



Sampling and Application of the Stream Condition Index

Aquatic Ecology and Quality Assurance
2018



SCI and Accompanying Protocols

- Stream Condition Index
 - Collection of organisms to be identified in the lab, metrics calculated from taxa list
- Habitat Assessment
 - Information critical to explaining SCI failures
- Companion biological assessments
 - Rapid Periphyton Survey
 - Linear Vegetation Survey



Course Overview

- Provide conceptual information on the SCI and its development
- Define expectations for samplers
 - Site selection
 - Habitats
 - Water level issues
 - Sampling techniques
- Provide hands-on training
 - Sweep and sort in field
 - Habitat assessment

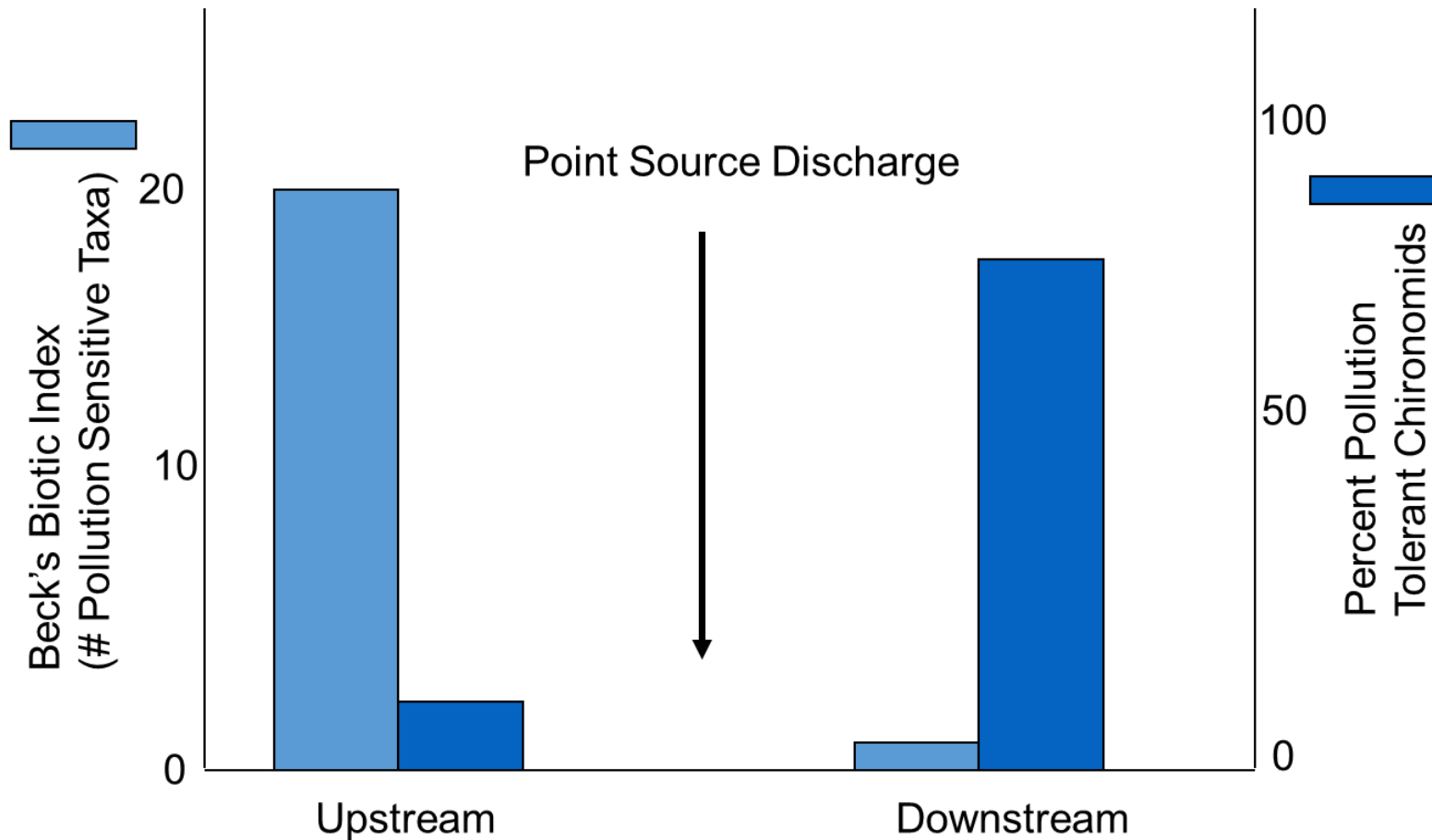


History of Bioassessment in Florida

- Beck's Biotic Index, 1950s
- Shannon-Weaver diversity, 1970s
 - Biological integrity (Rule 62-302.500 FAC)
- EPA Rapid Bioassessment using multi-metric index (Jim Karr approach), 1992
 - Original Stream Condition Index, 1996
 - Reference vs. test
 - Current Revised SCI, 2007
 - Human Disturbance Gradient
 - Biological Condition Gradient



Typical Macroinvertebrate Response to Organic Loading Associated with Primary Wastewater Treatment, Typical in the 1950s and 1960s.





Hester-Dendy samplers used for determining the Shannon-Weaver diversity index.



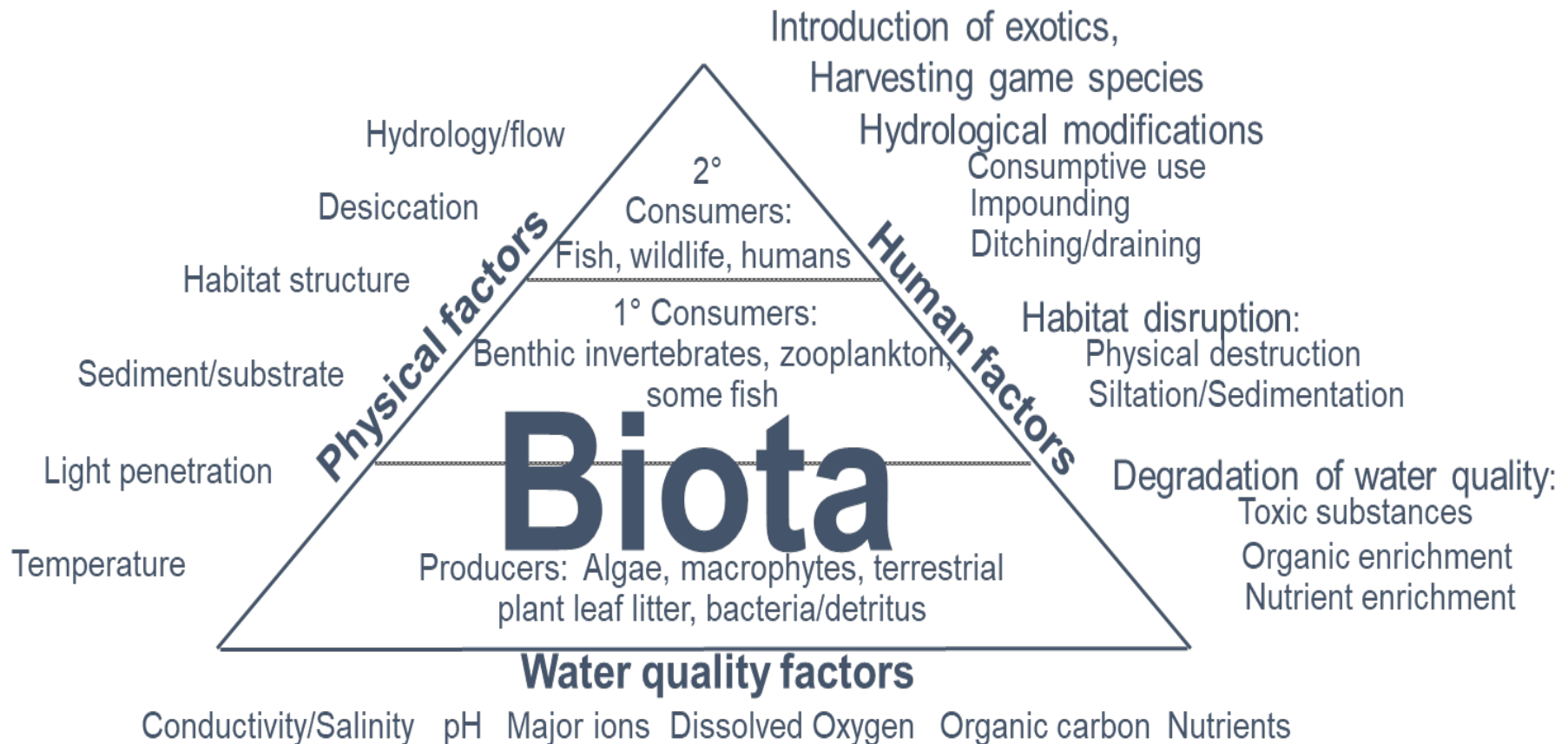


Bioassessment Theory

- Biota respond to a wide variety of cumulative factors, both natural and anthropogenic.
- As the organisms integrate factors over time, a characteristic community structure emerges.
- When human actions adversely affect a system, the biological population will change, leading to an impaired or imbalanced community.



Human Stressor & Natural Factors Shape Biota





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
 - Displaces natives
- Harvesting biomass
 - Disturbing predator-prey relationships



Interpreting Bioassessment Results

- Measures of ecosystem health that respond predictably to human influence = **metrics**.
- Comparing reference to "test" sites allows determination of unacceptable departures from the expected condition.
- The systems being compared should be similar except for potential human influences.
- Natural stressors (e.g., flood vs. drought) should be understood, and controlled for in the sampling design, to determine when human actions cause biological degradation.



Using the Human Disturbance Gradient to Develop SCI Metrics

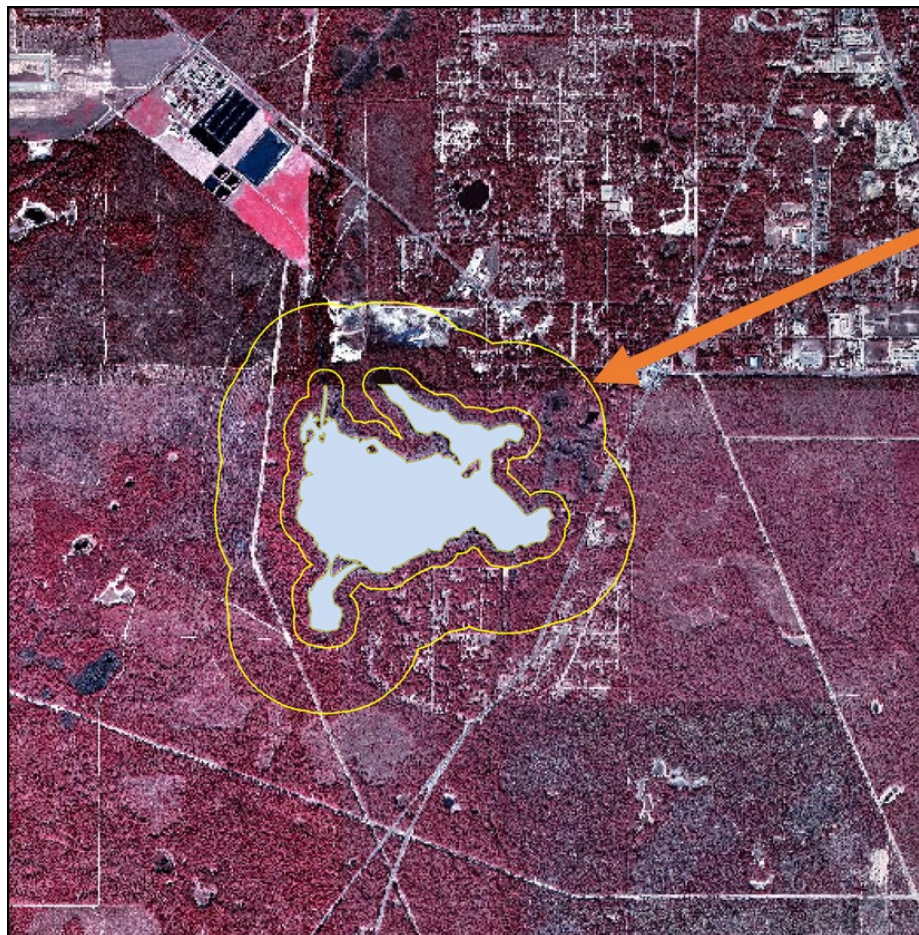
Objectively quantify relative level of human influence based on four factors:

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



Landscape Development Intensity Index

(Brown and Vivas 2004, UF Center for Wetlands)



Specific land-use near a waterbody receives a score from good (1) to bad (10). Based on non-renewable human energy inputs.



Summary of the Landscape Development Intensity Coefficients

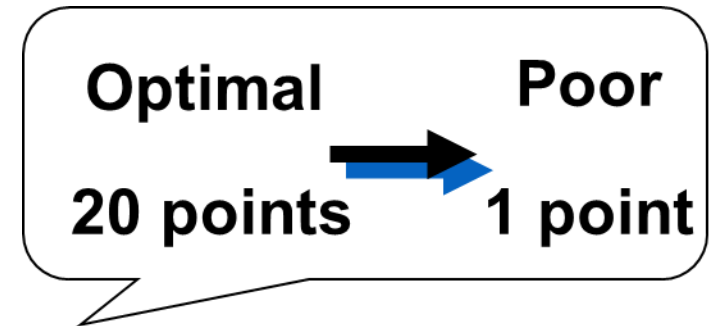
Category	Coefficient
Natural System	1
Pine Plantation	1.6
Pasture	3.4
Row Crops	4.5
Residential (low)	6.8
Residential (high)	7.6
Commercial	8.0
Industrial	8.3
Commercial (high)	9.2
Business District	10.0

Based on non-renewable Energy inputs, Odom's "Embodied Energy" concept.



Habitat Assessment Components

- Substrate Types
- Substrate Availability
- Water Velocity
- Artificial Channelization
- Habitat Smothering
- Bank Stability
- Riparian Zone Buffer Width
- Riparian Zone Vegetation Quality



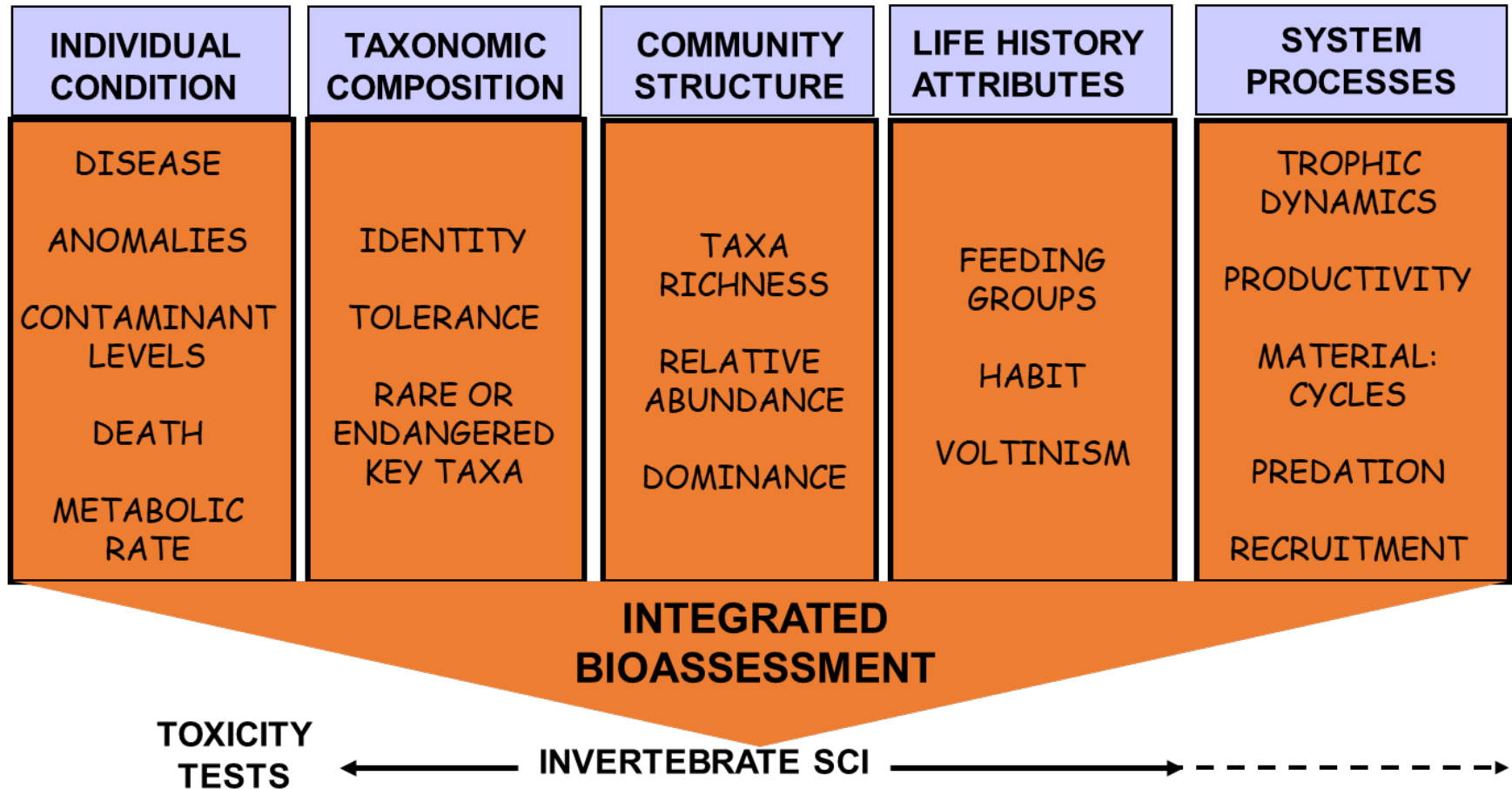


HDG as the x-axis

- These components were converted into a dimensionless index, with low values denoting low disturbance, and increasing values associated with more intense human influences.
- The index was subsequently used as the x-axis for testing a wide variety of biological attributes associated with the measurement of ecological integrity



Major Attribute Categories for Determining Biological Integrity





Metric Selection

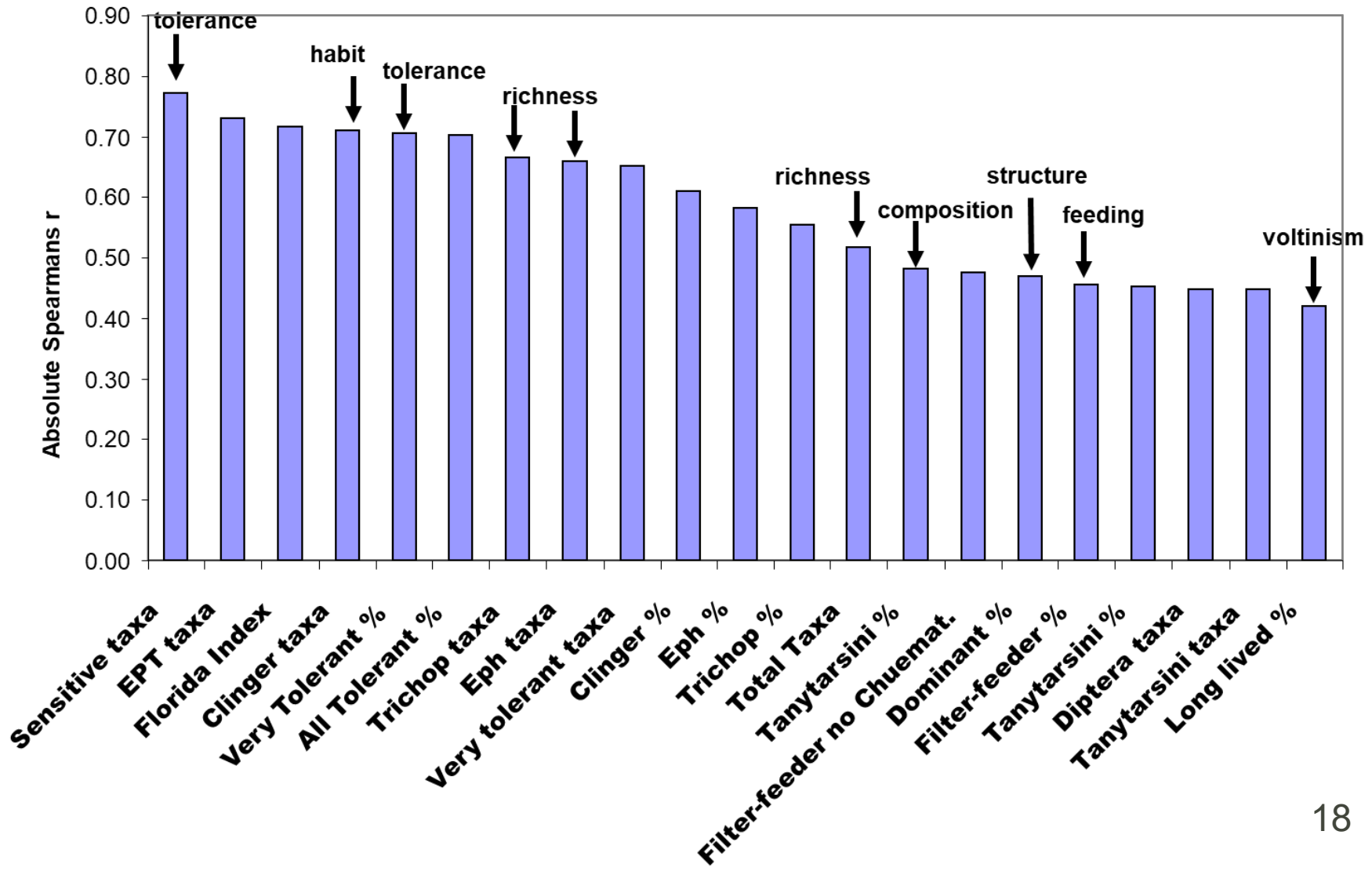
The 10 selected metrics were chosen to:

- Represent as many attribute categories as possible
- Provide meaningful and predictable assessment of human effects
- Avoid redundancy if several correlated metrics were providing similar information.



Correlation between various metrics and the Human Disturbance Gradient.

Arrows indicated metrics selected for the SCI, and associated attribute group.



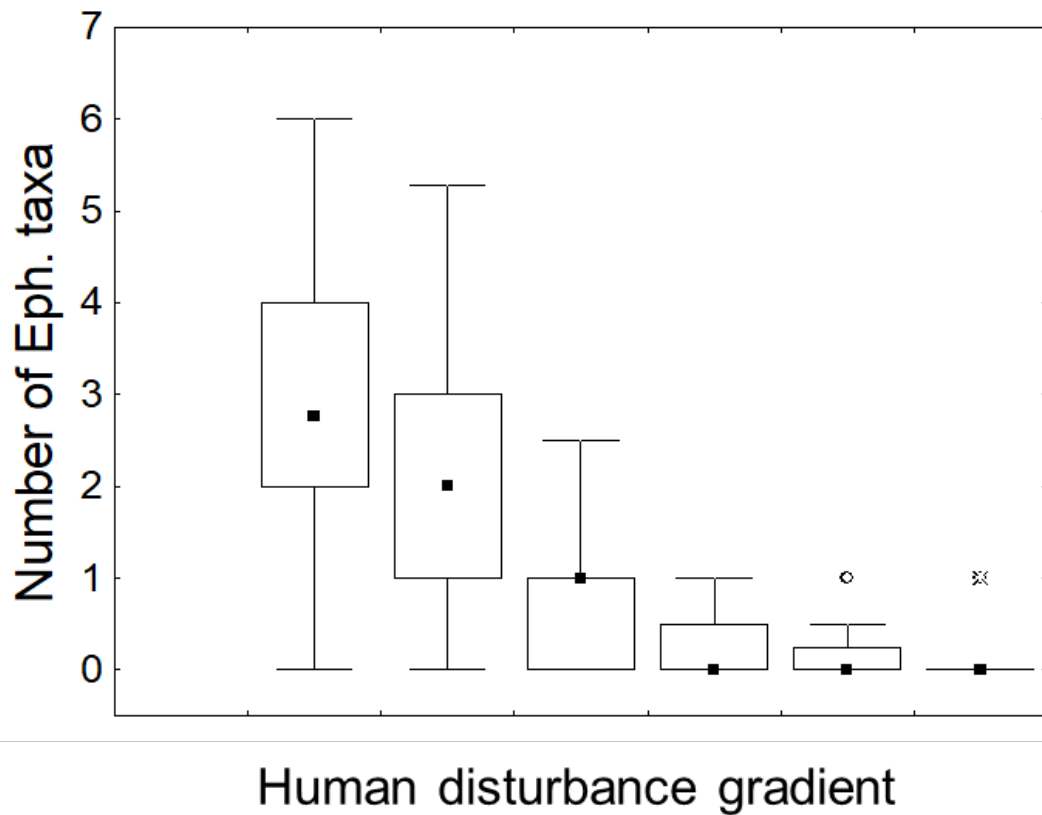


Taxa Richness Metrics

- Total taxa richness (the number of different types of organisms present).
- Trichoptera richness (caddisflies).
- Ephemeroptera richness (mayflies).
- These three measures have historically been shown to decrease with human disturbance.
- Three richness metrics were chosen since each one may respond differently, depending on the type of disturbance.
- Mayflies are more sensitive to metals, certain caddisflies may be more sensitive to flow disruption.



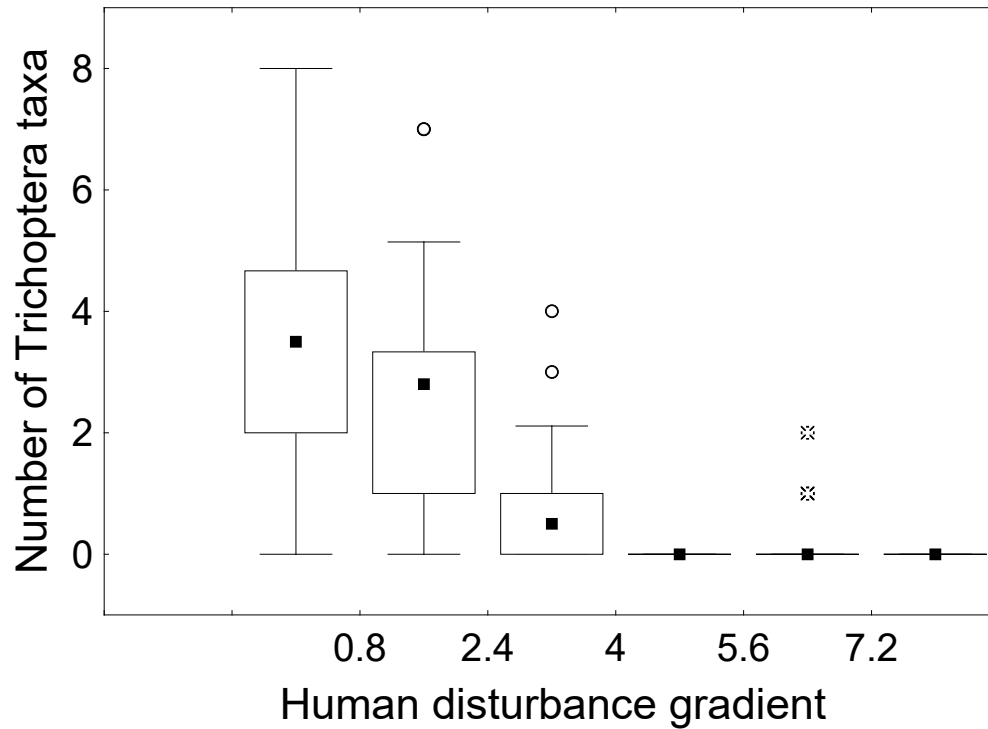
Ephemeroptera Metric



Tricorythodes, a sensitive mayfly.



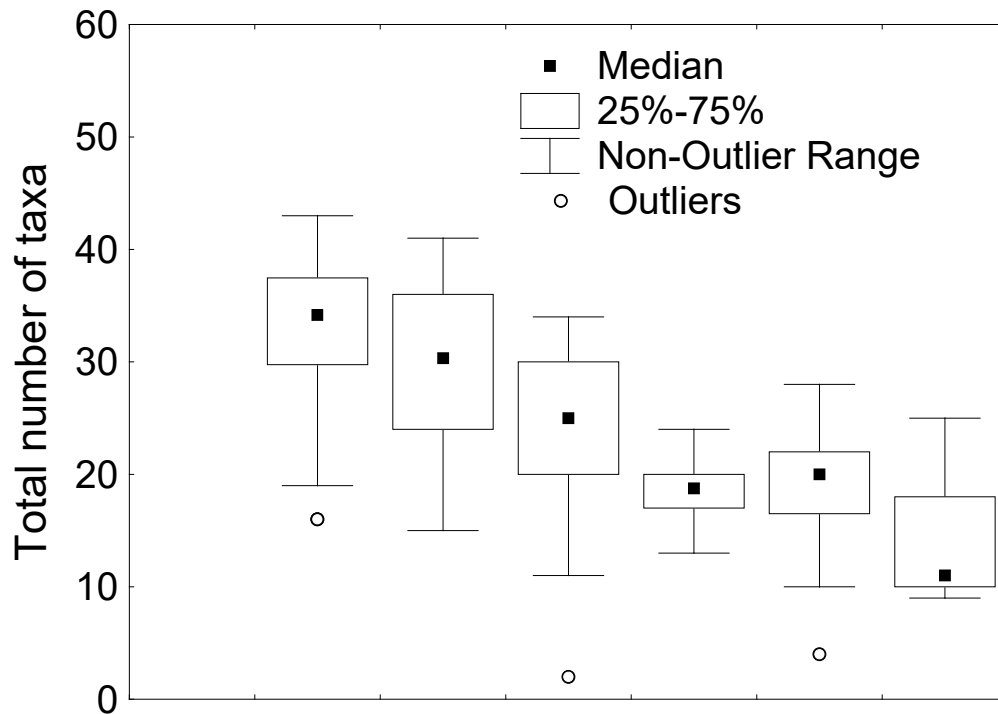
Trichoptera Taxa



Brachycentrus,
caddisfly



Taxa Richness



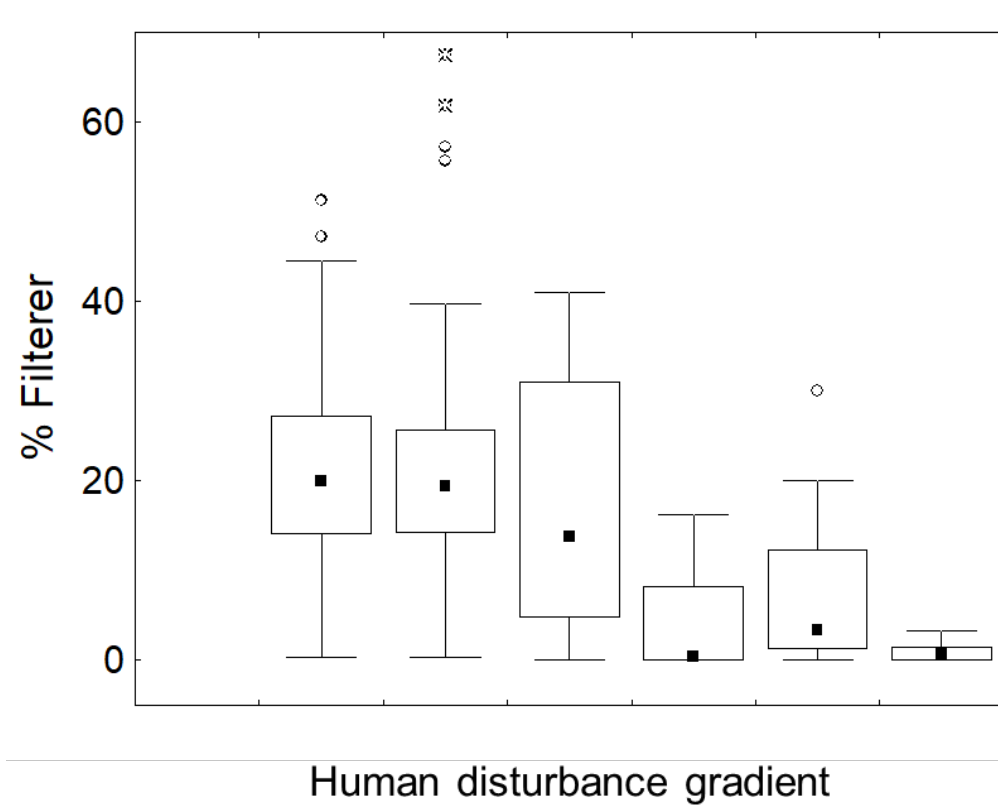


Feeding Groups Metrics

- Disruption of food webs has long been associated with human influence, especially organic pollution.
- The relative abundance of filterers (percentage filterer individuals) had the highest correlation and most consistent relationship with the HDG.
- Filter feeders extract nutrients by straining food particles from the water column. If the water flow or quality of the organic matter in the water is compromised, a reduction in filter feeders will occur.



% Filter-feeders Metric



Net-spinning caddisfly

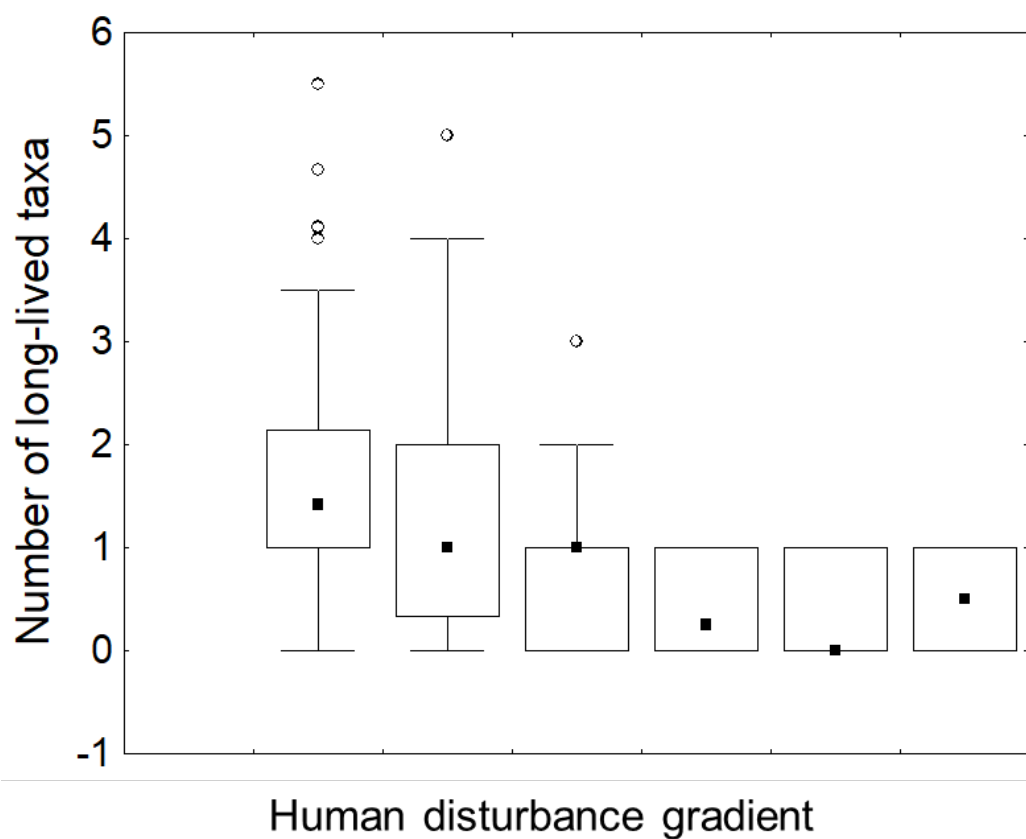


Voltinism Metric

- Voltinism refers to the number of distinct reproductive cycles for a given organism per unit of time.
- Long-lived taxa require greater than one year to complete their life cycles.
- Long-lived taxa richness would be expected to decrease if a disturbance event (e.g., sporadic illegal dumping, etc.) occurred at a site within a year of sample collection.



Long-lived Taxa Metric



Mollusk, the threatened
“purple bank climber”

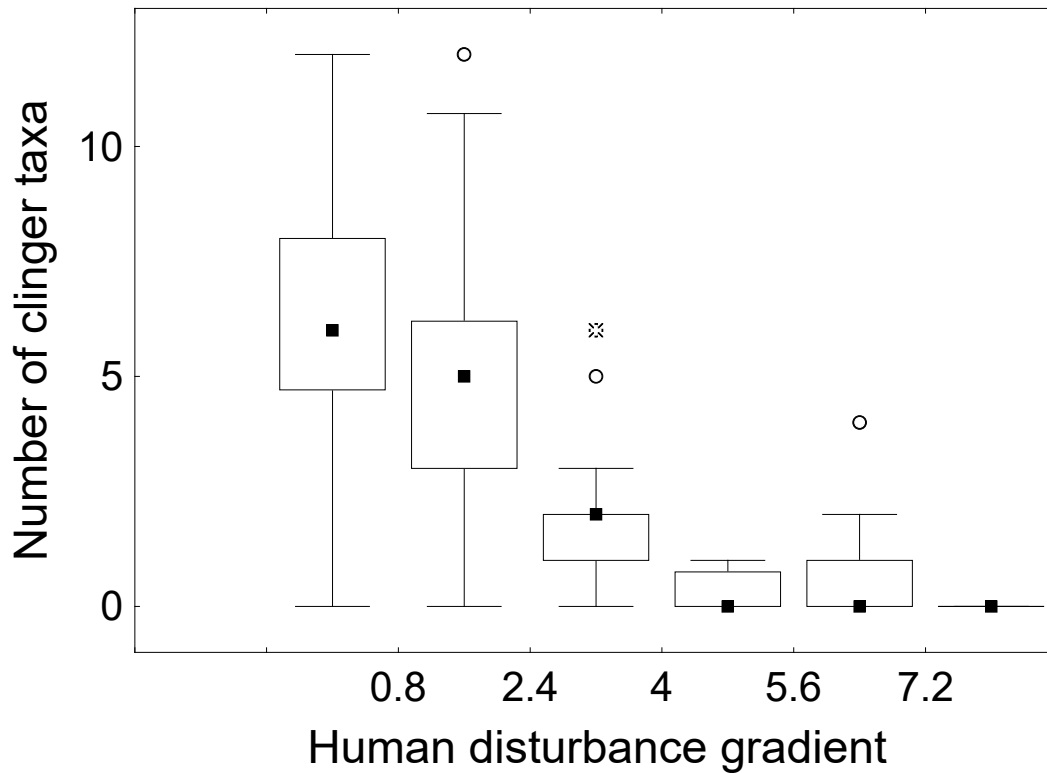


Organism Habit Metric

- Clingers are those taxa morphologically adapted to hold onto substrates during routine flow conditions, and would be expected to decline as humans alter a stream's hydrograph, especially during abrasive events caused by high stormwater inputs from impervious surfaces.



Clinger Taxa Metric



Damselfly larvae

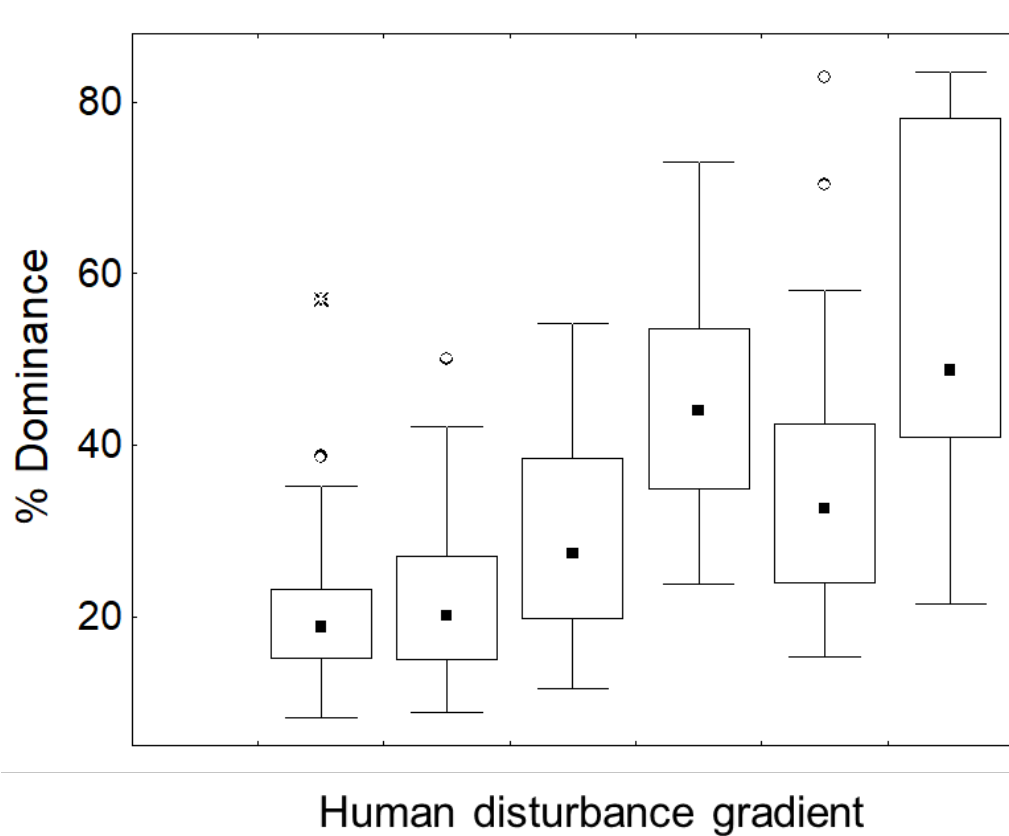


Community Structure Metrics

- Substantial shifts in proportions of major groups of organisms, compared to reference conditions, indicate degradation.
- The percent dominant taxon, which increases in conditions where a few pollution tolerant organisms are very abundant, to the exclusion of other taxa, was selected as a metric.
- Tanytarsini midges are sensitive to disturbance, including toxic metals. % Tanytarsini metric was included in the SCI as the best available measure of the chironomid assemblage.



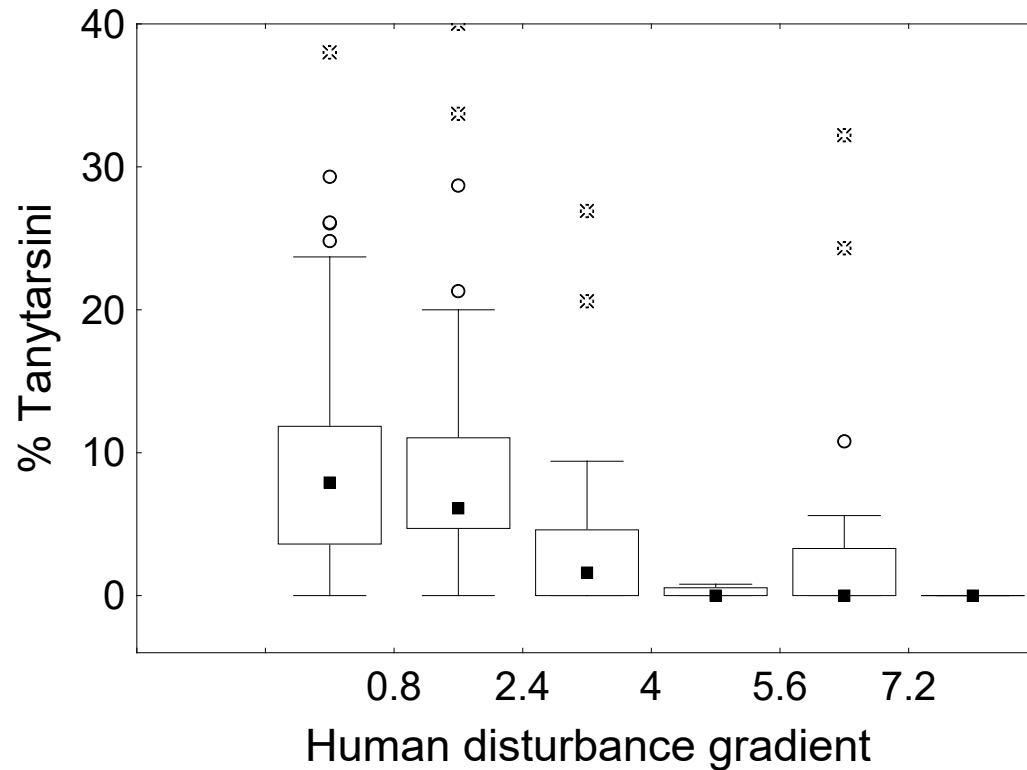
% Dominance Metric



Hyalla azteca, a tolerant amphipod



% Tanytarsini (Sensitive midges)



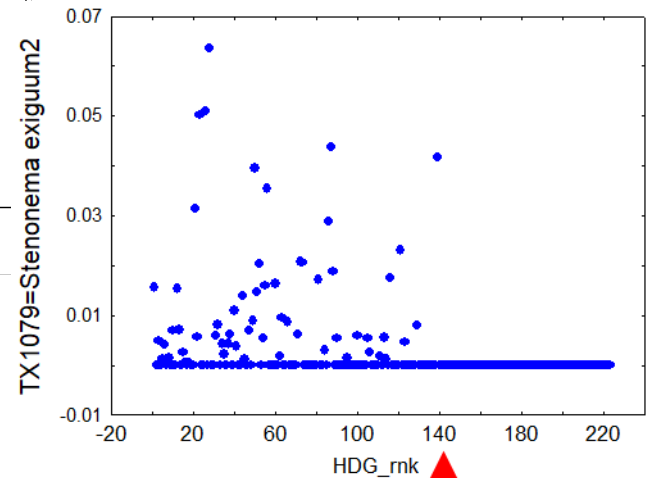
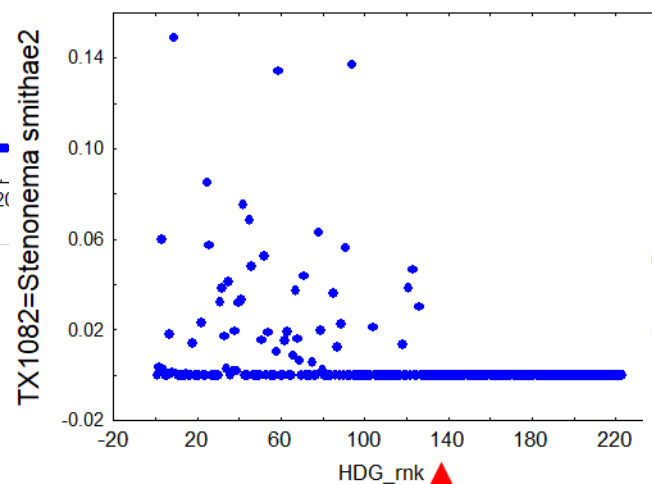
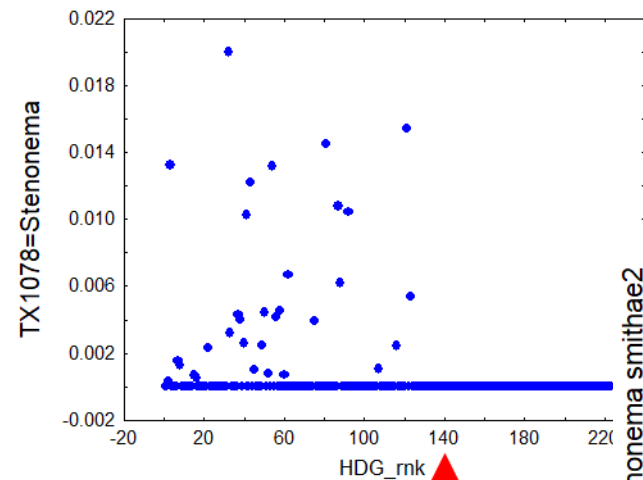


Tolerance Metrics

- A list of sensitive and very tolerant invertebrates were established by analyzing the responses of 1,200 individual species to the HDG.
- The number of taxa selected as sensitive equaled around 12% of the taxa tested, and the number of very tolerant taxa was approximately 10% of the taxa tested.
- Many sensitive taxa belonged to the Ephemeroptera, Trichoptera or Odonata; several chironomids were also included. All the Plecoptera were included as sensitive taxa.
- The number of sensitive taxa and the percent very tolerant taxa were highly correlated with the HDG



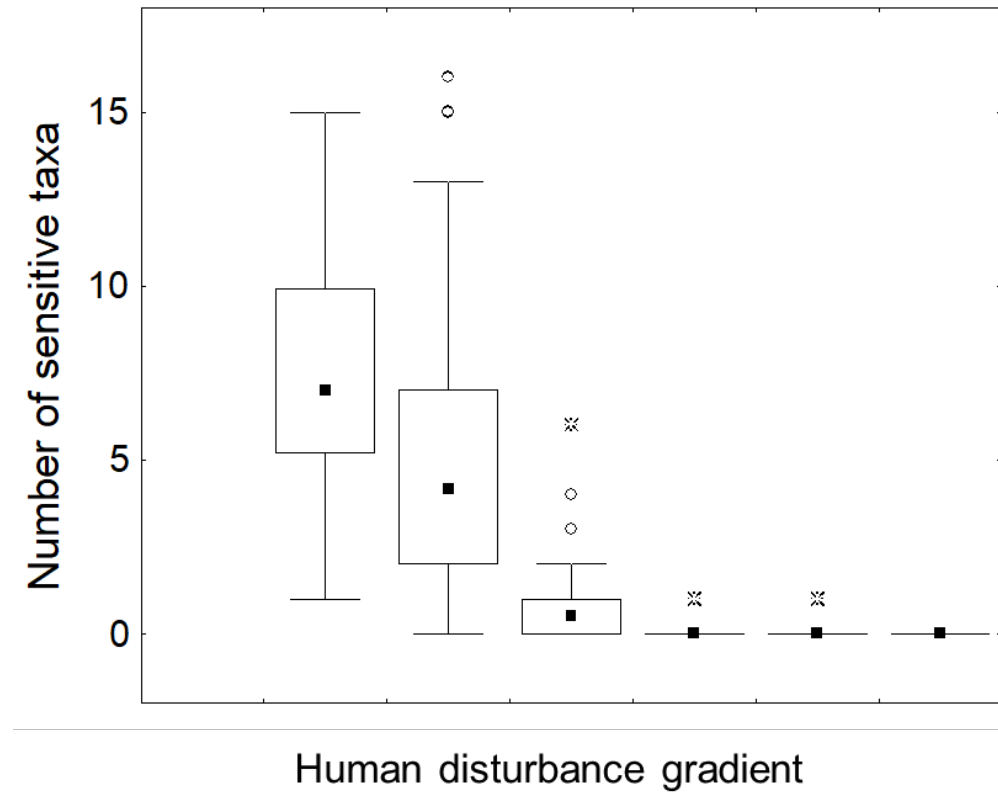
Sensitive Mayfly (*Maccaffertium*) vs. HDG



Increasing disturbance →



Sensitive Taxa Metric



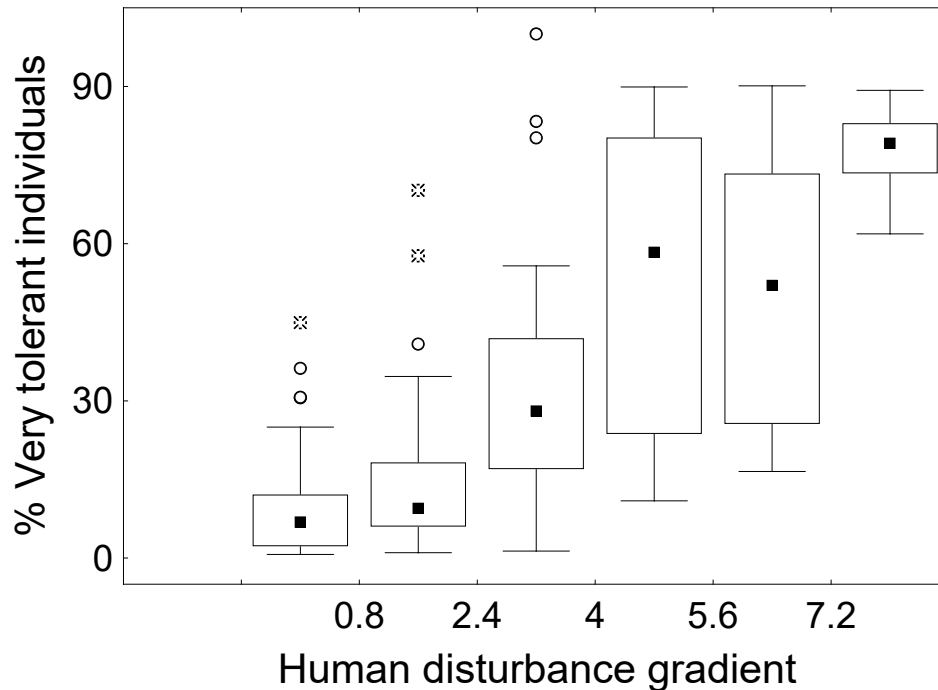
Plecopteran (stonefly)



Odonate (dragonfly)



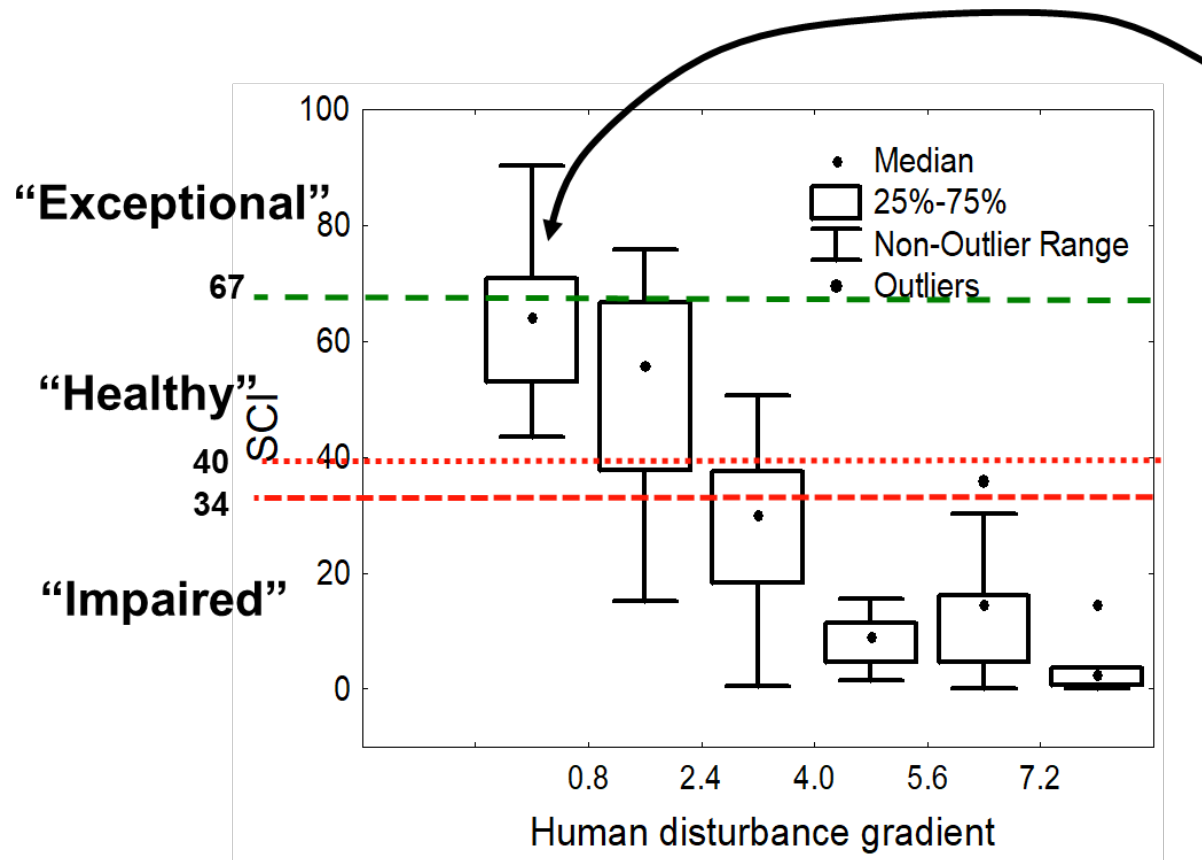
% Very Tolerant Metric



Lunged snails (top), tolerant midges (middle), and leeches (bottom) 35



Linking the Human Disturbance Gradient to SCI Thresholds



These zero HDG sites were selected by DEP District biologists to represent the very healthiest streams in Florida, experiencing minimal human disturbance. The majority are “healthy”, about 40% are “exceptional”.

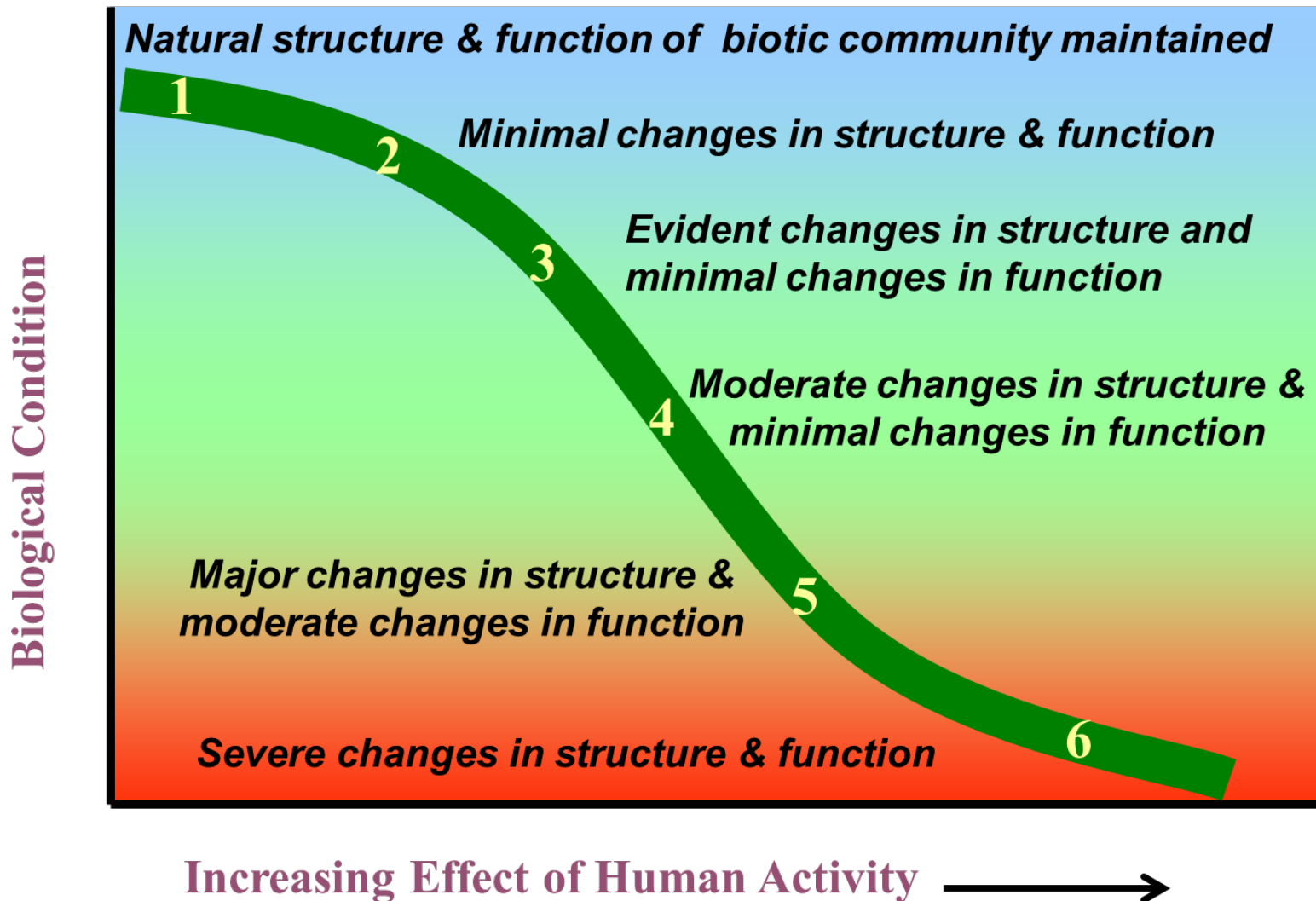


Establishing SCI Thresholds for Impairment

- Biological Condition Gradient Approach
- Reference Site Approach



The Biological Condition Gradient Concept



The Biological Condition Gradient: Biological Response to Increasing Levels of Stress

Levels of Biological Condition

Natural structural, functional, and taxonomic integrity is preserved.

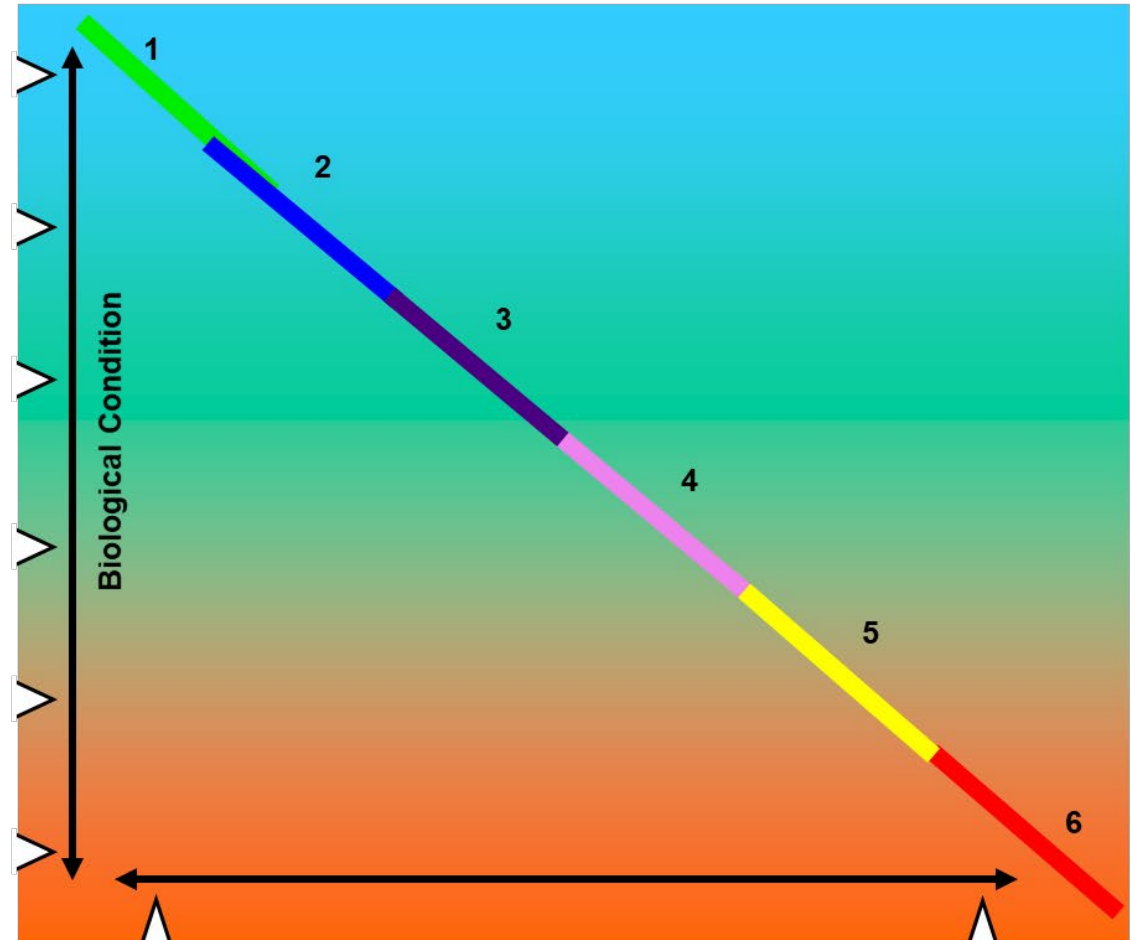
Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

Moderate changes in structure due to replacement of sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.



Watershed, habitat, flow regime and water chemistry as naturally occurs.

Chemistry, habitat, and/or flow regime severely altered from natural conditions.



10 BCG Attributes Extracted from Site Community Information

- Historically documented, sensitive, long-lived or regionally endemic taxa
- Sensitive and rare taxa
- Sensitive but ubiquitous taxa
- Taxa of intermediate tolerance
- Tolerant taxa
- Non-native taxa
- Organism condition
- Ecosystem functions
- Spatial and temporal extent of detrimental effects
- Ecosystem connectance



BCG Ranking Criteria

- 1) Natural or native condition
- 2) Minimal changes in structure of the biotic community and minimal changes in ecosystem function
- 3) Evident changes in structure of the biotic community and minimal changes in ecosystem function
- 4) Moderate changes in structure of the biotic community with minimal changes in ecosystem function
- 5) Major changes in structure of the biotic community and moderate changes in ecosystem function
- 6) Severe changes in structure of the biotic community and major loss of ecosystem function



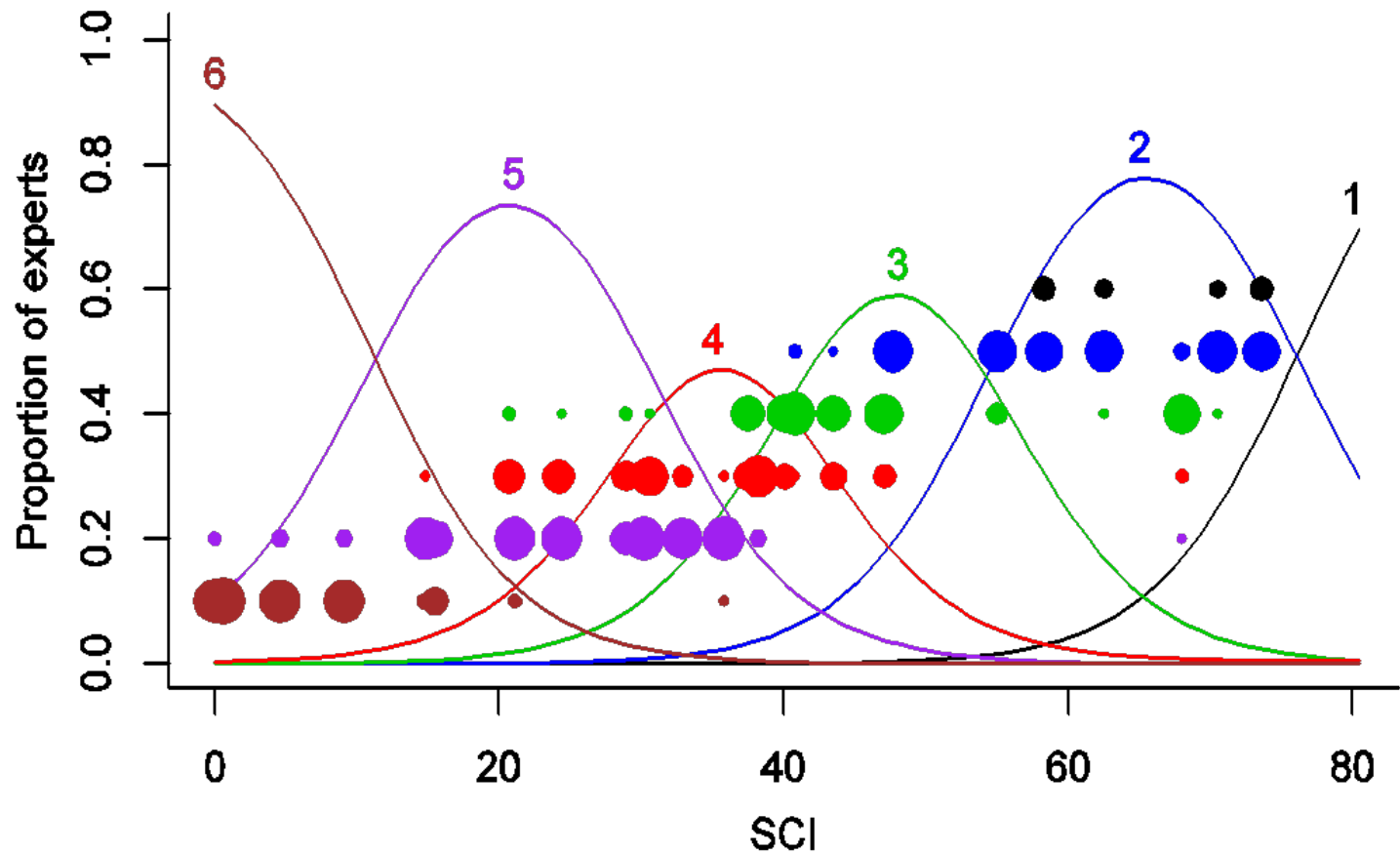
BCG Experts

Expert name		Affiliation	Years
Jerrell	Daigle	DSA, Inc.	>20
Dana	Denson	FDEP Central District	10-15
Doug	Durbin	Biological Research Associates	>20
John	Epler	John Epler Consulting	>20
Julie	Espy	FDEP Tallahassee	5-10
David	Evans	Water and Air Research	>20
Michael	Heyn	FDEP Tallahassee	>20
Joy	Jackson	FDEP Tallahassee	10-15
Deron	Lawrence	Biological Research Associates	10-15
Laura	Line	Water and Air Research	10-15
Rob	Mattson	St. Johns River Water Management District	>20
Peggy	Morgan	FDEP Southwest District	>20
Patrick	O'Connor	FDEP Northeast District	>20
Manuel	Pescador	Florida Agricultural and Mechanical University	>20
Marianne	Pluchino	Reedy Creek Improvement District	>20
Eric	Pluchino	FDEP Orlando District	>20
Donald	Ray	FDEP Northwest District	>20
Johnny	Richardson	Leon County	10-15
Gitta	Schmitt	FDEP Southwest District	5-10
Mary	Szafraniec	Southwest Florida Water Management District	5-10
Albert	Walton	FDEP South District	>20
Gary	Warren	Florida Fish and Wildlife Commission	>20



Proportional Odds Model

Assignment of BCG Category vs. SCI Score





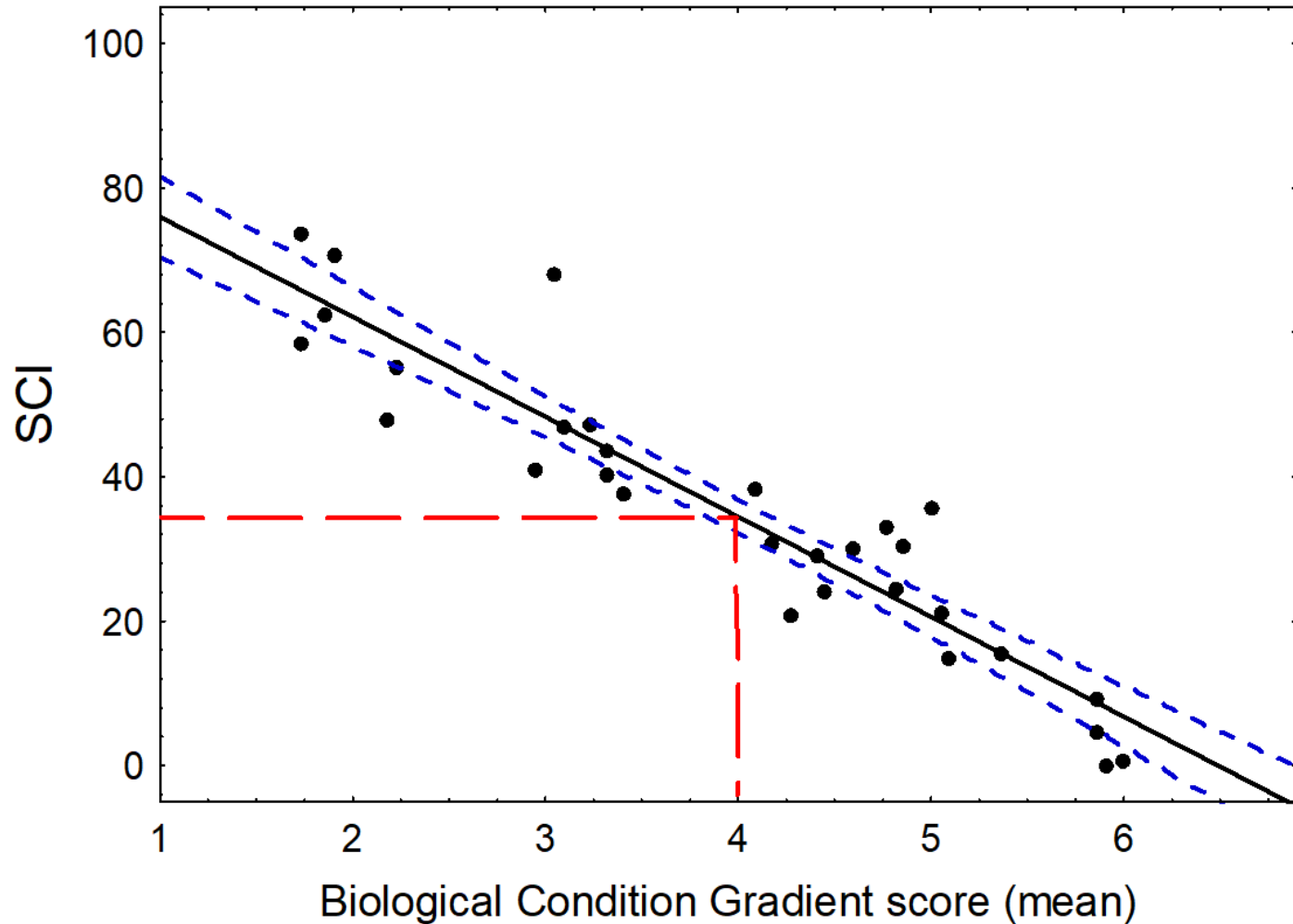
BCG Workshop

October 24, 2006

- Experts independently ranked 30 data sets.
- Consistency discussions occurred (Delphi Technique).
- Provided expert opinion on where “impairment” line (not meeting interim goal of CWA) existed in rankings.
- Later, expert rankings were used to modify the SCI thresholds
 - Regression
 - Change Point Analysis



Linear Regression Model





A Tier 1-2 Community

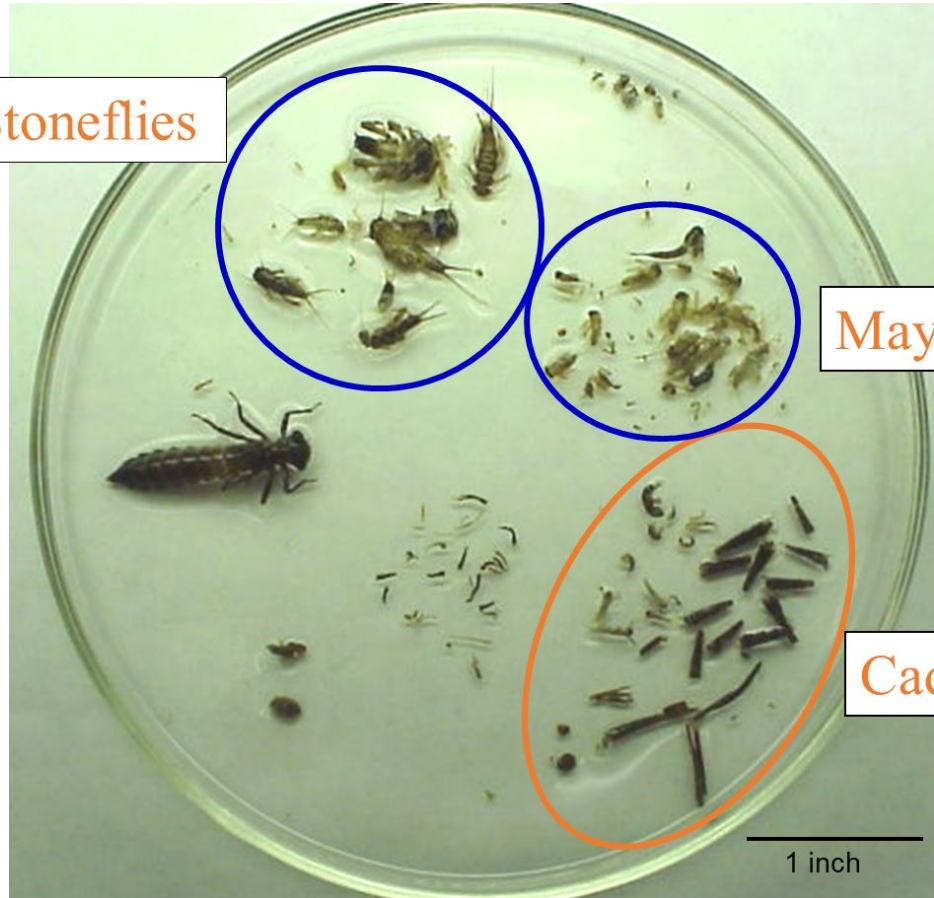
"Minimally disturbed"





A Tier 1-2 Community

"Minimally disturbed"





A Tier 1-2 Community

"Minimally disturbed"

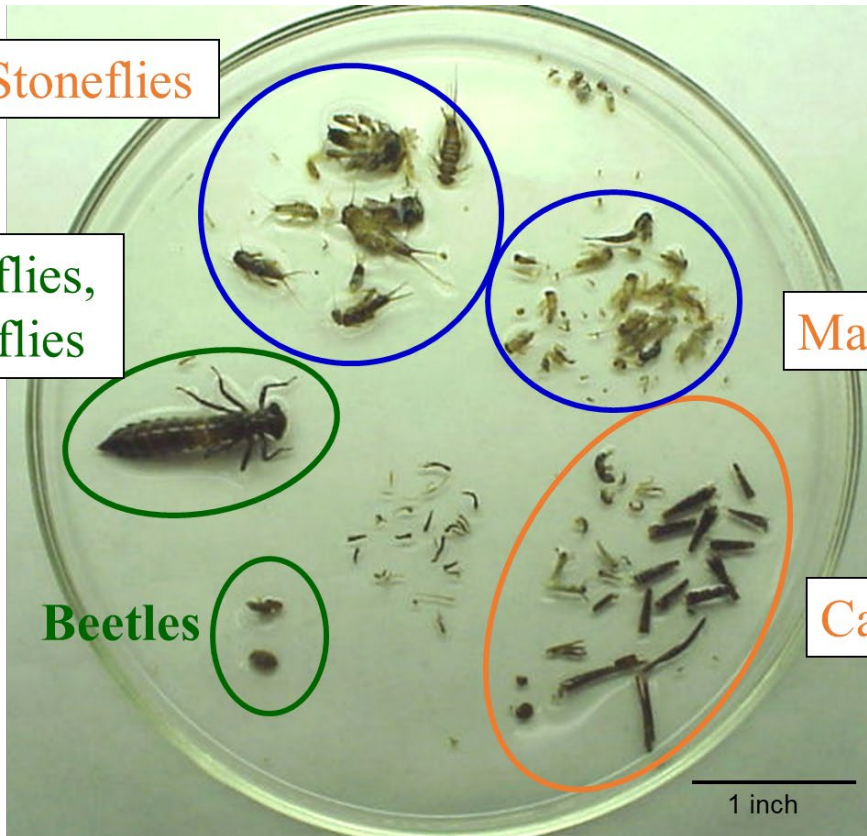
Stoneflies

Dragonflies,
Damselflies

Beetles

Mayflies

Caddisflies





A Tier 1-2 Community

"Minimally disturbed"

Stoneflies

Dragonflies,
Damselflies

Beetles

Midges

Mayflies

Caddisflies

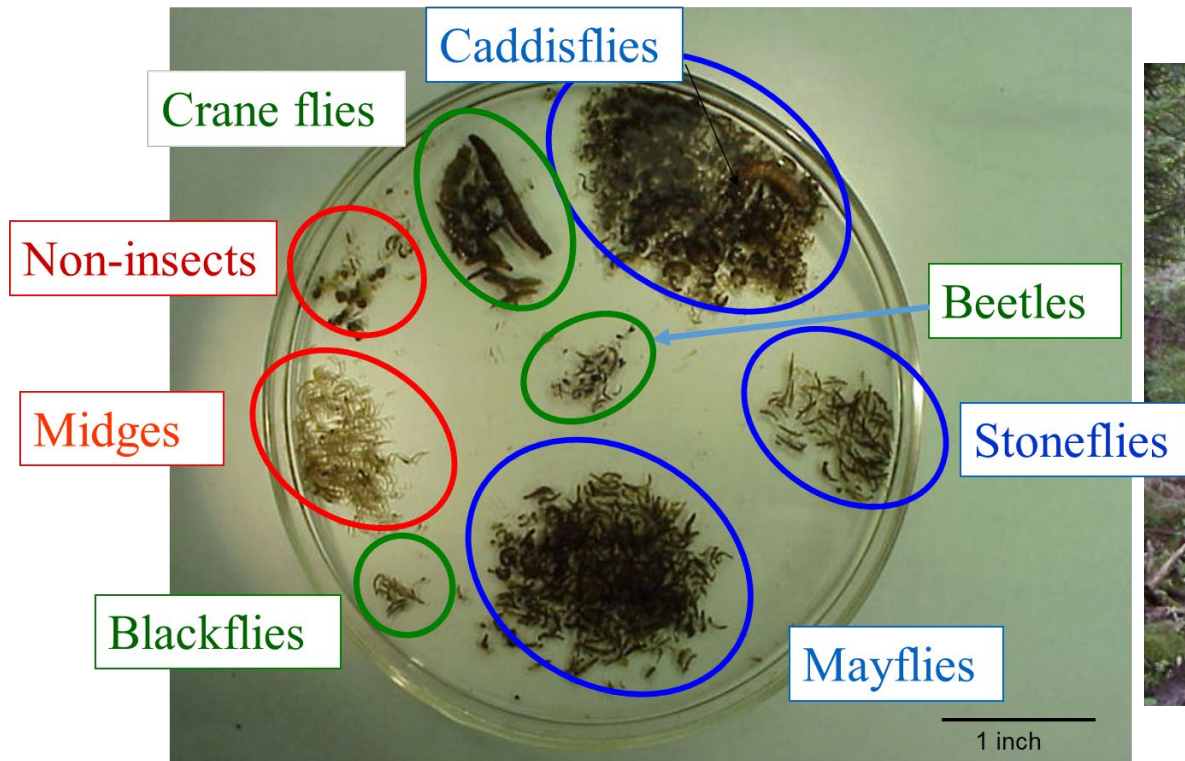
1 inch





A Tier 3 Community

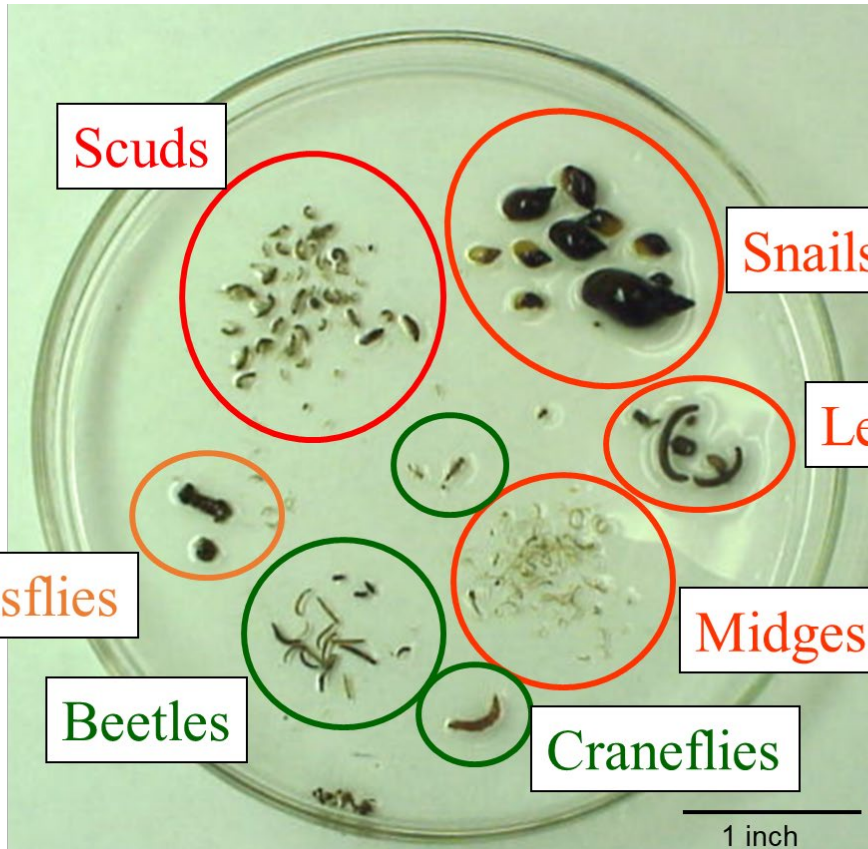
"Evident/moderate disturbance"





A Tier 5-6 Community

"Highly/severely disturbed"





Reference Site Approach

- Defining reference condition using minimally disturbed sites recognizes that natural stressors can affect the biology of a stream, introducing variability into the reference site data distribution.
- Natural drought will cause dry or stagnant flow conditions.
- High water, or floods, will limit the effectiveness of the sampling method.
- Substrate diversity at some reference sites may be naturally limiting



Reference Selection Criteria

- Landscape Development Intensity Index < 2 .
- Habitat Assessment Index $> 75\%$ of total points.
- Ammonia < 0.1 mg/L.
- Hydrologic Index < 6 .
- Exclude sites with average conductivity > 600 umhos/cm (eliminate “tidal” influence).
- Exclude sites receiving NPDES-permitted wastewater treatment facility discharges, based on a review of GIS coverage information from the Water Facilities Regulation (WAFR) database.
- Use samples with number of individuals identified ranging from 100-175 (inclusive).



Category III (“Impairment”) Line Based on Reference Sites

- Analysis to balance Type I and Type II errors given the inherent statistical error of the method.
- The examination of the two most recent visits at 55 reference streams showed that the 2.5th percentile of reference data was in the range of 35-44 points. The middle of this range was 40 points, which represents an impairment threshold that balances Type I and Type II errors.



Establishing SCI Thresholds for Impairment

- Biological Condition Gradient Approach
 - Workshop in 2006 with Florida experts
 - SCI = 35 was the lowest score that still meets CWA (BCG category 4)
- Reference Site Approach
 - 55 reference streams chosen through rigorous selection process
 - SCI = 40 determined to be protective



Using Multiple Lines of Evidence to Set the Exceptional Category

- Biological Condition Gradient Approach concluded that SCI scores of 64 and above were similar to natural (minimally disturbed).
- Reference site approach yielded 70.6.
- Averaging these complimentary approaches= 67.



Objectives Affect SCI Sampling Decisions and Interpretation of Results

- *from SCI Primer*

- Biota respond to natural and human stressors alike.
- Study objectives must be clearly articulated, and you must control for confounding factors that may interfere with the appropriate interpretation of the SCI scores.
- Especially consider:
 - existing and antecedent flow conditions,
 - habitat conditions, and
 - water quality issues.



Example TMDL Objective

- Determine if **water quality** issues are adversely affecting biological health.
- To place a waterbody on the verified list, must reasonably demonstrate the **pollutant** responsible for poor SCI scores.



Factors to Control for During TMDL Sampling

- Current and antecedent flow conditions
 - If desiccation or stagnant conditions have occurred, the flow regime, NOT water quality, will be dominant influence
- Habitat conditions at sampling site
 - By sampling where habitat is NOT limiting, you can emphasize water quality factors



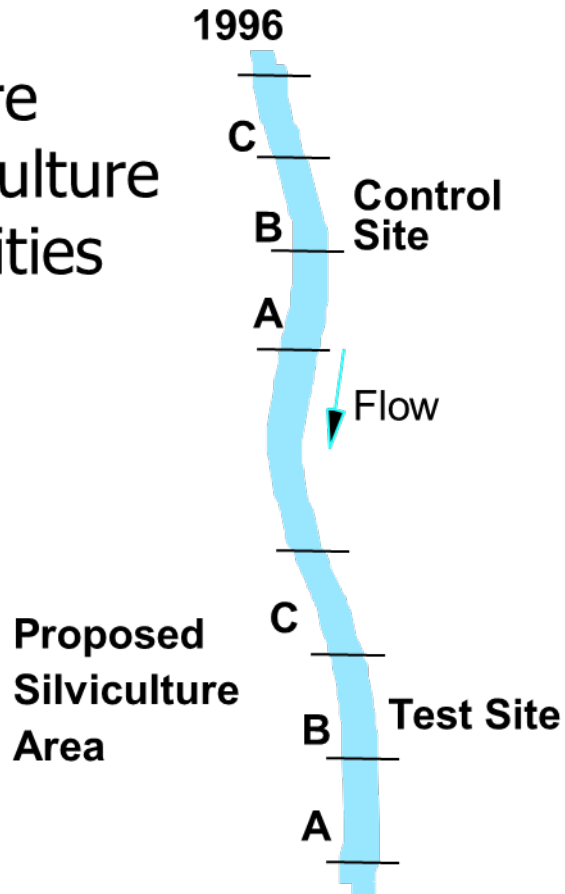
BMP Effectiveness Example

- Employed a “Before-After/Control-Impact” study design.
- Sites were selected where habitat and water quality were currently acceptable to determine if silviculture practices caused harm.
 - Controlled for prior habitat and water quality conditions to emphasize human activities and BMPs.

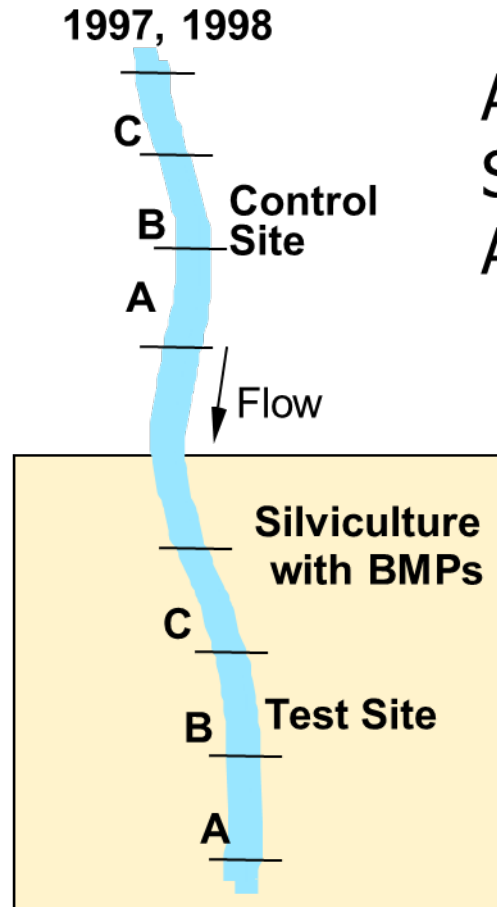


Experimental Design

Before
Silviculture
Activities

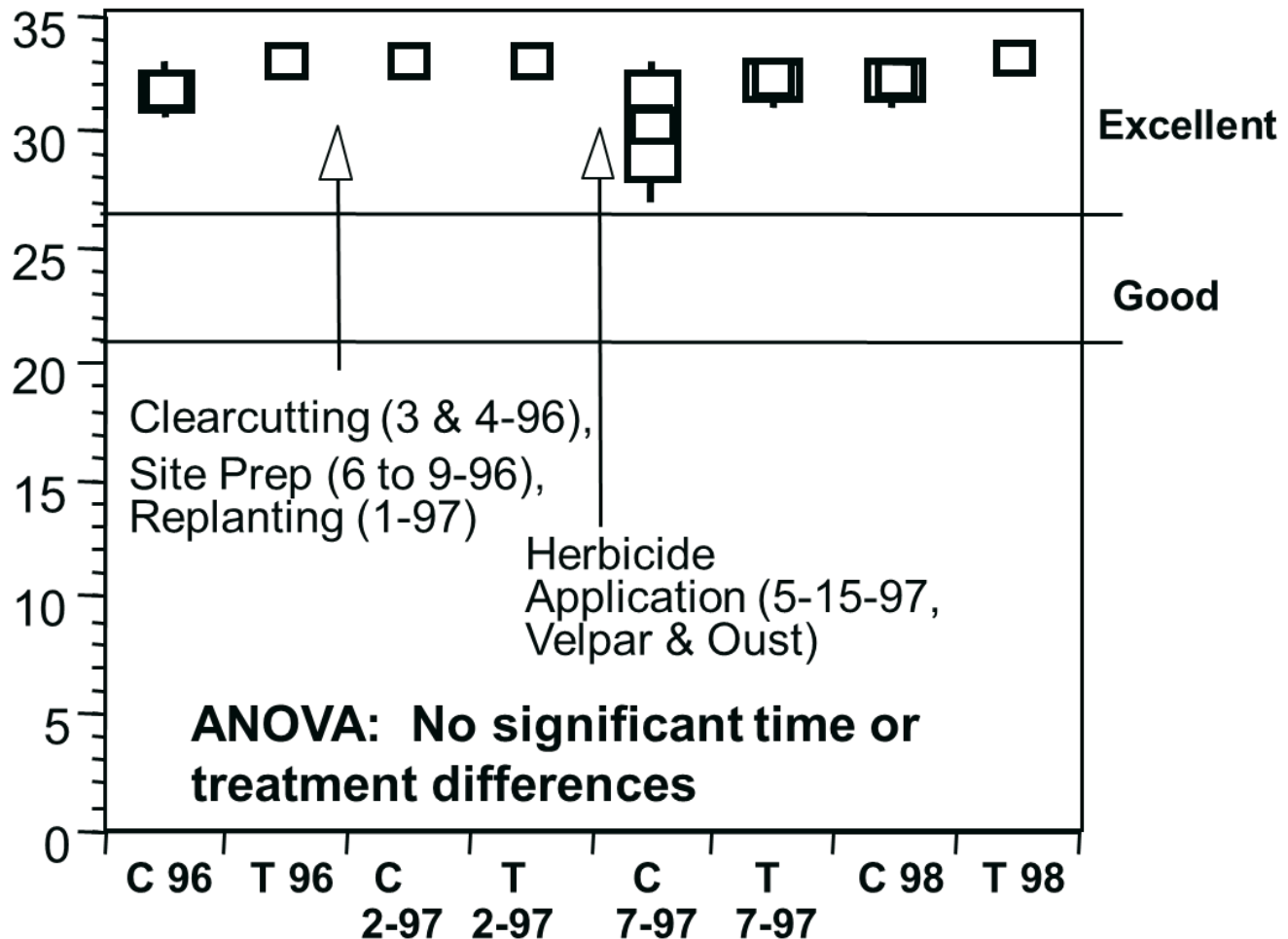


After
Silviculture
Activities





SCI results of a Before-After-Control-Impact study assessing the effectiveness of forestry Best Management Practices.





Objectives for Other DEP Programs

- BMP Effectiveness Studies
- Point Source Studies
- Stream Restoration Studies
- Minimum Flows and Levels Studies
- Status and Trends Monitoring Network

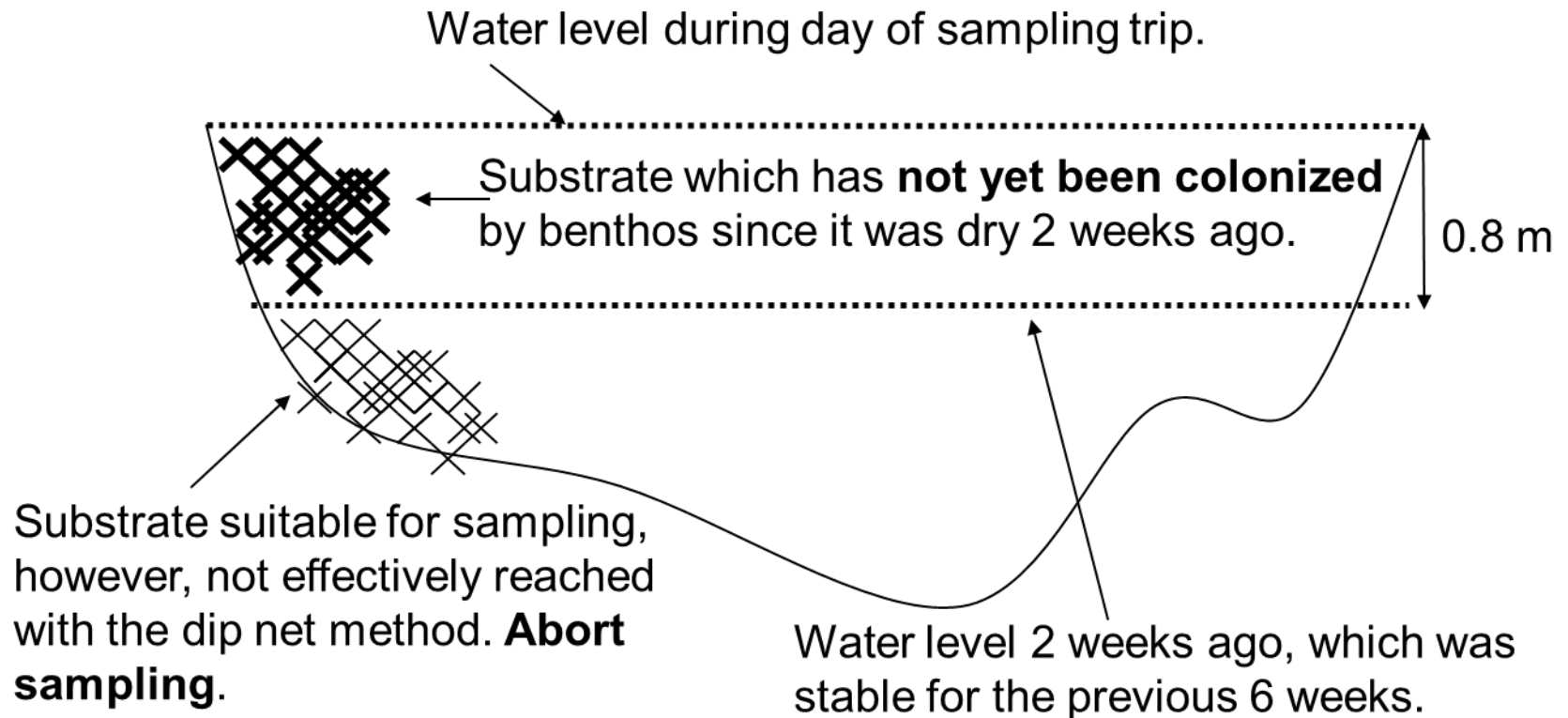


Water Level and the SCI

- Method can only effectively capture organisms residing in the top 0.5 m (reachable substrates).
- As water level increases, there is a one month lag time for taxa to colonize substrates.
- Aquatic organisms die if site goes dry, **minimum** of 3 month recovery period. Wait 6 months if you do not have information about recovery at that site.

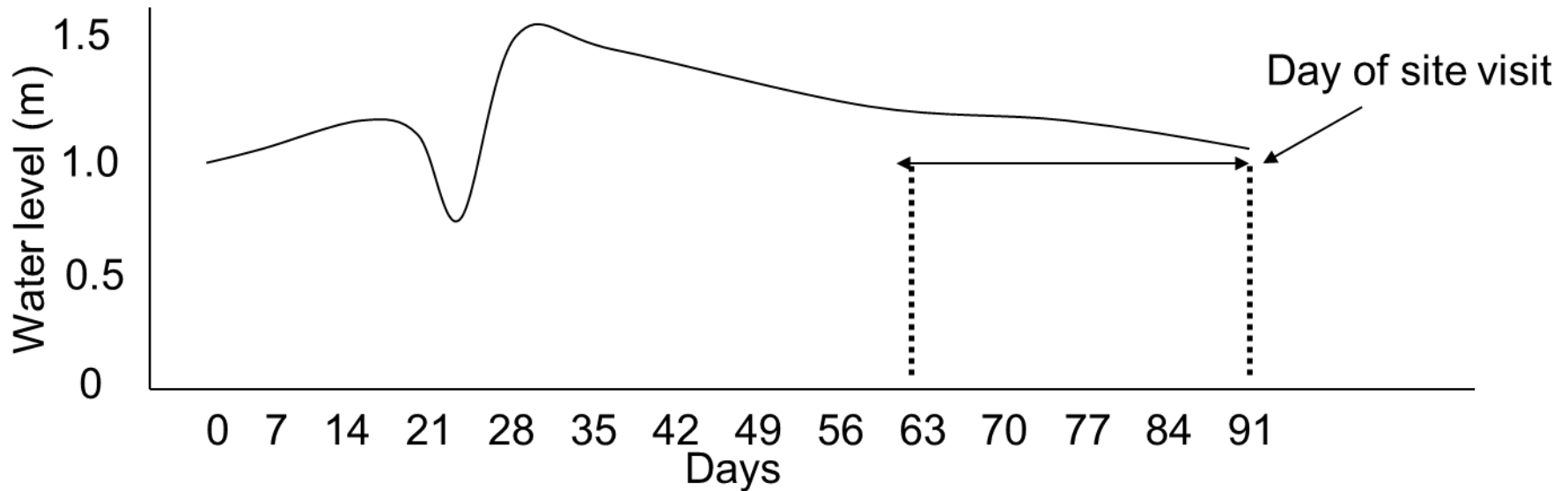


Schematic cross section of a stream showing recent increase in water levels indicating the SCI sampling should not be conducted.



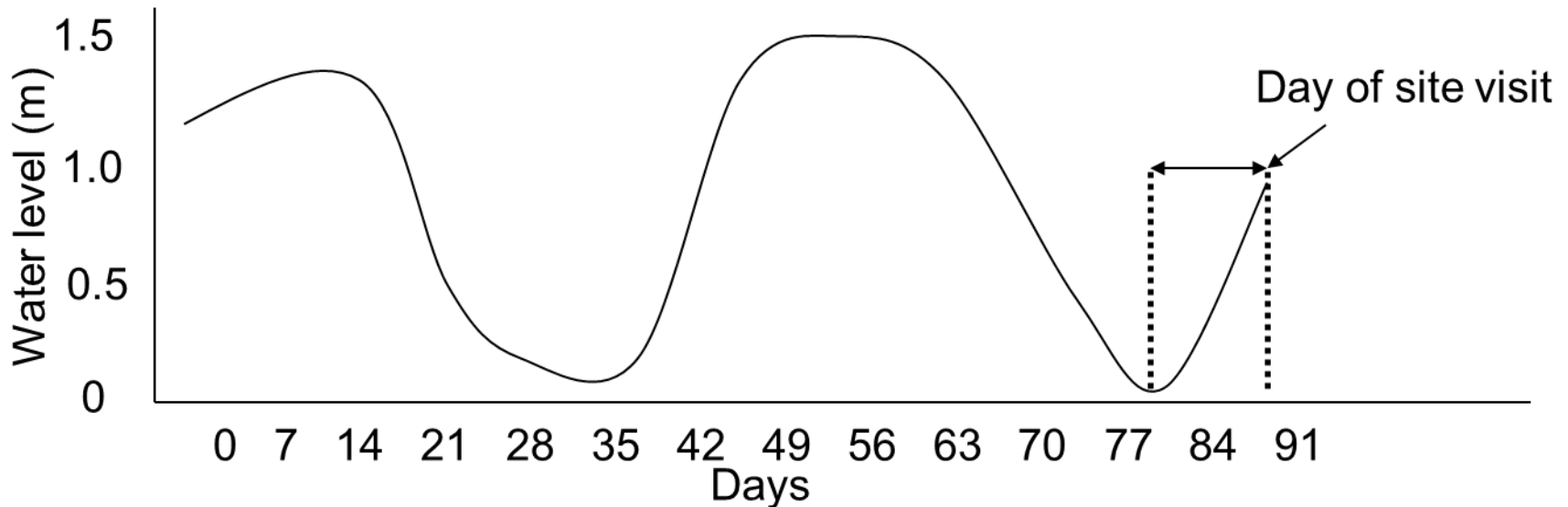


Hydrograph showing the reachable substrates have been inundated more than one month. This is a good time to sample SCI.





Recent increase in water level.
Reachable substrates have been
inundated for less than 2 weeks.
Abort sampling.





Before



After



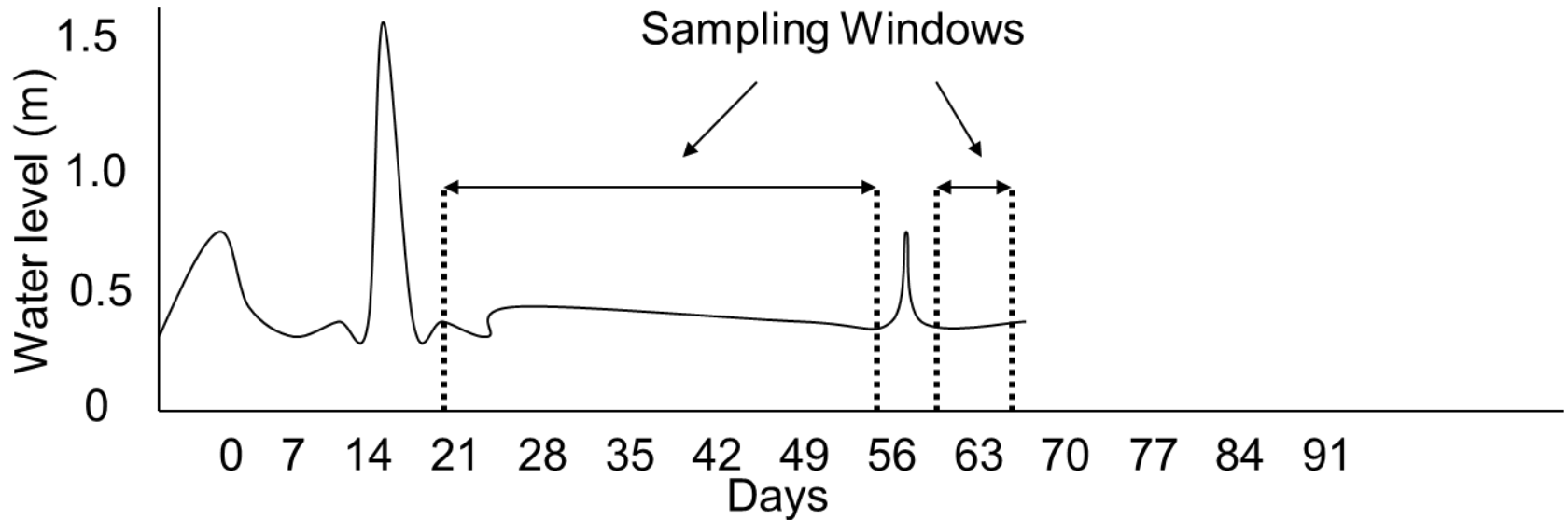


Before

After



Hydrograph showing times when substrates are reachable





SCI Samplers must exercise Best Professional Judgment

- Only an experienced, qualified SCI sampler can make the difficult field decisions necessary for proper application of the method.
- Samplers **MUST** understand objectives.
- There should be no artificial burdens that prevent samplers from making the correct scientific decision
 - Contract issues



Maintaining Linkages between the SCI and Important Associated Data

- All associated data (flow conditions, habitat scores, etc.) must be linked to the SCI results, so that a determination may be made that each sample was, or was not, consistent with the study objectives.
- Indiscriminate use of SCI scores will likely result in inappropriate or incorrect environmental decisions.
- Data analysts and managers have responsibility to fully understand the complexities associated with the SCI scores, and use the data appropriately.



The SCI Sampling Process

- Sampling Site Selection and System Classification
- Appropriate Antecedent Hydrologic Conditions
- Optimal Habitat Selection
- Sampling Technique
- Field Sorting as a Training Tool
- Apprenticeship



Relevant SCI Field SOPs

- SCI 1100 (FS 7420) – sampling method
 - Assess conditions and appropriateness for sampling, establish 100 m stretch
 - Complete Phys/Chem and HA
 - Determine productive habitats and perform 20 dipnet sweeps
 - Contain sample in jug and preserve
- SCI 1200, 1300 (FA 4310, 5700) contain training and proficiency requirements



Sampling Site Selection and System Classification

- Site should be appropriate for sampling objective.
 - Compare stream to stream, not stream to swamp-like or lake-like areas.
 - Unless MFL study, sample during some (0.05 m/sec) flow.
 - Generally sample areas with representative conditions, not atypical areas
 - Habitat and flow









Appropriate Antecedent Hydrologic Conditions

- Antecedent hydrologic conditions must be appropriate for the purpose of the study.
- How long have habitats in the top 0.5 m of the surface been inundated?
 - DO NOT sample recently dry habitats
- Hydrographs from area streams should be carefully examined
- Samplers need to develop intimate familiarity with the hydrology of streams in their regions.





Optimal Habitat Selection

- Target productive habitats (roots, woody debris, leaf material, macrophytes and rock)
- To be “major”, must have surface area greater than 2 m²
- Target optimal flow
- Think like a bug



Optimal Habitat Selection (cont.)

- Stream taxa are rheophyllic
 - Prefer areas with water velocity, which usually have higher DO and food availability
- Texture and architecture
 - Fine roots, peeling bark, nooks and crannies
- Ensure habitats have been inundated



Leaf packs/mats

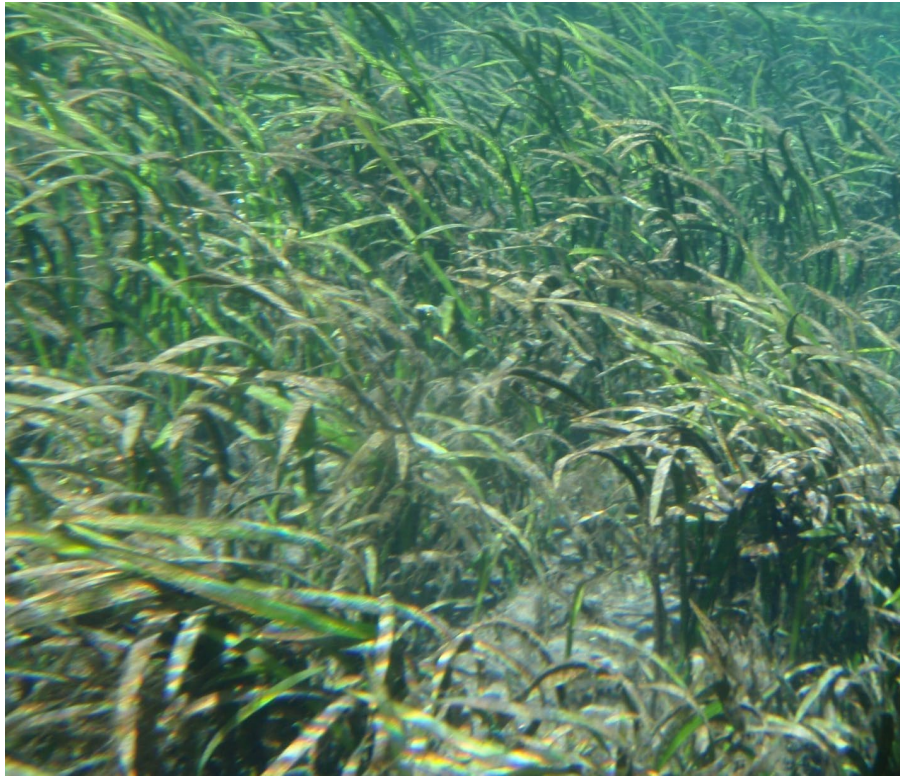


Roots





Aquatic vegetation





Sampling Technique

- Samplers absolutely must provide sufficient agitation of substrates to dislodge the organisms, and ensure that all organisms are captured (into the net) without loss.
 - Dip net should always be placed perpendicular to the flow
 - Agitate substrates with net very close
 - Scrub into the net (not parallel)



Sampling Technique (cont.)

- Vigorously shake and scrape all surfaces of the habitats at least 3 times, without organism loss
- Leaf packs are placed directly into the net and the organisms dislodged “one leaf at a time” before discarding excess leaves
 - Box technique for measuring packs
- Penetrate sand with fingers, to approximately 2 cm deep, and using a pulling motion, draw the organisms from the sand into the waiting dip net
 - Include partially buried bivalves



Sampling Technique (cont.)

- Leaf packs are preferred over leaf mats, unless only mats available
- For leaf mats, only sample the top 1-2 cm to avoid the anoxic layers below
- Large rivers can be sampled from the bow of a boat (best for reachable snags in deep areas) or by wading along the shoreline



20 Dipnet Sweeps for SCI

- Productive habitats – snags, roots, leaves, rock, aquatic vegetation (need 2m² for “major”)
- “Minor” sweeps are in sand, muck, and in productive habitats with < 2m² cover.

# Major habitats	# Sweeps in Majors	# Sweeps in Minor
1	10	10
2	7,7	6
3	5,5,5	5
4	4,4,4,4	4
5	3,3,3,3,3	5



Field Sorting as a Training Tool

- Field sorting provides the sampler immediate feedback regarding the degree of success associated with the field decisions and sampling effectiveness.
- Sort individual sweeps via white tray, and examine taxa with hand lens.
- Field sorting not part of actual SCI (Biorecon only).



Field Sorting Yields

Megalopteran, “Gator Flea”





Apprenticeship

- Experienced SCI samplers must contribute to the training of novice staff.
- Goal is to produce SCI samplers with the necessary critical thinking skills and sampling technique required by the SOP.
- Training should consist of numerous field visits (minimum of 10), at a variety of sites (starting at reference sites, followed by disturbed sites) and different water levels.

Bioassessment Training, Evaluation, and Quality Assurance

[Home](#) » [Divisions](#) » [Division of Environmental Assessment and Restoration](#) » [Bioassessment Program](#) » Bioassessment Training, Evaluation, and Quality Assurance

Bioassessment Program Quick Links

[What is Bioassessment?](#)

[Bioassessment Methods](#)

[Bioassessment Training, Evaluation, and Quality Assurance](#)

[Bioassessment Testing Registry](#)

[Biocriteria Meetings](#)

[Plant Identification Resources](#)

[Macroinvertebrate Resources](#)

[Bioassessment Links](#)

[All Bioassessment Program Content](#)

- [Stream Condition Index](#)
- [BioRecon](#)
- [Stream and River Habitat Assessment](#)
- [Lake Vegetation Index](#)
- [Stream Floral Tools – Rapid Periphyton Survey, Linear Vegetation Survey](#)

[Biological Assessment Training Requirements](#) - DEP Bioassessment Training and Testing Guidelines: Rivers and Streams

[Bioassessment Testing Registry](#) - Searchable query for individuals who have completed a sampling audit to support either SCI or BioRecon sampling events.

[DEP Field SOPs](#)

[Quality of Science e-newsletter](#) - Register for this e-newsletter to receive announcements from DEP about training or testing opportunities.

[Field Sampling Forms](#)

Additional Resources

Video training - [Stream Ecology, Module 1](#)

Stream Condition Index

DEP recommends the training process described in the following links, and recommends that anyone wishing to submit SCI data to

<https://floridadep.gov/dear/bioassessment/content/bioassessment-training-evaluation-and-quality-assurance#sci>



Training Log

- Complete for minimum of 10 practice sites (include 3 low impact sites, 3 high impact sites)
- Trainer signs off on training
- Evaluator conducts a “mock audit” when training is complete to ensure readiness
- Contact DEP for audit
- Pass online test and field audit
- Online registry of SCI samplers
 - <http://fldeploc.dep.state.fl.us/sci/query.asp>



Auditing

- The initial demonstration of capability audit is just a starting point
- Samplers should be periodically observed while conducting the entire 20 dip nets to ensure acceptable data.
- Refresher audit every 5 years
 - On-line test and submitting actual data from a reference site



Conclusions

- A scientifically robust SCI requires proper application of the method and correct interpretation of the results
 - Clearly defined objectives
 - Control of confounding variables
 - Post-hoc evaluation of associated data
 - Trained professional staff for sampling and analysis



For More Information

<https://floridadep.gov/dear/bioassessment/content/bioassessment-training-evaluation-and-quality-assurance>

