Using aquatic organisms to learn about river health

Rivers face many threats

Impoundment

Urbanization

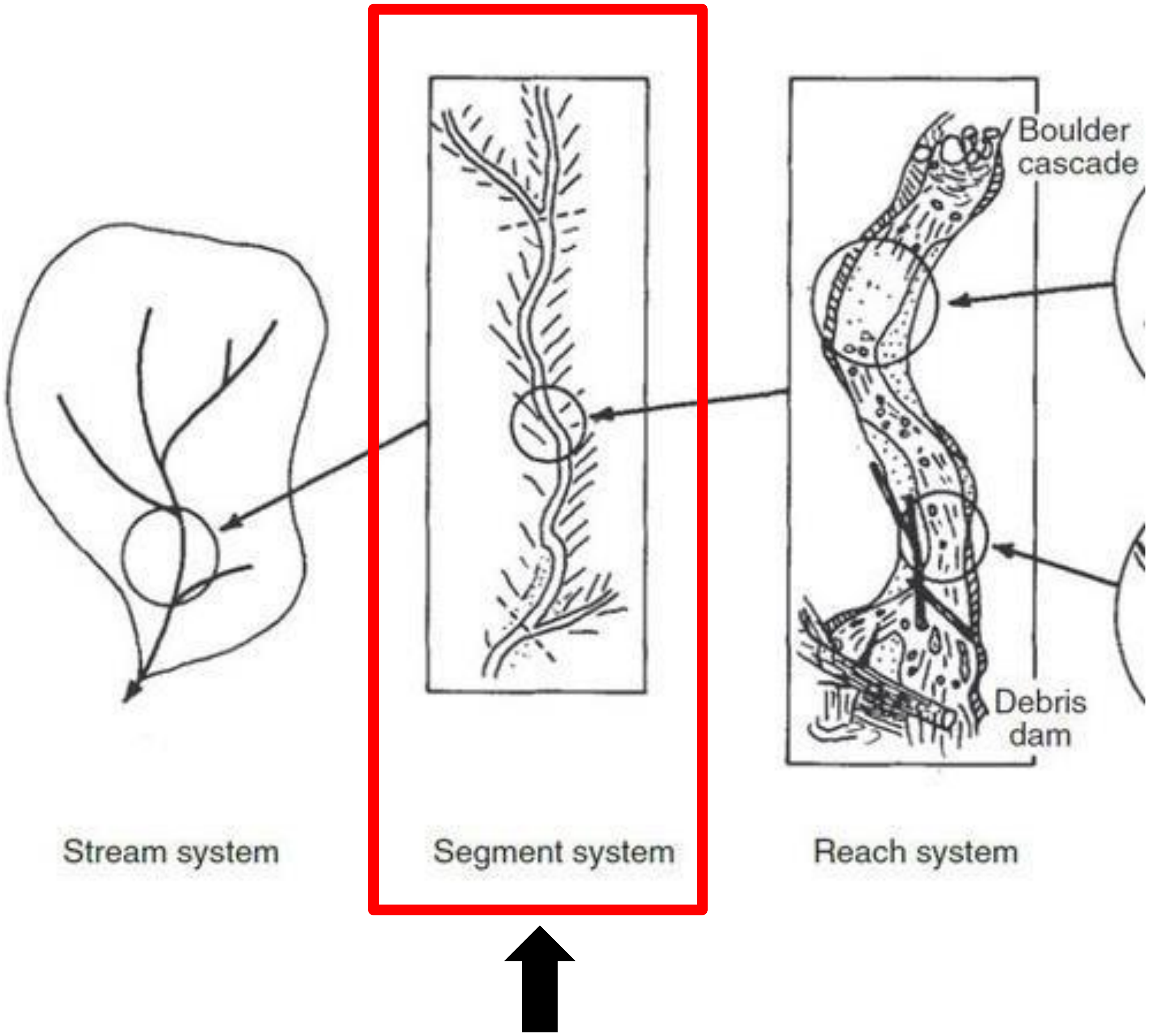
Nonpoint pollution

Flow alteration

Stormwater runoff

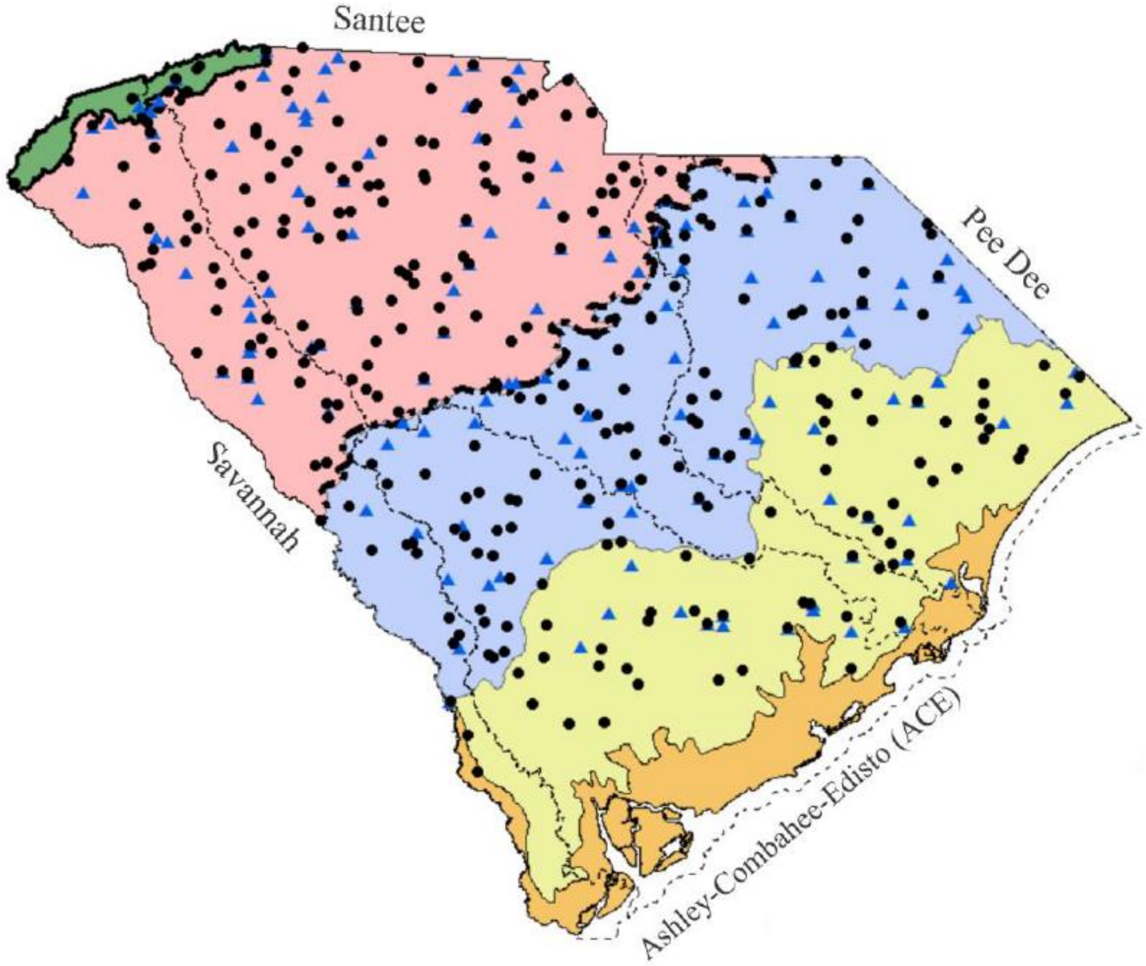
Monitoring helps sustain designated uses

Rivers are a hierarchy of habitats



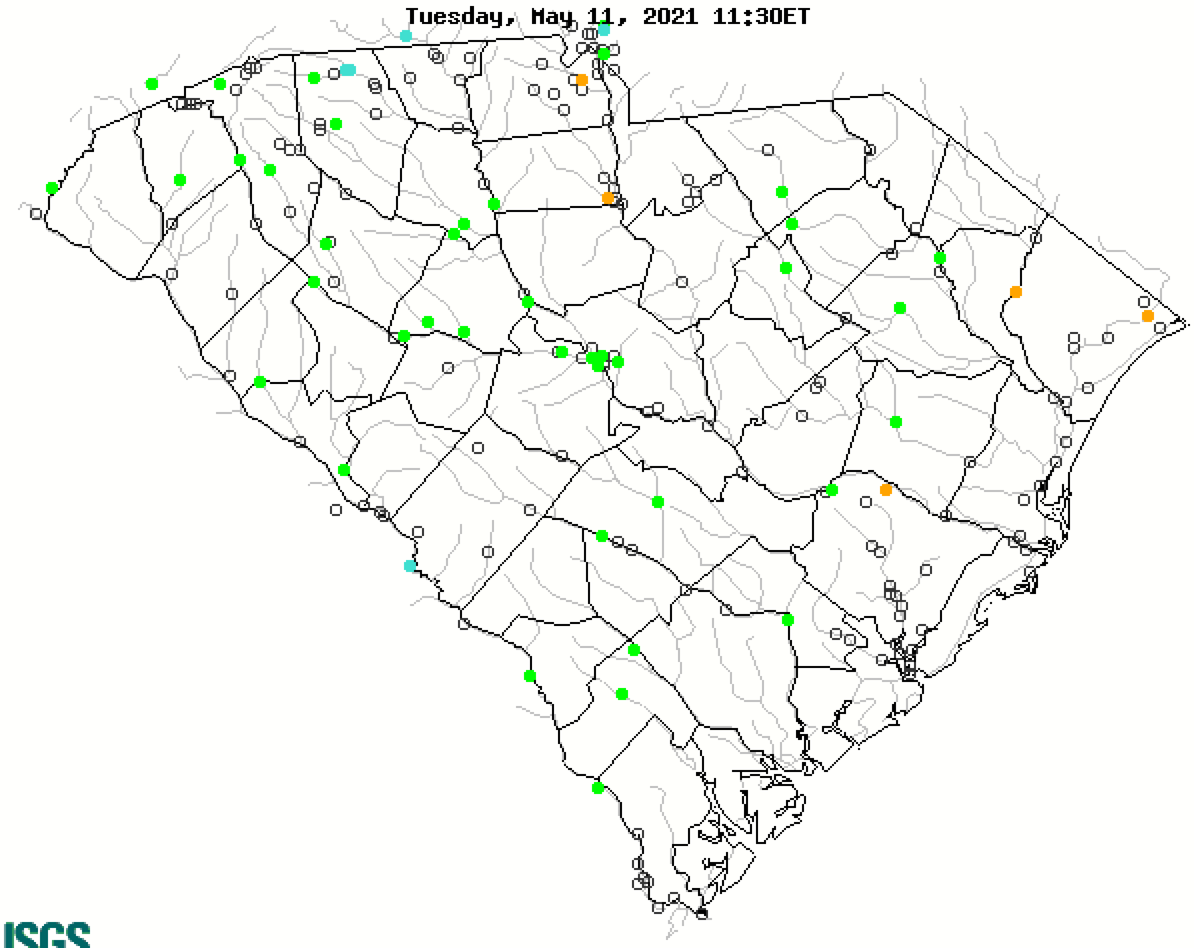
Most appropriate for monitoring

Too much water to monitor!



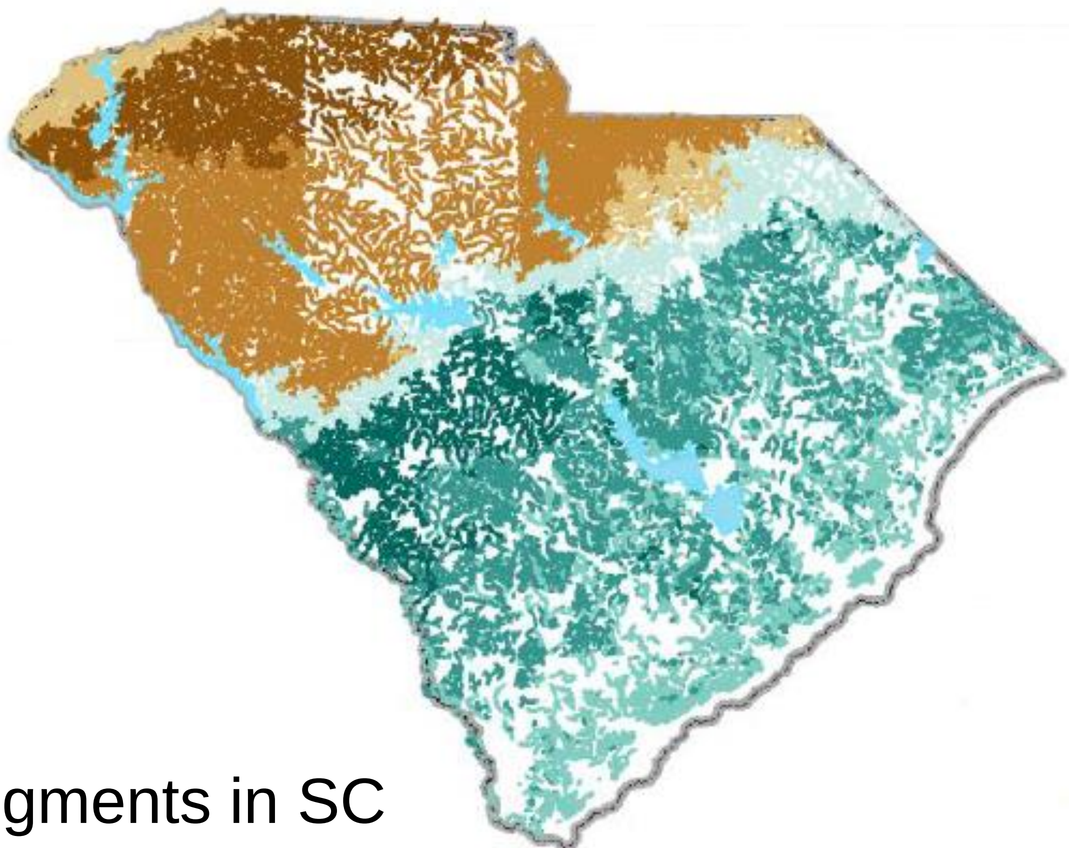
SCDNR: >400 fish sites

Too much water to monitor!



USGS flow gage sites

Too much water to monitor!

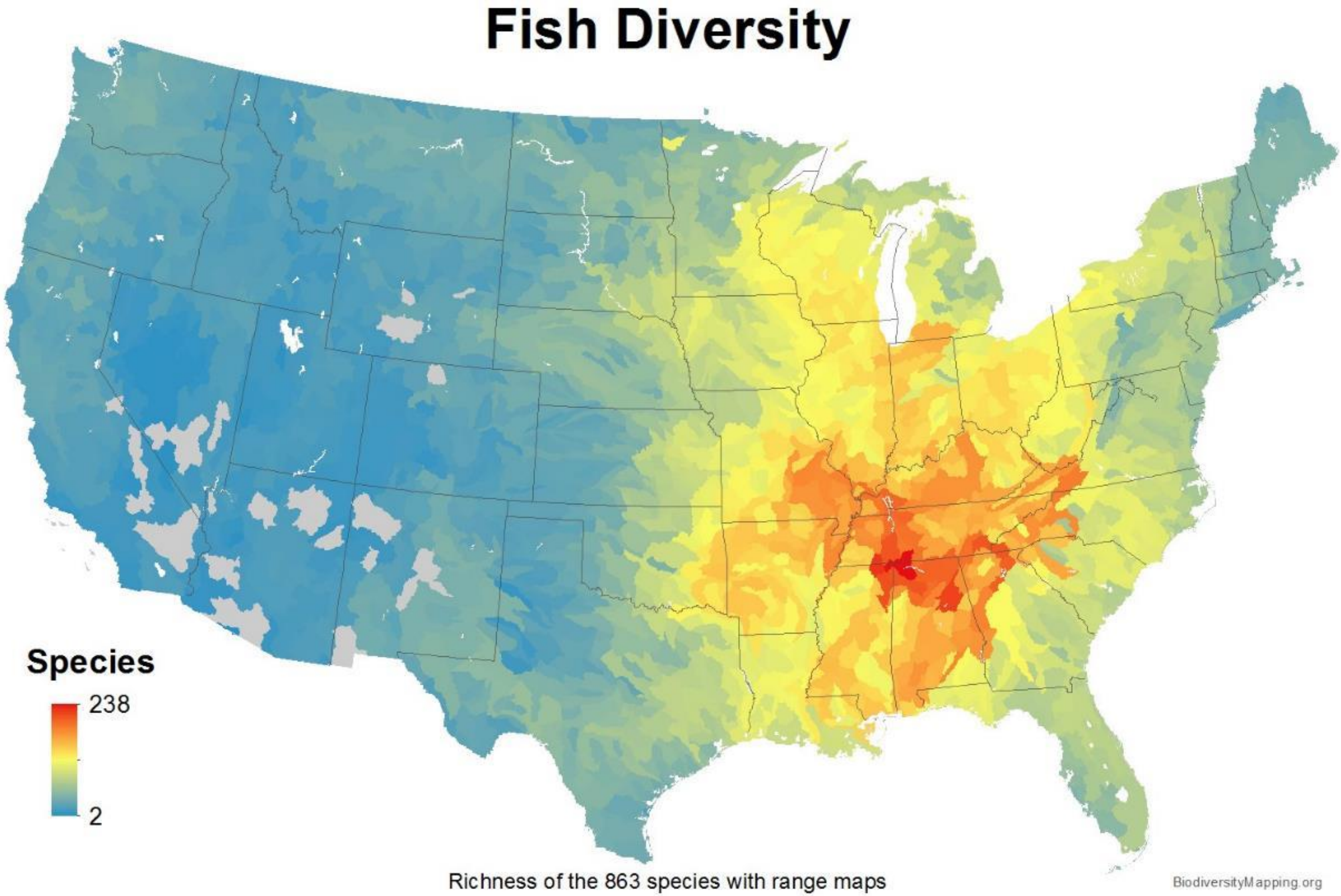


- >28,000 segments in SC
- >15,000 river miles
- And that's just wadeable streams

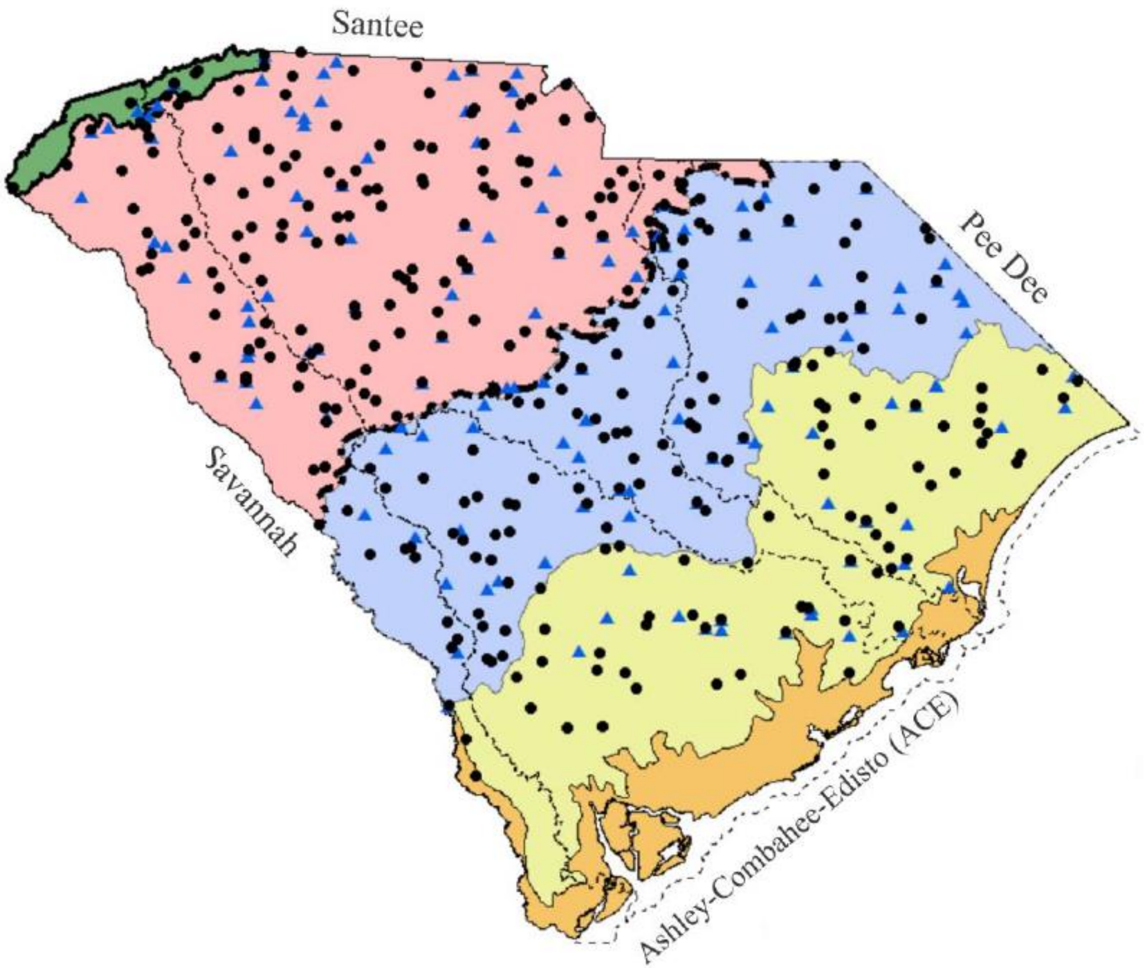
Too much water to monitor!

for people to

A freshwater biodiversity global hotspot



SC Freshwater Diversity



- 146 fish species
- 1,092 invertebrate groups (many more species)

Bio-assessment: using aquatic organisms to learn about river health

ASSESSMENT OF BIOTIC INTEGRITY USING FISH COMMUNITIES

James R. Karr

ABSTRACT

Man's activities have had profound, and usually negative, influences on freshwater fishes from the smallest streams to the largest rivers. Some negative effects are due to contaminants, while others are associated with changes in watershed hydrology, habitat modifications, and alteration of energy sources upon which the aquatic biota depends. Regrettably, past efforts to evaluate effects of man's activities on fishes have attempted to use water quality as a surrogate for more comprehensive biotic assessment. A more refined biotic assessment program is required for effective protection of freshwater fish resources. An assessment system proposed here uses a series of fish community attributes related to species composition and ecological structure to evaluate the quality of an aquatic biota. In preliminary trials this system accurately reflected the status of fish communities and the environment supporting them.

James R. Karr

Passage of the Water Quality Act Amendments of 1972 (PL 92-500) stimulated many efforts to monitor the quality of water resource systems. Unfortunately, these efforts concentrated on development of thresholds and criteria levels for specific contaminants, often based on acute toxicity tests. The use of these criteria has been attacked on numerous grounds (Thurston et al. 1979); for example, they have not taken into account naturally occurring geographic variation of contaminants (e.g., asbestos, iron, zinc), considered the synergistic effects of numerous contaminants, nor considered sublethal effects (e.g., reproduction, growth) of most contaminants. In addition, monitoring of water quality parameters (nutrients, DO, temperature, pesticides, heavy metals, and other toxics) often misses short-term events that may be critical to assessment of biotic impacts. Finally, it is impossible to measure all factors that may impact biotic integrity. In fact, much literature on chemical contaminants is of questionable value for setting water quality standards for aquatic organisms (Gosz 1980). Chemical monitoring misses many of the man-induced perturbations that impair use. For example, flow alterations, habitat degradation, heated effluents, and uses for power generation are not detected in chemical sampling. In short, criteria that emphasize physical and chemical attributes of water are unsuccessful as surrogates for measuring biotic integrity (Karr and Dudley 1981).

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Recent legislation (Clean Water Act of 1977, PL 95-217) clearly calls for a more refined approach when pollution is defined as "the manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." Despite this refinement, regulatory agencies have been slow to replace the classical approach (uniform standards focusing on contaminant levels) with a more sophisticated and environmentally sound approach.

The integrity of water resources can best be assessed by evaluating the degree to which waters provide for beneficial uses. Important uses as defined by society may include water supply, recreational, and other uses as well as the preservation of future options for the use of the resource. Since an ability to sustain a balanced biotic community is one of the best indicators of the potential for beneficial use, sophisticated monitoring programs should seek to assess "biotic integrity."

This paper describes a procedure for monitoring water resources using fish. My contention is that by carefully monitoring fishes, one can rapidly assess the health ("biotic integrity") of a local water resource. In short, carefully planned monitoring and assessment can rapidly and relatively inexpensively serve as an exploratory assessment of water resource quality. Where impaired use is suggested by biological monitoring, a more nearly complete monitoring program can be implemented in search of the causative agent(s).

WHY MONITOR FISH?

Biological communities reflect watershed conditions since they are sensitive to changes in a wide array of environmental factors. Many groups of organisms have been proposed as indicators of environmental quality, but no single group has emerged as the

<u>Bio-assessment:</u> using aquatic organisms to learn about river health

1. Identify which environmental attribute you want to evaluate

2. Hypothesize relationships between organisms and environmental attributes

3. Identify key relationships between organisms and environment

4. Use those results to inform management

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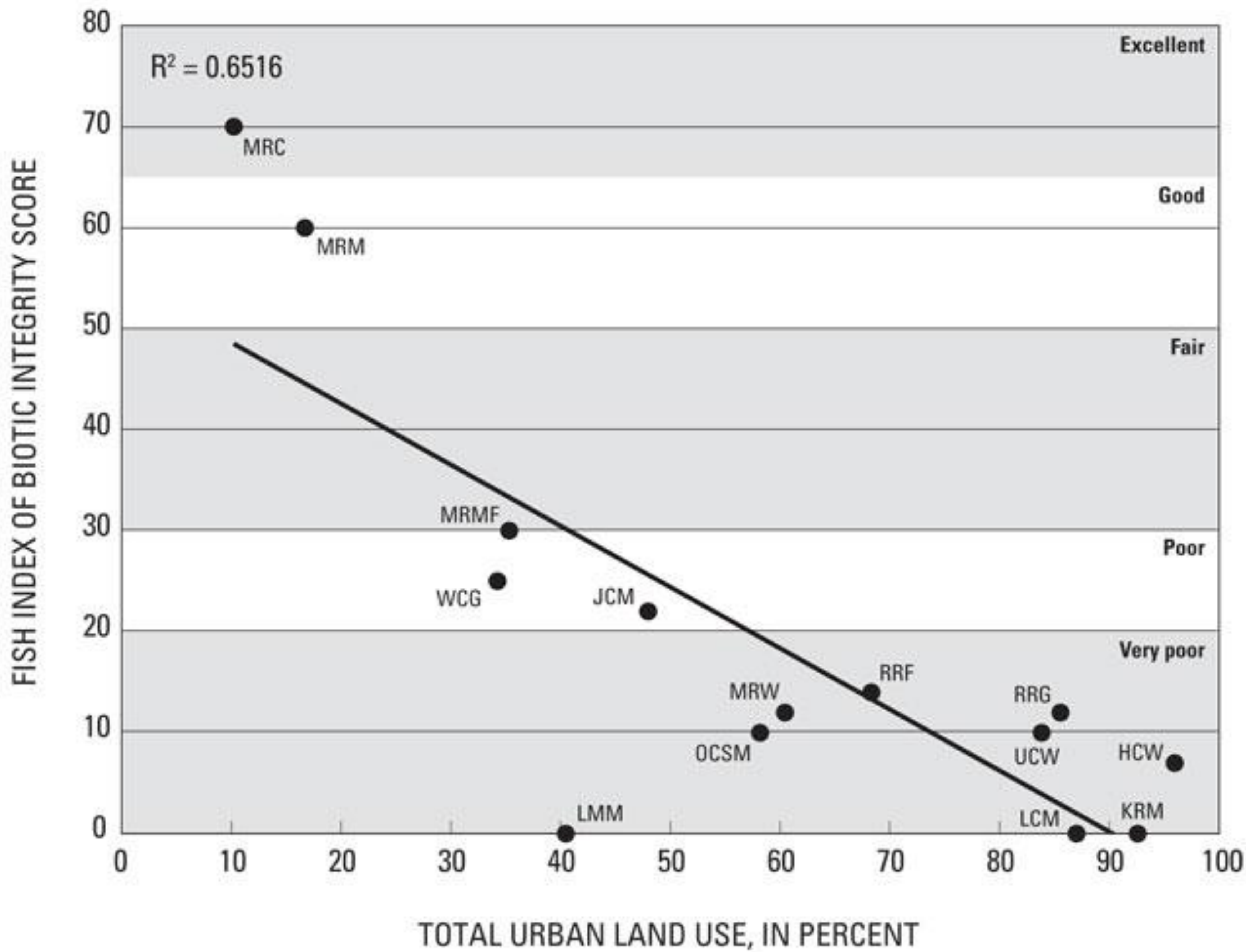
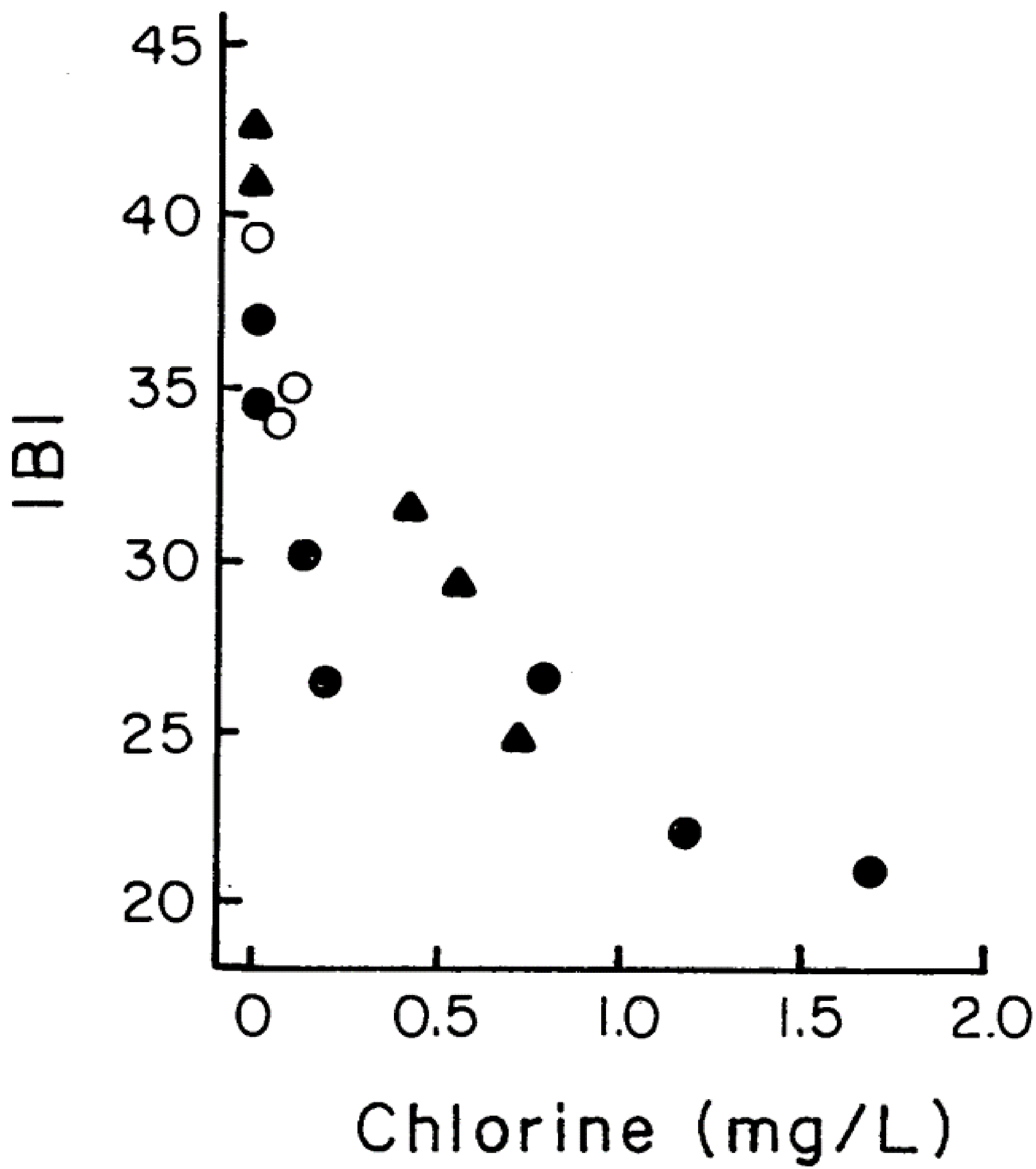


R² = 0.6516
Excellent
Good
Fair
Poor
Very poor
MRC
MRM
MRMF
WCG
JCM
MRW
OCSM
RRF
RRG
UCW
HCW
LMM
LCM
KRM
FISH INDEX OF BIOTIC INTEGRITY SCORE
TOTAL URBAN LAND USE, IN PERCENT
0
10
20
30
40
50
60
70
80
90
100


45
40
35
30
25
20
IBI
0
0.5
1.0
1.5
2.0
Chlorine (mg/L)

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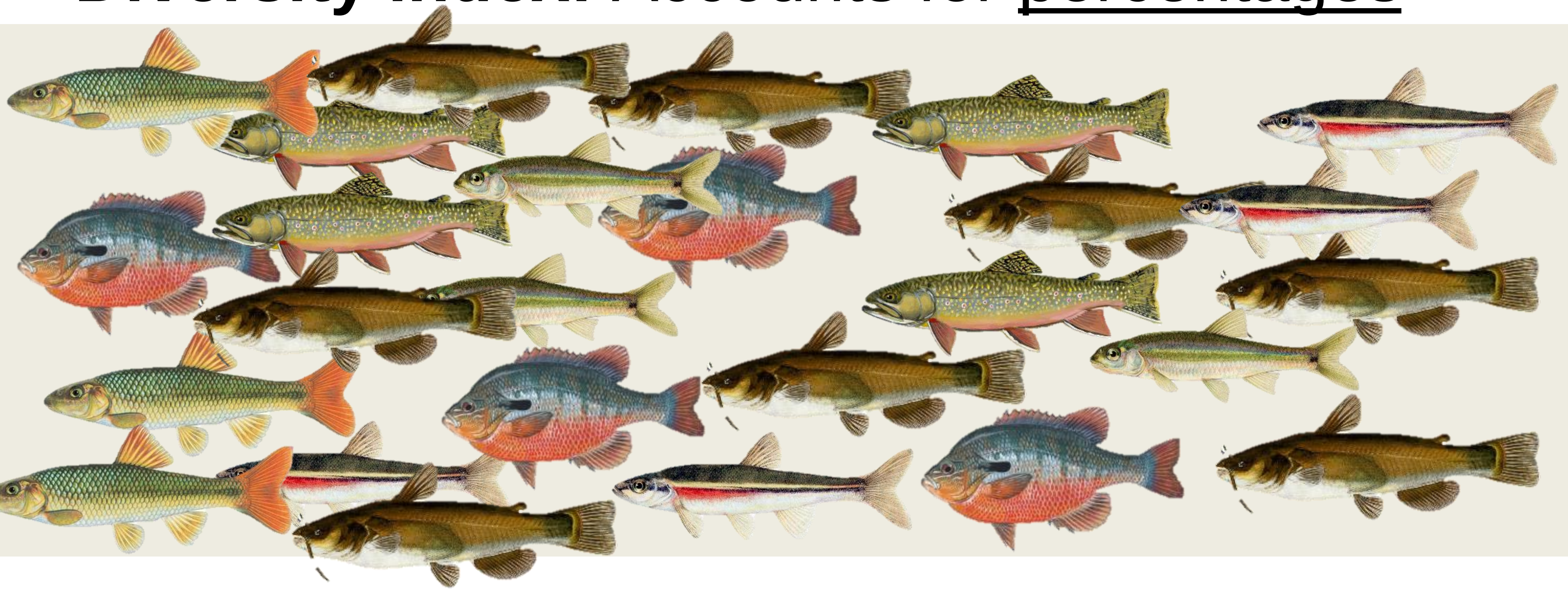
Characterizing aquatic diversity

- Diverse biota = healthy ecosystem
- **Species richness:** number of species
- **Diversity index:** Accounts for <u>percentages</u>



Negative relationship with flow alteration

Species traits: body shape

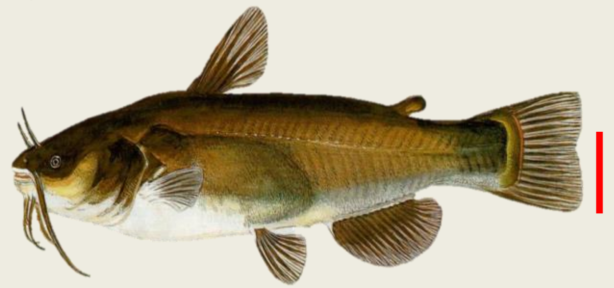
Flow specialists, need good flow

High tail aspect ratio

Long & slender (torpedo shaped)

- Negatively affected by flow alteration
- % will decrease with flow alteration

Flow generalists, live anywhere



Low tail aspect ratio

Short & stubby

- Not affected by flow alteration
- % will increase with flow alteration

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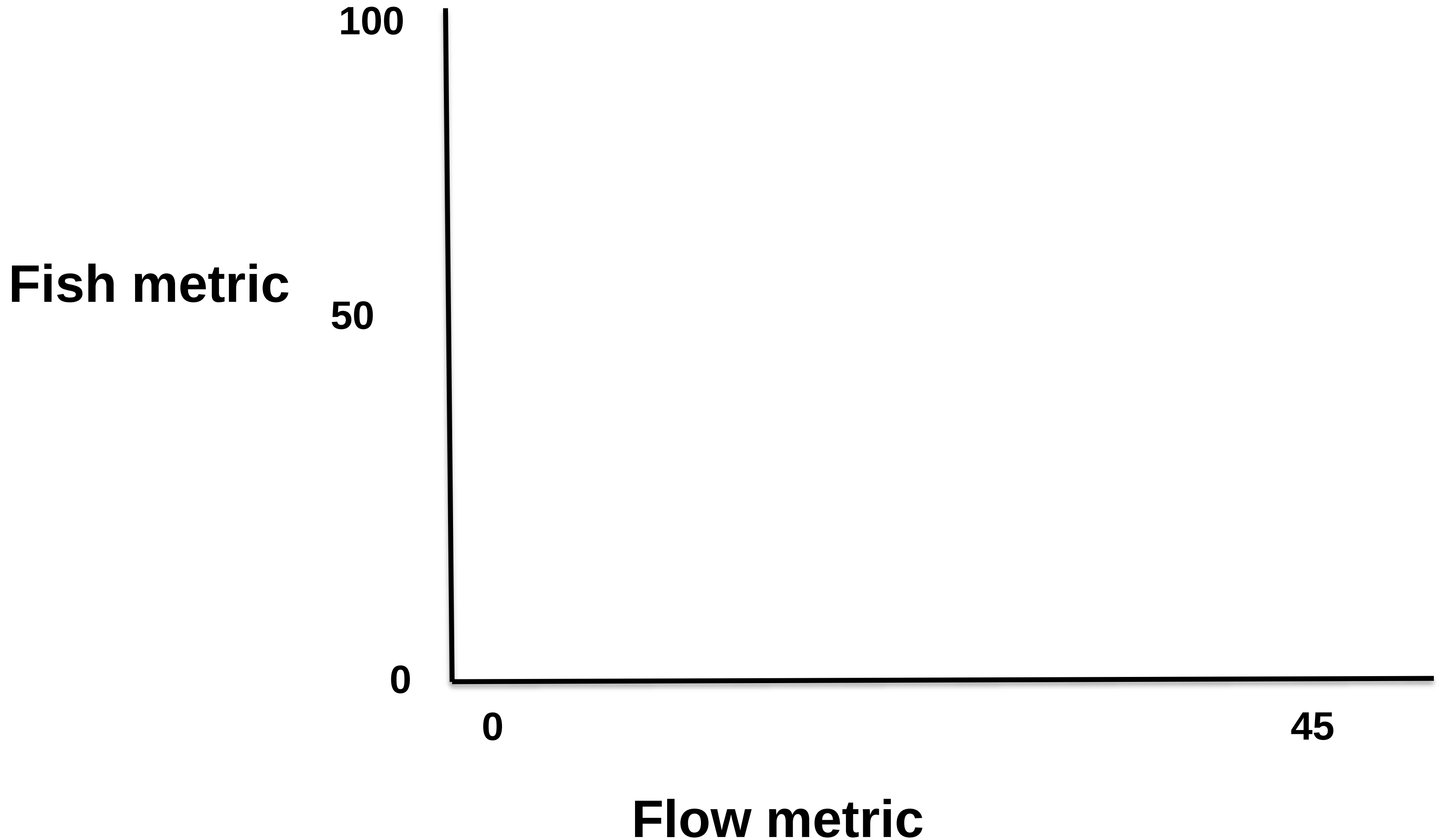
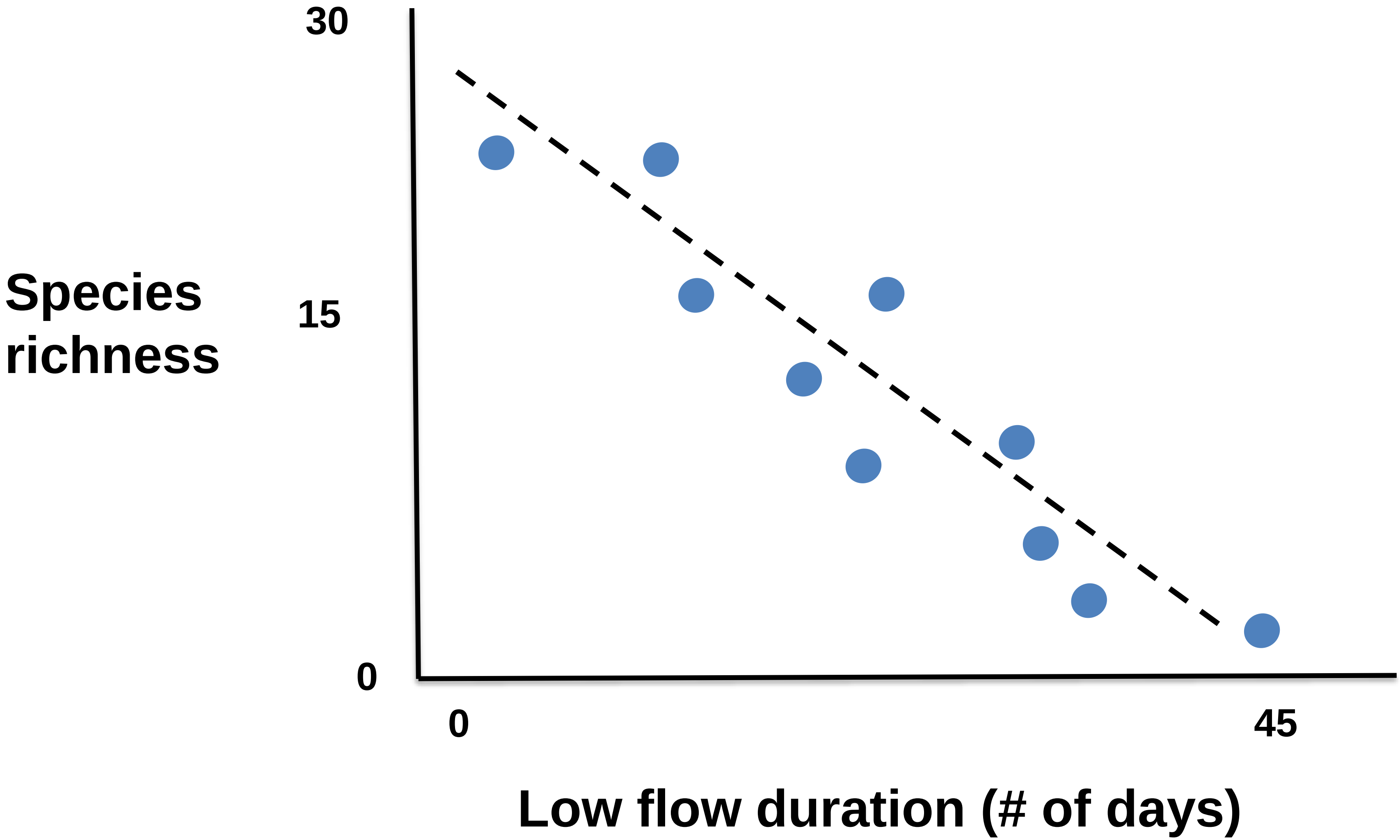
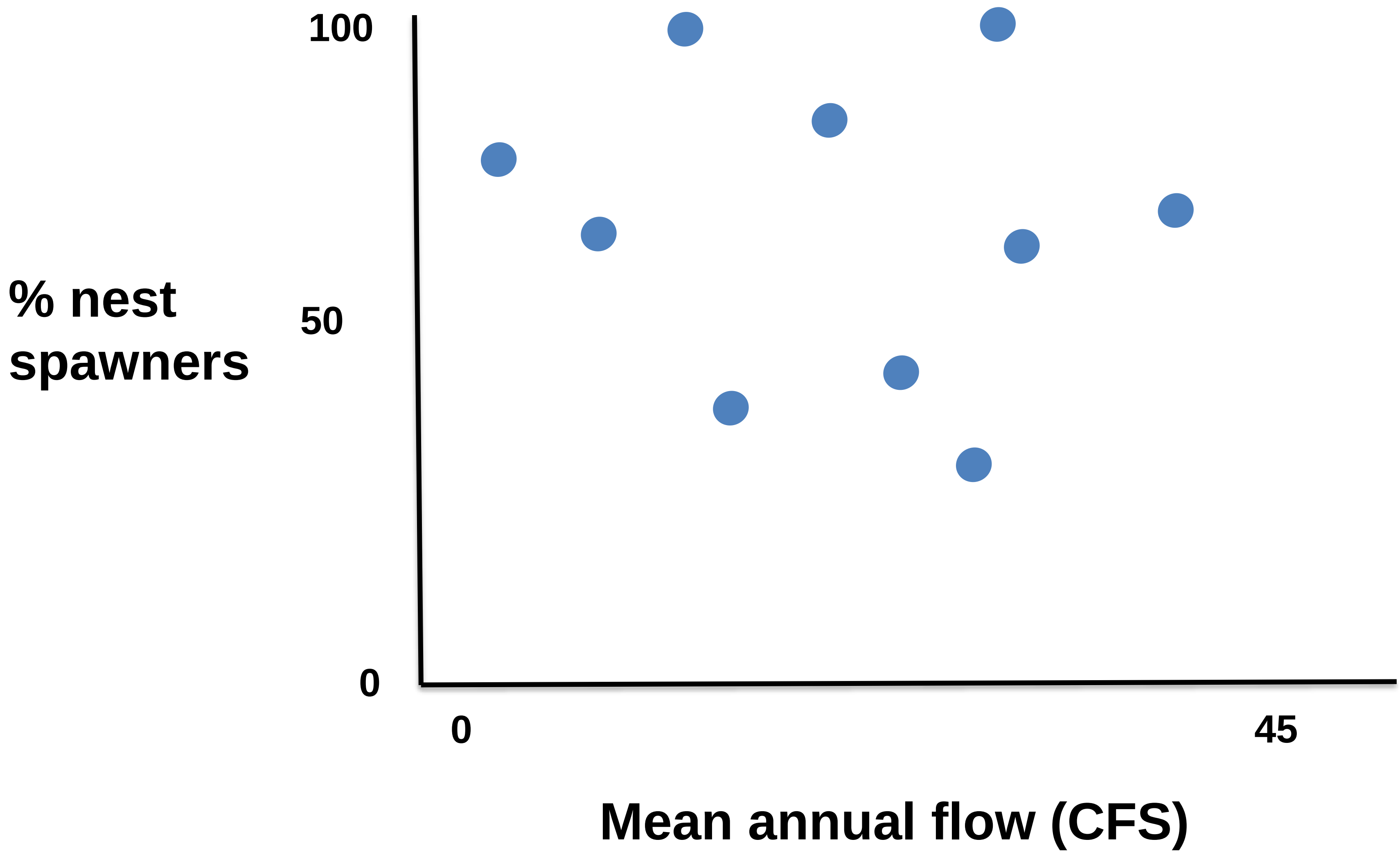
Identify relationships: plot biota against flow



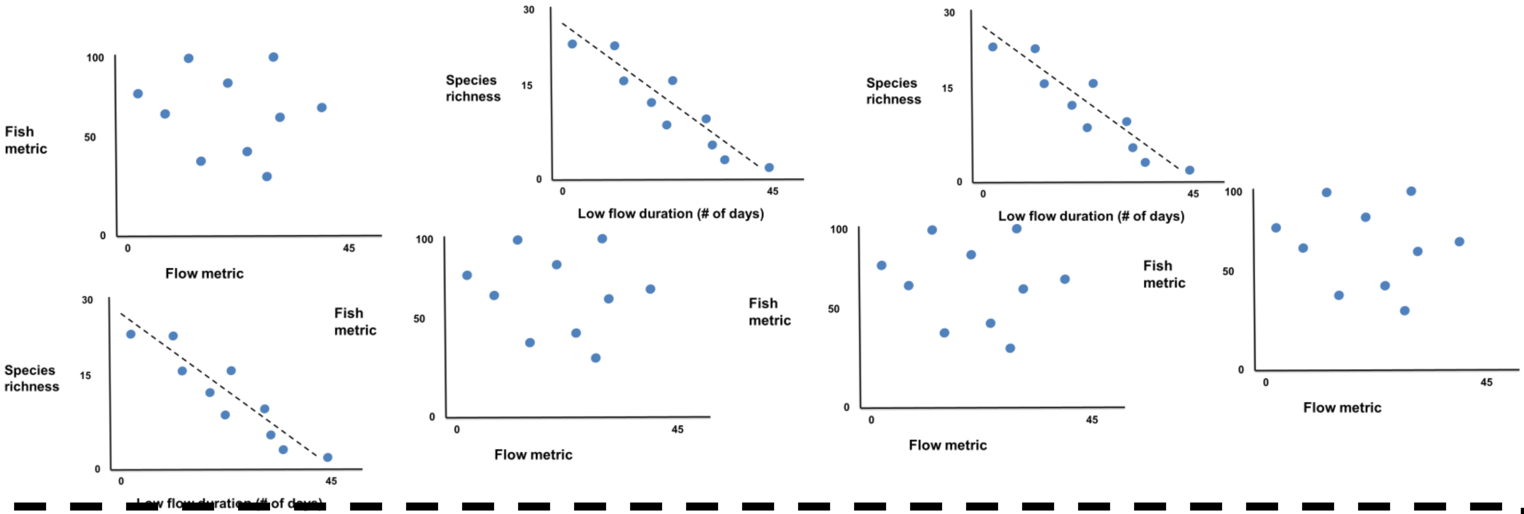
Identify relationships: some are informative



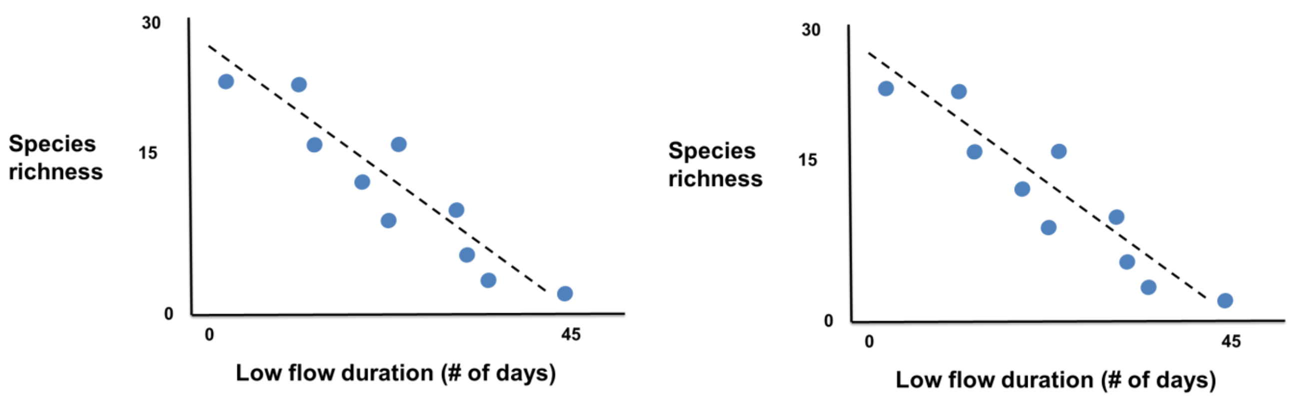
Identify relationships: some are not informative



Identify relationships: remove uninformative relationships



Filter: statistical modeling process



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…so here we are

- Identify potential thresholds
- Discuss ‘acceptable’ biodiversity loss
- Keep common species common