A Post-Impoundment Survey of Kinkaid Creek Fishes

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ABSTRACT

The impoundment of flowing aquatic ecosystems can have substantial physical and biological effects. We report here the results of field work conducted in 1998 and 1999 to determine the effects the 1970 impoundment of Kinkaid Creek in southern Illinois has had on the fish fauna of the Kinkaid Creek drainage. We duplicated the collecting methods of a pre-impoundment survey conducted in 1958 and show drastic shifts in species assemblages within the reservoir. Using other pre- and post-impoundment quantitative collections made in the drainage, we report an increase in the number of species known the Kinkaid Creek drainage of over 40%. Possible explanations for this increase include the introduction and dispersal of non-native fish species and habitat alteration.

INTRODUCTION

The practice of dam building and its subsequent impoundment of flowing waters has been occurring in United States for over 150 years. Between 1930 and 1975 over ten thousand dams were built in this country on rivers and creeks of all sizes (Reisner 1986). Due mainly to the lack of suitable sites and shifts in federal funding priorities, the construction of new dams on large, commercially navigable rivers has significantly dropped off since that time. However, the impoundment of smaller rivers and creeks has continued unabated with several such projects currently under consideration in almost every state. With the increased recognition of native aquatic biodiversity (Master 1990, Lydeard and Mayden 1995) rigorous examination of the effects of habitat altering activities such as river and creek impoundment seems prudent.

Dams are frequently implicated as causes of population decline and extirpation of freshwater fishes (Miller et al. 1989, Allan and Flecker 1993, Page et al. 1997). The following study was conducted to ascertain the effects of impoundment on a small creek fish fauna in southern Illinois. Our goals where to 1) duplicate, as closely as possible, the sampling methodology of the pre-impoundment fish survey (Stegman 1959) and determine if and how changes in diversity and community structure have occurred; and 2) compare Stegman's (1959) faunal list and the results of our sampling efforts with total species lists compiled from other historical collections made in the drainage, both pre- and post-impoundment, to determine if drainage wide changes in diversity have occurred.

The Kinkaid Creek basin drains 135 km^2 of the Shawnee Hills region of extreme southwestern Illinois (Fig. 1). The main channel of Kinkaid Creek is approximately 35.4 km long and is a third order stream at its confluence with the Big Muddy River. Given its hilly nature, the majority of land in the Kinkaid Creek basin has been spared from clearing and is forested. With the exception of some regions to the north and northeast, most of the basin is currently under United States Forest Service or Illinois Department of Natural Resources ownership. In 1970 an earthen dam was placed across Kinkaid Creek approximately 5.3 km upstream of its mouth to form the 1400 hectare Kinkaid Lake for recreational purposes. Average lake depth is 8.8 m and when water surface level is higher than 128 m above sea level, excess water runs over a concrete spillway, down a naturally occurring limestone bluff, and into a 0.4 hectare receiving pool that opens into the downstream section of Kinkaid Creek. To determine its potential as a "fisheries resource", an intensive survey of the Kinkaid Creek basin fish fauna was conducted (Stegman 1959). Stegman sampled a total of five sites during the spring and summer of 1958 using a variety of collecting methods including minnow seines, hoop and fyke nets, electroshocking, and sodium cyanide. Each site was sampled for fishes three times while water quality parameters such as pH, dissolved O_2, and turbidity were measured at each site on four occasions.

MATERIALS AND METHODS

Stegman's (1959) five sites were re-sampled on 2-3 March, 12-13 May, and 15-16 June 1999. Sampling sites were numbered 1 thru 5 and follow Stegman's (1959) numbering scheme. Site 1 was located approximately 3.2 stream kilometers downstream of the dam, sites 2 and 3 were located on an eastern arm of the reservoir, site 4 was located on the reservoir halfway between the upstream confluence of Kinkaid Creek with the reservoir and the dam, while site 5 was located on Kinkaid Creek approximately 1.5 km upstream of its confluence with the reservoir (Fig.1). The collection methods of Stegman (1959) were duplicated as closely as possible at each site, however given changes in habitat since impoundment different methods were imployed at sites 2 through 4. Given its steep banks and deep channel, site 1 was shocked with a 240 volt boat-mounted electrofisher for a period of one half-hour. Two 12.7 mm mesh hoop nets were also baited with chicken liver and set overnight at site 1. Sites 2, 3, and 4 were shocked for one half-hour with a 240 volt boat-mounted electrofisher. Site 5 was sampled with a 3.1 x 1.2 m, 6.4 mm mesh minnow seine and a Smith-Root Model 12 DC backpack electrofisher for periods of one half-hour. Given current restrictions, we could not duplicate Stegman's (1959) one time use of sodium cyanide at sites 2 through 5. Fishes collected at each site were identified and counted and voucher specimens of each species were preserved in the field with 10% formalin and returned for deposition in the Illinois Natural History Survey (INHS) Fish Collection.

A total of 10 additional sites in the Kinkaid Creek drainage (Fig.1) were sampled from one to three times in 1998 and 1999 using a 3.1 x 1.2 m, 6.4 mm mesh or a 3.1 x 1.8, 3.2 mm mesh minnow seine. One of these sites, a large pool at the base of the Kinkaid Lake spillway, was extensively fished using a 2.4 m diameter, 6.4 mm mesh cast net and a standard rod and reel.

Water temperature was measured in the field using a standard mercury thermometer. Dissolved oxygen was measured in the field using a YSI Model 57 D. O. meter. Water samples were also collected at each site and returned to the lab were turbidity was measured by weighing a millipore membrane filter (Type HA, 0.45 micron pore size), running 100 ml of water through it, drying the filter at 105° C for 1 hour, then re-weighing the filter. Values for *p*H were obtained in the lab with a hand held meter (model *p*Hep 3, Hanna Instruments) with a resolution of 0.1 *p*H and accuracy of ±0.1 *p*H. The *p*H meter was calibrated to *p*H 7.0 and *p*H 10.0 standards within 24 hours before each use.

Historical records of fishes known from the Kinkaid Creek drainage other than those collected by Stegman (1959) were compiled by searching the fish collections of INHS, Southern Illinois University at Carbondale, and the University of Michigan Museum of Zoology.

RESULTS

In our duplication of Stegman's (1959) sampling efforts we collected a total 898 fishes of 39 species and one hybrid (Table 1). While the our total number of species collected closely matches Stegman's number (38 plus one hybrid), faunal compositions were different. Thirteen of Stegman's 38 species (34%) and one hybrid were not collected in our sampling, 13 of our 39 species (36%) and one hybrid were not collected in Stegman's pre-impoundment survey (Table 2). Members of the family Centrarchidae dominated our total sample, comprising 54.4% of the total number of fishes collected. *Lepomis macrochirus* was the most abundant species, accounting for 32.7% of the total sample. Cyprinidae was the secondmost common family, making up 21.0% of the total sample while Clupeidae (11.1%), Percidae (3.7%), Catostomidae (3.6%), Atherinidae (1.7%), and Ictaluridae (1.0%) made up the remainder of diversity accounted for by families that comprised at least 1% of the total sample (Fig. 2). Families that individually accounted for less than 1% of the total sample included Fundulidae (0.8%), Amiidae (0.3%), Poeciliidae (0.3%), Moronidae (0.3%), Lepisosteidae (0.2%), and Esocidae (0.1%). Numbers of each species collected at each site are given in Table 1.

When examining relative abundances at individual sites, we combined sites 2, 3, and 4 given the homogenous nature of the lentic habitat found in the reservior. The fish fauna within the reservior was dominated by centrarchids which accounted for 78.6% of all fishes collected. The remaining fauna was comprised of clupeids (14.6%), catostomids (1.6%), ictalurids (1.6%), atherinids (1.2%), percids (0.7%), and moronids (0.4%) (Fig. 3). Upstream of the reservior at site 5 cyprinids accounted for 71.4% of the total sample followed by percids (11.8%), centrarchids (7.1%), catostomids (5.1%), fundulids (1.6%), poeciliids (1.2%), and ictalurids (0.4%) (Fig. 4). Downstream of the reservior at site 1 centrarchids again dominated the fauna accounting for 38.1% of the total sample (Fig. 5). Clupeids (18.5%), catostomids (17.3%), atherinids (9.8%), fundulids (4.9%), cyprinids (3.7%), *Amia calva* (3.7%), lepisosteids (1.2%), esocids (1.2%), and moronids (1.2%) made up the remaining sample (Fig. 5).

When all historical records are examined, a total of 48 species of fishes and one hybrid were recorded from the Kinkaid Creek drainage prior to impoundment (Table 3). Since impoundment of the creek a total of 74 species and two hybrids have been collected in the drainage (Table 4). Six species have not been collected in the drainage since Kinkaid Creek's impoundment, those six are *Carpiodes carpio, Notropis atherinoides, Pimephales promelas, Percopsis omiscomaycus, Micropterus punctulatus, and Percina maculata.* Species collected only after Kinkaid Creek's impoundment total 32 species (Table 4). Of these 32 species, four have been intentionally introduced into Kinkaid Lake for fisheries purposes (Table 4).

A comparison in three water quality parameters, dissolved oxygen (D. O.), turbidity, and pH, taken by Stegman (1959) and us revealed only slight differences between data sets (Table 5). Based on D. O., turbidity, and pH values reported for freshwater across Illinois, both data sets do not appear to be abnormal. Variation in turbidity values between data sets may be attributable to differences in laboratory procedures. Stegman (1959) recorded turbidity in parts per million (p. p. m.) by using a " Hellige Turbidimeter". This method must be vastly outdated since we could not locate such an instrument. To report our turbidity values in p. p. m. a filtration and dry weighing method was used to record total suspended matter (see Materials and Methods).

DISCUSSION

The impoundment of a flowing riverine system can significantly alter several attributes of that ecosystem. Besides the obvious changes in water depth and flow regimes within newly formed reservoirs, downstream effects include changes in channel morphology, water sediment loads, water chemical properties, thermal conditions, and flow regimes (Baxter 1977, Ward and Stanford 1987). Studies on how impoundments effect fishes have taken a variety of perspectives. These include studies of upstream (Erman 1973) and downstream (Hoyt and Robison 1980, Young 1980, De Jalon et al. 1994) faunal changes, surveys to document basin-wide changes (Eley et al. 1981, Rogner and Brinton 1982), and within-reservior faunal studies (Hashagen 1973, Kapasa and Cowx 1991). The results of these and other studies have been equally variable, documenting little noticeable change in overall diversity (Rogner and Brinton 1982), substantial reductions in diversity (Eley et al. 1981, Kapasa and Cowx 1991), and large shifts in dominate species assemblages (Erman 1973, Martinez et al. 1994). The results of our study add to this variation by documenting a substantial increase in basin-wide diversity, in addition to changes in relative abundances and species assemblages.

Prior to the impoundment of Kinkaid Creek a total of nine different sites within the relatively small Kinkaid Creek drainage had been sampled, several of which were sampled repeatedly (Stegman 1959) using a variety of techniques. We believe that this effort gives an accurate estimate of pre-impoundment fish species diversity in the basin. The extensive collecting efforts conducted in the basin between 1998 and 1999 for the current study (15 total sites, most of which were sampled repeatedly) likewise gives an accurate estimate post-impoundment species diversity. Since non-qualitative or unknown sampling techniques were used at many pre- and post-impoundment sites we are limited to using these two data sets to address changes in basin-wide species diversity only.

Since Kinkaid Creek was impounded in 1971 species diversity in the basin has increased by over 50%. The 74 species collected in the basin since 1971 represents 35% of the total Illinois fish fauna (Burr 1991, Laird and Page 1996). This is especially noteworthy given that the Kinkaid Creek subdrainage of the Big Muddy R. drainage encompasses only 135 km^2. When examined at another geographic level, the Kinkaid Creek drainage contains 70% of the Big Muddy R. drainage's fish fauna, with the Big Muddy drainage encompassing approximately 6182 km^2 (Burr and Warren 1993). We propose that a majority of the noted increase in diversity has occurred as the result of three actions: 1) the intentional and unintentional introduction of species not native the Big Muddy R. drainage; 2) range expansions of species introduced into other regions of Illinois or the lower midwest; and 3) habitat alteration that created conditions more favorable to certain species.

Introduction of Non-native Species

Kinkaid Lake was built for recreational purposes, one of which was for the establishment of a gamefish fishery. To meet this goal, three species not native to the Big Muddy R. drainage have been stocked into Kinkaid Lake, *Dorosoma petenense*, *Esox masquinongy*, and *Monone saxatilis*. While *Stizostedion vitreum* is historically known from the Big Muddy R. drainage, prior to impoundment it was collected on only two occasions and was never collected from Kinkaid Creek. Its presence in Kinkaid Lake and the downstream segment of Kinkaid Creek is most likely the result of stocking. Since 1971 over 23 million *S. vitreum* have been stocked into Kinkaid Lake. While there is no official record of *Micropterus dolomieu* being stocked in Kinkaid Lake, the single individual collected by us from below the lake spillway was most likely introduced in the lake by an unscrupulous angler. Prior to our record, *M. dolomieu* had never been recorded from the Big Muddy drainage (Burr and Warren 1993). The unintentional introduction of fishes through the release of unused bait may explain the presence of two cyprinids, *Luxilus zonatus* and *Notropis rubellus*, in Kinkaid Creek. Prior or our collection of single specimens of both species, neither was known to occur in southern Illinois (Smith 1979, Pfleiger 1997). Given that interstate transport and the sale of bait is at best loosely controlled (Meronek, et al. 1995) and that several fish species are frequently observed in single lots of bait (CAT per. obs.) it seems likely that both species were released into Kinkaid Lake by unaware anglers and subsequently escaped downstream. Native to the Atlantic and Gulf coast of the U. S. and the lower Mississippi River, the inland silverside, *Menidia beryllina*, has been introduced into several Illinois reservoirs as forage for game fish (Laird and Page 1996). One of these reservoirs is Baldwin Lake and an examination of Kinkaid Lake stocking records indicate that *D. petenense* stocked into Kinkaid Lake frequently came from Baldwin Lake. It seems reasonable to assume that small numbers of *M. beryllina* could have easily been introduced into Kinkaid Lake with shipments of *D. petenense*.

Range Expansion of Other Non-native Species

Both the silver carp, *Hypophthalmichthys molotrix,* and bighead carp, *H. nobilis* are native to Asia and were introduced into Arkansas in the early 1970s (Laird and Page 1996). Since then they have dispersed up the Mississippi River into Illinois. Their presence in lower Kinkaid Creek is the result of their continued expansion into southern Illinois via the Big Muddy River. Also native to Asia and introduced in Arkansas in the early 1960s, the grass carp, *Ctenopharyngodon idella* was first collected in Illinois in 1971 and now occurs sporadically across the state (Laird and Page 1996). Its post-impoundment collection in lower Kinkaid Creek is the result of this statewide spread.

Habitat Alteration

We believe that the impoundment of Kinkaid Creek not only transformed a 14 km stretch of the creek into deep standing body of water, but through reduced flow it has made the 4 km portion of the creek between the lake spillway and its confluence with the Big

Muddy River inhabitable by species commonly found in big or medium-sized rivers and their associated backwaters, low gradient creeks, and/or other lentic habitats. When lake water level is at or below 128 m above sea level, very little if any water flows over the spillway, resulting in barely detectable flow in lower Kinkaid Creek. While Stegman (1959) reported that flow in lower Kinkaid Creek ceased at flood stages on the Big Muddy River, we assume that as free flowing stream, water moved much more rapidly through the middle and lower reaches of Kinkaid Creek at normal to low stages on the Big Muddy. Thus Kinkaid Creek would now have slower flow rates throughout a much longer portion of the year. In our list of species collected since the impoundment of Kinkaid Creek (Table 4), we find 12 species that, according to Smith (1979) and Page and Burr (1991), prefer big rivers, lakes, backwater habitats with minimal flow, and low gradient creeks; *Polydon spatula*, *Lepisosteus oculatus*, *Alosa chrysochloris*, *Ictiobus bubalus*, *I. cyprinellus*, *I. niger*, *Labidesthes sicculus*, *Morone chrysops*, *M. mississippiensis*, *Centrarchus macropterus*, *Lepomis microlophus*, and *Aplodinotus grunniens*. We speculate that these species have colonized the lower reaches of Kinkaid Creek via the Big Muddy River.

Extirpation of Native Species

Just as the impoundment of Kinkaid Creek has created habitat more favorable to some species, it has also created conditions unsuitable to others. Six species have not been collected in the Kinkaid Creek drainage since 1970; *Carpiodes carpio*, *Notropis atherinoides*, *Pimephales promelas*, *Percopsis omiscomaycus*, *Micropterus punctulatus*, *and Percina maculata*. While most of these species require permanently flowing habitats, two species, *Pimephales promelas* and *Percopsis omiscomaycus*, are known to inhabit lakes. We can only speculate that their absence is due to the high concentrations of predatory game fishes found in the basin. Worth noting is the post-impoundment extirpation of *Carpiodes carpio* and/or *Percina maculata* from drainges in Arkansas (Dewey and Moen 1978), Illinois (Rogner and Brinton 1982) and Oklahoma (Eley et al. 1981).

Changes in Species Assemblages

Our duplication of Stegman's (1959) quantitative sampling at five sites in the Kinkaid Creek basin permits an examination of shifts in species abundances at those sites. A comparison of total fishes collected from all five sites reveals that the most notable change has been the 53.3 percentage point decrease in the number of cyprinids, and the 47.4 percentage point increase in the number of centrarchids (Fig. 2). Other noticeable changes include a 7.9 percentage point decrease in percid abundance and an 11 percentage point increase in clupeid abundance (Fig. 2). Faunal changes at sites 2, 3, and 4, now under Kinkaid Lake, strongly affect the above noted changes in the total sample. Cyprinids and percids dominated Stegman's (1959) collections at sites 2, 3, and 4, accounting for 74% and 12.7%, respectively (Fig. 3), of the total number of fishes collected at those sites. Almost 50% of all fishes collected during our sampling were centrarchids collected from Kinkaid Lake while clupeids collected from Kinkaid Lake accounted for 9% of our total sample (Table 1). This shift in dominate taxa within the reservior should not come as a surprise given three factors: 1) the loss of shallow, flowing habitat favored by percids and the increase in shallow, quiet shoreline habitat favored by centrarchids for spawning; 2) the intentional stocking of over 435,000 *Micropterus salmoides* since 1988; and 3) the increase in abundance of piscivorous game fishes and the relative susceptibility of cyprinids to such predators (Chapleau et al. 1997).

Upstream of the reservior (site 5) a 16.9 percentage point decrease in cyprinids and a 5.4 percentage point increase in centrarchids was recorded (Fig. 4). The biological significance remains questionable at this site given the relatively limited decrease in cyprinids compared to the reservior sites and the fact that centrarchids still account for less than 10% of the total sample at site 5. A decline in cyprinids upstream of a reservior was also reported by Erman (1973). Species diversity at site 5 has changed little since impoundment, Stegman (1959) collected 19 species while we collected 21. Only one of Stegman's (1959) species from site 5 not collected during 1998-1999, *Percina maculata* is believed to be extirpated from the drainage. Other species not collected at site 5 were collected at other upstream sampling sites in 1999. With the exception of 12 *Lepomis megalotis*, all species collected during 1998 and 1999 and not by Stegman occurred in small numbers and were native to the drainage before impoundment.

As previously discussed, we believe that a change in the flow regime throughout most of the year may account for some of the observable downstream faunal changes. At site 1 Stegman (1959) collected 5 species while we collected 16 (Table 1). We also report marked increases in clupeids, catostomids, and atherinids (Fig. 5). Species represented these families at site 1 prefer either big river or slow to non-flowing habitats. We cannot explain the 40% reduction in centrarchids at this site.

CONCLUSIONS

As a third order stream basin draining only 135 km^2, the Kinkaid Creek basin is now home to an incredibly diverse fish fauna. Thirty-five percent of all species known to occur in Illinois waters were collected in the Kinkaid Creek basin during our sampling. We report here on an almost 40% increase in total basin wide fish diversity since the impoundment of Kinkaid Creek. While we cannot totally disprove the pre-impoundment absence of all species that have been collected only since 1970 (Table 4), we think the pre-impoundment collecting efforts expended and types of gears used (including sodium cyanide poisoning) in the basin argues for the noted post-impoundment increase. We also note that this increase in diversity coincides with the loss of six native species and the occurrence of major changes in species assemblages at several sites.

The impoundment of Kinkaid Creek has caused significant changes in the fish fauna of that basin. It is debateable whether these changes are to be viewed in a positive or negative light. However, we feel that from a conservation standpoint, the loss of any native species must be seriously considered before future impoundments of smaller creeks are contemplated. We also feel that there is no advantage to the noted increase in species diversity since it is not the result of speciation events and all species newly represented in the drainage are fishes commonly collected in other parts of Illinois and the midwestern United States or are non-native species expanding their ranges.

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Table 1. Number of species collected from Stegman's (1959) five sites during 1999 sampling of Kinkaid Creek.

Species Name	Number of species by site			
	I	II - IV	V	Total
Lepistoseus oculatus	1			1
Amia calva	3			3
Dorosoma cepedianum	15	82	4	101
Esox americanus	1			1
Campostoma anomalum			6	6
Cyprinella lutrensis			13	13
Cyprinus carpio	3	4		7
Ericymba buccata			2	2
Lythrurus umbratilis			14	14
Notemigonus crysoleucus		1		1
Notropis ludibundus			14	14
Pimephales notatus		2	115	117
Semotilus atromaculatus			18	18
Catostomus commersoni			7	7
Ictiobus bubalus	4			4
I. cyprinellus	8			8
I. niger	2			2
Minytrema melanops		9		9
Moxostoma erythrurum			6	6
Ameirus natalis		2	1	3
Ictalurus punctatus		7		7
Fundulus notatus	4		2	6
F. olivaceus			2	2
Gambusia affinis			3	3
Labidesthes sicculus	7	3		10
Menidia beryllina	1	4		5
Morone chrysops		2		2
M. mississippiensis	1			1
Lepomis cyanellus		1		1
L. cyanellus x L. macrochirus			4	4
L. gulosus		7		7
L. macrochirus	13	283	2	298
L. megalotis	10	33	12	55
L. microlophus		52		52
Micropterus salmoides	4	62		66
Pomoxis annularis	4	4		8
Etheostoma flabellare			3	3
E. nigrum			15	15
E. spectabile			5	5
Percina caprodes		4	7	11
Total	81	562	255	898

Table 2. Species of fishes collected from at least one of five sampling sites during one of two Kinkaid Creek surveys; 1958 (Stegman 1959) and 1999 (current study).

Species collected by Stegman (1959) only	Species collected in current study only
Lepisosteus osseus	*Lepisosteus oculatus*
L. platostomus	*Notemigonus crysoleucas*
Carpiodes carpio	*Ictiobus bubalus*
Erimyzon oblongus	*I. cyprinellus*
Notropis atherinoides	*I. niger*
Phenacobius mirabilis	*Esox americanus*
Ameiurus melas	*Labidesthes sicculus*
Noturus gyrinus	*Menidia beryllina*
Aphredoderus sayanus	*Gambusia affinis*
Lepomis humilis	*Lepomis microlophus*
Micropterus punctulatus	*L. cyanellus* x *L. macrochirus*
Pomoxis nigromaculatus	*Micropterus salmoides*
Percina maculata	*Morone chrysops*
P. maculata x *P. caprodes*	*M. mississippiensis*

Table 3. Fishes known to historically occur in the Kinkaid Creek drainage prior to impoundment of Kinkaid Creek. Asterisks "*" indicate those species not collected in the drainage since the impoundment of Kinkaid Creek.

Lepisosteus osseus	*Ictalurus punctatus*
L. platostomus	*Noturus gyrinus*
Amia calva	*Percopsis omiscomaycus* *
Dorosoma cepedianum	*Aphredoderus sayanus*
Campostoma anomalum	*Fundulus notatus*
Cyprinella lutrensis	*F. olivaceus*
Cyprinus carpio	*Lepomis cyanellus*
Ericymba buccata	*L. gulosus*
Hybognathus nuchalis	*L. humilis*
Lythrurus fumeus	*L. macrochirus*
L. umbratilis	*L. megalotis*
Notemigonus crysoleucas	*Micropterus punctulatus* *
Notropis atherinoides *	*M. salmoides*
N. ludibundus	*Pomoxis annularis*
Phenacobius mirabilis	*P. nigromaculatus*
Pimephales notatus	*Etheostoma chlorosomum*
P. promelas *	*E. flabellare*
Semotilus atromaculatus	*E. gracile*
Carpiodes carpio *	*E. nigrum*
Catostomus commersoni	*E. proeliare*
Erimyzon oblongus	*E. spectabile*
Minytrema melanops	*Percina caprodes*
Moxostoma erythrurum	*Percina maculata* *
Ameiurus melas	*P. caprodes* x *P. maculata*
A. natalis	

Table 4. Fishes collected from the Kinkaid Creek drainage since the impoundment of Kinkaid Creek. Asterisk "*" indicates those species not present in pre-impoundment surveys. "I" denontes those species intentionally introduced for fisheries purposes.

Polydon spatula *	*Ictalurus punctatus*
Lepisosteus oculatus *	*Noturus gyrinus*
L. osseus	*Esox americanus* *
L. platostomus	*E. masquinongy* * I
Amia calva	*Aphredoderus sayanus*
Alosa chrysochloris *	*Labidesthes sicculus* *
Dorosoma cepedianum	*Menidia beryllina* *
D. petenense * I	*Fundulus notatus*
Campostoma anomalum	*F. olivaceus*
Ctenopharyngodon idella *	*Gambusia affinis* *
Cyprinella lutrensis	*Morone chrysops* *
C. whipplei *	*M. mississippiensis* *
Cyprinus carpio	*M. saxatilis* * I
Ericymba buccata	*M. chrysops* x *M. saxatilis* *
Hybognathus nuchalis	*Centrarchus macropterus* *
Hypopthalmichthys molitrix *	*Lepomis cyanellus*
H. nobilis *	*L. gulosus*
Lythrurus fumeus	*L. humilis*
L. umbratilis	*L. macrochirus*
Luxilus chrysocephalus *	*L. megalotis*
L. zonatus *	*L. microlophus* *
Notemigonus crysoleucas	*L. cyanellus* x *L. macrochirus* *
N. ludibundus	*Micropterus dolomieu* *
N. rubellus *	*M. salmoides*
N. volucellus *	*Pomoxis annularis*
Opsopoeodus emiliae *	*P. nigromaculatus*
Phenacobius mirabilis	*Etheostoma asprigene* *
Pimephales notatus	*E. chlorosomum*
P. vigilax *	*E. flabellare*
Semotilus atromaculatus	*E. gracile*
Catostomus commersoni	*E. nigrum*
Erimyzon oblongus	*E. proeliare*
Ictiobus bubalus *	*E. spectabile*
I. cyprinellus *	*Percina caprodes*
I. niger *	*P. shumardi* *
Minytrema melanops	*Stizostedion vitreum* * I
Moxostoma erythrurum	*Aplodinotus grunniens* *
Ameiurus melas	
A. natalis	

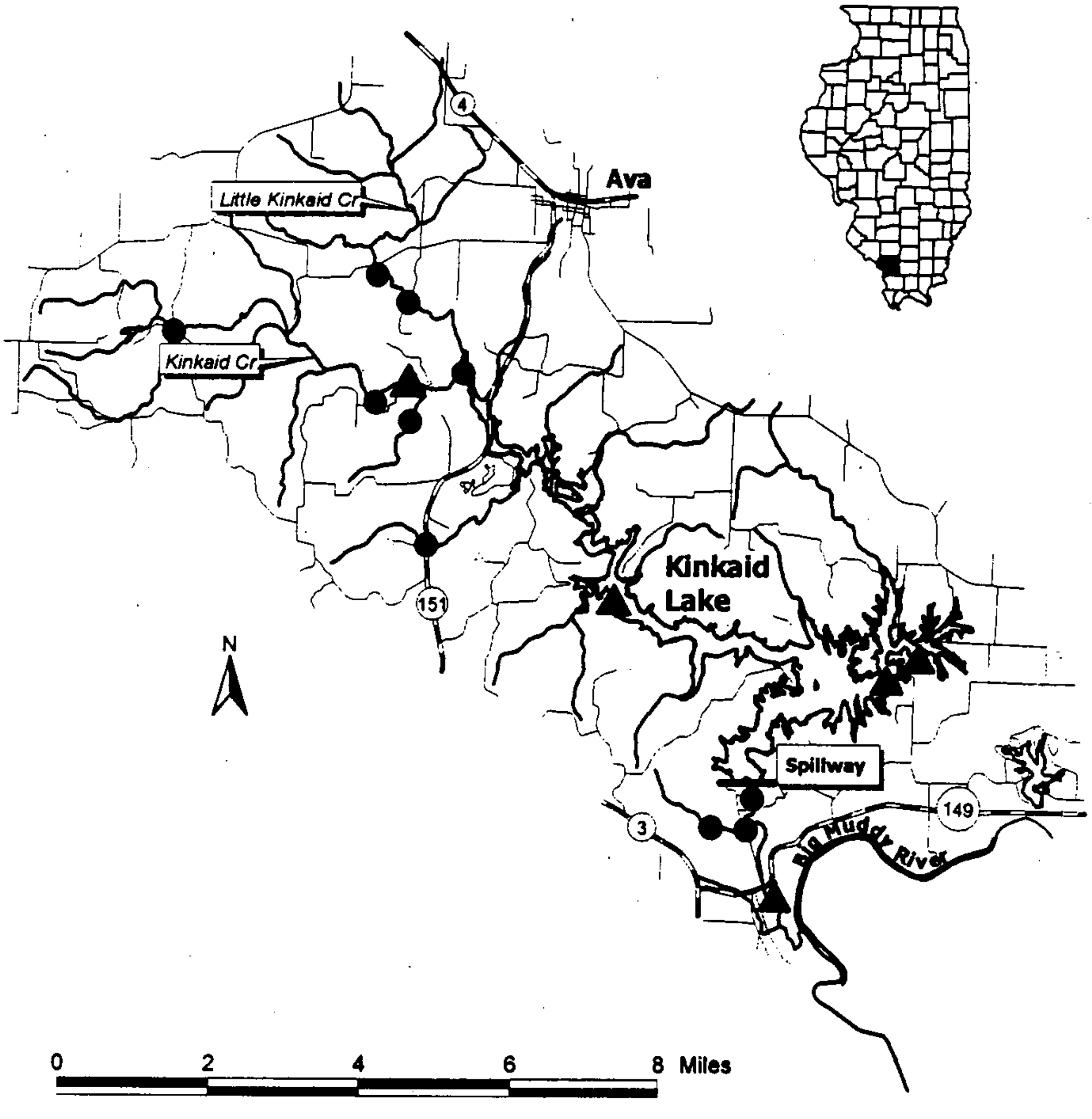

Figure 1. Map of Kinkaid Creek drainage in southwestern Illinois. Solid triangles denote Stegman's (1959) original five sampling sites that were re-sampled in 1999. Solid circles denote additional sites that quantitatively sampled in 1998 and 1999.

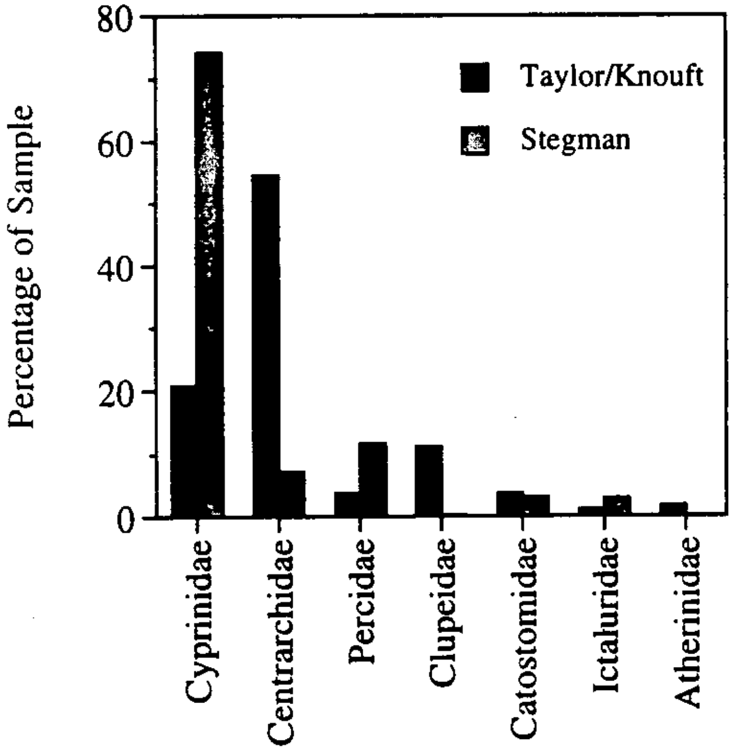

Figure 2. Percent abundances of families of fishes collected by Stegman (1959) and current study (1999) at all five sampling sites.

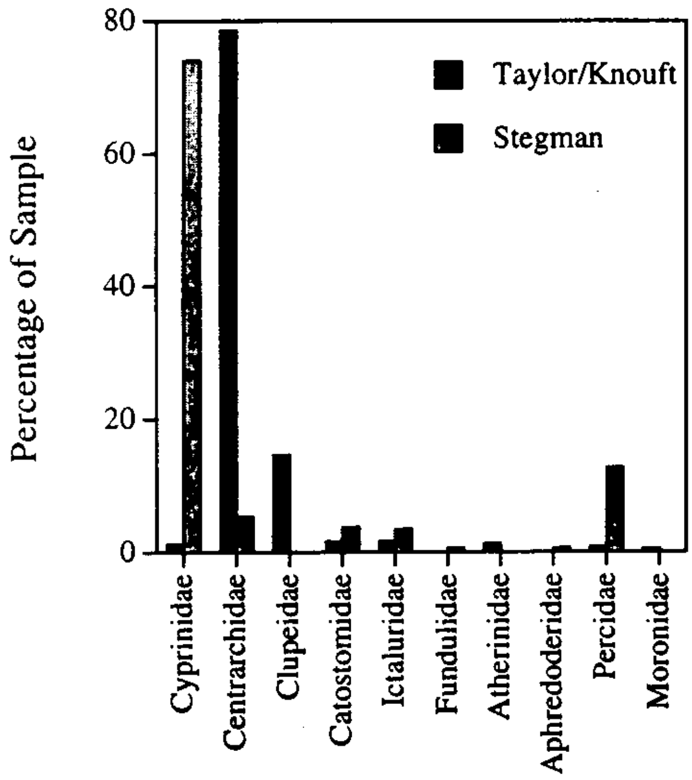

Figure 3. Percent abundances of families of fishes collected by Stegman (1959) and current study (1999) at sites 2, 3, and 4 (now within Kinkaid Lake).

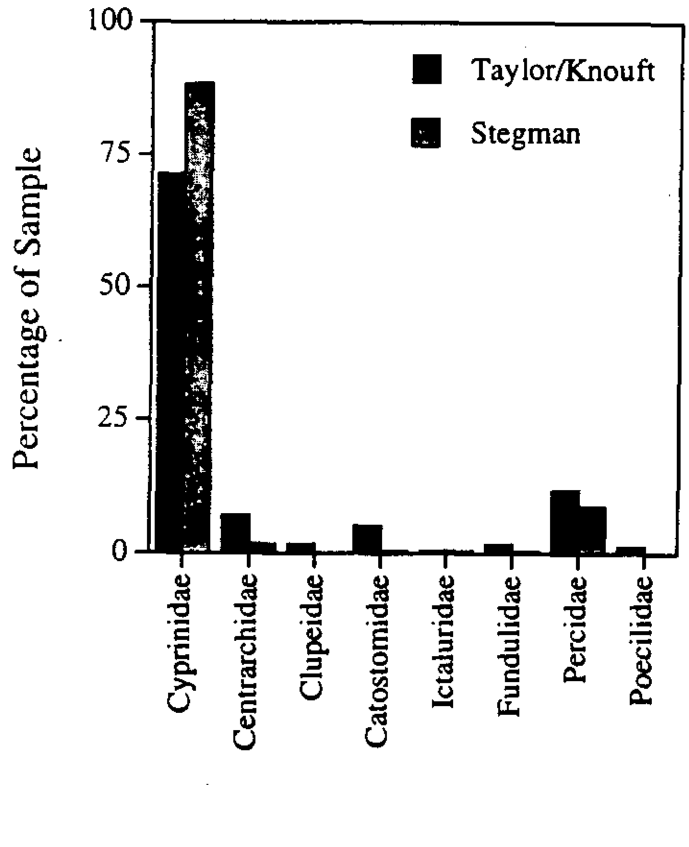

Figure 4. Percent abundances of families of fishes collected by Stegman (1959) and current study (1999) at site 5, upstream of Kinkaid Lake.

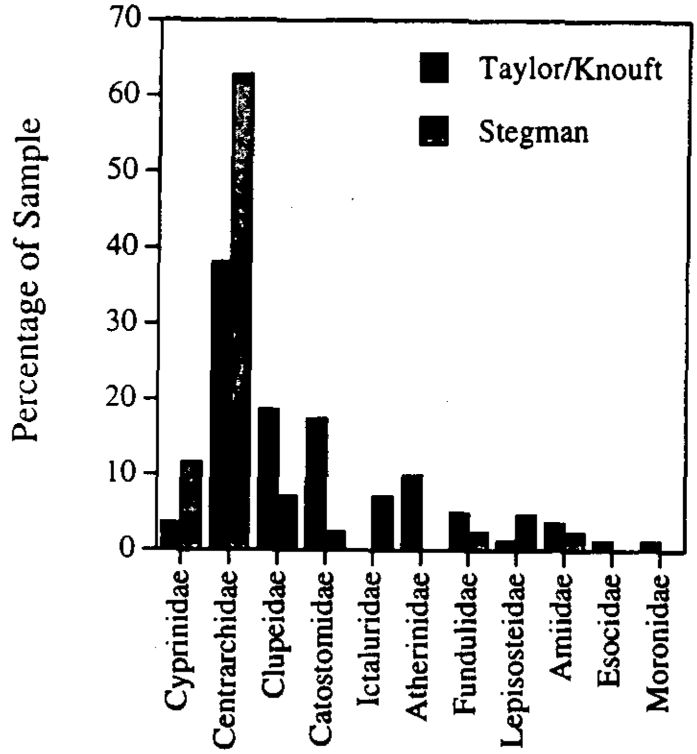

Figure 5. Percent abundances of families of fishes collected by Stegman (1959) and current study (1999) at site 1, downstream of Kinkaid Lake.