



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

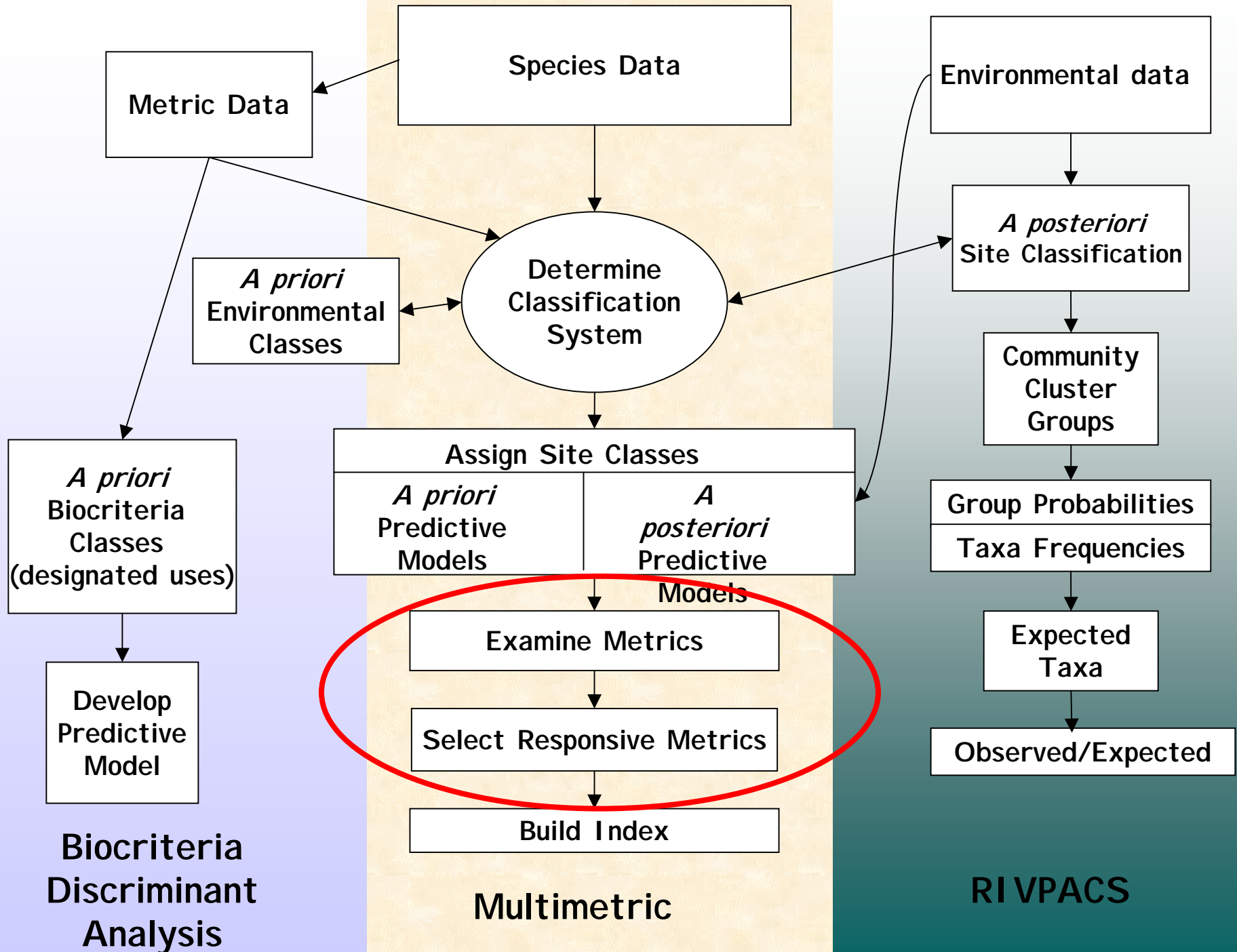
Biological Attribute Exploration, Metric Development

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Jeroen Gerritsen, Tetra Tech, Inc.

Quick Review:

Multimetric Index Development

1. Database consisting of reference and stressed populations (sites)
2. Classify resource
 - ✓ reference sites, ecoregions
3. Identify and test candidate metrics
4. Select metrics for dimensionless index
5. Select thresholds for assessment



Metric Selection Criteria

- Meaningful measure of ecological structure or function
- Strong and consistent correlation with human disturbance
- Statistically robust, low measurement error
- Represent multiple categories of biological organization
- Cost-effective to measure
- Not redundant with other metrics
 - Exception: “response signature” metrics

Metric Categories for Testing

1. Taxonomic richness & composition
2. Functional feeding groups
3. Life history, habit
4. Individual organism condition
5. Composition
 - Tolerance and intolerance

Attribute Groups

INDIVIDUAL CONDITION	TAXONOMIC COMPOSITION	COMMUNITY STRUCTURE	LIFE HISTORY ATTRIBUTES	SYSTEM PROCESSES
DISEASE ANOMALIES CONTAMINANT LEVELS DEATH METABOLIC RATE	IDENTITY TOLERANCE RARE OR ENDANGERED KEY TAXA	TAXA RICHNESS RELATIVE ABUNDANCE DOMINANCE	FEEDING GROUPS HABIT VOLITINISM	TROPHIC DYNAMICS PRODUCTIVITY MATERIAL: CYCLES PREDATION RECRUITMENT

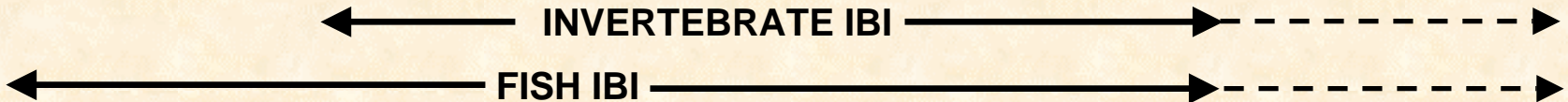
INTEGRATED BIOASSESSMENT

TOXICITY
TESTS

RIVPACS

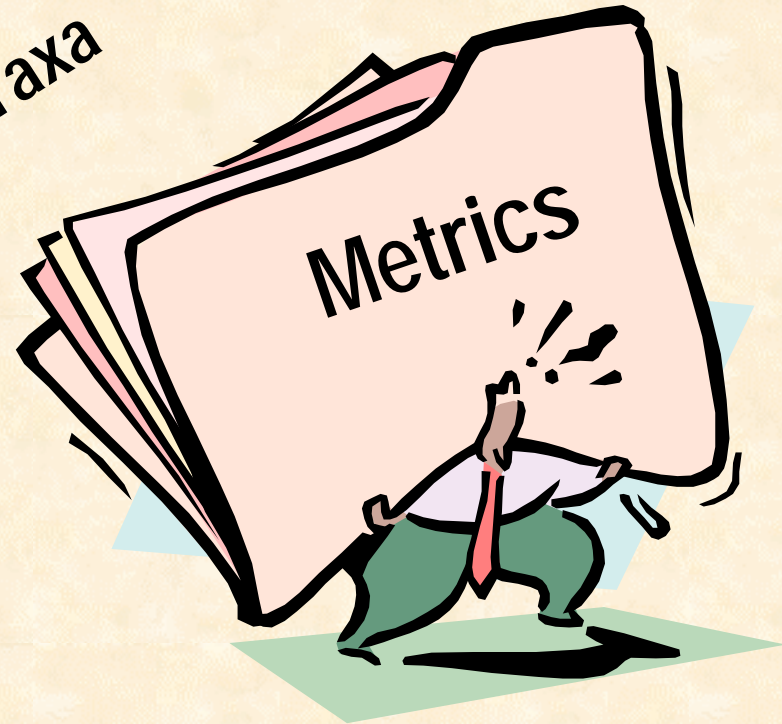
INVERTEBRATE IBI

FISH IBI



Evaluating Metrics

Redundancy
Scoring
72% Chironomids
10% Collector-Filterers
13% Ephemeroptera
Reference
Precision
23 Total Taxa
12 EPT Taxa
Discrimination Efficiency



Desirable Metric Qualities

- Ecologically Justified
- Discriminating
- Represent Integrity
- Precise
- Sufficient range of values

Potential Metric Sources

- Review the literature.
- Examine state and regional programs.
- **Mine your database** for indicator taxa, taxa groups, or taxa attributes.

To Ensure Scientifically Defensible Metrics:

- Develop criteria, independent from biology, to determine which sites are impaired by humans vs. those that are not (the fabled “x axis”)
 - Reference vs. Degraded Sites
 - Human Disturbance Gradient

Mining Existing Data Using the Human Disturbance Gradient

- Plot potential metric against HDG
 - Visual examination of patterns
 - Correlation coefficient
 - Excellent for determining tolerant vs. sensitive taxa



leaves
and
twigs

**Energy
source**

domestic
wastes

natural

**Chemical
variables**

excess
nutrients,
toxins

natural
flows

**Flow
regime**

extreme
flows

pools
and
riffles

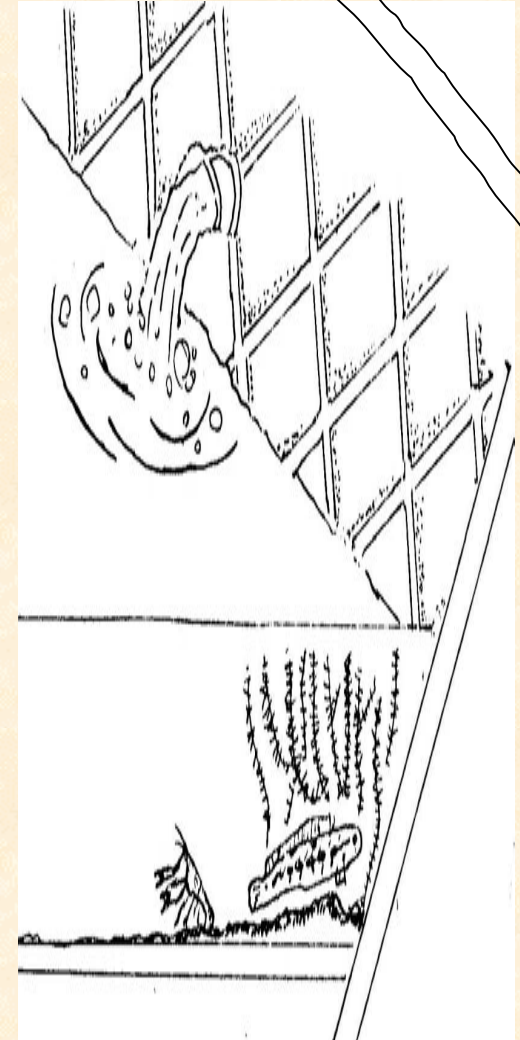
**Habitat
structure**

uniform

native
taxa

**Biotic
factors**

exotic
taxa



Karr & Rossano

Human Disturbance Factor Analysis (Florida system)

- Landscape level
 - Landscape Development Intensity Index
- Habitat alteration
 - Habitat assessment data
- Hydrologic modification
 - Hydrologic scoring process
- Chemical Pollution
 - Ammonia, etc.

Summary of the Landscape

Development Intensity* Coefficients

Category	Coefficient
Natural System	1
Pine Plantation	1.6
Pasture	3.4
Row Crops	4.5
Residential (low)	6.8
Residential (high)	7.6
Commercial	8.0
Industrial	8.3
Commercial (high)	9.2
Business District	10.0

*Developed by Mark Brown, University of Florida, based on non-renewable Energy inputs, Odom's "Embodied Energy" concept.

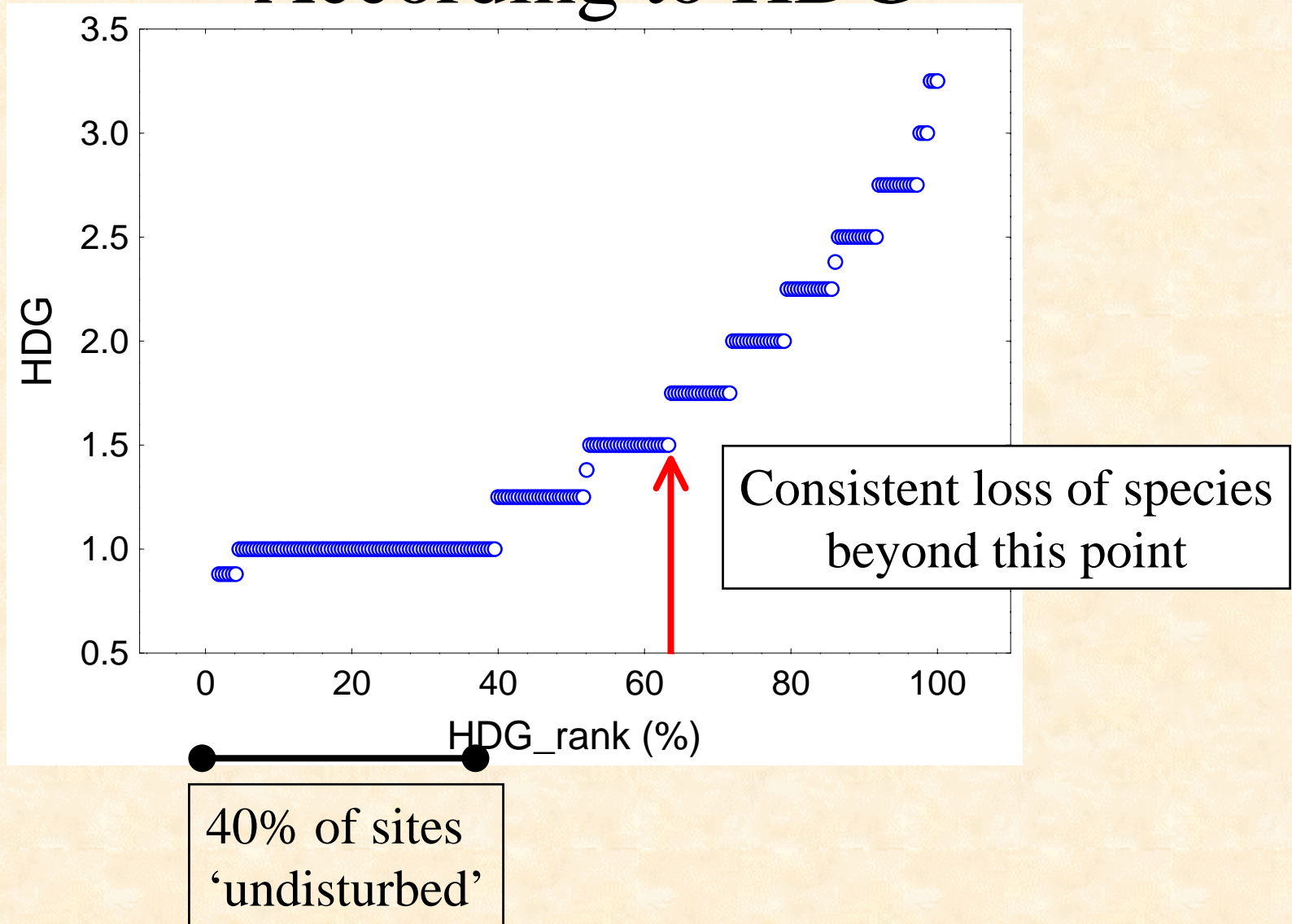
Hydrologic Modification Scoring

- Best, 1-2 points
 - Flow regime as naturally occurs (slow and fairly continual release of water after rains), few impervious surfaces in watershed; high connectivity with ground water and surface features delivering water (e.g., sandhills, wetlands; no ditches, berms, etc.)
- Very poor, 9-10 points
 - Flow regime entirely human controlled; hydrograph very flashy (scouring after rain events with subsequent reductions in flow, leading to stagnant or dry conditions, related to impervious surfaces and ditching throughout watershed); water withdrawals & impoundments fundamentally alter the nature of the ecosystem

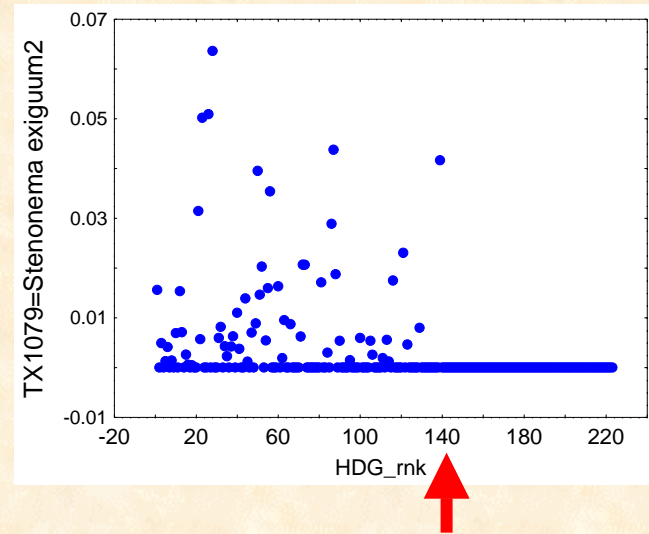
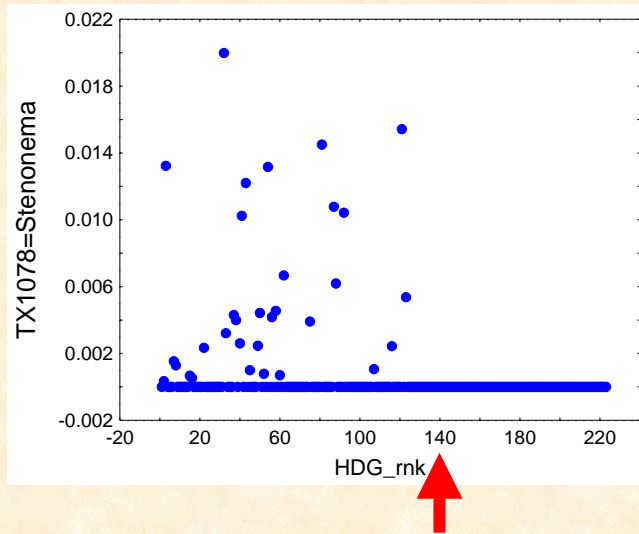
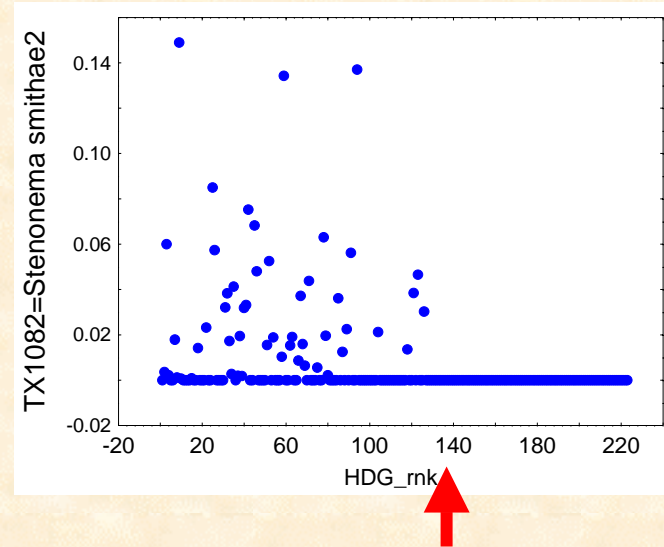
Florida's HDG: Combination of other Disturbance Measures

Scores Measure	1	2	3	4
NH3	<0.1	>0.1	>2	
Habitat	>65	>50 and <65	<50	
Hydro	<6	6-7	8-9	10
LDI (buffer)	<200	200-350	>350	
LDI (ws)	<200	200-350	>350	

Florida Sites Ranked According to HDG

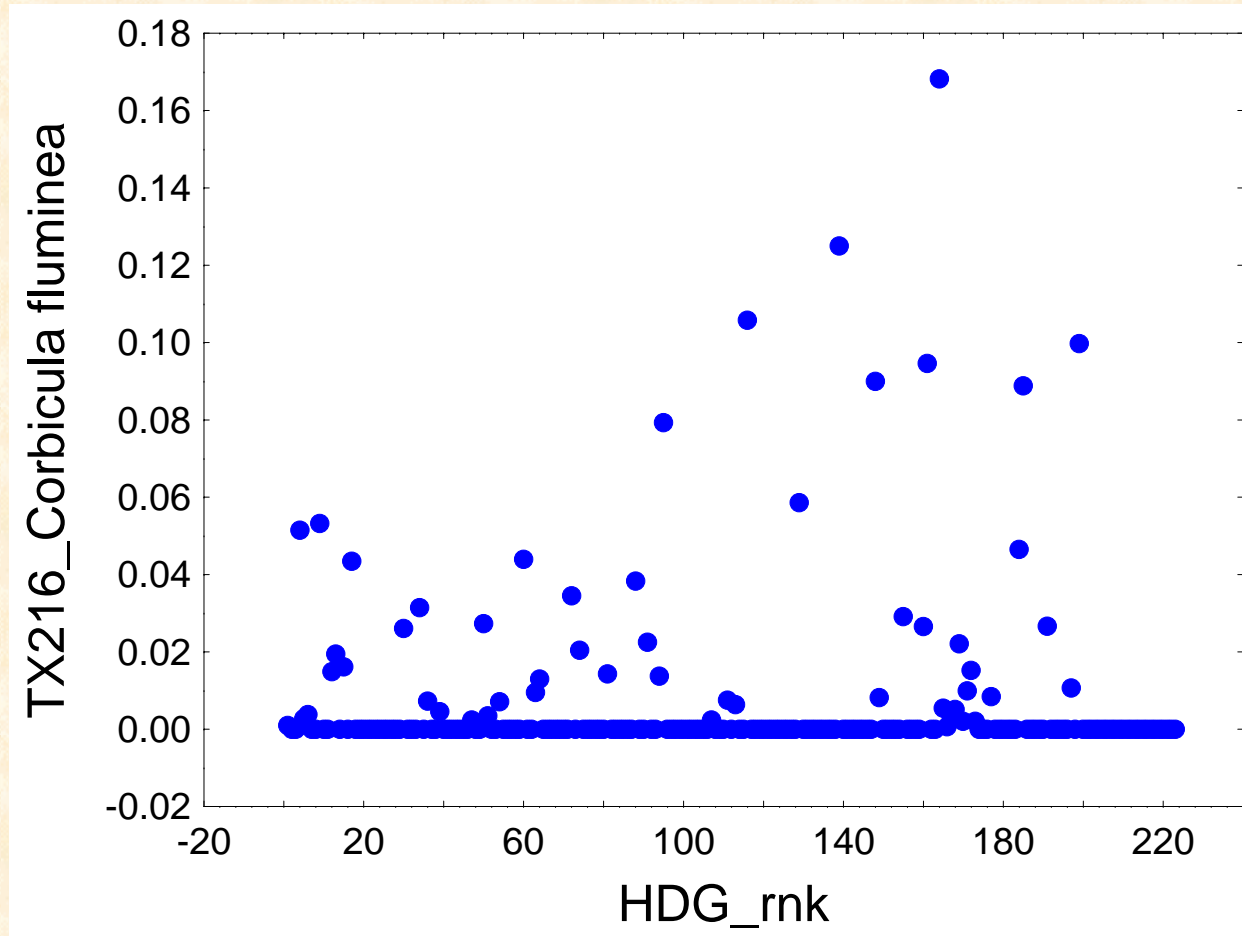


Example of a Sensitive Mayfly Genus (*Stenonema*)



Increasing disturbance →

Example of a Tolerant Clam Species



Increasing disturbance →

Incorporating “Integrity”

Include Robust, Discriminating Metrics
from a Variety of Categories:

- Richness
- Composition
- Tolerance
- Feeding Functions
- Habit
- Voltinism

Richness Measures

Total taxa
EPT taxa
Ephemeroptera taxa
Plecoptera taxa
Trichoptera taxa
Diptera taxa
Chironomidae taxa
Coleoptera taxa
Oligochaeta taxa
Insect taxa
Non-insect taxa
Shannon-Wiener Index

Composition Measures

% EPT
% EPT (no Baetidae or Hydropsychidae)
% Ephemeroptera
% Ephemeroptera (no Baetidae)
% Plecoptera
% Trichoptera
% Trichoptera (no Hydropsychidae)
% Diptera
% Diptera (no Chironomidae)
% Chironomidae
% Coleoptera
% Oligochaeta
% non-insects
% 5 dominant
% 10 dominant

Feeding Measures

% Collectors
% Scrapers
% Shredders
% Filterers
% Predators
Collectors taxa
Scrapers taxa
Shredders taxa
Filterers taxa
Predators taxa

Tolerance and Other Measures

HBI
BCI CTQa
Beck's Biotic Index
Intolerant taxa
% tolerant
% Clingers
Clingers taxa
% Semivoltine
Semivoltine taxa

Examples of Two Types of Successful Metric Exploration

- Idaho
 - Discrimination Efficiency Box and Whisker Plots
- Florida
 - Human Disturbance Gradient Correlations

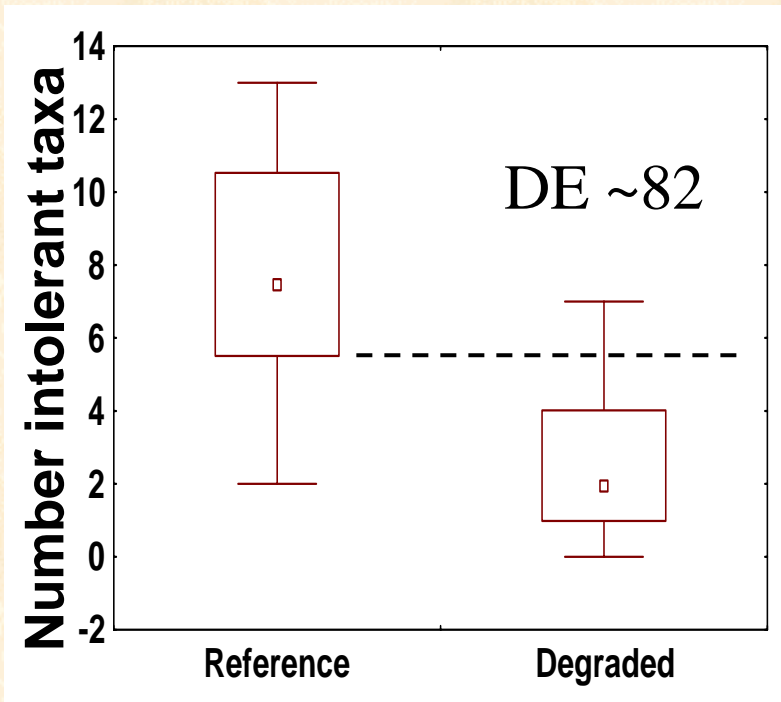
Discrimination Efficiency

- Measures the ability of an index (or metric) to indicate reference or degraded conditions.
- Definition: The percentage of stressed samples that have values below a selected percentile of the reference values.
- The 25th percentile of reference is commonly used as the threshold.

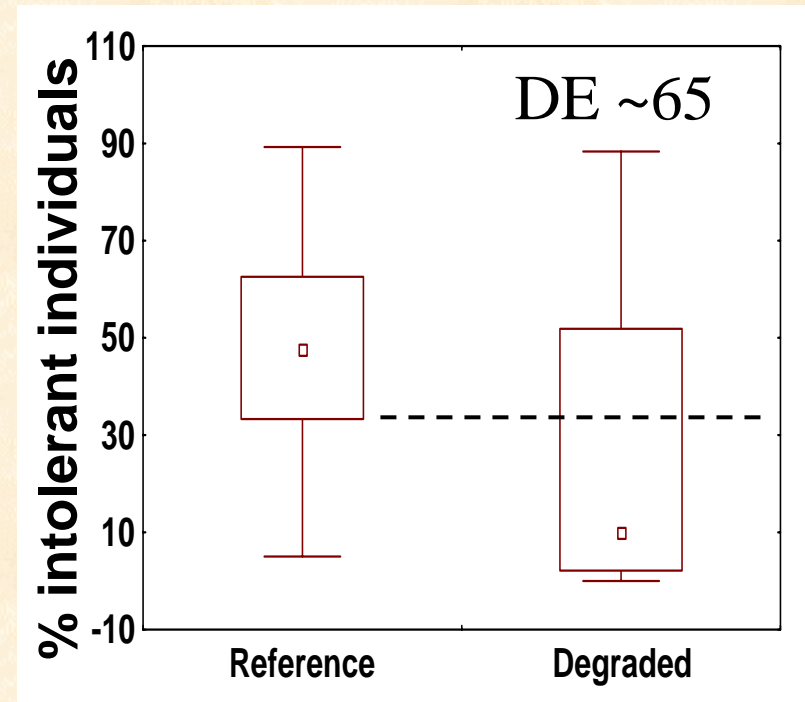
Calculating DE

1. Find the 25th or 75th percentile of reference values.
2. Find the number of stressed samples with values worse than the reference threshold (X).
3. Find the total number of stressed samples (Y).
4. Calculate $DE = 100 * X / Y$

Metric Discrimination

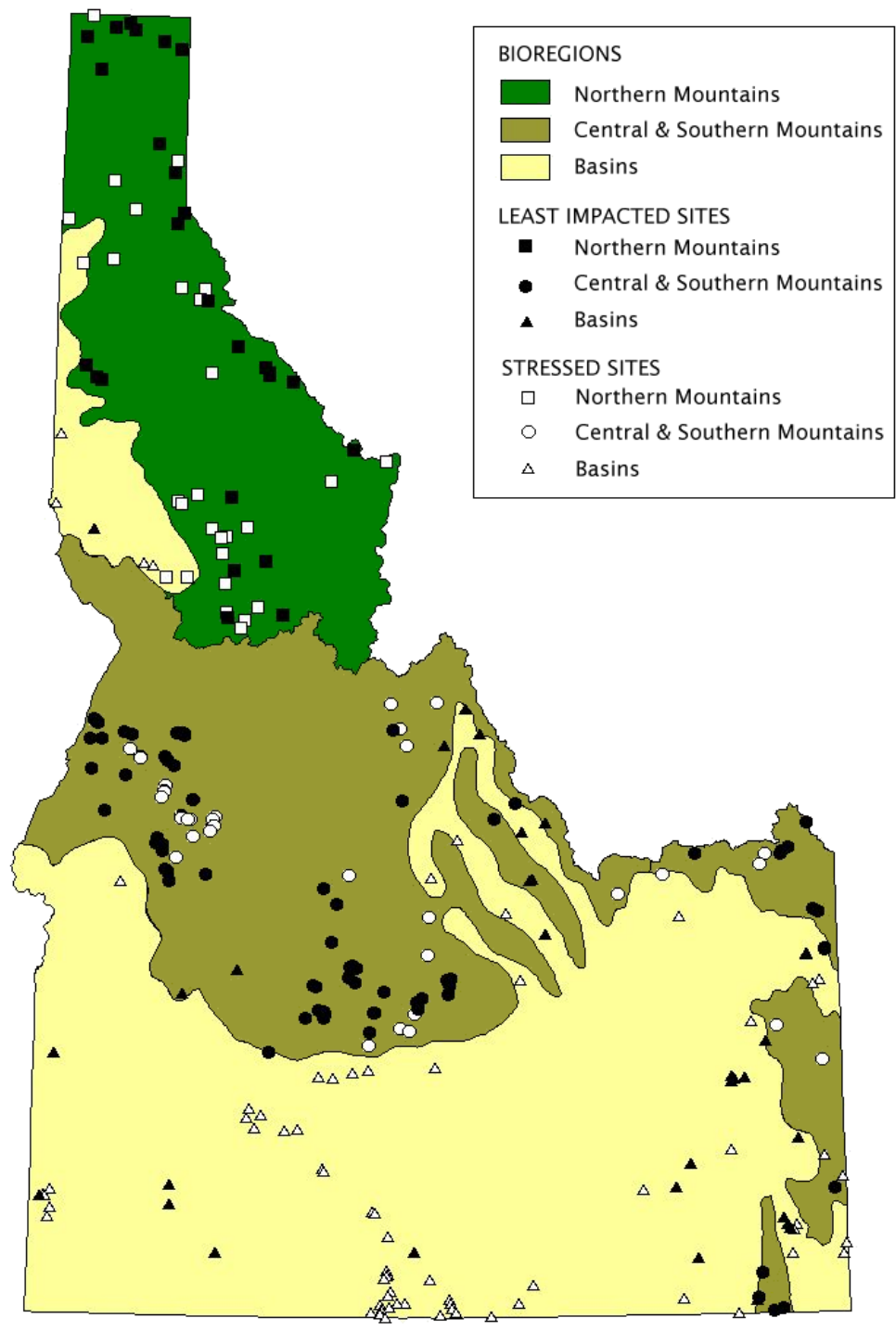


Strong response

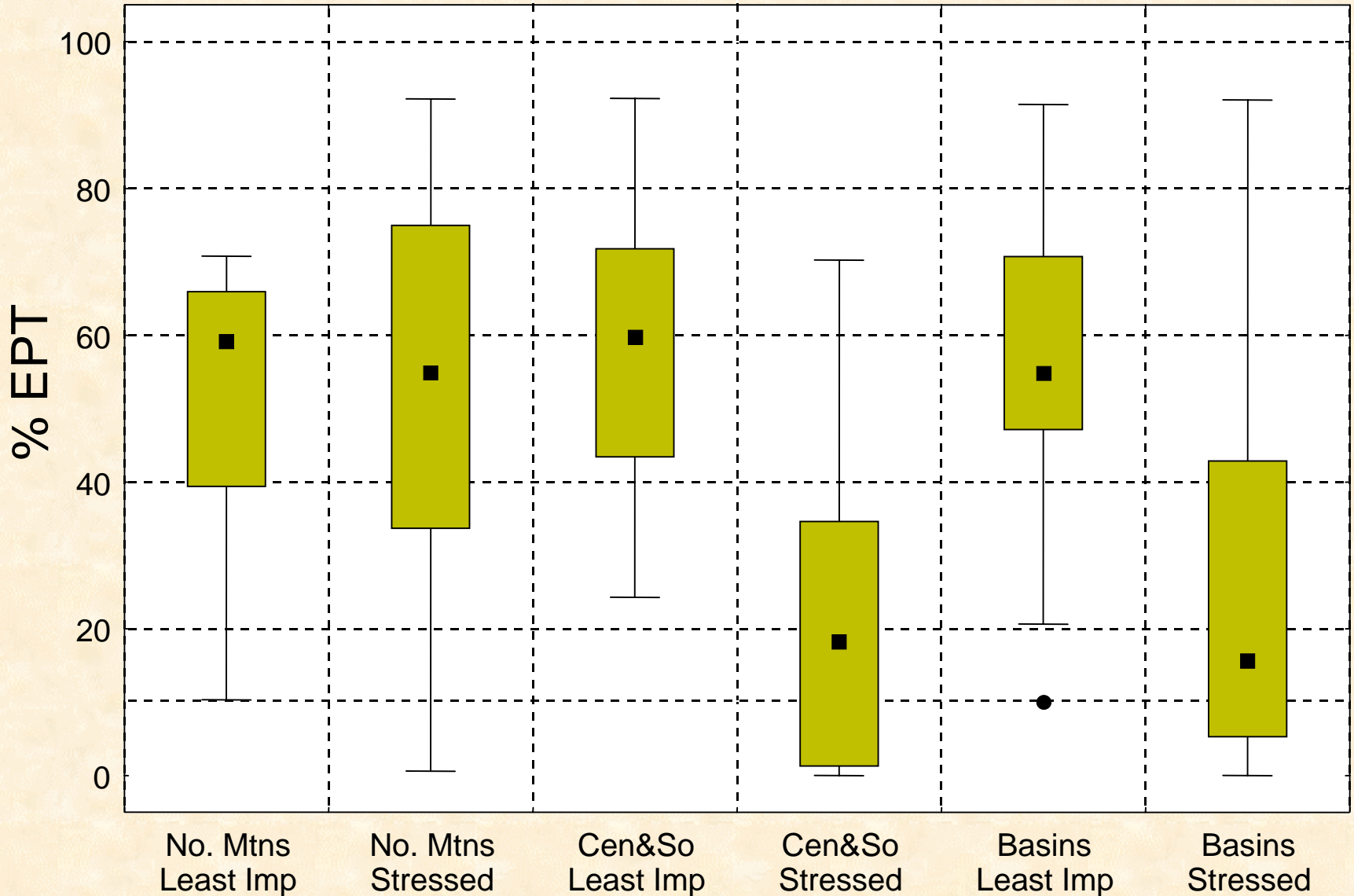


Weak response

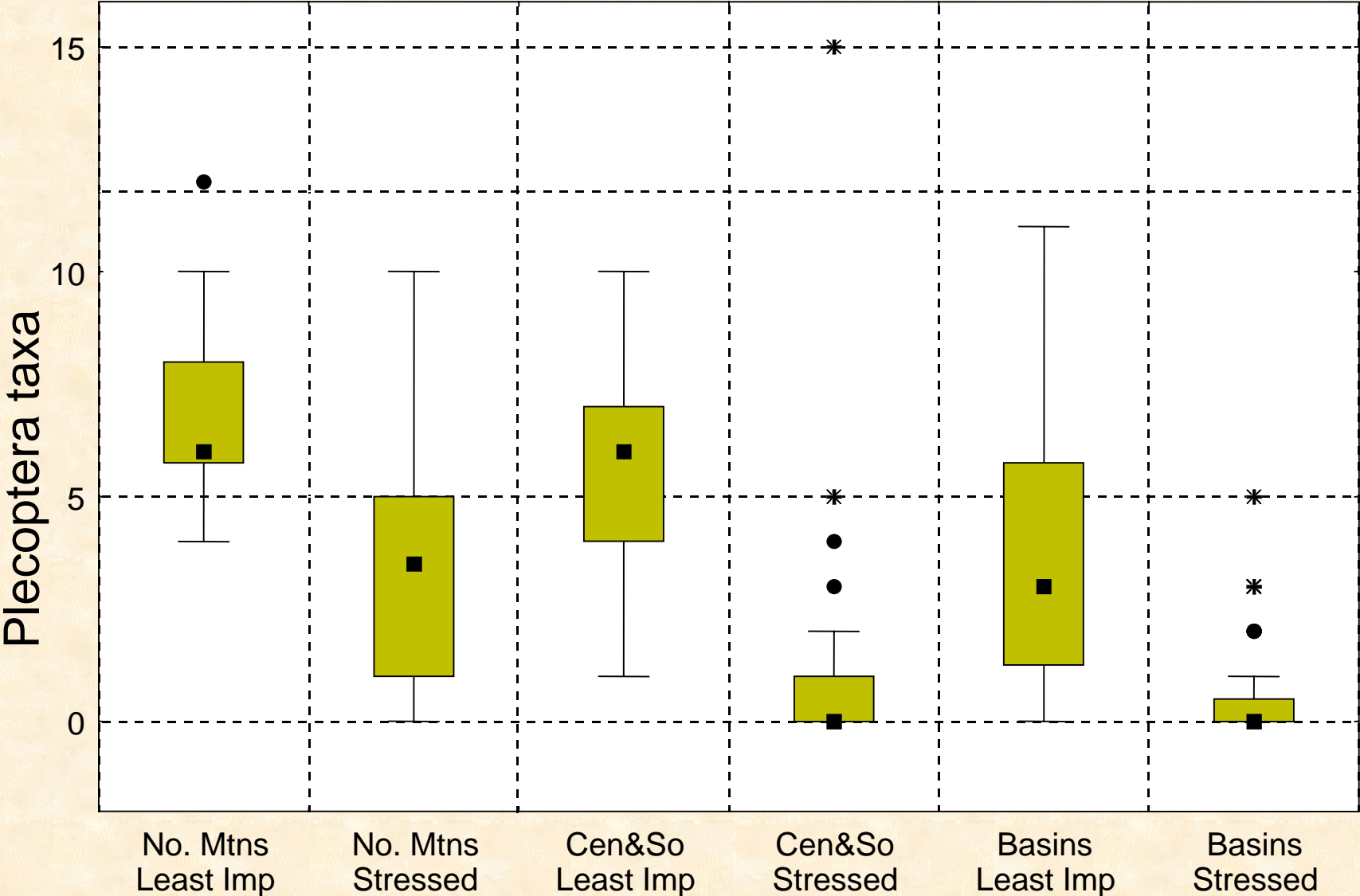
Bioregions of Idaho



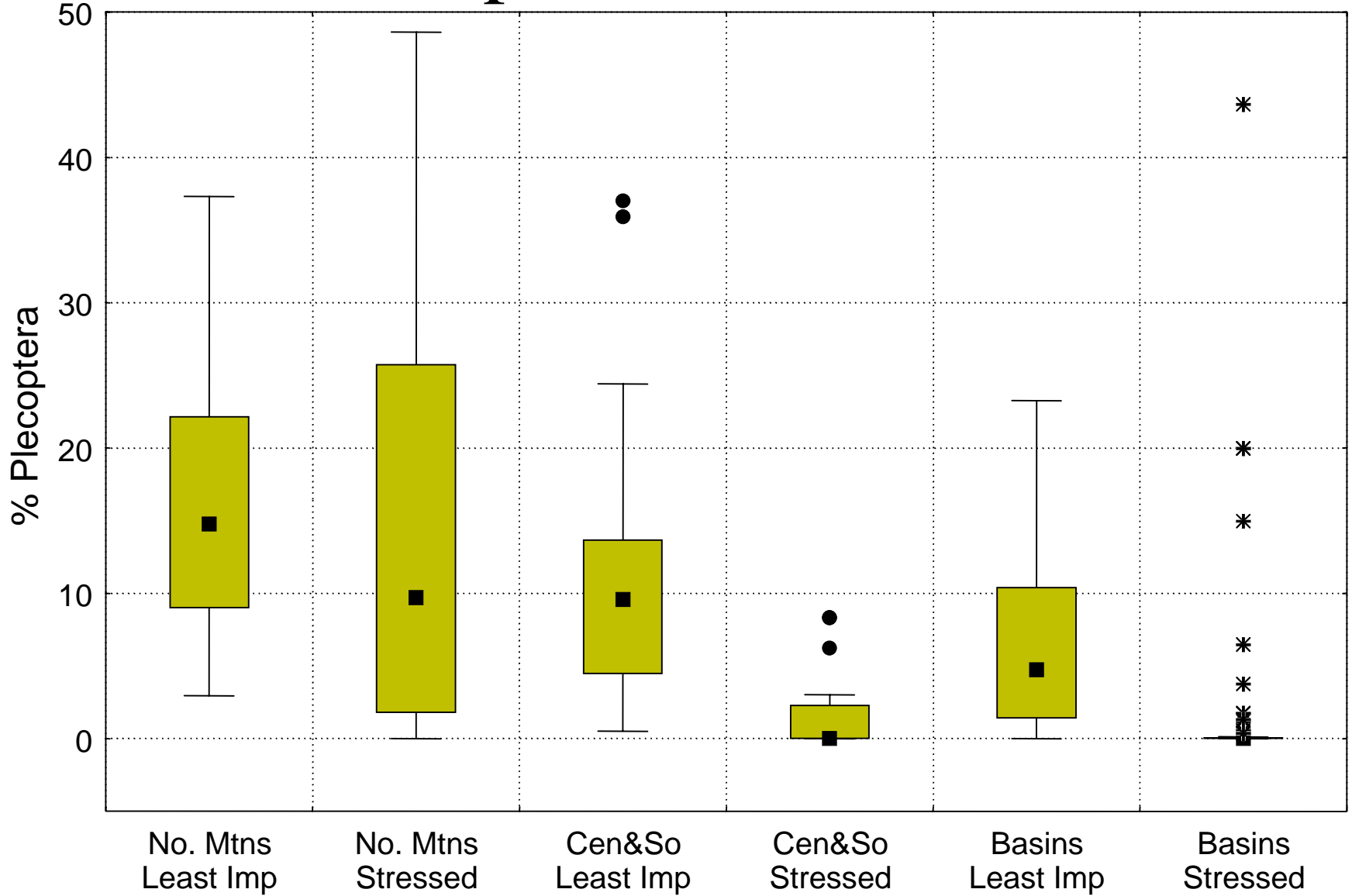
Idaho % EPT, Reference vs. Stressed



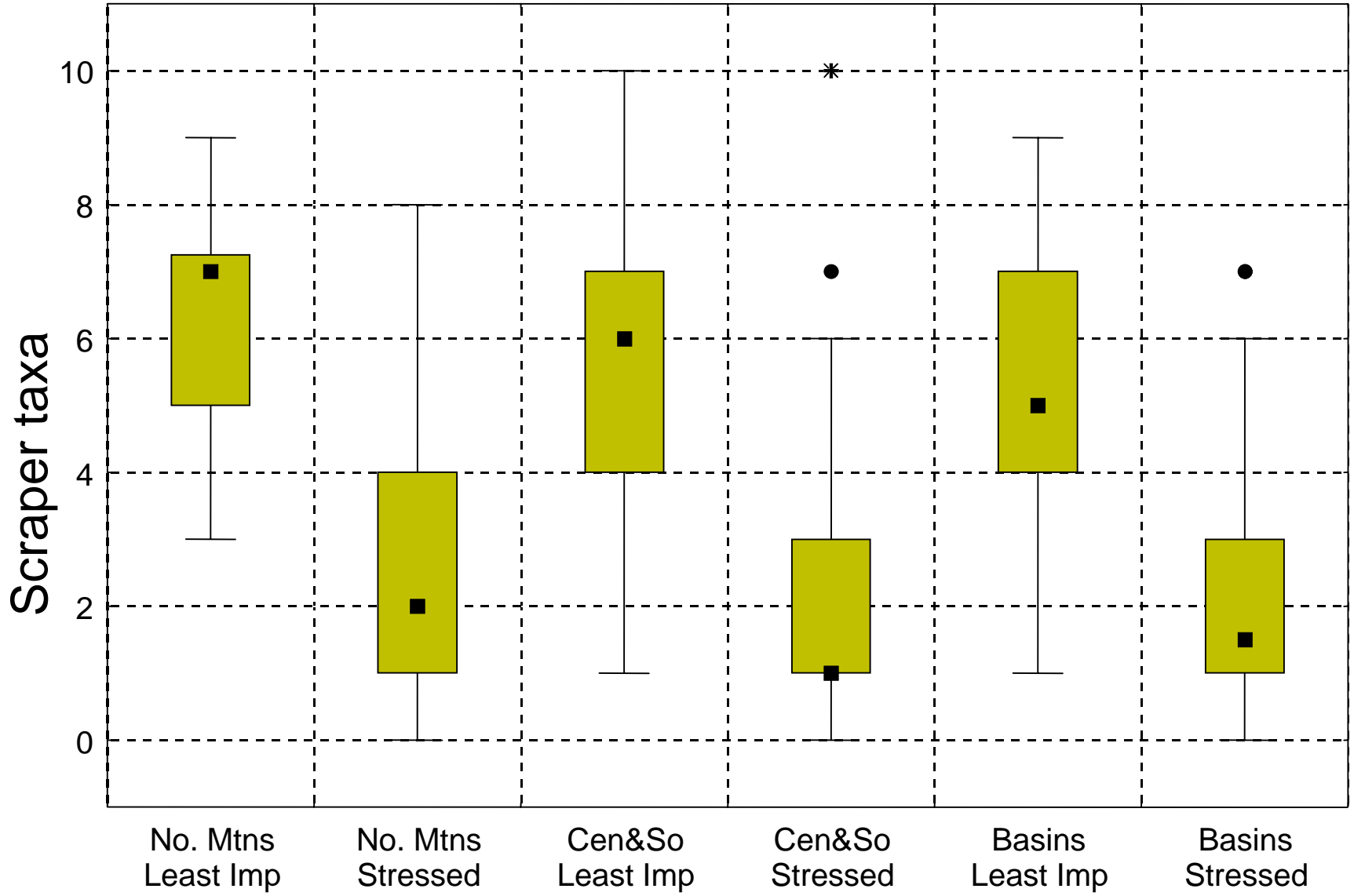
Idaho Plecoptera Taxa, Ref. vs. Stressed



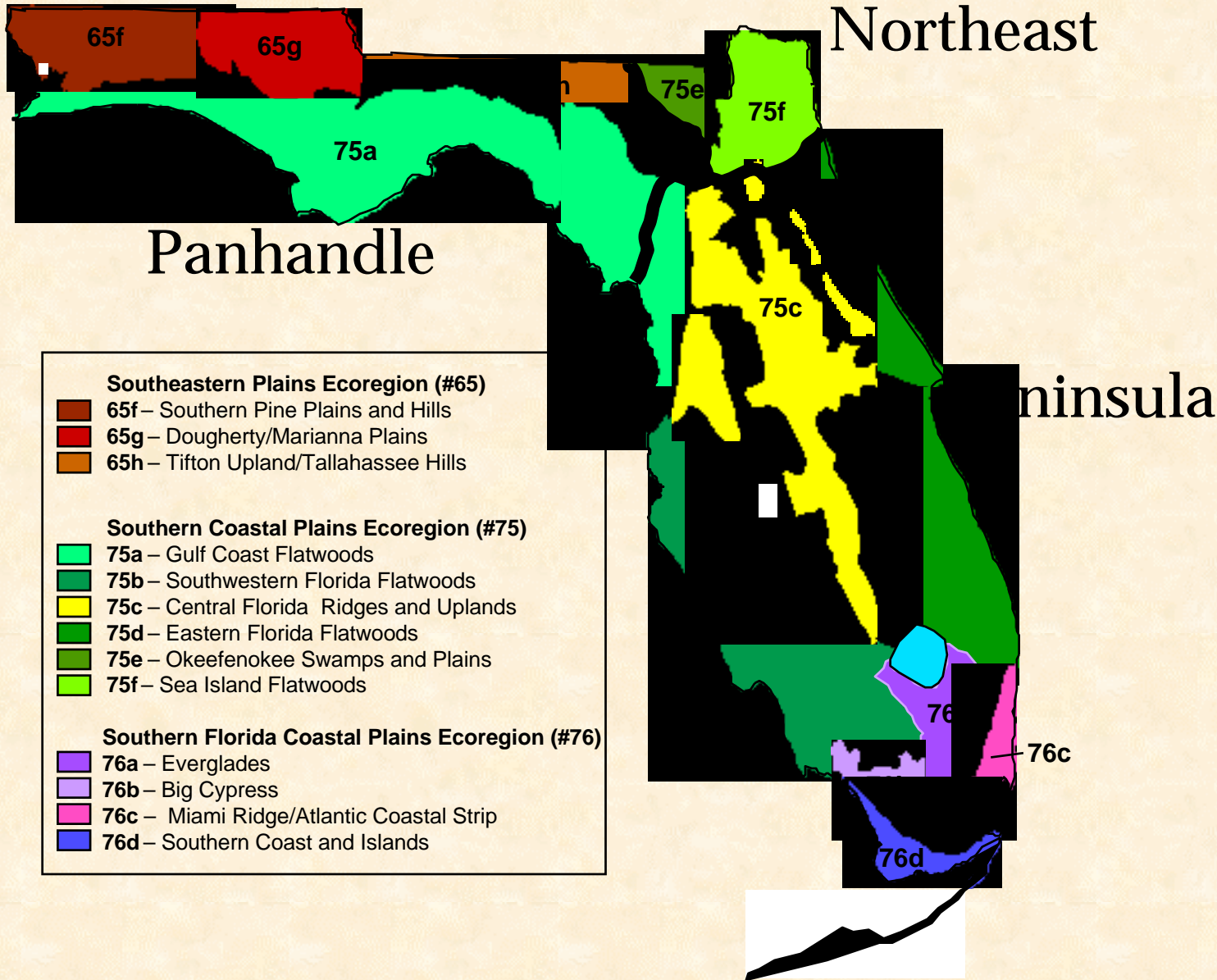
Idaho % Plecoptera, Reference vs. Stressed



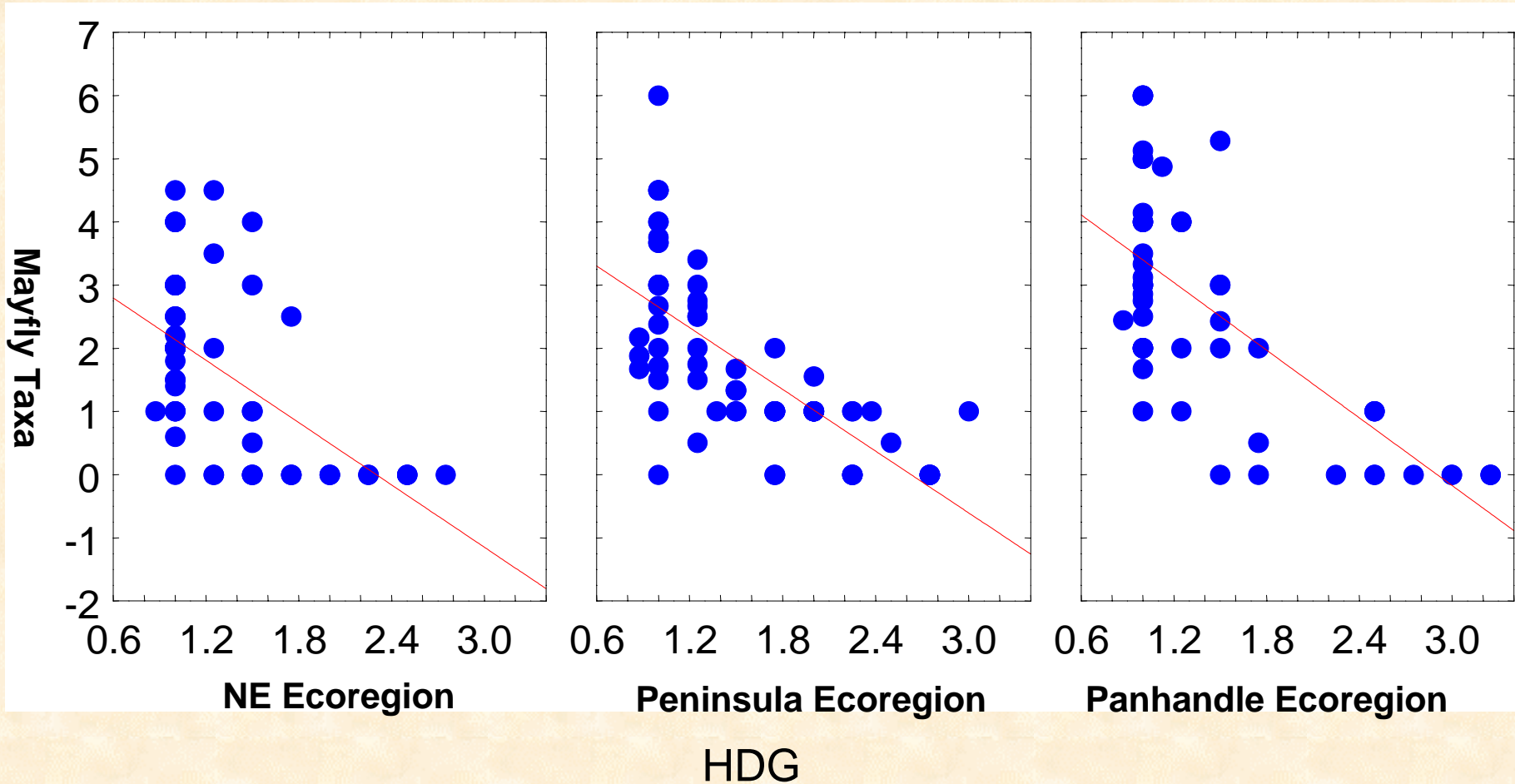
Idaho Scraper Taxa, Reference vs. Stressed



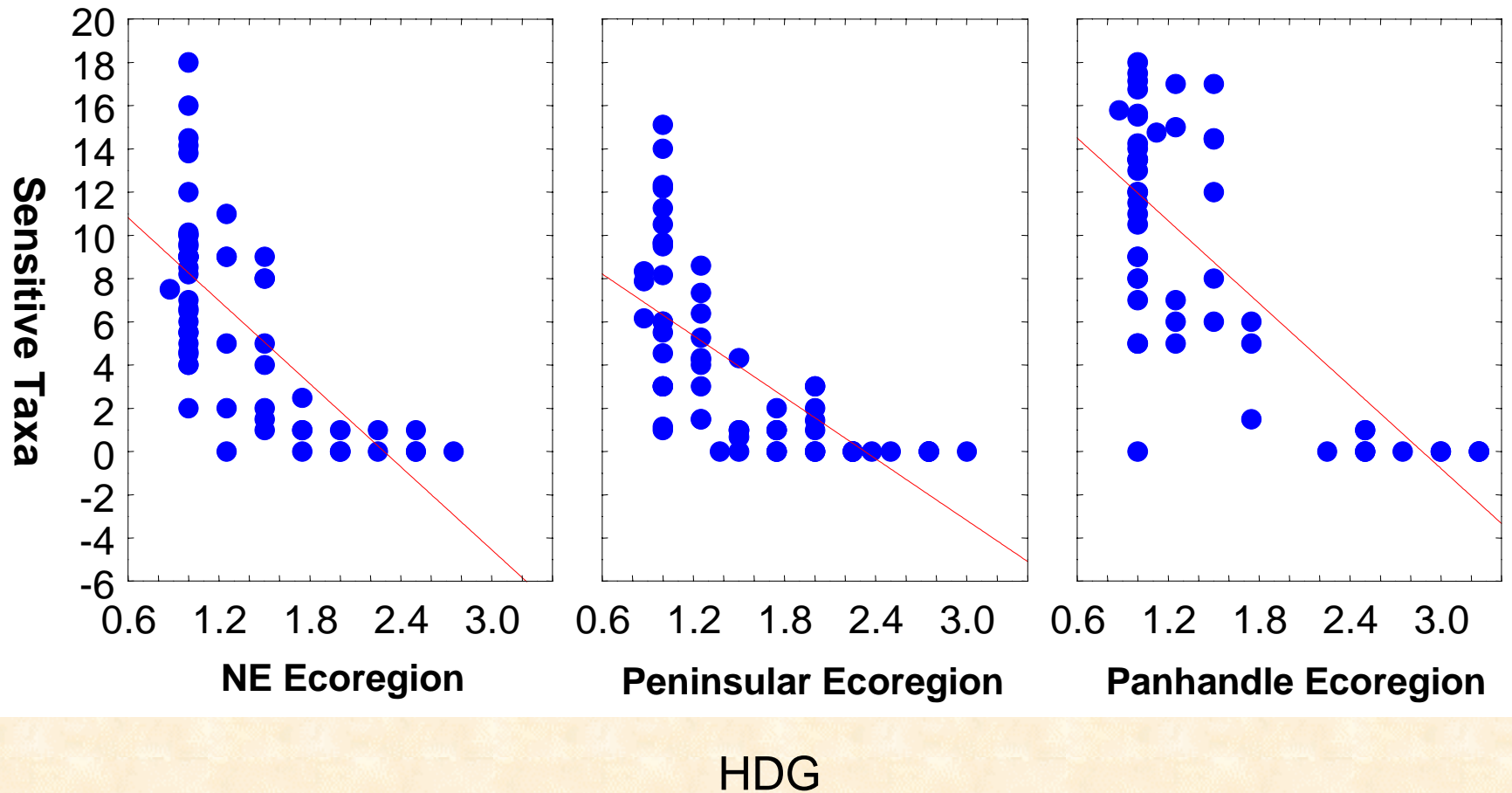
Bio-regions of Florida



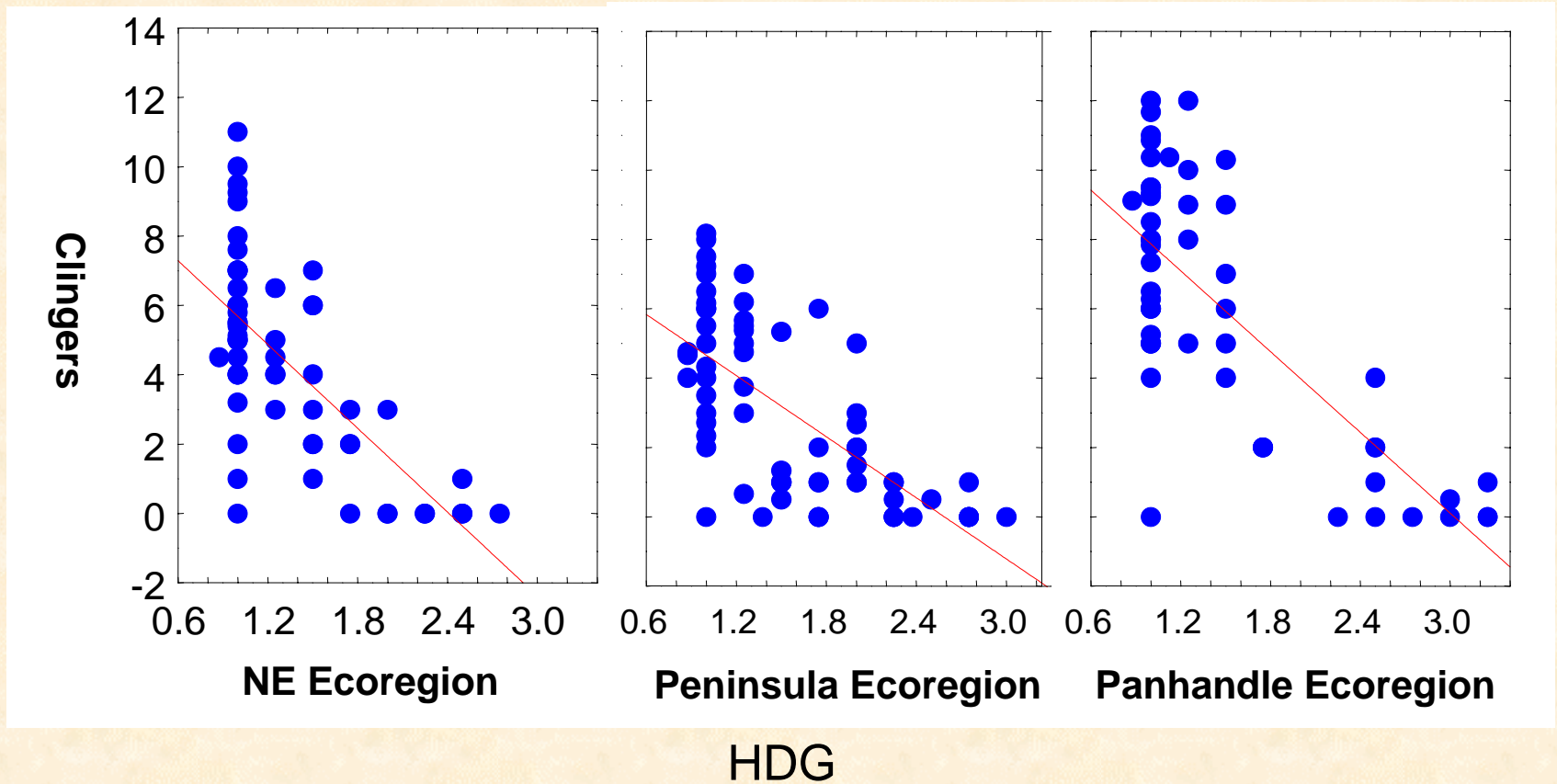
Florida Mayfly Taxa vs. HDG



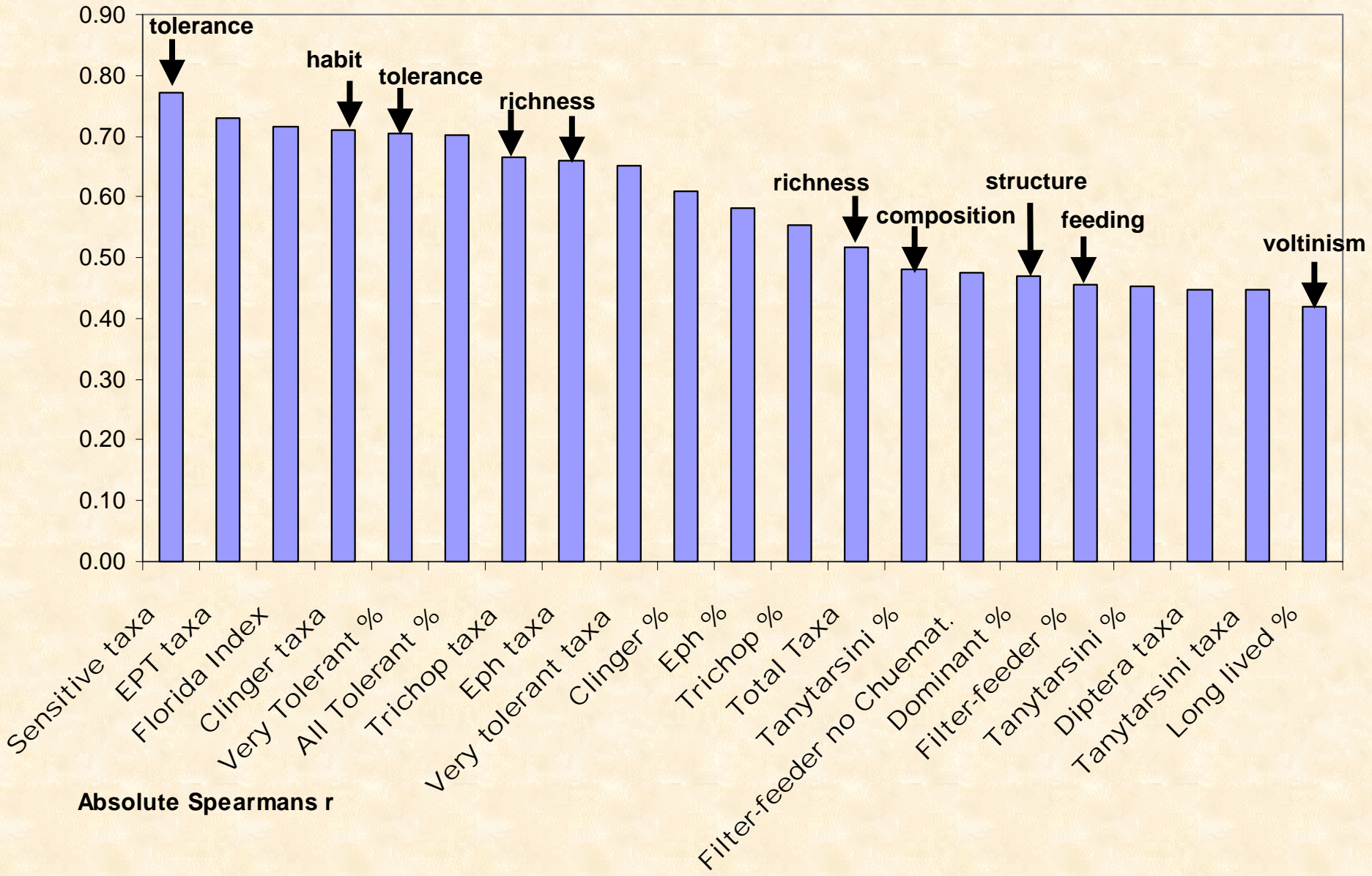
Florida Sensitive Taxa vs. HDG



Florida Clinger Taxa vs. HDG



Correlation Values for Metrics and HDG, Florida Selections



Some Discussion on Metrics

- Beware of “ratio” metrics
 - What do they really measure?
- Universal vs. regional metrics
 - Filter-feeders in Florida
- Redundancy
 - Choose only one or two correlated metrics from same category
- Responsiveness
- Range of Values

Final Words on Metric Exploration

- Human disturbance criteria top priority
- Examine range of attributes expected to relate to ecological health
- Select effective discriminators from major categories