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

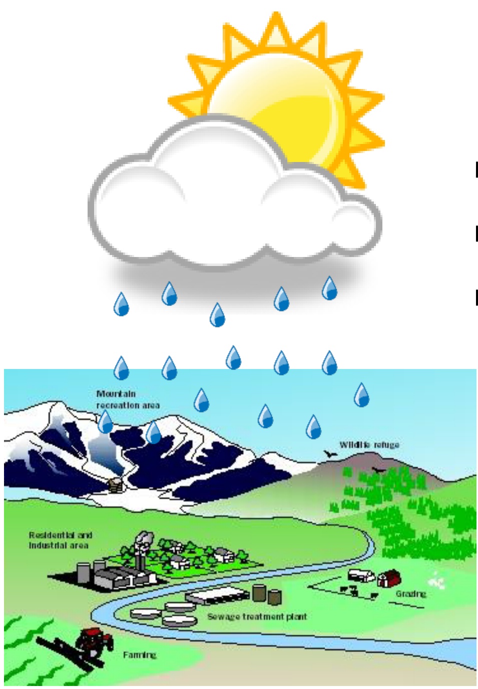
- How will water temperature and flow regimes change with predicted changes in climate in the coming century?

- 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

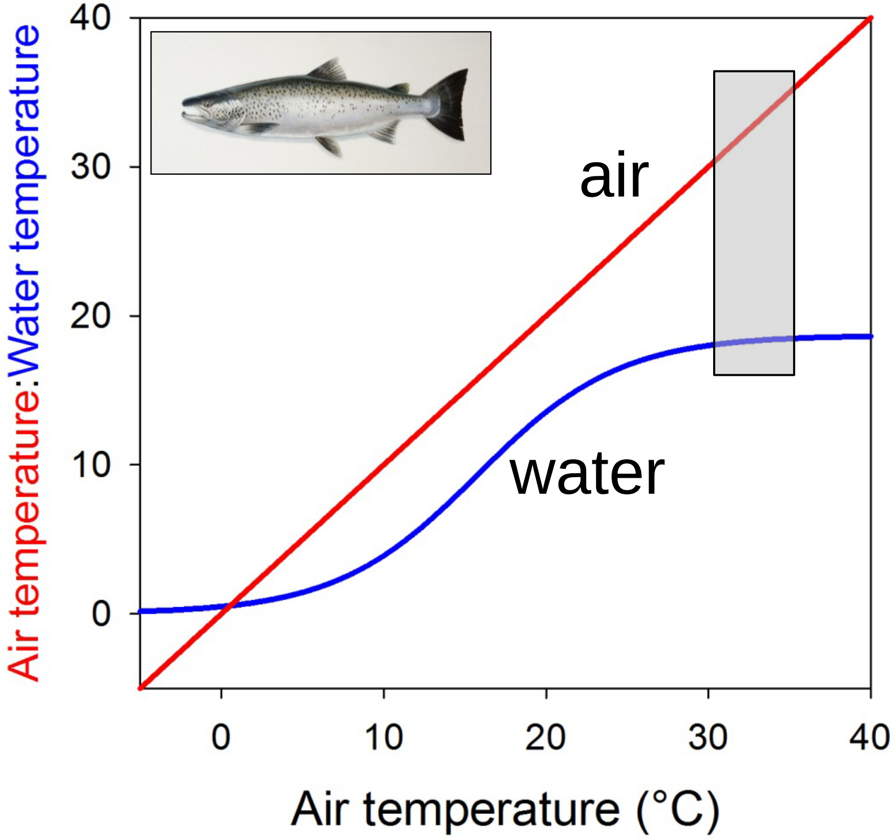
Climate + Landcover



Direct prediction

Biodiversity

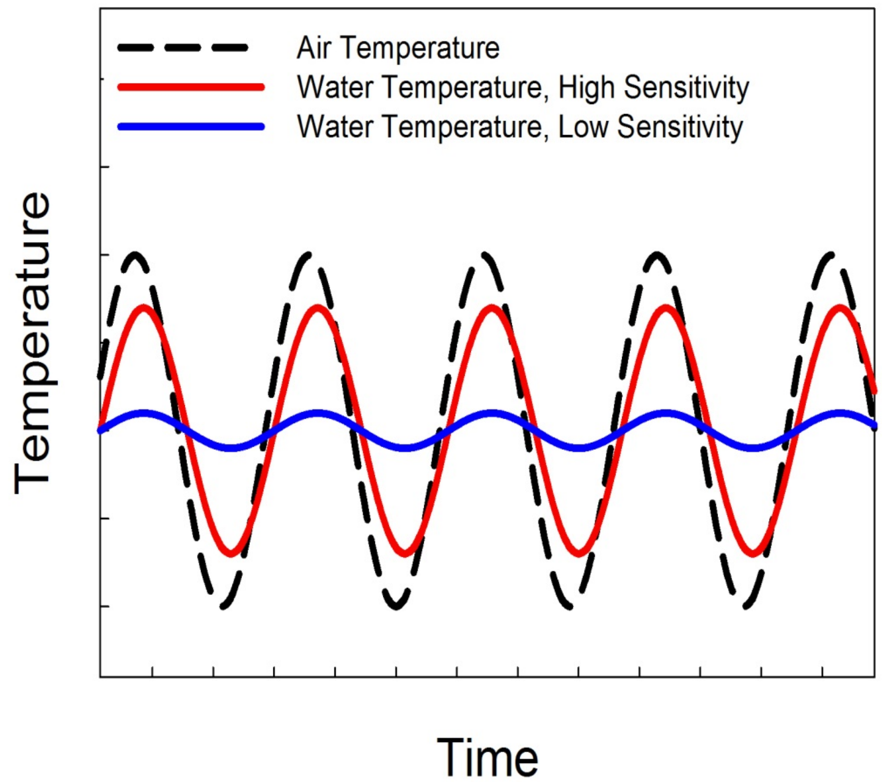
Air temperature and water temperature



- 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)

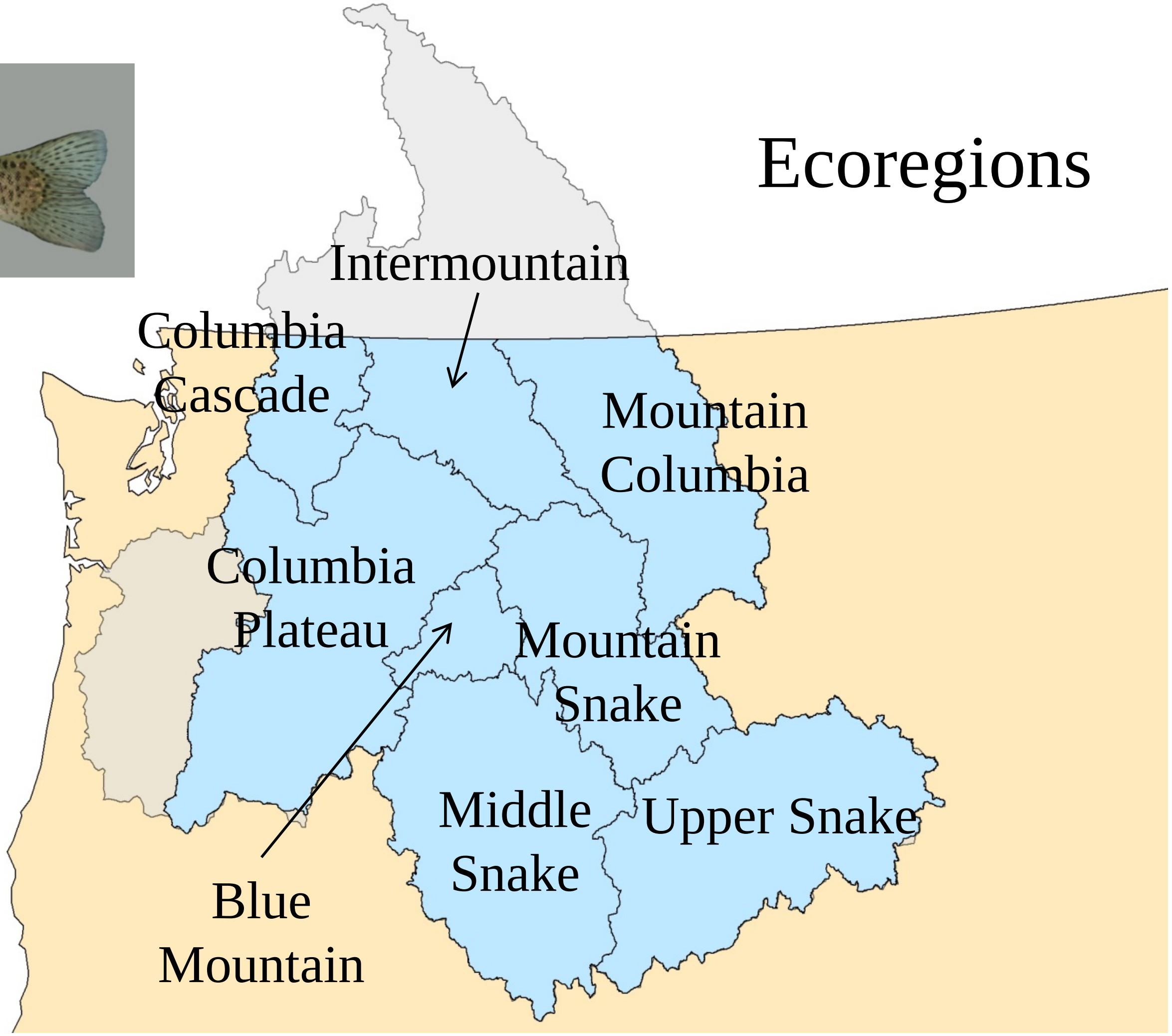
Caissie (2001), Journal of Hydrology

Water temperature sensitivity to changes in air temperature



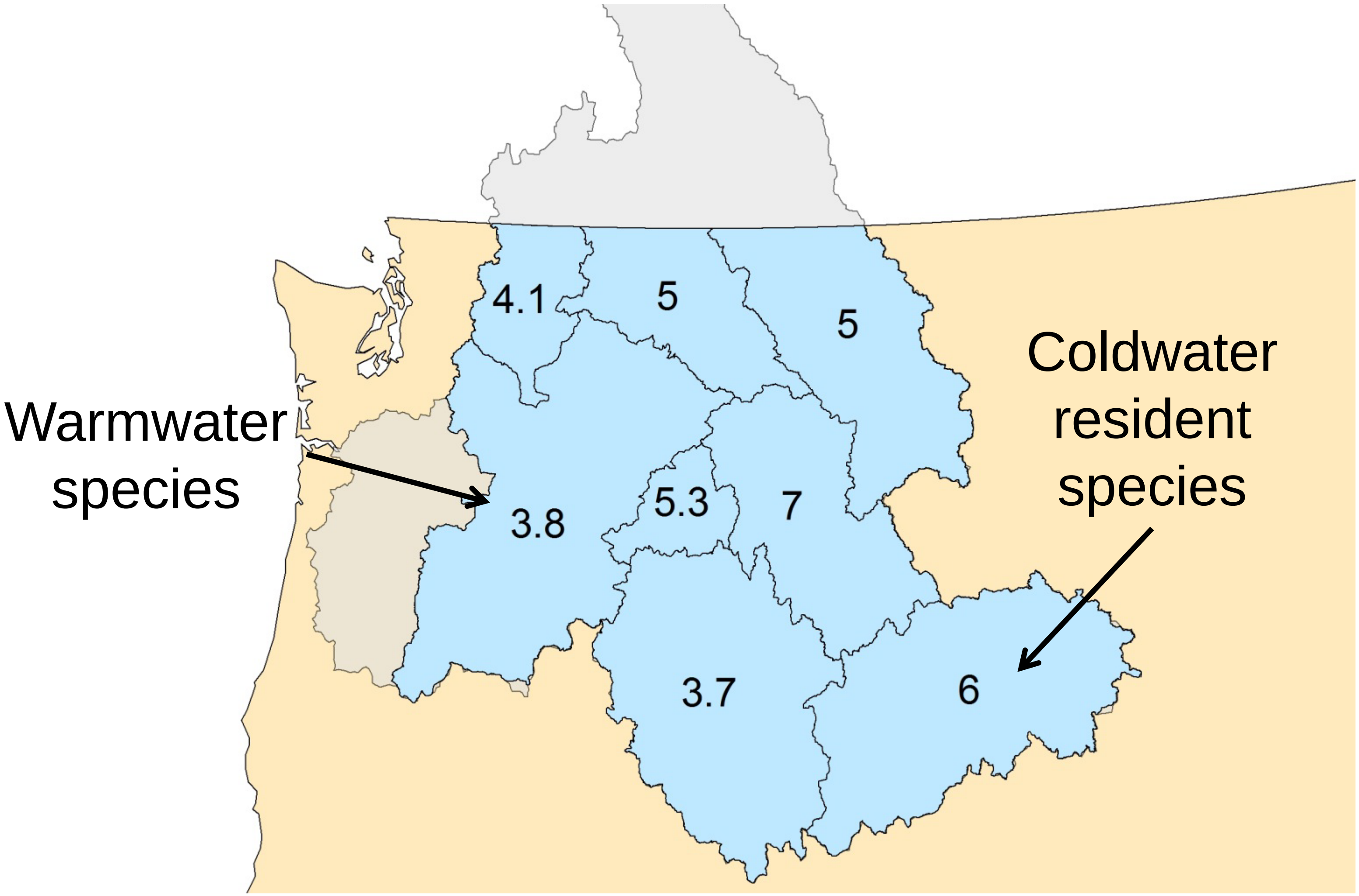
Knouft and Ficklin (2017) Ann Rev Ecol Evol Syst

Water temperature in the Columbia River Watershed



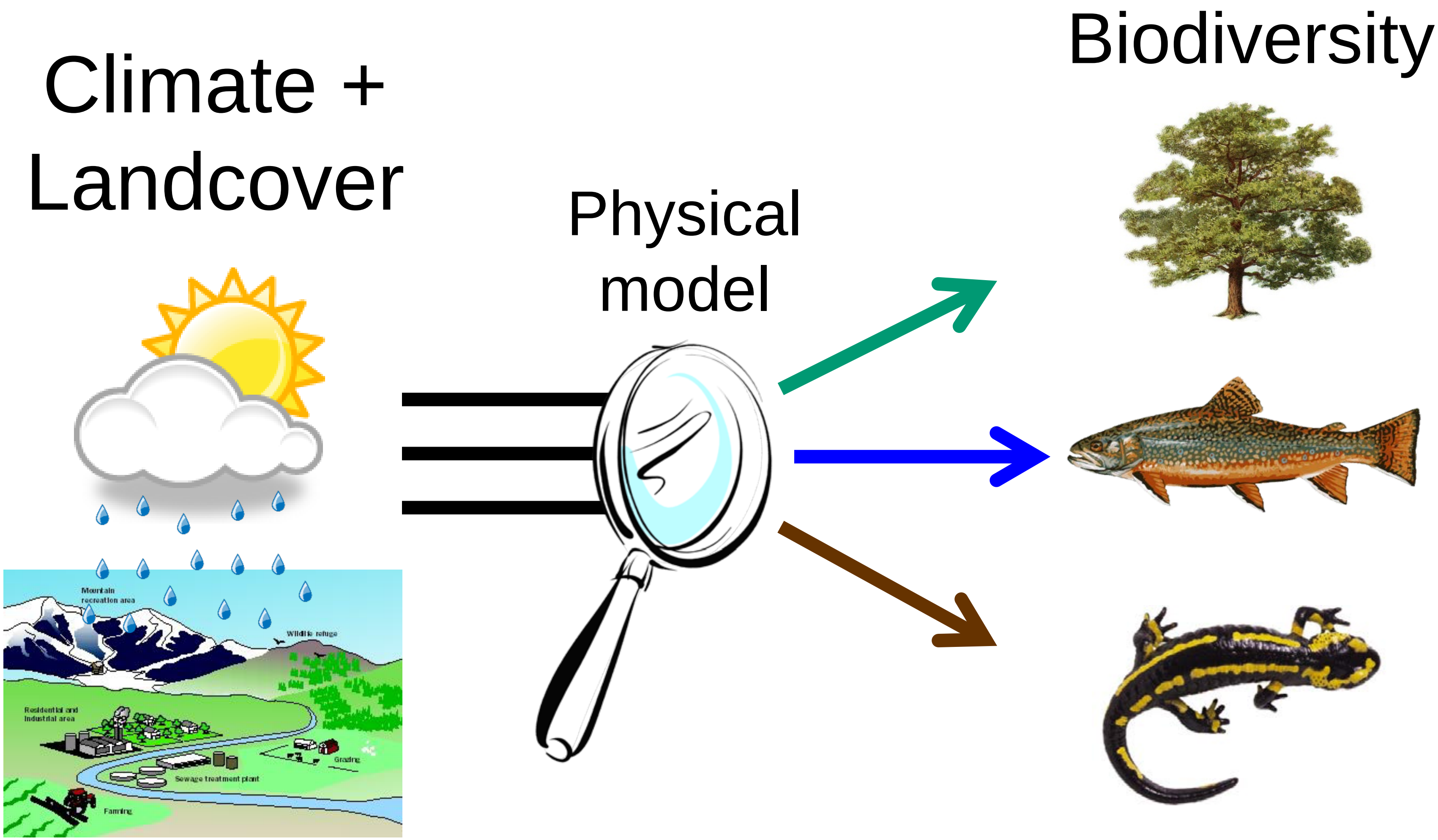
Ficklin et al. (2014) Hydrol Earth Syst Sci

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

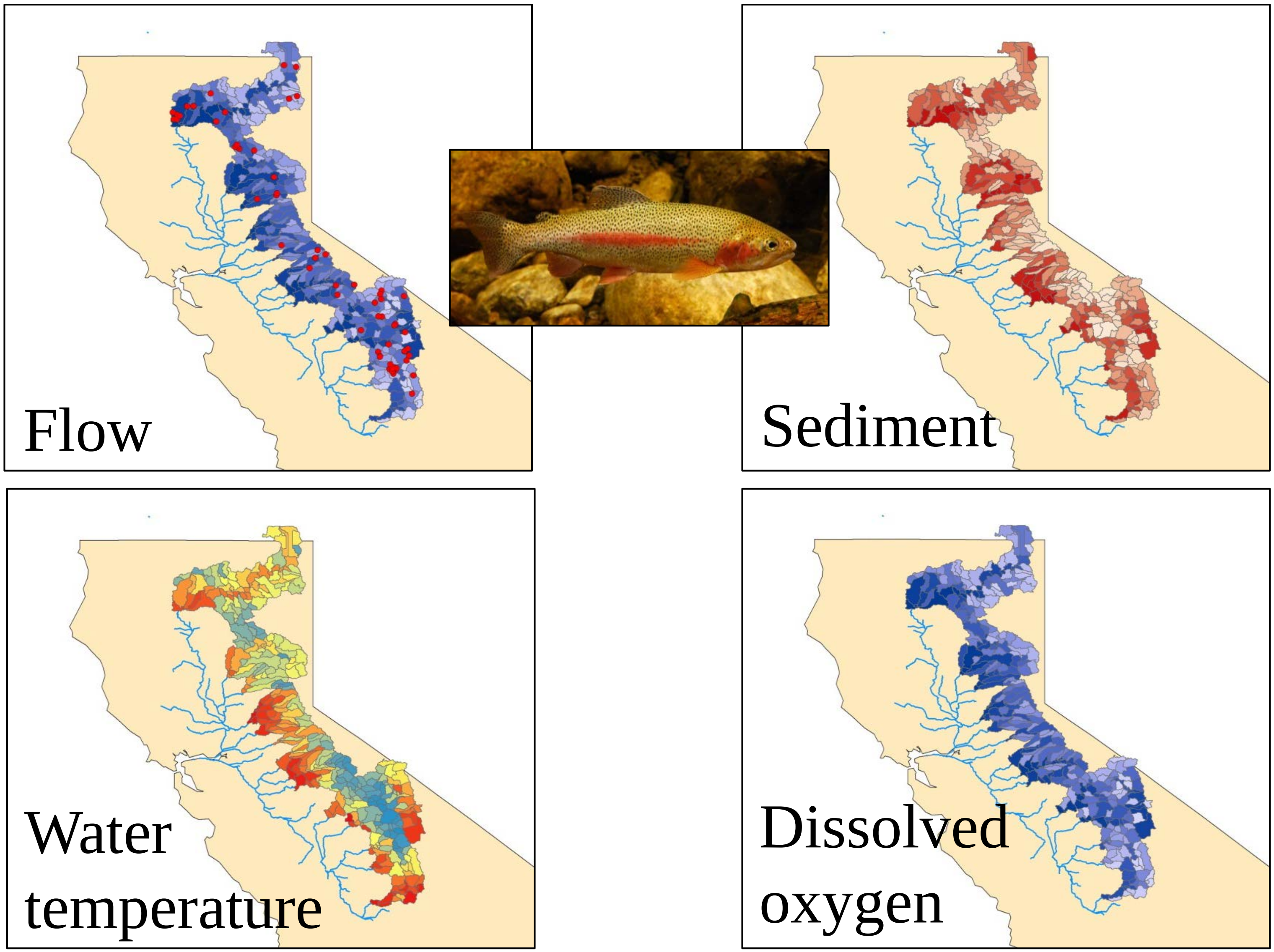


Integrating species locality data

- Species distribution modeling
- Species richness
- Local abundance

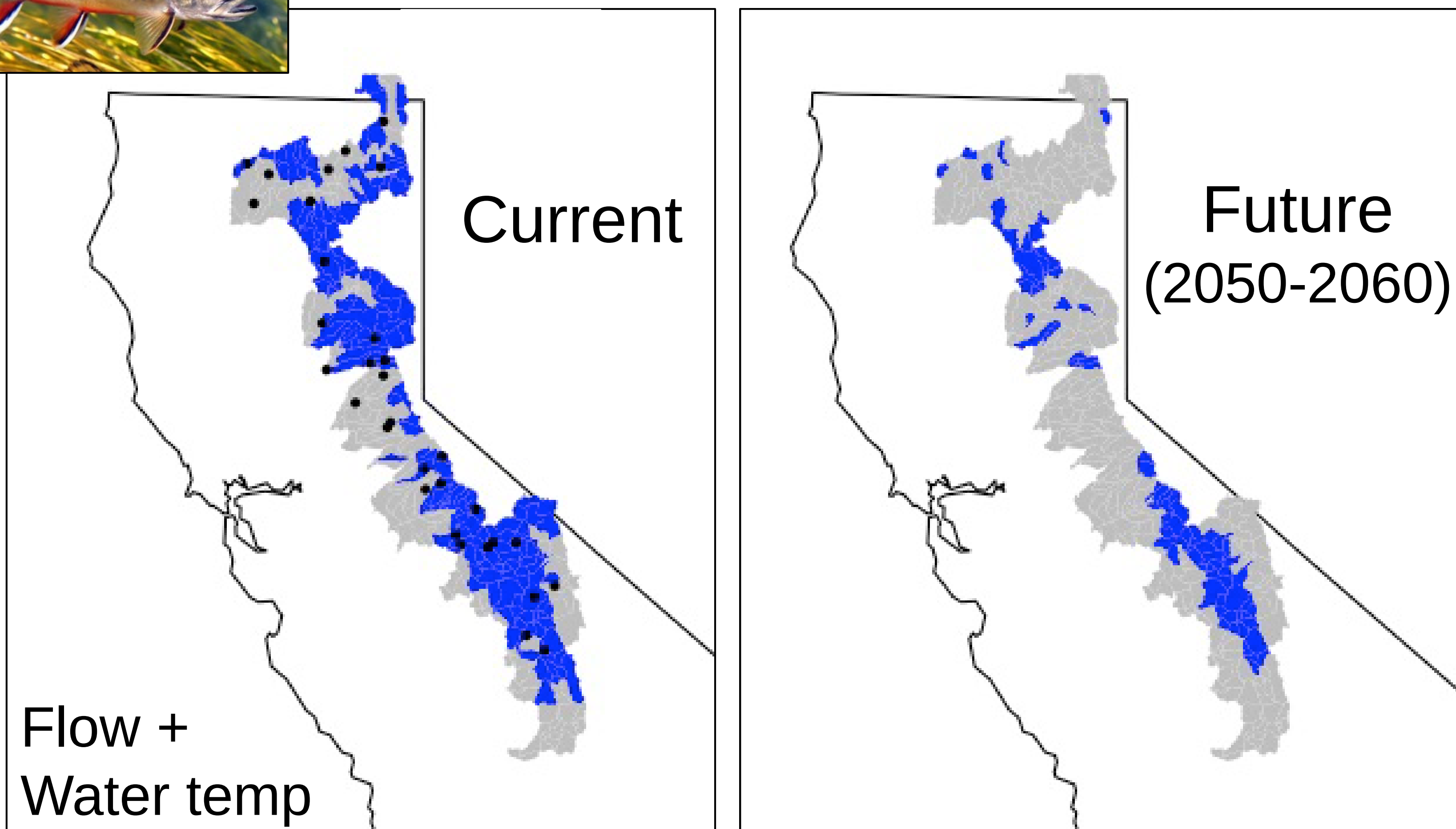
- Estimates of in-stream habitat are critical

Fish habitat in the Sierra Nevada region



Ficklin et al. (2012) *JAWRA*

Brook trout distribution in the Sierra Nevada region



Integrating species trait data

- Trait data derived from online images

Lepomis macrochirus
image from iDigBio

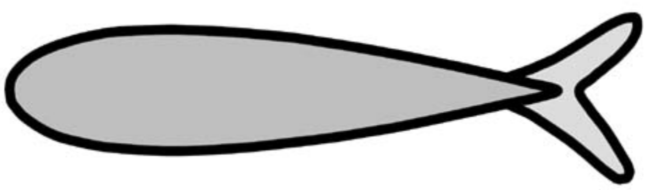
The relationship between flow and species morphology

High Flow

- Shallow/narrow caudal peduncle
- Deep/wide anterior body

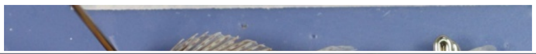
Low Flow

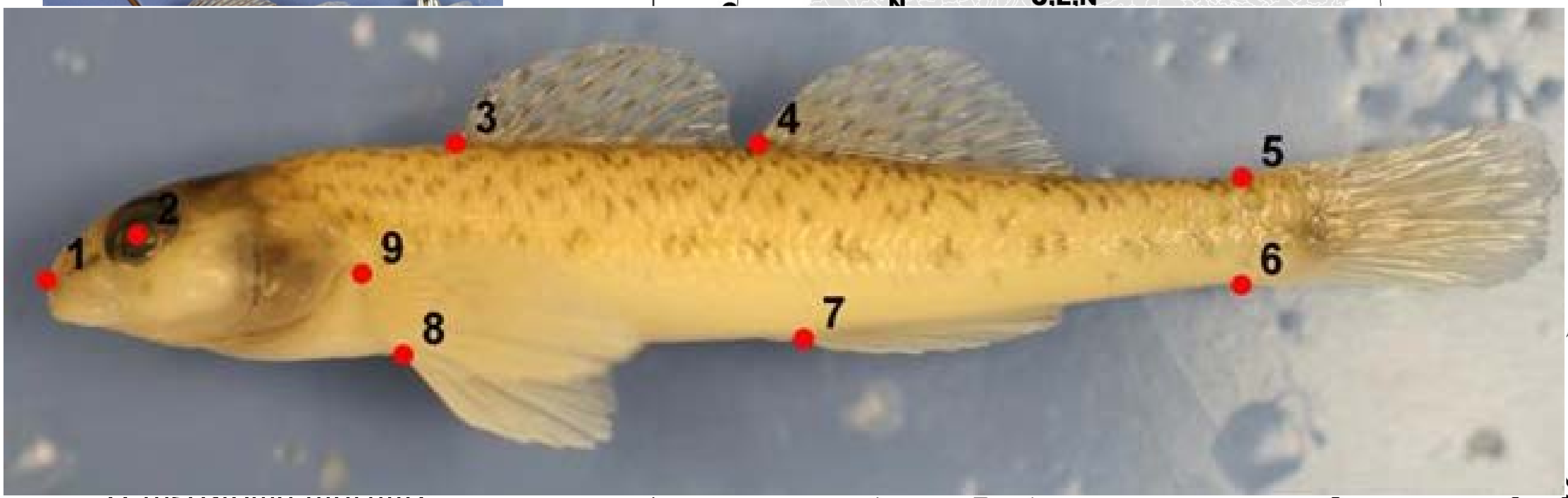
- Large caudal peduncle
- Deep posterior body



Langerhans & Reznick 2009

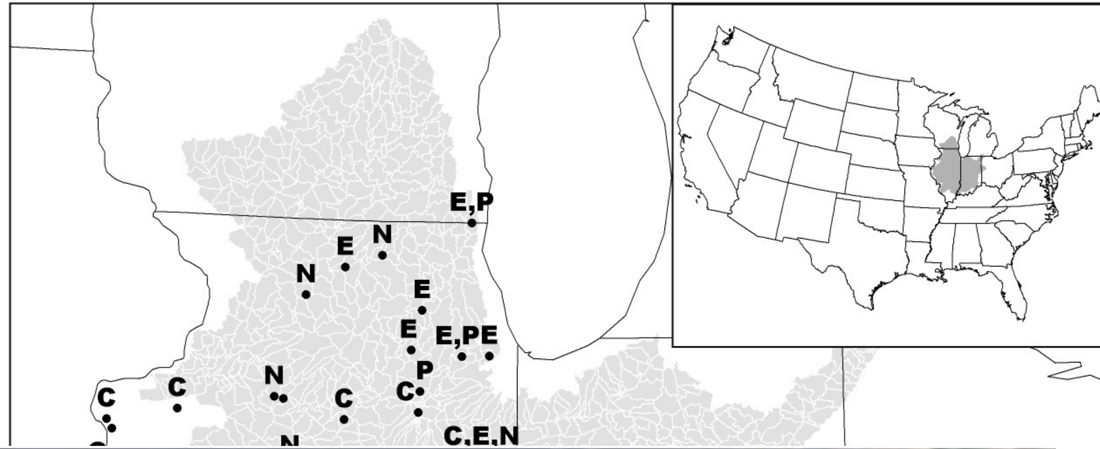
Stonecat
(*Noturus flavus*)





(*Etheostoma nigrum*)

Red shiner
(*Cyprinella lutrensis*)

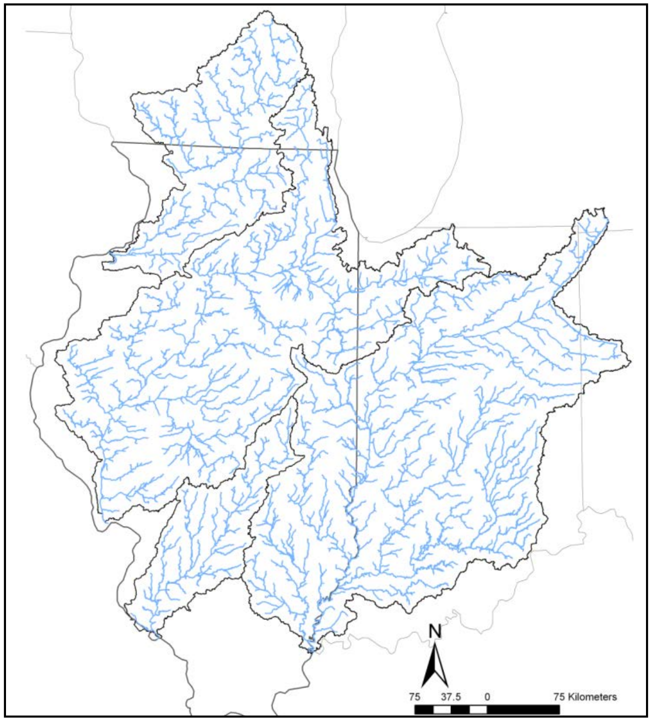


Predicting current and future stream flows

- Future monthly flows predicted based on 26 GCM scenarios using Soil and Water Assessment Tool (SWAT)

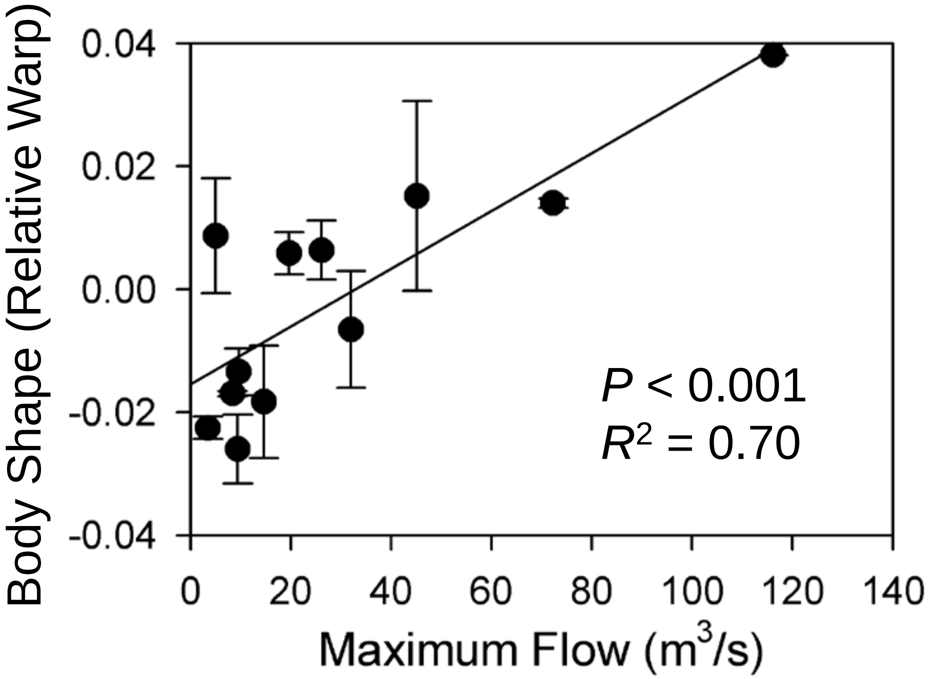
  - nine climate models

  - three emissions scenarios (A2, A1B, B1)



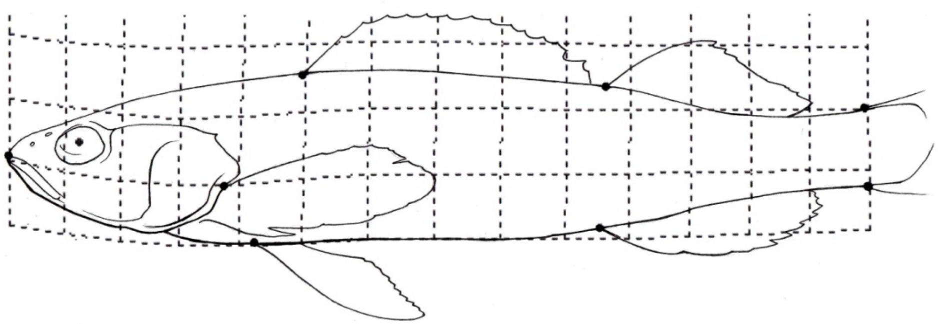
Chien, Yeh, and Knouft (2013) *Journal of Hydrology*

Flow Rate and Fish Morphology

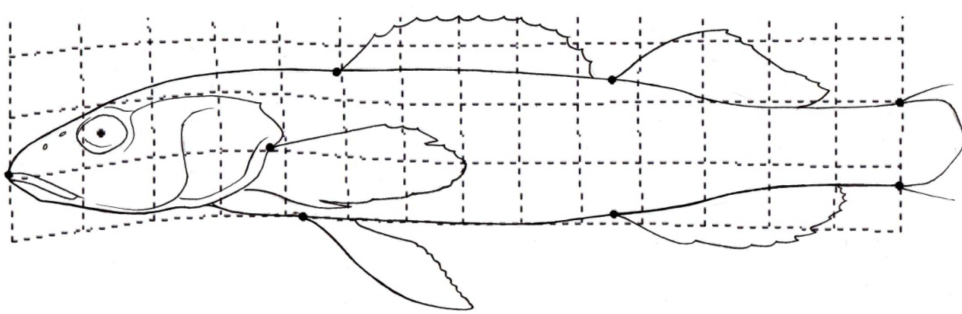


Blackside Darter (*Percina maculata*)

Low-flow



High-flow



Future flow data

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

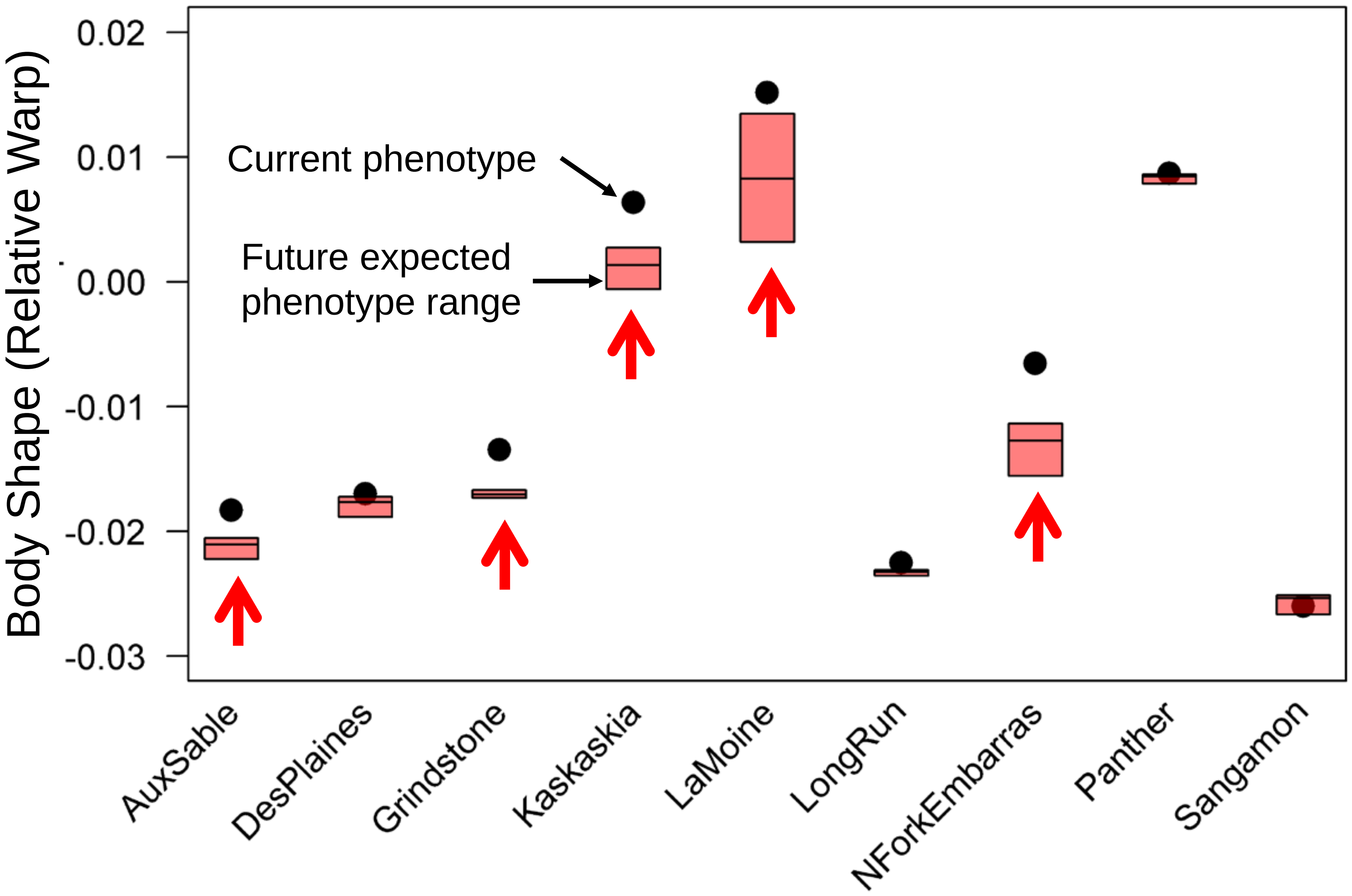
- 26 different flow scenarios

  Highest flow scenario - CGCM3, B1

  Median flow scenario - MIROC3.2, B1

  Lowest flow scenario - GFDL-CM2.0, B1

Future Expected Phenotypes



Michel et al. (2017) Climatic Change

Generating the environmental data

HydroClim

www.hydroclim.org

Jason Knouft – Saint Louis University
Darren Ficklin – Indiana University
Hank Bart – Tulane University

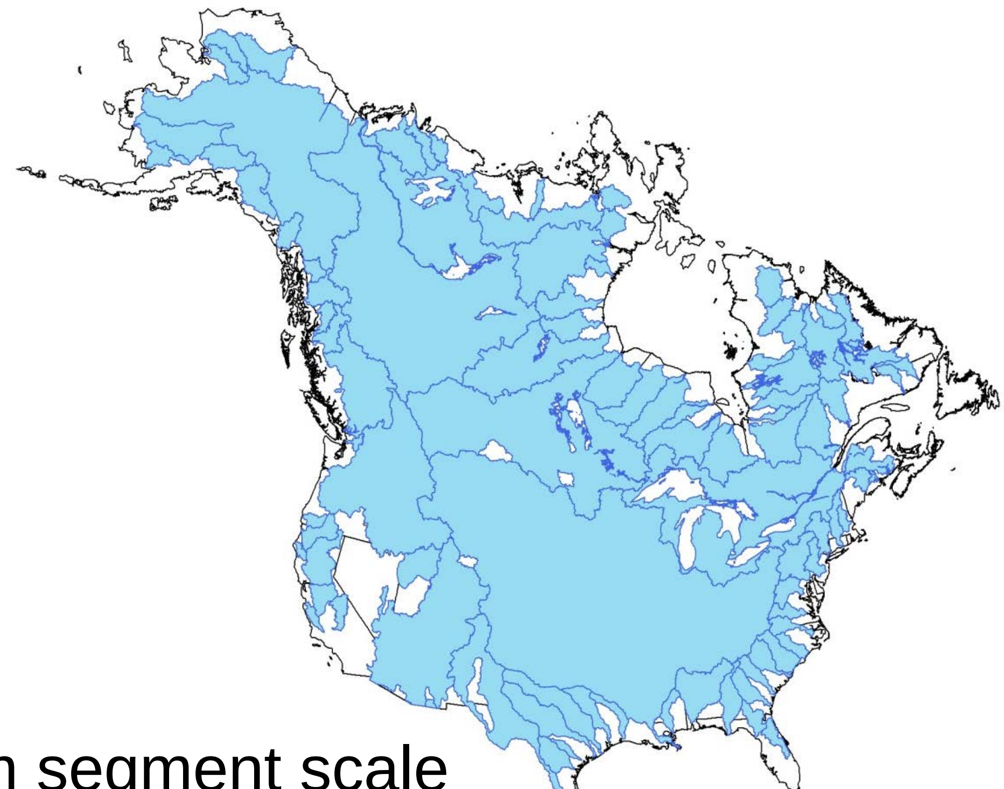
NSF DBI-1564727, 1564806, 1564896

HydroClim

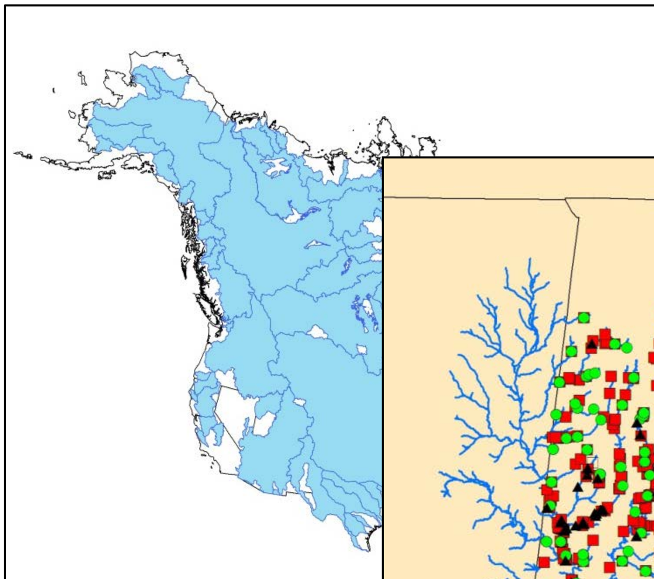
- Monthly discharge and water temperature from 1950 – 2099

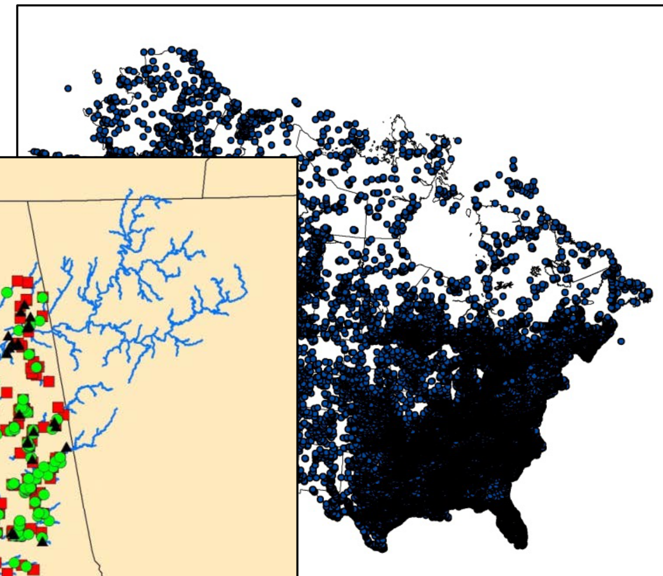
- 78 future GCM scenarios

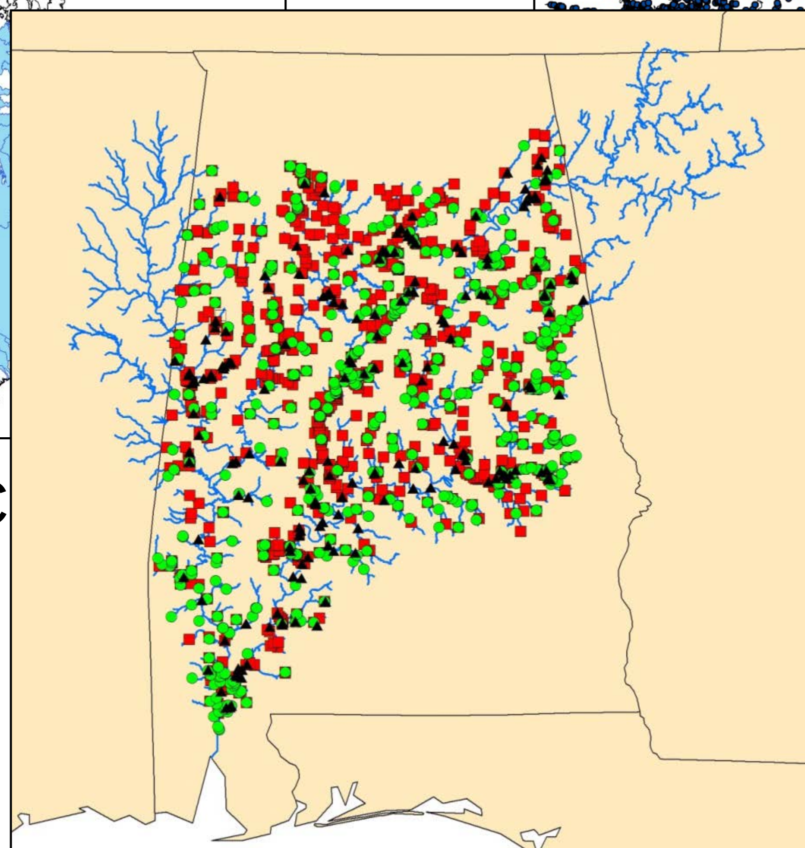
- SWAT hydrologic model



- Data generated at the stream segment scale







HydroC

shNet2

ishnet2.net

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

Acknowledgements

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