THERMAL & HYDROLOGIC INDICATOR ANALYSES

& THE FRESHWATER BIOLOGICAL TRAITS DATABASE

The views expressed in this talk are those of the author and they do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency

INDICATORS

- Which taxa and metrics are most likely to be impacted by changes in temperature and hydrology?
- How will changes in taxa and assemblages affect state biomonitoring indices and biocriteria (e.g., will corrections need to be applied?)
- Will indices be robust, or will they need to be recalibrated?

METHODOLOGY – THERMAL INDICATOR ANALYSIS

- Compiled biological samples with **instantaneous** water temperature measurements
- July-October samples
- Final n = 5,999

Table 1. Number of samples by entity and method.

Entity + method	Number of Samples
CTDEP_KN_2M2_Riffle	576
MEDEP_AS_RockBasket	367
NEWS_KN_Multihab	114
NHDES_AS_RockBasket	180
NHDES_KN_Riffle	9
NYDEC_KN_Riffle	3170
RIDEM_KN_RBP_ESS	228
USGS_Surber_nonsnag	41
VT_KN_Riffle	1428
WSA_KN_MultiHab	56

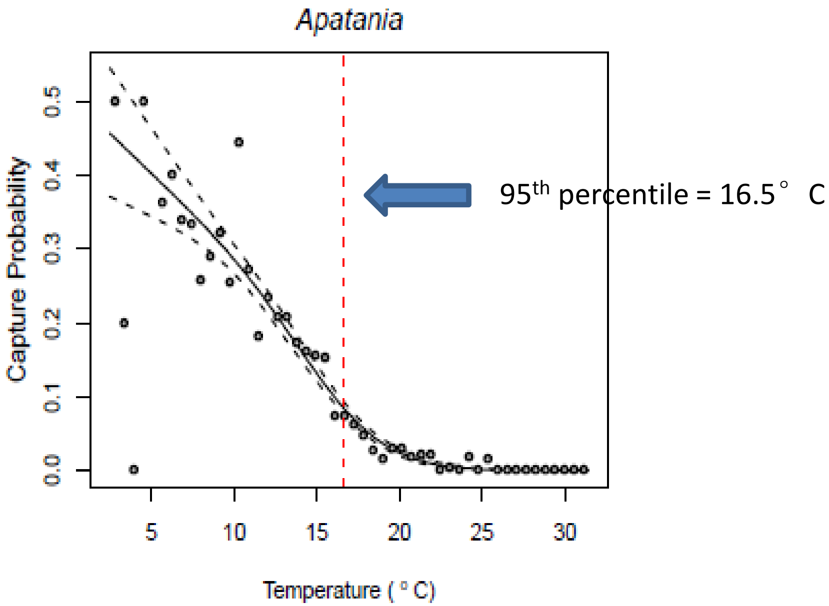
*we were unable to obtain water temperature data from MA DEP

- Several data sets splits for separate (test) analyses:
  - Single state datasets with >300 samples (CT, ME, VT, NY)
  - Random selection of 4000 samples as test set, remaining 1999 samples as validation set
- Compared multiple analytical methods
  - Weighted averaging, cumulative percentiles, linear regression models (LRM); quadratic logistic regression models (QLRM); and generalized additive models (GAM)
  - Best performers, ‘weight of evidence’ corroboration
  - Used ranks (relative order rather than actual temp values)
- Evaluated performance - regression coefficients between macroinvertebrate-inferred and observed temperatures

INTERPRETATION OF TOLERANCE PLOTS

Curve shapes generally fall into three categories: increasing, decreasing, or unimodal.

In this sample plot, the taxon is a decreaser; this means that the probability of capturing it decreases as temperature increases.

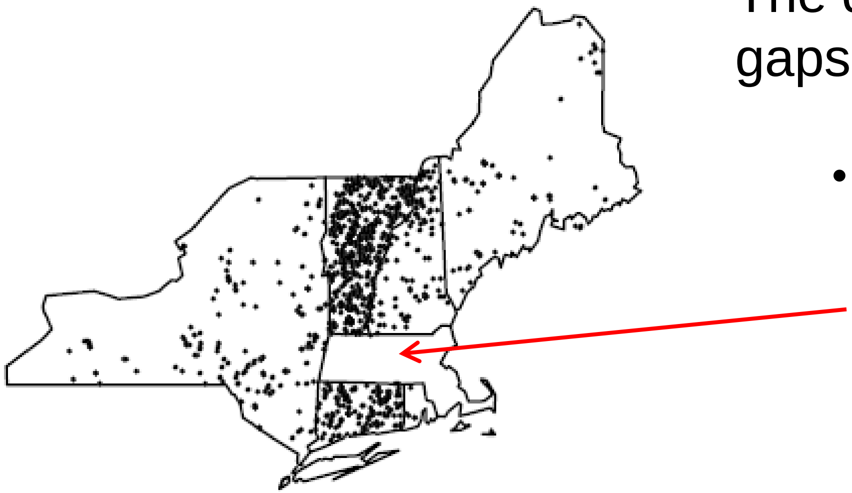


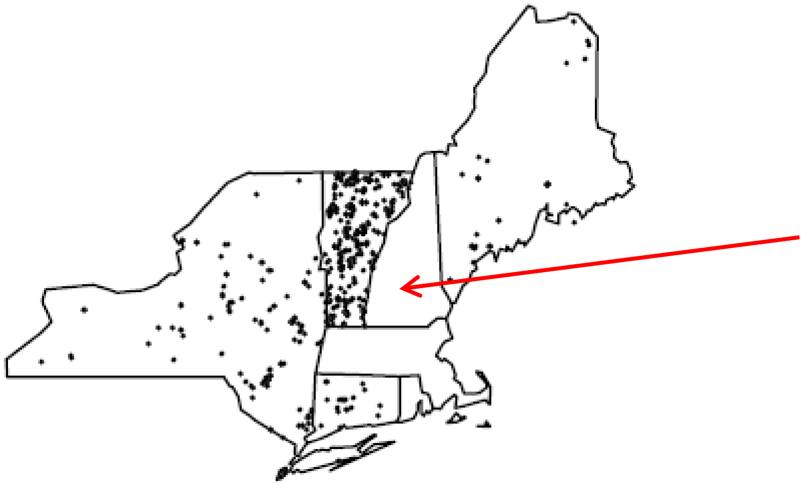
The vertical red dotted line marks the **95th percentile cumulative probability** derived from the **GAM model/full temperature range**; we considered this to be the environmental limit a taxon could tolerate (in this example = 16.5°C).

For more background on tolerance plots, see:

Yuan, Lester. 2006. Estimation and Application of Macroinvertebrate Tolerance Values. Report No. EPA/600/P-04/116F. National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

INTERPRETATION OF DISTRIBUTION PLOTS





The distribution plots have some obvious gaps:

- We have very few MA samples in our dataset; this is because MA DEP could not provide water temperature data; if MA samples are shown, they are from the NEWS & WSA projects.
- Some plots (in particular species-level) are influenced by differences in taxonomic resolution across states (i.e. NH does not ID to species-level, thus no NH samples are shown in this plot)
- Some plots are influenced by taxonomic ambiguities – we lacked the resources to fully address these in this project.

SELECTION OF COLD, COOL & WARM INDICATOR TAXA

Considerations:

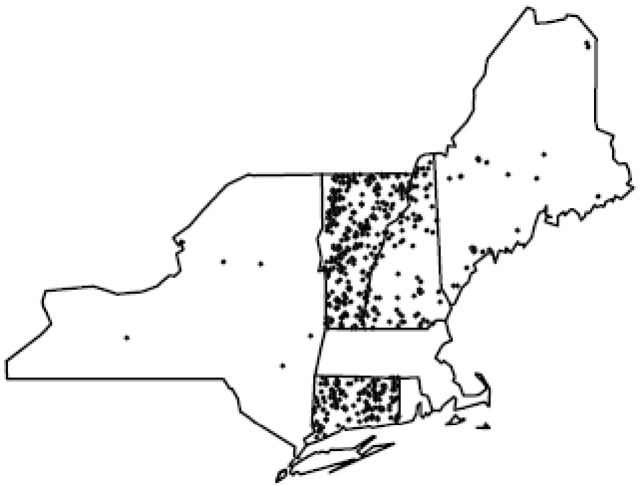
- Optima and tolerance values (lower tertiles)
- Agreement across models
- Capture probability (max value of at least 0.1)
- Proportion of points within confidence limits (‘noise’)
- Curve shape (mostly decreasers; a few unimodal)

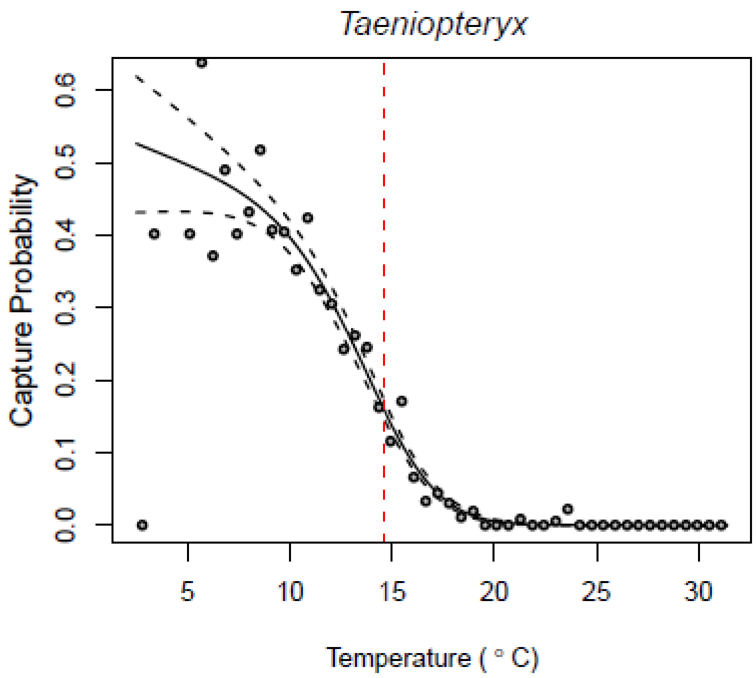
This list is divided into 3 groups:

- **Level 1- widespread (occur in ≥ 4 states):** least ‘noise,’ strongest agreement across models
- **Level 2 - widespread (occur in ≥ 4 states):** more noise, slightly less agreement across models
- **Limited distribution**: occur in < 4 states

COLD - Level 1

Order	Family	Regional_FinalID	Tolerance limit
Plecoptera	Taeniopterygidae	Taeniopteryx	14.8

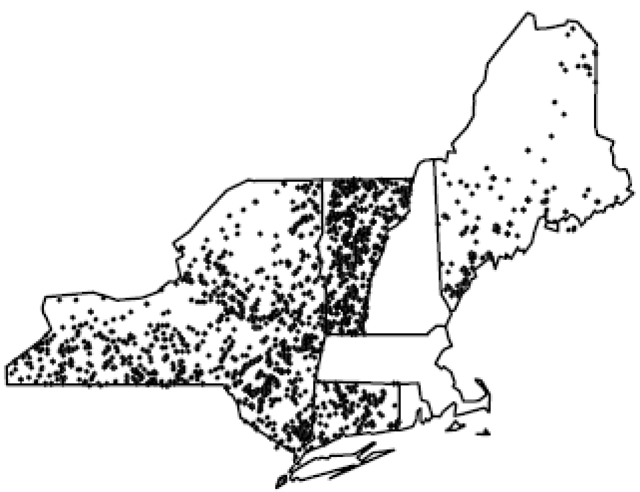


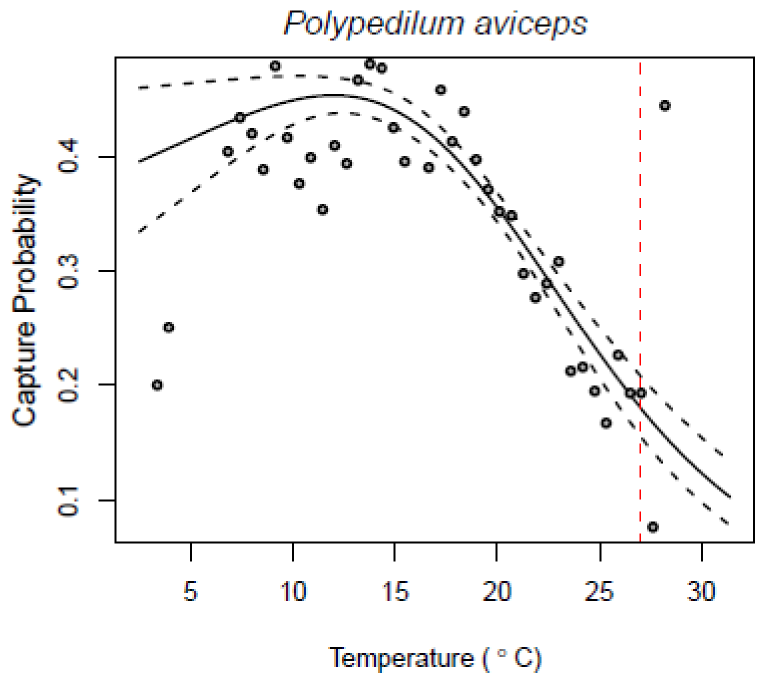


Analysis run by Lei Zheng, Tetra Tech

COOL - Level 1

Order	Family	Regional_FinalID	Tolerance limit
Diptera	Chironomidae	Polypedilum aviceps	27.6

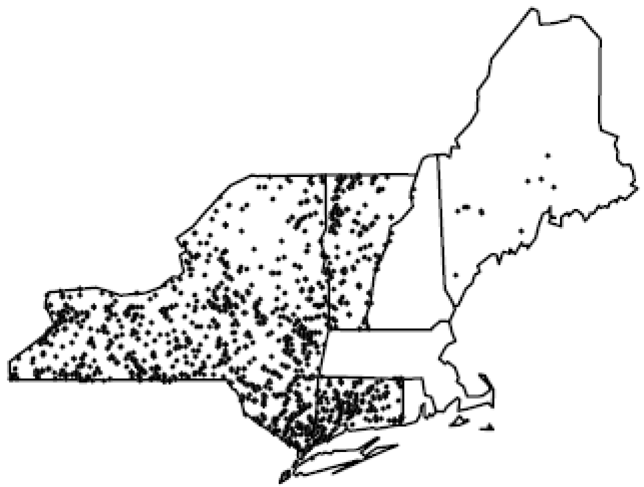


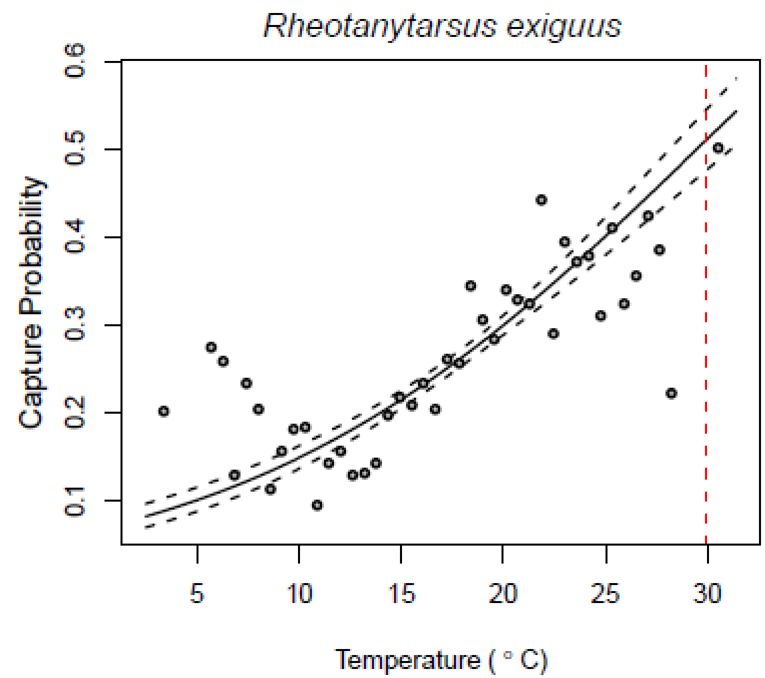


Analysis run by Lei Zheng, Tetra Tech

WARM - Level 1

Order	Family	Regional_FinalID	Tolerance limit
Diptera	Chironomidae	Rheotanytarsus exiguus	30.5





Analysis run by Lei Zheng, Tetra Tech

THIS IS A FIRST STEP…

- This list represents an improvement over our pilot study results but should still be regarded as a starting point; we recommend that it be reviewed by regional experts and compared to results from other studies
- Results are based on observational data; associations do not imply causation
- A next step would be to consider temperature in combination with other factors (i.e. Poff et al. 2010 - community types based on trait composition)
- Results are based on instantaneous data; as continuous temperature data become more widely available, it would be valuable to perform a similar exercise on statistics derived from those data (i.e. avg July temp)
- Our analyses exposed some taxonomic ambiguities; we recommend that efforts be made to resolve these issues at a regional level
- When possible, we recommend species-level IDs for all taxa on this list

DO SOMETHING SIMILAR FOR FISH?

METHODOLOGY – HYDROLOGIC INDICATOR ANALYSIS

Similar to thermal indicator analysis, except fewer data

Two datasets:

- NHDPlus stream/catchment layer.
- Indicators of Hydrologic Alteration (IHA) data from USGS gages located in proximity to biological sampling sites.

Spearman correlation analysis

	CUMDRAINAG	SLOPE	MAFLOWU	MAVELU	BSFLMEAN	SLPMEAN
CUMDRAINAG	1.00					
SLOPE	-0.56	1.00				
MAFLOWU	1.00	-0.56	1.00			
MAVELU	0.78	-0.01	0.79	1.00		
BSFLMEAN	-0.10	-0.09	-0.09	-0.17	1.00	
SLPMEAN	0.02	0.32	0.02	0.26	-0.34	1.00

Hydrologic parameters that were evaluated in the NHDPlus dataset

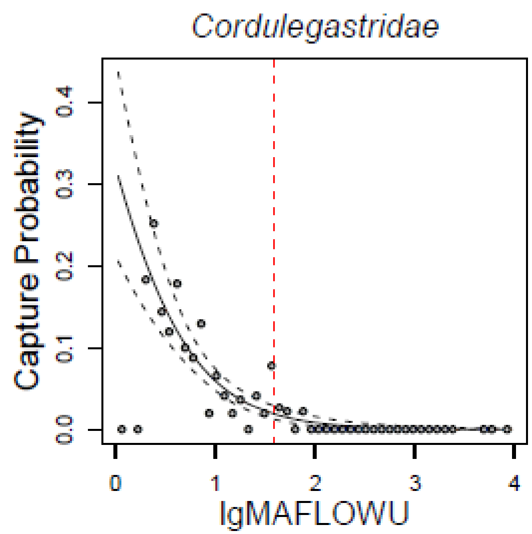
Abbrev Parameter	Description	Source
CUMDRAINAG	Cumulative drainage area in square kilometers at bottom of flowline	NHDPlus FlowlineAttributes
MAFLOWU	Mean annual flow in cubic feet per second (cfs) at bottom of flowline as computed by Unit Runoff Method	NHDPlus FlowlineAttributes
MAVELU	Mean annual velocity (fps) at bottom of flowline as computed by Unit Runoff Method	NHDPlus FlowlineAttributes
SLOPE	Slope of flowline (m/m)	NHDPlus FlowlineAttributes
BSFLMEAN	Mean baseflow index within NHDPlus local catchment based on a 1-kilometer raster (grid) dataset for the conterminous United States created by interpolating base-flow index (BFI) values estimated at U.S. Geological Survey (USGS) streamgages (Wolock 2003). Base flow is the component of streamflow that can be attributed to ground-water discharge into streams.	Olivero and Anderson 2008
SLPMEAN	Mean local catchment slope (terrestrial) based on the 2001 USGS NED 30m digital elevation model (http://ned.usgs.gov/)	Olivero and Anderson 2008

Hydrologic parameters that were evaluated in the IHA dataset

Abbrev Parameter	Description	Source
lgMAF	mean annual flow (cfs), based on calendar year	http://waterdata.usgs.gov/nwis/annual?referred_module=sw
lgX3daymax	annual maxima, 3-day mean (cfs)	IHA output
lgX3daymin	annual minima, 3-day mean (cfs)	IHA output
lgFallrate	median of all negative differences between consecutive daily values	IHA output
lgHigh1fall	median of high flow pulse event fall rates	IHA output
RBI*	Richards-Baker Flashiness Index (Baker et al. 2004). Flashiness reflects the frequency and rapidity of short term changes in streamflow, especially during runoff events. This index has low interannual variability, relative to most flow regime indicators, and thus greater power to detect trends.	R code output based on USGS daily streamflow data
lgBaseflow	Base flow index: 7-day minimum flow/mean flow for year	IHA output

Decreaser – Level 1

Order	Family	FinalID	Mean annual flow - 95th	Mean annual flow - 50th	Cum DrArea - 95th	Cum DrArea - 50th
Odonata	Cordulegastridae	Cordulegastridae	36.9	1.5	39.6	1.6



Plot scale = transformed

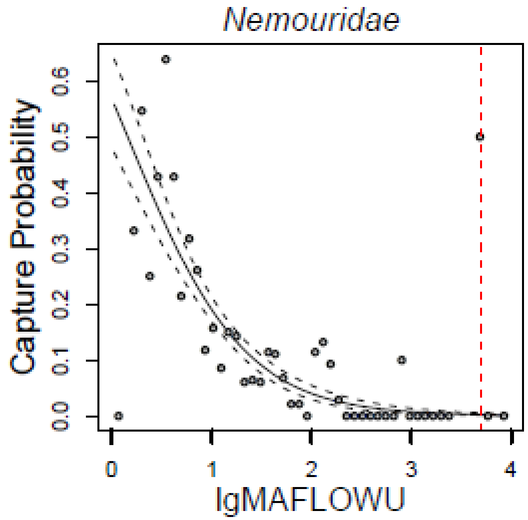
Units

- Flow – cubic feet per second (cfs)
- Cumulative drainage area – km^2

Analysis run by Lei Zheng

Decreaser – Level 1

Order	Family	FinalID	Mean annual flow - 95th	Mean annual flow - 50th	Cum DrArea - 95th	Cum DrArea - 50th
Plecoptera	Nemouridae	Nemouridae	89.2	2.4	108.4	2.8



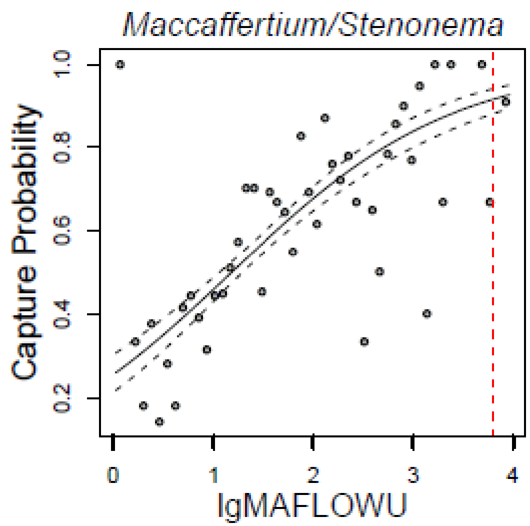
Plot scale = transformed

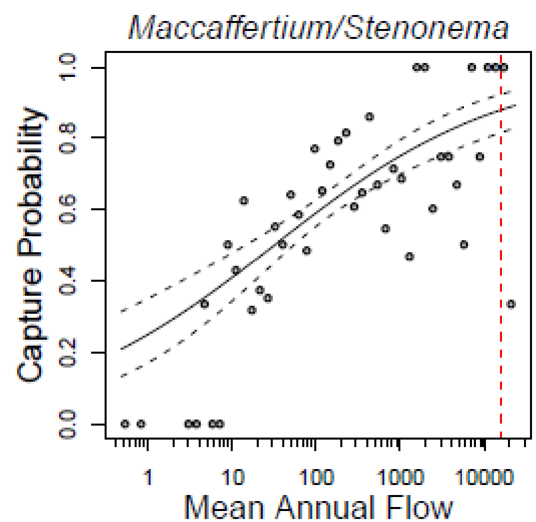
Units
- Flow – cubic feet per second (cfs)
- Cumulative drainage area – km^2

Analysis run by Lei Zheng

Increaser

Order	Family	FinalID	Mean annual flow - 5th	Mean annual flow - 50th	Cum DrArea - 5th	Cum DrArea - 50th
Ephemeroptera	Heptageniidae	Maccaffertium/Stenonema	1.7	294.1	2.0	390.7





Plot scale = transformed

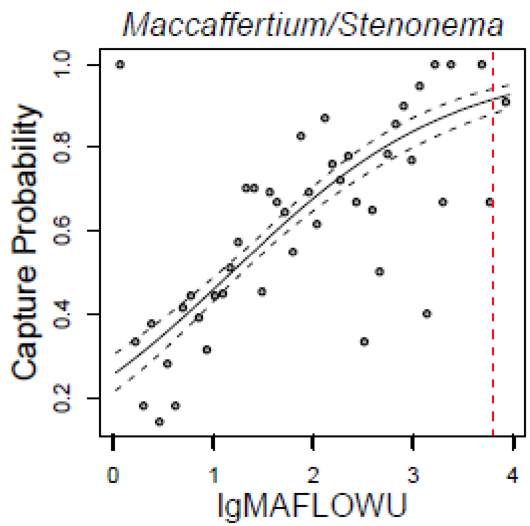
Units

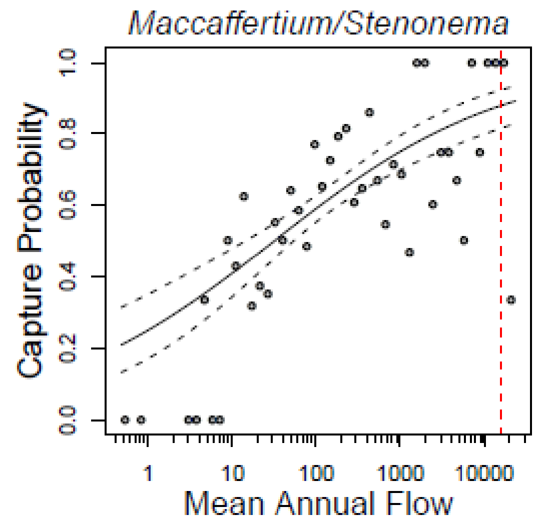
- Flow – cubic feet per second (cfs)
- Cumulative drainage area – km^2

Analysis run by Lei Zheng

Increaser

Order	Family	FinalID	Mean annual flow - 5th	Mean annual flow - 50th	Cum DrArea - 5th	Cum DrArea - 50th
Ephemeroptera	Heptageniidae	Maccaffertium/Stenonema	1.7	294.1	2.0	390.7





Plot scale = transformed

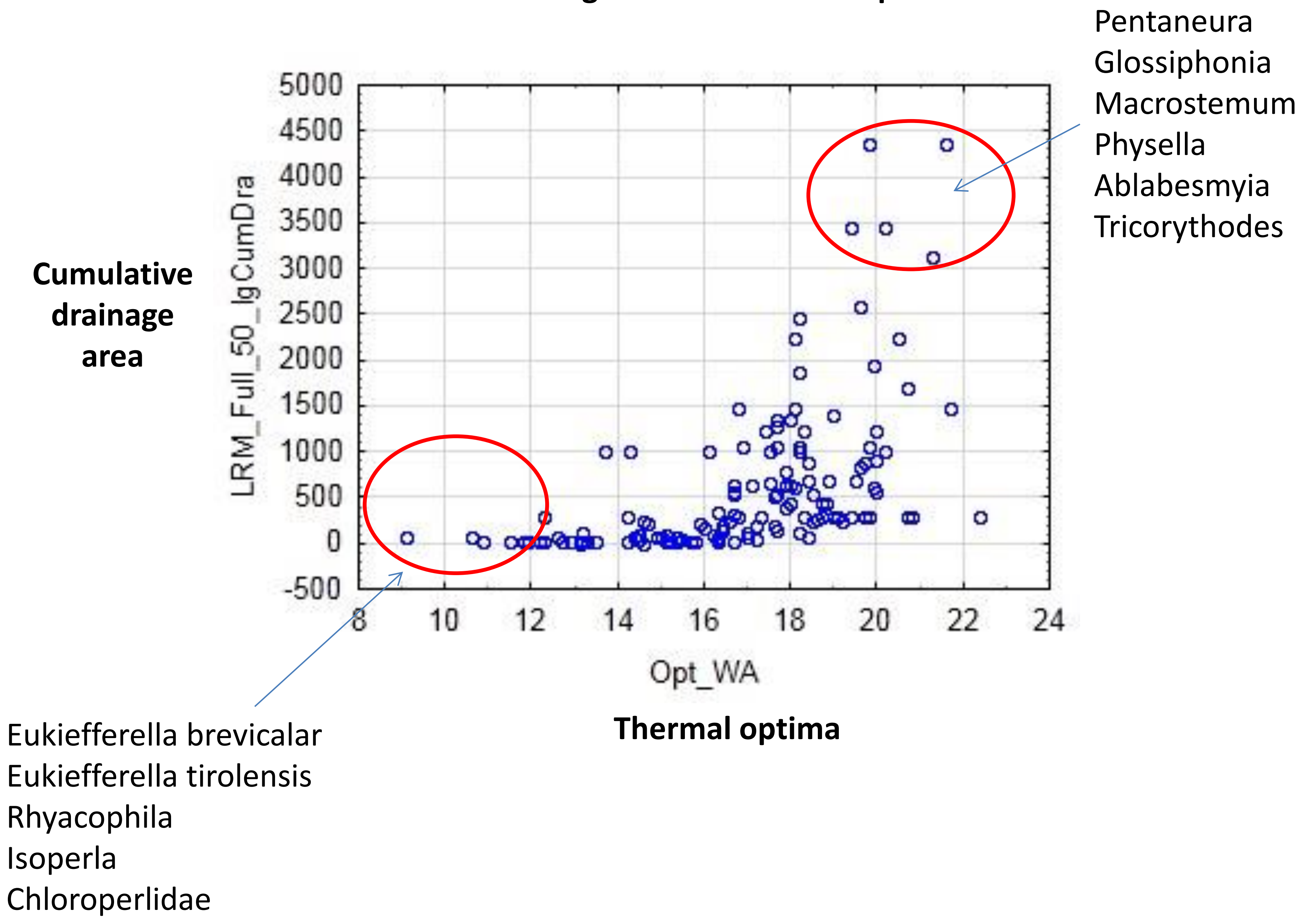
Units

- Flow – cubic feet per second (cfs)
- Cumulative drainage area – km^2

Analysis run by Lei Zheng

TEMPERATURE & HYDROLOGY IN COMBINATION

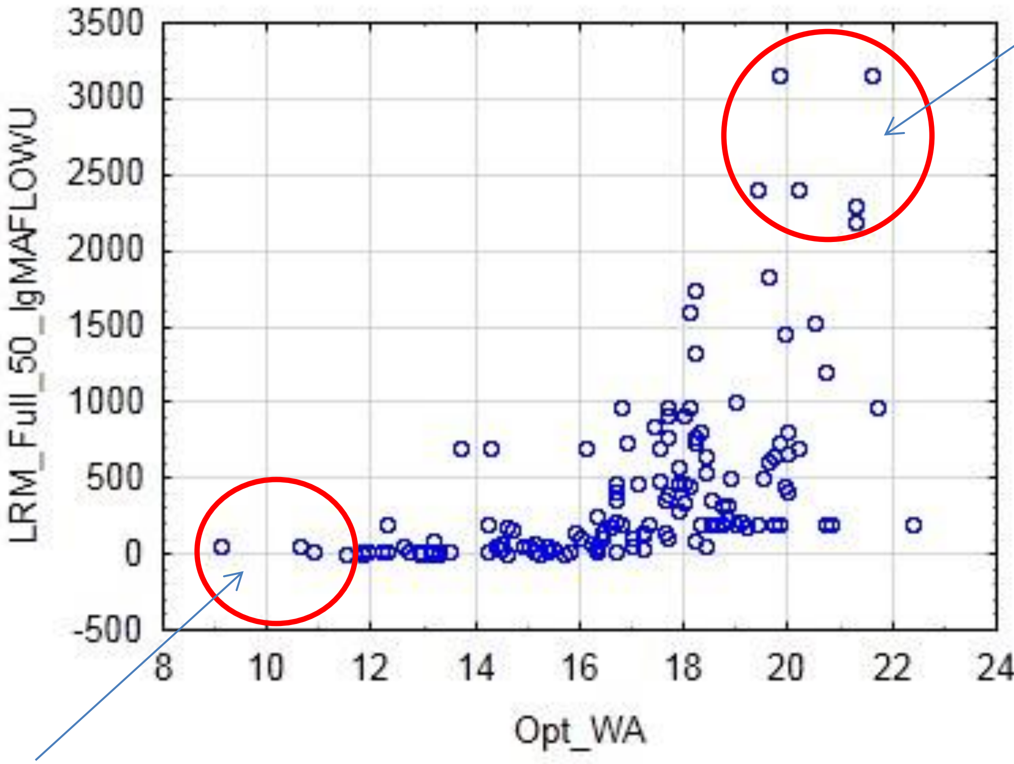
Cumulative drainage area vs. thermal optima



Mean annual flow vs. thermal optima

Pentaneura
Glossiphonia
Macrostemum
Physella
Ablabesmyia
Tricorythodes

Mean annual flow



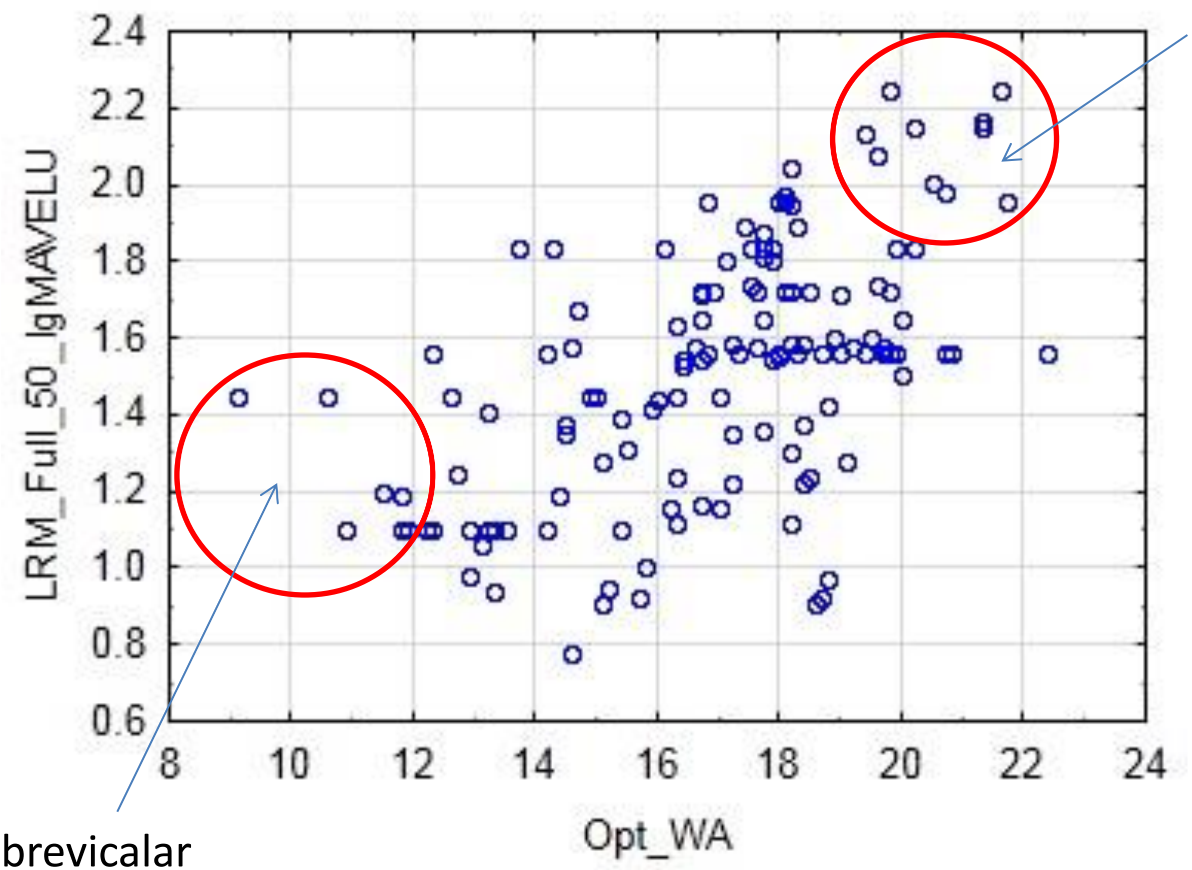
Thermal optima

Eukiefferella brevicalar
Eukiefferella tirolensis
Rhyacophila
Isoperla
Chloroperlidae

Mean annual velocity (which is based in large part on drainage area) vs. thermal optima

Pentaneura
Glossiphonia
Macrostemum
Physella
Ablabesmyia
Tricorythodes

Mean annual velocity

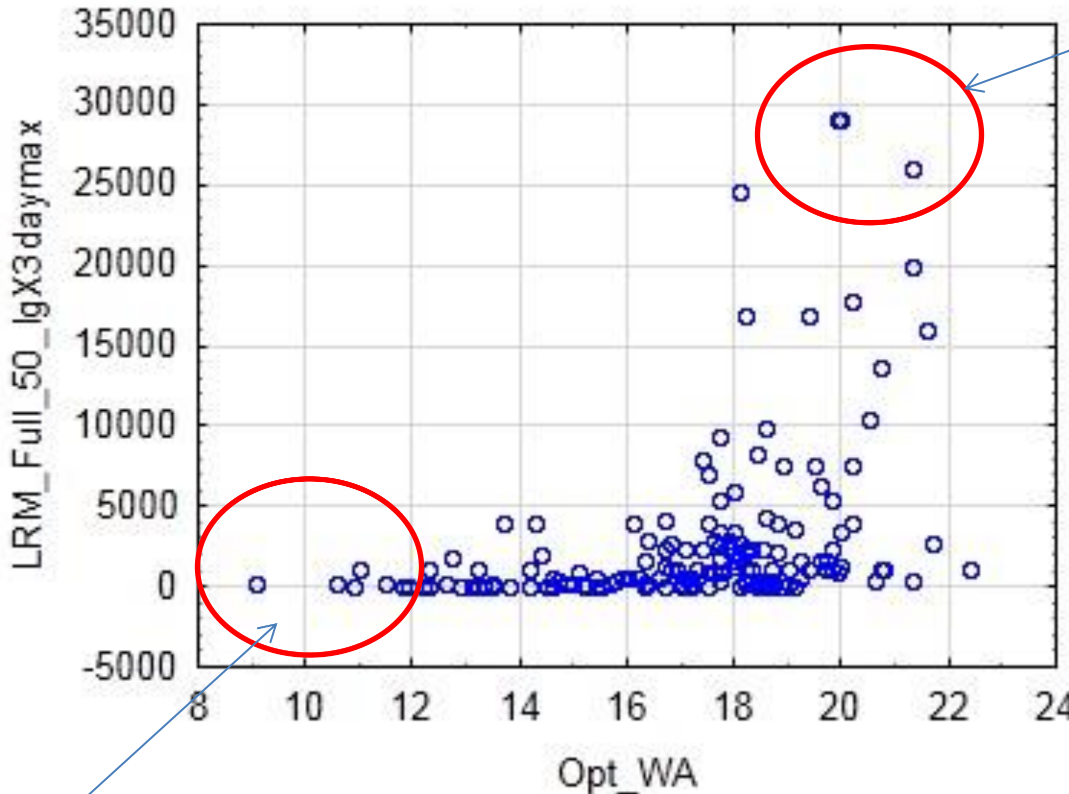


Thermal optima

Eukiefferella brevicalar
Eukiefferella tirolensis
Rhyacophila
Isoperla
Chloroperlidae

X3 day maximum vs. thermal optima

X3- day max



Thermal optima

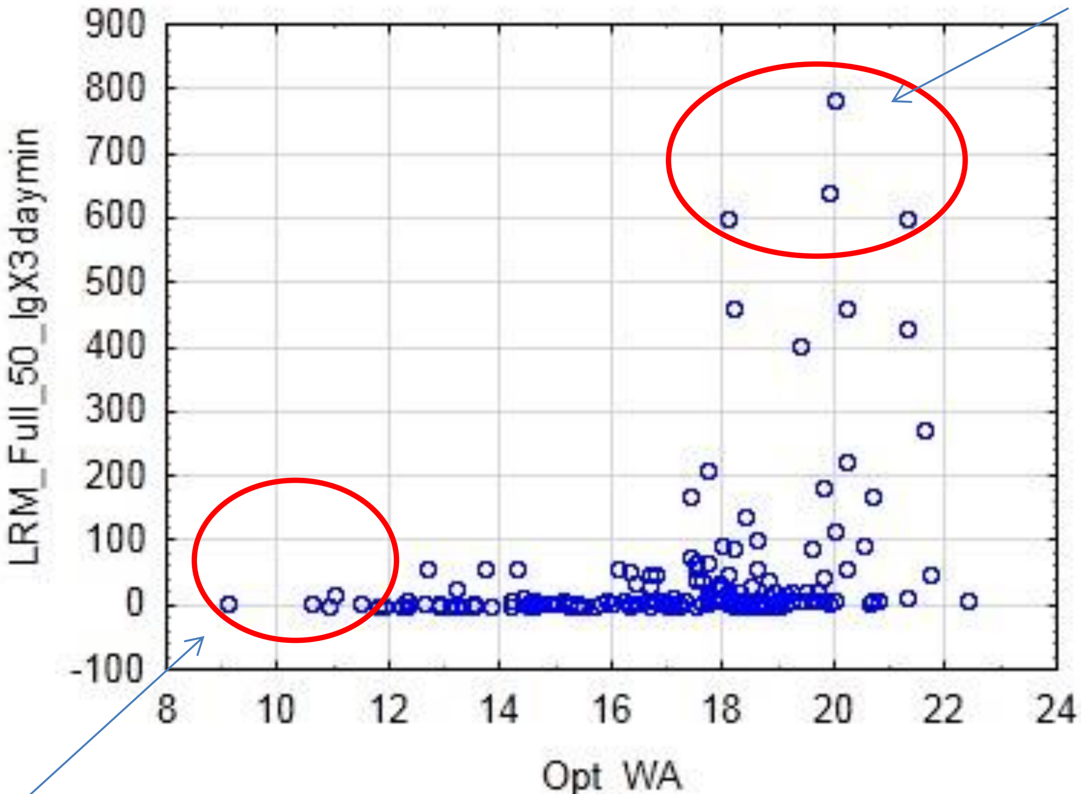
Pseudocloen
Stenacron
Ablabesmyia
Macrostemum
Tricorythodes
Ceraclea
Pentaneura

Eukiefferella brevicalar
Eukiefferella tirolensis
Rhyacophila invaria
Taniopteryx

X3 day minimum vs. thermal optima

Pseudocloen
Stenacron
Ablabesmyia
Macrostemum
Tricorythodes
Ceraclea

X3 day min

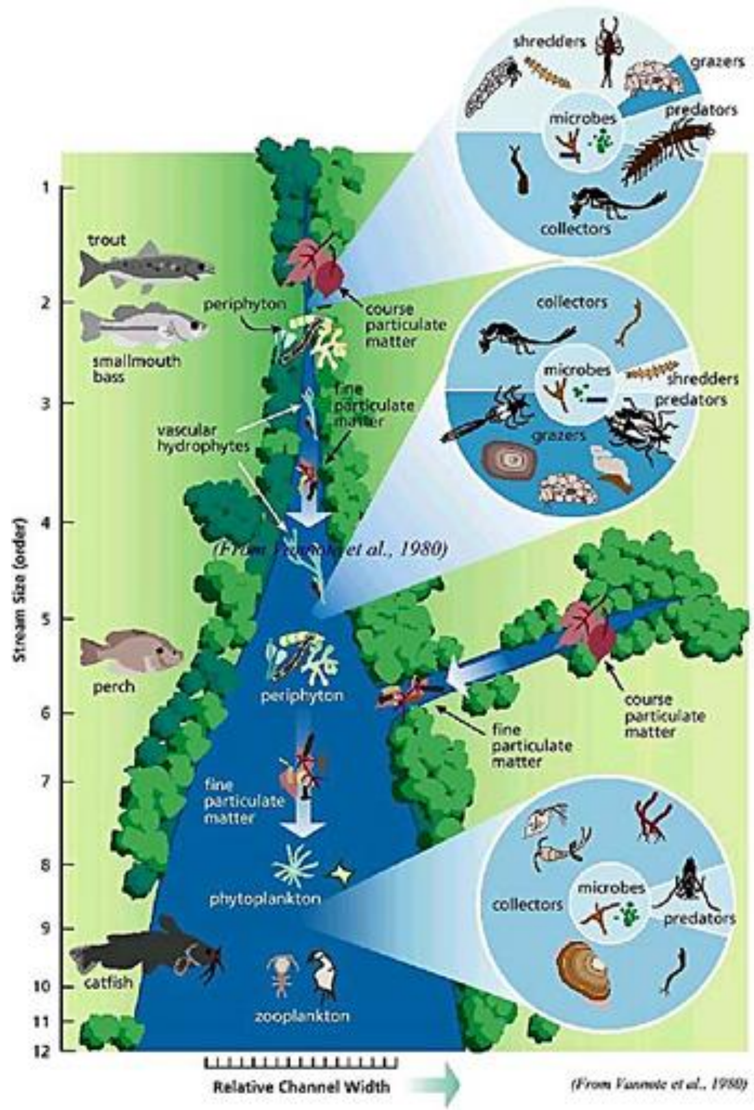


Thermal optima

Eukiefferella brevicalar
Eukiefferella tirolensis
Rhyacophila fenestra & invaria
Taniopteryx
Isoperla

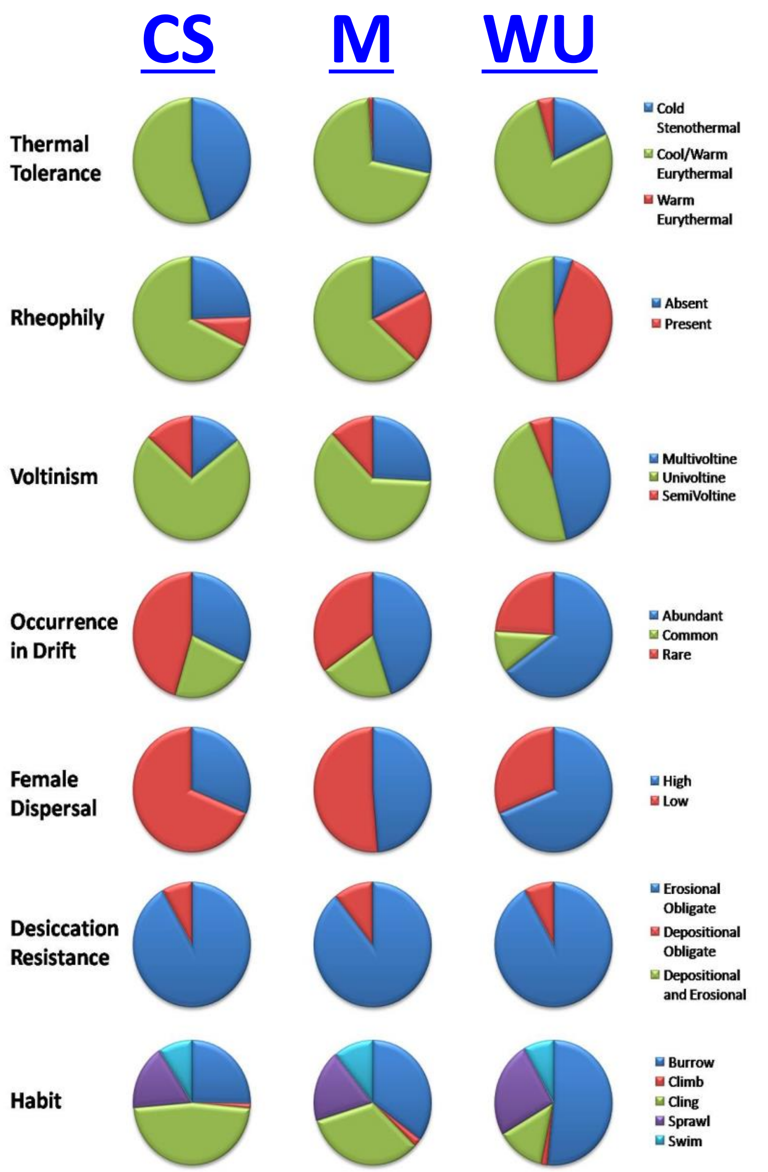
Vannote's River Continuum Concept (RCC)

(Vannote et al. 1980)



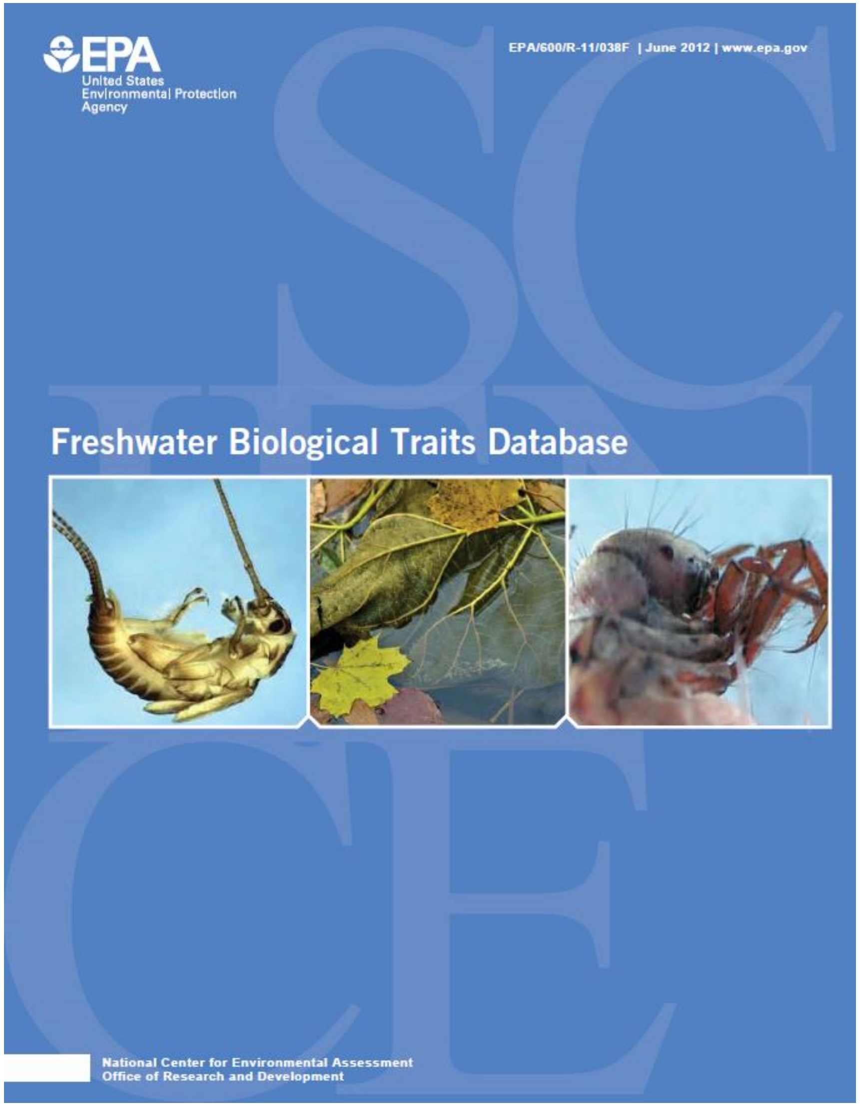
Traits-based "community types"

- Cluster Analysis
  - Cold Stable (CS)
    - Cold stenothermal (temp)
    - Erosional obligates (runoff?)
    - Low disturbance traits (e.g., drift, dispersal)?
    - Clingers
  - Warm Unstable (WU)
    - Warm/cool eurythermal and warm eurythermal
    - Depositional obligates
    - More disturbance traits
  - Intermediate (M)
    - intermediate



Poff et al. 2010

Freshwater Biological Traits Database



http://www.epa.gov/ncea/global/traits/

Data Gathering

- Focused on lotic systems and North American macroinvertebrate taxa
- Traits data fit the following criteria:
  - published or otherwise well-documented by trustworthy sources
  - accessible
  - appropriate for the regions being studied
  - in a standardized format that could be analyzed or easily converted to a format that could be analyzed
  - ecologically relevant to the gradients being considered, environmentally sensitive, non-redundant, and statistically tractable (modeled after Vieira et al. 2006)

Global Change Impacts & Adaptation

Database search

Download instructions for using the Freshwater Biological Traits Database

Download all traits information

Download all traits information - transposed

Traits Home
- Database search
- Data sources
- Metadata

The transposed format takes the traits data and organizes it so that trait names are shown as column headings vs. in rows. For some of you, this is likely to be a more user-friendly format (for more details on this, see Instructions).

Please select one or more options to search.

(Note: when you remove the Taxa items, they will be appended at the end of the original list.)

TaxaList:

Abedus
Abedus herberti
Abedus indentatus
Ablabesmyia
Ablabesmyia annulata
Ablabesmyia aspera
Ablabesmyia cinctipes
Ablabesmyia hauberi
Ablabesmyia illinoensis

Add >>

<< Remove

State: (Optional)

Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
Florida

Add >>

<< Remove

QUESTIONS? COMMENTS?

Jen Stamp (Jen.Stamp@tetratech.com)