Rapid Ecological Assessments: Data Collection and Indicator Metrics

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Empowered lives.
Resilient nations.

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Outline

- Data Collection
  - Planning
  - Objectives
  - Logistics
  - Resource Considerations
- Ecological levels of sampling
- Variables and Metrics
- Assessment Indices
- Final Notes

(Not going to spend time on sampling techniques)

Data Collection Planning

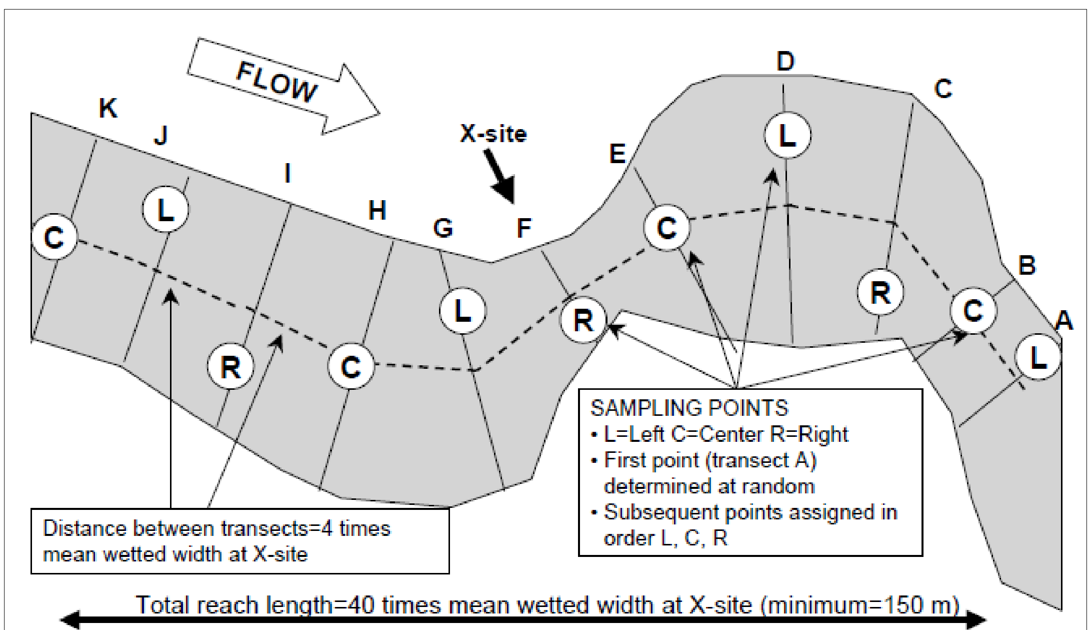
- Review REA Goal/Objective(s)
- Understand and deal with reality of logistical concerns
- Consider existing policies/data/ planning structures
- Utilize GIS/RS in planning
- Utilize GPS in field (ideal!)
- Always, always consider field safety

Common Objectives of Surveying

- Collect <u>repeatable</u> data (time/space <u>comparability</u>)
- Be spatially explicit (map locations)
- Be as quantitative as possible
- Be descriptive as possible (include photos, add notes)
- Collect the highest quality data given the limitation of time, money, and resources
  - Most rigorous methods yield higher level of certainty in assessment
  - Less rigorous approaches <u>are still valuable</u>; they just present relatively more uncertainty

Data Collection Logistics

- Separate Teams (SMEs)
- Collaborate on assessment area
- Identify variables of interest
- Select field methods
- Create Protocols
- Create Field Data Forms
- Individual discipline reports – start developing early, draft methods before fieldwork



(figure source: U.S.EPA. 2004. EPA 841-B-04-004)

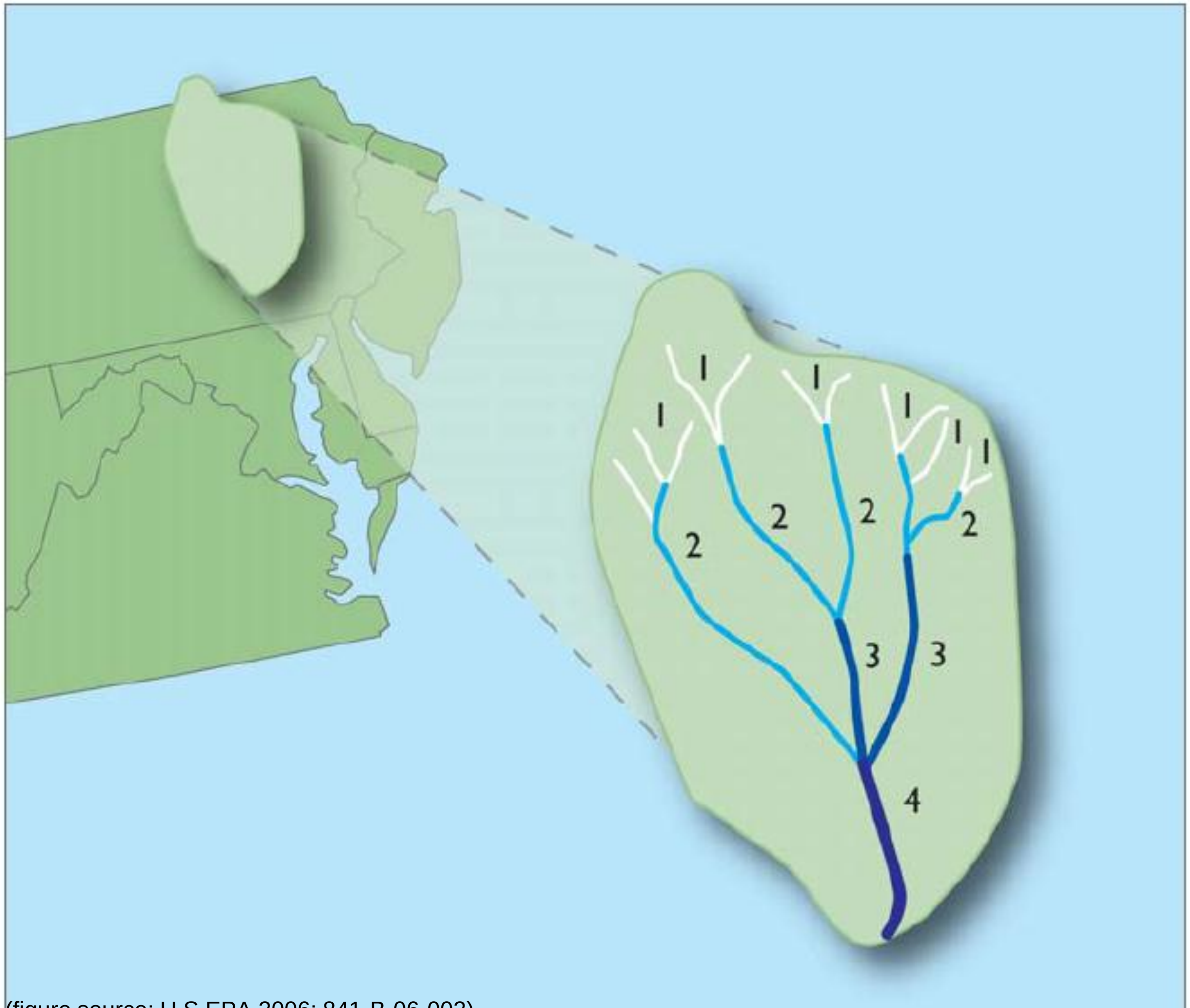
Example of site layout for stream sampling protocol

Consider the Resource

(Sampling Design, Data Collection)

- Important to understand the intrinsic complexity of stream/river systems, their interaction with the basin
- Classifying streams reduces natural variability among streams, allowing identification of potential adverse impacts
- Larger non-wadeable rivers are naturally and fundamentally different from wadeable rivers, smaller streams, lakes
- Where feasible/reasonable, have standardized protocols for different orders of streams

Classification Example:
Strahler Stream Order



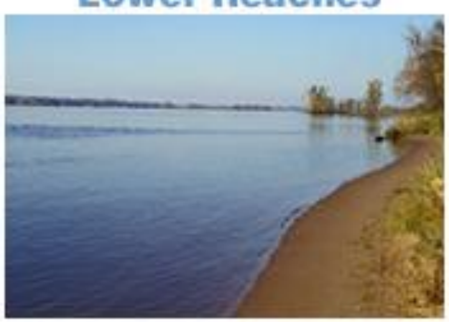
(figure source: U.S.EPA 2006; 841-B-06-002)

River Continuum Concept

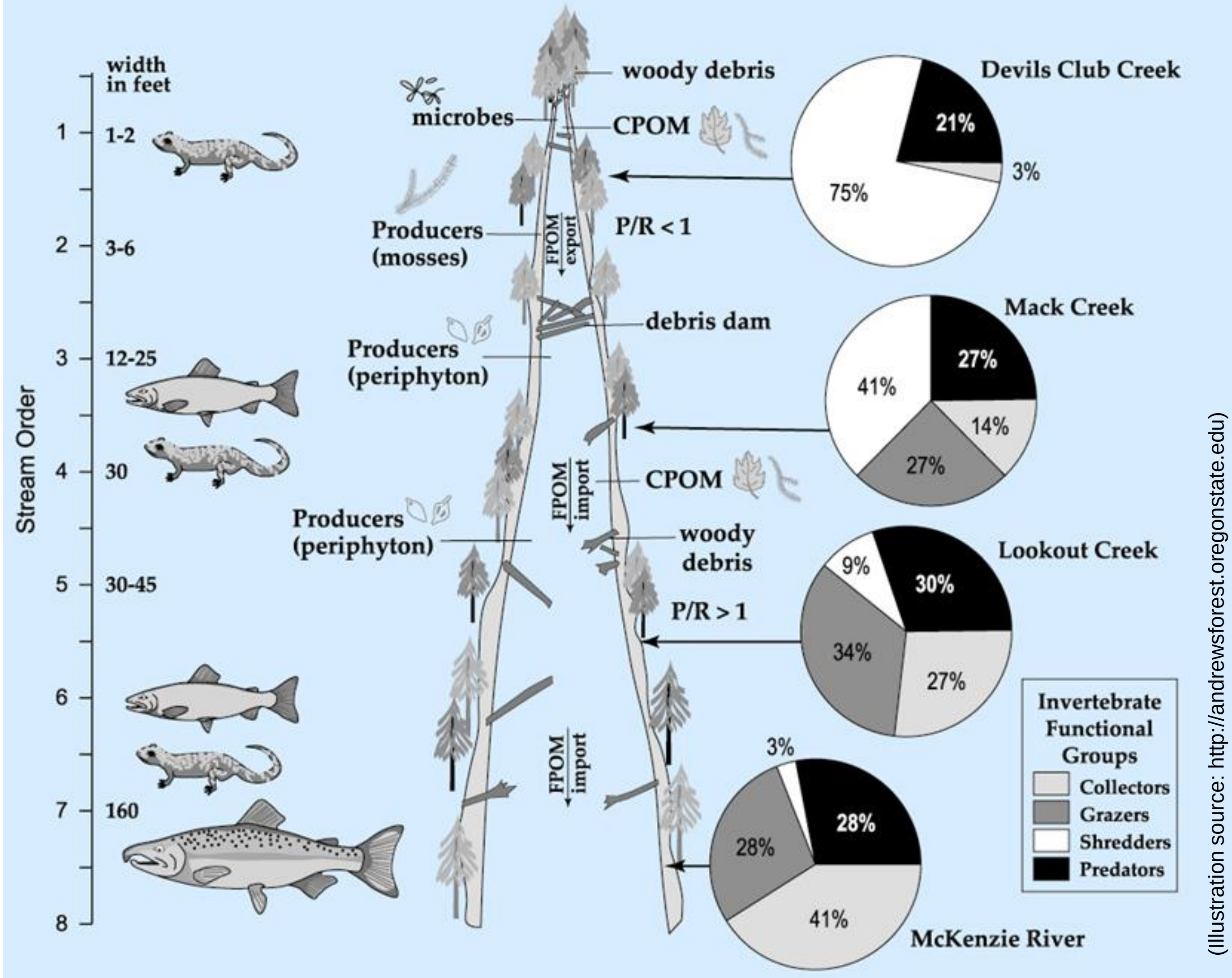
Headwaters

Midstream

Lower Reaches



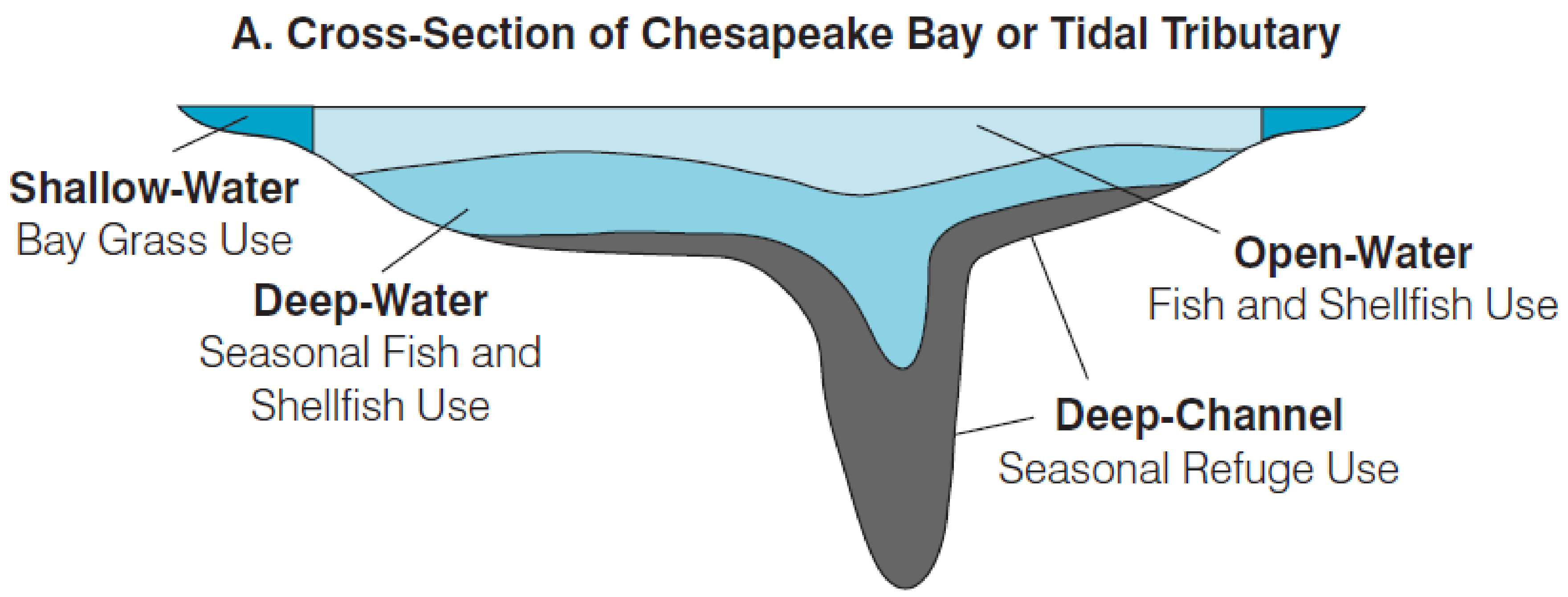
(photos by: Konrad P Schmidt)



FPOM is fine particulate organic matter; CPOM is coarse particulate organic matter; P/R is the production/respiration

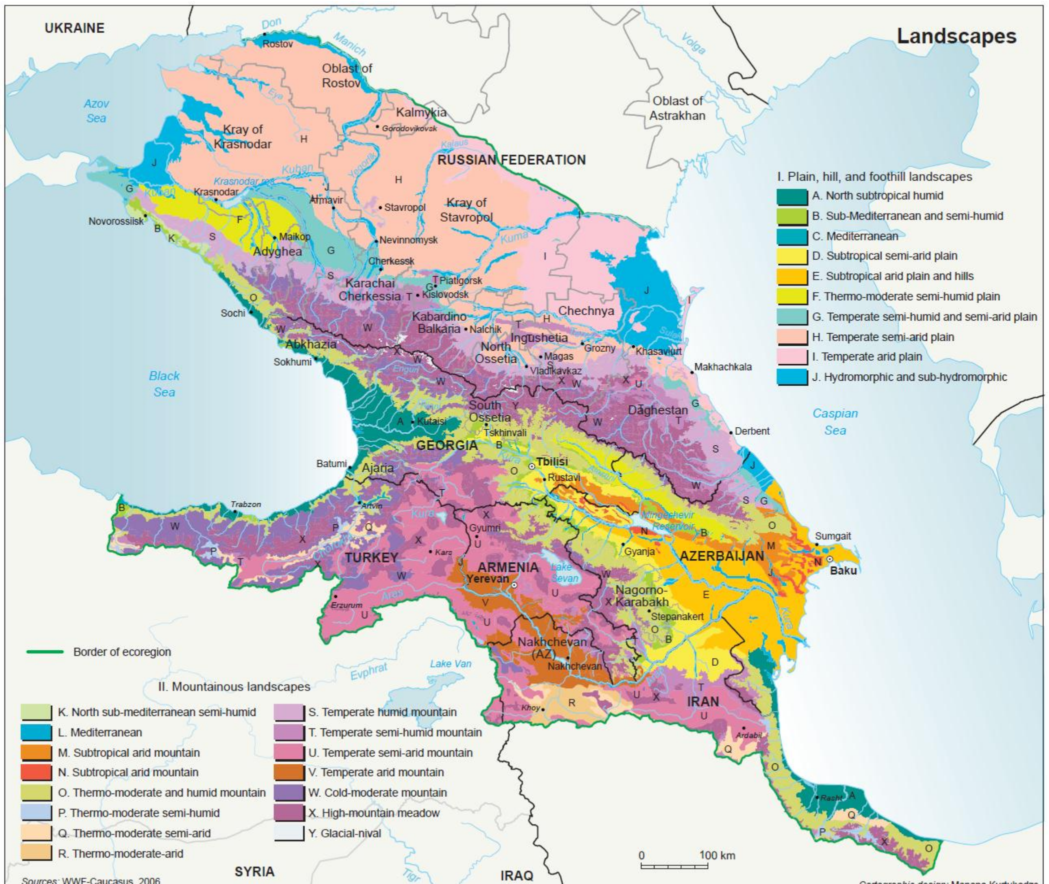
(Illustration source: http://andrewsforest.oregonstate.edu)

Example of Cross-Section of Habitat Zones



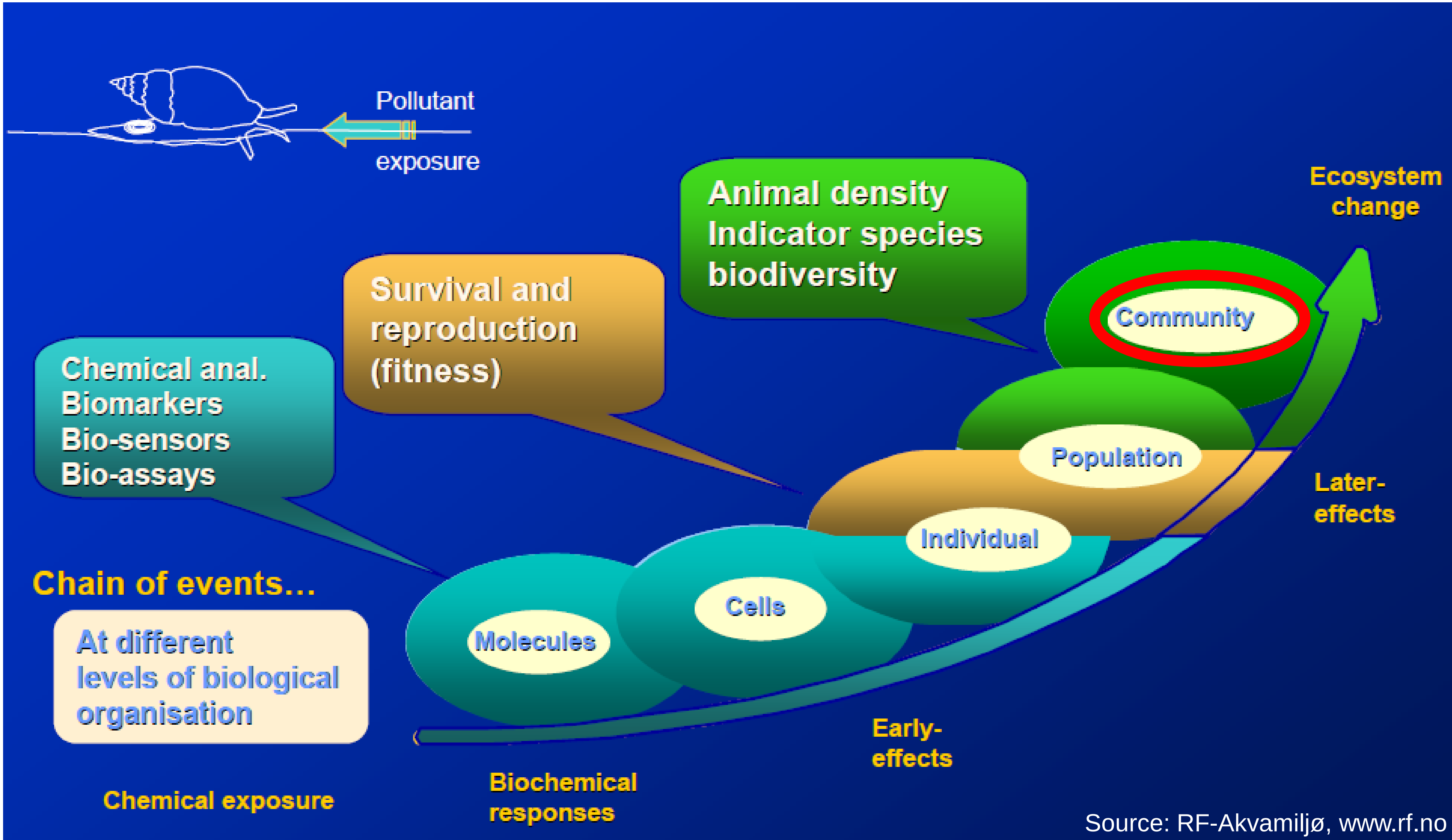
(figure source: EPA #903R03002)

Ecoregions and Other Classifications



- Classify sample sites according to ecoregion for comparability
- Other classifications may be desirable if biodiversity is expected to vary significantly

Levels of Biological Sampling



Source: RF-Akvamiljø, www.rf.no

Community Variables: Metrics & Indices

- **Metric** = Any characteristic of the aquatic community that can be measured reliably and reflects upon stream health (i.e., shows an empirical and predictable change along a gradient of human disturbance)

- **Index** = A multi-metric approach that involves combinations of metrics (indicators) into a simple model to provide an integrative assessment

Examples of Metrics Describing Wetland

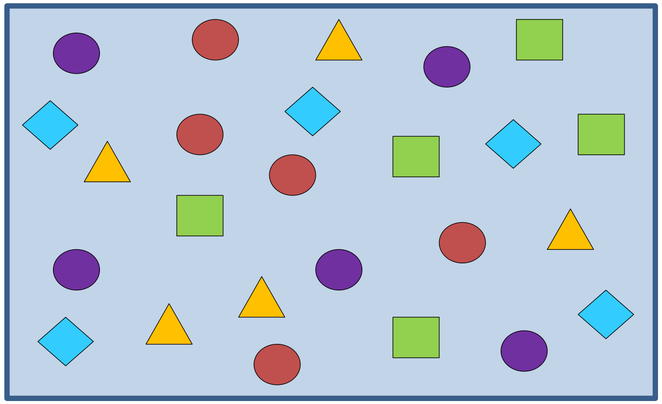
Community *Structure & Function*

- Structure Metrics
  - Diversity (Richness & Evenness)
  - Abundance
  - Biomass
  - Density
  - Community composition (e.g., proportion tolerant)
  - Community attributes (e.g., proportion exotics, endemics)

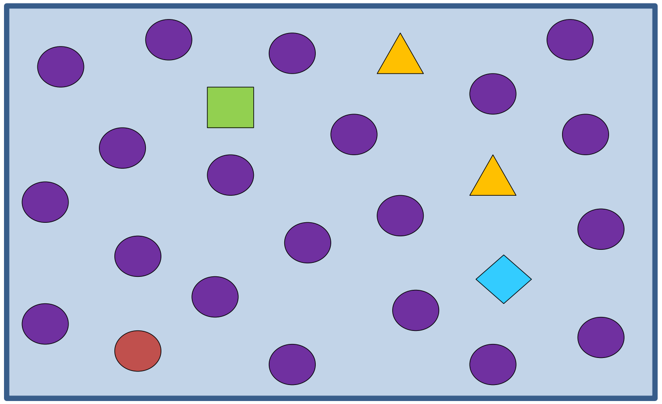
- Function Metrics
  - Decomposition/leaching productivity
  - Photosynthesis
  - Respiration Denitification
  - Nitrogen Fixation
  - Other biochemical functions (e.g., methanogenesis)

Species Diversity (Richness & Evenness)

Which population has more diversity?



Species = 5
Individuals = 25



Species = 5
Individuals = 25

- **Species Richness** = Total # of Species
- **Species Evenness** = Relative Abundance of each Species
- **Diversity Index** = **Species Richness Index** + **Species Evenness Index**

(reflects proportional representation of each species)

Example:
Shannon Diversity Index

sum from species 1 to total # species S

Fraction of the entire population made up of species i

Shannon diversity index

$$H = \sum_{i=1}^{s} -(P_i * \ln P_i)$$

Example:

Birds	N_i	P_i	$\ln P_i$	$-(P_i * \ln P_i)$
Pigeon	96	.96	-.041	.039
Robin	1	.01	-4.61	.046
Starling	1	.01	-4.61	.046
Crow	1	.01	-4.61	.046
House sparrow	1	.01	-4.61	.046
				$H = 0.223$

High values of "H" represents more diverse communities

Index of Biological Integrity

- **Index of Biotic Integrity (IBI) -** An integrative expression of site condition across *multiple* metrics.
  - Often composed of at least 7 metrics
  - IBI is specific to assemblage (fish, vascular plants, algae, macroinvertebrates, etc.)
  - Numeric index score is then compared to “standards” or “reference” streams in same ecoregion to determine whether a stream is meeting expectations for supporting aquatic life

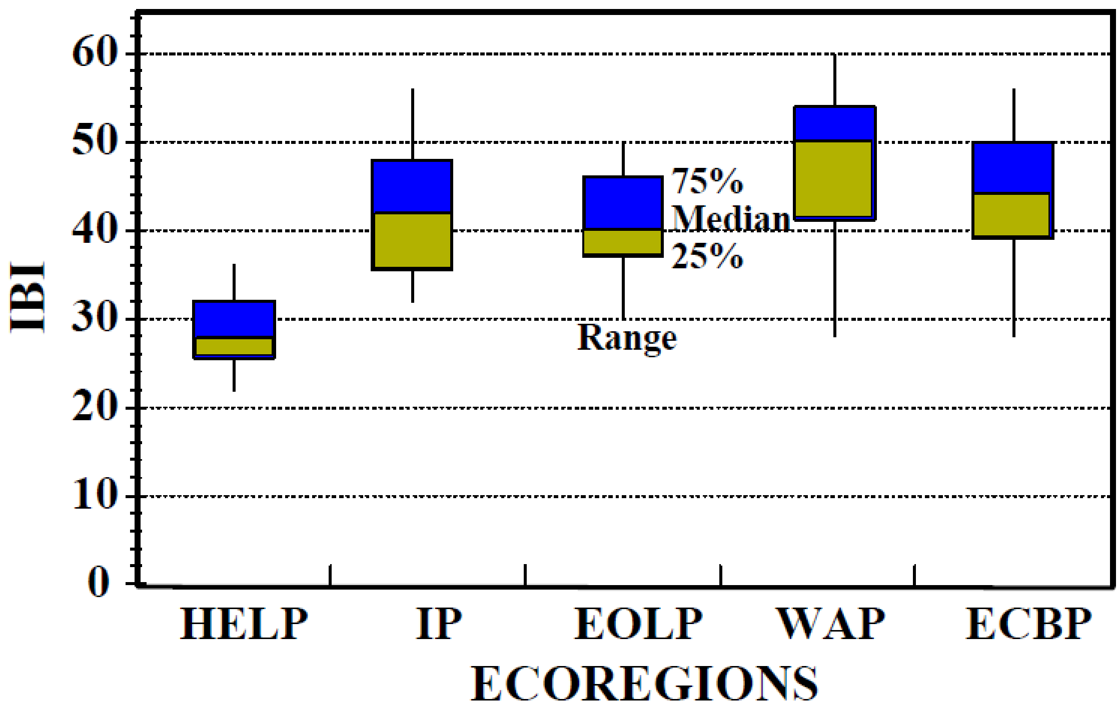
Many Types of Indices

- Ephemeroptera/Plecoptera/Trichoptera (EPT) Taxa Index (pollution sensitivity)
- Benthic Index Biotic Integrity
- Diatom Nutrient Index
- Diatom Biotic Index
- Amphibian Index Biotic Integrity
- Water Quality Index
- Etc.

Reference Conditions, Biocriteria, Thresholds

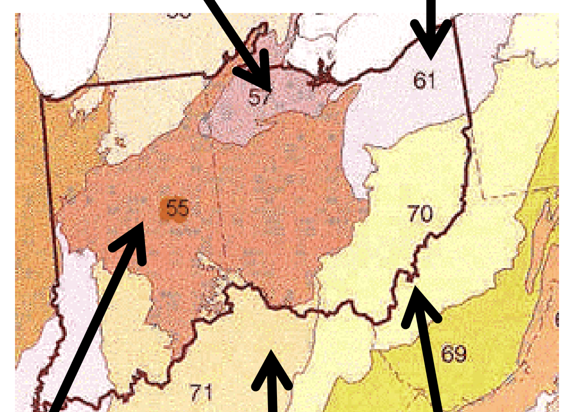
- **Reference Condition (for biological integrity)**: “standard” or benchmark of an unimpaired or minimally impaired (“natural”) system
- **Biocriteria**: Narrative descriptions or numeric values that describes the reference biological integrity; qualities of the reference standards against which results are compared
- **Thresholds**: Cut-off points for criteria values (e.g., good, fair, poor)

Reference Stream IBI Values Depend on Ecoregion



HELP
(Huron/Erie Lake Plains)

EOLP
(Erie/Ontario Lake Hills and Plains)



ECBP
(Eastern Corn Belt Plains)

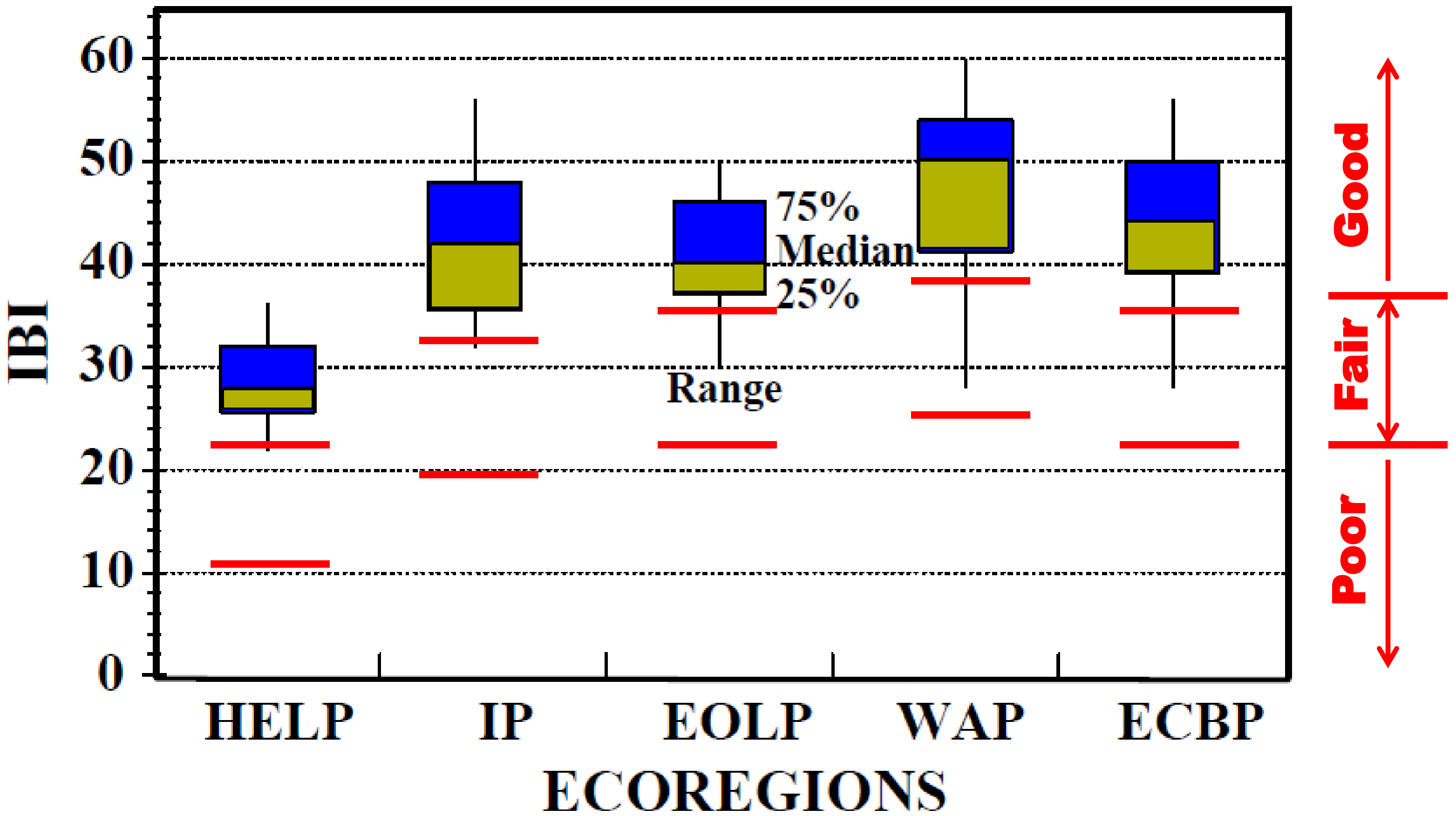
IP
(Interior Plateau)

WAP
(Western Allegheny Plateau)

(graph source: Barbour et al. 1999. EPA 841-B-99-002)

(figure source: http://water.epa.gov)

Adding Thresholds
(notional thresholds depicted)

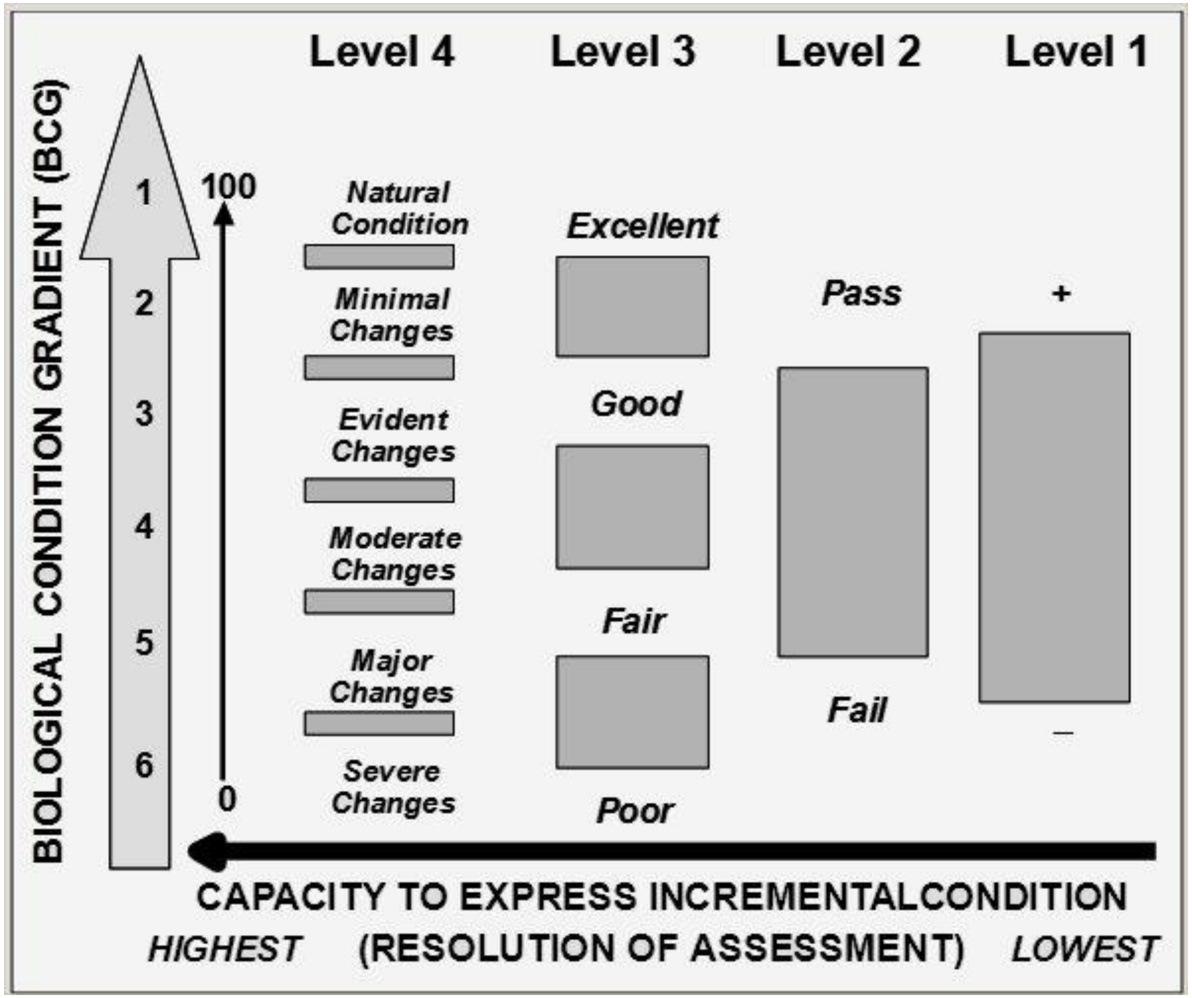


(graph source: Barbour et al. 1999. EPA 841-B-99-002)

A Note about Data Collection

- There are *many* ways to collect data
  - Rigorous field protocols
  - Many sampling designs, collecting techniques
  - Directed searches (e.g., certain taxa)
  - Opportunistic findings
  - Local knowledge
- Record as much as possible about methodology
- Incorporate random element to sampling design; don't just survey sites easiest to access

A Note about Levels of Data



(figure source: www.epa.gov/bioiweb1/html/biological_endpoints.html)

Level 1…

- No numeric biocriteria
- No thresholds
- Can detect severe impairments, but have less power to distinguish degrees of impairment.

All data are useful!

A Note about Data Management

- Well designed field data forms and training helps maintain quality and consistency of data
- Maintain hard and electronic copies of all <u>raw data</u> forms; file in logical manner
- Quality control check data entry
- Database Management
  - GIS and GeoDatabases are often most comprehensive way to maintain REA information
  - Populate metadata information!

Behavior of Metrics Along Stressor Gradient

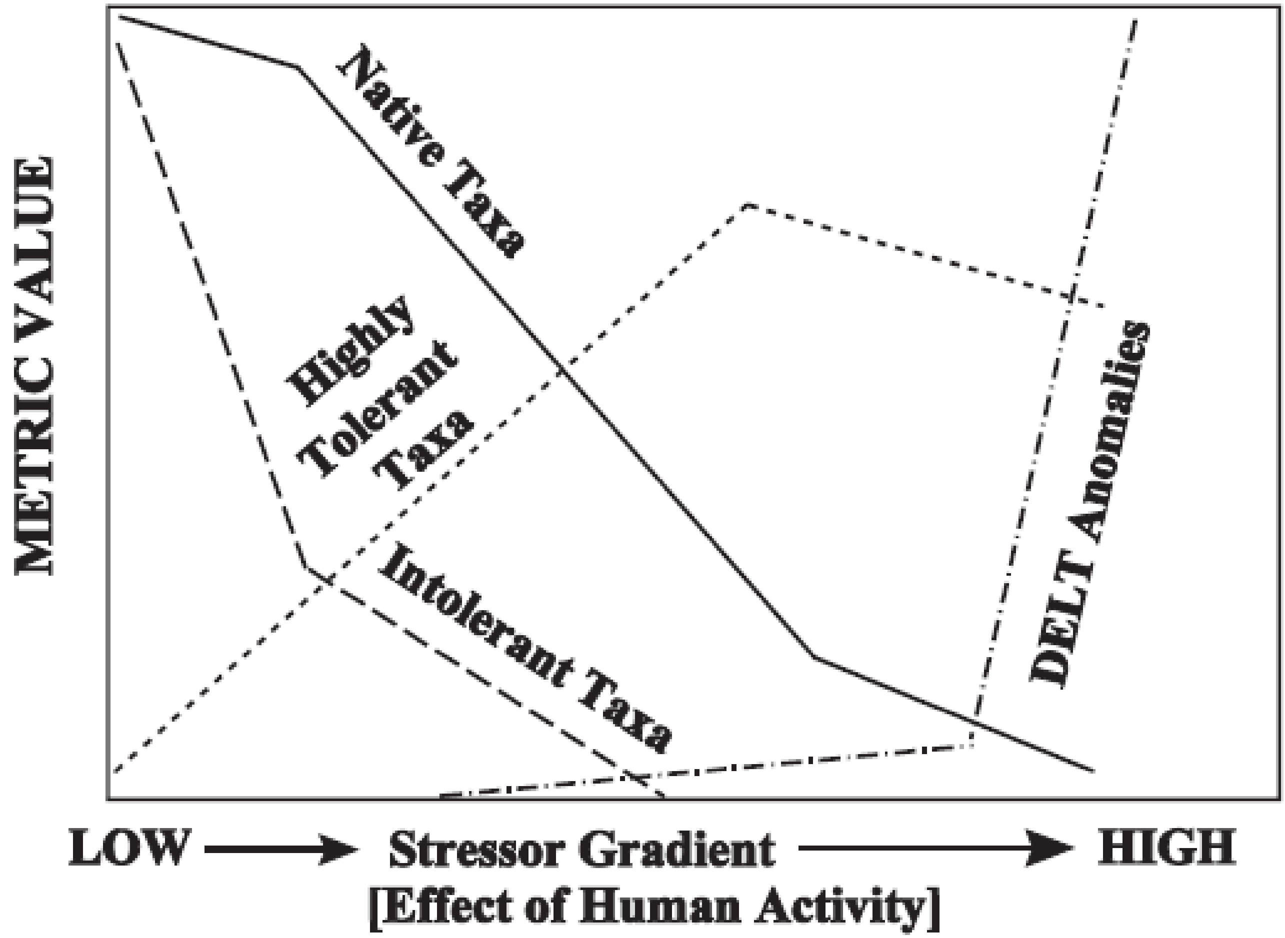


Fig. 2. Behavior of IBI metrics along the stressor gradient (from Yoder, 2002).

(Source: Novotny et al. 2005)

Example of Avifauna Index

Avifauna Index Metrics for Wetlands (source: Carlisle 1998)			
Metric	**Rationale**	**Response to Stressors**	**Metric Computation**
Taxa Richness	Feeding and breeding response based on habitat quality and food supply	Decline	Differences from reference site total taxa
% Neotropical Migrants	Migrants are generally sensitive to habitat quality and are habitat specialists	Decline	Percentage of total species
% Resident Species	Resident species less sensitive to habitat quality and tend to be generalists	Rise	Percentage of total species
% Tolerant Species	Tolerant species are generalists that have adapted to human-altered habitats and landscapes	Decline	Number of Species
Wetland-Dependent Species	Species with habitat requirements that tie them exclusively to aquatic habitats	Decline	Number of Species

Example of Avifauna Scoring

Avifauna Index Metric Scoring Criteria: Freshwater Sites				
Score:	**6**	**4**	**2**	**0**
Taxa Richness (diff. from reference site)	<2	2-5	6-9	>9
% Neotropical Migrants	>40	30-40	20-29	<20
% Resident Species	<30	30-40	41-50	>50
% Tolerant Species	<20	20-30	31-40	>40
Wetland-Dependent Species	>5	3-5	1-3	<1
(source: Carlisle 1998)				

Example of Avifauna Scoring

Avifauna Index Metric Scoring Criteria: Freshwater Sites				
	Site #1		Site #2	
	Value	**Score**	**Value**	**Score**
Taxa Richness	4	4	1	6
% Neotropical Migrants	30	4	57	6
% Resident Species	60	0	29	6
% Tolerant Species	40	2	35	6
Wetland-Dependent Species	4	4	2	2
FINAL AVI SCORE		14		26
(source: Carlisle 1998)				