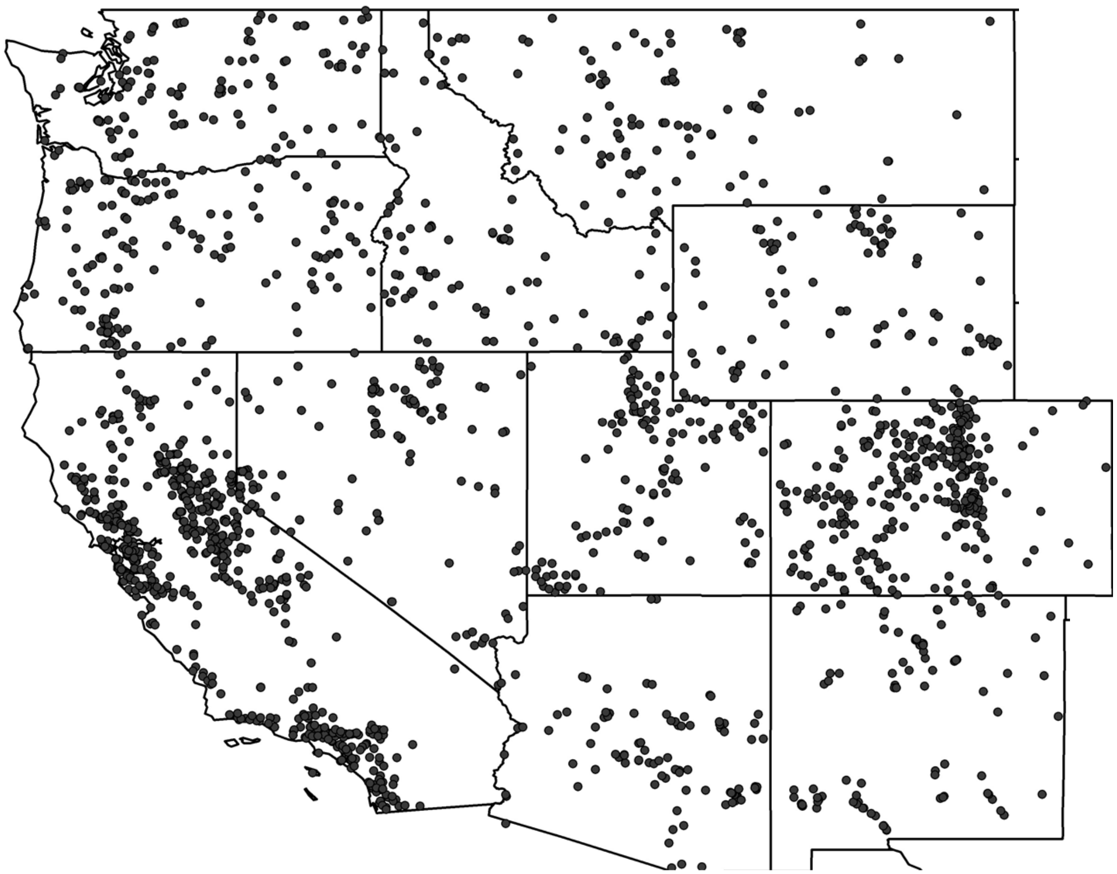
Contemporary and historic comparisons of aquatic macroinvertebrates in the regulated Green River and unregulated Yampa River within Dinosaur National Monument

Scott Miller, Joe Kotynek and Sarah Judson

BLM/USU National Aquatic Monitoring Center, Department of Watershed Sciences, Utah State University

Background

- Management of over 2,000 large dams (> 15 m)
- Altered hydrologic regimes = leading threat to freshwater biodiversity



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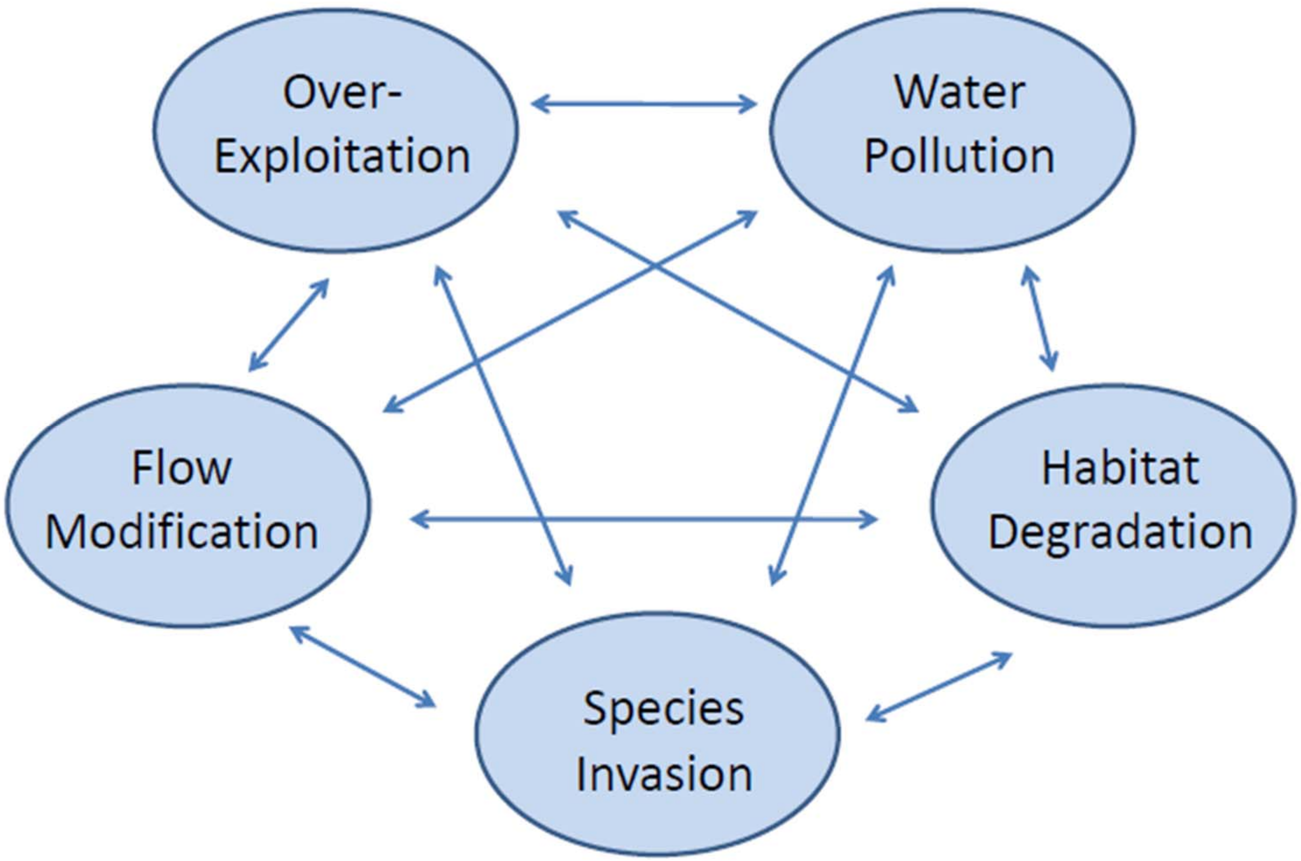
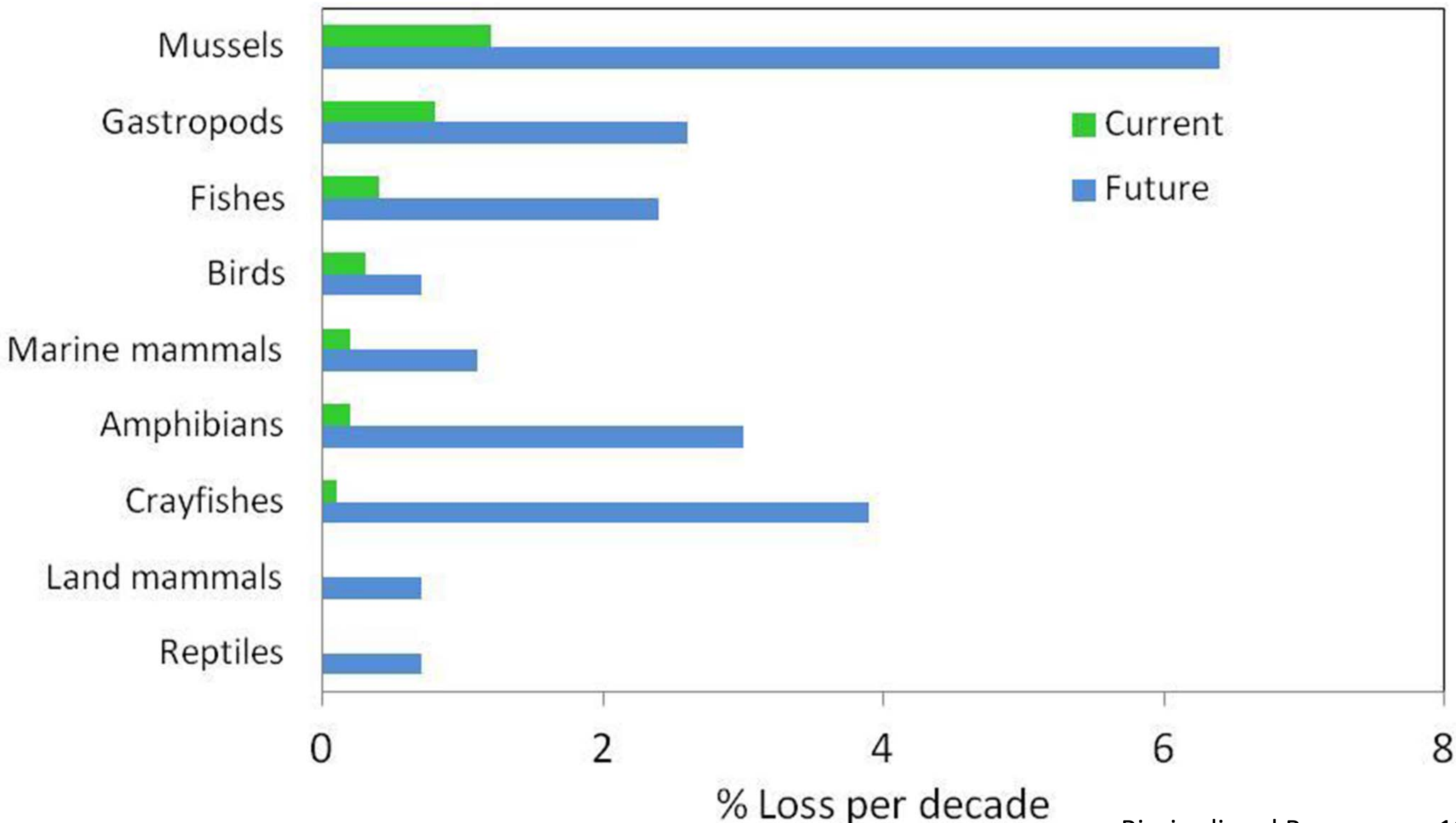


Background

- Unprecedented extinction rates for freshwater organisms

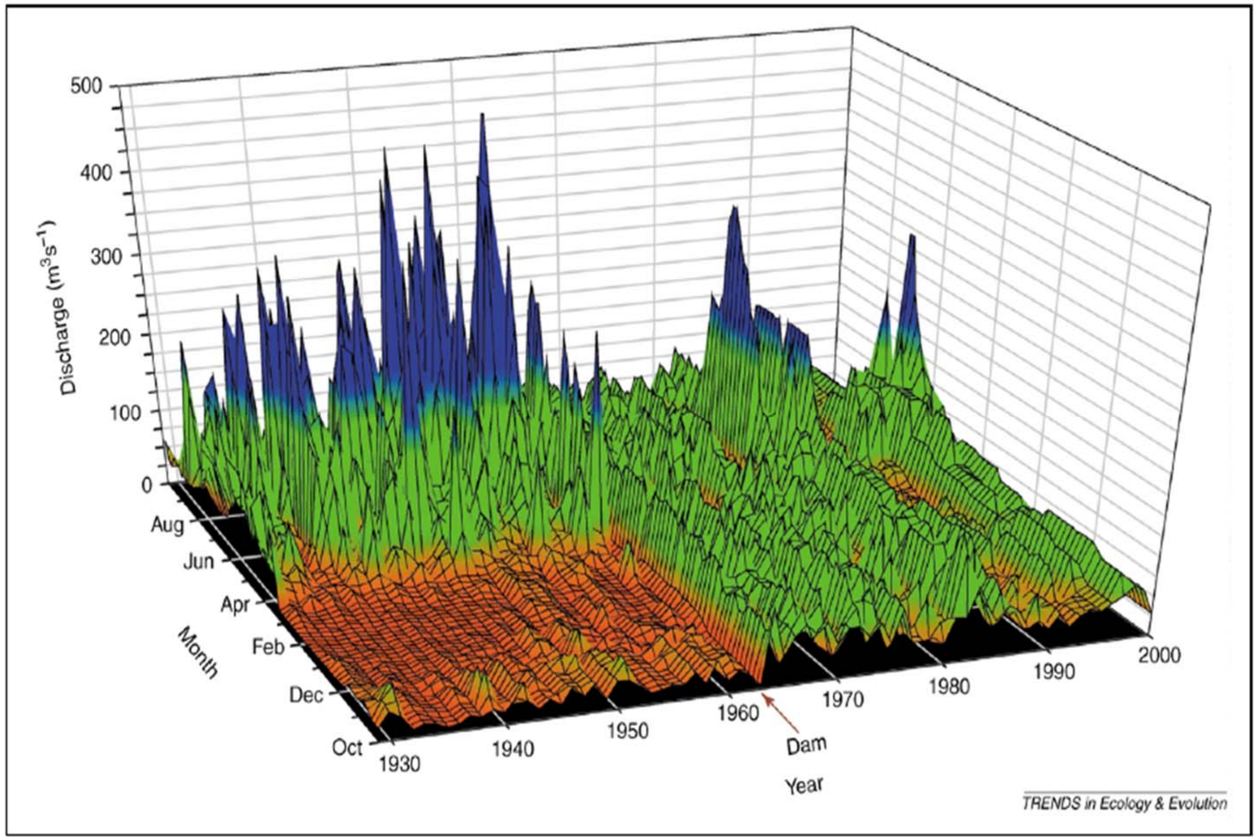


Ricciardi and Rasmussen, 1999

Background

Results – hydrologic alterations

- FGD altered all components of natural flow regime:
  - Magnitude
  - Frequency
  - Duration
  - Timing
  - Predictability



Lytle and Poff, 2004

Background

Dams alter hydrologic regimes

Timing, frequency, magnitude, and duration of high and low flow events

Chemical

- Dissolved solids
- Nutrient cycling
- Dissolved oxygen

Physical

- Sediment regime
- Thermal regime
- Connectivity

Biological

- Community composition
- Life history strategies
- Biotic interactions

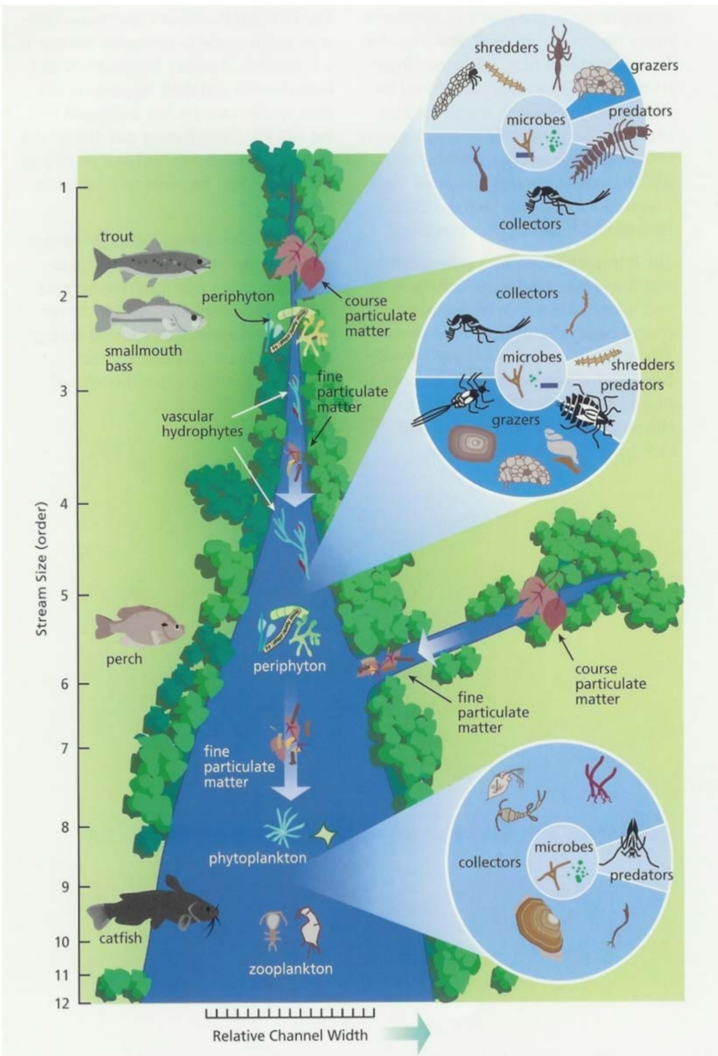
Background

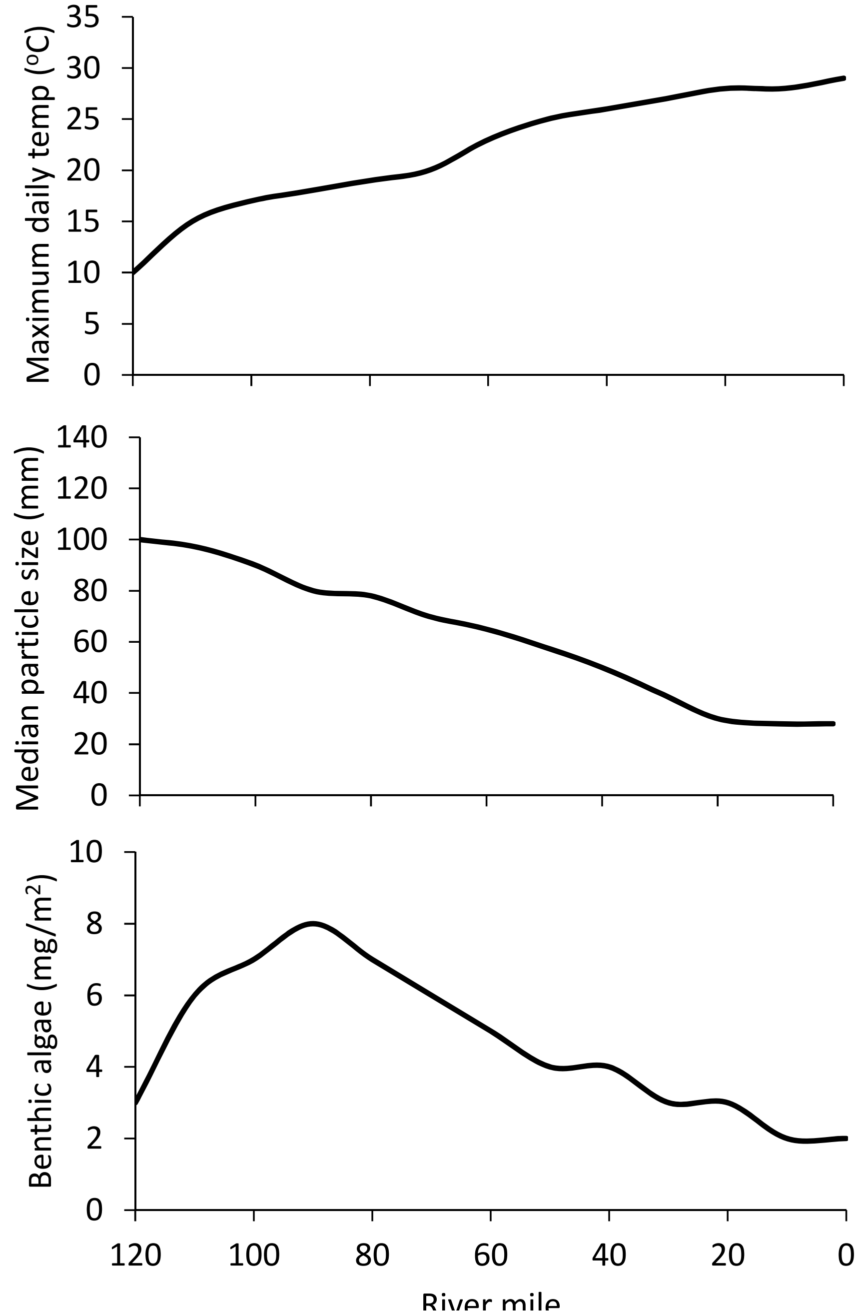
Green River

Yampa River

Background

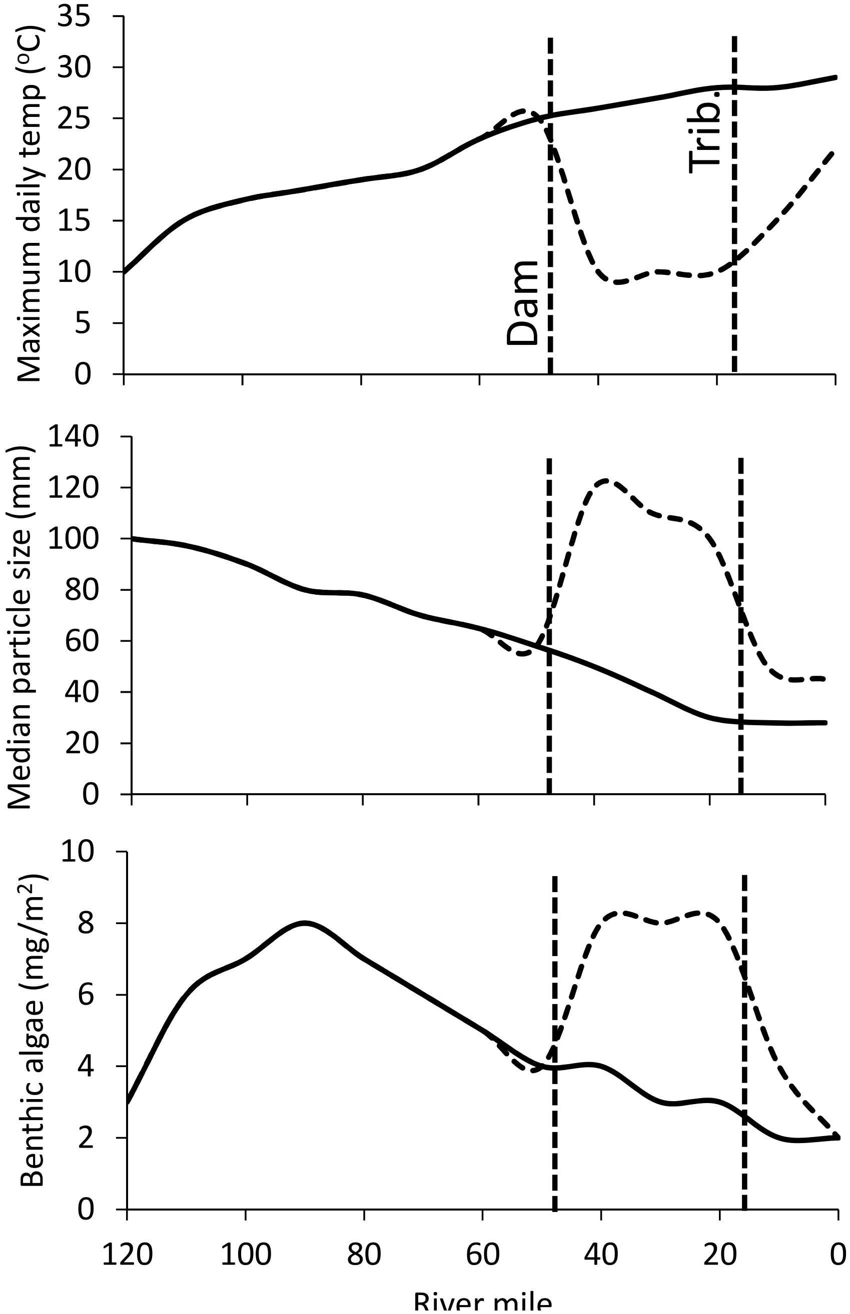
- Dams create discontinuities in the river continua





Background

- Dams create discontinuities in the river continua
- Chemical, physical and biological parameters = predictable response and recovery patterns
- Serial discontinuity concept (SDC)



Background

- Longitudinal response and recovery patterns of water clarity and benthic algae in the Green River below FGD

RKM: 280

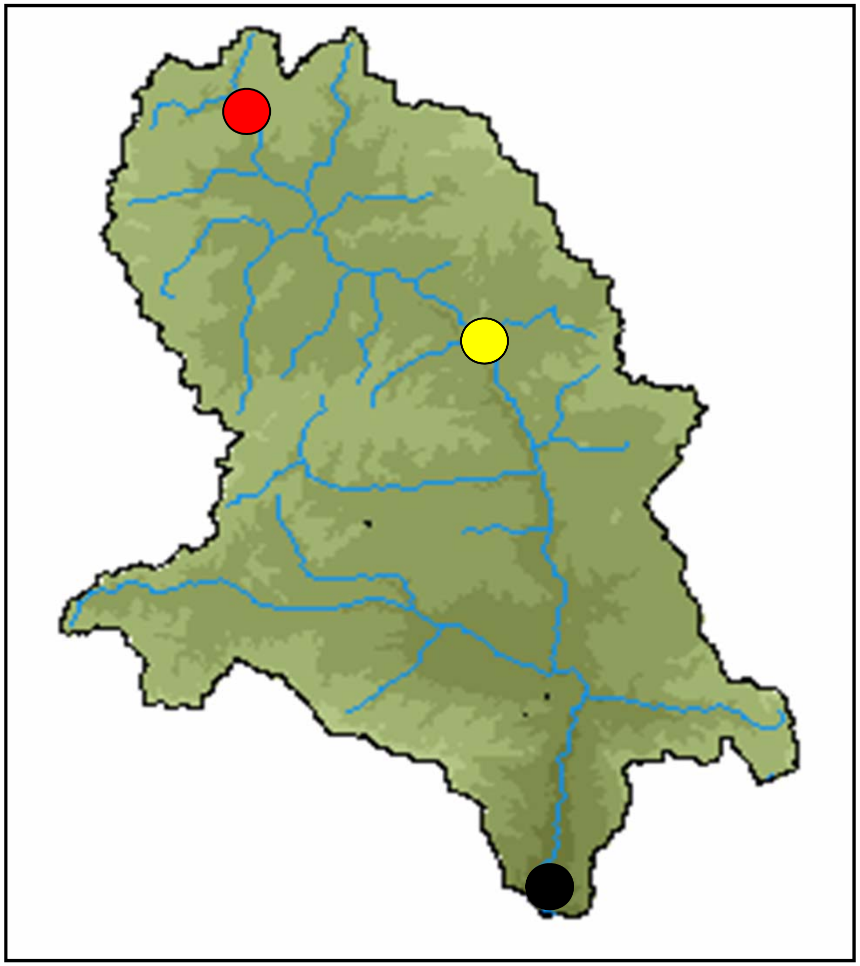
RKM: 278

RKM: 233

RKM: 224

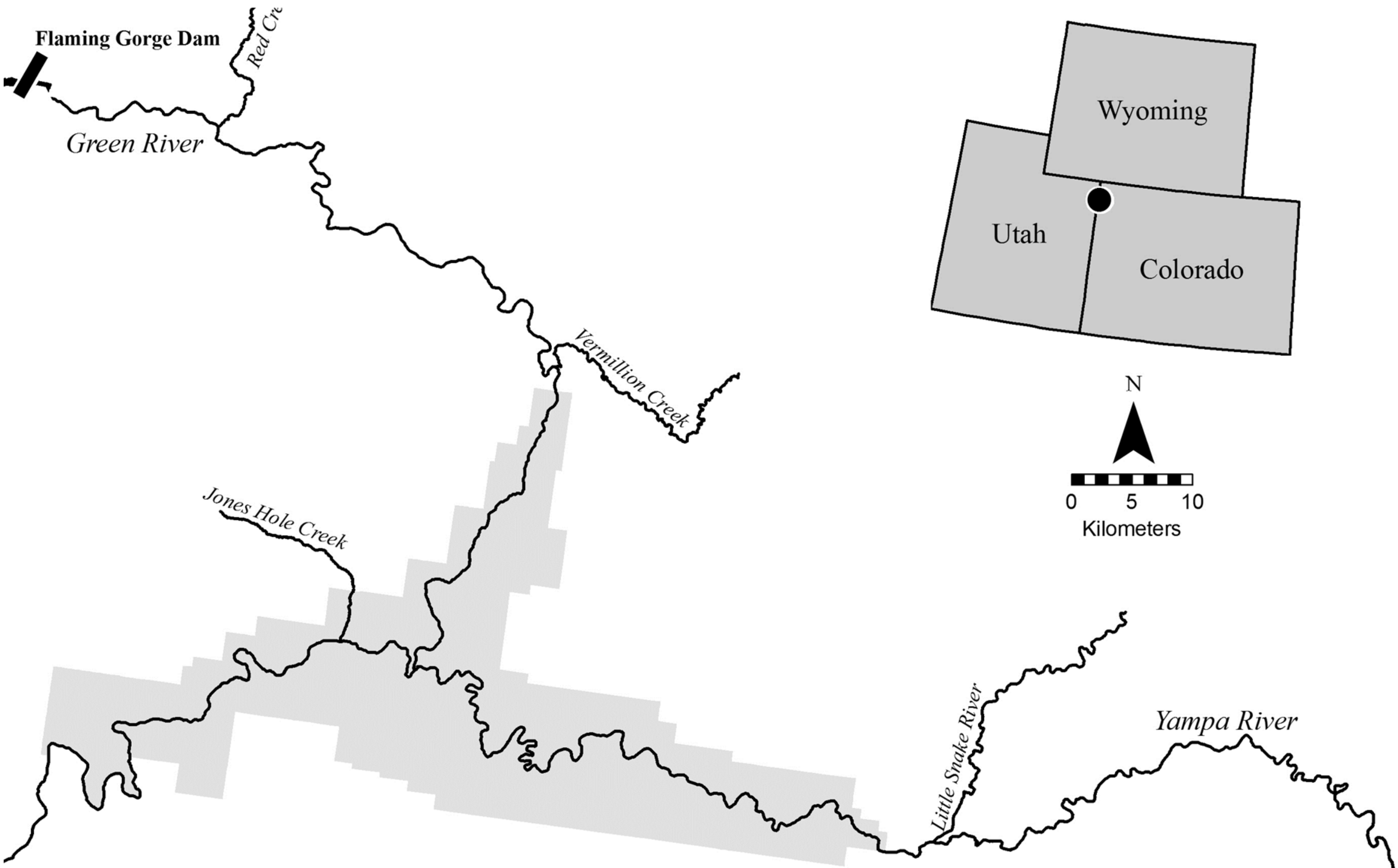
Background

- Rate of recovery depends on:
  - Where in the watershed the dam exists
  - Dam size: ratio of reservoir storage capacity to mean annual Q
- Tests of recovery from dams in large, arid-land rivers rare
- Recovery constrained by:
  - Low # of unregulated tribs.
  - Geographic isolation
  - Anthropogenic impacts



Background

- Green and Yampa Rivers in DINONM = unique opportunity



Background

- Vinson (2001): macroinvertebrate *<u>responses</u>* to FGD

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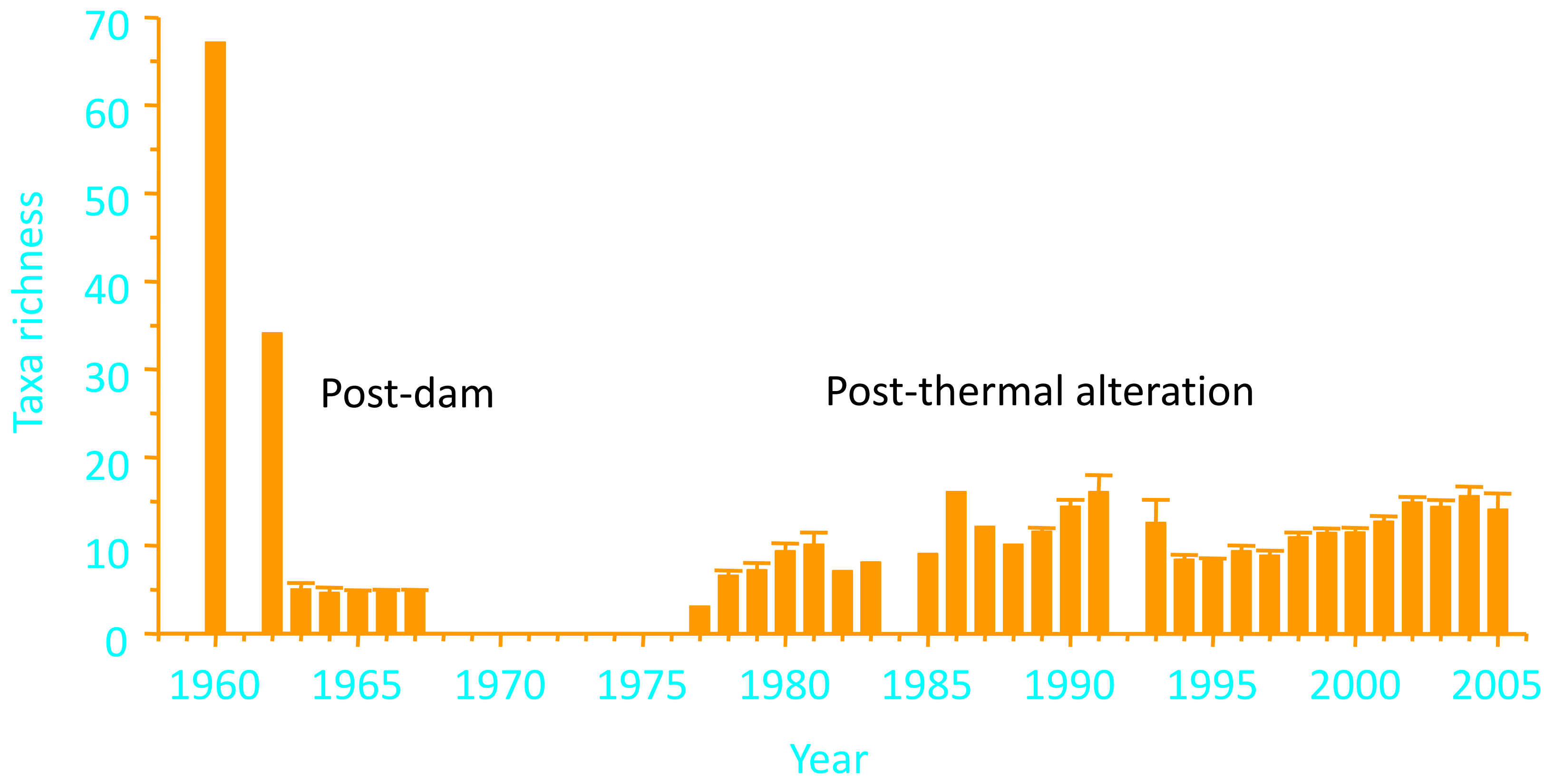
- Vinson (2001): macroinvertebrate ***temporal recovery*** below FGD (25 km)

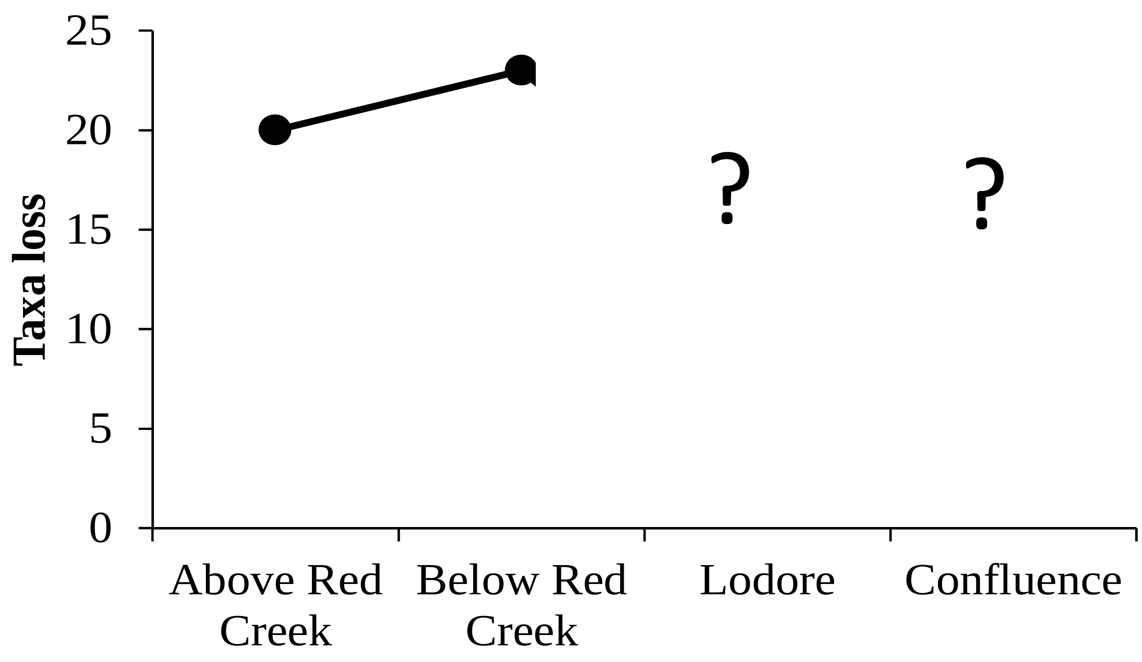
Minimal temporal recovery following thermal alterations to dam releases



Background

- Vinson (2001): macroinvertebrate *spatial recovery* below FGD (25 km)

Despite minor recovery, downstream species loss remains very high



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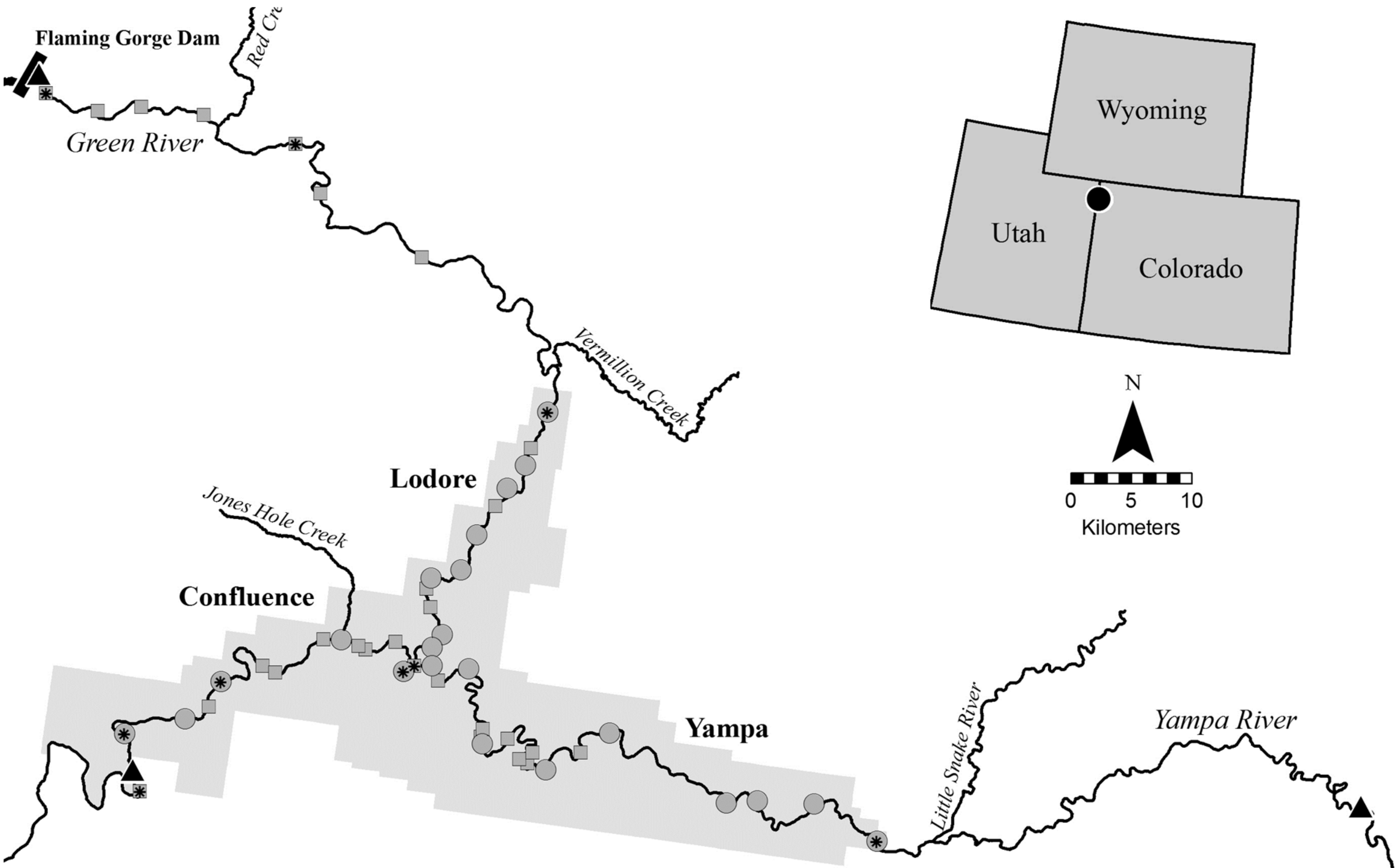

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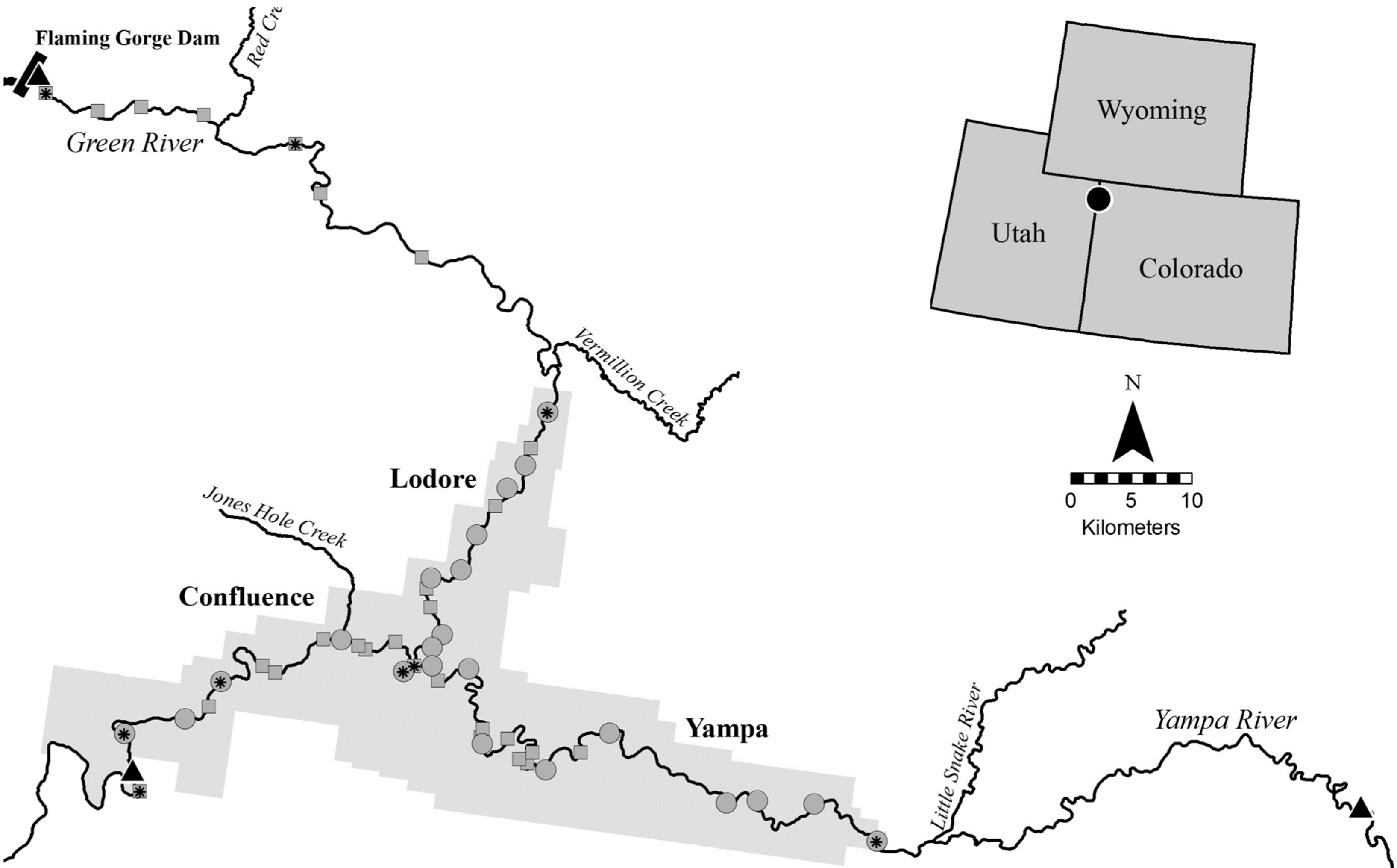


Research questions

1. How does BMI composition of the regulated Green River compare to that of the *unregulated* Yampa River?

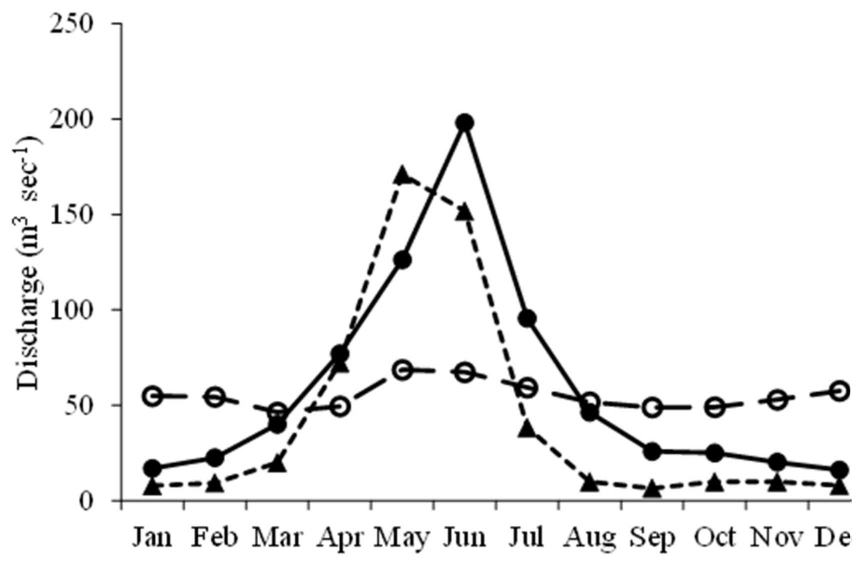
   - What remediating effects does the Yampa have on the Green River?

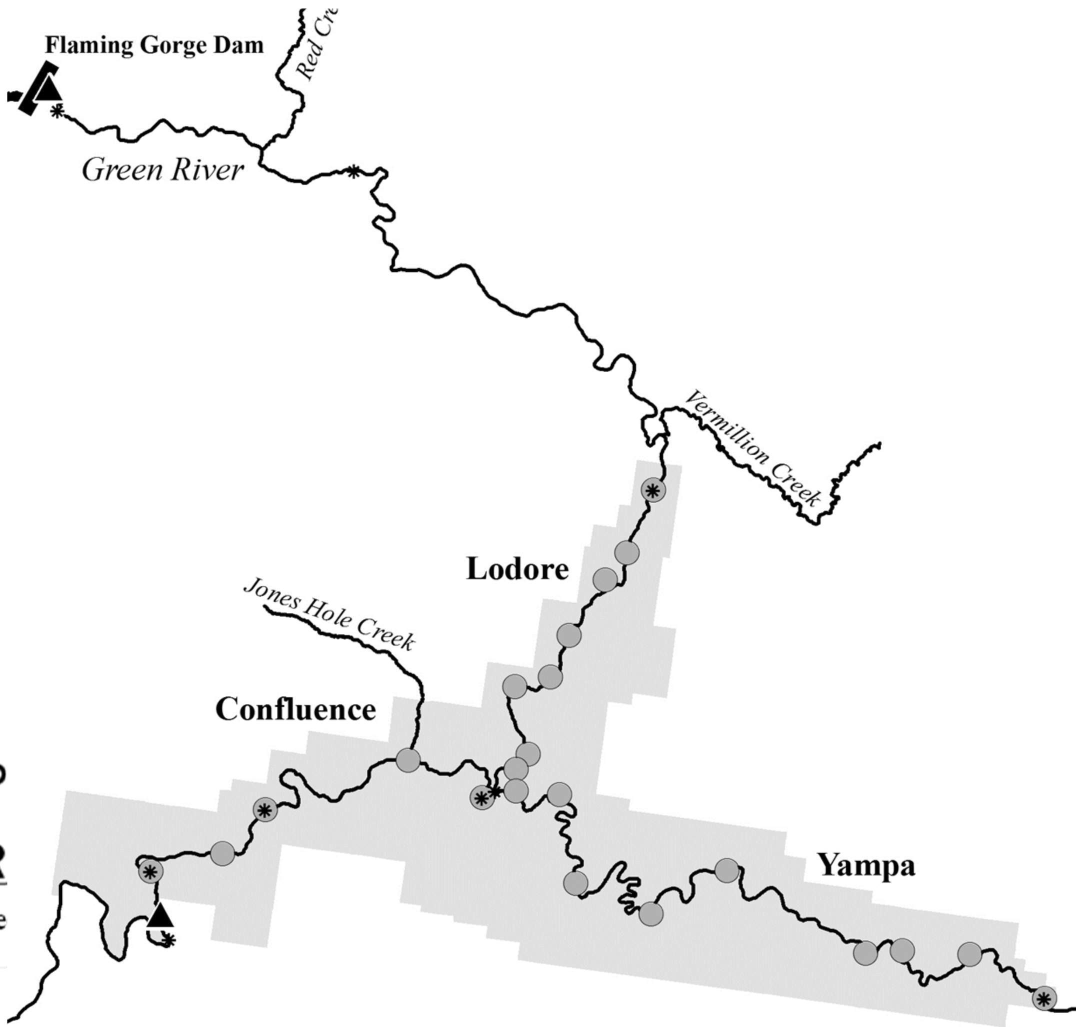
2. How do contemporary BMI assemblages of the Green and Yampa Rivers compare to the historical, regional species pool?

3. What is the current distribution of aquatic invasive invertebrates within DINONM and how are populations changing through time?

Methods - study design

- Stratified Green and Yampa Rivers into 3 segments:
  - Lodore (7)
  - Yampa (9)
  - Confluence (5)





Methods – field sampling

- Macroinvertebrate sampling:
  - Quantitative sampling
    - 8 Surber samplers collected from riffles
    - Standardize estimates of richness, density and and relative abundance
    - August/September 2009 – 2011 at 21 sites
  - Qualitative sampling
    - Sampling of all available microhabitats
    - Develop comprehensive species lists

Methods – field sampling and lab processing

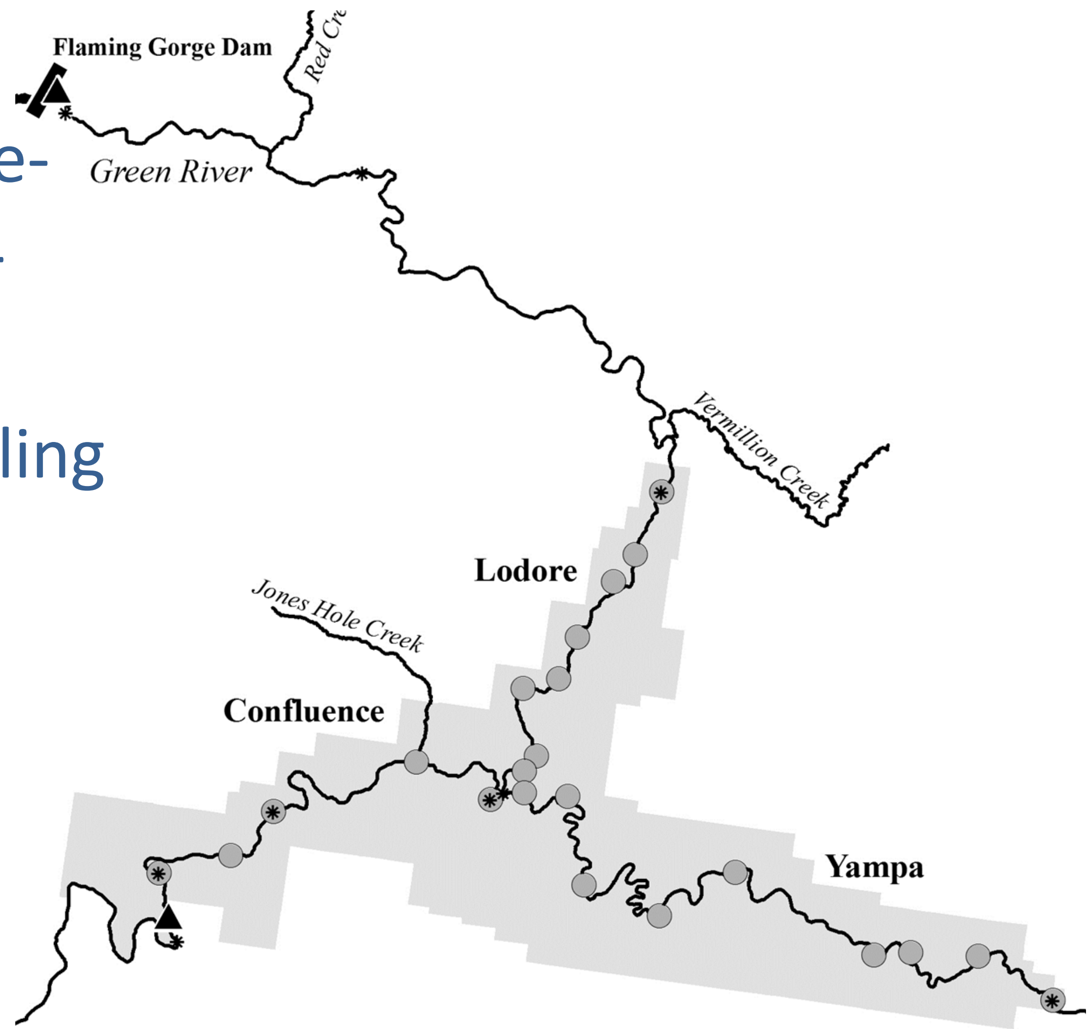
- Macroinvertebrate sampling:
  - Qualitative sampling Cont.
    - Decapoda targeted
    - Baited minnow traps for 12 hours @ 2 – 4 sites

- Macroinvertebrate sample processing:
  - All organisms identified to genus or species, except:
    - Non-biting midges (Chironomidae)
    - Non-insects

Methods – field sampling

Methods – historical surveys

- Historic macroinvertebrate surveys (quantify pre-dam regional species pool):
  - Utilized extensive pre-dam surveys (1947 – 1960)
    - o Multi-year sampling of 10 sites
    - o Qualitative collections

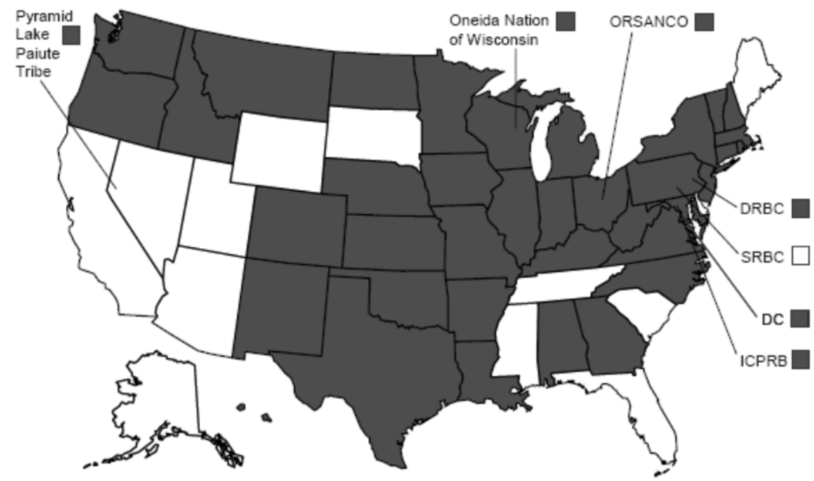


Methods – why macroinvertebrates…?

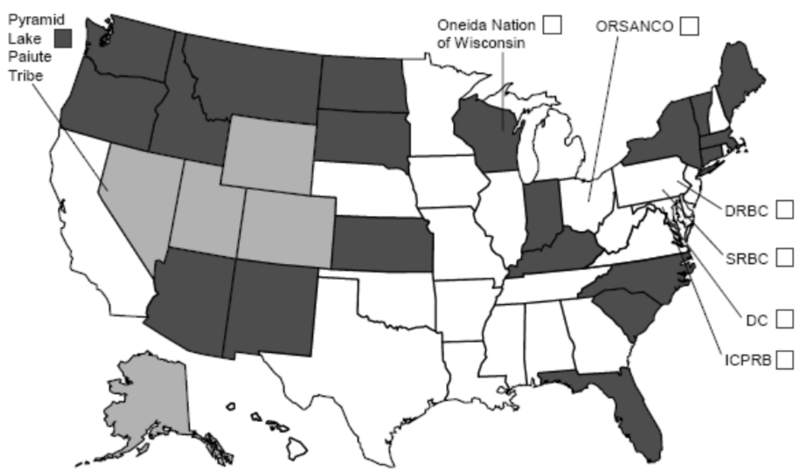
- All 50 states use BMI in state monitoring programs

Macroinvertebrates

Fishes

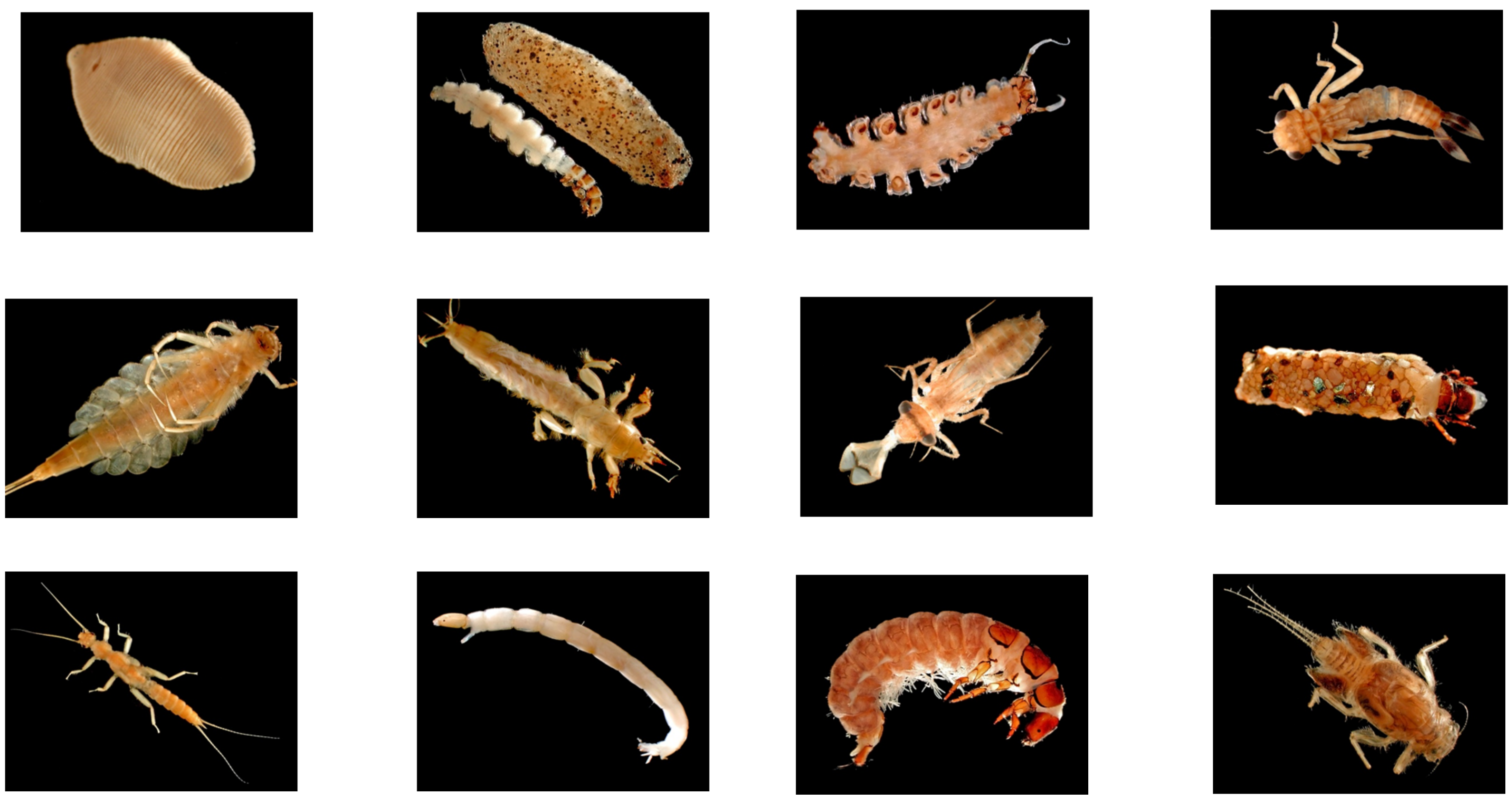


Periphyton



Methods – why macroinvertebrates…?

- Advantages of using BMI:
  - Ubiquitous: affected by perturbations in a variety of habitats
  - Large # of species: range of responses to different disturbances



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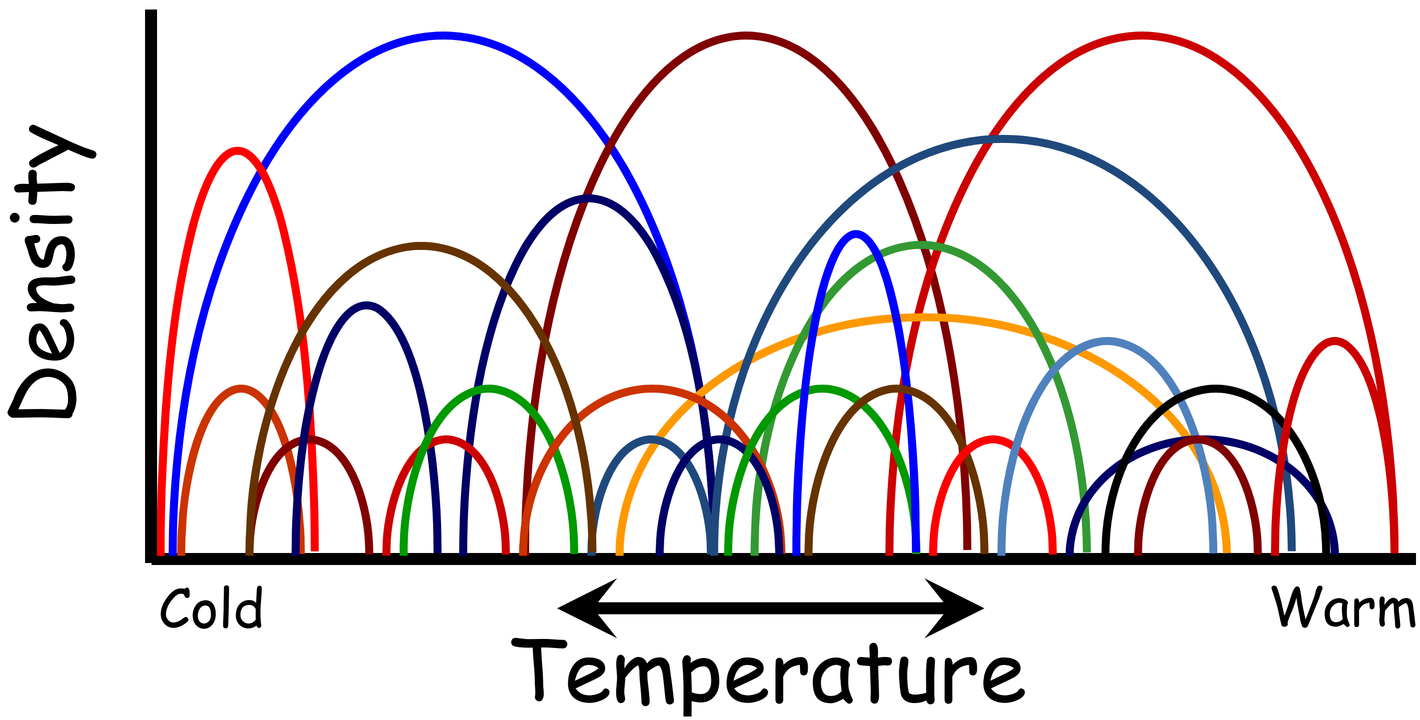
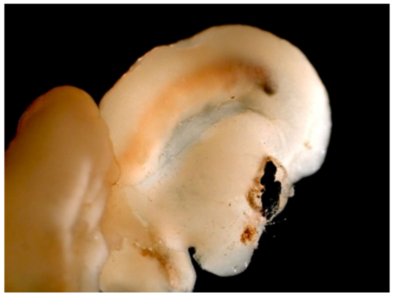


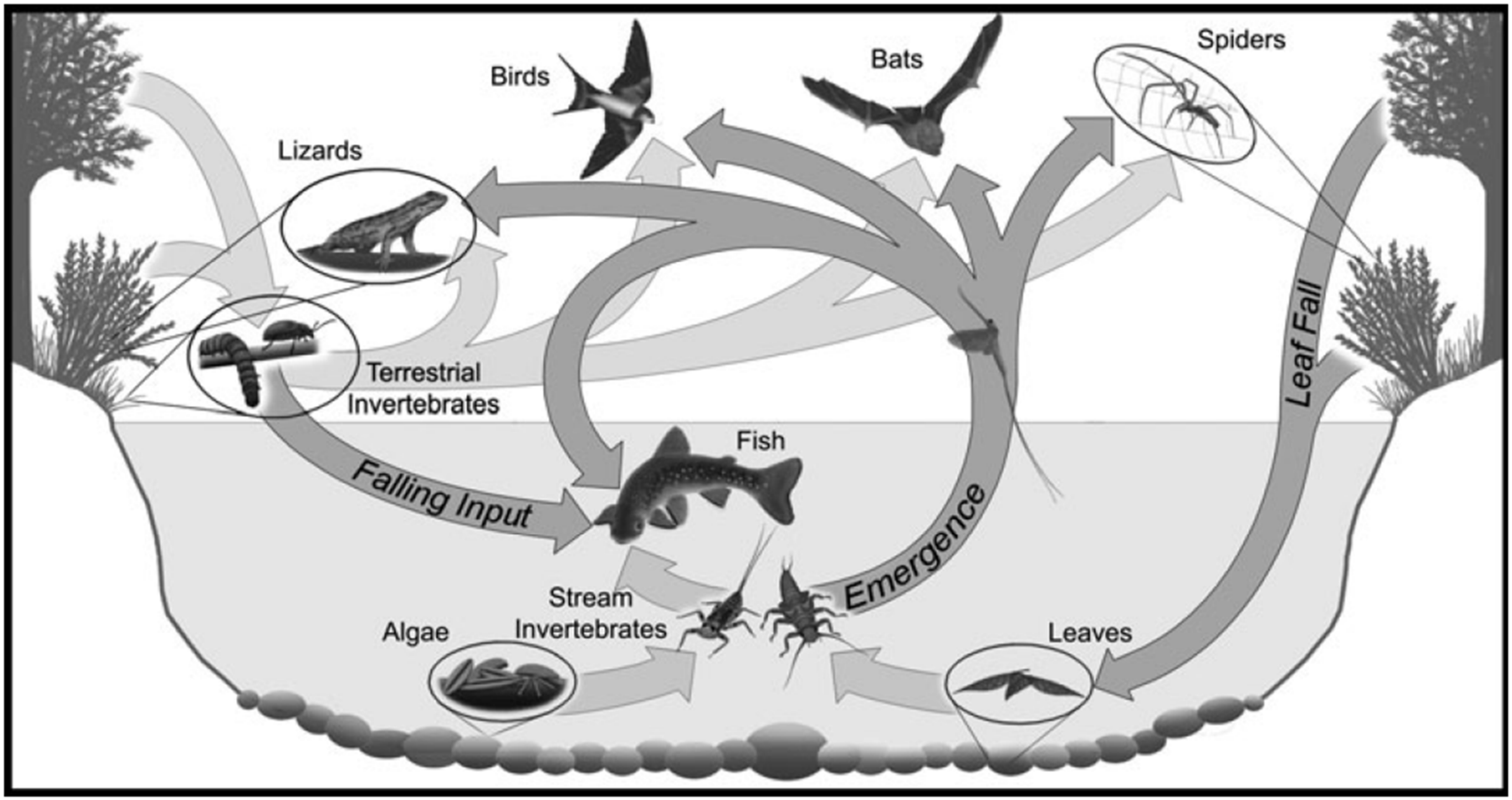
Methods – why macroinvertebrates…?

- Advantages of using BMI:
  - Ubiquitous: affected by perturbations in a variety of habitats
  - Large # of species: range of responses to different disturbances
  - Sedentary nature: allow assessments of the spatial extent of perturbations
  - Relatively long life span: integrate conditions over time
  - Sampling methodologies well developed and replicable



Methods – why macroinvertebrates…?

- Macroinvertebrates play critical roles in river ecosystems



Baxter et al., 2005

Results – macroinvertebrate assemblages

- Analyzed results from over 300 qualitative and quantitative samples
  - 153 unique taxa
    - Ephemeroptera (42 taxa)
    - Diptera (26)
    - Trichoptera (24)
    - Coleoptera (19)
    - Plecoptera (12)

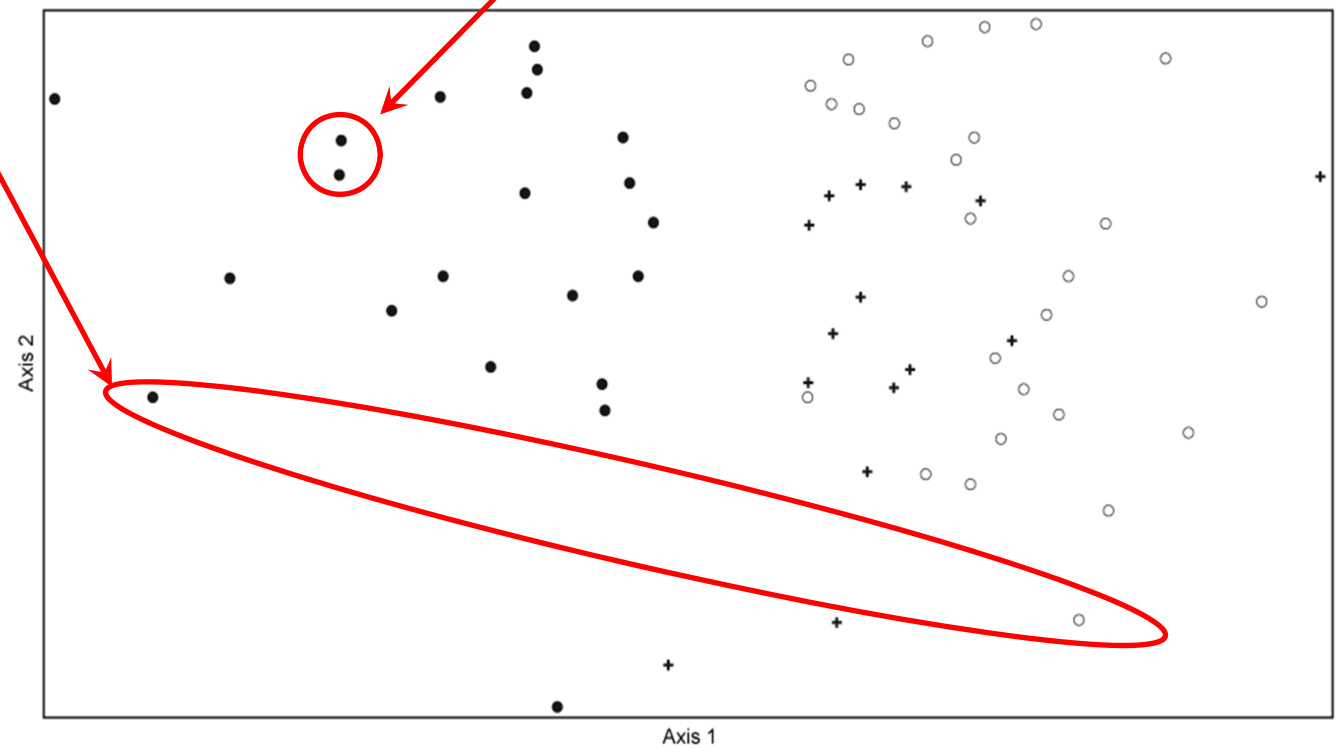



Results – contemporary differences among segments

- How does BMI composition of the regulated Green River compare to that of the *unregulated* Yampa River and the Green below confluence with Yampa?
- Ordination used to characterize differences among river segments
  - Sample sites arranged by species composition

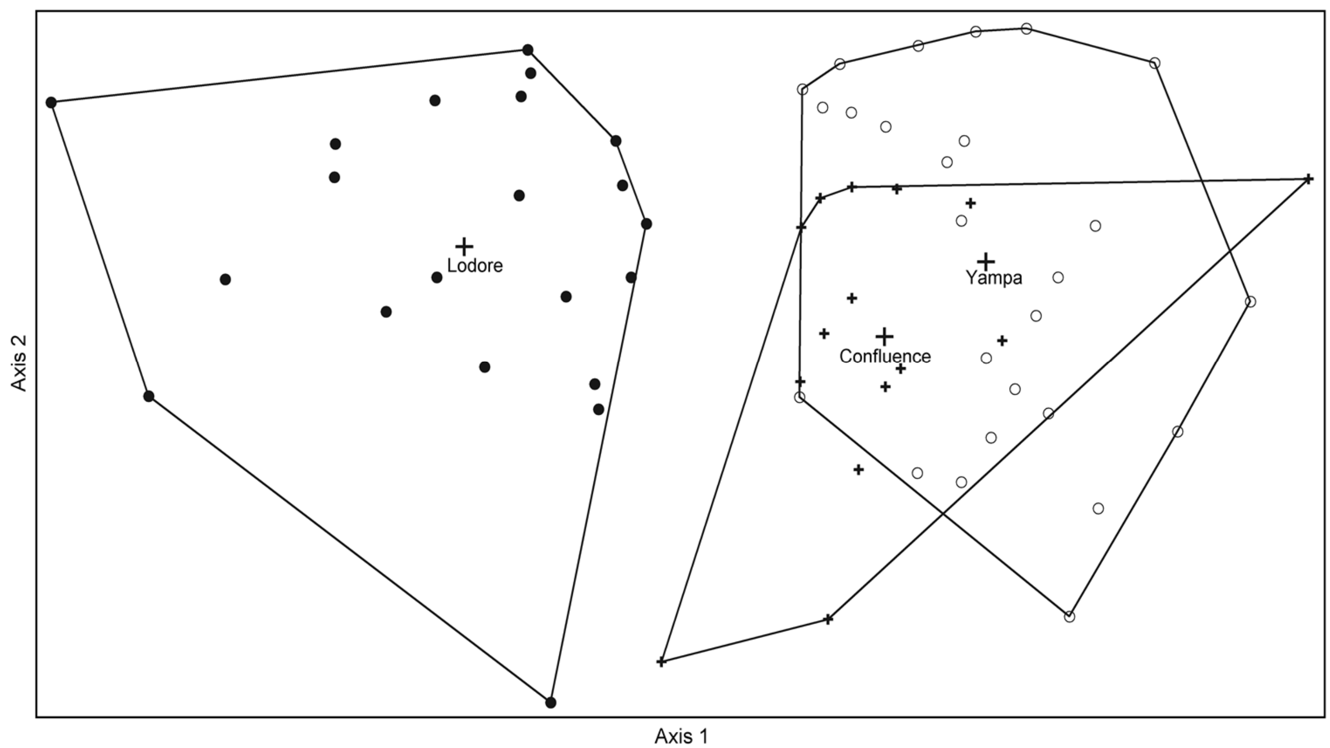
Very *different* BMI composition

Very *similar* BMI composition



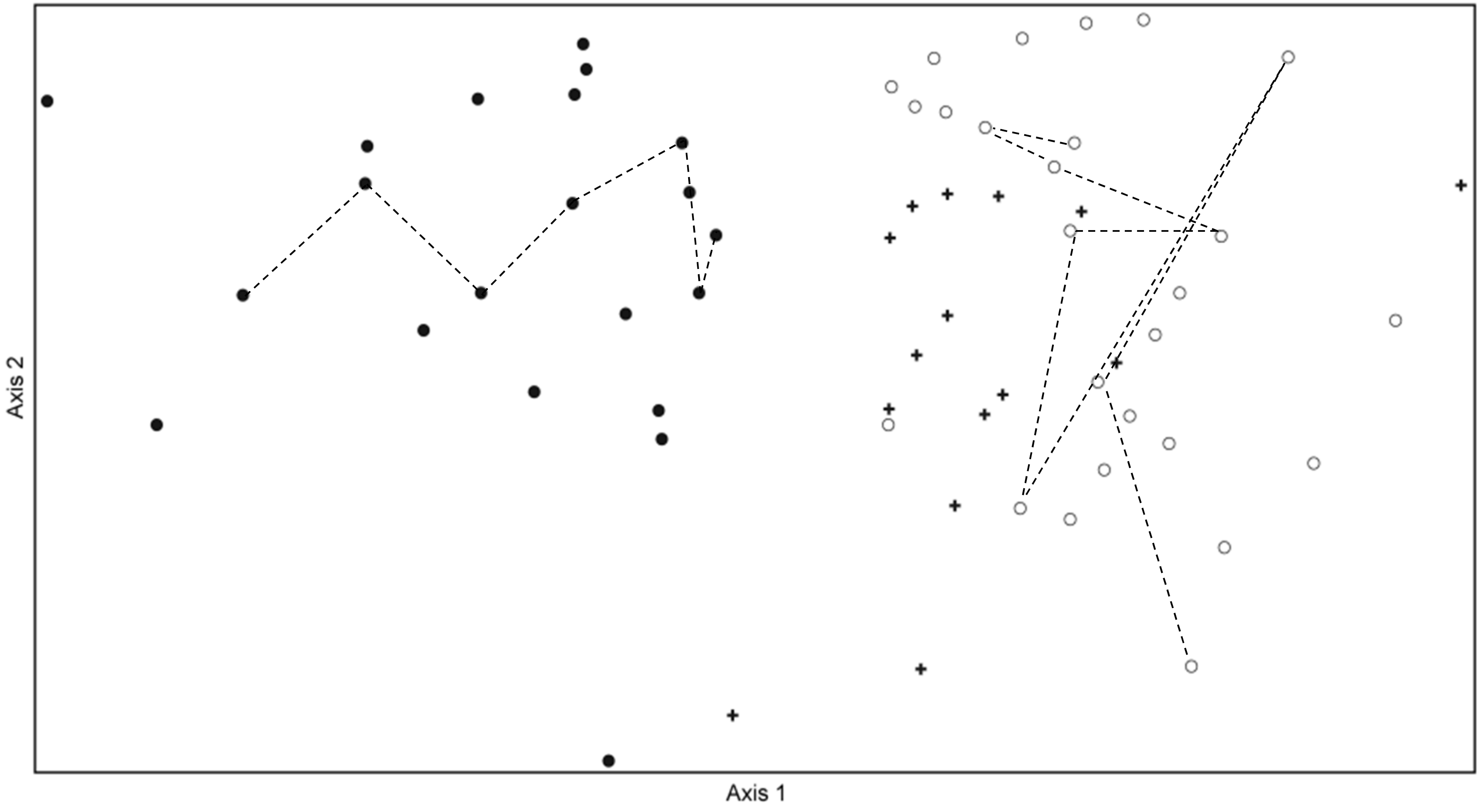
Results – contemporary differences among segments

- NMS ordination – two significant gradients (85%)
  - Differences among river segments (axis 1 – 70%)
    - Lodore ≠ Yampa ($p < 0.001$)
    - Lodore ≠ Confluence ($p < 0.001$)
    - Yampa = Confluence ($p < 0.10$)



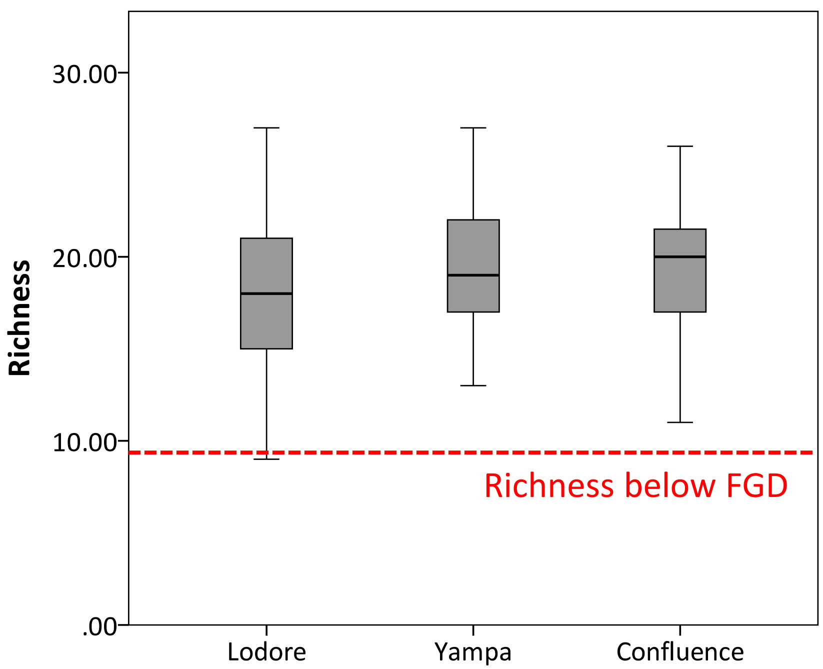
Results – contemporary differences among segments

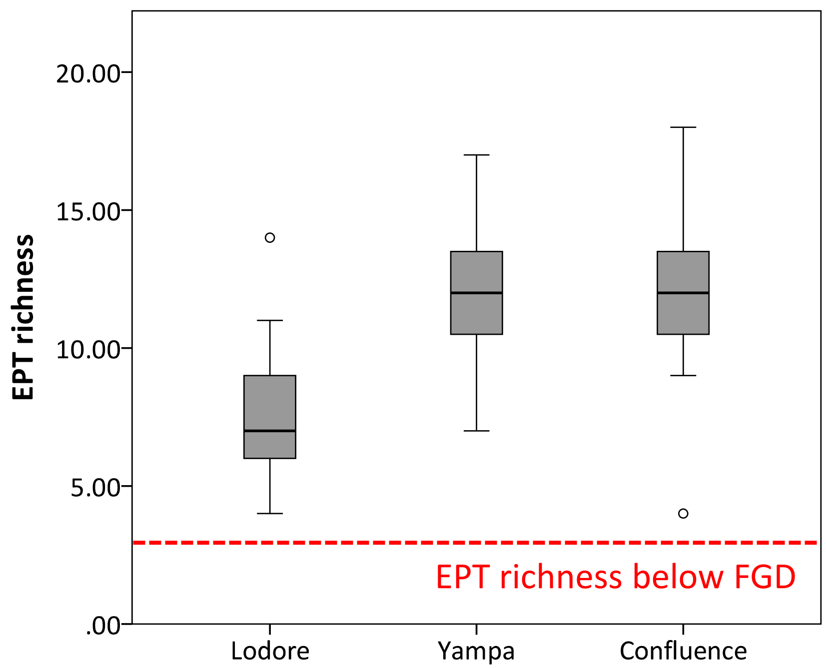
- Lodore exhibits longitudinal gradients, while change through space on Yampa and Confluence = random



Results – contemporary differences among segments

- What is the nature of differences among segments:
  - Not richness based
  - Relative abundance
  - Composition



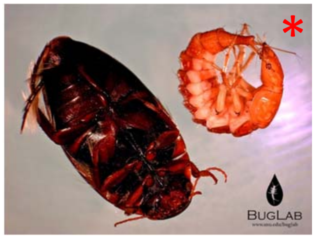


or below the confluence

Results – contemporary differences among segments

- Indicator taxa (* taxa unique to a segment):

Lodore



Yampa

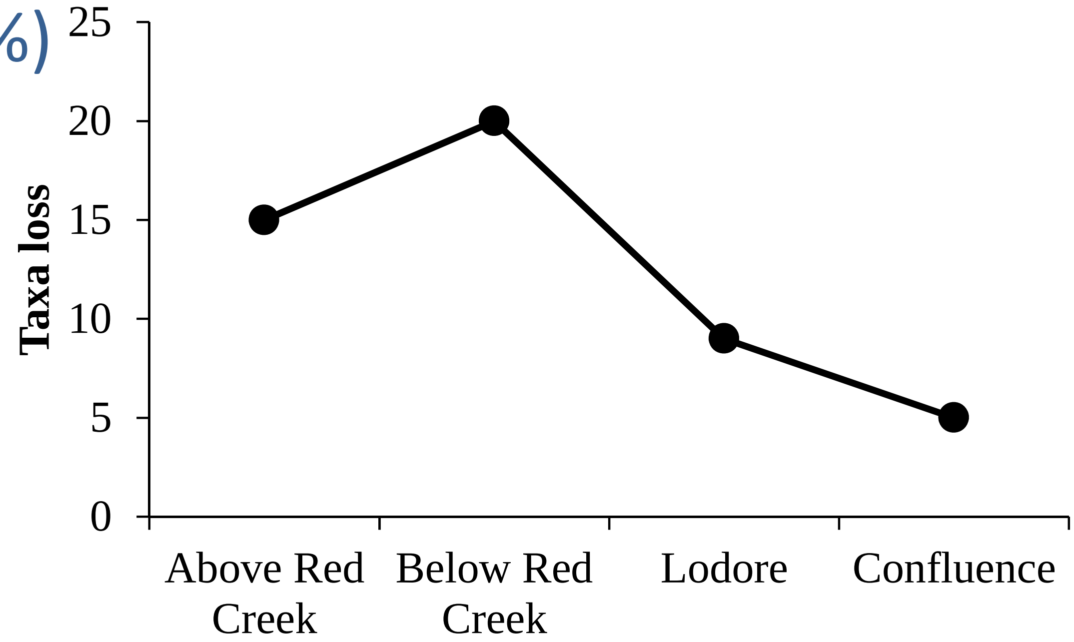



Confluence



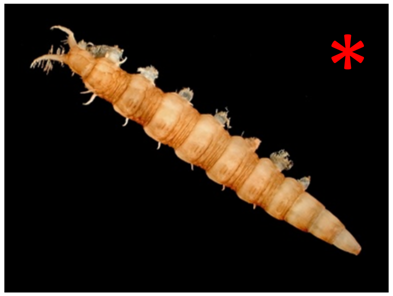

Results – contemporary versus historic assemblages

- Background rates of species loss
  - Extirpation of 9 taxa from Yampa
- Taxa loss from FGD
  - Peaked below Red Creek (20)
  - Greatly reduced throughout Lodore (10)
  - Low of 5 taxa in Confluence
  - Ephemeroptera (56%)



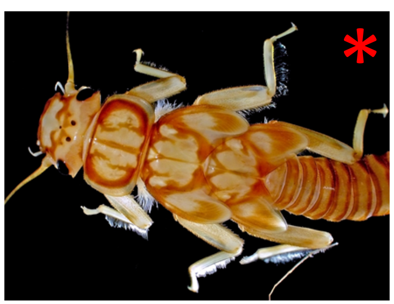
Results – contemporary versus historic assemblages

- Taxa thought to be extirpated from Lodore (9)



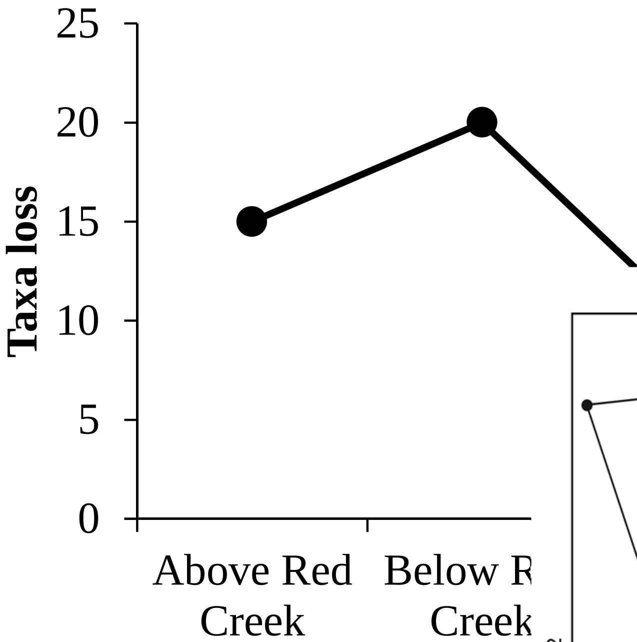


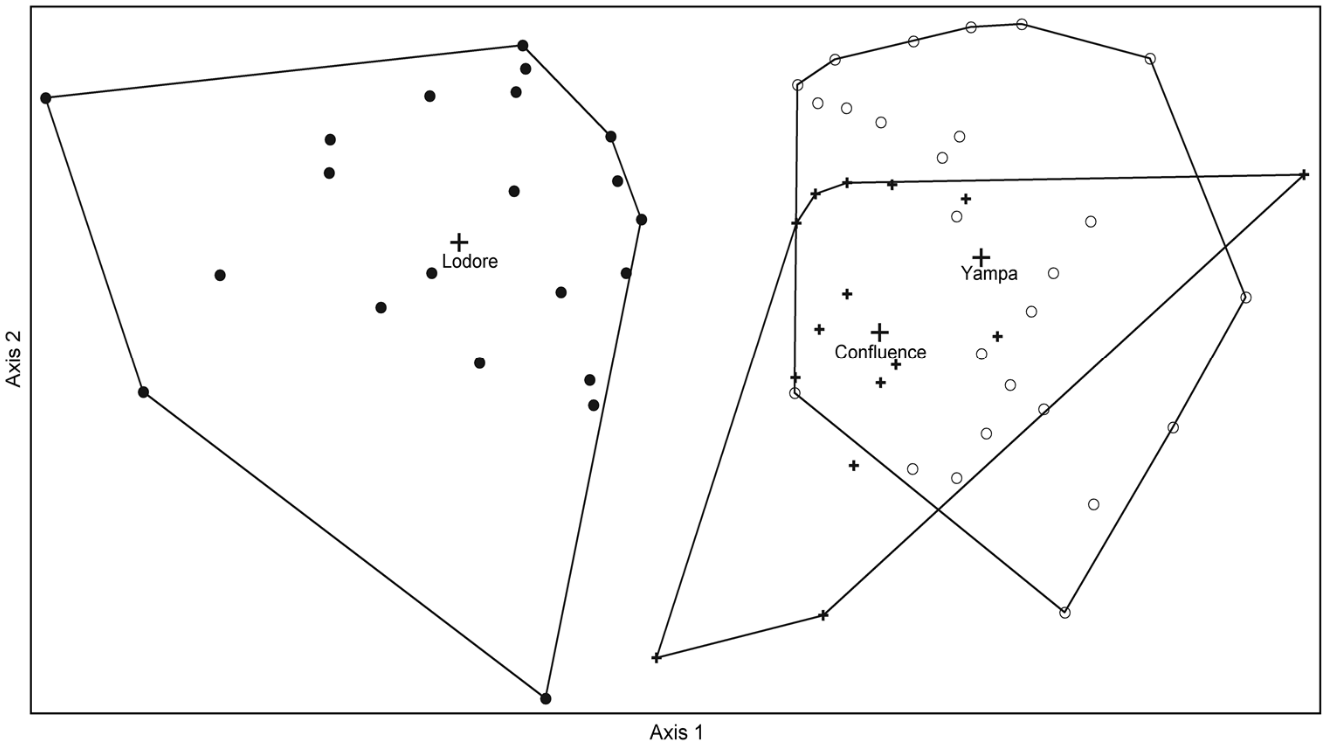




Results – remediating effects of Yampa

- Current and historic comparisons suggest: Yampa has significant remediating effects on the Green





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Results – Invasive aquatic inverts in DINO

- Two main taxa:
  - Northern crayfish
  - New Zealand mudsnail

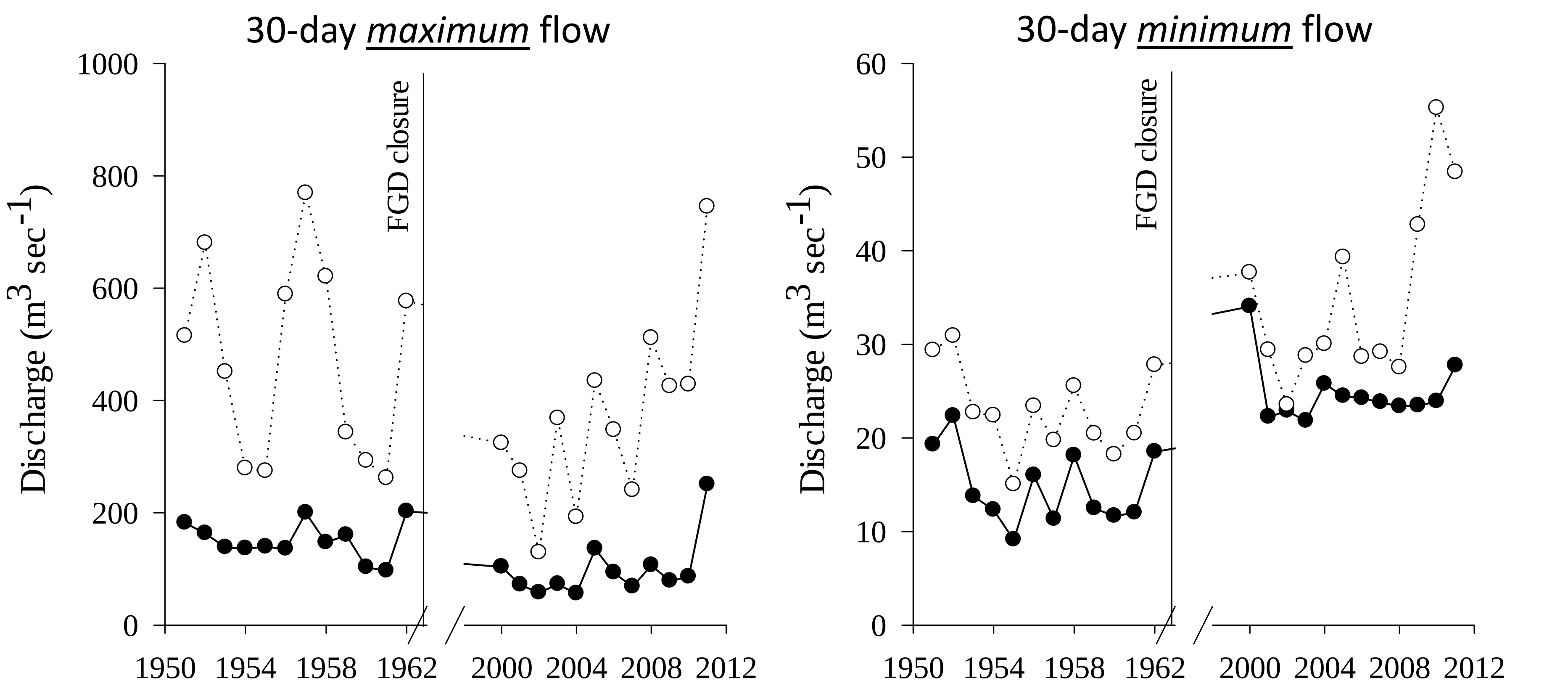
Consistently found in low densities throughout all three segment

Inconsistently found in the Green River, but not the Yampa

Discussion / conclusions

- FGD has fundamentally altered the physical template of the Green River through DINO

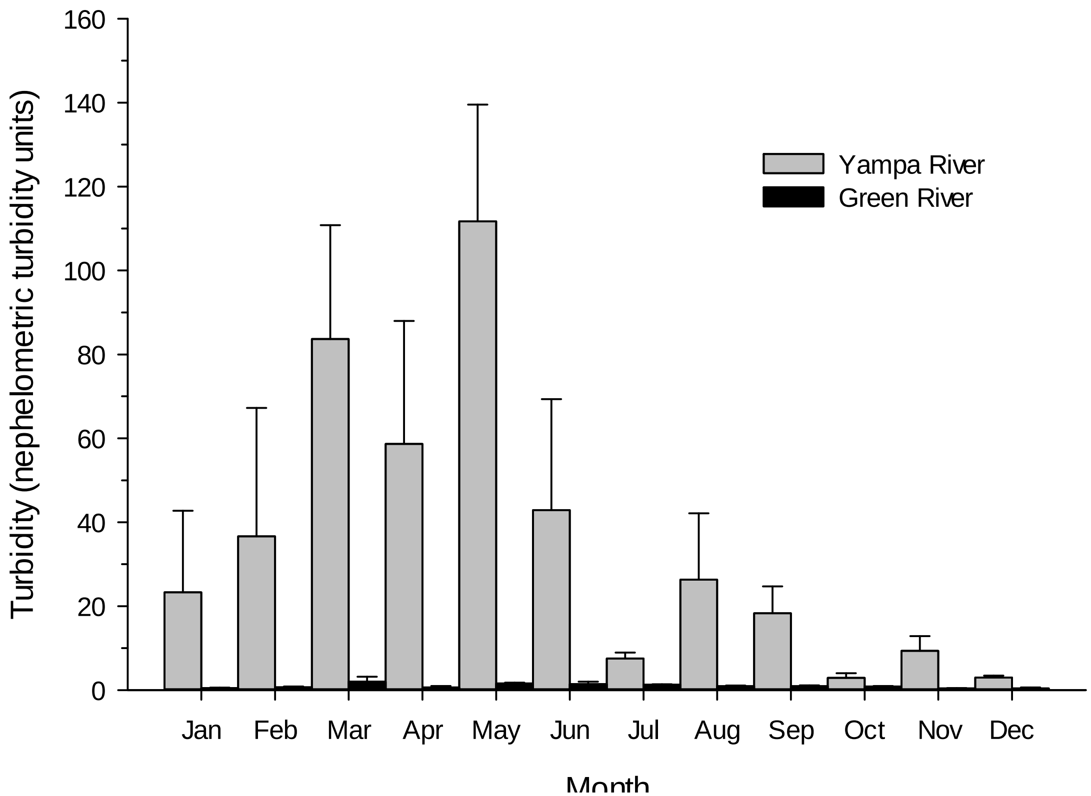
  - Increased hydrologic and geomorphic stability



Conclusions

- FGD has fundamentally altered the physical template of the Green River through DINO

    - Turbidity levels reduced to near zero = increased incoming solar radiation



Conclusions

- FGD has fundamentally altered the physical template of the Green River through DINO

  - Turbidity levels reduced to near zero = increased incoming solar radiation = increased algal and macrophyte growth

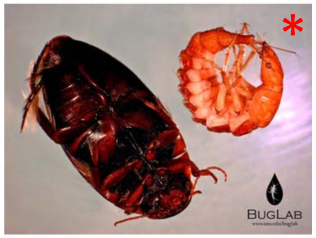
Green River

Yampa River

Conclusions

- FGD has fundamentally altered the physical template of the Green River through DINO

  - Hydrogeomorphic and water clarity alterations have fundamentally changed macroinvertebrate assemblages






Conclusions

- Results support downstream recovery trajectories of macroinvertebrate assemblages – SDC
- Importance of both small and large tributaries in remediating the Green River throughout DINONM
- Significant differences in assemblage composition remain throughout Lodore
- Invert biodiversity dependent upon maintaining natural hydrologic, sediment and thermal regimes
- Effects of compositional differences on food web structure and function and the subsequent ecological stability of the system