What is an appropriate reference framework for ecological assessment, restoration, and monitoring?

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Applications

Restoration

Assessment

Monitoring

Watershed Planning

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Framework: Preliminary considerations

- How will it be used? (Assessment, monitoring?)
- Target ecosystem?
- For what region?
- Who will use it?
- What level of training will be required?
- Will it use check lists, narratives, field metrics?
- How rapid must it be?
- Will it measure condition, functioning, or both?
Common attributes of a successful reference framework
1. Differentiate between natural (noise) and human-caused (signal) variation

The Good,

the Bad,

and the Ugly.
2. Identify environmental stresses

- Heavy foot traffic
- Eutrophied
- Restricted flow
- No buffer, channelized
- Impervious watershed
3. Quantify condition or functioning using reference data

**HGM Approach**
*(Logic Equation Framework)*

Function: **Maintain Characteristic Plant Community**
(for headwater floodplains)

\[
FCI = \left[ \frac{V_{HYDROALT} \left( \frac{V_{BIG3} + V_{TDEN}}{2} \right) + V_{COMP}}{2} \right]^{1/2}
\]

- \(V_{HYDROALT}\) = degree of hydrologic disconnect between floodplain and stream
- \(V_{BIG3}\) = mean diameter of 3 largest trees in 3 plots (n=9)
- \(V_{TDEN}\) = density of trees > 15 cm dbh
- \(V_{COMP}\) = composition of trees > 15 cm dbh

**EPA Wadeable Steams (Narrative Framework)**

<table>
<thead>
<tr>
<th>Habitat Parameter</th>
<th>Optimal</th>
<th>Suboptimal</th>
<th>Condition Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epiphyte Substrate/Available Cover</td>
<td>Greater than 70% of substrates favorable for epiphytic colonization and fish cover; mix of upturned, submerged logs, undercut banks, cobbles or other stable habitat at staging to allow full colonization potential (i.e., logs/edges that are not new fall and not treated).</td>
<td>Adequate habitat for maintenance of populations; presence of additional substrates in the form of invertebrates, but not yet prepared for colonization (may rate at high end of scale).</td>
<td>Marginal</td>
</tr>
</tbody>
</table>

**Parameters to be evaluated in sampling**

1. Epiphyte Substrate/Available Cover
2. Embryonic Potential
3. Velocity/Depth Regime
4. Sediment Deposition
5. Channel Flow Status

**SCORE**

- 20 = Excellent
- 10 = Good
- 5 = Fair
- 0 = Poor
4. *Identify potential constraints to recovery*  
(Applicable to restoration only)

- Surrounding landuse/land cover, watershed condition
- Proximity of invasive species
5. Identify a reasonable final target or intermediate target conditions

- Mature Forest
- 15yo Forest
- 8 yo Forest
- ?
Applications

Restoration

Reach Assessment

Monitoring

Network Assessment
Example 1: Salt marsh restoration:

**Stress:** trampling

**Condition:** area of bare soil

**Constraints:** continued use

**Target:** substantial increase in marsh cover
Example 2: Rapid assessment protocol for headwater ecosystems in an agricultural landscape

Stresses: channelization, poor buffers
Constraints: LULC (active farming), roadside ditches
Variation: channelized, deforested buffer zones to natural streams with intact, mature buffers
Condition: score 0-100 (worst to best)
Framework to measure condition at the scale of a defined reach (e.g., 100-m)

<table>
<thead>
<tr>
<th>Condition Categories</th>
<th>Degree of Alteration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
</tr>
<tr>
<td>Dominant LULC of watershed</td>
<td>Mature forest or agriculture with BMPs</td>
</tr>
<tr>
<td>Stream Channel</td>
<td>Natural or restored channel</td>
</tr>
<tr>
<td>Riparian zone</td>
<td>Mature forest buffer</td>
</tr>
</tbody>
</table>
### Narrative approach

- **Detailed description of indicators** \( n=6 \)
- **Similar to EPA Wadeable stream survey** \( 0-20 \) **scale**
- **Scale** = \( 0-100 \)

<table>
<thead>
<tr>
<th>Condition Indicator</th>
<th>Relatively Unaltered</th>
<th>Somewhat Altered</th>
<th>Altered</th>
<th>Severely Altered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Instream woody structure (detritus)</td>
<td>(a) Several pieces of large downed wood (LDW) are within the channel and along banks, representing a mix of sizes 4 to &gt;15 inches (10-40+ cm) in dia. and decay classes. (Recent treefalls from extreme weather events not applicable.) ( \text{BUT (b)} ), for streams channels that are dry for long periods, tree roots with hypertrophied lenticels are located at channel surface; large roots in channel create small pools that trap leaf litter when available.</td>
<td>(a) LDW sparse and/or small in size (few or none &gt;4 inches dia.) or not representing a variety of decay classes. ( \text{BUT (b)} ) For streams channels that are dry for long periods, tree roots located in stream bottom lack hypertrophied lenticels; few or no large tree roots present in channel capable of creating small pools that could trap leaf litter.</td>
<td>(a) No LDW or LDW represents only one decay class deposited during an extreme storm event; channel frequently de-snagged(^1). ( \text{BUT (b)} ) For stream channels that are dry for long periods, and channel has been channelized, it is maintained so infrequently that small trees or shrubs grow in and/or along channel.</td>
<td>Stream is channelized, lined with rocks, or has been frequently excavated or cleared of debris to maintain drainage. [Lowest score should be given to channels that are lined with rocks.]</td>
</tr>
</tbody>
</table>

| Score = | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | 0 |
Assessment using a narrative framework

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Narrative</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instream woody structure</td>
<td></td>
<td>Relatively Unaltered</td>
</tr>
<tr>
<td>Sediment Regime</td>
<td></td>
<td>Severely Altered</td>
</tr>
<tr>
<td>Channel-riparian zone connection</td>
<td></td>
<td>Severeley Altered</td>
</tr>
<tr>
<td>Factors affecting stream</td>
<td></td>
<td>Altered</td>
</tr>
<tr>
<td>Factors affecting riparian zone</td>
<td></td>
<td>Severeley Altered</td>
</tr>
<tr>
<td>Habitat quality</td>
<td></td>
<td>Relatively Unaltered</td>
</tr>
</tbody>
</table>
Develop and test with field data

A

B

C

D

E

F
Biomass (except roots) vs. Nitrogen (NO₃ and NO₂ from 1-yr of baseflow and stormflow data)
## Calibrate indicator (Riparian condition)

<table>
<thead>
<tr>
<th>Cover type</th>
<th>Age Midpoint</th>
<th>Biomass (MgC/ha)</th>
<th>Derived Biomass Index</th>
<th>RIGHT SIDE ZONES (distance from stream)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0-3 m</td>
</tr>
<tr>
<td>Old Forest</td>
<td>85.0</td>
<td>440</td>
<td><strong>1.00</strong></td>
<td>20</td>
</tr>
<tr>
<td>Mature Forest</td>
<td>62.5</td>
<td>375</td>
<td>0.85</td>
<td>17</td>
</tr>
<tr>
<td>Young Forest</td>
<td>37.5</td>
<td>275</td>
<td>0.63</td>
<td>13</td>
</tr>
<tr>
<td>Successional Forest</td>
<td>15.0</td>
<td>160</td>
<td>0.36</td>
<td>7</td>
</tr>
<tr>
<td>Recently Harvested</td>
<td>2.5</td>
<td>70</td>
<td>0.16</td>
<td>3</td>
</tr>
<tr>
<td>Shrubs/Saplings</td>
<td>NA</td>
<td>63</td>
<td>0.14</td>
<td>3</td>
</tr>
<tr>
<td>Perennial Herb (incl.</td>
<td>NA</td>
<td>38</td>
<td>0.08</td>
<td>2</td>
</tr>
<tr>
<td>residential lawns)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Rowcrop</td>
<td>NA</td>
<td>20</td>
<td>0.08</td>
<td>1</td>
</tr>
<tr>
<td>Impervious</td>
<td>NA</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
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Zone Score (column): 17 16 0

Total Score (biogeochemical indicator): 33
Riparian condition score (max = 100)

- A: 88
- B: 83
- C: 72
- D: 26
- E: 6
- F: 5
Scale up to drainage network

**Purpose:** Compare basin conditions or track through time

**Assessment:** Integrate condition of stream reaches in a drainage network (randomized approach)
Assess condition of random, 100-m reaches (10%)

Drainage basin condition

Cow Swamp

USGS Hydrography
Added Streams
Deleted Streams
• Random Points
○ Alternate Points
□ Sampled points

CHANNEL
RIPARIAN

0% Relatively unaltered
15% Somewhat altered
50% Severely altered
35% Altered


Compare condition between basins or through time

Stoney Creek watershed

Crisp Creek, all reaches

Channel Condition

Riparian Condition

Relatively Unaltered

Somewhat Altered

Altered

Severely Altered

Rural low order

Urban low order

Rural high order

Urban high order

10%

55%

28%

62%

2%

62%

36%

0%
Diagnose problems and prioritize efforts

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<td>32</td>
<td>74</td>
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Max score = 100
Example 3: Using multivariate techniques to monitor tree composition

**Variation:** space-for-time approach to examine trajectory of tree composition in wet hardwood flats

**Condition:** ordination position based on composition

**Target:** tree composition of mature stands

Trajectory? 2 y

(Reasonable target?) >75 y
Non-metric Multidimensional Scaling

Polar Ordination

Trajectory Analysis: year1 to year n

Non-riverine hardwood (CVS)
Hardwood flat (CVS)
Wet hardwood flat (ECU)
Abc (ABC: EEP)
Bal (Ballance: EEP)
Cro (Croatan: EEP)
Dis (Dismal Swamp: EEP)
Dow (Dowd Dairy: EEP)
Hus (Huskanaw: EEP)
Mil (Mildred Woods: EEP)
Tuc (Tucker: EEP)
Summary: Common attributes of a successful reference framework

1. Differentiates between natural and human-caused variation
2. Identifies environmental stresses
3. Quantifies condition or functioning using reference data
4. Identifies potential constraints on recovery
5. Identifies a reasonable target or some intermediate target condition
Acknowledgments

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