



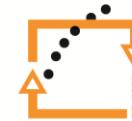
evropský  
sociální  
fond v ČR



EVROPSKÁ UNIE



MINISTERSTVO ŠKOLSTVÍ,  
MLÁDEŽE A TĚLOVÝCHOVY



OP Vzdělávání  
pro konkurenční schopnost

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

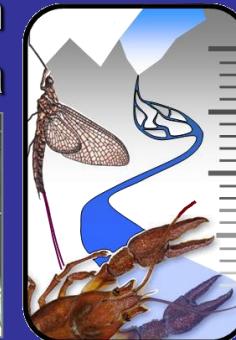
**Inovace studia hydrobiologických disciplín s důrazem na rozšíření možností uplatnění absolventů biologických oborů PřF UP v praxi.**

**reg. číslo: CZ.1.07/2.2.00/28.0173**

# Fundamental and Applied Research – freshwater ecology as a combining issue

**Leopold Füreder**

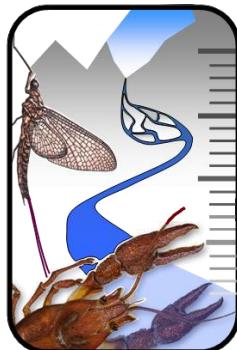
River Ecology and Conservation  
Institute of Ecology, University of Innsbruck, Austria





## River Ecology and Conservation

### Research group: River Ecology and Conservation



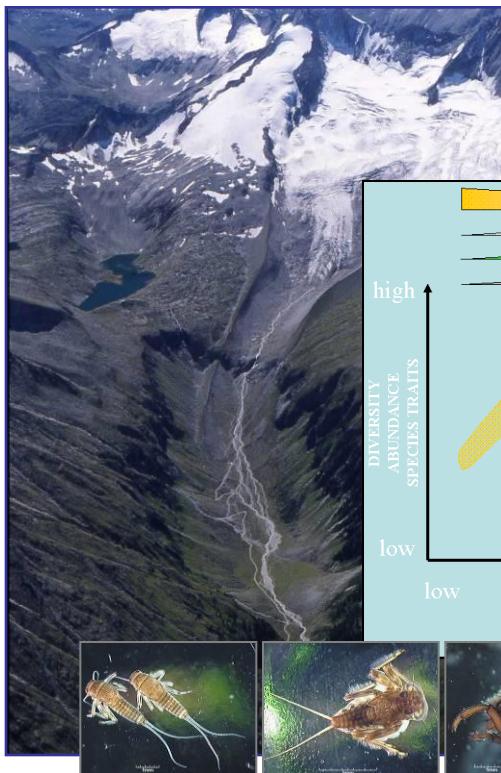
Keywords of research: *alpine river ecology, glacier-fed rivers, spring habitats, invertebrate taxonomy, tropical ecology, food and feeding ecology, adaptation, environmental (climate) change, anthropogenic impacts (landuse, hydropower), riverine landscape fragmentation and connectivity, aquatic conservation, freshwater crayfish, invasive species, indicators, species – habitat, symbiosis*



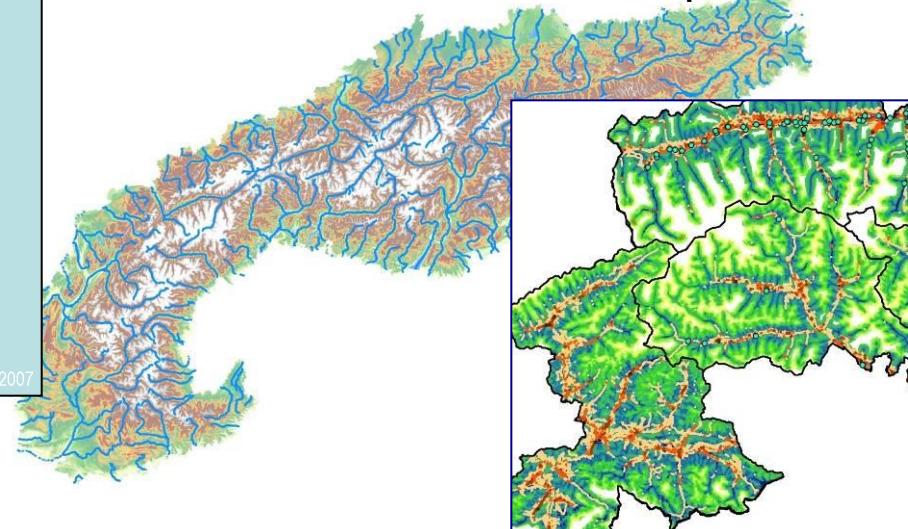
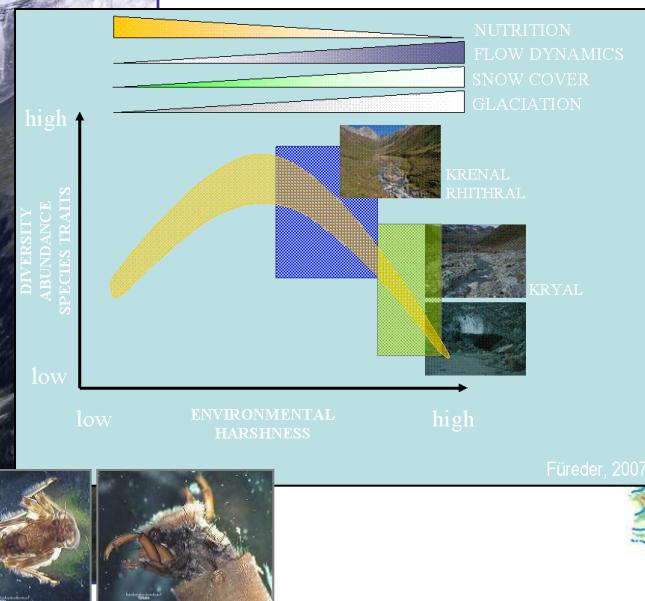


## River Ecology and Conservation

Research focus: Alpine river ecosystems – indicators of change



● river ecosystems and invertebrates  
as indicators for environmental  
(climate) change



Research topics:

- Tools for Long Term Ecological Research
- Functional organisation of freshwater communities
- Riverine Landscape: fragmentation and connectivity



# River Ecology and Conservation

## Research focus: Freshwater Crayfish - Aquatic conservation

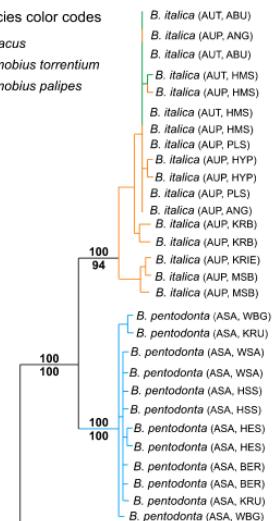
Crayfish as surrogate species  
 - indicators, keystones, flagships, umbrellas, targets



Crayfish – annelid symbionts

Crayfish species color codes

- *Astacus astacus*
- *Austropotamobius torrentium*
- *Austropotamobius pallipes*



*Branchiobdella italica*



*Branchiobdella pentodonta*



Research topics:

- Tool-box for indigenous crayfish conservation
- Functional role of freshwater crayfish
- Crayfish and their symbionts



## River Ecology and Conservation

### Research focus: Habitat assessments and benthic surveys



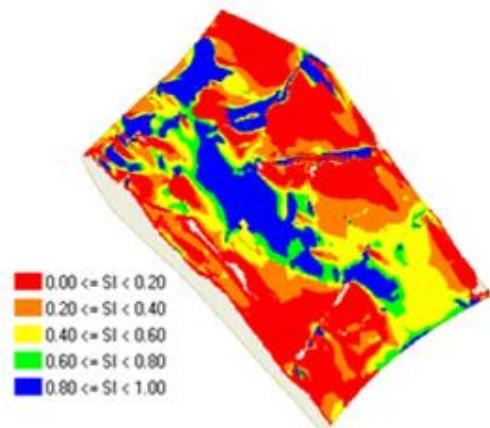
#### Surveys river ecology

- theoretical and practical training in habitat assessments, field and lab methodology, taxonomy of benthic invertebrates, Fauna Aquatica Austriaca, WFD implementation, etc.



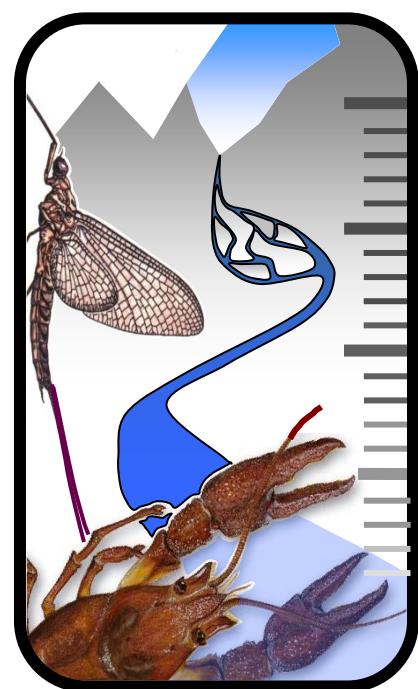
#### Quality test laboratory

- Austrian River Assessment Strategy, WFD - Ministry



### Research topics:

- Indicator quality of benthic invertebrates
- Species traits
- CASiMiR and benthic invertebrates



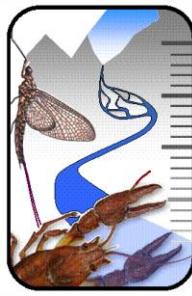
# Research Group

# River Ecology and

# Conservation

*Stefanie Aumayr, Martin Baldes, Christian Berger, Rainer Burger, Andrea Bou-Vinals, Andreas Declara, Viktoria Ennemoser, Lukas Hörtndl, Thomas Kapl, Felix Lassacher, Alexandra Mätzler, Georg Niedrist, Dunja Peduzzi, Christine Rangger, Johannes Rusch, Martin Schletterer, Sabrina Schönenberger, Cornelia Schütz, Stefan Schütz, Daniela Sint, Karin Staudacher, Manfred Wallinger, Hiranthi Walpola, Martin Weinländer, Camille Welter, Wasantha S. Weliange, Ursula Windner, Astrid Zauner, Laura Zeh, Benedikt Zeindl, a.o.*

*University of Poitiers; University of Oslo; University of Leeds; University of Zagreb; University of Kelaniya; Stroud Water Research Center, PA; a.o.*



# Fundamental and Applied Issues

1. Biodiversity of freshwater ecosystems  
alpine – arctic – tropical
2. Indication of environmental change
3. Species conservation and protection measures

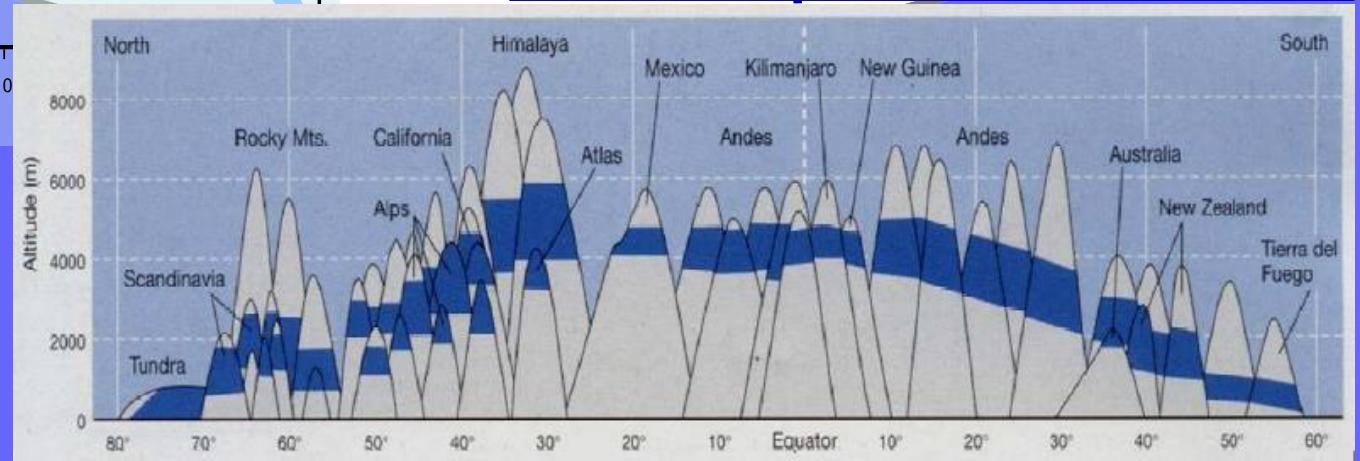
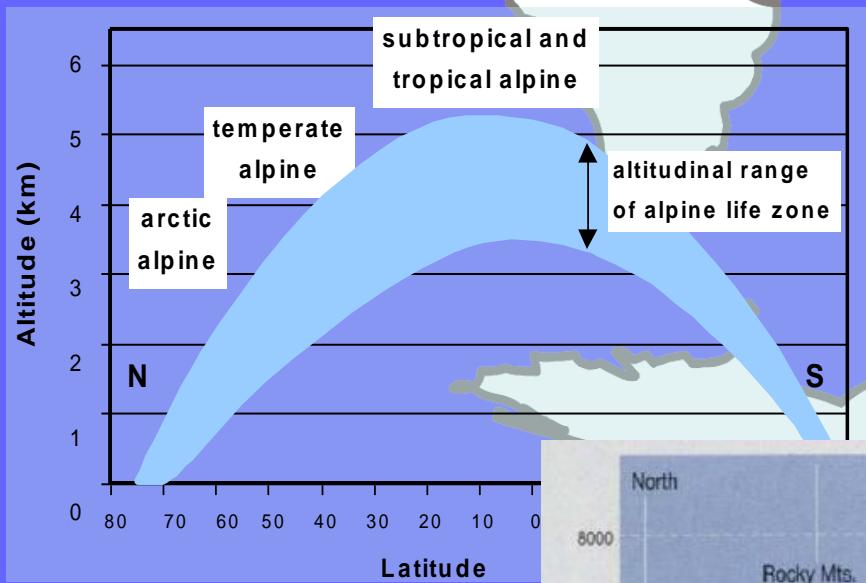
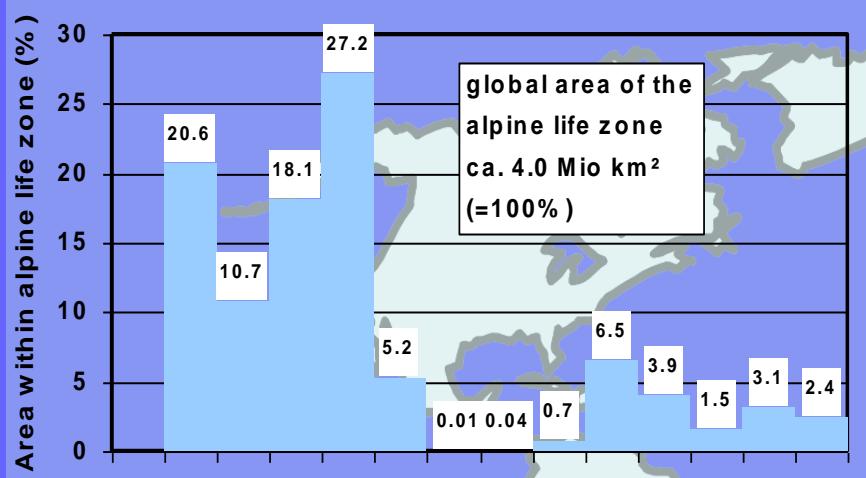
Svabard



Austrian Alps

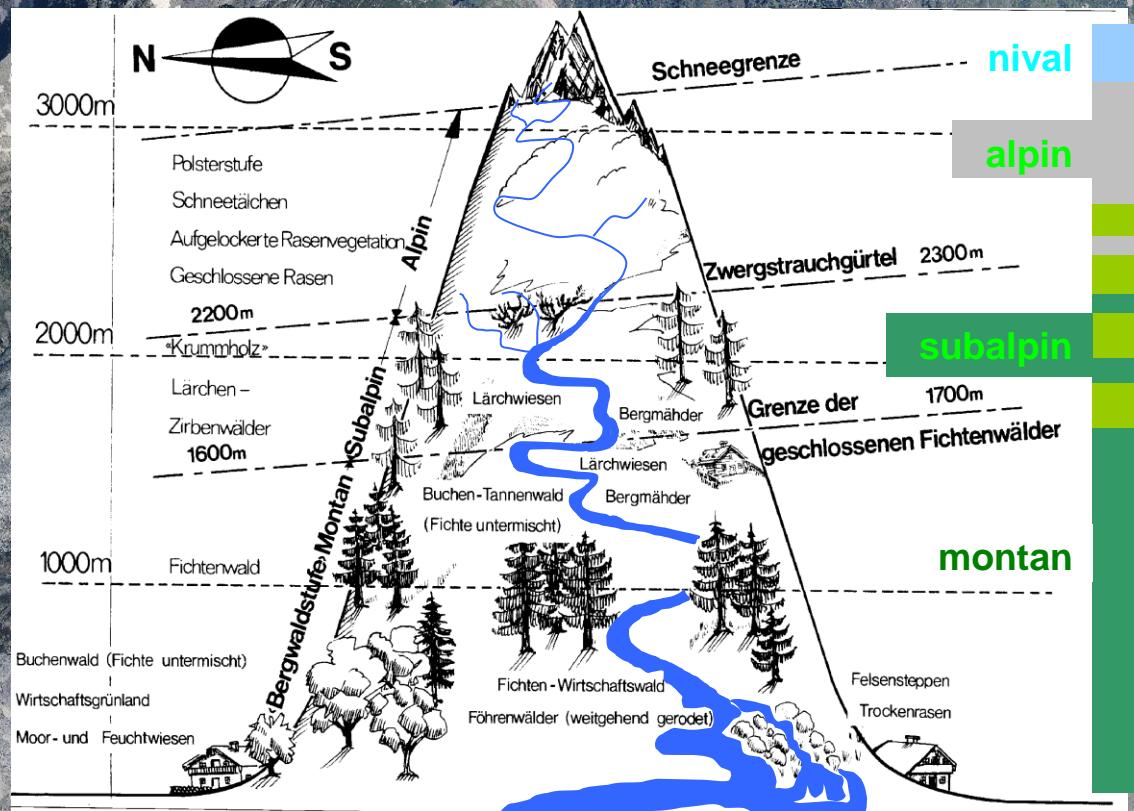


Costa Rica

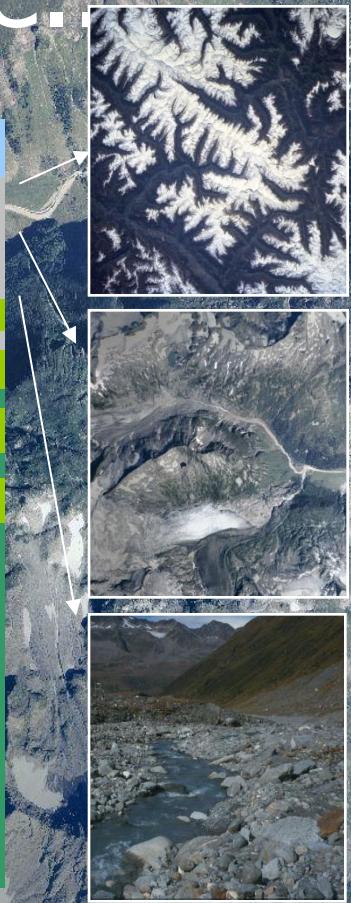


Körner (1999; 2003),  
Füreder (1999)

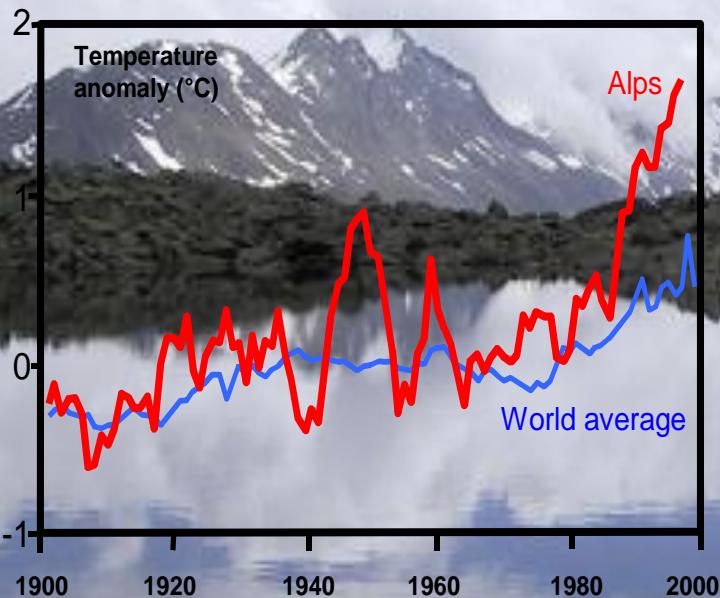
# Environmental harshness, vegetation, treeline.



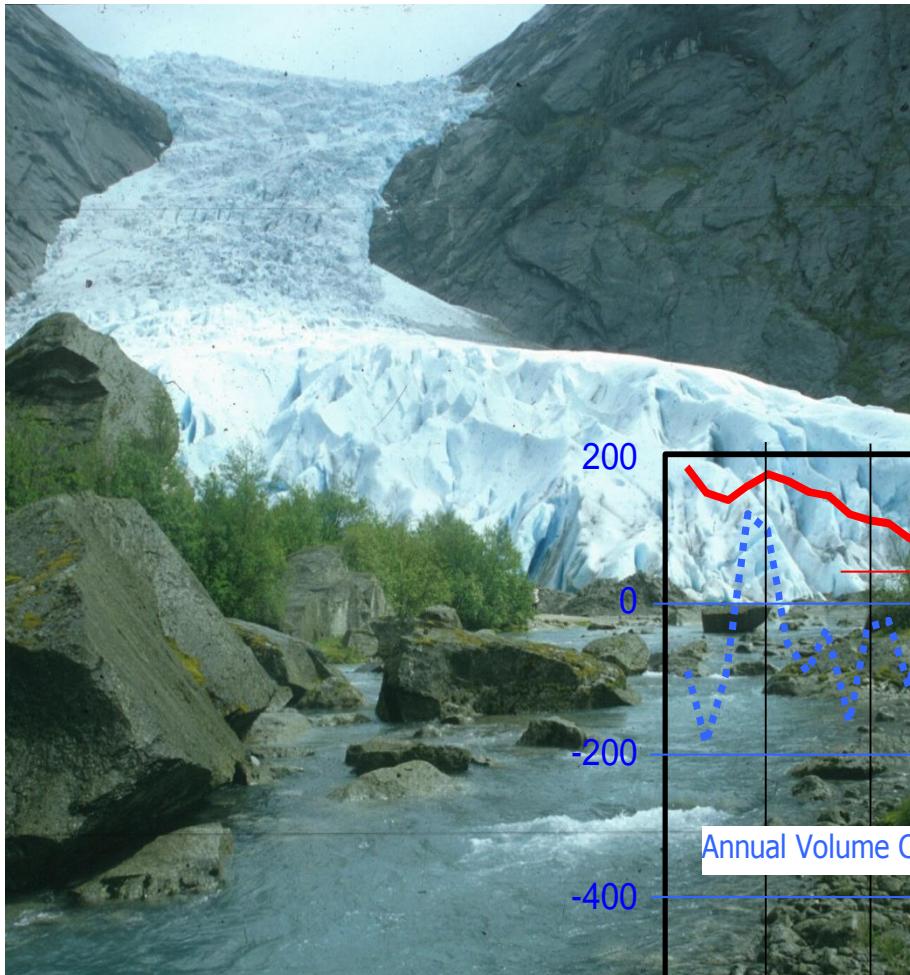
from Stüber & Winding (1990, modified)



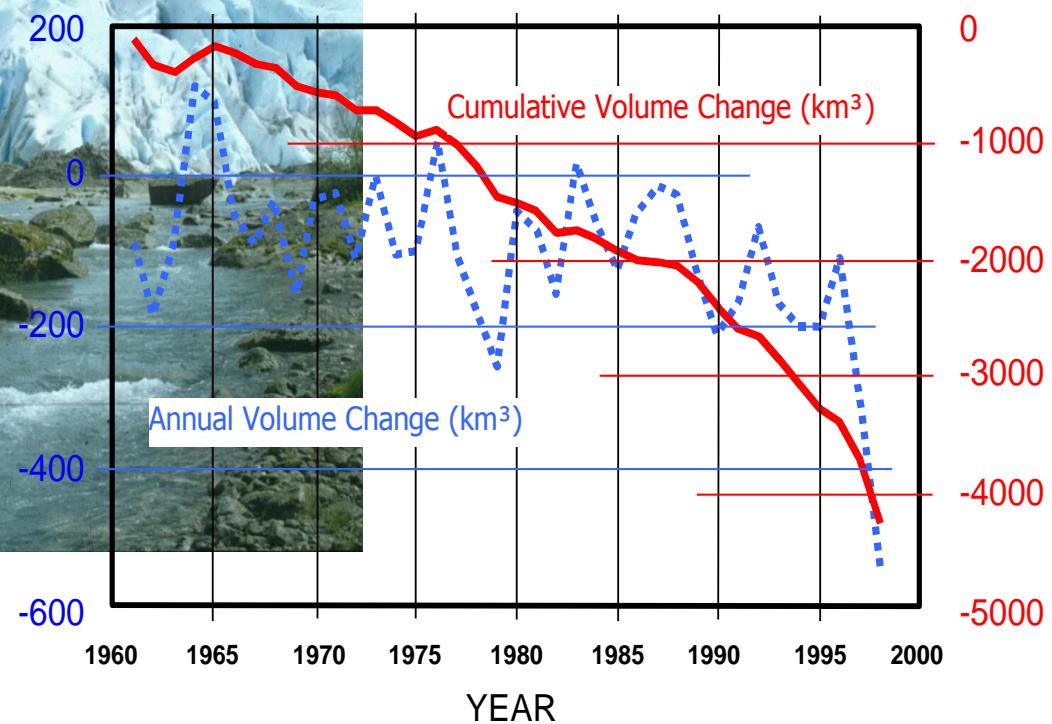
# Global warming



e.g. Benister (2002)



John Brittain, Oslo



*Biologists say climate change may already be affecting high-mountain ecosystems around the world, where plants and animals are adapted to cold, barren conditions now face higher temperatures and a surge of predators and competitors*

**All Downhill From Here?**  
Science 303 (2004)

# Alpine river systems

Alpine ecosystems have received considerable attention, glacial retreats - especially succession patterns of flora and fauna.

Rivers play an important role in these environments

- “landscape-engineering” role
- flooding
- solute transport and sedimentation
- land-water connectivity
- food-web links
- C-source and C-sinks
- ecosystem structure / function
- climate/environmental change



## *Species traits in the alpine stream fauna: a promising tool for freshwater monitoring*

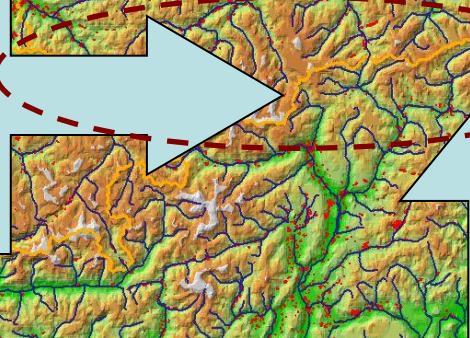
- Hydromorphology and ecology of alpine river ecosystems
- Species traits in the alpine stream fauna
- Environmental change and tools for freshwater monitoring





Füreder (1999): Types of alpine running waters  
(based on Illies, Steffan, Ward, Milner & Petts)

Biosphere Reserve  
“Gurgler Kamm”,  
Austria



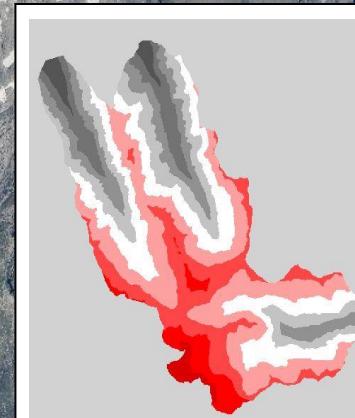
NP Hohe Tauern, Austria

NP Rieserferner-Ahrn, Italy

+ MZB-data from other  
investigations

# Alpine river typology

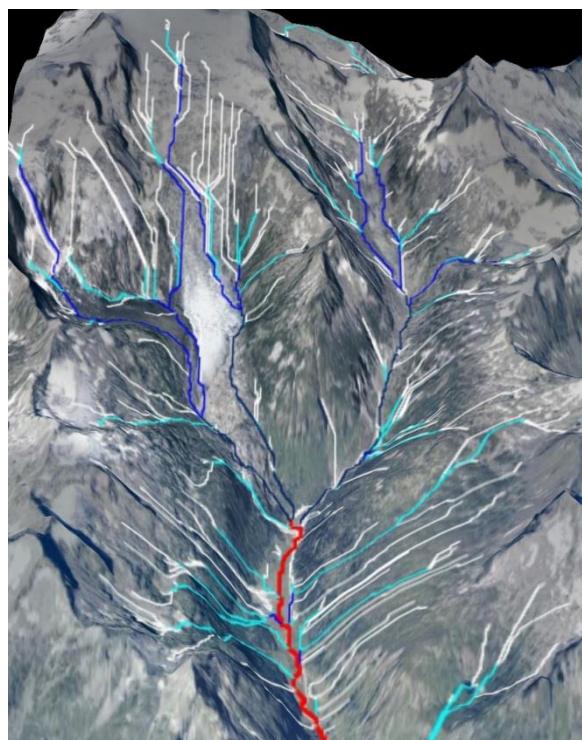
based on type-specific  
parameters (38 out of 61)



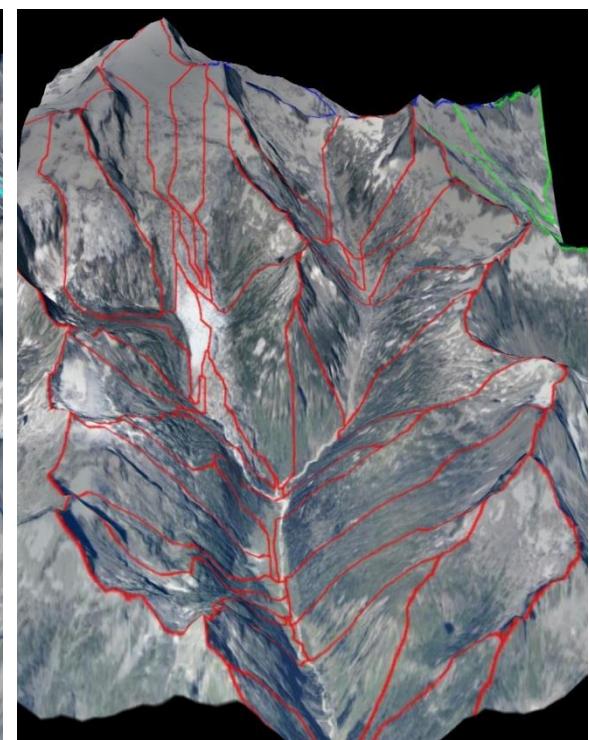
Altitudinal range



Gradient / Slope



Length / Order



Catchment size / Location



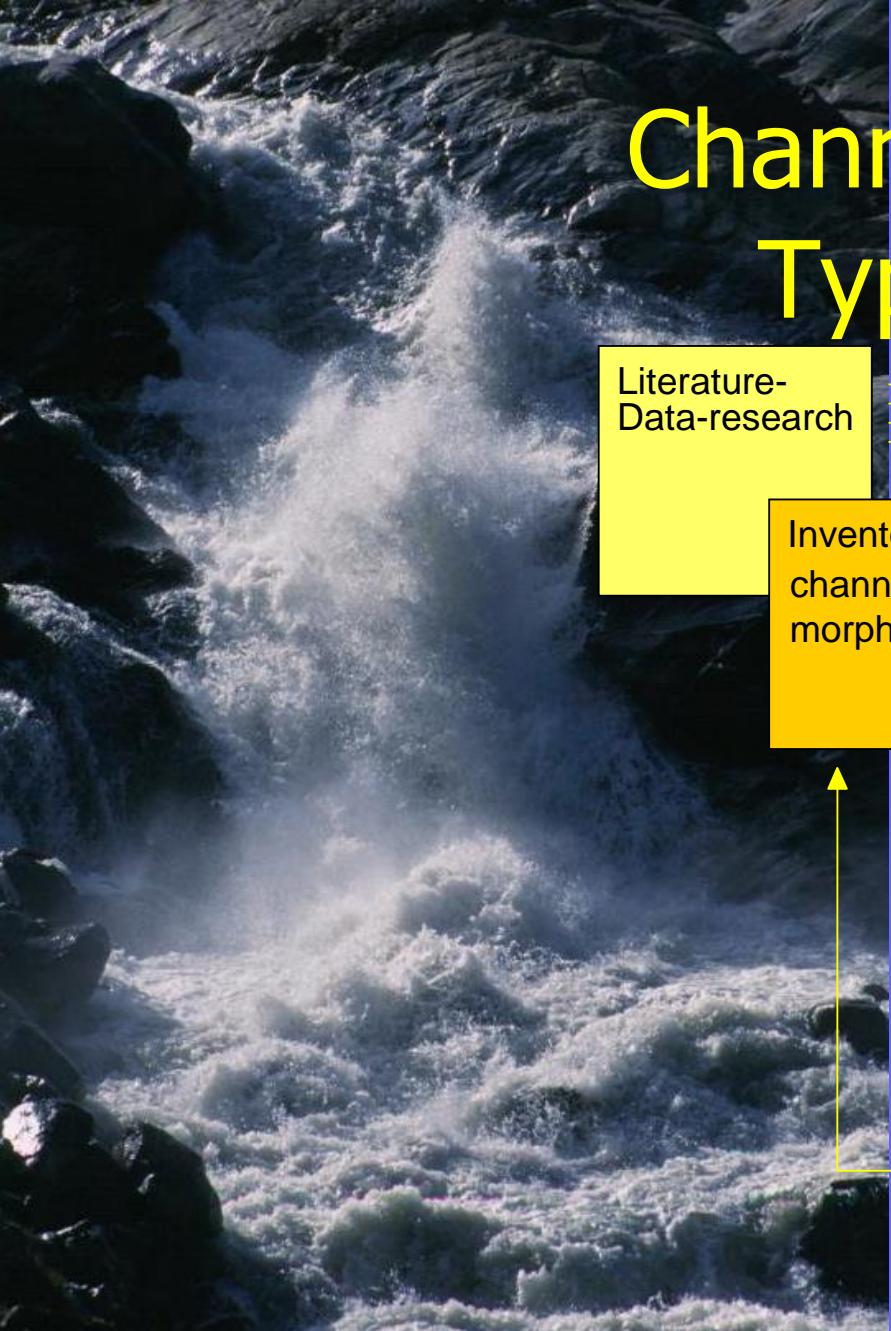
# Freshwater inventory – River morphology

## Hohe Tauern NP (A)

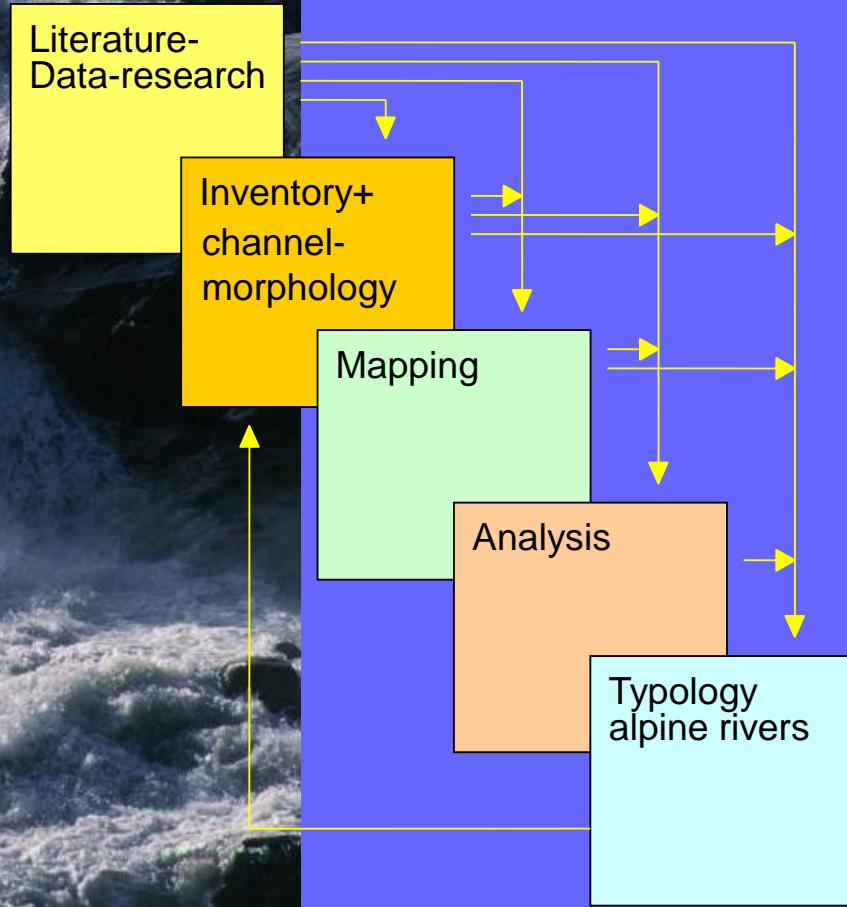
- 1787 Km<sup>2</sup>
  - 279 Rivers
- Catchment > 1 Km<sup>2</sup>  
(981 Km; 114 Km)

## Rieserferner-Ahrn NP (I)

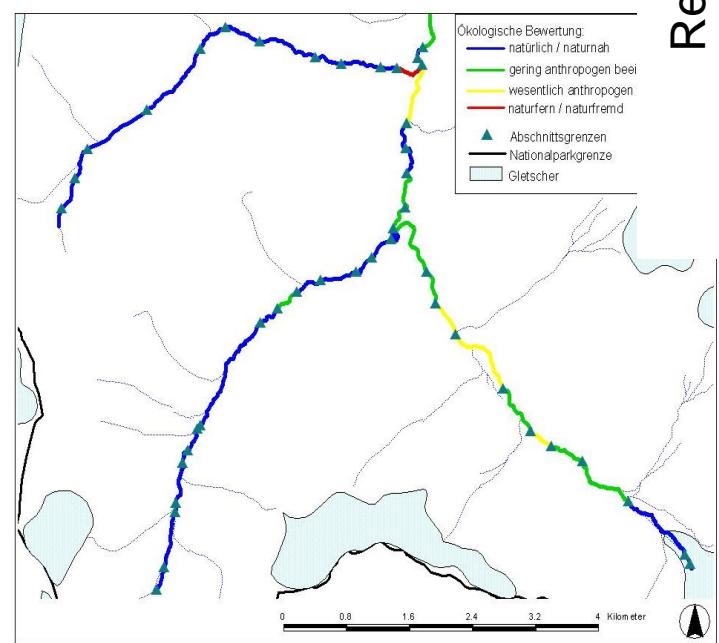
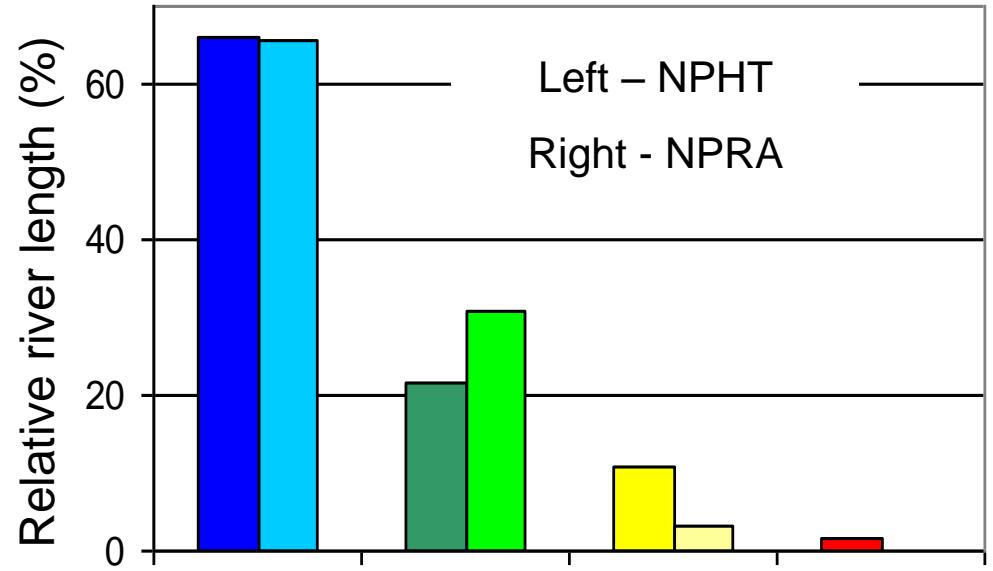
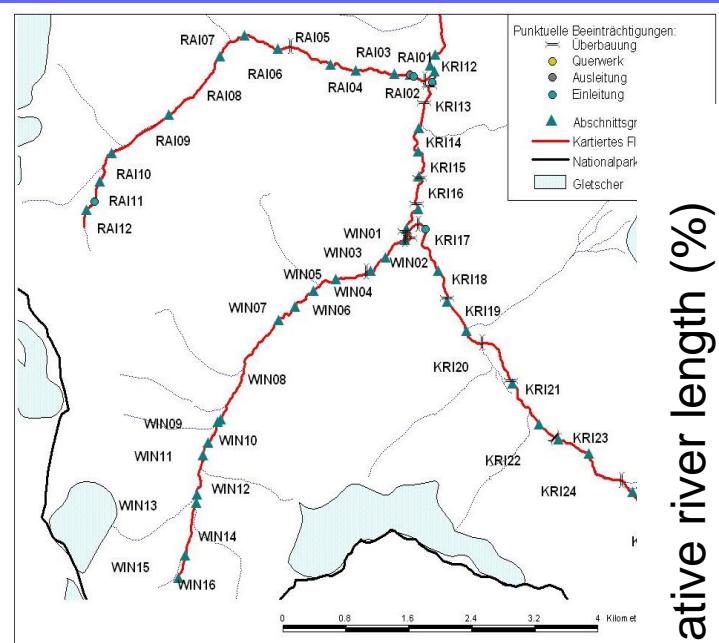
- 315 Km<sup>2</sup>
  - 65 Rivers
- Catchment > 1 Km<sup>2</sup>  
(178 Km; 71 Km)



# Channel morphology → Typology of rivers



Füreder & Amprosi (2001), Füreder et al. (2002)



## Habitat Integrity

# Integrity

# Hierarchial framework of river types

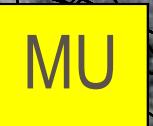
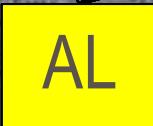
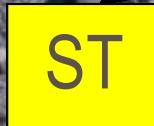
1. Origin  
(glacier, spring)

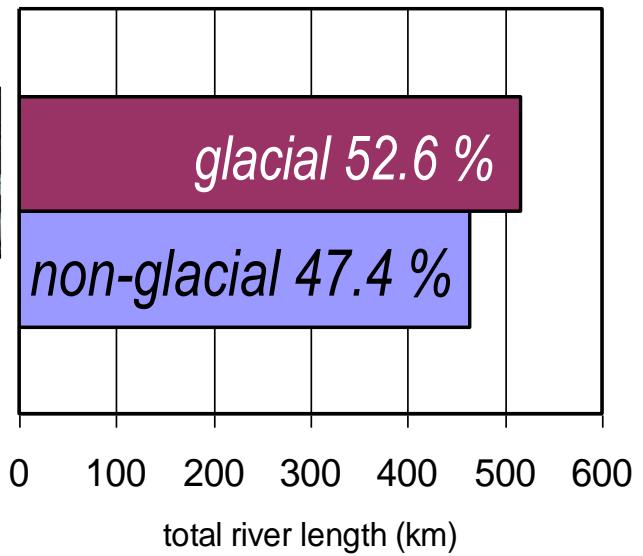
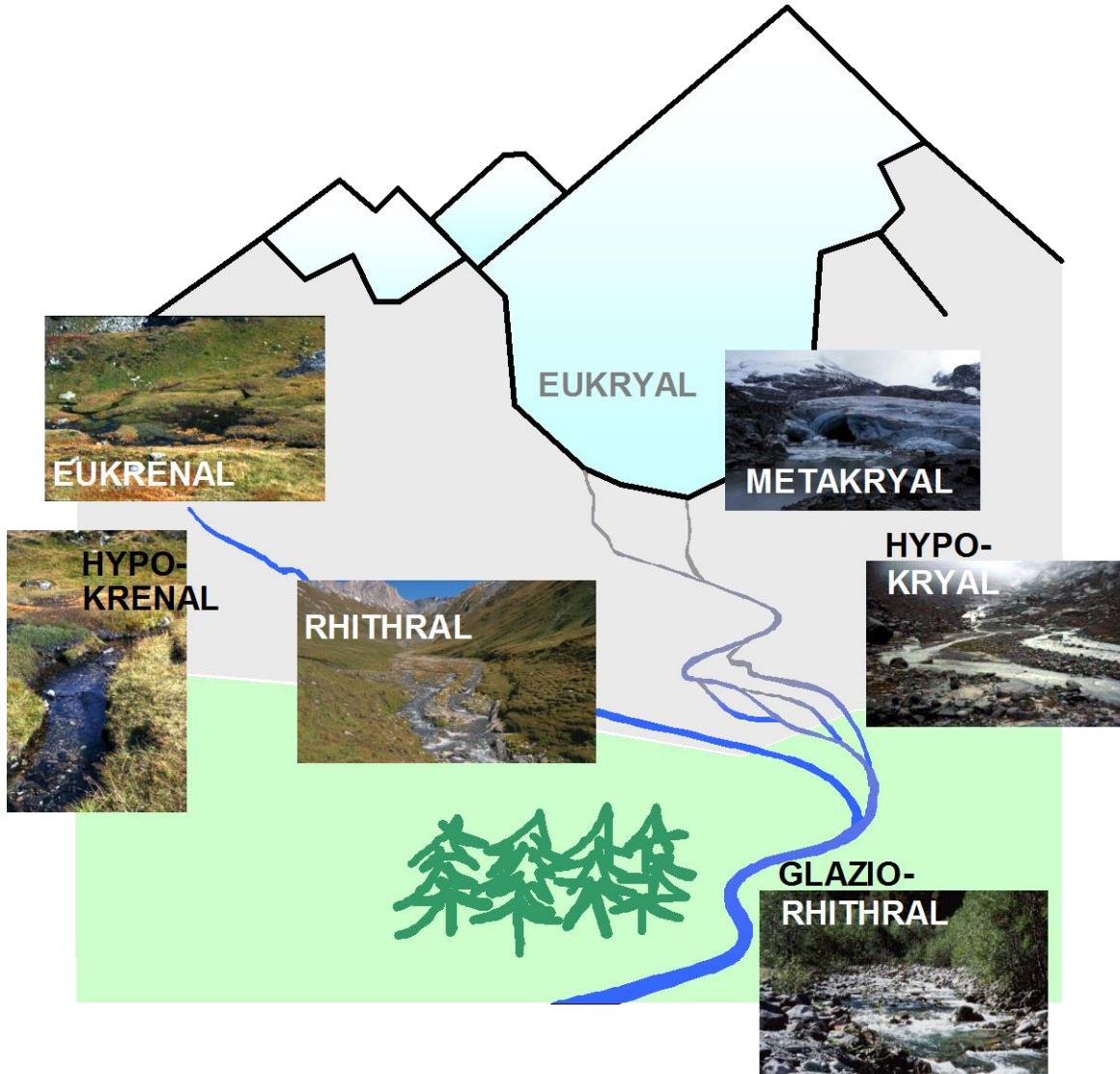


2. Location within  
river system



3. Hydromorphology  
(gradient, relief, habitat...)





Füreder (2006)

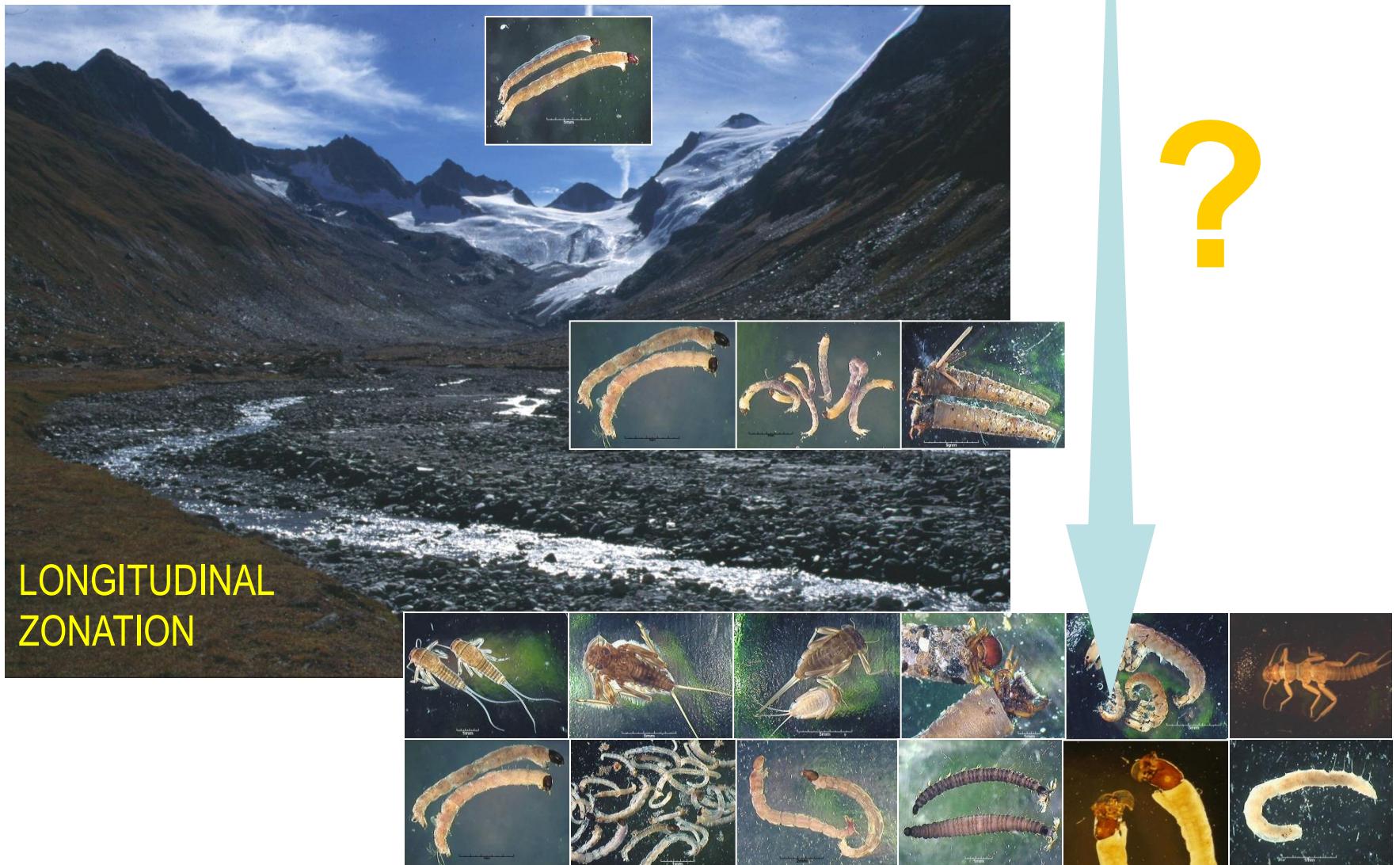






## LONGITUDINAL ZONATION





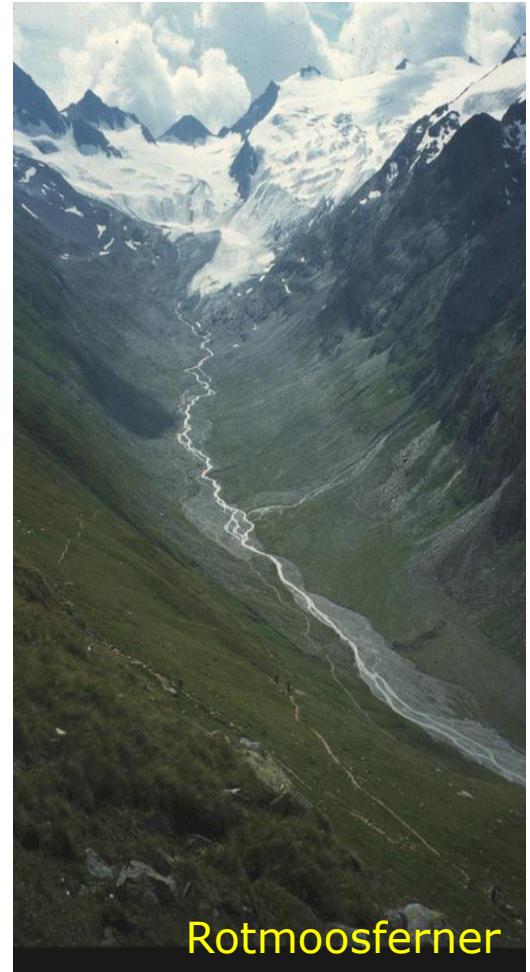
1850



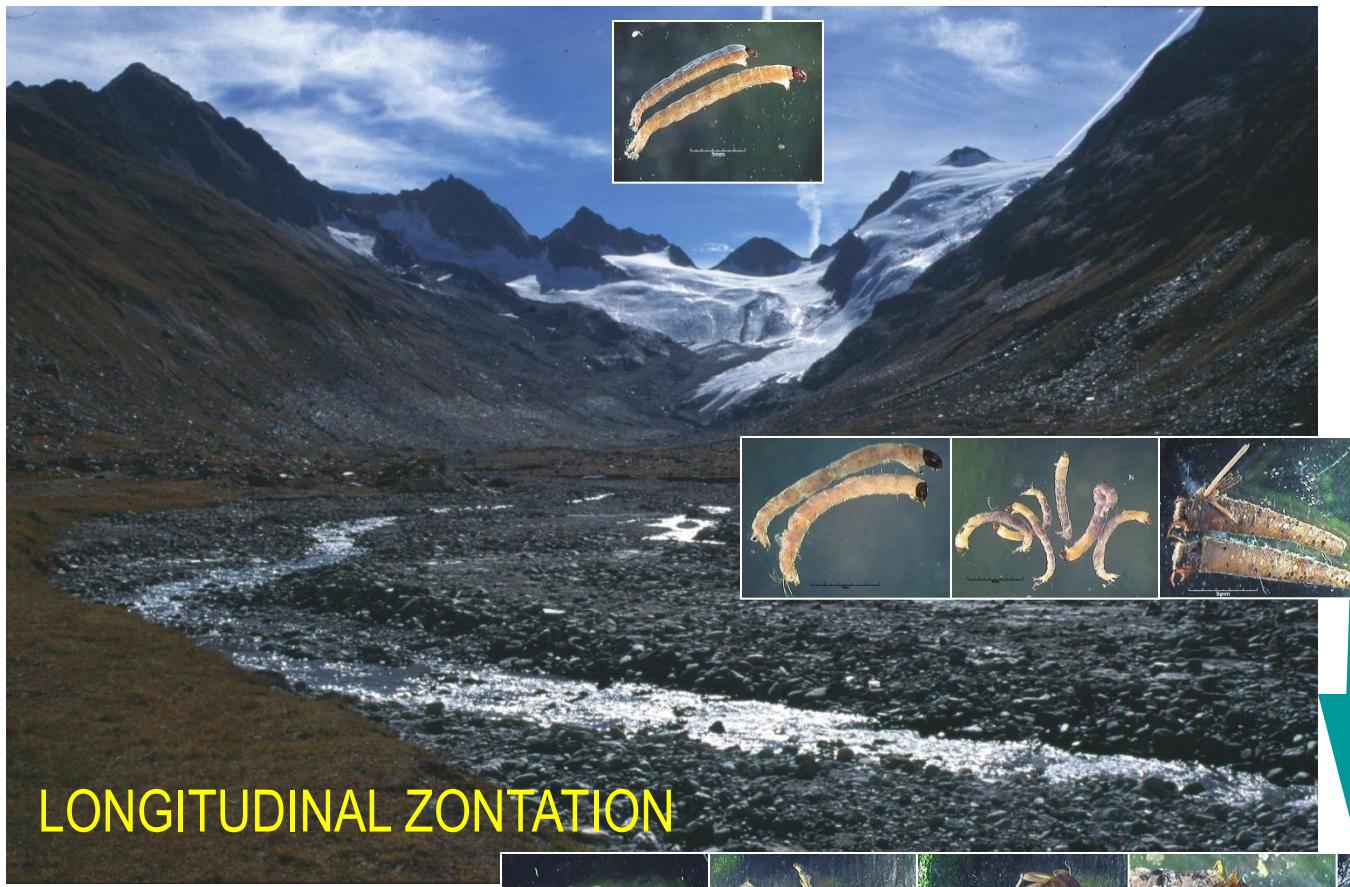
1920



1998



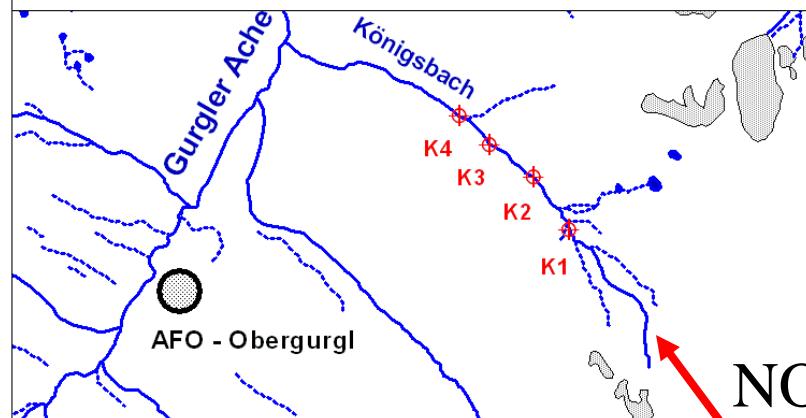
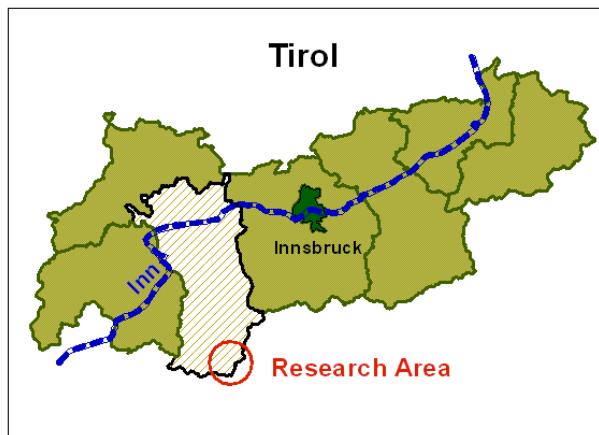
Rotmoosferner



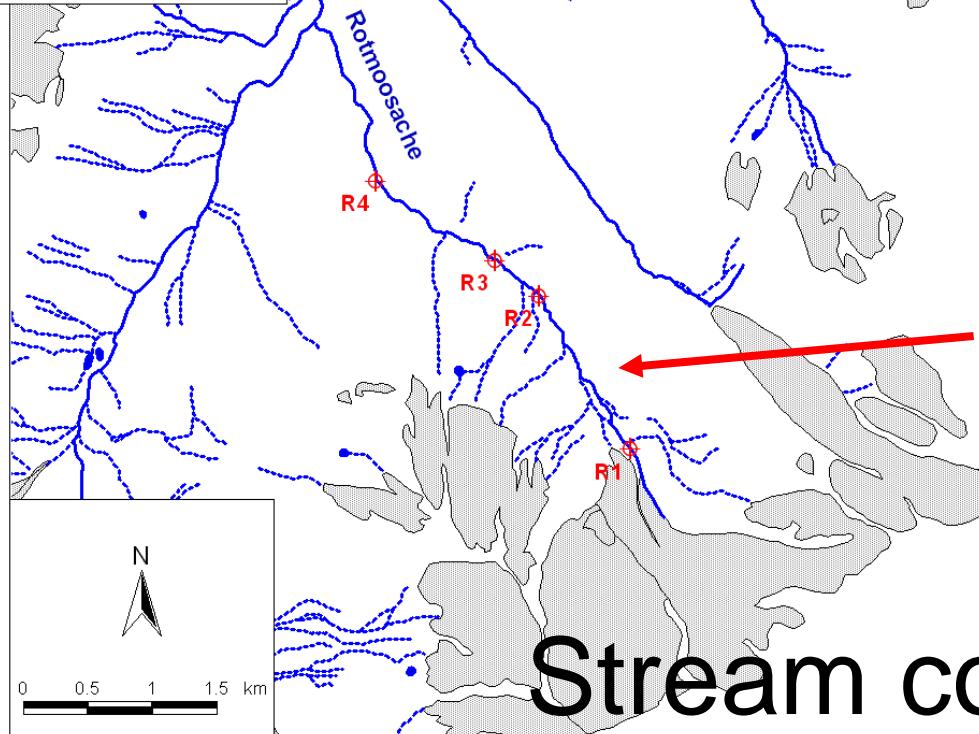
TIME SINCE LAST GLACIATION

LONGITUDINAL ZONTATION



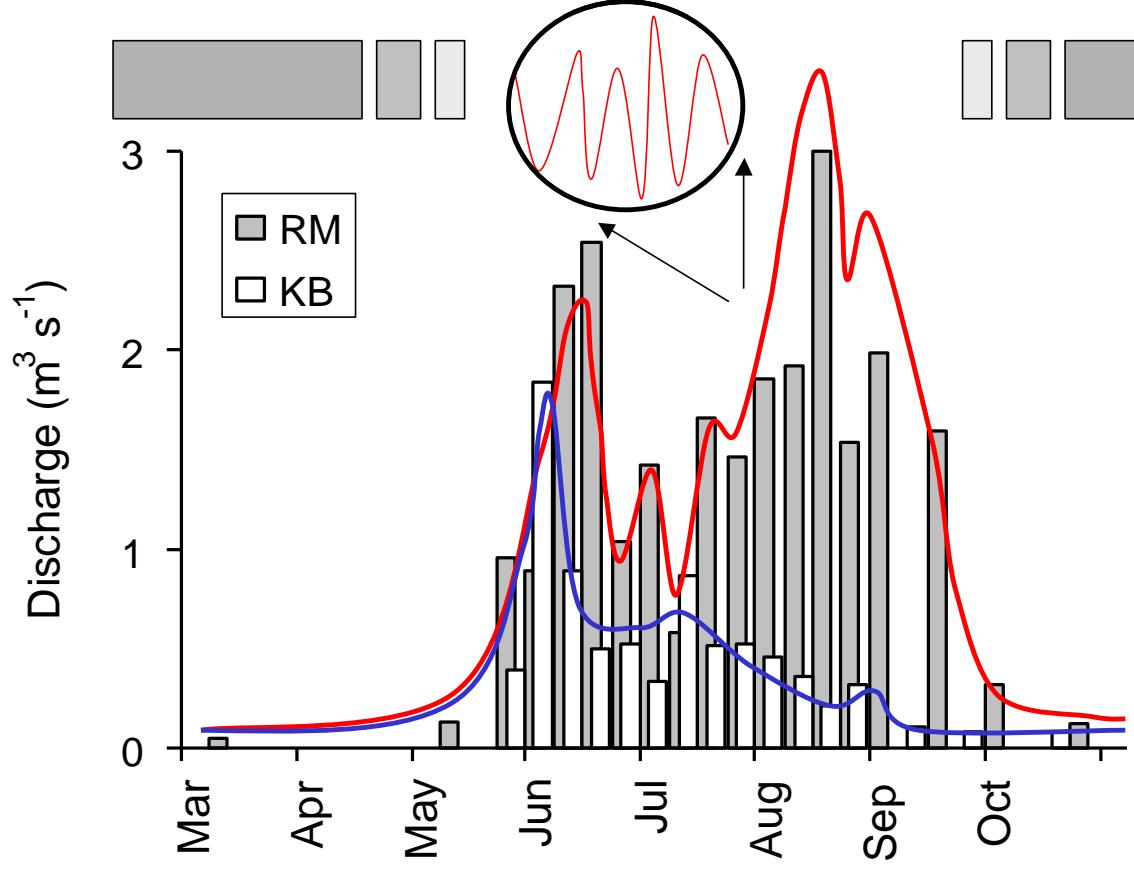


NON-  
GLACIAL

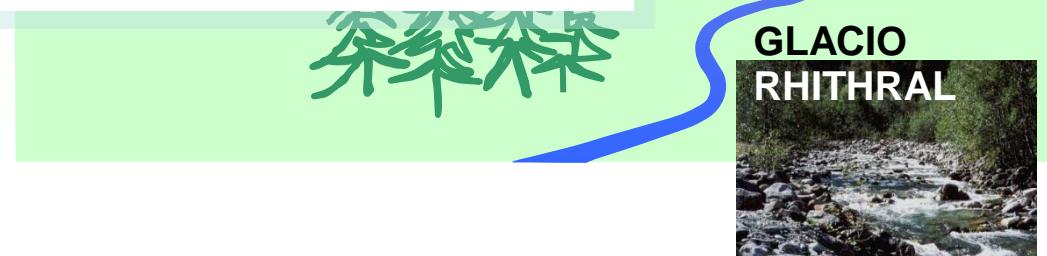


GLACIAL

Stream comparison

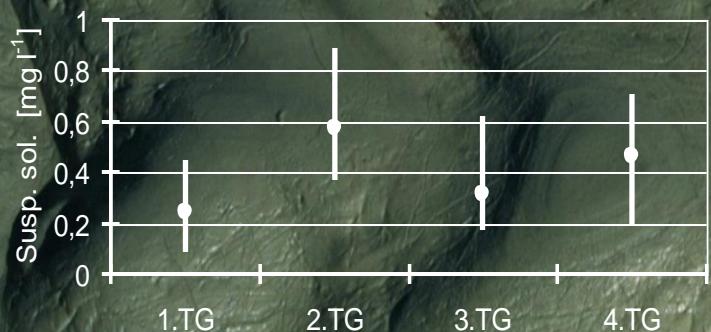


Füreder (1999)

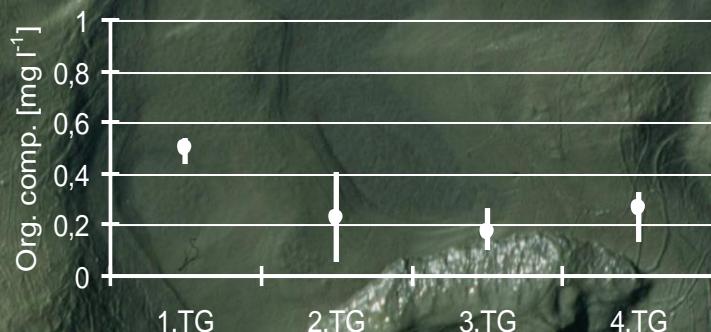


strong annual and diurnal dynamics  $\leftrightarrow$  better balanced

Königsbach (min.-mean-max.)



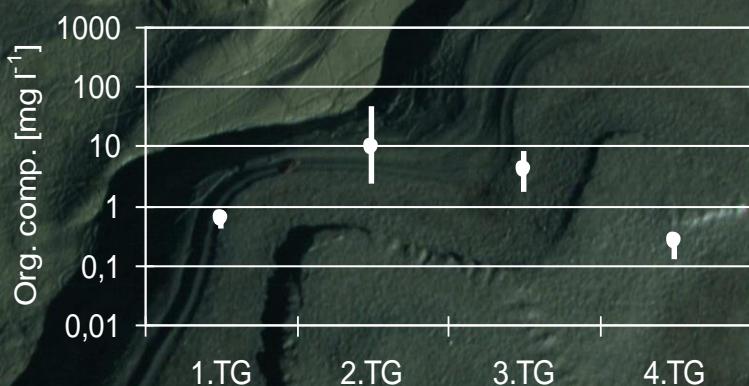
Königsbach (min.-mean-max.)

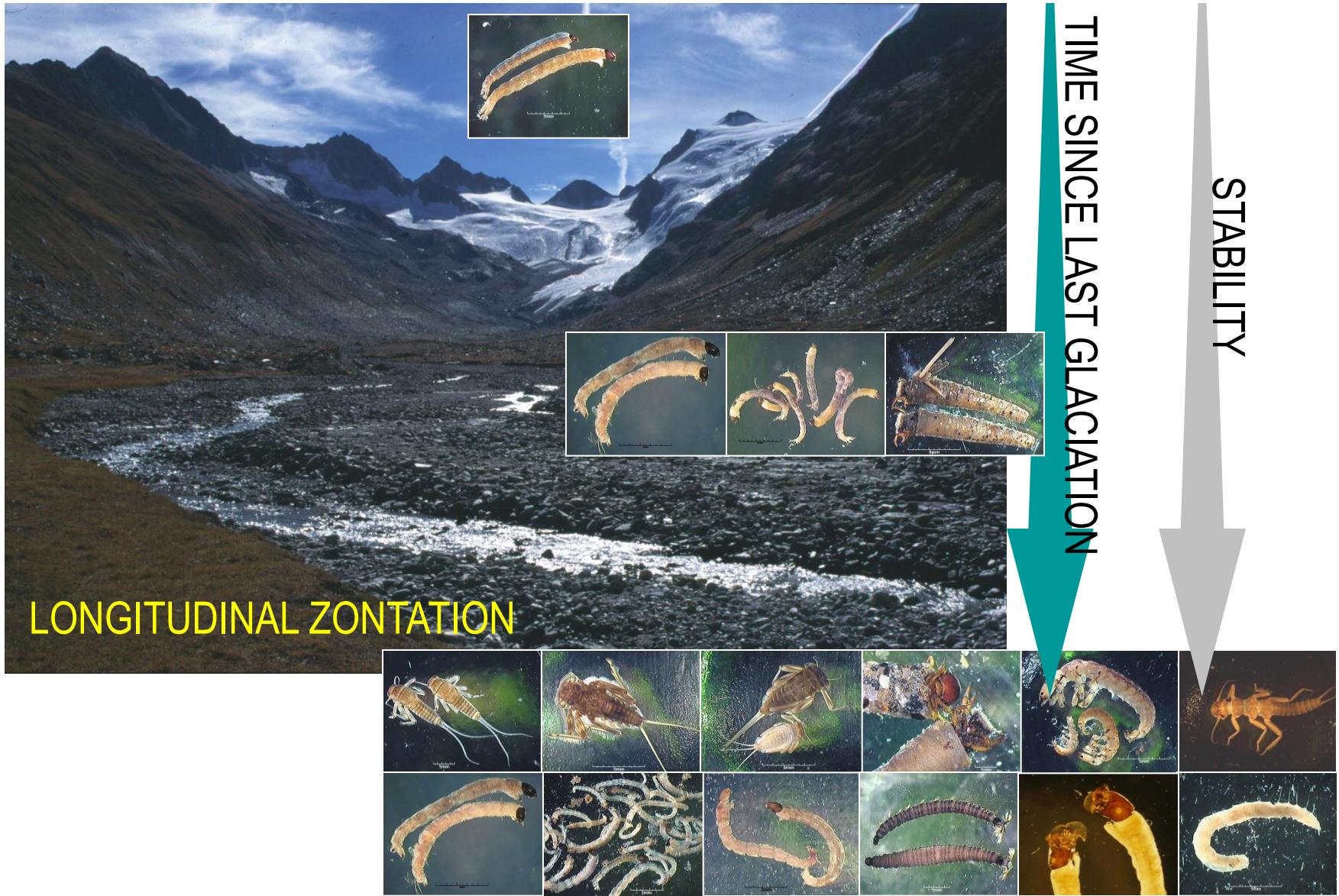


Rotmoosache (min.-mean-max.)

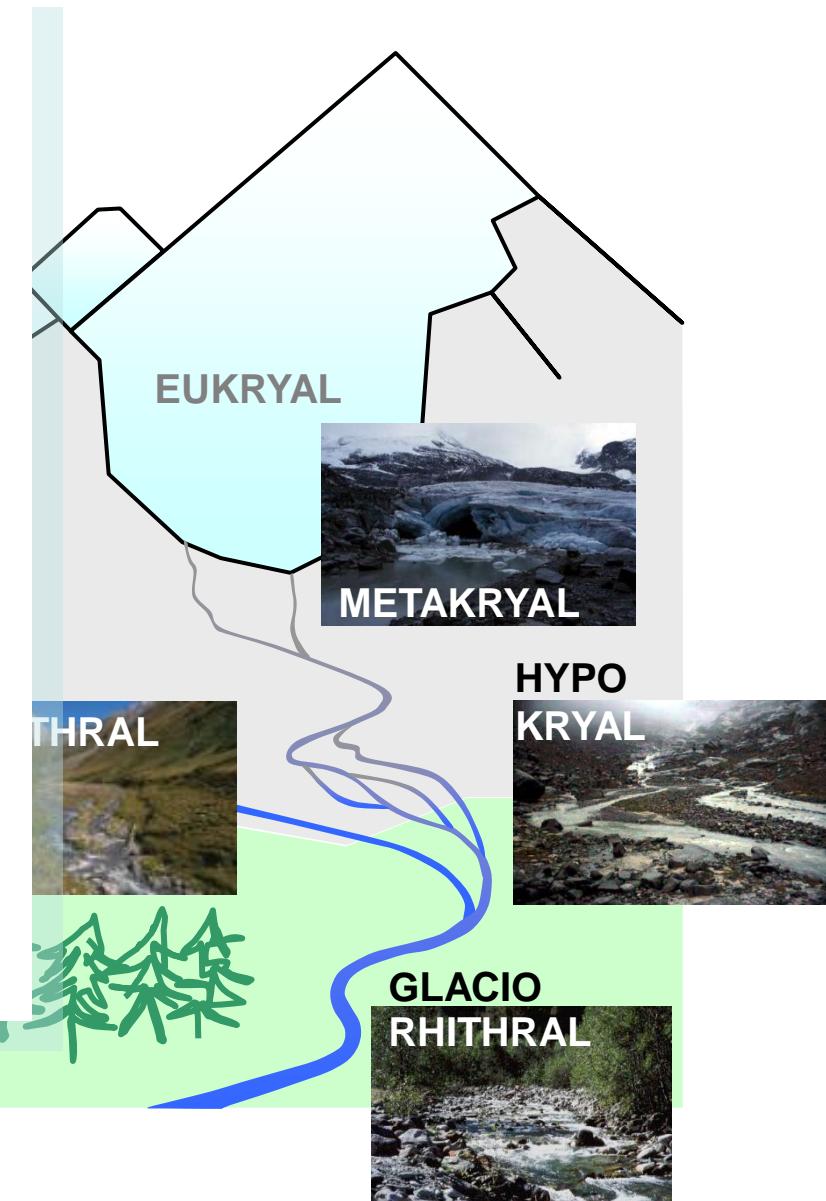
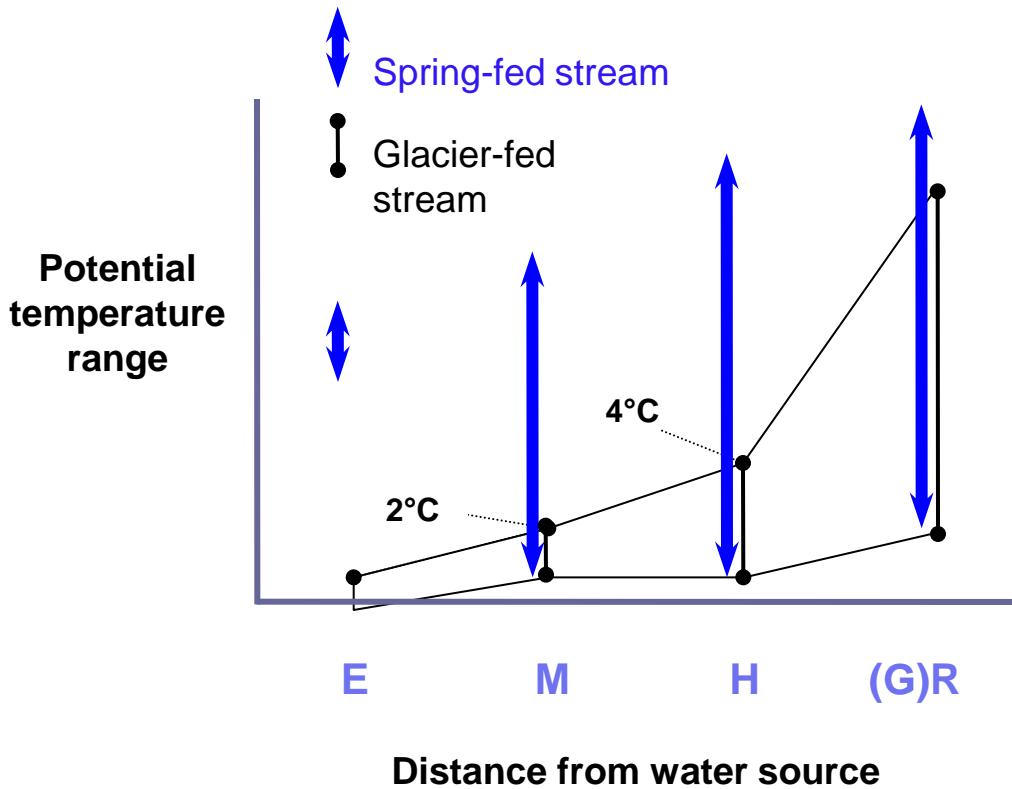


Rotmoosache (min.-mean-max.)

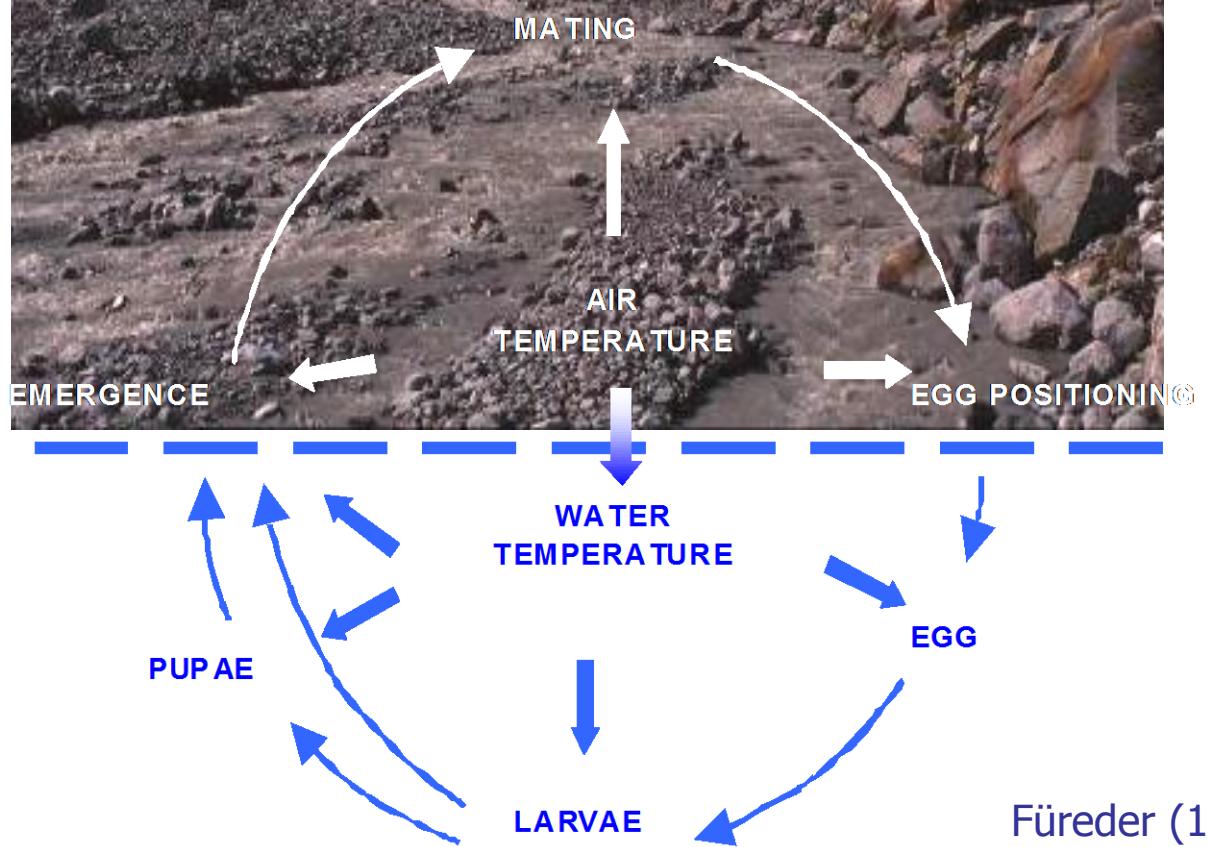
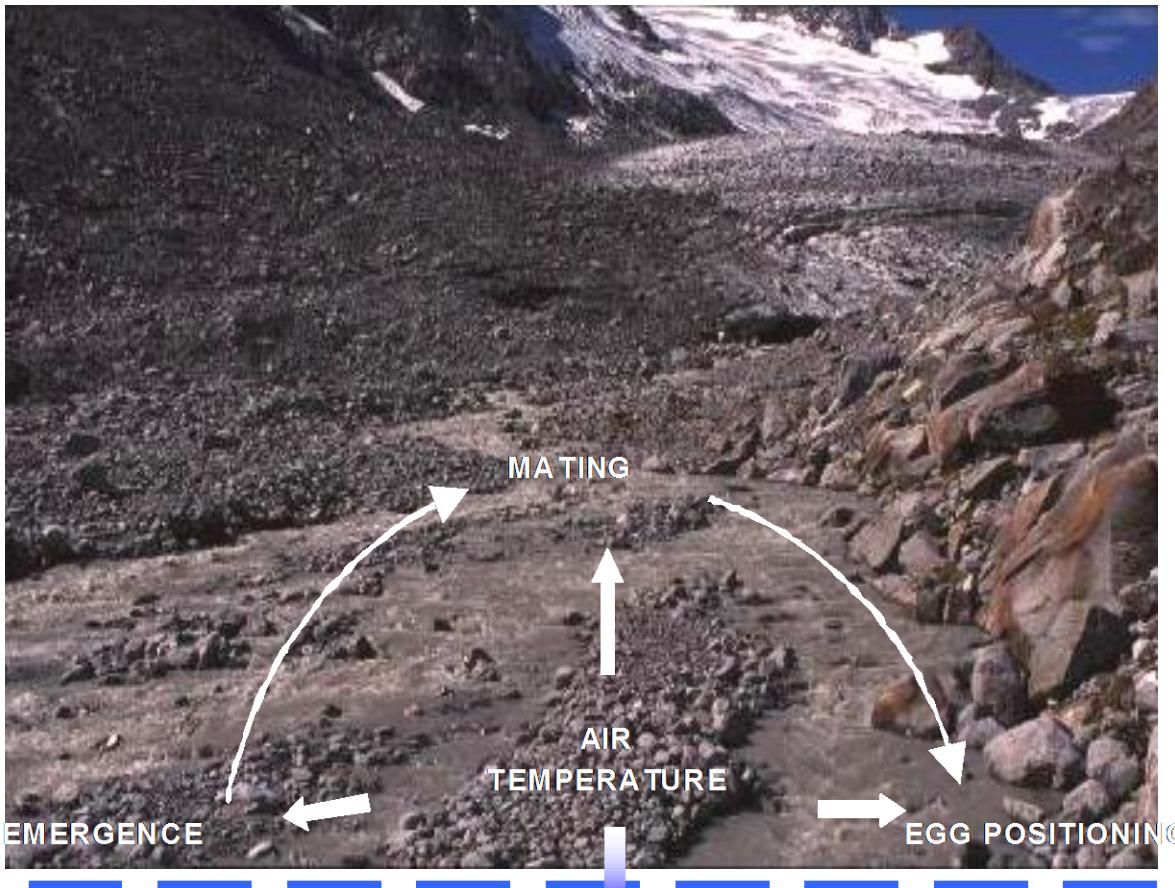


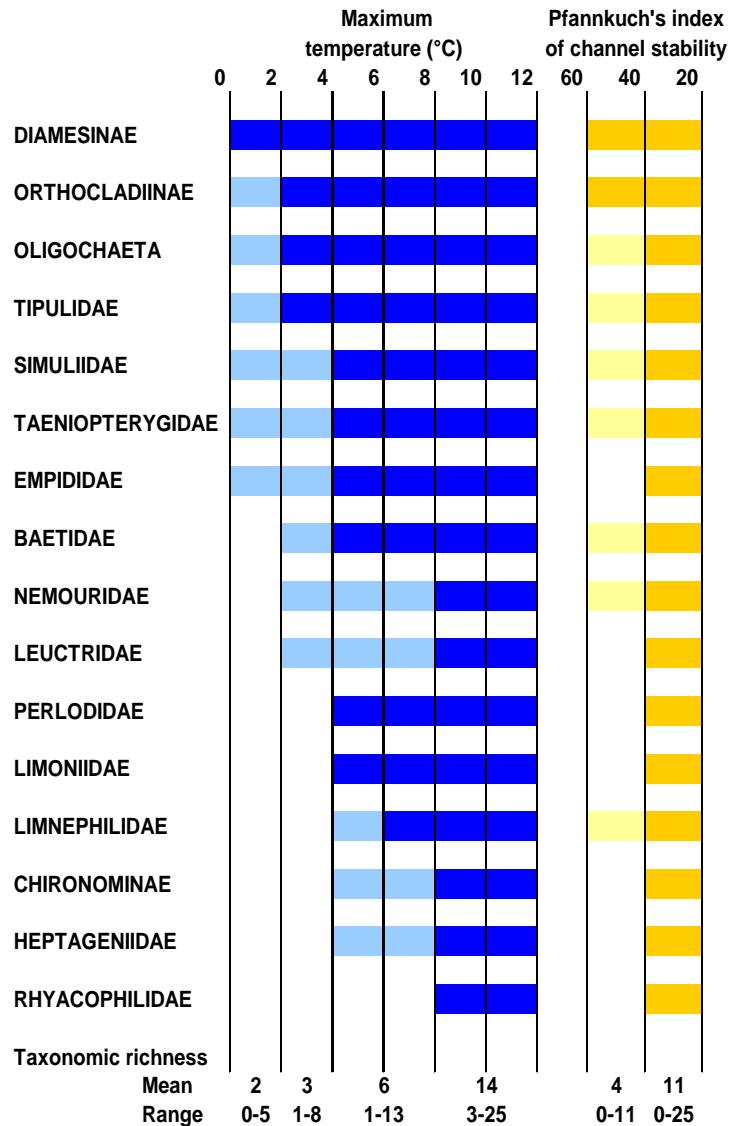


# Temperature



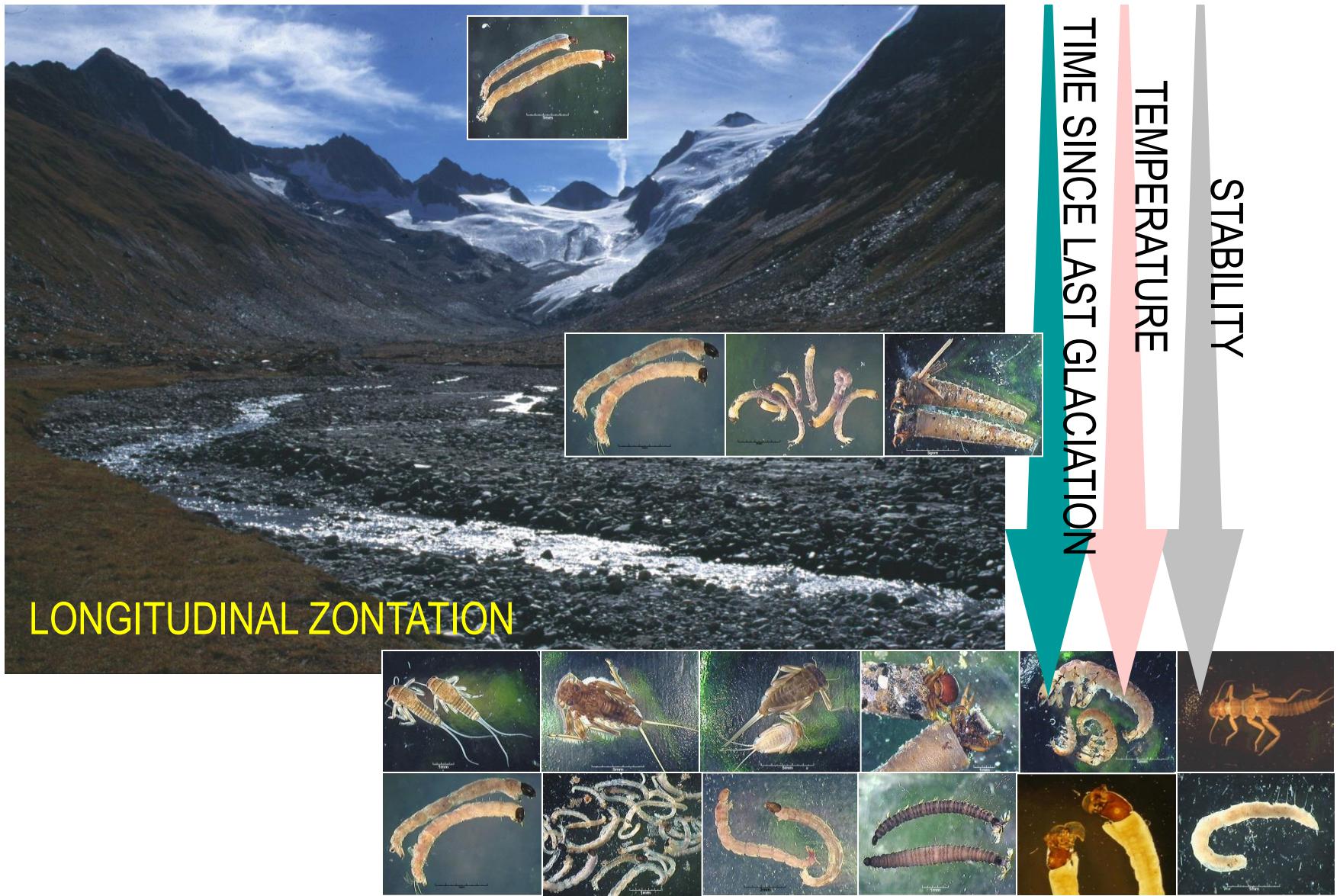
extremely low  $T_{\text{mean}}$  and  $T_{\text{max}}$  ↔ higher  $T_{\text{mean}}$  and  $T_{\text{max}}$   
 few degree days ↔ more-many degree days



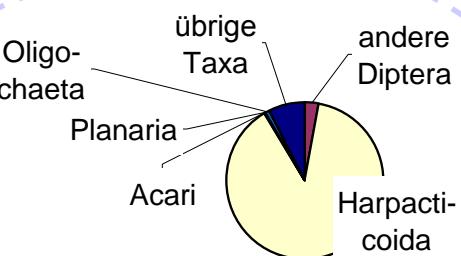
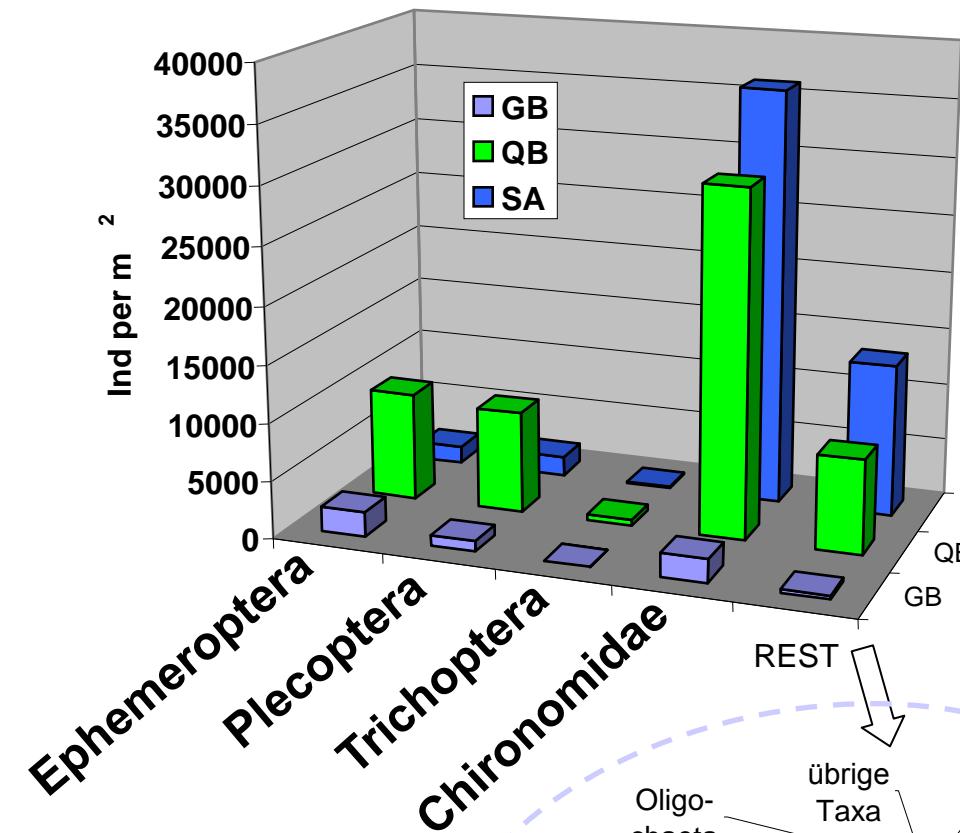


Milner et al. (2001)

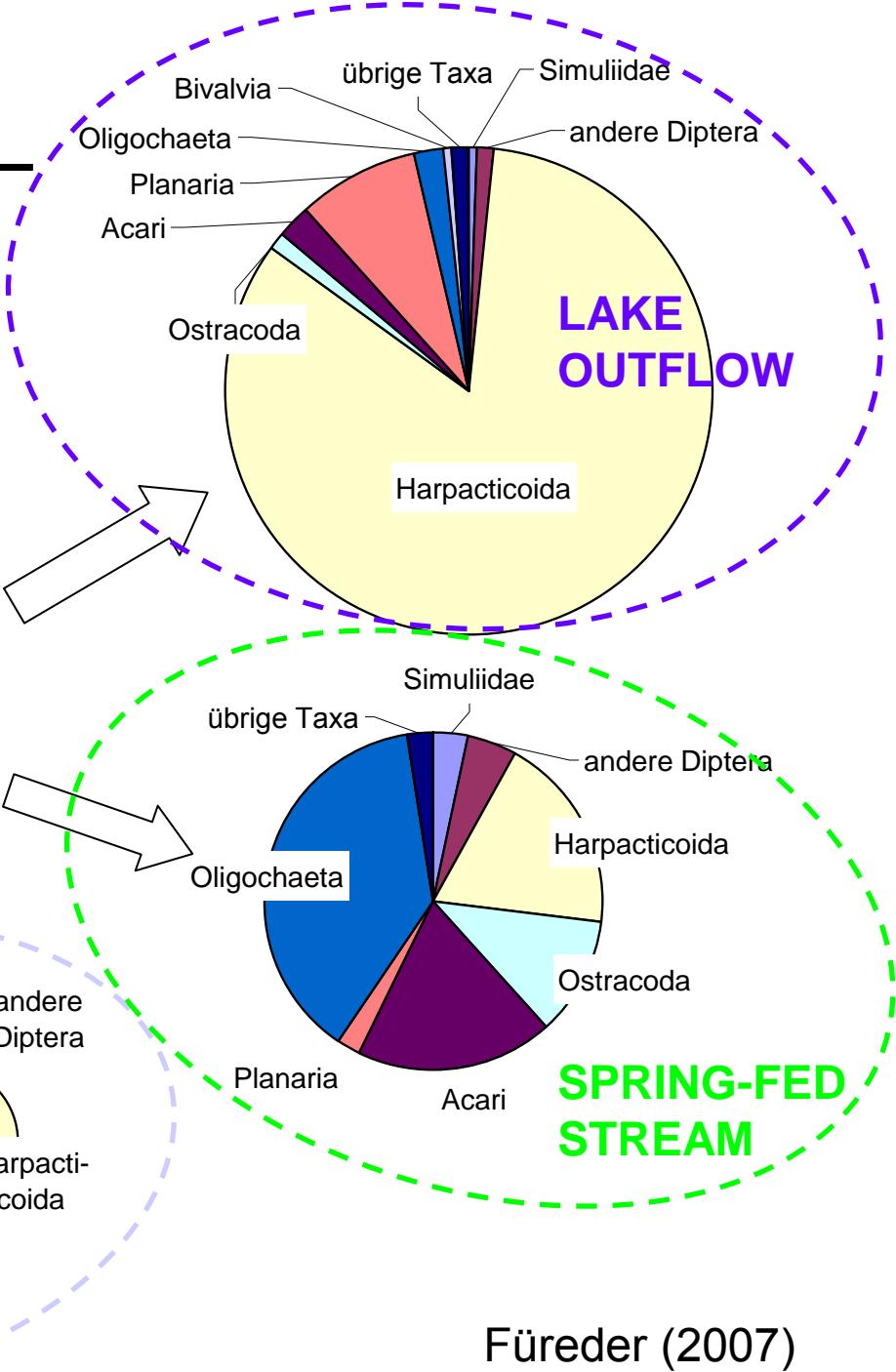




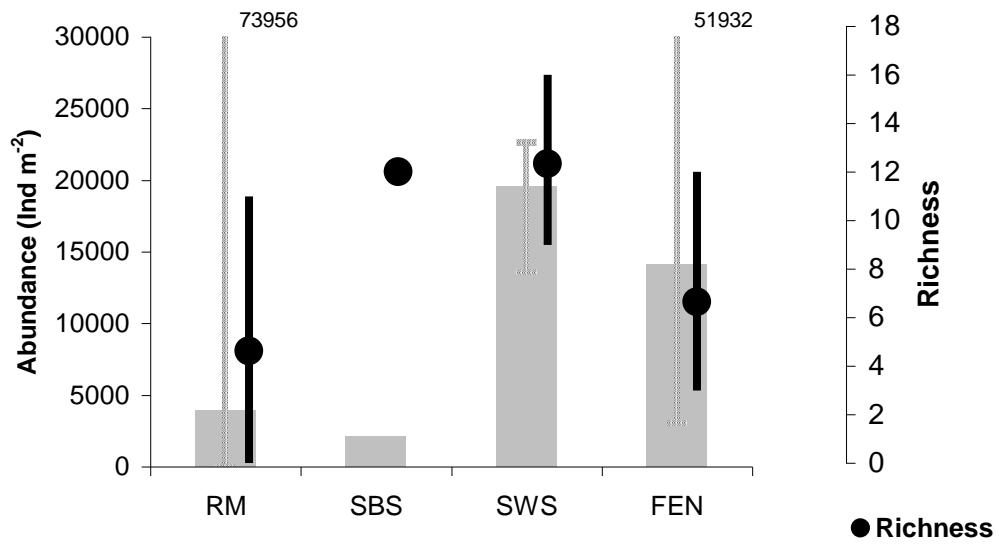
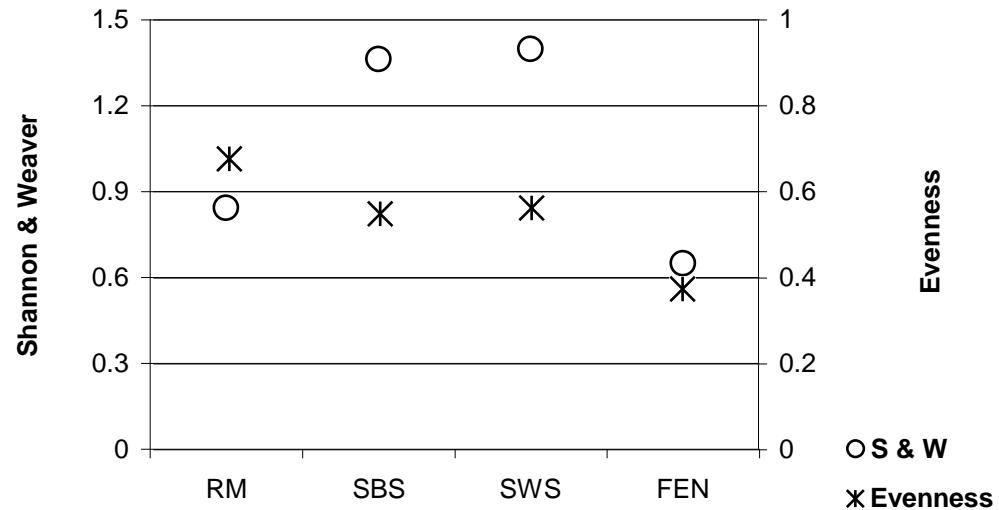
# River types

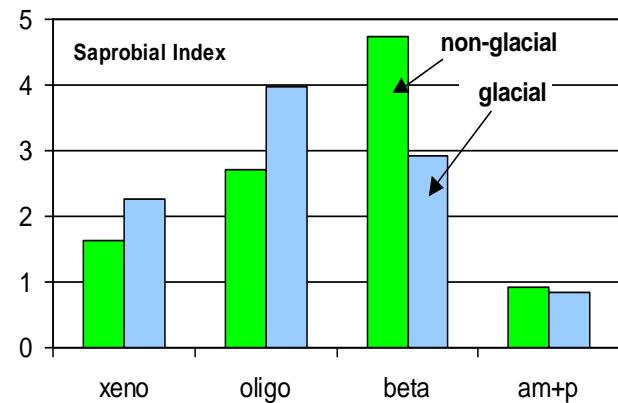


GLACIER-FED  
STREAM



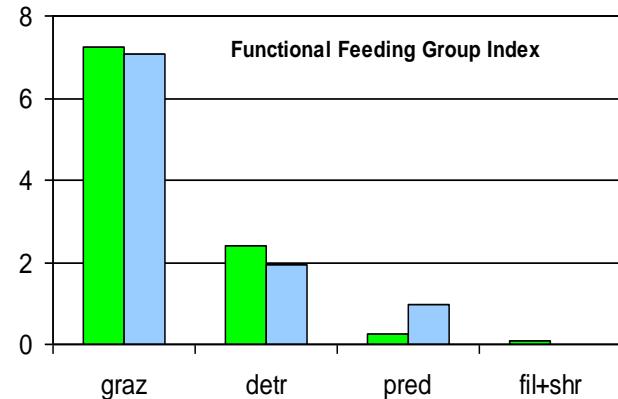
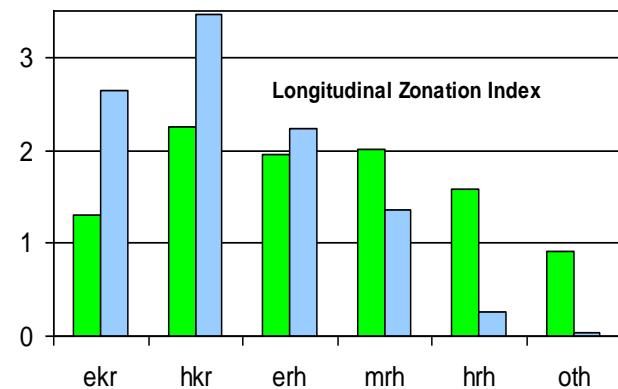
Füreder (2007)





# Species traits

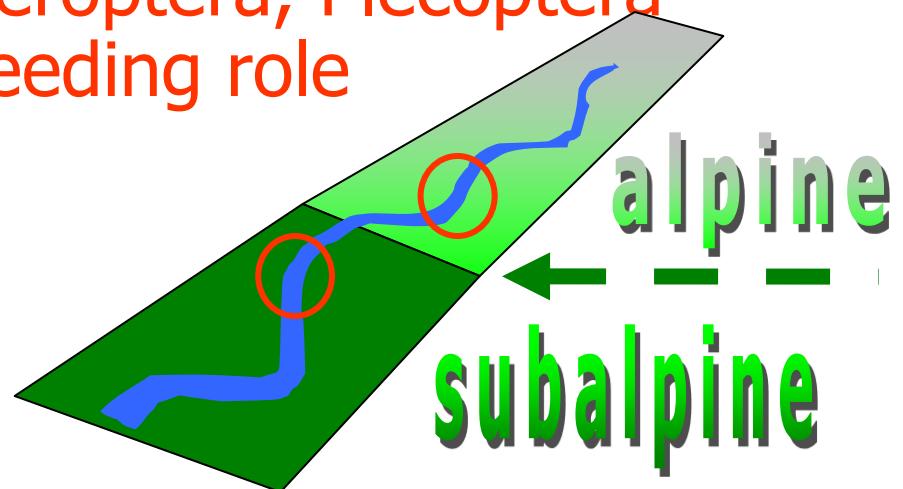
Füreder et al.  
(2001)



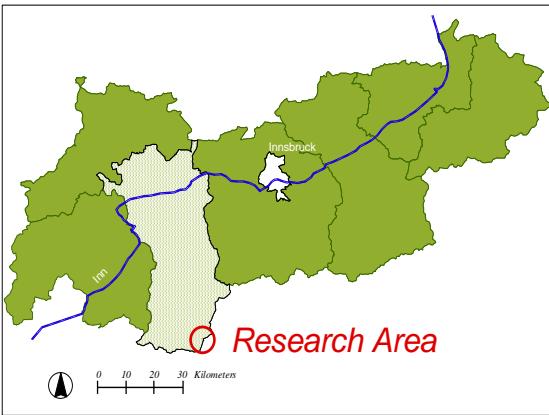


# Main objectives

- Food resources
- Invertebrate species, assemblages
- Food web structure
- Ephemeroptera, Plecoptera food, feeding role



# Research area



*Legend:*

— Running waters

Forest

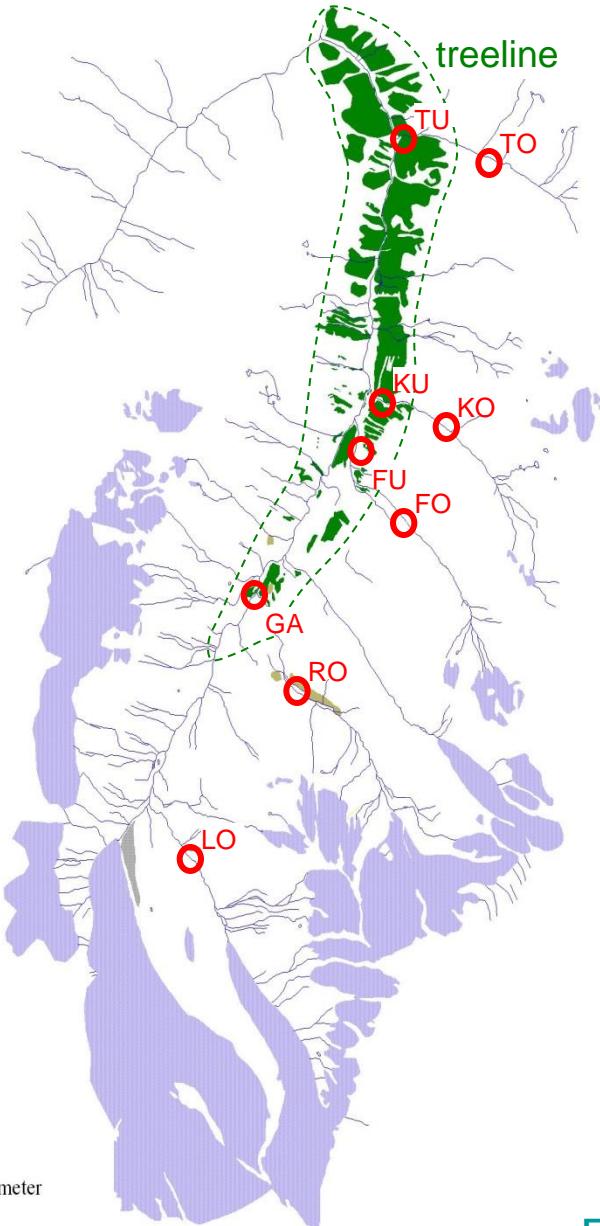
Glaciers

Moraine

Peat



1 0 1 2 Kilometer



Füreder et al. (2003)

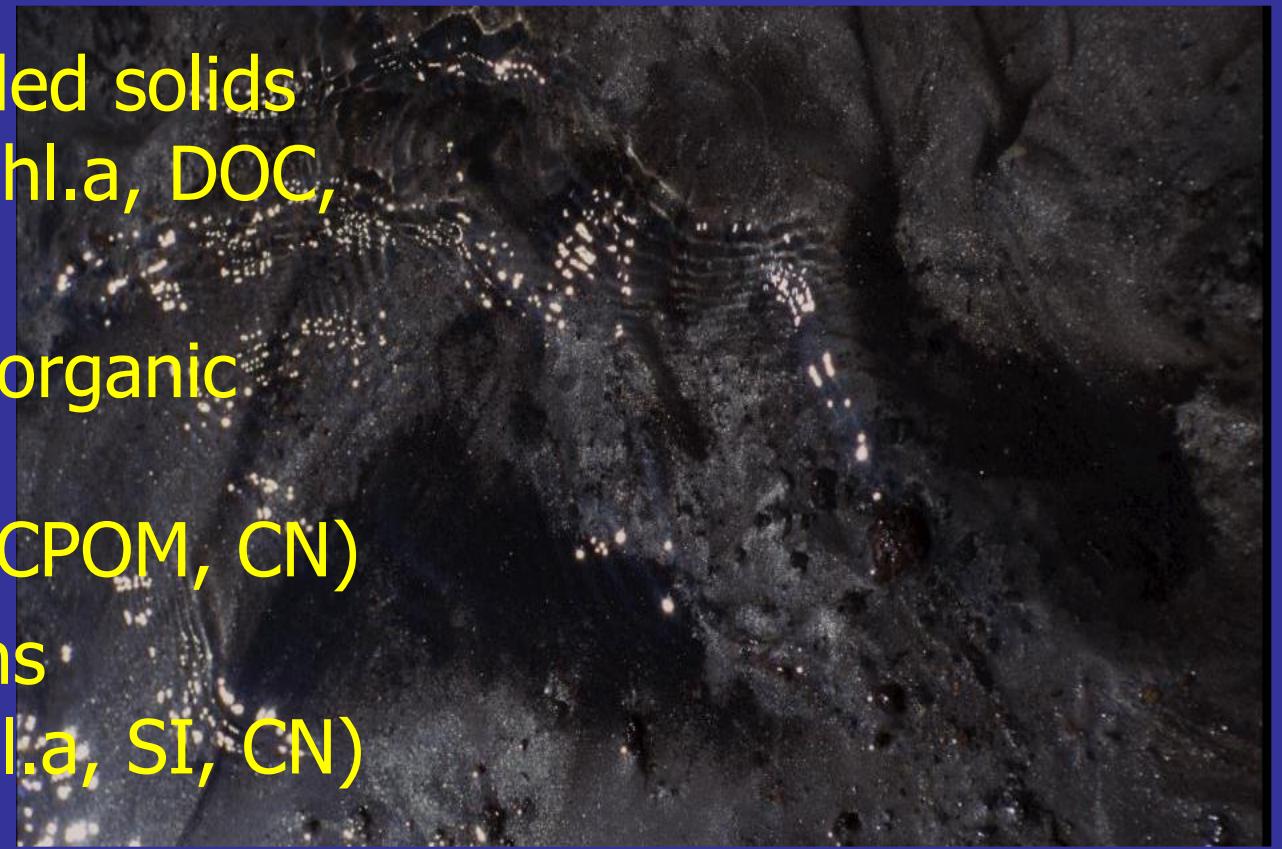


# Stream reach characteristics

Stream reach	Stream order	Altitude (m a.s.l.)	Watershed (Km <sup>2</sup> )	Source	Position resp. treeline
Königsbach Oberlauf (KO)	2	2240	4.4	Spring	above
Königsbach Unterlauf (KU)	2	1850	5.8	Spring	below
Timmelsbach Oberlauf (TO)	3	2100	3.6	Spring	above
Timmelsbach Unterlauf (TU)	3	1600	6.3	Spring	below
Ferwallbach Oberlauf (FO)	2	2380	4.1	Glacier	above
Ferwallbach Unterlauf (FU)	2	1960	7.9	Glacier	below
Rotmoosache (RO)	2	2280	10.4	Glacier	above
Langtaler Bach (LO)	2	2440	10.7	Glacier	above
Gurgler Ache (GA)	3	2030	39.1	Glacier	below

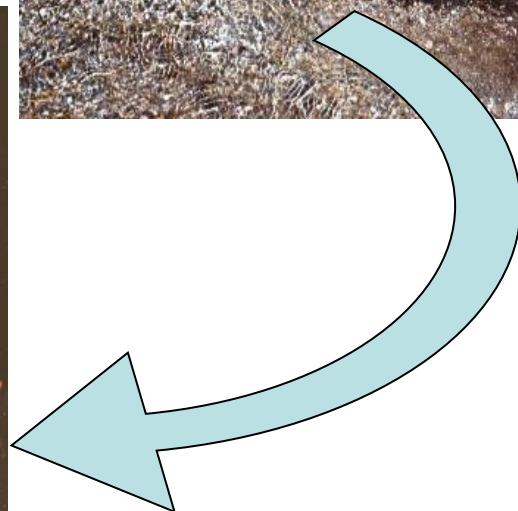
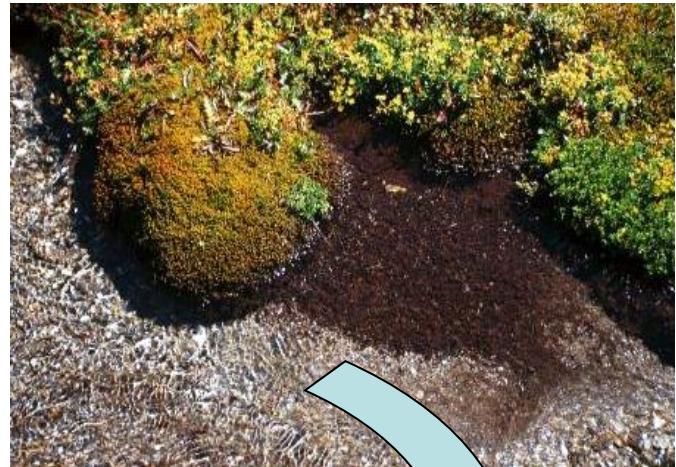
# Food resource availability

- Suspended solids  
(SOM, Chl.a, DOC, CN)
- Benthic organic matter  
(FPOM, CPOM, CN)
- Aufwuchs  
(OM, Chl.a, SI, CN)

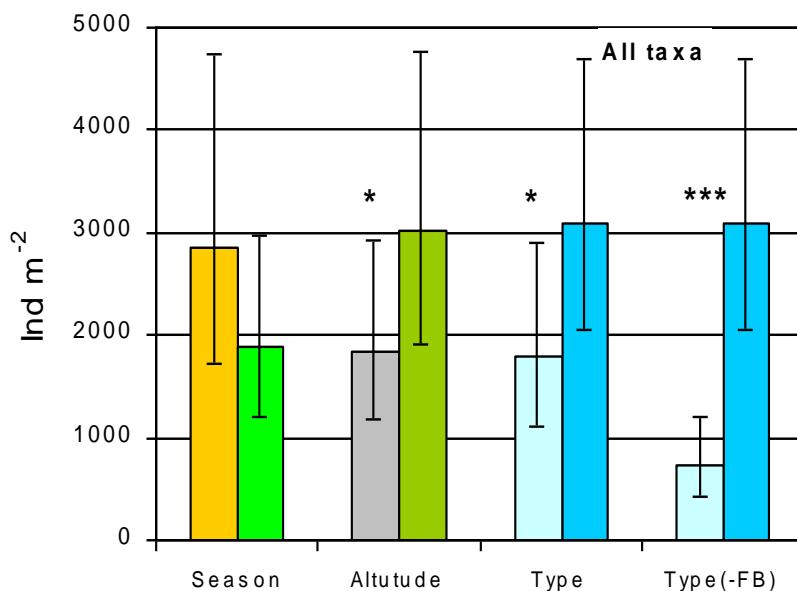
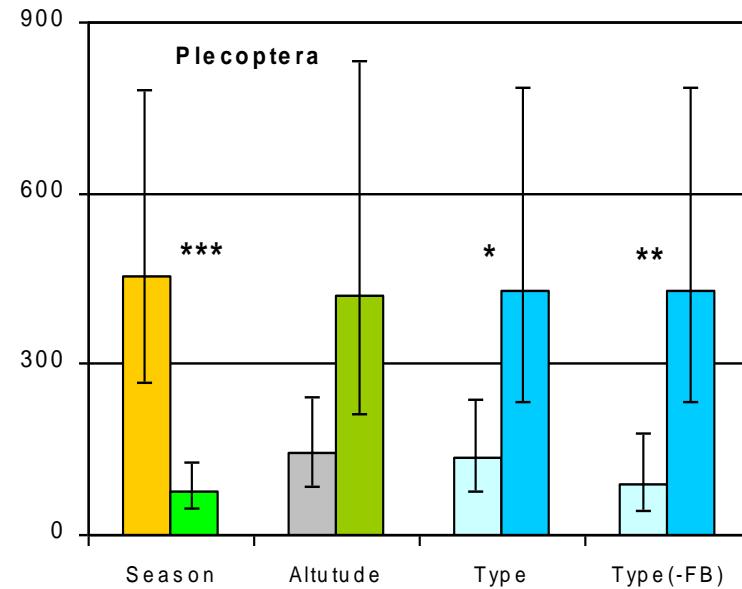
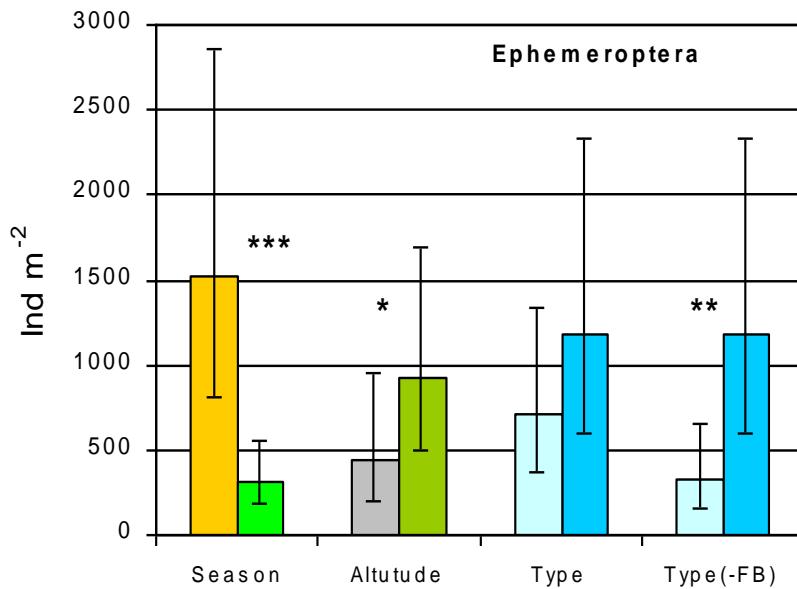


# Food utilization

- Gut contents  
relative proportion of food items
- Stable isotopes  
 $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$   
(e.g. Fry 1991)



Füreder et al. (2003)

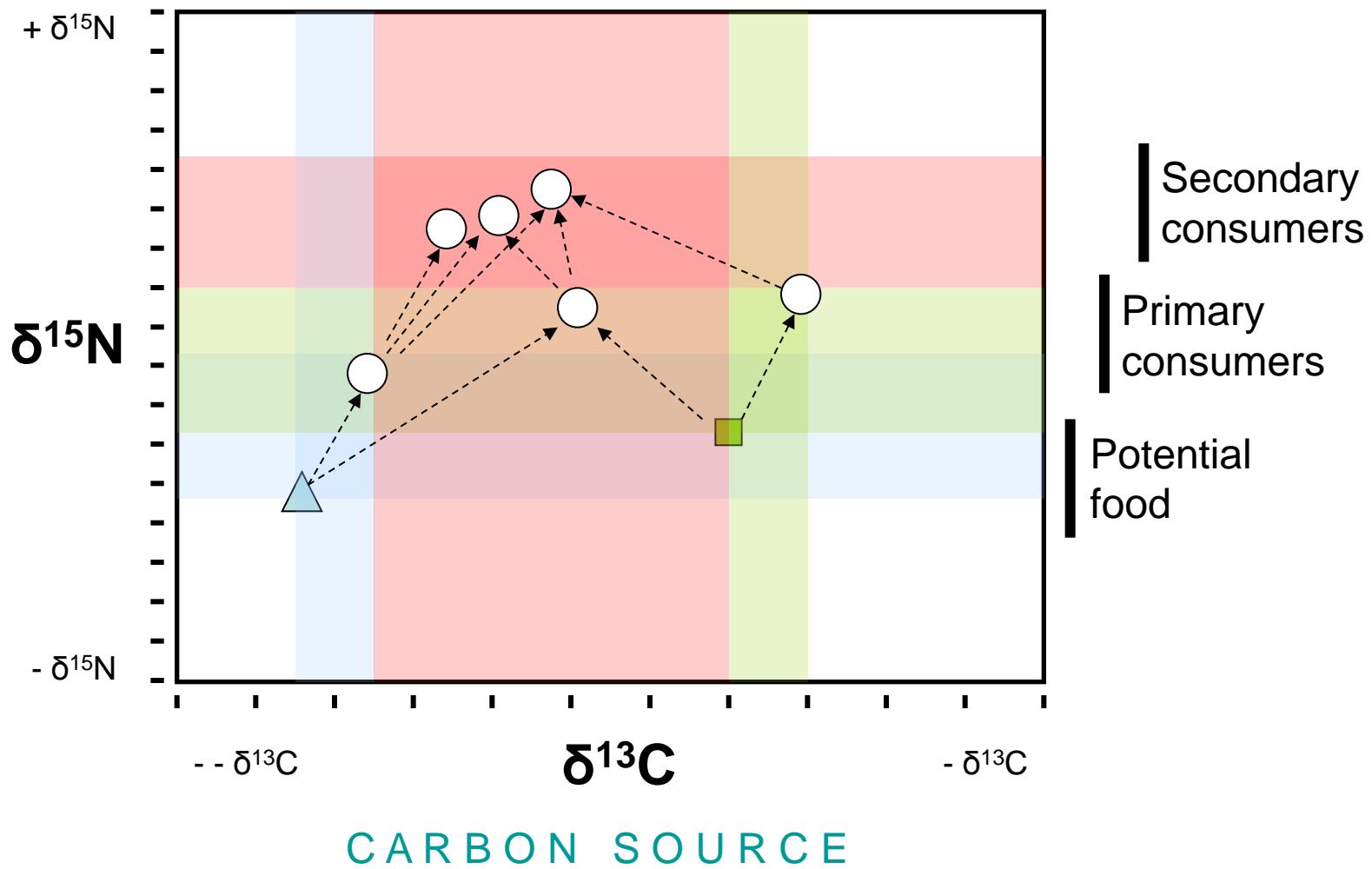


# Abundance vs. season, altitude and stream type

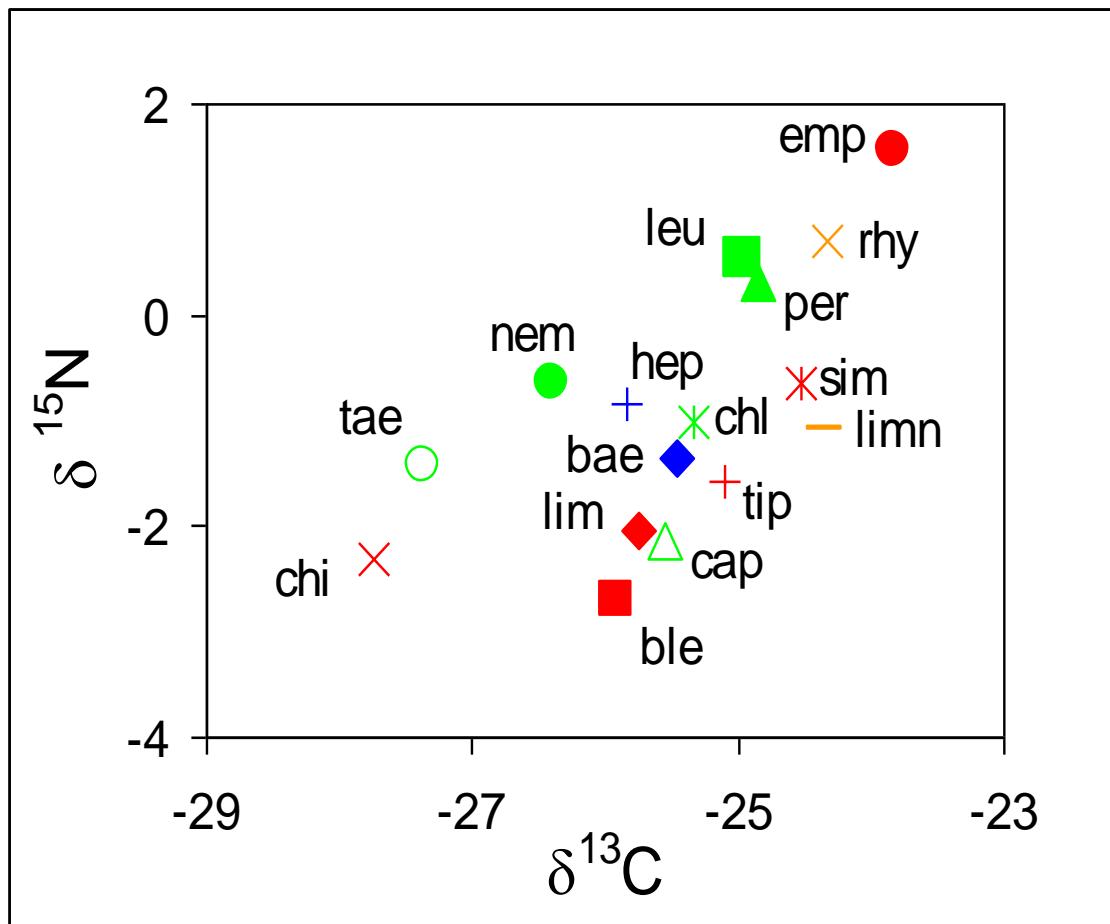


# Food webs Stable Isotopes

TROPHIC LEVEL

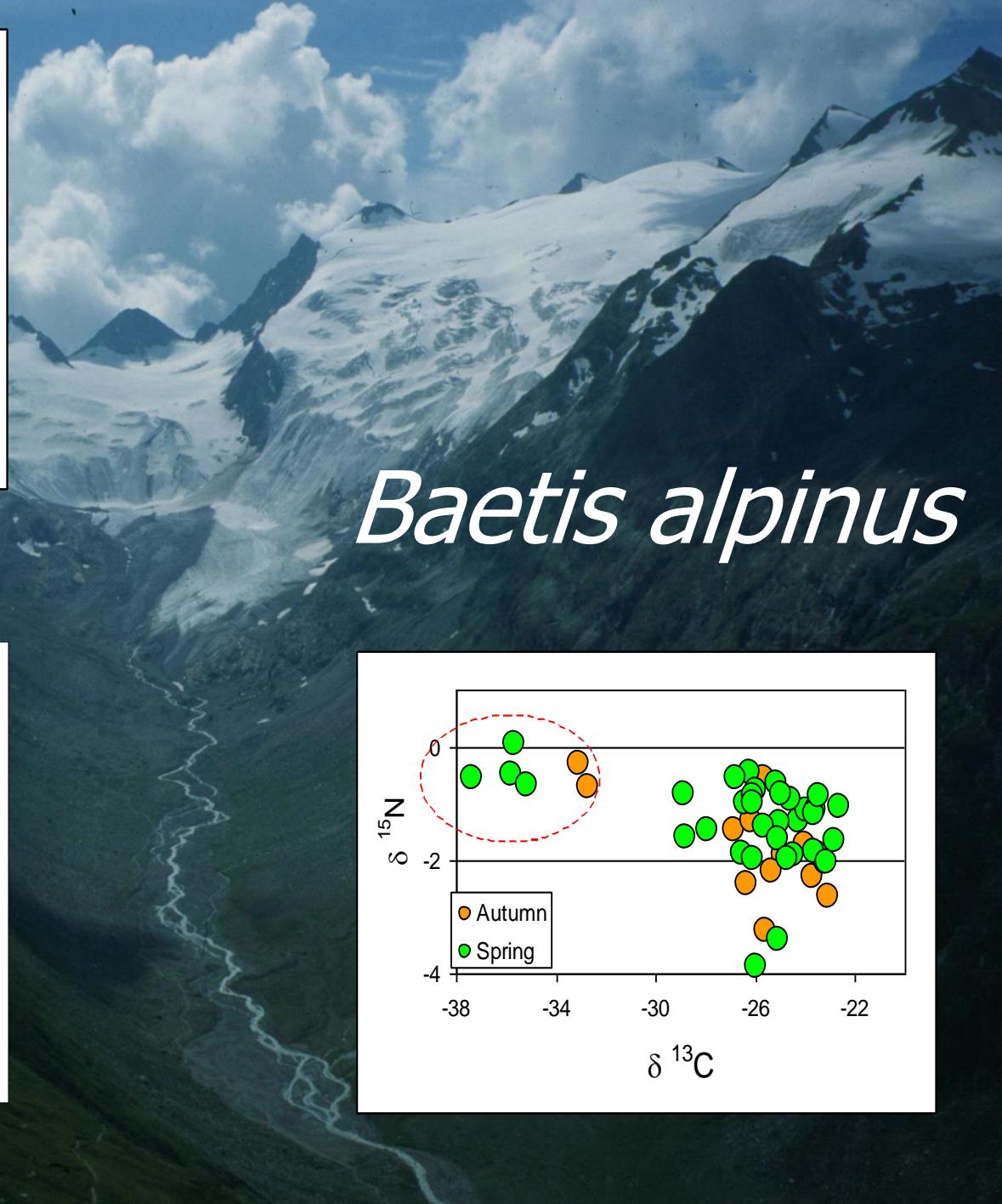
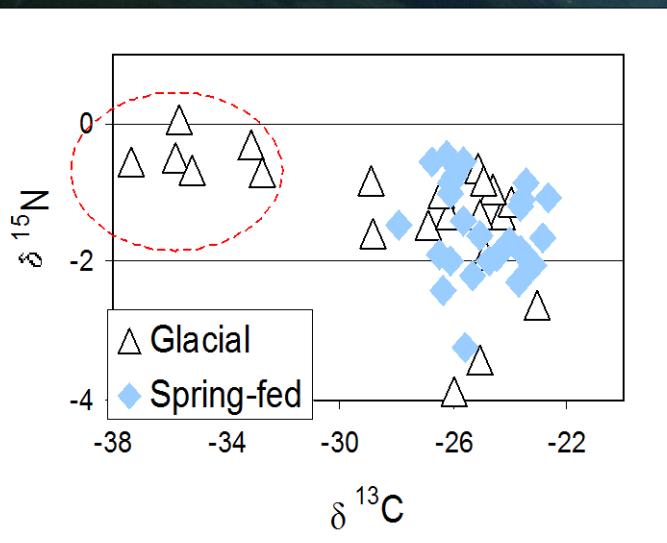
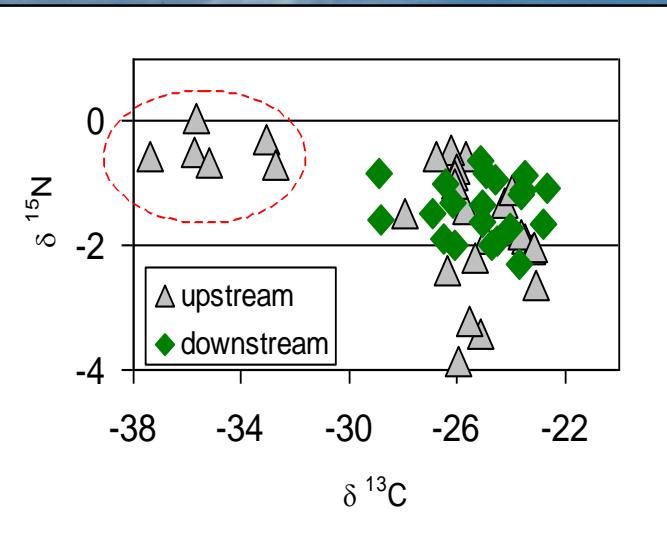


# C/N ratio - insect families

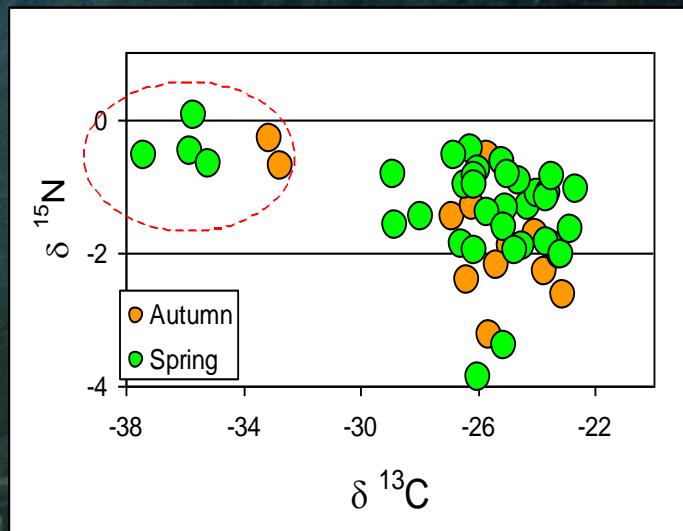


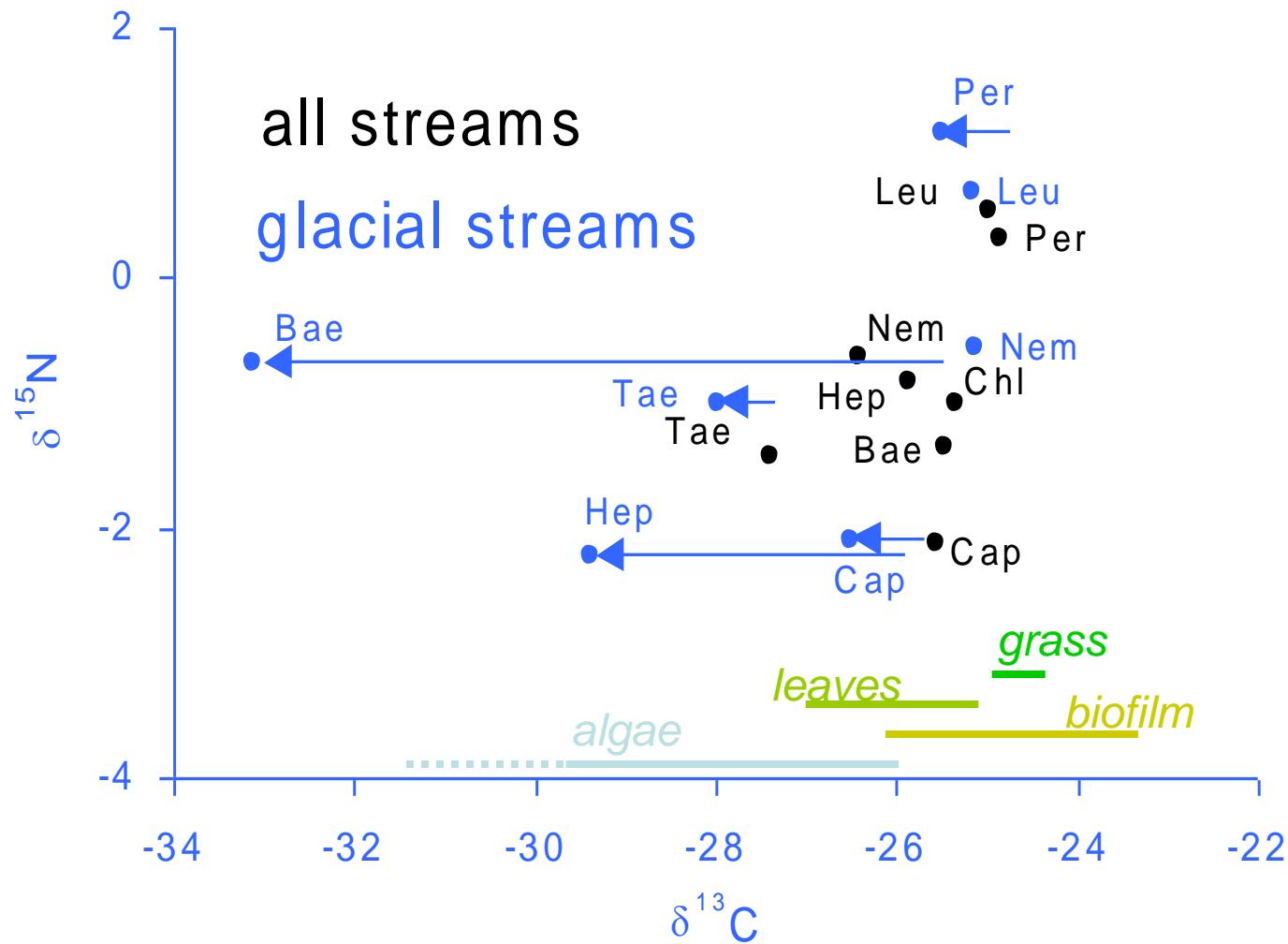
Means  
(n = 320)

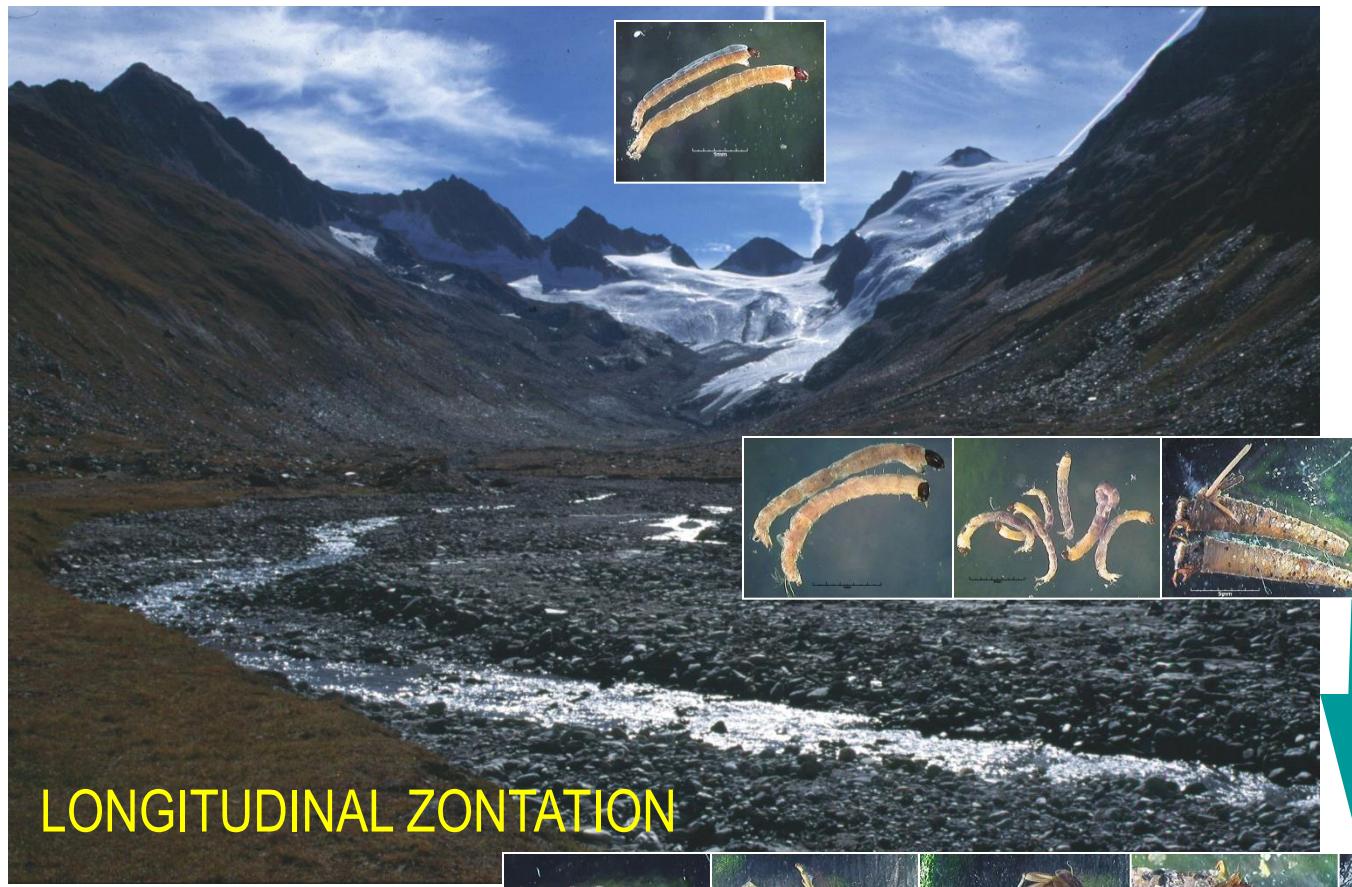




*Baetis alpinus*





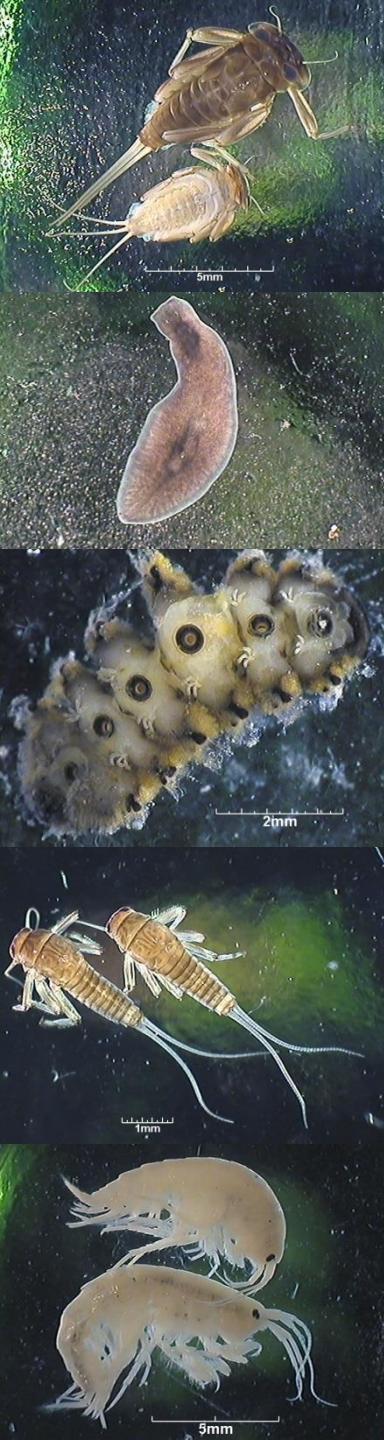


TIME SINCE LAST GLACIATION  
TEMPERATURE

STABILITY

FOOD RESOURCE AVAILABILITY





# Macroinvertebrates

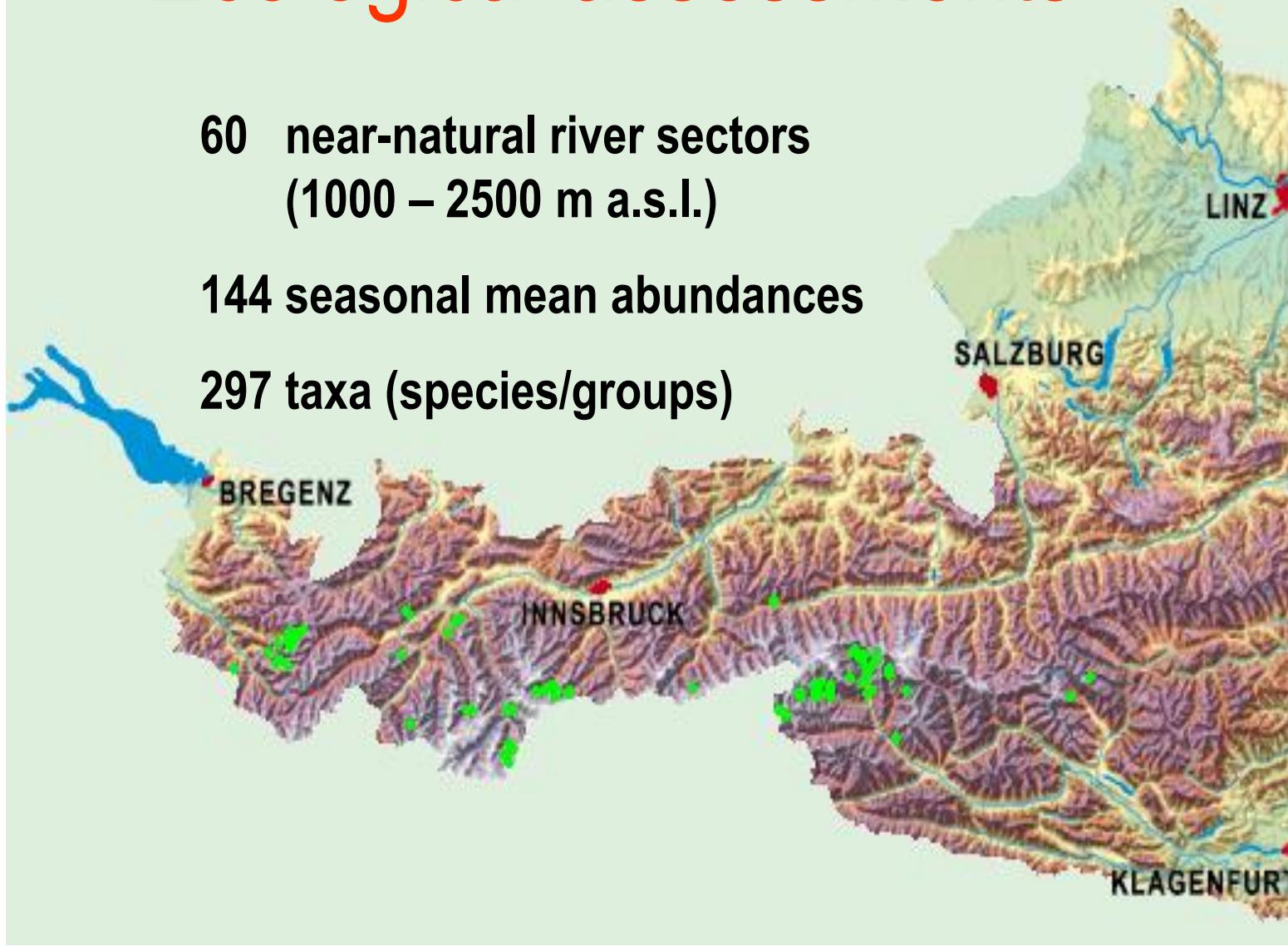
- Macroinvertebrates are ubiquitous and abundant in streams and rivers
- Relatively sedentary, relatively long-living, so they are good integrators of local conditions
- Widely used across the world in biomonitoring/bioassessment programs
- Provide an indicator which is consistent with National monitoring programs and EU-WFD

# Ecological assessments

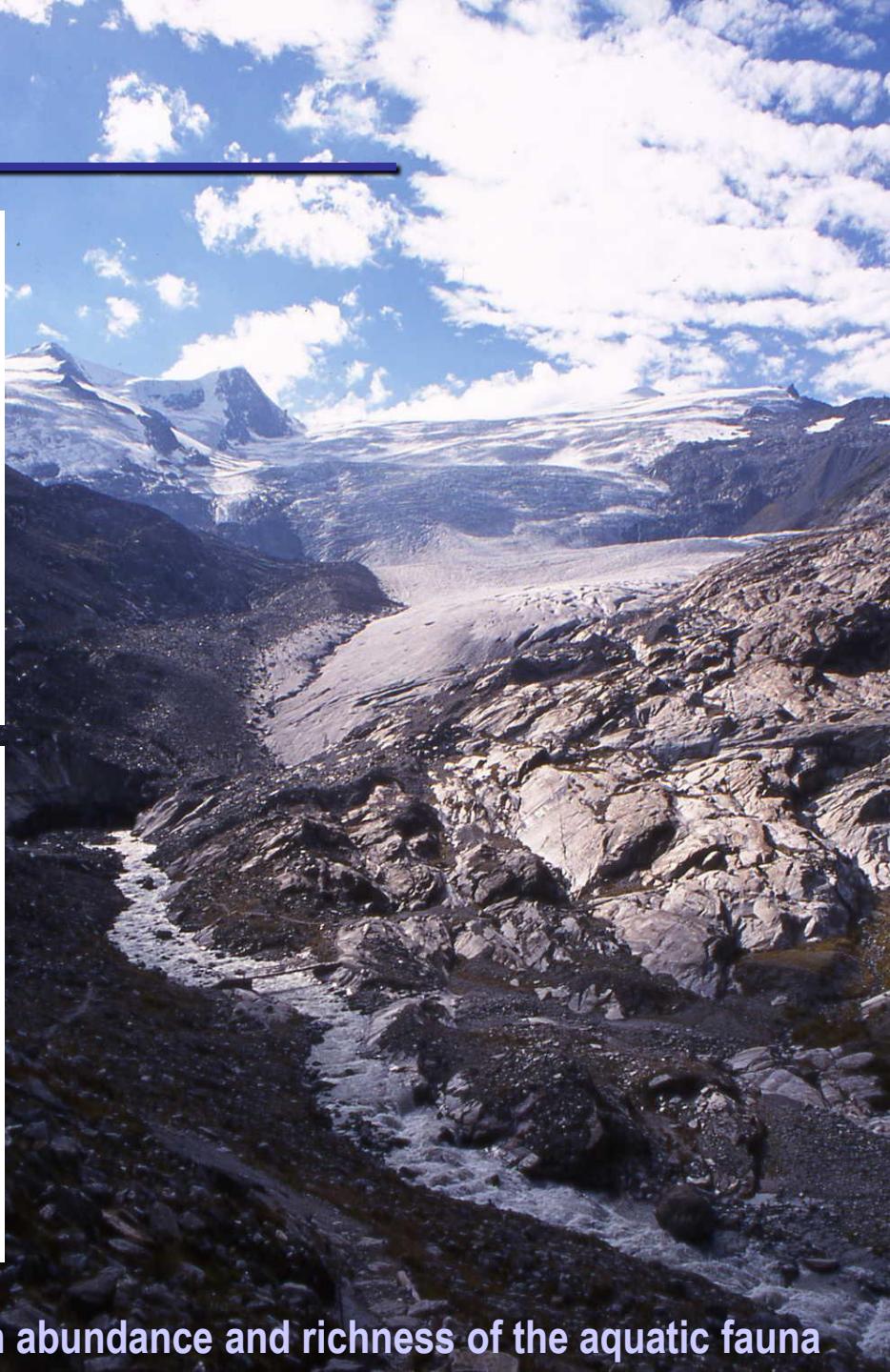
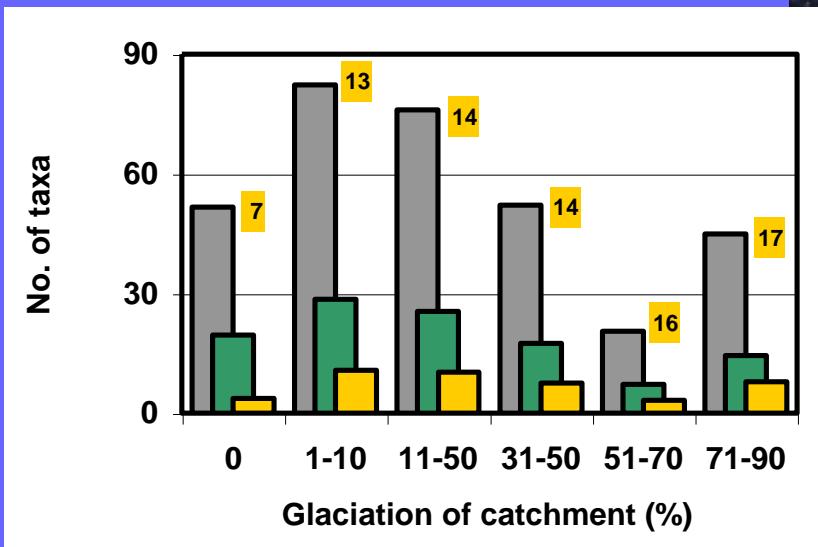
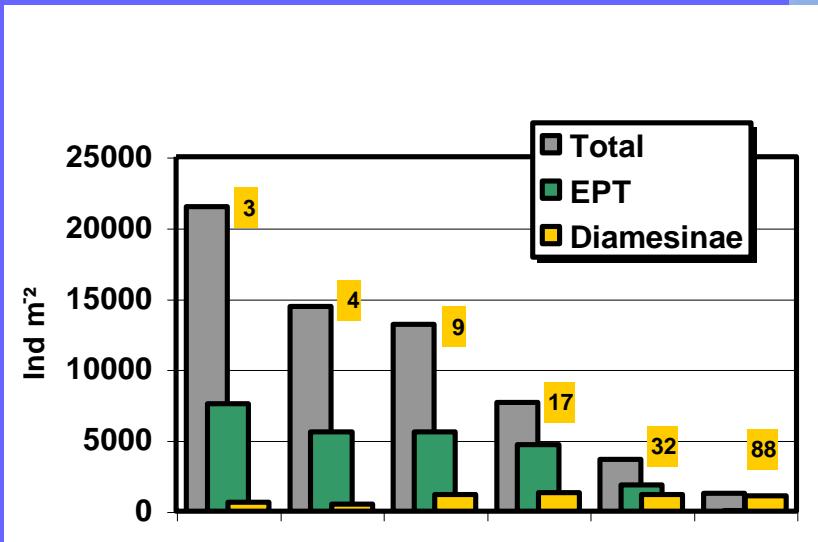
60 near-natural river sectors  
(1000 – 2500 m a.s.l.)

144 seasonal mean abundances

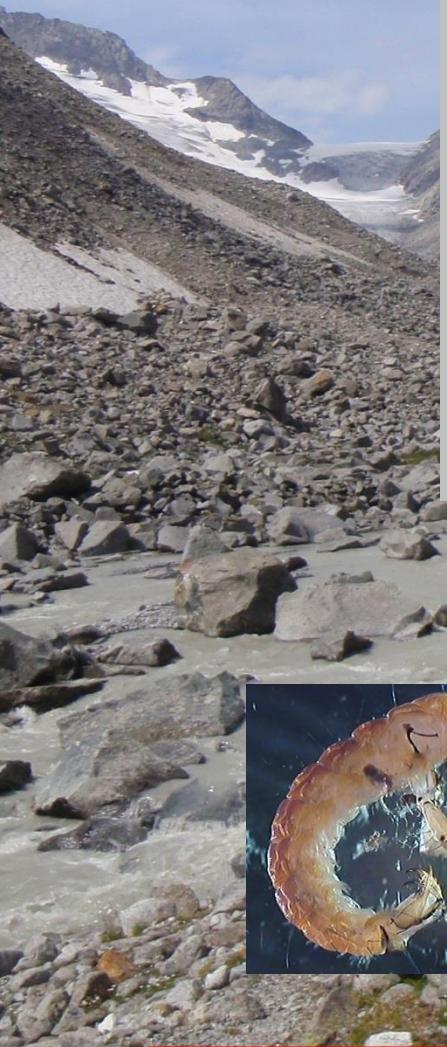
297 taxa (species/groups)



# Glaciation



...impact on abundance and richness of the aquatic fauna



**Resilience** – the capacity for a rapid return towards the density prevailing the disturbance

**Resistance** – the capacity to withstand the disturbance without appreciable loss of individuals

**Cold / low-food adaptation** – the capacity to survive cold temperature or overcome periods of low food availability

**Harsh environment**

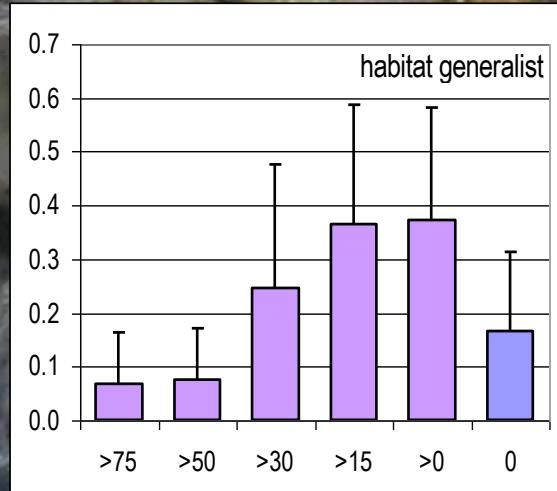
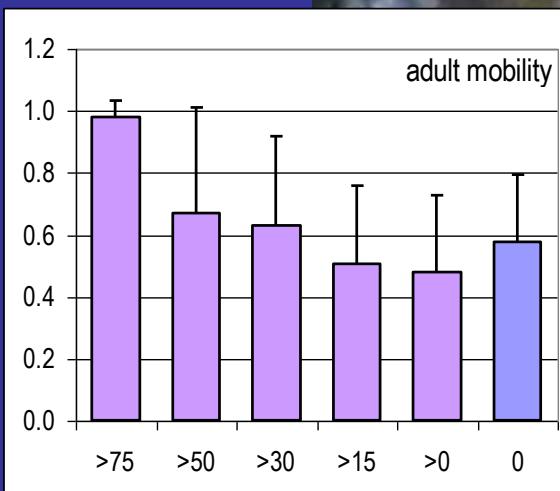
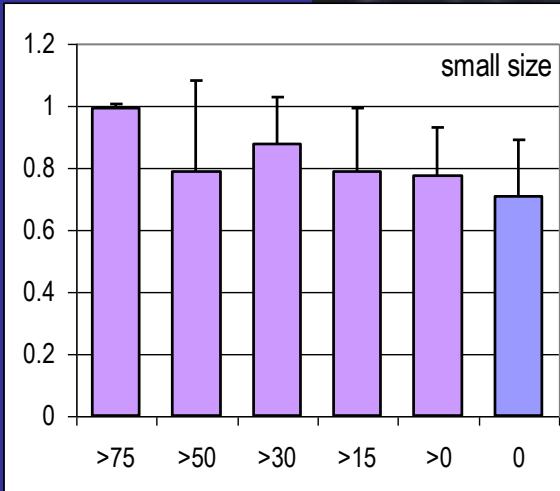
# Species traits

- **Resilience traits**  
small body length, high adult mobility,  
habitat generalist
- **Resistance traits**  
clinger, rheobiont, stream  
lined/flattened, two+ stages outside
- **Environmental harshness traits**  
cold temperature tolerance,  
omnivory, low food level exploitation



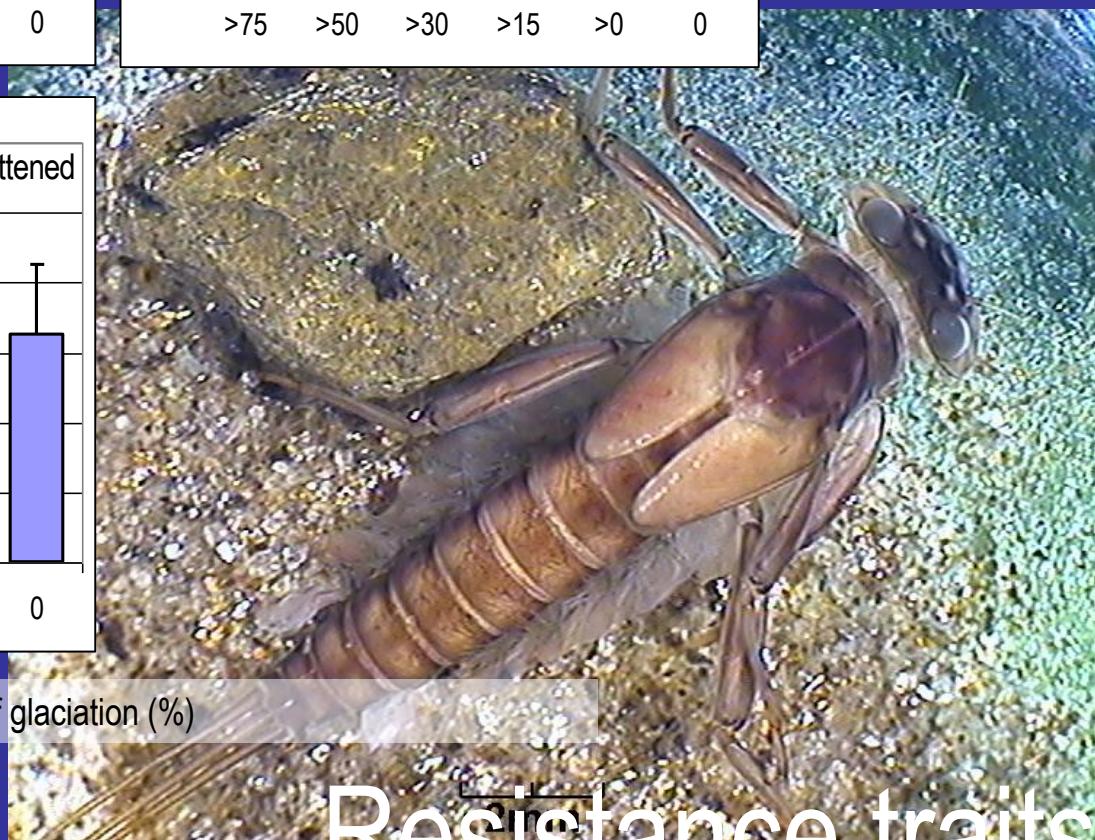
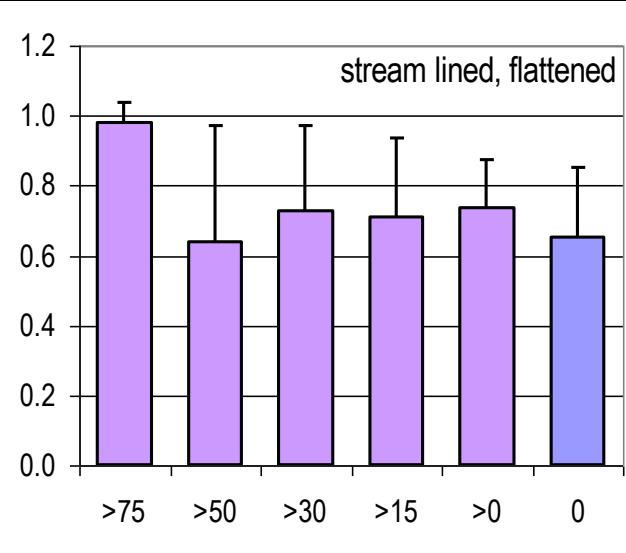
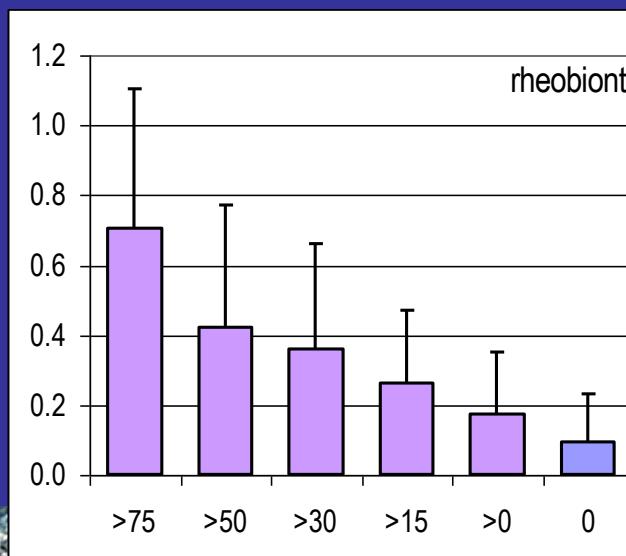
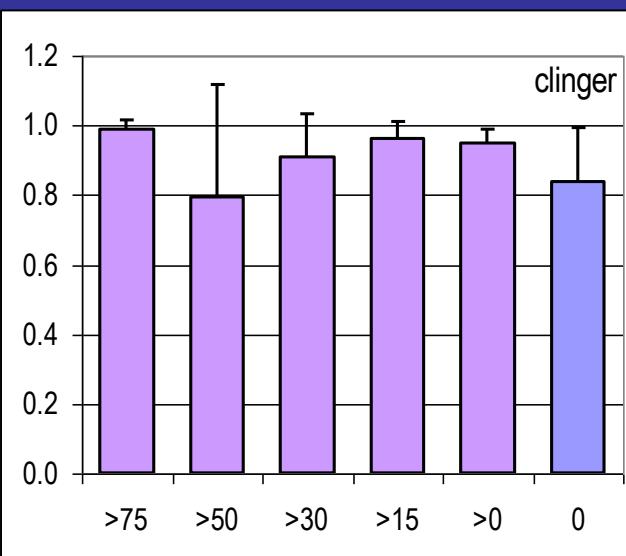
# Resilience traits

Relative abundance of traits

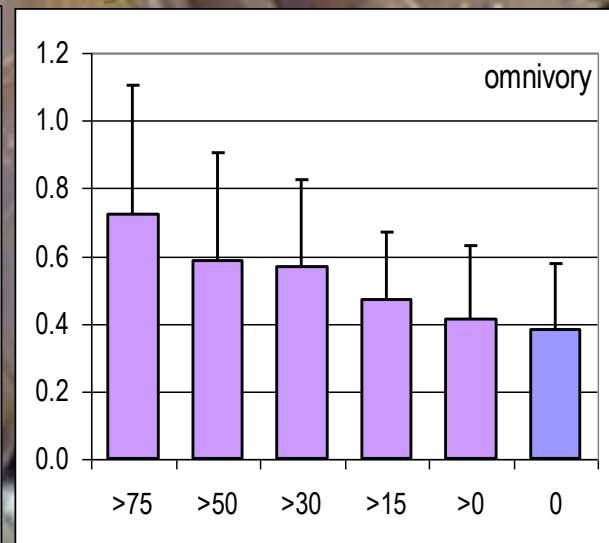
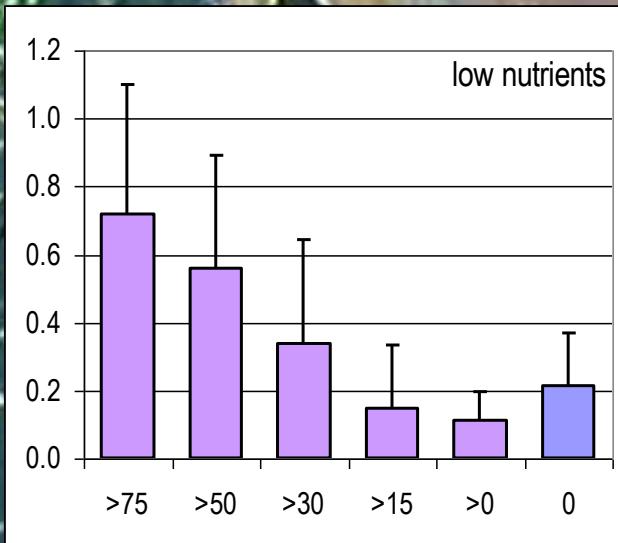
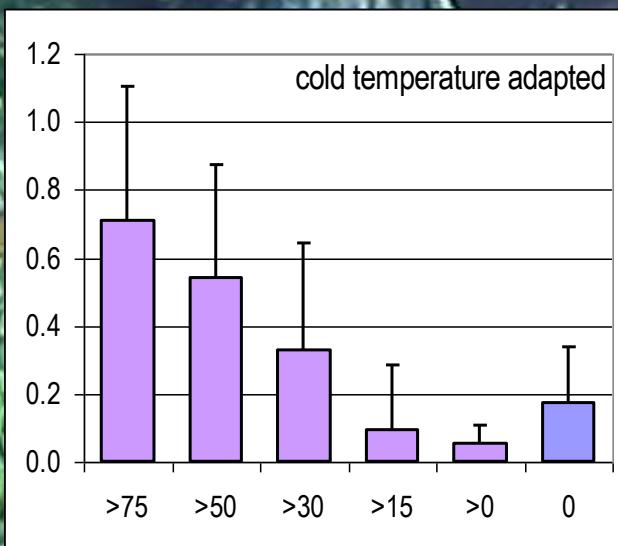


Degree of glaciation (%)

Relative abundance of traits



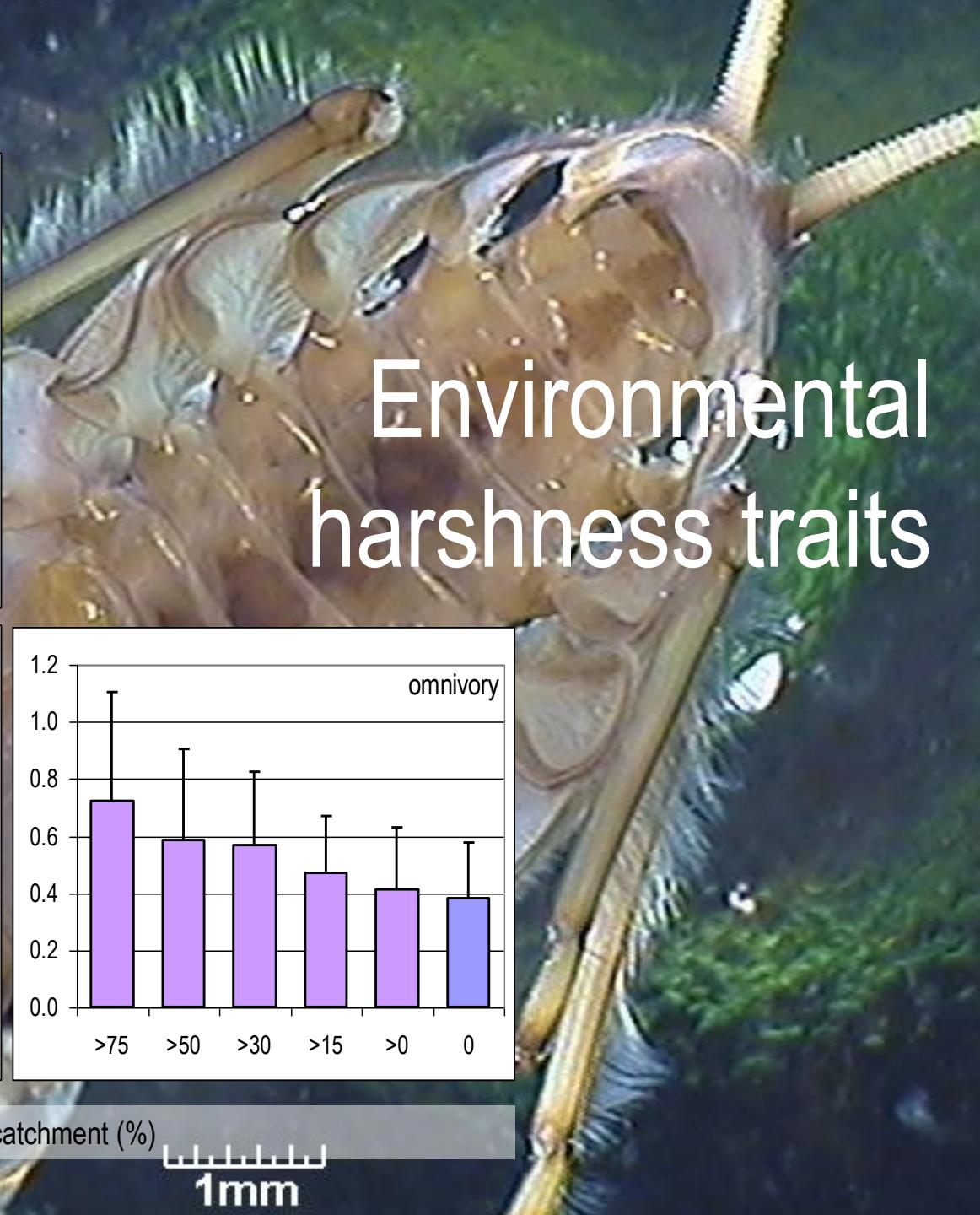
Relative abundance of traits

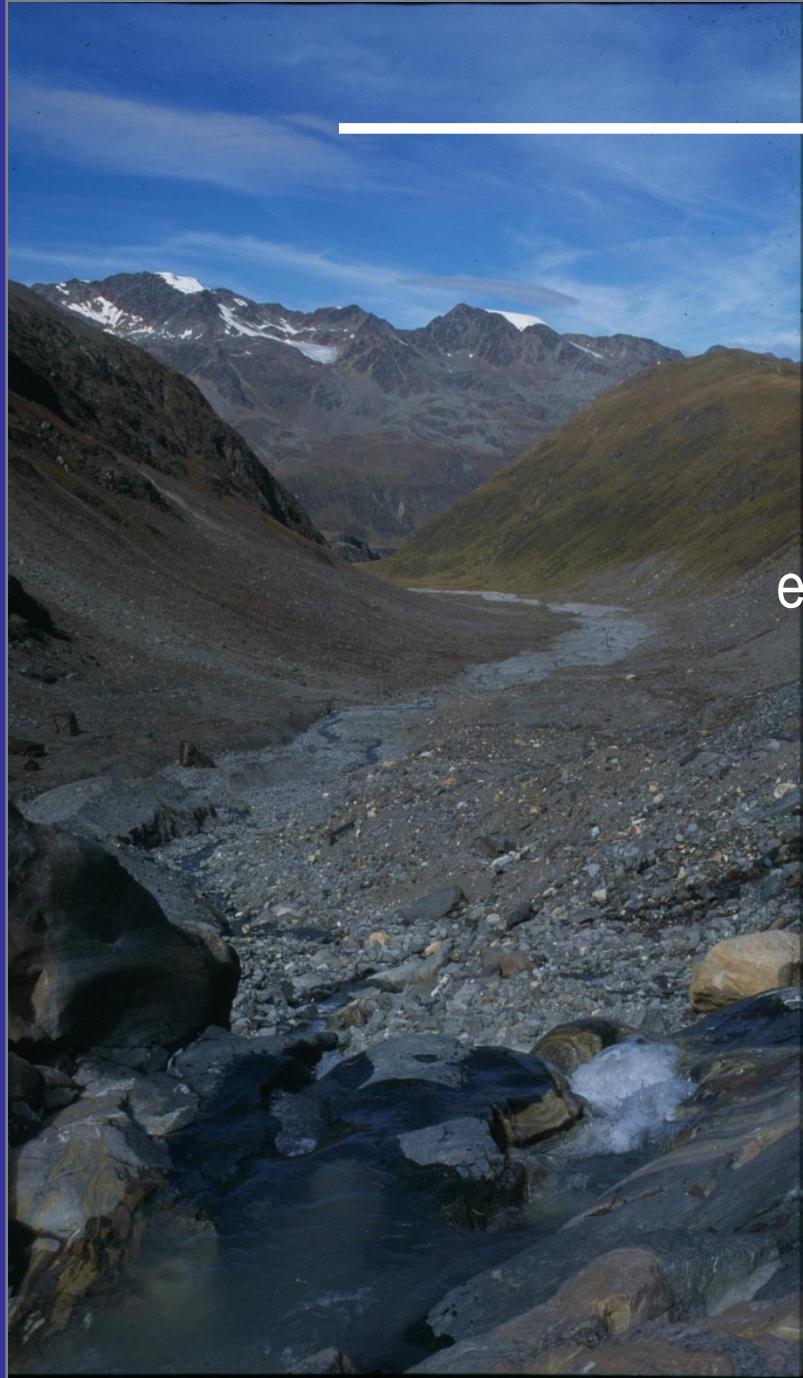


Glaciation in catchment (%)

1mm

# Environmental harshness traits





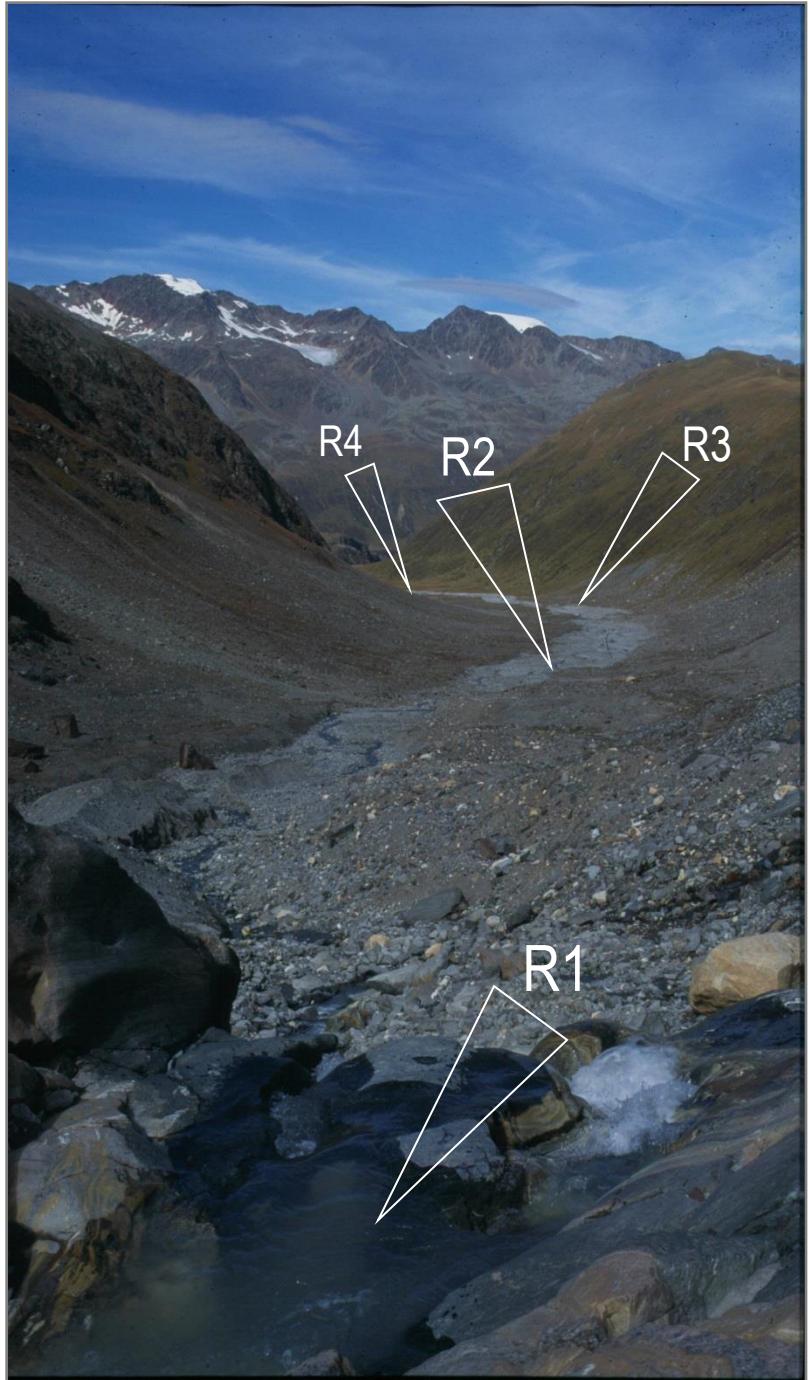
# species traits

along the gradient of environmental harshness

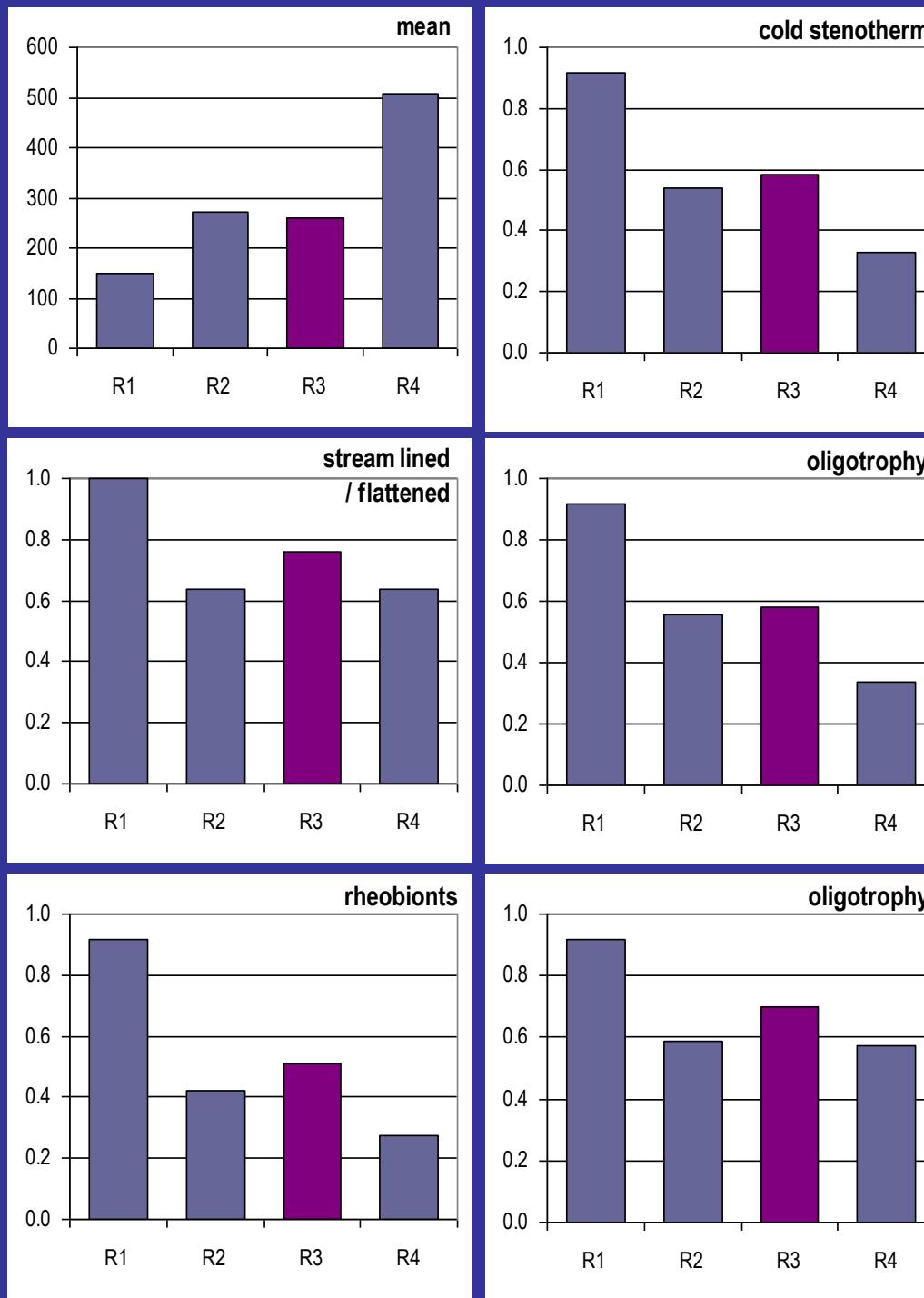
→ species with traits conferring resilience, resistance and ecophysiological tolerance were predicted to increase in importance

→ noise may result from lack of information or inprecision in some species

→ selected traits are a valuable tool to understand the role of specific habitat conditions, together with habitat and fauna relationships

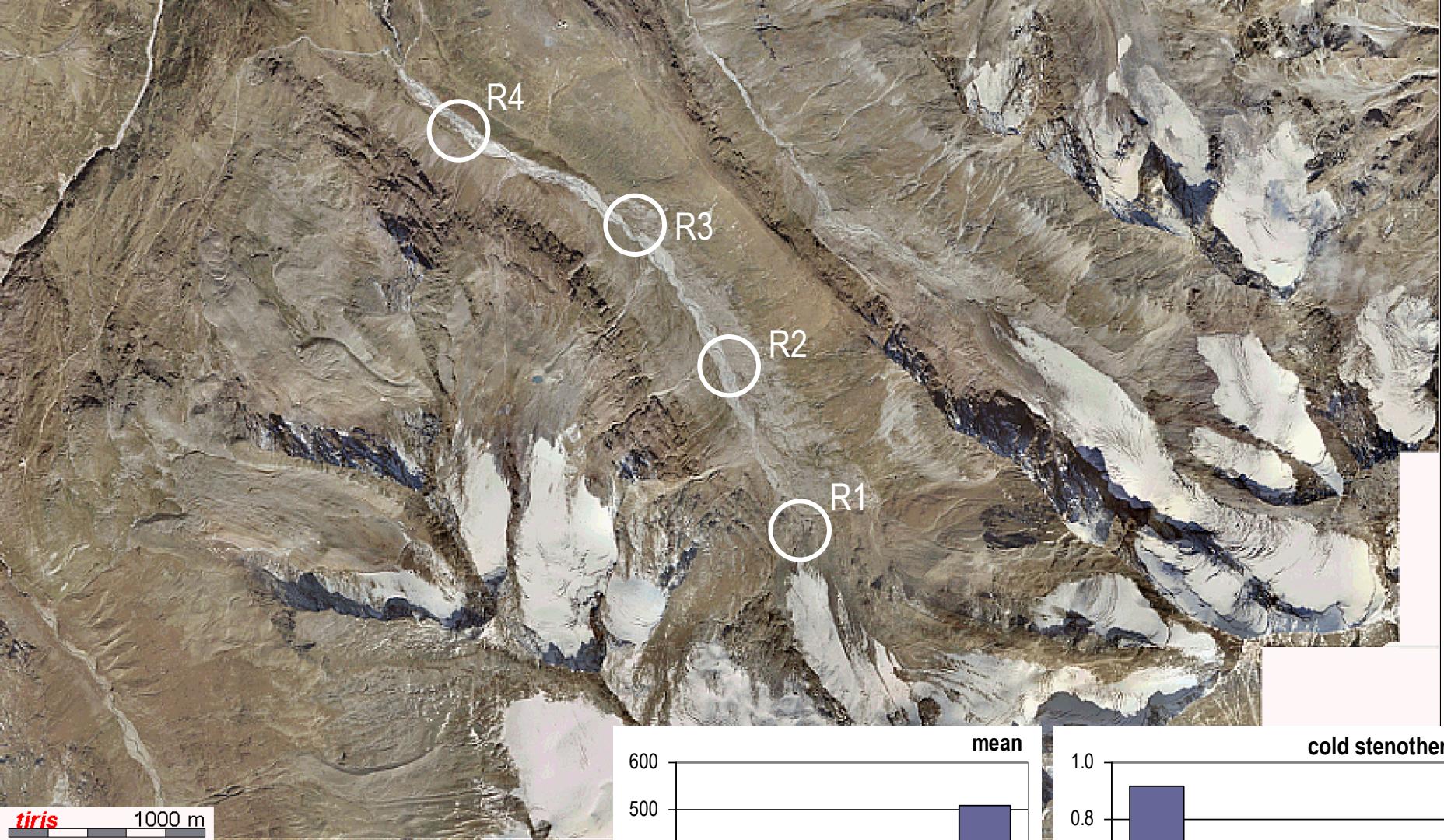


# species traits

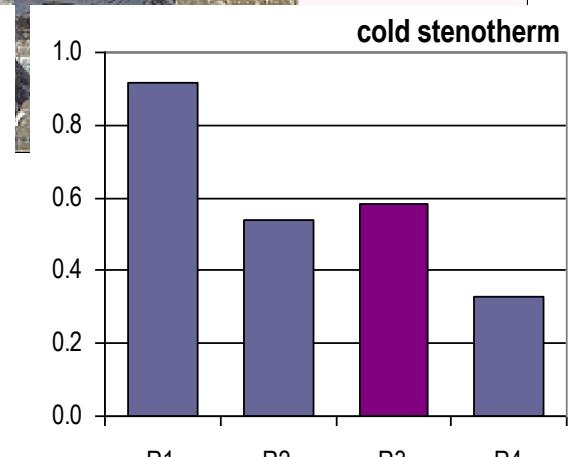
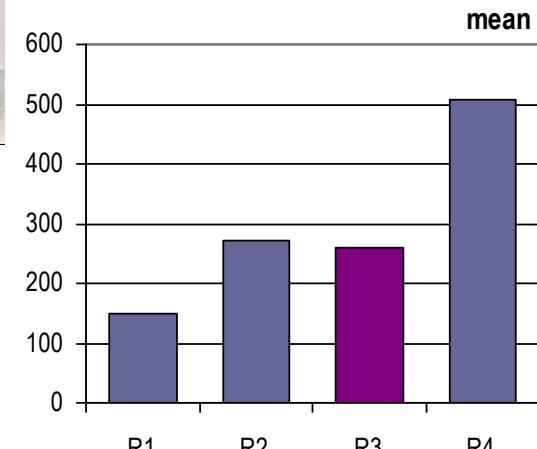


→ species with traits conferring resilience, resistance and to overcome environmental harshness were considerably affected in their relative proportions

→ most traits followed the expected pattern  
→ R 2 and R 3 were different



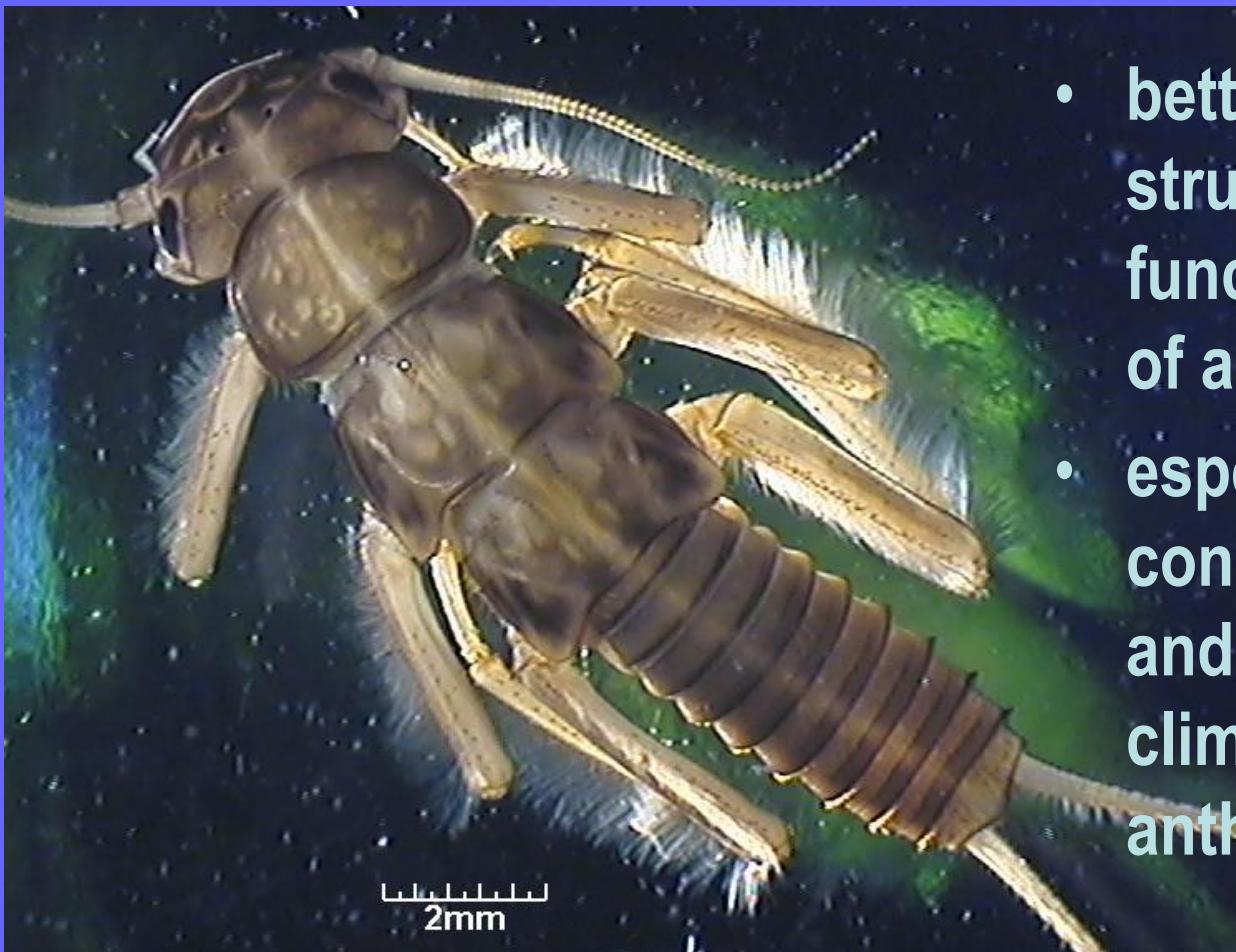
Füreder (unpubl. data)



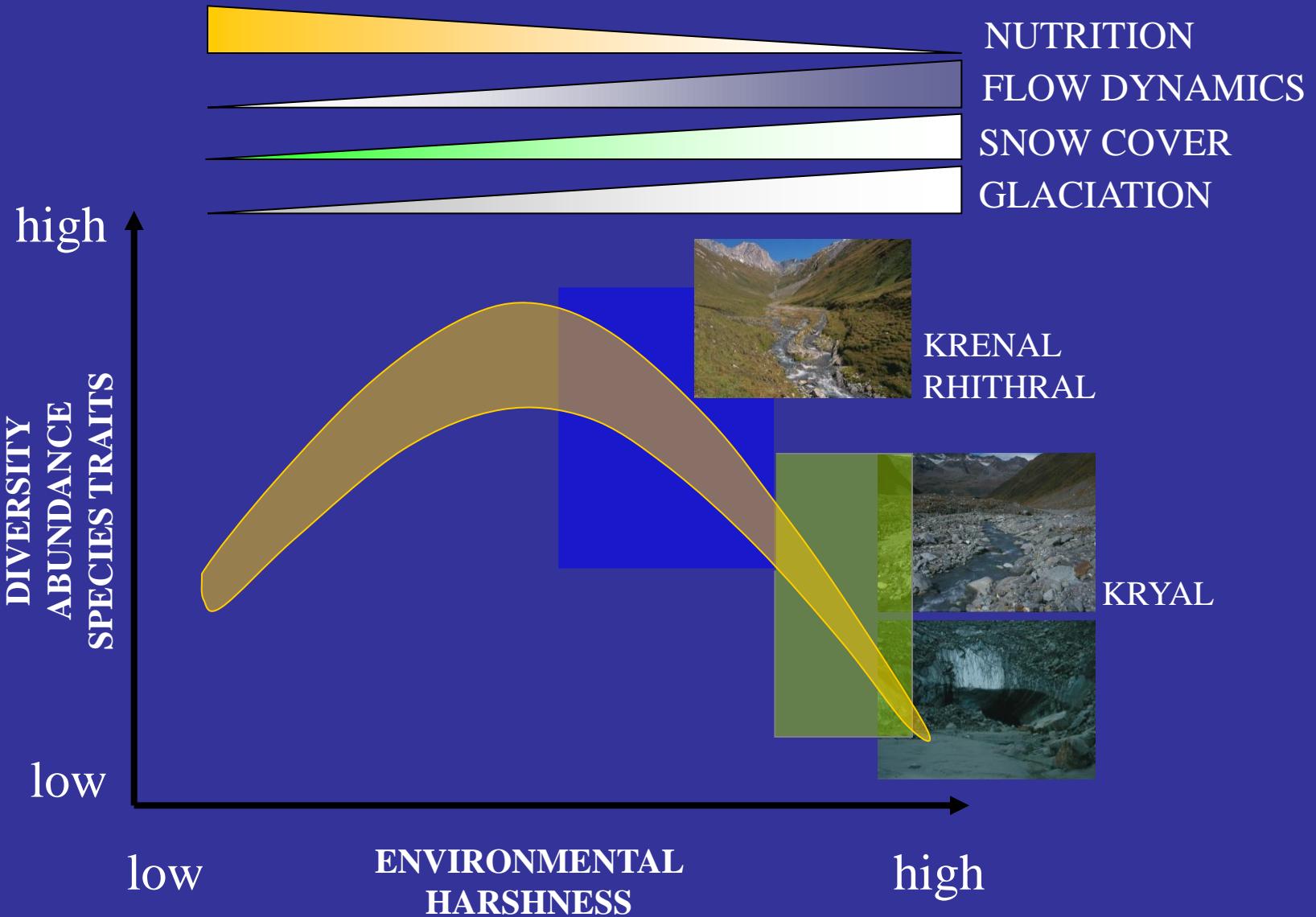
# Conclusions

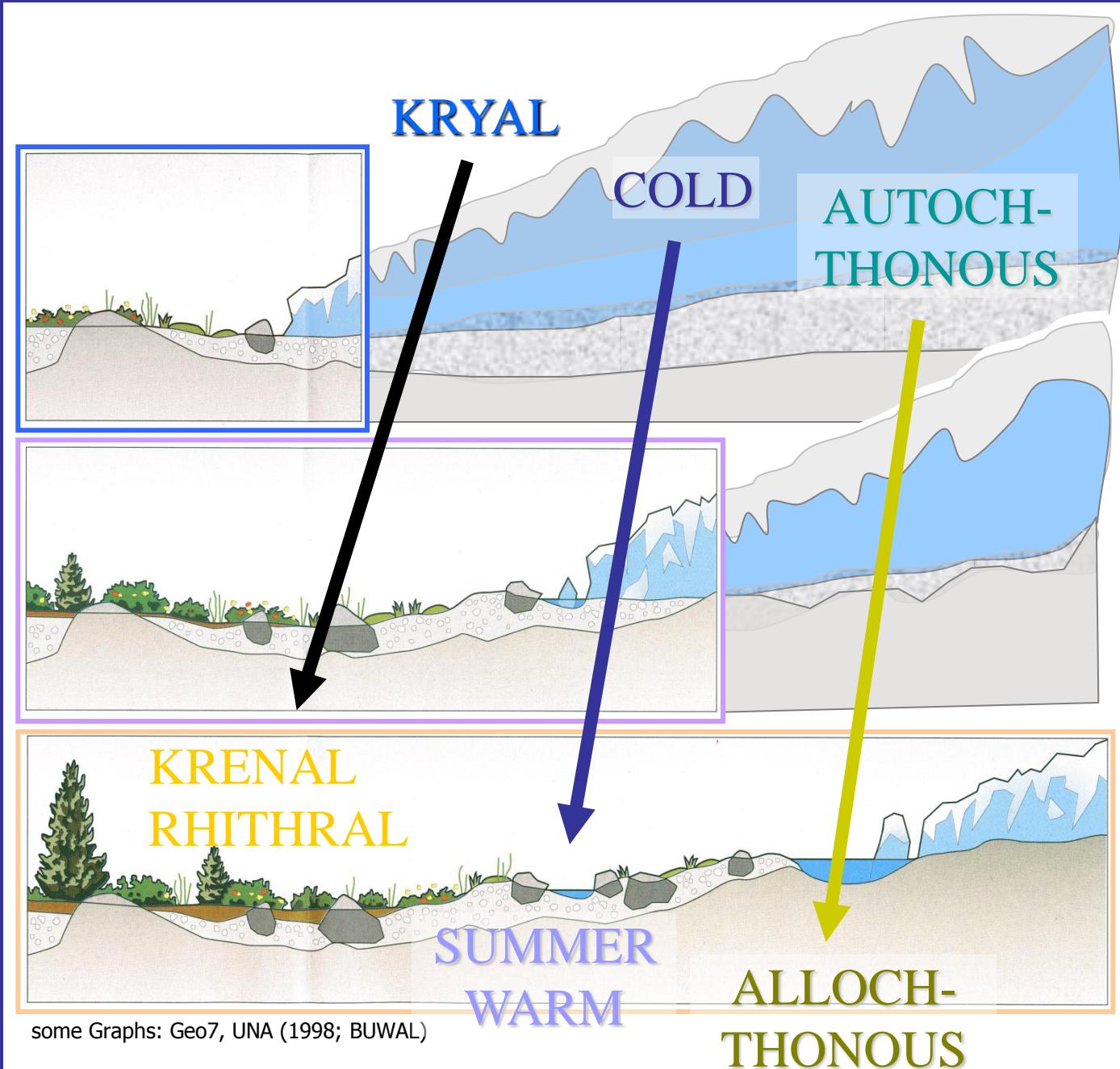
Definition and application of species traits in aquatic invertebrate assemblages in the investigation of alpine riverine systems are a promising tool to

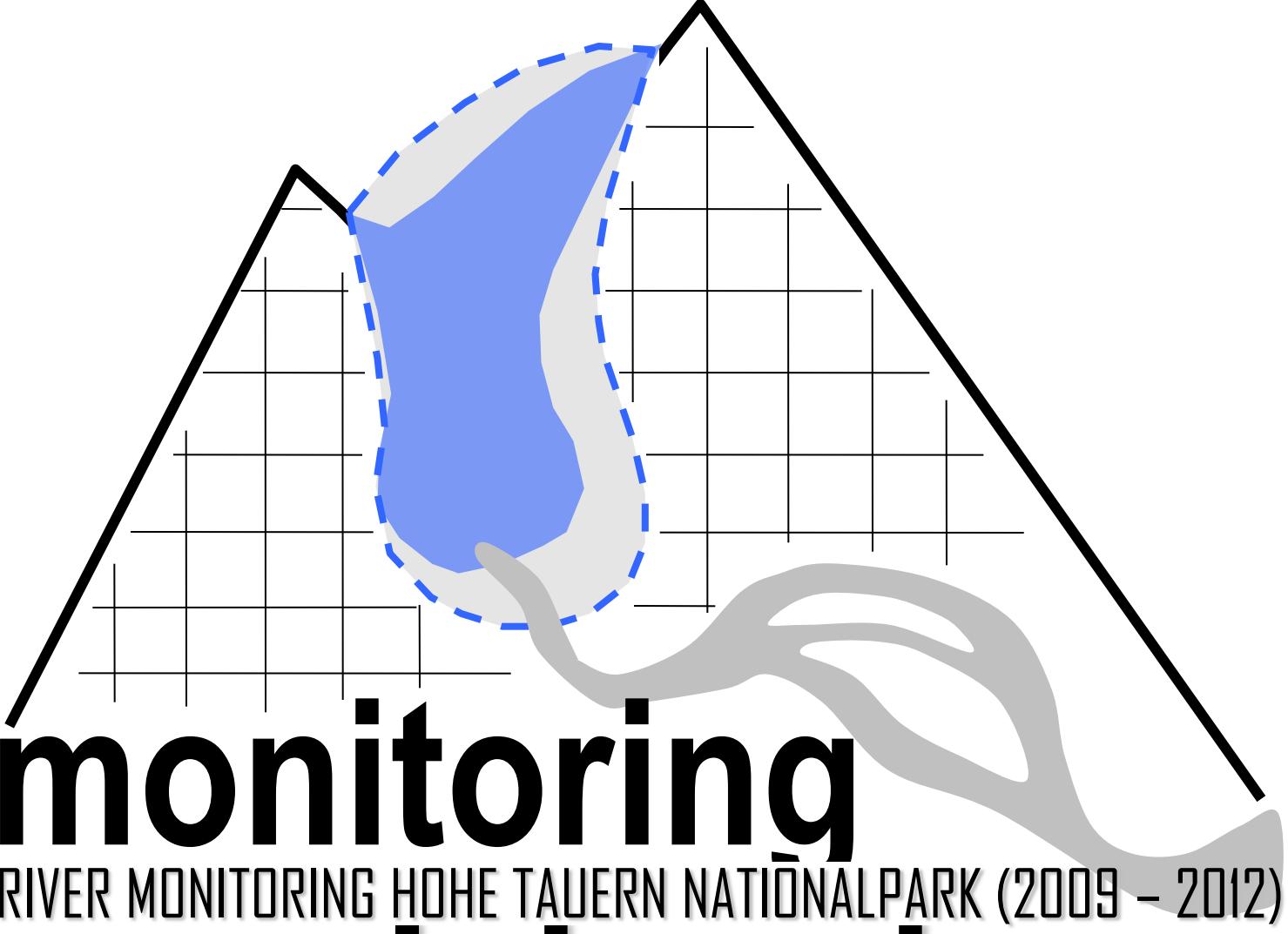
- better understand the structural and functional organisation of animal communities,
- especially when considering impacts and effects from global climate change and anthropogenic impacts



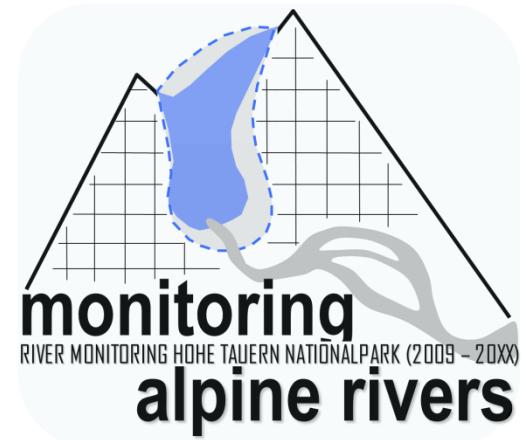
# Conclusion



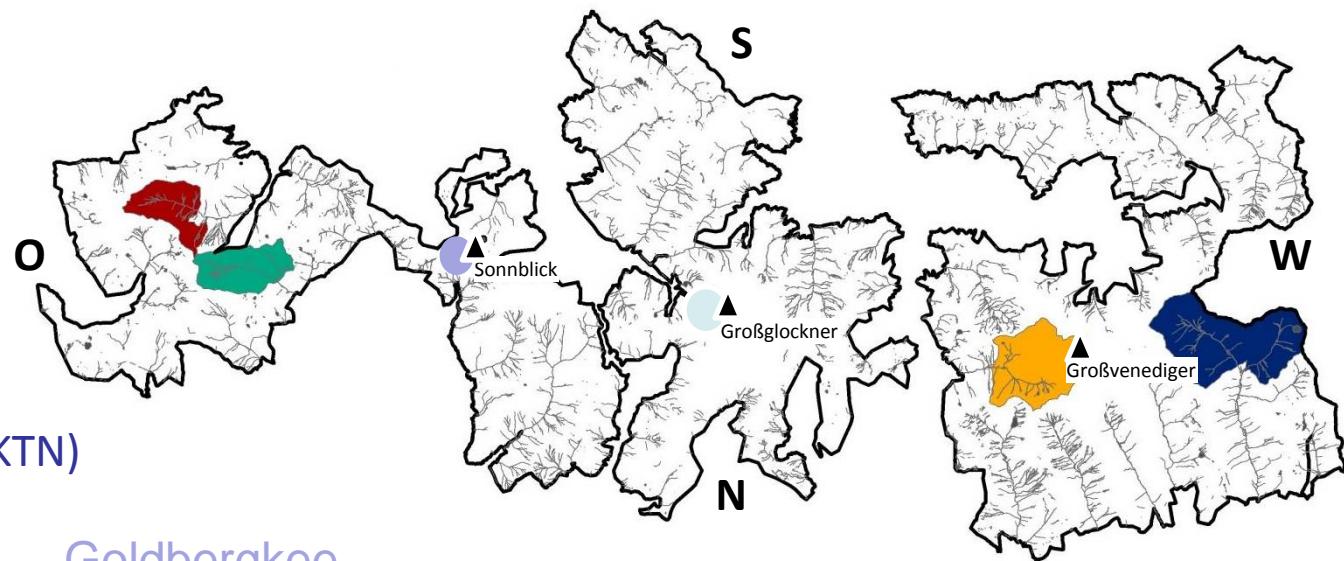




**monitoring**  
RIVER MONITORING HOHE TAUERN NATIONALPARK (2009 - 2012)  
**alpine rivers**



Seebachtal (KTN)



Anlauftal  
(SBG)

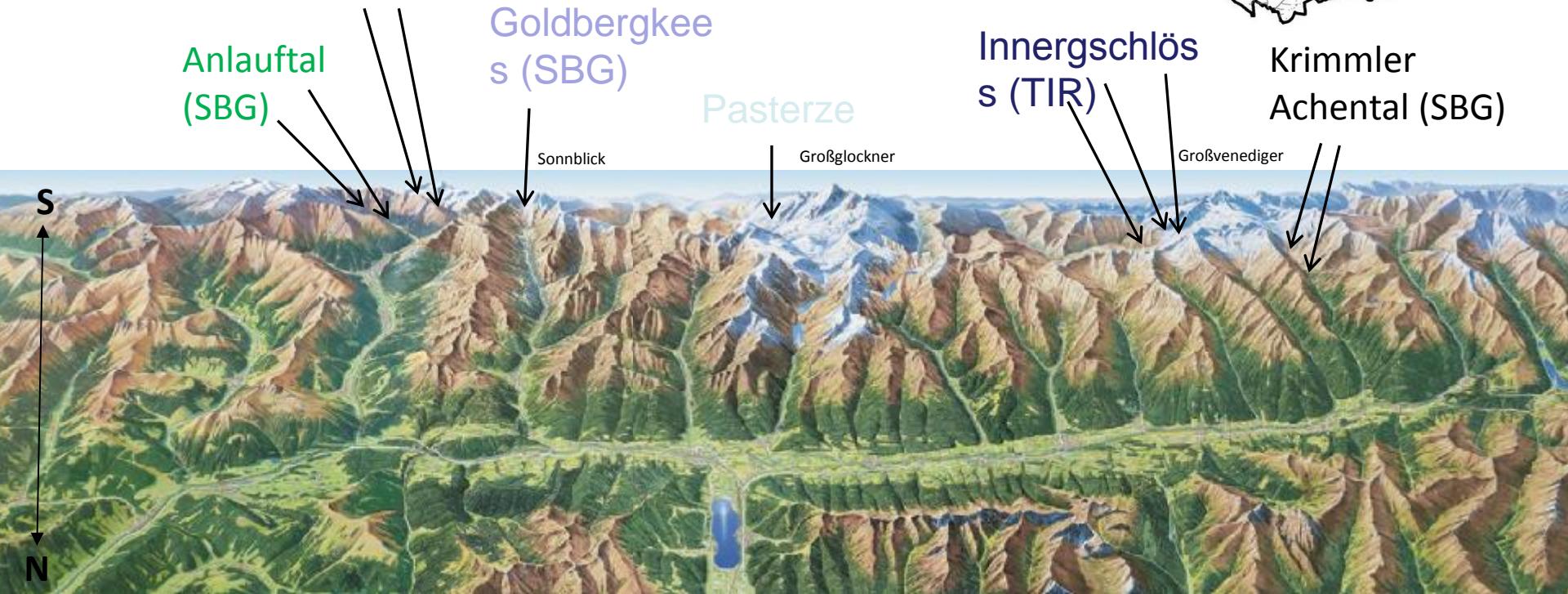
Goldbergkee  
s (SBG)

Pasterze

Innergchlös  
s (TIR)

Krimmler  
Achental (SBG)

S  
N



ZAMG



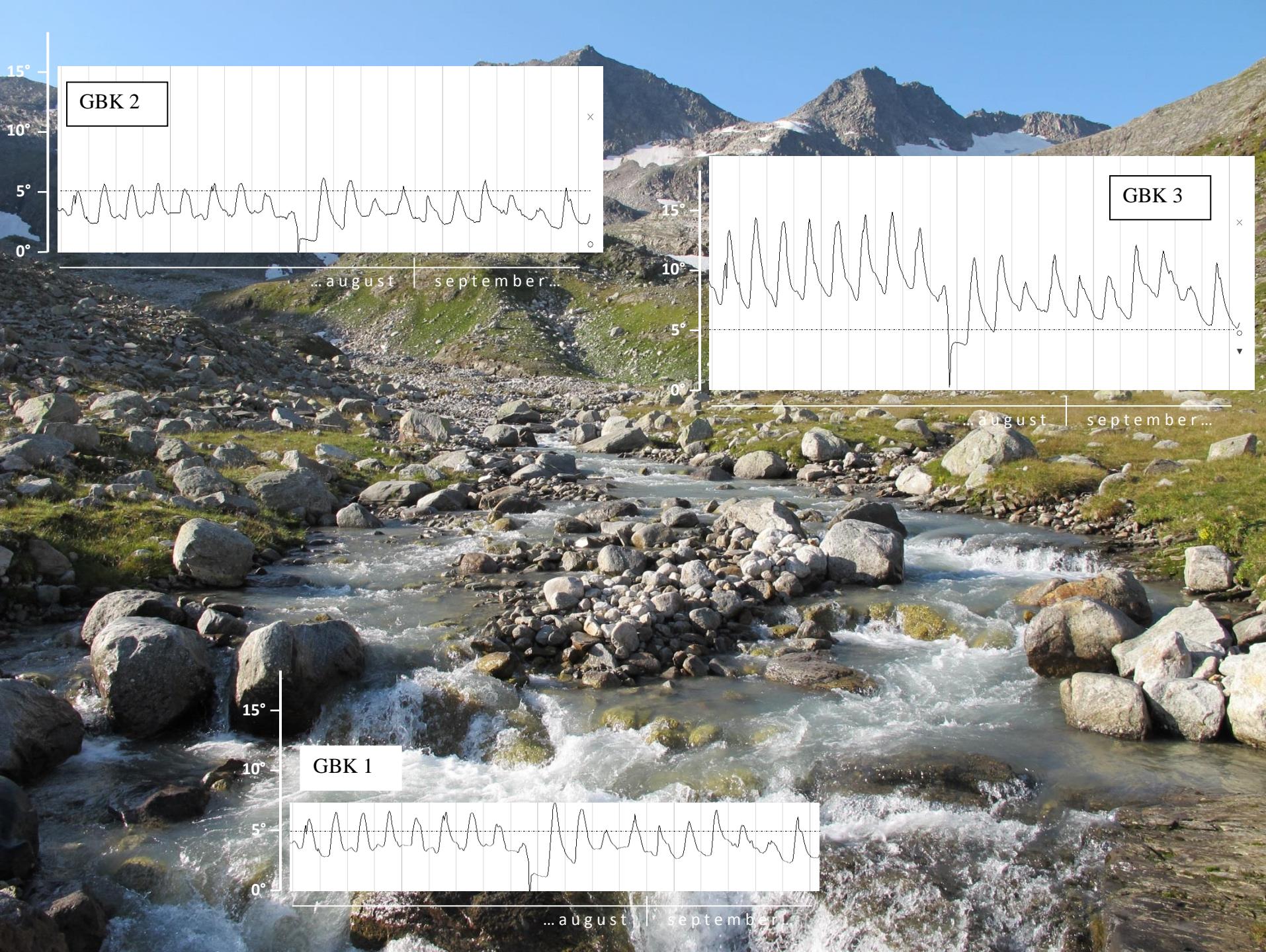
Nationalpark®  
Hohe Tauern

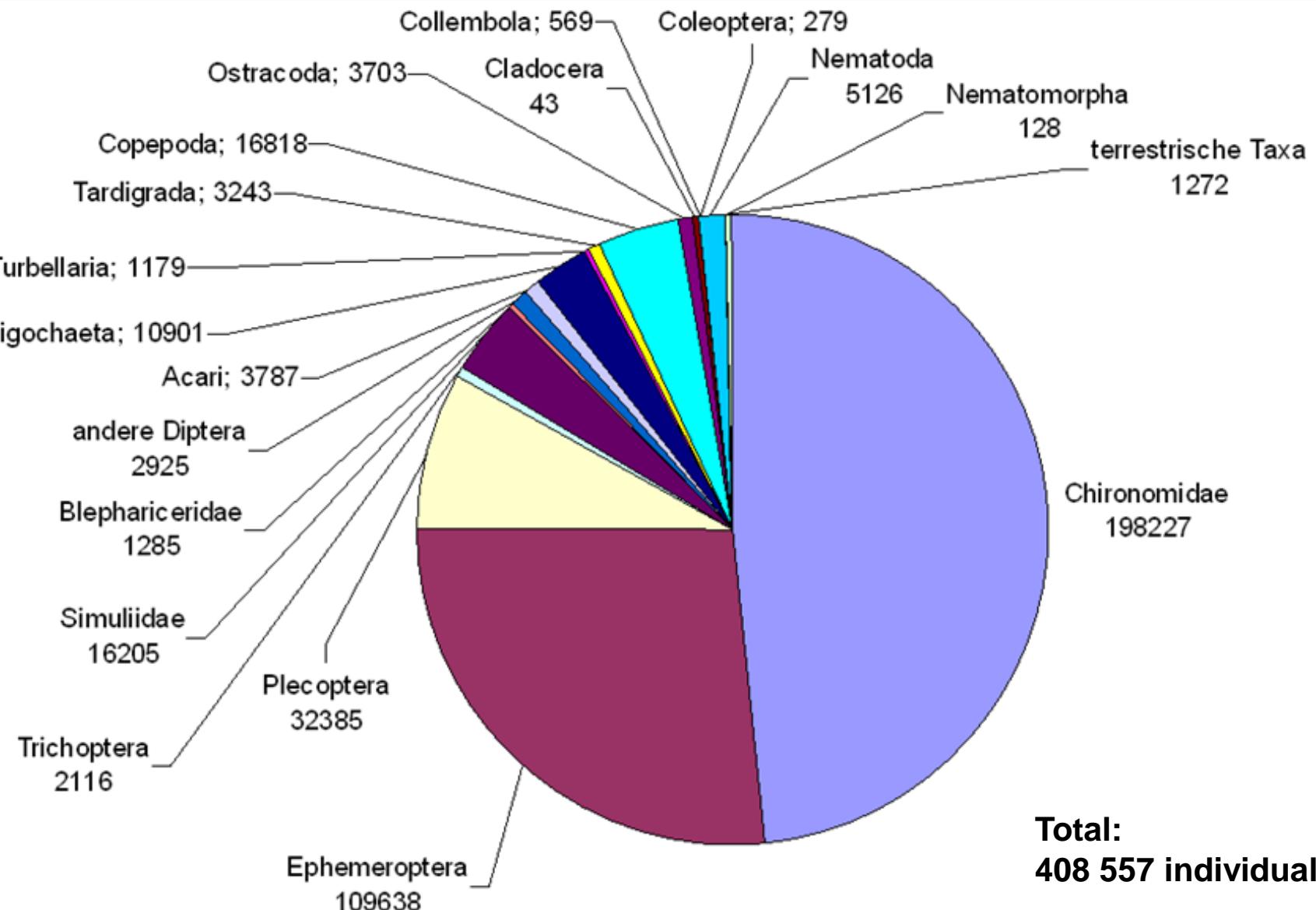


MIT UNTERSTÜTZUNG VON BUND, LAND SALZBURG UND EUROPÄISCHER UNION



lebensministerium.at





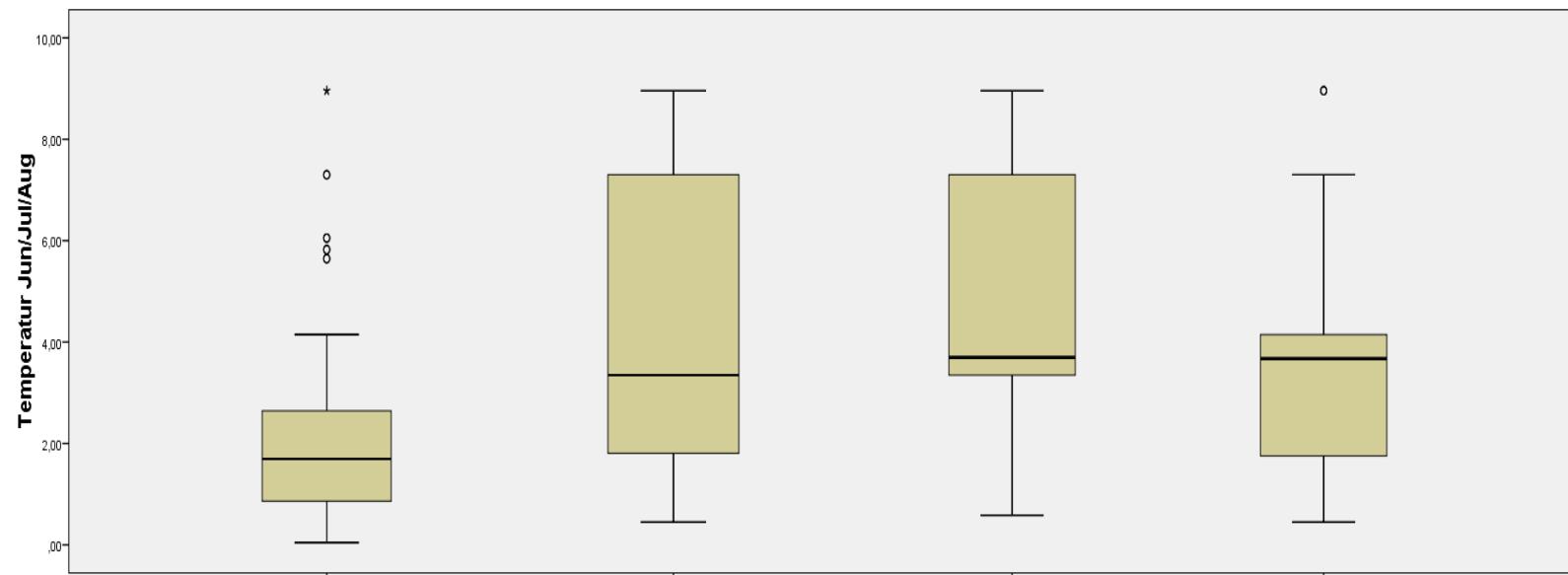
**Relative proportion of main taxonomic groups River Monitoring Program  
2009-2011: > 19 orders**

**Total:  
408 557 individuals**

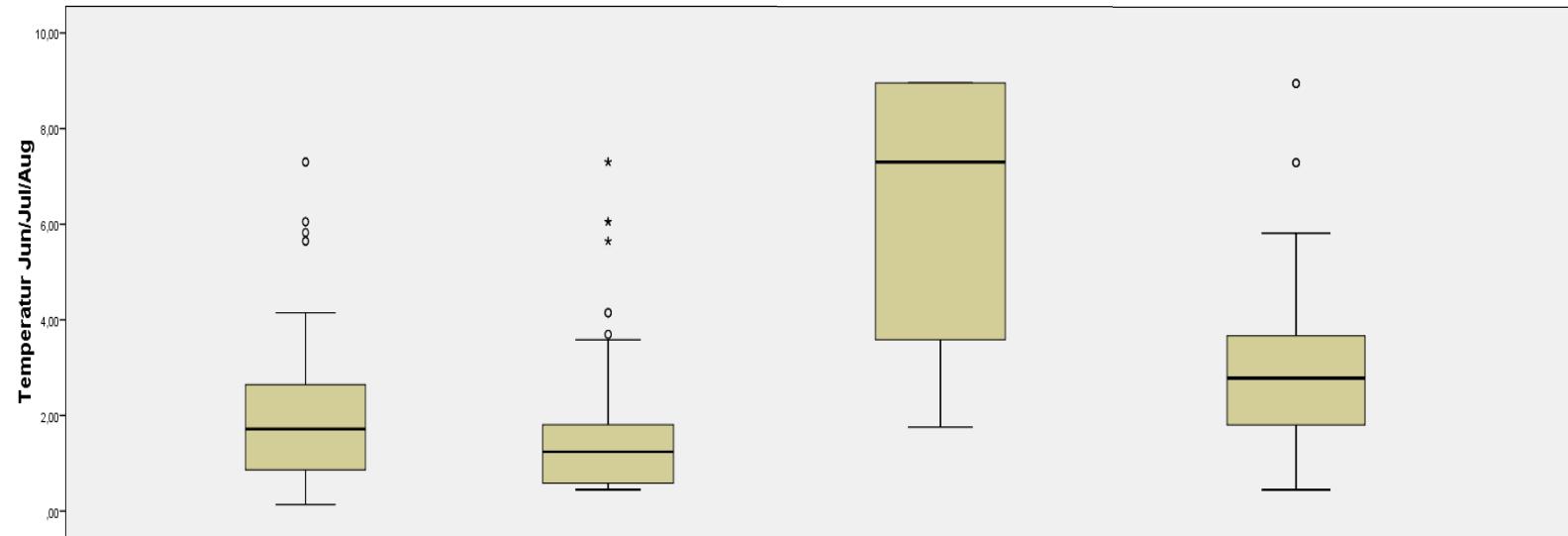
# → Temperaturpräferenzen

(Lassacher & Fürerer 2013)

## Chironomidae   Ephemeroptera   Plecoptera   Trichoptera



## *D. cinerella-zernyi*   *D. steinboecki*   *Rhithrogena loyolaea*   *Baetis alpinus*



# → Adequate Indices

(Schütz & Füreder 2013)

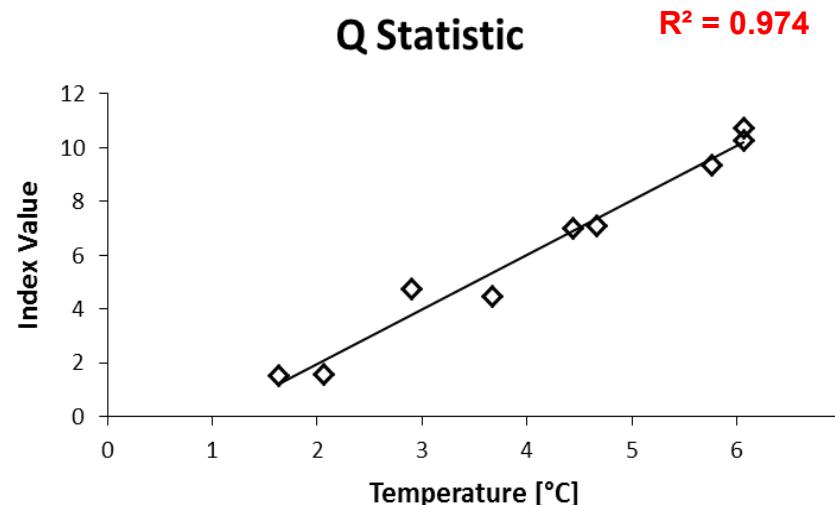
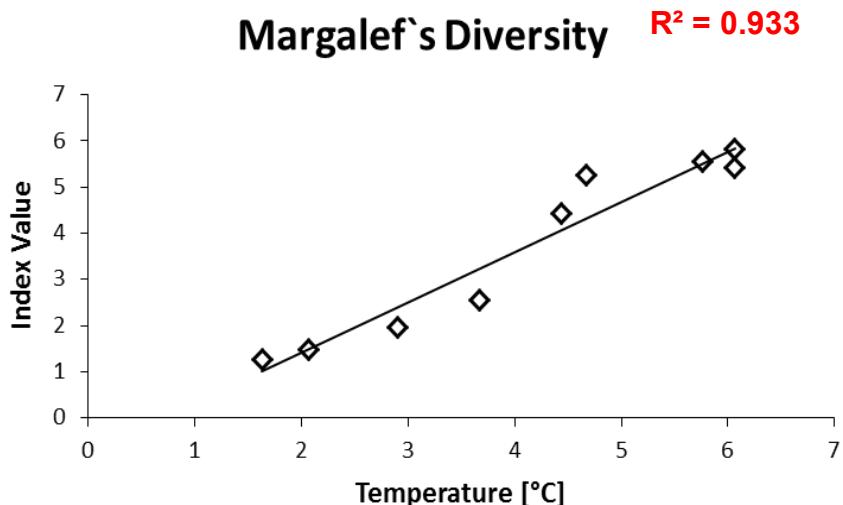
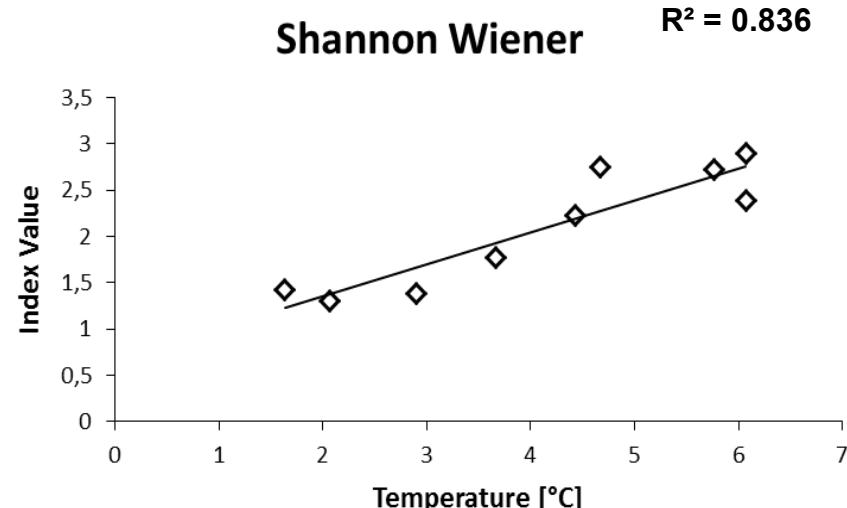
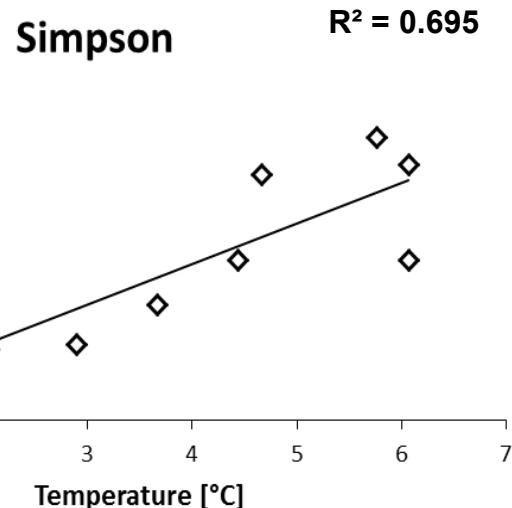


Fig. 3: Regression analysis of water temperature and  $\alpha$ -diversity indicator values of grouped individual densities of the nine sampling sites at Goldberg region (see Fig. 1 right site), September 2011; higher  $R^2$  mean a stronger relationship between the index values and water temperature; Shannon Wiener and Simpson index are commonly used in literature but we evaluated superior alpha diversity indicators (e.g. Q Statistic & Margalef's Diversity)

