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URBAN ICHTHYOLOGY: CHANGES IN THE FISH COMMUNITY ALONG AN URBAN-RURAL CREEK IN INDIANA

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ABSTRACT. We collected 39 species of fish from 10 sites along the East Fork of White Lick Creek in Marion and Hendricks counties, Indiana from May through August 2002 in order to quantify stream quality prior to the start of construction on Interstate Highway 70. These included 10 families, with 1 species each of Lepisosteidae, Clupeidae, Poeciliidae, Atherinidae, Cottidae; 2 species of Ictaluridae; 4 species of Percidae; 6 species of Catostomidae; 9 species of Centrarchidae; and 13 species of Cyprinidae. The most abundant species we encountered were: spotfin shiner (*Cyprinella spiloptera*), silverjaw minnow (*Notropis buccatus*), sand shiner (*N. stramineus*), bluntnose minnow (*Pimephales notatus*), striped shiner (*Luxilus chrysocephalus*), central stoneroller (*Campostoma anomalum*), largemouth bass (*Micropterus salmoides*), creek chub (*Semotilus atromaculatus*), johnny darter (*Etheostoma nigrum*), fathead minnow (*Pimephales promelas*), rainbow darter (*Etheostoma caeruleum*), bluegill (*Lepomis macrochirus*), and the orangethroat darter (*Etheostoma spectabile*). We documented eight new county records for Hendricks County and one new county record for Marion County. Species richness, abundance of fish, and a modified Index of Biological Integrity for the seining sites were all positively correlated with distance downstream from Indianapolis. A trend toward greater fish abundance was also recorded with increasing distance from Interstate Highway 70. Results suggest that urbanization of Hendricks and Marion counties has had a negative impact on the quality of the East Fork of White Lick Creek.

Keywords: Fish, fish distribution, Indianapolis International Airport, Index of Biological Integrity, urbanization, urban ecology

During the 1990s, urban ecology in North America graduated from being a fledgling science into an important ecological subdiscipline (Matson 1990; McDonnell & Pickett 1990; McKinney 2002). Much of the initial focus of this discipline was targeted at demonstrating patterns in species richness along strong urban to rural gradients. These gradients often ran from the downtown sections of major cities to pristine areas. Two patterns were repeatedly demonstrated along these gradients: urban areas harbored fewer species, and a greater percentage of those species were exotic (Limburg & Schmidt 1990; Blair 1996; Blair & Launer 1997; Germaine & Wakeling 2001; McKinney 2002). This focus is now changing to one of understanding how urbanization causes these patterns, and how urbanization impacts behavioral and physiological aspects of biology (Denys & Schmidt 1998; McKinney 2002). In addition to focusing on other aspects of biology, there remains a need to determine if the two classic species diversity patterns hold for shallower gradients (Germaine & Wakeling 2001), and a need also exists to apply these patterns toward developing management tools such as buffers to protect biodiversity in developing areas (Blair 1996; Denys & Schmidt 1998; Germaine & Wakeling 2001; McKinney 2002). Our study focuses on a gradient that ranges from subdivisions and commercial properties at the edge of Indianapolis to remnant forests buried in an agricultural matrix. In addition, this study examines whether the green space created by efforts to conserve the Indiana myotis (*Myotis sodalis*, a federally-endangered bat) is also an effective conservation tool for local fish communities.

This study has four goals. First is to establish stream baseline information as the Indianapolis International Airport (IIA) and its surroundings continue to develop. Of particular concern is moving a 489 m linear section of the East Fork of White Lick Creek during construction of the Six Points Interchange of Interstate Highway 70 (I-70). This goal was accomplished by surveying 10 sites along the

East Fork of White Lick Creek from Indianapolis (Marion County) south into and through southwestern Hendricks County, Indiana. Second, as a result of this survey this paper documents new county distribution records of fish from both Marion and Hendricks counties. We collected one new county distribution record for Marion County, where previous researchers (Gammon 1975; WAPORA 1978; Kingsley 1983; Whitaker et al. 1987; Stahl et al. 1997) had documented 72 species of fish. We also collected eight new records for Hendricks County, which has traditionally received little attention from collectors.

In addition to surveying the stream, we also wanted to examine the impacts of development on the local fish communities and to determine the value of the bat conservation areas for conserving fish. Stahl et al. (1997) examined the impact of the Indianapolis International Airport on the East Fork of White Lick Creek, but the results of their study suggested that Indianapolis itself maybe a greater source of disturbance than the airport. Thus we examined changes in species richness of fish, fish abundance, and the Index of Biological Integrity (an index of stream quality) with increasing distance from both I-70 and the Indianapolis metropolitan area (set at the junction of the stream and US Highway 40). Finally, we used the results of these distance analyses to infer how successful conservation efforts aimed at bats were at protecting fish.

METHODS

The East Fork of White Lick Creek flows south from a heavily settled and urbanized section of western Marion County. It joins with White Lick Creek in Morgan County near the Mooresville wastewater treatment facility and then flows into the West Fork of the White River (Stahl et al. 1997). The stream varies in width from 9–15 m, with a maximum depth of 2 m. The stream drains 135 km^2 of watershed, including urban, industrial, and agricultural runoff. Historically, the stream has been severely degraded due to runoff and habitat degradation, but a recent study has shown some stream quality regeneration in the southern half of the drainage (Stahl et al. 1997).

We established 10 seining sites (A–H in Hendricks County and J–K in Marion County) at locations that have been used since 1997 as mistnetting localities as part of the bat study (Sparks et al. 1998) (Fig. 1). We sampled each site three times (once per month during the mid-afternoon starting on 15 May 2002 and continuing until 15 August 2002) using a 9 m bag seine with a 0.64 cm mesh. Each seining consisted of a minimum of three seine hauls. Seining was concluded if no additional species were collected after the third haul for that visit. If an additional species was captured, additional seine hauls were conducted until no additional species were captured. Because all sites appeared similar in terms of the available habitat types (pools, riffles, runs, and extra-channel), different habitats were sampled in roughly equal proportions at each site. During the second and third seinings, minnow traps baited with dog food were placed in pools between 1–1.5 m deep at each site during the afternoon seining and collected between 2400–0200 h the next day. During the third and final round of seining, in addition to the standard seining regime, we used hand-held 0.64 cm mesh minnow dipnets to collect fish observed by flashlight from 1900–0200 h. All fish captured were identified, counted, and released, with the exception of voucher specimens for each seine site that were preserved and deposited in the Indiana State University Vertebrate Collection. Identification of these voucher specimens was verified using a combination of keys, including Trautman (1981), Page & Burr (1991), and Pflieger (1997). Specimen identifications were later confirmed by Dr. John O. Whitaker, Jr. at Indiana State University.

After seining was completed, we calculated three measures of stream health. Fish abundance was calculated by dividing the total number of fish taken at a site by the number of seine hauls at that site. We did this to make our results comparable between sites because our seining technique resulted in more speciose sites receiving greater seining effort, and relatively few fish were captured in dipnets or minnow traps. We used the species richness of each site as a measure of biodiversity. This is an appropriate index because each site received consistent sampling effort (Magurran 1988). Finally, we used an index of biological integrity (IBI) as a measure of the quality of the stream at each site.

An index of biological integrity is the most common technique used to infer stream qual-

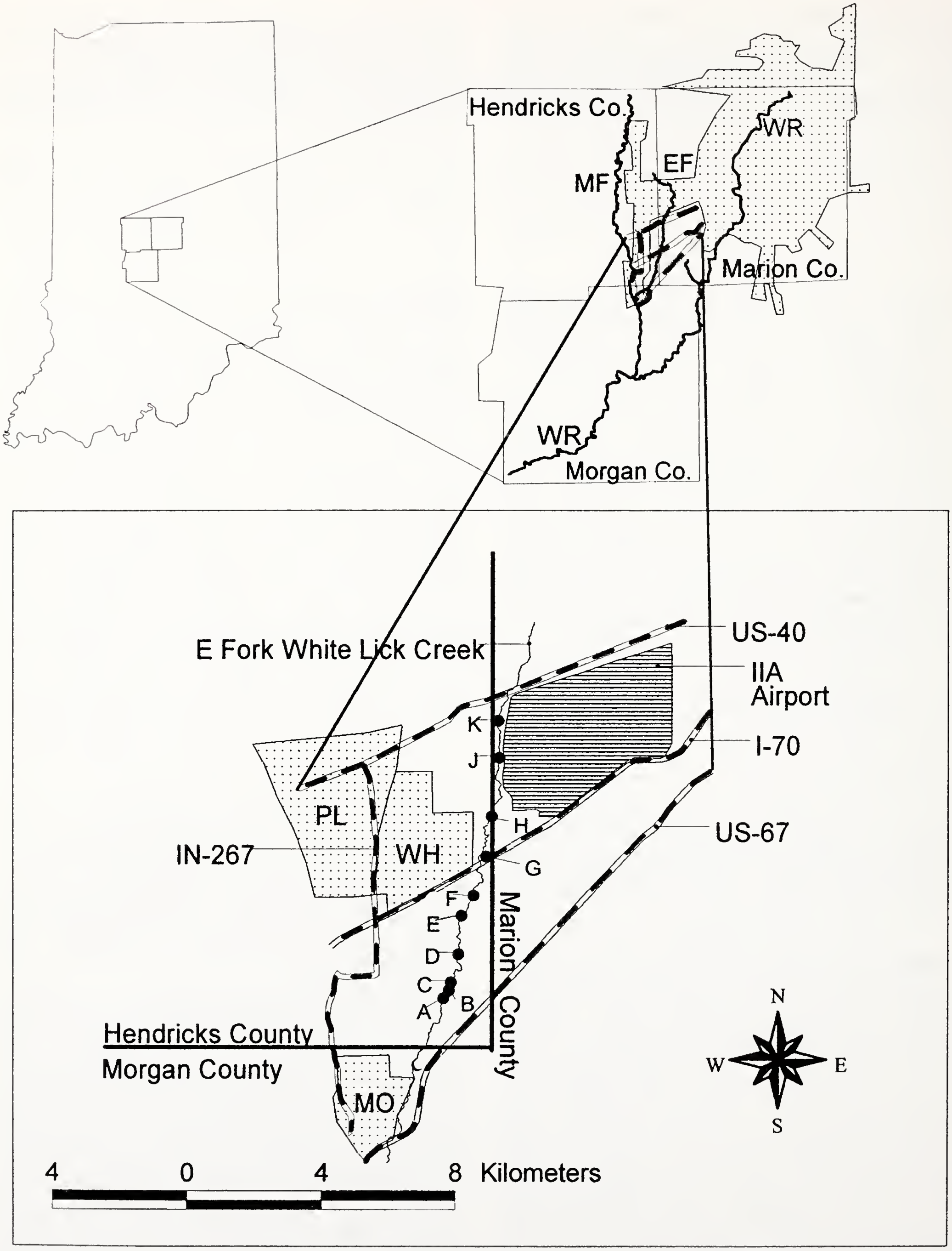

Figure 1.—Map showing proximity of seining sites to local landmarks. The upper left figure represents the location of Hendricks, Marion, and Morgan counties in Indiana. The upper right figure shows how the study area (hashed lines) relates to the greater Indianapolis metropolitan area (stippled polygon) and important streams (MF = Main Fork of White Lick Creek, EF = East Fork of White Lick Creek, and WR = White River). The bottom figure details the proximity of the seining sites (labeled A–K) to local landmarks including developed areas (stippled polygons abbreviated as PL = Plainfield, WH = warehouse district of Plainfield, and MO = Mooresville), transportation corridors (IIA = Indianapolis International Airport, US-40 = US Highway 40, US-67 = US Highway 67, I-70 = Interstate Highway 70, IN-267 = Indiana Highway 267), and other features (listed on figure).

ity from fish captures, and it is useful for measuring and comparing streams on both geographical and temporal bases (Karr et al. 1986; Simon & Dufour 1997; Stahl et al. 1997; Milewski et al. 2001). Thus, we developed an IBI (Table 1) for our stream by combining parts of IBIs developed by Karr et al. (1986) and Simon & Dufour (1997). Although the regional IBIs were developed using electroshocking, a representative collection of fish from seining can also be used provided the sampling methodology provided similar collections (Simon & Dufour 1997; T. Simon pers. commun.). Because the species diversity of our study was comparable to the early work on the stream (Stahl et al. 1997), the robustness of the regional IBI would allow comparison of this site with other local streams. We modified the metrics used in the IBI to account for the East Fork of White Lick Creek being a small stream, whereas other measurements are better adapted to larger streams. In particular, because the stream was mostly wadeable (between 0–1 m, with occasional 2 m depressions), we choose the number of sunfish species instead of percent of headwater species and the number of sucker species instead of the number of minnow species. Despite these modifications, our results should remain comparable with other studies that make use of IBIs (Karr et al. 1986; Simon & Dufour 1997; Milewski et al. 2001).

We used a series of regressions to examine changes in the IBI, number of fish species (species richness), and number of fish per seining effort (abundance) with increasing distance from US-40 or I-70 (Figs. 2–4). These regressions were performed in the curve estimation module of SPSS version 10.0. We initially examined each data set with a linear regression, but the changes in abundance of fish with increasing distance were clearly a curvilinear relationship (Fig. 3). Thus, we used a quadratic regression to analyze these results. Finally, the results of these regressions were used to infer the effectiveness of the bat project as a conservation tool for fish.

RESULTS AND DISCUSSION

We collected 39 species of fish from the East Fork of White Lick Creek (Table 2). Eight of the 38 fish species taken in Hendricks County were new county records (Gerking 1945; Stahl et al. 1997). New records for Hendricks County were *Lepisosteus osseus*, *Dorosoma cepedianum*, *Pimephales vigilax*, *Carpiodes carpio*, *Ictalurus punctatus*, *Gambusia affinis*, *Lepomis microlophus*, and *Pomoxis nigromaculatus*. Of the 24 species taken in Marion County, the mosquitofish (*Gambusia affinis*) was the only species that was not reported in previous collections (Whitaker et al 1987: Clem & Whitaker 1995). No federal or state threatened or endangered species were found along the East Fork of White Lick Creek.

Most of the fish were collected by seining, with less than 1% of fish being taken by minnow trap, and 2.4% of fish taken by dipnet. Four species, indicated below, were more commonly taken by dipnet. For each species of fish, the total number of individuals observed is reported in the text within parenthesis.

Family Lepisosteidae (gars).—The longnosed gar (*Lepisosteus osseus*) has not been reported from Marion County since the 1870s (Whitaker et al. 1987). Their collection west of Marion County at four sites (B, C, E & F) in Hendricks County (4) suggests that this species may have recolonized Marion County.

Family Clupeidae (herrings).—The gizzard shad (*Dorosoma cepedianum*), an invasive species, was first captured in Marion County in 1967 (Christensen 1968). This fish was encountered twice (2), once in both Hendricks (site C) and Marion counties (site J).

Family Cyprinidae (minnows).—During Summer 2002, thirteen species of minnows were collected, with the most abundant being spotfin shiner (*Cyprinella spiloptera*, 2642), silverjaw minnow (*Notropis buccatus*, 2368), sand shiner (*N. stramineus*, 1403), bluntnose minnow (*Pimephales notatus*, 578), striped shiner (*Luxilus chrysocephalus*, 460), central stoneroller (*Campostoma anomalum*, 381), creekchub (*Semotilus atromaculatus*, 298), and fathead minnow (*Pimephales promelas*, 183). These fish were common along the length of the stream, although more abundant at the southern end than the northern end. Carp (*Cyprinus carpio*, 8), suckermouth minnow (*Phenacobius mirabilis*, 7), and blacknose dace (*Rhinichthys atratulus*, 32) were rarely encountered in the stream, although they were considered abundant in other small streams and the White River in Marion County by earlier researchers (Gerking 1945; Christensen 1968; WAPORA 1978; Kingsley

Table 1.—Index of Biological Integrity metrics used to evaluate the East Fork of White Lick Creek. Measures of stream quality are based on Simon & Dufour (1997), except where noted in text. IBI scoring follows traditional standards, in that higher values are favorable to lower values, with total scores based on a 60 point scale. In the category of fish condition, DELT represents deformities, eroded fins, lesions, and tumors.

Metric classification category	Measure of stream quality	Scoring 5	3	1
Species composition	Total number of species	>14	14–7	<7
	# of darter/sculpin species	>3	3–2	<2
	# of sunfish species	>3	3–2	<2
	# of sucker species	>3	3–2	<2
	# of sensitive species	>5	5–3	<3
	% tolerant individuals	<25%	25–50%	>50%
Trophic composition	% omnivore individuals	<25%	25–50%	>50%
	% insectivore individuals	>50%	50–25%	<25%
	% carnivore individuals	10–25%	25–50% & 5–10%	>50% & <5%
Fish condition	Catch per unit effort	135–91	90–46	45–0
	% simple lithophil individuals	>40%	20–40%	<20%
	% DELT anomalies	<0.1%	0.1–1.3%	>1.3%

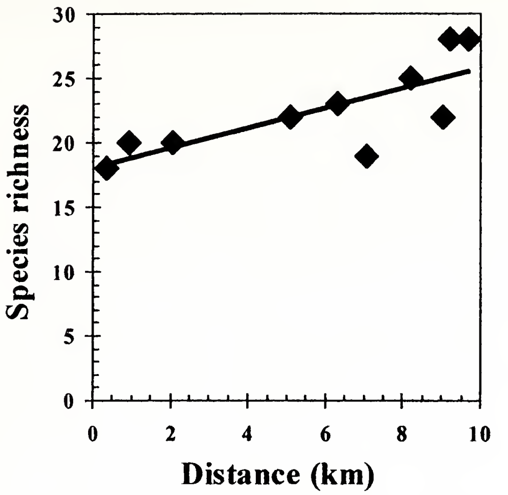

Figure 2.—Relationship between species richness of fish and distance from Indianapolis. A positive linear relationship ($F_{(df=8)} = 8.756$, $P = 0.018$, $r^2 = 0.523$) is observed between increased species richness and increasing distance downstream from Indianapolis.

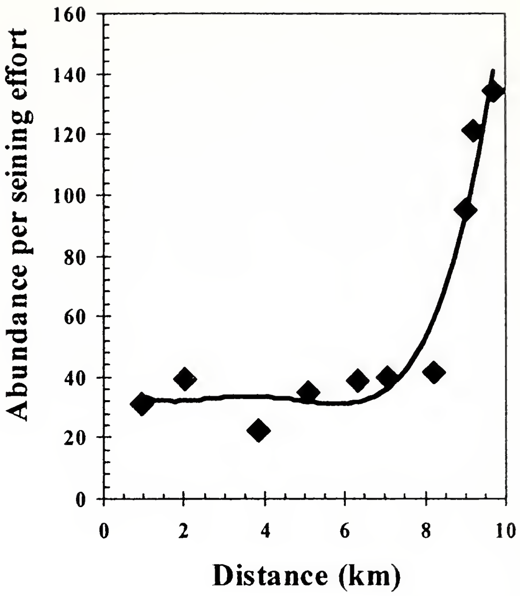

Figure 3.—Relationship between abundance of fish per seining effort and distance downstream from Indianapolis explained by a quadratic regression ($F_{(df=7)} = 20.6$, $P = 0.001$, $r^2 = 0.855$). The number of fish captured per seine haul increased dramatically 8 km downstream from Indianapolis.

1983; Whitaker et al. 1987; Stahl et al. 1997). The redfin shiner (*Lythrurus umbratilis*, 69) was uncommon in the East Fork of White Lick Creek and has been rarely encountered during previous work in similar streams in Indiana (Gerking 1945; Christensen 1968; Whitaker & Wallace 1973; Gammon 1975; WAPORA 1978; Kingsley 1983; Whitaker et al. 1987; Stahl et al. 1997; Whitaker et al. 1998). The bullhead minnow (*Pimephales vigilax*, 1) was encountered only once and its presence was a surprise because it is mostly found in rivers.

Family Catostomidae (suckers).—Six species of suckers were observed during the current study, and only the common white sucker (*Catostomus commersoni*, 51) and northern hogsucker (*Hypentelium nigricans*, 23) were common. We rarely collected the river carpsucker (*Carpiodes carpio*, 5), quillback (*C. cyprinus*, 4), black redhorse (*Moxostoma duquesnei*, 1), and golden redhorse (*Moxostoma erythrurum*, 1). Absence of the spotted sucker (*Minytrema melanops*) was unexpected, considering its abundance in Marion County during earlier studies (Gammon 1975; WAPORA 1978; Kingsley 1983; Whitaker et al. 1987).

Family Ictaluridae (catfish).—We observed two species of catfish, the channel catfish (*Ictalurus punctatus*, 3) and the yellow bullhead (*Ameiurus natalis*, 32). Neither fish was common, with channel catfish being seen but never captured during the study. Yellow bullheads were collected largely by dipnetting during the third round of seining. Other catfish collected in Marion and Hendricks counties historically, but not found during this study, included the black bullhead (*A. melas*), brown bullhead (*A. nebulosus*), and flathead catfish (*Pylodictis olivaris*) (Christensen 1968; Gammon 1975; WAPORA 1978; Kingsley 1983; Stahl et al. 1997; Whitaker et al. 1987).

Family Poeciliidae (livebearers).—Although the western mosquitofish, *Gambusia affinis*, was not reported previously in either Hendricks or Marion County, its presence (22) was not unexpected because it has been increasing its range throughout the state. It has previously been collected from the tributaries of the White River and Pigeon Creek drainages in Davies and Gibson counties in 1985, and in Vigo County in 1990 (Clem & Whitaker 1995). It is suspected to have moved up the White River system into Hendricks and Marion counties. This collection may there-

Table 2.—Fishes taken from the East Fork of White Lick Creek in Hendricks County (Sites A–H) and Marion County (Sites J & K) during Summer 2002.

Family Species	Sites along White Lick Creek			
	A–D	E–G	H–K	Total
Lepisosteidae				
Lepisosteus osseus	2	2	0	4
Clupeidae				
Dorosoma cepedianum	1	0	1	2
Cyprinidae				
Campostoma anomalum	312	26	43	381
Cyprinella spiloptera	1607	478	377	2462
Cyprinus carpio	1	6	1	8
Luxilus chrysocephalus	266	91	103	460
Lythrurus umbratilis	24	23	22	69
Notropis buccata	1699	401	268	2368
Notropis stramineus	891	310	202	1403
Phenacobius mirabilis	7	0	0	7
Pimephales notatus	382	116	89	587
Pimephales promelas	124	12	47	183
Pimephales vigilax	0	1	0	1
Rhinichthys atratulus	17	0	15	32
Semotilus atromaculatus	203	17	78	298
Catostomidae				
Carpiodes carpio	5	0	0	5
Carpoides cyprinus	4	0	0	4
Catostomus commersoni	17	6	28	51
Hypentelium nigricans	17	5	1	23
Moxostoma duquesnei	1	0	0	1
Moxostoma erythrurum	1	0	0	1
Ictaluridae				
Ameiurus natalis	13	2	17	32
Ictalurus punctatus	2	1	0	3
Poeciliidae				
Gambusia affinis	7	1	14	22
Atherinidae				
Labidesthes sicculus	6	8	0	14
Centrarchidae				
Ambloplites rupestris	1	0	0	1
Lepomis cyanellus	9	14	0	23
Lepomis macrochirus	77	52	31	160
Lepomis megalotis	12	26	8	46
Lepomis microlophus	4	12	0	16
Micropterus dolomieu	3	17	0	20
Micropterus salmoides	215	40	65	320
Pomoxis annularis	0	0	2	2
Pomoxis nigromaculatus	2	0	0	2
Percidae				
Etheostoma blennioides	22	5	1	28
Etheostoma caeruleum	108	17	40	165
Etheostoma nigrum	134	23	136	293
Etheostoma spetabile	61	15	25	101

Table 2.—Continued.

Family Species	Sites along White Lick Creek			
	A–D	E–G	H–K	Total
Cottidae				
Cottus bairdi	2	0	0	2
Total species	36	28	24	39
Total individuals	6259	1727	1614	9600

fore represent the northeastern boundary of this species within Indiana. This species was collected largely in dipnets, and occasionally in seines.

Family Atherinidae (silversides).—The brook silverside (*Labidesthes sicculus*, 14) was collected solely from sites A, B, E & G in Hendricks County. This fish was uncommon to rare in the stream, which is similar to data reported from Marion County (Whitaker et al. 1987), as well as Vigo County (Whitaker & Wallace 1973). Brook silversides were collected in seines as well as by dipnetting at night when they swam at the surface of the water and were attracted to spotlights.

Family Centrarchidae (blackbass and sunfish).—Nine species of bass and sunfish were collected from the area, with only bluegill (*Lepomis macrochirus*; 160) and largemouth bass (*Micropterus salmoides*, 320) abundant in both counties. Green sunfish (*L. cyanellus*, 23), longear sunfish (*L. megalotis*, 46), redear sunfish (*L. microlophus*, 16), smallmouth bass (*M. dolomieu*, 20), and black crappie (*Pomoxis nigromaculatus*, 2), were all collected from Hendricks County, along with a bluegill-green sunfish hybrid. The only rock bass (*Ambloplites rupestris*, 1) was collected in Hendricks County at site B with a dipnet. The longear sunfish, largemouth bass, and white crappie (*P. annularis*, 2) were collected from Marion County in relatively low abundance.

Family Percidae (darters).—Four species of darter were observed, with the decreasing order of abundance being johnny darter (*Etheostoma nigrum*, 293), rainbow darter (*E. caeruleum*, 163), orangethroat darter (*E. spectabile*, 103), and the greenside darter (*E. blennioides*, 28). The only other darter associated with this stream has been the dusky darter (*Percina sciera*) (Stahl et al. 1997), but it was not observed during this survey.

Family Cottidae (sculpins).—The mottled sculpin (*Cottus bairdi*, 2) was collected only from site B in Hendricks County in 2002, although a specimen was collected from site E in 2001. Based on other work (Stahl et al. 1997); this species is believed to be more abundant than observed, but due to their rock-dwelling behavior, specimens were difficult to obtain using seines.

IBI AND OTHER MEASURES OF QUALITY RELATIVE TO DISTANCE FROM INDIANAPOLIS

Examination of the fish fauna of the East Fork of White Lick Creek provided an opportunity to measure the impact of the Indianapolis metropolitan area (from highway US-40) and a heavily-used transportation corridor (I-70) on the fish assemblage of this small stream. Stahl et al. (1997) found that the three sites south of the airport had IBI qualities of good, while the two sites north of the airport were fair to poor, thus suggesting that urbanization may be the cause of these observations. A more intensive survey and assessment of the stream was needed to determine if the Indianapolis metropolitan area or I-70 could have been the disturbance in question. The first comparison performed was that of fish species richness (total number of species of fish recovered from each site). Species richness was positively correlated with distance from US-40 (Linear Regression, $F_{(df=8)}$ = 8.756, P = 0.018, r^2 = 0.523; Fig. 2), while distance from I-70 was not significantly related to species richness (Linear Regression, $F_{(df=8)}$ = 1.276, P = 0.291, r^2 = 0.138). Fish abundance per seining effort was strongly reduced by distance from US-40 (Quadratic Regression, $F_{(df=7)}$ = 20.6, P = 0.001; r^2 = 0.855; Fig. 3), and weakly associated with distance from I-70 (Quadratic Regression, $F_{(df=8)}$ = 4.062, P = 0.079; r^2 = 0.337). The fact that increasing distance from the Indianapolis metropolitan area is reflected by a nonlinear increase in fish abundance (Fig. 3) is interesting because it provides insight into the size of the buffer that could serve to preserve this fish community. In the East Fork of White Lick Creek, a dramatic increase in fish abundance occurred at a distance of 8 km from the Indianapolis metropolitan area. This corresponds closely with the area of the stream that received "good scores" in the IBI. This is also the portion of the stream that is at the heart of the bat conservation area, and it will be permanently preserved. Thus, management activities aimed at bats are also preserving fish.

The IBI calculated for the East Fork of White Lick Creek suggested that stream quality in relation to fish community ranged from good to fair-poor (Fig. 4). These results suggested that stream quality also significantly increased with distance from the Indianapolis metropolitan area (linear regression, $F_{(df=8)}$ = 14.45, P = 0.005; r^2 = 0.644), and that no relationship existed between stream quality and distance from I-70 (linear regression, $F_{(df=8)}$ = 0.96, P = 0.355; r^2 = 0.108). Because the IBI is an index that incorporates a wide range of ecological attributes to describe a community, improved IBI scores with increasing distance from the Indianapolis metropolitan area are evidence that either the area is poor habitat or that the metropolitan area is disrupting the natural fish community. The preliminary assessment of the stream south of the airport resulted in consistent IBI scores of 50 (Stahl et al. 1997), which were not significantly different than our downstream results ($t_{(df=2)}$ = 1.00, P = 0.4). Stahl et al. (1997), however, did not measure enough sites to detect the degree of change over distance in stream quality that we detected. Both the relative abundance of fish and IBI scores increased dramatically with distance from Indianapolis at US-40. Fish communities did not score in the good category of the IBI until a minimum of 8 km from US-40. Simon and DuFour (1997) included a single sampling point along the Main Fork of White Lick Creek, which received an IBI score of 36, two points below the lowest score we recorded on the East Fork. Given that the Main Fork is much more heavily developed than the East Fork, we consider this additional evidence for the negative impacts of development.

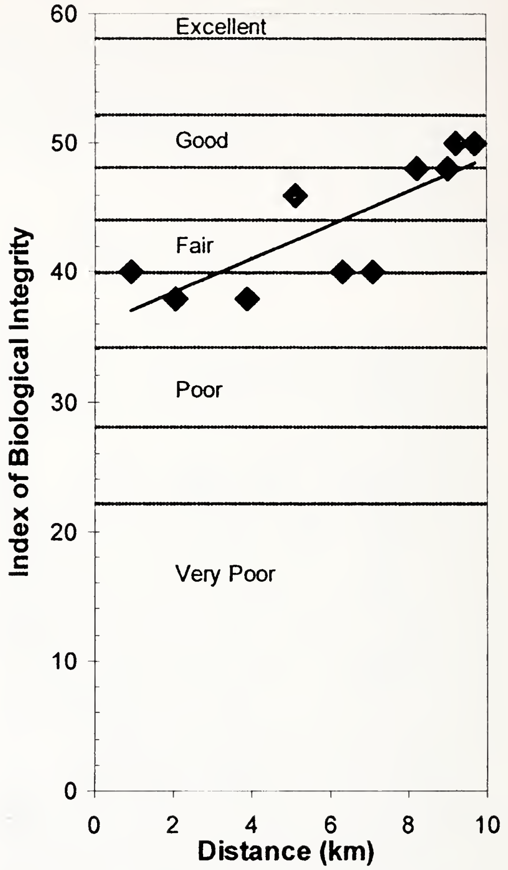

Figure 4.—Relationship between Index of Biological Integrity scores and distance downstream from Indianapolis. A positive linear relationship is observed between the increasing IBI scores and distance from Indianapolis.

Flooding is another factor that needs to be considered in any future analyses of this and other similar streams. The section of the East Fork of White Lick Creek that we sampled was prone to increase nearly 1 m in depth in as little as 30 min (pers. obs.). This may be influenced by the presence of large areas of urbanized, solidified concrete matrix to the north of our site. Although we attempted to avoid flooding events, one collection each at sites J and K was performed under flooded conditions. During flooded conditions, we captured larger individuals as well as a greater biodiversity and abundance of fish. This could be a result of larger fish being better at avoiding capture in clearer water at low water levels. For example, at site J, the flooded collection accounted for 529 out of 786 (67.3%) individuals captured during three visits. Had we collected these samples at times when the stream was not flooded, we probably would have found even stronger evidence of the impact of the Indianapolis metropolitan area. Future studies should consider a combination of seining and electro-shocking, to compensate for these variations in sampling. In particular, the effect of flooding needs to be considered when collecting and analyzing data along streams of this size. In addition, the behaviors of fish and other aquatic organisms may bear examination during these turbulent conditions.

As additional areas become heavily urbanized, the natural drainage systems will become further modified because of increased runoff. These modifications may lead to a decrease in stream quality and would be reflected by an increase in pioneer and tolerant species and a decrease in the percentage of simple lithophilic breeders. This may become a bigger problem with the development of a new interchange near the junction of I-70 and the stream. This interchange is currently under construction, and one aspect of the plan involves moving a 489 m portion of the stream. The effects of moving this section of the stream and the affiliated construction should be addressed in a future study. Finally, this study area presents a unique opportunity to address questions about the impact of urbanization on wildlife. By combining the results of this study with ongoing studies of other taxa, including the habitat monitoring that is being conducted as part of the bat management plan (American Consulting, Inc. 2002), we hope a better understanding of the effects of urbanization will be obtained.

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