Factors Determining Thresholds of Reliable Change Detection in Water Quality Resulting from Stream Restoration: A question of signal to noise.

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History and Drivers for Water Quality Measurement in Restoration/Mitigation in NC

• Water quality improvement is often stated as a goal in restoration, but infrequently measured Palmer et al., (2007)

• The functional efficacy of restoration for pollutant attenuation absent watershed controls has been questioned, particularly in urban settings. Walsh et al., 2005; Bernhardt and Palmer, 2007; Selvakumar et al., 2010.

• The last decade has shown a range of results, but understanding efficacy considering scale, setting, and specific practices still requires attention. (Craig et al., 2008; Palmer et al. (2014); Newcomer Johnsen et al., (2016); Lammers and Bledsoe (2017)

• 2008 Federal Mitigation rule requiring “ecological performance standards” USACE 33CFR 325, 332; USEPA 40CFR 230

• NCIRT encourages/incentivizes water quality assessment USACE Federal Public Notice October 24, 2016
1. Large provider of Mitigation in NC.

2. Opportunity for long term observation and monitoring.

3. Tied to a robust watershed planning approach.
DMS Objectives for Water Quality Monitoring of Mitigation

1. Provide case examples of water quality response to restoration for settings and mitigation practices in NC.

2. Gain understanding of the relative efficacy of different practices.

3. Gain understanding of the time frames of improvement and their sustainability.

4. Utilize data collected to potentially refine current models in use in mitigation plans for pollutant reduction estimates.

5. Gain an understanding of the reach and watershed attributes that inform detection of change in water quality to help refine stated mitigation plan goals (i.e. examine a gradient of “signal to noise”)

6. Gain understanding of sampling regime necessary
General Concept of Signal to Noise

The separation or relative magnitude of what you want to measure (Signal).

SIGNAL

to the background variation (Noise)

NOISE

Larger the difference in magnitude (i.e. larger the signal to noise ratio), the greater resolving power for detecting differences/changes)
Categories of Reach and Watershed Attributes that Characterize Signal to Noise

1. Spatial Distribution / Proportions of Stressor Areas Treated
2. Stressor Intensity
3. Stressor Types
Concept of Signal to Noise in Restoration Context

1. Distributions of Stressor Areas
2. Stressor Intensity

The combination of these can be viewed as the overall stressor load at the downstream ‘treatment’ station for a reach. The greater the proportion of items 1 and 2 that exists within the treatment area (i.e. protected and treated via restoration) the greater the likelihood of reliable detection in change or improvement. High signal to low noise. **Better resolving power**
Station 3 LULC Distributions and Treatment Proportions

54% of Ag stressors draining to station 3 are in treatment zone

Treatment Zone in between station 3 and 5. 12% of drainage network treated

Upstream Control Station

Legend
- Control
- Treatment
- Easement
- Forested Pasture
- Open Pasture
- Row Crop

Moderate Signal to Noise
Station 4 LULC Distributions and Treatment Proportions

Treatment Zone in between stations 6, 7 and 4. 82% of drainage network protected or treated.

96% of Ag stressors draining to station 4 are in treatment zone.
Differences in Pre-Restoration water quality distributions as stressor intensity varies
Supporting LULC data DMS is Collecting

- LULC history to help document stressor intensity and distribution
- Historical orthoimagery
- Landowner discussions
  - e.g. Livestock densities
  - e.g. Rotation schedules
  - e.g. Application rates
Type of Stressor – Effects on change detection expectations in mitigation timeframes

e.g. Row crop versus pasture
DMS WQ Study Sites

NC Physiographic Regions:
- Mountains
- Piedmont
- Inner Coastal Plain
- Outer Coastal Plain

Map showing locations such as Buckwater, Stinking Quarter, Heath Dairy, Millstone, Pen-Dell, Big Harris, Crane, and Cross Creek.
## DMS WQ Study Sites

<table>
<thead>
<tr>
<th>Project</th>
<th># of Reaches</th>
<th>Param</th>
<th>Years Pre</th>
<th>Years Post</th>
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<tbody>
<tr>
<td>Heath Dairy*</td>
<td>2</td>
<td>F,N,S,M</td>
<td>3</td>
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<td>Millstone*</td>
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<td>F</td>
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<td>2</td>
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<td>F,N,S</td>
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<td>2</td>
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<tr>
<td>Big Harris**</td>
<td>13</td>
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<td>5</td>
<td>3</td>
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<td>Stinking Quarter</td>
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</tr>
</tbody>
</table>

* Indicates a year or more of post restoration data

* Dan Line P.E. NCSU  **Dr. Jerry Miller WCU
F – Fecal; N – Nutrients; S – Total Suspended Solids; M–Macrobenthos  FS – Fish
In Conclusion

- DMS will continue to add reaches of varying scale and complexity to provide an adequate gradient of signal to noise in order to:

  - Identify factors of scale, stressor distributions, and treatment proportions that could inform change detection expectations.

  - Assist mitigation practitioners in grouping reaches and sub-watersheds within a project into coarse bins of ‘likelihood’ in terms of reliable change detection.

  - Add spatial granularity to the development of goals and performance standards within Mitigation Plans.
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  Wildlands Engineering (Buckwater, Cross Creek, Big Harris)
Citations


Questions?