Incorporating fish monitoring into your project

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Before we get started

- What is your objective/goal?
  - To improve or protect water quality – duh.
- Why is the water quality bad or in need of protection?
  - Because of that stressor – over there.
- What stressor?
  - The impervious surface, the agriculture, the deforestation, urban sprawl, etc.
- How is that affecting the water quality?
  - Its causing increased sedimentation, flashiness, temperature fluctuations, changes in the water chemistry
  - Abiotic changes are causing changes in the biota
- What are you going to do about it?
  - We have a project!

Tell me more

- How is that project going to improve or protect the water quality?
  - It will………
- How fast will the ABIOTIC response be?
  - May be immediate for somethings, longer for others (i.e., years)
- How large of an area or much of a stream will this project effect?
  - That depends.
- How will you know if your project worked?
  - We will monitor stuff?
- Like what? Why?

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Fish measures that may respond to your project

Depending on the stressor(s) addressed, the following may be useful for monitoring:

- Relative density - Catch Per Unit Effort (CPUE), proportions
- Density/Population size - abundance; #/100m
- Community/assemblage structure
- Indices of biotic integrity (IBIs)
- Length-Frequency
- Age-Frequency
- Growth rate - daily or annual growth
- Condition - relative weight, relative condition
- DELTs - Deformities, Lesions, and Tumors
- I'm sure I'm forgetting some

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When to use fish?

- After you determine what stressor(s) your project will address
  - How will the physiochemical and biotic environments change in response?
- Choose the best monitoring tool(s) for the job
  - No silver bullet
  - Prioritize monitoring options by the measures that are most likely to respond to the stressors your project will address
- Use fish measures when aspects of their biology and ecology are:
  - the most likely parameter to respond to a change in the identified stressor (as caused by your project)
  - See Day 2 fish presentation on the biological characteristics of watersheds
  - Consult a fisheries professional

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2 ways of looking at fish responses

(**These are not mutually exclusive)

1) Assemblage/Community
   - Shifts in amounts of species, groups, or guilds
   - Changes in community structure, groupings (tolerance), or guild, etc.
   - E.g., Assemblage similarity (ANOSIM)

2) Species specific
   - Indicator species, species of concern
   - Changes in number, growth, condition, length, age, biomass, or reproduction
   - E.g., Mean condition of trout; # of Sea Lamprey redds or carcasses

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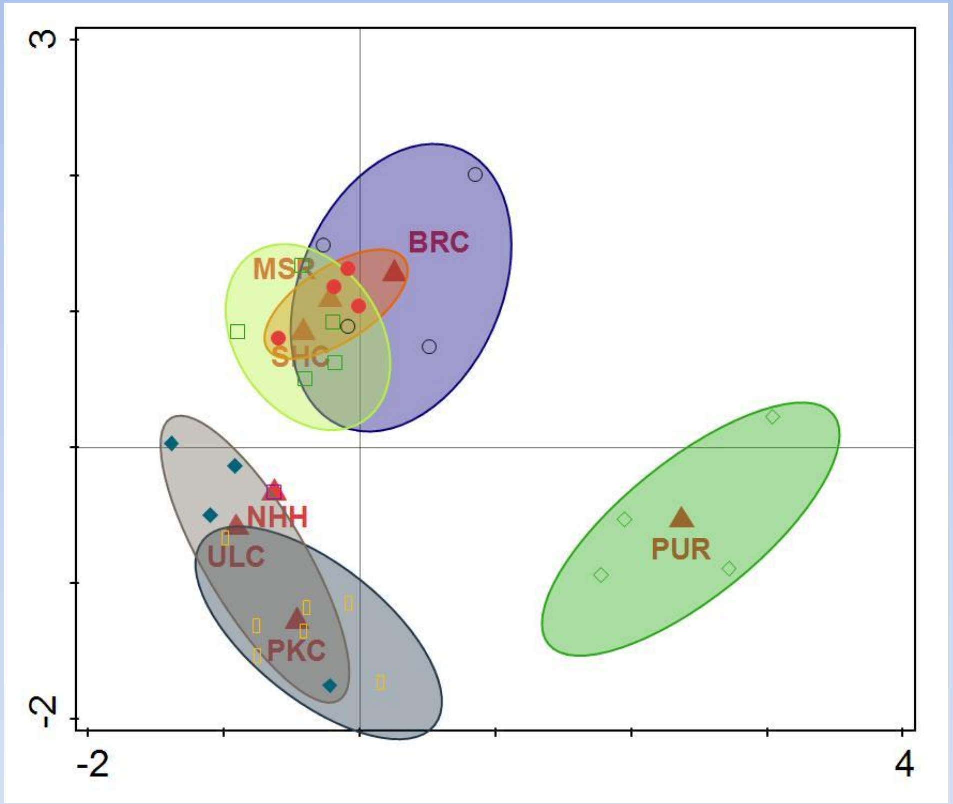
Assemblage Response

-Canonical Correspondence Analysis (CCA)

-Each ellipse surrounds a group of samples

-How similar is each group? (e.g., US/DS; Before/After; Reference/Impaired)

-Have groups become more similar over time (in response to your project)?



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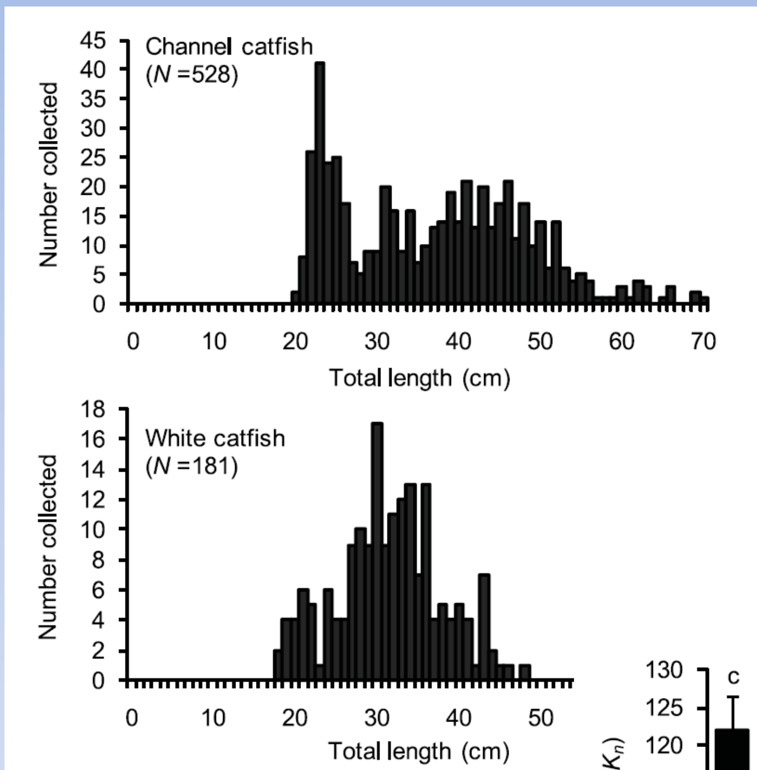
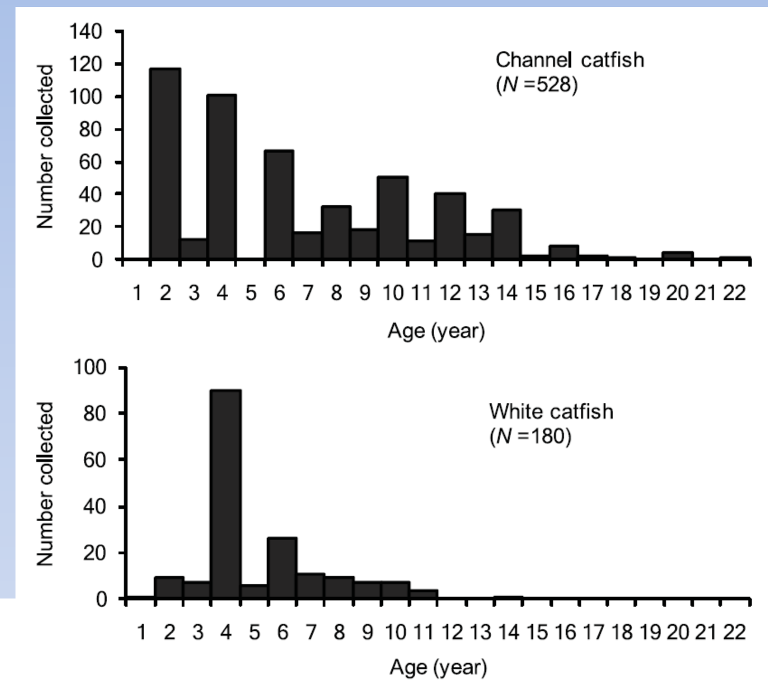
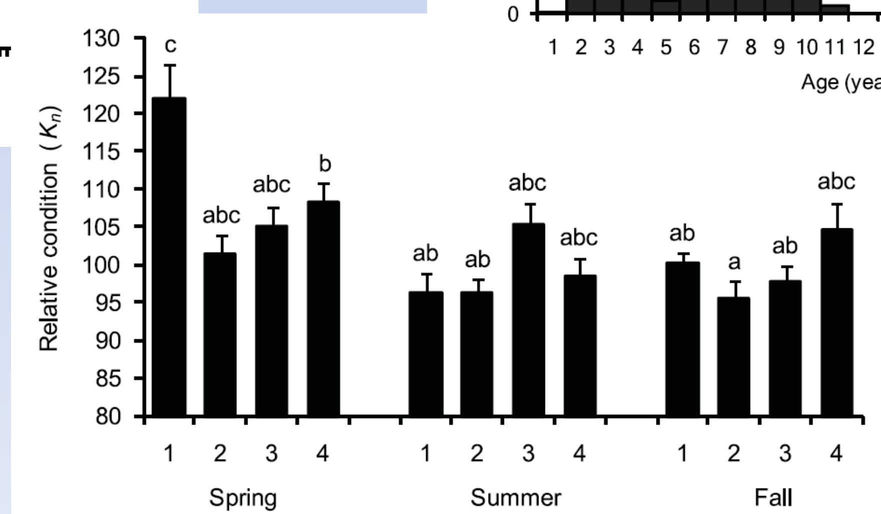
Species Specific Responses







Keller 2011

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Types of fish responses and associated monitoring

- Electrofishing can be used to assess both assemblage and species specific responses
- Single pass electrofishing
  - Assessing relative densities (i.e., CPUE, proportions), condition, length-frequencies, biomass, growth rates (collecting material for age determination), reproduction
- Multi-pass electrofishing
  - Used to assess all of the above, plus abundance estimate (i.e., density per unit reach length or area)
  - Not sensitive to differences in crew size between visits
  - Assumptions: no emigration or immigration, consistent collection effort among passes, constant capture probability, descending removal pattern
  - Method used for the DRWI

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Types of fish responses and associated monitoring

- Other techniques may be used for species specific responses
  - angling, seining, trapping, observation
    - To collect fish tissues or observe fish for signs of disease, deformities, lesions, tumors or growths.
    - Observation/counting nests, redds, or carcasses
    - Seining may be used to determine CPUE
- DRWI uses standardized electrofishing protocols for comparability across the basin

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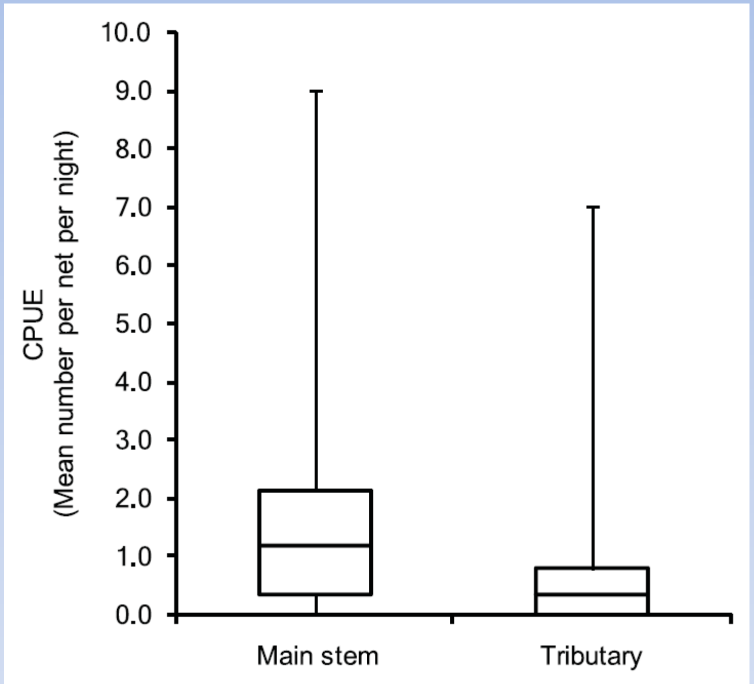
Examples of other techniques



Catch rates from trapping

(Keller 2011)

Centrarchid (bass and sunfish) nests
(http://archive.northjersey.com/news/fish-nests-in-shallow-lake-hopactong-waters-1.695636)

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Habitat matters

- Habitat template model
  - If you build it they will come; the physiochemical environment dictates the assemblage found
- Therefore it is important to account for
    - Physical structure (e.g., woody debris, cobble)
    - Water conditions/quality (pH, DO, conductivity)
    - Flow and temperature regime
    - Other physiochemical aspects that influence fish assemblages
- The DRWI has standard protocols for assessing reach level habitat
  - Finer resolution habitat monitoring may be appropriate depending on your project

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Disturbance

- Other models of community assembly also apply
  - E.g., Disturbance model - Disturbances shape communities
  - An altered flow regime (e.g., periodic flashiness or drought) can shape an assemblage
- Interactions with other species are also important

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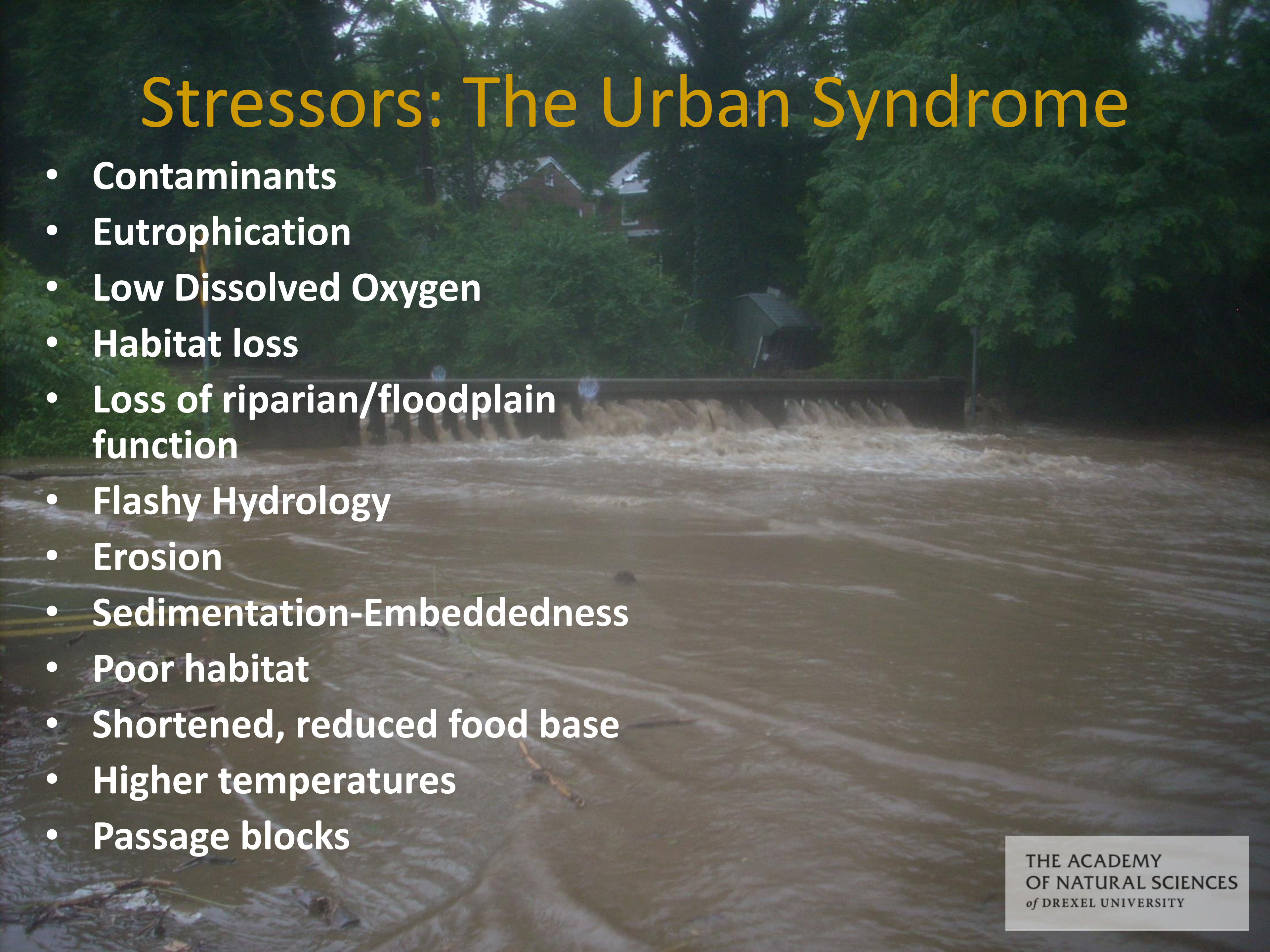
Urban and Ag Syndromes

- While single causes may be present in some cases
- Many disturbances affect many stream processes and stream assemblages in different ways
- Urban Syndrome (well known, i.e., I didn't make it up)
- Agricultural Syndrome (Made this up, but others probably have too)

Stressors: The Urban Syndrome

- **Contaminants**
- **Eutrophication**
- **Low Dissolved Oxygen**
- **Habitat loss**
- **Loss of riparian/floodplain function**
- **Flashy Hydrology**
- **Erosion**
- **Sedimentation-Embeddedness**
- **Poor habitat**
- **Shortened, reduced food base**
- **Higher temperatures**
- **Passage blocks**



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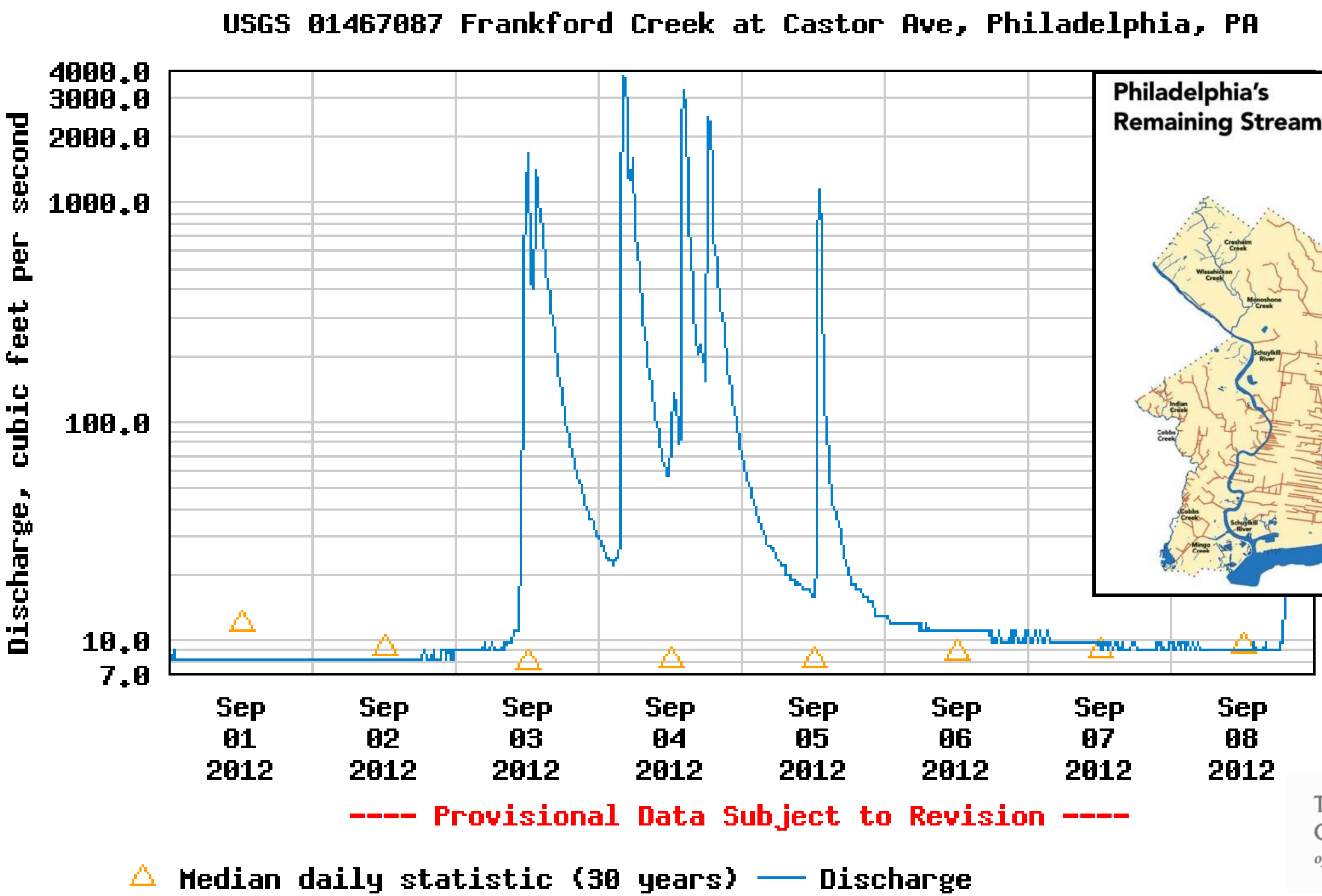
Flashy discharge downstream of two main storm sewers



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Response: Urban Syndrome

- Fewer cold water species
- Fewer intolerant species
- More tolerant species
- More omnivores

Response at high urbanization

Increase in:

- Estuarine (Mummichog)

- Arid/Great Plains (Green sunfish, Fathead minnow, Western Mosquitofish)
- Large river species (Spottail Shiner)

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Stressors: Ag Syndrome

- High nutrient loading
- Channel simplification (channelization, etc.)
- Loss or reduction of forested riparian zone
- Bank and channel disturbance (livestock)
- Low summer flows (intermittency of some small head water tributaries)

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Response: Ag Syndrome

- Many of those measured by IBIs
  - IBIs originally developed for agricultural landscapes
- Possibly higher abundance due to nutrient enrichment, but unclear which taxa are benefitted
- Increase in early colonizer species that are able to move out and in drying and newly wetted streams
  - E.g., Creek Chub

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Species or guild specific responses

- Fish dispersal limited mostly by:
  - Reproductive capabilities (Balon 1975)
  - Affinities for different substrates during spawning, egg, or larval development (Balon 1975)
    - Possible stressors
      - altered pH, DO, conductivity, temperature and flow regime
      - Substrate impacts/decreased pore space: siltation, embeddedness
    - Possible response (assuming negative but opposite could be true – species dependent)
      - Absence from the local area
      - Reduced abundance
      - Age structure/Reproduction – few or no young fish
        - E.g., adult trout present but not reproducing

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Species or guild specific responses

- Weight-length relationships can indicate fatness, gonad development, and provide a measure of overall well-being (Le Cren 1951)
  - O/E approach
  - Condition determined by:
    - Physical and biological factors related to ingestion, digestion, and metabolism (Anderson and Neumann 1996 p.458)
    - Possible stressors
      - » altered pH, DO, conductivity, nutrients, turbidity, temperature and flow regime
      - » Substrate impacts as they relate to foraging: siltation, embeddedness
  - Possible response
      - » Decreased or increased condition – species/guild dependent

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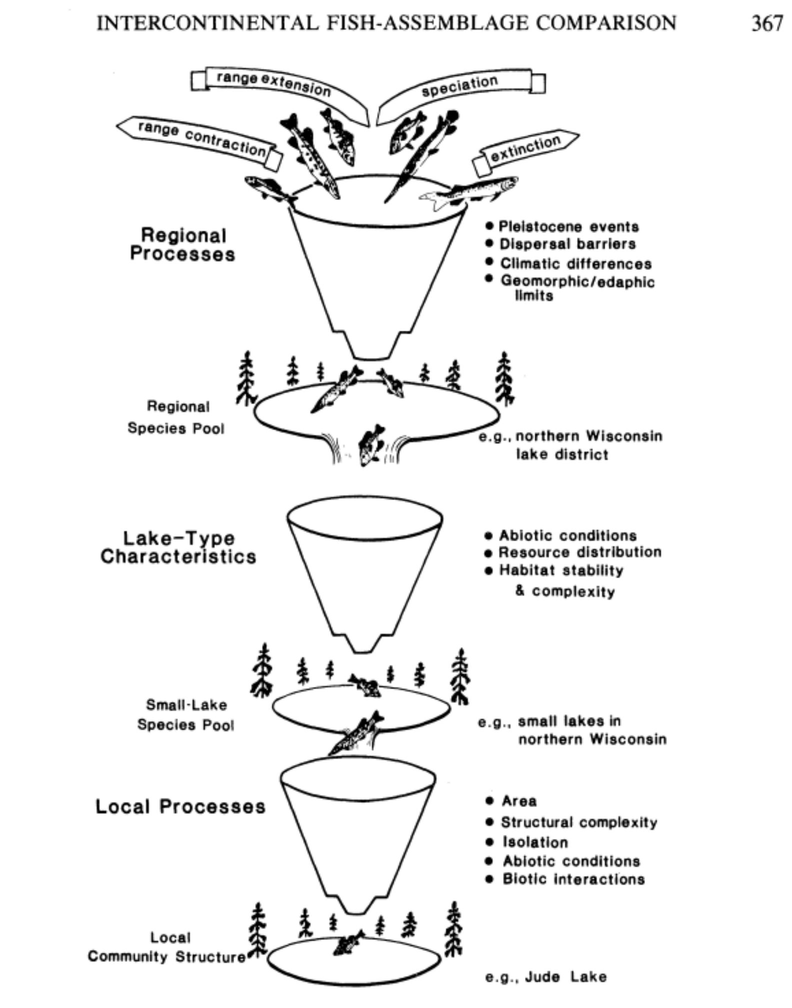
Assemblage Recovery

- Not well established for projects
- Depends on regional species pool
  - Physiochemical environment may change due to restoration but regional species pool may no longer include sensitive species to recolonize restored habitat
- May not be well described by IBI or metric approach
- Finer scale species, group or guild specific responses may be of use
  - Using tolerance groups or expected species specific changes
  - Testing hypothesized guild responses to restoration
    - E.g., decreases in herbivores in response to reduced nutrients
- Aspects of the Target Fish Community approach may be applicable (Bain and Meixler 2008)

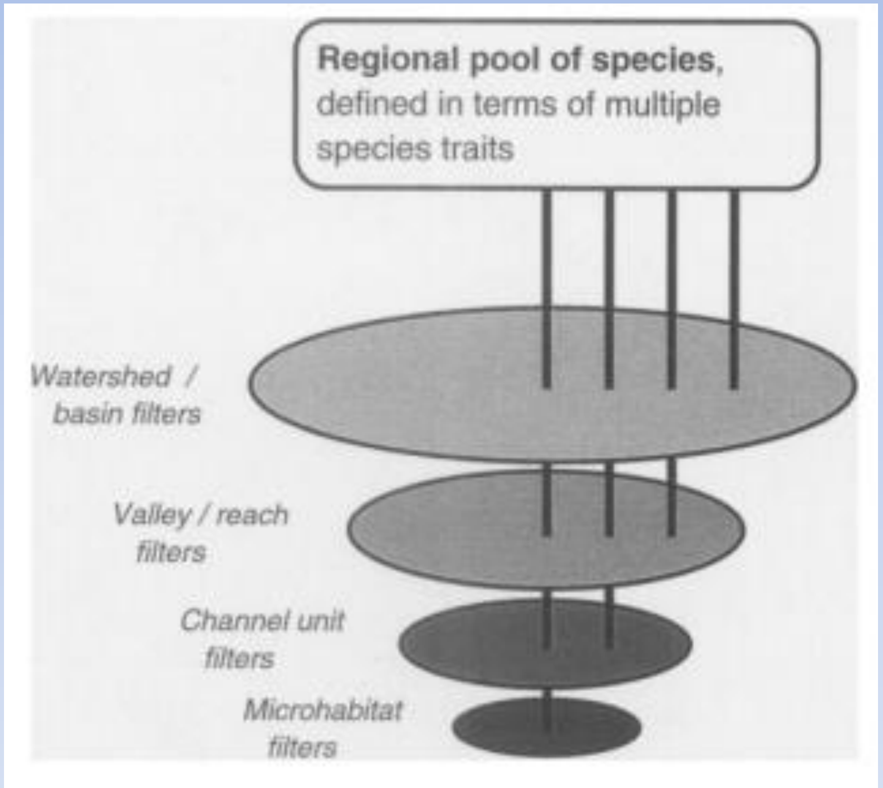
Accounting for scale

- Need to understand the influence of variables at higher and lower scales, and temporally for your project
- Identify the scale(s) on which your project is operating/influencing the stream
  - Regional
    - Climate, geology, current land use and landscape factors (dams, slopes), nutrients, chemistry, etc.
  - Local
    - Reach – 100, 200, 300m length of stream
    - Channel Unit/Mesohabitat – riffle, run, pool
    - Microhabitat – depth, velocity, substrate of individual
  - Historical
    - Land use change, species introductions, past industry

Environmental Filtering Model: Food for thought



Tonn et al. 1990



Poff 1997

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Hypothetical approach: Project/study design example 1

- Problem: Channelized stream resulting in 1)flashiness, 2)erosion DS, 3)poor structural complexity
- Solution/hypothesis: Reconnecting stream to floodplain will reduce 1-2 and improve 3
- BACI; Monitor before and after, include a control and impact if possible
- Physiochemical monitoring may consist of:
  - discharge monitoring (link to flashiness)
  - bank erosion pins (link to erosion DS)
  - amount of woody debris (link to structural complexity)

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Hypothetical approach: Project/study design example 1

- Fish hypothesized to respond to changes in physiochemical environment.
- Potential fish response/monitoring may consist of:
  - Assemblage monitoring of restored and downstream reaches (link to stressors via generalized stressor gradient)
  - Expect assemblage shift away from most tolerant fishes
  - Expect decrease in DELTs with overall decreased disturbance
  - Expect improved IBI score
  - Expect increased Trout and/or pool species (link to woody debris/structural complexity)
  - Expect increased richness with increased structural complexity
  - Expect changes in growth rates or condition of some species
  - Expect more stable age and length frequency structures
  - Expect species previously absent to colonize area if present in regional species pool - depends on species' proximity to the restored reach

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Hypothetical approach: Project study design example 2

- Problem: Eutrophication of headwater stream
- Solution/hypothesis: Implementing ag BMP will reduce nutrient input to a more natural state.
- BACI; Monitor before and after, include a control and impact if possible
- Physiochemical monitoring may consist of:
  - nutrient monitoring (link to eutrophication)
- Potential fish monitoring (depends on local species):
  - Fish hypothesized to respond to changes in physiochemical environment (nutrients).
  - Assume only tolerant fishes are present due to history; IBIs and metrics of limited use
  - Recommend monitoring guild or fish biomass, fish condition, and fish growth rates which should decrease in response to decreasing nutrients

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Hypothetical approach: Project study design example 3

- Problem: Flashy hydrology due to large amounts of impervious surface
- Solution/hypothesis: Installing rain gardens will reduce runoff and decrease flashiness
- BACI; Monitor before and after, include a control and impact if possible
- Physiochemical monitoring may consist of:
  - discharge monitoring (link to flashiness)
- Fish monitoring (depends on local species):
  - Annual assemblage monitoring
  - Or identify a species or guild specific response to flashiness

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Available Data

- Available fish data (and potential partners!)
  - NJDEP, NJDFW, USGS, EPA
  - The Academy of Natural Sciences/Delaware River Watershed Initiative
- Consult/collaborate with fisheries professionals

Questions?

Feel free to contact when considering monitoring options.

- David Keller (dhk44@drexel.edu; 215-299-1150)
- Allison Stoklosa (ams844@drexel.edu; 215-299-1150)

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