Proposed approach to develop a Biological-Environmental Classification (BEC) system and supporting flow – biology relationships in North Carolina

Funded by: Environmental Defense Fund
Conducted by: RTI International
Background:

- Biofidelity Analysis showed:
  - EFS and McManamay stream classifications systems could not be extrapolated beyond catchments with USGS gages
  - 49-64% match between classifications based on USGS gage versus WaterFALL modeled hydrologic data
  - ~270 USGS gages in NC
  - ~70,000 NHD+ catchments
Background:

CONCLUSION:

- Need a classification system that is:
  - Not based on sensitive threshold values
  - Consistent and reproducible using USGS stream gage and modeled data
  - Easy to understand and implement
  - Can be applied throughout state
  - Captures the distribution of aquatic biota in North Carolina
Objectives of Proposed Project:

1. Develop a classification system based on geographical assemblages of aquatic biota (fish) and associated environmental (physiographic and hydrologic) attributes – Biological-Environmental Classification (BEC) system
2. Determine flow–biology response relationships for each BEC class
3. Link significant flow metrics (and associated flow–biology relationships) to each BEC class to support ecological flow determinations
Step 1 – Determine BEC classes based on aquatic biota assemblages and environmental characteristics

Step 2 – Determine flow-biology relationships for each BEC class

Step 3 – Link significant flow metrics to each BEC class to support determination of ecological flows
Step 1 – Determination of BEC class

- Iterative, cluster-classification approach using aquatic biota and environmental attribute data to develop BEC classes:
  - Aquatic biota:
    - NC fish (DWQ Fish community dataset) – 858 monitoring stations
  - Environmental attributes:
    - Regional classifications (6 classifications – ecological, physiographic, hydrologic)
    - Physiographic (watershed and stream channel) characteristics
    - Climatic variables
    - Hydrologic variables
### Environmental attributes potentially used in BEC classes

<table>
<thead>
<tr>
<th>Environmental Attributes</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climatic</strong></td>
<td>Average precipitation</td>
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<tr>
<td></td>
<td>Average temperature</td>
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<tr>
<td><strong>Physiographic</strong></td>
<td>Elevation</td>
</tr>
<tr>
<td></td>
<td>Channel Width</td>
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<td></td>
<td>Channel Gradient</td>
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<td>Channel Sinuosity</td>
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<td></td>
<td>Local connectivity (stream fragmentation)</td>
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<td>Stream size/Drainage area</td>
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<td></td>
<td>Geology (catchment and local)</td>
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<tr>
<td><strong>Hydrologic</strong></td>
<td>Stream hydrologic regime (ground-water vs. surface water dominated)</td>
</tr>
</tbody>
</table>
Step 1 – Determination of BEC class

- Iterative, cluster-classification approach using aquatic biota and environmental attribute data to develop BEC classes
Approach 1:
- Sites
  - Abundance
- Environment
- Biology Based Classes

Approach 2:
- Sites
  - Variables
- Environment
- Biology
- Environmental Attribute Based Classes
**APPROACH 1**
- Biology Based Classes

**APPROACH 2**
- Environmental Attribute Based Classes

**NCDENR – EF SAB feedback**

**Final BEC Classes**
Step 1 – Determine BEC classes based on aquatic biota assemblages and environmental characteristics

Step 2 – Determine flow-biology relationships for each BEC class

Step 3 – Link significant flow metrics to each BEC class to support determination of ecological flows
Step 2. Determination of Flow-Biology Relationships

- Flow alteration – biological response relationships for each BEC class:
  - Flow alteration (% change):
    - Ecologically-relevant flow metrics
      - based on TNC Indicators of Hydrologic Alteration (IHA)
      - NC DENR management-focused
      - Generated using WaterFALL model
# Flow Metrics

<table>
<thead>
<tr>
<th>Time Step</th>
<th>Component</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>Extreme Low Flow</td>
<td>10\textsuperscript{th} percentile</td>
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<tr>
<td></td>
<td>Low Flow</td>
<td>25\textsuperscript{th} percentile</td>
</tr>
<tr>
<td></td>
<td>Median Flow</td>
<td>50\textsuperscript{th} percentile</td>
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<tr>
<td></td>
<td>High Flow</td>
<td>75\textsuperscript{th} percentile</td>
</tr>
<tr>
<td>Annual Winter (10–6)</td>
<td>Extreme Low Flow Threshold</td>
<td>10\textsuperscript{th} percentile</td>
</tr>
<tr>
<td>Annual Summer (7–9)</td>
<td>Extreme Low Flow Events</td>
<td>Number of events</td>
</tr>
<tr>
<td></td>
<td>Extreme Low Flow Duration</td>
<td>Maximum</td>
</tr>
</tbody>
</table>

Expressed as % change:
- Historic = 1970’s land-cover or Potential Natural Vegetation (PNV), no in-stream flow alterations
- Current = 2006 land-cover, with discharges, withdrawals, and impoundments
Step 2. Determination of Flow-Biology Relationships

- Flow alteration – biological response relationships for each class:
  - Biological response:
    - NC Fish Community data (858 catchments with monitoring stations)

<table>
<thead>
<tr>
<th>Level</th>
<th>Analysis metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Individual species</td>
<td>- Species abundance (count of individuals)</td>
</tr>
<tr>
<td>- Full community</td>
<td>- Number of species (diversity)</td>
</tr>
<tr>
<td>- Habitat guilds (6)</td>
<td>- Shannon Weaver Diversity Index</td>
</tr>
</tbody>
</table>
Step 2. Determination of Flow-Biology Relationships

- Flow alteration – biological response relationships for each class:
  - Analysis:
    - Space-for-time analysis
    - Quantile regression (90th percentile)
Example of Flow-Biology Relationship

No observed values

90th % Regression (p = 0.08)

90th % Regression (p < 0.001)

90% of zero flow alteration “gold standard”

Abundance

Percent Hydrologic Alteration
Step 1 – Determine BEC classes based on aquatic biota assemblages and environmental characteristics

Step 2 – Determine flow-biology relationships for each BEC class

Step 3 – Link significant flow metrics to each BEC class to support determination of ecological flows
Step 3. Link flow metrics to each BEC class

- Link statistically significant flow metrics (from the flow-biology analyses) to each BEC class
- Some metrics (associated with individual species analyses) may be associated with more than one BEC class
Questions?