National Biological Assessment and Criteria Workshop

Advancing State and Tribal Programs

Coeur d'Alene, Idaho
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TALU 201

Scaling Biological Assessment Variables

Presented by

Lester Yuan, US EPA
Office of Research and Development
National Center for Environmental Assessment

Motivation

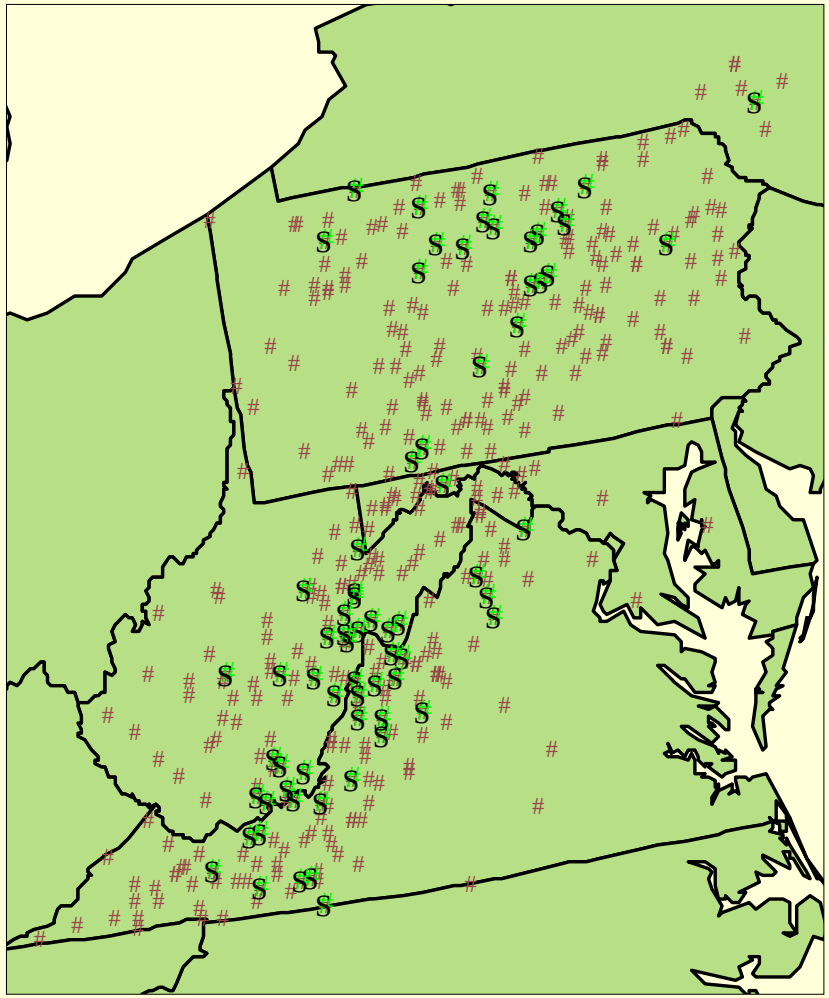
- Can we observe the patterns of degradation described in the TALU?
- What are the relative effects of different types of human disturbances on stream biota?

Disparate Measurement Units

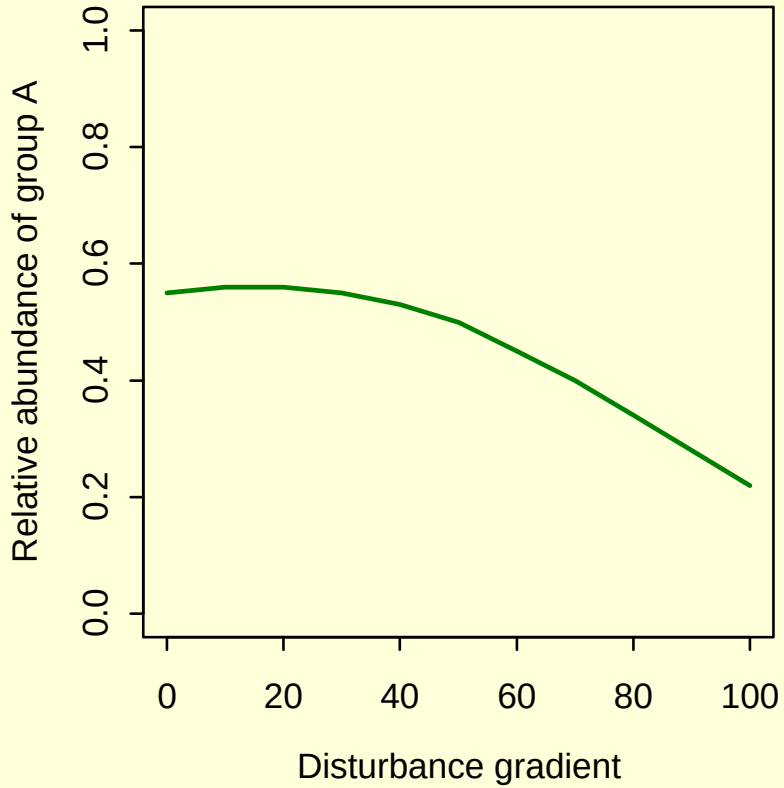
- Biological, chemical, and physical variables are expressed in disparate measurement units.
- Scaling variables appropriately can improve our ability to compare linkages between different human disturbances and ecological responses.

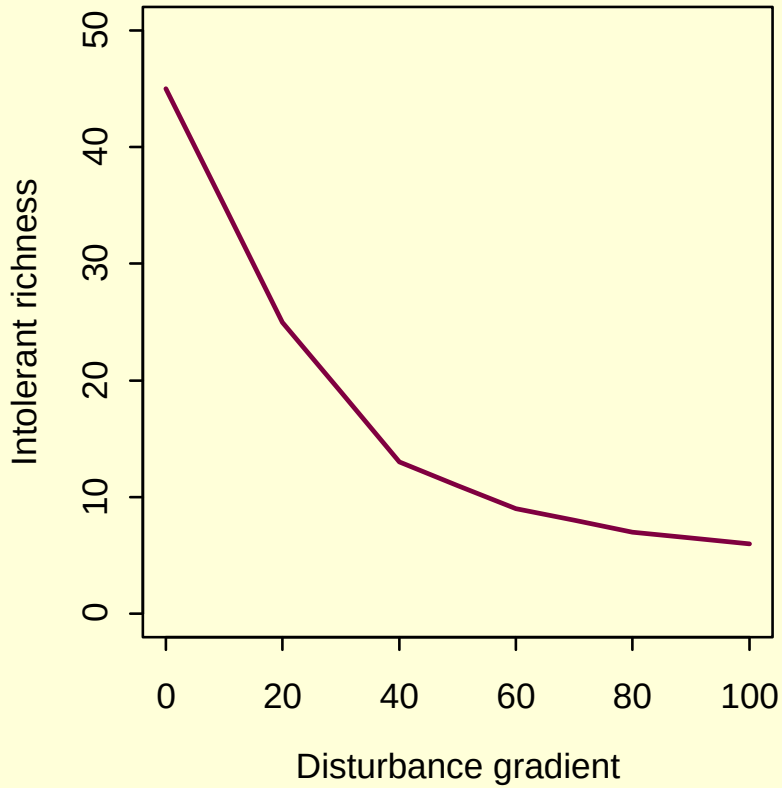
Data

- Data collected by U.S. EPA EMAP Surface Waters Program.
- Streams sampled during summer low flow conditions from 1993-1996.
- Stratified random sampling of mostly 1st - 3rd order streams.
- Collected periphyton, macroinvertebrates, fish, physical habitat and water chemistry data.
- 585 samples.
- Majority of sampled streams represent the *middle* of the environmental gradient.

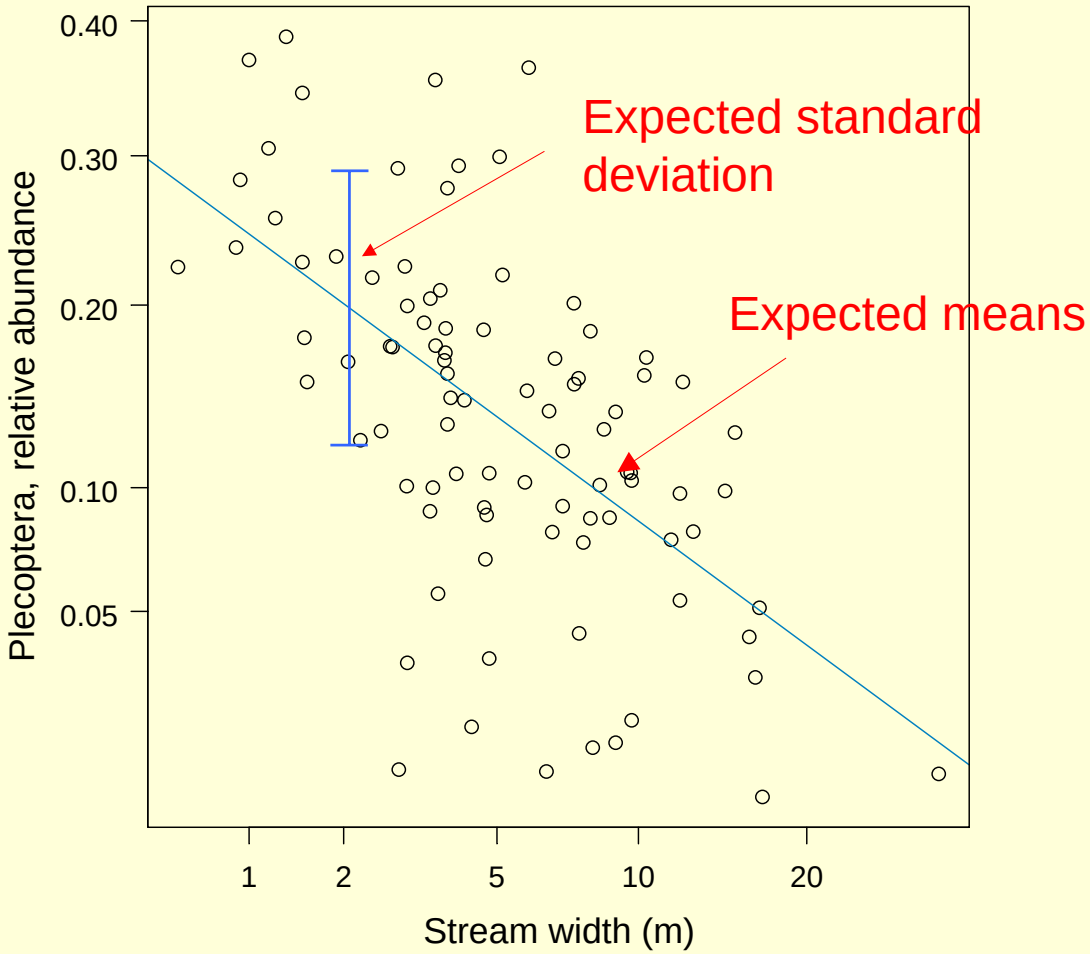


How do we scale dissimilar metrics?





Scaling by Reference Condition



Approach

Scale metrics by the means and variances expected under unimpaired conditions.

Observed metric value at test site

Predicted metric value based on test site characteristics (catchment area)

Scaled metric value

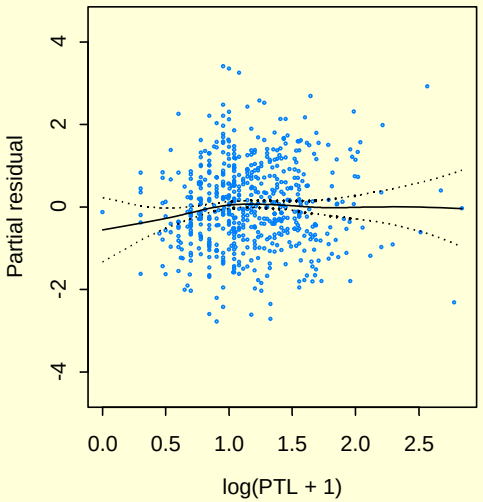
$$m_{sc} = \frac{m_{test} - m_{ref}}{s_{ref}}$$

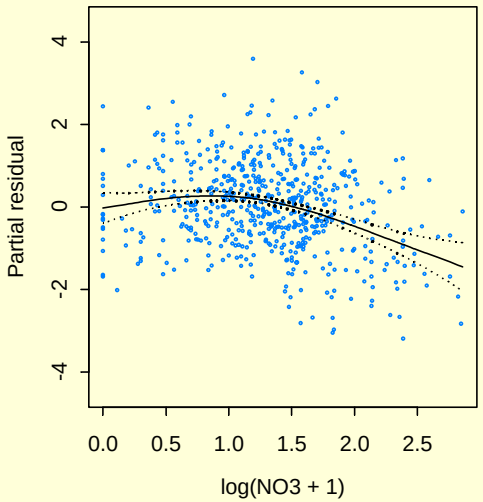
Residual standard deviation of reference site regression model

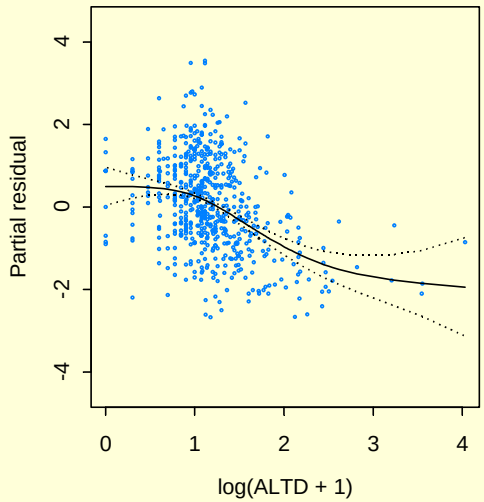
$m_{sc} = 0$ ♦ Conditions are the same as reference.

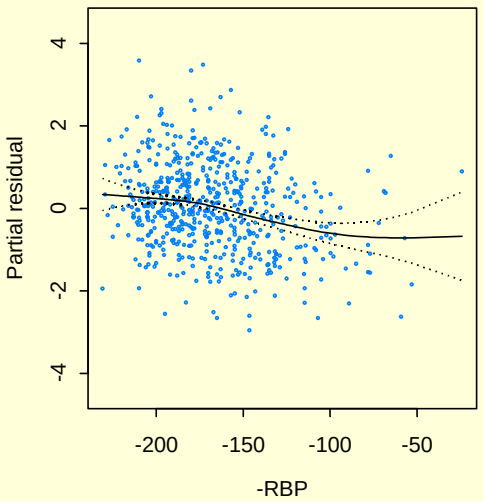
$m_{sc} = +/- 1$ ♦ Conditions differ from reference by one standard deviation

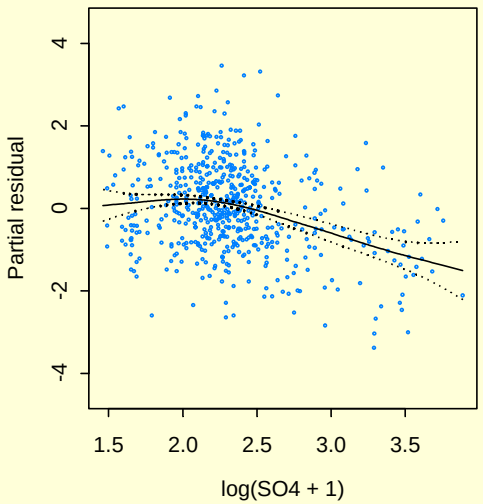
Model Responses with Generalized Additive Models



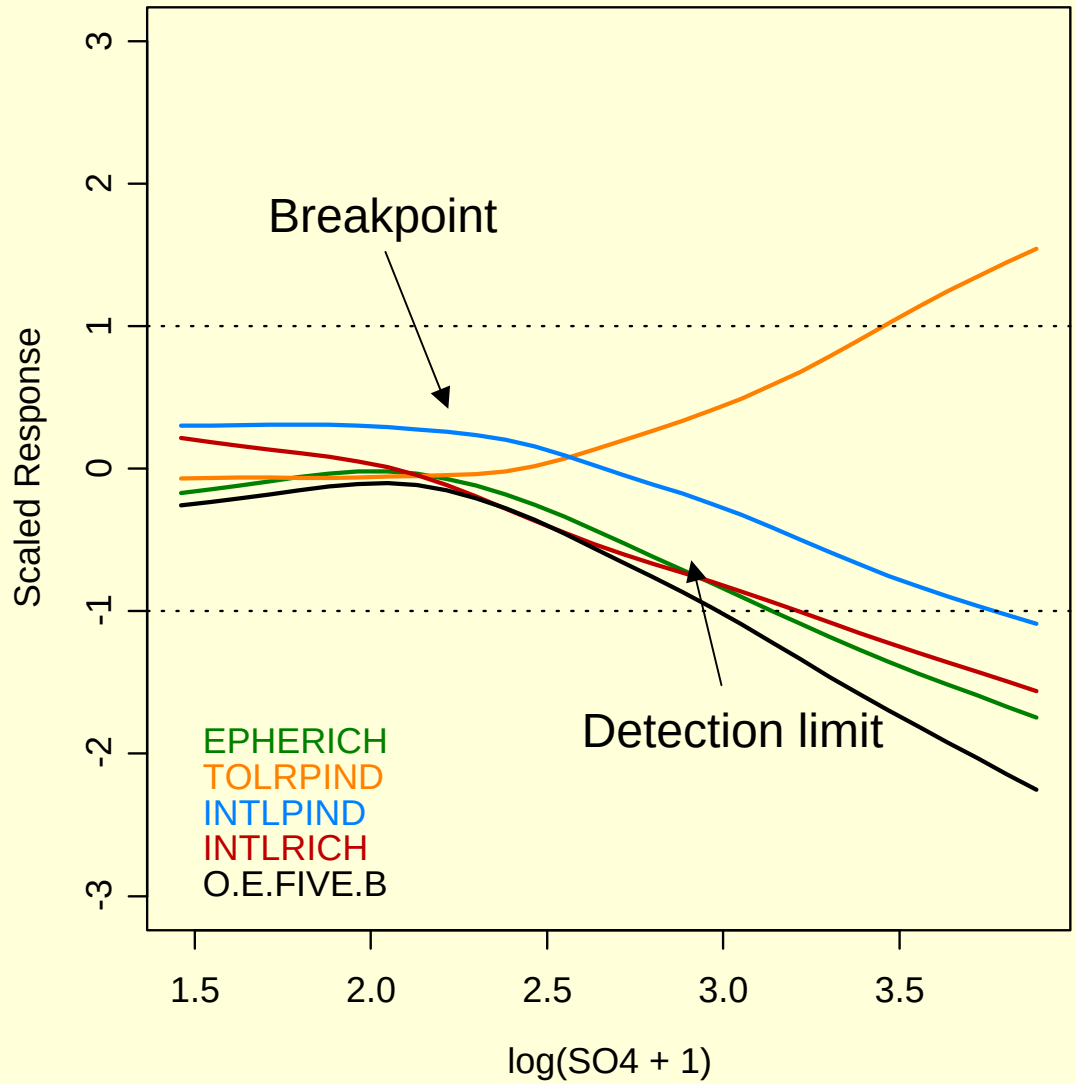




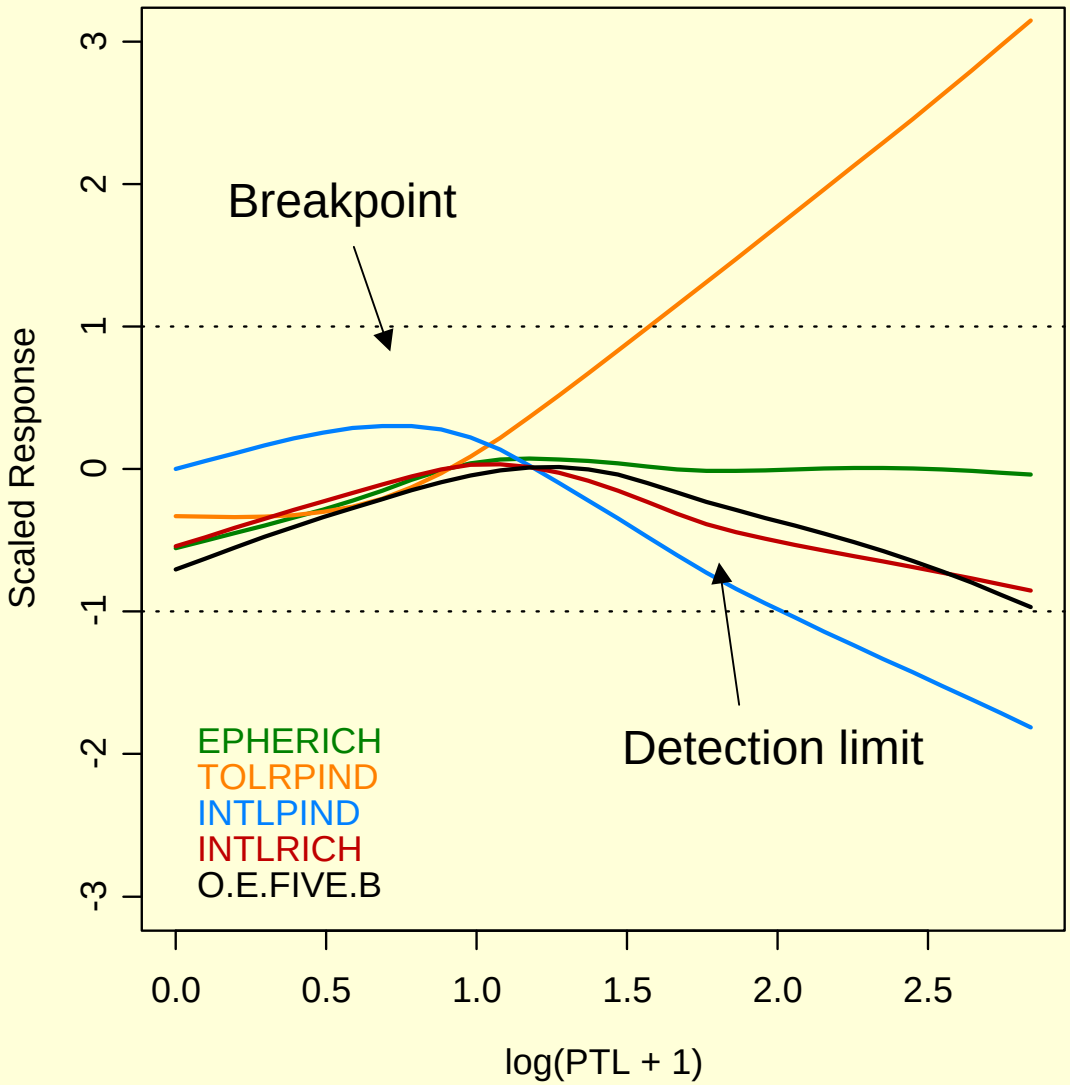




Scaled Responses to SO4



Scaled Responses to Total P



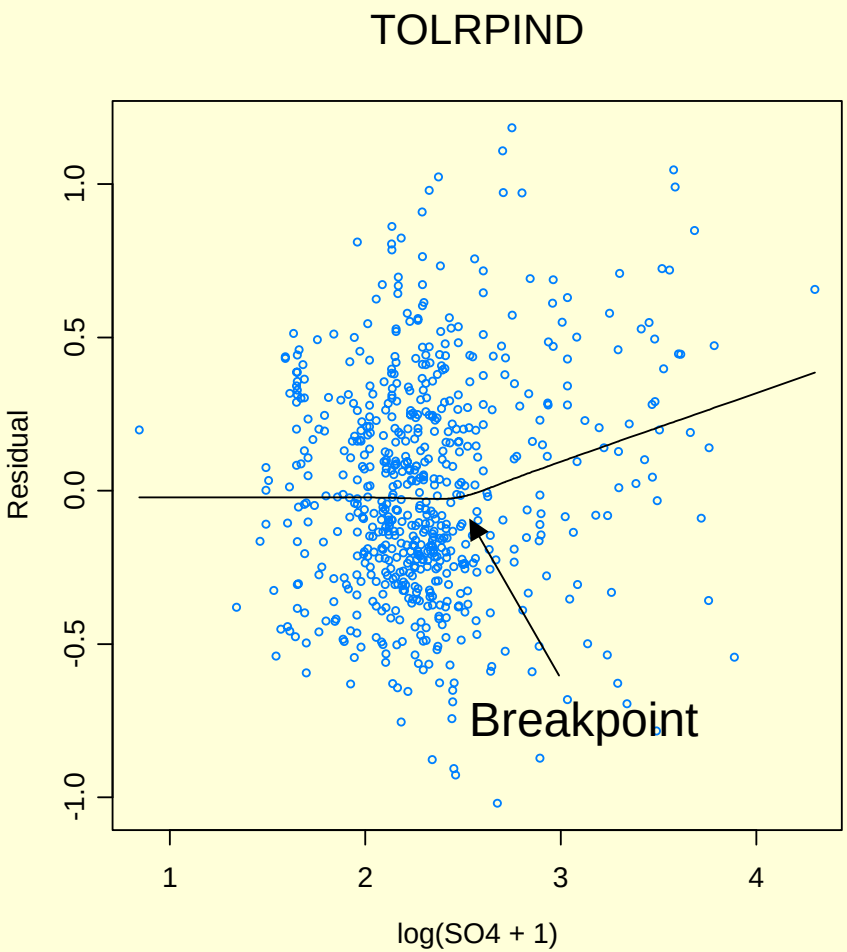
Observations and Issues

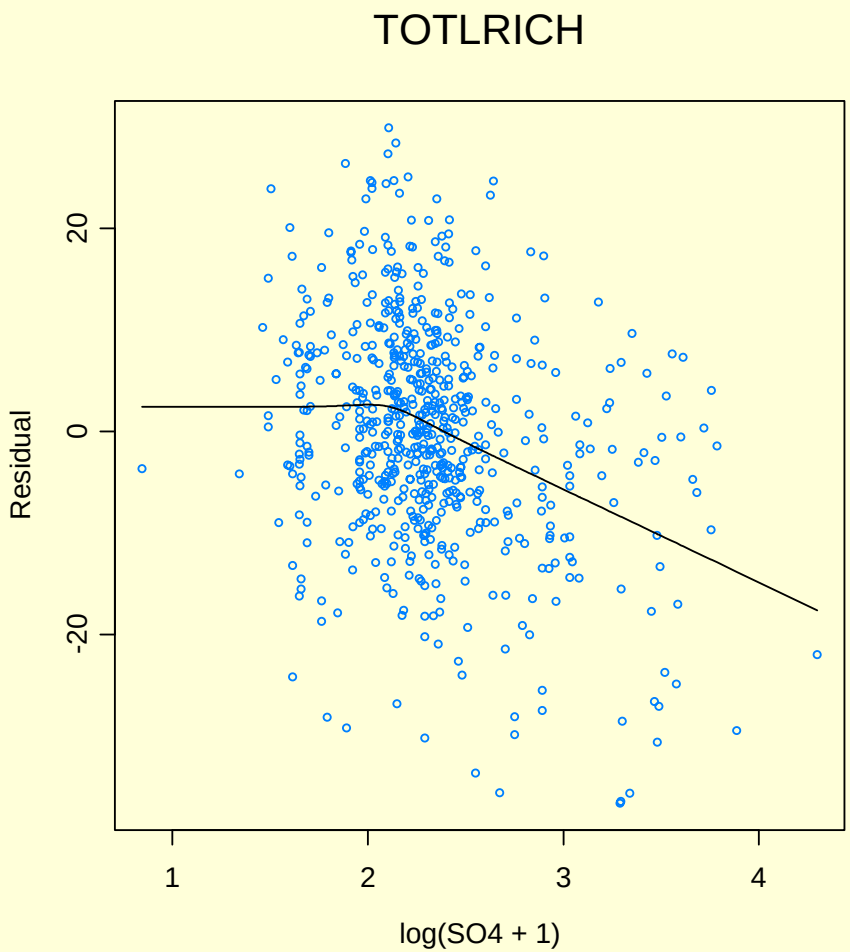
- Patterns of response differ across stressors.
- We can characterize each curve with a breakpoint and a detection limit.
- Non-parametric curves are difficult to quantify.
  - Where's the breakpoint?
  - What are the confidence intervals around the breakpoint?

Analyses to Quantify Features of the Response Curves

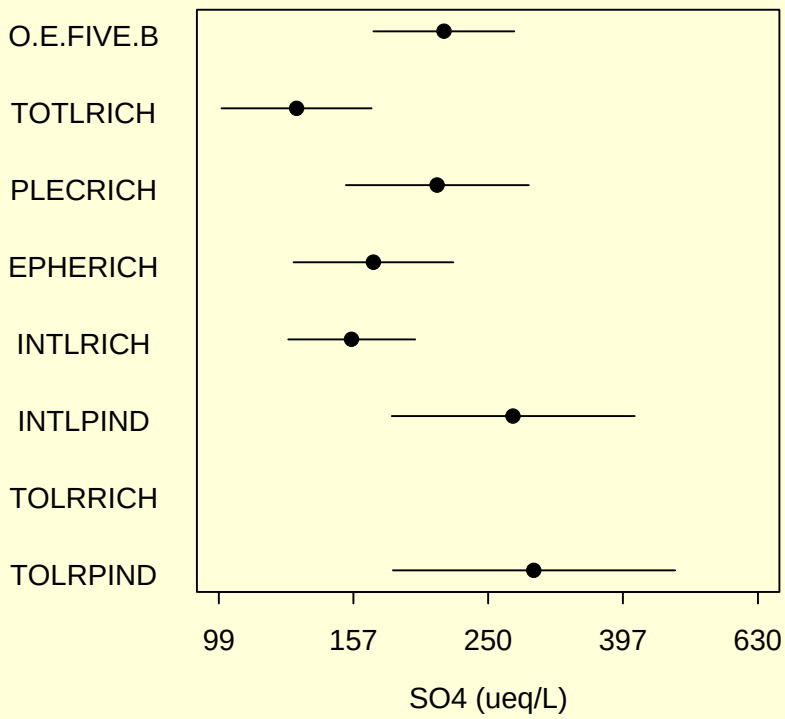
- Breakpoints:
  - Piecewise linear models
- Detection limits:
  - Binned t-tests
- Control for covarying variables using generalized additive models.

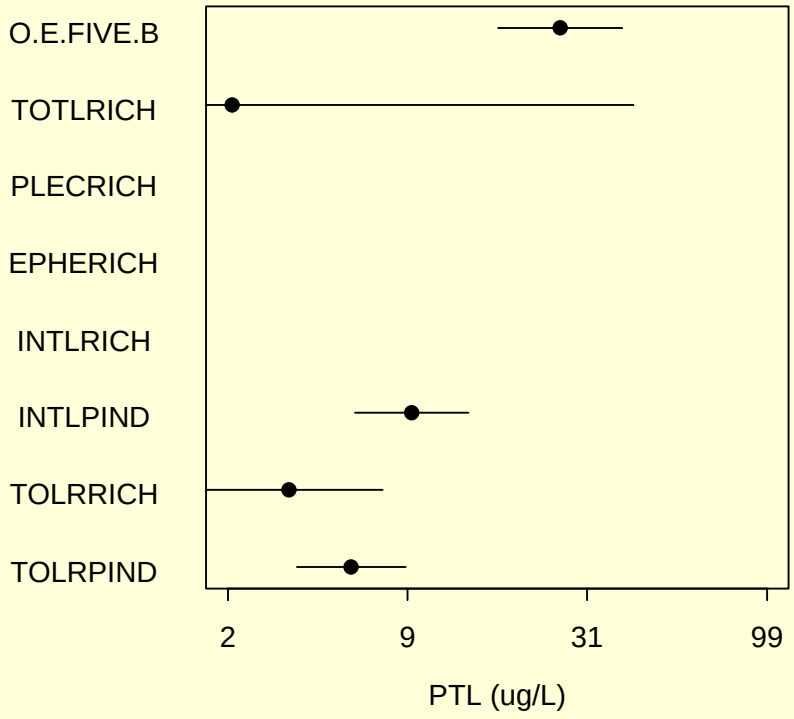
Finding Breakpoints



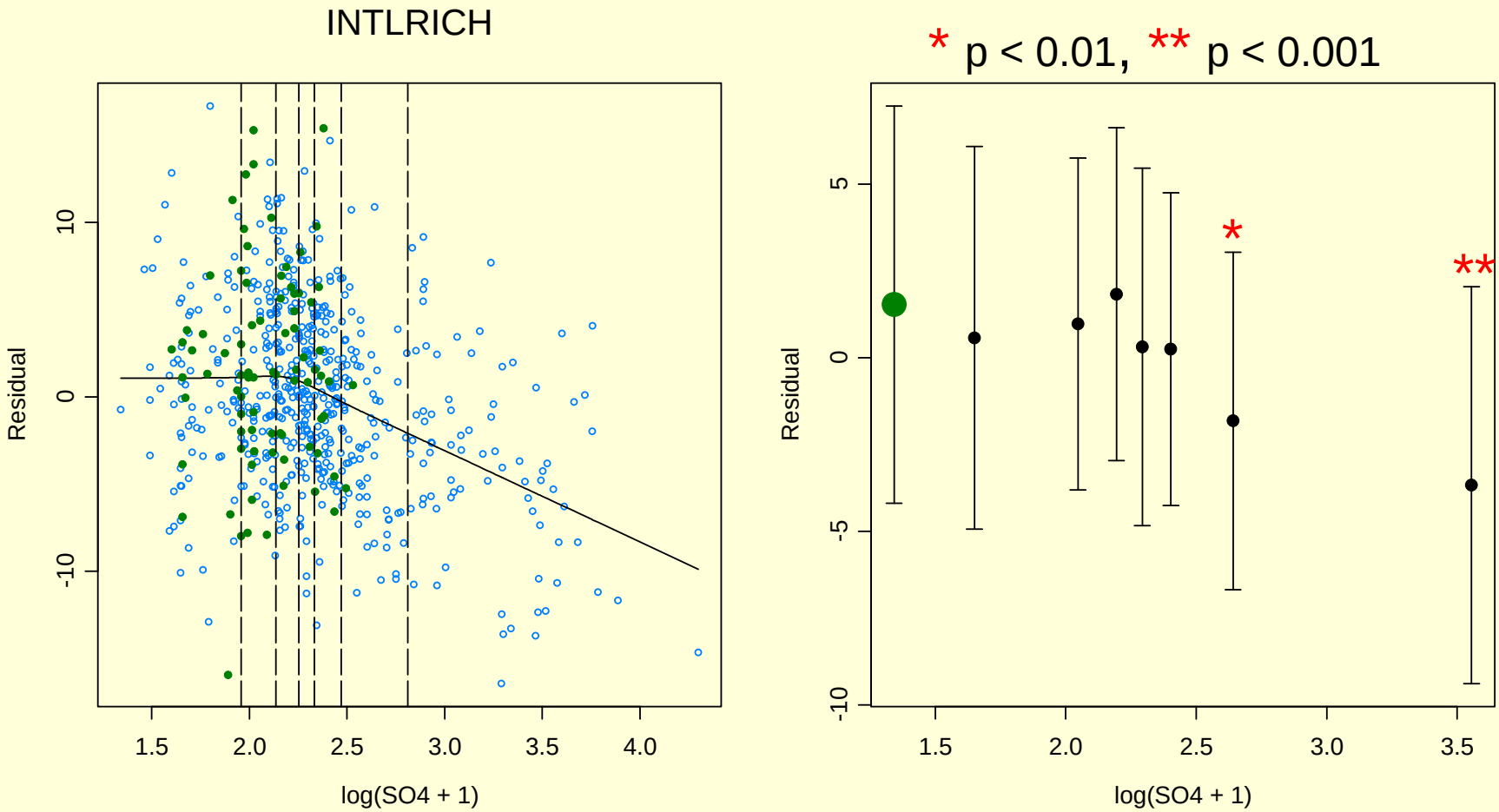


Comparing Breakpoints

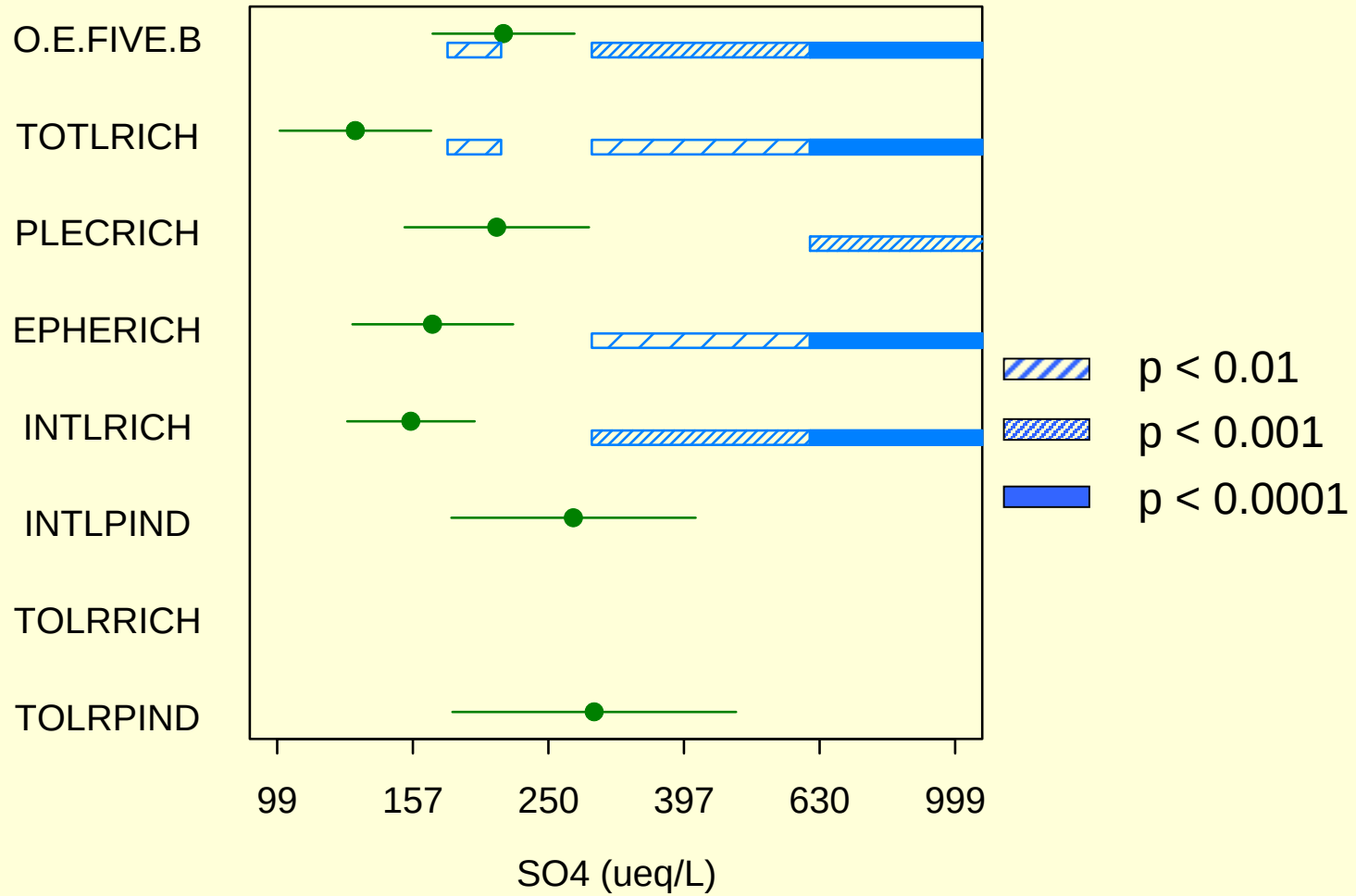




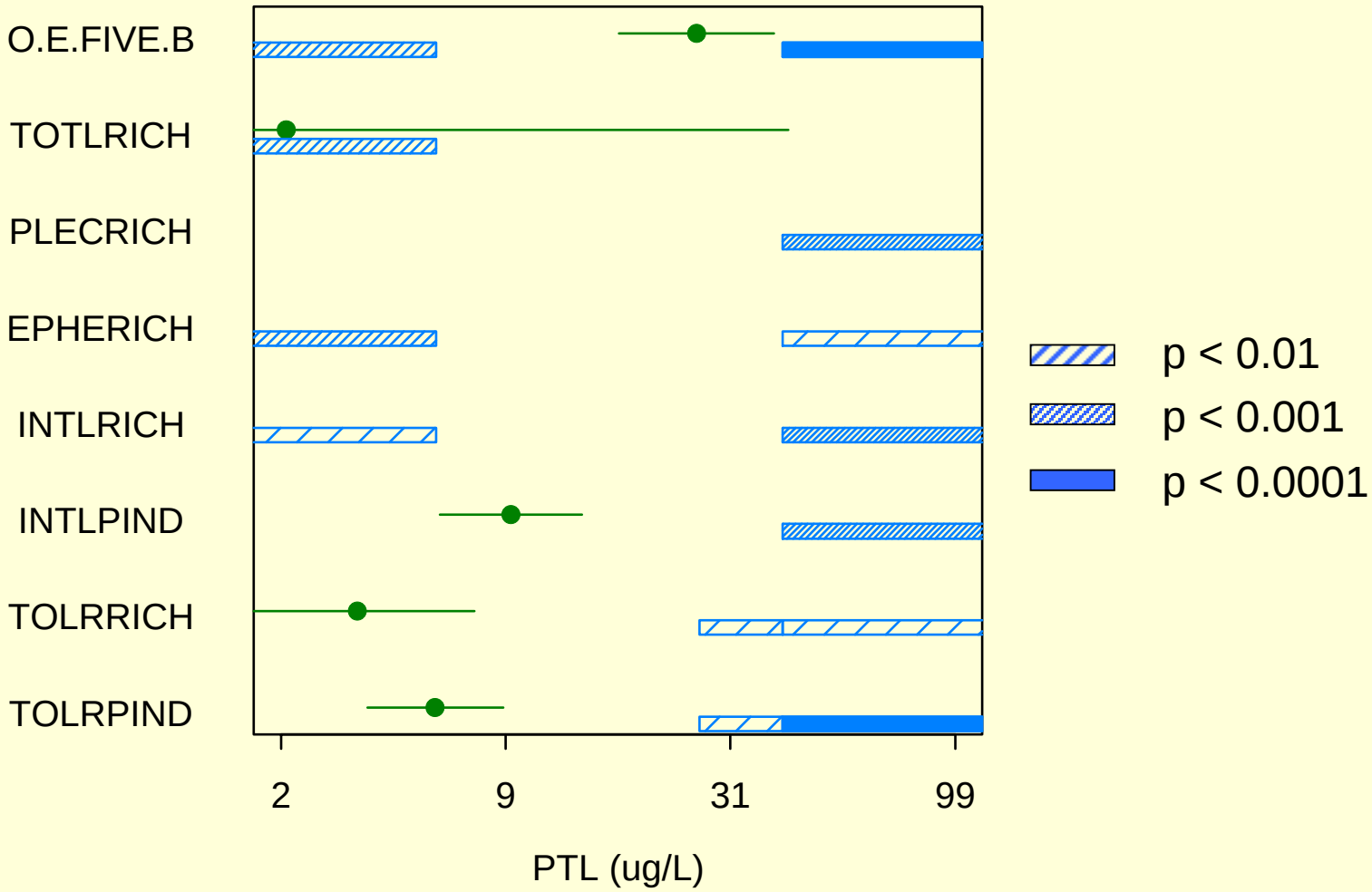
Binned Responses



Comparison of SO_4 Responses



Comparison of PTL Responses



Observations

- Patterns in detection limits generally mirror patterns in breakpoints.
- Richness of intolerant taxa respond at lowest SO_4 concentrations.
- Tolerant richness and relative abundance respond at lowest PTL concentrations.

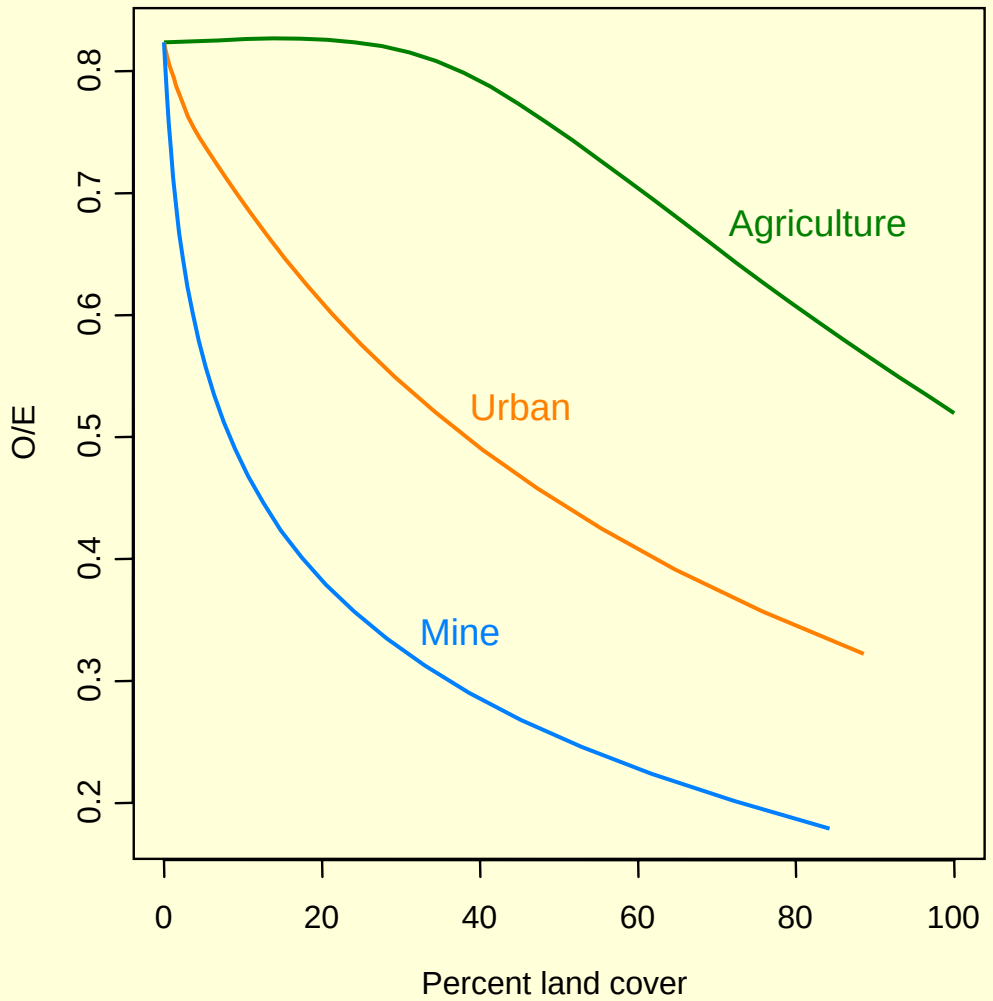
Scaling Human Disturbances

- Can we apply the same approach to compare effects of different human disturbances?
  - Scale different human disturbances using a common valued ecological attribute.

Approach

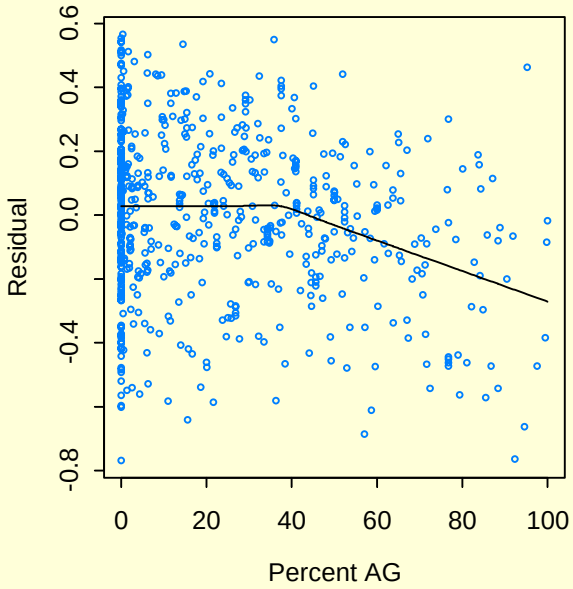
- Select metrics representing valued ecological attributes.
  - Observed/Expected for macroinvertebrates
  - Ephemeroptera richness
- Estimate associations between biological metrics and human disturbance using GAMs.
  - Variables considered: Agriculture, urban, and mining land use in each watershed.
- Quantify differences between responses using piecewise linears and binned t-tests.

Scaling by O/E

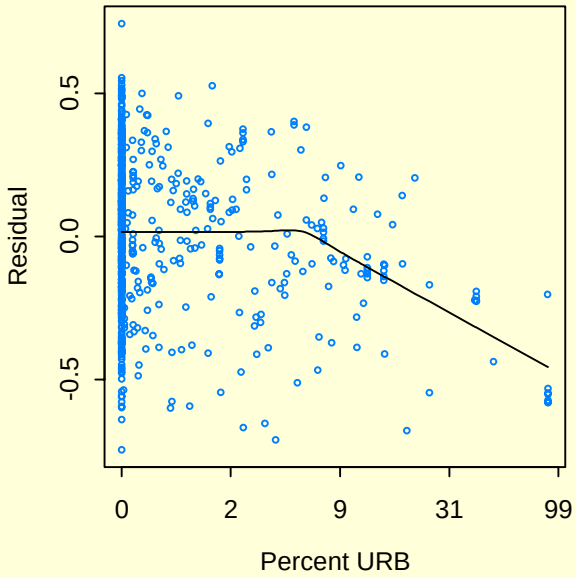


Model $R^2 = 0.23$

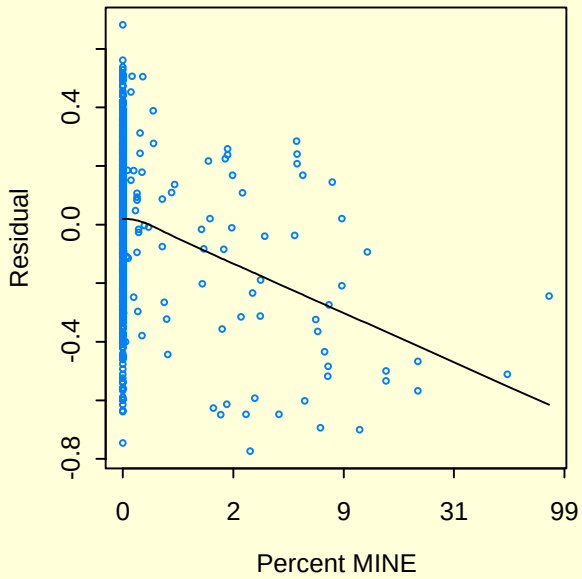
Breakpoints: O/E vs. Land Use



AGRICULTURE
Breakpoint = 37.5 %

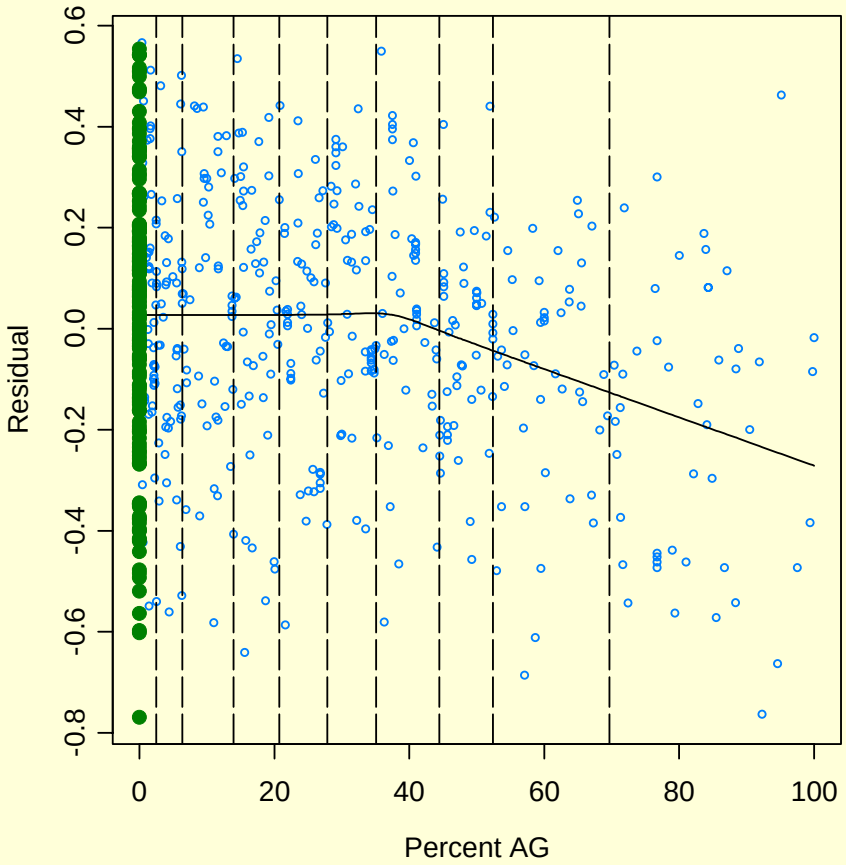


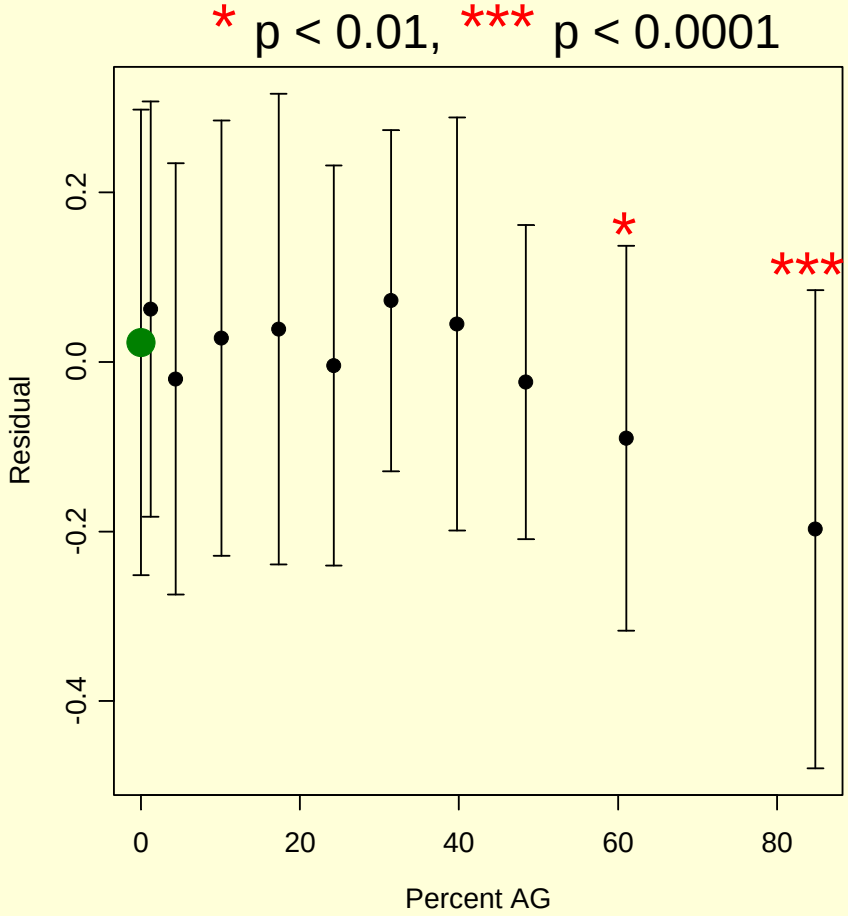
URBAN
Breakpoint = 5.8 %



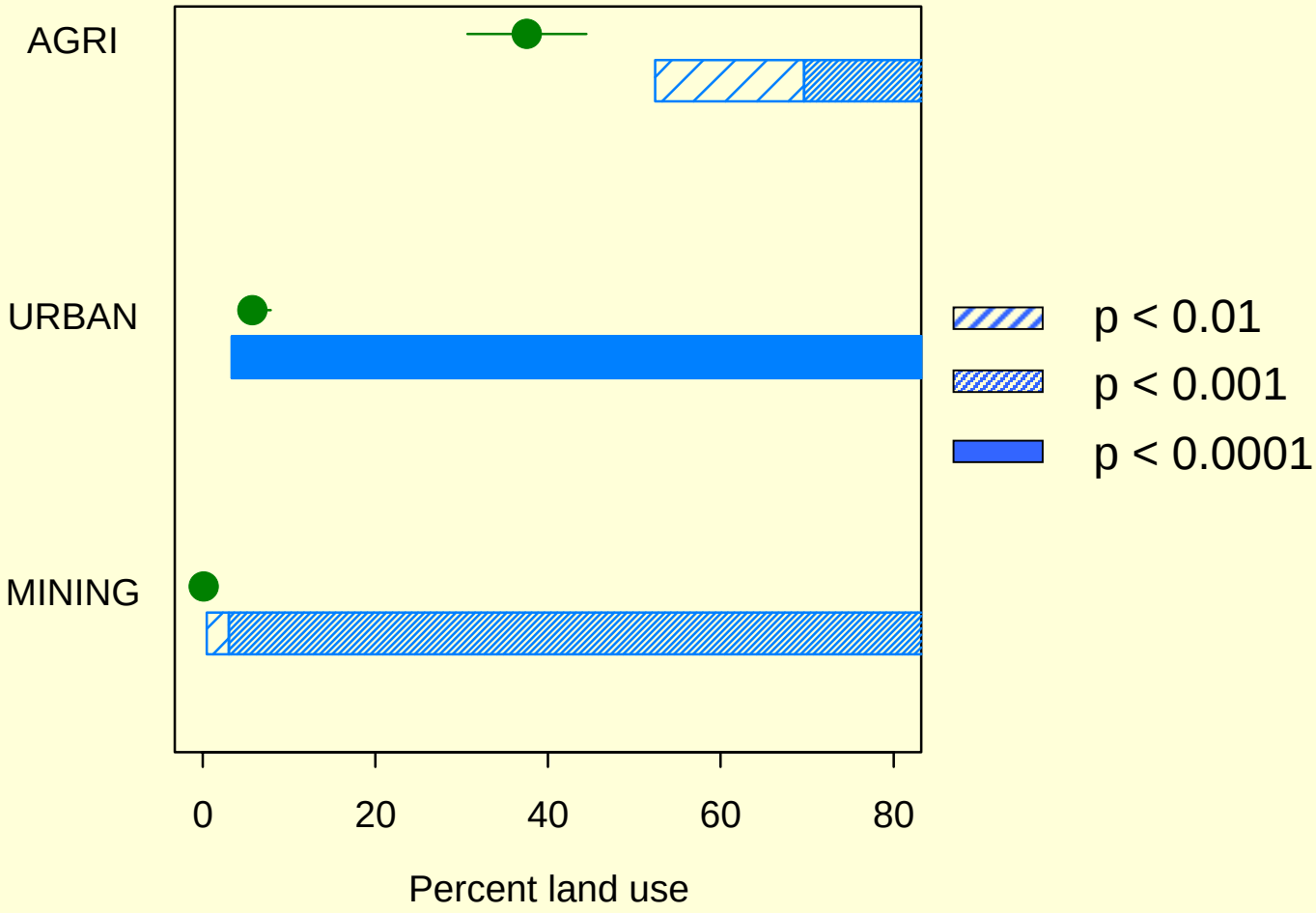
MINING
Breakpoint = 0.1 %

Association between O/E and Agricultural Land Use

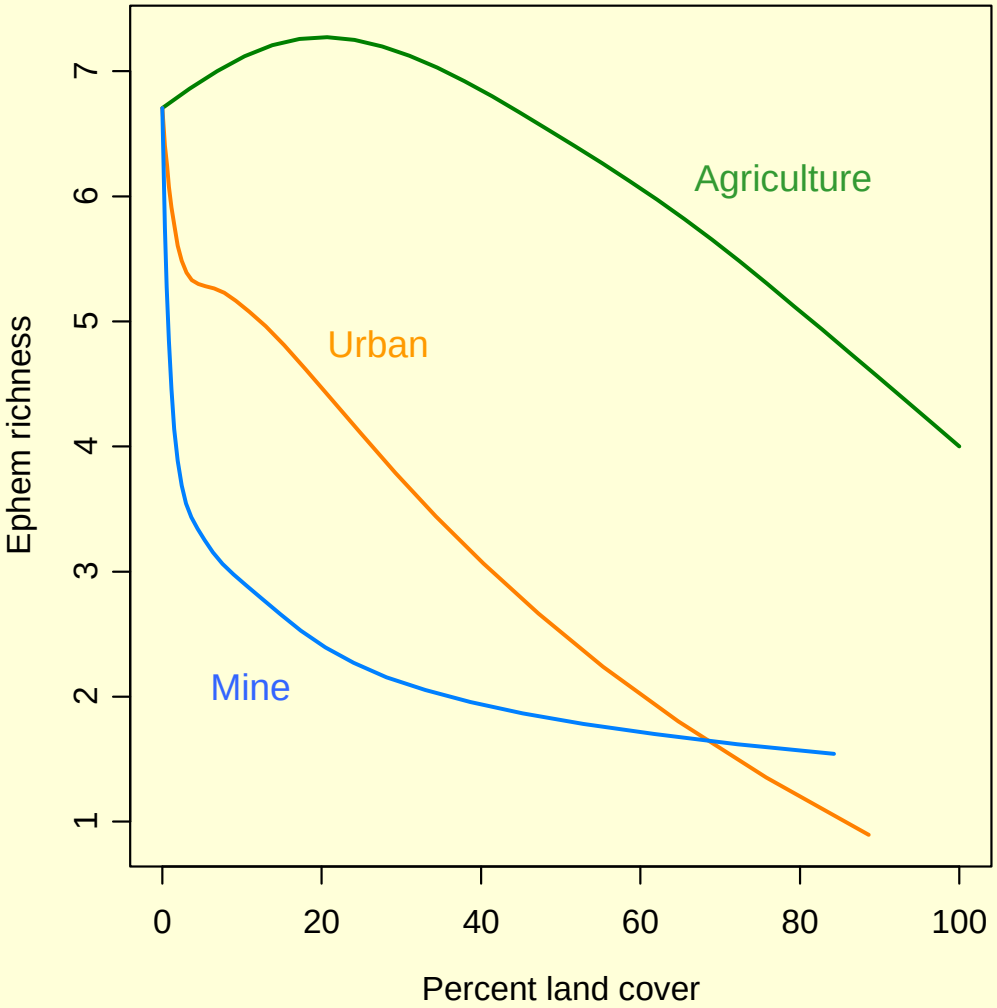




Comparison of O/E Responses to Land Use

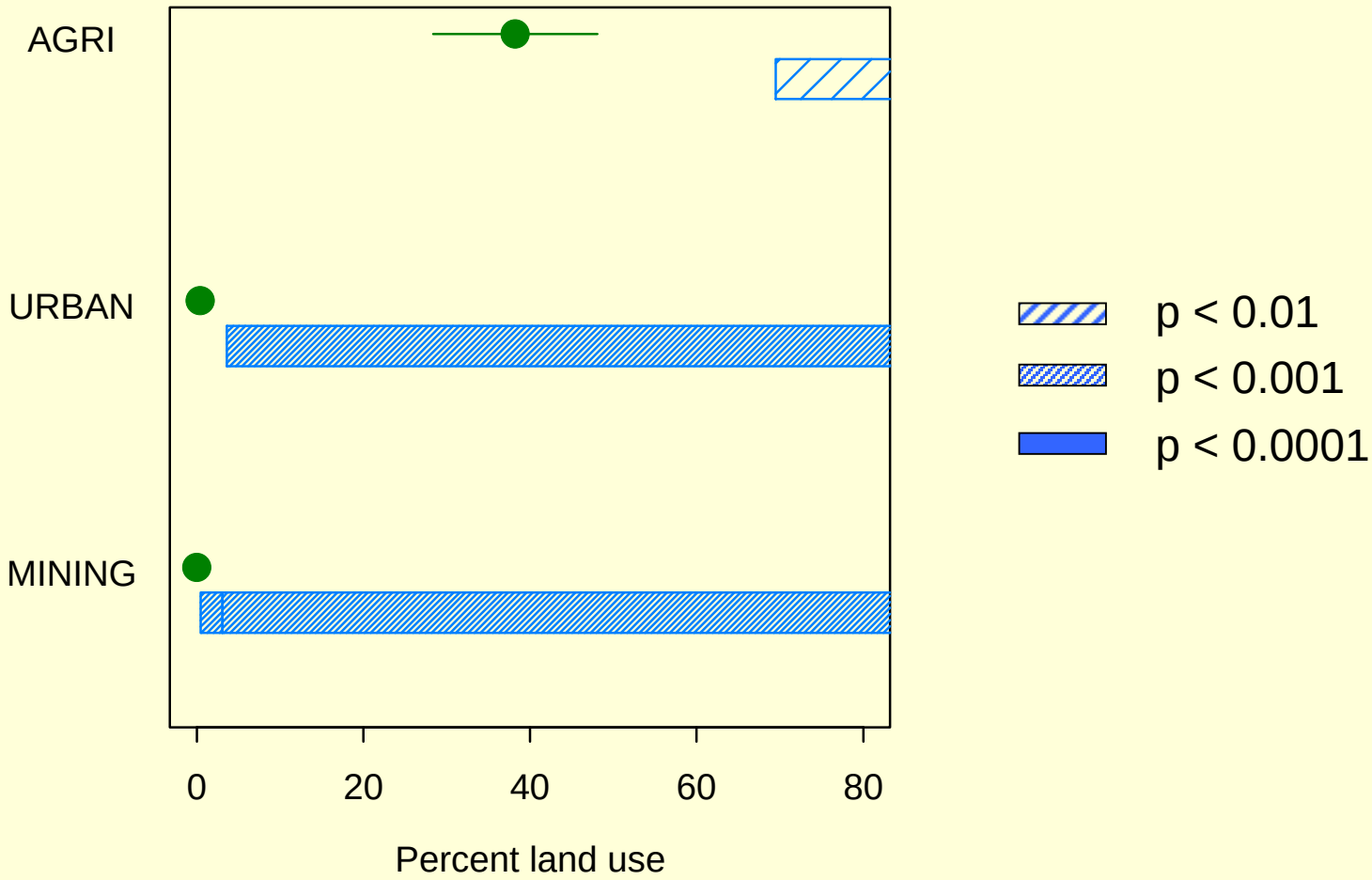


Scaling by Ephemeroptera Richness



Model $R^2 = 0.30$

Comparison of Ephemeroptera Richness Responses to Land Use



Observations

- Relative effects of land cover changes can depend on the selection of the valued ecological attribute.
- Sequence of detection limits was similar to sequence of breakpoints.

Issues

- Urban and mining gradients were not heavily sampled in this data set.
- Land use alone explains a relatively small fraction of biological variability compared to in-stream stressors.
- Other important human disturbances were not included:
  - Point sources
  - Logging
  - Acid deposition
  - Riparian zone land use
- Assumptions for piecewise linears may not be appropriate in all cases.