Development of an Index of Biotic Integrity for Macroinvertebrates in Freshwater Low-Gradient Wadeable Streams in Southern New England

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Acknowledgments

Project Partners
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Katie DeGoosh & Jane Sawyers (RIDEM)
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Forgotten & Wannabees (Sorry and Welcome)
Overview of project

- Objective
- Study area
- Timeline

Sampling analysis plan

- Target population
- Protocols
  - Macroinvertebrates
  - Water quality
  - Habitat
- Site selection

Summer 2019 sampling

IBI development
Objectives

Compile a dataset that will be used to develop an Index of Biological Integrity (IBI) for macroinvertebrate communities in freshwater, wadeable, non-tidal, low gradient streams in southern New England.
Study area

SNEP geographic boundaries

L3 Ecoregions:
• Northeastern Coastal Zone
• Atlantic Coastal Pine Barrens
Project timeline

Phase 1
- Site selection & sampling plan
- Protocols

Phase 2
- Field sampling for macroinvertebrates, water quality and habitat
- Macroinvertebrate laboratory processing and taxonomic IDs

Phase 3
- Analysis and index development

October 2018 - June 2019

June 2019 – February 2020

March 2020 – April 2021
Sampling & analysis plan

- Target population
- Protocols
  - Macroinvertebrates
  - Water quality
  - Habitat
- Site selection

Available upon request, along with a compilation of low gradient methods being used in the Northeast (and other regions as well)
Target Population

Streams:
- Within the Southeast New England Program’s geographic boundaries
- Wadeable
- Non-tidal
- Perennial
- Have a defined channel
- Have infrequent riffle habitat (<~10% of reach)
- Not too large (5th Strahler order or less)
- Not too small (drainage area ≥ ~ 1 mi²/2.5km²)
- Not in cranberry bogs
- Not lined with concrete channels
- Not highly acidic (pH ≥ 4.5)
Protocols

- Macroinvertebrates
- Water quality
- Habitat
## Macroinvertebrate protocols

### Multihabitat Sampling, 10 Jab/Sweep/Kick Method

<table>
<thead>
<tr>
<th>FIELD COLLECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Habitat</strong>: submerged wood, submerged vegetation, undercut banks/overhanging vegetation, hard bottom/rocky substrates</td>
</tr>
<tr>
<td><strong>Effort</strong>: composite of 10 jabs, sweeps or kicks over a 100-meter reach; each jab/sweep/kick will last for a minimum of 30 seconds and maximum of 45 seconds</td>
</tr>
<tr>
<td><strong>Mesh size</strong>: 500-600 μm</td>
</tr>
<tr>
<td><strong>Index Period</strong>: July 1-Sept 30</td>
</tr>
</tbody>
</table>

**Habitats are sampled in rough proportion to their occurrence** within the reach. For example, if the habitat is 50% submerged wood, 30% submerged vegetation and 20% vegetated margins/banks, then 5 jabs will be taken from submerged wood, 3 from submerged vegetation and 2 from vegetated margins/banks.

Appendix B1 in Sampling Analysis Plan
Macroinvertebrates - Laboratory Processing

- Fixed-count subsample using a Caton gridded tray

- Large-rare search of the remaining unsorted fraction of the sample

- Remove 325-350 organisms or the entire sample is sorted, whichever occurs first

- Taxonomic identifications –
  - Northeast Regional Standard Taxonomic Effort (STE) (Cole Ecological)
  - As a general rule, aquatic insects are identified to genus or species as much as condition and maturity allow

Appendices B3 & B4 in Sampling Analysis Plan
Water Quality

In situ measures
• Dissolved Oxygen
• pH
• Temperature
• Specific conductivity

General characteristics
• Color
• Odor
• Surface oils
• Turbidity

Habitat

• Flow habitat (% riffle, run, glide, pool)
• RBP Rapid Habitat Assessment (low gradient)
• Substrate composition (visual estimate)
• Woody debris
• Canopy cover (visual estimate)
• Flow velocity ( neutrally buoyant object)
• Physical characteristics (width, depth, bankful, high water mark)

Appendix D in Sampling Analysis Plan

Appendix F in Sampling Analysis Plan
Site selection

Goal: compile dataset with sites that meet the target population criteria and cover as much of the human disturbance gradient as is represented in the study area.

Steps:
- Developed disturbance gradient using a slightly modified version of the MassDEP Stream Biocriteria project approach (Jessup and Stamp 2019).
- Applied to existing low gradient sites with comparable data (MassDEP multi-habitat); evaluated their distribution across disturbance categories.
- Used a GIS-based approach to identify new candidate sites that filled in gaps in the disturbance gradient and were most likely to meet the target population criteria (wadeable, non-tidal, low gradient, soft substrate).
- Needed reference sites!

Targets:
- 30 “Best”
- 6 Cape Cod
- 14 “Worst”
## Disturbance variables

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall watershed condition</td>
<td>IWI</td>
<td>Index of catchment integrity v 2.1</td>
</tr>
<tr>
<td></td>
<td>ICI</td>
<td>Index of watershed integrity v 2.1</td>
</tr>
<tr>
<td>Urban</td>
<td>% Urban land cover</td>
<td>% of watershed area classified as developed, high + medium + low-intensity land use (NLCD 2011 class 24+23+22)</td>
</tr>
<tr>
<td></td>
<td>Road density</td>
<td>Density of roads (2010 Census Tiger Lines) within catchment (km/square km)</td>
</tr>
<tr>
<td>Dam</td>
<td>Dam storage volume</td>
<td>Volume all reservoirs (NID_STORA in NID) per unit area of watershed (cubic meters/square km)</td>
</tr>
<tr>
<td>Ag</td>
<td>% Hay + crop land cover</td>
<td>% of catchment area classified as hay and crop land use (NLCD 2011 class 82+81)</td>
</tr>
<tr>
<td></td>
<td>Modeled manure and fertilizer application + biological nitrogen fixation</td>
<td>[CBNFWs]+[FertWs]+[ManureWs]</td>
</tr>
</tbody>
</table>

Source: USEPA's Stream-Catchment (StreamCat) Dataset (Hill et al. 2016)
Index of Watershed Integrity (IWI) v. 2.1

Existing low and high gradient sites from MassDEP & RI DEM

Highest quality catchments located in western RI

Disturbance gradient

- Low gradient sites
- Riffle/kick sites
- SNEP study area
### Disturbance levels/thresholds for each variable

Table A-2. Thresholds and scoring scheme (in parentheses) that were used to define the disturbance gradient. These are the same thresholds that were used for the MA stream biocriteria project except for the ICI and IWI, which were adjusted downward to account for lower scores in the version 2.1 dataset.

<table>
<thead>
<tr>
<th>Category (score)</th>
<th>IWI v2.1</th>
<th>ICI v2.1</th>
<th>PctUrbLMH 2011Ws</th>
<th>PctHayCrop 2011Cat</th>
<th>AllAgNWs</th>
<th>RdDensCat</th>
<th>DamNrmStorWs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disturb Level 1</strong> (least disturbed) (+3)</td>
<td>≥0.85</td>
<td>≥0.85</td>
<td>≤1</td>
<td>≤1</td>
<td>≤0.5</td>
<td>≤1.5</td>
<td>≤0.1</td>
</tr>
<tr>
<td><strong>Disturb Level 2</strong> (+2)</td>
<td>≥0.80</td>
<td>≥0.80</td>
<td>≤2</td>
<td>≤2</td>
<td>≤1</td>
<td>≤2</td>
<td>≤1,000</td>
</tr>
<tr>
<td><strong>Disturb Level 3</strong> (+1)</td>
<td>≥0.70</td>
<td>≥0.70</td>
<td>≤5</td>
<td>≤5</td>
<td>≤2.5</td>
<td>≤3</td>
<td>≤10,000</td>
</tr>
<tr>
<td><strong>Disturb Level 4</strong> (0)</td>
<td>&gt;0.60 and &lt;0.70</td>
<td>&gt;0.60 and &lt;0.70</td>
<td>&gt;5 and &lt;10</td>
<td>&gt;5 and &lt;10</td>
<td>&gt;2.5 and &lt;5</td>
<td>&gt;3 and &lt;5</td>
<td>&gt;10,000 and &lt;50,000</td>
</tr>
<tr>
<td><strong>Disturb Level 5</strong> (-1)</td>
<td>≤0.60</td>
<td>≤0.60</td>
<td>≥10</td>
<td>≥10</td>
<td>≥5</td>
<td>≥5</td>
<td>≥50,000</td>
</tr>
<tr>
<td><strong>Disturb Level 6</strong> (-2)</td>
<td>≤0.50</td>
<td>≤0.50</td>
<td>≥40</td>
<td>≥15</td>
<td>≥7.5</td>
<td>≥7.5</td>
<td>≥100,000</td>
</tr>
<tr>
<td><strong>Disturb Level 7</strong> (most disturbed) (-3)</td>
<td>≤0.40</td>
<td>≤0.40</td>
<td>≥60</td>
<td>≥20</td>
<td>≥10</td>
<td>≥10</td>
<td>≥200,000</td>
</tr>
</tbody>
</table>

Each variable is assigned a score ranging from least disturbed (+3) to most disturbed (-3)
## Disturbance categories

Scores for each variable were combined using these rules:

Each site was assigned to a disturbance category, ranging from BestRef to HighStrs.

<table>
<thead>
<tr>
<th>Disturbance category</th>
<th>Scoring criteria (based on scores for the seven metrics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Reference (BestRef)</td>
<td>Minimum score $\geq 2$</td>
</tr>
<tr>
<td>Reference (Ref)</td>
<td>Min score $= 1$</td>
</tr>
<tr>
<td>Sub-reference (SubRef)</td>
<td>Min score $= 0$ and count of positive scores ($&gt;0$) is $\geq 5$</td>
</tr>
<tr>
<td>Other</td>
<td>Min score $= 0$ and count of positive scores ($&gt;0$) is $&lt; 5$</td>
</tr>
<tr>
<td>Some Stress (SomeStrs)</td>
<td>Min score $= -1$ AND count of negative scores ($&lt;0$) is $\leq 2$; OR Min score $&lt;-1$ but for only 1 variable (the other variables score 0 or better)</td>
</tr>
<tr>
<td>Stress (Strs)</td>
<td>Min score $= -1$ AND count of negative scores ($&lt;0$) is $\geq 3$; OR Min score $=-2$ for $\geq 2$ variables; OR Min score $=-3$ AND count of negative scores ($&lt;0$) is $\leq 3$</td>
</tr>
<tr>
<td>High stress (HighStrs)</td>
<td>Min score $= -3$ AND count of negative scores ($&lt;0$) is $&gt;3$</td>
</tr>
</tbody>
</table>

Table A-3. Sites were placed into disturbance categories based on the criteria below.
NHDPlusV2 catchments color-coded by disturbance category
Substrate may influence the composition of the macroinvertebrate assemblages to the point where sites should be broken into two stream classes to account for natural biological variability.

To explore this, we tried to sample similar numbers of hard vs. soft bottom low gradient sites.

We used Level 4 ecoregions for guidance (Coastal Plain vs. Lowlands; initial screening showed low gradient streams in the Coastal Plains of western RI tended to have more rocky substrates than sites in the Lowlands).

- Coastal Plain – Gulf of Maine Coastal Plain, Southern New England Coastal Plains and Hills
- Lowlands – Long Island Sound Coastal Lowland and Narrangansett/Bristol Lowland
MassDEP also collected multi-habitat samples in 2019 that we will use.
21 sites visited but unsampleable

Most unsampleable sites were not wadeable or were in wetlands. Others were excluded due to low pH, intermittency or access issues.
Examples of hard bottom streams

CP-Best-R4

LO-Best-P1

New-Worc2

31 sites
Examples of soft bottom streams

LO-Best-P9

LO-Worst-P6

23 streams
Examples of ‘gray area’ streams

Cobble and sand

New_Brock1

LO-Best-R11
Next step - low gradient IBI development

- Macroinvertebrate data delivered Monday
- Tetra Tech samples + MassDEP multi-hab samples

Revisiting the disturbance gradient for the sampled sites (working on exact watershed delineations, as well as better gradient metrics that may be used for classification).

Researching other existing low gradient IBIs (e.g., VT DEC, NY DES)

Confirming taxa traits, especially pollution tolerance
Regional low gradient work group

Organized/facilitated by NEIWPCC

Collaborating where possible

Existing low gradient sites – CT DEEP, NY DES, VT DEC, MassDEP, RI DEM
Questions? Comments?

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