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# Status and Condition of streams in the East Branch-Little Calumet River watershed

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# Status and Condition of the streams in East Branch-Little Calumet River watershed

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**Abstract:** The East Branch of the Little Calumet River watershed (EBLCR) was assessed using three different Indexes of Biotic Integrity (IBI) based on average water temperature over three study periods between 1990-2015. Researchers employed a variety of electrofishing methods to sample sites retrieved from the U.S. Environmental Protections Agency's random draw protocol (EMAP-GRTS) for aquatic analysis. The most abundant taxonomic families of the EBLCR over the 25-year period in descending order are: *Cyprinidae* (n=2525), *Centrarchidae* (n=1487), *Umbridae* (n=820), and *Salmonidae* (n=755). The community structures were subjected to the IBIs and weighted for individual stream class representatives to characterize the condition of the EBLCR per stream mile. The total combined weighted IBI scores show that 74% (coldwater), 89% (coolwater), or 98% (warmwater) of the EBLCR's total stream miles consist of impaired aquatic habitat. The assessment results suggest a poor state for the EBLCR over the 25-year lifetime of the study.

## 1. Introduction

Long-term studies associated with the integrity of aquatic biota and the physical condition of the streams and rivers they occupy are limited (Simon et. al. 2014). These types of studies are needed in order to identify the lasting effect of urbanization, such as flow modifications, habitat degradation, land use, and outfalls (Karr et. al. 1981). Identifying long-term trends in biotic integrity of surface waters provides information on the condition and status of the waterway itself. Often the best and most efficient approach to determine the effects of urbanization on stream habitats is to directly compare pre- and post-development biological data (Wang et. al. 2000). This evidence can yield trends in habitat state and subsequently utilized to identify areas of concern and inform managers of current and past conditions.

Northwestern Indiana has seen a wide variety of habitat modification from dredging, exotic species invasions, toxic legacy sediments, extensive channelization, and large-scale flow alterations (Powers et. al. 2014; Simon and Morris 2015; Simon et. al. 1989; Simon and Moy 2000). As early as the 1800's, settlers began to channelize, drain, fill, or otherwise degrade the watershed's unique natural hydrology (Applied Ecology Services, 2001). These past insults and the continual expansion of the Greater Chicago Metropolitan area have resulted in the patchwork of urban centers, industry, wetlands, marshes, and swamps that characterize the region. This study may also serve as a foundation to understanding the effects of land use change and fragmentation on the communities present in this regions' waterways.

Investigators used three indices of biotic integrity (IBI) in order to assess the condition of the East Branch-Little Calumet River (EBLCR) watershed (HUC:0404000401). Biotic integrity is defined as "the ability to support and maintain a balanced, integrated adaptive assemblage of organisms" which includes "species composition, diversity, and functional organization comparable to that of natural habitats of the region" (Karr & Dudley 1981, Karr et. al. 1986). Three region-specific IBIs (warmwater, coolwater, and coldwater) were subjected to the collection data and the results scrutinized for trends in class integrity structure.

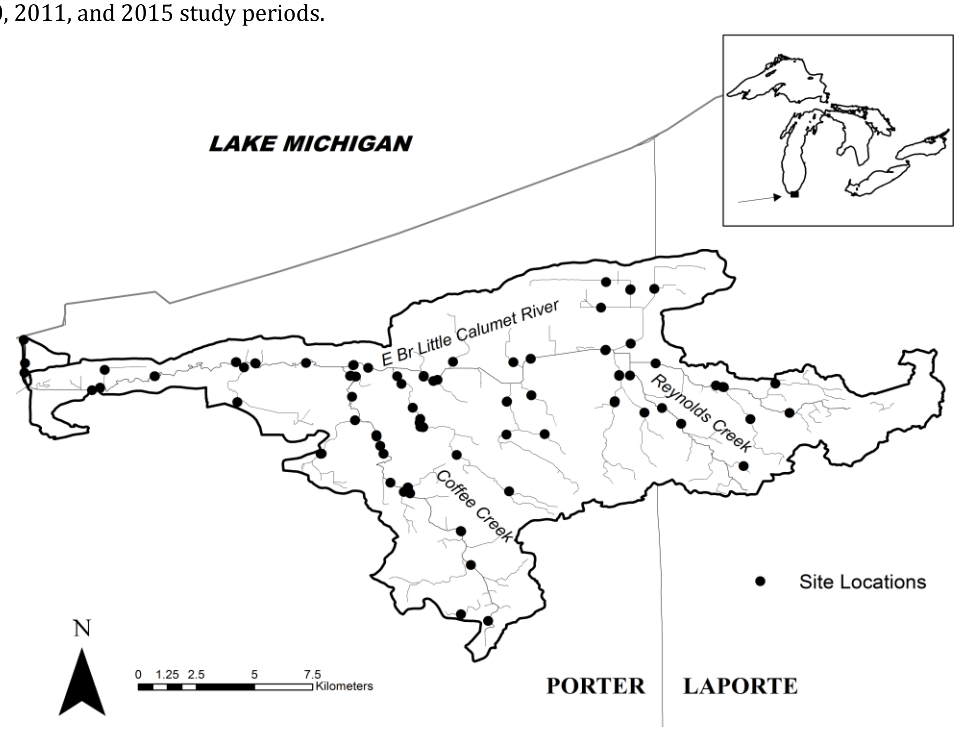
One of the primary assumptions that researchers operate under is that any of the three IBIs, delineated by daily maximum water temperatures, may represent and yield useful results to infer the status and condition of the EBLCR watershed. This assumption protects against the region being incorrectly determined as a particular temperature regime during transition or uncharacteristic periods. For instance, coldwater streams can develop into warmwater streams when anthropogenic discharges increase water temperatures or if warmwater species begin to out compete coldwater species due to major disturbance to the natural setting (Dauwalter et. al. 2010). This can lead to improper listing of streams as an area of concern and can systemically complicate analysis and the interpretations of results (ARCINBS 2007). Additionally each index is tailored to different expected communities and consequently composed of slightly different metrics; therefore, the presentation of all three indices allows different aspects of the watershed to be quantified which may have otherwise been lost in a single-index based analysis.

## 2. Methods

### 2.1 Study Area

The Little Calumet-Galien sub-basin (HUC# 04040001) is one of the more industrialized areas in the Lake Michigan Basin. The basin is characterized by urbanized and developed land (18.01%), farmland (39.56%), forest (27.68%), wetlands (7.53%), and grassland (4.34%) (O'Leary et. al. 2001, Lake Michigan Basin 2015). Of the original pre-settlement wetlands, approximately 5% remains as small patches and narrow strips of habitat (Little Calumet-Galien 2015). This study focused on The East Branch-Little Calumet River (EB-LCR) watershed (HUC# 0404000104) located within the Little Calumet-Galien basin, which includes a portion of the Indiana Dunes National Lakeshore (fig.1).

*Figure 1*. Map of the East Branch-Little Calumet River watershed (HUC#0404000104) with site locations for the 1990, 2011, and 2015 study periods.



The EBLCR includes north-central portions of Indiana's Porter and LaPorte counties. Major waterways include: East Branch-Little Calumet River, Salt Creek, Reynolds Creek and Coffee Creek (IDEM 2010). The basin drains approximately 190 sq. km across the southern extent of the Lake Michigan Basin.

Two major ecoregions are drained by the EBLCR: the Central Corn Belt Plain and the Southern Michigan/Northern Indiana Drift Plain. The Central Corn Belt Plain (CCBP) consists predominantly of glacial till plain and loess soils. Due to the high rainfall and little elevation change of the CCBP in relation to the Eastern and Western Corn Belts Plain, the CCBP is largely used for the production of feed crop for livestock (Omernik and Gallant 1998, Woods et. al. 2015). Extensive channelization of rivers and streams caused by increasing agriculture and urbanization has isolated many habitats, fragmented others, and irrevocably damaged the natural condition. In terms of natural land cover, the CCBP historically was covered in hickory-oak hardwood forests with large switchgrass, bluestem, and dropseed prairies scattered throughout the moraine. Most of the remaining original habitat has been removed or confined to small or narrow patches located between population centers (Omernik and Gallant 1998). The largest sources of environmental concern of the CCBP are herbicides, pesticides, and fertilizers from crop production, animal wastes and stream bank erosion from livestock, as well as point and non-point pollution sources associated with the heavy steel industry prevalent along the Lake Michigan shoreline.

The Southern Michigan/Northern Indiana Till Plain (SMNITP) is much more varied in land use than any surrounding ecoregion. Often referred to as a transition region, this expanse contains livestock and crop production, dense woodlands and forests separated by marshes, prairies and intense urbanization (Omernik and Gallant 1998, Woods et. al. 2015). The soils are similar to the glacial till of the CCBP however the SMNITP soils contain a much higher percentage of sand and small gravel. Peat deposits and darker mineral and soil deposits are scattered throughout the swamp kettle depression that form the marshes and swamps (Omernik and Gallant 1998). Sources of environmental concern are similar to the CCBP; however the SMNITP has much more livestock and therefore more problems with stream bank erosion and water chemistry. Compared to the CCBP, the SMNITP has less intense urbanization and channelization of streams but heavy industries along the Lake Michigan shore are still a large point source of pollution.

**2.2 Study Design**

Sampling sites were selected using the U.S. Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP) GRTS selection method. This probabilistic program uses a randomized sample survey design to provide statistically significant characterizations of overall water quality and biotic integrity for a study basin (USEPA 1990, Horn et. al. 1994). The generated site selection is based on the universe of sites within the region that includes all rivers, streams, canals, and waterways indexed by the USEPA River Reach File (Horn et. al. 1994). This program uses equally weighted-stream order categories to ensure all different stream orders are sampled and represented in the data (Garceau 2004).

The data collected was used to assess the water quality of the watersheds using an Index of Biological Integrity (IBI) for the EBLCR (Simon 1991). The IBI is an important tool for researchers and managers because it incorporates structure, composition, trophic-level ecology, niche, and reproductive attributes at multiple ecological organizations (Simon 1991, Karr 1981). Therefore continued monitoring of the temporal dependent IBI scores will yield trends in fish species composition and structure for this specific basin over time. The three study periods include watershed surveys conducted during 1990 for our baseline data and probabilistic sampling during 2011 and 2015.

## 2.3 Field Collection

Fish were collected using backpack, long-line, or boat-mounted electrofishing units' depending on different sized streams and rivers. Small (<3.3m wetted width) streams were sampled with either a long-line or backpack unit. Wadeable (>3.3m wetted width) streams were sampled with a long-line unit. Larger rivers that were non-wadeable were sampled with a boat mounted electrofishing unit. Each stream was sampled a distance equal to 15x the wetted width with a minimum of 50m and a maximum of 100m (Simon and Morris 2015). All large rivers sample reaches were at least 300m (maximum 500m) with special attention to sample in all habitats along the reach in order to obtain a representable sample for each reach.

A pulsed direct current (DC) of 200-300V with amperage of 2-3amps was adjusted for each site in order to maximize the power function. Depending on the size of the stream, each crew included 2-5 crew members with dip nets with standard mesh sizes of 3.25 mm stretch mesh. Sampling was conducted in an upstream direction to minimize disturbance and increase visibility. All observed fish were captured and placed into a live-well until the completion of the sampling reach. At the conclusion of the stream reach sampling, individuals were inspected for DELT (deformities, eroded fins, lesions, tumors) anomalies then sorted by species. Each species was measured for a minimum and maximum total length (TL, mm), batch weighed (g) by species, then returned to the stream. Efforts were made to ensure that all individuals were returned to the stream alive and unharmed.

Invasive species such as goldfish (*Carassius auratus*), common carp (*Cyprinus carpio*), round goby (*Neogobius melanostomus*), and oriental weatherfish (*Misgurnus anguillicaudatus*) were not returned to the stream, but were first placed in MS-222 until reduced swimming ability was observed and were then preserved in 10% formalin.

## 2.4 Indices of Biotic Integrity: warm, cool, and cold water

Data was subjected to three different IBI's developed for Indiana based on maximum daily water temperatures (Simon 1991, Mundahl and Simon 1999). Water temperature is a fundamental regulator of the distribution, growth, feeding preferences, and tolerance of fishes, which in turn dictates the presence of species (ARCINBS 2007).

The IBIs are composed of 12 metrics to quantify trophic structures, fish assemblages, and individual fish condition. The sum of metrics for a site determines the condition of the reach. IBI scores range from 0-60; where 0 indicates no fish present, 1-22 indicates 'very poor', 23-34 indicates 'poor', 35-44 indicates 'fair', 45-52 indicates 'good', and 53-60 indicates 'excellent' conditions. Table 1 summarizes the general characteristics associated with each integrity category.

*Table 1*. Integrity class characteristics for the Index of Biotic Integrity (modified from Karr *et. al.* 1986).

| Total IBI Score | Integrity class | Assemblage Characteristics |
|---|---|---|
| 53-60 | Excellent | Exceptional fish diversity. Native, sensitive, and intolerant species abundant. |
| 45-52 | Good | Decreased species richness with adequate amounts of sensitive and intolerant species |
| 35-44 | Fair | Sensitive and intolerant species rare. Skewed trophic structures and guild structure disturbance. |
| 23-34 | Poor | Many expected species rare or absent. Tolerant species begin to dominate. |
| 1-22 | Very Poor | Few individuals' present, tolerant species dominate, frequency of DELT anomalies high. |
| 0 | No Fish | No fish captured. |

The coldwater IBI (coldIBI) was developed by Mundahl and Simon (1999) and calibrated for the Northern Midwestern states where maximum daily water temperatures fall below 22˚C. The coolwater IBI (coolIBI) was developed by the Aquatic Research Center of the Indiana Biological Survey in order to characterize streams and rivers in Indiana with daily maximum temperatures between 22-26˚C (Lyons et. al. 1996, ARCINBS 2007). The need for the coolIBI was reasoned when streams were being incorrectly classified as degraded warmwater streams leading to improper listing of sites on Indiana's "List of Impaired Waters"(ARCIBS 2007).

The warmwater IBI (warmIBI) developed by Simon (1991) is a modification of Karr (1981), Karr et. al. (1986), and Ohio EPA (1987) warmwater indices. Warmwater streams are those that have a daily maximum temperature of 22-30˚C (ARCIBS 2007). Waterways that experience daily maximum temperatures above 30˚C will experience suppression of all benthic organism survival (ARCIBS 2007). Sites with small (<50 individuals) sampling yields required special scoring considerations for 6 metrics: percentage as omnivores, percentage as insectivores, percentage as top carnivores, percentage as simple lithophils, DELT anomalies, and percentage as pioneer species (Simon 1991).

According to Indiana biological policy descriptions, waters that are not listed as limited use shall be able to support a "well-balanced aquatic community" which includes "diverse species composition, several trophic levels, and […] not composed mainly of pollution tolerant species"(IDEM 2006a, IDEM 2006b). The Indiana Department of Environmental Management policy mandates that an IBI below a score of 35 are considered "non-supportive of aquatic assemblages" (IDEM 2006b).

### 2.5 Statistics and data analysis

The site list retrieved from the EMAP program produced a list of probable flowing streams, which were then surveyed in the field. Upon field reconnaissance a selection of sites were found to be inaccessible (i.e., dry, impounded, denied access, buried, etc.). In order to estimate the characteristics of the study area while accounting for any loss of stratification due to inaccessible sites a statistical correction is applied to the study in order to rebalance the study design (Diaz-Ramos et. al. 1996). A procedure developed by the U.S. EPA National Health and Environmental Effects Research Laboratory (Corvallis, Oregon) was applied to correct for loss of stream class representatives (Sobat et. al. 2006).

To normalize the results a *post-hoc* analysis was completed to weigh the stream classifications and IBI scores as related to total stream miles within the EBLCR. The weight factor for each stream class was calculated by the ratio of the area of stream class 'X' by overall total area surveyed. IBI scores were then weighted and summed respective of integrity class. CI% represents the ratio of integrity class weighted IBI scores to the total sum of weighted IBI scores. SE represents the standard deviation of the weighted IBI scores per integrity class. The number of integrity class representatives is denoted as 'n' (Table 3).

## 3. Results & Discussion

### 3.1 Fish Assemblage

Between the 1990 and 2011 surveys there were 61 species confirmed in the EBLCR watershed, while the 2015 survey confirmed 48 species in the EBLCR. Native species composed 81.9% and 84.7% of total individuals in 1990 and 2011, respectfully. The 2015 survey saw a significant increase in native species increasing to 94.7%. The first known ichthyology survey of this area, conducted by Gerking (1945), found native species composed 94.2% of total individuals. Table 2 summarizes the field collection results.

The most prominent exotic species are the common carp (*Cyprinus carpio),* brown trout (*Salmo trutta*) and goldfish (*Carassius auratus).* The most common non-indigenous species are the Chinook salmon (*Oncorhynchus tshawytscha*), rainbow trout (*Oncorhynchus mykiss*), and the Atlantic salmon (*Salmo salar*). The sea lamprey (*Petromyzon marinus*) was found at one site located in a tributary of the East Branch of the Little Calumet River.

The most abundant taxonomic families in the EBLCR over the 25-year study period in descending order are: *Cyprinidae* (n=2525), *Centrarchidae* (n=1487), *Umbridae* (n=820), and *Salmonidae* (n=755). Most abundant individual species in descending order are: creek chub (*Semotilus atromacultatus,* n=1245), green sunfish (*Lepomis cyanellus*, n=874), central mudminnow (*Umbra limi*, n=820), and white sucker (*Catostomus commersonii*, n=681).

*Table 2*. Checklist of fish species in the East Branch-Little Calumet River watershed from 1990, 2011, and 2015 surveys. This list includes only fish found in one or more surveys within the East Branch-Little Calumet River watershed (HUC#0404000104).

| Family / Common Name | Scientific Name | East Branch Little Calumet River Survey | | |
|---|---|---|---|---|
| | | 1990 | 2011 | 2015 |
| | | n=16 | n=46 | n=29 |
| **PETROMYZONTIDAE** | | | | |
| American Brook lamprey | *Lampetra appendix* | 12 | 39 | 35 |
| Least Brook lamprey | *Lampetra aepyptera* | | 6 | |
| Sea lamprey | *Petromyzon marinus* | | | 24 |
| **LEPISOSTEIDAE** | | | | |
| Longnose gar | *Lepisosteus osseus* | | | 7 |
| **AMIIDAE** | | | | |
| Bowfin | *Amia calva* | | 1 | 1 |
| **CLUPEIDAE** | | | | |
| Alewife | *Alosa psuedoharengus* | 10 | 1 | |
| Gizzard shad | *Dorosoma cepedianum* | 121 | 28 | |

| | | | | |
|---|---|---|---|---|
| **SALMONIDAE** | | | | |
| Coho salmon | *Oncorhynchus kisutch* | 13 | 61 | |
| Rainbow trout | *Oncorhynchus mykiss* | 30 | 292 | 15 |
| Chinook salmon | *Oncorhynchus tshawytscha* | 10 | 15 | 39 |
| Atlantic salmon | *Salmo salar* | 6 | 5 | 1 |
| Brown trout | *Salmo trutta* | 71 | 182 | 15 |
| **CYPRINIDAE** | | | | |
| Central stoneroller | *Campostoma anomalum* | | 57 | 56 |
| Largescale stonroller | *Campostoma oligolepis* | | 2 | 20 |
| Goldfish | *Carassius auratus* | | 1 | 1 |
| Carp | *Cyprinus carpio* | 33 | 42 | 21 |
| Spotfin shiner | *Cyprinella spiloptera* | 112 | 14 | |
| Common shiner | *Luxilus cornutus* | | 15 | 35 |
| Golden shiner | *Notemigonus crysoleucas* | 3 | 18 | 15 |
| Hornyhead chub | *Nocomis biguttatus* | | 32 | 36 |
| Emerald shiner | *Notropis atherinoides* | 16 | | |
| Spottail shiner | *Notropis hudsonius* | 58 | | |
| Sand shiner | *Notropis stramineus* | 6 | 2 | 8 |
| Bluntnose minnow | *Pimephales notatus* | 322 | 64 | 4 |
| Fathead minnow | *Pimephales promelas* | 12 | 149 | 1 |
| Western Blacknose dace | *Rhinichthys obtusus* | | 81 | 44 |
| Creek chub | *Semotilus atromacultatus* | 146 | 544 | 555 |
| **CATOSTOMIDAE** | | | | |
| Quillback | *Carpiodes cyprinus* | 1 | 3 | |
| White sucker | *Catostomus commersonii* | 62 | 396 | 223 |
| Creek chubsucker | Erimyzon oblongus | | | 6 |
| Northern hogsucker | *Hypentelium nigricans* | | 13 | 6 |
| Smallmouth buffalo | *Ictiobus bubalus* | | | 1 |
| Black buffalo | *Ictiobus cyprinellus* | | 8 | |
| Spotted sucker | *Minytrema melanops* | | 1 | 3 |
| Silver redhorse | *Moxostoma anisurum* | | 2 | |
| Golden redhorse | *Moxostoma erythrurum* | | 1 | 3 |
| Shorthead redhorse | *Moxostoma macrolepidotum* | | 1 | |
| **ICTALURIDAE** | | | | |
| Black bullhead | *Ameiurus melas* | 6 | | 1 |
| Yellow bullhead | *Ameiurus natalis* | 1 | 22 | 2 |
| Brown bullhead | *Ameiurus nebulosus* | | | |
| Channel catfish | *Ictalurus punctatus* | | 1 | 1 |
| Tadpole madtom | *Noturus gyrinus* | | | |
| Flathead catfish | *Pylodictis olicaris* | | | |
| **UMBRIDAE** | | | | |
| Central mudminnow | *Umbra limi* | 266 | 533 | 21 |
| **ESOCIDAE** | | | | |
| Grass pickerel | *Esox americanus* | 11 | 44 | 42 |
| Northern pike | *Esox lucius* | | 2 | 4 |
| **COBITTIDAE** | | | | |
| Oriental weatherfish | *Misgurnus anguillicaudatus* | | 1 | |
| **APHREDODERIDAE** | | | | |
| Pirate perch | *Aphredoderus sayanus* | 22 | 20 | 17 |
| **FUNDULIDAE** | | | | |
| Starhead topminnow | *Fundulus dispar* | 2 | 1 | |
| Blackstripe topminnow | *Fundulus notatus* | | 4 | 1 |
| **CENTRARCHIDAE** | | | | |
| Rock bass | *Ambloplites rupestris* | 2 | 30 | 5 |
| Green sunfish | *Lepomis cyanellus* | 137 | 600 | 137 |
| Orangespotted sunfish | *Lepomis humilis* | 3 | | |
| Pumpkinseed | *Lepomis gibbosus* | 13 | 21 | 14 |
| Warmouth | *Lepomis gulosus* | 1 | | 2 |
| Bluegill | *Lepomis macrochirus* | 31 | 181 | 106 |
| Redear sunfish | *Lepomis microlophus* | | 1 | |
| Longear sunfish | *Lepomis peltastes* | | | |
| Smallmouth bass | *Micropterus dolomieu* | | 1 | 10 |
| Largemouth bass | *Micropterus salmoides* | 11 | 63 | 75 |
| White crappie | *Pomoxis annularis* | | | |
| Black crappie | *Pomoxis nigromaculatus* | 5 | 37 | 1 |

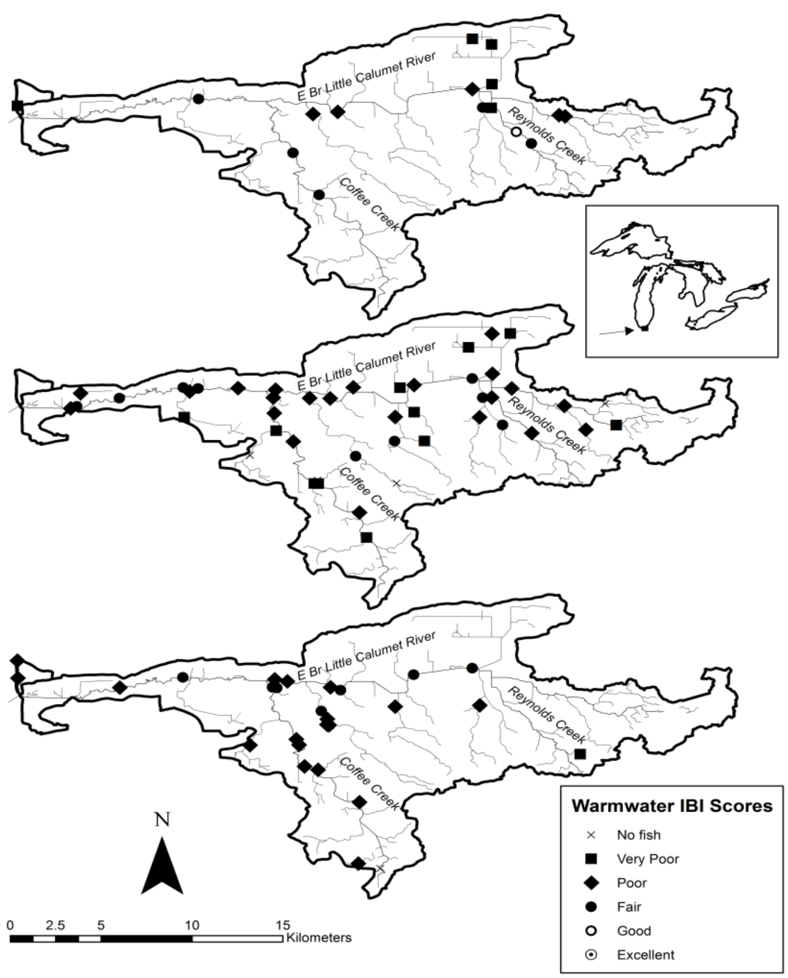
| | | | | |
|---|---|---|---|---|
| **PERCIDAE** | | | | |
| Rainbow darter | *Etheostoma caeruleum* | | 7 | 14 |
| Scaly darter | *Etheostoma eulepis* | | 324 | |
| Least darter | Etheostoma microperca | 11 | | |
| Johnny darter | *Etheostoma nigrum* | 52 | | 256 |
| Orangethroat darter | *Etheostoma spectabile* | | 4 | 17 |
| Logperch | *Percina caprodes* | | | |
| Blackside darter | *Percina maculata* | 1 | 5 | 1 |
| Walleye | *Sander vitreus* | | | 1 |
| **COTTIDAE** | | | | |
| Mottled sculpin | *Cottus bairdii* | 5 | 16 | |
| **GOBIIDAE** | | | | |
| Round goby | *Neogobius melanostomus* | | 102 | 5 |
| | **Total Individuals:** | **1624** | **4096** | **1908** |
| | **Total Species:** | **37** | **54** | **48** |

## 3.2 Status

### 3.2.1 Warmwater IBI

Based on the warmwater IBI results for the watershed (fig. 2) over the three time periods, the biotic integrity of the watershed has slightly decreased. The 1990 survey showed the most even distribution of scores across all IBI integrity classes; however had no sites scored as 'excellent'. The 1990 survey also saw the lowest amount of 'no fish' sites (0%). In comparison, the 2011 and 2015 surveys had 8.7% and 3.4%, respectfully, of sites scored as 'no fish'. Surveys conducted in 2011 and 2015 found no sites scored as 'excellent' or 'good' and increasing proportions of 'poor' sites over the 25-year survey period.

Figure 2. Warmwater IBI scores and site locations for 1990 (Top), 2011 (Middle), 2015 (Bottom) surveys of the East Branch-Little Calumet River watershed (HUC# 0404000104).



The 1990 survey observed equal proportions of 'fair', 'poor', and 'very poor' (31.3%) sites with 6.3% of sites scored as 'good'. The 2011 survey saw decreased 'good' (0.0%), 'fair' (19.6%), and 'very poor' (23.9%) sites and increases in 'poor' (47.8%) and 'no fish' (8.7%) sites. The 2015 survey consisted of 27.6% of sites scored as 'fair' and 65.6% of sites scored as 'poor' and equal proportions of 'very poor' and 'no fish' sites (3.4%).

According to the Indiana Department of Environmental Management (IDEM), sites below an IBI score of 35 are considered "non-supportive of aquatic assemblages" and consequently do not meet IDEM biological criteria for aquatic communities (IDEM 2006a, IDEM 2006b). The most recent survey found 72.4% of sites fell below the 35 score threshold, 2011 showed the largest (80.4%) proportion of non-supportive sites and 1990 contained the lowest proportion (62.5%) of non-supportive sites.

The average IBI score of 1990 (29.3), 2011(26.1), and 2015 (30.3) were all considered 'poor' biotic integrity and below the IDEM mandated threshold of supportive habitats. The 1990 survey found the eastern portion of the EBLCR and portions of Reynolds Creek to have the relatively lowest biotic integrity of the watershed. The 2011 data showed minor improvement in biotic integrity throughout the eastern portion of the EBLCR with minor decreases in IBI in the Coffee Creek headwaters and main stem. The 2015 showed slight improvements in biotic integrity in the vicinity of Coffee Creek and along the main stem of the Little Calumet River; however, an overall suppression in biotic integrity was observed for the 2015 EB-LCR watershed.

### 3.2.2 Coldwater IBI

Based on the coldwater IBI results (fig. 3) the overall biotic integrity of the EB-LCR has decreased over the 25-year period of study. Over the lifetime of the study a decrease in 'fair' sites and 'poor' sites coupled with an increase in 'very poor' and fluctuating 'no fish' sites was observed. The 1990-91 survey observed no sites scored as 'no fish'; however, surveys in 2011-12 and 2015 had 8.7% and 3.4%, respectfully scored as 'no fish'. No sites in any of the three survey periods scored in either the 'good' or 'excellent' integrity category.

The 1990 survey had 12.5% of sites scored as 'fair', 50% of sites scored as 'poor', and 37.5% of sites scored as 'very poor'. In comparison, the 2011 had slightly decreased 'poor' (43.5%) and 'very poor' (32.6%) sites and increases in 'fair' (15.2%) and 'no fish' (8.7%) sites. The 2015 survey showed a decrease in 'fair' (3.4%), 'poor' (34.5%), and 'no fish' (3.4%) sites, but a large increase in 'very poor' (58.6%) sites.

Surveys in 1990 and 2011 had an average IBI score of 27.0 and 24.8 respectfully which falls under the 'poor' biotic integrity category. The 2015 survey had an average of 21.6, which categorizes the EBLCR watershed as 'very poor'. Most of the 1990 EBLCR is considered 'poor' to 'very poor' with the least impacted sites located along the Reynolds Creek corridor. The 2011 EBLCR experienced the most significant decreases in biotic integrity in the far-eastern headwaters of the E. Branch-Little Calumet River.

IBI scores below 35 are considered 'non-supportive of aquatic assemblages"(IDEM 2006a, IDEM 2006b). In accordance with IDEM biological criteria: 87.5% of 1990 survey sites, 84.8% of 2011 survey sites, and 96.6% of 2015 survey sites fall below this threshold.

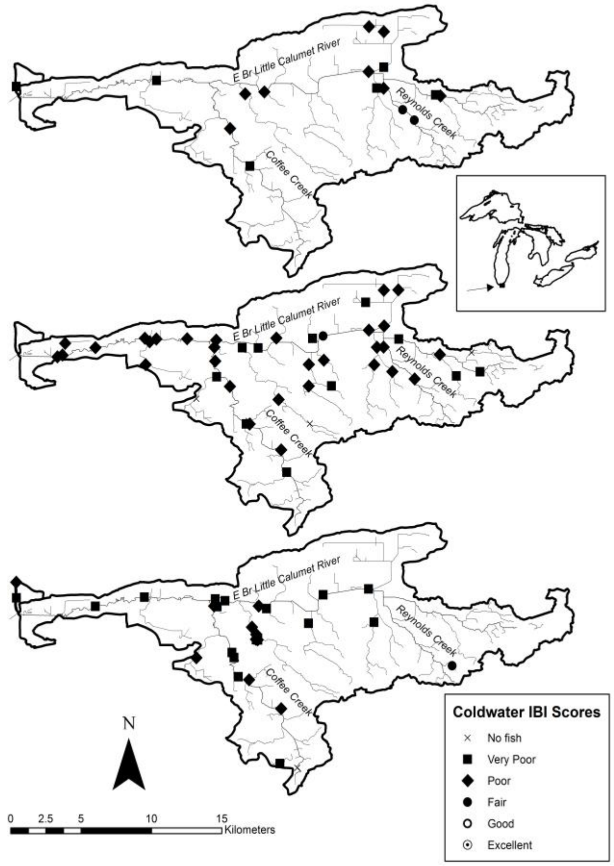



Figure 3. Coldwater IBI scores and site locations for 1990 (top), 2011 (middle), and 2015 (bottom) surveys of the East Branch-Little Calumet River watershed (HUC#0404000104)

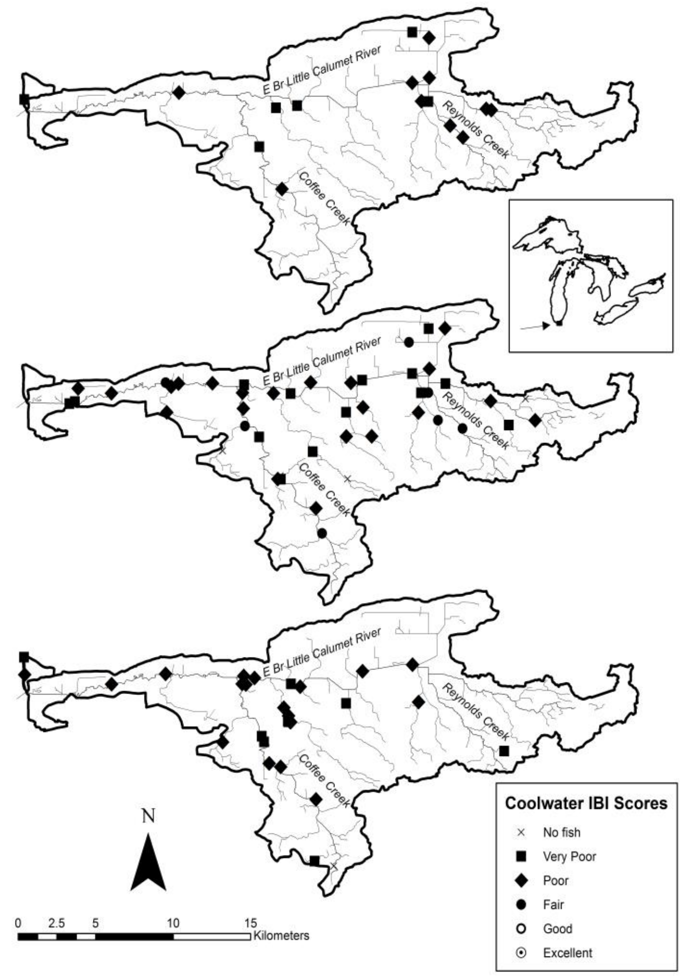
### 3.2.3 Coolwater IBI

Based on the coolwater IBI results (fig. 4) the overall biotic integrity of the EBLCR has stayed relative stable over the 25-year period. Although stable, the results of the coldwater IBI reveal a poor condition for the EBLCR watershed. Only one site during the 2011 survey scored in the 'fair' integrity category, all other sites fell below an IBI score of 31. No sites in the 25-year period scored in the 'good' or 'excellent' integrity category. Surveys in 2011 and 2015 found 8.7% and 3.4% of sites, respectively, scored as 'no fish'.

The 1990-91 survey sites fell in either the 'poor' (62.7%) or 'very poor' (37.5%) integrity categories. The 2011-12 survey had 'fair' (2.2%) and similar 'poor' (65.2%) sites with a decrease in 'very poor' (23.9%) sites. The 2011 had similar sites scored as 'poor' (65.5%) and an increase in 'very poor' (31.0%) sites.

The 1990, 2011, and 2015 survey periods had IBI score averages of 23.5, 21.8, and 23.0 respectfully. Therefore according to the coolwater IBI, the EBLCR watershed has been in poor condition for the entire 25-year study period. The most relatively impacted sites occurred along the main stem of the E. Branch-Little Calumet River and Coffee Creek. 'No fish' sites were located in Reynolds Creek headwaters in 2011 and at one 2015 site in the headwaters of Coffee Creek.

*Figure 4*. Coolwater IBI scores and site locations for 1990 (Top), 2011 (Middle), 2015 (Bottom) surveys of the East Branch-Little Calumet River watershed (HUC# 0404000104).




IDEM considers IBI scores below 35 as unsupportive for aquatic communities (IDEM 2006a, IDEM 2006b). According to IDEM mandate the 1990 and 2015 survey showed that 100% of sites are categorized as unsupportive, while the 2011 survey found 97.8% of sites as unsupportive.

### 3.3 Condition of the EBLCR

Table 4 displays the results of the *post-hoc* weighted IBI score correction with respect to stream class. Each survey period is represented by three weighted IBIs (cold, cool, warm) and a combined cold-, cool-, and warmwater adjusted scores for the EBLCR. Investigating the combined adjusted IBI integrity class statistics yields an overall impression of the EBLCR watershed. The combined weighted IBIs show that 64% (coldwater), 53% (coolwater), or 78% (warmwater) of the EBLCR total stream miles consist of impaired habitat (Table 3). The coldwater combined IBI had only one site, accounting for 4% of stream miles, as ‘good’ integrity class while the coolwater and coldwater combined IBI had no sites above the ‘fair’ integrity category. Large portions of the watershed fail to meet IDEM (2006a, 2006b) mandate for non-limited use waterways no matter what IBI method used. This investigation of the EBLCR watershed provides a poor outlook for the past 25 years.

*Table 3.* Estimates of the condition of the EBLCR watershed in terms of total stream miles for the 1990, 2011, 2015, and combined survey periods. Adjusted IBI Score is the result of stream class grouped IBI scores multiplied by a weight factor. CI% is the confidence interval of the estimate. SE is the standard deviation of the adjusted IBI scores. n = represents the number of sites within each integrity class.

| | 1990 | | | | 2011 | | | | 2015 | | | | Combined | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Coldwater** | | | | | | | | | | | | | | | | |
| Integrity Class | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n |
| Excellent | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0 | 0 | | 0 |
| Good | 5.136 | 61.03 | | 1 | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 5.136 | 4.07 | | 1 |
| Fair | 1.023 | 12.16 | 0.344 | 5 | 61.727 | 34.85 | 16.080 | 10 | 37.718 | 37.01 | 10.039 | 8 | 40.18 | 31.83 | 9.03 | 23 |
| Poor | 0.726 | 8.62 | 0.108 | 5 | 59.744 | 33.73 | 7.695 | 21 | 33.121 | 32.50 | 5.368 | 19 | 41.946 | 33.23 | 5.09 | 45 |
| Very Poor | 1.531 | 18.19 | 1.011 | 5 | 52.879 | 29.86 | 4.303 | 11 | 29.237 | 28.69 | | 1 | 36.386 | 28.83 | 6.41 | 17 |
| No Fish | 0.000 | 0.00 | | 0 | 2.764 | 1.56 | 0.203 | 4 | 1.827 | 1.79 | | 1 | 2.577 | 2.04 | 0.25 | 5 |
| Total: | 8.416 | 100% | | 16 | 177.114 | 100% | | 46 | 101.903 | 100% | | 29 | 126.225 | 100% | | 91 |
| **Coolwater** | | | | | | | | | | | | | | | | |
| Integrity Class | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n |
| Excellent | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0 | 0 | | 0 |
| Good | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0 | 0 | | 0 |
| Fair | 2.739 | 39.43 | 2.06 | 2 | 83.391 | 42.95 | 15.332 | 7 | 63.956 | 53.06 | | 1 | 65.317 | 46.79 | 14.9 | 10 |
| Poor | 3.794 | 54.62 | 2.4 | 6 | 69.429 | 35.76 | 8.807 | 20 | 36.268 | 30.09 | 7.756 | 10 | 49.279 | 35.3 | 6.74 | 36 |
| Very Poor | 0.414 | 5.95 | 0.07 | 8 | 38.587 | 19.87 | 6.312 | 15 | 18.495 | 15.34 | 3.772 | 17 | 22.413 | 16.06 | 3.61 | 40 |
| No Fish | 0.000 | 0.00 | | 0 | 2.764 | 1.42 | 0.203 | 4 | 1.827 | 1.52 | | 1 | 2.577 | 1.85 | 0.25 | 5 |
| **Total:** | 6.947 | 100% | | 16 | 194.171 | 100% | | 46 | 120.546 | 100% | | 29 | 139.586 | 100% | | 91 |
| **Warmwater** | | | | | | | | | | | | | | | | |
| Integrity Class | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n | Adjusted IBI | CI% | SE | n |
| Excellent | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0 | 0 | | 0 |
| Good | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 0.000 | 0.00 | | 0 | 5.136 | 4.07 | | 1 |
| Fair | 0.000 | 0.00 | | 0 | 17.607 | 16.53 | | 1 | 0.000 | 0.00 | | 0 | 40.18 | 31.83 | 9.03 | 23 |
| Poor | 1.102 | 39.30 | 0.39 | 7 | 58.010 | 54.47 | 6.310 | 30 | 27.895 | 50.94 | 5.025 | 19 | 41.946 | 33.23 | 5.09 | 45 |
| Very Poor | 1.703 | 60.70 | 1.07 | 9 | 28.112 | 26.40 | 4.844 | 11 | 25.040 | 45.72 | 5.131 | 9 | 36.386 | 28.83 | 6.41 | 17 |
| No Fish | 0.000 | 0.00 | | 0 | 2.764 | 2.60 | 0.203 | 4 | 1.827 | 3.34 | | 1 | 2.577 | 2.04 | 0.25 | 5 |
| **Total:** | 2.805 | 100% | | 16 | 106.493 | 100% | | 46 | 54.762 | 100% | | 29 | 126.225 | 100% | | 91 |

An increased emphasis on long-term monitoring of stream and river habitats is needed to fully understand the effects of urbanization and the trends it produces. The proximity of Little Calumet River to the Lake Michigan shores highlights the importance of this regions' stream and river health, as the Lake Michigan basin provides massive amounts of resources, both recreational and economic necessity. Although many different evaluation tools can be utilized, this research's IBI results act as a 25-year inventory for the EB-LCR. A comprehensive catalog of IBI trends over time can be used to observe the effects of construction, channel modification, and management decisions resulting from urbanization of population centers.

## 4. Conclusions

Investigating the combined adjusted IBI integrity class statistics yields an overall impression of the EBLCR watershed (Table 4). The combined weighted IBIs show that 73% (coldwater), 89% (coolwater), or 98% (warmwater) of the total EBLCR stream miles consist of impaired habitat (Table 3). The coldwater combined IBI had only one site, accounting for 4% of stream miles, as 'good' integrity class while the coolwater and coldwater combined IBI had no sites above the 'fair' integrity category. Large portions of the watershed fail to meet IDEM (2006a, 2006b) mandate for non-limited use waterways no matter what IBI method used. This investigation shows that the EBLCR has been in poor condition for the past 25 years.

An increased emphasis on long-term monitoring of stream and river habitats is needed to fully understand the effects of urbanization and the trends it produces. The proximity of Little Calumet River to the Lake Michigan shores highlights the importance of this regions' stream and river health, as the Lake Michigan basin provides massive amounts of resources, both recreational and economic necessity. Although many different evaluation tools can be utilized, this research's IBI results act as a 25-year inventory for the EBLCR. The research conducted suggests that more emphasis needs to be put on assessing the state of waterways in the region so as to provide evidence for protection of this important natural resource. A comprehensive catalog of IBI trends over time can be utilized to observe the adverse effects of urbanization and management decisions on watershed condition.

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