

Development and Application of Tolerance Values for the Western U.S.

D. P. Larsen and D.V. Peck

**U.S. EPA Office of Research and Development
National Health and Environmental Effects Research
Laboratory, Western Ecology Division
Corvallis, OR**

L. Yuan

**National Center for Environmental Assessment
Washington, DC**

**California Aquatic Bioassessment Workgroup
Davis, CA**

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Intentions

- Background on a current research effort
 - Producing empirically-derived “Tolerance Values” for benthic macroinvertebrates in streams and rivers of the western U.S.
- What’s been done
- What is planned

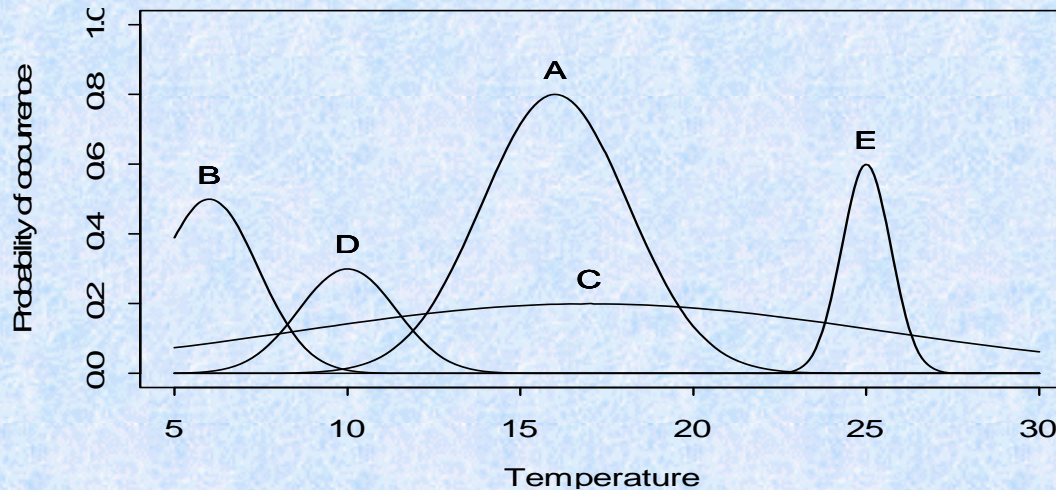


A Collaborative Effort

- U.S. EPA
 - ORD
 - Lester Yuan (Natl. Ctr. For Env. Assessment)
 - Phil Larsen, John VanSickle (NHEERL-WED)
 - Florence Fulk, Karen Blocksom (Natl. Exposure Research Lab, Ecosystem Exposure Research Division)
 - EPA Regions
 - Maggie Passmore, Greg Pond (Region 3)
 - Patti Tyler, Tina Laidlaw (Region 8)
 - Bobbye Smith (Region 9)
 - Gretchen Hayslip (Region 10)
- U.S. Geological Survey
 - Darren Carlisle
- State Agencies
 - David Huff, Doug Drake (Oregon DEQ)
 - Darren Brandt (Idaho DEQ)
 - Andy Rehn (California DFG)
- Utah State University
 - Chuck Hawkins



What is a “Tolerance Value”?



- For bioassessment: A single value that represents tolerance (or sensitivity) of a taxon to anthropogenic stressor(s)
 - Stressor can be single or “composite”
 - Tolerance value can be number or class
- Derived from “taxon-stressor” relationship
 - Several different ways to do this



Historical Derivations

- Hilsenhoff index
 - Scored individual taxa from 0-10 based on distribution of taxa across gradient of organic pollution
- Tolerance values modified by BPJ for different regions, different stressors
 - e.g., Wisseman has done this for Pacific Northwest taxa
 - General “tolerance”
 - Sediment tolerance/intolerance
 - Metrics based on grouping tolerance values use number of taxa or % individuals of each group
- Limitations
 - Many taxa do not have values assigned
 - Potentially inappropriate extrapolation
 - No contribution to assessment (=missing value)
 - Uncertainty about whether values developed for one region can be applied to other regions
 - Not enough “experts” to go around
 - Limited number of stressors



Current Potential

- Newer methods for deriving tolerance values from taxon-stressor relationship can provide:
 - Improved stressor-specific metrics
 - Richness or abundance of sediment-tolerant (or sensitive) taxa
 - Infer “condition” from tolerances of resident biota
 - Similar to reconstructing lake condition history from sediment diatoms
 - Moves towards diagnosing possible stressor(s) affecting assemblage



Research and Development Priorities

- Evaluate and establish “best methods” for deriving tolerance values
 - Develop guidance manual for States and Tribes
- Define primary stressor gradients
- Derive and compile tolerance values for major taxa with respect to major stressors
 - Temperature, fine sediment, nutrients, metals, organic enrichment
- Address some more basic ecological questions



Basic Research Needs

- Evaluating causality: Need to go beyond association-based analyses
- Effect of taxonomic resolution: Potential impact on cost, data turnaround time, who can/can't do it
- Geographic stability: Are tolerance values transferable?
- Interactions affecting taxon-stressor relationship
 - Biological– do they shift the curve?
 - Non-biological: stressor interactions (are “composite” stressor gradients OK?)
- Best approach to use for diagnostics
- Temporal stability of estimated tolerance values



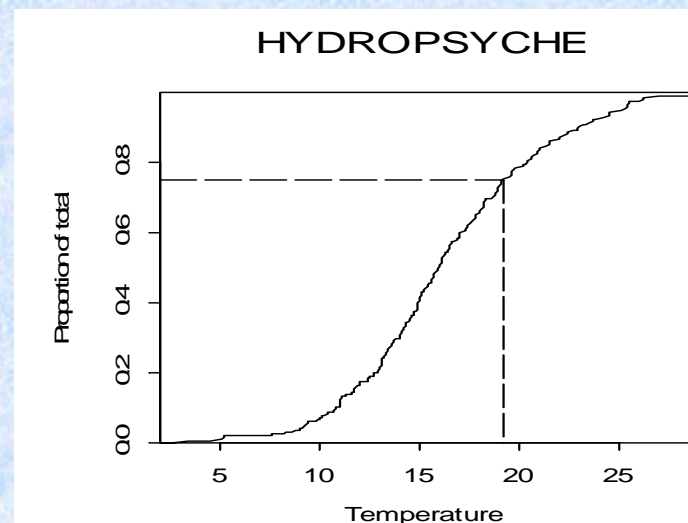
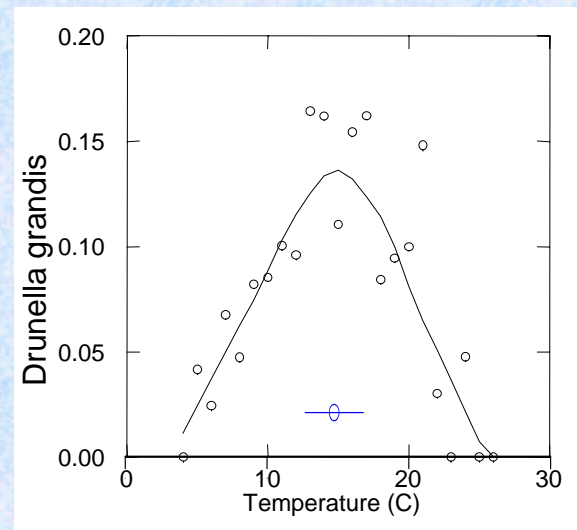
Data Sources

- Workshop: Western Tolerance Value Expert Panel held in Corvallis, Feb 3-5, 2004
- Using benthic data from first 2 years of EMAP-West
 - Eventually all 5 years will be available
 - Will include lots of “reference” sites
 - Range of stream sizes and types
- Additional data from Oregon
 - Oregon DEQ sites
- Independent efforts in other states and agencies
 - Idaho
 - USGS



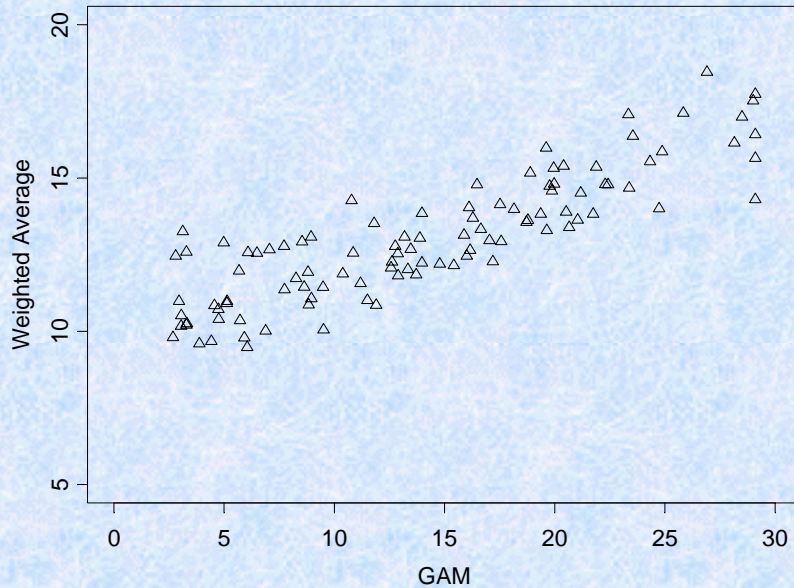
Methods Being Evaluated

- To derive tolerance values from taxon-stressor curves:
 - Weighted average
 - General additive models (GAM)
 - Logistic regression
- To derive tolerance values based on “environmental limits”:
 - Cumulative percentiles (e.g., 75th)

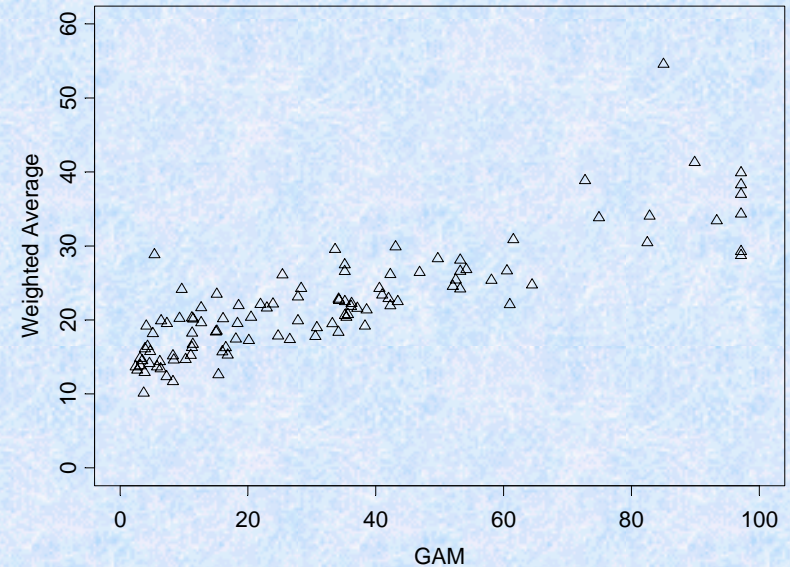


Are Methods Comparable?

GAM right-hand limit vs. WA optimum for temperature (deg. C), genus-level



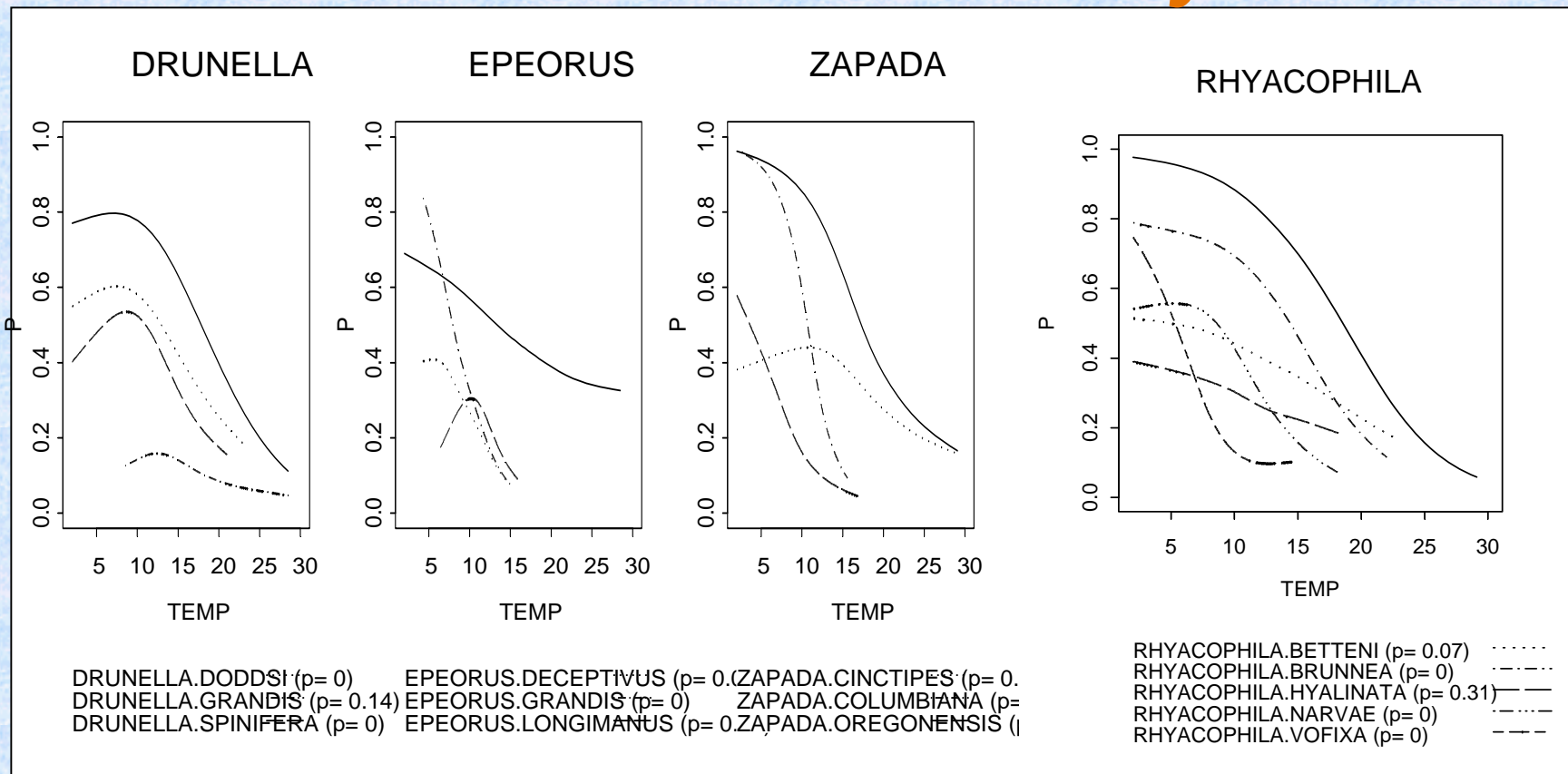
GAM right-hand limit vs. WA optimum for sediment (%Sand&Fines), genus-level



- Tolerance values derived from weighted averaging vs. general additive model for temperature (left), and sediment (%sand+fines; right)
 - Comparable, but not identical



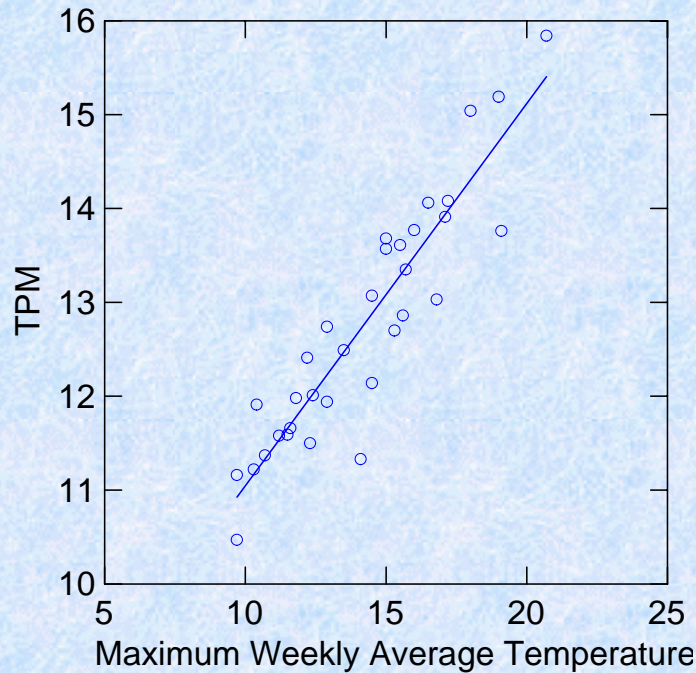
What about Taxonomy?



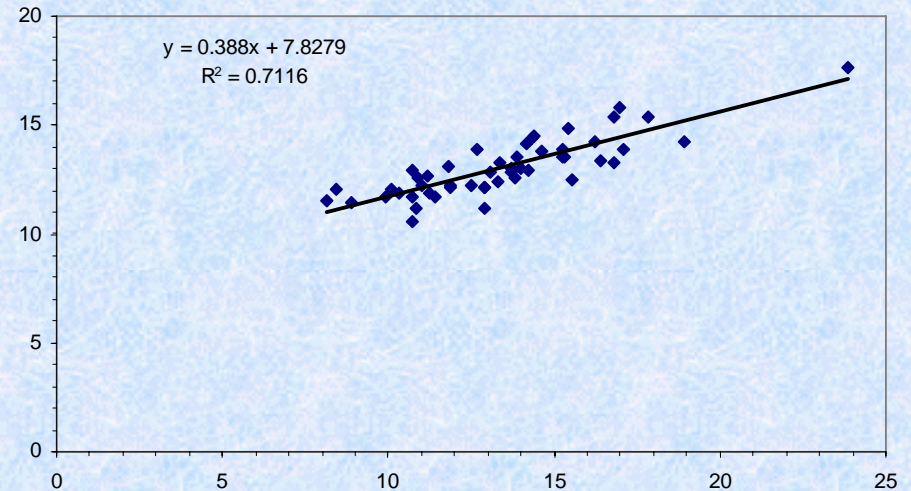
- Species within 4 genera
 - Solid line- curve based on genus-level ID
 - Get some differences in both optima and curve shape (=tolerance class) with species-level IDs



Are Tolerance Values Transferable?



TPM vs. Avg. July/Aug Temp for 50 Oregon Streams

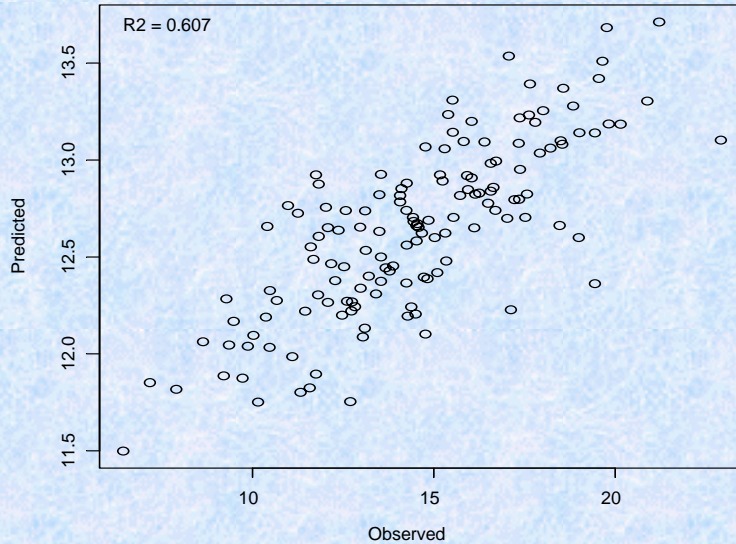


- Tolerance values for temperature developed from Idaho streams (left) used on data from Oregon streams
 - Good agreement between predicted temp. from tolerance values and observed stream temperature
 - Less agreement expected when study areas are more geographically distant from one another

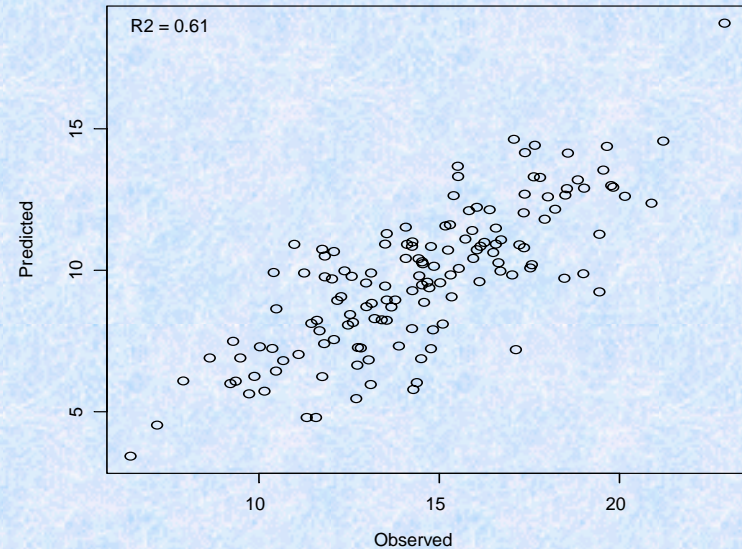


Can Biota Predict Stressor Severity?

Temperature predictions, WA



Temperature predictions, GAM

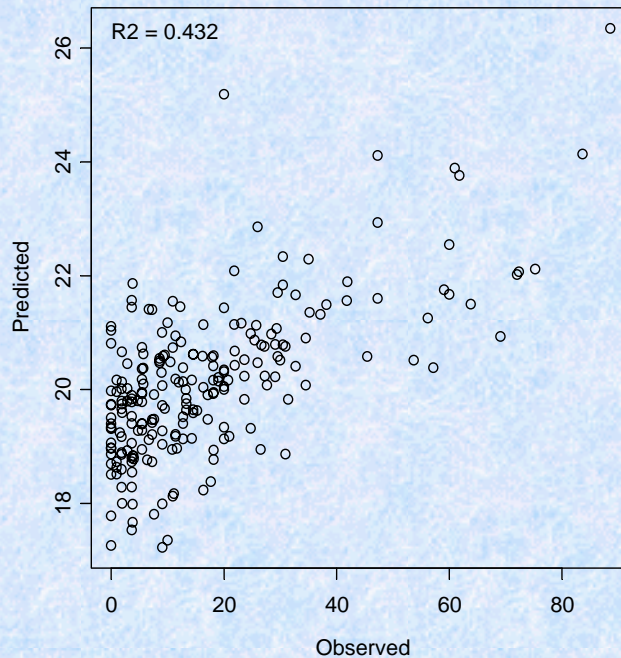


- Develop predicted stressor value by averaging tolerance values (=optima) for all taxa collected at a site

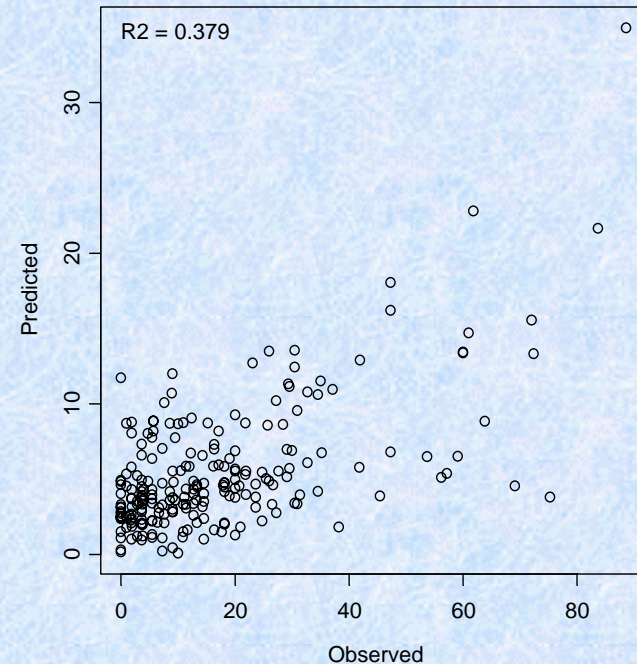


Can Biota Predict Stressor Severity?

Sediment predictions, WA



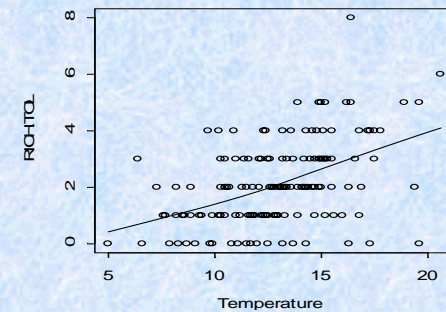
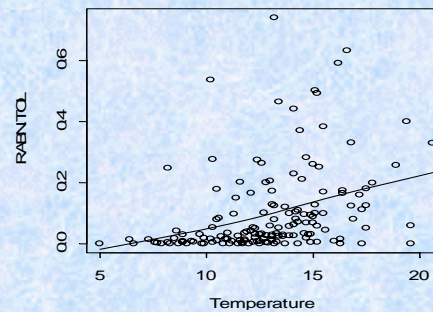
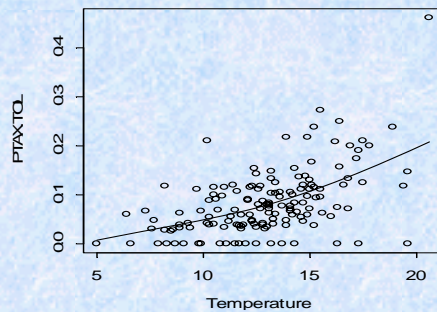
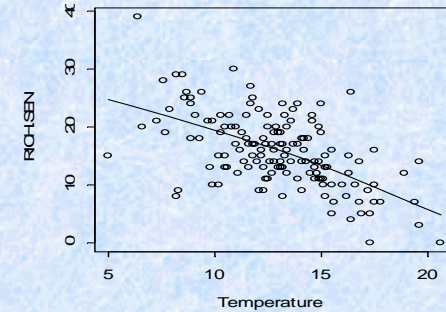
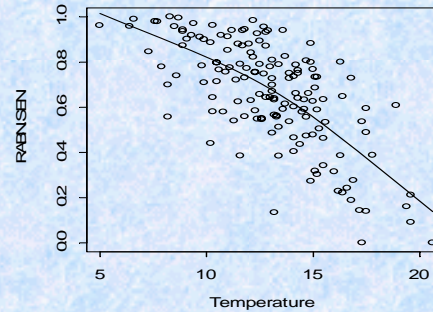
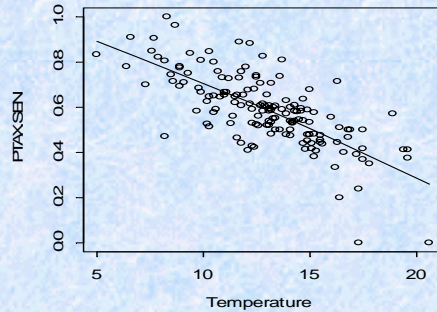
Sediment predictions, GAM



- Sediment relationship is noisier than temperature
 - Harder to measure “sediment”?
 - Taxonomic resolution?



Metrics Derived from Tolerance Values

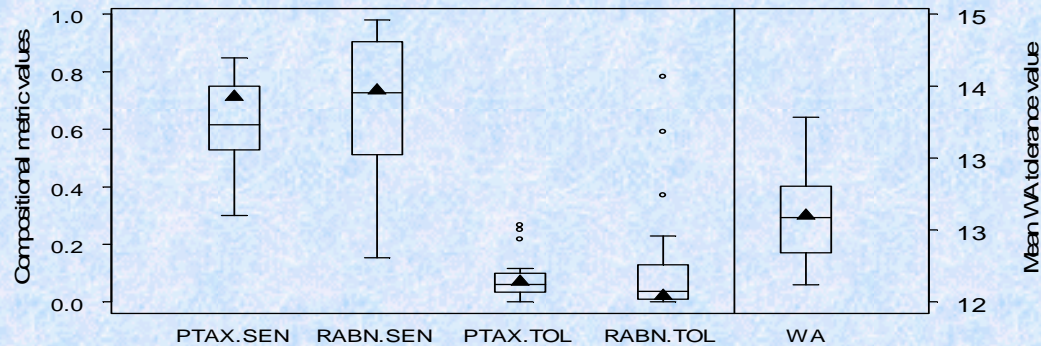


- Example from OR: Three variants of same metrics based on classifying taxa as “sensitive” (top row) or “tolerant” (bottom row) based on tolerance values or shape of tolerance curve (narrow vs. wide)
 - % of total taxa (left)
 - % individuals (center)
 - Number of taxa (right)

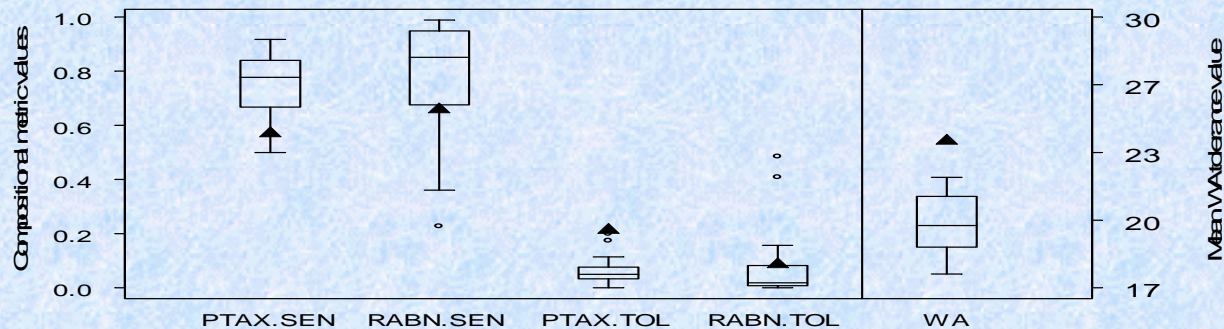


Diagnostic Potential

Temperature metrics



Sediment metrics



- Comparison of metrics (% sens. Taxa, % sens. Ind., %tol taxa, %tol ind) vs. avg. of tolerance values from all taxa (derived using weighted averaging)
- Single site compared to distribution from reference sites
- Temperature: site is not stressed, consistent answer for all metrics
- Sediment: site is stressed
 - Fewer sensitive taxa and individuals, more tolerant taxa and individuals



Anticipated Products

- Workshop: Western Tolerance Value Expert Panel
 - Corvallis, Feb 3-5, 2004
- Workshop report: The estimation and application of macroinvertebrate tolerance values: 10/2004—draft ready for external review
- Manuscript: Sources of bias in weighted average inferences of environmental conditions. Yuan. *J. of Paleolimnology* (accepted).
- Manuscript: Diagnosing the sources of impairment using predictive models and tolerance values. Yuan, Hawkins,...; 11/2004



More Products

- Tolerance value tutorial module for Causal Analysis/Diagnosis Decision Information System (CADDIS; early 2005)
- Tolerance value database for CADDIS (late 2005)
- Synthesis of State/Tribal usage of tolerance values (2005)
- Tolerance estimation methods comparison and guidance (2005)
- Region 3 tolerance value workshop (2005)



The Next Path to Fame and Fortune...?

- Tolerance values just one wrench in the bioassessment toolbox
- Functional attributes (feeding group, habit) needs as much or more work
 - Many, many taxa are undefined, or get assigned attributes from other regions or from higher taxon level
 - Many have “mixed” designations, which essentially equates to no information
 - Derive FFG based on ecomorphology (similar to fish studies)
 - Requires making measurements or classifying from direct observation of specimens
 - Compare morphological characteristics to taxa whose attributes are definitive

