Developing Expectations for Wisconsin Streams

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What should healthy streams be like?
Overview:

- Classification evaluated
- Reach – specific modeling (RF)
- Reference sites limitations
What Are Reference Conditions?*

- Pristine?
- Historical?
- Minimally - disturbed?
- Least - disturbed?
- Best - attainable?
- Other?

*After Stoddard et al. 2006*
This Study:

• Pristine Conditions

• Historical Conditions

• Minimally - disturbed

• Least - disturbed

• Best - Attainable Conditions

• Current conditions
Reference Condition Measures

**Stream Habitat**
- Fish Habitat Suitability Index
- Width / Depth Ratio
- Percent Fine Sediment
- Percent Rocky Substrate
- Percent Fish Cover

**Water Chemistry**
- Phosphorus
- Nitrogen
  - Dissolved Inorganic Nitrogen
  - Total Suspended Solids
  - Conductivity
  - Transparency
  - Dissolved Oxygen

**Fish**
- Fish IBI
- Percent Simple Lithophiles
- Number Intolerant Species
- Percent Tolerant Individuals

**Macroinvertebrates**
- Hilsenhoff’s Biotic Index
  - Macroinvertebrate IBI
  - Species Richness
  - Percent EPT Taxa
  - Percent Chironomidae
  - Functional Feeding Groups

**Dissolved Oxygen**
Overview:

- Classification
- Reach – specific modeling
- Reference sites limitations
Stream Classes:

- Ecoregions (4)
- Flow volume (2)
- Thermal class (4)
Least – Disturbed Stream Sites Data

$n = 297$

Limitations:
- Varying quality
- Unrepresentative
- Moving target
Overview:

- Classification methods evaluated (just two examples)
- Reach – specific modeling
- Reference sites limitations
Ecoregional Classification Results

Ecoregional differences often exist, but ...

- Natural factors?
- **Anthropogenic** factors?

Within class variability usually large
Ecoregional Classification Results

- Only SWTP distinct
  - Natural factors?
  - Anthropogenic?

Graph showing box plots for different ecoregions (NLF, NCHF, DA, SWTP) with Hilsenhoff's Biotic Index ranging from Poor (2) to Good (8), indicating varying levels of environmental quality.
Typologic Classification Results

- No thermal or size class differences
- Within-class variability often large
Typologic Classification Results

- Cold and warm streams different
- Stream sizes not different
Conclusion #1

- Classification results not great
- Ecoregions may differentiate streams, but . . .

Potential solution:
Develop reach-specific expectations
Random Forests Models

Inputs:
- Stream monitoring data
- Watershed and channel characteristics

Outputs:
- Stream reach predictions (n = 110,000)
- Identification of key predictor variables
Watershed and channel predictor variables

WI Hydrography Dataset
100s of attributes, e.g.

- Land cover
- Topography
- Soil and bedrock
- Hydrology
- Channel features
- Climate
- Meteorology
Random Forests Results
(Current conditions)

Used all sample sites data regardless of quality.

n = ~ 2,000
Random Forests Results (Least-disturbed conditions)

Used least – disturbed sites data only
n = 178
Also . . .
Expectations using Least – disturbed sites data are still largely driven by disturbance

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Top 10 predictor variables
Conclusion #2

Use caution when drawing conclusions from least-disturbed reference sites input data.

Potential solution:
Account for differences in land use disturbances in stream model input data.
Controlling for site-quality differences (use residuals to adjust for land use, TP example)

Residuals used as the response variables in the RF models (Robertson et al. 2006)
Not limited to reference sites data only
○ = sample site (2003 – 2013)

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<td>Fish</td>
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Conclusion #3

Adjusting for land use often resulted in very different expectations.

Least - disturbed

NSE: 0.72
PBIAS: 1.7
%RMSE: 14.4

Minimally - disturbed

NSE: 0.67
PBIAS: 15.1
%RMSE: 15.7
## Random Forests Models Predictive Power

### Good  Fair  Poor  (based on: RMSE, NSE, %Bias)

### Water Chemistry
- Phosphorus
- Nitrogen
- Diss. Inorganic Nitrogen
- Conductivity
- Total Suspended Solids
- Transparency
- Dissolved Oxygen

### Fish
- Fish IBI
- % Lithophiles
- No. Intolerant Species
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### Macroinvertebrates
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- Species richness
- % EPT
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### Habitat
- Fish Habitat Index
- Width / Depth Ratio
- % Fine Sediment
- % Rocky Substrate
- % Fish Cover
Stream Reach – specific  \( (n = 110,000) \)

Expectations
Study Conclusions:

- Ecoregions may differentiate streams, but difficult to separate natural from anthropogenic differences.
- Caution is required when drawing conclusions using least - disturbed reference site data.
- Adjusting for land use may provide better estimates of stream expectations.
Questions?

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