Temporal response patterns in fish and benthic invertebrate communities in streams of the North Central and Northeastern U.S.

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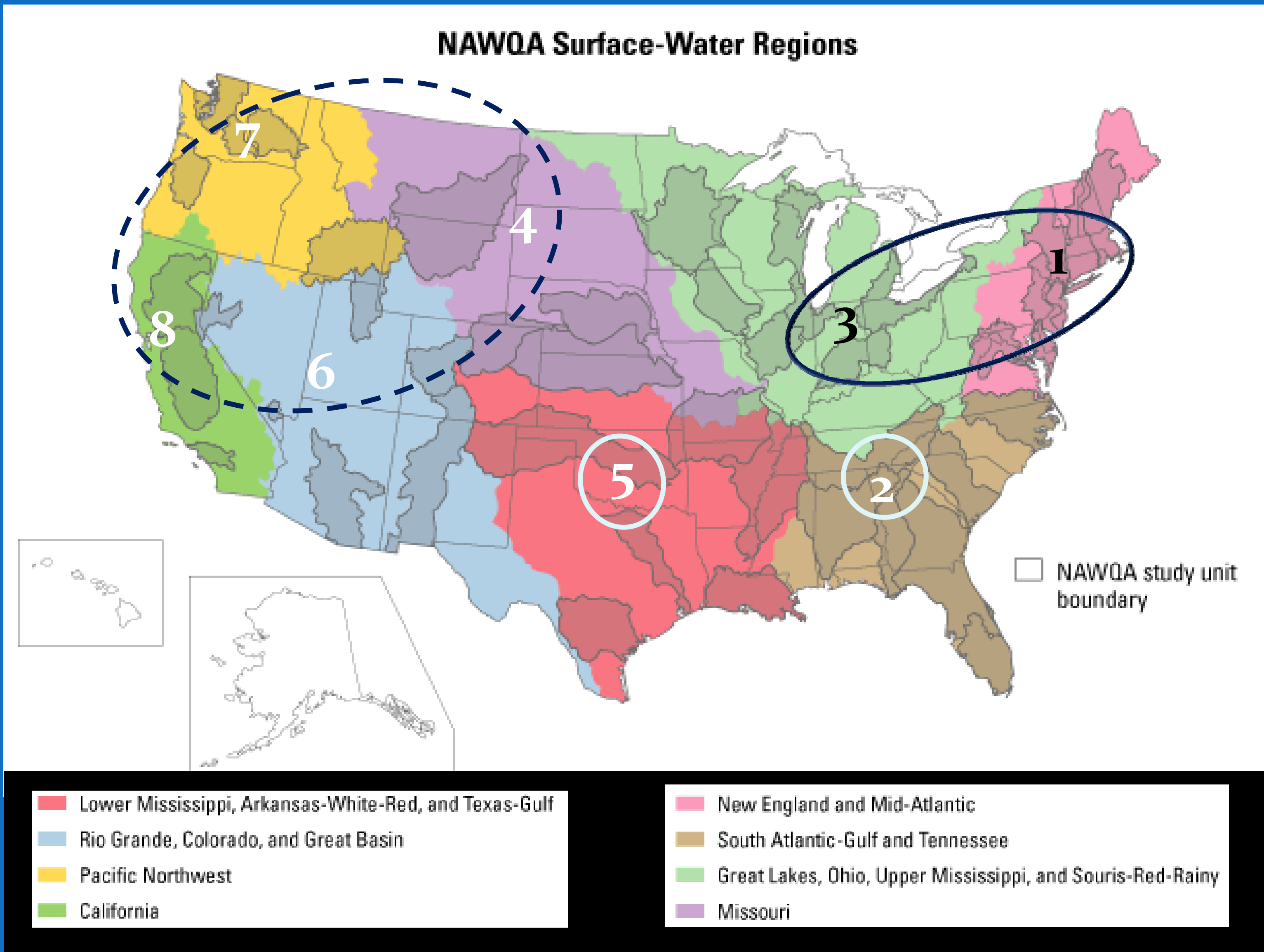
- Dan Sullivan-Wisconsin
- Karen Beaulieu-Connecticut

US Geological Survey-WRD

National Water-Quality Assessment Program Surface-Water Regions (Major River Basins)



Null Hypothesis Testing

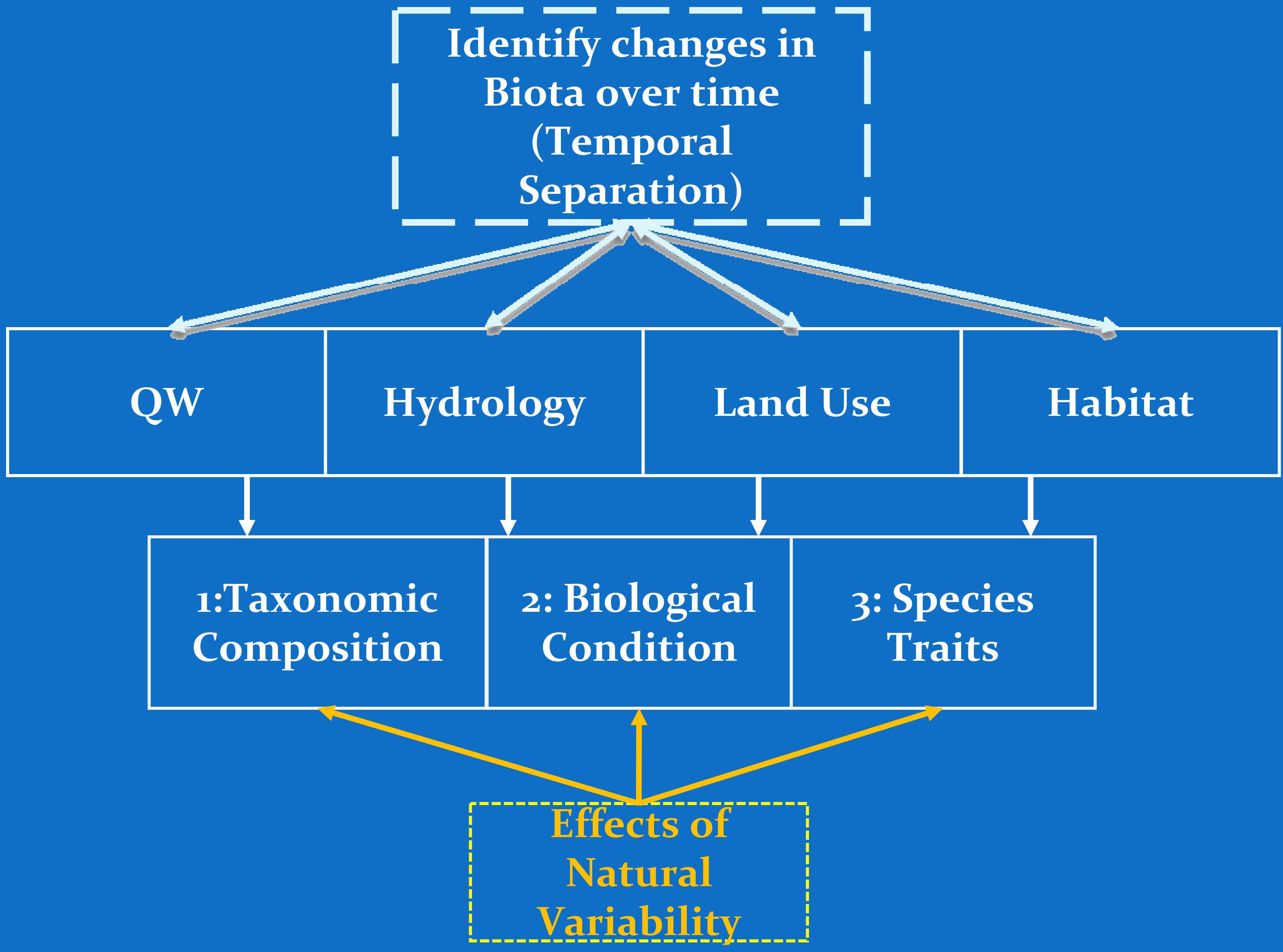
- H_{01}: Aquatic assemblages will not exhibit significant changes in composition over time.
- H_{02}: Fish and invertebrate assemblages will not differ in their response to environment degradation.
- H_{03}: Aquatic assemblages response will not be related to temporal changes in environmental processes.
- H_{04} Natural variability does not influence temporal changes in assemblage composition.
- H_{A1}: Sites which have been significantly altered over time periods prior to or exceeding the NAWQA sampling effort will show little or no trends in biotic assemblages and/or abiotic parameters.

Types of potential trends response patterns/trajectories for specific sites over time

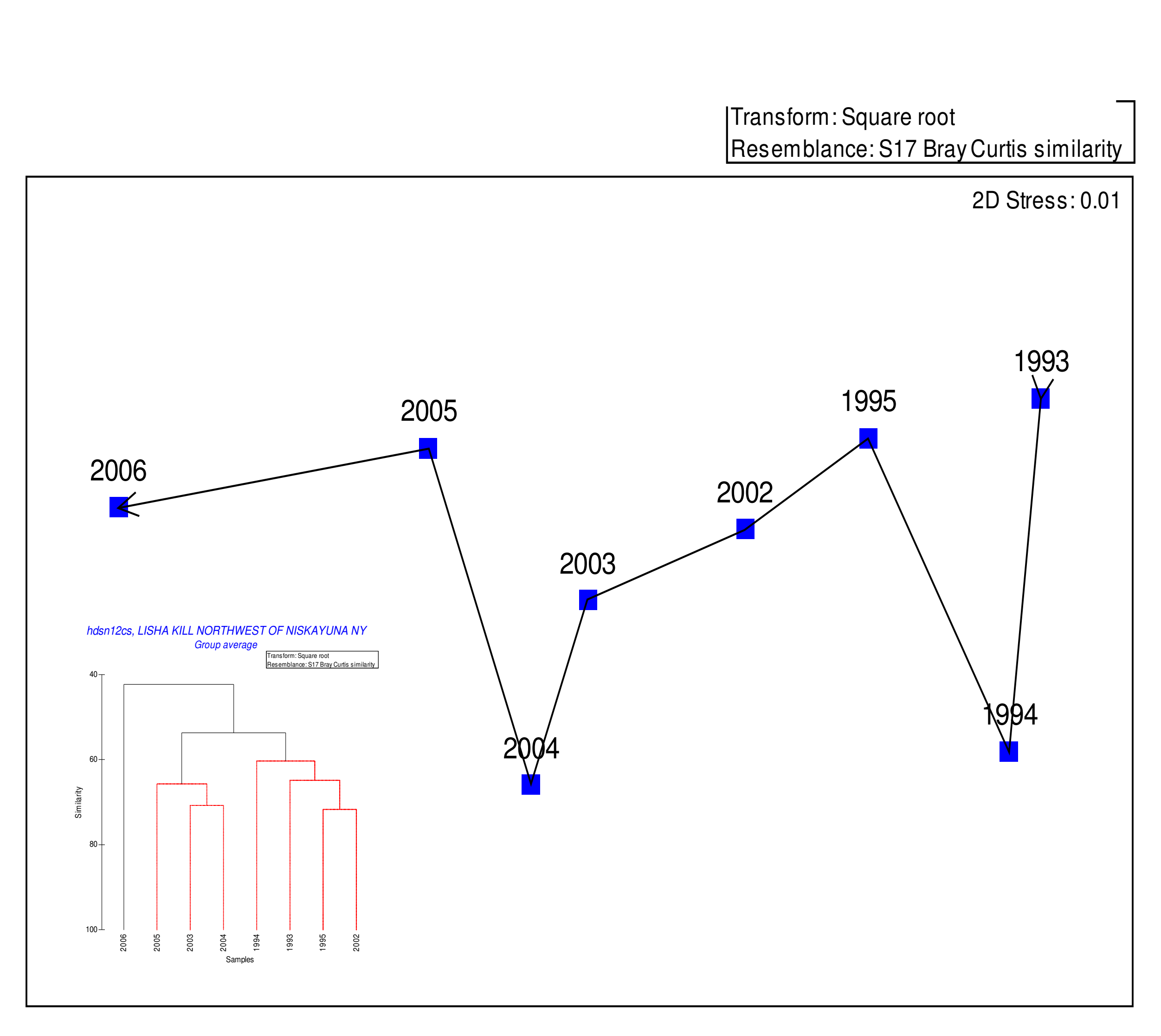
- No response
- Upward/downward trends
- Recover trends

- Caveats
  - Pre-disturbed prior our sampling
  - Human influenced
  - Antecedent Influenced conditions

Trends Conceptual Model



Assemblage Trajectory over time – Example



Departure Distance (=temporal separation)

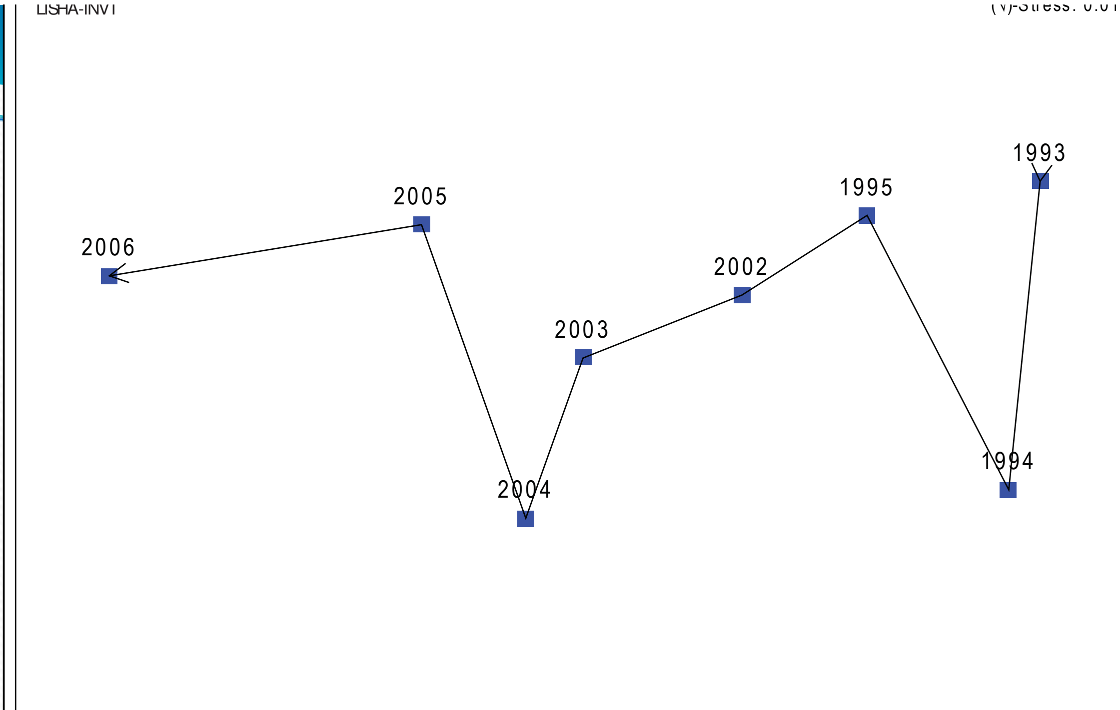
- Null hypothesis: "No tendency to show temporal separation".
- In general: assemblages with adjacent samples are closest in species composition, those further apart differ the most.

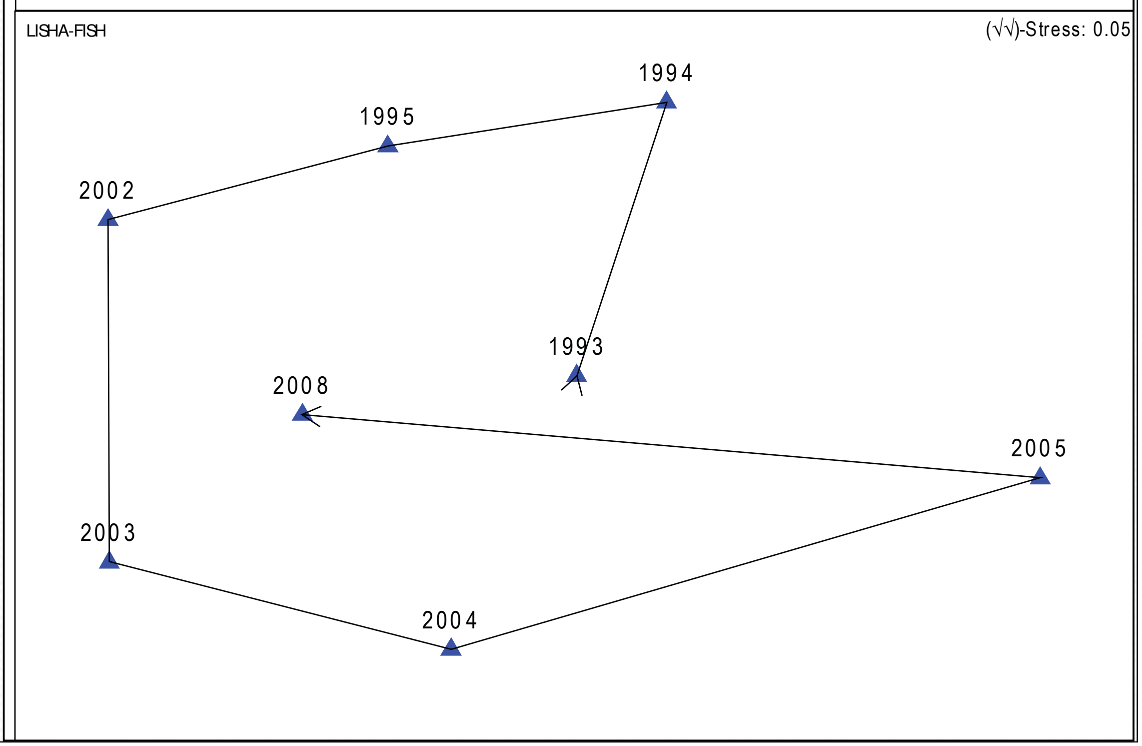
Same site

Inverts-significant change over time

&

fish-N.S.

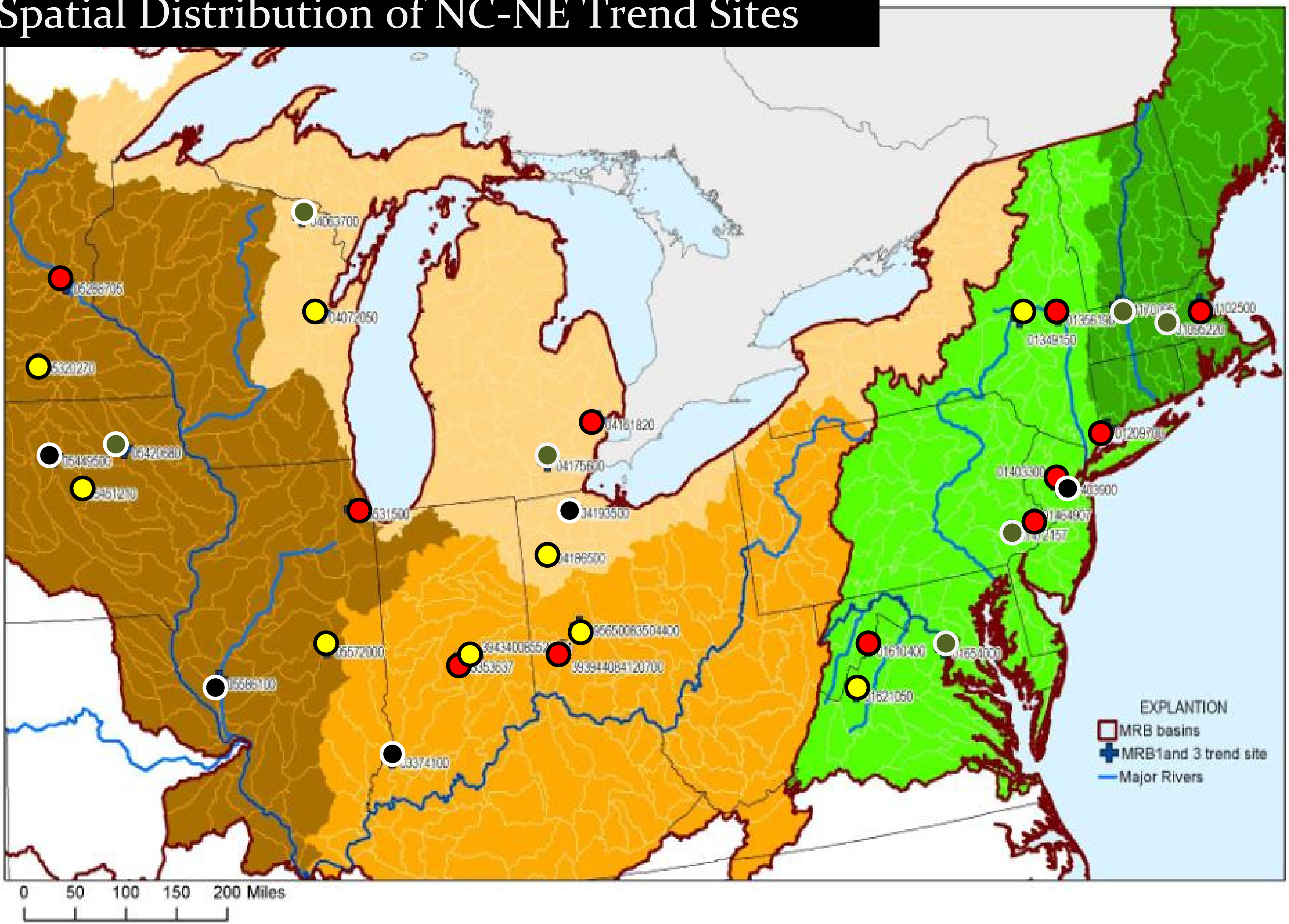




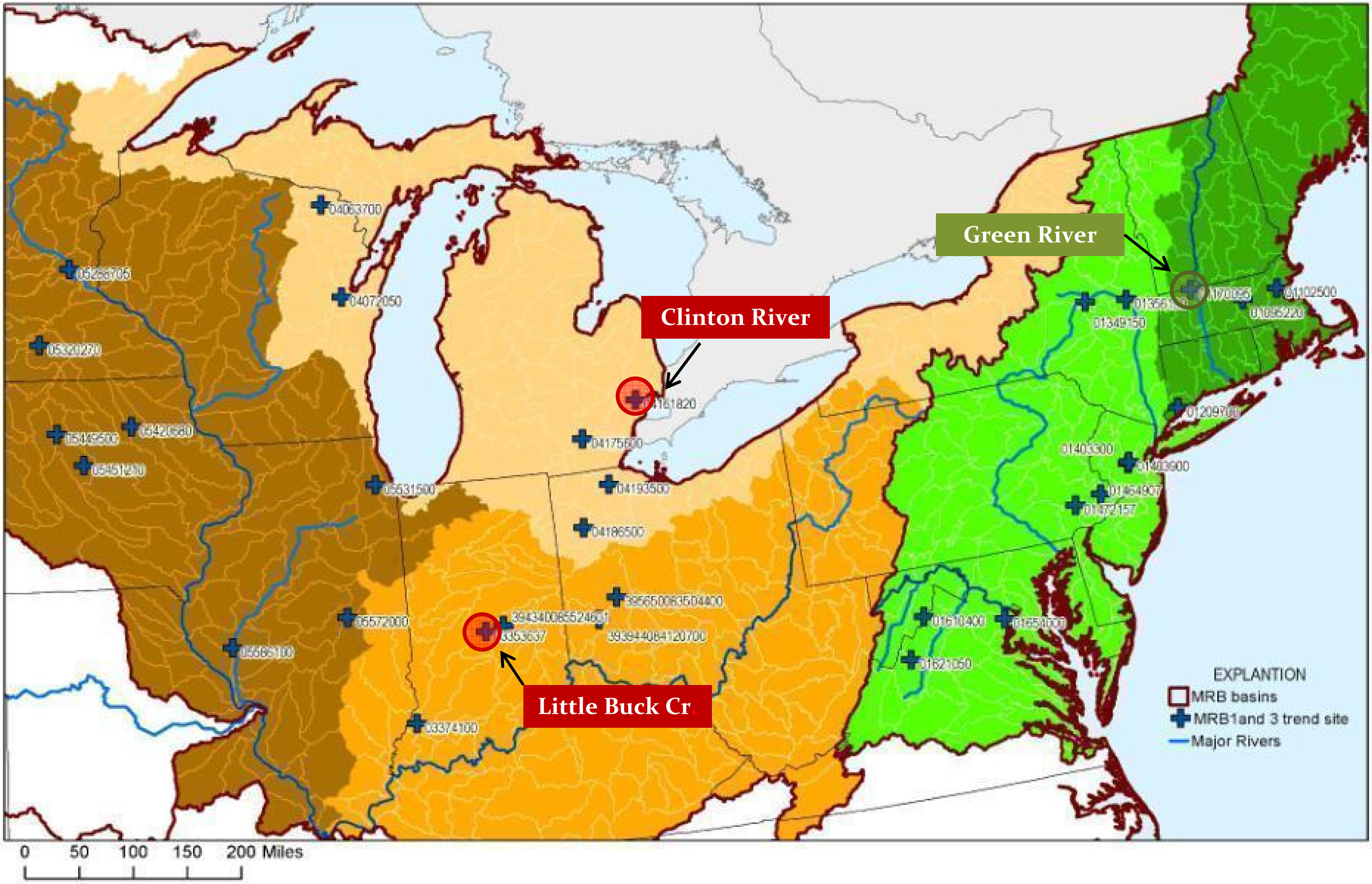
Data Elements

- 32 sites within NC-NE US (MRB 1 & 3), 5 larger river sites dropped after some initial analyses
- Sites were required to have at least 6 years of sequential invertebrate and fish data to be included in these analyses- mean of 8 years of data max 11yrs
- A single year 'best' representative sample was selected for each site
- **Biotic Data:**
  - Inverts & fish assemblage , metrics, and species traits data
- **Abiotic Data**
  - Habitat information
  - Chemistry
  - Field parameters, Major Ions, Nutrients, DOC and Pesticides
    - Single sample prior ecology sample
    - Mean monthly average across the year of the ecology sample
    - Pesticide toxicity index (PTI) information
  - Stream flow statistics that encompass timing, magnitude, duration, etc.
  - GIS: (GIRAS, NLCDe 1992/1995, NLCDe 2001)
- PRISM-Climatic data precipitation and air temperature

Spatial Distribution of NC-NE Trend Sites



MRB1&3 Focus Sites For Presentation



Analysis road map

Preparatory phase:

-Data aggregation and QA

Exploratory phase:

-Data and range screening and outlier evaluation

-Data reduction, univariate, and multivariate analyses

-Initial model development

  -Identifying subset of ancillary variables

Finalizing analyses phase:

-Final model development

  -Evaluating potential effects of natural env. variability

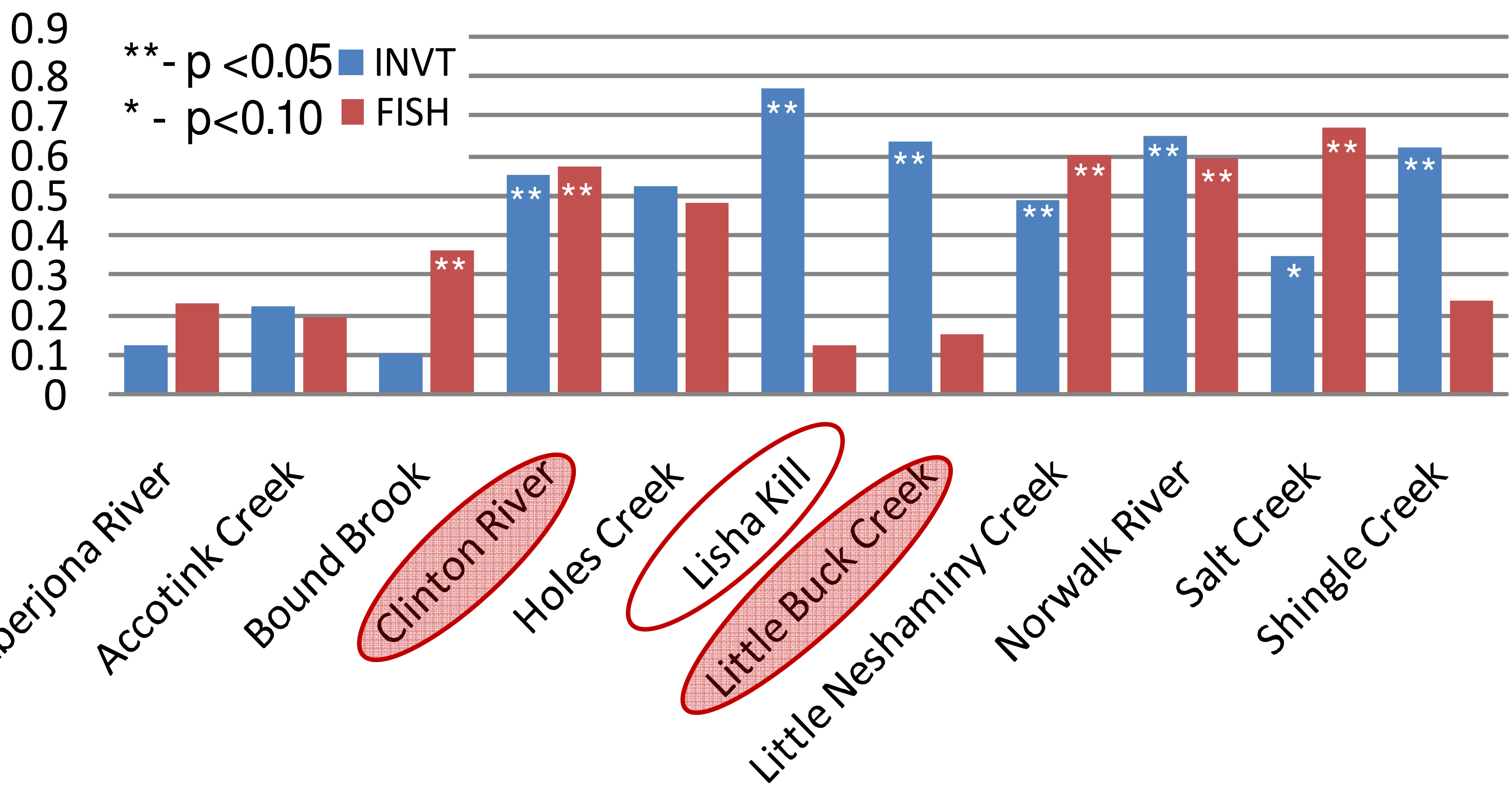
Overview of presentation:

- Highlight significant temporal changes in assemblage composition
- Highlight the level of consistency in patterns among assemblage and environmental indicators
- Show example relations for inverts/fish with habitat, QW, and hydrology
- Show an example of response patterns within site type and address the question whether we can group responses by site type

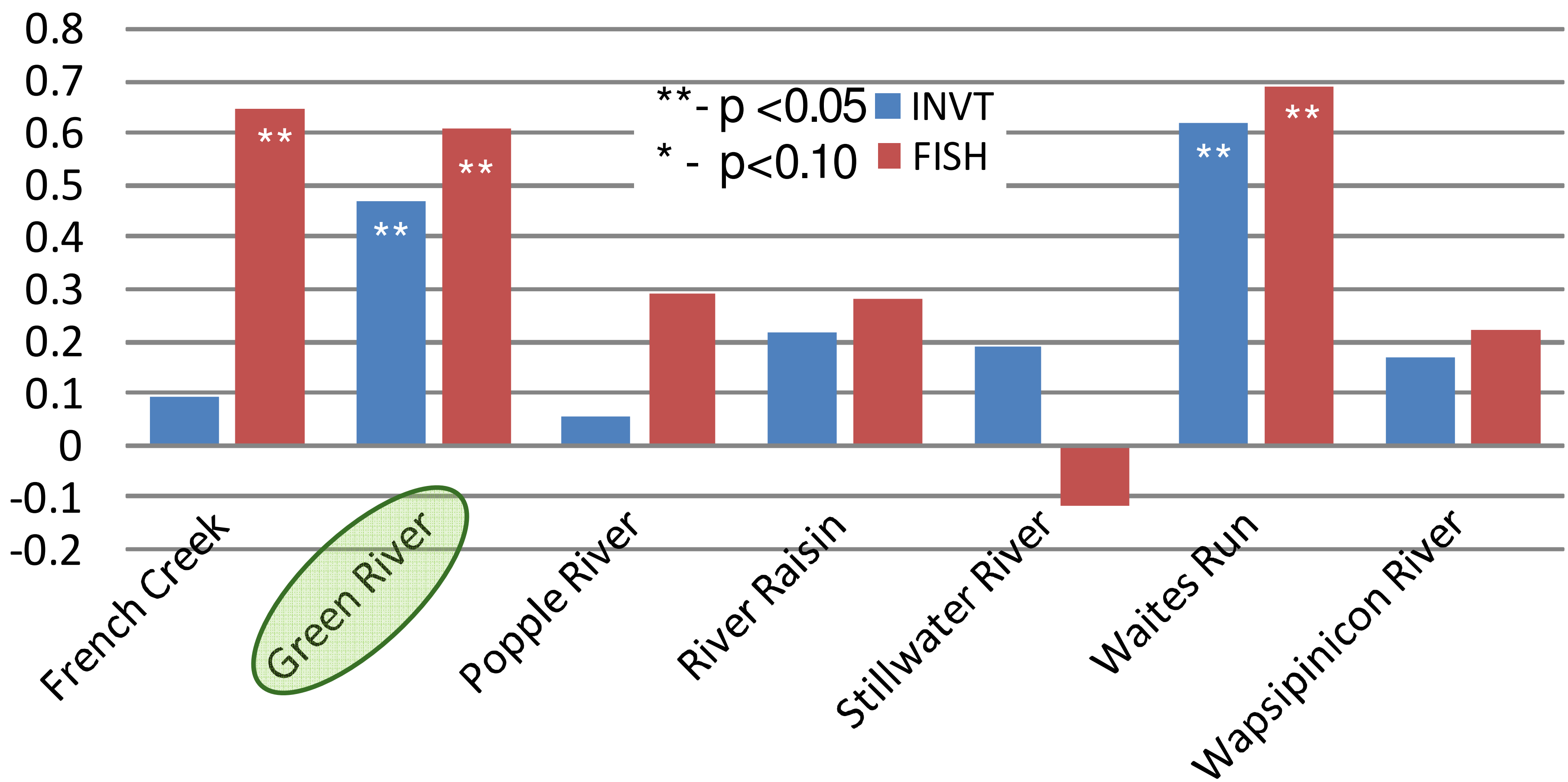
Summary of Significant Assemblage Trajectories (TRENDS) by Site Type

Invertebrates				
URB	AG	REF	INT	Total
8/11	5/9	2/7	4/5	19/32
Fish				
URB	AG	REF	INT	Total
6/11	5/9	4/7	0/5	15/32
Both				
URB	AG	REF	INT	Total
5/11	3/9	2/7	0/5	10/32

Urban Sites: Strength of Assemblage Trajectories over time



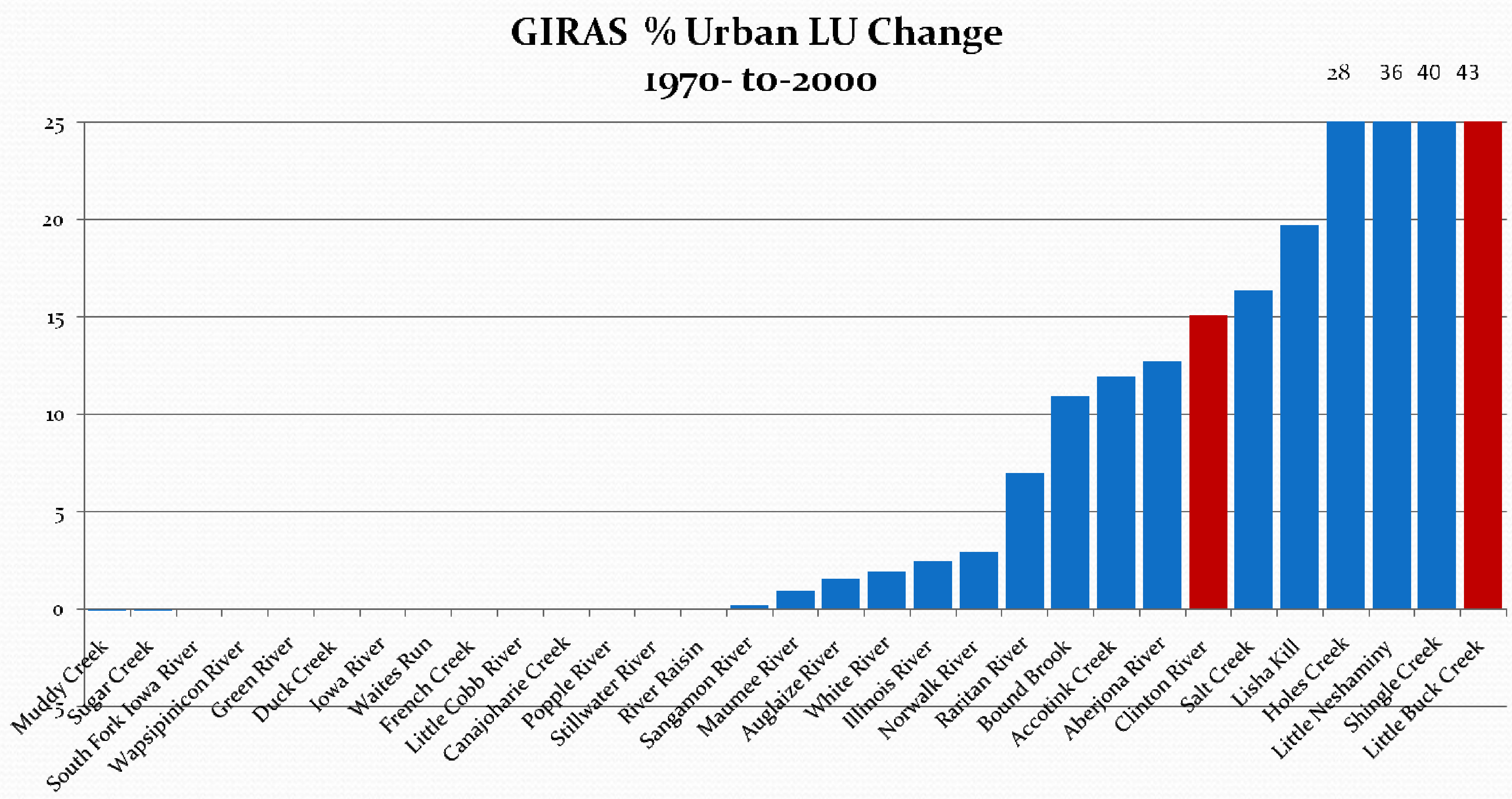
Reference Sites: Strength of Assemblage Trajectories over time



-Highlight specific examples of sites that show change over time

-Discuss how the patterns relate to what we observed for our indicators

Urban Land Use Change at NC-NE Sites

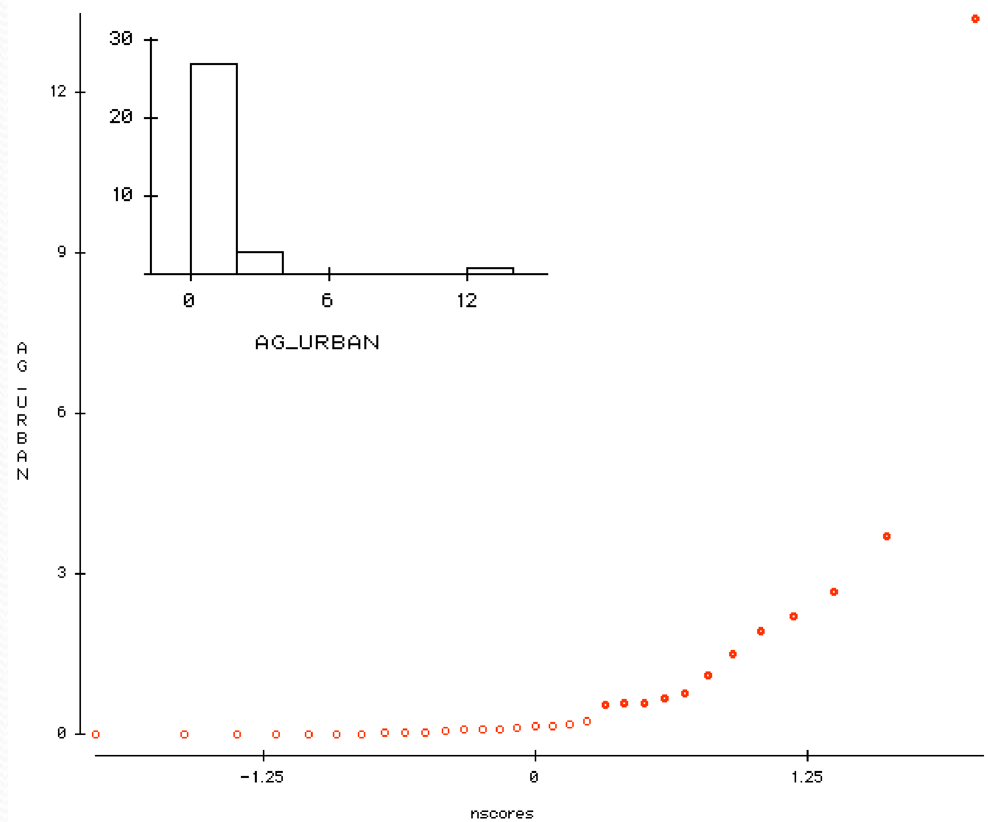


Urban Example: Little Buck Creek

-45 km^2
-headwater stream occasionally goes dry.
-GW public supply well located near this site

- Changing from AG to URB LU- (1992-2001 NLCDe)
  - *Little Buck Creek (13%)*

Urban site in suburban Indianapolis




1992
Little Buck recent time series
2000
2005
2009
Little Buck
Little Buck
Little Buck
Little Buck

Little Buck Creek continued.

Ancillary Variables Indicative of change over time:

<u>StreamFlow Variables:</u>

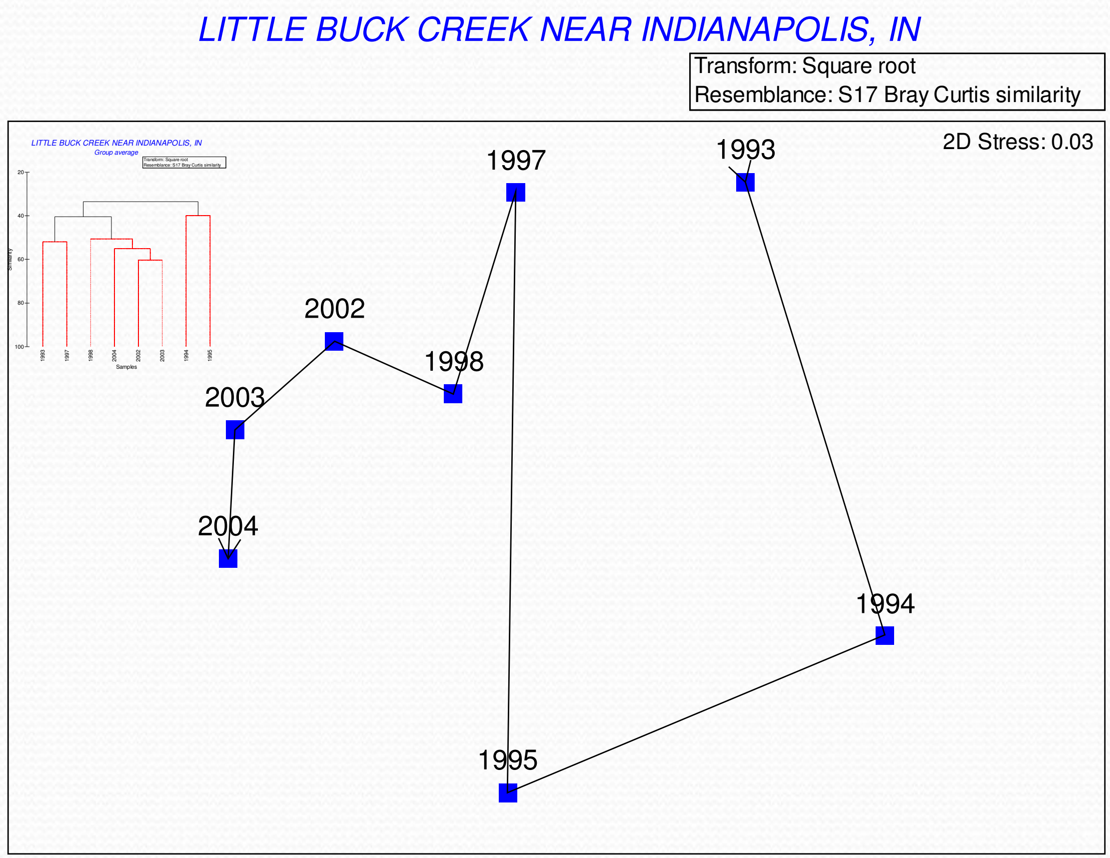
-Freq. low pulse spells(#events/yr)

<u>Habitat:</u>

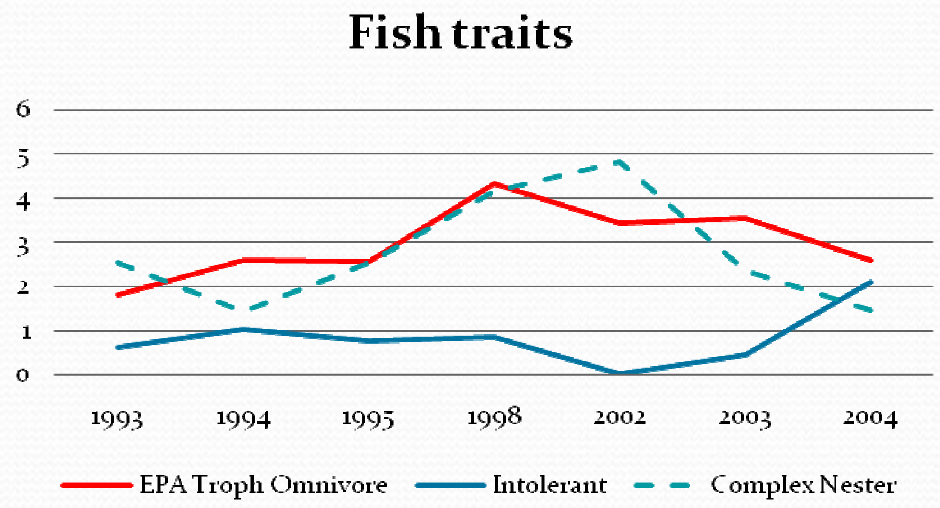
-Wetted X Area

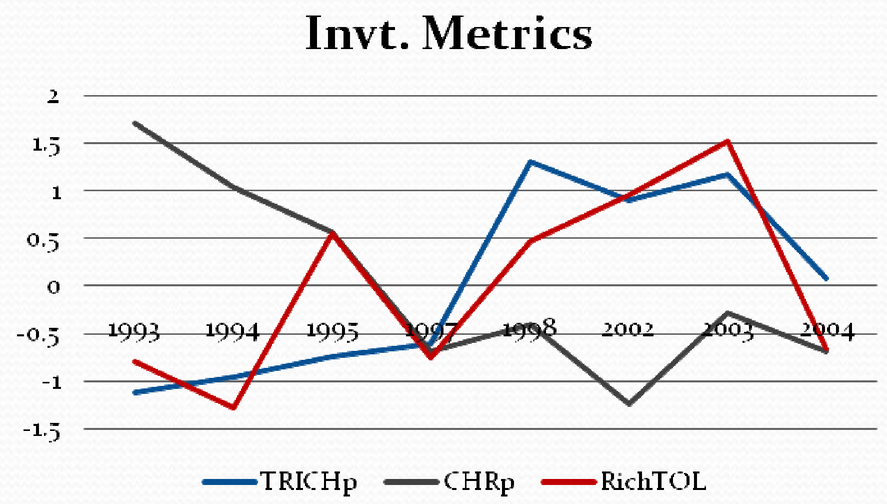
<u>QW:</u>

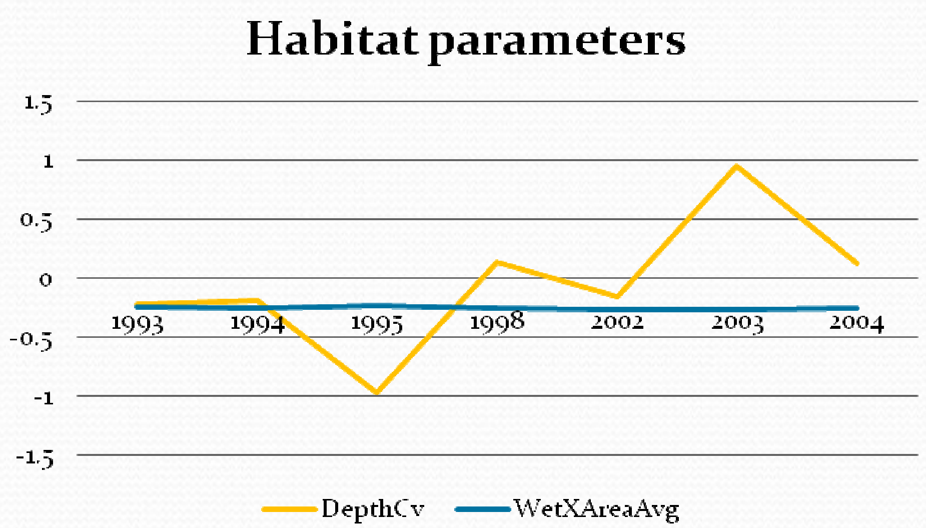
pH

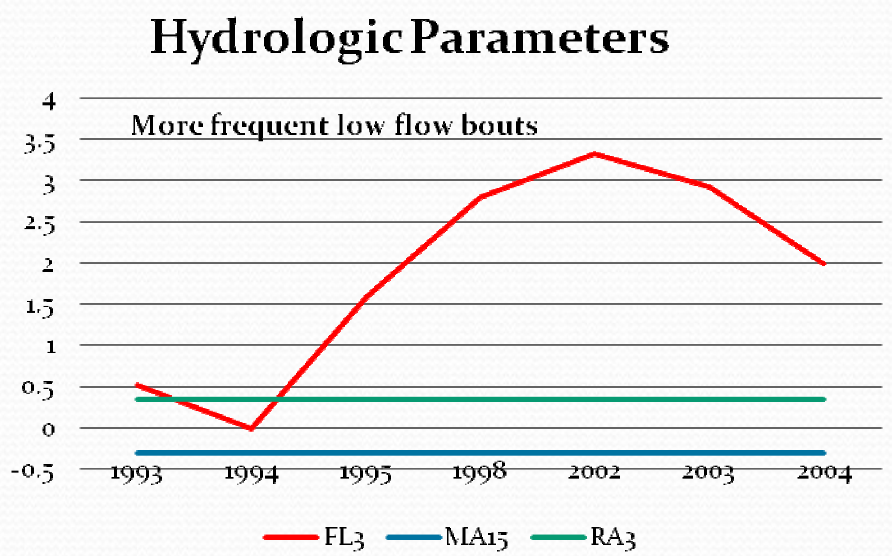


Little Buck examples of trends of select fish, invert, habitat, hydrology parameters

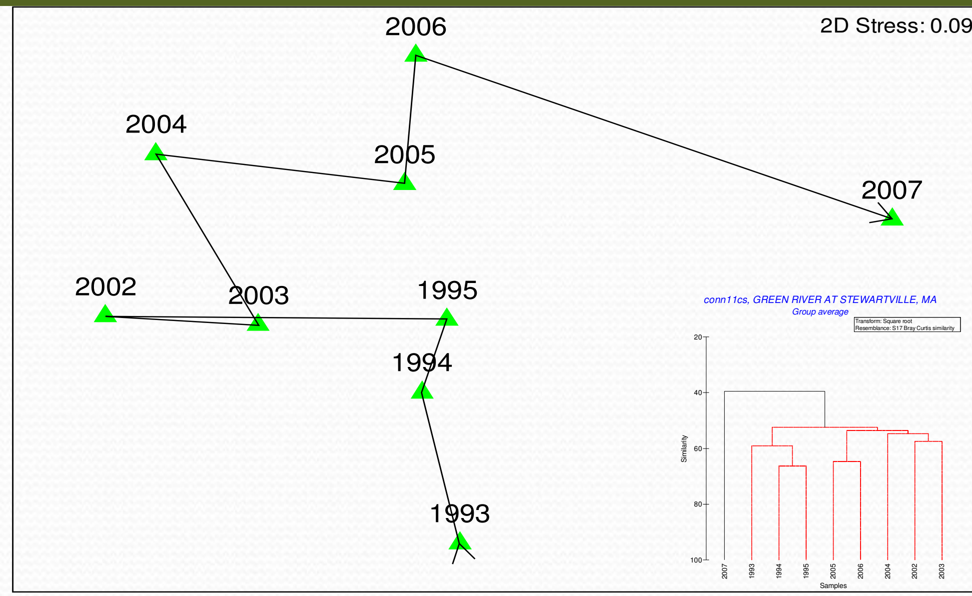








Reference site example: Green River



Ancillary Variables Indicative of change over time:

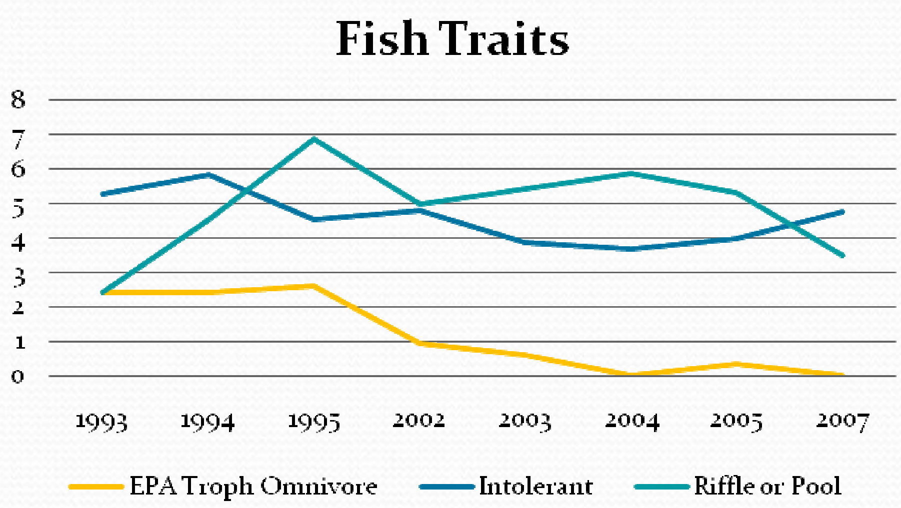
StreamFlow Variables:

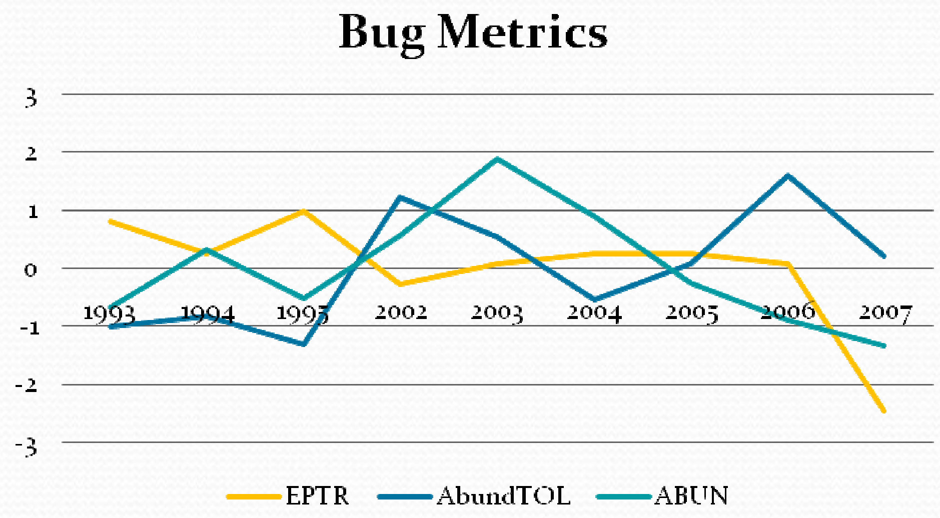
-Mean Annual Max daily flows (cfs)
-Mean Min May flows over POR
-Rise Rate (CFS/day)

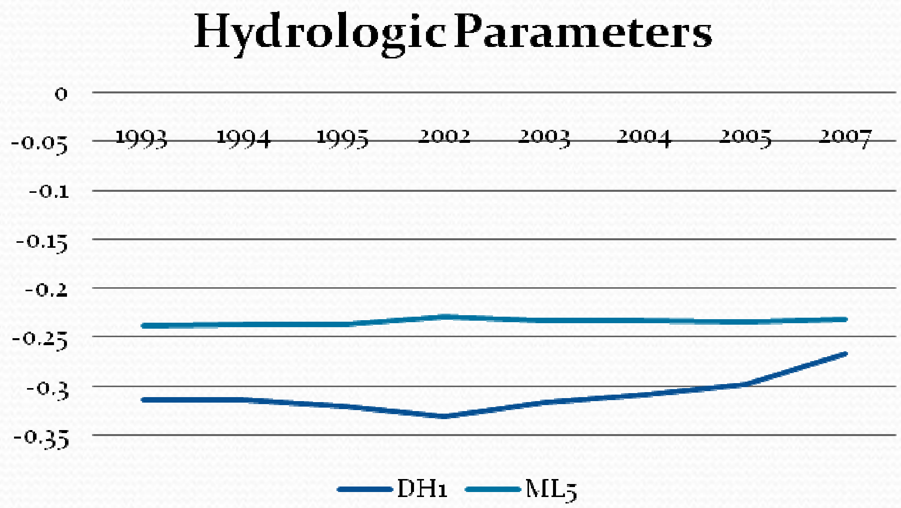
Habitat:

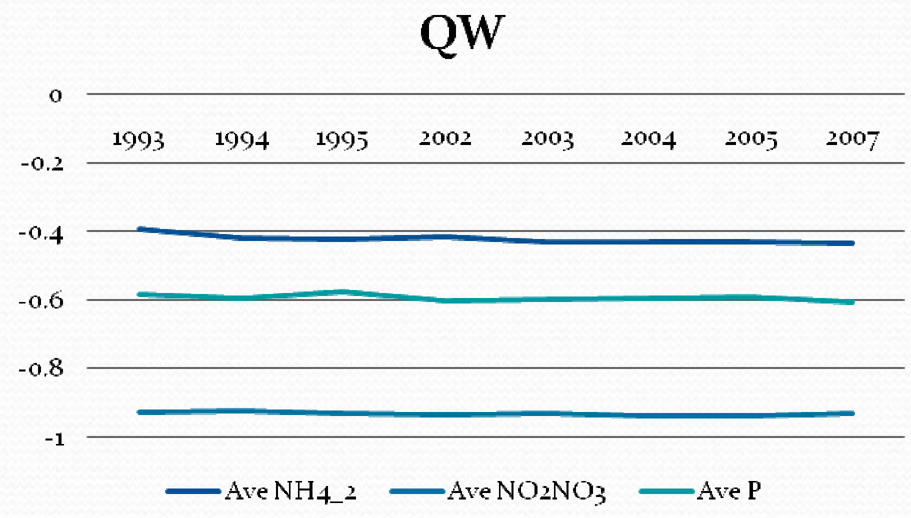
Bank Vegetative Cover, Wetted shape, Froude

Green River examples of trends of select fish, invert, habitat, QW parameters



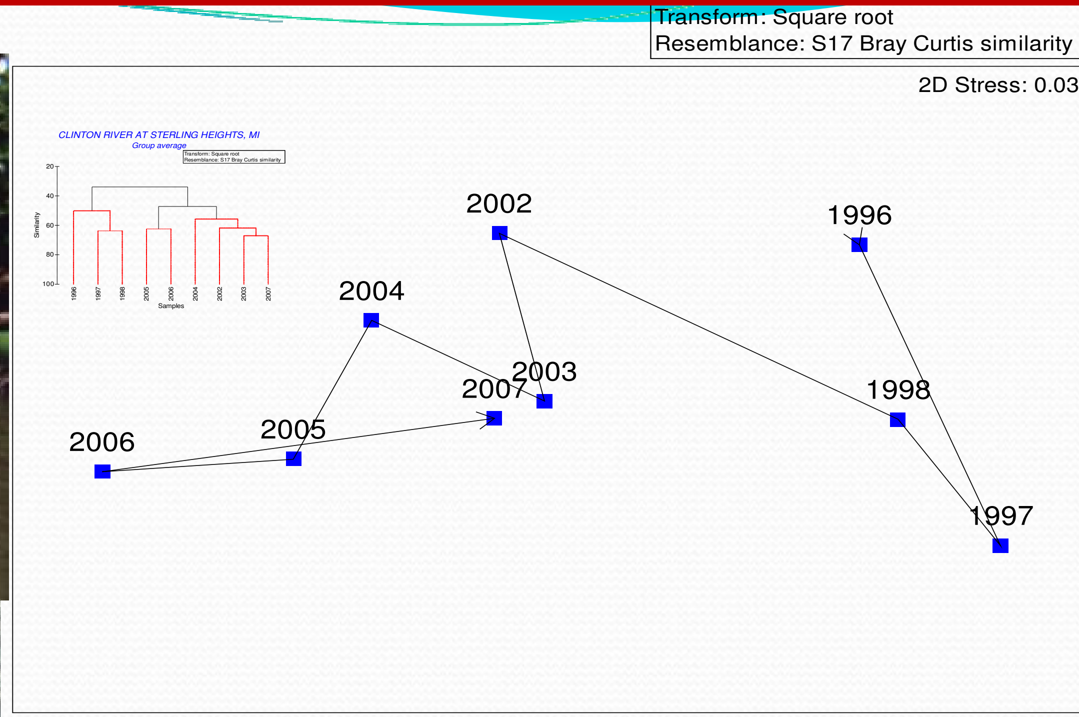






Urban Example: Clinton River

Urban site in suburban Detroit



Ancillary Variables Indicative of change over time:

StreamFlow Variables:

-Mean Min May flows over POR

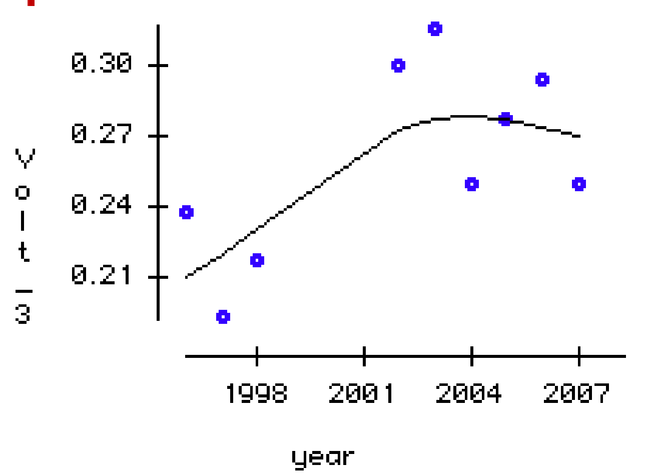
Habitat:

%Riffles, CV of Open Canopy, %Embedd, Froude

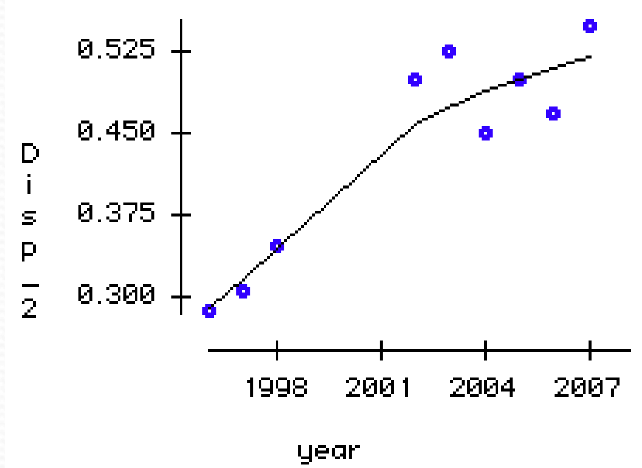
QW: Ave P, Ave_pH

Clinton River Invert. Richness Based-Traits

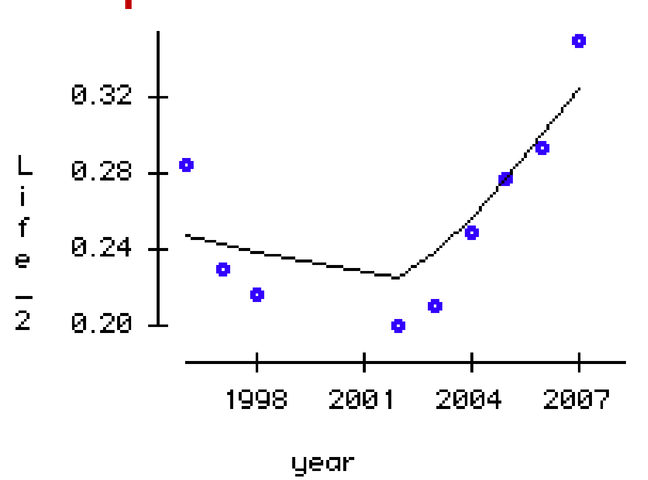
Number Generations per year



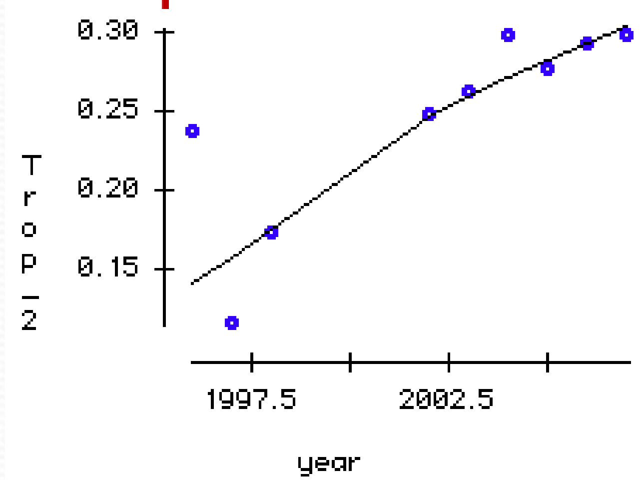
Dispersal Ability



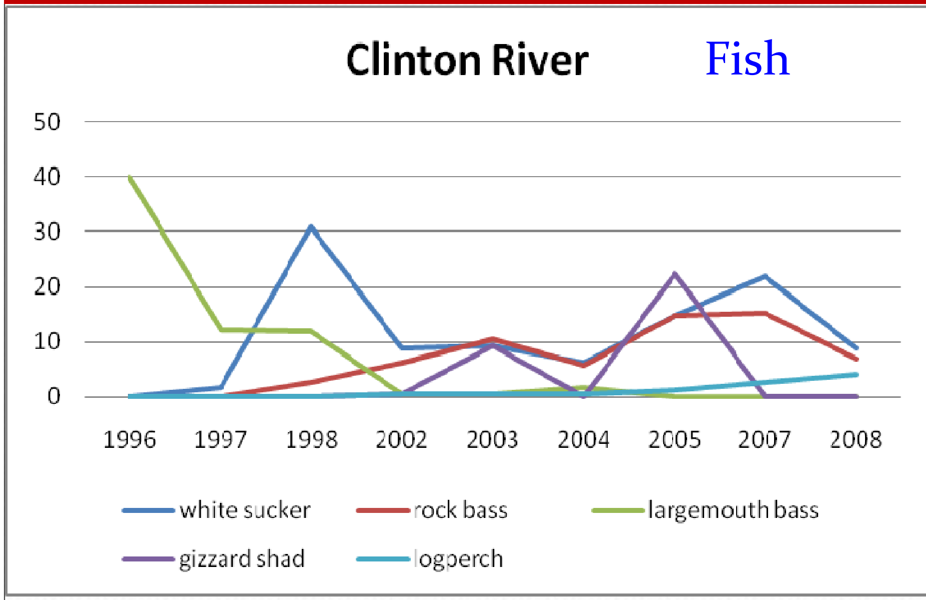
Quick Adult lifespan

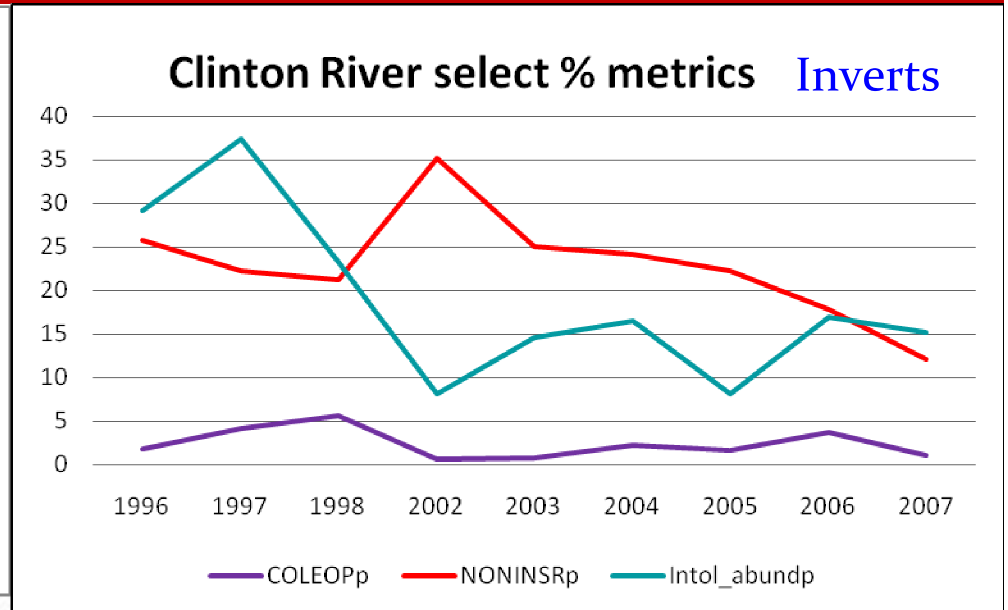


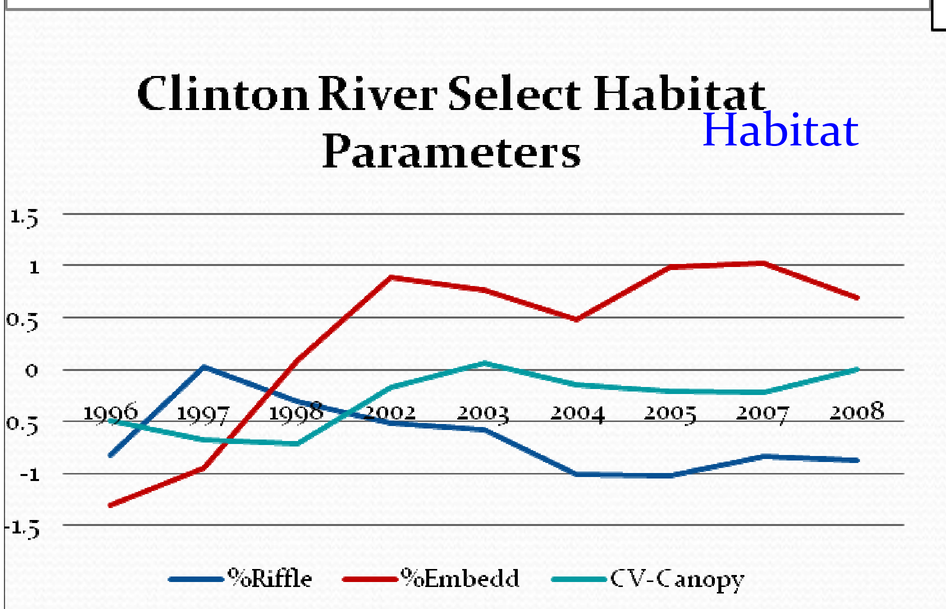
Collector-Filters

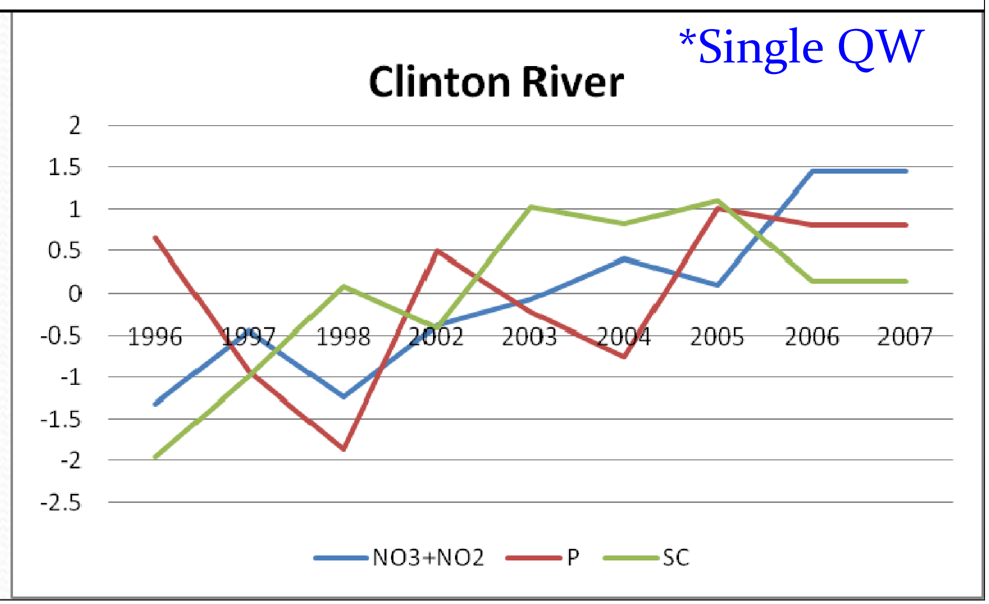


Clinton River examples of trends of select fish, invert, habitat, QW parameters









Can we generalized site type response patterns?

- We can see some similarity in responses to ancillary variables across sites within a site type (e.g., URB or AG)
- But size, climate, and biogeographical differences represent a significant influence
- Our real power for understanding trends is best evaluated on a individual site basis

Urban Invertebrates

HYDRO	HABITAT	QW
Important Variables	Important Variables	Important Variables
DH1, DH21, DL5, TA2	BKER, Frd	P, pH
MA20	Depth_ave	NH4, P
RA1, RA3, TA2	Riff%, BFD, WetShape	NH4, SC
MA15, MA20, ML5, MH7	Riff%, Embed%, OC_Cv, WetSh, Frd	P, pH
DL5, DH21	Pool/riff, D, BKER, WetShape, BO%	P, pH
DH1, RA1	W/D, BKvegCov, BKER, CO%, OTH%	NO2NO3, SC, pH
FL3, MA15, ML13, RA3	D_cv, WetArea,	pH
DH21, MA20, ML15	W-cv, BFD, OC, CO_PCT	NO2NO3, pH
DL, FH9, FL3, MA20	D,W/D, BKER, WP, BO_p	NO2NO3, pH
DL5, MH6, ML13, ML3	Depth_cv	NH4, pH
DH1, DH21, DL5, MA15, MA20	Pool/riff, Si%, SA%, OTH%	P

AG Invertebrates

HYDRO	HABITAT	QW
Important Variables	Important Variables	Important Variables
DH1, DH21, DH5, MA20, ML13	Riff%, BKVegCov, Frd, BO%, OTH%	P, pH
DH21, FL3, ML5	HydRad, Depth	SC, pH
FH9, FL3	W_cv, BFD, BKER, Emb	SC
FL3, MA20, ML15	BKVegCov, Emb, Wetshap, Hydrad,SA%	NH4
ML13, MH7	Riff%,RUN%, BFW, BKER, SA%	NO2NO3
DH21, FL3, ML5	Pool%, D, BKER, SA%, OTH%	NO2NO3
FH9, MA15, ML5	BFD, BKvegCov, HydRad, Si%	pH
DH21, DL5, FH9, MA15, MA20	W_cv, BKvegCov, BKER,OC, Si%	P, pH
ML5	W_cv, OC, WetArea, SI%, OTH%	NH4

Summary of findings- NC/NE trend sites

- Established significant patterns of change in fish and invertebrate assemblages at 15 and 19 sites, respectively
  - Ten of which are sites significant for both
- We delineated some of the potential mechanisms influencing these assemblages (i.e. habitat, QW, hydrology parameters accounting change)
- Noted some consistency of indicators over time
- Although we can see some similarities for sites within particular site type (AG or URB), the real strength of our analyses is to look at individual site patterns over time

Take home points from these trends studies so far

- Change in assemblage composition was evident, but response differed relative to assemblage type.
- Hydrologic variability appears to be a major factor most of our analyses
- Difficulties with attributing the change in community patterns to ancillary variables.
- Accounting for climatic variability is very important
- Sample size is important-the more data more likely ability to detect change over time.