Bioassessment, the Human Disturbance Gradient, and Applicability to Environmental Decisions

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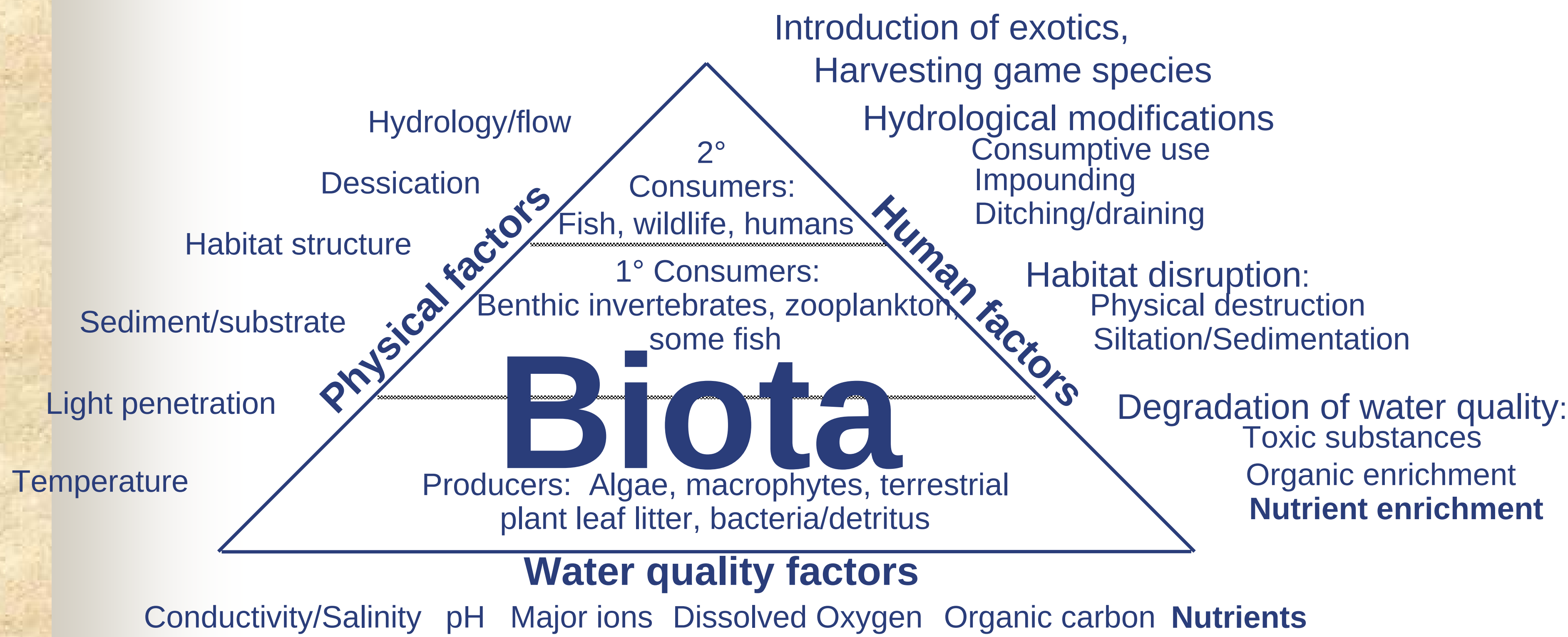
Factors Affecting Aquatic Biological Communities



Defining Ecological Expectations

- Absent human interference, ecological communities have evolved in response to:
  - physical,
  - chemical, and
  - bio-geographic processes
- Expectations are set by studying reference condition (and its variability) in each community type.

Adverse Human Factors

- Hydrologic modifications
  - (consumptive use, impounding, ditching/draining)
- Habitat disturbance
  - (physical removal, sedimentation)
- Degradation of water quality
  - (toxic substances, **nutrient** and organic enrichment)
- Introduction of invasive exotic taxa
- Harvesting biomass

Biological Integrity

- The ability of an aquatic ecosystem to support and maintain a **balanced**, adaptive community of organisms having:
  - species composition,
  - diversity,
  - and functional organization

  comparable to that of natural habitats within a region.

Procedure to Develop Biologically-Based Criteria

1) **Classify** aquatic systems into meaningful units
2) Sample biota across human **disturbance gradient** (define expectations)
3) Select relevant **biological attributes** that provide a reliable signal about human effects (nutrient imbalances)
4) Extract and interpret **patterns** in the data
5) Develop **reasonable policy** to protect designated aquatic life use

Florida’s Stream Condition Index: 1990’s Multimetric Approach

- Established reference condition in various sub-ecoregions
  - Best professional judgment
    - Surrounding land use, in-stream habitat
- Sampled known impaired sites
  - Point source discharge studies
    - Toxicity, low DO, poor habitat

Florida's Stream Condition Index: 1990's Multimetric Approach (cont.)

- Selected 7 metrics
  - Box and whisker plots determined discrimination power
- Aggregated by summing metrics
  - 5, 3, 1 point, depending on departure from reference condition

Florida's SCI Re-calibration

- Develop human disturbance gradient
  - Test disturbance gradient for each Bioregion
  - Evaluate metric response to disturbance gradient (new thresholds, new metrics)
- Determination of metric variability
- Power analysis for trend detection
- Develop consistency with EPA Tiered Aquatic Life Use Support guidance (TALUS)

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

Human Disturbance Factor Analysis

- 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.

Landscape Development Intensity Index

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	

Evaluating Metrics

Redundancy

23 Total Taxa

Discrimination Efficiency

Scoring

13% Ephemeroptera

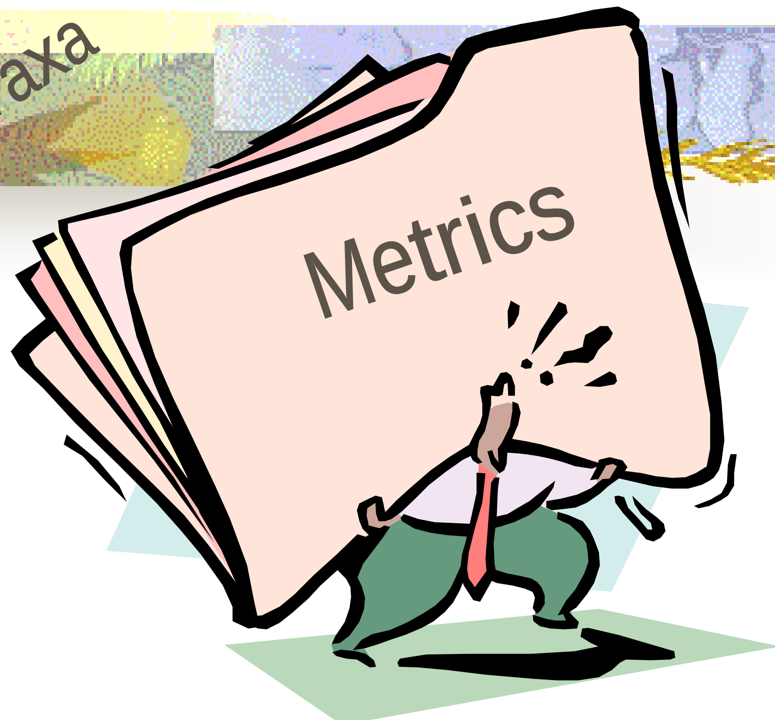
12 EPT Taxa

72% Chironomids

Reference

10% Collector-Filterers

Precision



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

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 VOLTINISM	TROPHIC DYNAMICS PRODUCTIVITY MATERIAL: CYCLES PREDATION RECRUITMENT

INTEGRATED BIOASSESSMENT

TOXICITY TESTS

RIVPACS

← INVERTEBRATE IBI → - - - - →

← FISH IBI → - - - - →

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

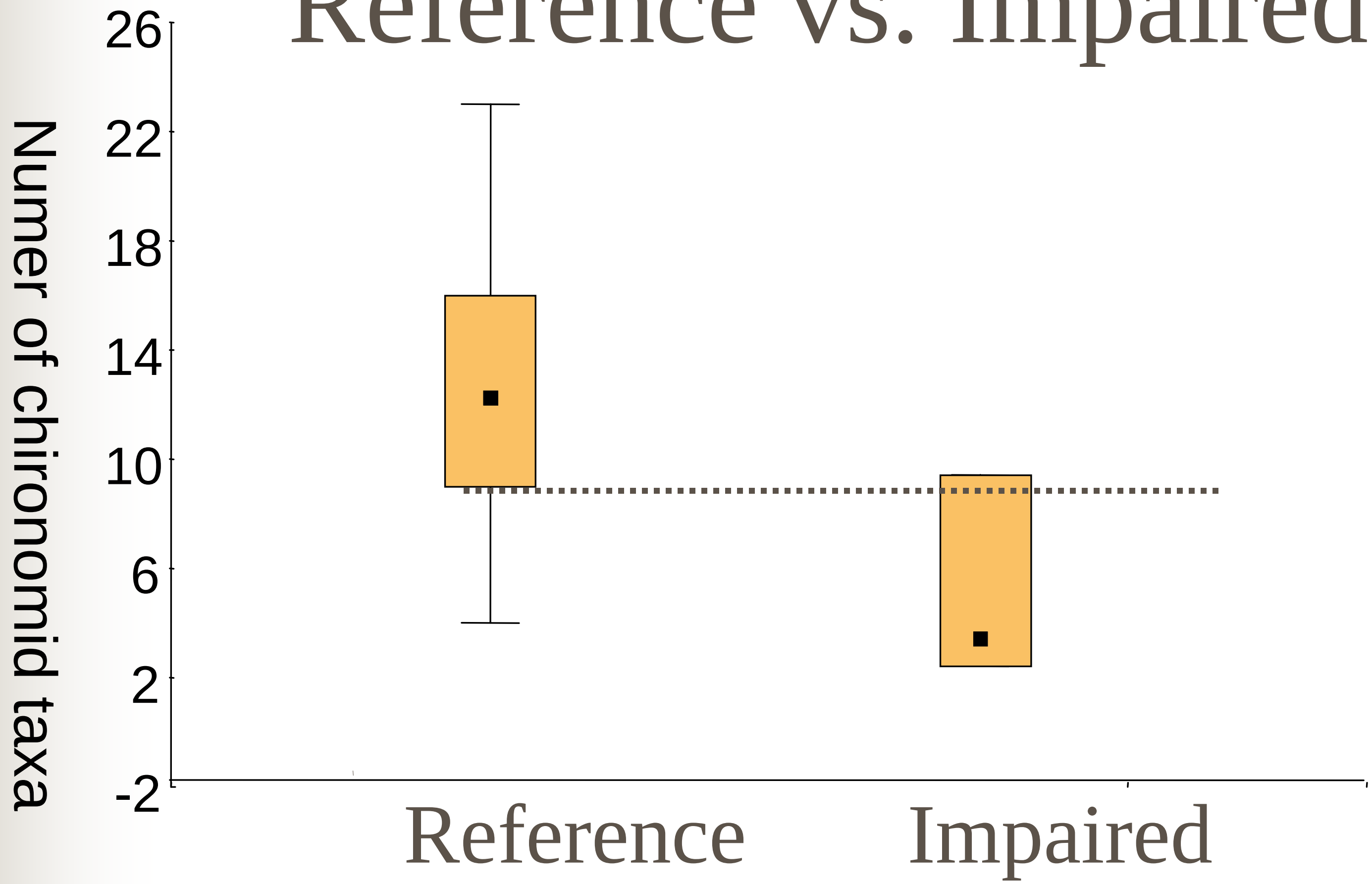
Tolerance and Other Measures

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

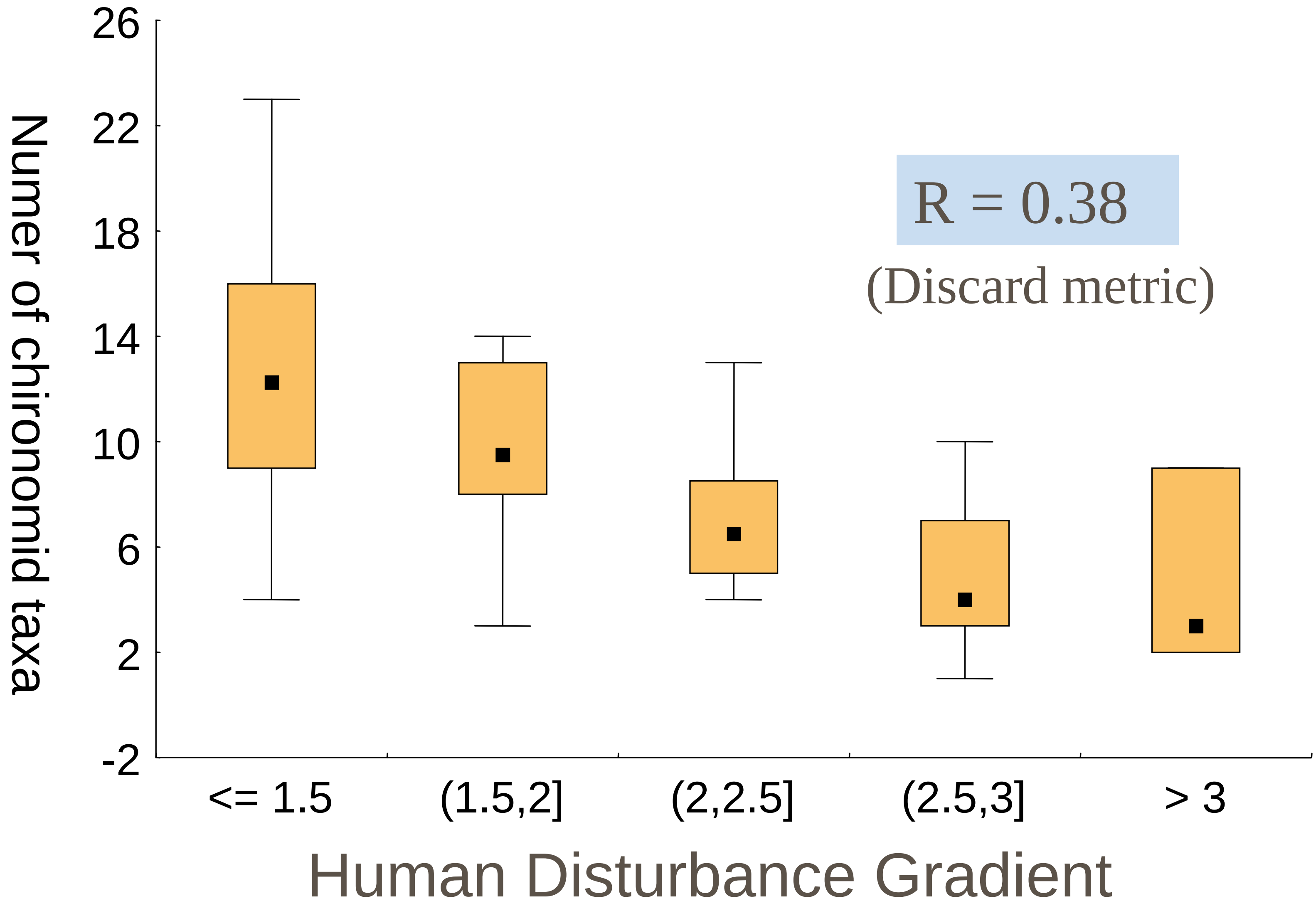
Two Approaches to Assessing Metrics

- Compare extremes
  - reference vs. impaired
- Compare across contiuum of disturbance
  - Human Disturbance Gradient

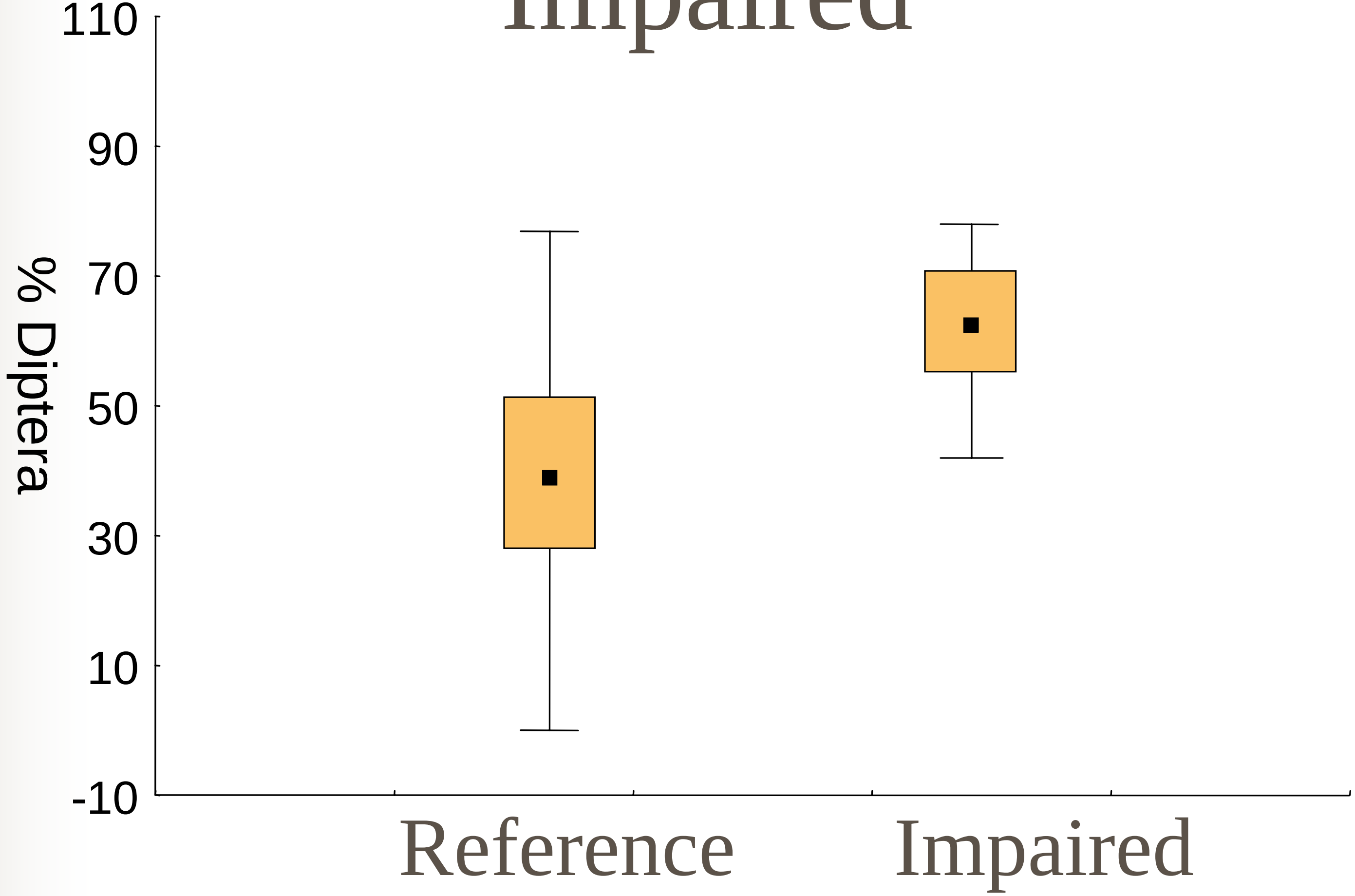
Chironomid Taxa : Reference vs. Impaired



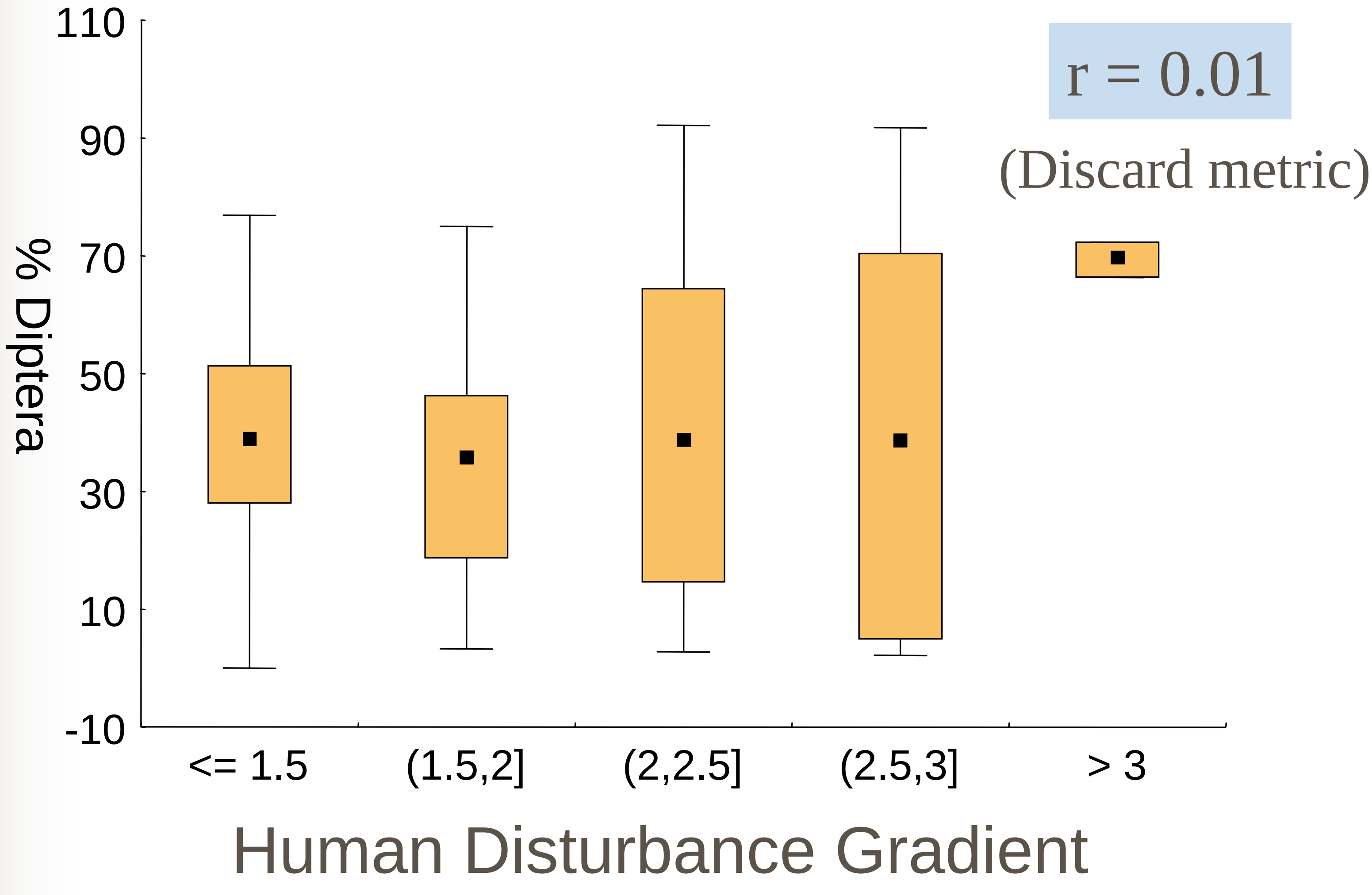
Chironomid taxa vs. HDG



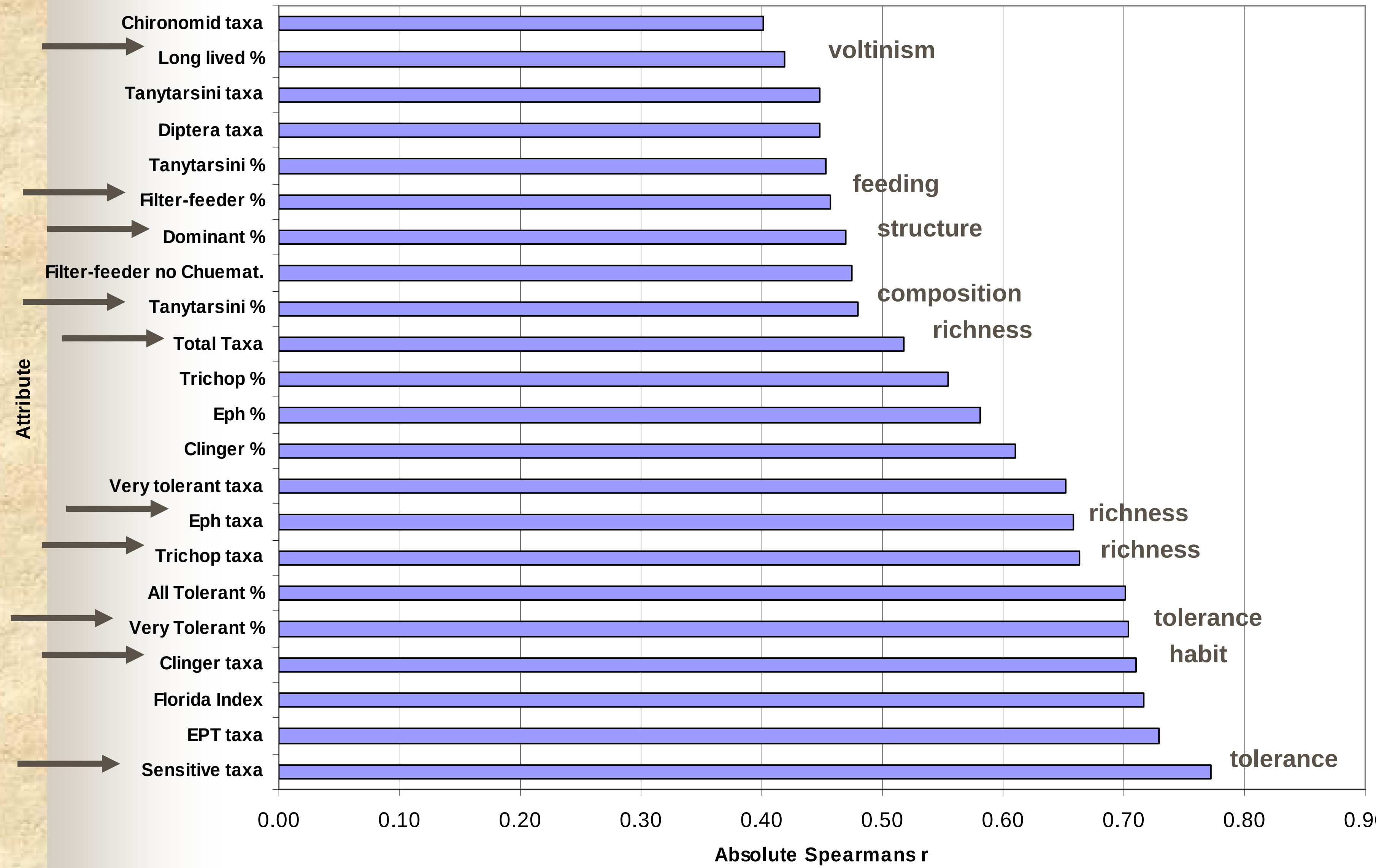
% Diptera : Reference vs. Impaired



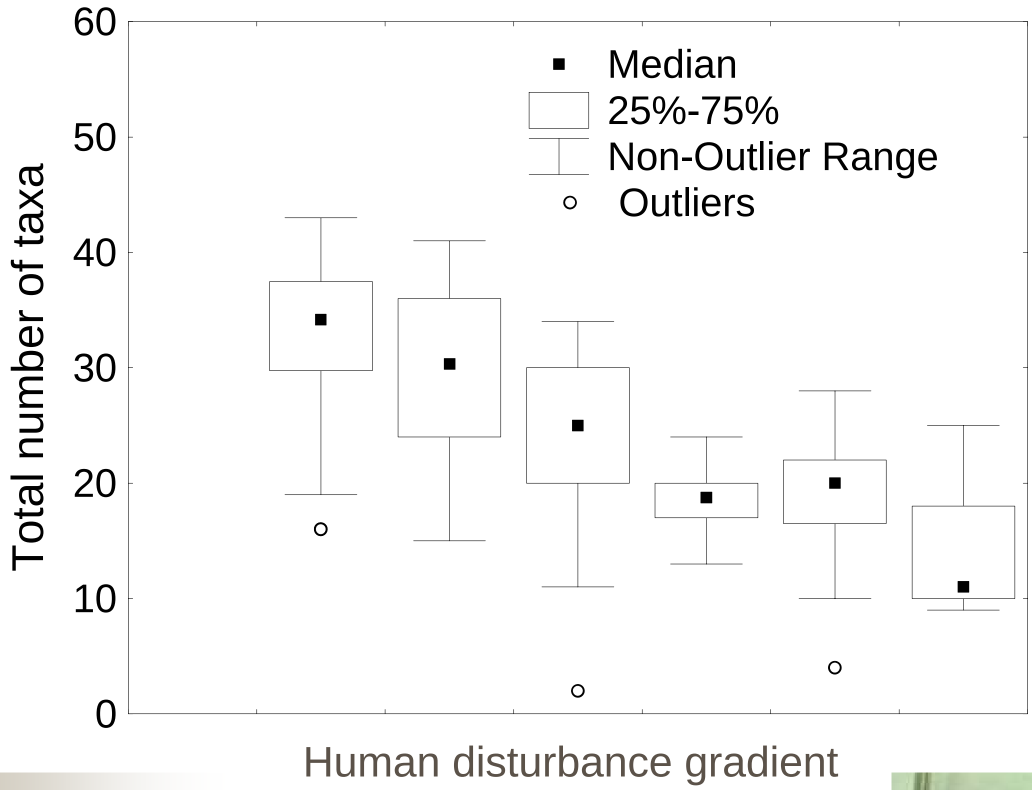
% Diptera vs. HDG



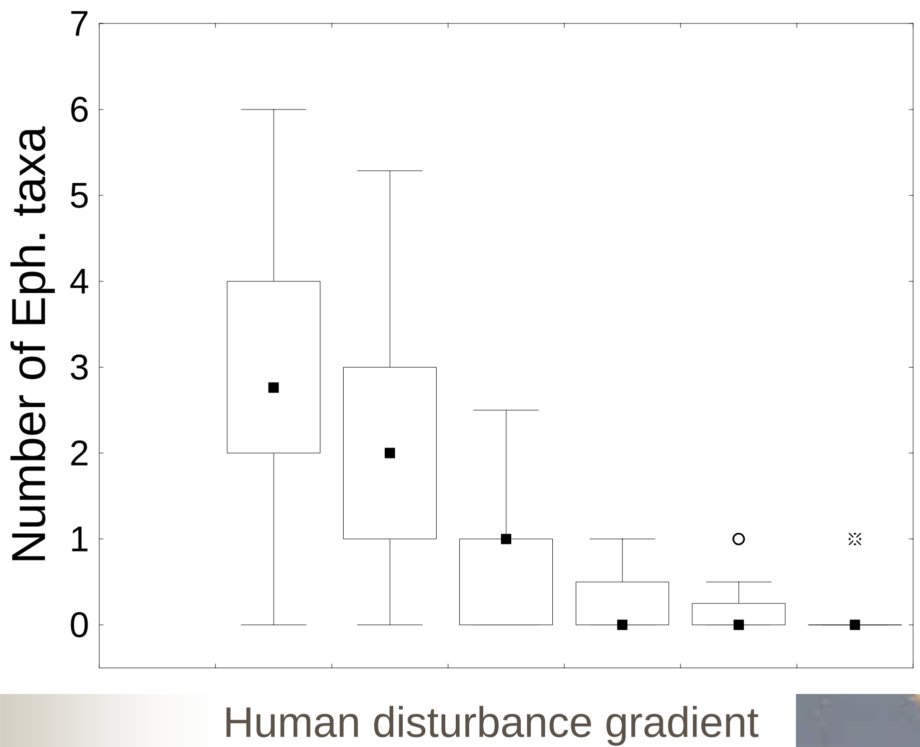
Correlation for Metrics and HDG

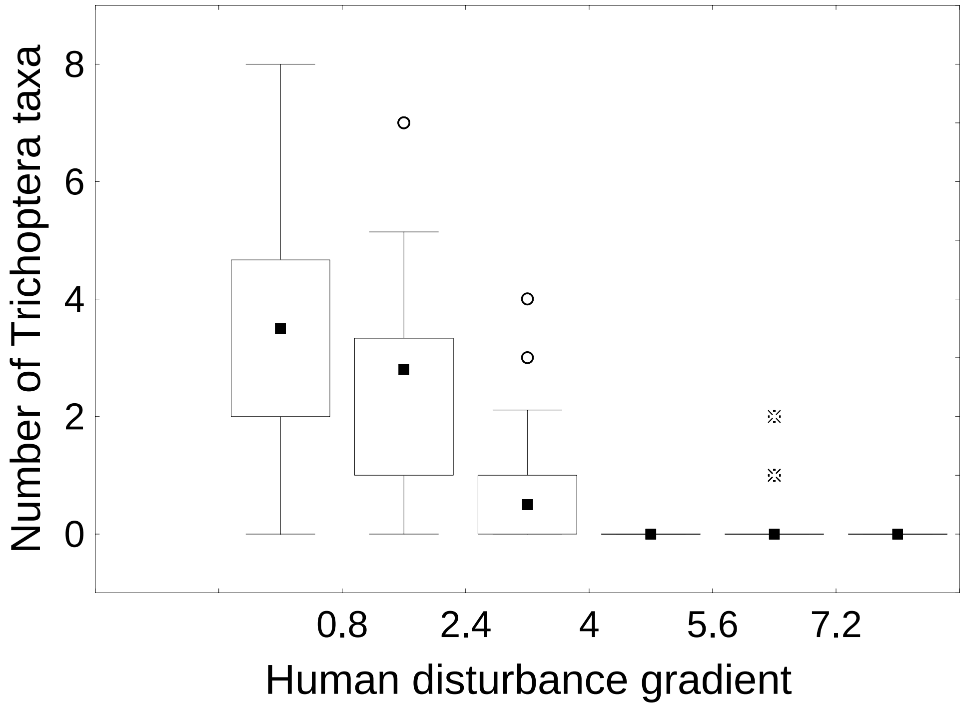


Taxa Richness

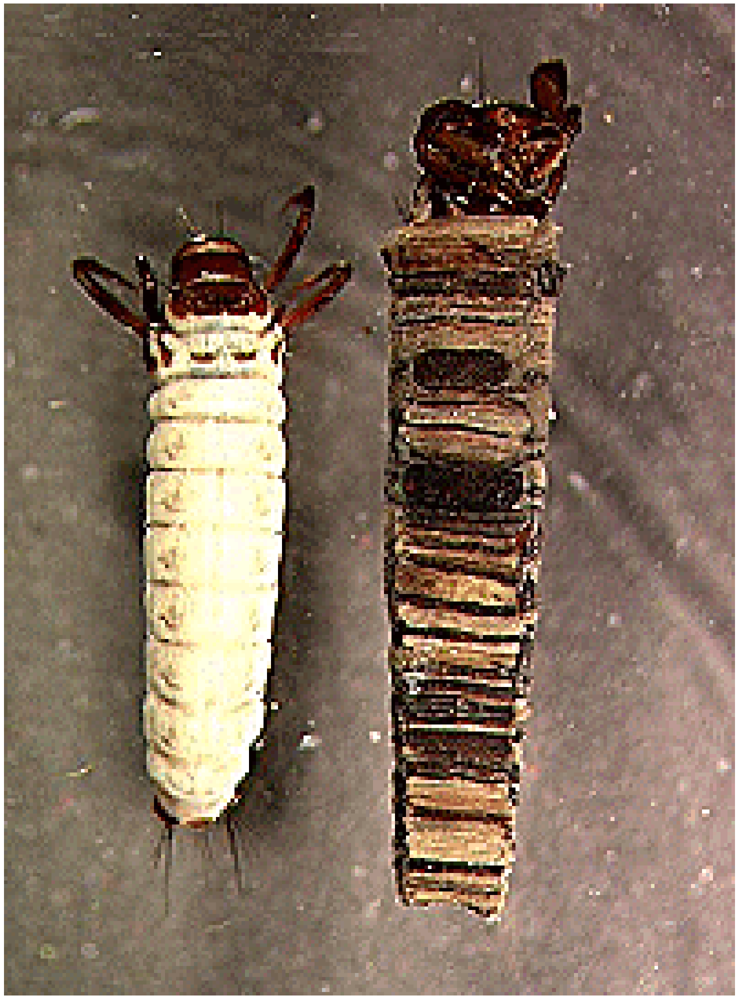


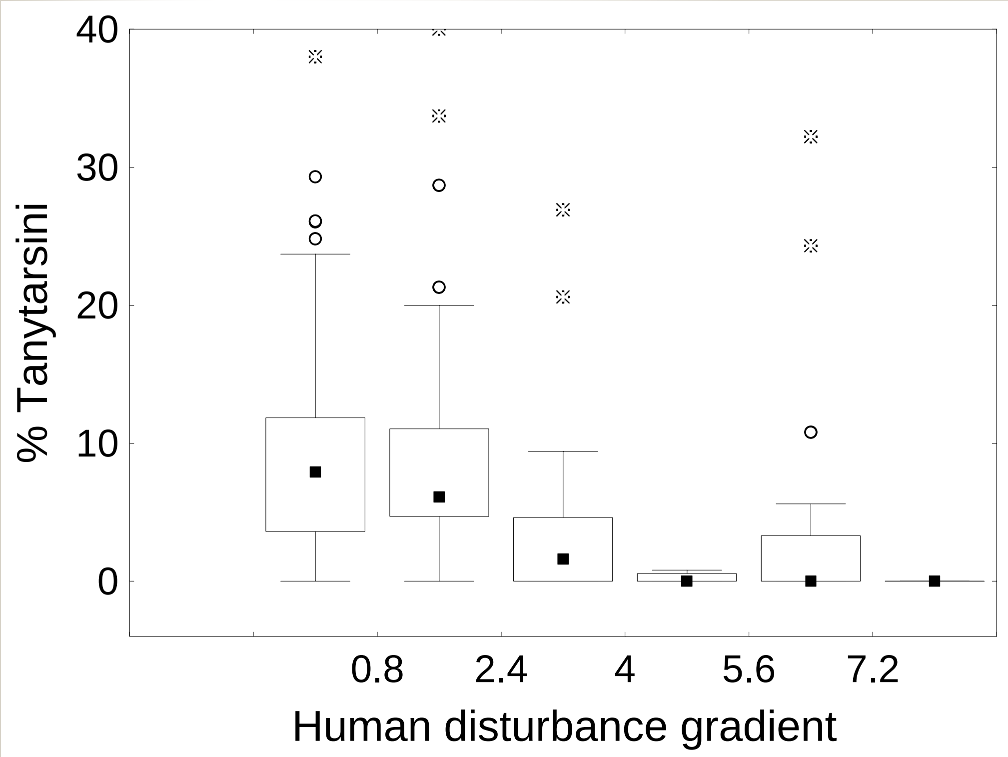
Ephemeroptera Taxa





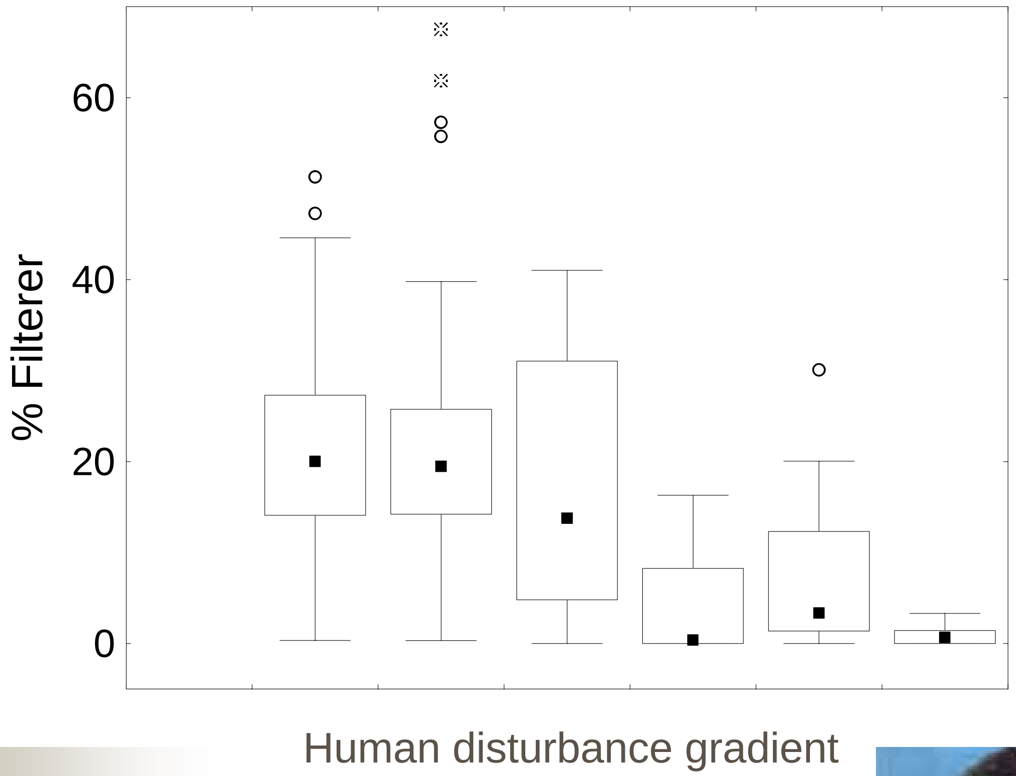
Trichoptera Taxa



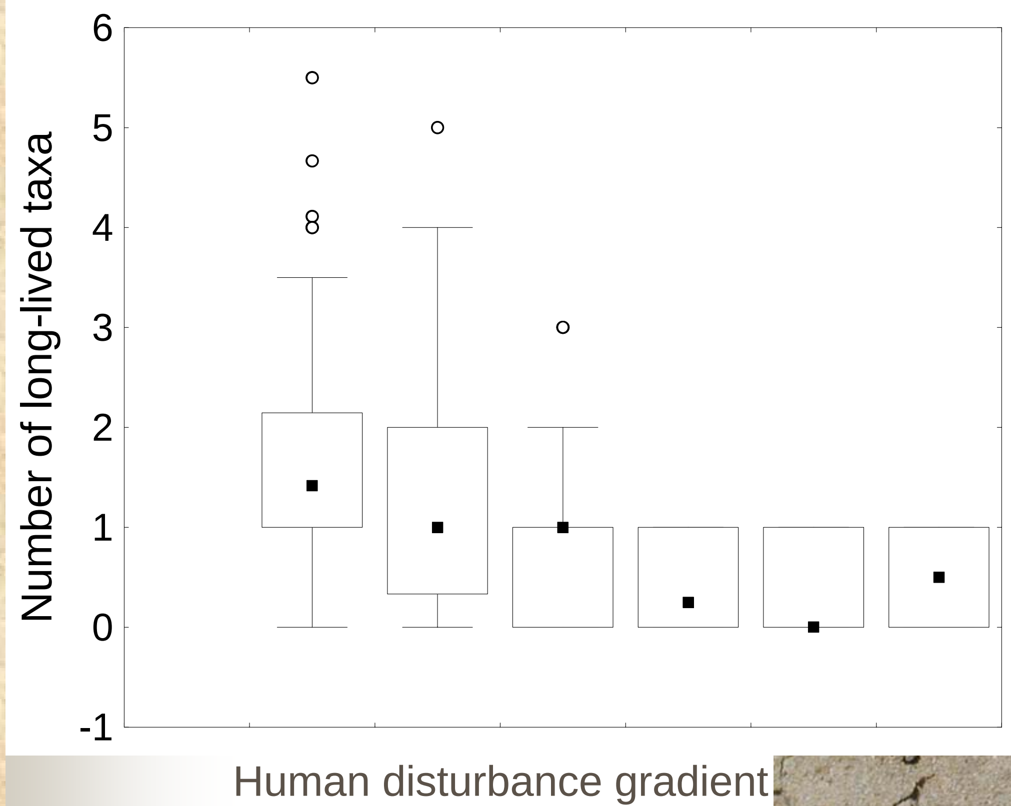


% Tanytarsini
(Sensitive midges)

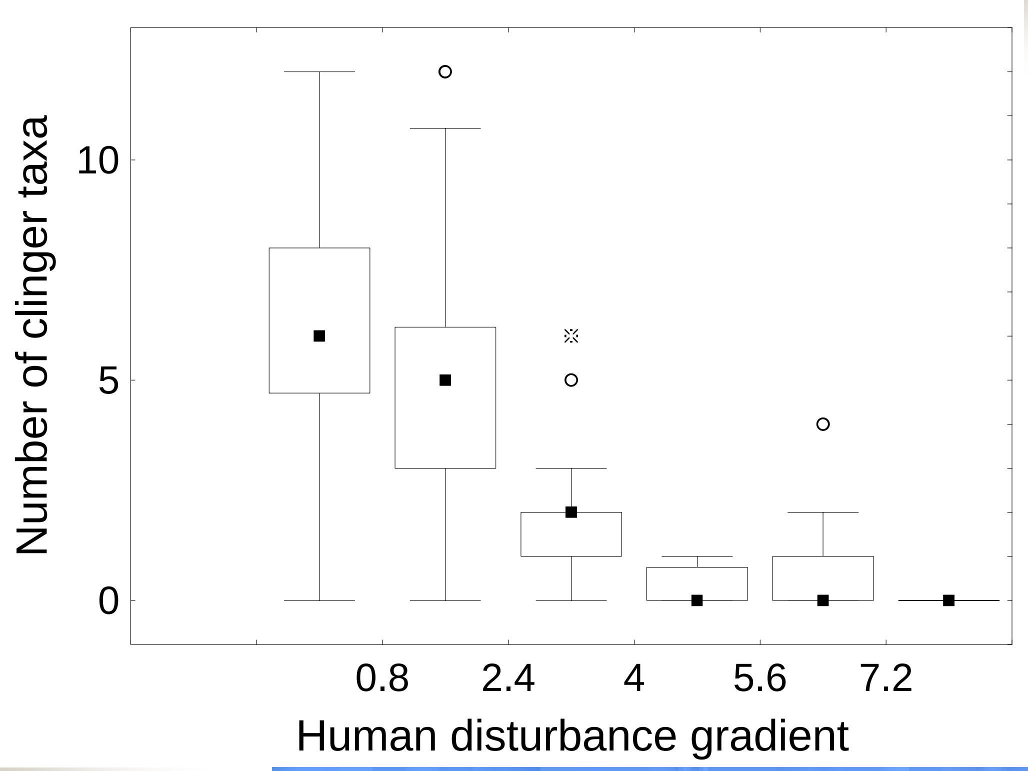
% Filterers

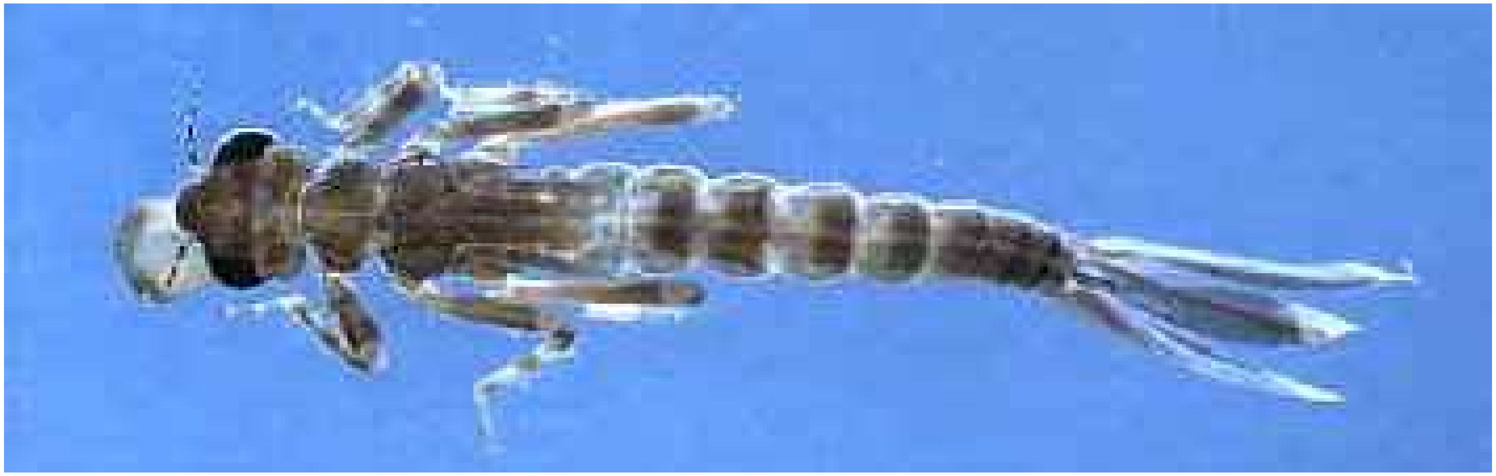


Long-lived Taxa

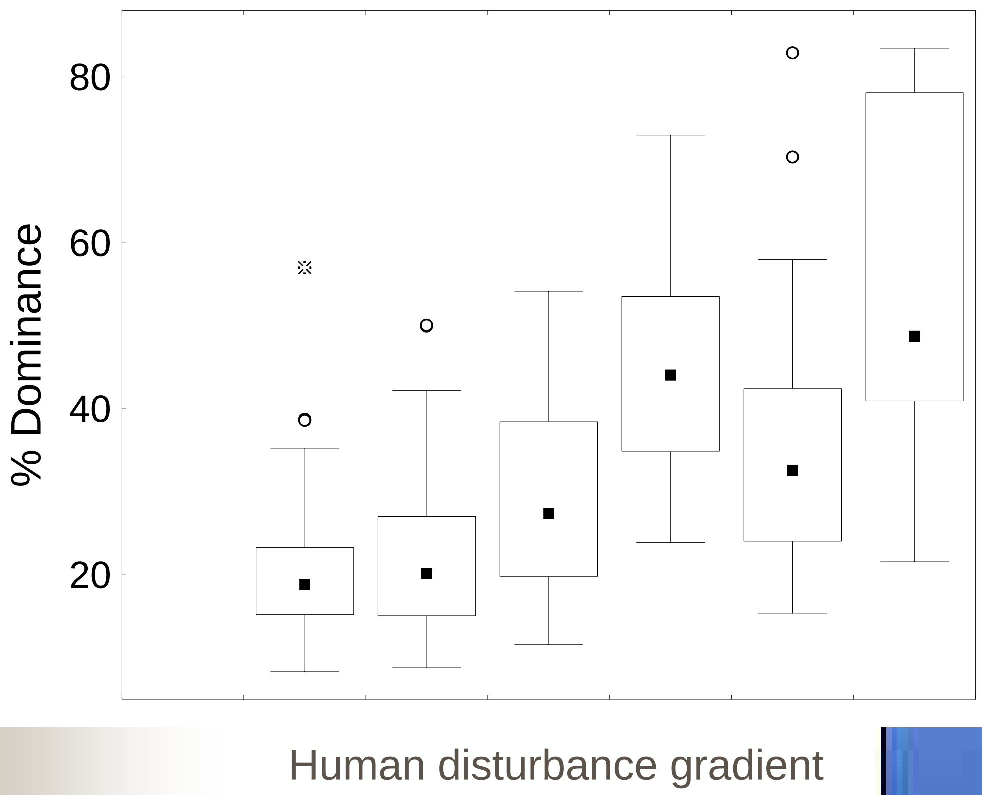


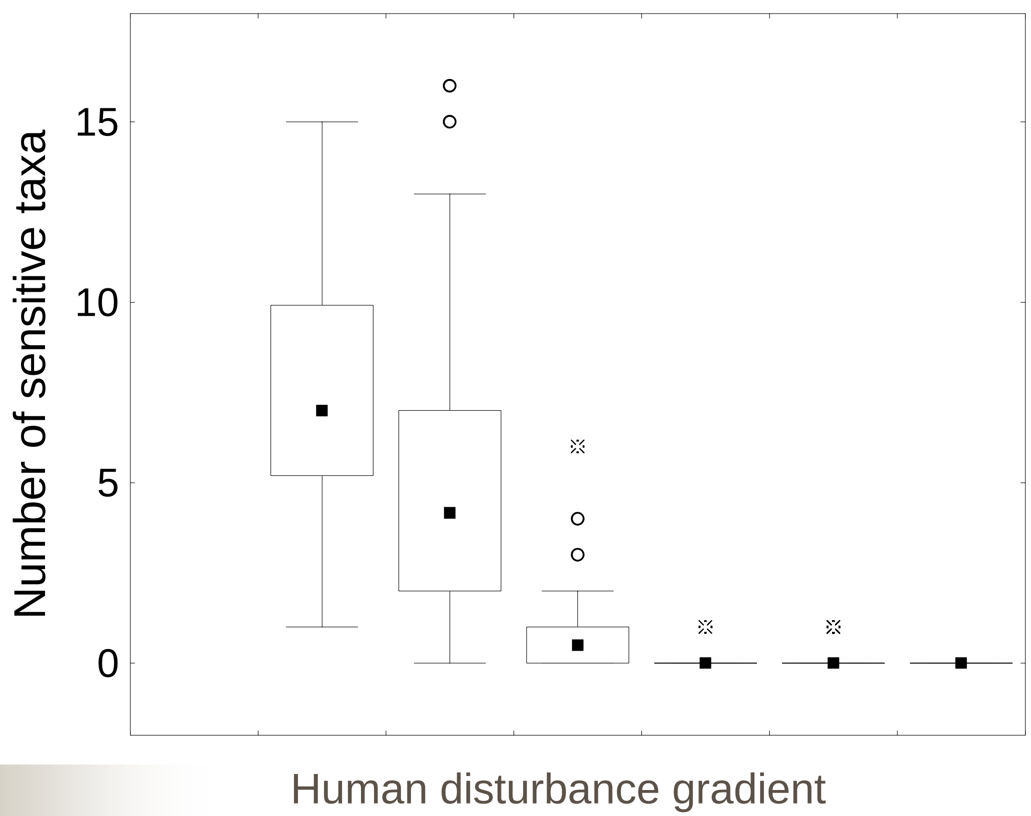
Clinger Taxa





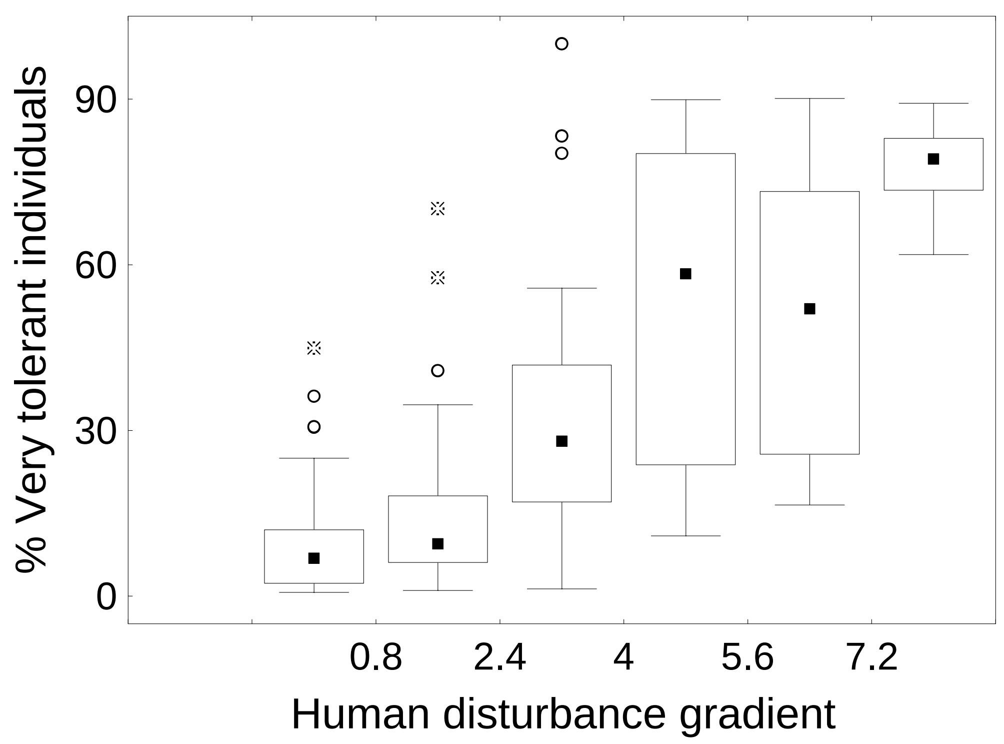
% Dominance

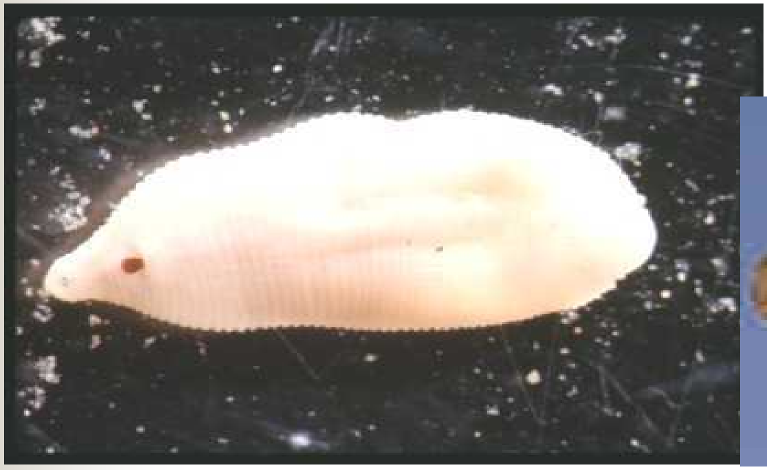




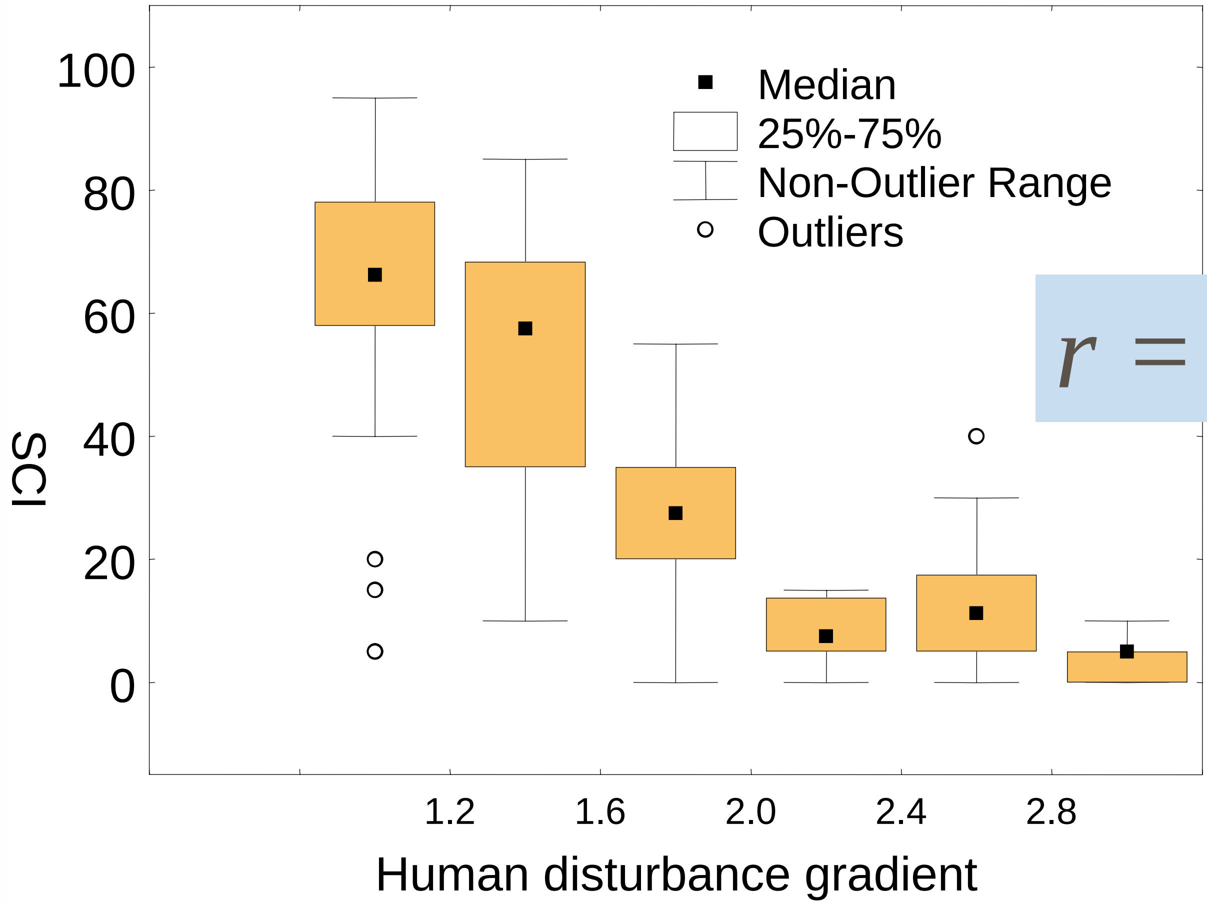
Sensitive Taxa

% Very Tolerant Taxa



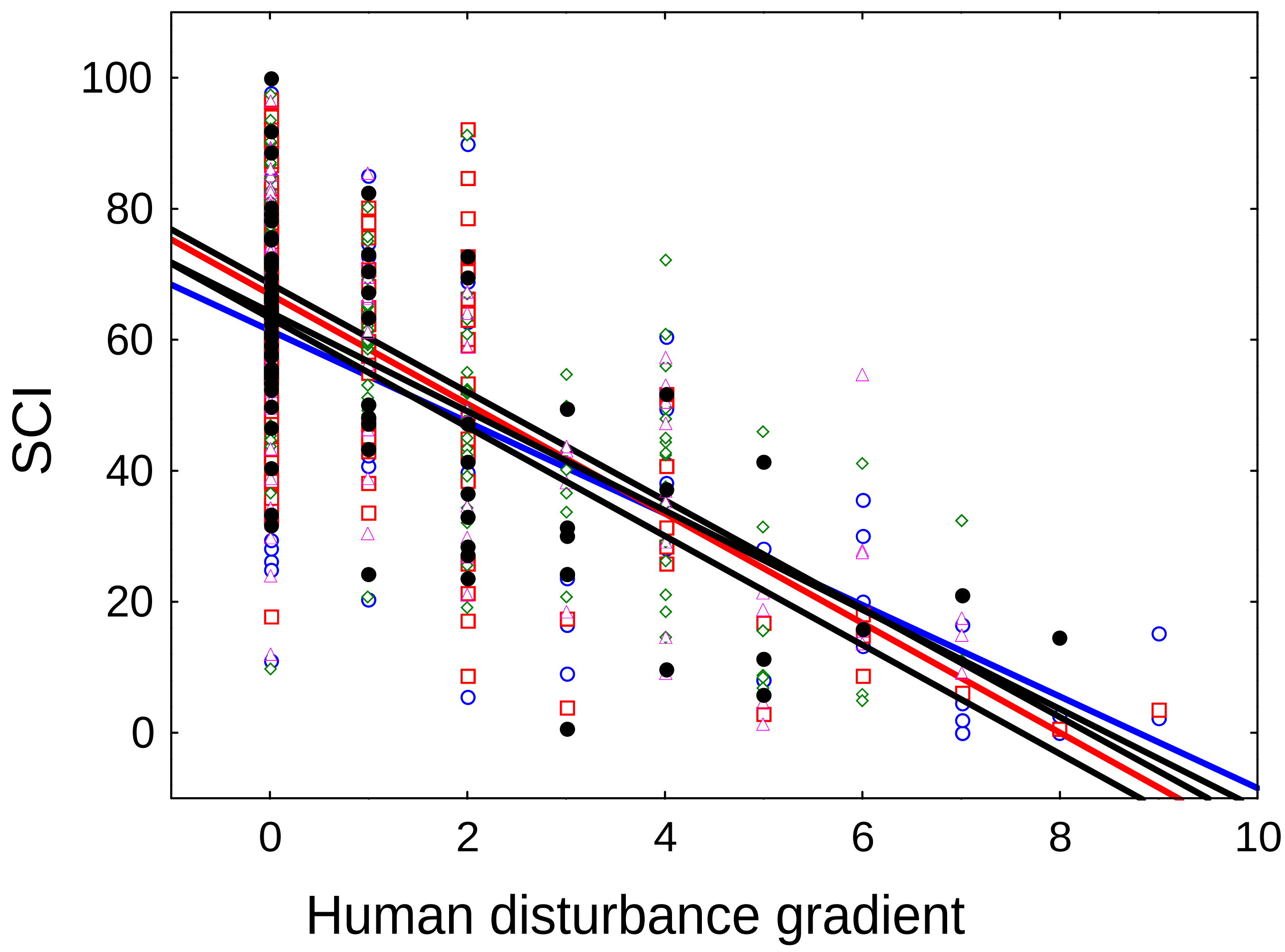


SCI vs.
Human Disturbance Gradient

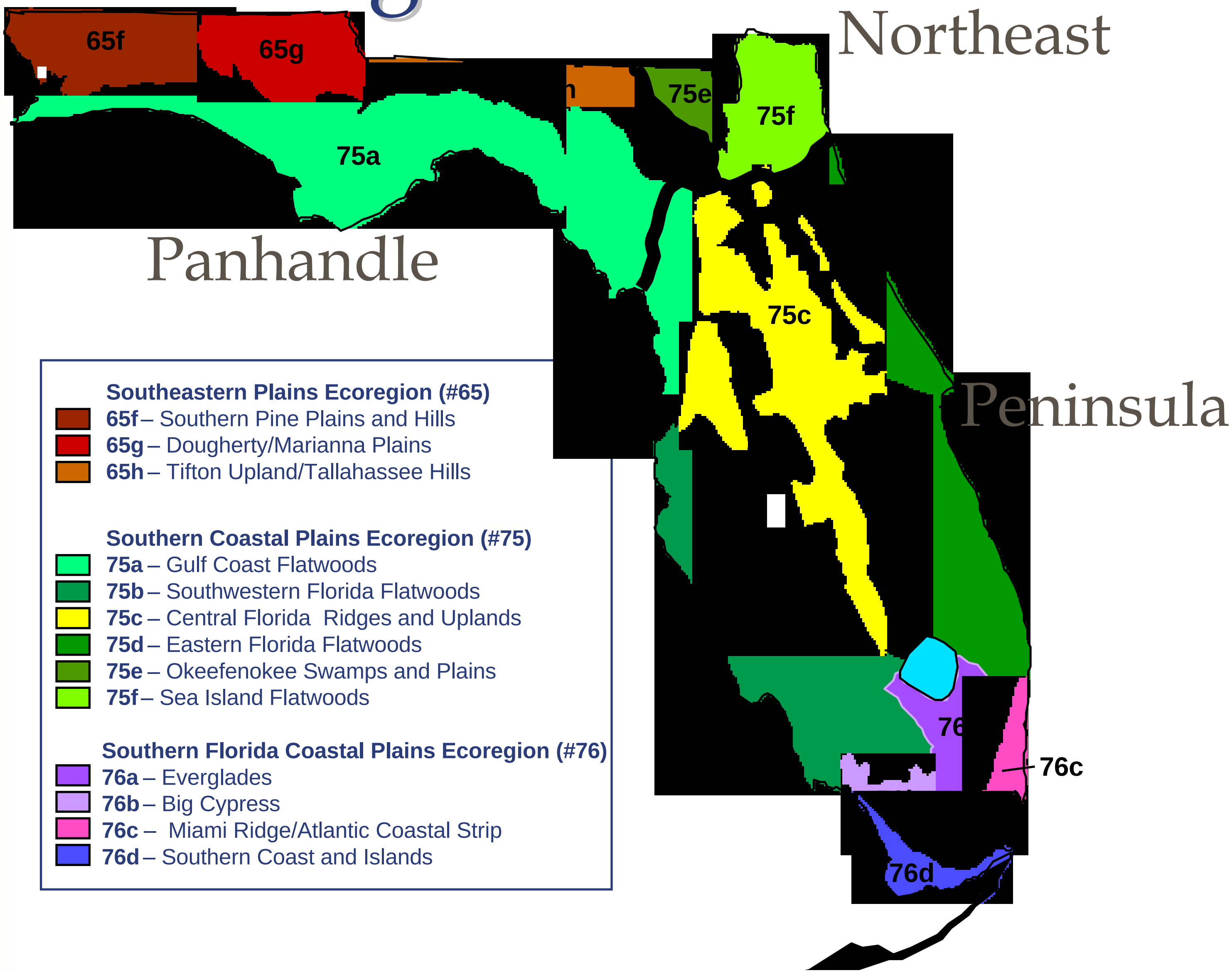


$r = 0.72$

SCI from 1992 to 2001



Bio-regions of Florida



Southeastern Plains Ecoregion (#65)

- **65f** – Southern Pine Plains and Hills
- **65g** – Dougherty/Marianna Plains
- **65h** – Tifton Upland/Tallahassee Hills

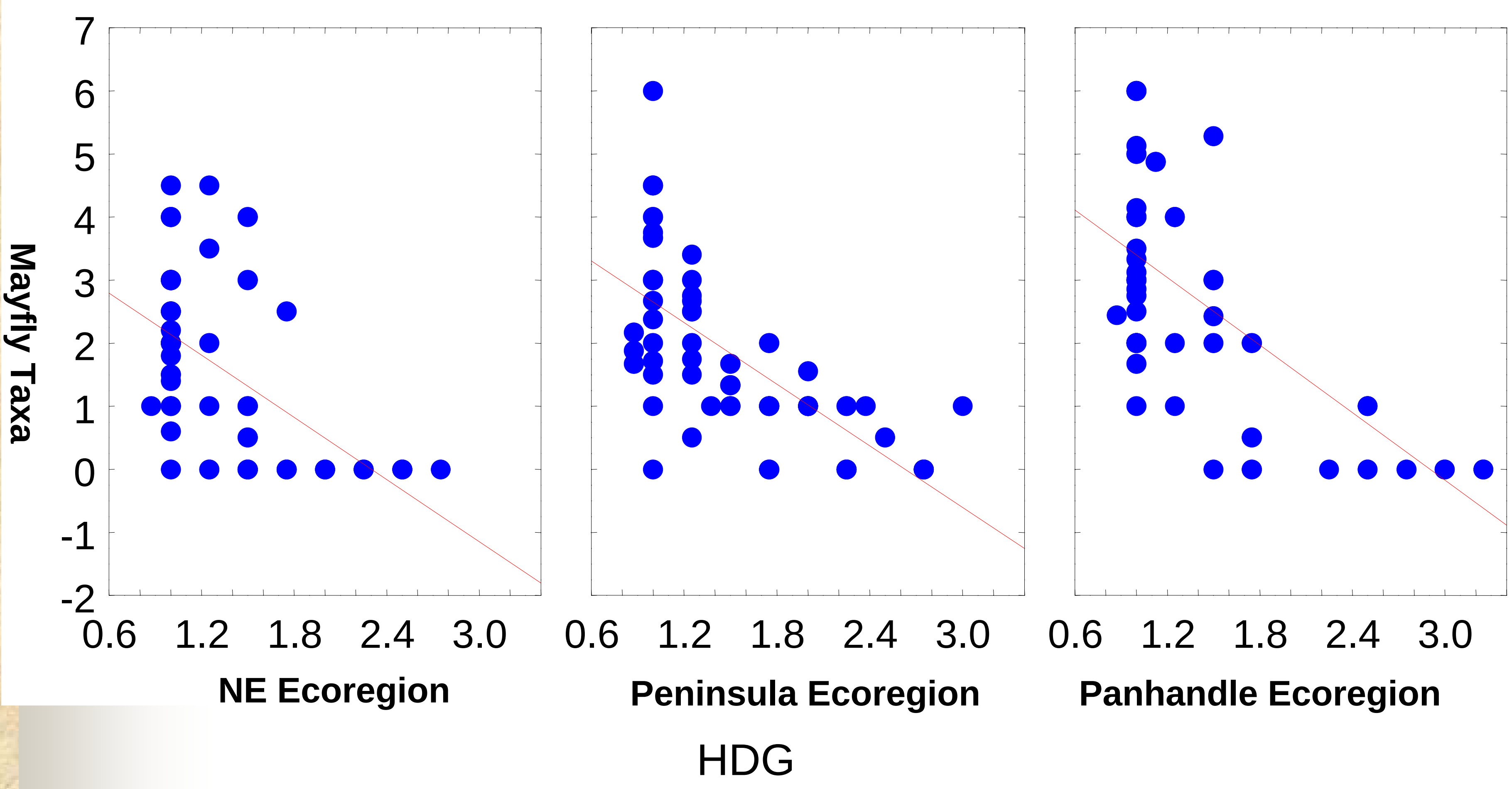
Southern Coastal Plains Ecoregion (#75)

- **75a** – Gulf Coast Flatwoods
- **75b** – Southwestern Florida Flatwoods
- **75c** – Central Florida Ridges and Uplands
- **75d** – Eastern Florida Flatwoods
- **75e** – Okeefenokee Swamps and Plains
- **75f** – Sea Island Flatwoods

Southern Florida Coastal Plains Ecoregion (#76)

- **76a** – Everglades
- **76b** – Big Cypress
- **76c** – Miami Ridge/Atlantic Coastal Strip
- **76d** – Southern Coast and Islands

Florida Mayfly Taxa vs. HDG



SCI can reliably detect 3 categories based on 1 sample

Number of categories:

~ 15 points x 2 = 30 points

100 / 30 = 3 categories

SCI	Description
70-100	“Good”
40-69	“Fair”
0-39	“Poor”

SCI Can Reliably Detect 5 Categories Based on 2 Samples

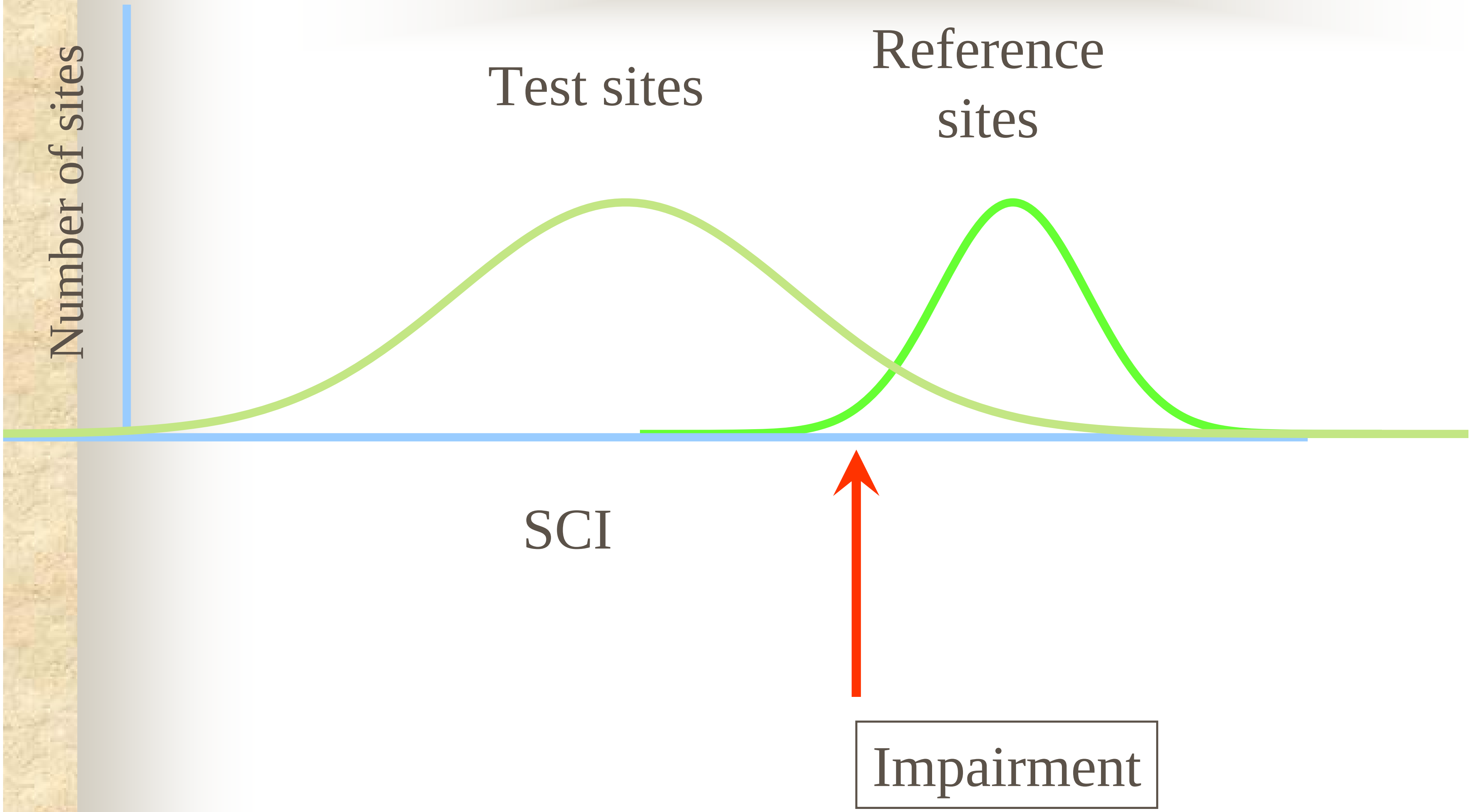
SCI	Description
80-100	"Excellent"
60-79	"Good"
40-59	"Fair"
20-39	"Poor"
0-19	"Very poor"

BioRecon Metrics

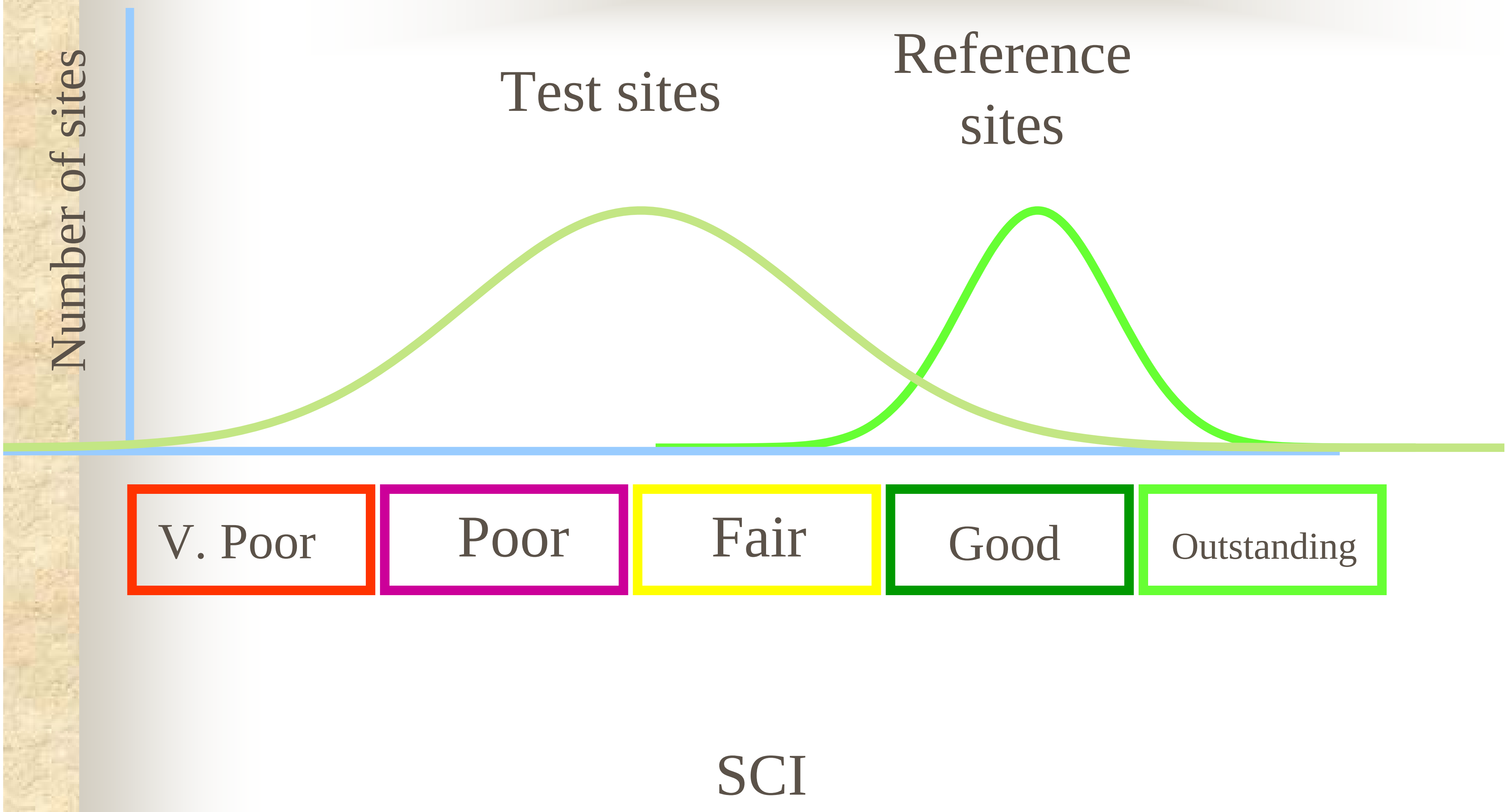
Metric		0	0.5	1.0
Total taxa				
	Northeast	<20	20-30	>30
	Panhandle	<23	23-33	>33
	Peninsula	<19	19-29	>29
Ephemeroptera taxa				
	Northeast	<2	2	>2
	Panhandle	<5	5-8	>8
	Peninsula	<2	2	>2
Trichoptera taxa		<2	2-4	>4
Long-lived taxa				
	Northeast	<2	2-3	>3
	Panhandle	<3	3-4	>4
	Peninsula	<2	2-3	>3
Clinger taxa				
	Northeast	<3	3-5	>5
	Panhandle	<4	4-7	>7
	Peninsula	<2	2-4	>4
Sensitive taxa				
	Northeast	<3	3-6	>6
	Panhandle	<5	5-8	>8
	Peninsula	<3	3-5	>5

BioRecon Final Evaluation

BioRecon	Index range
1 sample	
Pass	5-10
Fail	0-5
2 samples	
Good	7-10
Fair	4-7
Poor	0-4

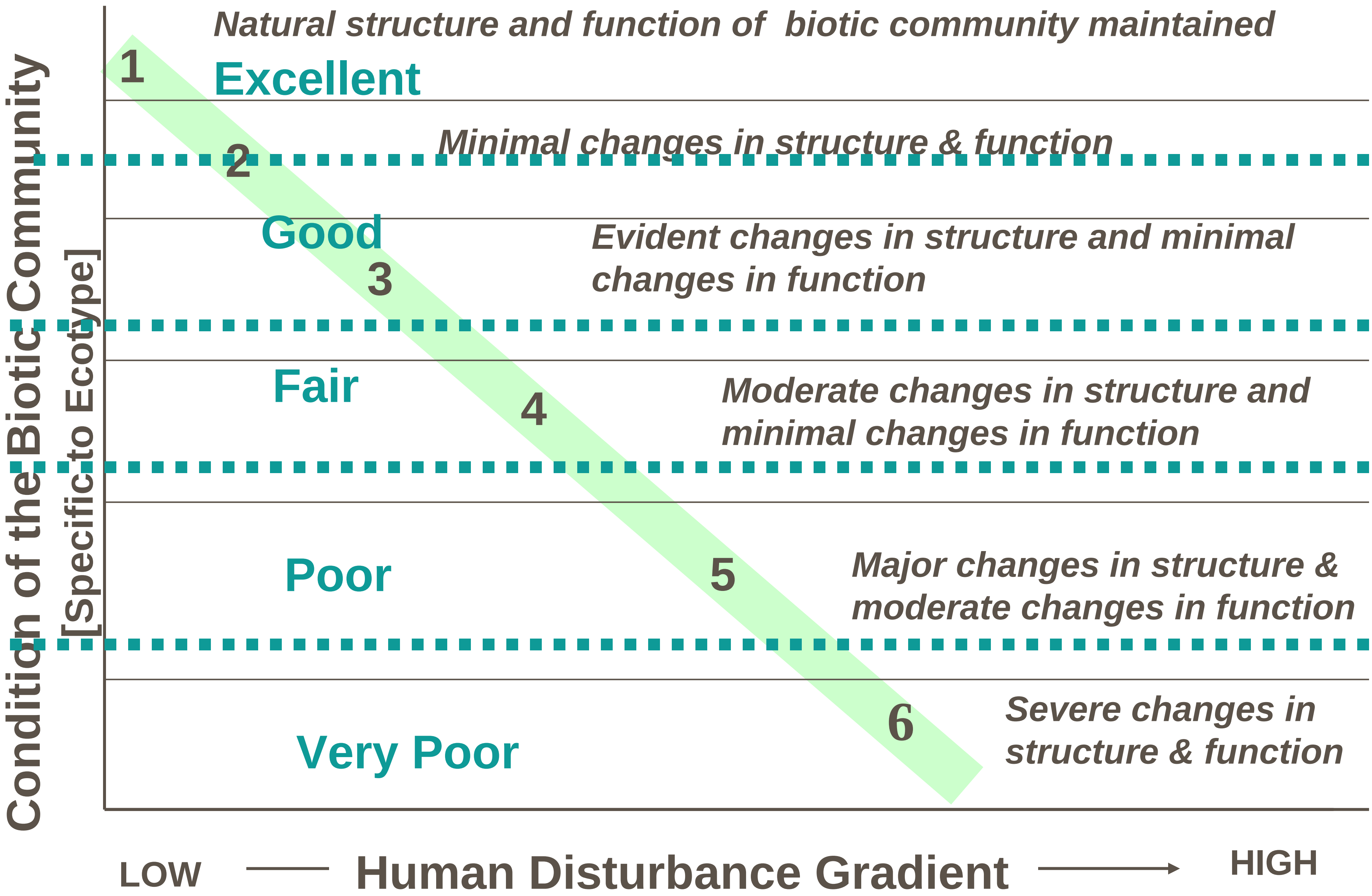


Number of sites
Test sites
Reference sites
SCI
Impairment



Number of sites
Test sites
Reference sites
V. Poor
Poor
Fair
Good
Outstanding
SCI

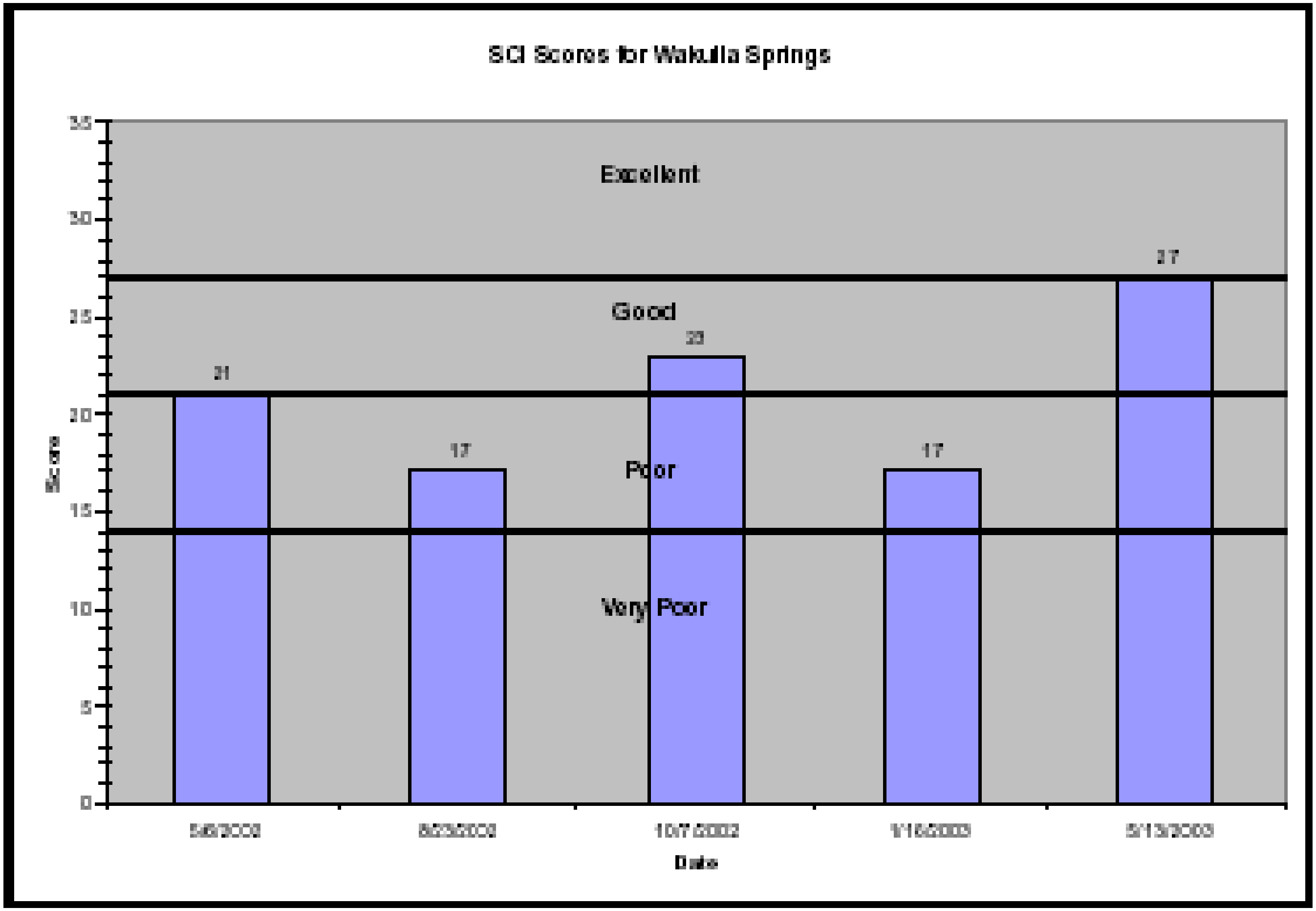
SCI Categories and TALUS Axis



Existing Applications of SCI

- Springs Studies
- Ambient Monitoring
- Impaired Waters Rule (TMDLs)
- Point Source Permitting
- Watershed (NPS) Studies
- BMP Effectiveness Studies

Recent SCI Scores for Wakulla



Conclusions

- The SCI is effective in regulatory programs
- Discriminatory power of metrics
  - Comparing extremes identifies strong metrics, but includes some “noisy” metrics
  - Human Disturbance Gradient improves metric selection and provides an independent measure for comparing biological response