State of New Jersey
James E. McGreevey, Governor

2002 IBI EXECUTIVE SUMMARY

New Jersey Department of Environmental Protection
Bradley M. Campbell, Commissioner

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NJ Department of Environmental Protection
P.O. Box 427, Trenton, NJ 08625-0427

WATER MONITORING AND STANDARDS
Leslie J. McGeorge, Administrator

Bureau of Freshwater & Biological Monitoring
Alfred L. Korndoerfer, Jr., Chief

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Report Design By:
WILLIAM HONACHEFSKY, SECTION CHIEF

FIELD SUPERVISOR
Bud Cann, Supervising Environmental Specialist

DATA REDUCTION AND GRAPHICS
William Honachefsky
Brian Margolis
Johannus Franken

FISH IDENTIFICATIONS
Brian Margolis and William Honachefsky
Confirmation by: Philadelphia Academy of Natural Sciences

FIELD COLLECTION STAFF
Bud Cann
Brian Margolis
Charles Lawless
William Honachefsky
Johannus Franken

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INTRODUCTION

Monitoring the health of aquatic systems is a critical component of watershed management. Historically, aquatic systems were monitored primarily through chemical means. Unfortunately, chemical monitoring provides only a "snapshot" of conditions at the time of sampling and may fail to detect acute pollution events (e.g. runoff from heavy rain, spills) and non-chemical pollution (e.g. habitat alteration). In order to address the shortcomings of chemical monitoring, the New Jersey Department of Environmental Protection supplements chemical monitoring with biological monitoring. Biological monitoring is based on the premise that biological communities are shaped by the long-term conditions of their environment and more accurately reflect the health of an ecosystem.

The monitoring of stream fish assemblages is an integral component of many water quality management programs for a variety of reasons (See Table 1), and its importance is reflected in the aquatic life use support designations adopted by many states. Narrative expressions such as "maintaining coldwater fisheries", "fishable", or "fish propagation" are prevalent in many state standards. Here in New Jersey, surface water quality criteria are closely aligned with descriptors such as *trout production, trout maintenance* and *non-trout* waterways. Fish assemblages can be stand alone indicators of a waterbody's health and/or fishability. In addition, they may be combined with other biological and chemical indicators to assist in the nomination of waters for upgrade to Category One classification (NJAC 7:9B) based on exceptional ecological significance.

TABLE 1

ADVANTAGES OF USING FISH AS INDICATORS OF ENVIRONMENTAL HEALTH

1. Fish are good indicators of long-term (several years) effects and broad habitat conditions because they are relatively long-lived and mobile (Karr et al. 1986).

2. Fish assemblages generally include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). They tend to integrate effects of lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health.

3. Fish are at the top of the aquatic food chain and are consumed by humans, making them important subjects in assessing contamination.

4. Fish are relatively easy to collect and identify to the species level. Most specimens can be sorted and identified in the field and released unharmed.

    - Environmental requirements of common fish are comparatively well known.
    - Life history information is extensive for most species.
    - Information on fish distributions is commonly available.

5. Aquatic life uses (water quality standards) are typically characterized in terms of fisheries (coldwater, coolwater, warmwater, sport, forage).

    - Monitoring fish assemblages provides direct evaluation of "fishability", which emphasizes the importance of fish to anglers and commercial fisherman.

6. Fish account for nearly half of the endangered vertebrate species and subspecies in the United States (Warren and Burr 1994).

The general methodology currently employed in the compilation of these studies and reports is the Rapid Bioassessment Protocol described in Barbour et al. (1999) with some modifications for regional conditions (Kurtenbach 1994). The principal evaluation mechanism utilizes the technical framework of the *Index of Biotic Integrity (IBI),* a fish assemblage approach developed by Karr (1981). The IBI incorporates the zoogeographic, ecosystem, community and population aspects of the fish assemblage into a single ecologically based index. Calculation and interpretation of the IBI involves a sequence of activities including: fish sample collection, data tabulation, and regional modification[1] and calibration of metrics and expectation values. This concept has provided the overall multimetric index framework for rapid bioassessment in this document.

Data provided by the IBI will become another component of the DEP's suite of environmental indicators. The data will help to measure water quality use attainment and the Department's success in attaining the Clean Water Act goal of "fishable" waters as elaborated in the Department's integrated 305(b) and 303(d) Integrated Assessment Report. IBI data will also be used to develop biological criteria, prioritize sites for further studies, provide biological impact assessments, and assess status and trends of the state's freshwater fish assemblages. Currently, IBI data collected from northern New Jersey are used in an approach to nominate candidate waters for upgrade to a Category One classification (NJAC 7:9B) based on exceptional ecological significance.

FIELD COLLECTION PROCEDURES

Primary objectives of the fish collections are to obtain samples with representative species and abundances, at a reasonable level of effort. Sampling effort is standardized by using similar stream lengths, collection methods, and habitat types. Stream segments selected for sampling must have a minimum of one riffle, run, and pool sequence to be considered representative.

TABLE 2

REQUIREMENTS FOR FISH SAMPLING BASED ON STREAM SIZE

	A	B	C
Stream Size	Moderate to large streams and rivers (5^{th} order or greater)	Wadeable streams (3^{rd} and 4^{th} order)	Headwater streams (1^{st} and 2^{nd} order)
Sampling Distance (meters)	500 m	150 m	150 m
Electrofishing Gear	12' boat	2 Backpacks or barge electrofishing unit	1-2 Backpack electrofisher(s)
Power Source	5000 watt generator	24 volt battery or 2500 watt generator	24 volt battery

Streams with drainage areas less than 5 square miles are presently excluded from IBI scoring because of naturally occurring low species richness. Often streams classified as trout production waters fall into this category. More appropriate assessment methods for these streams include the measurement of trout abundance and/or young of the year production. Benthic macroinvertebrate assessments are also a viable alternative. In addition, atypical habitats such as dams and mouths of tributaries are avoided, unless the intent of the study is to determine the influence these habitats have on the fish assemblage. Most often, sampling atypical habitats results in the collection of fish species not represented in typical stream reaches. Sampling intermittent streams should also be avoided. These streams require the development of a separate set of IBI scoring criteria.

[1] The IBI methodology presently being used in these studies was modified from Plafkin et al. (1989) to meet the regional conditions of New Jersey (not all of the state, however, is covered, **see Fig. 1)** based on work by Kurtenbach (1994). It should be noted, however, that an enumeration of fish assemblages, regardless of whether an IBI is calculated or not, is still a useful *environmental indicator* capable of providing stand alone information useful to determine whether the affected stream(s) are capable of meeting the narrative criteria of "fishable".

Fish are sampled primarily with electrofishing gear using pulsed direct current (DC) output. This method of collection has proved to be the most comprehensive and effective single method for collecting stream fishes. Direct current is safer, more effective, especially in turbid water, and less harmful to the fish. In waters with low conductivity (less than 75 µmhos/cm) it may be necessary to use an AC unit (Lyons 1992). Selection of the appropriate electrofishing gear is dependent on stream size (Table 2). A typical sampling crew consists of four to seven people (Fig. 2), depending on the gear being utilized. A minimum of two people are required for netting the stunned fish. Electrofishing is conducted by working slowly upstream for 150 meters and placing the electrodes in all available fish habitat. Stunned fish are netted at and below the electrodes as they drift downstream. Netters attempt to capture fish representing all size classes. All fish captured are immediately placed in water filled containers strategically located along the stream bank in order to reduce fish mortality.

Sampling time generally requires 1.5 to 2 hours per station. This includes the measurement of chemical and physical parameters. Sampling is conducted during daylight hours, June through early October, under normal or low flows, and never under atypical conditions such as high flows or excessive turbidity caused by heavy precipitation. Fish collections made in the summer and early fall are easier, safer and less likely to disturb spawning fish.

SAMPLE PROCESSING

Fish are identified to the species level, counted, examined for disease and anomalies, measured (game fish), released and recorded on fish data sheets in the field. The sampling protocol employed is ineffective in capturing a representative sample of smaller fish because they are difficult to see and tend to congregate. Consequently, only fish greater than 25 mm in length are counted. Reference specimens and difficult to identify individuals are placed in jars containing 10 percent formaldehyde and later confirmed at the laboratory using taxonomic keys; (Werner 1980; Eddy and Underhill 1983; Smith 1985; Page and Burr 1991; Jenkins and Burkhead 1993). Species particularly difficult to identify are forwarded to fisheries experts outside the Bureau of Freshwater and Biological Monitoring for confirmation (at present the Philadelphia Academy of Natural Sciences).

Once the fish from each sample collection have been identified, counted, examined for disease and anomalies, and recorded, several biometrics are used to evaluate biological integrity. Fish assemblage analysis is accomplished using a regional modification of the original IBI (Karr 1981), developed by Kurtenbach (1994). Consistent with Karr et al. (1986), a theoretical framework is constructed of several biological metrics that are used to assess a fish assemblage's richness, trophic composition, abundance and condition, and compared to fish assemblages found in regional reference streams[2, 3]. The modified IBI (New Jersey version) uses the following ten biometrics: 1) total number of fish species, 2) number of benthic insectivorous species, 3) number of trout and sunfish species, 4) number of intolerant species, 5) proportion of individuals as white suckers, 6) proportion of individuals as generalists (carp, creek chub, goldfish, fathead minnow, green sunfish and banded killifish), 7) proportion of individuals as insectivorous cyprinids, 8) proportion of individuals as trout or proportion of individuals as piscivores (top carnivores) - excluding American eels, 9) number of individuals in the sample and 10) proportion of individuals with disease or anomalies (excluding blackspot disease). **See Appendices 1 and 2.**

Quantitative scoring criteria were developed for each biometric based upon the degree of deviation; 5 (none to slight), 3 (moderately), and 1 (significantly) from appropriate ecoregional reference conditions. Scores for the individual biometrics at each sampling location are summed to produce a total score, which is then assigned a condition category. The maximum possible IBI score is 50, representing excellent biological integrity. A score of less than 29 indicates a stream has poor biological integrity. 10 is the lowest score a site can receive. Further descriptions of all of the metrics used in the IBI calculations are presented below:

[2] For regional reference conditions Kurtenbach (1994) used historical fisheries data collected by the New Jersey Division of Fish, Game and Wildlife (unpublished) at 126 stream sites located in the Delaware, Passaic, and Raritan River watersheds. The fish collection methods and the stream lengths sampled in these historical studies were compatible with Kurtenbach's work.

[3] Trophic guilds, pollution tolerances and origins (native or introduced) of each fish species utilized by Kurtenbach to calculate the IBI were assigned using several fisheries publications (Stiles, 1978; Smith, 1985; Hocutt et al. 1986; Karr et al. 1986; Ohio EPA, 1987; Miller et al. 1988).

MEASUREMENT OF PHYSICAL AND CHEMICAL PARAMETERS

Physical and chemical measurements (e.g. pH, conductivity, temperature, depth) of existing stream conditions are recorded on physical characterization/water quality field data sheets and later summarized.

HABITAT ASSESSMENT

Habitat assessments are conducted at every sampling site and all information is recorded on field sheets (Barbour et al. 1999). Habitat assessments provide useful information on probable causes of impairment to instream biota when water quality parameters do not indicate a problem. The habitat assessment consists of an evaluation of the following physical features along the 150 meter reach: substrate, channel morphology, stream flow, canopy and stream side cover. Individual parameters within each of these groups are scored and summed to produce a total score, which is assigned a habitat quality category (**Appendix 3**).

QUALITY ASSURANCE/QUALITY CONTROL

A Quality Assurance/Quality Control plan is approved by the Office of Quality Assurance prior to sampling. A copy of this plan is available by contacting the BFBM.

FURTHER INFORMATION

The current report summarizes the third year of IBI sampling. By summer 2004, the IBI network will have 100 stations in northern New Jersey (an IBI for southern New Jersey is currently being evaluated). Stations will be visited every five years as part of the Bureau's monitoring efforts.

Reports and data for the first three years of the IBI can be obtained on the Bureau of Freshwater and Biological Monitoring's web page: http://www.state.nj.us/dep/wmm/bfbm or by calling 609-292-0427.

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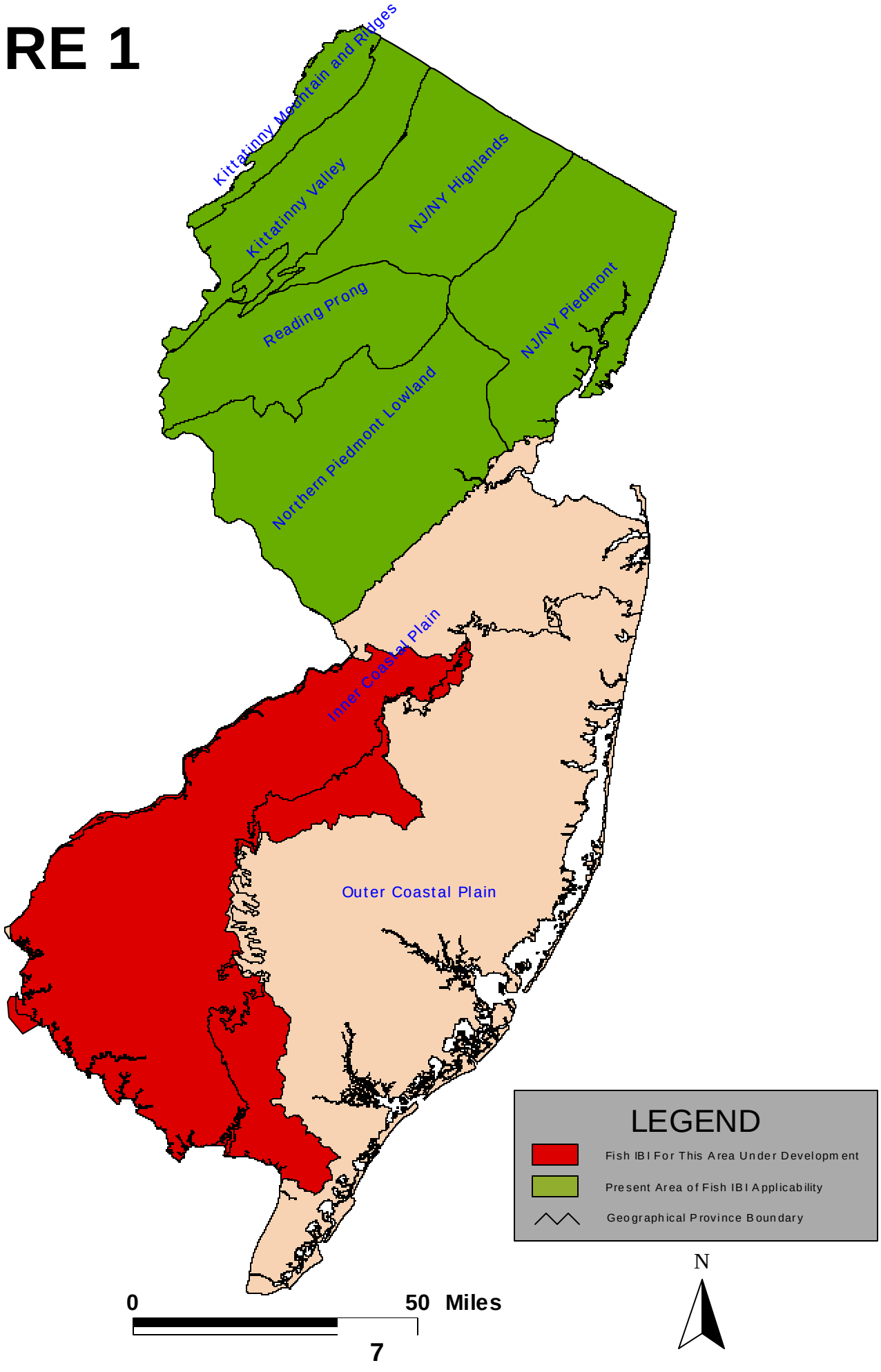
FIGURE 1


Kittatinny Mountain and Ridges
Kittatinny Valley
NJ/NY Highlands
Reading Prong
NJ/NY Piedmont
Northern Piedmont Lowland
Inner Coastal Plain
Outer Coastal Plain
LEGEND
Fish IBI For This Area Under Development
Present Area of Fish IBI Applicability
Geographical Province Boundary
N
0
50 Miles
7

Summary of Results

2002 IBI Sites

2002 IBI Sites

- Excellent
- Good
- Fair
- Poor
- Major Streams
- Watershed Management Areas

20 0 20 Miles

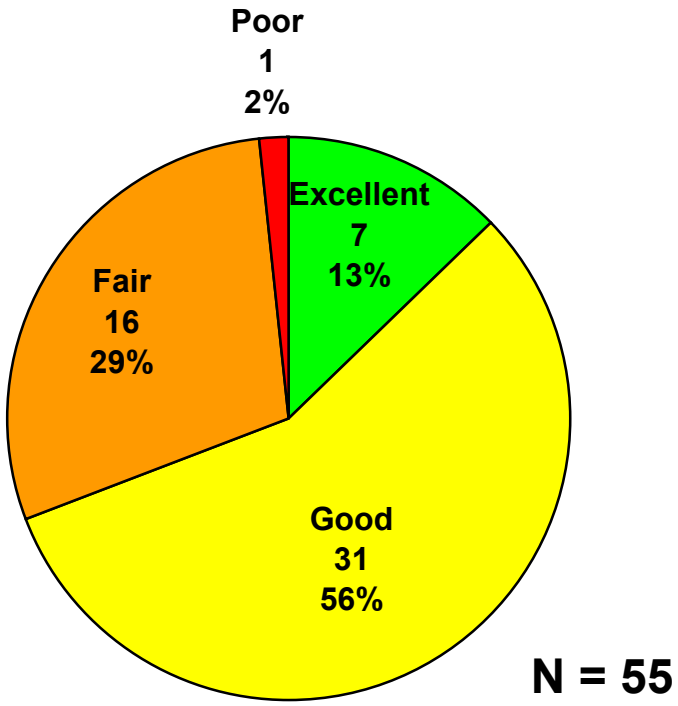
N

2002 Results*

FIBI Site	Waterbody	County	Habitat Rating	IBI Rating	
FIBI022	Six Mile Run	Somerset	Suboptimal	Fair	
FIBI041	Shabakunk Creek	Mercer	Suboptimal	Good	
FIBI042	Elizabeth River	Union	Marginal	Poor	
FIBI043	Third River	Essex	Marginal	Fair	
FIBI044	Deepavaal Brook	Essex	Marginal	Fair	
FIBI045	Beaver Dam Brook	Morris	Marginal	Fair	
FIBI046	Clove Brook	Sussex	Optimal	Excellent	
FIBI047	Beaver Brook	Warren	Optimal	Good	
FIBI048	Buckhorn Creek	Warren	Optimal	Good	
FIBI049	Walkill River	Sussex	Suboptimal	Good	
FIBI050	Lubbers Run	Sussex	Suboptimal	Good	
FIBI051	Ireland Brook	Middlesex	Suboptimal	Fair	
FIBI052	Ramapo River	Bergen	Suboptimal	Good	
FIBI053	Mulhockaway Creek	Hunterdon	Suboptimal	Excellent	
FIBI054	Lamington River	Hunterdon	Optimal	Good	
FIBI055	Paulins Kill	Warren	Suboptimal	Good	

*Due to severe drought conditions at the end of the sampling season, only 16 sites were sampled. Additional sites will be added in 2003 to make up for the deficit.

IBI Ratings - 2000-02



Summary of 1st round IBI ratings to date. It is anticipated that approximately 100 sites will be sampled by the end of the 1st Round (Summer 2004).

APPENDIX 1

Revised List of New Jersey Freshwater Fishes

December 2000

	Trophic Guild	Tolerance	Historical Presence
Petromyzontidae:			
American Brook Lamprey (*Lampetra appendix*)	NF	IS	N
Sea Lamprey (*Petromyzon marinus*)	PF	--	N
Acipenseridae:			
Atlantic Sturgeon (*Acipenser oxyrhynchus*)	BI	--	N
Shortnose Sturgeon (*A. brevirostrum*)	BI	IS	N
Lepisosteidae:			
Longnose Gar (*Lepisosteus osseus*)	P	--	EX
Amiidae:			
Bowfin (*Amia calva*)	P	--	NN
Anguillidae:			
American Eel (*Anguilla rostrata*)	P	--	N
Clupeidae:			
Blueback Herring (*Alosa aestivalis*)	PL	--	N
Hickory Shad (*A. mediocris*)	I/P	--	N
Alewife (*A. pseudoharengus*)	PL	--	N
American Shad (*A. sapidissima*)	PL	--	N
Gizzard Shad (*Drosoma cepedianum*)	O	--	N
Salmonidae:			
Rainbow Trout (*Oncorhynchus mykiss*)	I/P	IS	NN
Brown Trout (*Salmo trutta*)	I/P	IS	E
Brook Trout (*Salvelinus fontinalis*)	I/P	IS	N
Lake Trout (*S. namaycush*)	P	--	NN
Osmeridae:			
Rainbow Smelt (*Osmerus mordax*)	I	--	N
Umbridae:			
Eastern Mudminnow (*Umbra pygmaea*)	I	--	N
Esocidae:			
Redfin Pickerel (*Esox americanus*)	P	--	N
Northern Pike (*E. lucius*)	P	--	NN
Muskellunge (*E. masquinongy*)	P	--	NN
Chain Pickerel (*E. niger*)	P	--	N
Cyprinidae:			
Goldfish (*Carassius auratus*)	O	--	E
Grass Carp (*Ctenopharyngodon idella*)	H	--	E
Satinfin Shiner (*Cyprinella analostana*)	I	--	N
Spotfin Shiner (*C. spiloptera*)	I	--	N
Common Carp (*Cyprinus carpio*)	O	--	E
Cutlips Minnow (*Exoglossum maxillingua*)	BI	IS	N
Eastern Silvery Minnow (*Hybognathus regius*)	H	--	N
Common Shiner (*Luxilis cornutus*)	I	--	N
Golden Shiner (*Notemigonus crysoleucas*)	O	--	N
Comely Shiner (*Notropis amoenus*)	I	--	N

APPENDIX 1

	Trophic Guild	Tolerance	Historical Presence
Bridle Shiner (*N. bifrenatus*)	I	--	N
Ironcolor Shiner (*N. chalybaeus*)	I	--	N
Spottail Shiner (*N. husdonius*)	I	--	N
Swallowtail Shiner (*N. procne*)	I	--	N
Bluntnose Minnow (*Pimephales notatus*)	O	--	NN
Fathead Minnow (*P. promelas*)	O	--	NN
Blacknose Dace (*Rhinichthys atratulus*)	BI	--	N
Longnose Dace (*R. cataractae*)	BI	--	N
Creek Chub (*Semotilus atromaculatus*)	I	--	N
Fallfish (*S. corporalis*)	I	--	N
Catostomidae:			
White Sucker (*Catostomus commersoni*)	BI	--	N
Creek Chubsucker (*Erimyzon oblongus*)	BI	--	N
Northern Hog Sucker (*Hypentelium nigricans*)	BI	IS	N
Ictaluridae:			
White Catfish (*Ameiurus catus*)	I/P	--	N
Black Bullhead (*A. melas*)	BI	--	NN
Yellow Bullhead (*A. natalis*)	BI	--	N
Brown Bullhead (*A. nebulosus*)	BI	--	N
Channel Catfish (*Ictalurus punctatus*)	I/P	--	NN
Tadpole Madtom (*Noturus gyrinus*)	BI	--	N
Margined Madtom (*N. insignis*)	BI	IS	N
Aphredoderidae:			
Pirate Perch (*Aphredoderus sayanus*)	I	--	N
Cyprinodontidae:			
Banded Killifish (*Fundulus diaphanus*)	I	--	N
Mummichog (*F. heteroclitus*)	I	--	N
Poeciliidae:			
Mosquitofish (*Gambusia affinis*)	I	--	NN
Eastern Mosquitofish (*G. holbrooki*)	I	--	N
Gasterosteidae:			
Fourspine Stickleback (*Apeltes quadracus*)	I	--	N
Threespine Stickleback (*Gasterosteus aculeatus*)	I	--	N
Ninespine Stickleback (*Pungitius pungitius*)	I	--	N
Moronidae:			
White Perch (*Morone americana*)	I/P	--	N
Striped Bass (*M. saxatilis*)	P	--	N
Centrarchidae:			
Mud Sunfish (*Acantharchus pomotis*)	I	--	N
Rock Bass (*Ambloplites rupestris*)	I	--	NN
Blackbanded Sunfish (*Enneacanthus chaetodon*)	I	--	N
Bluespotted Sunfish (*E. gloriosus*)	I	--	N
Banded Sunfish (*E. obesus*)	I	--	N
Redbreasted Sunfish (*Lepomis auritus*)	I	--	N
Green Sunfish (*L. cyanellus*)	I	--	NN

APPENDIX 1

	Trophic Guild	Tolerance	Historical Presence
Pumpkinseed (*L. gibbosus*)	I	--	N
Bluegill (*L. macrochirus*)	I	--	NN
Smallmouth Bass (*Micropterus dolomieu*)	I/P	--	NN
Largemouth Bass (*M. salmoides*)	P	--	NN
White Crappie (*Pomoxis annularis*)	I/P	--	NN
Black Crappie (*P. nigromaculatus*)	I/P	--	NN
Percidae:			
Swamp Darter (*Etheostoma fusiforme*)	BI	IS	N
Tessellated Darter (*E. olmstedi*)	BI	--	N
Yellow Perch (*Perca flavescens*)	I/P	--	N
Shield Darter (*Percina peltata*)	BI	IS	N
Walleye (*Stizostedion vitreum*)	P	IS	NN
Cottidae:			
Slimy Sculpin (*Cottus cognatus*)	BI	IS	N

Abbreviations:

BI	Benthic Insectivore or Invertivore	IS	Intolerant Species
E	Exotic	N	Native
EX	Extirpated (no longer found in NJ)	O	Omnivore
NF	Nonparasitic filterer	P	Piscivore (top carnivore)
PF	Parasitic / Filterer	PL	Planktivore
H	Herbivore	NN	Non Native (introduced)
I	Insectivore		

APPENDIX 2

IBI For Northern New Jersey

(Metrics and Scoring Criteria)
as of 05/03/2000

	SCORING CRITERIA		
	5	**3**	**1**
SPECIES RICHNESS AND COMPOSITION:			
1) Total Number of Fish Species	VARIES WITH STREAM SIZE		
2) Number and Identity of benthic insectivorous species	VARIES WITH STREAM SIZE		
3) Number and identity of trout and/or sunfish species	VARIES WITH STREAM SIZE		
4) Number and identity of intolerant species	VARIES WITH STREAM SIZE		
5) Proportion of individuals as white suckers	<10%	10-30%	>30%
TROPHIC COMPOSITION:			
6) Proportion of individuals as generalists (carp, creek chub, goldfish, fathead minnow, green sunfish, banded killifish)	<20%	20-45%	>45%
7) Proportion of individuals as insectivorous cyprinids	>45%	20-45%	<20%
8) Proportion of individuals as trout	>10%	3-10%	<3%
OR (whichever gives better score)			
Proportion of individuals as piscivores (excluding American eel)	>5%	1-5%	<1%
FISH ABUNDANCE AND CONDITION:			
9) Number of individuals in the sample	>250	75-250	<75
10) Proportion of individuals with disease and anomalies (excluding blackspot disease)	<2%	2-5%	>5%

Condition Categories (modified from Karr et al. 1986)

45-50 Excellent Comparable to the best situations with minimal human disturbance: all regionally expected species for the habitat and stream size, most intolerant forms are present and there is a balanced trophic structure.

37-44 Good Species richness somewhat below expectation, especially due to the loss of some intolerant species; some species present with less than optimal abundances or size distributions; trophic structure shows some signs of stress (increasing frequency of generalists, white suckers and other tolerant species).

29-36 Fair Signs of additional deterioration include fewer species, loss of most intolerant species, highly skewed trophic structure (high frequency of generalists, whites suckers and other tolerant species); older age classes of trout and/or top carnivores may be rare.

10-28 Poor Low species richness, dominated by generalists, white suckers or other tolerant species, few (if any) trout or top carnivores, individuals may show signs of disease/parasites and site may have overall low abundance of fish.

APPENDIX 2

Species to be included in each of the metrics used by the NJDEP:

Benthic Insectivores (Metric 2) – Sturgeon, Cutlips Minnow, Dace, Suckers, Bullheads, Madtoms, Darters and Sculpins

Trout* and Sunfish (Metric 3, 8) – All species in the families Salmonidae and Centrarchidae

Intolerant Species (Metric 4) – American Brook Lamprey, Shortnose Sturgeon, All Trout species, Cutlips Minnow, Northern Hog Sucker, Margined Madtom, Swamp Darter, Shield Darter, Walleye and Slimy Sculpin

Insectivorous Cyprinids (Metric 7) – All minnows (Family Cyprinidae) in the following genera: *Cyprinella, Exoglossum, Luxilus, Notropis, Rhinichthys* and *Semotilus*

Piscivores (Metric 8)[+]

* Streams that have been stocked with trout are sampled during July and August. Both stocked and resident trout found during these months are counted in the IBI scoring. The ability of a stream to support trout during these harsh months (high temperature, low dissolved oxygen) is indicative of good water quality and habitat.

[+]The current form of the New Jersey IBI (Kurtenbach 1994) requires the classification of fish species into trophic categories prior to scoring metric #8. However, many fish species fall into multiple categories as a function of size and life stage. Consequently, the bureau has used available literature (Turner and Kraatz, 1921; Keast and Webb, 1966; Goldstein, 1993), stomach content analysis (Bremer-Faust, 2001; Margolis, unpublished data) and best professional judgement to designate trophic guilds for these species for the 2002 IBI. These designations, which only affect Metric #8, are as follows:

Green Sunfish	Insectivorous
Rock Bass	Insectivorous
Smallmouth Bass	> 90 mm - Piscivorous
Largemouth Bass	> 90 mm - Piscivorous
Yellow Perch	>150 mm - Piscivorous

Literature Cited

Bremer-Faust, C.M. 2001. *Piscivory in green sunfish (Lepomis cyanellus): A comparison of methods of analysis.* George H. Cook Honors Thesis, Cook College, Rutgers University. 49 pp.

Goldstein, R.M. 1993. *Size selection of prey by young largemouth bass.* Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 47:596-604.

Karr, J. R., K.D. Fausch, P.L. Angermeier, P. R. Yant, and I.S. Schlosser. 1986. *"Assessing biological integrity in running waters: a method and its rationale"* Illinois Natural History Survey, Champaigne, IL, Special Publication 5.

Keast, A. and D. Webb. 1966. *Mouth and body form relative to feeding ecology in the fish fauna of a small lake, Lake Opinicon, Ontario.* J. Fish. Res. Bd. Canada. 23(12):1845-1874.

Kurtenbach, J.P. 1994. *Index of biotic integrity study of northern New Jersey drainages.* U.S. EPA, Region 2, Division of Environmental Science and Assessment, Edison, NJ.

Turner, C.L. and W.C. Kraatz. 1921. *Food of young large-mouth black bass in some Ohio waters.* Trans. Am. Fish. Soc. 50:372-380.

APPENDIX 3

IBI AND HABITAT SCORING SHEETS/GRAPHS - SAMPLE

FIBI045 07-10-2002

Beaver Dam Brook

LISTED IN ORDER OF ABUNDANCE FOUND

COMMON NAME	SCIENTIFIC NAME	# FOUND	SIZE RANGE (INCHES)
Tesselated Darter	*Etheostoma olmstedi*	131	
Green Sunfish*	*Lepomis cyanellus*	27	1.4-4.5
White Sucker*	*Catostomus commersoni*	26	
Creek Chub	*Semotilus atromaculatus*	13	
Redfin Pickerel*	*Esox americanus americanus*	10	3.1-7.5
Bluegill*	*Lepomis macrochirus*	2	2.8
Redbreast Sunfish*	*Lepomis auritus*	2	4.1-5.5
Eastern Mudminnow	*Umbra pygmaea*	1	

* Regulated as a fishable species under current New Jersey Fish and Wildlife codes

FIBI045 - Beaver Dam Brook off Park Avenue Excellent Good **Fair** Poor

Date Sampled - 7/10/2002

	Score
# of Fish Species	5
# of Benthic Insectivorous Species (BI)	3
# of Trout and Centrarchid Species (trout, bass, sunfish, crappie)	3
# of Intolerant Species (IS)	1
Proportion of Individuals as White Suckers	3
Proportion of Individuals as Generalists (carp, creek chub, banded killifish, goldfish, fathead minnow, green sunfish)	5
Proportion of Individuals as Insectivorous **Cyprinids** (I and BI)	1
Proportion of Individuals as Trout *whichever gives better score OR Proportion of Individuals as Pisciviores (Excluding American Eel)*	3
Number of Individuals in Sample	3
Proportion of Individuals w/disease/anomalies (excluding blackspot)	5
Total	**32**

Stream Rating

45-50	**Excellent**
37-44	**Good**
29-36	**Fair**
10-28	**Poor**

HABITAT ASSESSMENT FOR *HIGH* GRADIENT STREAMS **Beaver Dam Brook (FIBI045) – 7/10/02**

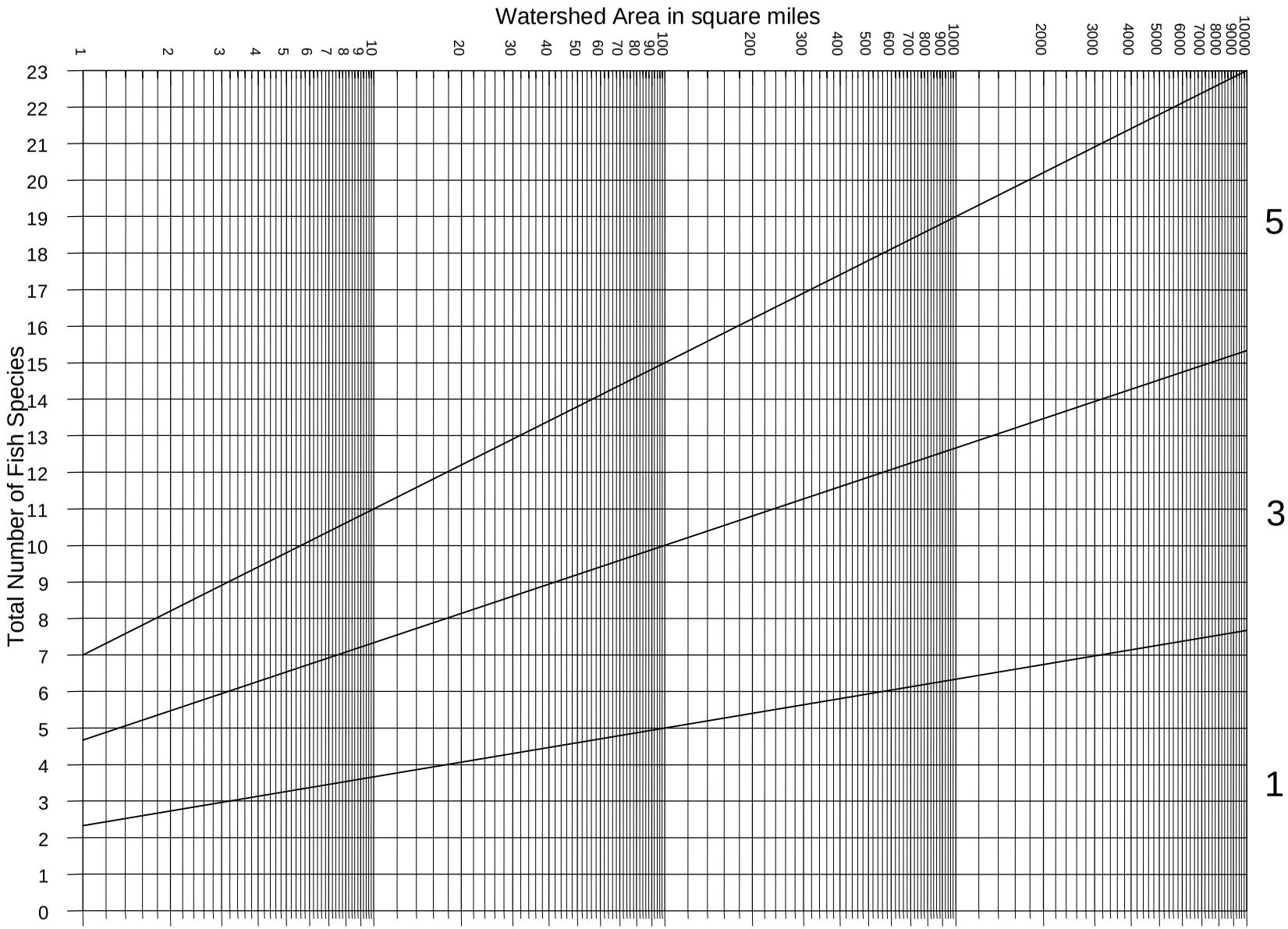
	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate /Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 **8** 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 **8** 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is >0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 **8** 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 12	20 19 18 17 16	15 14 13 **12** 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 18	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 **6**	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 **7** 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___**2**___ (LB)	Left 10 9	8 7 6	5 4 3	**2** 1 0
SCORE ___**4**___ (RB)	Right 10 9	8 7 6	5 **4** 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___**2**___ (LB)	Left 10 9	8 7 6	5 4 3	**2** 1 0
SCORE ___**5**___ (RB)	Right 10 9	8 7 6	**5** 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___**2**___ (LB)	Left 10 9	8 7 6	5 4 3	**2** 1 0
SCORE ___**4**___ (RB)	Right 10 9	8 7 6	5 **4** 3	2 1 0

HABITAT SCORE

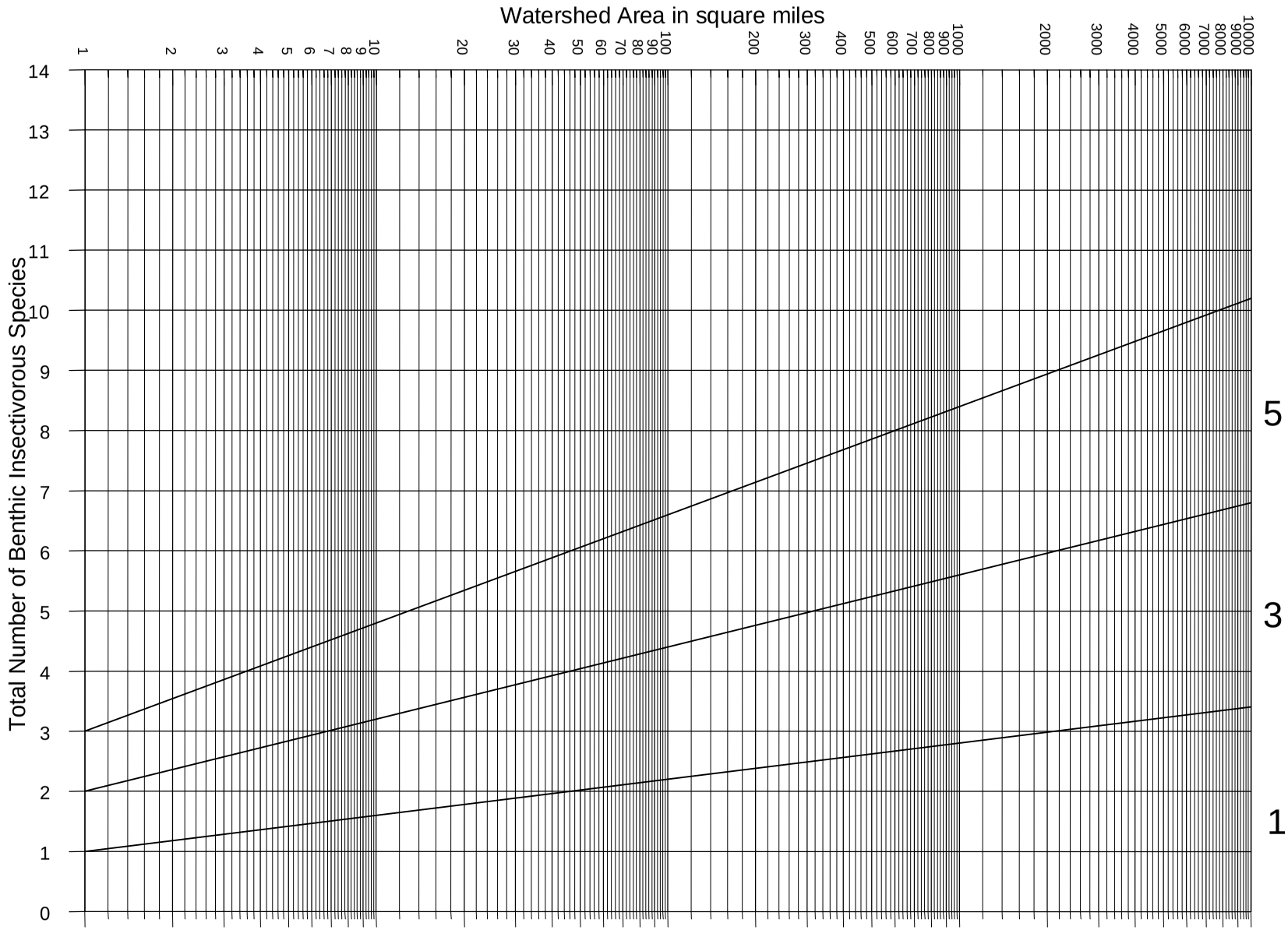
86

HABITAT SCORES	VALUE
OPTIMAL	160 – 200
SUB-OPTIMAL	110 – 159
MARGINAL	**60 – 109**
POOR	< 60

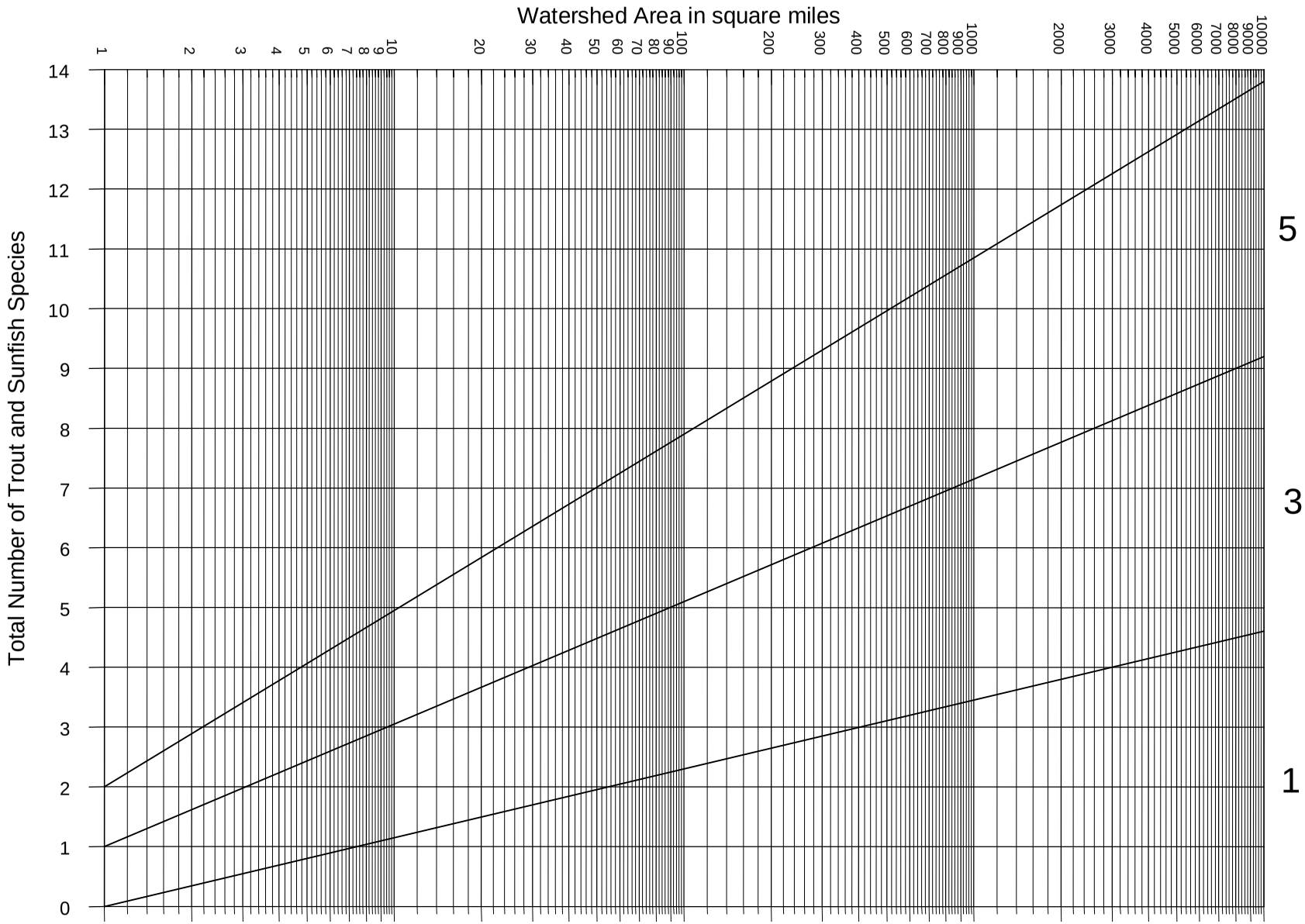
Total number of fish species versus watershed area for New Jersey ecoregion reference sites.



Total number of benthic insectivorous fish species versus watershed area for New Jersey ecoregion reference sites



Total number of trout and sunfish species versus watershed area for New Jersey ecoregion reference sites



Total number of intolerant fish species versus watershed area for New Jersey ecoregion reference sites