Development of a Lake Macroinvertebrate Index of Biotic Integrity for Illinois

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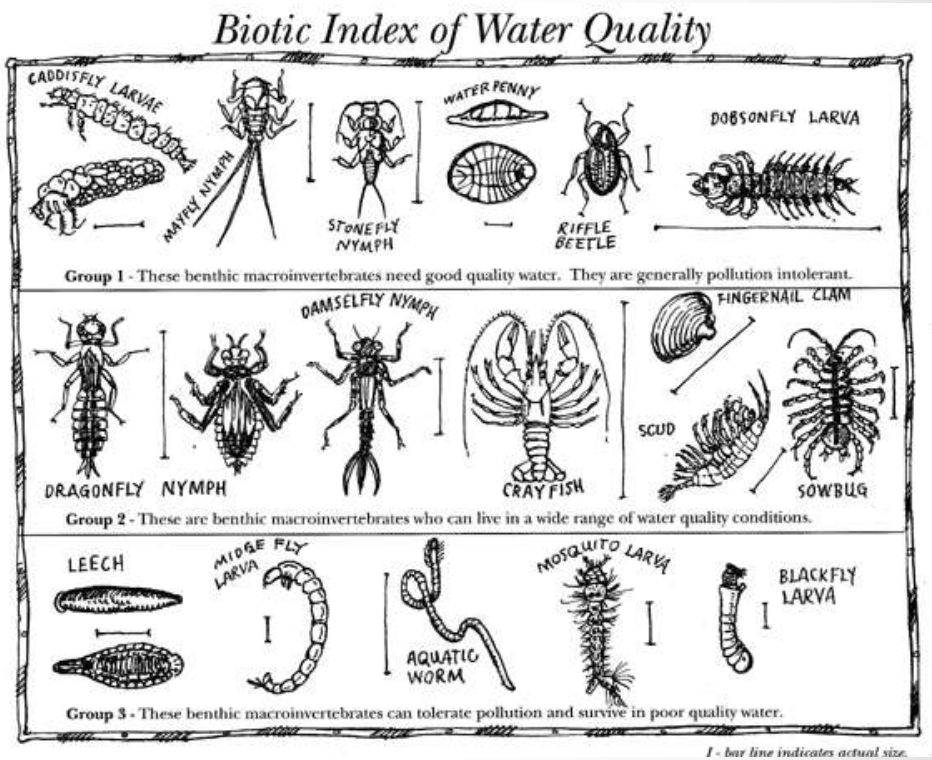
What is an m-IBI?

- Combination of metrics to generate numeric scores responding across a gradient of human disturbance
- Scores can be compared between lakes, or for a single lake overtime
- Good for lakes because it can describe the impacts of multiple pollutants or physical disturbances



http://www.epa.gov/superfund/students/clas_act/spring/critter.htm#Biotic Index

* **Shelburne Farms**, Copyright © 1995.

Metrics and Stress Response

- Biological Metric- condenses a list of organisms into a number that responds predictably to natural or anthropogenic changes

  Metric Categories

  - Richness and Composition Metrics: *total number of taxa, number of long lived taxa*
  - Tolerance Metrics: *number of tolerant taxa, percent of intolerant taxa*
  - Feeding Group Metrics: *Percent abundance of scrapers, percent of predators*
  - Population Metrics: *total abundance per sample, percent dominance*
  - Habit Metrics: *percent clingers, number of burrower taxa*

- Each metric increases or decreases in response to stress.
- Stress can include many variables for example: habitat destruction, nutrient inputs, or lack of oxygen.

Macroinvertebrate

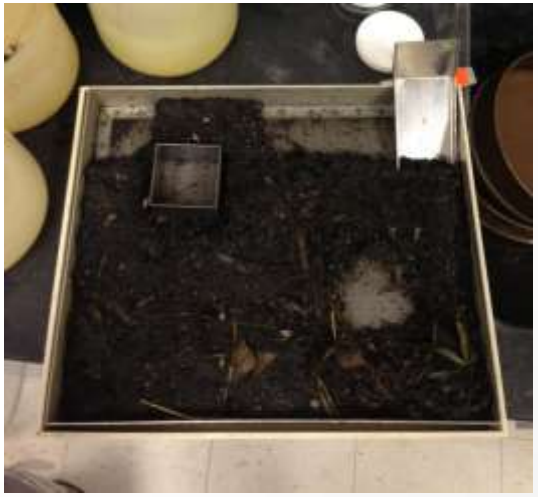
- 5 habitat method
- Littoral Plant
- Littoral Fine
- Littoral Hard Substrate (woody debris/cobble)
- Sub-littoral
- Profundal
- 3 grabs/jabs composite for each habitat type
- Each lake generated 5 samples

Data Collection

- 2008 to 2012
- IL EPA data collections, each office conducted additional surveys at about 5 lakes each year. (15 per year)
- 2011 Contracted out monitoring of 50 lakes
- 102 surveys conducted total
- Temporally standardized as late summer macroinvertebrate samples
- Also collected physical and chemical parameters, sediment chemistry. Shoreline habitat surveys and macrophyte surveys at IL EPA sampled lakes only.

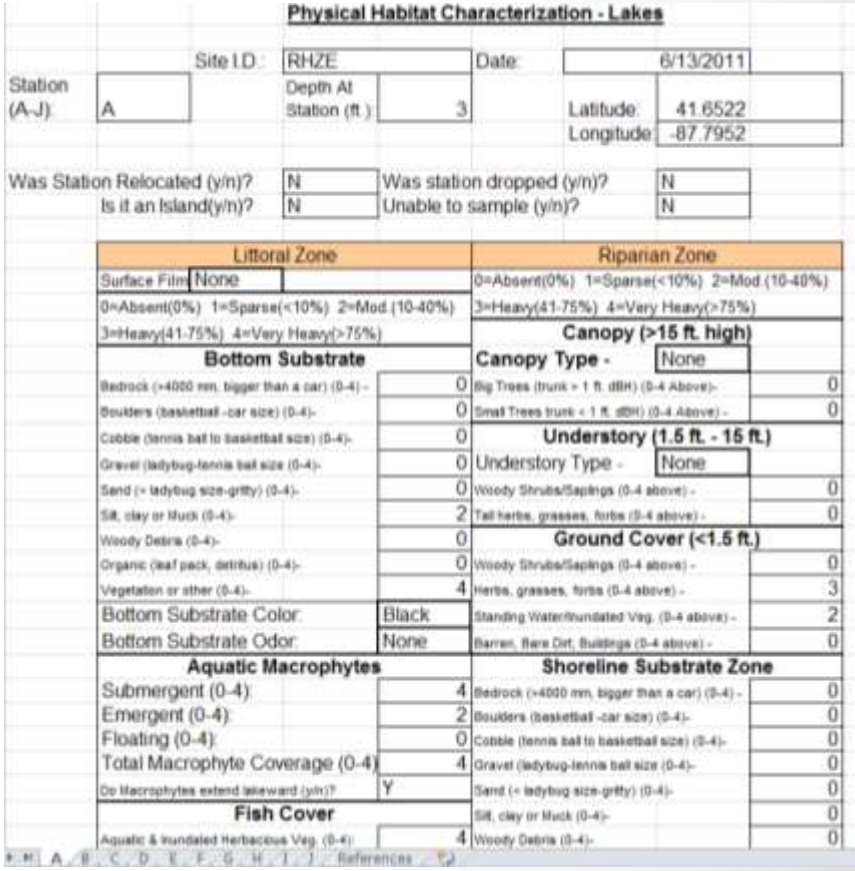
Sorting and Taxonomy

- Subsample to a standard 500 organism count
- Taxonomy to the lowest possible level
- Usually to genus
- Few key taxa routinely identified to species level: *Ablabesmyia, Dicrotendipes,* and *Polypedilum*
- Had to contract out some taxonomy



Shoreline Habitat

- Followed a method described by the USEPA National Lake Assessment Surveys in 2007.
- 10 equally spaced locations are chosen at random on the shoreline of a lake.
- Navigate to stations by boat
- Fill out form which describes:
  - Bottom substrates-Littoral
  - Aquatic macrophytes-Littoral
  - Fish cover-Littoral
  - Canopy-Riparian
  - Understory-Riparian
  - Shoreline substrate-Riparian
  - Human Influence-Riparian
  - Physical Habitat Features



Physical Habitat Characterization - Lakes

		Site I.D.	RHZE	Date	6/13/2011
Station (A-J)	A	Depth At Station (ft.)	3	Latitude	41.6522
				Longitude	-87.7952
Was Station Relocated (y/n)?	N	Was station dropped (y/n)?	N		
Is it an Island(y/n)?	N	Unable to sample (y/n)?	N		

Littoral Zone		Riparian Zone	
Surface Film	None	0=Absent(0%) 1=Sparse(<10%) 2=Mod.(10-40%)	
0=Absent(0%) 1=Sparse(<10%) 2=Mod.(10-40%)		3=Heavy(41-75%) 4=Very Heavy(>75%)	
3=Heavy(41-75%) 4=Very Heavy(>75%)		**Canopy (>15 ft. high)**	
Bottom Substrate		Canopy Type -	None
Bedrock (>4000 mm, bigger than a car) (0-4) -	0	Big Trees (trunk > 1 ft. dBH) (0-4 Above)-	0
Boulders (basketball -car size) (0-4)-	0	Small Trees trunk < 1 ft. dBH) (0-4 Above) -	0
Cobble (tennis ball to basketball size) (0-4)-	0	**Understory (1.5 ft. - 15 ft.)**	
Gravel (ladybug-tennis ball size (0-4)-	0	Understory Type -	None
Sand (< ladybug size-gritty) (0-4)-	0	Woody Shrubs/Saplings (0-4 above) -	0
Silt, clay or Muck (0-4)-	2	Tall herbs, grasses, forbs (0-4 above) -	0
Woody Debris (0-4)-	0	**Ground Cover (<1.5 ft.)**	
Organic (leaf pack, detritus) (0-4)-	0	Woody Shrubs/Saplings (0-4 above) -	0
Vegetation or other (0-4)-	4	Herbs, grasses, forbs (0-4 above) -	3
Bottom Substrate Color:	Black	Standing Water/Inundated Veg. (0-4 above) -	2
Bottom Substrate Odor:	None	Barren, Bare Dirt, Buildings (0-4 above) -	0
Aquatic Macrophytes		**Shoreline Substrate Zone**	
Submergent (0-4):	4	Bedrock (>4000 mm, bigger than a car) (0-4) -	0
Emergent (0-4):	2	Boulders (basketball -car size) (0-4)-	0
Floating (0-4):	0	Cobble (tennis ball to basketball size) (0-4)-	0
Total Macrophyte Coverage (0-4)	4	Gravel (ladybug-tennis ball size (0-4)-	0
Do Macrophytes extend lakeward (y/n)?	Y	Sand (< ladybug size-gritty) (0-4)-	0
Fish Cover		Silt, clay or Muck (0-4)-	0
Aquatic & Inundated Herbaceous Veg. (0-4):	4	Woody Debris (0-4)-	0

A B C D E F G H I J References

Macrophyte Surveys

Aquatic Macrophyte Survey Sample Size by Lake Size and Secchi Depth

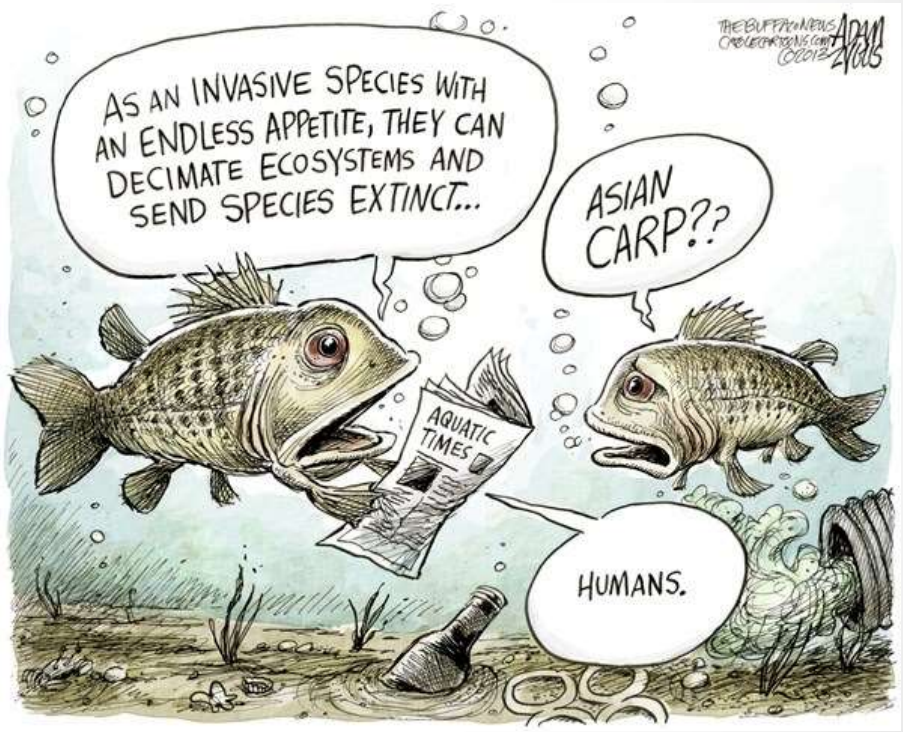
Lake Size (acres)	Total Sample Points	Surface to Secchi	Secchi to 2x Secchi
<10	20	13	7
10-49	30	20	10
50-99	40	27	13
100-199	50	34	16
200-299	60	40	20
300-399	70	48	22
400-499	80	53	27
500-799	90	60	30
≥800	100	67	33

- Conducted once during monitoring season
- July or August
- Samples dependent on lake size
- Qualitative Measure of aquatic plants

Macrophyte Survey

Stressor Gradients

- Targeted Stressors are related to human impact
- Anthropogenic nutrient inputs
- Eroded shorelines
- Habitat destruction
- Management Activities
- ***Not*** targeting natural variation



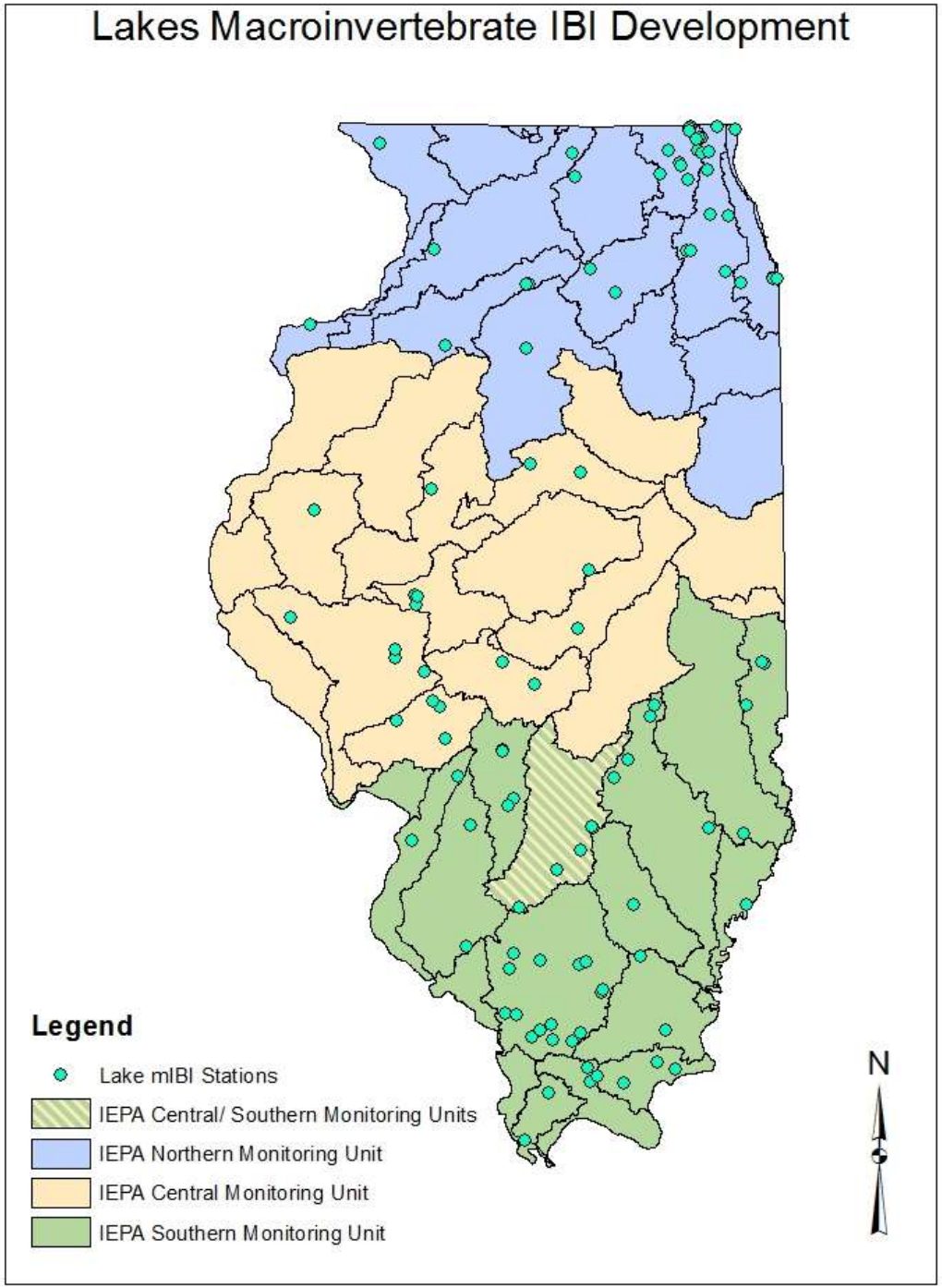
Reference site criteria descriptions

Variable	Description
Primary Variables	
ImprvPct	% imperviousness in the whole catchment
UrbIndWgt	% low, med, and high development land uses; weighted by distance: (catchment stat + 2* 500m stat + 3 * 100 stat)/6
AgIndWgt	% crops and pasture uses; weighted by distance: (catchment stat + 2* 500m stat + 3 * 100 stat)/6
RdDens	Count of road/stream crossings per 100 acres
RdXDens	Length of roads in miles per 100 acres
Mine	Gravel & coal mines, weighted by distance: # in 1km + 3*# in 100m buffer
PtSrc	NPDES & CERCLIS sites, weighted by distance: # in 1km + 3*# in 100m buffer
Secondary Variables	
RDist	Riparian Disturbance Habitat Index (as calculated by National Lakes Assessment)
LitRip	Littoral and Riparian Complexity Habitat Index (as calculated by NLA)

Station	name	county	unit	TetraTech rating	IEPA rating	Final
RCJ	ALTAMONT NEW	EFFINGHAM	CENTRAL	Other	Near Reference	Near Reference
RDE	ARGYLE	MCDONOUGH	CENTRAL	Other	Other	Other
RHZE	ARROWHEAD	COOK	NORTHERN	Extreme Stressed	Extreme Stressed	Extreme Stressed
RGZQ	AXEHEAD	COOK	NORTHERN	Extreme Stressed	Extreme Stressed	Extreme Stressed
RBZH	BEALL WOODS	WABASH	SOUTHERN	Other	Near Reference	Near Reference
RNO	BENTON	FRANKLIN	SOUTHERN	Other	Other	Other
RPK	BLACK OAK	LEE	NORTHERN	Near Reference	Other	Other
RAZI	BLOOMFIELD	JOHNSON	SOUTHERN	Other	Other	Other
RML	GEORGE	ROCK ISLAND	NORTHERN	Near Reference	Near Reference	Near Reference
RAF	GLEN O JONES	SALINE	SOUTHERN	Reference	Near Reference	Near Reference
RAP	GLENDALE	POPE	SOUTHERN	Reference	Near Reference	Near Reference
ROL	GLENN SHOALS	MONTGOMERY	CENTRAL	Near Reference	Other	Other
ROP	GOVERNOR BOND	BOND	SOUTHERN	Near Reference	Stressd	Stressd
VTI	GRASSY	LAKE	NORTHERN	Stressed	Stressed	Stressed
RGK	GRAYS	LAKE	NORTHERN	Extreme Stressed	Other	Other
RDZF	GREENFIELD	GREENE	CENTRAL	Other	Stressed	Stressed
REZQ	GRIDLEY	CASS	CENTRAL	Other	Near Reference	Near Reference
RTY	GRISWOLD	MCHENRY	NORTHERN	Other	Near Reference	Near Reference

Classification Variables

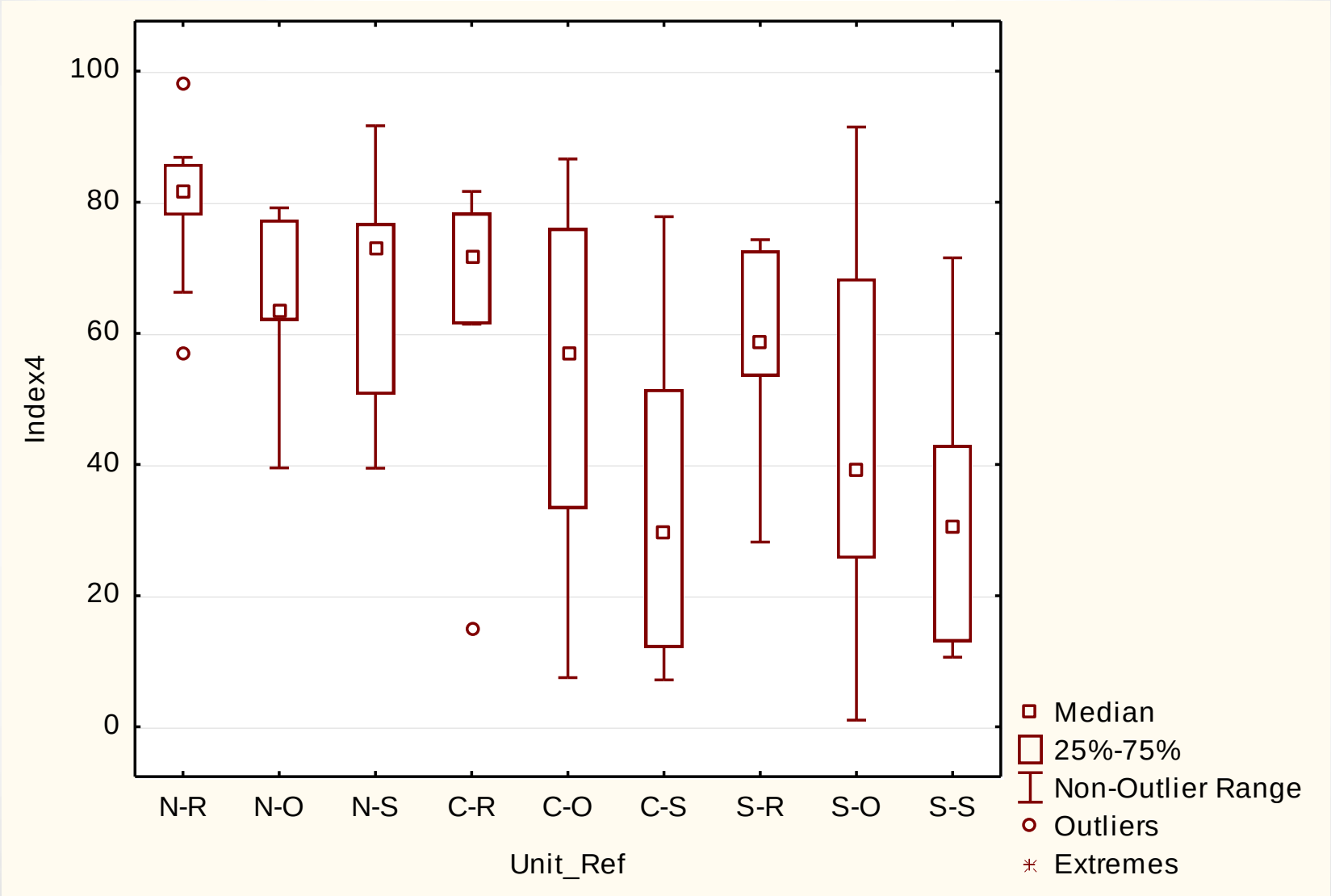
- Macroinvertebrate metric variance, correlation with class variables
  - Average Latitude
  - Average Longitude
  - Lake surface area
  - Watershed area
  - Shoreline length
  - Maximum depth
  - Mean depth
  - Relative depth
- Best fit? Only fit…Latitude


Lakes Macroinvertebrate IBI Development
Legend
Lake mIBI Stations
IEPA Central/ Southern Monitoring Units
IEPA Northern Monitoring Unit
IEPA Central Monitoring Unit
IEPA Southern Monitoring Unit
N

Metric Testing

- Within the classes metrics were calculated 3 ways
  - Grand composite
  - Deep zone composite (profundal+sub-littoral)
  - Littoral zone composite (littoral fine+littoral plant+littoral hard substrate)
- Virtual composites developed and tested with 68 metrics representing 5 metric categories
- Metrics were tested for sensitivity of discrimination between reference and stressed sites
- Tested metrics for redundancy

Index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80
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40
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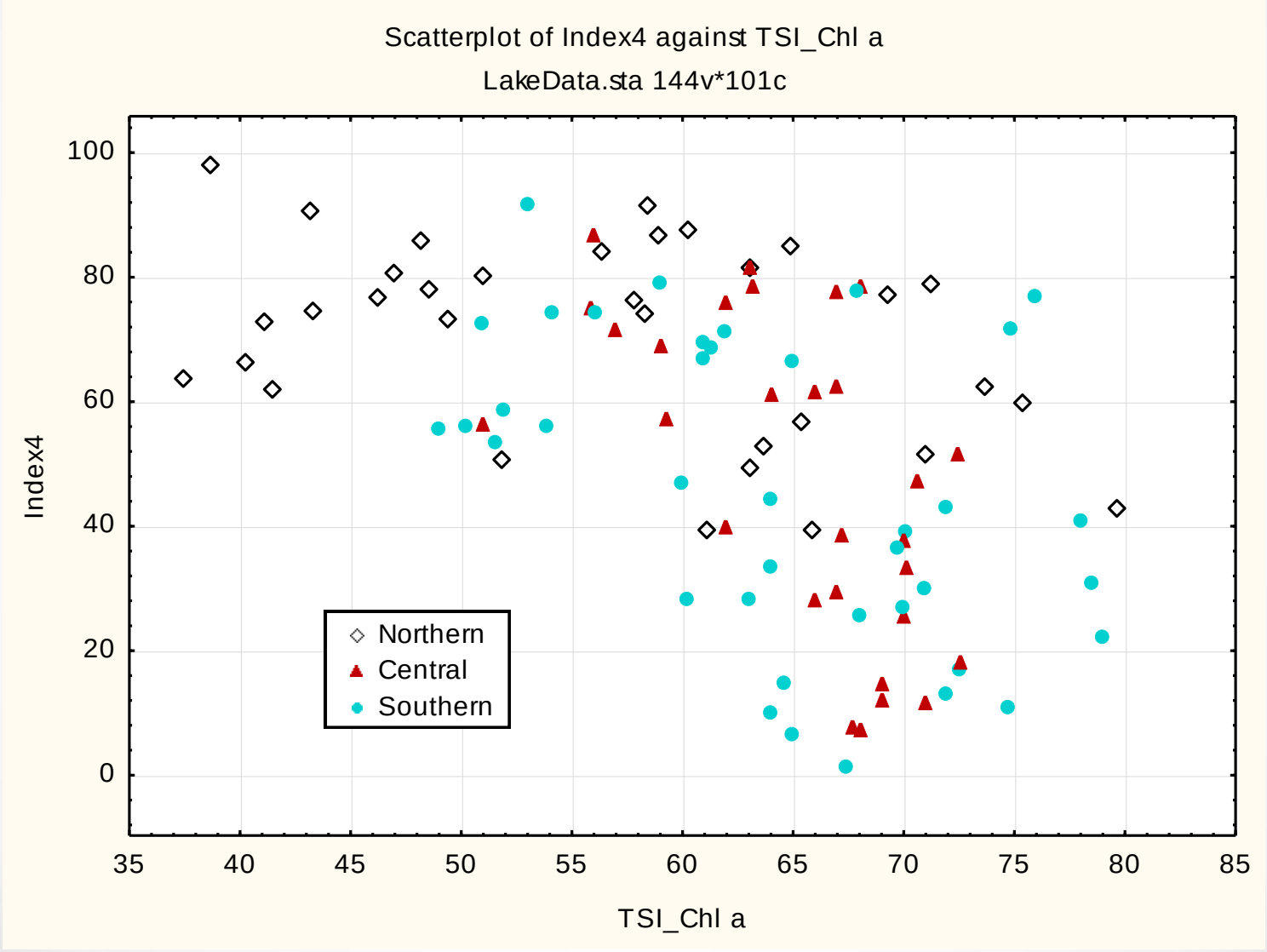
Index4
N-R
N-O
N-S
C-R
C-O
C-S
S-R
S-O
S-S
Unit_Ref
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

Index Validation



Index Calculation

Metric	Scoring formula[a]
Count of ECT taxa	(X – 2) / 8
% Diptera individuals	(92.2 – X) / 83.4
% filterer individuals	(65.5 – X) / 65
Count of climber taxa	(X – 3) / 11
% tolerant individuals	(80.6 – X) / 70.7

Metric scoring formulae.

a: “X” represents the metric value. In each formula, the result is multiplied by 100 to convert to a percentage scale. Scores that are above 100 are re-set to 100 and those below 0 are re-set to 0 before averaging in an index.

Index Calculation

Scores calculated from metrics and scoring formulae in Table 12 are averaged to arrive at an index score. Any metric score that is above 100 or below 0 should be re-set to 100 or 0 before averaging.

Application

- IL EPA will continue to work with the index to develop impairment thresholds for Illinois lakes.
- The index will be incorporated into assessments for aquatic life use with other measures of human impacts.
- The index can identify high quality waters.
- Used to evaluate the effectiveness of best management practices.
- Evaluate sampling and sorting effort.

Case #1

- You're lake biologist for the IL EPA, and your boss just called wanting some information on a lake.
- It's Lake Kind-ofa-Mystery, in central Illinois.
- The lake has never been monitored.
- The lab also just called and said no more chemical samples can be collected until they fix all of their equipment which just broke simultaneously and possibly maliciously…
- What do you do?!

Macroinvertebrate Sample

Lake Kind-ofa-Mystery

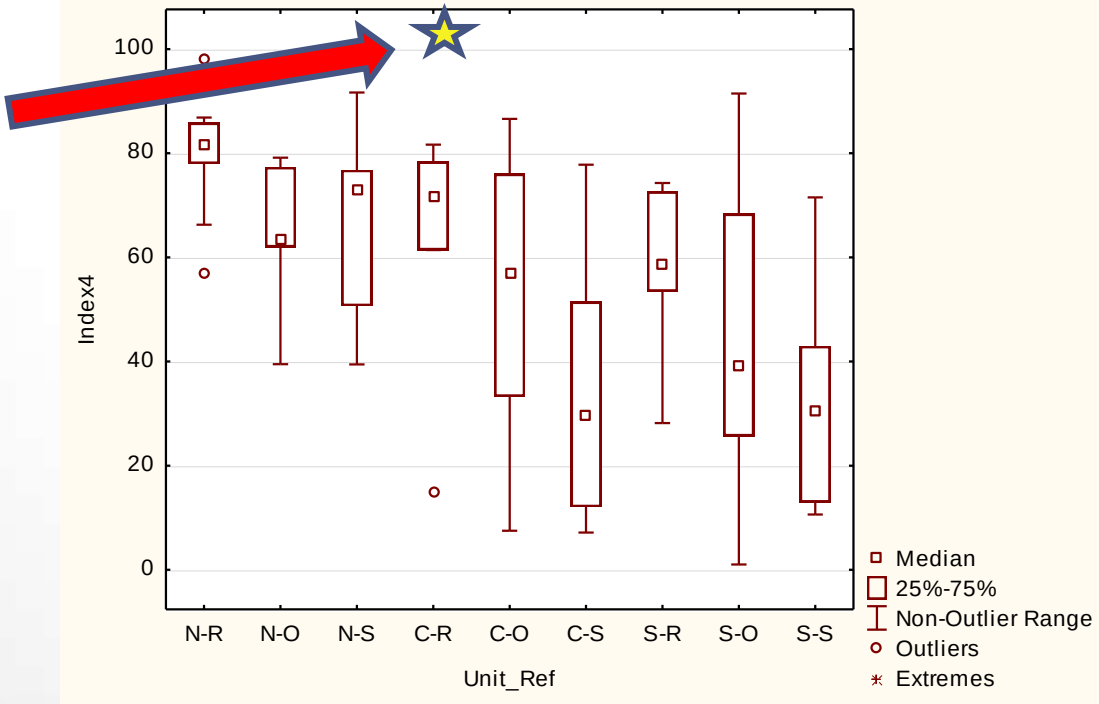
Metrics	Kind-ofa-Mystery Scores
Count ECT taxa	15
% Diptera Ind.	7
% Filterer Ind.	20
Ct. Climber taxa	18
% tolerant Ind.	14

- Your macroinvertebrate dataset yields an index score of **113**!

Lake Kind-ofa-Mystery

- This is the highest m-IBI score found in the central region.
- Lake Kind-ofa-Mystery is a high quality and pristine lake in need of protection.
- Degradation and human impacts should be limited in and around Lake Kind-ofa-Mystery.
- Future monitoring should done to track changes in the lake.

Lake Kind-ofa-Mystery



Case #2

- Lake HABs-Alot is a nutrient rich lake in the southern region of IL.
- HABs-Alot has many invasive species and received an index score of 23 when it was monitored in 2008.

Lake HABs-Alot

- The lake has recently adopted a management plan for the lake, and watershed.
- Nutrient runoff has been greatly reduced, and the shoreline has been improved using natural native plantings.
- Has the biological integrity of Lake HABs-Alot improved yet?

Lake HABs-Alot

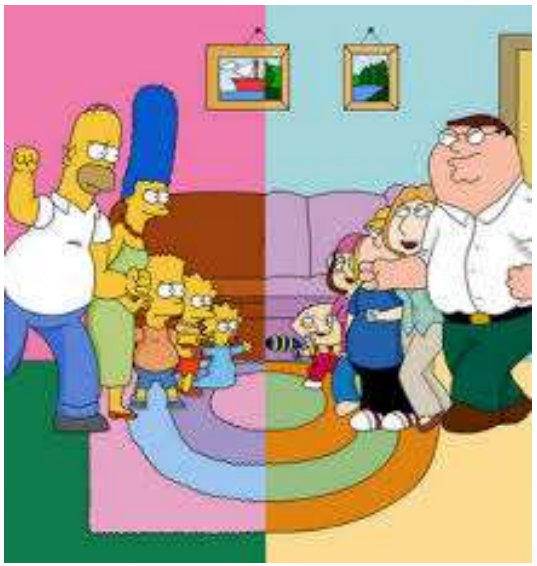
- Some questions are best answered by looking at the biology directly.
- We don't have to collect a ton of chemical and physical parameters to guess whether the biology is improving, we can prove it with the macroinvertebrates.

Metrics	HABs-A lot scores
Count ECT taxa	5
% Diptera Ind.	45
% Filterer Ind.	35
Ct. Climber taxa	14
% tolerant Ind.	78

- Our current index score after the management activities yields an index score of **48.9**!

Case #3

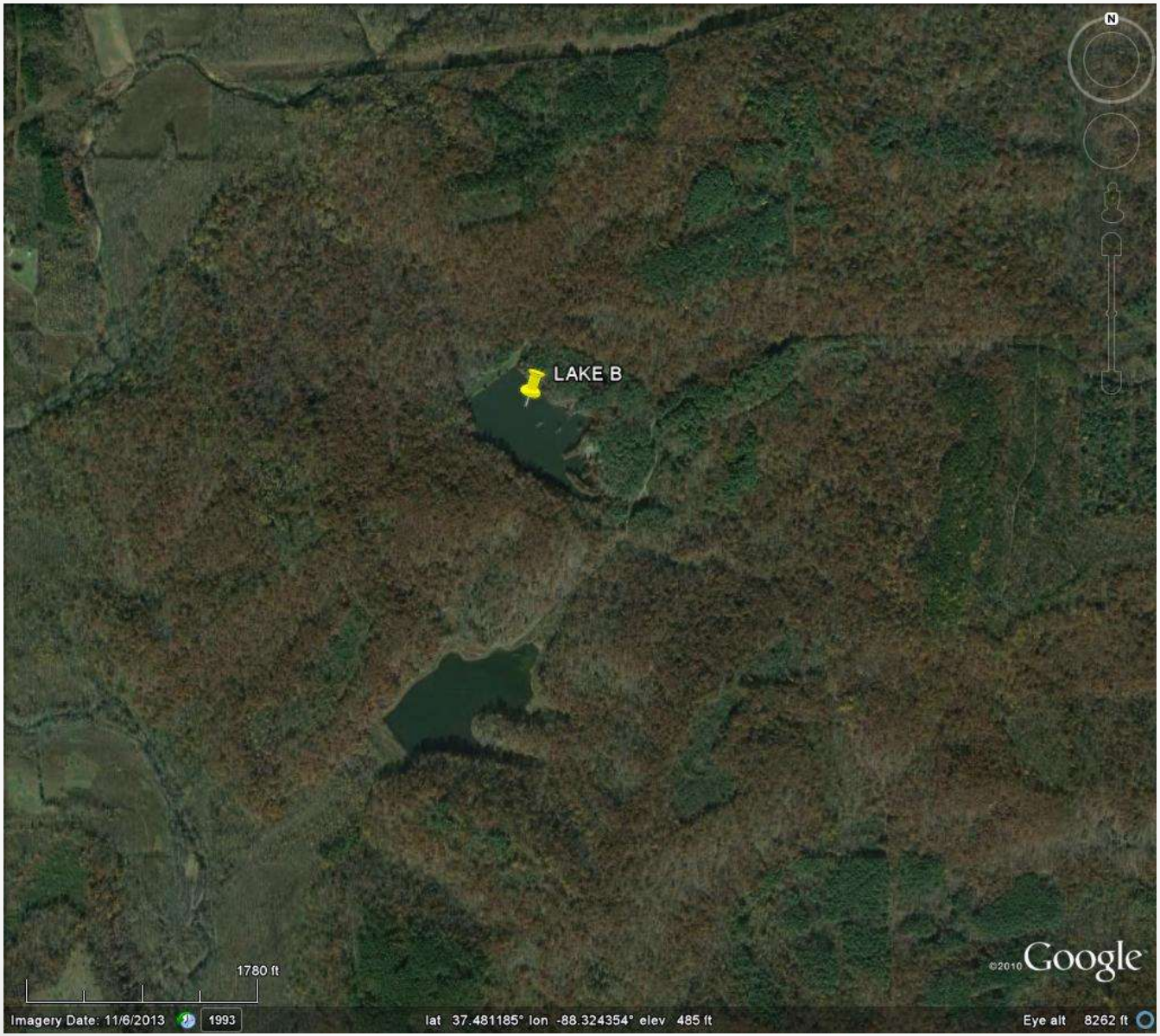
- You have 2 lakes from different regions of Illinois. One lake is in the Northern region, the other is in the Southern region of Illinois.
- You want to compare and contrast the 2 lakes, show how they are different and how they are similar.

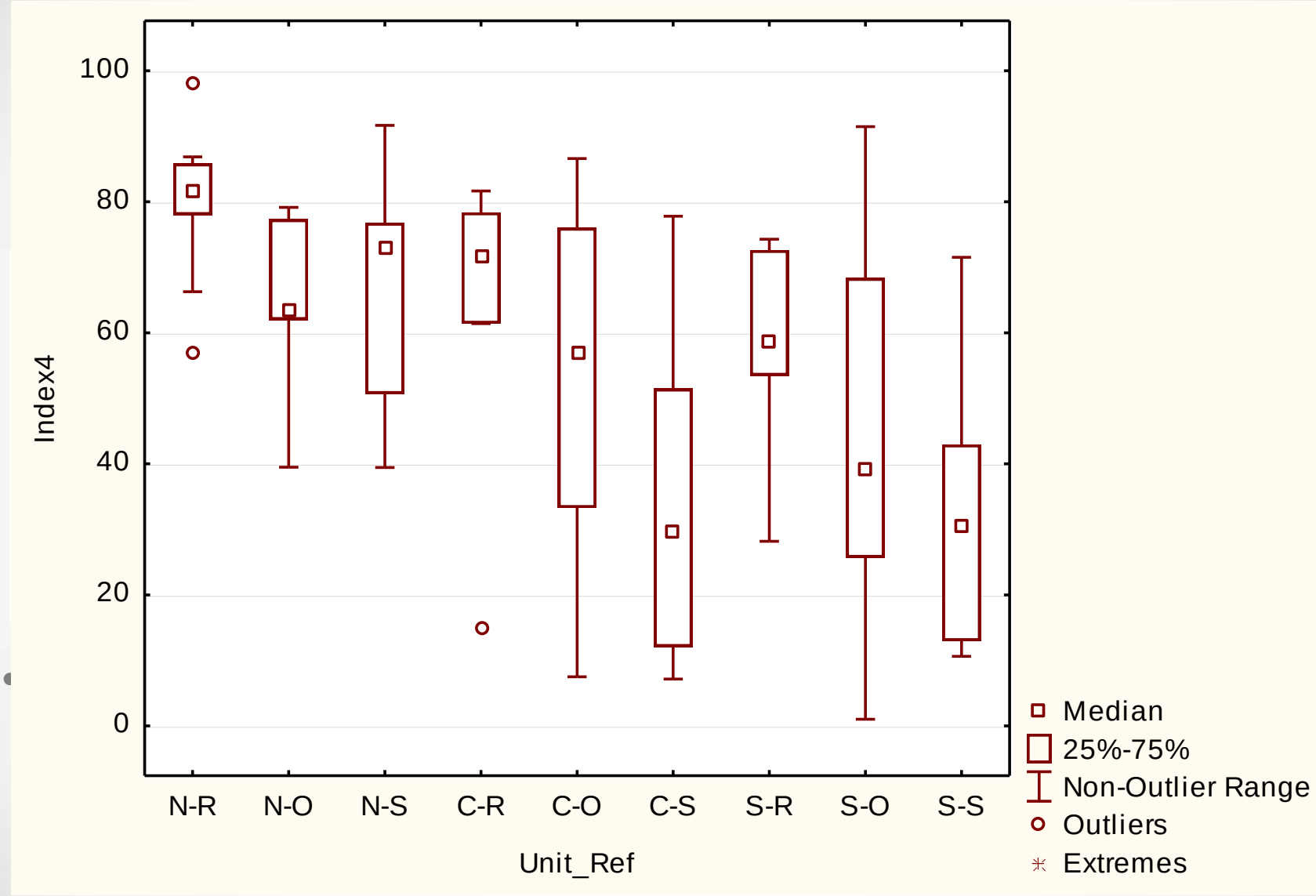


Lake A

N
Imagery Date: 4/2/2013
1999
lat 41.771617° lon -87.710841° elev 608 ft
Eye alt 29433 ft

Lake B


LAKE B
1780 ft
©2010 Google
Imagery Date: 11/6/2013
1993
lat 37.481185° lon -88.324354° elev 485 ft
Eye alt 8262 ft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Index4
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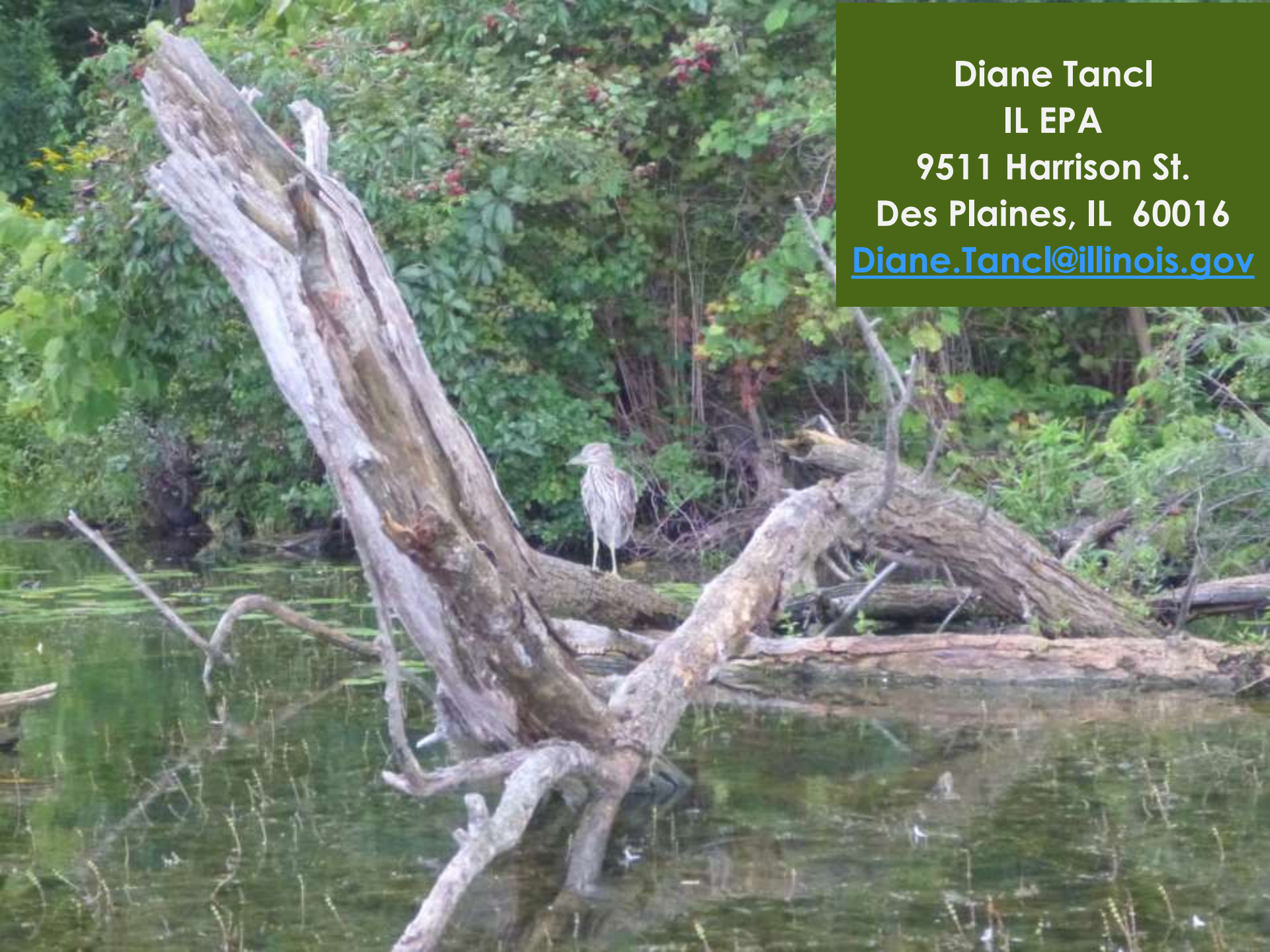
N-O
N-S
C-R
C-O
C-S
S-R
S-O
S-S
Unit_Ref
Median
25%-75%
Non-Outlier Range
Outliers
Extremes



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