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

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US Geological Survey-WRD
National Water-Quality Assessment Program
Surface-Water Regions (Major River Basins)
Null Hypothesis Testing

- $H_{o1}$: Aquatic assemblages will not exhibit significant changes in composition over time.
- $H_{o2}$: Fish and invertebrate assemblages will not differ in their response to environment degradation.
- $H_{o3}$: Aquatic assemblages response will not be related to temporal changes in environmental processes.
- $H_{o4}$: 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

Identify changes in Biota over time (Temporal Separation)

QW
Hydrology
Land Use
Habitat

1: Taxonomic Composition
2: Biological Condition
3: Species Traits

Effects of Natural Variability
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.

Departure Distance (=temporal separation)
Same site
Inverts-significant change over time & fish-N.S.
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.
- PRISM-Climatic data precipitation and air temperature
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

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<th>Invertebrates</th>
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<td>5/9</td>
<td>2/7</td>
<td>4/5</td>
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<td>19/32</td>
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<tr>
<td></td>
<td>Fish</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6/11</td>
<td>5/9</td>
<td>4/7</td>
<td>0/5</td>
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<tr>
<td></td>
<td>Both</td>
<td></td>
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<tr>
<td>5/11</td>
<td>3/9</td>
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<td>0/5</td>
<td></td>
<td>10/32</td>
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</tbody>
</table>
Urban Sites: Strength of Assemblage Trajectories over time

** - p < 0.05
* - p < 0.10

** - p < 0.05
* - p < 0.10

INVT
FISH

Aberjona River
Accotink Creek
Bound Brook
Clinton River
Holes Creek
Lisha Kill
Little Buck Creek
Little Neshaminy Creek
Norwalk River
Salt Creek
Shingle Creek
Reference Sites: Strength of Assemblage Trajectories over time

** - p <0.05
* - p <0.10

INVT
FISH

French Creek
Popple River
River Raisin
Stillwater River
Waites Run
Wapsipinicon River

Green River
- Highlight specific examples of sites that show change over time

- Discuss how the patterns relate to what we observed for our indicators
Urban site in suburban Indianapolis

Changing from AG to URB (1992-2001 NLCD)

- Little Buck Creek (13%)

Six 

Little Buck Creek (13%)

- 9 km²

- headwater stream occasionally goes dry

GW public supply well located near this site.
Little Buck recent time series
Ancillary Variables Indicative of change over time:

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

Habitat:
- Wetted X Area

QW:

pH

LITTLE BUCK CREEK NEAR INDIANAPOLIS, IN
Little Buck examples of trends of select fish, invert, habitat, hydrology parameters

**Fish traits**

- EPA Troph Omnivore
- Intolerant
- Complex Nester

**Invt. Metrics**

- TRICHp
- CHRp
- RichTOL

**Habitat parameters**

- DepthCv
- WetXAreaAvg

**Hydrologic Parameters**

- More frequent low flow events

Reference site example: Green River

- 107 km²
- Cold water
- Gravel/Cobble
- Some logging influences

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

Fish Traits

Bug Metrics

Hydrologic Parameters

QW

EPA Troph Omnivore  Intolerant  Riffle or Pool

EPTR  AbundTOL  ABUN

DHI  ML5

Ave NH4,2  Ave NO2NO3  Ave P
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

**Clinton River**

**Fish**

- white sucker
- rock bass
- largemouth bass
- gizzard shad
- logaerch

**Clinton River select % metrics**

**Inverts**

- COLEOPp
- NONINSRp
- Intol_abundp

**Clinton River Select Habitat Parameters**

**Habitat**

- %Riffle
- %Embedd
- CV-Canopy

**Clinton River**

*Single QW*

- NO3+NO2
- P
- SC
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
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.