National Biological Assessment and Criteria Workshop

Advancing State and Tribal Programs

Coeur d'Alene, Idaho
31 March – 4 April, 2003

BIO 101

Biological Assessments, Biocriteria & Water Quality Standards in Ohio

Presented by

Chris Yoder, Midwest Biodiversity Institute

Aquatic Bioassessments by Ohio EPA

Where

- Mainly rivers, streams, and small waterways
- In use and development for Lake Erie, Ohio River, and wetlands

What

- Fish, macroinvertebrates, physical habitat
- Sediments, water quality, fish contamination
- Biomarkers, other tools as developed

Why

- Provide empirical information for water quality management and decision-making
- Determine status of Ohio's aquatic resources
- Assure that waters are correctly classified

CORE INDICATORS

• Fish Assemblage • Macroinvertebrates • Periphyton
(Use Community Level Data From At Least Two)

Physical Habitat Indicators	Chemical Quality Indicators
• Channel morphology • Flow • Substrate Quality • Riparian	• pH • Temperature • Conductivity • Dissolved O_2

For Specific Designated Uses Add the Following:

AQUATIC LIFE
Base List:
- Ionic strength
- Nutrients, sediment

Supplemental List:
- Metals (water/sed.)
- Organics (water/sed.)

RECREATIONAL
Base List:
- Fecal bacteria
- Ionic strength

Supplemental List:
- Other pathogens
- Organics (water/sed.)

WATER SUPPLY
Base List:
- Fecal bacteria
- Ionic strength
- Nutrients, sediment

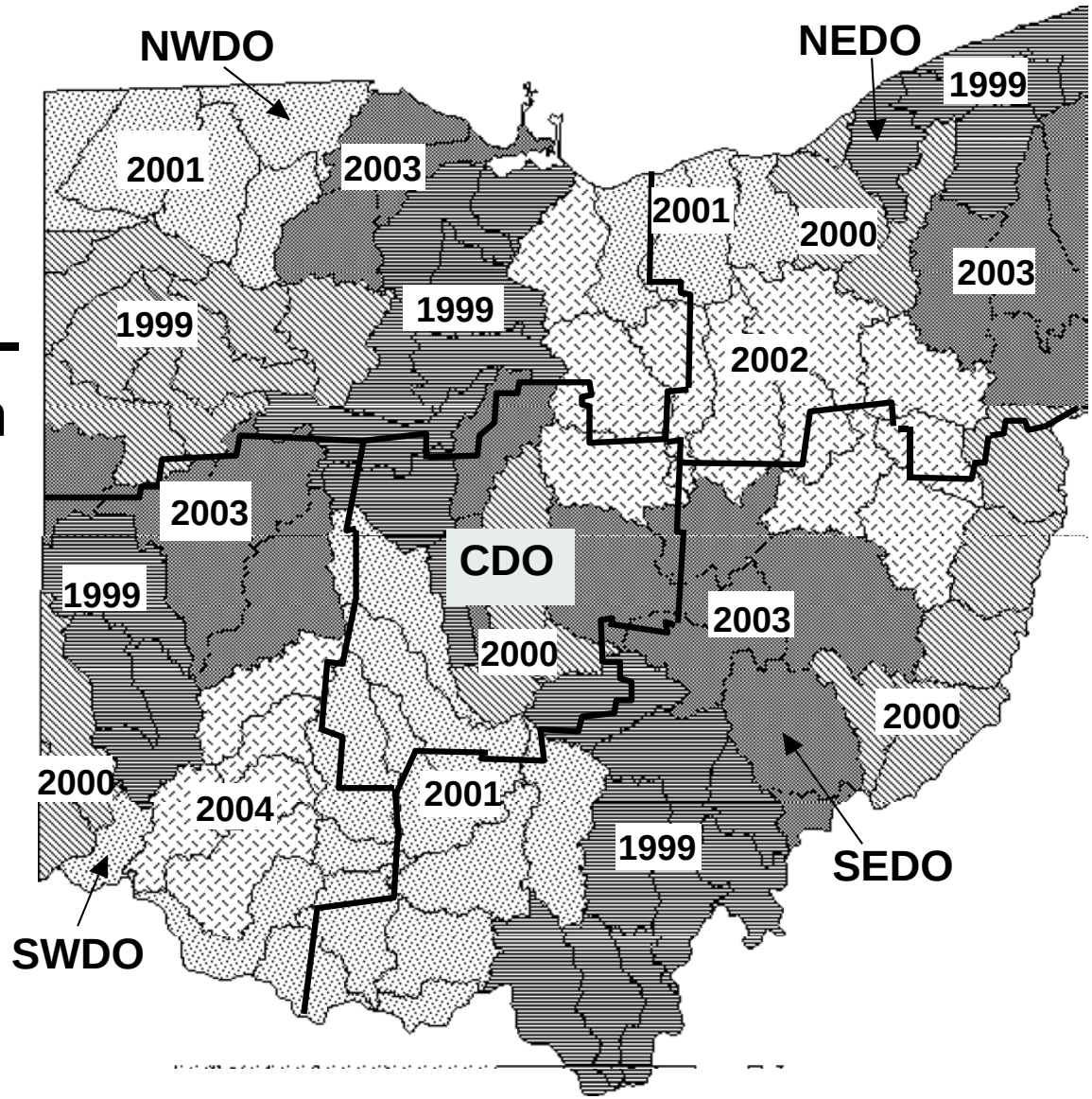
Supplemental List:
- Metals (water/sed.)
- Organics (water/sed.)
- Other pathogens

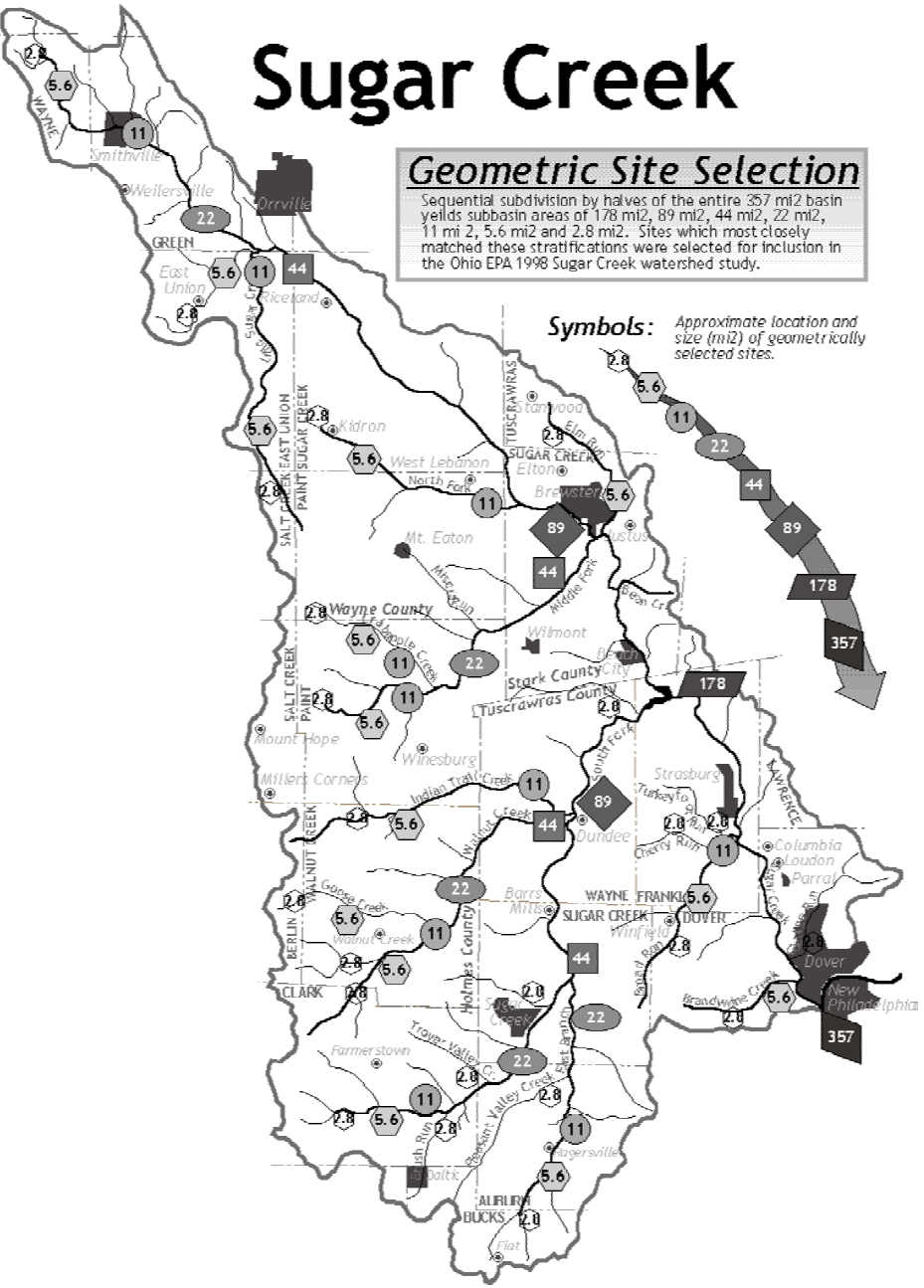
HUMAN/WILDLIFE CONSUMPTION
Base List:
- Metals (in tissues)
- Organics (in tissues)

ITFM Indicators

Ohio EPA 5-Year Basin Approach for Monitoring & Assessment

- Rotating basin approach for determining annual monitoring activities.
- Correlated with NPDES permit schedule.
- Supports annual WQS use designation rule-making.
- Aligned with 15 year TMDL schedule.





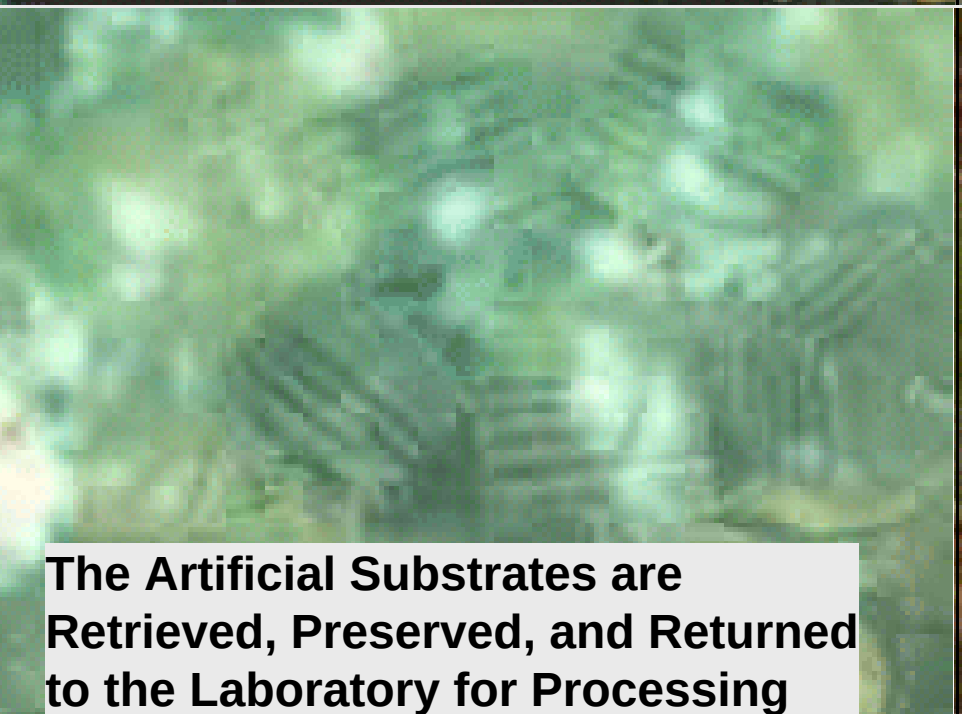
Sugar Creek Subbasin: Example of Geometric Site Selection Process

- Used in TMDL development 5 year basin watersheds
- Increased miles of assessed streams & rivers annually
- Resolve undesignated streams
- Close 305b/303d listing gaps
- Generate broader database for development of improved tools
- Part of 15 yr. TMDL development schedule beginning in 1998
- Augmented by 5 -year basin approach process (1980-1997)
- Standardized biological, chemical, physical tools and indicators

Ohio EPA Macroinvertebrate Methods: Field Procedures

Artificial Substrates are Set for a Six-Week Exposure (July-Sept. Index Period)

Artificial Substrates are Placed in Run Habitat with Constant Current

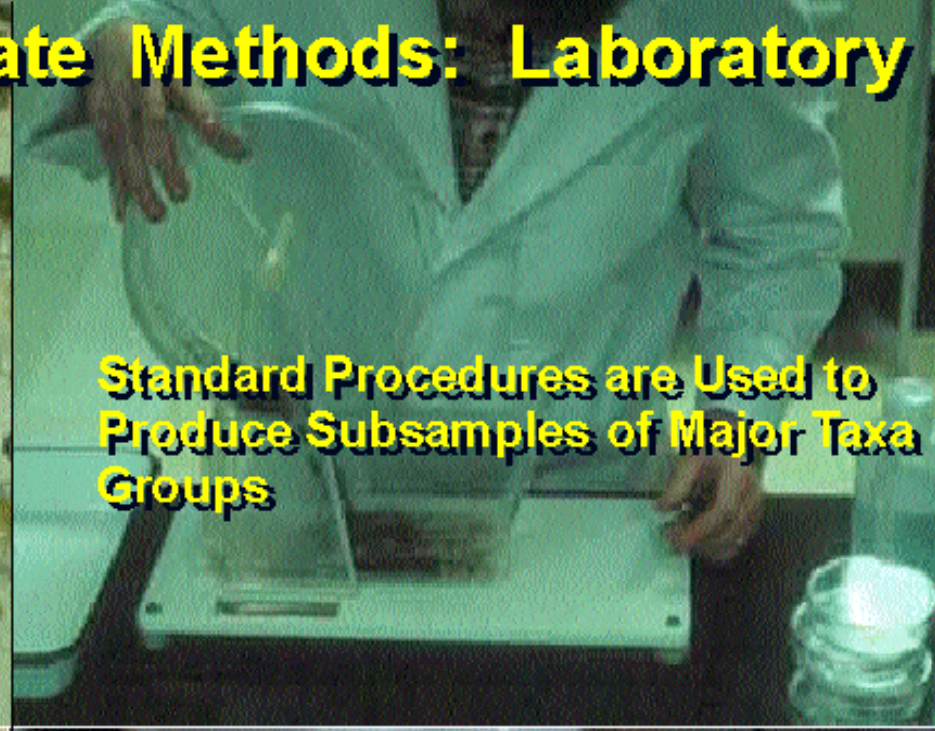


The Artificial Substrates are Retrieved, Preserved, and Returned to the Laboratory for Processing

A Qualitative Dip Net/Hand Pick Method is Used to Supplement the Artificial Substrates or as a Stand Alone Evaluation

Ohio EPA Macroinvertebrate Methods: Laboratory Procedures

After Cleaning and Seiving, the Entire Sample is Scanned and Picked



Standard Procedures are Used to Produce Subsamples of Major Taxa Groups

Portion of a Sample Ready for Identification

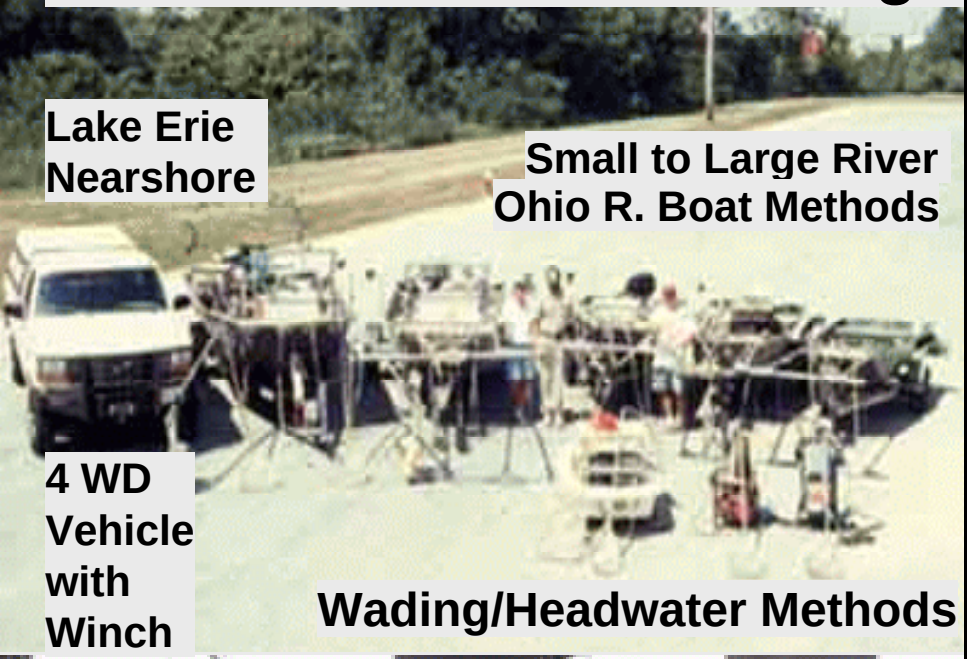
Identification to the Lowest Taxonomic Level Practicable is a Major Data Quality Objective

Macroinvertebrate Assemblage Assessment: Ohio EPA Approach

- Standardized & Representative Sampling - artificial substrates & qualitative dip-net/handpick methods, mid-June to late-September.
- Taxa Richness & Relative Abundance - counts and numbers per unit area (sq. ft.).
- Data Quality Objectives - lowest taxonomic level practicable for common orders/families (genus or species), standard keys.
- Key Component of Biocriteria - ICI and component metrics
- Basin/Sub-basin Sampling Design - longitudinal and watershed scale interpretation of results.
- Watershed Scale Considerations - ICI metrics are calibrated against stream and river size.
- Experienced Biologists - detailed familiarity with regional fauna, natural history, response signatures, impact types.

Fish are a widely identifiable component of aquatic systems and are valued for their recreational uses. Most species, however, are more obscure, and comprise the second most endangered group.

Ohio EPA Fish Assemblage Methods: Field Procedures



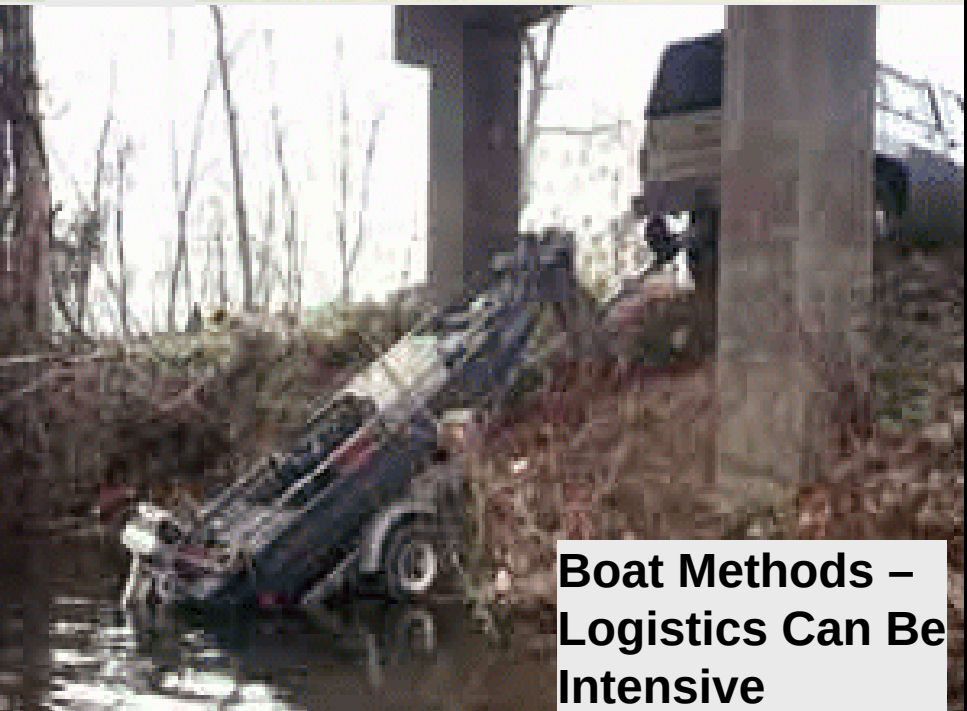
Lake Erie Nearshore

Small to Large River Ohio R. Boat Methods

4 WD Vehicle with Winch

Wading/Headwater Methods

Wading Methods – Effort is Standardized by Distance Sampled



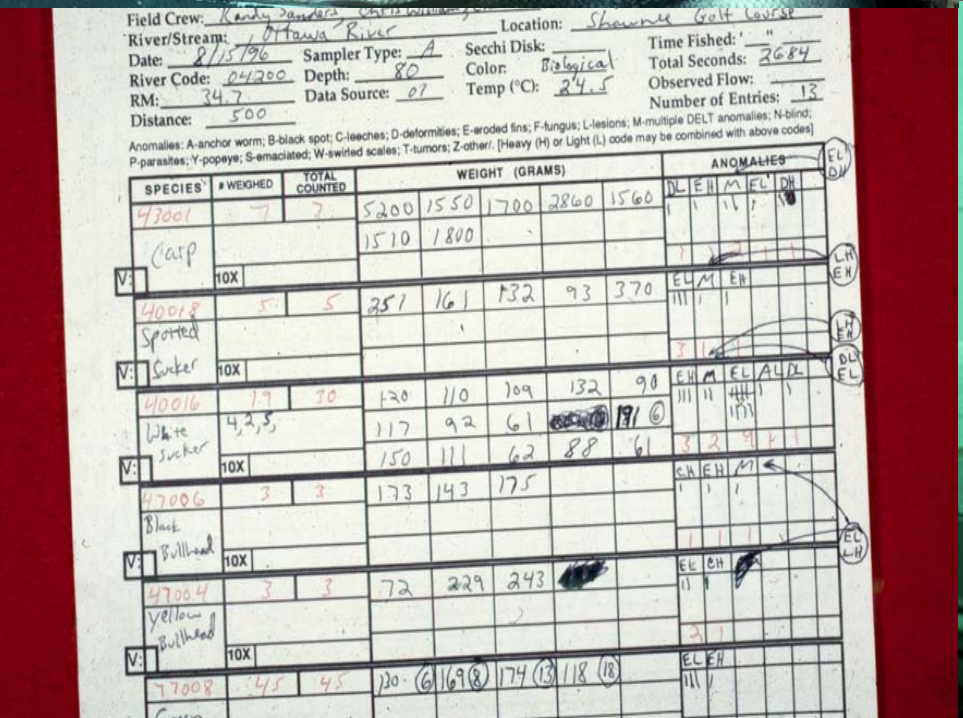
Boat Methods – Logistics Can Be Intensive

All Samples are Processed in the Field

Fish Assemblage Assessment: Ohio EPA Approach

- Standardized & Representative Sampling - stratified pulsed D.C. electrofishing methods, mid-June to mid-October.
- Relative Abundance - numbers and weight (biomass) per unit distance (effort).
- Data Quality Objectives - genus/species based on regional ichthyology keys and AFS nomenclature.
- Key Component of Biocriteria - IBI, MIwb, and component metrics.
- Basin/Sub-basin Sampling Design - longitudinal and watershed scale interpretation of results.
- Watershed Scale Considerations - headwaters, wading, and boat sites; metric calibration accomplished for each strata.
- Experienced Biologists - regional fauna, natural history, response signatures, impact types.

Ohio EPA Fish Assemblage Methods: Sample Processing and Data Management Procedures



The Qualitative Habitat Evaluation Index (QHEI)

QHEI Includes Six Major Categories of Macrohabitat

- Substrate - types, origin, quality, embeddedness
- Instream Cover - types and amounts
- Channel Quality - sinuosity, development, stability
- Riparian/Bank Stability - width, quality, bank erosion
- Pool/Riffle/Run - max. depth, current types, morphology, substrate embeddedness
- Gradient - local gradient (varies by drainage area)

Source: The Qualitative Habitat Evaluation Index (Rankin 1989)

QHEI: Qualitative Habitat Evaluation Index - I

What it is:

- A visual, qualitative method of measuring habitat quality
- Aids in designating aquatic life uses; ***may be conclusive in obvious cases***
- A set of stressor variables - it aids in assessing causes of impairments defined by the biological criteria
- Generally correlated with biological integrity
- Reach-level habitat quality is an important covariate
- Depends on standardized definitions of habitat types (training is very important)

Aquatic Life Designated Uses

Ohio Water Quality Standards

- Uses are portrayed as narratives.
- Chemical and biological criteria are assigned to each in accordance with the attributes ascribed by the designated use narrative.

Uses Are Assigned Based on Demonstrated Potential (in order of importance)

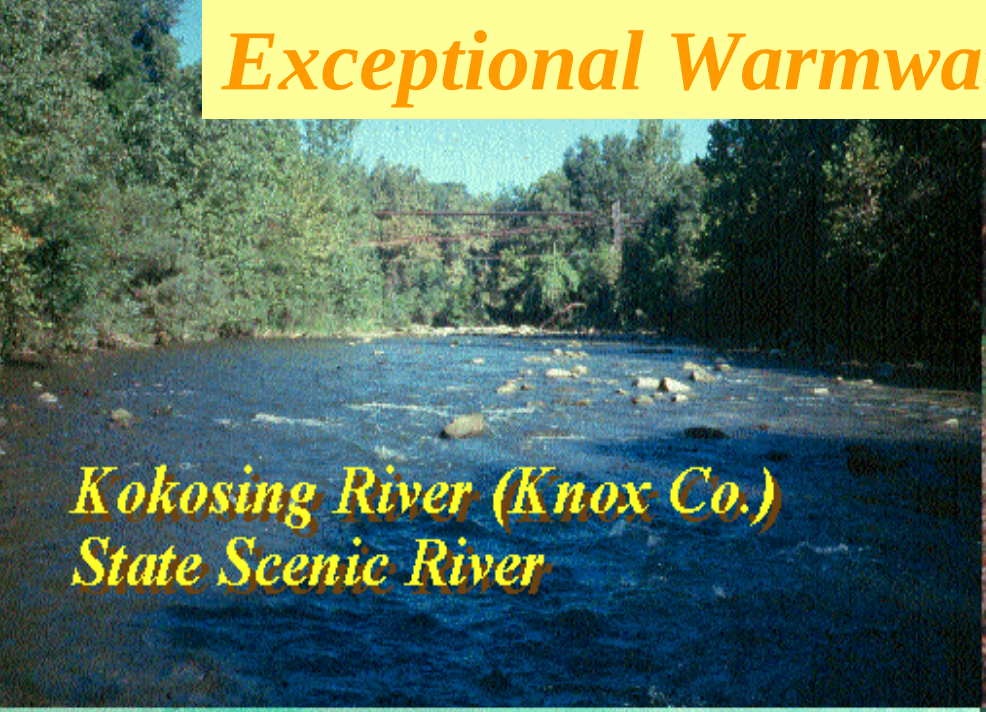
- Attainment of the biological criteria.
- Habitat assessment demonstrates the potential to attain the designated use.
- Attainment of uses is tracked in State 305[b] reports.

Aquatic Life Use Designations: Ohio WQS

Based on Biological Community Attributes

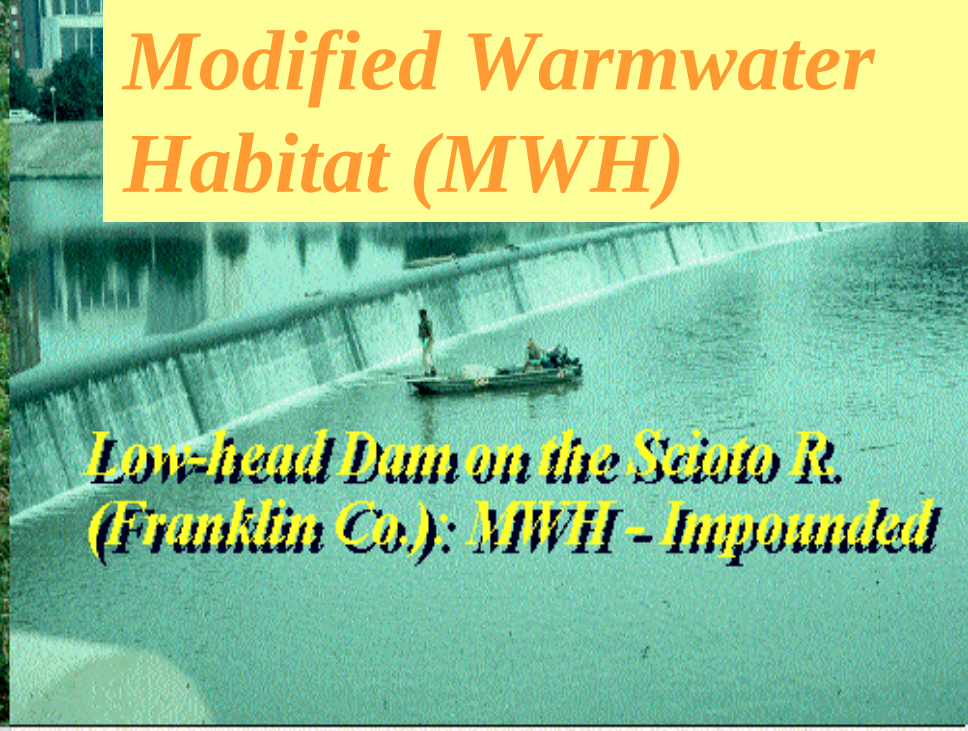
- Exceptional Warmwater Habitat (EWH): preserve & maintain existing high quality.
- Warmwater Habitat (WWH): basic restoration goal for most streams.
- Modified Warmwater Habitat (MWH): attainable condition for streams under drainage maintenance or other essentially permanent hydromodifications (*e.g.*, impoundments).
- Limited Resource Waters (LRW): essentially irretrievable, human induced (*e.g.*, widespread watershed modifications) or naturally occurring conditions (*e.g.*, ephemeral flow).

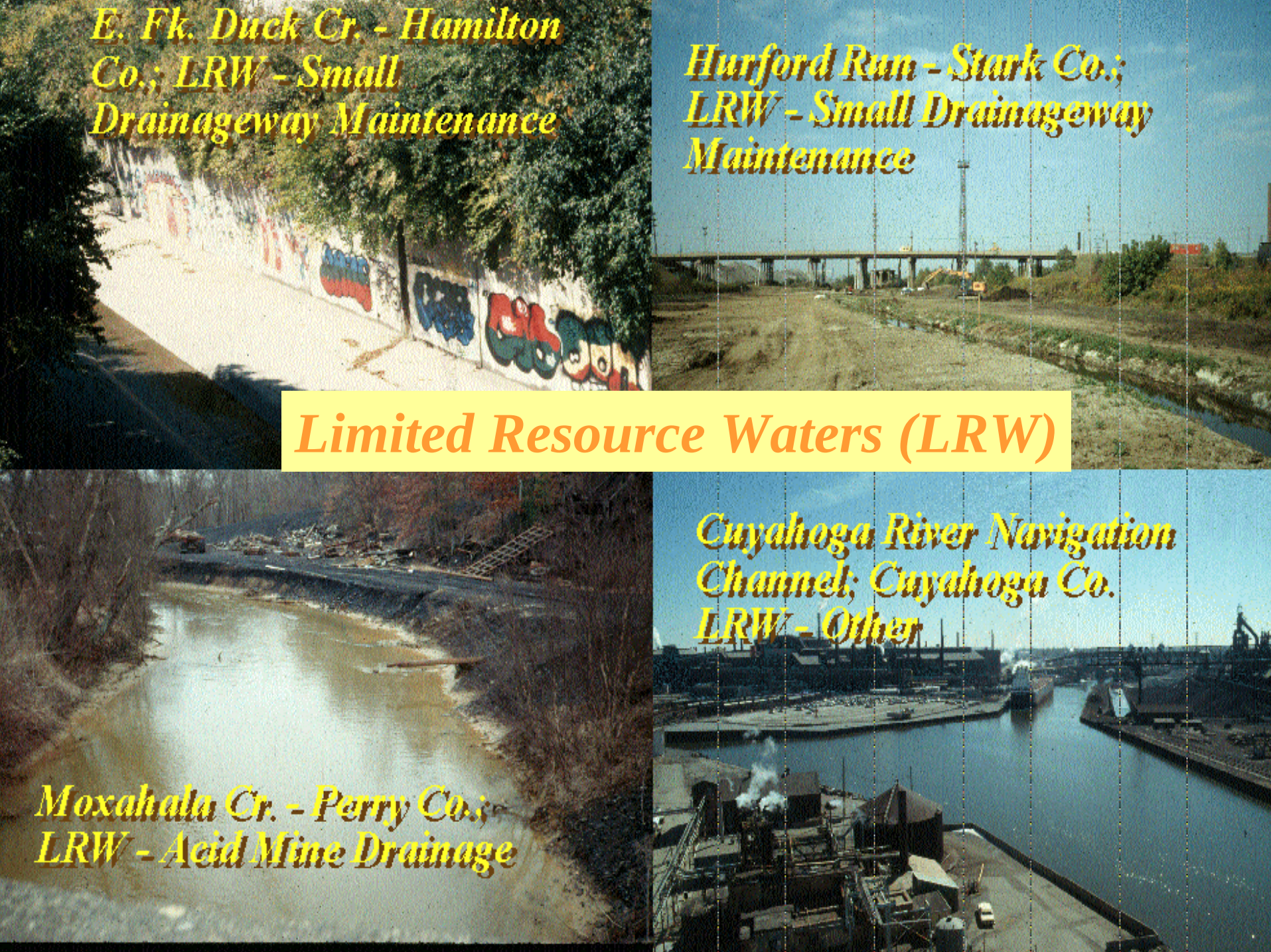
Exceptional Warmwater Habitat (EWH)




Bokengehalas Cr. (Logan Co.)
E. Corn Belt Plain Ecoregion
Powell Creek (Defiance Co.)
Huron/Erie Lake Plain
Warmwater Habitat (WWH)
Wolf Creek (Summit Co.)
Erie/Ontario Lake Plain Ecoregion
Duck Cr. Subbasin (Wash. Co.)
W. Allegheny Plateau Ecoregion

Modified Warmwater Habitat (MWH)




E. Fk. Duck Cr. - Hamilton Co.; LRW - Small Drainageway Maintenance
Hurford Run - Stark Co.; LRW - Small Drainageway Maintenance
Limited Resource Waters (LRW)
Moxahala Cr. - Perry Co.; LRW - Acid Mine Drainage
Cuyahoga River Navigation Channel; Cuyahoga Co. LRW - Other

Aquatic Life Designated Uses

Ohio Water Quality Standards

- Uses are portrayed as narratives.
- Chemical and biological criteria are assigned to each in accordance with the attributes ascribed by the designated use narrative.

Uses Are Assigned Based on Demonstrated Potential (in order of importance)

- Attainment of the biological criteria.
- Habitat assessment demonstrates the potential to attain the designated use.
- Attainment of uses is tracked in State 305[b] reports.

Use Attainability Analysis I: Are CWA Goal Uses Attainable?

U.S. EPA regulations allow lower than CWA goal uses where precluded by:

- naturally occurring pollutant levels;
- natural flow conditions (i.e., ephemeral)**;
- human-induced conditions which cannot be remediated;
- hydrological modifications (dams, diversions, channel modifications) which cannot be operated in a manner consistent with the CWA goal use;
- natural physical features (substrate, flow, depth);
- controls to attain use would cause widespread, socioeconomic impacts.

****- does not apply when flow is augmented by an effluent discharge.**

Source: 40 CFR Part 131.10 (g)(1-6)

Use Attainability Analysis II: Process and Information Requirements**

Use attainability analysis requires the following information and knowledge:

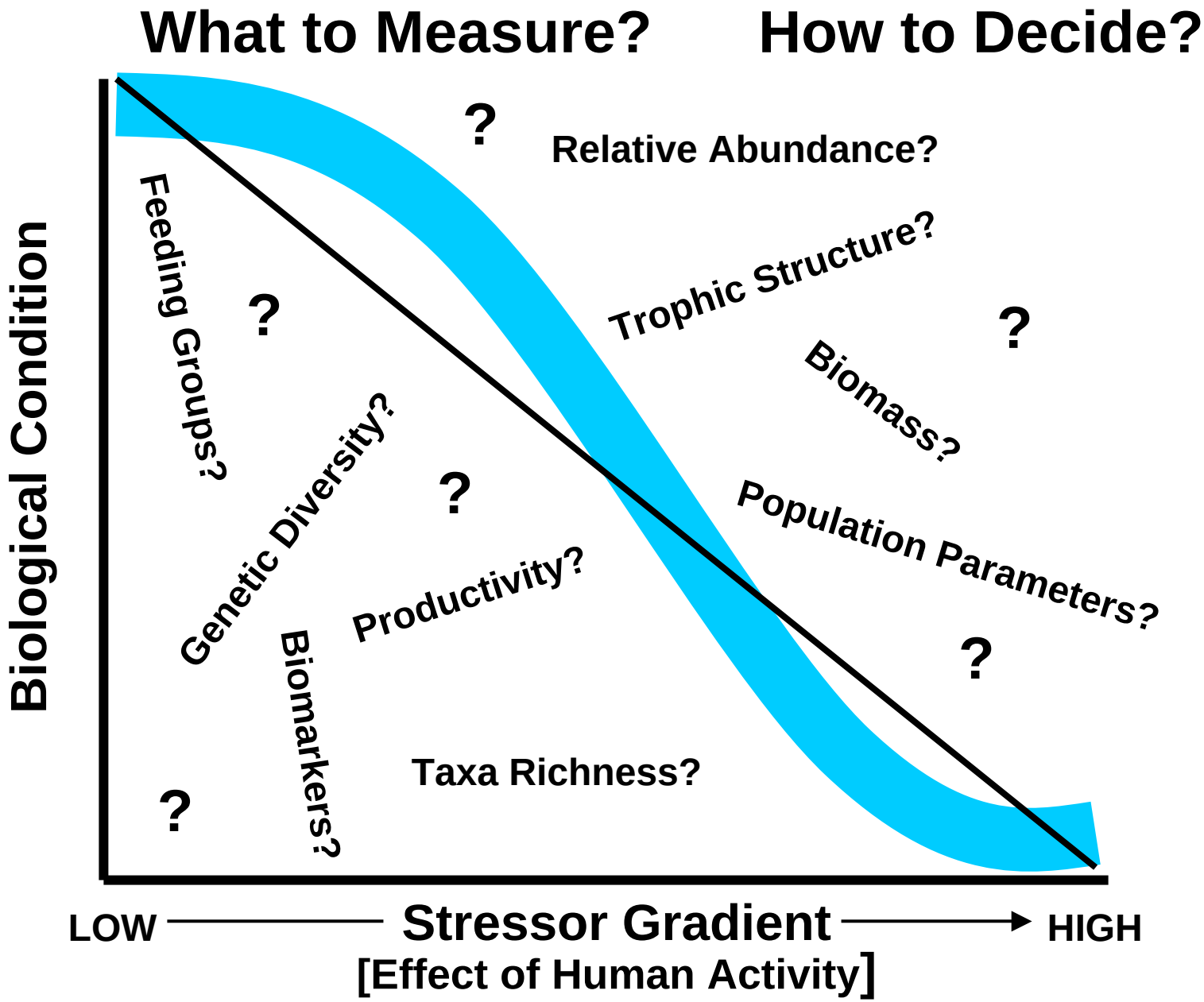
- existing status of waterbody based on biocriteria;
- habitat assessment to evaluate potential;
- reasonable relationship between impaired state and precluding activity based on assessment of multiple indicators used in appropriate roles;
- recommendation subject to WQS rulemaking process
- < CWA uses reviewable every three years - a "temporary" designation.

**** -All data collection and analysis must conform to Ohio WQS and Five-Year Monitoring Strategy data and design quality objectives.**

Important Considerations for Biological Criteria Programs

Six criteria that programs should satisfy:

- The measures used must be biological.
- The measures must be interpretable at or extend to multiple trophic levels.
- The measures must be sensitive to the conditions being assessed.
- The response range must be suitable for intended uses.
- The measures must be reproducible and sufficiently precise.
- The variability of the measures must be low enough to detect and quantify changes.


What to Measure?
How to Decide?
Biological Condition
?
Relative Abundance?
Feeding Groups?
?
Trophic Structure?
?
Biomass?
Genetic Diversity?
?
Population Parameters?
Productivity?
?
Biomarkers?
Taxa Richness?
?
LOW
Stressor Gradient
HIGH
[Effect of Human Activity]

Symptoms of Ecological Degradation

A Partial List:

- Reduced populations of native species.
- Fewer size (age) classes.
- Reduced number of intolerant species.
- Increased proportion of exotic species.
- Reduced proportion of ecological specialists.
- Simplified trophic web and interactions.
- Increased incidence of serious disease & anomalies.

Index of Biotic Integrity (Karr 1981)

12 Metrics

- Species richness
- #Darter species
- #Sunfish species
- #Sucker species
- %Intolerant species
- %Green sunfish
- %Omnivores
- %Insectivores
- %Top Carnivores
- %Hybrids
- %Diseased individuals
- Number of Fish

Community Composition

Environmental Tolerance

Community Function

Community Condition

- 5,3,1 metric scoring categories.
- 12 to 60 scoring range.
- Calibrated on a regional basis.
- Scoring adjustments needed for very low numbers.

Basic Premise of IBI Type Measures

- Least impacted biological systems have distinctive structural and functional attributes.
- Some attributes can be measured in the field and aggregated into metrics.
- Departure of metrics from a reference condition is correlated with the degree (severity) of a perturbation.
- Synthesis of multiple, representative metrics reflects the overall integrity of the community.

Invertebrate Community Index (Ohio EPA 1987; DeShon 1995)

- Taxa Richness
- #Mayfly taxa
- #Caddisfly taxa
- #Dipteran taxa
- %Mayflies
- %Caddisflies
- %Tanytarsini Midges
- %Other Diptera/Non-Insects
- %Tolerant taxa
- Qualitative EPT taxa

• 6,4,2,0 metric scoring categories.
• 0 to 60 scoring range.
• Calibrated on regional basis.
• Scoring adjustments needed for very low numbers of specific taxa.

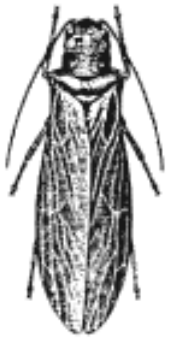
Key Invertebrate Metrics: Intolerant & Specialist Taxa

mayflies

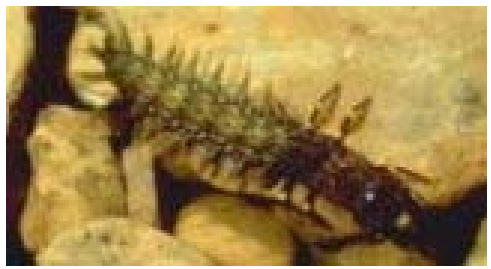
stoneflies

water penny

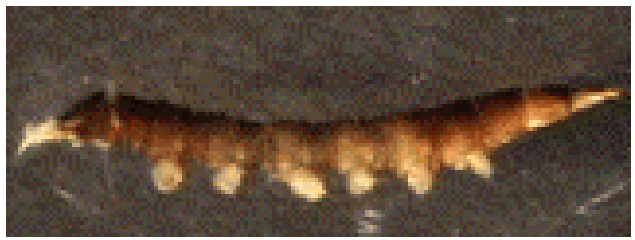
bivalves



alderflies



dobson flies

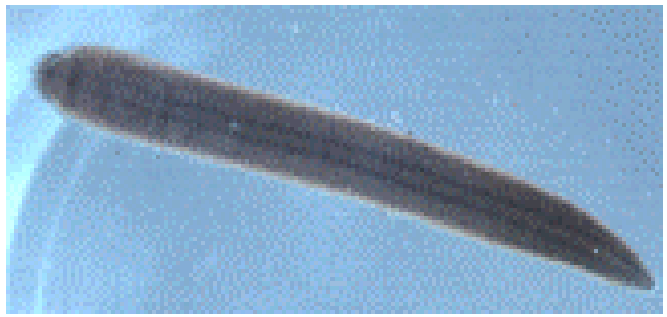


snipe flies

Expected Response to Stress: Declines in abundance and proportion of assemblage

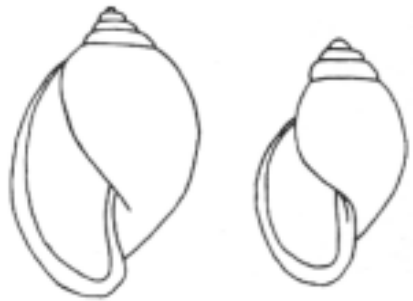
Key Invertebrate Metrics: Highly tolerant taxa

Chironomid midges[1]



leeches

worms

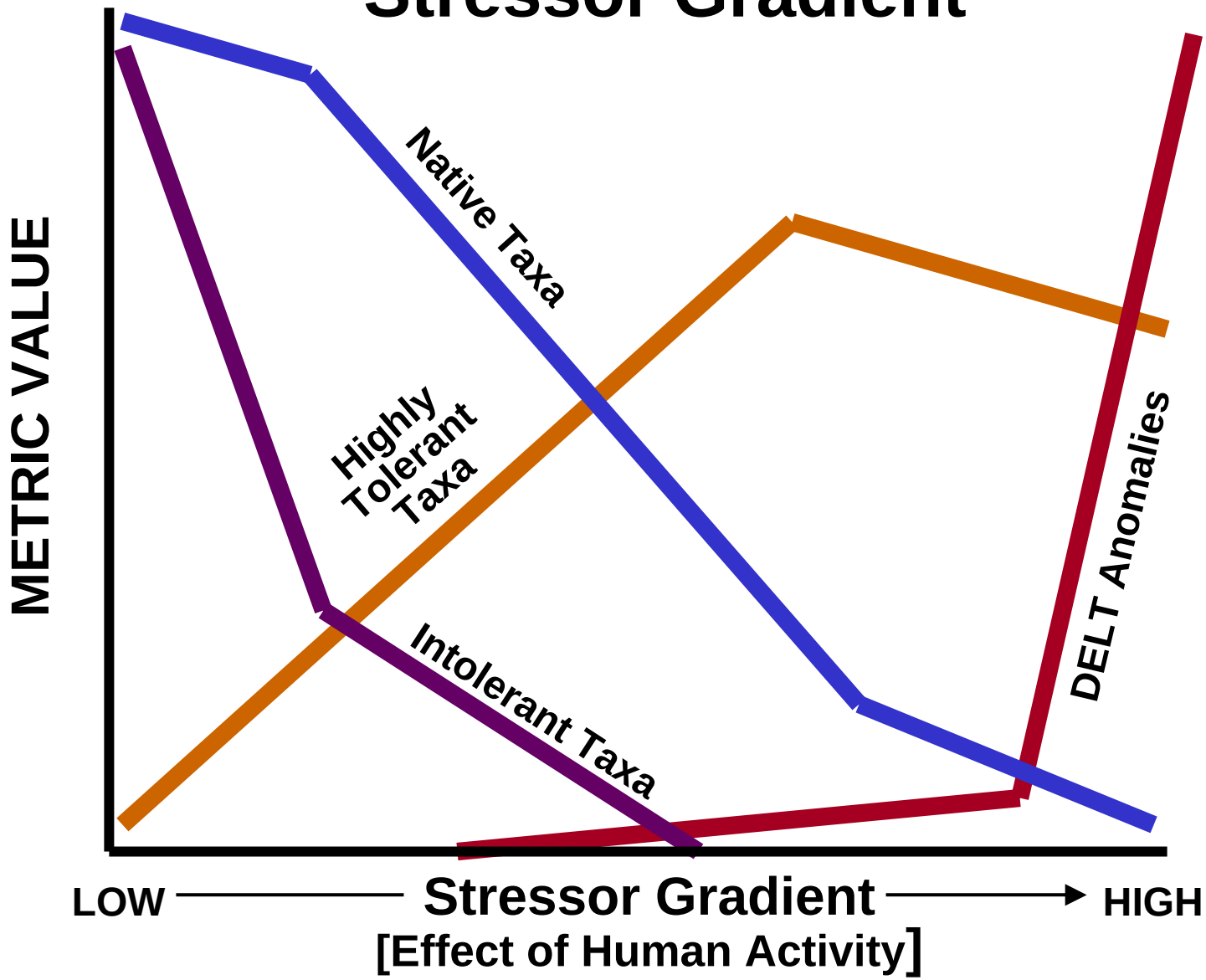


pouch snails

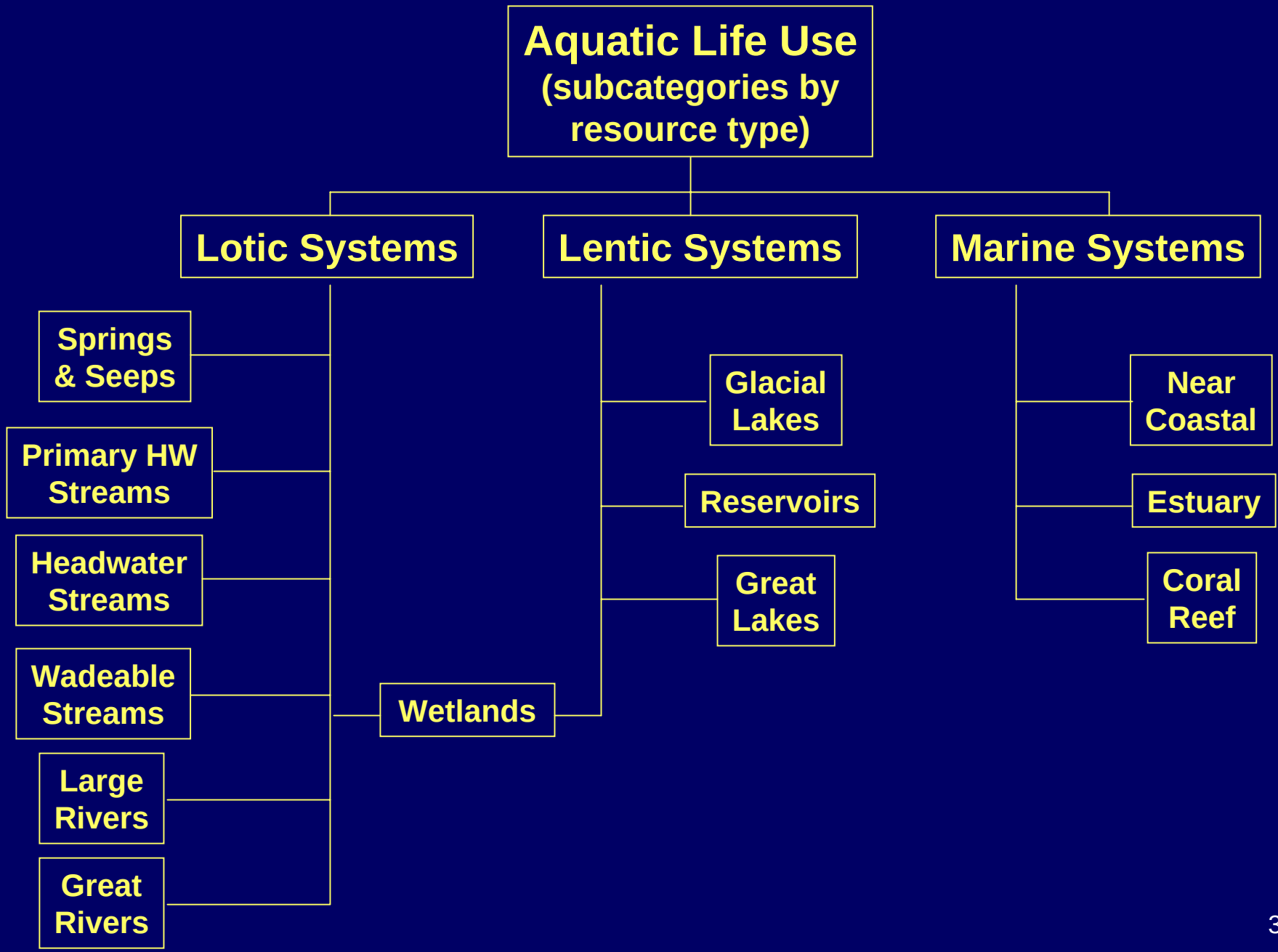
[1] There are at least three distinct responses exhibited by the Chironomidae; sensitive (*Tanytarsini*), facultative (*Glyptotendipes*), and toxic tolerance (*Cricotopus*); taxonomic resolution is needed at genus level.

Expected Response to Stress: Increased abundance or proportion of assemblage

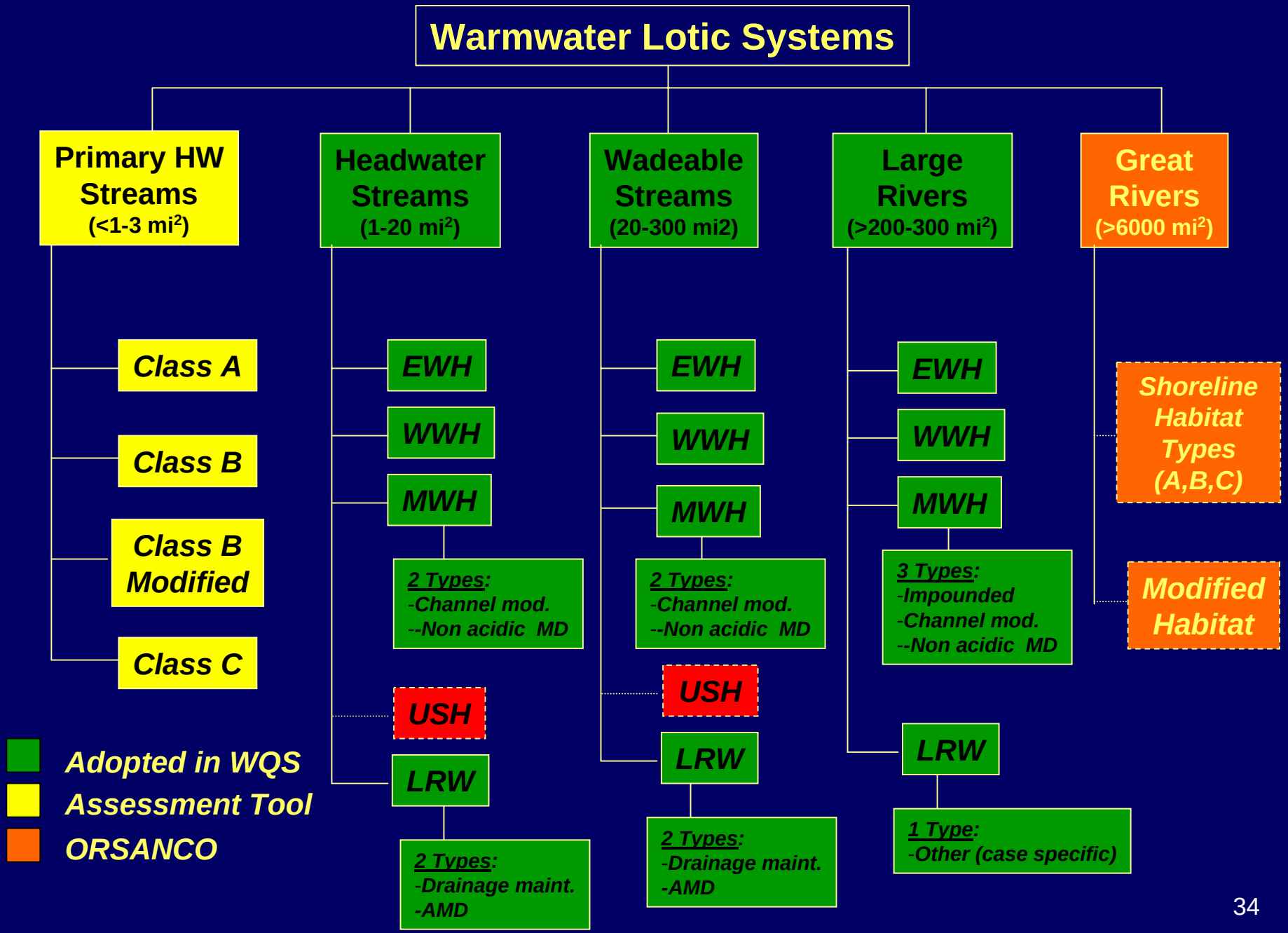
Metric Behavior Along the Stressor Gradient



GENERAL TEMPLATE FOR STRATIFYING RESOURCE TYPES



OHIO SPECIFIC TEMPLATE FOR STRATIFICATION



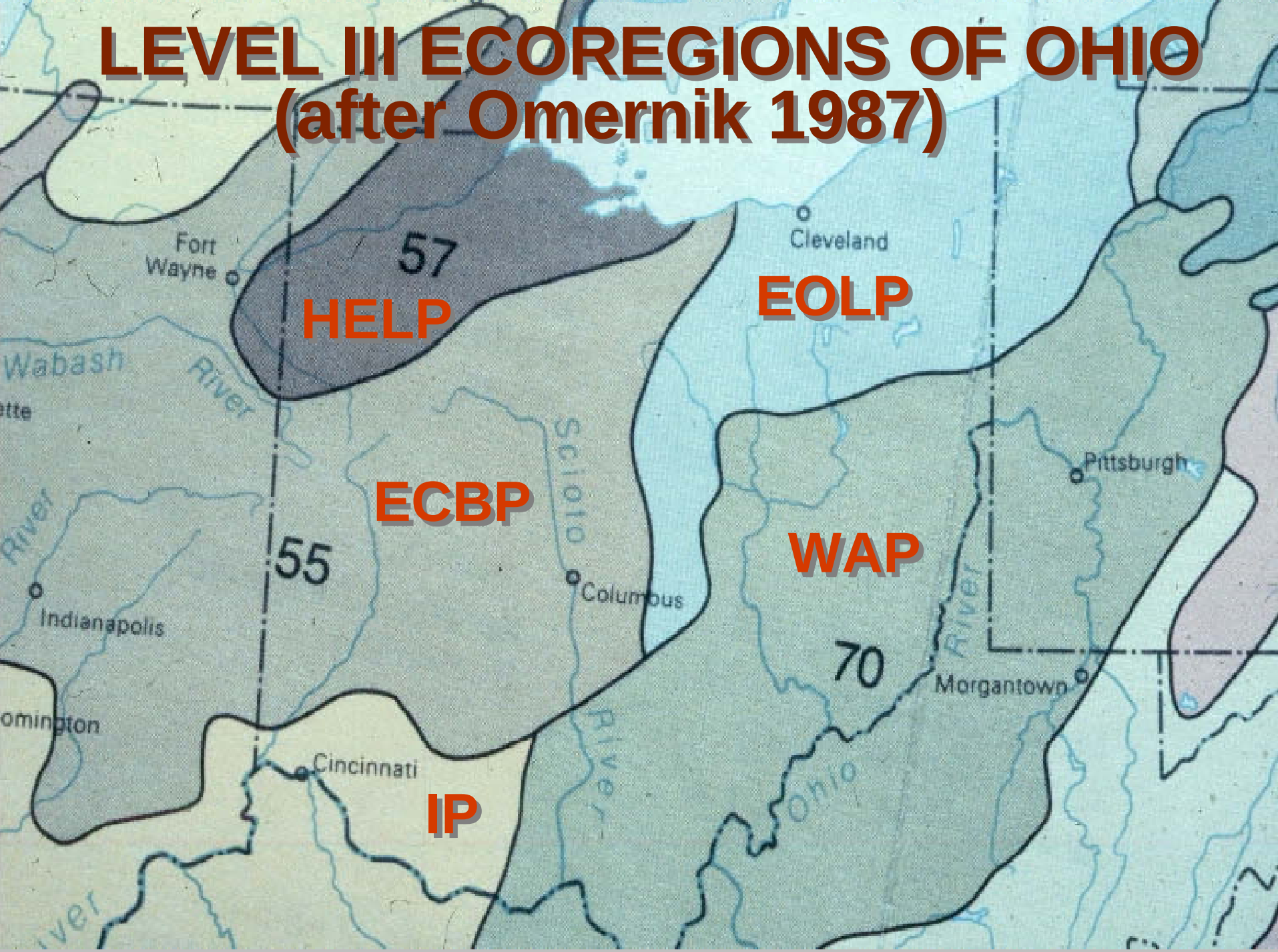
OHIO EPA MODIFIED IBI METRICs	HEADWATER SITE TYPE (<20 SQ. MI.)	WADEABLE SITE TYPE (20-300 MI^2.)	BOATABLE SITE TYPE (200-6000 MI^2.)
1. Total Native Species	X	X	X
2. #Darter Species		X	
#Darters + Sculpins	X*		
%Round-bodied Suckers			X*
3. #Sunfish Species		X	X
#Headwater Species	X*		
%Pioneering Species	X*		
4. #Sucker Species		X	X
#Minnow Species	X*		
5. #Intolerant Species		X	X
#Sensitive Species	X*		
6. %Tolerant Species	X	X	X
7. %Omnivores	X	X	X
8. %Insectivores	X	X	X
9. %Top Carnivores		X	X
10. %Simple Lithophils	X*	X*	X*
11. %DELT Anomalies	X	X	X
12. Number of Individuals	X	X	X

* - Substitute for original IBI metric described by Karr (1981) and Fausch et al. (1984)

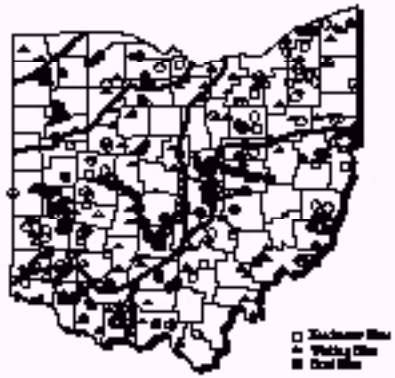
OHIO EPA MODIFIED IBI METRICs	BOATABLE SITE TYPE (Inland Rivers)	LAKE ERIE LACUSTUARY (Harbors/Rivers)	LAKE ERIE NEARSHORE (Shoreline)
1. Total Native Species	X	X	X
2. #Darter Species			
%Round-bodied Suckers	X*		
#Benthic Species		X*	X*
3. #Sunfish Species	X		
#Centrarchid Species		X*	X*
4. #Sucker Species	X		
#Cyprinid Species		X*	
#Phytophilic Species			X*
5. #Intolerant Species	X	X	X
6. %Green Sunfish			
%Tolerant Species	X*	X*	X*
7. %Omnivores	X	X	X
8. %Insectivores	X		
%Phytophilic Individuals		X*	
%Lake Species			X*
9. %Top Carnivores	X	X	X
10. %Hybrids			
%Simple Lithophils	X*		
%Nonindigenous Species		X*	X*
11. %DELT Anomalies	X**	X**	X**
12. Number of Individuals	X	X	X

X* - Substitute for original IBI metric described by Karr (1981) and Fausch et al. (1984)

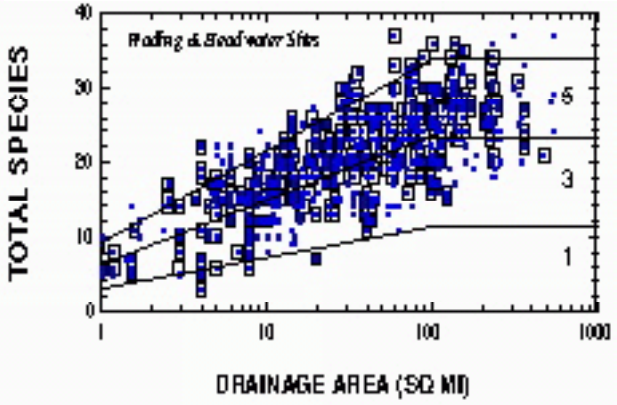
** - Excludes highly tolerant species in all and additionally gizzard shad in the L. Erie IBIs.


LEVEL III ECOREGIONS OF OHIO
(after Omernik 1987)
HELP
EOLP
ECBP
WAP
IP
57
55
70
Fort Wayne
Cleveland
Pittsburgh
Columbus
Indianapolis
Cincinnati
Morgantown
Wabash River
Scioto River
Ohio River

Ohio IBI Calibration & Biocriteria Derivation Process



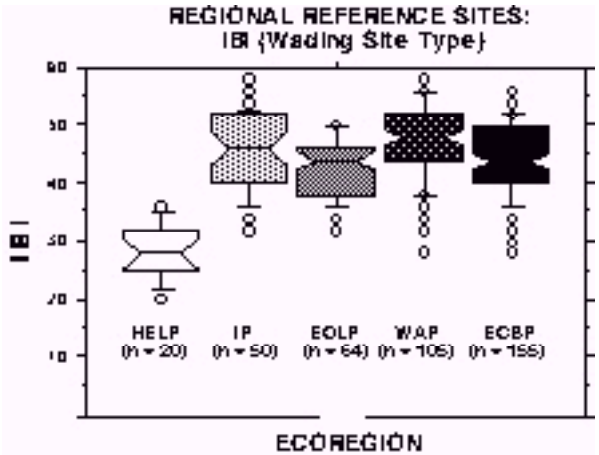
I. Select & sample reference sites



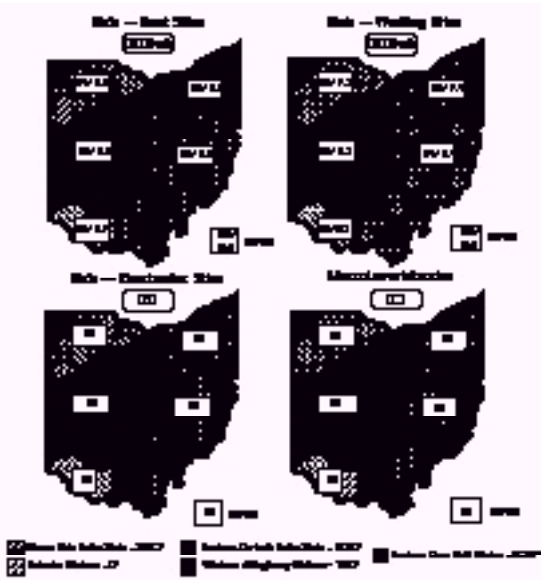
II. Calibration of IBI metrics

Metric	5	3	1
Number of Species	Varies x Drainage Area		
No. of Darter Spp.	Varies x Drainage Area		
No. of Sunfish Spp.	>3	2-3	<2
No. of Sucker Spp.	Varies x Drainage Area		
Intolerant Species			
>100 sq. mi.	>5	3-5	<3
<100 sq. mi.	Varies x Drainage Area		
%Tolerant Species	Varies x Drainage Area		
%Omnivores	<19	19-34	>34
%Insectivores			
<30 sq. mi.	Varies x Drainage Area		
>30 sq. mi.	>55	26-55	<26
%Top Carnivores	>5	1-5	<1
%Simple Lithophils	Varies x Drainage Area		
%DELT Anomalies	>1.3	0.5-1.3	<0.5
Relative Abundance	>750	200-750	<200

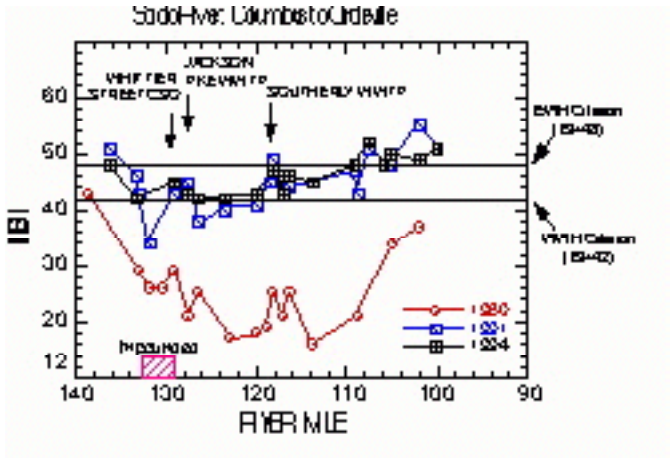
III. Calibrated IBI modified for Ohio waters



IV. Establish ecoregional patterns/expectations

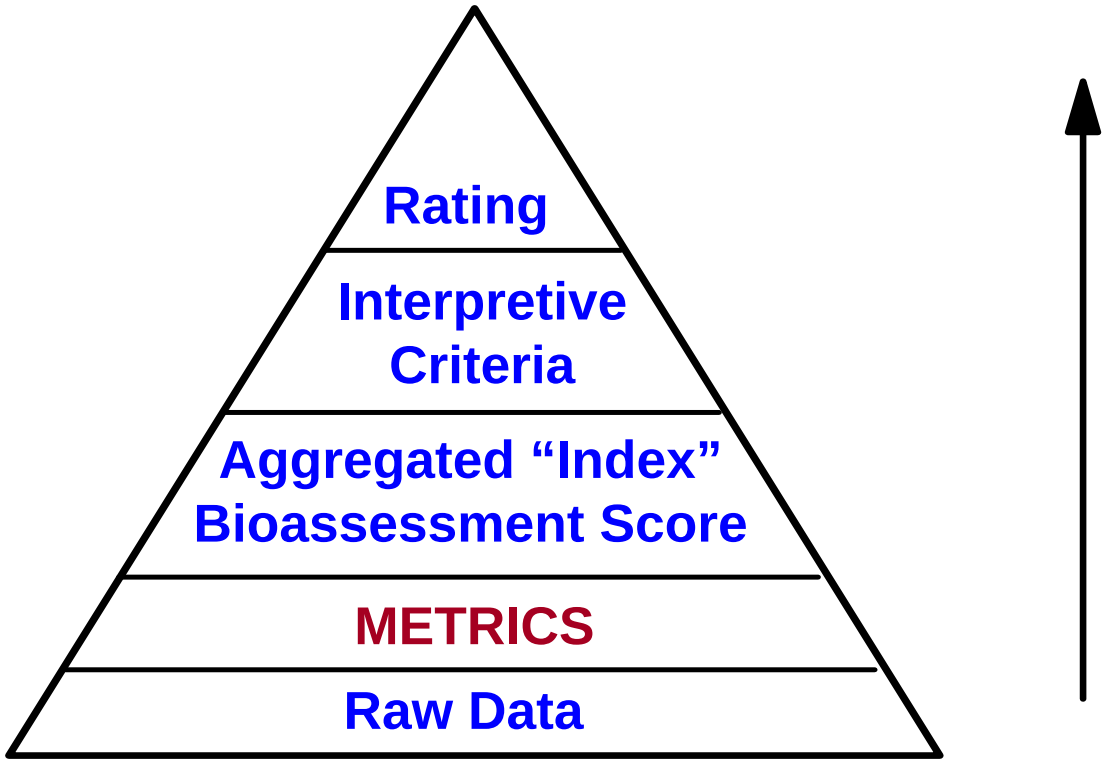


V. Derive numeric bio-criteria: Codify in WQS



VI. Numeric biocriteria are used in bioassessments

Data Manipulation Hierarchy of Field-Collected Biological Samples



Ohio Biological Criteria: Adopted May 1990 (OAC 3745-1-07; Table 7-14)

Huron Erie Lake Plain (HELP)

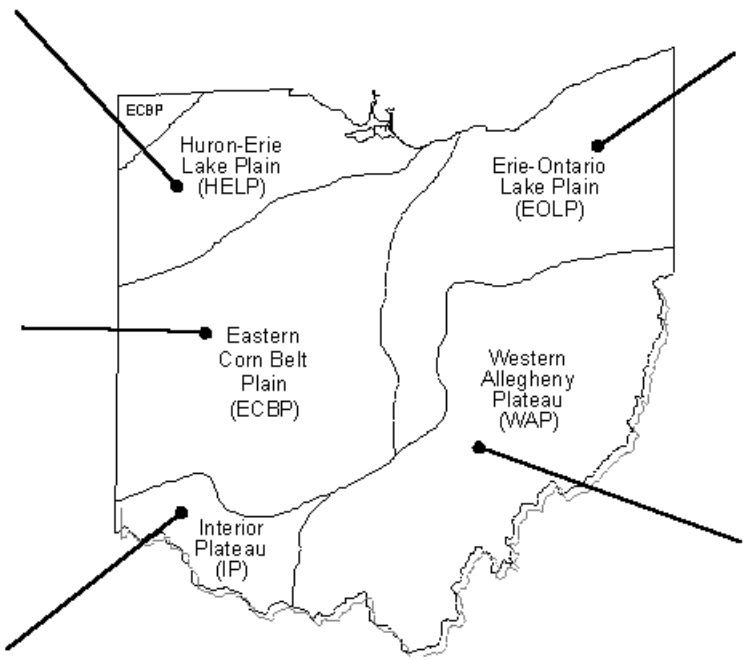
Use	Size	IBI	MIwb	ICI
WWH	H	28	NA	34
	W	32	7.3	34
	B	34	8.6	34
MWH-C	H	20	NA	22
	W	22	5.6	22
	B	20	5.7	22
MWH-I	B	30	5.7	NA

Eastern Corn Belt Plains (ECBP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	36
	W	40	8.3	36
	B	42	8.5	36
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Interior Plateau (IP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	30
	W	40	8.1	30
	B	38	8.7	30
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA



Statewide Exceptional Criteria

Use	Size	IBI	MIwb	ICI
EWH	H	50	NA	46
	W	50	9.4	46
	B	48	9.6	46

Erie Ontario Lake Plain (EOLP)

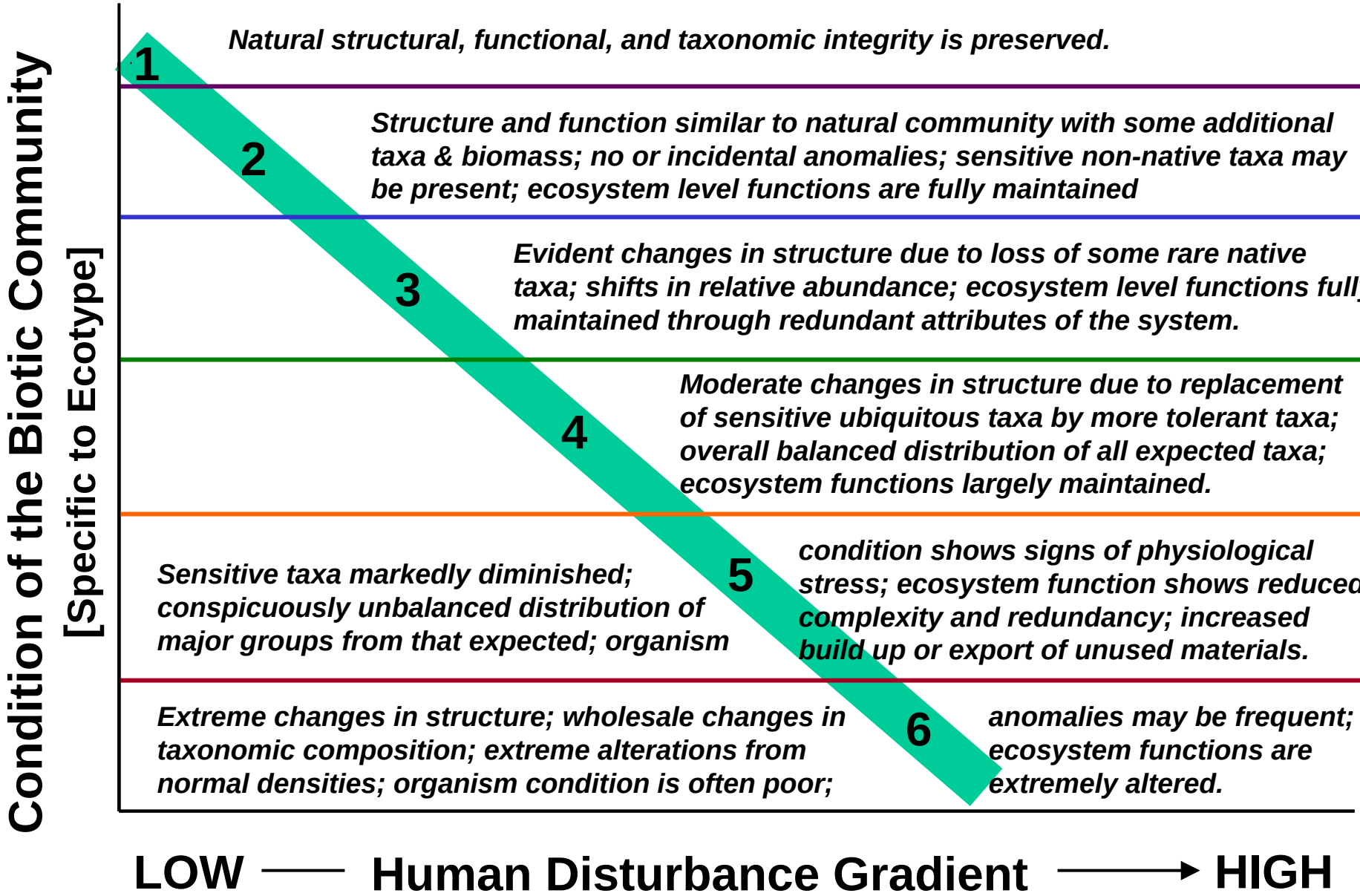
Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	34
	W	38	7.9	34
	B	40	8.7	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Western Allegheny Plateau (WAP)

Use	Size	IBI	MIwb	ICI
WWH	H	44	NA	34
	W	44	8.4	34
	B	40	8.6	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-A	H	24	NA	30
	W	24	5.5	30
	B	24	5.5	30
MWH-I	B	30	6.6	NA

Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers

(10/22 draft)



Biological Integrity: Putting Theory Into Practice

Essential Elements of the Regional Reference Site Approach

- Biological Performance - need ways to measure (e.g., IBI, ICI, BI, RIVPACS, etc.).
- Natural Habitats - come to grips with the attainability issue (e.g., ‘‘least impacted’ reference sites.
- Region - need to stratify and account for natural variability (e.g., ecoregions and tiered uses).
- Reference site ‘‘re-sampling’’ to account for broad scale, long term changes in attainable conditions.

The Regional Reference Site Approach: The Role of Stratification

Recognizing the relative importance of landscape, geographic, physical, and socioeconomic factors in deriving regionally relevant benchmarks or criteria

Inter-Regional Factors:

- Ecoregions - overall synthesis of taxonomy, biogeography, diversity, ecological function, and attainability.
- Water Quality Standards - define goals and criteria.

Intra-Regional Factors:

- Site-Specific Stratification - stream size (drainage area, width), gradient, temperature, elevation, latitude etc.

Biological Criteria "Maintenance"

- Reference sites "re-sampling" linked to basin monitoring cycle (10 yr. process).
- Keeps tabs on reference condition change.
- Update consistent with new technologies.
- Template for developing stressor thresholds and gradients.
- Formally linked to WQS via tiered designated use descriptions and derivation system.

Coping With Biological Data Variability

- **Compress Variability**: use multi-metric measures (e.g. IBI, ICI, etc.).
- **Stratify Variability**: use ecoregions (or subsets) and tiered aquatic life use classification system.
- **Control Variability**: select efficient sampling methods that yield informative and consistent results.

Resolution and Detail in WQS and Monitoring and Assessment Affect Overall WQ Management Program Effectiveness

Program Attribute	Least Accurate → Most Accurate	
WQS/Des. Uses:	General Uses (Generic AQLU)	Refined Uses (Tiered AQLU)
WQ Criteria:	Simple, Chemical (Conventionals)	Chemical & Biological (Acute/Chronic, Biocriteria)
Monitoring:	Fixed Stations	Rotating Basins (Stratified, Probabilistic)
Indicators:	Chemical, Narrative	Chem., Phys., Biological (Numeric, Calibrated)
Detail:	Coarse (Low Signal)	Refined (Integrated Signal)
Resolution:	Pass/Fail (No Increments)	Incremental (Continuous Scale)