Integrating relevant hydrologic measures with digitized biodiversity data to investigate climate change impacts on freshwater fishes

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Environmental change and freshwater systems

• How will water temperature and flow regimes change with predicted changes in climate in the coming century?

• How will freshwater biodiversity respond to these changes?

• What is the role of digital biodiversity data?
Predicting species responses to environmental variation at large spatial scales

Climate + Landcover → Direct prediction → Biodiversity
Air temperature and water temperature

- 4°C increase in air temperature at 30°C (30°C to 34°C)
- Results in 0.4°C increase in water temperature (18.0°C to 18.4°C)

Caissie (2001), Journal of Hydrology
Water temperature sensitivity to changes in air temperature

Water temperature in the Columbia River Watershed

Ecoregions

Ficklin et al. (2014) Hydrol Earth Syst Sci
Predicted changes in summer water temperature in 2080

Ficklin et al. (2014) Hydrol Earth Syst Sci
Predicting species responses to environmental variation at large spatial scales

Climate + Landcover

Physical model

Biodiversity
Integrating species locality data

• Species distribution modeling

• Species richness

• Local abundance

• Estimates of in-stream habitat are critical
Fish habitat in the Sierra Nevada region

Flow

Sediment

Water temperature

Dissolved oxygen

Ficklin et al. (2012) JAWRA
Brook trout distribution in the Sierra Nevada region

Flow + Water temp
Integrating species trait data

- Trait data derived from online images

*Lepomis macrochirus*
image from iDigBio
The relationship between flow and species morphology

**High Flow**
- Shallow/narrow caudal peduncle
- Deep/wide anterior body

**Low Flow**
- Large caudal peduncle
- Deep posterior body

*Langerhans & Reznick 2009*
Stonecat  
*(Noturus flavus)*  

Blackside darter  
*(Percina maculata)*  

Red shiner  
*(Cyprinella lutrensis)*  

Johnny darter  
*(Etheostoma nigrum)*
Predicting current and future stream flows

- Future monthly flows predicted based on 26 GCM scenarios using Soil and Water Assessment Tool (SWAT)
  - nine climate models
  - three emissions scenarios (A2, A1B, B1)

Chien, Yeh, and Knouft (2013) *Journal of Hydrology*
Flow Rate and Fish Morphology

Body Shape (Relative Warp) vs. Maximum Flow (m³/s)

- Low-flow
- High-flow

$P < 0.001$

$R^2 = 0.70$

Blackside Darter (*Percina maculata*)
Future flow data

• Use current flow vs. morphology relationships with future flow estimates (2050-2059) to predict future morphology

• 26 different flow scenarios
  Highest flow scenario - CGCM3, B1
  Median flow scenario - MIROC3.2, B1
  Lowest flow scenario - GFDL-CM2.0, B1
Future Expected Phenotypes

Current phenotype

Future expected phenotype range

Body Shape (Relative Warp)

AuxSable, DesPlaines, Grindstone, Kaskaskia, LaMoine, LongRun, NForkEmbarrass, Panther, Sangamon

Michel et al. (2017) Climatic Change
Generating the environmental data

HydroClim

www.hydroclim.org

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• Monthly discharge and water temperature from 1950 – 2099

• 78 future GCM scenarios

• SWAT hydrologic model

• Data generated at the stream segment scale
Conclusions

- There are a wealth of biodiversity data for freshwater taxa

- Environmental data requirements are different for freshwater taxa compared to terrestrial taxa

- Generation of relevant physical data for freshwater systems is critical for the appropriate use of digital biodiversity data
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