Long-term monitoring in the era of big-data: Using native fish to create regional instream flow thresholds for the nation

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Environmental Sciences & Policy
Background: Fish-flow curves

- Fish-flow curves influence streamflow management
  - Manage for Adverse Resource Impacts (ARI)
- Typically done on watershed-level and state-level scale

(Zorn et al. 2008)
Background: Regional presumptive standard

- Regional presumptive standard of 20% flow alteration (Richter et al., 2012)
  - Based on the ELOHA framework (Poff et al. 2010)
- Flow alteration – a river’s departure from its natural flow regime
- No quantitative threshold

(Poff et al., 2010)
Research Question:

What are the best-fit relationships between flow alteration and species richness in the US?

Identify:

1. Relationships between river size and species richness
2. Relationships between flow alteration and species richness, using different streamflow metrics
3. The best-fit flow alteration metrics from and the spatial and ecologic patterns of the metrics
4. Where can flow alteration thresholds be identified using our flow-richness relationships.
Dataset

**Streamflow Data**

1. Hydrologic alteration model
   - predicts values of alteration for gaged and ungaged rivers (McManamay et al, 2017)
   
   *Alteration formula: \( ((\text{Observed-Expected})/\text{Expected}) \times 100 \)*

2. 48 Streamflow Metrics
   - describe magnitude, timing, duration, frequency, and rate of change of streamflow

**Richness Data**

1. Reach-level fish data
   - Standardized fish surveys

2. Basin-level fish data
Dataset - coverage

- 5,849 stream data points with overlapping streamflow and ecological data.

- Least coverage in Western U.S.

- Most coverage in Eastern U.S. and Pacific Northwest
Methodology

Regional Stratification

- Data is divided into **205 HUC4** catchments and **29 Ecohydrologic** regions
- **HUC4** – USGS Hydrologic unit code digit 4
- **Ecohydrologic Regions** – subdivision of HUC2 watersheds based on fish habitat (freshwater ecoregions)
Methodology

1. **First control for scale**
   - Use a Generalized Linear Model (GLM) to model stream size and observed native fish species for each HUC4 watershed
   - Extract residuals

2. **Determine flow-richness relationships**
   - Use Quantile Regression to compare stream alteration and residuals for every streamflow metric in each HUC4 watershed. (Knight et al. 2014)
   - P values < .10 pass (small sample sizes)

3. **Identify best metrics and extract thresholds**
   - Metric with the highest r2 is chosen in HUC4
   - **Threshold** = level of flow alteration where modeled line crosses 0 on the Y axis
   - Use of quantiles to establish different thresholds
1. River Size-Richness Relationships

- HUC 0102/New England: $n=9$, slope $=0.1757$
- HUC 0504/Midwest-Ohio: $n=22$, slope $=0.2387$
- HUC 0305/Southeast: $n=43$, slope $=0.0815$
- HUC 1018/Intermountain West: $n=28$, slope $=0.2802$
- HUC 1501/Southwest: $n=27$, slope $=0.0425$
- HUC 1710/Northwest: $n=125$, slope $=0.3227$
I think you should show some sort of information about r² or uncertainty. How good are these relationships???
Results

2. Flow-Richness Relationships and Best Metrics

HUC 0109/ Northeast
Alteration of mean June flow (MA17)

HUC 0304/ Southeast
Alteration of mean August flow (MA19)

HUC 0507/ Midwest
Alteration of reversals (RA8)

HUC 1604/ West
Alteration of high flood pulse count (FL1)

HUC 1501/ Southwest
Alteration of annual minima of 3-day means (DH2)

HUC 1710/ Northwest
Alteration of mean November flow (MA22)
Threshold Identification

Pacific Northwest
West ecohydrologic region

HUC 1710 flow alteration thresholds for three quantiles

Percent Alteration of December Mean Flow (MA23) vs. Species Richness

- 95th quantile: T = 0.52
- 85th quantile: T = 0.36
- 75th quantile: T = 0.43

MA23
1. Different streamflow metrics were significant around the country
   • Supports the work of Poff et al. 2010 and Richter et al. 1996
   • Can identify what metrics we should be prioritizing

2. It is possible to identify thresholds of flow at which significant river impacts occur
Future Considerations

How can we *improve* this model?

- Do we need a better hydrologic alteration model?
- Should we be considering different metrics for species richness?
- How does low species richness affect our results?
Thank you!
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<th>Quantile</th>
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<th>Ecohydrologic Region Coverage</th>
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<td>P-value ≤.10</td>
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