Linking fish species through common traits to optimize stream monitoring protocols

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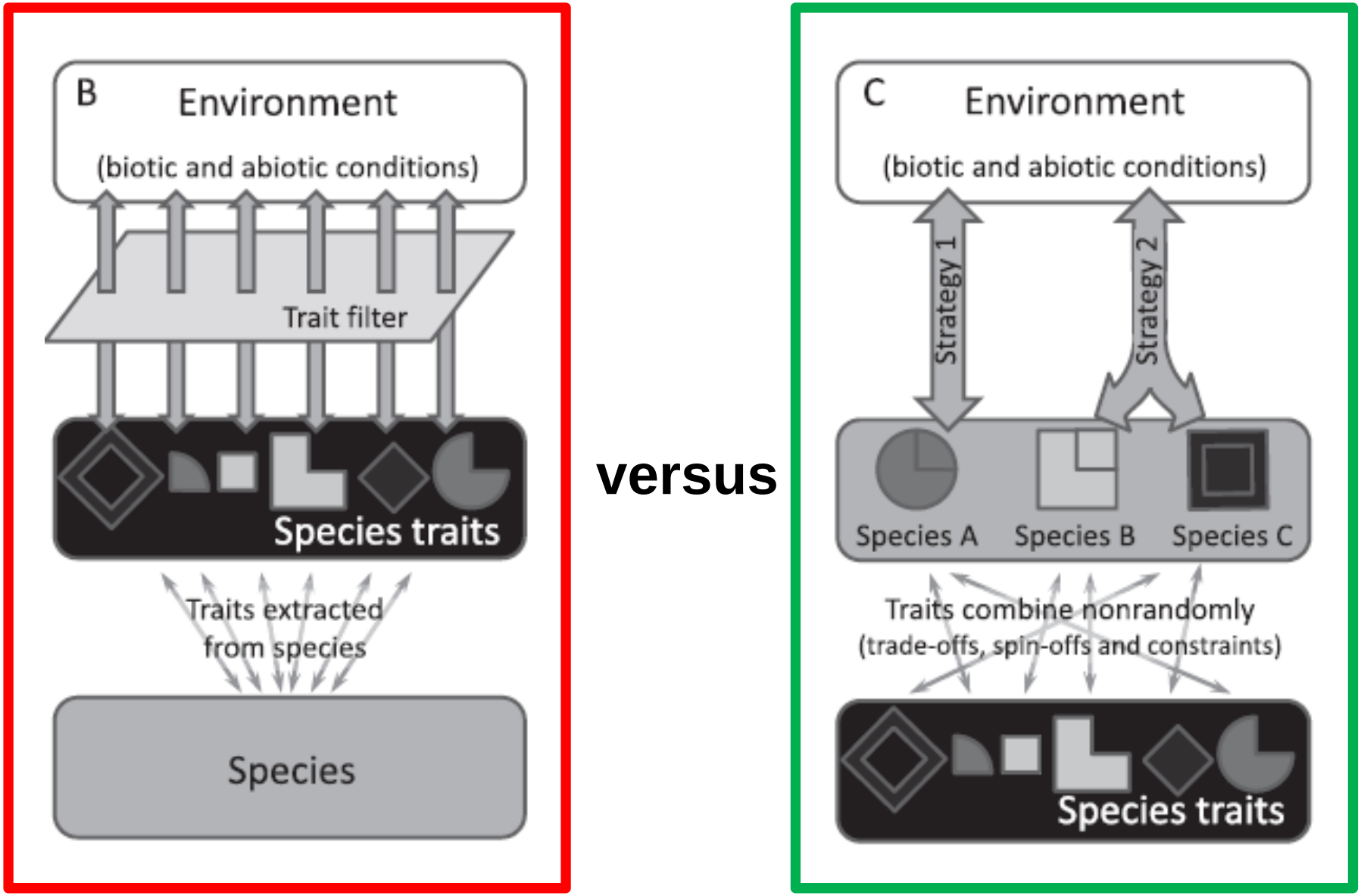
Problem Statement

- **Extinction of freshwater fishes 800 times higher than historical rates (Burkhead 2012)**
- **Biological condition of U.S. streams declining (EPA 2013)**
- **Altered flow regimes threaten stream fishes worldwide (Xenopoulos et al. 2005)**

"Reactive" vs "Predictive" management

1. **What factors are driving declines?**
2. **How will species respond to changes in environmental conditions?**
3. **Unknown population status?**

- **Trait-based approach**
  - **Frimpong and Angermeier 2010; Verberk et al. 2013**
  - **Species evolve *<u>suites of traits</u>* to maximize fitness**



Modified from Verberk et al. 2013; Figure 1

Traits

- Tall
- Long wingspan
- Strong
- Fast
- Can jump high
- Efficient use of 0_2
- Competitive
- Disciplined

Combination of traits

Desert streams

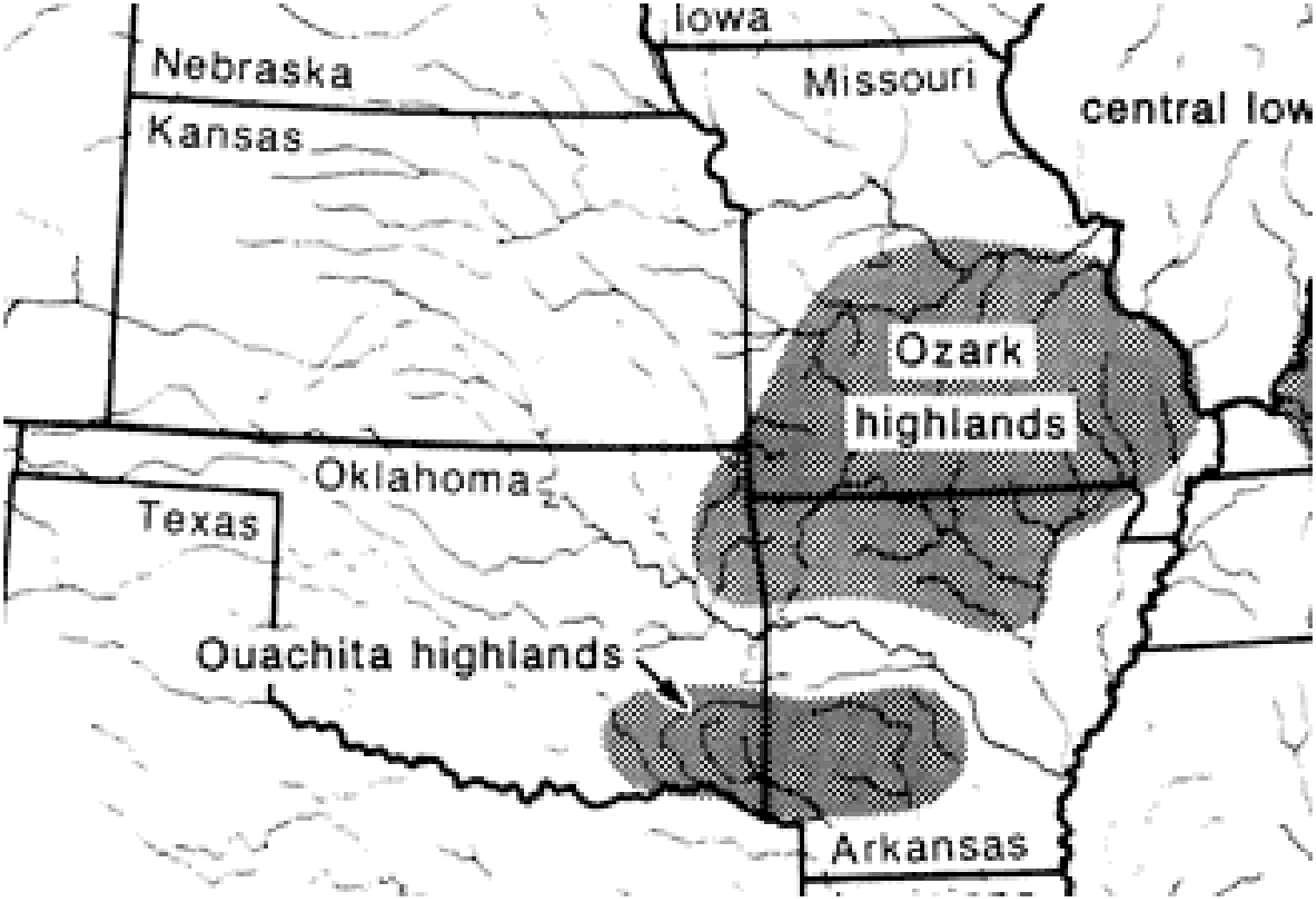
desert pupfish
Cyprinodon macularius

8 cm → Sexually mature at 6 weeks

Tolerate 4°- 45°C Tolerate high salinities

Ozark Highlands

Spring-fed, warmwater streams



Species of conservation concern

?

Photo credit: Brandon Brown

Project objectives

1. **Construct trait groups of Ozark stream fishes based on morphology and behavior**

2. **Develop standardized stream-fish sampling protocols and establish conservation status**

3. **Understand how trait combinations explain the population dynamics of Ozark fishes across a flow-regime gradient**

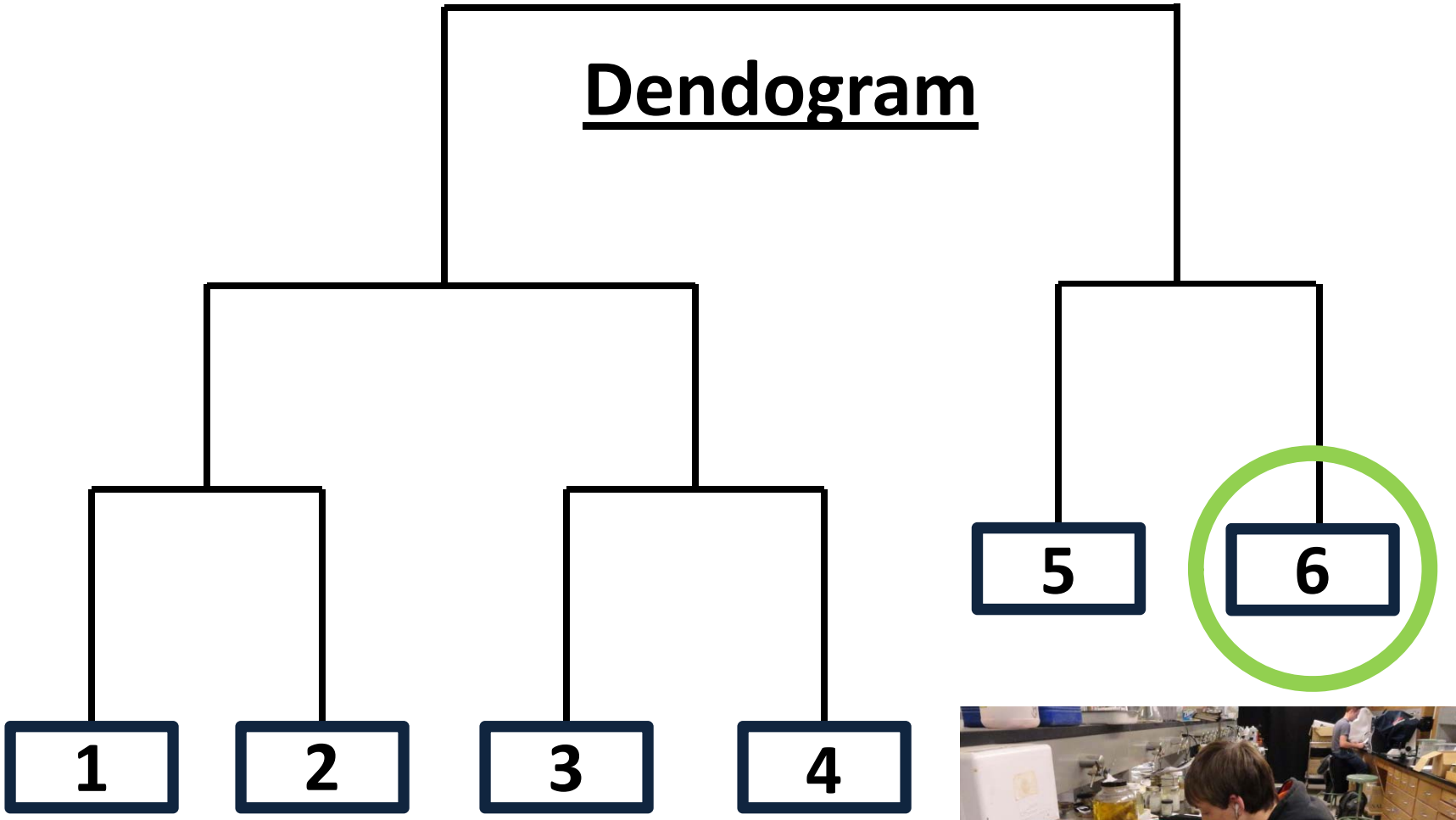
(1) Construct ecomorphological groups

- **Groups that make sense ecologically**
  - **Use morphology to capture behavioral element**

- **Ecomorphological traits (Gatz 1979)**
  - **Head depth and length, body depth and width, trunk length, caudal peduncle depth, width, and length, snout length, fin characteristics**

- **Hierarchical clustering with bootstrapping**
  - **pvclust (R package) - assess group uncertainty**

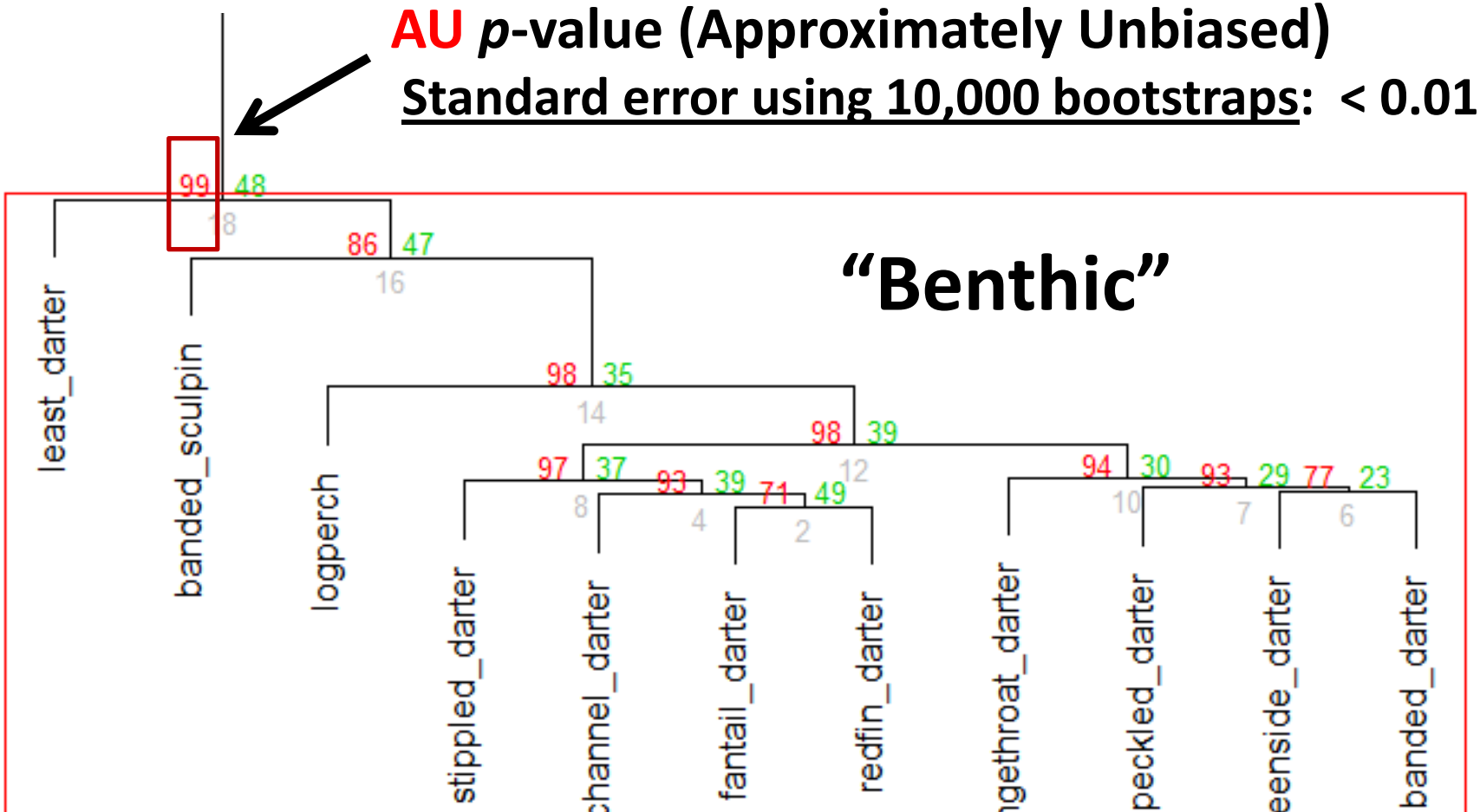
Dendogram



- ~80 species (to date)
- 10-20 individuals per species

AU *p*-value (Approximately Unbiased)

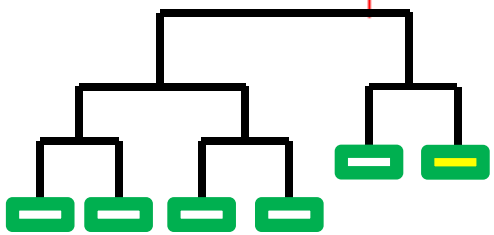
Standard error using 10,000 bootstraps: < 0.01



"Benthic"

Cottus carolinae

Etheostoma spectabile



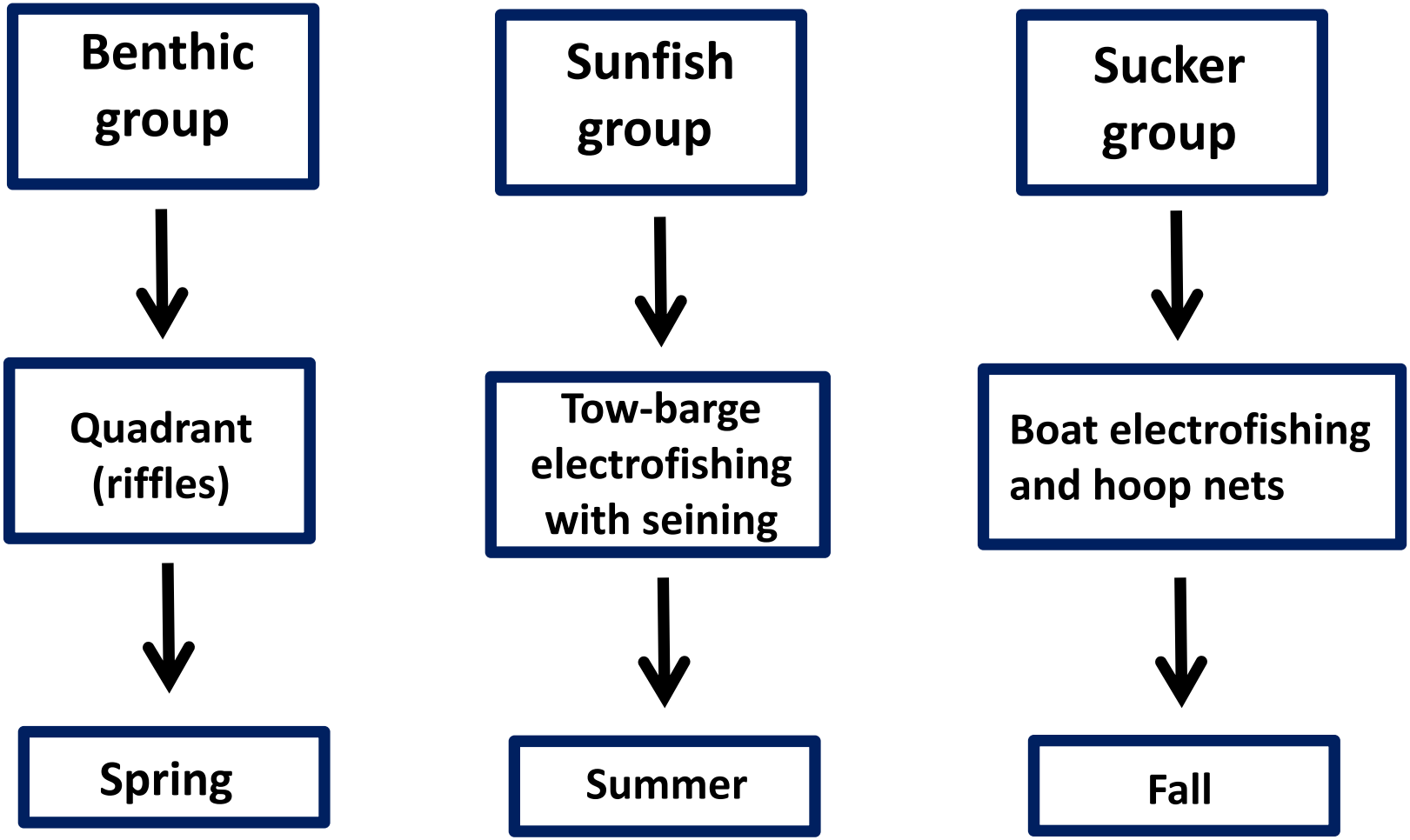
(2) Capture-efficiency model

- **Adjusted vs. unadjusted fish-sampling data (CPUE)**

- **CPUE data unreliable for detecting population trends**
  - **Environmental variation affects capture efficiency**
  - **Change in fish population or change in sampling conditions?**

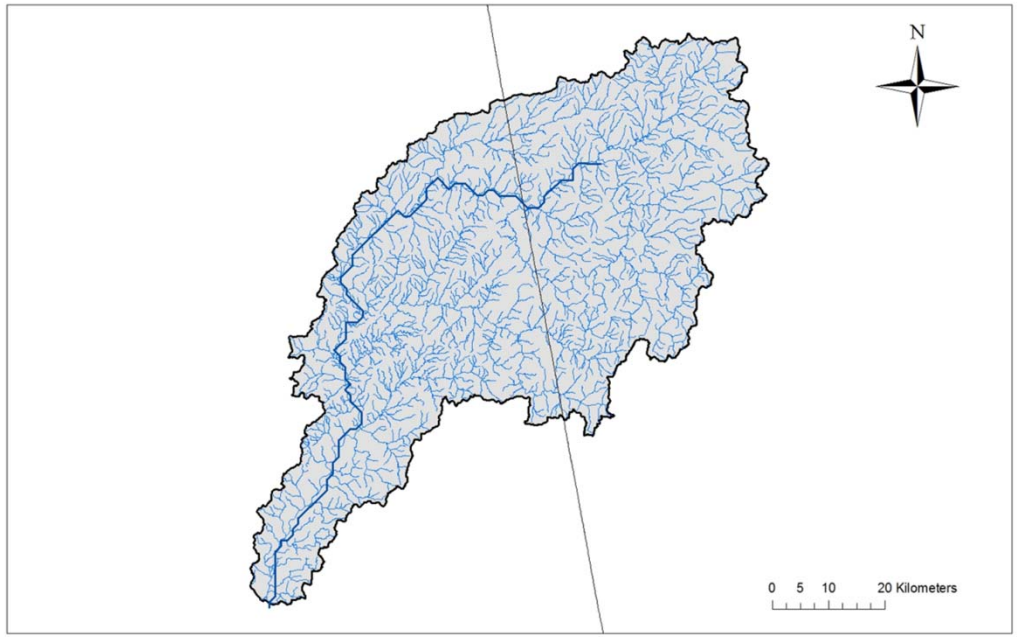
- **Sampling-gear bias different for different fish species**
  - **Unadjusted data may misrepresent assemblage structure**
  - **Example: 20 of species 1 (capture efficiency of 0.2) = 100**
    40 of species 2 (capture efficiency of 0.5) = 80

- **Same morphology/behavior = Same capture efficiency**
  (Peterson and Paukert 2009; Rabeni et al. 2009)



(2) Capture-efficiency model

- **Calibrate sampling gear across range of environmental sampling conditions**
- **The model (equation)**
  - **Capture efficiency = conductivity + discharge + turbidity + ….**

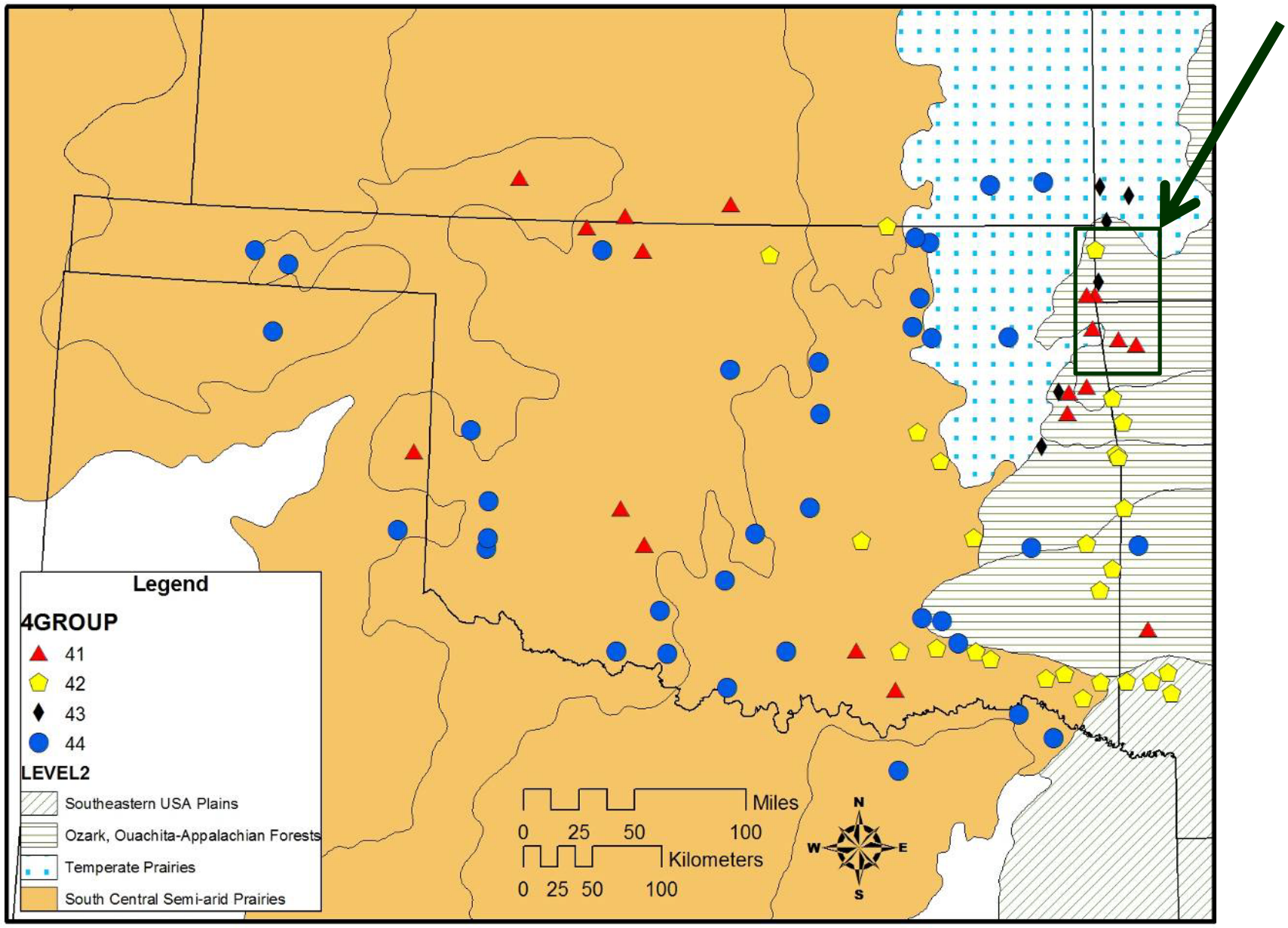


Develop model in Illinois River watershed and test its applicability across the Ozark Highlands

(3) Link trait combinations to flow regime

- **Classification of flow regime**
  1. **Flow regime type (reference conditions)**
  2. **Level of alteration**
     - **Indicators of Hydrologic Alteration (IHA)**
       (Richter et al. 1996, 1997)

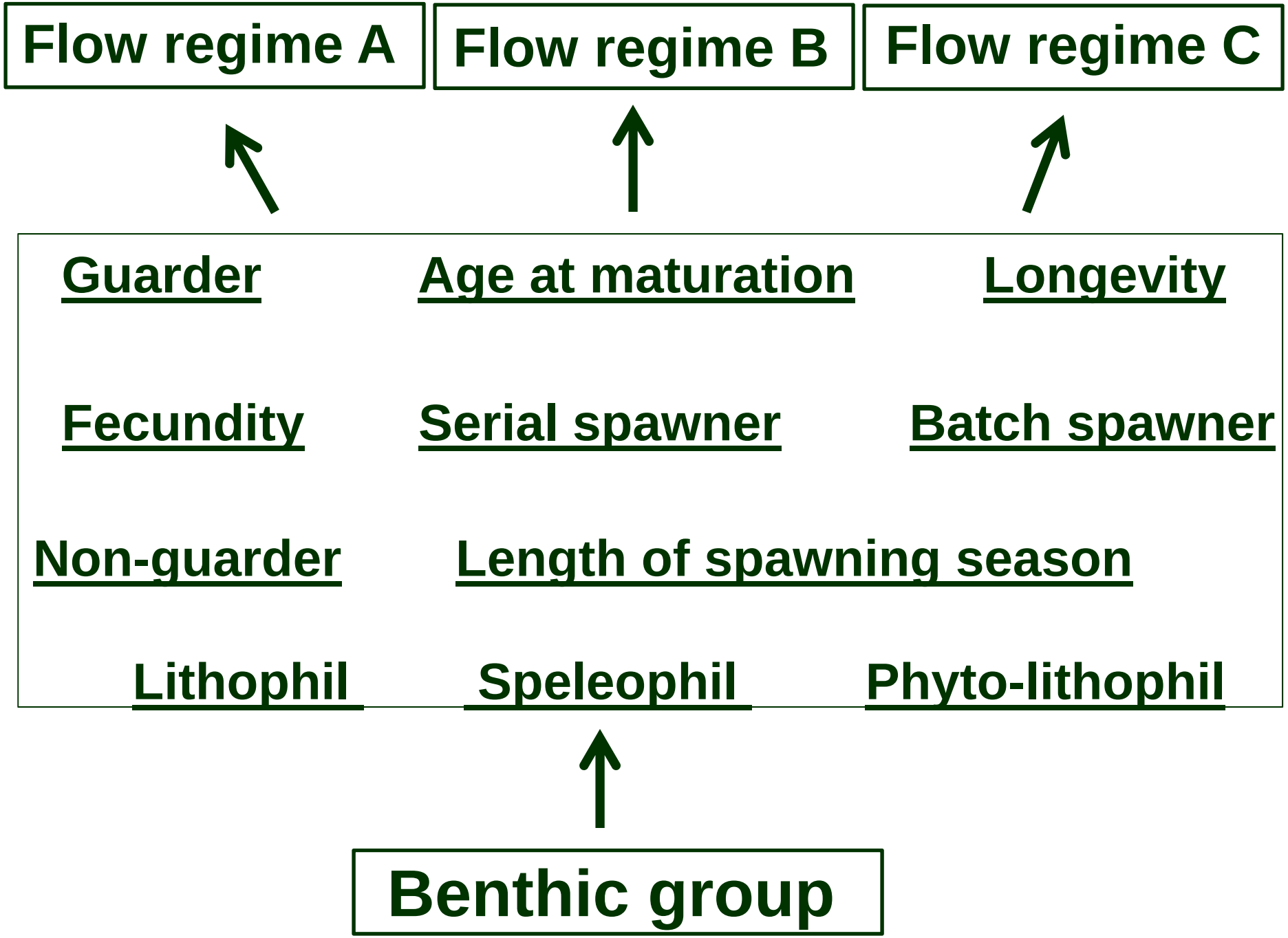
Assessment of Environmental Flows for Oklahoma



(3) Link trait combinations to flow regime

- **Classification of flow regime**
  1. **Flow regime type (reference conditions)**
  2. **Level of alteration**
     - **Indicators of Hydrologic Alteration method (IHA) (Richter et al. 1996, 1997)**

- **Which traits drive adaptations to flow regime?**
  - **e.g., How do reproductive strategies relate to differences in abundance of a similar group of fish species?**


Flow regime A
Flow regime B
Flow regime C
Guarder
Age at maturation
Longevity
Fecundity
Serial spawner
Batch spawner
Non-guarder
Length of spawning season
Lithophil
Speleophil
Phyto-lithophil
Benthic group

(3) Link trait combinations to flow regime

- **Develop predictive models**
  - **Simulate changes in Ozark stream-fish assemblages under climate-change scenarios**
  - **How will climate change alter future flow-regimes?**
- **What stream fishes should we be worried about?**

Summary

- **Trait-based approach useful for improving stream-fish monitoring**
  - **Population status and predictive management**

- **Understand trait combinations**

- **Clustering to develop ecomorphological groups an effective starting point**

- **To be continued…**

Acknowledgements

- **Oklahoma Department of Wildlife Conservation**
  - **Brandon Brown, Jim Burroughs**

- **Techs**
  - **Josh Mouser, Jake Holliday, Brandon Melton, Dakota McNeil, Dawson McNeil, Chris Brown**

- **Dr. Jim Peterson, Dr. Dan Storm, Dr. Mike Palmer**

- **Oklahoma State University**