale, Illinois (SIUC). A specimen was retained for the SIUC fish collection and was given catalogue number SIUC-12317. Specimens of American brook lamprey collected were also sent to SIUC for confirmation and retainment. An adult and three ammocoetes were given the following catalogue numbers: SIUC-12315, SIUC-12316, and SIUC-12314. Species collected from all eight pools were carp and golden redhorse. Species collected from all but one pool were gizzard shad, northern hog sucker, bluegill, and spotted bass. The three most numerous species in 1982 were gizzard shad, carp, and golden redhorse. In 1983, the most numerous species were gizzard shad, white sucker, and golden redhorse. A total of 32 species were collected in 1982; 30 species were collected in 1983 (Tables 17 and 18).

Middle Fork Kentucky River

Twelve pools, representing 13.62 stream mi, were sampled in 1982 from Dryhill to Beattyville; the Buckhorn Lake area was omitted. The 12 pools were electrofished in 1983 for a total of 12.72 stream mi sampled. Four muskellunge were captured and six more were seen in 1983

(Tables 6-10). In 1982, muskellunge captured ranged from 16.8 to 25.1 in long and weighed 0.79 to 3.20 lb. Mean length was 20.6 in and mean weight was 1.84 lb. No muskellunge were 30 in or larger; therefore, none were tagged in 1982. Total time spent electrofishing was 25.0 hours, resulting in a catch rate of 0.2 fish/hour and 0.3 fish/mi. In 1983, 11 muskellunge were captured that ranged from 15.6 to 33.7 in long. Mean length of these fish was 26.1 in and mean weight was 4.81 lb. Two fish were 30 in or larger and were tagged. Muskellunge collected in 1982 came from pools 7, 8, and 11. Fish captured in 1983 came from pools 7 and 8, only (Table 11). Catch rates of muskellunge in 1982 were 0.2 fish/hour and 0.3 fish/mi. In 1983, catch rates were 0.6 fish/hour and 0.8 fish/mi. Muskellunge collected in 1982 were found to represent two year classes. Two were from the 1979 year class and two were from the 1980 year class. Muskellunge collected in 1983 represented four year classes (1979-1982). Five fish were from the 1979 year class, four were from the 1980 year class, one from the 1981 year class, and one from the 1982 year class. Mean length of all muskellunge was 12.7 in at age 1, 17.0 in at age 2, 22.2 in at age 3, and 27.5 in at age 4 (Tables 12 and 13). Information on three fish harvested by anglers was received by means of the mail-in survey. Only two of the returned envelopes contained scale samples. Scale samples from the two muskellunge indicated the fish to be from the 1976 and 1977 year classes. Mean growth of these fish was found to be 11.2 in at age 1, 15.6 in at age 2, 21.0 in at age 3, 25.7 in at age 4, 29.8 in at age 5, 33.7 in at age 6, and 37.5 in at age 7 (Table 14). Mean growth rates for muskellunge from electrofishing studies and the mail-in survey are presented in Table 15.

A total of 45 species were collected from the Middle Fork during both years (Table 16). Species present in all stations were northern hog sucker, golden redhorse, longear sunfish, and spotted bass. The three most numerous species in 1982 were golden redhorse, gizzard shad, and longear sunfish (Table 19). The three most numerous species in 1983 were golden redhorse, gizzard shad, and freshwater drum (Table 20). Three species collected in the Middle Fork Kentucky River were listed by the Endangered Species Committee (Branson et al. 1981). As mentioned earlier, Ohio muskellunge were given "special concern" status. Also found and listed under "special concern" was American brook lamprey. One other species found is listed, this being the popeye shiner that has been given "undetermined" status. This status is defined to mean a species that has been suggested as threatened, endangered, or extirpated, but insufficient information exists for assignment to Special Concern, Threatened, or Endangered status categories. A total of 1,511 fish representing 38 species were collected in 1982. A total of 918 fish and 38 species were collected in 1983.

North Fork Kentucky River

A total of 10 study pools were located on the North Fork. Ten pools were sampled in 1982 and 9 were sampled in 1983. Pool 1 was not sampled in 1983. This pool was the lower-most station, being located from the mouth of the river upstream to the first riffle. Total time spent sampling the North Fork Kentucky River during both years was 28.3 hours. During this time, no muskellunge were captured

years was 28.3 hours. During this time, no muskellunge were captured or seen. Also, no reports of muskellunge being caught by anglers were received. A total of 789 fish representing 32 species were collected in 1982, while 988 fish representing 39 species were collected in 1983. Though not recorded, an additional species was collected. This fish was the black redhorse Moxostoma duquesnei, found in the cleaner pools of the North Fork and misidentified as golden redhorse. A total of 45 species were collected over the two year period. Species present in all study pools were golden redhorse, longear sunfish, and spotted bass (Table 16). Species present in all but one pool were carp, northern hog sucker, river redhorse, shorthead redhorse, and channel catfish. The three most numerous species in 1982 were golden redhorse, spotted bass, and channel catfish (Table 21). The three most numerous species in 1983 were spotted bass, golden redhorse, and sand shiner. Two species of darters collected were listed by the Kentucky Endangered Species Committee. These were channel darter and gilt darter, both of which were given "special concern" status. One unknown lamprey was also collected.

Troublesome Creek

A total of eight sampling stations were located on this stream. Sampling was conducted in 1984. Studies were conducted on Troublesome Creek due to the fact that it is a major tributary to the North Fork Kentucky River and was probably a spawning area for muskellunge while they were present in the North Fork.

A total of 737 fish were collected during a total of 4.5 hours of electrofishing (Tables 16 and 23). Fish collected represented 33 species. Species collected at all eight stations were northern hog sucker, golden redhorse, longear sunfish, and spotted bass. The three most numerous species were golden redhorse, spotted bass, and longear sunfish. Species present in all but one station were shorthead redhorse and smallmouth bass. No muskellunge were collected or seen in Troublesome Creek. None of the species collected have been listed by the Kentucky Endangered Species Committee for consideration for special status.

Physical-Chemical Determinations

Upper Licking River

Three stations on the Upper licking River were visited during the spring, summer, and fall during 1982 and 1983. The upper Licking River above Cave Run Lake runs for a total of 82.0 mi and is an order Vi stream (Kuehne 1963). The mean gradient for this section of the Licking River is 3.3 ft/mi. Fish shelter was described as abundant and was composed of logs, brush, and undercut banks. The riparian zone ranged from 33 to 66 ft. The amount of stream shaded by shoreline vegetation was about 50-75 percent. Bottom-type of the pools was usually composed of silt, muck, and detritus. Riffle bottom type was composed of large rubble, small rubble, and coarse gravel. Average pool riffle ratio was 65-35 (Table 24). Water temperatures of the upper licking River at each station during each season in 1982 ranged

from 41 to 76 F; temperatures in 1983 ranged from 56 to 80 F. Dissolved oxygen ranged from 7 to 12 mg/l in 1982 and from 3.6 to 10 mg/l in 1983. The range of pH values in 1982 was 6.6 to 8.5; in 1983 pH ranged from 7.3 to 7.6. Total alklainity ranged from 68 to 120 mg/l in 1982; in 1983, it ranged from 68 to 137 mg/l. Turbidity levels at the time of sampling in 1982 ranged from 9 to 130 NTU; in 1983, turbidity ranged from 8 to 166 NTU. Salinity measurements were taken during the fall sampling in 1982 and during spring, summer, and fall in 1983. Salinity levels during the fall in 1982 ranged from 0 at the upper station to 0.03 ppt at the lower station. In 1983, the values ranged from 0 to 0.5 ppt. The mean salinity level was 0.06 ppt. Conductivity values were not measured in 1982. Values obtained in 1983 ranged from 160 to 700 umhos/cm (Tables 25 and 26).

Middle Fork Kentucky River

Basic physical and chemical determinations were made on the Middle Fork during the spring, summer, and fall at three stations in 1982 and 1983. Total stream length measured 92.0 mi. This river is an order V stream and has a mean gradient of 7.0 ft/mi. Amount of fish shelter was considered medium and was composed of undercut banks, logs, and brush. The riparian zone averaged from 43 to 75 ft, and 15 to 30% of the stream was shaded. Bottom structure of pools was composed of silt, rubble, and detritus. Bottom structure of riffle areas was described as large and small rubble along with coarse gravel. The pool-riffle ratio was estimated to be 75-25 (Table 24).

Water temperatures in 1982 ranged from 50 to 75 F during sampling. In 1983, the range was 61 to 82 F. Dissolved oxygen levels in 1982 ranged from 9.0 to 12.0 mg/l; in 1983, the range was 8.3 to 12.0 mg/l. The pH levels in 1982 ranged from 7.5 to 8.1 and from 7.2 to 8.3 in 1983. Total alkalinity ranged from 51 to 86 mg/l in 1982 and 1983. Turbidity ranged from 5 to 50 NTU in 1982 and from 5 to 32 NTU in 1983. Salinity was not measured during the spring and summer of 1982. Values obtained in the fall, however, ranged from 0 to 0.01 ppt. In 1983, salinity values ranged from 0 to 0.2 ppt. Conductivity measurements were taken only in 1983. These values ranged from 125 to 385 umhos/cm (Tables 25 and 26).

North Fork Kentucky River

The North Fork Kentucky River was the longest of the four streams sampled. Total length is 161.0 mi from the headwaters to the confluence with the South Fork Kentucky River. It is an order VI stream and has a mean gradient of 3.8 ft/mi. The amount of fish shelter was described as medium, being composed primarily of logs, brush, and undercut banks. The riparian zone averaged from 50 to 82 ft and provided shade over the stream ranging from 10 to 30%. Bottom composition of pools was boulder, large rubble, and small rubble. Riffle composition was boulder, large rubble, and small rubble. The pool-riffle ratio was estimated to be 75-25 (Table 24).

Range of water temperature was 46 to 76 F in 1982 and from 61 to 82 F in 1983. Dissolved oxygen in 1982 ranged from 9 to 13 mg/l and from 7.0 to 13 mg/l in 1983. The pH during 1982 varied little but

ranged from 7.3 to 8.5. More variance was observed in 1983, with values ranging from 6.6 to 8.9. Total alkalinity ranged from 103 to 205 mg/l in 1982. Values obtained in 1983 ranged from 86 to 239 mg/l. Turbidity levels ranged from 5 to 50 NTU in 1982 and from 7 to 70 NTU in 1983. Salinity levels during the fall in 1982 ranged from 0 to 0.0 ppt and from 0 to 0.3 ppt during all sampling in 1983. Measurement of conductivity was not done in 1982 at North Fork. Measurement in 1983 resulted in a range of values measuring from 350 to 750 umhos/cm (Tables 25 and 26).

Troublesome Creek

Troublesome Creek was sampled during the spring, summer, and fall of 1984. It was the shortest of the streams sampled, with a total length of 45.5 mi. It is an order V stream and has a mean gradient of 6.2 ft/mi. Fish shelter was considered to be medium in amount and composed of undercut banks, boulders, and logs. The riparian zone ranged from 43 to 75 ft, and from 14 to 30% of the stream was shaded. Pool substrate was composed of sand, fine gravel, and silt. Riffle-area substrate was small rubble, coarse gravel, and large rubble. The pool-riffle ratio was estimated to be 55-45 (Table 24).

Water quality determinations were made during the three seasons at an upper and lower station. Water temperature ranged from 49 to 76 F. Dissolved oxygen ranged from 4.6 to 10.8 mg/l. The pH measurements ranged from 7.8 to 8.6. Total alkalinity ranged from 102.6 to 153.9 mg/l during the course of sampling. Turbidity ranged from 14 to 33 NTU. Salinity was only detectable during the spring and summer at the lower station. Both values were 0.02 ppt. Conductivity ranged from 245 to 715 umhos/cm (Table 27).

Bottom Fauna Survey

Upper Licking River

Benthic macroinvertebrates were sampled during the spring, summer, and fall at lower, middle, and upper section of the river. Two square-meter samples were taken at each site to provide estimates on the quantity and quality of invertebrate populations. During the course of data tabulation, the sample from the upper station taken in the spring was lost.

A total of 48 taxa were separated from samples taken on the upper Licking River (Table 28). As some of the taxa wre unidentifiable, the total number of taxa may be slightly less than realized due to duplication. The mayflies were the most numerous group, with 11 genera identified. Orders Diptera and Coleoptera each had nine taxa identified. The three most numerous genera from all stations and seasons were the Trichopteran Cheumatopsyche sp. and two Ephemeropterans Stenonema vicarium and Isonychea sp. The highest total number of invertebrates was collected in the fall. The stations with the highest number of invertebrates were the middle station (fall), the lower station (fall), and the upper station (summer). The middle (fall) station had the highest number of taxa (17) with the middle

with the three highest diversity indices were the upper (summer), lower (summer), and the middle (fall). The three highest equitability values were obtained at the lower (summer), lower (spring), and middle (summer) stations. Of the four streams sampled, the upper Licking River had the highest mean equitability value (Table 32).

Middle Fork Kentucky River

Benthic macroinvertebrates were collected during three seasons at an upper, middle, and lower stations. Two square-meter samples were collected at each site. One collection sample was lost, however, during data tabulation. The lost sample was that collected from the lower station in the summer. A total of 62 taxa were collected, though this figure may be somewhat high due to incomplete identification of several organisms (Table 29). The order with the most taxa present was Diptera with 16 species. The Ephemeroptera were represented by 15 taxa and the Coleoptera had 7 species. The three genera with the highest density or organisms were the mussel Corbicula fluminea, Trichopteran Cheumatopsyche sp. and mayfly Isonychea sp. The seasons with the highest density of invertebrates present appeared to be the fall. Stations with the highest number of invertebrates were the upper (summer), middle (fall), and the lower (spring) stations. Stations with the most taxa were upper (summer), lower (spring), and middle (fall) stations. The upper (summer) station had the highest diversity index, with the upper (spring) and lower (spring) stations being second and third. Equitability was highest at the upper (fall) station, middle (summer) station, and upper (spring) station. Of the four streams sampled, the Middle Fork Kentucky River had the highest mean diversity index value (Table 32).

North Fork Kentucky River

Sampling for benthic macroinvertebrates was conducted over three seasons at an upper, middle, and lower station. Sampling consisted of two square-meter substrate samples at each station. A total of 64 taxa were collected (Table 30). The order with the most genera present was the Diptera with 17 taxa. Next were the Ephemeroptera with 15 taxa, and Trichoptera with 8 taxa. Organisms with the highest density were Corbicula fluminea, Trichoperan Cheumatopsyche sp., and Dipteran Hemerodromia sp. The highest total number of invertebrates was collected in the summer. The three stations with the highest number of invertebrates were the lower (summer), middle (summer), and upper (spring) stations. The highest numbers of taxa were taken from the lower (spring), upper (spring), and lower (summer) stations. The three highest diversity indices came from the upper (spring), lower (spring), and middle (summer) stations. Equitability was highest at the middle (spring), upper (spring), middle (summer), and upper (summer) stations. Of the four streams sampled, the North Fork Kentucky River had the highest number of organisms per square meter (Table 32).

Troublesome Creek

Benthic macroinvertebrates were sampled during the spring, summer, and fall at an upper and lower stations in 1984. As in previous

summer, and fall at an upper and lower station in 1984. As in previous sampling, two square-meter samples were taken at both sites during the three seasons. A total of 55 taxa were collected from Troublesome Creek (Table 31). The order that was represented the most ws the Diptera with 24 taxa. The Ephemeroptera had 11 taxa, and the Plecoptera, Coleoptera, and Gastropoda each has 4 taxa. The three mos numerous taxa were Cheumatopsyche sp., Gastropod Elmia semicarinata, and Asiatic clam Corbicula fluminea. The highest total number of benthic macroinvertebrates was collected in the summer. Stations with the highest number of invertebrates were the upper (summer), lower (spring), and upper (fall) stations. The highest number of taxa came from the lower (spring) station. The three highest diversity indices came from the upper (spring), lower (summer), and lower (fall) stations. The three highest equitability values came from the upper (spring), lower (summer), and lower (fall) stations, all with values of 1.0.

DISCUSSION

Native muskellunge streams in Kentucky are valued for their unique fishing opportunities. Due to quality habitat requirements, native muskellunge are usually associated with aesthetic stream conditions. These streams are subjected to limited impact from watershed disturbance and land usage. Muskellunge range throughout more than 700 miles of 18 streams in Kentucky. Such established muskellunge streams are mainly found throughout eastern Kentucky, though some are in southern and western Kentucky. Native muskellunge are found in the Barren River drainage, Green River drainage, upper Kentucky River drainage, Licking River drainage, Kinniconick Creek, Tygarts Creek, and the Little Sandy River. Three of the four streams investigated in this report are located in the upper Kentucky River drainage. All three supported native muskellunge populations at one time, and one stream currently has a muskellunge population as a result of stocking. The fourth stream, the Licking River above Cave Run Lake, was also a native muskellunge stream. Muskellunge are still found in this section of the river but are present primarily because of spring spawning migration from Cave Run Lake. These four streams were studied to gain information on why muskellunge disappeared from these streams and if populations can be restored. A general examination of all four drainages reveals that habitat degradation has been occurring over an extended period of time. All of the four study streams lie in the heart of the eastern coal fields. Coal mining and logging have been occurring throughout this century and part of the last in this area. Only within the last decade has mining, as well as other natural resource exploitation, been better regulated. During the course of this study, destructive impacts on the aquatic systems by mining activities in these drainages have subsided somewhat though noticeable increases in siltation and brine-water releases due to oil and gas exploitation were observed. Brewer (1980) stated that two factors appeared to be resulting in a statewide decline in the muskellunge population in Kentucky. These two factors were impoundments and/or pollution. Two major impoundments are located on two of the study streams, these being Cave Run Lake on the Licking River and Buckhorn Lake on the Middle Fork Kentucky River. Smaller, county-owned dams are located at Hyden on the Middle Fork

Kentucky River, at Hazard on the North Fork Kentucky River, and Salyersville on the upper Licking River. Low-water bridges with elevated pipes or otherwise restricted flow capabilities are also present on all the streams visited. Not only do all of these stream barriers restrict movement of muskellunge during spawning migrations, but they cause flowing water to slow, causing silt deposition above the impoundments or barriers. Sediments build up in these areas as well as at sites where chronic siltation from surface disturbance occurs, and eliminate muskellunge habitat. This crucial habitat can be in the form of feeding areas, spawning structure, or areas for cover such as deep water and underwater structure. Muskellunge streams are important to area fisheries not only for muskellunge, but also for black bass, panfish, catfish, and various rough fish species. In an attitude survey conducted in 1982, Kinman (1984) found that angler preference in the eastern region for streams (27%) was nearly equal with reservoirs (29%). He also found that anglers in the eastern region of the state showed a stronger preference for an increase in emphasis on muskellunge management.

Muskellunge have been stocked periodically in the upper Licking River and the Middle Fork Kentucky River (at and above Buckhorn Lake) since the mid-1970's. A minimum of over 8,000 fingerling muskellunge have been stocked in the Licking River in the headwater area of Cave Run Lake since 1975. Almost 9,000 fingerlings have been placed in the Middle Fork Kentucky River in the headwaters of Buckhorn Lake since 1976 in hopes of establishing a muskellunge fishery in that impoundment. These stocking efforts have resulted in several catches of muskellunge in stream sections above and below these lakes.

Quality habitat in the form of clean, rocky stream substrate was not present in any of the eight stations sampled on the Licking River. In 1982, the only two muskellunge captured were collected from station 7. This site is located just above Royalton in a heavily mined area. This site, however, was one of the cleaner stations, even though silt and much were present. The site also had bedrock and large rubble in the pools, though riffles contained silt and detritus. A diverse fish population was collected in conjunction with the muskellunge.

During the electrofishing studies, only 38 species of fish were collected from the upper Licking River. This was considered low when compared to other muskellunge streams. The diversity and numbers of native forage species such as minnows, shiners, and darters was low. Only two species of darters were collected, one of which (logperch) is able to adjust to impounded habitat. The commercial or rough fish species, such as redhorses, were also low in quantity and diversity. Golden redhorse were found at all stations. Other redhorses such as river redhorse, silver redhorse, black redhorse, and shorthead redhorse were either low in numbers or non-existant. Other suckers, usually indicative of fairly clean conditions, such as the white sucker and spotted sucker, were found only in the headwaters. Spotted bass were the dominant black bass species. Largemouth bass were collected from only two stations, while smallmouth bass were never collected. Indicator species associated with muskellunge in streams were present in the study streams and found in most of the stations. These were

spotted bass, longear sunfish, and golden redhorse. Low diversity and numbers of redhorses may be an indicator to habitat degradation. Forage species of the stream community appear to have been replaced by those of the reservoir such as gizzard shad and carp. Golden redhorse are also found in reservoirs as well. Dominant species present are not indicative of clean water habitat, but are more indicative of impacted and impounded conditions. The Kentucky Nature Preserves Commission (1979) conducted fish studies in 1978 during June and July on the upper Licking River. They found 22 species of fish present. They commented that continued siltation in the watershed will degrade the existing ichthyofauna and, in turn, the existing fishery. No muskellunge were collected in their studies. The primary forage for muskellunge in streams appear to be redhorses. In 1981, Kornman (1983) conducted electrofishing studies on two quality muskellunge streams in northeast Kentucky. He collected redhorses in Kinniconick Creek at the rate of 17.1 fish/hour. In Tygarts Creek, they were collected at the rate of 56.5 fish/hour. In the upper Licking River, they were collected at the rate of 25.3 fish/hour in 1982 and 16.9 fish/hour in 1983. Catch rate of muskellunge in Kinniconick Creek during 1980 and 1981 was 0.5 fish/hour. Catch rate in Tygarts Creek during the same period was 1.3 fish/hour. The muskellunge catch rate for the upper Licking River during 1982 and 1983 averaged 0.3 fish/hour.

The Middle Fork Kentucky River above Buckhorn Lake is shallow due to siltation; the river below the lake is rather free of siltation immediately below the dam, with slightly increasing sedimentation. The native muskellunge population in this stream made a sharp decline with the construction of Buckhorn dam in the early 1960's. Virtually all major spawning areas in the headwaters became inaccessable due to the impoundment. Such spawning streams were Cutshin Creek, Beech Fork, Greasy Creek, and upper Middle Fork. No major tributaries exist below the dam. During electrofishing studies in 1982 and 1983, only one muskellunge was observed in the headwater stations above Buckhorn Lake. Sampling in this area was done during the summer months both years. Therefore, it was not determined if muskellunge in Buckhorn Lake have a spring spawning migration into the headwaters.

Muskellunge that have escaped through the dam seem to be localized throughout most of the year in approximately the first 5 mi below the dam. During the spring, however, spring migrations cause a concentration of muskellunge immediately below Buckhorn Lake. During the past several years, anglers have been quite successful in catching muskellunge in the spring below the dam. Reports of more than one fish per day per angler were not uncommon. During 1982 and 1983 electrofishing studies, all muskellunge collected came from stations 7 and 8. These stations are the first two study sites from Buckhorn Lake dam downstream. A total of four muskellunge were collected in 1982 and 11 in 1983 at these stations. In 1982, station 8 was sampled on May 19, resulting in the capture of one muskellunge. In 1983, it was sampled on June 28 and seven muskellunge were collected. Station 7 was electrofished on 4 August 1982, with three muskellunge captured. In 1983, four were captured when electrofished on June 29. Station 8 was the nearest sampling location to the dam. A distance of about 0.7 mi of riffle and pool habitat exists between this station and the dam. This area probably contains muskellunge throughout the year. This site

is also the location of spring muskellunge fishing in the Middle Fork Kentucky River.

Catch rates of muskellunge in the Middle Fork Kentucky River increased from 0.2 f/hr (0.3 f/mi) in 1982 to 0.6 f/hr (0.8 f/mi) in 1983. Muskellunge that were collected were almost always located around structure such as fallen trees, logs, or rock piles. At station 8 in 1983, three large muskellunge were electrofished from a large fallen sycamore tree. In this case, one fish was captured around the outside of the tree, while the two larger fish were within tree limbs. These two fish were not captured. Fallen trees were particularly productive for harboring muskellunge. It was observed in the field that fallen trees with trunk diameters of no less than 5 inches were potential cover. Small islands of driftwood embedded in silt or sand in the mainstream were also productive. Such habitat is considered very important for muskellunge. Fallen trees and brush are a direct product of an undisturbed, mature, riparian zone. Muskellunge stream management should therefore include protection of riparian vegetation in order to provide shade to the stream by trees and cover for muskellunge from fallen trees.

Muskellunge collected from the Middle Fork Kentucky River represented four year classes. Thirteen of the 15 collected were estimated to be from the 1979 or 1980 year classes. These may indicate strong year classes, but are probably a result of escapement over a longer period of time from Buckhorn Lake. Larger numbers of 9-inch muskellunge (1,200) were stocked beginning in 1980, as opposed to an average of 343 fish/yr of 6-inch fish from 1976 to 1979 in the headwaters above the lake. If current stocking rates in the lake continue, the muskellunge population and fishery should increase.

No muskellunge captured in 1982 were large enough to be tagged; three captured in 1983 were tagged, however. None of these tags were returned during the course of the study.

A total of 45 fish species were collected from the Middle Fork Kentucky River during the 2-year period. Species of interest collected other than muskellunge were American brook lamprey and popeye shiner. These species have been given special status by the Endangered Species Committee of Kentucky (Branson et al 1981) and may be indicators of generally unimpacted water conditions. Sauger were also found, which are a result of stocking efforts by the Department of Fish and Wildlife Resources. Four species of redhorses were collected, with golden redhorse being present in all stations. In 1982, catch rate of all redhorses was 68 f/hour, while in 1983 it was 28 fish/hour. Good numbers of redhorse are indicative of particularly clean riffle and pool areas with good food supplies. Usually good populations of redhorses were associated with areas where muskellunge were seen or captured.

North Fork Kentucky River was the largest of the four streams studied. Muskellunge habitat appears to be present but limited. Muskellunge stocking activities have never been conducted on the North Fork Kentucky River. The only report of an esocid-type fish being caught from the North Fork in recent years was around 1978. At this

time, a picture appeared in a Hazard, Kentucky newspaper of a man holding what he claimed was a northern pike. He had caught this fish from the North Fork Kentucky River. The fish appeared to be about 25 inches in length. This fish was never traced to confirm an identification. Local fishermen do recall muskellunge being present in the North Fork. Increased logging and mining activities and their associated siltation, coal fines, and acid water apparently caused the muskellunge population to be extirpated by the mid-50's. The river has areas of good stream habitat as well as areas of heavy siltation.

A total of 45 fish species were collected from the North Fork Kentucky River. Species collected were generally considered to be indicative of unimpacted communities. When interpreting these results it should be realized that areas with clear water and clean substrate were more often electrofished and held many fish. Degraded areas of stream that were shallow with silt and had less suitable habitat usually produced few fish and were harder to sample. Impacted stations therefore had a shorter species list as opposed to higher species diversity at cleaner stations. Species found in all stations were golden redhorse, longear sunfish, and spotted bass. The top three species in order as far as numbers are concerned, were golden redhorse, spotted bass, and channel catfish in 1982. In 1983, they were spotted bass, golden redhorse, and sand shiner. Redhorses were cpatured at the rate of 21 f/hr in 1982 and 36 f/hr in 1983. Species of particular interest collected were channelc arter and gilt darter. These species have been given special status by the Kentucky Endangered Species Committee (Branson et al 1981). Forage species were present in good numbers. Also present was preferred habitat such as fallen trees, rocks, drift piles, and islands. No major tributaries that may be utilized for muskellunge spawning, other than the headwters, are located above Hazard, Kentucky. The only major barrier to fish migration is a small dam located in Hazard. Fish species diversity and overall nubmers were lower above Hazard than below. Factors could be decreased depths due to sedimentation and inability of fish to freely migrate above the dam at Hazard.

Troublesome Creek, one of the main tributaries to the North Fork Kentucky River, was electrofished over a period of 1 year. A total of 33 fish species were collected throughout the eight stations. None of the species collected were considered rare or unusual. Dominant species in the stream as far as greatest numbers were concerned were golden redhorse, spotted bass, and longear sunfish. Species found in all stations were northern hog sucker , golden redhorse, longear sunfish, and spotted bass. This stream was likely where muskellunge spawned in the past before the population was extirpated. This stream has a moderate amount of human residential and commercial activity near the main stem. Domestic sewage and garbage have been a problem in the past but conditions seem to be improving. The greatest problem with habitat conditions is the extent of sedimention in the pools. The Kentucky Nature Preserves Commission (1979) conducted fish studies on Troublesome Creek in 1978 and found 32 species. They reported those species compared favorably with numbers of species observed in high quality streams. They also noted field observations indicated relatively low numbers of individuals representing many species. They reported Latrich (1973) in a detailed

study was able to show that the entire fish community declined as a unit rather than as separate components in the face of siltation from surface mines. His study indicated that at least in the initial stages of breakdown, the fish community retains its organizational integrity even though total numbers have been reduced.

Levels of siltation appear to be the main difference between the four study streams. Silt and muck were located throughout the upper Licking River in pools and riffles. Significant levels of silt were present in the North Fork Kentucky River and Troublesome Creek, particularly in areas adjacent to sources of heavy run-off and erosion. Heavily silted areas in both of these streams have accumulations of up to 2 ft or more. Chemical analyses of the streams revealed no major differences in seasonal or geographical locations. Chemical parameters sampled indicated no significantly harmful levels of pH, alkalinity, salinity, or turbidity. Water temperatures did not range above 76F in any of the streams when sampled. Dissolved oxygen levels as determined from the stream surface usually were not less than 9 mg/l. Water quality characteristics were closely related to the physical structure of each stream to some degree. Areas of stream with low shade levels, disturbed riparian zones, and accumulations of silt usually had warmer water temperatures, lower oxygen levels, higher pH levels, and higher total alkalinity levels. A good example of this is the upper station on Troublesome Creek during the summer sample. This station is located just below Hindman, Kentucky where riparian vegetation is reduced and a high nutrient load from waste materials enters the stream. At this site during the summer months, the water level is low and becomes suscepable to high water temperatues and low oxygen levels.

A general evaluation of the eight stations visited on the upper Licking River show moderate degradation of the stream. Silt was present at all stations to a noticable degree, with some stations having sediment depths up to 2.0 ft. The section of stream from just above to just below Salyersville appeared to be the most heavily affected. In this section, heavy disturbance of riparian vegetation, erosion, and the outflow from the sewage treatement plant are evident. This area was also the site for sampling station 6. Stations 7 and 8 upstream from this station to the ford at Half Mountain contained sediment depths of from 1 to 2 ft. Silted conditions were evident in all stations below Salyersville as well, with heavy deposits in the area where the licking River empties into Cave Run Lake. No good muskellunge habitat was found in the upper Licking River.

The Middle Fork Kentucky River contained high quality stations from the dam at Buckhorn Lake downstream to the mouth just above Beattyville. This area includes station 8 through station 1. Periods of precipitation do cause the river to become turbid, particularly at and below the confluence with tributary streams. Silted conditions were more evident in stations 9 through 12 above Buckhorn Lake. Silt was most evident in the uppermost station, with a measured depth of about 1 ft.

The North Fork Kentucky River exemplified the most diverse stream habitat at study stations. Station 7 between Hazard and Jackson

was shallow and silt was deep from bank to bank in this area. In 1983, sampling was possible in about half the area sampled in 1982 due to shallow pools. Stations 1, 2, 5, 6, 8, and 10 were areas of moderate siltation. At these sites, silt was found to be about 1/8- to 1/4-inch in depth on submerged strata. Stations 3, 4, and 9 were considered areas of highest quality, with negligable silt deposits and clean substrate.

Troublesome Creek sampling stations appeared to have moderate levels of silt on the substrate. Stations 6, 7, and 8 from Rowdy, Kentucky upstream appeared to have the heaviest concentrations of silt. The lower stations below this contained many sand deposits as well as some silt.

Little published information is available on macroinvertebrate populations in the upper Licking River, Middle Fork and North Fork Kentucky River, and Troublesome Creek. Jones (1970), in his study of the Licking River, only listed orders of invertebrates observed in the stream. Included in his observations of the upper Licking River were Ephemeroptera, Coleoptera, Odonata, Plecoptera, and Decapoda. The Kentucky Nature Preserves Commission (1979) found 35 taxa, the lowest number found in all their Licking River sites, at a station near Ivyton, Kentucky in Magoffin County. They found species diversity and equitability values to be moderate in June and low in October. They collected large populations of Stenonema vicarium and Cheumatopsyche sp. Jones (1973) noted seeing abundant amount of Ephemeroptera at a station near Saylor, Kentucky on the Middle Fork. In studies on North Fork, he noted abundant Ephemeroptera, Odonata, Pelecypoda, and Megaloptera at station at Rock Lick, Kentucky; abundant to medium populations of Ephemeroptera, Gastropoda, and Coleoptera at a station near Wolfe Coal, Kentucky; and abundant to medium populations of Decapoda, Gastropoda, Ephemeroptera, and Trichoptera at a station just above Viper, Kentucky. Jones also conducted studies on Troublesome Creek during the same study and noted Ephemeroptera and Decapoda being present at a station near Caney School; he also noted sparse popultions of Ephemeroptera, Diptera, and Decapoda at a station in Hindman, Kentucky. The Kentucky Nature Preserves Commission (1979) conducted studies on Troublesome Creek in June and October 1978. They found 25 taxa of mcroinvertebrates and noted this was comparable to numbers observed at other sites degraded by mining. They found the June and October species diversity indices to be moderate and equitability to be high. They found average densities to be very low. They found the Ephemeroptera, Diptera, and Odonata to be the most speciose groups, with Ephemeroptera being the most speciose. They reported Plecopterans, which normally inhabit clear, cool, highly oxygenated waters, were not found.

A total of 48 taxa of benthic macroinvertebrates representing 12 orders were collected in the upper Licking River in this study. Collections represent spring, summer, and fall sampling of an upper, middle, and lower sections of the river. Numbers of organisms appeared to be higher in the summer and fall than in the spring. No difference could be determined between stream sections. Diversity indices seemed

to indicate degradation in the lower section. Moderate degradation was evident at the middle station during the summer. High diversity indices were obtained at some stations. Equitability indices were high at the lower station during the spring and summer, and at the middle station during the summer. Numbers per square meter were highest in the upper station in the summer and the lower and middle stations in the fall. Numbers were very low in the lower station in the spring. The Ephemeroptera were the most abundant order collected. Cheumatopsyche sp. was the most abundant species.

A total of 62 macroinvertebrate taxa were collected from stations on the Middle Fork Kentucky River. The Ephemeroptera were the most abundant in numbers and species. Excluding shells of Corbicula fluminea, Cheumatopsyche sp. was the most abundnat species. Stations with the highest number of organisms varied from season to season. Higher numbers were in the lower section during the spring, with numbers increasing in the middle and upper stations during the summer and fall. High diversity indices indicated little if no degradation in the headwaters, with indications of greater degradation downstream as diversity decreased. Equitability indices were highest in the middle and upper stations, depending upon the season. Most values were low, with only the summer middle station and the fall upper station relfecting high values.

A total of 64 species of benthic macroinvertebrates were separated from samples taken on the North Fork Kentucky River. The Diptera appeared to be represented by the most species. Aside from Corbicula fluminea, Cheumatopsyche sp. was the most abundant species. The highest number of organisms per square meter was taken from the lower station in the summer. The lower station usually contained the highest number of taxa. Diversity indices were highest at all stations in the spring sample and lowest in the fall. Equitability was highest at the middle station during the spring sample. Equitability was consistantly low in the lower station and moderate in the upper station.

A total of 55 taxa of benthic macroinvertebrates were collected from Troublesome Creek. Diptera was the most speciose order with 24 species separated. The most numerous individual, as in the other streams, was Cheumatopsyche sp. With the exception of the spring sample, the upper station contained a higher number of organisms than the lower. Overall numbers were highest in the summer, though the highest number of taxa was in the spring. Diversity indices indicated moderate degradation, with high degradation observed at the upper station in the summer. Equitability appeared to be influenced by the seasons. The equitability index was lowest at the lower station in the spring, but had the highest values during the summer and fall. The upper station had a high equitability index in the spring and low values in the summer and fall.

RECOMMENDATIONS

The upper Licking River, Middle Fork Kentucky River, North Fork Kentucky River, and Troublesome Creek once supported populations of muskellunge. Increased efforts should be taken to reduce sedimentation in these systems. Water quality standards should be maintained by industrial facilities in order to reduce the amount of sediments, coal fines, acid water, and brine water entering the streams. Any private or industrial enterprise should be informed of any damaging affects of waste release and silt run-off, and monitor during and after such an occurence.

A buffer zone of riparian vegetation should be maintained throughout each river or stream. Riparian vegetation should be protected within no less than 25 ft from the shoreline. This action should help to provide bank stabilization, shade, and eventually in-stream habitat improvement. Habitat in the stream such as logs, trees, islands, and boulders should be maintained. Natural habitat entering the stream should not be removed.

The integrity of the stream structure itself, in the form of meanders, should be maintained to provide diverse habitat such as eddys undercut banks, shoals, and pools. Pools provide areas of cover and escapement, while shoals provide areas for forage species to feed, spawn, and congregate.

Muskellunge stocking in the upper Licking River is not recommended due to available migrating fish from Cave Run Lake and poor habitat conditions in the stream. Muskellunge stocking rates in Buckhorn Lake currently appear to be adequate to populate the lake and provide good numbers in the Middle Fork below the dam. Muskellunge should be reintroduced into the North Fork Kentucky River once sedimentation in the stream has been sufficiently reduced and watershed disturbances are adequately controlled to reduce sedimentation into the stream. Habitat conditions have been improving in recent years and these stockings should re-establish this species in the river. Stockings of 7-9 in fingerlings should be made from Hazard downstream. Muskellunge should be stocked at the rate of one fish per 2 acres of pool habitat. There are approximately 80 total mi of stream and 60 mi of pool habitat. This would require 350 muskellunge per annual stocking. Stocking should be done for 4 consecutive years and every other year thereafter. Muskellunge should be stocked in the larger pools throughout the area to be stocked.

Electrofishing studies should be conducted periodically, no more than every 4 years, to determine growth, reproduction, and survival of muskellunge and habitat conditions in the stream.

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APPENDIX A

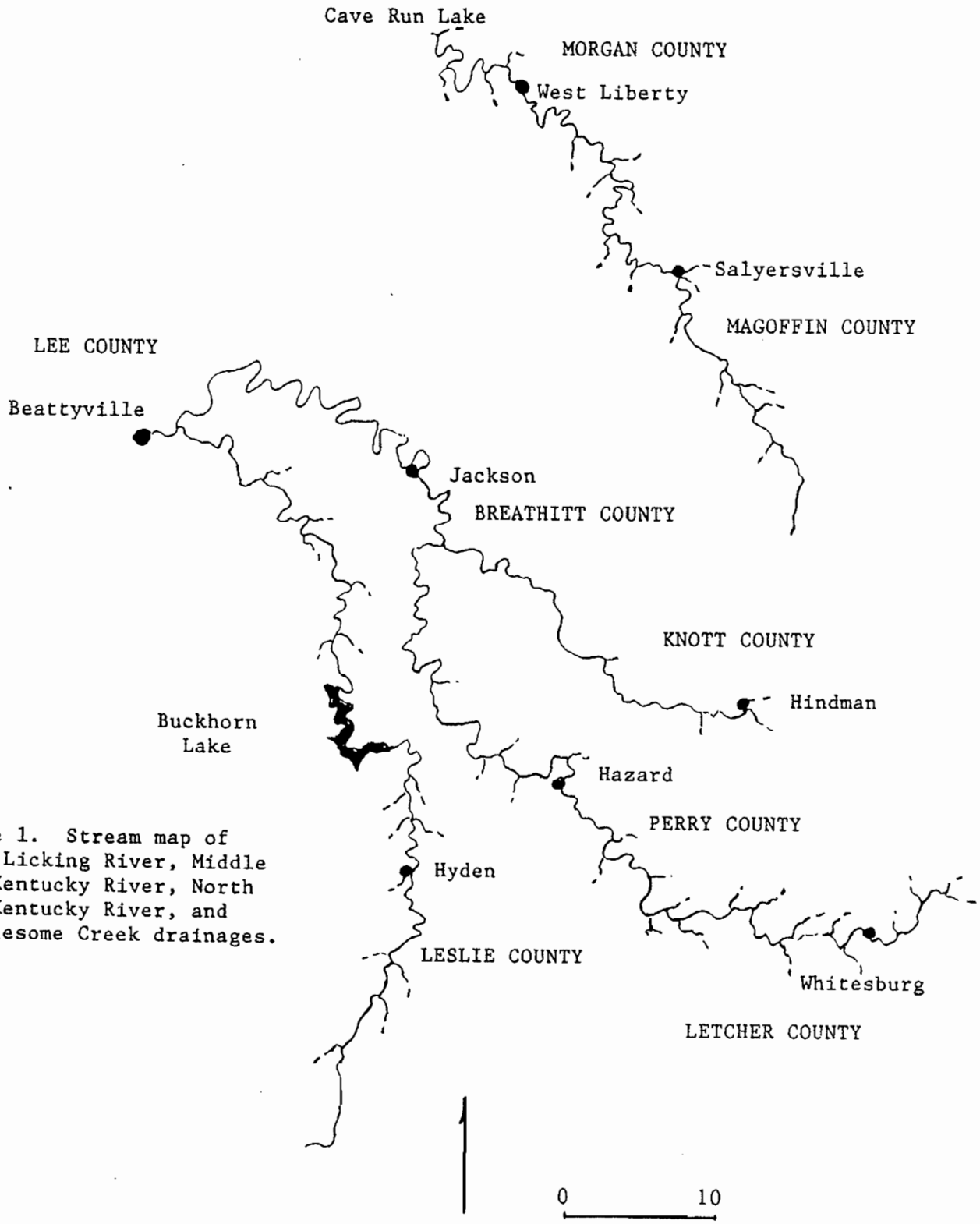

Figure 1. Stream map of upper Licking River, Middle Fork Kentucky River, North Fork Kentucky River, and Troublesome Creek drainages.

Table 1. Stockings of 6-8 inch muskellunge at Upper Licking River and Middle Fork Kentucky River since 1973.

Stream	1975	1976	1978	1979	1980	1981	1982	1983
Upper Licking River (above Cave Run Lake)	417	674	1,078	3,504	1,474		671	564
Middle Fork Kentucky River		270	500	258				
Buckhorn Lake (Middle Fork Kentucky River)					1,275	615	1,211	1,226

Table 2. Locations of pools sampled by electrofishing during 1982 and 1983 on the upper Licking River in Magoffin and Morgan counties.

Station 1	From first shoal above mouth of Lucky Branch, west of Henry Cemetary downstream to just above benchmark 793 (entrance of Licking River tc Cave Run Lake); access via ramp off Route 772, about 4 mi downstrean from study station, pool length 1.75 mi, average width 64 ft, average depth 4 ft; located between Licking River and Woodsbend; West Liberty Quad., Morgan County.
Station 2	From ford downstream to first riffle; ford at lower end of Cottle Bend, below Cottle Cemetary, downstream to first bend in river off routes 460 and 7; pool length 1.12 mi, average width 65 ft, average depth 2 ft, about 3 road-miles above West Liberty; Lenox Quad., Morgan County.
Station 3	From ford upstream to first riffle; second ford off Route 1869 in Morgan County, Morgan-Magoffin County line; pool lnegth 0.28 mi, average width 50 ft, average depth 2.5 ft; White Oak Quad.
Station 4	From ford upstream to first riffle off Route 1869 on Morgan-Magoffin County line; pool length 0.25 mi, average width 60 ft, average depth 1.5 ft, White Oak Quad.
Station 5	From 400 feet below ford at Elsie, upstream to first narrow shoal below acute bend in river; pool length 1.33 mi, average width 46 ft, average depth 1.7 ft; located between Greasy Branch and lower end of Fanning Bend; White Oak Quad., Magoffin County.
Station 6	From just below mouth of State Road Fork down to just above first nameless intermittant stream on right bank, within Salyersville City limits, bordering city park; pool length 0.06 mi, average width 20 ft, average depth 2 ft; Salyersville North Quad, Magoffin County.
Station 7	From just above the ford at the mouth of Higgins Branch, upstream to first riffle; pool length 0.25 mi, average width 35 ft, average depth 1 ft; 1.2 mi upstream from Royalton; Salyersville South Quad., Magoffin County.
Station 8	From just above Big Half Mountain ford upstream to first riffle (Highway 1471 ford); pool length 0.4 mi, average width 35 ft., average depth 3 ft; 2.1 mi upstream from Royalton; Salyersville South Quad., Magoffin County.

Table 3. Locations of pools sampled by electrofishing during 1982 and 1983 on the Middle Fork Kentucky River.

Station 1	From confluence with North Fork upstream to first riffle, 0.6 mi above mouth of Long Shoal Branch, St. Helen's pool; pool length 3.0 mi, average width 84.7 ft, average depth 4.6 ft; Beattyville Quad., Lee County.
Station 2	From ford at Copebranch upstream to first shoal; pool length 1.0 mi average width 80 ft, average depth 2.5 ft; Tallega Quad., Breathitt County.
Station 3	From ford at Jetts Creek upstream to first riffle below mouth of Lick Branch; pool length 0.38 mi, average width 78 ft, average depth 2.1 ft; Tallega Quad., Breathitt County.
Station 4	From mouth of Elsome Creek to mouth of Turners Creek (riffle to riffle); pool length 0.95 mi, average width 91 ft, average depth 3.1 ft; Canoe Quad., Breathitt County.
Station 5	From ford just above Talbert, upstream to first riffle, off Route 315; pool length 1.6 mi, average width 65 ft, average depth 3 ft; Canoe Quad., Breathitt County.
Station 6	From riffle at second ford upstream from Crocketsville at mouth of Freeman Fork to first riffle below islands; total length of pool 1.15 mi, average width 115 ft, average depth 5 ft; Canoe Quad., Breathitt County.
Station 7	From first riffle, located 0.5 mi below Highway 28 bridge, downstream over two passable shoals to impassable riffle; named "three-hole pod" by crew; total length of study area 2.0 mi, average width 100 ft, average depth 3 ft; Buckhorn Quad., Perry County.
Station 8	From riffle under Highway 28 bridge upstream to first riffle about 0.7 mi below Buckhorn Lake dam; pool length 1.62 mi; average width 80 ft, average depth 3 ft; Buckhorn Quad., Perry County.
Station 9	From low-water bridge upstream to first riffle off route 257 at confluence; pool length 0.75 mi; average width 110 ft, average depth 4.5 ft; first pool above Buckhorn Lake; Buckhorn Quad., Leslie County.
Station 10	From just below mouth of Hell for Certain Creek upstream to first riffle, pool length 0.2 mi, average width 100 ft, average depth 3 ft; pool above Grace Chapel Church; Hayden West Quad., Leslie County.
Station 11	From ribble under Daniel Boone Parkway bridge downstream to first riffle (at powerline); pool length 0.5 mi, average width 140 ft, average depth 2 ft; pool at Dryhill, Hyden West Quad., Leslie County.
Station 12	From riffle under Daniel Boone Parkway bridge upstream to first riffle; pool length 0.4 mi, average width 100 ft, average depth 1.5

ft; located above first riffle above Dryhill; Hyden West Quad., Leslie County.

Table 4. Locations of pools sampled by electrofishing during 1982 and 1983 on the North Fork Kentucky River.

Station 1	From mouth of North Fork (confluence with South Fork at Beattyville upstream to riffle at mouth of Laurel Branch above Airedale; pool length 8.1 mi, average width 151.4 ft, average depth 6.9 ft; Beattyville Quad., Lee County.
Station 2	From ford at mouth of Little Rock Lick Creek upstream to riffle at mouth of Lower Crooked Shoal Branch; pool on west side of Spencer Bend; pool length 1.9 mi, average width 95 ft, average depth 4.9 ft Tallega and Compton Quad., Breathitt County.
Station 3	From ford at mouth of Howards Creek upstream to first riffle 0.3 mi below Copeland; pool length 0.96 mi, average width 81 ft, average depth 2.2 ft; Haddix and Canoe Quad., Breathitt County.
Station 4	From Fishtrap Shoals at mouth of Sugar Branch downstream to riffle just above Strong Branch; pool located in Stidham Bend at Barwick; pool length 1.8 mi, average width 88 ft, average depth 2.4 ft; Krypton Quad., Breathitt County.
Station 5	From ford across from Krypton, downstream to first riffle; pool length 0.2 mi, average width 87.6 ft, average depth 2.7 ft; Krypton Quad., Perry County.
Station 6	From riffle at ford across from Krypton, upstream to first riffle just below mouth of Meadow Branch; pool length 1.15 mi average width 82.6 ft, average depth 2.3 ft; Krypton Quad., Perry County.
Station 7	From riffle at bridge at mouth of Jake Campbell Branch upstream to first riffle below mouth of Rocklick Branch across from Dunraven; pool length 0.77 mi, average width and depth undetermined; however, shallow and silted conditions present; Krypton Quad., Perry County.
Station 8	From riffle at Viper at mouth of Maces Creek upstream over one deep riffle to first impassable riffle in second bend in river above Viper; pool length 1.24 mi, average width 105.5 ft, average depth 2.9 ft; Hazard South Quad., Perry County.
Station 9	From riffle in second bend in the river above Viper, upstream to first riffle barrier below ford; pool length 0.58 mi, average width 83.4 ft, average depth 2.5 ft; Vicco and Hazard South Quad., Perry County.
Station 10	From riffle between mouth of Big Branch and bridge at Fusonia upstream to riffle just below swinging bridge below Fort Branch; pool length 0.95 mi, average width 97.3 ft, average depth 3.0 ft; Vicco Quad., Perry County.

Table 5. Locations of pools sampled by electrofishing during 1984 on Troublesome Creek in Breathitt and Perry counties.

Station 1	Upstream from access at ford at Benchmark 767 off Highway 476 to first riffle; pool length 0.3 mi, average width 50 ft, max. depth 4 ft, average depth 1.9 ft; sampled June 5; Haddix Quadrangle, Breathitt County.
Station 2	Upstream from access at ford at mouth of Barge Creek to first shoal pool length 0.7 mi, average width 41.6 ft, average depth 1.6 ft, maximum depth 4.0 ft; sampled June 6; Haddix Quad., Breathitt County.
Station 3	Above ford off Highway 476, 0.25 mi upstream from Clayhold bridge; pool length 0.3 mi, average width 40.3 ft, average depth 2.1 ft, maximum depth 3.0 ft, sampled June 6; Haddix Quadrangle, Breathitt County.
Station 4	Pool above low-water bridge at mouth of Fugate Creek; pool length 0.7 mi, average width 65 ft, average depth 2.30 ft, maximum depth 7.5 ft; sampled June 6; Noble Quadrangle, Breathitt County.
Station 5	At ford at mouth of Upper Beaverdam Branch, about 1 mi southeast of county line; pool length 0.4 mi, average width 35 ft, average depth 1.0 ft, maximum depth 2.0 ft; sampled June 7; Noble Quadrange, Perry County.
Station 6	At second ford below Rowdy Post Office, at mouth of Cat Hollow; pool length 0.4 mi, average width 35 ft, average depth 2.33 ft, maximum depth 5 ft; sampled June 7; Noble Quadrangle, Perry County.
Station 7	Pool upstream from ford at mouth of Durg Branch; pool length 0.2 mi, average width 56.7 ft, average depth 1.6 ft, maximum depth, 3.0 ft; sampled June 7; Noble Quadrangle, Perry County.
Station 8	Pool upstream from ford at mouth of McGilton Branch; pool length 0.3 mi, average width 53.3 ft, average depth 2.3 ft, maximum depth 5.0 ft; sampled June 8; Noble Quadrangle, Perry County.

Table 6. Muskellunge captured or seen by electrofishing at Licking River and Middle Fork Kentucky River in 1982.

Station number	Total length (mi)	Total mi of shoreline sampled	Date	Length (in)	Weight (lb)	Musky seen but not boated (no.)	Musky seen but not boated (in)
Licking River							
7	0.25	1.0	May 18	21.2	2.18		
				21.8	2.63	1	20
Middle Fork Kentucky River							
11	0.50	2.0	Jul 28			1	30
8	1.62	6.5	May 19	16.8	0.79	1	25
						2	--
7	2.00	8.0	Aug 04	21.2	2.08		
				25.1	3.20		
				19.4	1.30		
						1	20

Table 7. Muskellunge captured or seen by electrofishing at Licking River and Middle Fork Kentucky River in 1983.

Station number	Pool length (mi)	Total mi of shoreline sampled	Number muskellunge per mi	Date	Length (in)	Weight (lb)	Tag number	Muskellunge seen but not boated (no.)	Muskellunge seen but not boated (in)
Licking River									
1	1.75	3.5	0.3	11/21	30.2	8.04	383		
Middle Fork									
7	2.0	4.0	1.0	06/29	25.0	3.52			
					28.8	6.06			
					30.2	7.15	389		
					26.1	4.13		1	14
8	1.62	3.2	2.2	06/28	23.5	3.73			
					27.8	5.42		1	40
					31.4	7.19	388	1	50
					33.7	9.80	355		
					24.5	3.65			
					20.1	1.57			
					15.6	0.69		3	25

Table 8. Muskellunge catch and length distribution from total sampling effort of electrofishing at Licking River, Middle Fork Kentucky River, and North Fork Kentucky River in 1982.

Stream	17	19	21	22	25	Number of fish	Fish per hour	Fish per mile
Licking River			1	1		2	0.4	0.4
Middle Fork	1	1	1		1	4	0.2	0.3
North Fork						0	0.0	0.0

Table 9. Muskellunge catch and length distribution from total sampling effort of electrofishing at Licking River, Middle Fork Kentucky River, and North Fork Kentucky River in 1983. Sampling of Troublesome Creek was done in 1984 only.

Stream	Inch group										Number of fish	Fish per hour	Fish per mile
	16	20	24	25	26	28	29	30	31	34			
Licking River								1			1	0.3	0.2
Middle Fork	1	1	1	2	1	1	1	1	1	1	11	0.6	0.8
North Fork											0	0.0	0.0
Troublesome Creek											0	0.0	0.0

Table 10. Muskellunge mark and recapture results at the upper Licking River and Middle Fork Kentucky River.

Year	Stream	No. of fish marked	Recapture	
			No. of unmarked fish	No. of marked fish
1982	Licking River	2	0	1
	Middle Fork Kentucky River	3	1	0
1983	Licking River	1	0	0
	Middle Fork Kentucky River	5	6	0

Table 11. Physical characteristics of pools in each stream that were sample sites and the number of muskellunge captured and observed in each pool. Pools are numbered by location from the lower to upper sample sites. Numbers in parenthesis indicate number of years sampled.

	Muskellunge numbers		Mean depth	Maximum depth	Mean width	Length	Gradient
	Muskellunge numbers						
	Captured	Observed	(ft)	(ft)	(ft)	(mi)	(ft/mi)
Licking River							
1 (2)	1	0	4.0	7	64	1.8	1.6
2 (2)	0	0	2.0	4	65	1.1	1.6
3 (2)	0	0	2.5	6	50	0.3	2.3
4 (2)	0	0	1.5	4	60	0.1	2.3
5 (2)	0	0	1.7	3	46	1.3	2.5
6 (2)	0	0	2.0	3	20	0.1	3.3
7 (2)	2	1	1.0	3	35	0.3	3.8
8 (2)	0	0	3.0	4	35	0.4	3.8
Mean			2.2	4.2	47	0.7	2.6
Middle Fork Kentucky River							
1 (2)	0	0	4.6	8	85	3.1	2.0
2 (2)	0	0	2.5	4	80	1.0	2.2
3 (2)	0	0	2.1	3	78	1.6	2.2
4 (2)	0	0	3.1	6	91	1.2	2.1
5 (2)	0	0	3.0	4	65	2.0	2.1
6 (2)	0	0	2.9	7	115	1.6	2.1
7 (2)	3	1	3.3	6	100	0.9	2.1
8 (2)	8	8	3.2	7	80	0.3	2.5
9 (2)	4	1	3.7	9	110	0.5	3.2
10 (2)	0	0	3.4	5	100	0.2	3.2
11 (2)	0	1	3.3	7	140	0.5	3.2
12 (2)	0	0	2.2	5	64	0.4	3.2
Mean			3.1	6	92	1.1	2.5
North Fork Kentucky River							
1 (1)	0	0	6.9	18	151	8.1	1.4
2 (2)	0	0	4.8	8	95	1.9	1.8
3 (2)	0	0	2.2	5	81	1.0	2.5
4 (2)	0	0	2.4	4	88	1.8	2.5
5 (2)	0	0	2.7	8	88	0.2	2.6
6 (2)	0	0	2.3	8	83	1.2	2.6
7 (2)	0	0	1.0	2	80	0.8	2.6
8 (2)	0	0	2.9	10	105	1.2	4.4
9 (2)	0	0	2.5	8	83	0.6	4.4
10 (2)	0	0	3.0	8	97	1.0	4.4
Mean			3.1	8	95	1.8	2.9
Troublesome Creek							
1 (1)	0	0	1.9	4	50	0.3	4.9
2 (1)	0	0	1.6	4	42	0.7	4.9
3 (1)	0	0	2.1	3	40	0.3	4.9
4 (1)	0	0	2.3	8	65	0.7	3.8
5 (1)	0	0	1.0	2	35	0.4	3.8
6 (1)	0	0	2.3	5	35	0.4	3.8
7 (1)	0	0	1.6	3	57	0.2	7.5
8 (1)	0	0	2.3	5	53	0.3	7.5
Mean			1.9	4	47	0.4	5.1

Table 12. Age and growth (in) of muskellunge taken from Licking River and Middle Fork Kentucky River during 1982.

Stream	Number of fish	Year class	Age 1	Age 2	Age 3
Licking River	2	1980	12.1	18.6	
Middle Fork	2	1980	11.4	15.1	
	2	1979	9.1	14.1	18.2
Mean			10.2	14.6	18.2

Table 13. Age and growth (in) of muskellunge taken from Licking River and Middle Fork Kentucky River during 1983.

Stream	Number of fish	Year class	Age 1	Age 2	Age 3	Age 4
Licking River	1	1979	10.9	13.8	20.9	25.9
Middle Fork	1	1982	12.6			
	1	1981	13.8	18.2	21.6	
	4	1980	12.7	16.3	21.6	
	5	1979	11.7	16.6	22.7	27.5
Mean			12.7	17.0	22.2	27.5

Table 14. Age and growth (in) of muskellunge, harvested by anglers at the Middle Fork Kentucky River from March 1983 through April 1984.

Date harvested	Weight (lb)	Year class	Age 1	2	3	4	5	6	7
March 1983	13.0	1976	10.2	15.3	19.4	24.6	28.7	33.4	37.5
April 1983	10.0	1977	12.3	15.9	22.6	26.8	30.9	34.0	
April 1984	9.5		(Total length 24.0 in; no scales available)						
Mean			11.2	15.6	21.0	25.7	29.8	33.7	37.5

Table 15. Mean growth (in) of muskellunge from electrofishing studies and mail-in survey.

Stream	Number of fish	Age 1	2	3	4	5	6	7
Licking River	3	11.5	16.2					
Middle Fork Kentucky River	17	11.4	15.7	20.5	26.6	29.8	33.7	37.5

Table 16. Fish collected by station number from Licking River, Middle Fork Kentucky River, and North Fork Kentucky River while electrofishing during 1982 and 1983. Troublesome Creek was sampled in 1984 only.

	Licking River Stations								Middle Fork Stations												North Fork Stations									Troublesome Creek Stations							
	8	7	6	5	4	3	2	1	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
American brook lamprey			X				X												X																			
Lethenteron wilderi																																						
Unidentified lamprey																						X																
Longnose gar									X	X			X	X	X	X				X	X	X	X	X				X				X				X	X	X
Lepisosteus osseus																																						
Gizzard shad		X	X	X	X	X	X	X	X	X	X	X		X	X	X		X		X									X	X	X	X			X	X
Dorosoma cepedianum																																						
Rainbow trout													X																									
Salmo gairdeneri																																						
Muskellunge		X						X					X	X																								
Esox masquinongy																																						
Central stoneroller	X																																				X	
Campostoma anomalum																																						
Goldfish														X																								
Carassius auratus																																						
Carp	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X				X	X	X	X	X	X	X		X	X	X							
Cyprinus carpio																																						
Silverjaw minnow																								X				X							X	X		
Ericymba buccata																																						
Bigeye chub																												x										
Hybopsis amblops																																						
Streamline chub				X												X	X	X																				
Hybopsis dissimilis																																						
Silver chub	X	X	X			X	X										X												X								
H. storeriana																																						
River chub						X							X																							X		
Nocomis micropogon																																						
Emerald shiner	X	X				X					X	X	X				X	X	X		X			X				X	X								X
Notropis atherinoides																																						
Striped shiner	X	X	X		X											X	X	X	X				X					X				X	X	X	X	X	X
N. chrysocephalus																																						
Popeye shiner																	X																					
N. ariommus																																						
Rosyface shiner																												X							X	X	X	X
N. rubellus																																						
Mimic shiner																																			X	X		
N. volucellus																																						
Silver shiner	X						X		X		X			X	X	X	X	X	X			X	X				X	X				X		X			X	
N. photogenis																																						
Spotfin shiner							X		X	X	X	X		X							X	X	X		X				X							X		
N. spilopterus																																						

	Licking River Stations								Middle Fork Stations												North Fork Stations										Troublesome Creek Stations							
	8	7	6	5	4	3	2	1	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Sand shiner																				X			X		X			X					X		X				
N. straurineus																																						
Redfin shiner	X																																					
N. umbratilus																																						
Steelcolor shiner																								X							X			X			X	X
N. whipplei																																						
Bluntnose minnow	X	X			X						X	X	X			X	X	X				X						X	X	X		X			X	X	X	
Pimephales notatus																																						
Creek chub																	X																					
Semotilus atromaculatus																																						
River carpsucker														X							X				X		X	X											
Carpiodes carpio																																						
Quillback carpsucker		X								X				X	X						X	X	X	X	X		X				X				X			
C. cyprinus																																						
Highfin carpsucker		X								X		X									X	X	X		X		X	X				X						
C. velifer																																						
White sucker	X	X	X													X		X															X					
Catostomus commersoni																																						
Northern hog sucker	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Hypentelium nigricans																																						
Bigmouth buffalo		X	X					X																														
Ictiobux cyprinellus																																						
Smallmouth buffalo								X																														
I. bubalus																																						
Spotted sucker	X		X	X									X	X	X		X													X								
Minytreama melanops																																						
River redhorse								X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X										
Moxostoma carinatum																																						
Silver redhorse	X			X	X		X	X																														
M. anisurum																																						
Golden redhorse	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M. erythrurum																																						
Black redhorse																X	X	X													X	X	X	X	X		X	
M. duquesnei																																						
Shorthead redhorse				X	X			X									X	X	X			X	X		X	X	X	X	X	X	X		X	X	X	X	X	X
Moxostoma macrolepidotum																																						
Channel catfish				X	X		X		X		X	X	X	X	X		X				X	X	X	X	X	X	X	X	X	X		X						X
Ictalurus punctatus																																						
Brindled madtom																												X										
Noturus miurus																																						

	Licking River Stations								Middle Fork Stations												North Fork Stations										Troublesome Creek Stations							
	8	7	6	5	4	3	2	1	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Flathead catfish								X				X										X	X				X	X	X		X								
Pylodictus olivaris																																						
Brook silverside						X	X	X					X					X										X										
Labidesthes sicculus																																						
White bass										X			X				X																					
Morone chrysops																																						
Rock bass	X	X	X		X		X		X								X	X														X	X		X	X	
Ambloplites rupestris																																						
Green sunfish	X																																					
Lepomis cyanellus																																						
Warmouth																														X								
Lepomis gulosus																																						
Bluegill	X	X	X	X	X	X	X				X	X	X	X	X	X	X				X	X	X					X		X								
L. macrochirus																																						
Longear sunfish	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
L. megalotis																																						
Smallmouth bass														X	X	X	X	X				X	X		X		X	X	X		X	X	X	X	X	X	X	X
Microplenus dolomieui																																						
Spotted bass	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M. punctulatus																																						
Largemouth bass	X			X					X	X		X	X	X	X								X						X	X								
M. salmoides																																						
White crappie			X	X			X	X					X	X									X															
Pomoxis annularis																																						
Black crappie														X									X	X	X													
P. nigromaculatus																																						
Greenside darter																											X											
Percina blennioides																																						
Logperch			X			X	X				X	X	X			X	X			X			X	X		X	X	X					X		X	X	X	X
P. caprodes																																						
Channel darter																												X	X									
P. copelandi																																						
Gilt darter																												X										
P. evides																																						
Blackside darter			X										X		X	X	X							X	X		X	X					X					
P. maculata																																						
Dusky darter																X												X	X									
P. sciera																																						

	Licking River Stations								Middle Fork Stations												North Fork Stations										Troublesome Creek Stations							
	8	7	6	5	4	3	2	1	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Banded darter *Etheostoma zonale*																												X										
Rainbow darter *E. caeruleum*																												X										
Johnny darter *E. nigrum*																												X									X	
Sauger *Stizostedion canadense*																X	X	X	X	X																		
Freshwater drum *Adodinotus grunniens*		X		X	X	X			X	X	X	X	X	X	X	X				X				X	X		X	X	X									

Table 17. Fish species and relative abundance at Licking River. Total time for fish population sampling was 4.5 hours; 5.6 hours were sampled for muskellunge in 1982.

Species	Inch group																								Number of fish	Fish per hour
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	25	26	27	
American brook lamprey						1																				1	0.2
Gizzard shad		6	79	39	72	83	34	7	6	1	1	1														329	73.1
Muskellunge																				2						2	0.4[a]
Carp								1			1	6	14	23	32	32	26	23	7	3	6	6	2	1	2	185	41.1
Streamline chub			1	7	2																					10	2.2
Silver chub		4	3	1																						8	1.8
River chub			1																							1	0.2
Emerald shiner	4	4	2																							10	2.2
Striped shiner	4	25	8	3	1	1																				42	9.3
Silver shiner		4																								4	0.9
Redfin shiner	1																									1	0.2
Bluntnose minnow	10	5																								15	3.3
Quillback carpsucker															14	2										16	3.6
Highfin carpsucker																1										1	0.2
White sucker			4	9	7	5			1																	26	5.8
Northern hog sucker	1	3	11	4	11	3																				33	7.3
Bigmouth buffalo													1	2	3	1										7	1.6
Spotted sucker			1	7		3		1		2	1	2														17	3.8
River redhorse																			1							1	0.2
Golden redhorse			1	5	3	6	27	16	20	13	5	5	3	3	2	2										111	24.7
Shorthead redhorse								1				1														2	0.4
Channel catfish											1		2				1									4	0.9
Flathead catfish								1																		1	0.2
Brook silverside		9																								9	2.0
Rock bass				1		1	1																			3	0.7
Bluegill			2		3	1																				6	1.3
Longear sunfish		4	2	6																						12	2.7
Spotted bass	1			3	1	3	4	3	2	2	1		2													22	4.9
Largemouth bass		1																								1	0.2
White crappie					3	1		2																		6	1.3
Logperch			1																							1	0.2
Blackside darter		1																								1	0.2
Freshwater drum						5	1		1	1	3	2														13	2.9
Total																										901	

[a]Number per hour for muskellunge collected during fish population sampling plus time spent electrofishing for muskellunge only.

Table 18. Fish species and relative abundance at Licking River. Total time for fish population sampling was 3.3 hours. A total of 3.8 hours was spent electrofishing for muskellunge in 1983.

Species	Inch group																							Number of fish	Fish per hour
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	30		
American brook lamprey						1	2																	3	0.9
Gizzard shad		1	3	5	24	50	34	19	4		1													141	42.7
Muskellunge																							1	1	0.3
Carp									1				1	3	3	7	3	5	3	2	2	1		31	9.4
Silver chub				3	5																			8	2.4
Spotfin shiner		2																						2	0.6
Striped shiner		4	4	6	5	3																		22	6.6
Silver shiner		3	1																					4	1.2
Redfin shiner	1																							1	0.3
Central stoneroller			1		1																			2	0.6
Bluntnose minnow	4	6																						10	3.0
White sucker				51	24	17	4	2		1														99	30.0
Northern hog sucker		1			6	1	1																	9	2.7
Spotted sucker						4	1	1	1			1												8	2.4
Shorthead redhorse											2		1											4	1.2
Silver redhorse								2	2	1		1	1				1							8	2.4
Golden redhorse			1	1		4	10	11	9	6	2													44	13.3
Smallmouth buffalo																	1							1	0.3
Bigmouth buffalo														3										3	0.9
Channel catfish											1		1			1								3	0.9
Brook silverside		1																						1	0.3
Rock bass	1		1	1	1		1	1																6	1.8
Bluegill	1	5	1	4	7																			18	5.4
Longear sunfish		1	4	1	2																			8	2.4
Green sunfish				1																				1	0.3
White crappie					2	1																		3	0.9
Spotted bass	1	1		2	5	2	2	2	2	1		1												19	5.8
Largemouth bass								1																1	0.3
Logperch			2																					2	0.6
Freshwater drum							3	4	1	2				1	2									13	3.9
Total																								526	

t < 0.5%.

[a]Fish per hour for muskellunge was determined by total time spent electrofishing for muskellunge.

Table 19. Fish species and relative abundance at Middle Fork Kentucky River. Time spent collecting fish samples was 10.3 hours; a total of 25.0 hours was spent electrofishing for muskellunge in 1982.

Species	Inch group																							Number of fish	Fish per hour
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
American brook lamprey							1																		1	0.1
Longnose gar											1		2	1	1	3	5	6	3	2					24	2.3
Gizzard shad	290	28	1			1		5	18	69	20	1		1	1										435	42.2
Rainbow trout							1																		1	0.1
Muskellunge															1			1		1				1	4	0.2[a]
Goldfish							1																		1	0.1
Carp									2	5	2	1	3		2	9	5	2	2	3	3	2	3		44	4.3
Streamline chub			2	1																					3	0.3
Silver chub			1																						1	0.1
River chub			1																						1	0.1
Emerald shiner	3	11																							14	1.3
Striped shiner				3																					3	0.3
Silver shiner	2	18	7	4																					31	3.0
Spotfin shiner	1	10	5																						16	1.5
Bluntnose minnow	2	2																							4	0.4
Creek chub						1																			1	0.1
River carpsucker									1																1	0.1
Quillback carpsucker										1				1											2	0.2
White sucker									1																1	0.1
Northern hog sucker	1	2	2	9	10	10	4	3		1		1													43	4.1
Spotted sucker							1			1															2	0.2
River redhorse						3	8	5	1		2	6	1												26	2.5
Golden redhorse	1	5	11	43	33	227	141	20	32	56	46	28	12	6	1										662	64.3
Shorthead redhorse						1		4	1	1		1	1												9	0.9
Channel catfish						2	3	3			3	2		2											15	1.4
Brook silverside	1	1																							2	0.2
White bass								1	1																2	0.2
Rock bass				1				1																	2	0.2
Bluegill	10	5	11	4																					30	2.9
Longear sunfish	10	11	16	10	3																				50	4.8
Smallmouth bass			1	2		1	1	1	1					1											8	0.7
Spotted bass		1	1	3	2	7	5	3	1	1															24	2.3
Largemouth bass						1			3			2													6	0.6
White crappie			1	1																					2	0.2
Logperch	1	2	3																						6	0.6
Blackside darter	1	1	1																						3	0.3
Sauger					1	4	1																		6	0.6
Freshwater drum					1		5	7	4	3	3	2													25	2.4
Total																									1,511	

[a]Muskellunge numbers per hour includes time spent collecting fish samples as well as all time spent electrofishing for muskellunge only.

Table 20. Fish species and relative abundance at Middle Fork Kentucky River. Time spent collecting fish samples was 10.9 hours; a total of 19.9 hours was spent electrofishing for muskellunge in 1982.

Species	Inch Group																														Number of fish	Fish per hour
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	28	29	30	31	32	34		
Longnose gar															3	2	6		2	1	2	1											12	1.6
Gizzard shad			1	12	51	45	2		3	4	32	35	11	2		1																	199	18.3
Muskellunge																1				1				1	2	1	1	1	1	1		1	11	0.6[a]
Carp						1		2	1	1		2	3	1	4	1	1	2	2	2	2	7	4	3	3								42	3.8
Streamline chub				1																													1	0.1
Emerald shiner	1	11	10	4																													26	2.4
Silver shiner		3	8	4	1																												16	1.5
Spotfin shiner			2	1																													3	0.3
Sand shiner	2																																2	0.2
Striped shiner			2	1	2																												5	0.5
Popeye shiner		3																															3	0.3
Bluntnose minnow	3	5	3																														11	0.6
Quillback carpsucker												1	3																				4	0.4
Highfin carpsucker													1				1																2	0.2
White sucker									1																								1	0.1
Northern hog sucker		1	2	7	9	8	4	3	5	3	5	1																					48	4.4
Spotted sucker									2			2																					4	0.4
Golden redhorse			7	7	3	5	46	58	62	29	22	21	11	11	2																		284	26.1
River redhorse										2			1		1																		4	0.4
Black redhorse							1		2	7	2																						12	1.1
Shorthead redhorse										1	3		3																				7	0.6
Channel catfish									1		2	2	3	1		2		1	2														14	1.3
Flathead catfish																																1	1	0.1
Brook silverside			1	1																													2	0.2
White bass									1																								1	0.1
Rock bass					1		1																										2	0.2
Bluegill		7	6	10	5																												28	2.6
Lognear sunfish		5	7	16	20	3																											51	4.7
Smallmouth bass										1		1																					2	0.2
Spotted bass		1	4		3	6	5	3	7	3	1																						33	3.0
Largemouth bass				1	1			2		2	2	2	3																				13	1.2
White crappie			1																														1	0.1
Black crappie								1																									1	0.1
Sauger									1	1																							2	0.2
Logperch			1	6																													7	0.6
Blackside darter			3																														3	0.3
Dusky darter			2																														2	0.2
Freshwater drum							2	8	8	14	10	5		3		2						1											53	4.9
Total																																	918	

[a]Muskellunge captured during time spent collecting fish samples as well as all time spent electrofishing for muskellunge only.

t < 0.5%.

Table 21. Fish species and relative abundance at North Fork Kentucky River. A total of 21.0 hours of electrofishing was performed in 1982.

Species	Inch group																												Number of fish	Fish per hour
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
Longnose gar								1		1						1	1		1	3										8	0.4
Gizzard shad				1		1							1																	3	0.1
Carp														1			1			1	1	5	2	7	1	1	1	2	1	24	1.1
Silverjaw minnow	1																													1	0.1
Striped shiner	2																													1	0.1
Silver shiner		2		1																										3	0.1
Spotfin shiner		1	1																											2	0.1
Sand shiner	4																													4	0.2
Steelcolor shiner		5																												5	0.2
Emerald shiner	1																													1	0.1
Bluntnose minnow		1																												1	0.1
River carpsucker													2		1															3	0.1
Quillback carpsucker								1		1	2	4	3	2	1															14	0.7
Highfin carpsucker										1	3	2	8	2																16	0.8
Northern hog sucker							11	8	4	2		2																		27	1.3
Spotted sucker							1																							1	0.1
River redhorse		2		1		1		3	12	7	2	6	1	1		1		1		1			1							40	1.9
Golden redhorse	1	1		2	14	47	59	89	72	16	13	11	26	17	5	1	4													378	18.0
Shorthead redhorse								5	9	1	1																			16	0.8
Channel catfish					1	1		5	14	7	5	3	9	5	6	6	4	1	1		1									69	3.3
Flathead catfish							1	1	1																					3	0.1
Warmouth				1																										1	0.1
Bluegill		1		2	1	2																								6	0.3
Longear sunfish		10	10	19																										39	1.9
Smallmouth bass		1			1		1	1	2		1																			7	0.3
Spotted bass	1	4	1	3	12	17	24	14	6	4	5	8	2																	101	4.8
Largemouth bass										1		1	1																	3	0.1
White crappie									1																					1	0.1
Black crappie						2		1																						3	0.1
Logperch		1	1	4																										6	0.3
Blackside darter		1																												1	0.1
Freshwater drum												2	2	2	1	1				1										9	0.4
Total																														789	

Table 22. Fish species and relative abundance at North Fork Kentucky River. A total of 7.3 hours of electrofishing was performed in 1983; 96 hours for muskellunge.

Species	Inch group																											Number of fish	Fish per hour
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24	26	27	29	30	32		
Longnose gar												1					3		1	3									13	1.1
Gizzard shad												1		2															3	0.4
Unknown lamprey						1																							1	0.1
Carp								1												1	1	1		2	2	1	1	1	11	1.5
Bluntnose minnow		27	8																										35	4.8
Silverjaw minnow		2																											2	0.3
Silver chub					1																								1	0.1
Bigeye chub		4																											4	0.5
Emerald shiner		33	13	1																									47	6.4
Spotfin shiner		1	6	1																									8	1.1
Rosyface shiner		5																											5	0.7
Sand shiner	165																												165	22.6
Striped shiner	1																												1	0.1
Silver shiner		1	5	1																									7	1.0
Highfin carpsucker											1	2	6	10	3														22	3.0
Quillback carpsucker													4	7	3	1		1											16	2.2
River carpsucker														1	1	1													3	0.4
Northern hog sucker						3	1	3	1	5	3	3	1																20	2.7
Golden redhorse		3	1			3	2	7	14	23	20	52	42	14	16	9	1	1	1	1		1							211	28.9
River redhorse											1	1	2	3		1					1								9	1.2
Shorthead redhorse			1	1			1	1	3		8	17	5	1	2														40	5.5
Channel catfish	1									3	2	5	2	3		1	5		1	1									24	3.3
Flathead catfish						1									1	1			1										4	0.5
Brindled madtom			1																										1	0.1
Brook silverside			1																										1	0.1
Spotted bass		48	129	17	2	1	4	5	14	8	2	2	2	1															235	32.2
Smallmouth bass		2	9	2				2			1		2																18	2.5
Longear sunfish		4	4	7	3	4																							22	3.0
Bluegill				1	1																								2	0.3
Logperch			10		3	1																							14	1.0
Channel darter		8																											8	1.1
Dusky darter		11	3																										14	1.9
Greenside darter		2																											2	0.3
Banded darter		3																											3	0.4
Rainbow darter		1																											1	0.1
Johnny darter		1																											1	0.1
Gilt darter		1																											1	0.1
Blackside darter		7	4																										11	1.5
Freshwater drum														2	2	1				1									6	0.8
Total																													987	

t < 0.5%.

Table 23. Fish species and relative abundance at Troublesome Creek. Total time for fish population sampling was 4.6 hours in 1984.

Species	Inch group																			Number of fish	Fish per hour
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22		
Longnose gar																1	1	3	2	7	1.6
Gizzard shad					1	18		1	1											21	4.7
Central stoneroller		4																		4	0.9
Carp																	1			1	0.2
Silverjaw minnow	2																			2	0.4
Bigeye chub	5																			5	1.1
River chub		1																		1	0.2
Silver shiner		1	2	1																4	0.9
Emerald shiner		1																		1	0.2
Striped shiner	2	4	4	1																11	2.4
Steelcolor shiner	1	5	3	1																10	2.2
Spotfin shiner		1																		1	0.2
Rosyface shiner	6	1																		7	1.6
Mimic shiner	7																			7	1.6
Sand shiner	2																			2	0.4
Bluntnose minnow	14	4																		18	4.0
Quillback carpsucker							1				3	3	2	1						9	2.0
Highfin carpsucker					3															5	1.1
White sucker									1											1	0.2
Northern hog sucker		1	3		2	4	6	4	2											22	4.9
Golden redhorse		9	18		3	13	59	163	117	38	21	15	6	2	2					466	103.6
Shorthead redhorse								1	11	3										15	3.3
Black redhorse							2	7	8	1	1									19	4.2
Channel catfish									1			1			1		1			4	0.9
Flathead catfish													1							1	0.2
Rock bass				2		1	5	1												9	2.0
Longear sunfish	1	6	15	9	1															32	7.1
Smallmouth bass						1		2	2	3	2	1								11	2.4
Spotted bass		1	1	5	7	1	2	7	7	2	1									34	7.6
Largemouth bass						1														1	0.2
Logperch		2		1																3	0.7
Blackside darter		1																		1	0.2
Johnny darter	2																			2	0.4
Total																				737	163.8

Table 24. Basic and mean physical characteristics of the four muskellunge study streams.

	Upper Licking River	Middle Fork Kentucky River	North Fork Kentucky River	Troublesome Creek
Stream length (mi)	82.0	92.0	161.0	35.5
Order	VI	V	VI	V
Gradient (ft/mi)	3.3	7.0	3.8	6.2
Fish shelter	abundant; logs, brush, undercut banks	medium; undercut banks, logs, brush	medium; logs, brush, undercut banks	medium; undercut banks, boulders, logs
Riparian zone (m)	10-20	13-23	15-25	13-23
Shade (%)	50-75	15-30	10-30	14-30
Pool bottom type	silt, muck, detritus	silt, rubble, detritus	boulder, large rubble, small rubble	sand, fine gravel, silt
Riffle bottom type	small rubble, large rubble, coarse gravel	large rubble, small rubble, course gravel	boulder, large rubble, small rubble	small rubble, coarse gravel, large rubble
Pool-Riffle ratio (%)	65-35	75-25	75-25	55-45

Table 25. Water quality determinations for the Licking River, Middle Fork Kentucky River, and North Fork Kentucky River during 1982.

	Licking River			Middle Fork			North Fork		
	Lower	Middle	Uppper	Lower	Middle	Upper	Lower	Middle	Upper
Water temperature (F)									
Spring	68	71	75	71	70	66	74	76	71
Summer	72	73	76	73	75	74	73	75	70
Fall	41	41	43	55	53	50	46	47	49
Dissolved oxygen (ppm)									
Spring	10	10	10	9	11	11	13	11	11
Summer	9	7	8	9	9	10	9	9	12
Fall	12	12	12	11	12	12	13	13	12
Total alkalinity (grams/gal. $CaCO_3$)									
Spring	86	86	68	86	68	51	103	120	205
Summer	86	120	103	86	86	68	103	137	205
Fall	68	103	68	68	68	68	103	103	154
Turbidity (FTU)									
Spring	20	13	10	45	45	25	50	10	10
Summer	38	130	28	10	50	5	20	25	--
Fall	9	19	50	30	10	15	9	10	5
pH									
Spring	7.3	7.9	8.1	7.5	8.0	8.1	8.5	8.4	8.3
Summer	7.2	7.1	7.6	7.8	8.0	8.0	7.3	8.2	8.3
Fall	6.9	6.6	8.5	7.7	7.7	8.0	8.2	8.0	8.5
Salinity (ppt)									
Spring & Summer	--	--	--	--	--	--	--	--	--
Fall	0.03	0.02	0	0.01	0	0	0.01	0	0.01

Table 26. Water quality determinations in the spring (sp), summer (su), and fall (fa) at Licking River, Middle Fork Kentucky River, and North Fork Kentucky River during 1983.

	Temp. (F)			Dissolved oxygen (mg/l)			pH			Total alkalinity (mg/l)			Turbidity (NTU)			Salinity (ppt)			Conductivity (umhos/cm)		
Stream/section	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa
Licking River																					
Lower	70	76	56	10.0	9.0	8.3	7.3	7.6	7.6	68	86	103	18	166	22	0.02	0.01	0.5	325	495	700
Middle	75	80	58	10.0	8.0	5.9	7.3	7.6	7.6	86	103	137	16	146	156	0	0	0.01	255	380	345
Upper	78	77	57	9.0	8.0	3.6	7.5	7.5	7.3	68	120	120	8	22	18	0	0.1	0	160	355	310
Middle Fork																					
Lower	68	77	63	10.0	9.0	8.3	7.2	7.5	7.5	51	68	68	23	22	5	0	0	0	125	210	180
Middle	70	73	65	11.0	10.0	8.8	7.3	7.3	7.8	51	68	68	32	27	16	0	0	0	140	200	200
Upper	64	82	61	12.0	10.0	8.8	7.6	8.3	7.9	51	86	86	6	29	15	0	0.2	0	160	385	278
North Fork																					
Lower	70	80	61	10.0	7.0	8.3	7.7	7.7	8.0	86	120	120	32	70	8	0.01	0	0	350	600	395
Middle	76	82	64	12.0	9.0	9.5	6.6	8.4	8.4	103	154	103	16	11	24	0.01	0.2	0.1	350	750	350
Upper	65	75	62	13.0	7.0	10.2	7.9	8.2	8.9	205	239	223	7	16	21	0.03	0.3	0.03	490	750	650

Table 27. Water quality determinations for Troublesome Creek during 1984, in the spring (sp), summer (su), and fall (fa).

Section	Temp (F)			Dissolved oxygen (mg/l)			pH			Total alkalinity (mg/l)			Turbidity (NTU)			Salinity (ppt)			Conductivity (umhos/cm)		
	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa
Lower	75	76	49	8.4	7.0	10.8	8.4	8.5	8.6	102.6	119.7	103.2	14	33	17	0.02	0.02	0	700	715	380
Upper	72	75	49	7.5	4.6	10.6	7.8	8.5	8.4	119.7	153.9	103.2	14	30	14	0	0	0	465	435	245

Table 28. Number of individuals per taxa, composition, density, diversity ($\bar{d}$), and equitability (e) values for benthic macroinvertebrates collected seasonally at three stations in the upper Licking River in 1983. The total sample from each station is from 2 square meter riffle areas.

	Stations								
	June 13			August 10			October 19		
Taxa	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Decapoda									
Orconectes sp.					3	12			
unidentifiable sp.		13							
Plecoptera									
Perlidae		1							
Phasganophora capitata				6					
Acroneuria sp.								2	
Ephemeroptera									
Stenacron interpunctatum	1	1						10	
Baetis sp.		27			3			5	
B. tricandatus				5		2			
Baetisca sp.		1							
Isonychia sp.		1		3	3	15	8	20	1
Caenis sp.		3				1			
Stenonema sp.		3							
Stenonema vicarium				7	12	32	8	42	13
S. tripunctatum						3			
Pentagenia sp.								1	
Brachycercus sp.									
Odonata									
Stylogomphus albistylis						3			
Boyeria vinosa						1			
Ophiogomphus sp.								1	
Dromogomphus sp.								1	
Lanthus sp.									1
Hemiptera									
Macrovelia sp.				3					
Megaloptera									
Corydalus cornutus				6	1	3	11	8	5
Trichoptera									
Cheumatopsyche sp.		4		8	3	13	82	19	16
Chimarra sp.				1			1		
Lepidoptera									
Pyralidae	1								
Archanara sp.						1		1	
Coleoptera									
Macronychus glabratus		2							
Helichus sp.		2							

Taxa	Stations								
	June 13			August 10			October 19		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Dubiraphia sp.				1					
Stenelmis sexlineata				2		1			
Stenelmis sp.						10		6	22
S. crenata								3	
Optioservus sp.							2		
Unidentified beetle								1	
Psephenus herrickii									1
Diptera									
Chironomidae		2							
Tipula sp.		1					1		
Limnophila sp.						4	4	1	4
Tienemannimyia gp. sp.						2		1	
Hemerodromia sp.							1		1
Prionocera sp.							1		3
Rheotanytarus distmetissimus							1		
Atheris sp.								1	
Tabanus sp.									1
Gastropoda									
Ferrissia sp.							1		
Pelecypoda									
Species 1		1							
Species 2		1							
Total	2	63		42	25	103	121	123	72
Number of taxa	2	15		10	6	15	12	17	12
Diversity ($\bar{d}$)	0.99	2.80		3.06	2.16	3.10	1.82	2.97	2.80
Equitability (e)	1.0	0.6		1.2	1.0	0.8	0.4	0.6	0.8
No. per square meter	1	32		21	12	52	61	62	36

Table 29. Number of individuals per taxa, composition, density, diversity ($\bar{d}$), and equitability (e), values for benthic macroinvertebrates collected seasonally at three stations at the Middle Fork Kentucky River in 1983. The total sample from each station is from 2 square meter riffle areas.

	Stations								
	June 10			August 11			October 21		
Taxa	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Decapoda		1							
Orconectes rusticus			1						
O. putnami						2	1		
Orconectes sp.								1	
Plecoptera									
Isoperla sp.	2								
Ephemeroptera									
Isonychia sp.	2	1				46	2	2	
Baetis bicaudatus	2		19					2	
B. tricaudatus			3						
Stenonema mediopunctatum mediopunctatum	15					2			
S.m. xarwini	2					2			
S. vicarium	22		4		3	12	4	4	
S. exigium					1				
Stenonema sp.			2						
S. tripunctatum							8		
Dannella simplex	1		5						
Baetis sp.						4			
Caenis sp.			2					3	
Ephemera sp.									
Ephemera simulans			4						
Ephemerella sp.			1						
Odonata									
Octogomphus sp.	1								
Stylogomphus albistylus			1			1			
Boyeria vinosa						3			
Dromogomphus sp.								1	
Argia sp.									2
Megaloptera									
Corydalus cornutus	2					2			
Trichoptera									
Cheumatopsyche sp.	4		3		2	20		35	1
Hydroptilidae		1							
Triaenodes sp.					2				
Chimarra sp.								1	
Hydropsyche simulans								2	
Ochrotrichia sp.								6	
Lepidoptera									
Archanara oblonga					1				
Coleoptera									
Stenelmis crenata	1								

Taxa	Stations								
	June 10			August 11			October 21		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Stemelmis sp.	2								9
Psphenus herricki	1		1			3			
Gonielmis sp.			1						
Dubiraphia sp.A						7			
Dubiraphia sp.B						20			
Macronychus sp.									5
Diptera									
*Polypedilum illinoense*l									
Eukiefferiella pseudomontana gp	1								
Parametriocnemus lundbecki	1								
Parametriocnemus sp.	1								
Protoplasa fitchii			1			1			
Hemerodromia sp.			2			7			
Rheotanytarsus exiguus gp					1			4	
Atherix sp.						2			1
Limnophila sp.						2			
Cricotopus tremulus gp.						2		2	
Orthocladius obumbratus						1			
Tanytarsus guerlus						2			
Thienemannimyia gp sp.						2			
Simulium venustrum								1	
Chaoborus punctipennis								1	
Dicrotendipedes neomodestus								4	
Gastropoda									
Elimia semicarinata	1				7	4	2	30	5
Elmia sp.		2	1						
Pleurocera sp.		6							
Campeloma sp.		1							
Pleurocera acuta					1			2	
Pelecypoda									
Corbicula fluminea	3	36			12		25	44	
Total	64	48	52		30	147	42	145	24
Number of taxa	18	7	17		9	22	6	18	7
Diversity ($\bar{d}$)	3.16	1.46	3.32		2.53	3.50	1.77	2.90	2.35
Equitability (e)	0.7	0.4	0.8		0.9	0.7	0.7	0.6	1.0
No. per sq. meter	32	24	26		15	74	21	72	12

Table 30. Number of individuals per taxa, composition, density, diversity ($\bar{d}$), and equitability (e) values for benthic macroinvertebrates collected seasonally at three stations at the North Fork Kentucky River in 1983. The total sample from each station is from 2 square meter riffle areas.

	Stations								
	June 9			August 11			October 20		
Taxa	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Annelida									
Lumbriculus sp.		1				1			
Branchiura sowerbyii				1					
Isopoda									
Lirceus sp.	2								
Decapoda									
Orconectes putnami	1								4
Orconectes sp.						2			
Plecoptera									
Perlesta placida	2								
Acroneuria sp.		3							
Ephemeroptera									
Isonychia pictipes	8								
Caenis sp.	1			17	57		1		
Stenonema sp.	28			7			2	24	
Stenonema mediopunctatum		1	15						
S. interpunctatum		1	6		7				
S. mediopunctatum x arwini			12						
S. vicarium			16						
S. exigium			3						
Isonychia sp.			60	3	1				
Baetis sp.						3			
Baetis tricaudatus			10	8	21				
B. bicaudatus			4						
Stenacron sp.					5				
S. interpunctatum					1				
Tricorythodes sp.								26	
Odonata									
Macromia illinoiensis	1							1	
Progomphus obscurus		1							
Dromogomphus sp.						2			
Megaloptera									
Corydalus cornutus	6		8	14	20		6	9	6
Trichoptera									
Glossosoma sp.	1								
Cheumatopsyche sp.			2	7		4	9	1	97
Hydropsyche simulans			1						
Orthotrichia sp. A				3					
Ochrotrichia sp. B				9					1
Hydroptila sp.							3		
Symphitopsyche chelonis								1	2
Hydropsyche betteni									1

Taxa	Stations								
	June 13			August 10			October 19		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Coleoptera									
Ectopria sp.	1								
Ancyronyx variegatus	1								
Stenelis sp.	1								
Dineutes sp.	1								
Hydrochara sp.		1							
Laccobius sp.							2		
Gonielmis sp.								1	
Diptera									
Bezzia, *Probezzia* sp.	1								
Rheotanytarsus sp.	1								
Tipula sp.	1								
Hemerodromia sp.			2	3	70	7		3	
Thienemannimyia gp sp.			1		7	1		2	1
Rheotanytarsus exiguus gp			2		3	22			
Simulium venustrum								1	
Simulium sp.				2					
Polypedilum illinoense					10				
Polypedilum convictum				6					
Bezzia, *Probezzia*, *Johannasomyia* gp					2				
Crypochironomus fulvus						2			
Orthocladius obumloratus						2			
Cricotopus tremulus gp					2				
C. bicinctus								3	2
C. trifascia gp									6
Ablabesmyia parajanta								2	
Gastropoda									
Elimia sp.	22								
Elimia semicarinata				53			9		
Physa sp.				1					
Physella sp.							5	5	
Pelecypoda									
Corbicula fluminea	15		7	1140			45		
Actinonaias carinata							1		
Total	94	5	152	1274	203	49	83	79	126
Number of taxa	18	5	16	15	11	12	10	13	11
Diversity ($\bar{d}$)	2.99	2.32	3.06	0.80	2.94	2.75	2.28	2.68	1.46
Equitability (e)	0.6	1.4	0.8	0.1	0.8	0.8	0.6	0.7	0.3
No. per square meter	47	2	76	637	102	24	42	40	63

Table 31. Number of individuals per taxa, composition, density, diversity ($\bar{d}$), and equitability (e) values for benthic macroinvertebrates collected seasonally at two stations at Troublesome Creek in 1984. The total sample from each station is from 2 square meter riffle areas.

	Stations								
	June 7			August 3			November 8		
Taxa	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Nematoda									
unidentified spp.			18						
Oligochaeta									
Limnodrilus sp. A	1		3		2				
Lumbriculus sp. B			7						
Dero sp.						2			
Plecoptera									
Acroneuria sp.	1								
Leutra sp.	1								
Taeniopteryx sp.A							12		
Taeniopteryx sp.B							10		
Ephemeroptera									
Drunella cornuta	1								
Tricorythodes sp.	1								
Stenecron interpunctatum	2 1								
Baetis bicaudatus	1								3
Baetis sp.				1		45			
B. tricaudatus	3								
B. propinquus			13						
Stenonema sp.			3						
Isonychia sp.				1					
Caenis sp.									3
Stenonema vicarium									4
Odonata									
Boyeria grafiana						1			
Megaloptera									
Corydalus cornutus	3			6		1			
Trichoptera									
Cheumatopsyche sp.	42		5	10		332	5		98
Coleoptera									
Stenelmis sp.A	4					1	1		
S. crenata	1								
Stenelmis sp.B						1			
Dubiraphia sp.							5		
Diptera									
Dicrotendipes neomodestus	2								
Polypedilum convictum	1								
Rheotanytarsus exiguus	3								

Taxa	Stations								
	June 7			August 3			November 8		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Thienemannimyia gp sp. 1			18						
Cricotopus trifascia gp									
C. tremulus gp sp			18						
C. bicinctus									11
Simulium vittatum			16						
Cardiocladius obscurus			2						
Chironomus halophilus gp									2
C. decous gp									10
Chironomus sp.			3						
Polypdilum illinoense			2						
Limnophila sp.			2		1				1
Chrysops sp.						1			
Hemerodromia sp.						1			1
Endochironomus sp.						1			
Djalmaratista pulcher						1			
Larsia sp.									
Pseudochironomus sp.								1	
Simulium venustrum									6
Diplocladius sp.									1
Tanytarsus exiguus									1
Tabanus sp.									1
Gastropoda									
Elimia semicarinata	162				6			18	
Helisoma anceps					1				
Pleurocera acuta					10				
Physa sp.						1			
Pelecypoda									
Corbicula fluminea	15		1		7			34	
Total	246		111		43	393		89	158
Number of taxa	19		14		9	14		9	16
Diversity ($\bar{d}$)	1.84		3.29		2.70	0.92		2.46	2.24
Equitability (e)	0.3		1.0		1.0	0.1		1.0	0.4
No. per square meter	123		56		22	196		44	79

Table 32. Summation of benthic macroinvertebrate data from muskellunge study streams.

	Upper Licking River (1983)			Middle Fork KY River (1983)			North Fork KY River (1983)			Troublesome Creek (1984)	
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Upper
Mean no. per square meter	28	35	44	26	37	37	242	48	54	63	110
Mean no. of taxa	8	13	14	12	11	15	14	10	13	12	15
Mean diversity	1.95	2.64	2.95	2.46	2.29	3.05	2.02	2.64	2.42	2.33	2.15
Mean equitability	0.9	0.7	0.8	0.7	0.6	0.8	0.4	1.0	0.6	0.8	0.5
Mean diversity/year		2.51			2.60			2.36			2.24
Mean equitability/year		0.8			0.7			0.6			0.7
Mean no. per square meter/year		36			33			115			87