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CHANGES IN THE CONDITION OF THE WABASH RIVER DRAINAGE FROM 1990–2004

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ABSTRACT. The Wabash River drainage was evaluated based on three hydrologic watershed units that were sampled from 1990–2004 so that patterns in biological integrity and assessment of aquatic life designated uses could be determined. The three units included: 1) the West Fork and lower White River, 2) the East Fork White River, and 3) the remainder of the Indiana portions of the Wabash River system above its confluence with the Ohio River. Targeted sampling was done in each of the three watershed units from 1990–1995, while a random probability sample design was used from 1996–2004. Assessment of the fish assemblage information for the three periods showed increasing biological integrity for each of the three watersheds. The watershed with the highest biological integrity was the East Fork White River, followed by the West Fork White River, and Wabash River. Aquatic life designated uses were met in 76% of the East Fork White River stream miles; 62% of the West Fork and lower White rivers; and 53% of the Wabash River stream miles.

Keywords: Biotic integrity, biological assessment, probabilistic design, Index of Biotic Integrity (IBI)

The mandate of water quality monitoring agencies is to assess the condition of the waters of the United States and to report on their status. As new tools are developed (Morris et al. 2006) and indices are calibrated (Simon 1992; Simon & Stahl 1998; Simon in review), increasingly more accurate assessments of the status of these waters can be generated which will allow for more emphasis to be placed on restoration of vulnerable and threatened systems, as well as protection of high quality waters. Over the last two decades monitoring tools developed in Indiana have focused primarily on the use of biological indicators (Simon 1992; Simon & Dufour 1998; Simon 2006).

An environment that supports an assemblage of organisms similar to that produced by long-term evolutionary processes is considered to have high biological integrity. Biological integrity has been defined as "the ability to support and maintain a balanced, integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr & Dudley 1981; Karr et al. 1986). Human activities often degrade the environment, resulting in a detectable decline in biological integrity.

When comparing all streams in North America, large rivers are disproportionately degraded (Karr et al. 1985; Poff et al. 1997). The loss of biological integrity in these large river systems is the result of widespread land use changes and anthropogenic land scale disturbance. Few studies have evaluated the long-term changes in biological integrity in drainage units as large as the Wabash River, with emphasis on large mainstem rivers (Hughes et al. 2005).

The purpose of the current study was to document changes in three hydrologic watershed units within the Wabash River drainage from 1990–2004. We compared changes during three assessment periods and the status of the watershed based on a stratified probability based approach.

METHODS

Study area.—The Wabash River is the largest northern tributary of the Ohio River and is the longest free-flowing large river east of the Mississippi. For this study, the Wabash River drainage was divided into three watershed study areas based on 8-digit hydrologic units as defined by the U.S. Geological Survey (USGS). The Wabash River and its direct tributaries include the headwater areas from the State of Ohio to its confluence with the Ohio River (Posey County). The other two drainage units include the largest tributaries of the Wabash River, which are the East and West Forks of the White River. Together these three drainage units represent nearly two-thirds of the total area of central Indiana and encompass portions of the Eastern Corn Belt Plain (ECBP), which is primarily rowcrop agriculture, and the Interior River Lowland (IRL), which includes forest landscapes, as well as oil, gas, and coal exploration land uses (Omernik & Gallant 1988).

Study design.—The State of Indiana uses a Probabilistic Monitoring Program as one portion of the state's comprehensive strategy to provide an evaluation of stream water quality and biological integrity in major basins of Indiana. The probability design generates statistically valid estimates of the percent of total stream miles impaired for aquatic life and recreational uses.

Three hydrologic units in the Wabash River drainage were assessed based on a random, stratified probabilistic design (Messer et al. 1991). The Probabilistic Monitoring Program divided the state into nine major watersheds that are sampled once every five years, providing a complete assessment of the entire state.

Sites were generated using U.S. Environmental Protection Agency (USEPA) Environmental Monitoring and Assessment Program (EMAP) selection methods, which used randomly selected sites to assess and characterize the overall water quality and biotic integrity of the study basin (USEPA 1994; USGS 1994). The target population was defined as all perennial streams within the geographic boundaries of Indiana for the basin of interest. "Perennial" for the purpose of the Probabilistic Monitoring Program was defined as water present in at least 50% of the stream reach (reach was defined as 15 times the average wetted width of the stream, minimum 50 m, maximum 500 m). The sample population included all rivers, streams, canals, and ditches as indexed through the USEPA River Reach File 3 excluding marshes, wetlands, backwaters, impoundments, dry and tiled sites. Site selection was stratified to ensure streams of all sizes/orders (Strahler 1952) were sampled allowing for a spatially accurate representation of the various stream sizes (USEPA 1994; USGS 1994).

Table 1.—Total IBI score, integrity class and attributes to define the fish assemblage characteristics in Indiana streams and rivers (modified from Karr et al. 1986).

Total IBI score	Integrity class	Attributes
53–60	Excellent	Comparable to "least impacted" conditions, exceptional assemblage of species.
45–52	Good	Decreased species richness (intolerant species in particular), sensitive species present.
35–44	Fair	Intolerant and sensitive species absent, skewed trophic structure.
23–34	Poor	Top carnivores and many expected species absent or rare, omnivores and tolerant species dominant.
12–22	Very poor	Few species and individuals present, tolerant species dominant, diseased fish frequent.
<12	No fish	No fish captured during sampling.

Three study periods included the baseline study that was conducted from 1990–1995 and two rounds of the probability sampling that included the periods 1996–1999 and 2001–2004.

Field collection.—Fish assemblages were assessed using a variety of electrofishing equipment. Small streams (<3.3 m wetted width) were sampled using either backpack or long-line electrofishing units; wadeable streams (>3.3 m wetted width) were sampled using long-line or tote-barge electrofishing equipment; large river (non-wadeable >2580 km^2 drainage area) and great river (>5956.97 km^2) reaches were sampled using boat mounted electrofishing units. Sampling was conducted along a linear reach of stream based on 15 times the wetted width with minimum distances of 50 m and maximum distances of 500 m (500 m each bank for large rivers). All

Table 2.—Checklist of fish species collected from the three hydrologic units including the Wabash River, West Fork White River, and East Fork White River from three study periods (1990–2004).

	Wabash River			West Fork White River			East Fork White River		
Family, *species,* common name	90–95	96–99	01–04	90–95	96–99	01–04	90–95	96–99	01–04
Petromyzontidae									
Ichthyomyzon castaneus, chestnut lamprey	1	1		2			1	1	4
I. fossor, northern brook lamprey			4						
I. unicuspis, silver lamprey	3			3	4		3		3
Lampetra aepyptera, least brook lamprey				1				1	
L. appendix, American brook lamprey	2	1		2	3		1		1
Acipenseridae									
Scaphirhynchus platorynchus, shovelnose sturgeon	4	1	4						
Polyodontidae									
Polyodon spathula, paddlefish	26								
Lepisosteidae									
Lepisosteus oculatus, spotted gar				7			3		
L. osseus, longnose gar	138	12	2	56			13	1	6
L. platostomus, shortnose gar	159	15	63	30		3	2	5	4
Amiidae									
Amia calva, bowfin	7	4	3	3		1	3	1	1
Hiodontidae									
Hiodon alosoides, goldeye	18								
H. tergisus, mooneye	16						1		
Anguillidae									
Anguilla rostrata, American eel							1		
Clupeidae									
Alosa chrysochloris, skipjack herring				3				1	
Dorosoma cepedianum, gizzard shad	3648	267	319	1276	16	27	393	60	364
D. petenense, threadfin shad	6	5		9			1		

Table 2.—Continued.

Family, *species,* common name	Wabash River			West Fork White River			East Fork White River		
	90–95	96–99	01–04	90–95	96–99	01–04	90–95	96–99	01–04
Cyprinidae									
Campostoma anomalum, central stoneroller	6715	2166	1136	4744	551	1021	2443	809	2425
C. oligolepis, largescale stoneroller	17	130	92	191					
Carassius auratus, goldfish				96	1				
Ctenopharyngodon idella, grass carp			2						
Cyprinella lutrensis, red shiner	11			3					
C. spiloptera, spotfin shiner	2018	2328	418	13,822	258	262	3939	291	872
C. whipplei, steelcolor shiner	512	119	93	208	20		20	202	74
Cyprinus carpio, common carp	630	200	270	221	36	100	65	9	74
Ericymba buccata, silverjaw minnow	840	360	646	1069	147	120	187	305	60
Erimystax dissimilis, streamline chub	3						5		14
E. x-punctatus, gravel chub	3								
Hybognathus hayi, cypress minnow	11								
H. nuchalis, Mississippi silvery minnow	803	82	76	55	12		4	192	22
Hybopsis amblops, bigeye chub	39	295	170	39			161	39	303
H. amnis, pallid shiner	3						2		
Hypophthalmichthys molitrix, silver carp			4						
Luxilus chrysocephalus, striped shiner	900	216	301	762	116	47	849	68	587
L. cornutus, common shiner	6	3					2		
Lythrurus fumeus, ribbon shiner	9	6		3		2			
L. umbratilis, redfin shiner	196	26	126	137	87	3	125	62	70
Macrhybopsis hyostoma, shoal chub	20	1		1					
M. storeriana, silver chub	168	5	2	4		2	3		
Nocomis biguttatus, hornyhead chub	62	35	90	32	4		14	5	41
N. micropogon, river chub	317	143	80	8	4		11		44
Notemigonus crysoleucus, golden shiner	74	9		106	5		26	3	2
Notropis ariommus, popeye shiner				132					
N. atherinoides, emerald shiner	862	666	114	48	18	22	91	37	42
N. blennius, river shiner	242	1625	20	20					
N. boops, bigeye shiner	6		1	1	7		14	11	2
N. buchanani, ghost shiner	3			3			1		
N. heterodon, blackchin shiner	1								
N. heterolepis, blacknose shiner	1								

Table 2.—Continued.

Family, *species*, common name	Wabash River			West Fork White River			East Fork White River		
	90–95	96–99	01–04	90–95	96–99	01–04	90–95	96–99	01–04
N. ludibundus, sand shiner	677	576	574	891	76	86	140	17	280
N. photogenis, silver shiner		1	1	11	9	24	6		35
N. rubellus, rosyface shiner	15	61	98	61	9	2	48	18	44
N. shumardi, silverband shiner	49	81		186			2	7	
N. volucellus, mimic shiner	14	1	259	29	3		7	25	12
N. wickliffi, channel shiner	91	1	13	2					
Opsopoeodus emiliae, pugnose minnow				1			12	4	
Phenacobius mirabilis, suckermouth minnow	702	157	65	477	49	11	165	39	26
Phoxinus eythrogaster, southern redbelly dace	177	59	37	70	38		179	76	
Pimephales notatus, bluntnose minnow	5063	2644	2448	3404	1268	393	1847	1009	802
P. promelas, fathead minnow	106	5	36	23	2	17	3		
P. vigilax, bullhead minnow	364	422	100	2409	29	71	1023	59	331
Rhinichthys atratulus, western blacknose dace	2587	1061	575	489	131	388	556	79	98
Semotilus atromaculatus, creek chub	6177	2247	1899	2482	582	968	1650	650	840
Catostomidae									
Carpiodes carpio, river carpsucker	490	214	127	76	1	34	31	3	37
C. cyprinus, quillback	62	6	15	214		9	10	1	1
C. velifer, highfin carpsucker	16		11	8		1	5		1
Catostomus catostomus, longnose sucker	3								
C. commersoni, white sucker	2441	194	298	1099	282	347	516	59	270
Cycleptus elongatus, blue sucker	85	14	29						7
Erimyzon oblongus, creek chubsucker	139	29	46	16	32	9	48	25	18
Hypentilium nigricans, northern hogsucker	990	370	242	600	192	101	397	27	453
Ictiobus bubalus, smallmouth buffalo	40	2	11	99		2	4	3	27
I. cyprinellus, bigmouth buffalo	21	4	9	2			2	2	6
I. niger, black buffalo	7		14						2
Minytrema melanops, spotted sucker	86	37	31	59	17	9	73	2	32
Moxostoma anisurum, silver redhorse	45	26	12	27			14	3	17
M. carinatum, river redhorse	5	2	4	1			3	1	25
M. duquesnei, black redhorse	145	127	216	182	31	135	67	27	393
M. erythrurum, golden redhorse	234	85	310	248	60	136	173	58	491
M. macrolepidotum, shorthead redhorse	120	14	51	20		5	30	12	39
M. valenciennesi, greater redhorse			1						

Table 2.—Continued.

Family, *species,* common name	Wabash River			West Fork White River			East Fork White River		
	90–95	96–99	01–04	90–95	96–99	01–04	90–95	96–99	01–04
Ictaluridae									
Ameiurus melas, black bullhead	22	1	9	6	5	4	2	5	
A. natalis, yellow bullhead	238	126	128	161	36	63	102	61	48
A. nebulosus, brown bullhead	4	1	2	6		1	3		2
Ictalurus furcatus, blue catfish	24						13		
I. punctatus, channel catfish	605	83	126	164	1	9	156	12	132
Noturus eleutherus, mountain madtom	1	1		36	1		5		
N. flavus, stonecat	47	70	16	16	17		7		12
N. gyrinus, tadpole madtom	24	9	3	2	1	3			3
N. miurus, brindled madtom	7	9	20	6	3	12	4	30	25
N. nocturnus, freckled madtom	4	4		3					
Pylodictus olivaris, flathead catfish	81	41	21	36		11	15	11	43
Esocidae									
Esox americanus, grass pickerel	82	27	52	22	9	29	7	12	39
E. lucius, northern pike				1					
E. lucius x masquinongy, tiger muskie	2								
Umbridae									
Umbra limi, central mudminnow	75	9	193				1	1	1
Salmonidae									
Oncorhynchus mykiss, rainbow trout									1
Aphredoderidae									
Aphredoderus sayanus, pirate perch	21	95	6	1	1		4	15	12
Fundulidae									
Fundulus catenatus, northern studfish							1	6	8
F. dispar, starhead topminnow				3					
F. notatus, blackstripe topminnow	148	148	97	171	103	115	104	46	10
F. olivaceus, blackspotted topminnow		10					18		
Poeciliidae									
Gambusia affinis, western mosquitofish	117	28	13	23	31	207	1		33

Table 2.—Continued.

Family, *species,* common name	Wabash River			West Fork White River			East Fork White River		
	90–95	96–99	01–04	90–95	96–99	01–04	90–95	96–99	01–04
Atherinidae									
Labidesthes sicculus, brook silverside	54	3	9	103	3	3	72		16
Cottidae									
Cottus bairdi, mottled sculpin	1411	838	167	1003	237	238	312	31	118
C. carolinae, banded sculpin		27		15		16			
Moronidae									
Morone chrysops, white bass	45	1	10	13			1		
M. chrysops x saxatilis, wiper		11							
M. mississippiensis, yellow bass	6	2	2	11		7			
M. saxatilis, striped bass				3					
Centrarchidae									
Ambloplites rupestris, rock bass	260	276	223	162	107	41	100	71	203
Centrarchus macropterus, flier								1	
Lepomis cyanellus, green sunfish	1312	765	517	1000	343	338	527	201	243
L. gibbosus, pumpkinseed	6	25		2			8		
L. gulosus, warmouth	17	11	8	8			22	3	30
L. humilis, orangespotted sunfish	121	64	41	85	2	9	1		1
L. macrochirus, bluegill	495	513	254	897	130	633	711	253	692
L. megalotis, longear sunfish	1872	1473	1293	2017	674	395	1427	629	1407
L. microlophus, redear sunfish	27	10	8	32		1	7	1	17
L. punctatus, spotted sunfish	8			6			4		
Micropterus dolomieu, smallmouth bass	176	60	116	145	101	67	78	13	200
M. punctulatus, spotted bass	188	150	123	250	71	67	400	115	227
M. salmoides, largemouth bass	48	48	12	179	11	47	64	24	27
Pomoxis annularis, white crappie	120	6	9	20	4		9	5	34
P. nigromaculatus, black crappie	10	18	13	14		4	1	6	29
Percidae									
Ammocrypta clara, western sand darter				1			8		
A. pellucida, eastern sand darter			1				1		5
Etheostoma asprigene, mud darter	5	12		19		1	28	21	
E. blennioides, greenside darter	938	718	391	417	168	138	438	276	554

Table 2.—Continued.

Family, *species,* common name	Wabash River			West Fork White River			East Fork White River		
	90–95	96–99	01–04	90–95	96–99	01–04	90–95	96–99	01–04
E. caeruleum, rainbow darter	1108	462	488	809	106	444	207	82	380
E. camurum, bluebreast darter	8	10	13						
E. chlorosomum, bluntnose darter		5							
E. flabellare, fantail darter	467	155	153	98	18	118	196	171	57
E. gracile, slough darter	9	9	7	5	1	1		1	
E. histrio, harlequin darter								16	8
E. microperca, least darter	1	2	4				11	13	
E. nigrum, johnny darter	1608	417	518	641	132	595	425	191	328
E. spectabile, orangethroat darter	912	283	287	646	137	632	253	411	138
E. squamiceps, spottail darter	3		12	1					
E. zonale, banded darter		4							
Perca flavescens, yellow perch	13	8							
Percina caprodes, logperch	143	59	36	44	11	21	27	11	72
P. evides, gilt darter	1	2							
P. maculata, blackside darter	33	43	11	35	17	21	42	18	35
P. phoxocephala, slenderhead darter	92	28	10	14		6	4	11	29
P. sciera, dusky darter	41	115	58	19	11	59	58	18	111
P. shumardi, river darter		8							4
Sander canadense, sauger	22	2	7	2			1	2	5
S. vitreum, walleye	8	3	3						
Sciaenidae									
Aplodinotus grunniens, freshwater drum	578	182	164	464		6	14	12	40

representative habitats were sampled within the stream reach. All fish encountered were netted and placed into a live well. At the completion of the sampling, all fish were identified to species, counted, batch weighed by species, and minimum and maximum length recorded. All individuals were inspected for deformities, eroded fins, lesions, and tumor (DELT) anomalies. Fish were identified using regional identification manuals (Gerking 1955; Smith 1973; Trautman 1981), and voucher specimens are curated at the Indiana Biological Survey Aquatic Research Center, Bloomington, Indiana.

Calculations of biological integrity.—The Index of Biotic Integrity (IBI) was used to assess the biological integrity of the stream (Simon 1992; Simon & Dufour 1998; Simon & Stahl 1998; Simon 2006). The IBI is composed of 12 metrics that assess fish assemblage structure, trophic composition (feeding and reproductive guilds), and fish condition and health. The total IBI score, integrity class and attributes help define fish assemblage characteristics. Table 1, modified from Karr et al. 1986, uses total IBI score, integrity class and attributes to define the fish assemblage characteristics in Indiana streams and rivers.

Indiana narrative biological criteria [327 IAC 2-1-3(2)] states that "all waters, except those designated as limited use, will be capable of supporting a well-balanced, warm water aquatic community" (IDEM 2006a). The water quality standard definition of a "well-balanced aquatic community" is "an aquatic community which is diverse in species composition, contains several different trophic levels, and is not composed mainly of strictly pollution tolerant species" [327 IAC 2-1-9(60)] (IDEM 2006a). A stream segment is non-supporting for aquatic life use when the monitored fish assemblage receives an IBI score of less than 35 which is considered poor or very poor (IDEM 2006b).

Statistics and data analysis.—When estimates for characteristics of the entire target watershed are computed, the statistical analysis must account for any loss of stratification or unequal probability selection due to some sites not being sampled (i.e., access denied, impounded, dry, etc.). This method applies a *post-hoc* statistical correction factor (weighting factor) to an unbalanced sample stratification resulting in a corrected probability design (Diaz-Ramos et al. 1996).

The USEPA National Health and Environmental Effects Research Laboratory (NHEERL) in Corvallis, Oregon, created a software program "psurvey.analysis" that is used to adjust the weighting of sites and develop accurate estimates for a measured parameter in a target population. This software program contains functions which calculate the final weight value for each site and estimates the percentage of integrity class for each hydrologic unit in the Wabash drainage (http://www.epa.gov/nheerl/arm/analysispages/techinfoanalysis.htm).

RESULTS & DISCUSSION

Fish assemblage.—Based on surveys of the entire Wabash River, 150 species were found from 1990–2004. This number of species represents 72.1% of the entire fish fauna of Indiana (Simon et al. 2002). We collected 135 species from the Wabash River hydrologic unit, 113 species from the West Fork and lower White River hydrologic unit, and 115 species from the East Fork White River hydrologic unit (Table 2).

Status.—Based on the sampling and IBI results of three hydrologic units that comprise the Wabash River drainage, the Wabash River and tributaries drainage unit has remained relatively stable during the last 15 years. However, the East Fork White River (EFWR) and West Fork White River (WFWR) drainage units show an increase in biological integrity with higher percentages of fair, good, and excellent integrity classes (Table 3). The EFWR had the highest percentage (17%) of excellent streams, while the Wabash River had the lowest (1%). Watershed ranking of sites that met designated uses for aquatic life (IBI Score >35) included EFWR (76%), WFWR (62%), and Wabash River (53%) (Table 3). The Wabash River possessed the highest percentage of poor sites based on biological integrity (36%), followed by the WFWR (27%), and the EFWR (22%).

Wabash River: Three sampling periods included targeted sampling during 1990–1995, and two probabilistic survey periods during 1998–1999, and 2003–2004 (Fig. 1). Surveys of the Wabash River from 1990–1995 resulted in an average IBI score that classified sites as fair (Fig. 1). None of the Wabash River mainstem sites rated as excellent. The frequency

Table 3.—Probability estimates of condition +/− 95% confidence interval for three hydrologic units in the Wabash River drainage in Indiana (CI = confidence interval, n = number of sites).

Wabash and tributaries						
	1st cycle (1996–1999)		2nd cycle (2001–2004)		Combined	
Integrity class	95% CI	n	95% CI	n	95% CI	n
Excellent	1% ± 1	2	2% ± 2	2	1% ± 1	4
Good	10% ± 6	13	14% ± 7	17	13% ± 5	30
Fair	46% ± 11	37	35% ± 11	27	39% ± 8	64
Poor	35% ± 11	30	37% ± 12	23	36% ± 8	53
Very poor	8% ± 7	5	12% ± 8	6	11% ± 6	11
East Fork White River						
	1st cycle (1996–1999)		2nd cycle (2001–2004)		Combined	
Integrity class	95% CI	n	95% CI	n	95% CI	n
Excellent	1% ± 1	1	22% ± 8	11	17% ± 10	12
Good	9% ± 7	5	20% ± 12	8	16% ± 7	13
Fair	30% ± 15	10	37% ± 16	12	43% ± 12	22
Poor	53% ± 16	14	19% ± 14	6	22% ± 7	20
Very poor	7% ± 9	2	2% ± 3	1	2% ± 2	3
West Fork White River and Lower White River						
	1st cycle (1996–1999)		2nd cycle (2001–2004)		Combined	
Integrity class	95% CI	n	95% CI	n	95% CI	n
Excellent	0%	0	6% ± 8	2	3% ± 4	2
Good	12% ± 10	6	15% ± 10	7	14% ± 7	13
Fair	35% ± 15	12	54% ± 17	18	45% ± 12	30
Poor	48% ± 17	12	8% ± 7	4	27% ± 11	16
Very poor	5% ± 8	1	17% ± 12	5	11% ± 7	6

distribution for each of the IBI condition categories from 1990–1995 included good–excellent (3.6%), good (7.1%), good–fair (14.3%), fair (32.1%), fair–poor (21.4%), poor (17.9%), and very poor (3.6%). Biological integrity for the Wabash River mainstem was low in 1993 from Fountain County to Posey County (Simon & Stahl 1998), possibly influenced by prolonged early summer flooding (Gammon & Simon 1998). For the Wabash River mainstem, the lowest IBI scores occured near old Grand Rapids dam (IBI = 22); and there was a large depression in biological integrity along Vermillion County down river to northern Vigo County (Simon & Stahl 1998). Overall, streams in the watershed improved in the excellent and good condition categories during 1998–99, but categories that failed to meet aquatic life designated uses also increased (Table 3). Continued improvements were observed during 2003–2004 with increases in excellent and good categories, and declines in the fair condition category (Fig. 1). Unfortunately, the poor and very poor condition categories also increased (Table 3). The three frequency distribution curves of total IBI score for the Wabash River watershed over three survey periods show increases in the fair and good integrity classes (ranging from 35 to 53) (Fig. 4).

East Fork White River: Biological integrity increased in the EFWR from 1990-2002 (Fig. 2). During 1990–1995, the fish assemblage conditions ranged from poor–very poor (IBI = 25) to good (IBI = 51). The frequency distribution was: good (16.7%), fair (11.1%), fair–poor (50.0%), poor (16.7%), poor–very poor (5.6%). Sampling conducted during 1997

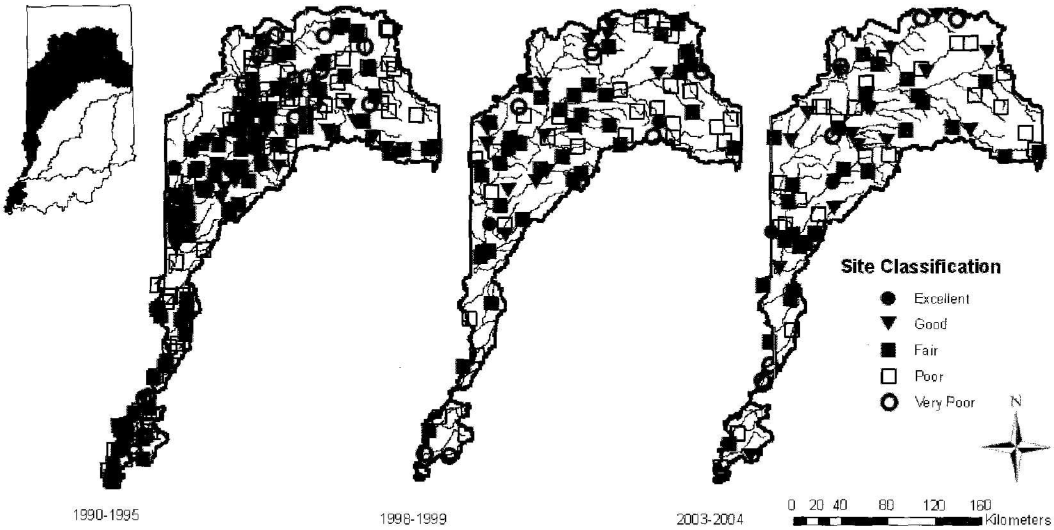

Figure 1.—Status of the Wabash River hydrologic unit based on three survey periods; 1990–1995, 1998–1999, and 2003-2004.

produced similar results to the 1990–1995 period (Fig. 2), with the only difference being an increase in the amount of poor condition sites. During 2002, excellent and good condition sites increased in frequency and poor and very poor condition sites decreased (Table 3). Overall, there were fewer poor sites in 1990–1995 than in both 1997 and 2002. However, more good and excellent integrity classes were found in 2002 than in 1990–1995 and 1997 (Fig. 5).

West Fork White River: Biological integrity in the WFWR and lower White River improved with the largest increases occurring between the poor and fair integrity categories (Fig. 3). During 1990–1995, an increase in biological integrity was observed downstream from the East and West Fork junction to the mouth of the lower White River (Simon 1992). The condition of fish assemblages in the lower White River (1990-1995) ranged from poor to fair (IBI = 27–44), and IBI

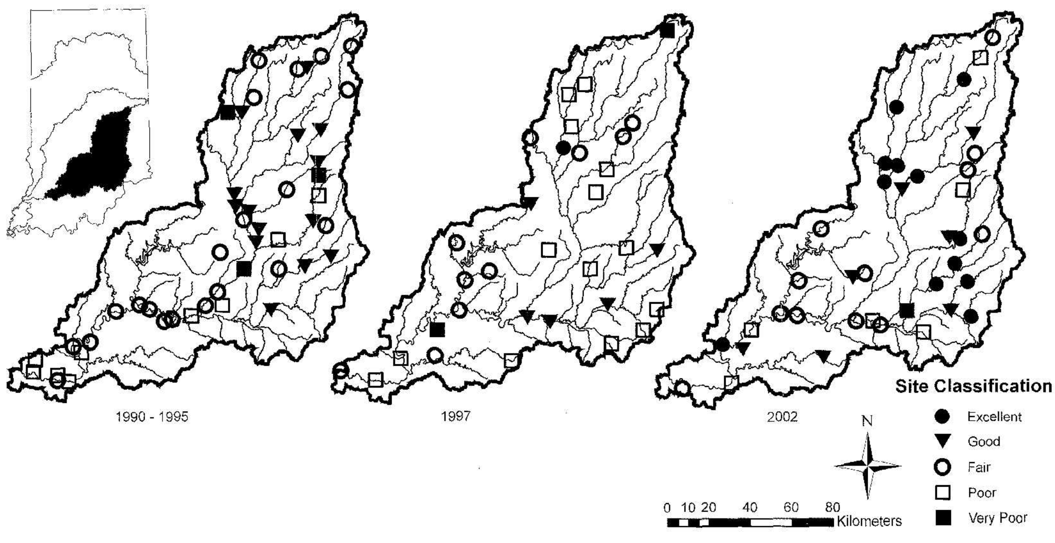

Figure 2.—Status of the East Fork White River hydrologic unit based on three survey periods; 1990–1995, 1997, and 2002.

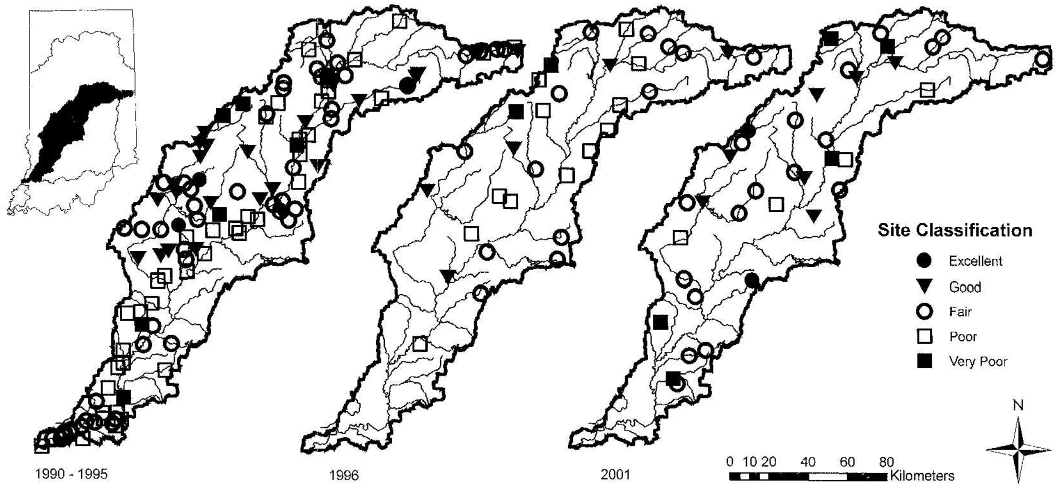

Figure 3.—Status of the West Fork White River hydrologic unit based on three survey periods; 1990–1995, 1996, and 2001.

scores approximated a normal curve with a frequency distribution including, fair 31.3% (n = 5), fair–poor 37.5% (n = 6), and poor 31.3% (n = 5) (Simon 1992). The condition of the fish assemblages in the WFWR (1990–1995) ranged from poor–very poor (IBI = 24) to good (IBI = 46), and the IBI frequency distribution for the 1990–1995 period for the WFWR included: good (5.6%), fair (11.1%), fair–poor (16.7%), poor (22.2%), and poor–very poor (33.3%). During 1996, the biological integrity of the WFWR watershed improved with the increase of the good and fair categories and the decline of the very poor category (Table 3). The frequency distribution of total IBI scores for the West Fork and lower White rivers over the three survey periods indicates a decrease in fair and good integrity classes from 1990–1995 to 1996. However, the high integrity classes rebound in 2001 to levels greater than those seen from 1990–1995 and 1996 (Fig. 6).

Assessment of the three watershed units.—The benefit of the random probability design was a narrower confidence interval for estimated parameters with increasing number of data points; however, this assumes that no changes in water quality affected the biological assemblages (Messer et al. 1991). Assessments of each watershed can be evaluated based on either each of the three time periods or based on a combination of the random probability design sites during each of the two sample rounds (Table 3).

Each watershed estimate reflects a high degree of confidence; however, combination of the data for the ten year period from 1996–2006 can be used to determine trends in aquatic life designated uses. Based on the combined assessment conditions, the Wabash River watershed unit has about 53% of all stream miles meeting aquatic life designed uses; EFWR has 76% of all stream miles meeting aquatic life designated uses (IBI > 35); and WFWR has 62% of all stream miles meeting aquatic life designated uses (Table 3). The EFWR has 33% of all stream miles classified as either good or excellent based on biological integrity, while the WFWR has 17% of stream miles and the Wabash River has 14% classified as good or excellent. The Wabash River had 47% of stream miles failing aquatic life designated uses (classified as poor or very poor), WFWR had 38% failing, and EFWR had 24% as either poor or very poor (Table 3).

An increasing need for Water Quality agencies to report on the entire waters of the nation requires monitoring and assessment tools that can be used to provide accurate classification of water resources. The Wabash River drainage is perhaps one of the most important waters in the State of Indiana. Water quality agencies are increasingly challenged with the responsibility for providing clean water and for restoring the biological integrity of the nation's surface waters. The use of a probabilistic sample design allows all waters to be clas-

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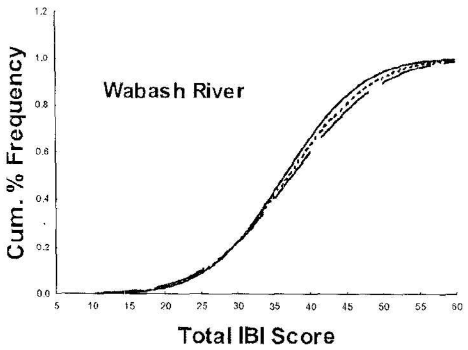

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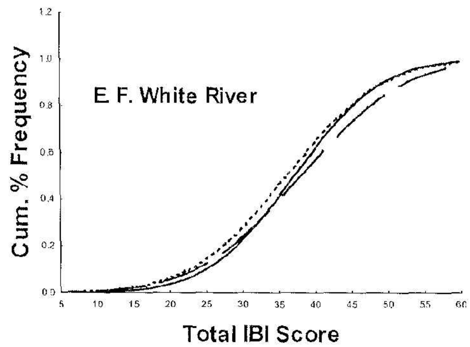

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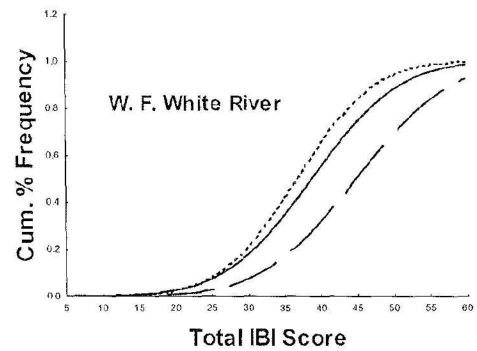

____ 1990-1995
...... 1996-1999
_ _ _ 2001-2004

Figures 4–6.—Cumulative percent frequency distribution of total IBI scores. 4. Wabash River watershed; 5. East Fork White River watershed; 6. West Fork and lower White River watershed. (Solid line = Ecoregion data: 1990–1995, Dotted line = 1st round probabilistic: 1996–1999, Dashed line = 2nd round probabilistic: 2001–2004.

sified and accurate reporting and inventory to be classified. Trends in biological integrity can be followed as management and restoration programs are implemented.

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