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Introduction to Benthic-invertebrate Biomonitoring and Biocriteria

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Why Monitor?

"Change is an intrinsic property of ecosystems.

For effective conservation, acceptable rates and directions of change need to be determined. A preliminary step is the development of methods for detecting, measuring and assessing the significance of ecological change."

— J.M. Hellawell, 1977

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Biomonitoring Rationale

"Biomonitoring is required … because the consequences of environmental stress can only be determined by an appraisal of the biota". –Wright (2000)

"Since the effect of stream pollution is an alteration of the aquatic ecosystem, evaluation of that ecosystem is the logical way to detect pollution" –Hilsenhoff (1977)

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Stressor- and Effect-based Monitoring Activities are Complementary

Water-chemistry Survey

We need both

Benthic-invertebrate Biomonitoring

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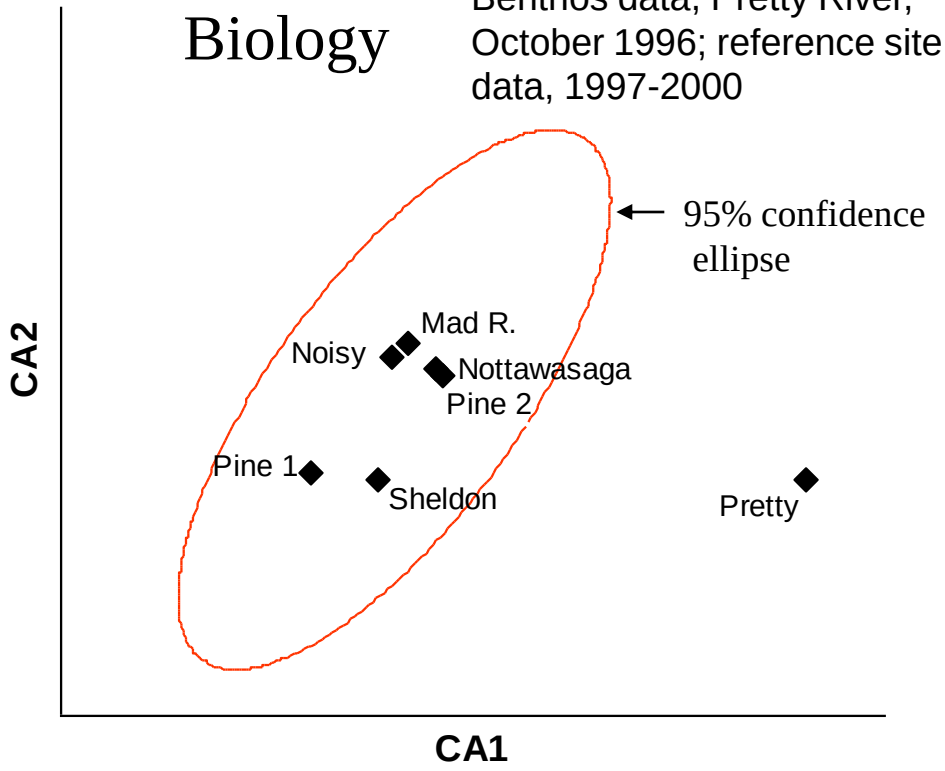
Stressor and Effect-based Approaches are Complementary

Biology

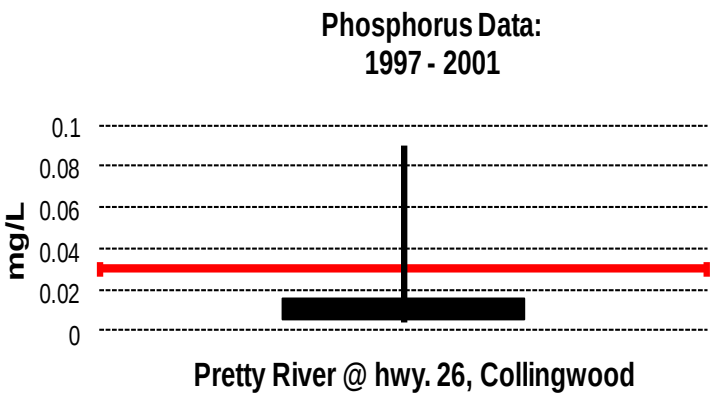
Benthos data, Pretty River, October 1996; reference site data, 1997-2000

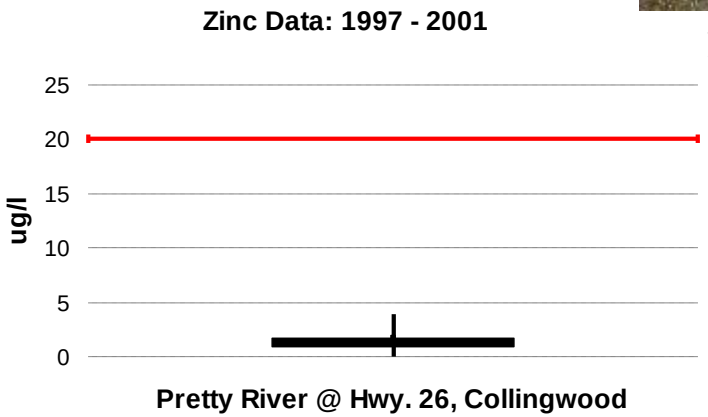


Pretty River, Highway 26, Collingwood, Ontario

Chemistry

= Ontario Water Quality Objective





What are Benthos?

Bottom-dwelling aquatic invertebrates

Include animals like insects, worms, mollusks, crustaceans, and mites

Mayfly of the family Ephemerellidae.

Caddisfly of the family Helicopsychidae

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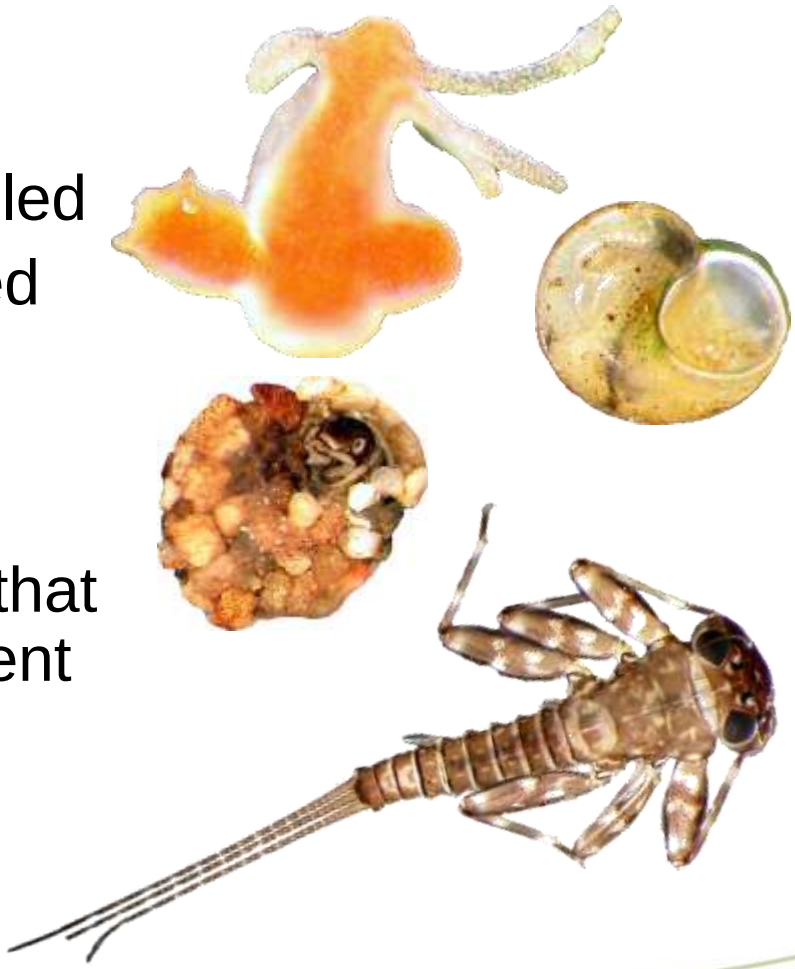
Benthic Invertebrate Community: an Example of a Good Indicator

- Abundant and widespread
- Easily and inexpensively sampled
- Sedentary & relatively long lived (months to years)
- Many species, having different tolerances
- Respond to multiple stressors that affect habitat and water/sediment chemistry
- Provide early-warning



(Rosenberg & Resh 1993, 1996; Mackie 2001)

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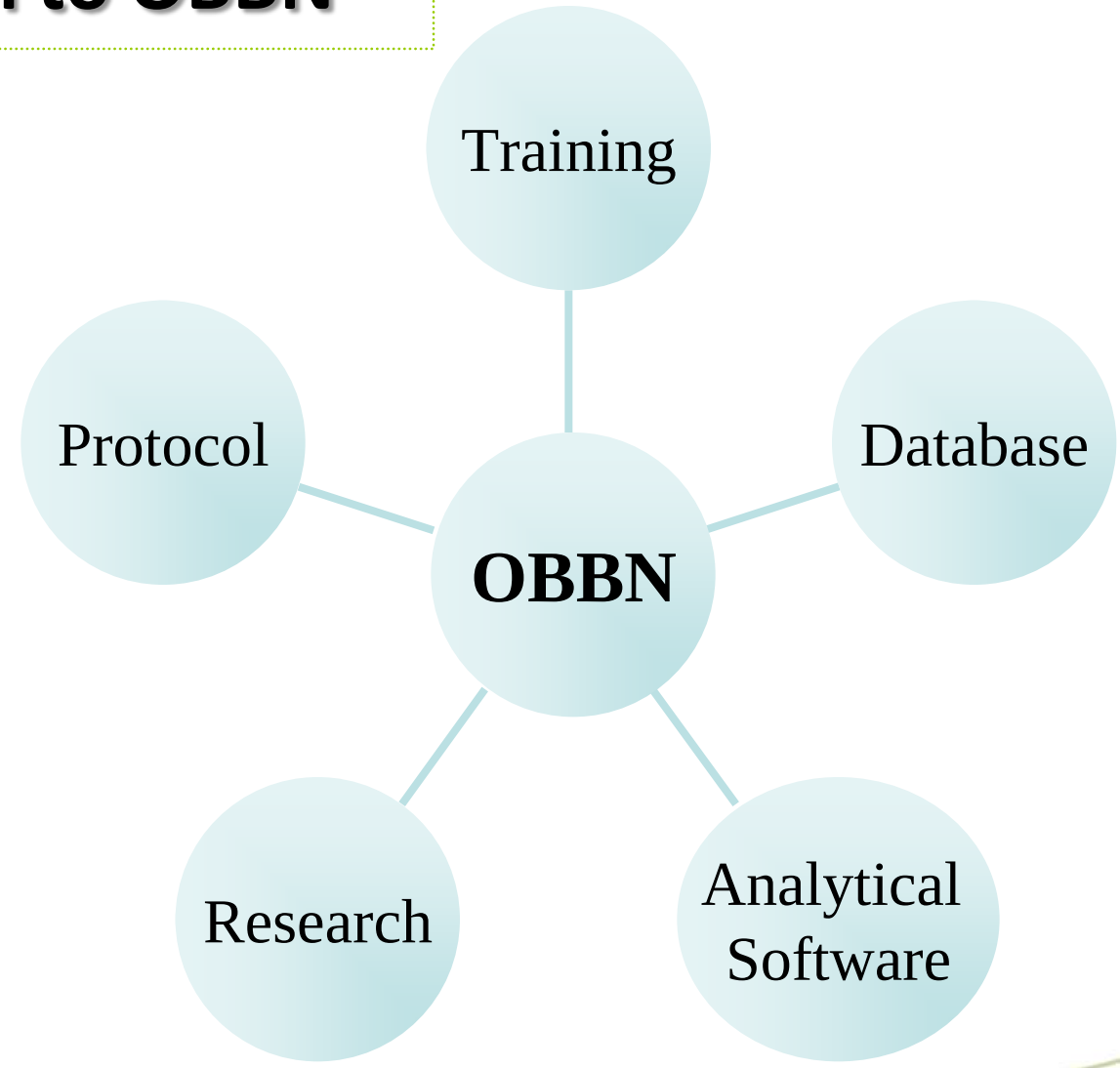
Introduction to OBBN



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Sampling Methods





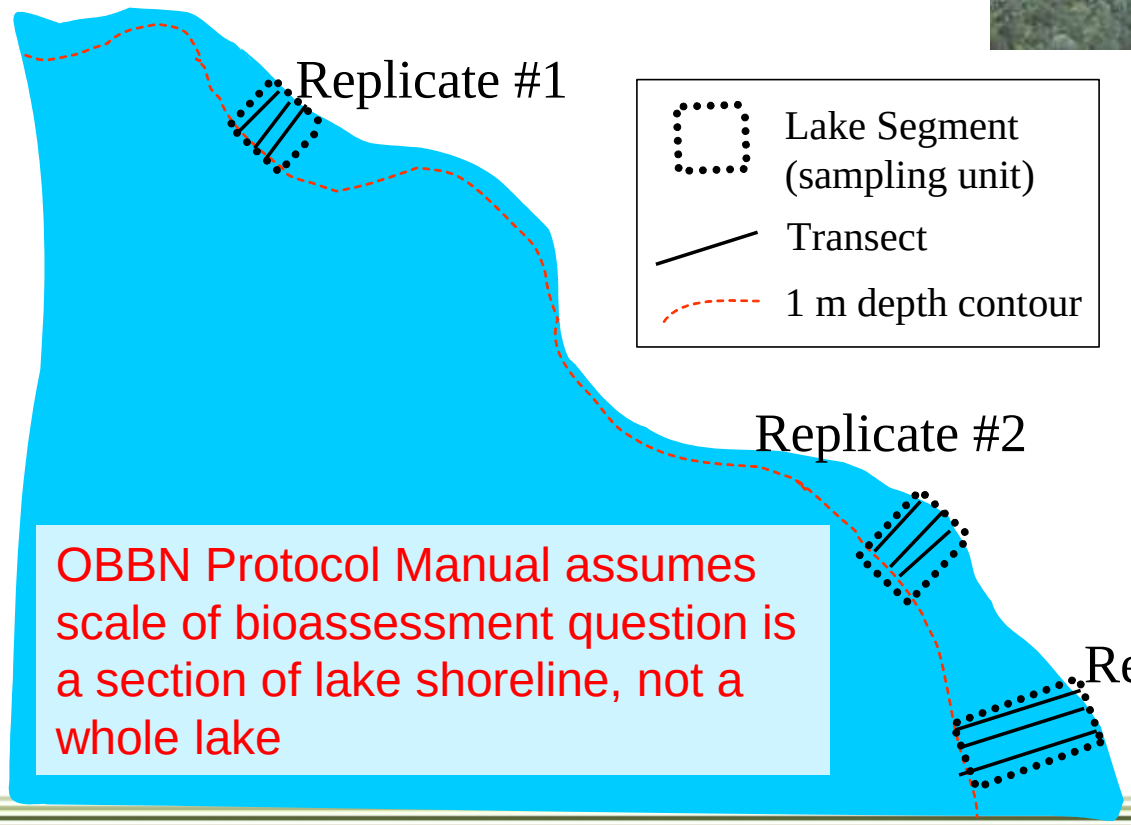



Lakes

Sampling Unit

Replication

Collection Method



- Sampling unit is "lake segment"
- 10 minute traveling kick and sweep along transects
- 3 replicates collected

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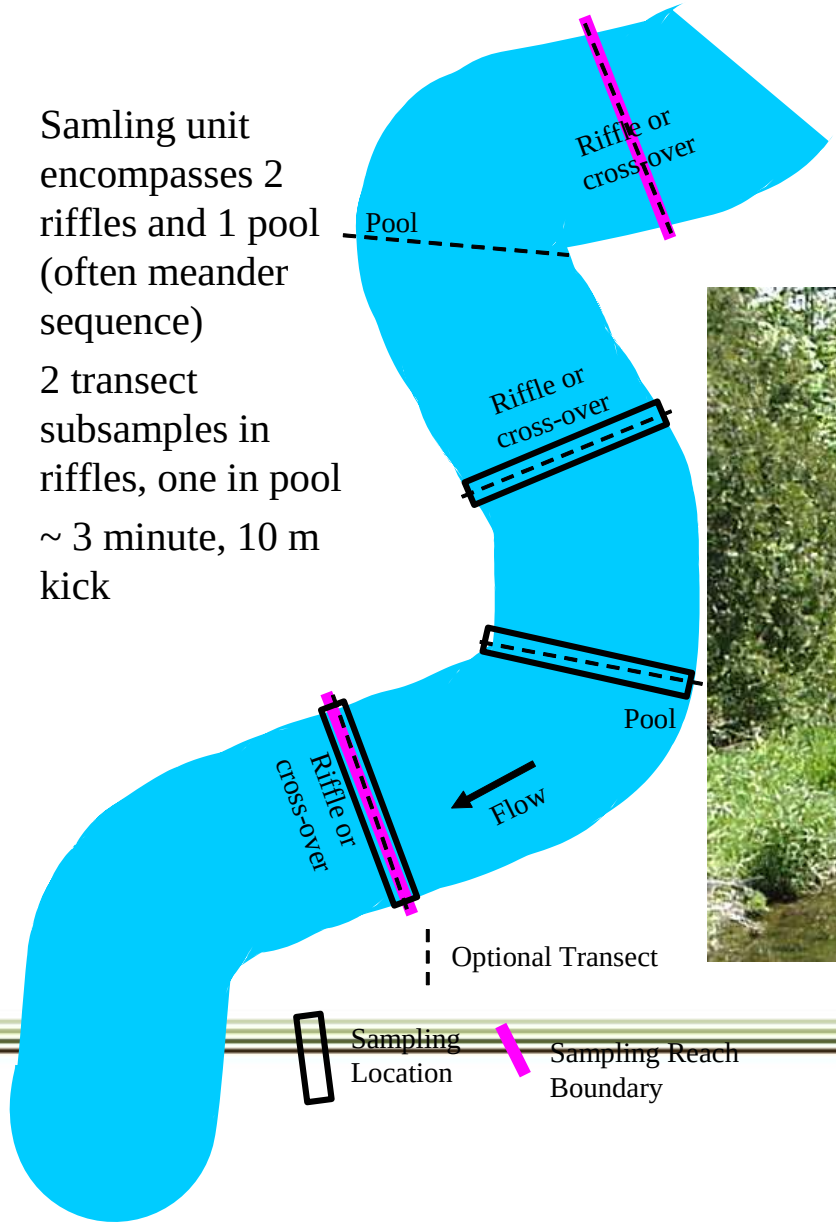
Streams

Replication & collection methods

- Samling unit encompasses 2 riffles and 1 pool (often meander sequence)
- 2 transect subsamples in riffles, one in pool
- ~ 3 minute, 10 m kick



Transect Traveling Kick and Sweep

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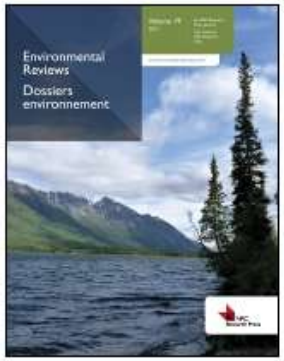
Sample Processing

- Sieve
- Sub-sample
  - Marchant Box (preferred)
  - Bucket method
- Sort carefully (microscope preferred)
- ID and tally (taxonomic level matches training; Family or more detailed preferred)
- 100-count (minimum)
- Preserve and archive sample



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Taxonomic sufficiency: The influence of taxonomic resolution on freshwater bioassessments using benthic macroinvertebrates

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ABSTRACT

Changing the taxonomic scale of a biotic-assemblage dataset influences our ability to detect ecological patterns. In bioassessments, a test-site's biological community is compared against a benchmark to indicate ecosystem condition, but the taxonomic resolution needed to judge impairment reliably is the subject of much scientific debate. This paper reviews taxonomic sufficiency for freshwater benthic-macroinvertebrate bioassessments. Three main issues are discussed: (1) the ecological significance of different taxonomic aggregations; (2) trade-offs involving taxonomic detail and information content versus money, time, expertise, and data quality; and (3) sampling- and analytical-method-specific factors affecting taxonomic sufficiency. Although Species should be the default taxonomic level for bioassessments, taxonomic sufficiency is chiefly determined by a study's purpose, and pragmatism often dictates reduced detail. When a taxonomic-minimalism approach is necessary, a quantitative criterion for taxonomic sufficiency should be specified; this criterion should be based on an optimization of cost-benefit trade-offs associated with different taxonomic scales. Mixed-level aggregations, as well as morpho-species and ecological-trait classifications should be considered in this optimization process. Looking to the future, closer ties between taxonomists and bioassessment researchers would benefit both of their disciplines. Such coordination would provide the autoecological information and better diagnostic tools (such as keys and molecular methods) needed for biomonitoring, and better (and more widespread) biomonitoring would fuel

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Problem:

"Healthy is Variable."

–Dr. Robert Bailey, University of Western Ontario

- 2 equally healthy sites may have different biological assemblages
- Need to determine what normal is
- Biomonitoring conundrum: Is an observed difference greater than expected by chance? Is it biologically meaningful?

Stream		
Sample		
Date		
Partner		
HYDRACARINA		
Trhypochthoniidae	2	1
EPHEMEROPTERA		
Baetidae	81	49
Ephemerellidae	1	2
PLECOPTERA		
Leuctridae	1	1
Capniidae	1	0
Perlodidae	6	5
Chloroperlidae	0	1
TRICHOPTERA		
Rhyacophilidae	2	1
Hydropsychidae	2	3
COLEOPTERA		
Elmidae	11	20
DIPTERA		
Chironomidae	20	29
Ceratopogonidae	3	2
Tipulidae	4	6
Simulidae	0	2
Empididae	1	0
Total:	135	122

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Problem:

"Healthy is Variable."

–Dr. Robert Bailey, University of Western Ontario

- 2 equally healthy sites may have different biological assemblages
- Need to determine what normal is
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Stream	Baxter	Baxter
Sample	Riffle 1	Riffle 2
Date	16-Aug-04	16-Aug-04
Partner	ORCA	ORCA
HYDRACARINA		
Trhypochthoniidae	2	1
EPHEMEROPTERA		
Baetidae	81	49
Ephemerellidae	1	2
PLECOPTERA		
Leuctridae	1	1
Capniidae	1	0
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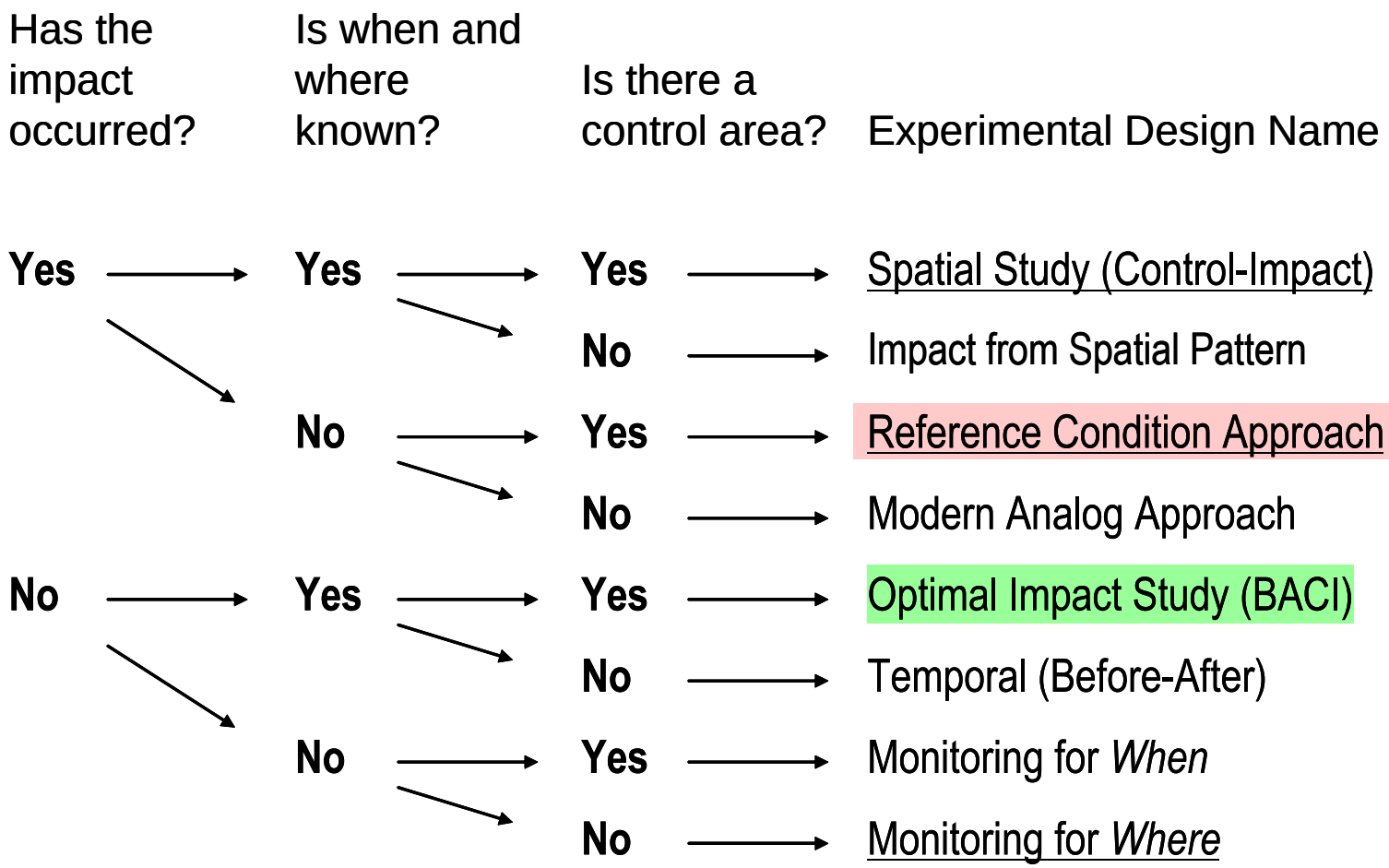
Experimental Designs for Bioassessments



(Adapted from Green 1979 [Bowman and Somers 2005]; see also Underwood 1997)

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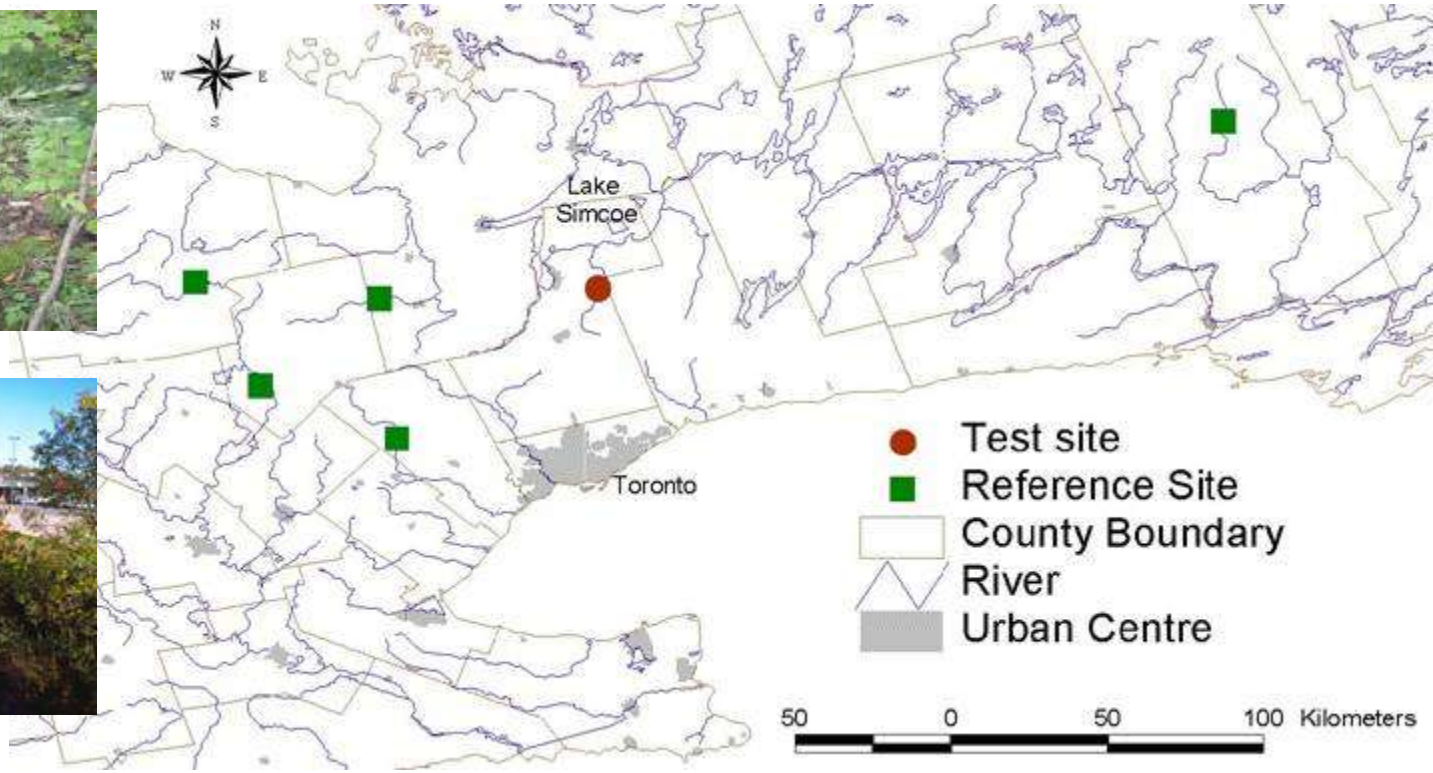
Reference Condition Approach (RCA)

Multiple, minimally impacted control sites to define the normal range of biological conditions to be expected at a test site

Reference site

Test site



"Long-term monitoring programs…provide the measures of normal (reference data) against which the abnormal is judged. It is impossible to convince a court that something is wrong if 'right' is not defined." – MOEE Biomonitoring Review Committee, 1994

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Can You Spot the Reference Site?

☺?

☺?

☺?

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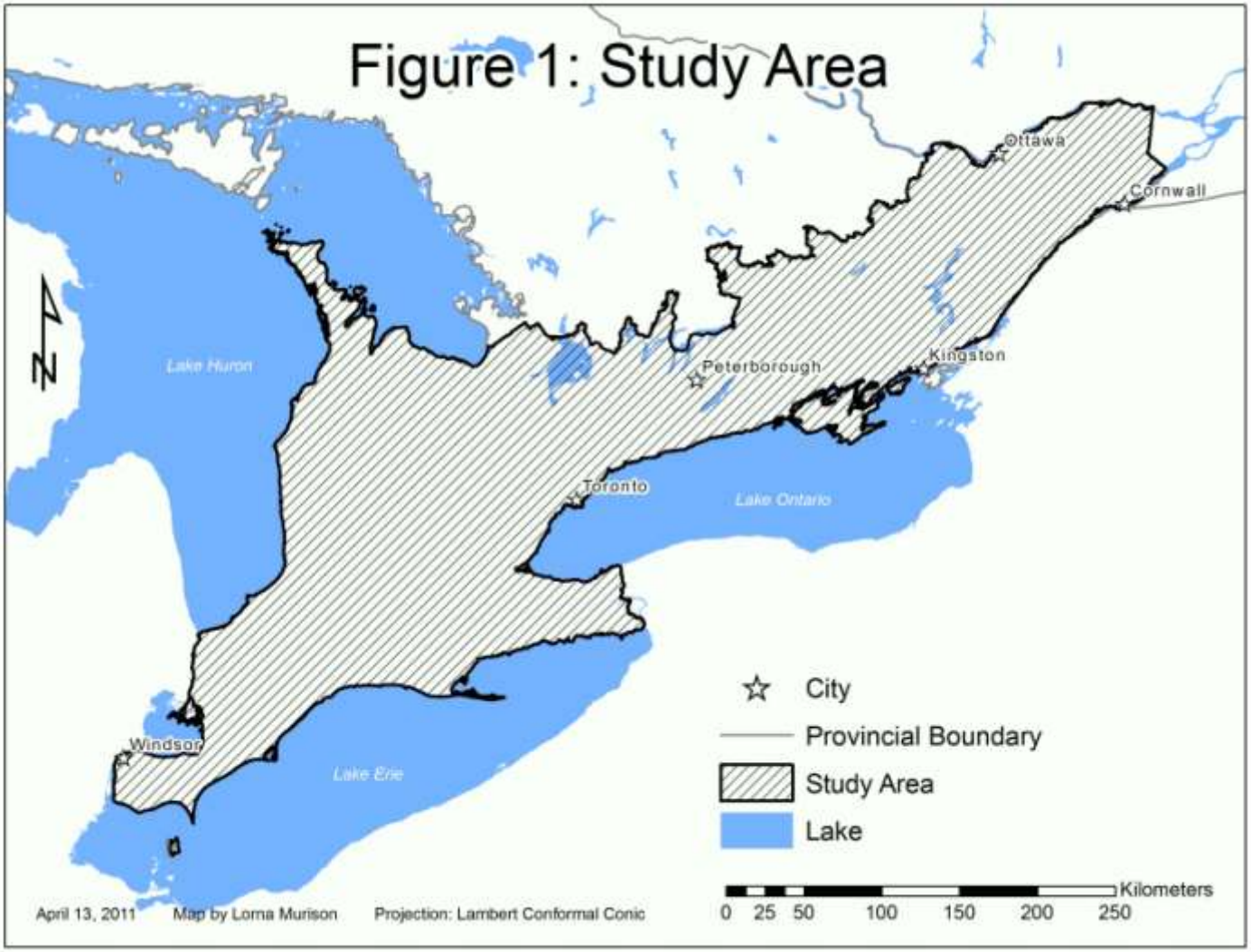
Reference Criteria and Biocriteria



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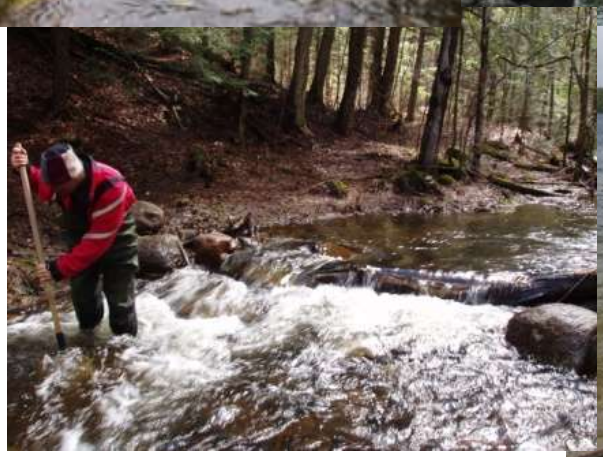
Example of Biocriteria (south-western Ontario)

Biological Indices	Biocriteria	
	10^{th} Percentile	90^{th} Percentile
% Chir.	18.7	65.6
% CIGH	0.0	3.9
% Clit.	0.3	13.0
% EPT	3.3	49.6
% FC	0.3	9.2
% GC	34.2	74.2
% P	8.0	19.3
% SC	2.3	37.0
% SH	0.4	15.9
FBI	4.5	6.7
Richness	10.7	19.2

Other Research



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Summary