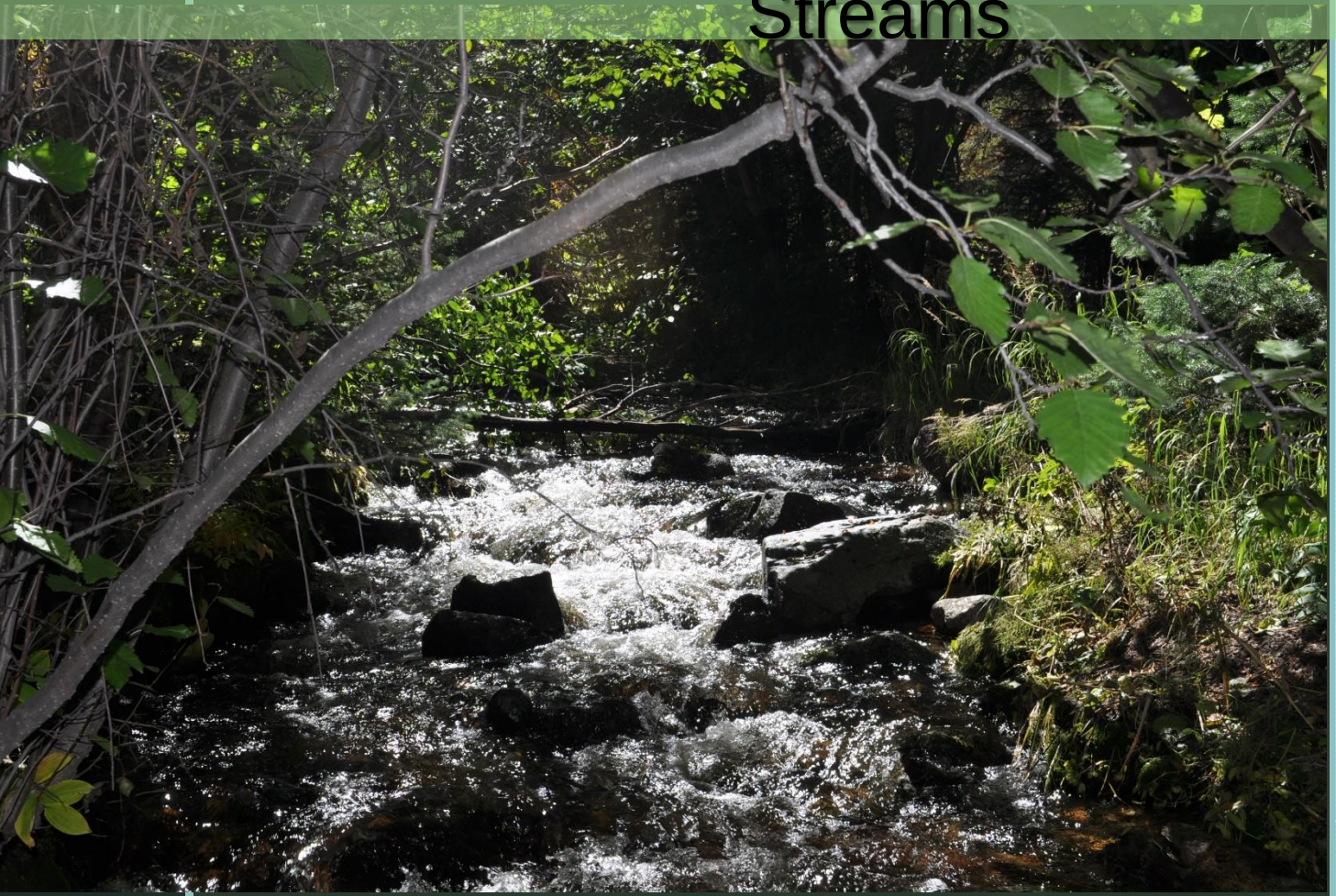
Aquatic Insect Community Functional Responses to Canopy Cover Changes Along Gradients of Elevation and Temperature in Rocky Mountain Headwater Streams



Colorado State University

Carolina Gutiérrez, Rachel Harrington, Boris Kondratieff, Colleen Webb, Cameron Ghalambor and N. LeRoy Poff

GRADUATE DEGREE PROGRAM IN ECOLOGY
COLORADO STATE UNIVERSITY

FULBRIGHT COLOMBIA

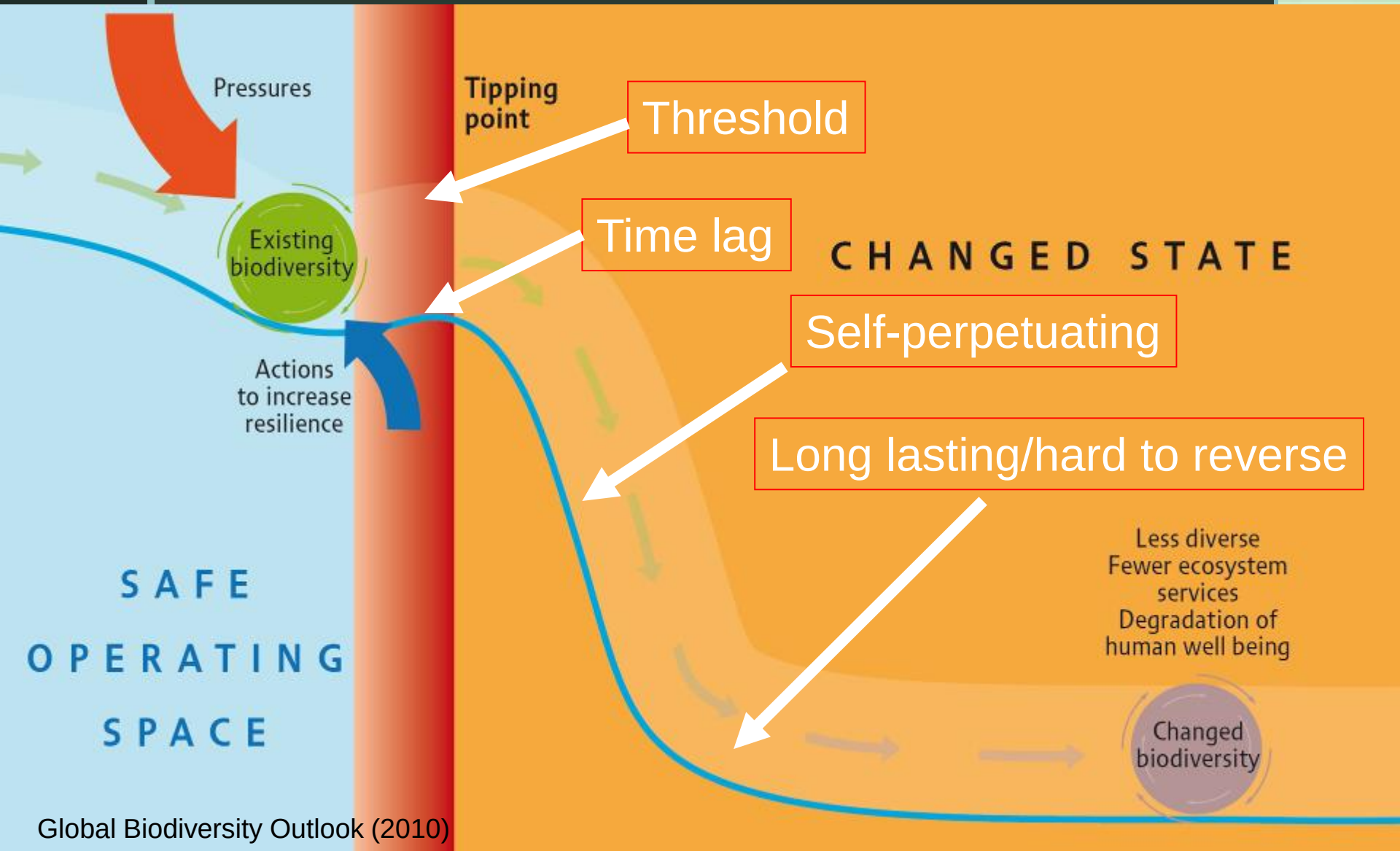
COLCIENCIAS

TURNER DESIGNS
Reliable Instruments for an Unreliable World

esa
Aquatic Ecology Section

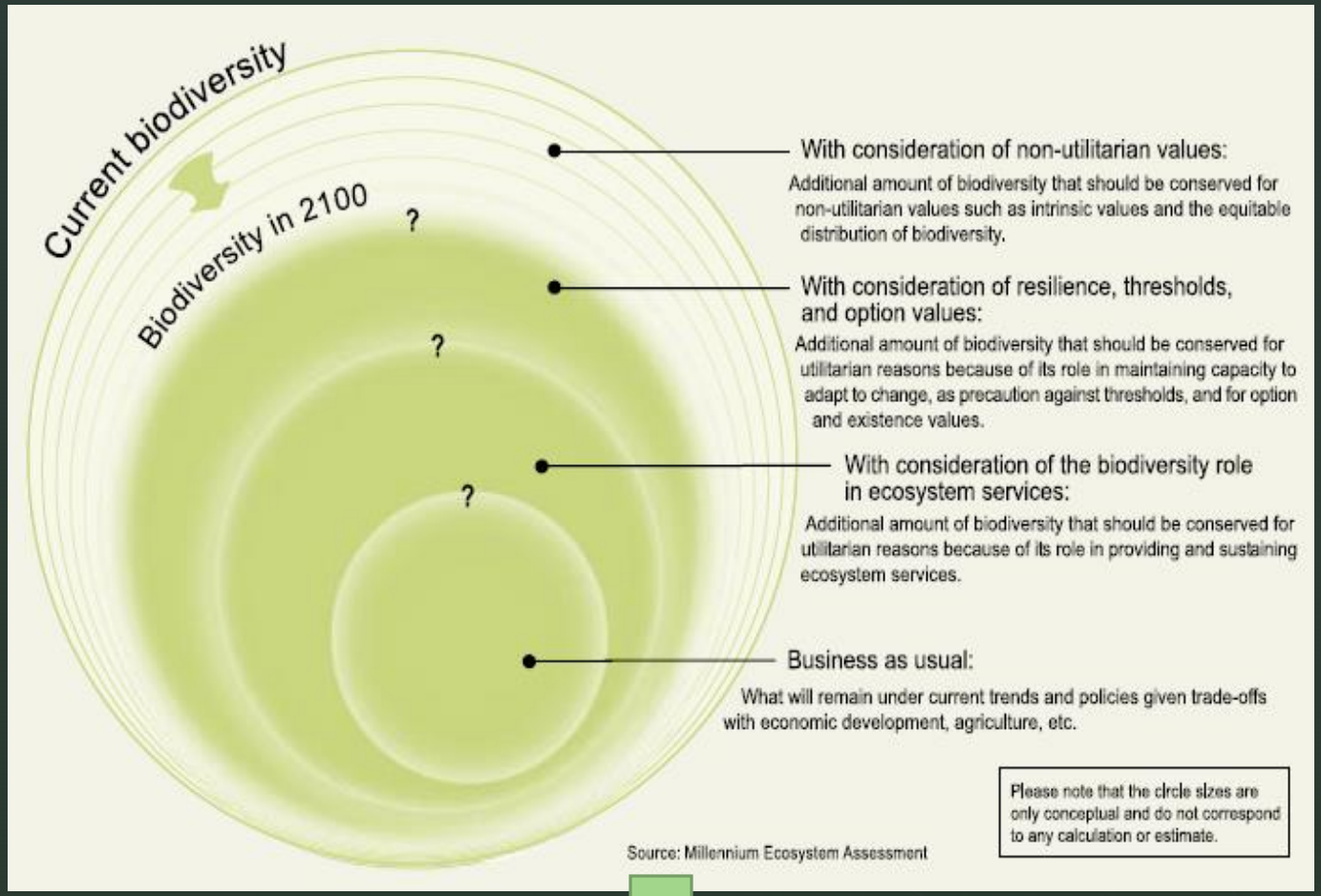
NSF | neon Operated by Battelle

Biodiversity in the Anthropocene



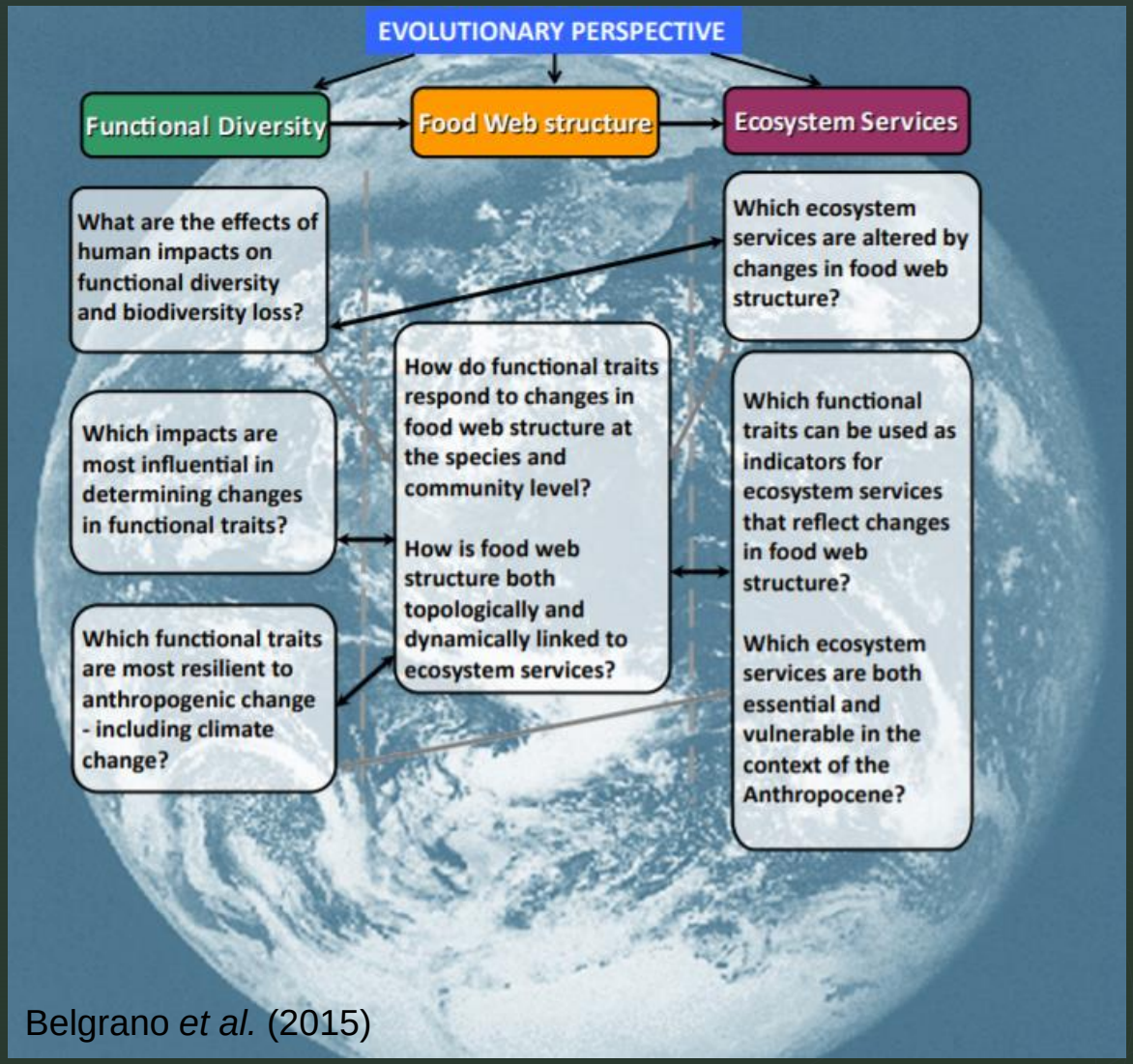
Global Biodiversity Outlook (2010)

Different frameworks



FUNCTION

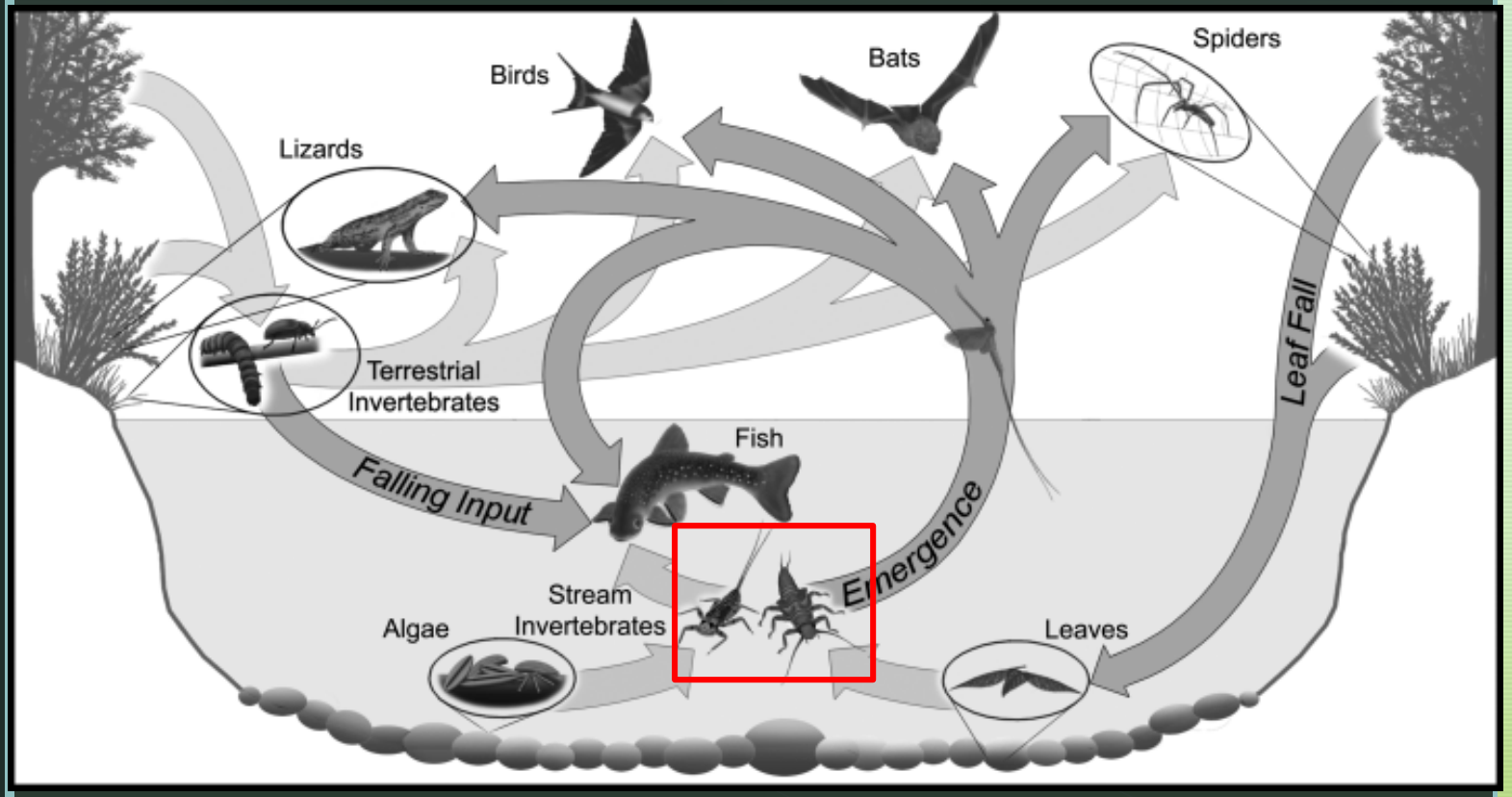
Challenges



Belgrano *et al.* (2015)

Study System

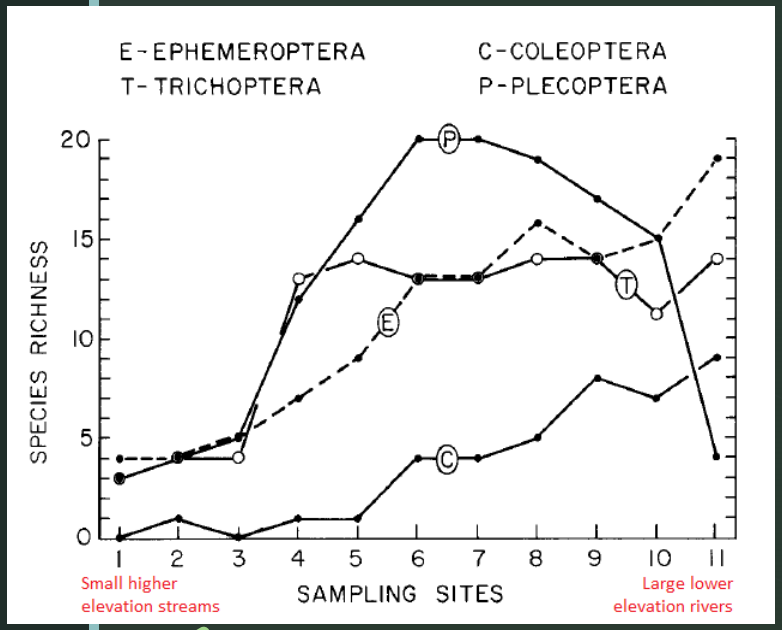
Study System Importance



Baxter, Fausch & Saunders (2005)

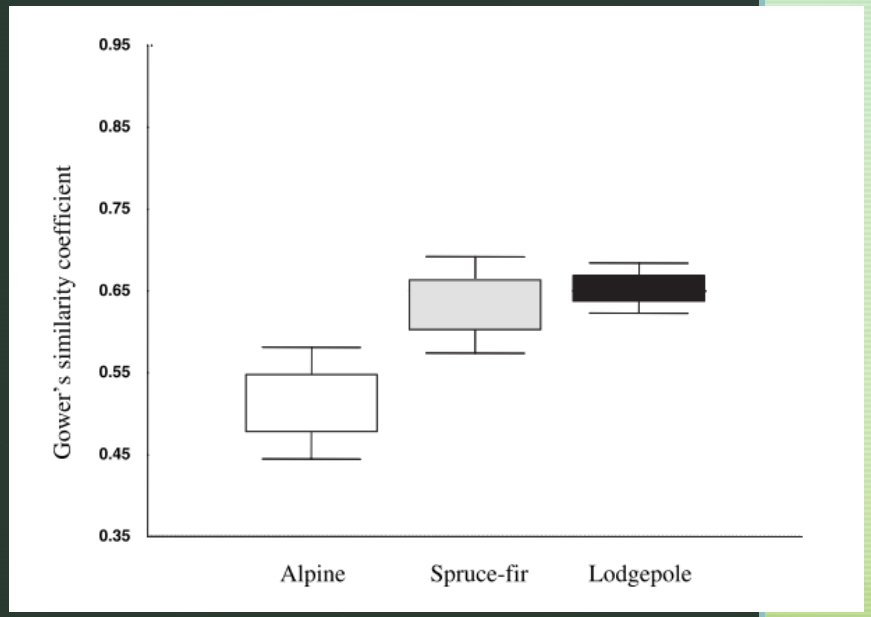
Why measure along environmental gradients?

- Less consideration given to elevation gradients than to longitudinal gradients
- Abiotic conditions change rapidly over small spatial scales



Elevation

Ward (1986)



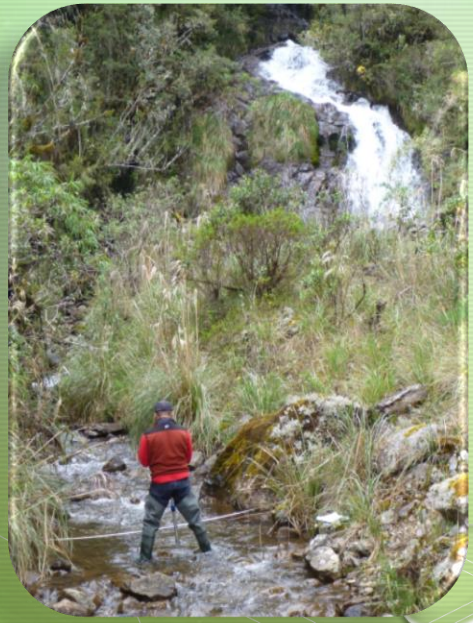
Elevation

Finn & Poff (2005)

Higher elevations = lower richness, less similarity

Our Main Question?

How is the functional structure of aquatic insect communities changing across Environmental Gradients of elevation, water temperature and canopy cover in Mountain Streams?



Functional Diversity (FD)

What is it?

Broadly defined as:

The value, range, distribution and relative abundance of the functional traits in a given ecosystem

(Díaz *et al.,* 2007)

Why should we be interested?

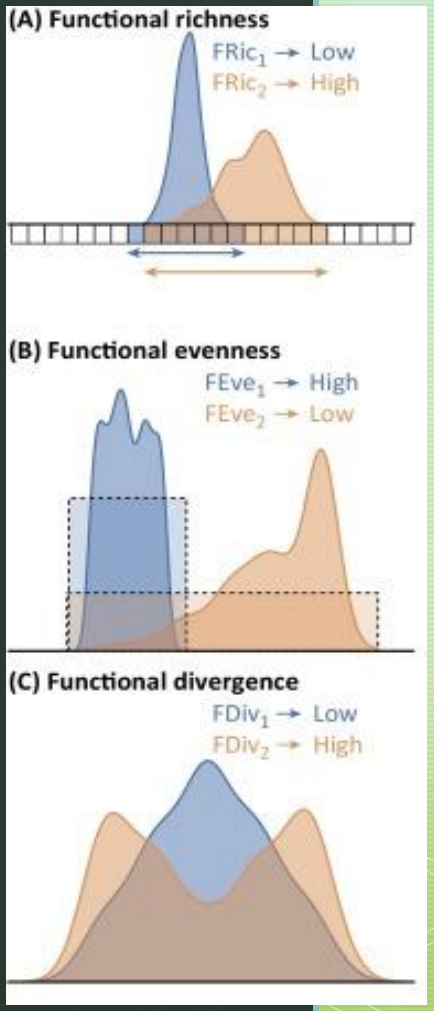
- Quantify the value and range of organismal traits
- Influence of traits in organismal performance in ecosystem
- Rather than species diversity, FD enhances insight into ecosystem functions.

How to measure FD?

Multidimensional framework: 3 facets of FD

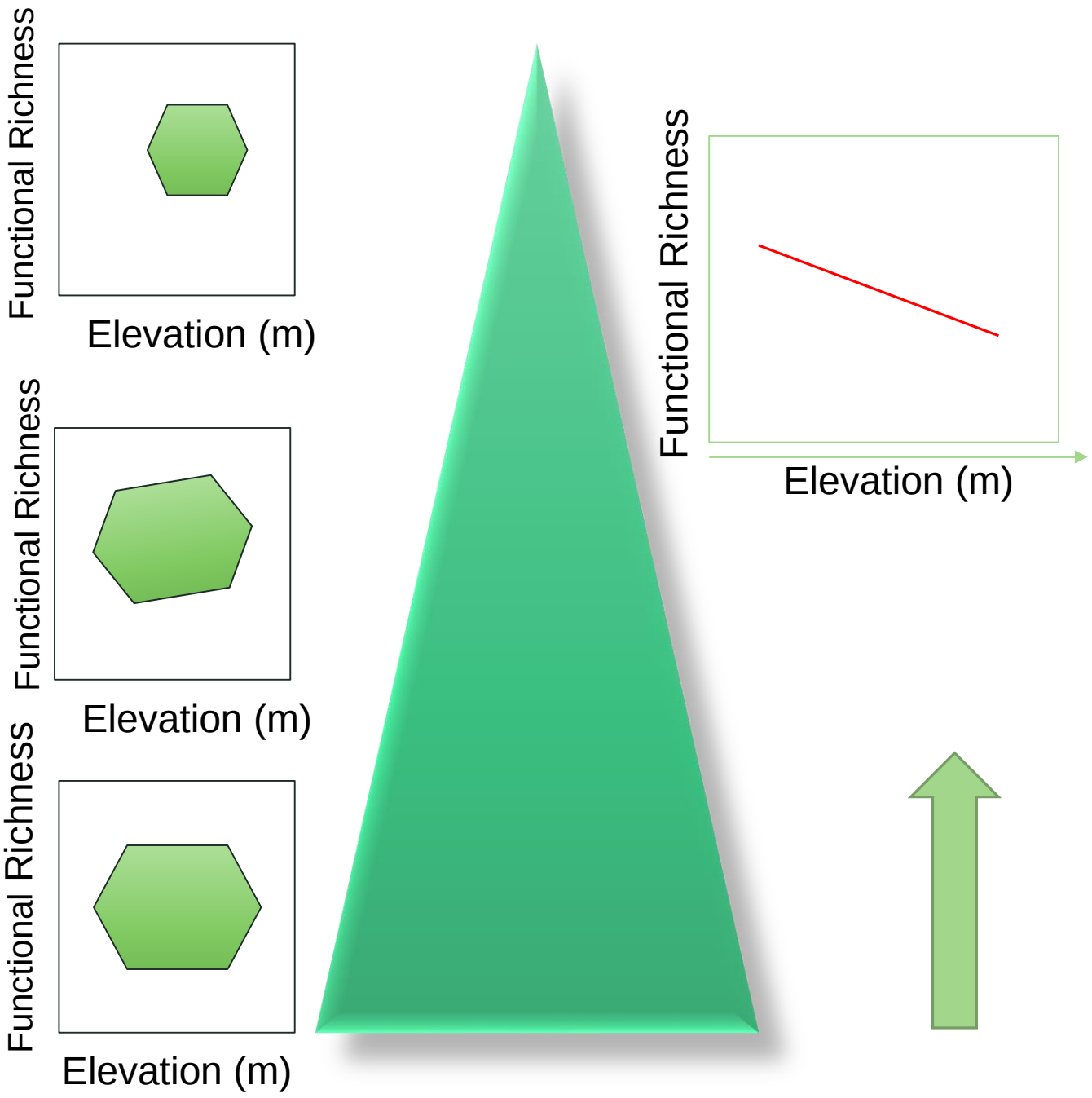
- Three indices for a community with species distributed in a multidimensional functional space:
  - Functional richness (FRic)
  - Functional evenness (FEve)
  - Functional divergence (Fdiv)

- Functional richness
  - Volume of multidimensional space
  - All species in a community within functional space.
- Functional evenness
  - Regularity of
  - Distribution
  - Relative abundance of species in functional space for a given community.
- Functional divergence
  - Proportion of total abundance
  - Supported by species with the most extreme trait values
  - Within a community.

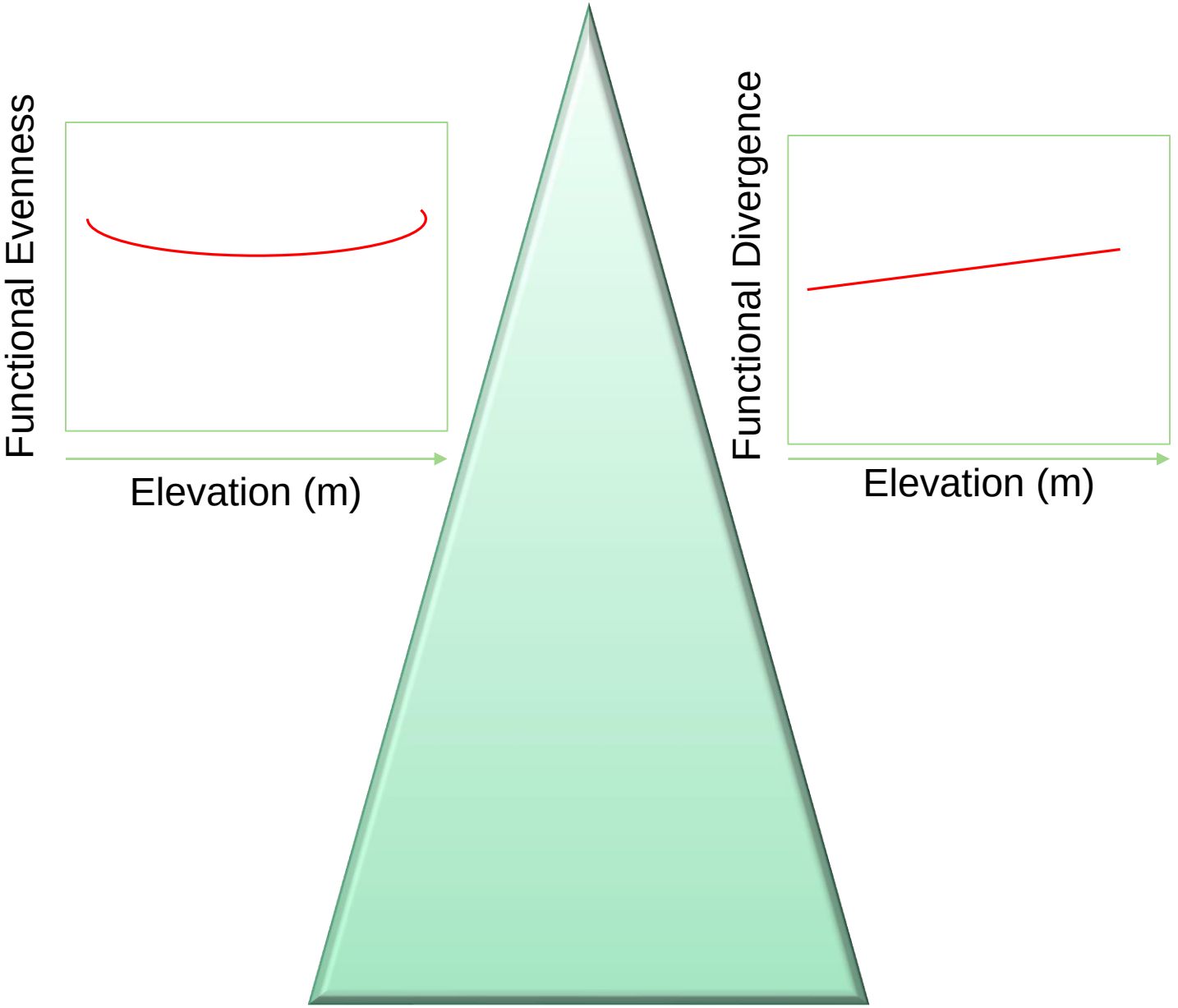


Source: Adapted from Villéger *et al*., 2008 & Carmona *et al.,* 2016; Mouillot *et al*., 2013.

Hypothesis & Prediction

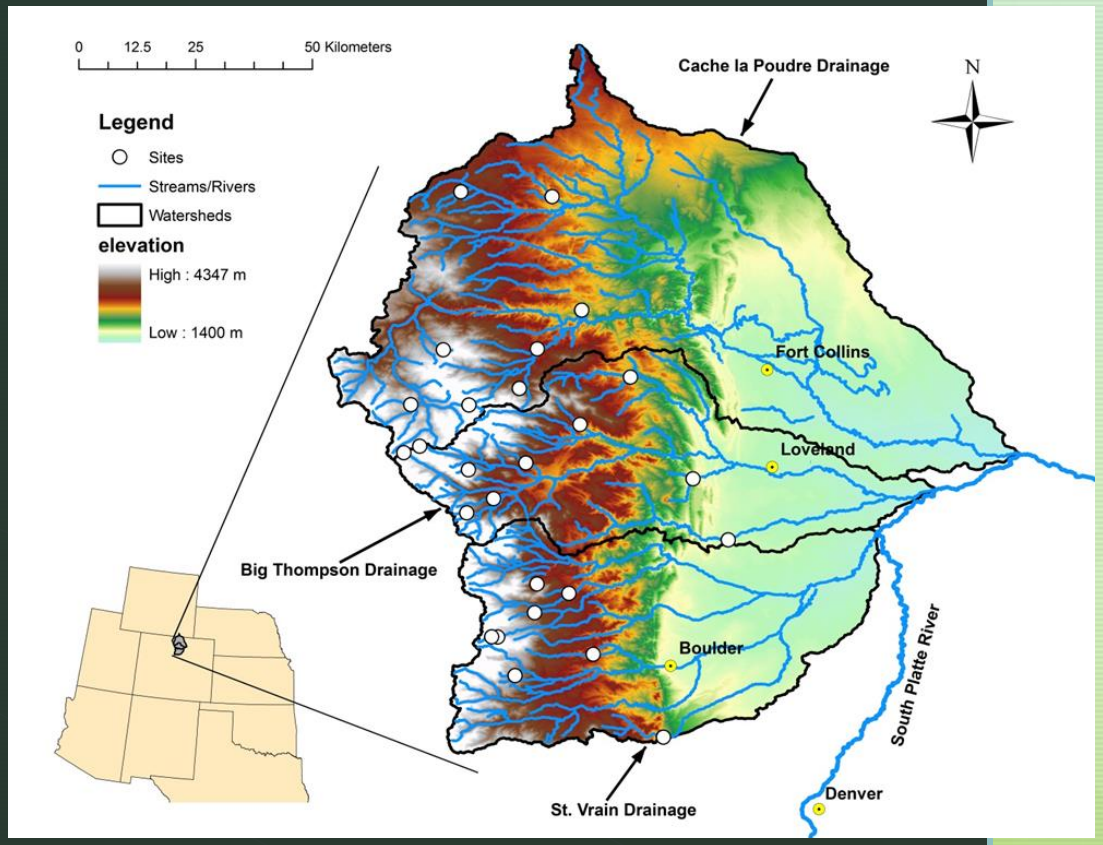


Hypothesis & Prediction



METHODS: Field locations

- 24 streams total
- 200-meter elevation bands ranging from 1500m-3500m
- Replicated in 3 different drainages



Elevation

Source: Harrington (2016)

METHODS: Insect collection

Resources

Physical conditions

- Temperature
- Flow regime
- Light availability/cover

Resources

- Benthic Organic Matter
- Algae (chlorophyll a)
- Prey density

RESOURCES: Chlorophyll *a*

In situ filtration of rock slurry using glass fiber filters at both open and closed replicate sites.

Freeze preservation of filters to perform chl *a* extraction in the laboratory.

Chl *a* extraction and concentration measured using a Turner Designs *Aqua*Fluor® Handheld Fluorometer.

Algal Classification to distinguish among algal groups (mixed, cyanobacteria and green/brown algae) using PhytoFind™.

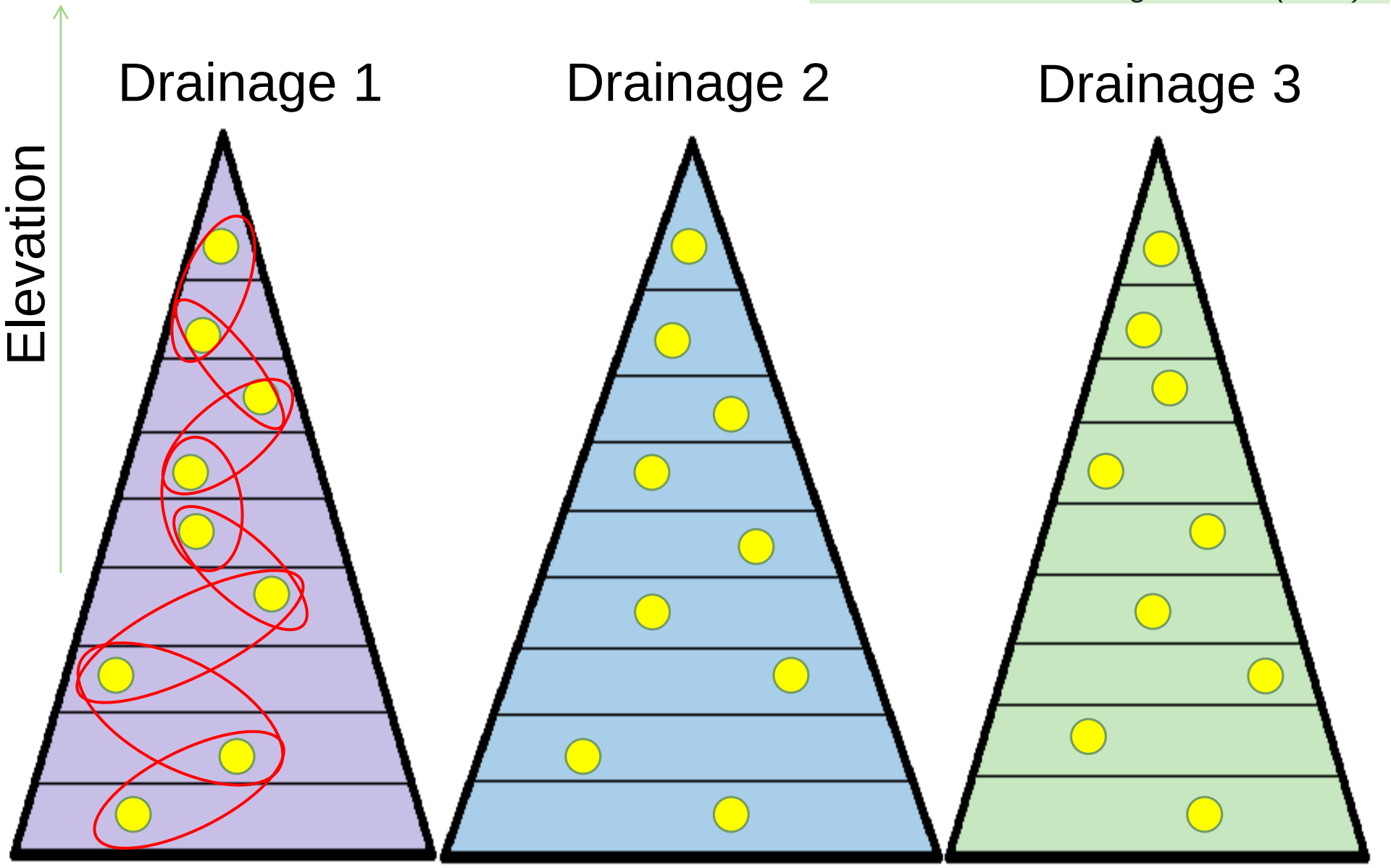
Methods: 20 traits used

Traits	Trait States (#)
Life history	
Ability to survive desiccation	2
Adult ability to exit	2
Adult life span	3
Development	3
Synchronization of emergence	2
Voltinism	3
Mobility	
Adult flying strength	2
Female dispersal	2
Maximum crawling rate	3
Occurrence in drift	3
Swimming ability	3
Morphology	
Armoring	3
Attachment	3
Respiration	3
Shape	2
Size at maturity	3
Ecology	
Habit (in ecosystem)	6
Rheophily	3
Thermal preference	3
Trophic Habit	5

Source: Adapted for use from Poff *et al*. (2006)

Turnover

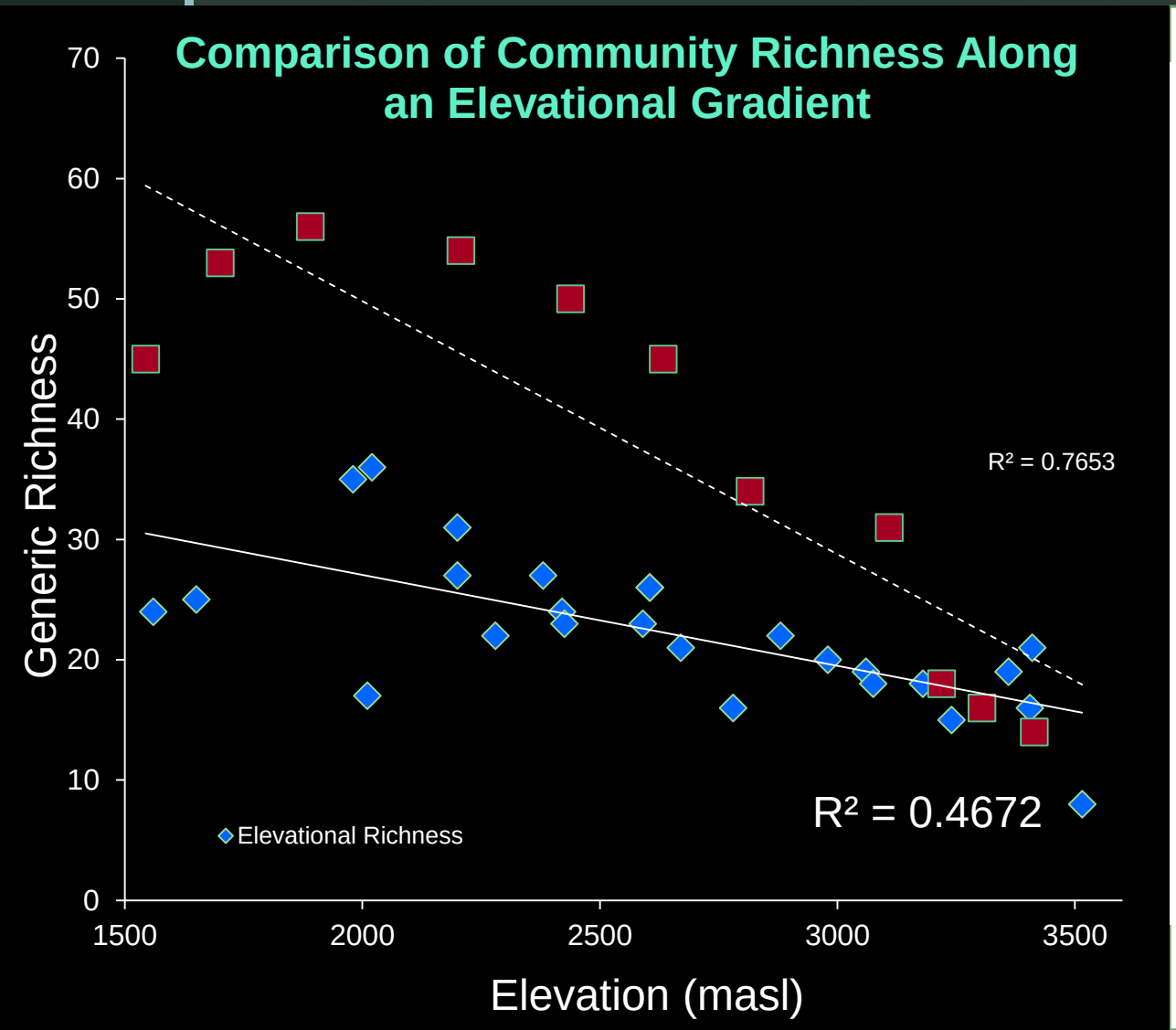
Harrington et al. (2016)



Statistical analysis

- Taxonomic richness and community structure analysis
- Functional Richness, Evenness & Divergence Indexes analysis
- ANOVA on indexes' values to test the hypothesis of variation along elevation gradients
- β- Diversity Partitioning: Nestedness (by richness) and turnover (identity).
- Ordination Analysis on Traits' distribution
- Analysis of Chl *a* concentration along the elevation gradient.

Taxonomic Richness



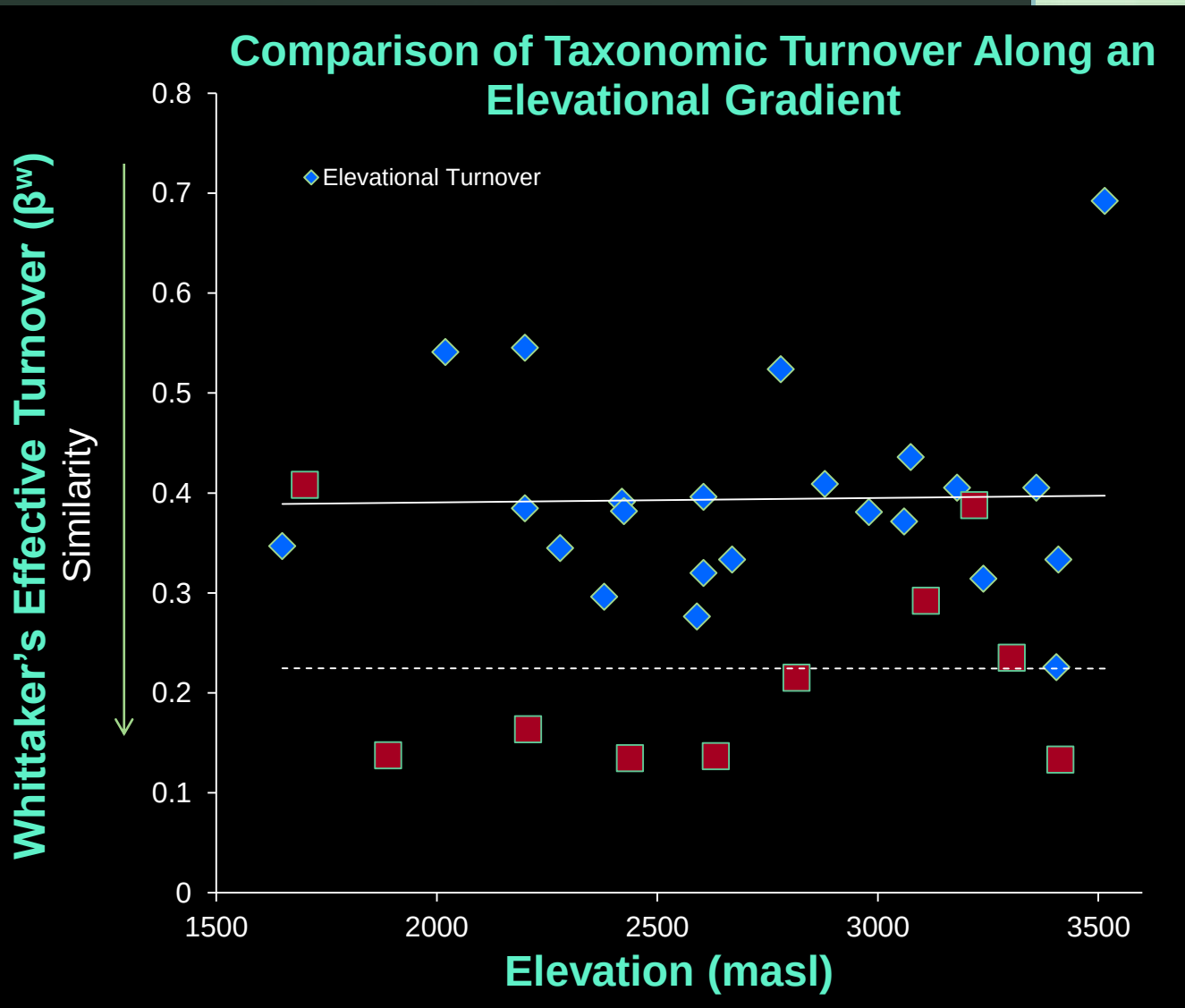
- Negative trend
- Supports results from Ward (1986)
- Less richness in low order streams ($P<0.02$)
- Confirms lower richness (α diversity) in low order/ headwater streams

Harrington et al. (2016)

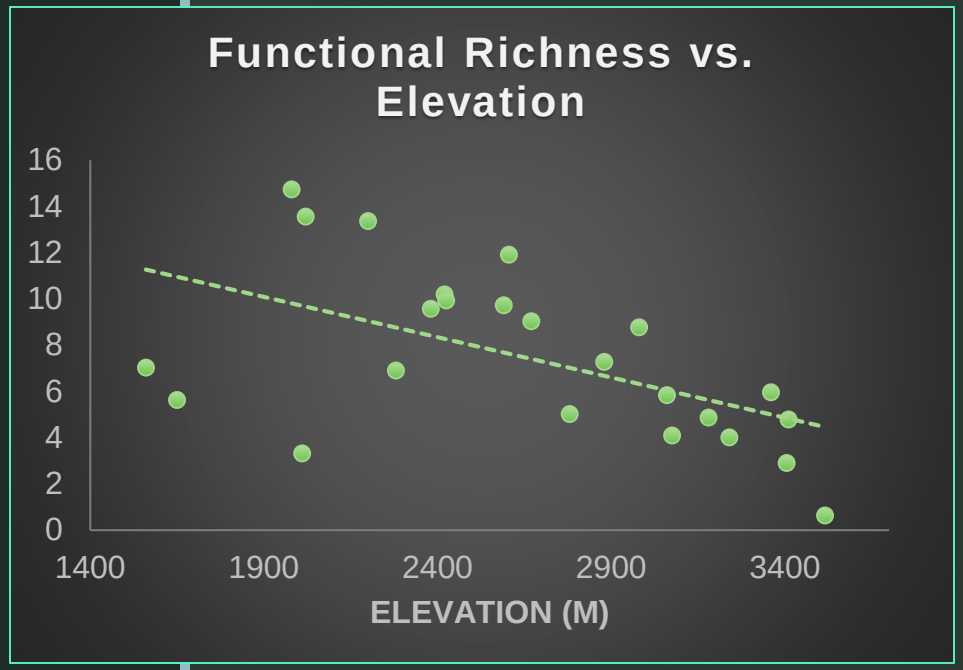
Taxonomic Turnover

- Taxonomic turnover: no trend
- Relatively high turnover values (P<0.008)
- Confirms greater heterogeneity (β diversity) in low order/ headwater streams

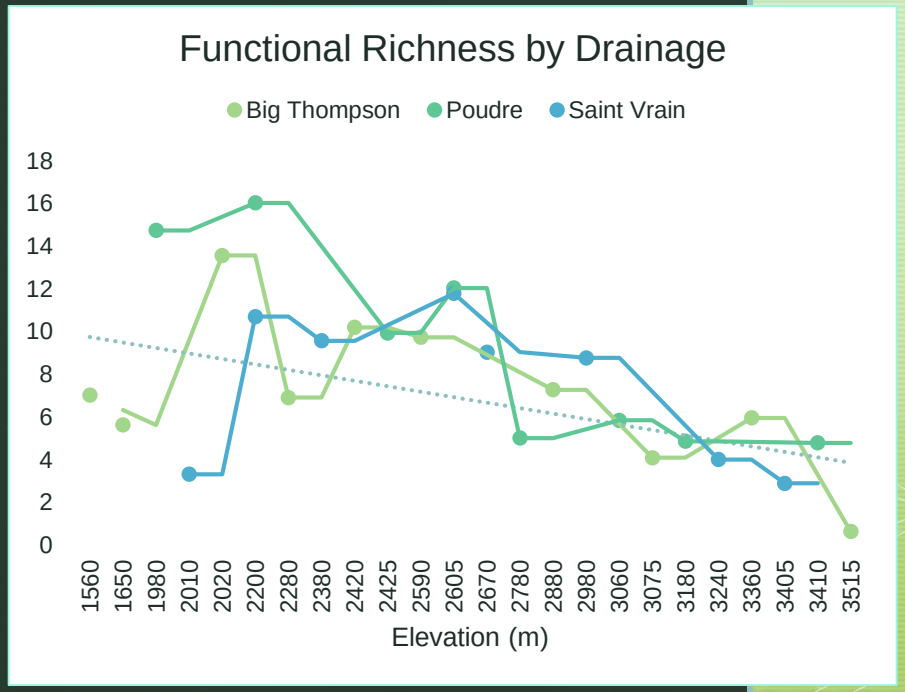
Harrington et al. (2016)

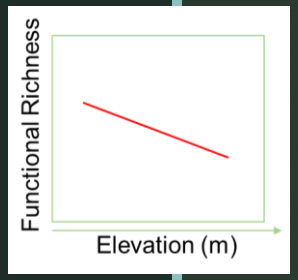


Functional Richness *

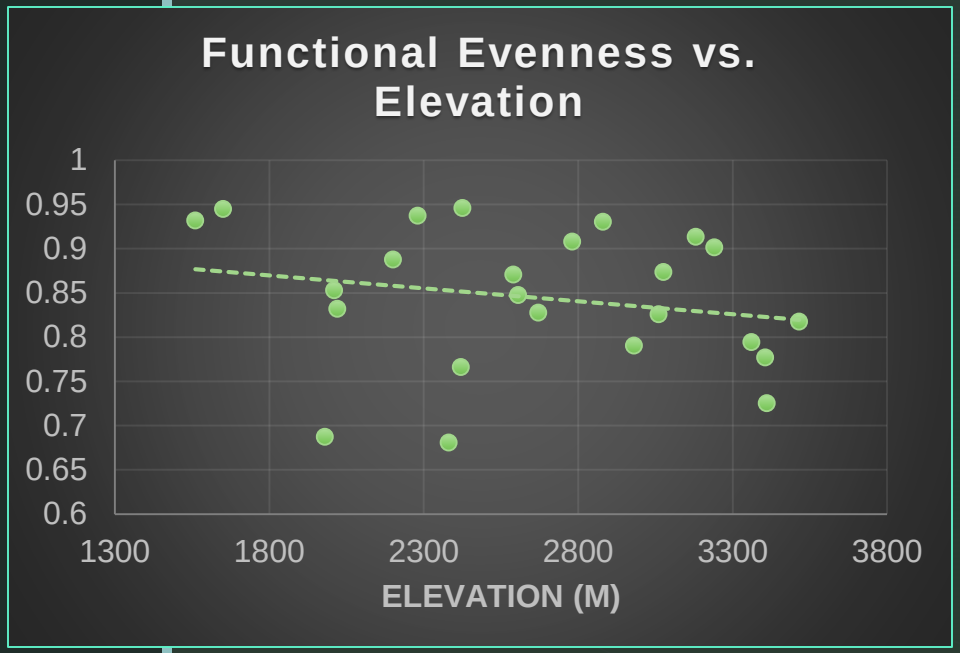


P<0.01

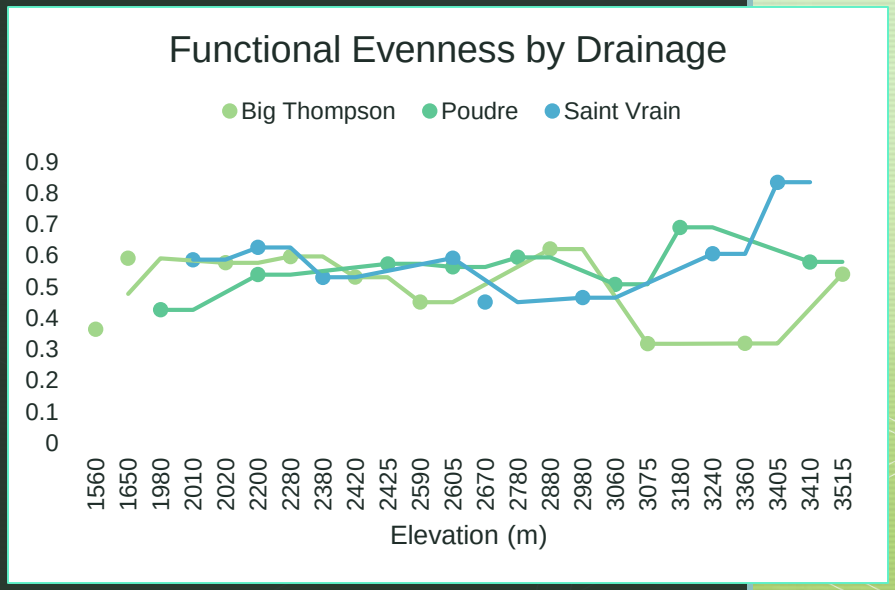


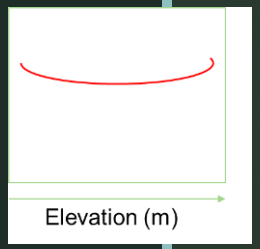


Functional Evenness

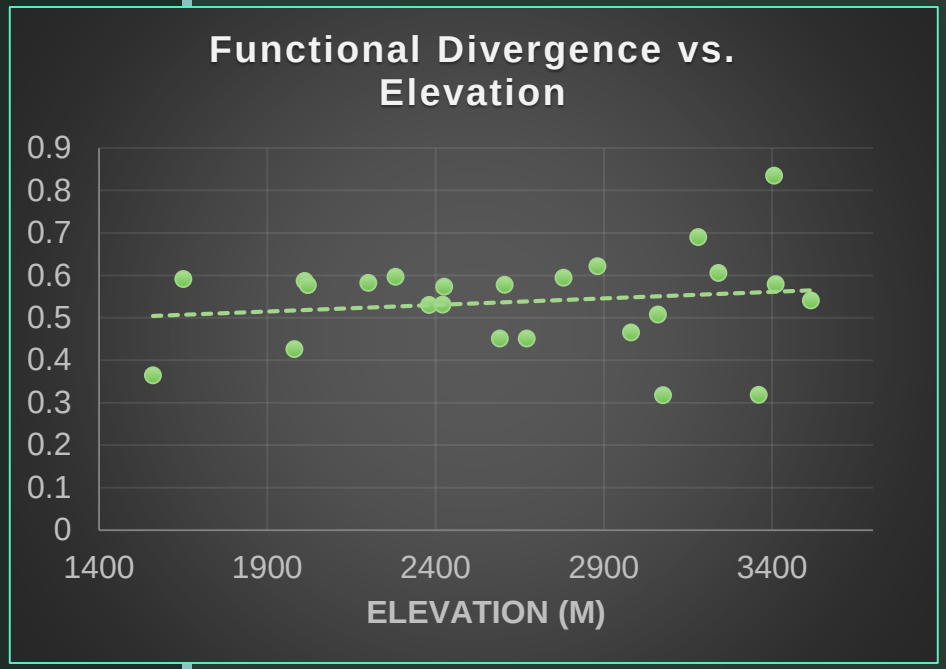


p=0.13

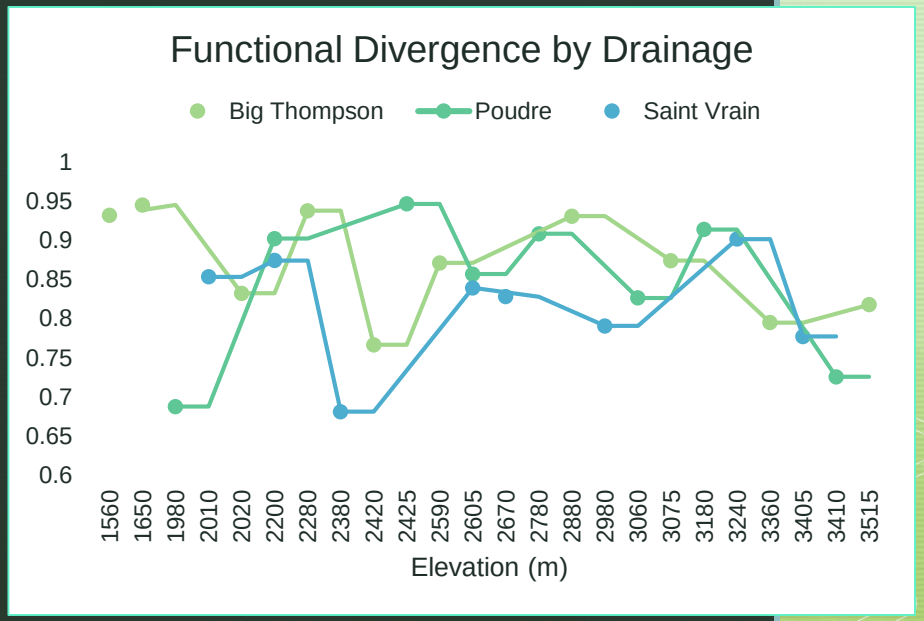


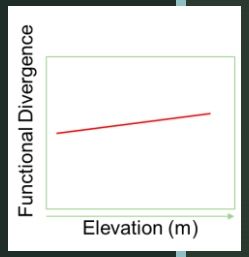


Functional Divergence

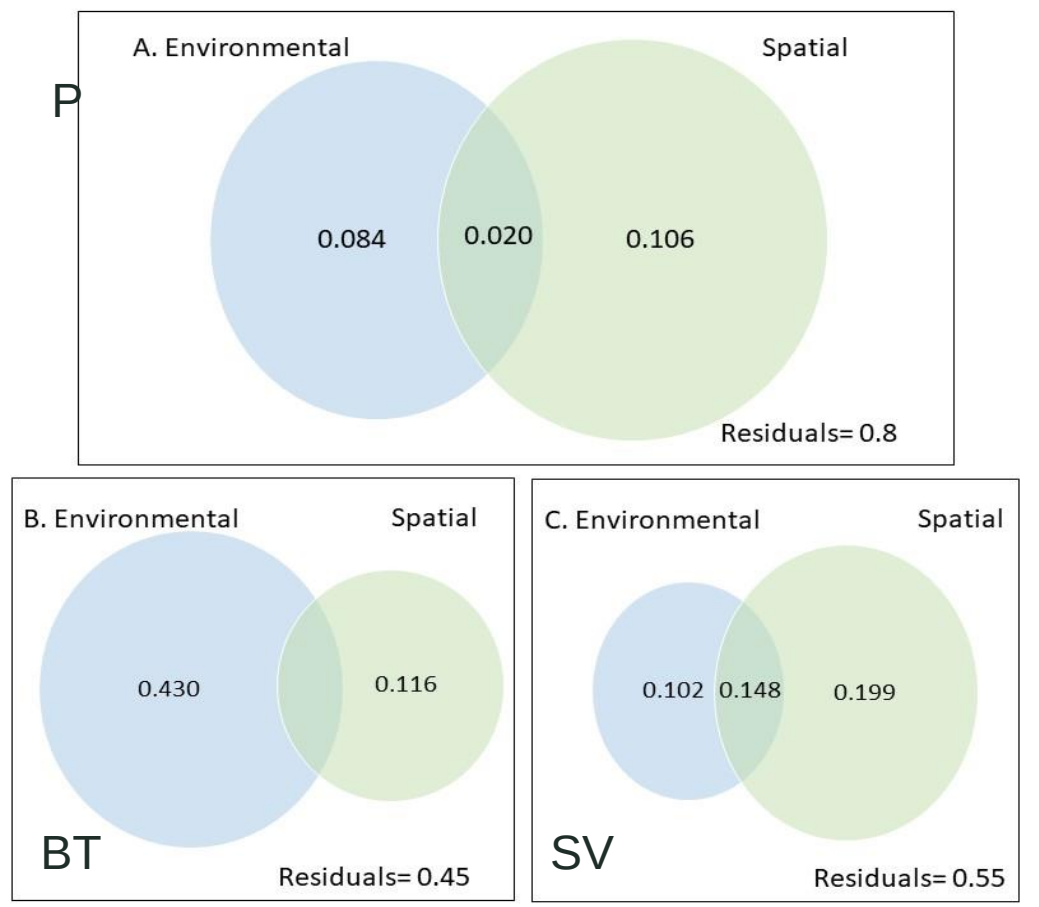


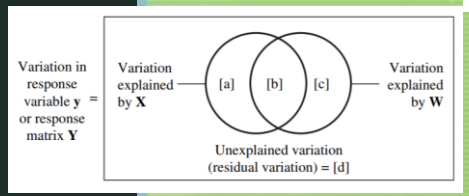
p=0.48





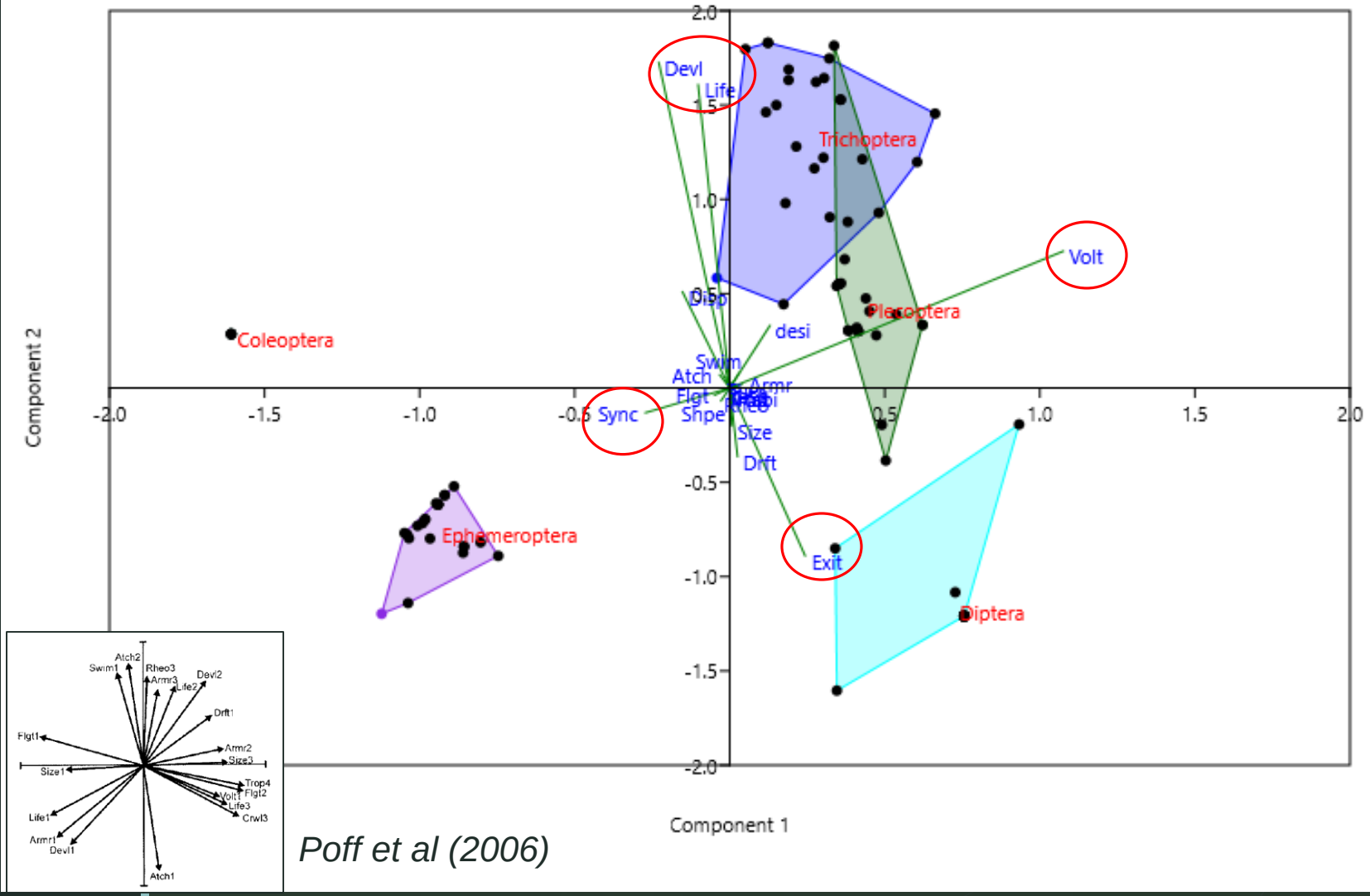
Components of β-Diversity





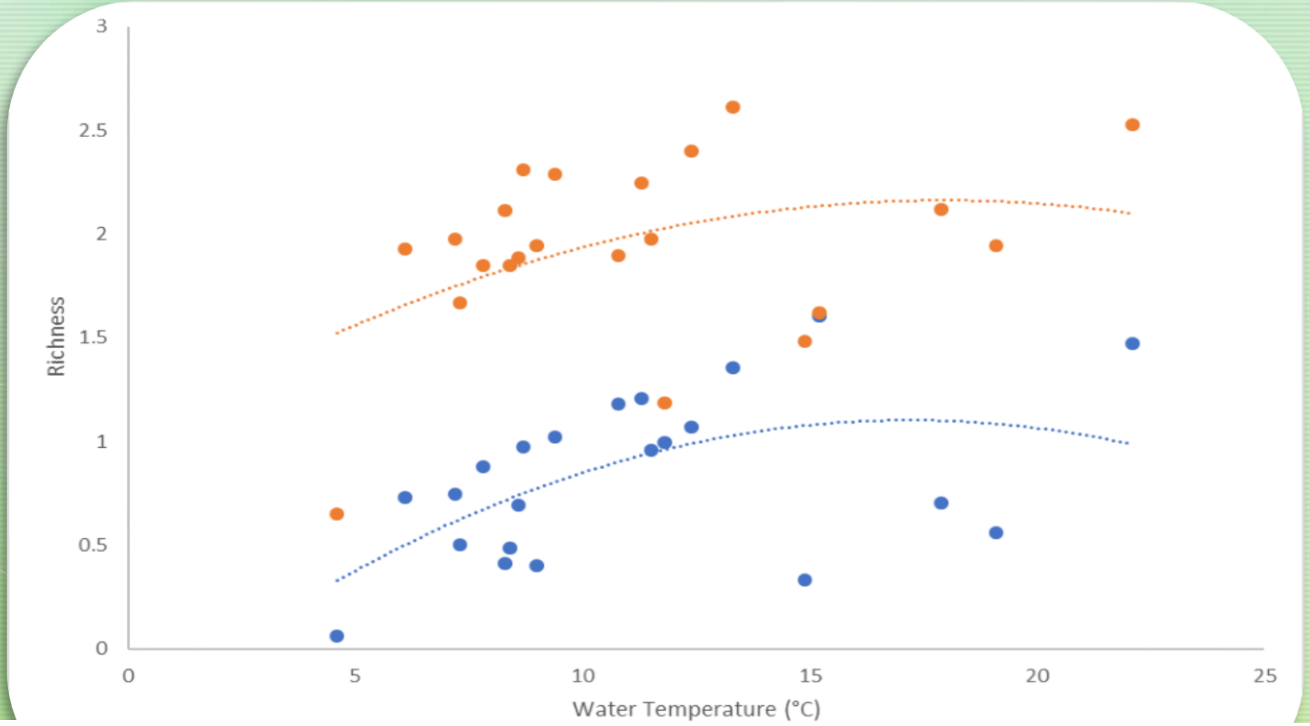
Legendre (2008)

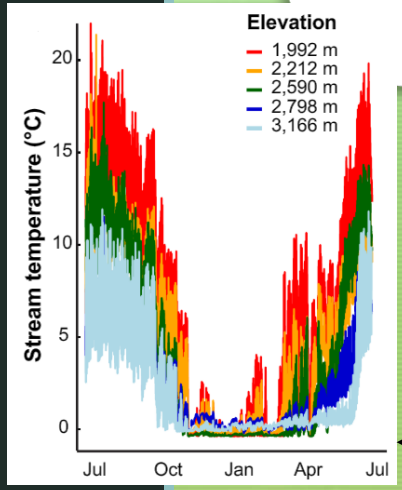
What is the traits' distribution?

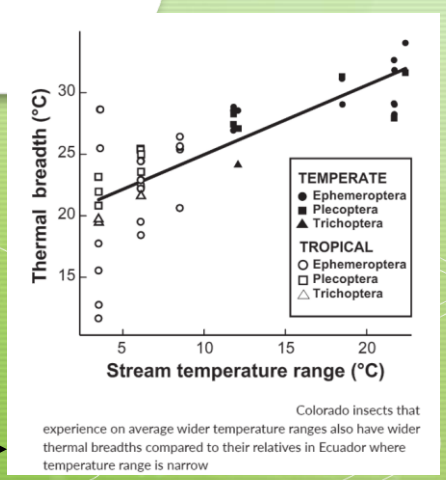


Poff et al (2006)

What about Water temperature?

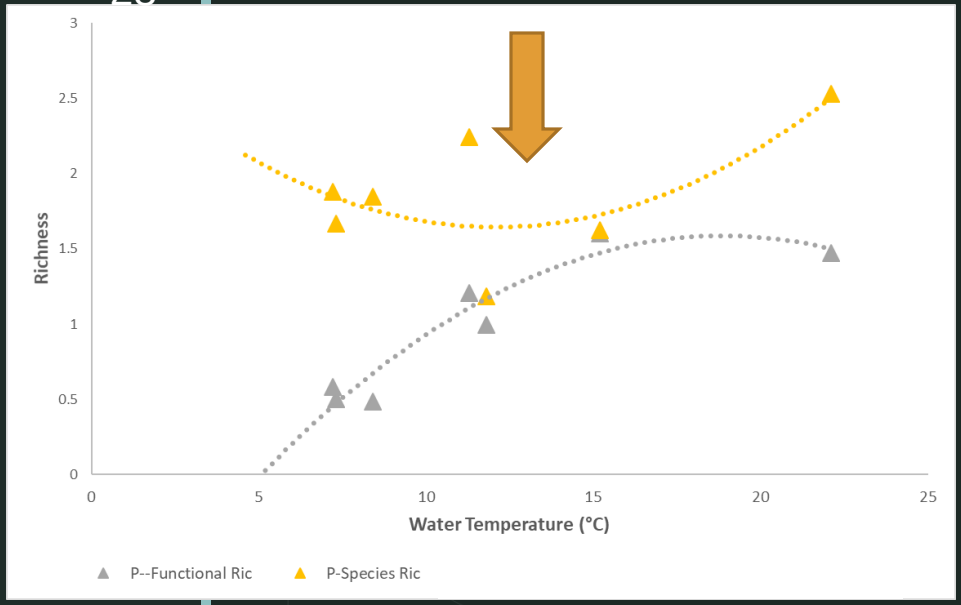


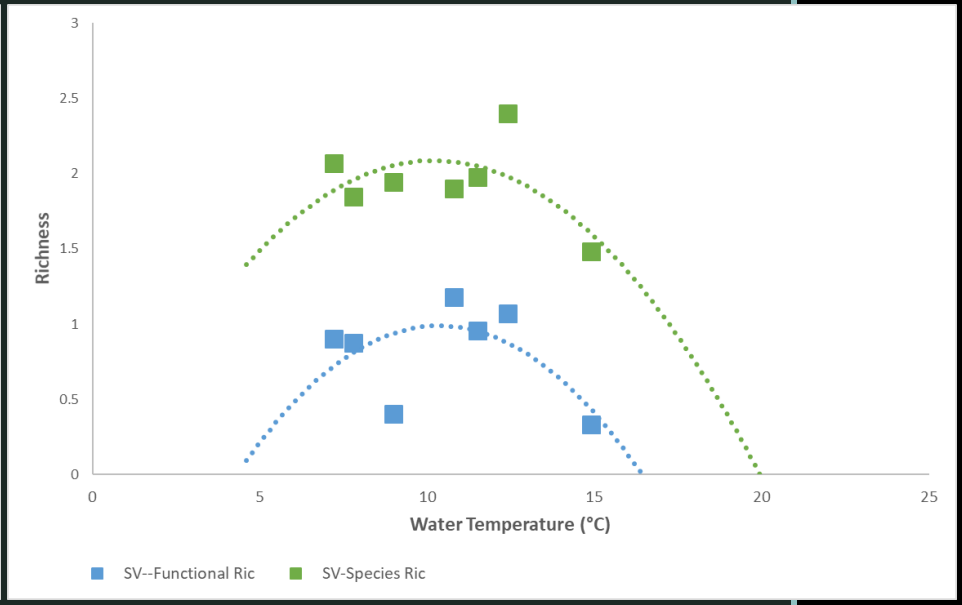


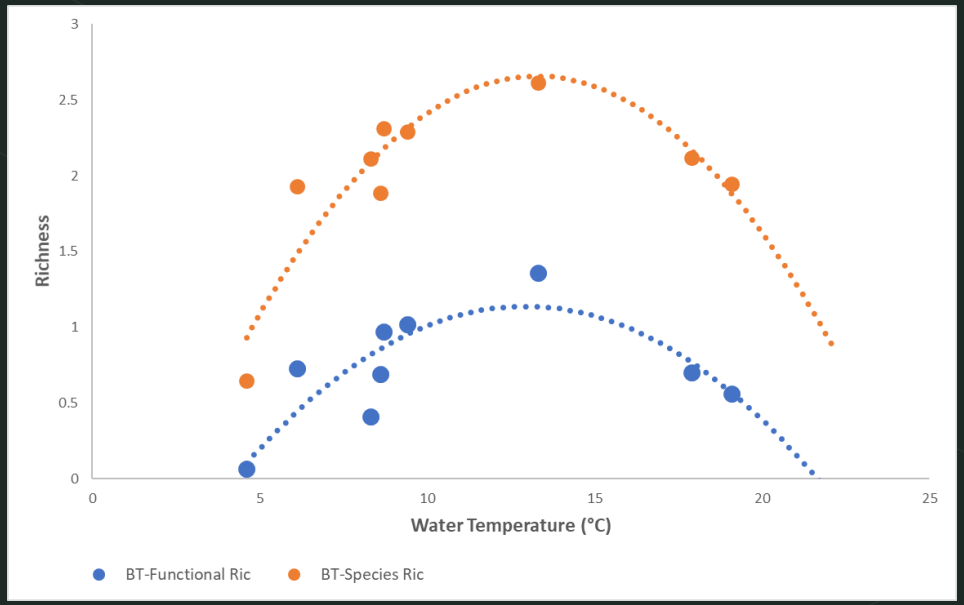


Colorado insects that experience on average wider temperature ranges also have wider thermal breadths compared to their relatives in Ecuador where temperature range is narrow

Source: Shah et al. (2017)


Richness
Water Temperature (°C)
P--Functional Ric
P-Species Ric

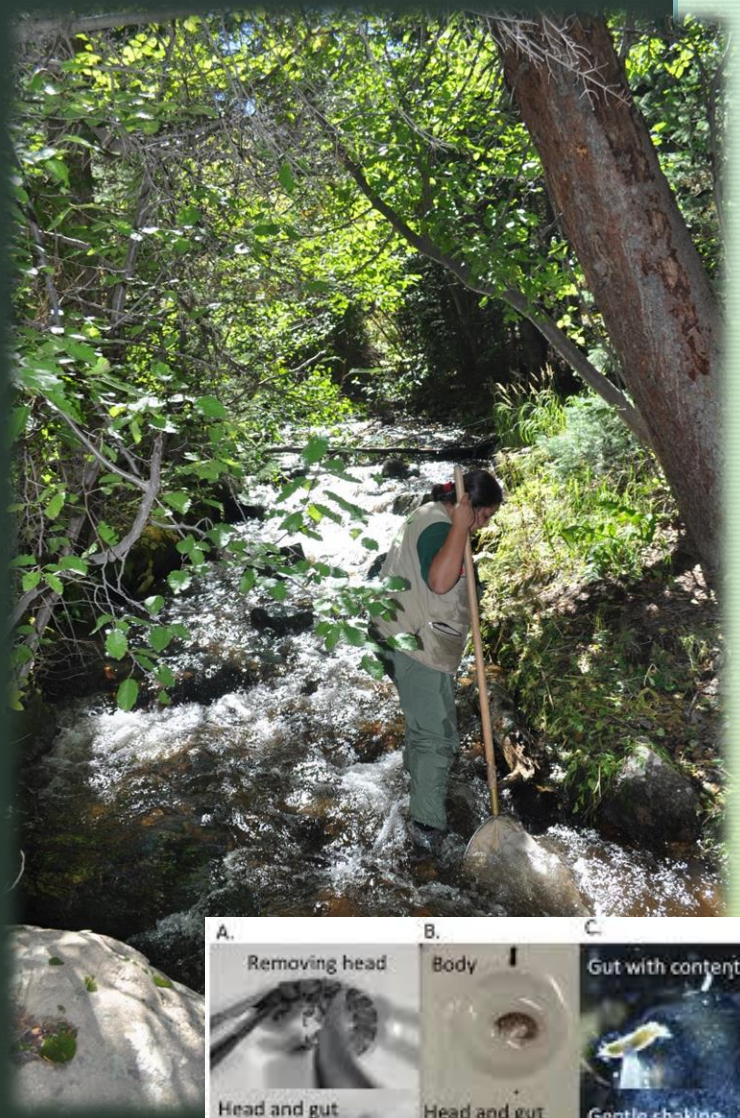

Richness
Water Temperature (°C)
SV--Functional Ric
SV-Species Ric


Richness
Water Temperature (°C)
BT-Functional Ric
BT-Species Ric

Sampling sites in Colorado

COLORADO (Poudre Drainage)

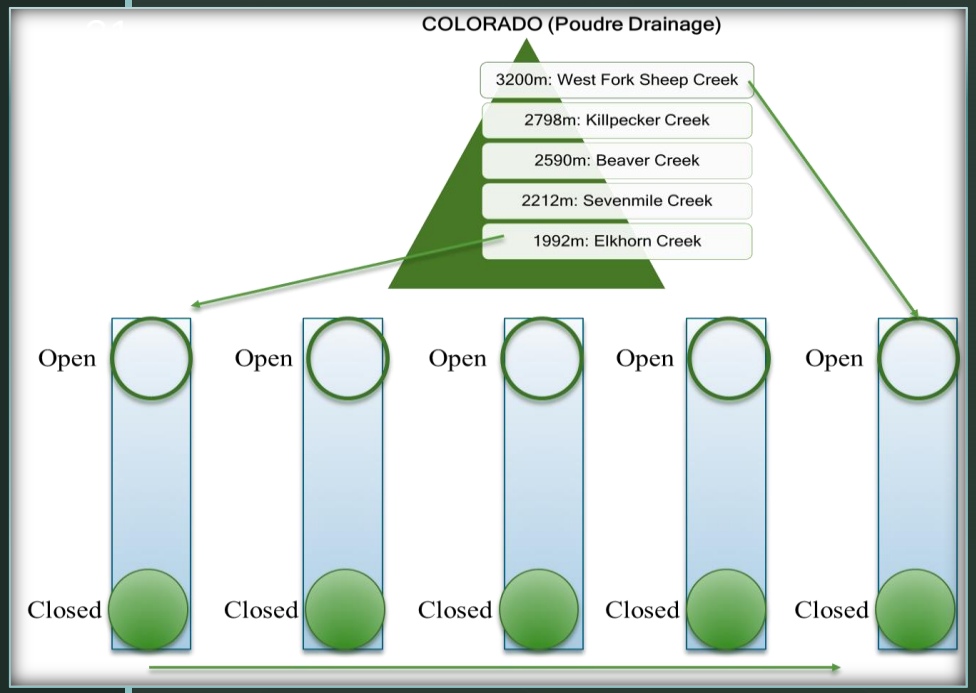
- 3200m: West Fork Sheep Creek
- 2798m: Killpecker Creek
- 2590m: Beaver Creek
- 2212m: Sevenmile Creek
- 1992m: Elkhorn Creek



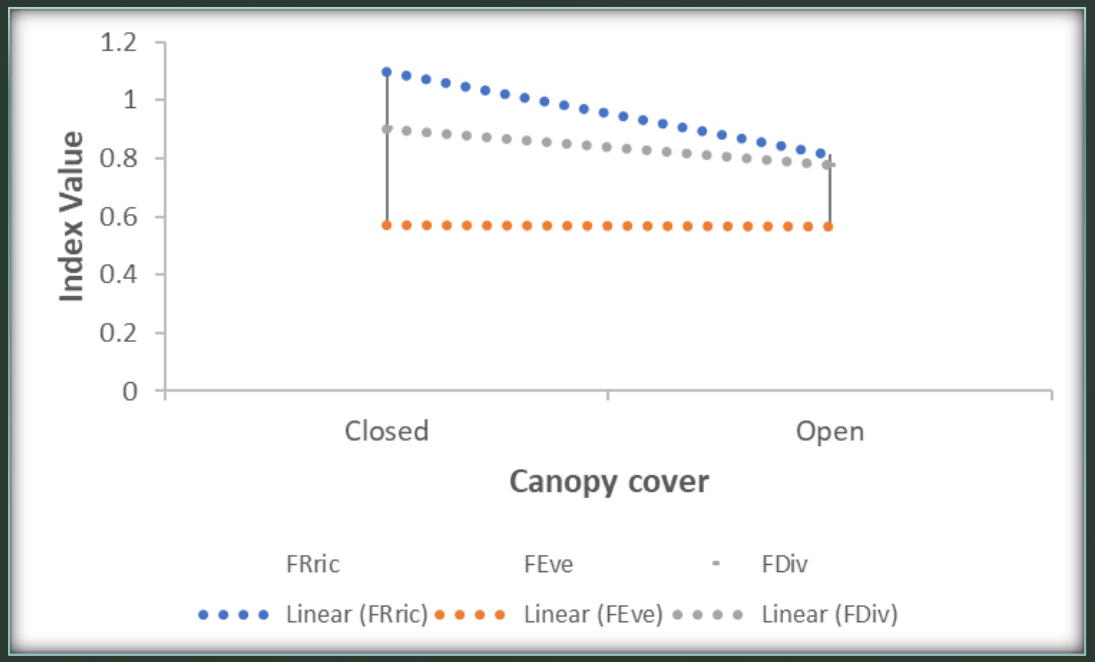
Summer 2013

Data Analysis

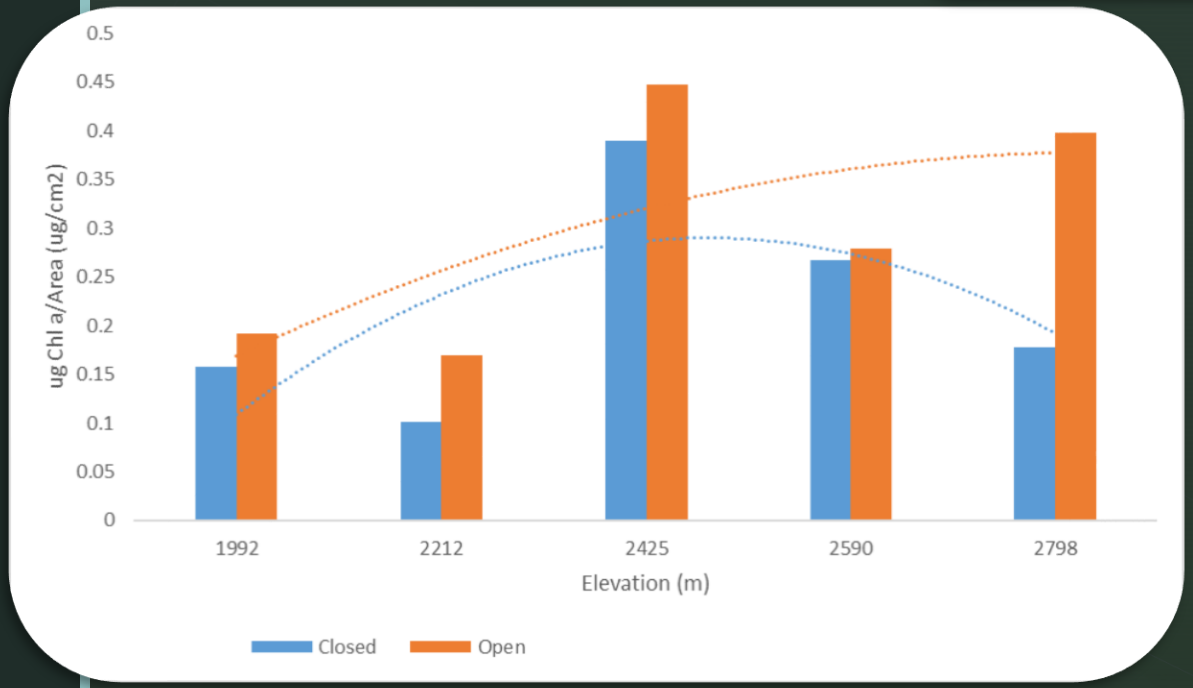
- Functional Diversity Metrics (FRic, FDiv, FEve)
- Binary matrix of predator vs. prey.
- Estimated ten attributes of the trophic networks according to Dunne et al. (2002) and Bersier et al. (2002).
- All trophic analyses and trophic models were performed in the Network3D program (Yoon et al., 200; Williams, 2010).
- Discriminant analysis was performed using mean values of gut content area to evaluate the variation in the composition of the food resources consumed at the different sites. (RWizard 2.3 - Guisande *et al.,* 2016).



What about canopy cover?

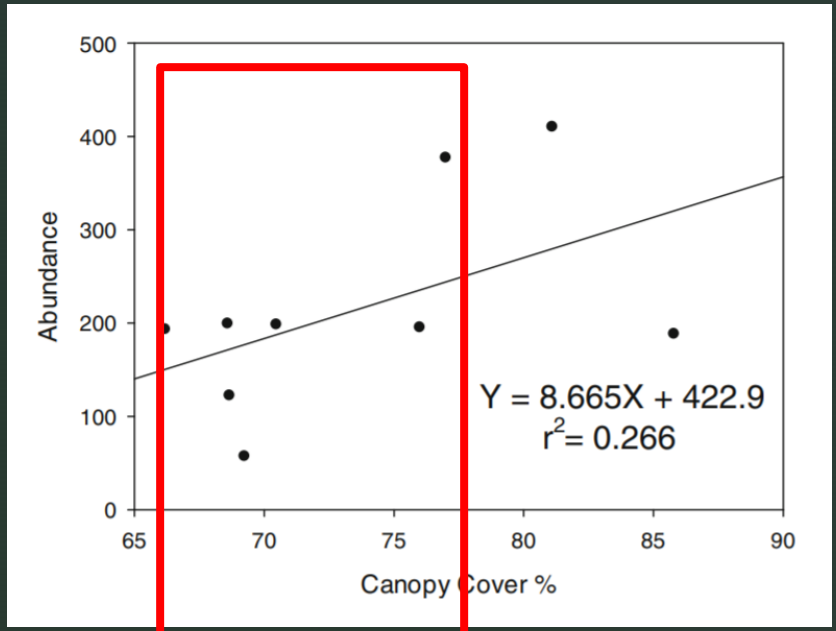


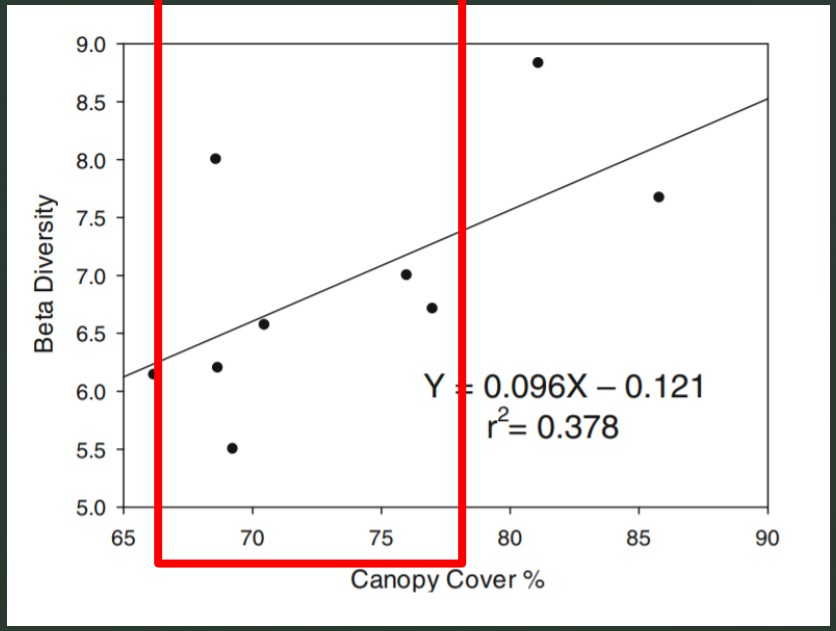
What about resources?: Chl *a*



Chl *a* concentracion increases with elevation in open canopy areas

- Highest abundance between 68%-78% canopy cover.





Take home messages

- Functional Richness of the aquatic insect community decreased significantly with increasing elevation in RMS.
- Highest Functional Richness in two out of our three drainages of study (Big Thompson and Saint Vrain) was observed **between 8ºC and 15ºC.**
- Highest Functional Richness and Diversity on **closed canopy areas (65%-78% cover)**
- .Traits with the highest influence on variability in the community of insects in the RMS studied were those related to:
  - Voltinism
  - Adult life span
  - Synchronization of emergence
  - Adult ability to exit
  - Development
  - Ability to survive desiccation
  - Female dispersal

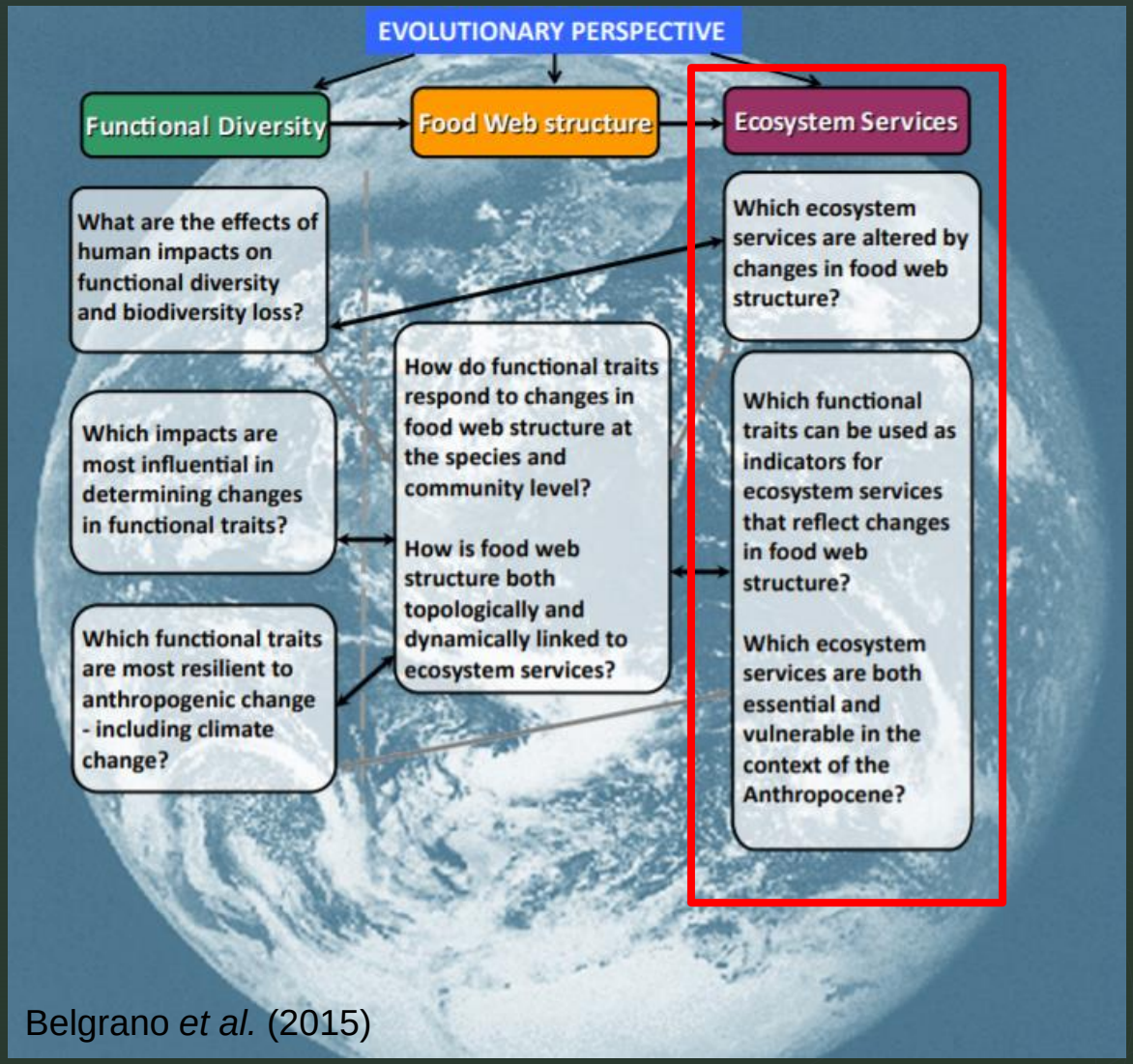
Take home messages

- Findings support the previous understanding that small tributary streams, despite having low individual α-diversity, exhibit high β-diversity collectively (Clarke et al., 2008; Finn et al., 2011).
- This study seems to be the first to evaluate aquatic insect community assembly using functional α and β diversity partition analysis in Rocky Mountain Streams.
- It is likely that **local environmental** conditions are associated with functional assemblage structure, and functional groups turnover according local environmental conditions, and there is some degree of nestedness in this pattern.

Future work

- Context of results along gradients comparing mountain temperate streams vs. tropical mountainous streams in the Ecuadorian Andes.
- Implications for headwater stream ecosystem management and conservation in lieu of vulnerabilities of the functional structure of aquatic insect communities.
- Addressing the challenges in the Anthropocene…

Future work



Belgrano *et al.* (2015)

Acknowledgements…

EVOTRAC

Evolutionary and Ecological
Variability in
Organismal
Trait
Response with
Altitude and
Climate

- Boris Kondratieff
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- David Martin
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- Alisha Shah
- Brian Gill
- Erin Larson
- Amanda Rugenski
- Carla Atkinson
- Poff Lab members since 2011 to date!

Thanks for listening!

Questions?