Human stressors and their impacts on freshwater fish communities – a cross-continental comparison of European and United States Freshwater Ecoregions

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Why are riverine ecosystems / fish assemblages threatened all over the world?

Why are large scale analyses important?

- Biological response might differ among spatial scales
- Better understanding of stressor patterns and biological responses
- To understand mechanistic principles behind
- And finally to support (international) river basin management

(Friberg, 2014; Vörösmarty et al., 2010; Schinegger et al., 2012; Allan, 2004)
Objectives of CROSSFISH

- Characterize patterns of dominant human stressors at large scales in the United States and Europe

- Compare stream fish responses to stressors in various freshwater ecoregions across the two continents

- Synthesize findings to describe dominant cross-continental stressors to river fish

- Describe outcomes to aid in future large-scale assessments
CROSSFISH database

Facts

- 25,580 fish sampling sites
- 43 WWF Freshwater Ecoregions of the World (Abell et al., 2008; 33 used)
- Fish metrics classification by Frimpong and Angermeier (2009)

- 5,648 fish sampling sites
- 12 WWF Freshwater Ecoregions of the World (11 used)
- Fish metrics classification by EFI+ (European Fish Index + Consortium, 2009)

Harmonized Data
- Fish metrics: relative abundance
- Land cover: 6 classes (ub, ag, scrub, past, frst, noveg)
- Sites: river reaches (section between 2 confluences)
- **Local catchment**
  
area between two tributaries draining directly to the river reach

- **Network catchment**
  
sum of all local catchments upstream

(Wang et al. 2011)
Overview

FEOWs in the United States and Europe
Overview
Environmental parameters

- US
  - km²
  - m.a.s.l.
  - °C

- EU
  - Catchment area
  - Elevation
  - Mean Temperature

FEOW

CROSSFISH
Average land use in the network catchment

United States

Europe

Land use
- Forest
- Shrubland
- Pasture
- Agriculture
- Urban area
- No vegetation
### Overview

#### Fish metrics

<table>
<thead>
<tr>
<th>Categories</th>
<th>Fish metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat preference</td>
<td>% rheophilic individuals</td>
</tr>
<tr>
<td></td>
<td>% lentic (EU: limnophilic) individuals</td>
</tr>
<tr>
<td>Trophic ecology</td>
<td>% herbivorous individuals</td>
</tr>
<tr>
<td></td>
<td>% planktivorous individuals</td>
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<tr>
<td></td>
<td>% piscivorous individuals</td>
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<tr>
<td></td>
<td>% detrivorous individuals</td>
</tr>
<tr>
<td></td>
<td>% invertivorous (EU: insectivorous) individuals</td>
</tr>
<tr>
<td>Reproductive ecology</td>
<td>% pelagophilic individuals</td>
</tr>
<tr>
<td></td>
<td>% lithophilic individuals</td>
</tr>
<tr>
<td></td>
<td>% phytophillic individuals</td>
</tr>
<tr>
<td></td>
<td>% speleophilic individuals</td>
</tr>
<tr>
<td>Migration</td>
<td>% individuals of migratory species</td>
</tr>
<tr>
<td>Social preference</td>
<td>% individuals of Salmonidae</td>
</tr>
<tr>
<td></td>
<td>% individuals of game fish</td>
</tr>
<tr>
<td></td>
<td>% individuals of endangered species</td>
</tr>
<tr>
<td>Tolerance</td>
<td>% individuals of tolerant species</td>
</tr>
<tr>
<td></td>
<td>% individuals of intolerant species</td>
</tr>
</tbody>
</table>
**Methodical approach**

**Analysis**

**Spearman ranks correlation**

\[ r \geq 0.5 \]

**Boosted Regression Tree Analysis**

**Criteria for least disturbed sites**

- Network catchment:
  - Urban area < 1%
  - Agriculture < 10%
  - Pasture < 10%
- Fish metrics can not have a zero value

(Daniel et al. 2015)

**Threshold analysis**

Piecewise linear regression
Identifies hockey-stick thresholds

(Daniel et al. 2015)

First investigation to determine relationships between fish metrics and human stressors

Correction of fish metrics for natural gradient

% intolerant species vs Stressor density

\[ p\text{-value} \leq 0.01 \]
**Results**

**Correlation analysis**

**Human stressors** (urban area, agriculture, road crossing density, population density)

**United States**

- **lc_creek**
- **lc_river**
- **nc_creek**
- **nc_river**

**Europe**

- **lc_creek**
- **lc_river**
- **nc_creek**
- **nc_river**

Number of correlations $r \geq 0.5$

Fish metrics

*CROSSFISH*
Preliminary results
Threshold analysis

Columbia Unglaciated

Upper Danube

Intolerant species abundance (%)

Urban land use in the network catchment (%)

Threshold
We have ....

- identified comparable stream fish metrics
- identified comparable landscape factors to use in analysis
- identified major gradients in natural and anthropogenic landscape factors
- developed common spatial units and a basic spatial framework to facilitate analyses on EU and US river fishes and their habitats

What are we learning?

- Challenges in terms of stressors are similar on the two continents
- Fish assemblages are much more diverse in the US ecoregions
- Therefore, different/more specific metrics might be needed
Conclusions

How can this study be used?

- To untangle mechanistic principles of biota response to stressors at various scales
- To identify metrics which are responsive over a wide range of FEOWs
- To identify future research & management needs, data requirements etc. and to advice policy

How can this study support conservation and global assessment?

- Outcomes can form the basis for discussion of large-scale conservation strategies for stream fishes in the EU and US
- Lessons learned related to spatial units and management of landscape-scale datasets can be applied in other countries
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