Sample questions

- Storm hydrograph separation: Draw a storm hydrograph and separate its different contributions. Discuss how some of its contributions can induce innundations and how this is influenced by catchment impermeabilisation.

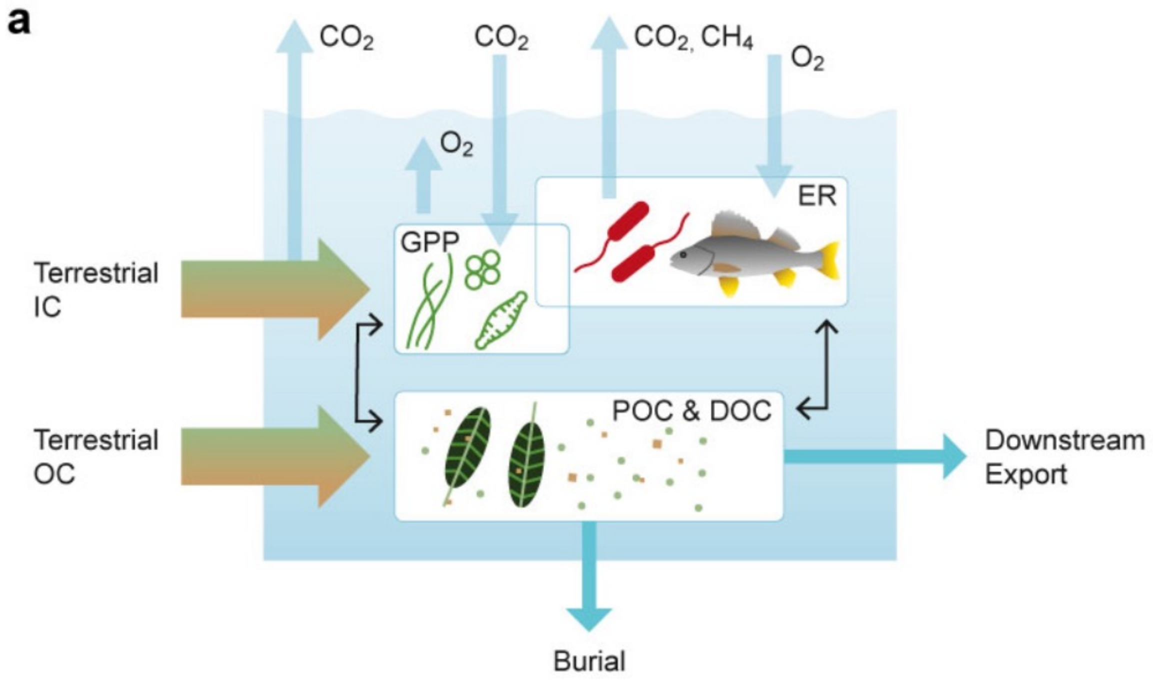
- Explain hysteresis loops between discharge and solute concentrations. Elaborate on how hysteresis loops inform on solute sources and behaviour.

- Explain how streamwater turbidity, nutrient concentrations and grazing can affect ecosystem GPP.

- Why would small streams draining lowland catchment may become particularly prone to hypoxia as streamwater temperature increases?

Ecology

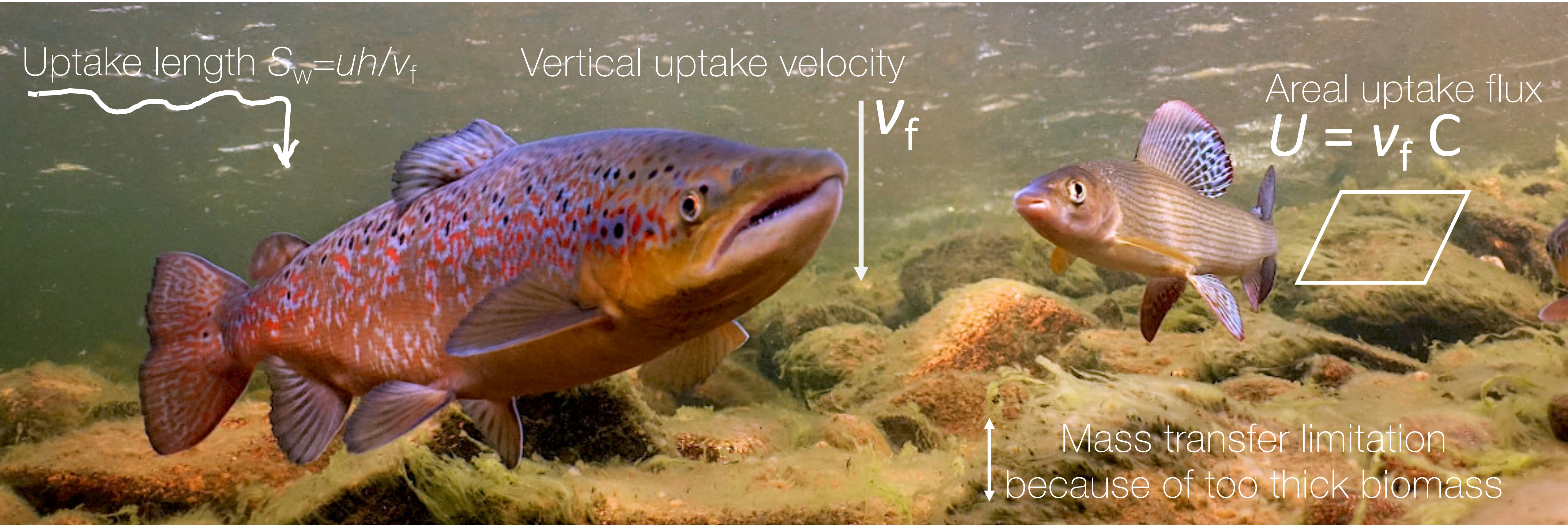
Ecological communities, including diverse representatives from all three domains of life (archaea, bacteria, eukaryotes) are the engines of ecosystem processes and services



<u>Ecology:</u> Understand and predict the interactions within ecological communities and the environment across spatial and temporal scales

EPFL

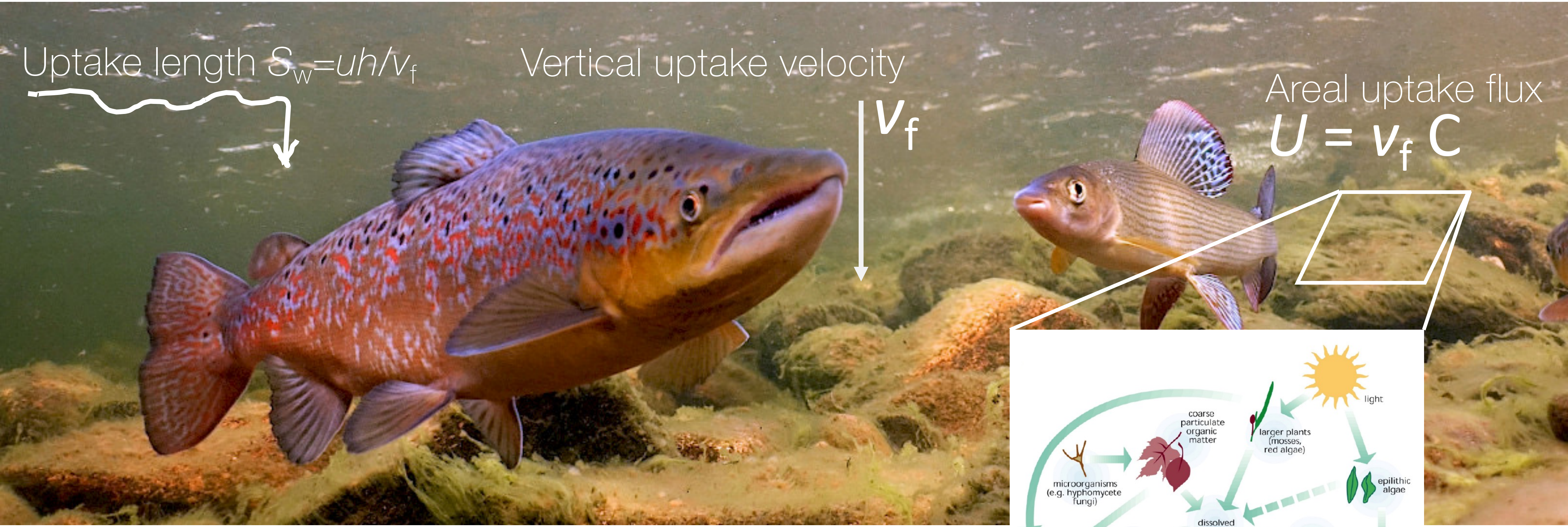
From ‘biogeochemistry’ to ecology



S_w: travel length (m)
V_f: vertical uptake velocity (m/s)
U: areal uptake flux ($g/m^2/s$)
u: flow velocity (m/s)
h: water depth (m)

EPFL

From ‘biogeochemistry’ to ecology



Uptake length $S_w = uh/v_f$

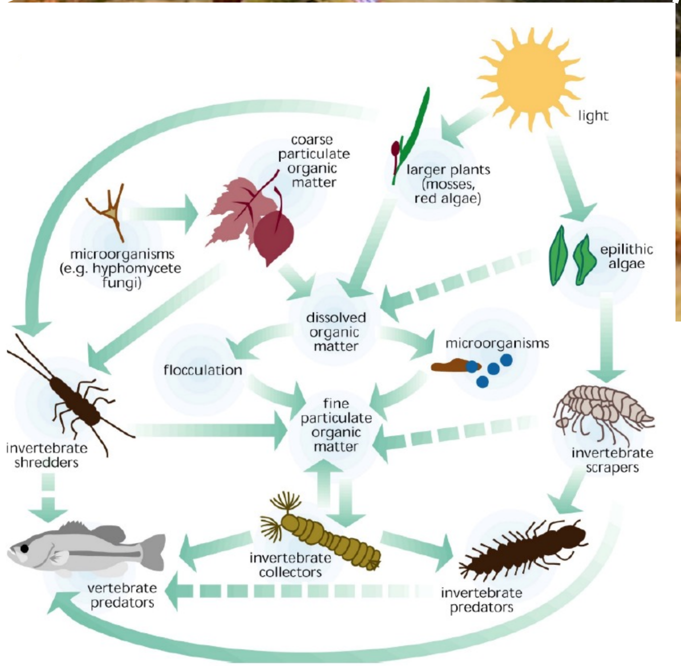
Vertical uptake velocity

v_f

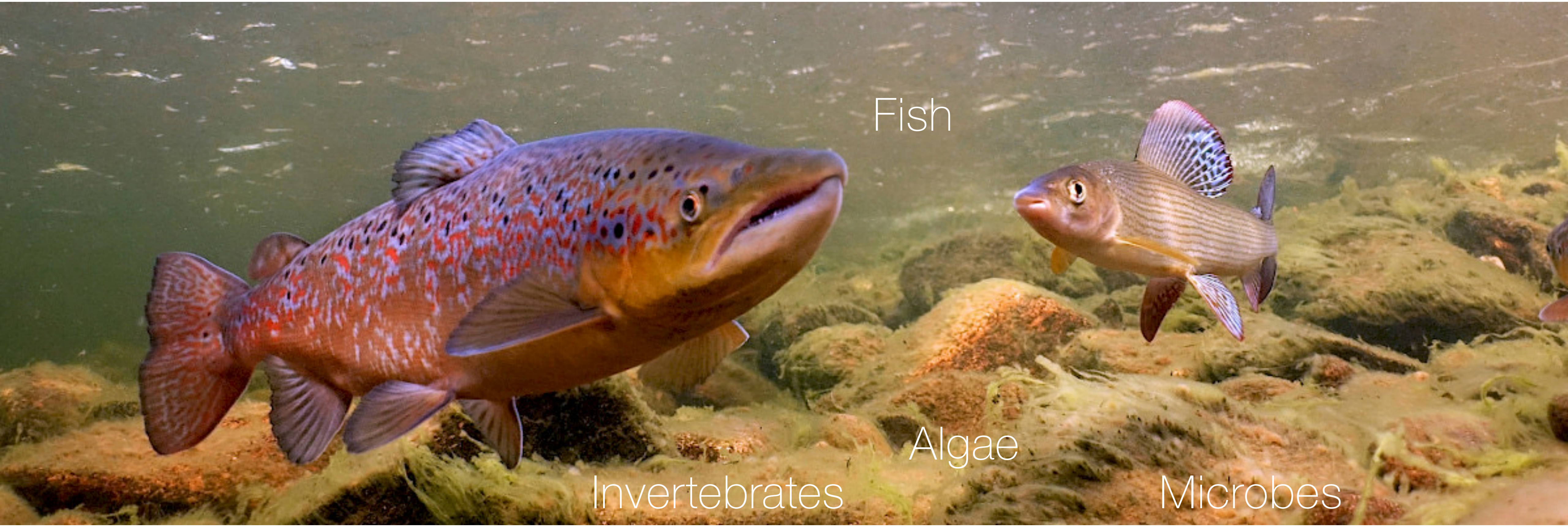
Areal uptake flux

$U = v_f\,C$

Biodiversity, food webs etc



Streams and rivers are among the most biodiverse ecosystems



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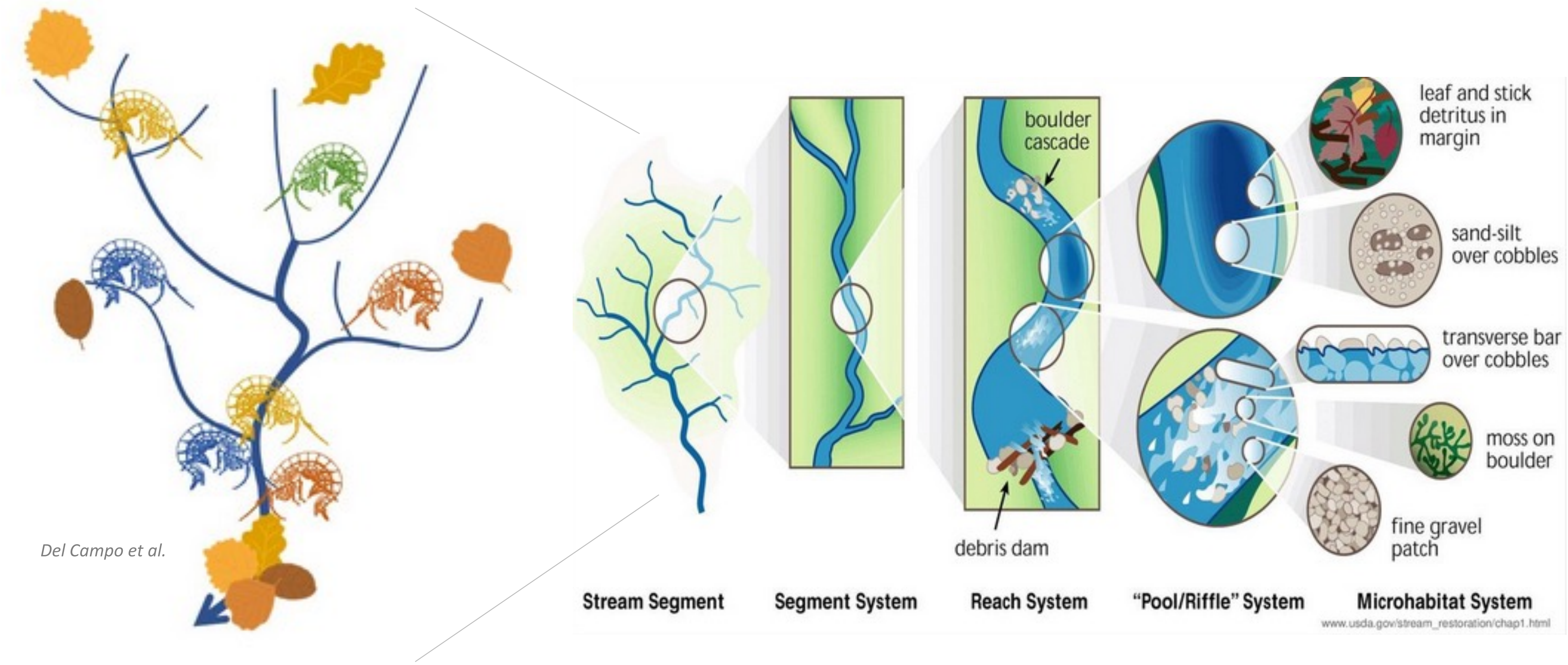
Key to the high biodiversity in streams and rivers

- Hierarchical organisation of stream and river ecosystems
- Environmental heterogeneity (in space and time)



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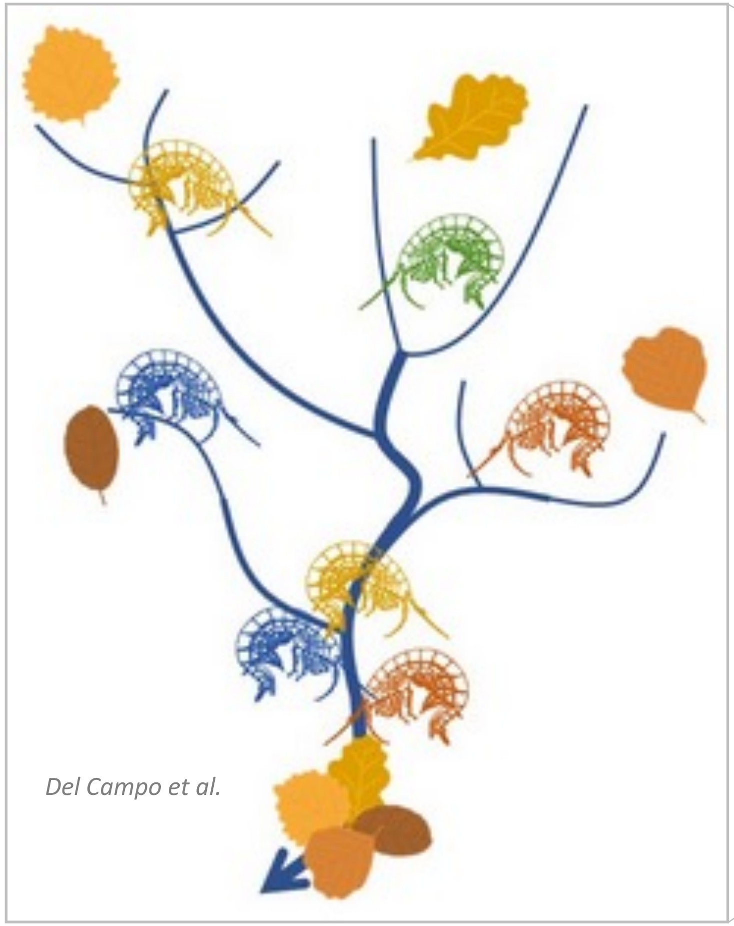
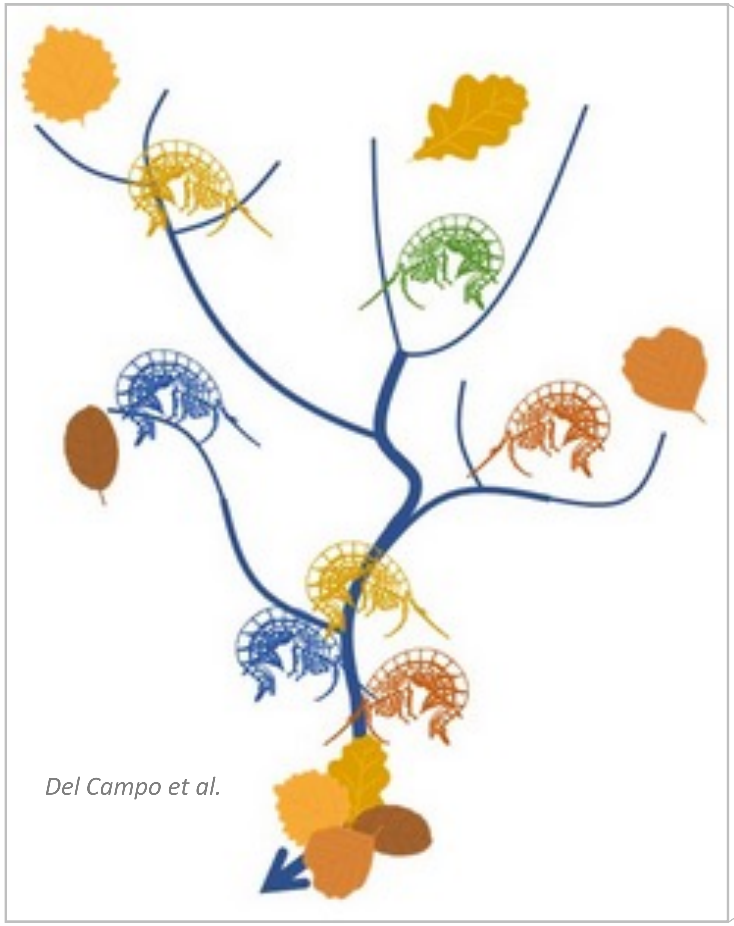
Hierarchical organisation of stream and river ecosystems
Environmental heterogeneity (in space and time)



- Dendritic network structure
- Spanning catchments and biomes
- Spatial isolation
- Connectivity and dispersal
- Metacommunity dynamics

EPFL

Hierarchical organisation of stream and river ecosystems
Environmental heterogeneity (in space and time)



- Fluvial networks are not static
- They expand and contract
- Flow intermittency
- Further contributing to environmental heterogeneity

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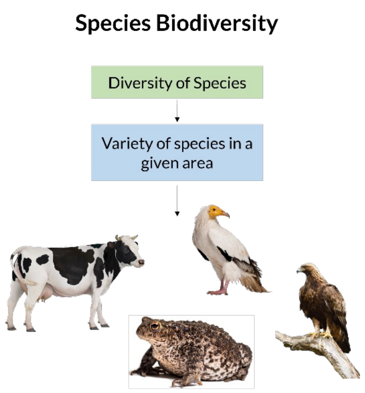
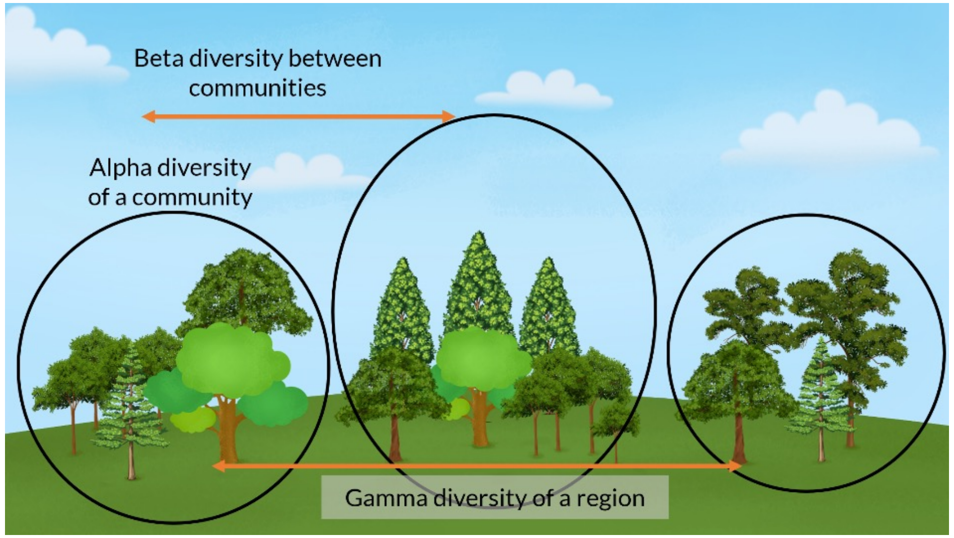
What is biodiversity?



- Species diversity
- Genetic diversity
- Functional diversity

The distribution of biodiversity in space (and time)

- Alpha-diversity
- Beta-diversity (similarity, dissimilarity)
- Gamma-diversity



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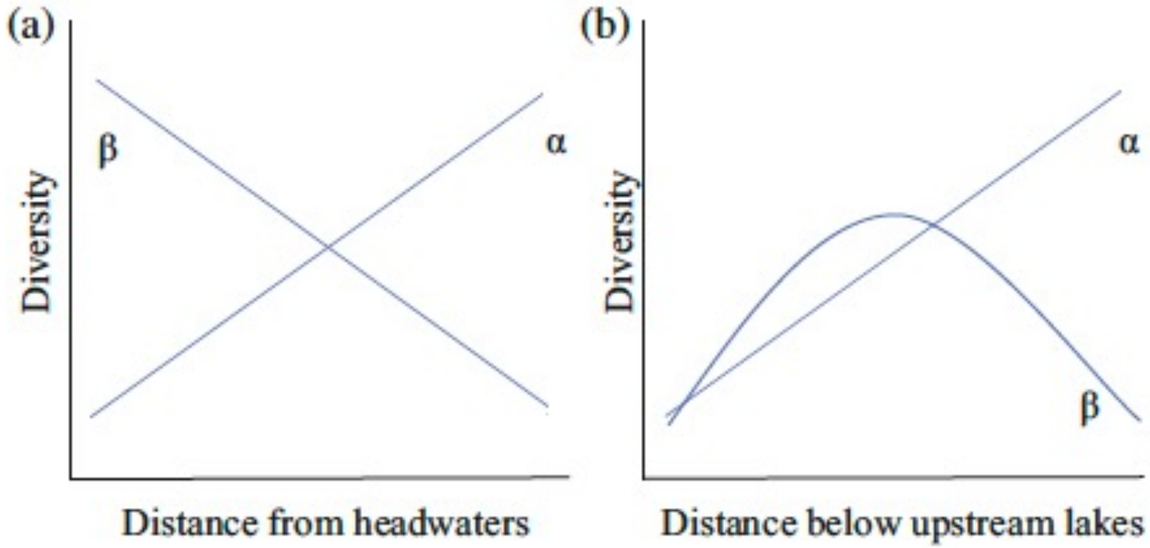
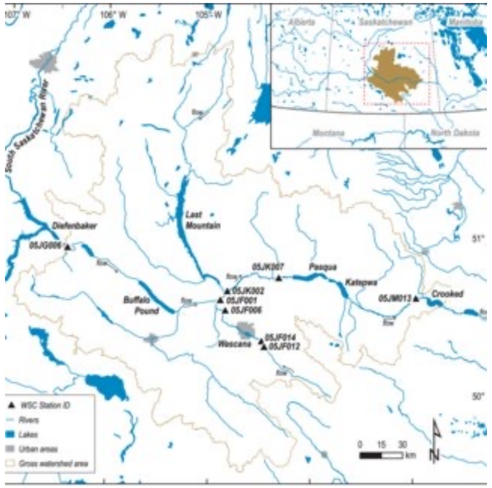
ARTICLE

ECOLOGICAL MONOGRAPHS
ECOLOGICAL SOCIETY OF AMERICA

Rethinking biodiversity patterns and processes in stream ecosystems

Matthew D. Green[1] | Kurt E. Anderson[1] | David B. Herbst[2,3] |
Marko J. Spasojevic[1]





Alpha- and beta- diversity change inversely downstream across a river network

- Spatial isolation of headwaters at the tips of the river network
- Little exchange (dispersion) between headwaters
- Downstream systems colleact diversity from upstream, hence their elevated local diversity

Lakes interupt the downstream gradient of beta-diversity

- Homogenisation reduces beta-diversity (elevated similarity)
- Effect decreases downstream

EPFL

The ISME Journal (2015) 9, 516–526

www.nature.com/ismej

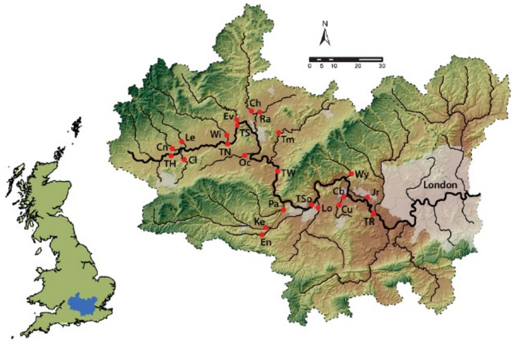
ORIGINAL ARTICLE

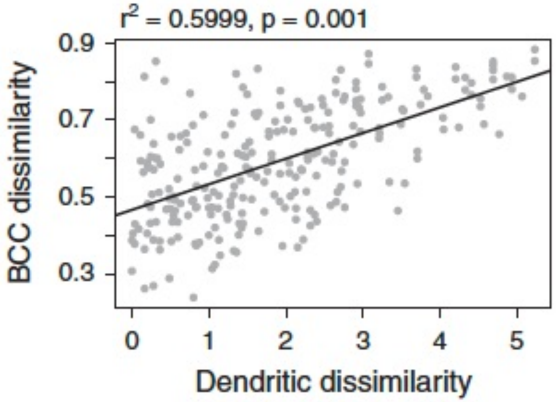
Catchment-scale biogeography of riverine bacterioplankton

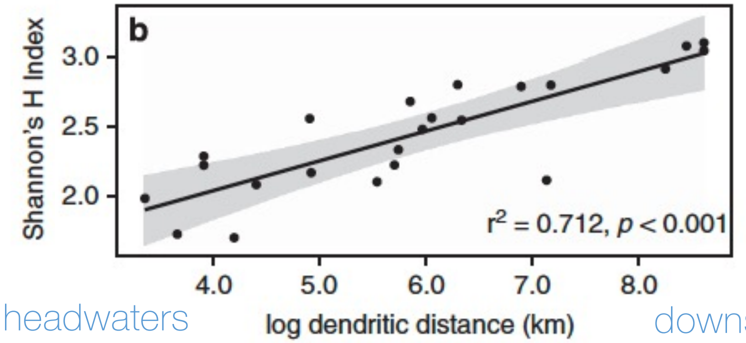
Daniel S Read, Hyun S Gweon, Michael J Bowes, Lindsay K Newbold, Dawn Field, Mark J Bailey and Robert I Griffiths
Centre for Ecology & Hydrology, Wallingford, UK

Bacterial diversity is not randomly distributed across river networks

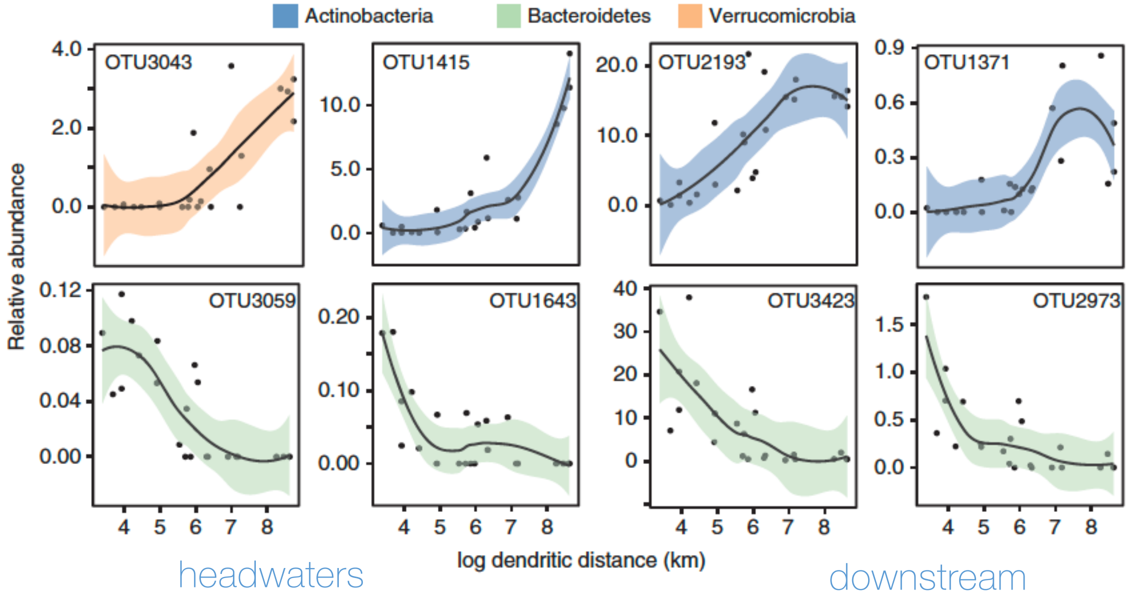
- Beta-diversity: Network structure affects community composition — highest BCC dissimilarity when channel dissimilarity is highest (environmental heterogeneity)
- Alpha-diversity: Headwaters have overall lower local diversity than downstream reaches (collection effect)
- Downstream turnover of certain bacterial groups







headwaters downstream



headwaters downstream

Streams and rivers are among the most biodiverse ecosystems

Current Biology
Magazine

Essay

Multiple threats imperil freshwater biodiversity in the Anthropocene

David Dudgeon

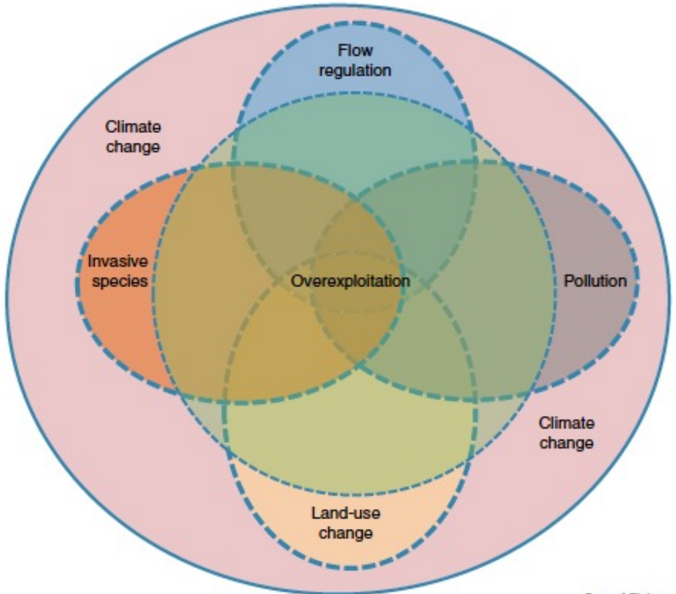


Figure 1. A conceptual diagram of global threats to freshwater ecosystems.
The total planetary operating space is equivalent to the climate-change ellipse, and individual freshwater bodies can be positioned within this space according to the combination of threat categories that they experience. Overexploitation occupies the centre of the space because this is the earliest and sometimes the only threat to freshwater biodiversity in remote or sparsely populated localities. Most fresh waters are located within spaces where three or more threat categories overlap.

Annu. Rev. Ecol. Evol. Syst. 2005. 36:267–94
doi: 10.1146/annurev.ecolsys.36.102003.152636

First published online as a Review in Advance on August 12, 2005

Biodiversity-Ecosystem Function Research: Is It Relevant to Conservation?

Diane S. Srivastava[1] and Mark Vellend[2,3]

From global-change stressors to ecosystem functioning

Is their a role of biodiversity and community composition?

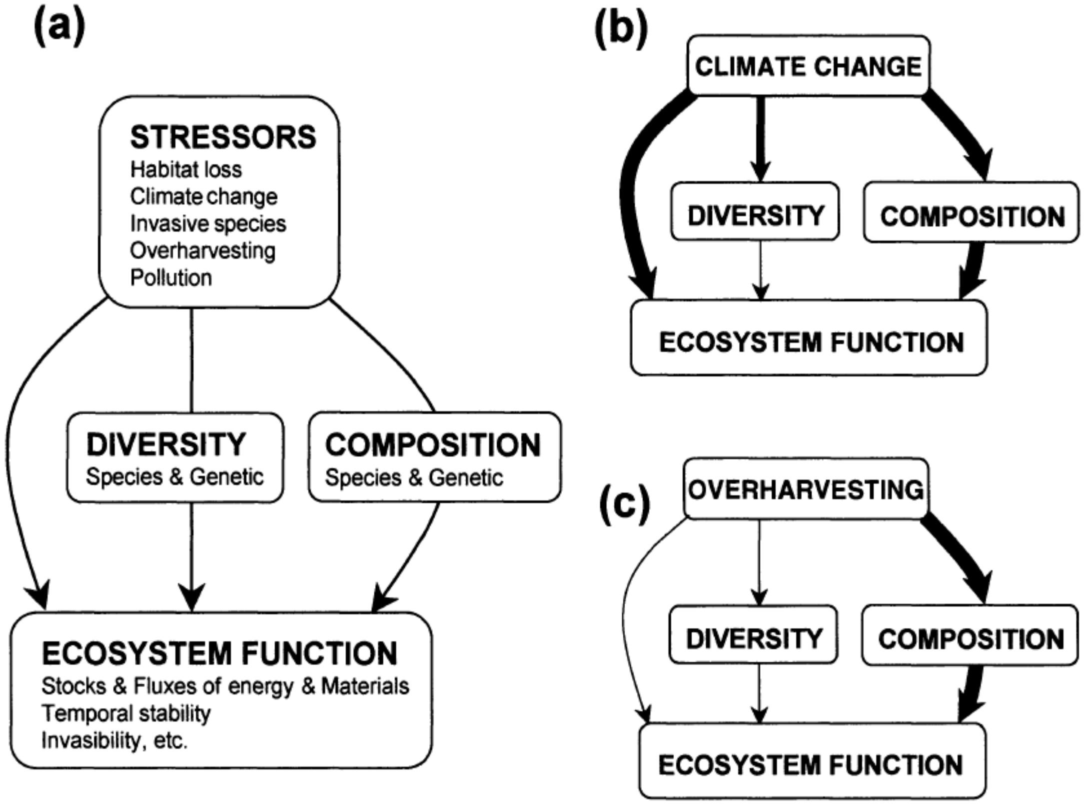
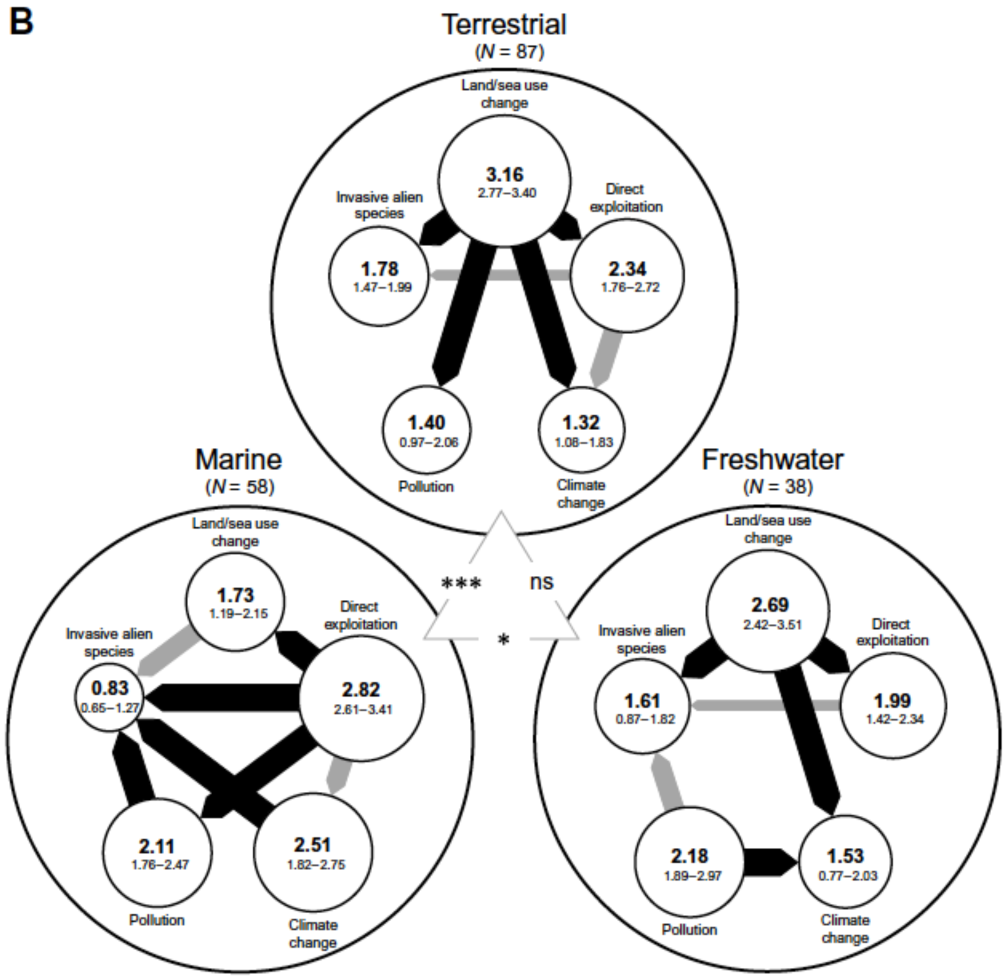


Figure 1 (*a*) There are many pathways between environmental stressors and ecosystem functions. Simply showing a positive effect of diversity on ecosystem function is insufficient evidence that reducing a stressor will lead to improvements in ecosystem functioning. The relative importance of each pathway (indicated by arrow width in *b*,*c*) may differ between specific stressors, in this case (*b*) climate change and (*c*) overharvesting.

ENVIRONMENTAL STUDIES

The direct drivers of recent global anthropogenic biodiversity loss

Pedro Jaureguiberry[1]†, Nicolas Titeux[2,3,4]†, Martin Wiemers[2,5], Diana E. Bowler[3,6,7], Luca Coscieme[8], Abigail S. Golden[9,10], Carlos A. Guerra[3,11], Ute Jacob[12,13], Yasuo Takahashi[14], Josef Settele[2,3,15], Sandra Díaz[1], Zsolt Molnár[16], Andy Purvis[17,18]*



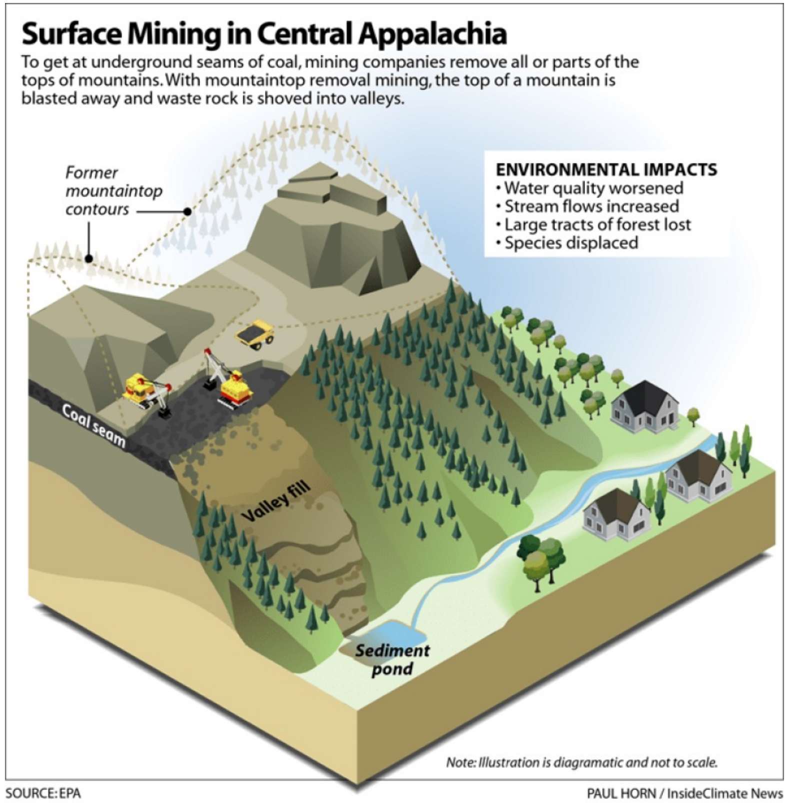
Freshwaters:
Land use change is the dominant direct driver of recent biodiversity loss worldwide.
Pollution ranks second, direct exploitation third; climate change and invasive alien species have been significantly less important than the top two drivers.

However, ecosystems and their biodiversity are increasingly exposed to multiple stressors

A catchment perspective of fluvial ecosystems

Land use change

- Urbanisation
- Deforestation
- Mountain top mining and valley filling



ARTICLE

doi:10.1038/nature09440

Global threats to human water security and river biodiversity

C. J. Vörösmarty[1]*, P. B. McIntyre[2]*†, M. O. Gessner[3], D. Dudgeon[4], A. Prusevich[5], P. Green[1], S. Glidden[5], S. E. Bunn[6], C. A. Sullivan[7], C. Reidy Liermann[8] & P. M. Davies[9]

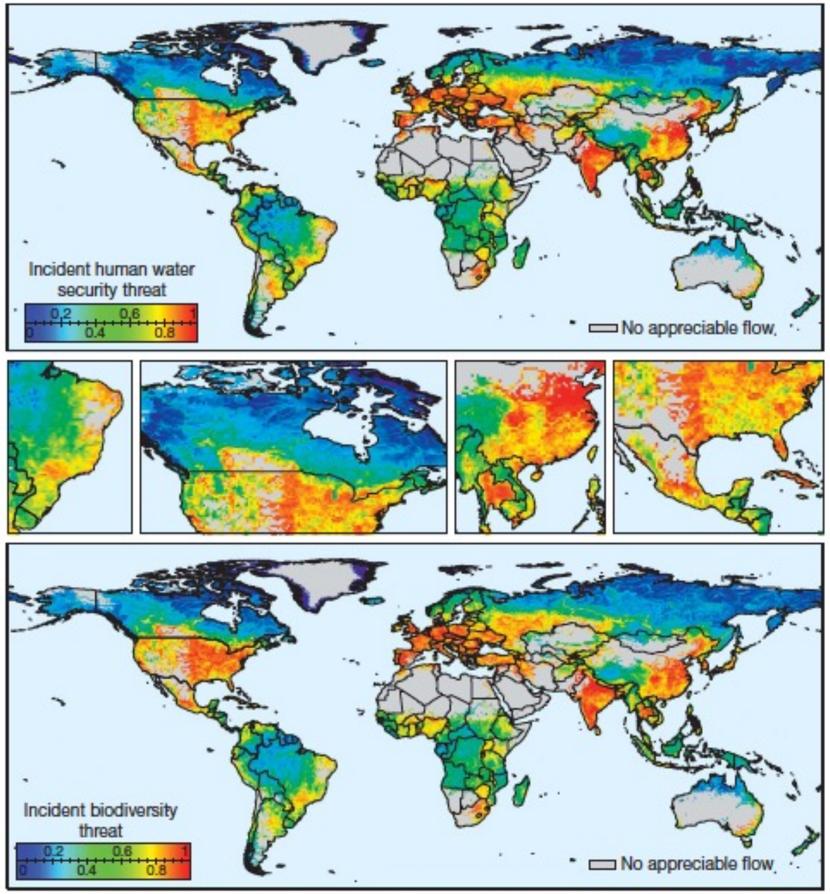


Figure 1 | Global geography of incident threat to human water security and biodiversity. The maps demonstrate pandemic impacts on both human water security and biodiversity and are highly coherent, although not identical (biodiversity threat = 0.964 × human water security threat + 0.018; $r = 0.97$, $P < 0.001$). Spatial correlations among input drivers (stressors) varied, but were generally moderate (mean $|r| = 0.34$; $n = 253$ comparisons). Regional maps exemplify main classes of human water security threat (see main text and Supplementary Fig. 4). Spatial patterns proved robust in a variety of sensitivity tests (Supplementary Methods and Supplementary Discussion). Threat indices are relative and normalized over discharging landmass.

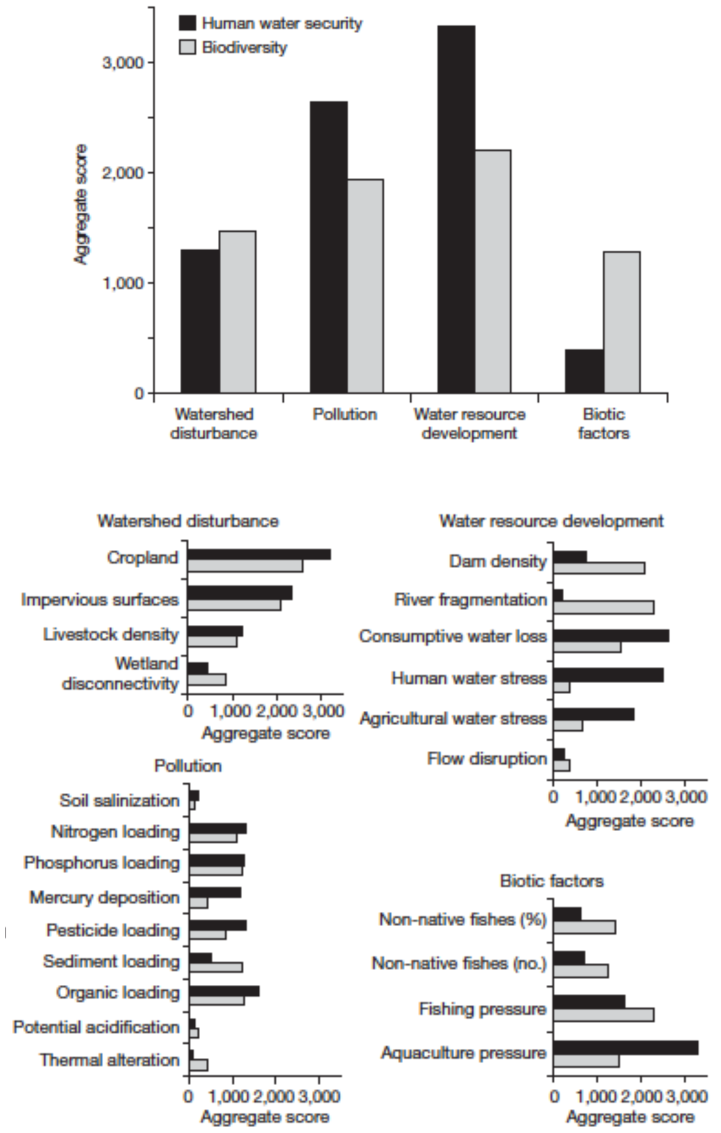


Figure 3 | Theme and driver contributions in areas where incident threat exceeds the 75th percentile. High incident threat typically arises from the spatial coincidence of multiple themes and/or drivers of stress acting in concert. Each aggregate score represents the number of grid cells exceeding the 75th percentile for each individual theme or driver over the high incident threat areas. Influence of each of the four themes (left) is relative to its contribution to overall incident threat. For the individual drivers (right), scores are relative to other drivers in the same theme. Bars summarize results over the entire discharging landmass.

EPFL

Stream and river biodiversity in space and time

Stream and river biodiversity in space

The River Continuum Concept[1]

ROBIN L. VANNOTE
Stroud Water Research Center, Academy of Natural Sciences of Philadelphia, Avondale, PA 19311, USA
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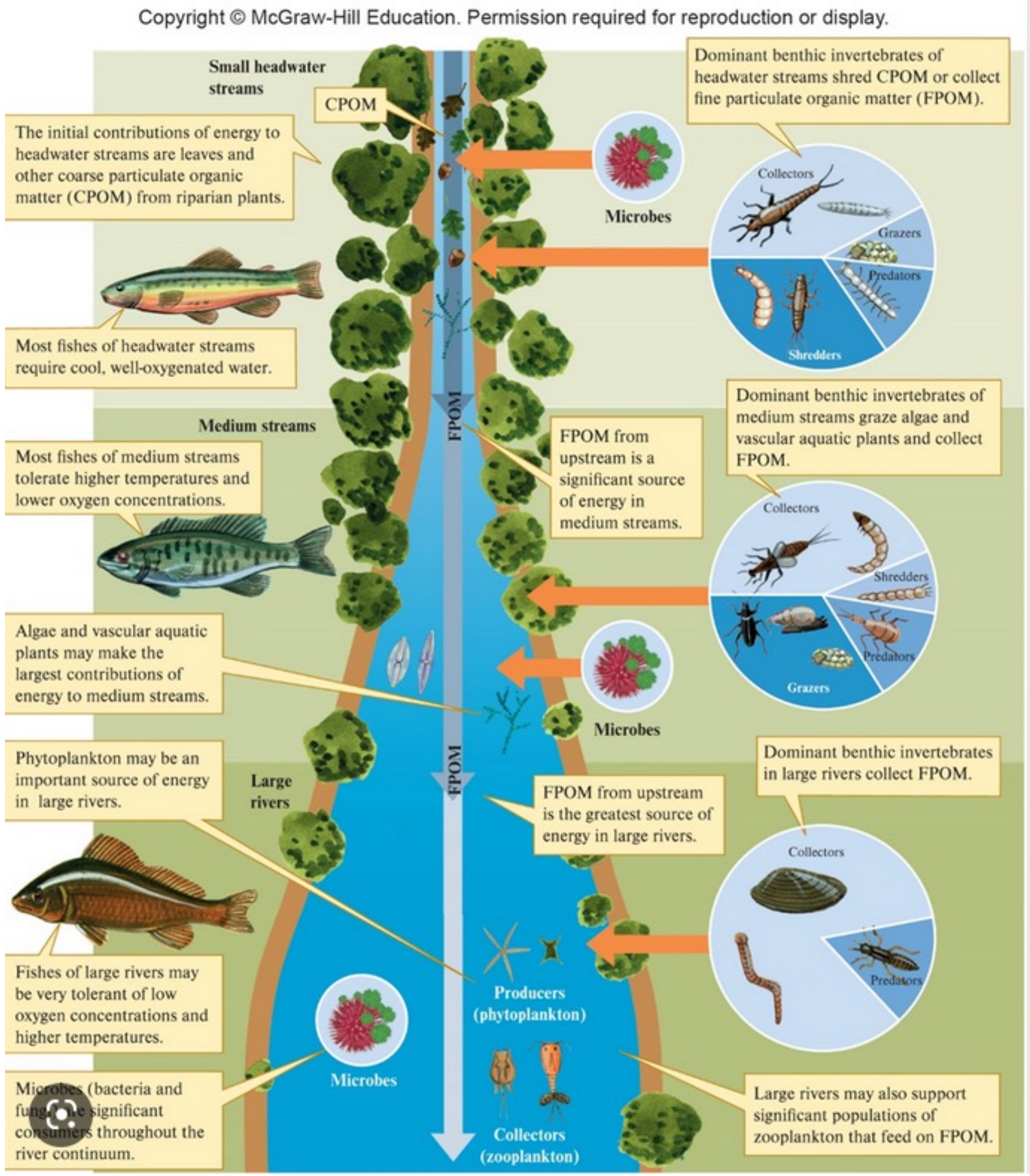
Department of Biology, Idaho State University, Pocatello, ID 83209, USA
KENNETH W. CUMMINS
Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331, USA
JAMES R. SEDELL
Weyerhauser Corporation, Forestry Research, 505 North Pearl Street, Centralia, WA 98531, USA
AND COLBERT E. CUSHING
Ecosystems Department, Battelle-Pacific Northwest Laboratories, Richland, WA 99352, USA

VANNOTE, R. L., G. W. MINSHALL, K. W. CUMMINS, J. R. SEDELL, AND C. E. CUSHING. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37: 130–137.

Longitudinal gradients

- Geomorphology and hydraulics
- Connectivity with land
- Energy subsidies (allochthonous *versus* autochthonous)
- Ecosystem metabolism
- Biodiversity, community composition



The River Continuum Context

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Stream and river biodiversity in space

The River Continuum Concept[1]

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Stroud Water Research Center, Academy of Natural Sciences of Philadelphia, Avondale, PA 19311, USA
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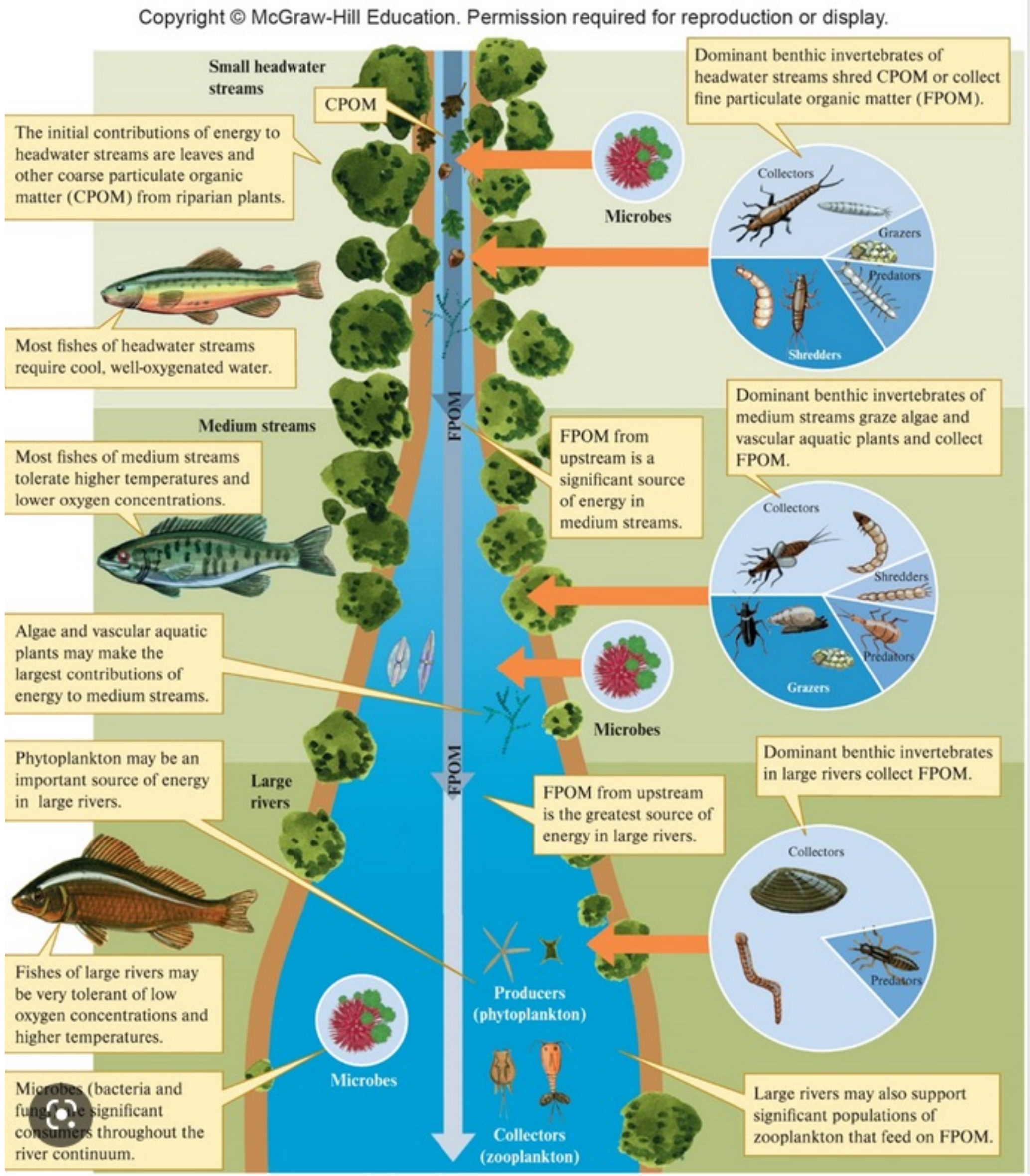
VANNOTE, R. L., G. W. MINSHALL, K. W. CUMMINS, J. R. SEDELL, AND C. E. CUSHING. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37: 130–137.

- Macrozoobenthos communities change downstream as a function of varying resource supply
- Depending on channel geomorphology, light availability and terrestrial subsidies
- Induces changes in functional diversity as shown by functional feeding groups (i.e., grazers, shredders, collectors, filterers, predators)
- Linked to ecosystem processes (e.g., GPP)



The River Continuum Context

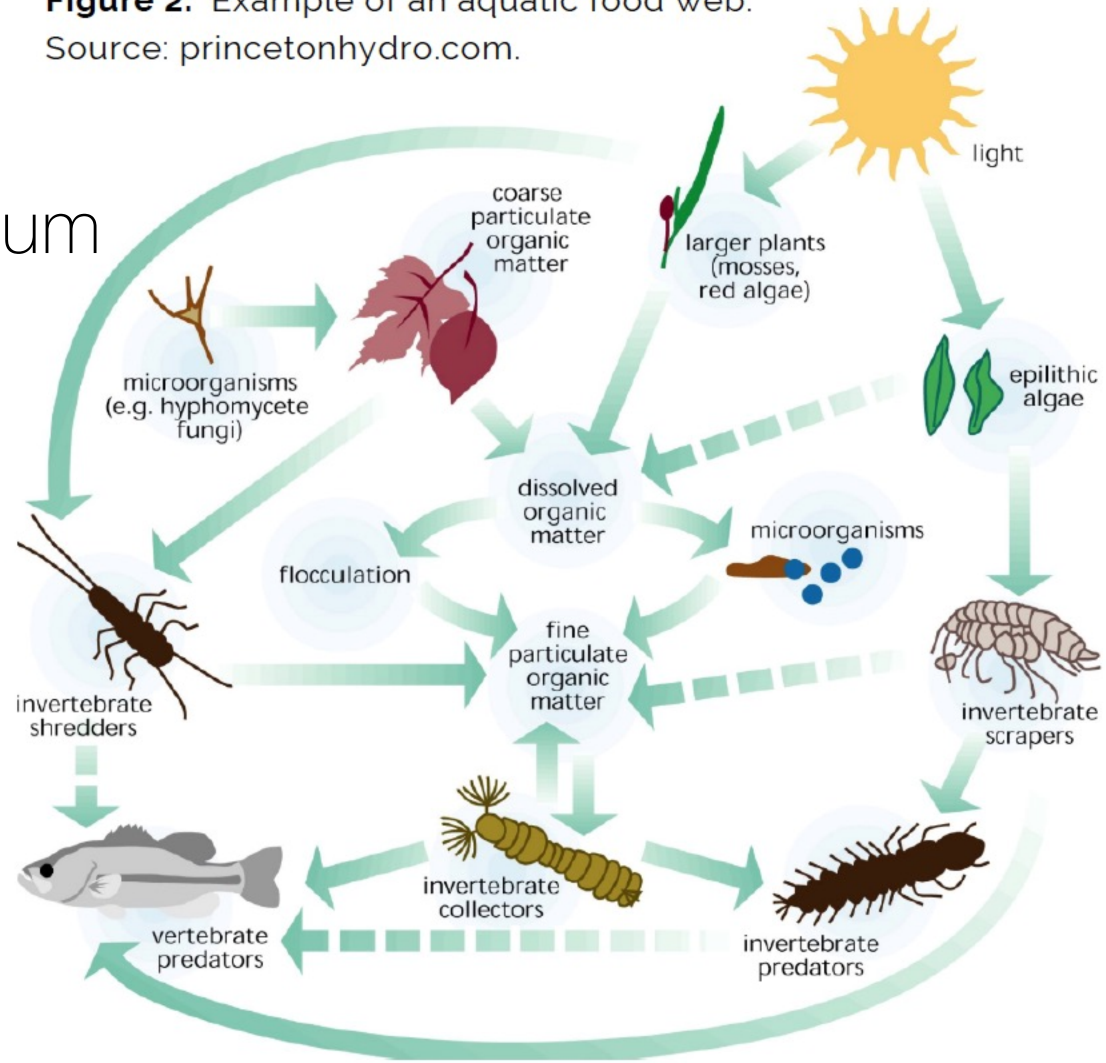
EPFL

A food web along the longitudinal continuum

- Sustained by allochthonous and autochthnous energy
- Grazers and scrapers (feed on microbial biofilms/GPP)
- Shredders (feed on plant material; POM)
- Collectors (feed on suspended particles; FPOM)
- Invertebrate predators
- Vertebrate predators (e.g., fish)

Resources change with seasons

Figure 2. Example of an aquatic food web.
Source: princetonhydro.com.



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Stream and river biodiversity in time

LIMNOLOGY AND OCEANOGRAPHY
Letters
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Limnology and Oceanography Letters 6, 2021, 1–17

doi: 10.1002/lol2.10172

CURRENT EVIDENCE

Thinking like a consumer: Linking aquatic basal metabolism and consumer dynamics

Janine Rüegg[1a*], *Caitlin C. Conn*[2], *Elizabeth P. Anderson*[3], *Tom J. Battin*[1], *Emily S. Bernhardt*[4], *Marta Boix Canadell*[1], *Sophia M. Bonjour*[5,6], *Jacob D. Hosen*[7,8], *Nicholas S. Marzolf*[9], *Charles B. Yackulic*[10]

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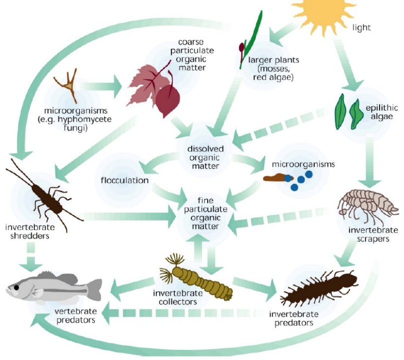


Ecosystem phenology

Seasonal timing of the combined effects of environmental, ecological and ecosystem processes.

Example:

- Solar radiation and temperature (seasonality)
- Ecosystem GPP
- Resource availability
- Consumers (e.g., macrozoobenthos and fish) diversity have adapted their life histories to seasonality

‘Encoded’ in the biota’s adaptive strategies
(e.g., life history) (Consequences: see Lytle and Poff; Sabo et al.)

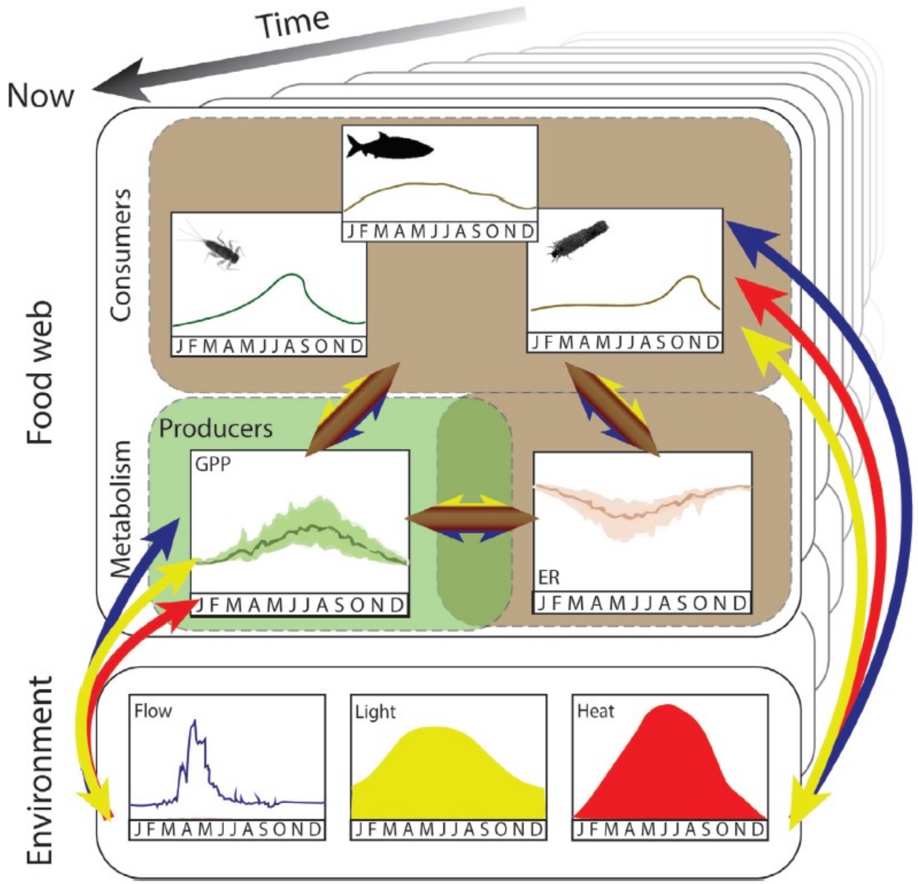
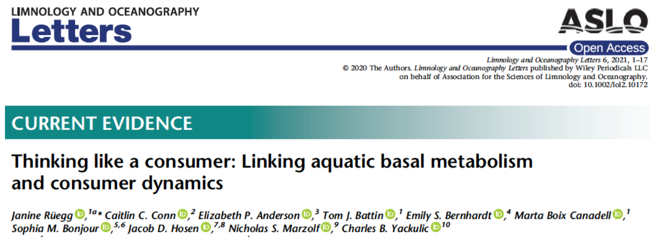


Fig. 2. Our conceptual framework considers metabolism as an emergent property of aquatic food webs. Here, we propose that the links between this emergent property and traditional, organismal-based food web ecology are modulated by the environment. The environment, here depicted as the physical stream environment including flow, light and temperature regimes, affects both the metabolic regimes via influences on GPP (indicated by the shorter blue, yellow and red arrows) and the provision of allochthonous resources, as well as the consumers directly through physiological effects (indicated through the longer blue, yellow and red arrows). Research needs to determine to what degree ER represents macroscopic consumer respiration as opposed to autotrophic or microbial respiration, and whether those ratios are altered by environmental influences (width of arrow between GPP and ER depends on the environment), and if primary production conversion to consumer production and biomass is modulated by the environment (with of arrow between ER/GPP and consumers). Consumer patterns presented here are hypothetical at the moment. The research into current patterns, here expressed on an annual basis, we believe to have developed over time to arrive at the current state of consumer traits and phenology.

Stream and river biodiversity in time


LIMNOLOGY AND OCEANOGRAPHY
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Limnology and Oceanography Letters 6, 2021, 1–17
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doi: 10.1002/lol2.10172
CURRENT EVIDENCE

Thinking like a consumer: Linking aquatic basal metabolism and consumer dynamics

Janine Rüegg[1a*] *Caitlin C. Conn*[2] *Elizabeth P. Anderson*[3] *Tom J. Battin*[1] *Emily S. Bernhardt*[4] *Marta Boix Canadell*[1] *Sophia M. Bonjour*[5,6] *Jacob D. Hosen*[7,8] *Nicholas S. Marzolf*[9] *Charles B. Yackulic*[10]

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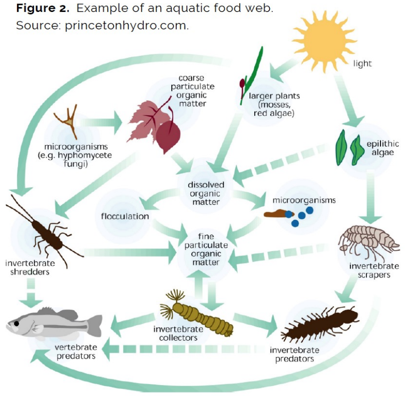

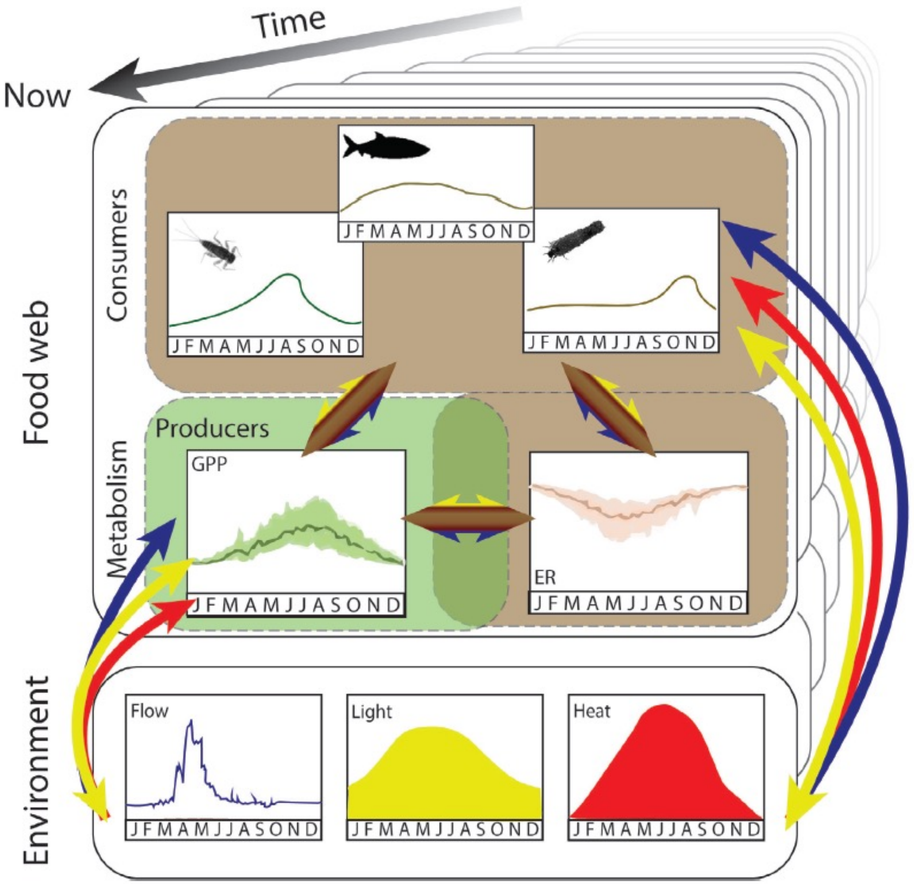

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Perturbing stream and river ecosystem phenology

- Climate-induced hydrological extremes (droughts, floods)
- Seasonal shifts (temperature, leaf shedding)
- Altered flow regimes (e.g., damming and hydropeaking)

EPFL

Stream and river biodiversity in time

Homogenisation of stream biodiversity

nature ecology & evolution
ARTICLES
https://doi.org/10.1038/s41559-019-1042-8

A global synthesis of biodiversity responses to glacier retreat

Sophie Cauvy-Fraunié[1]* and Olivier Dangles[2]

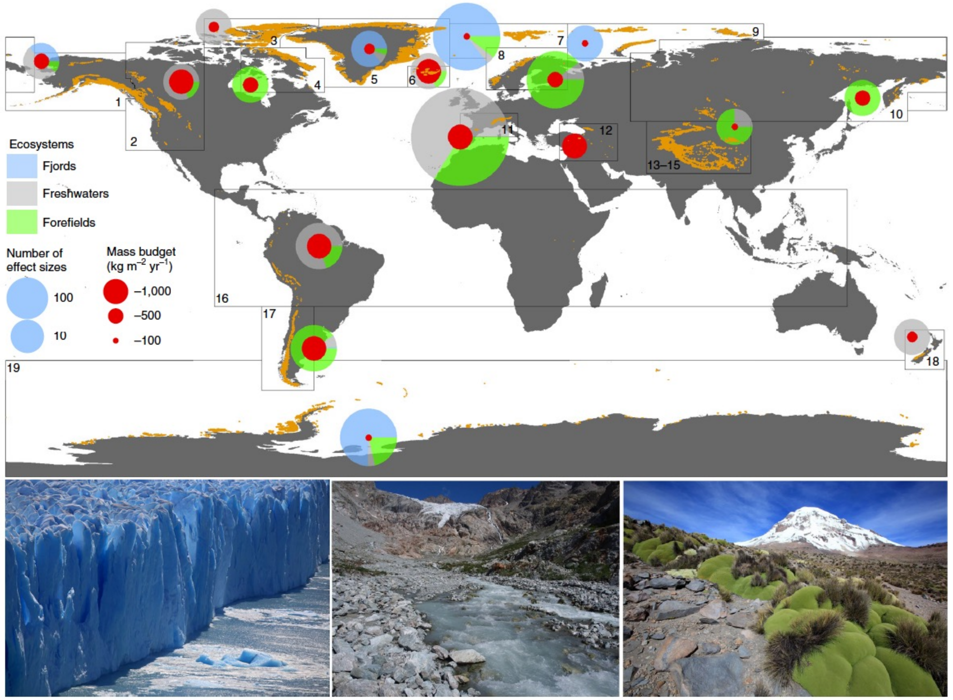
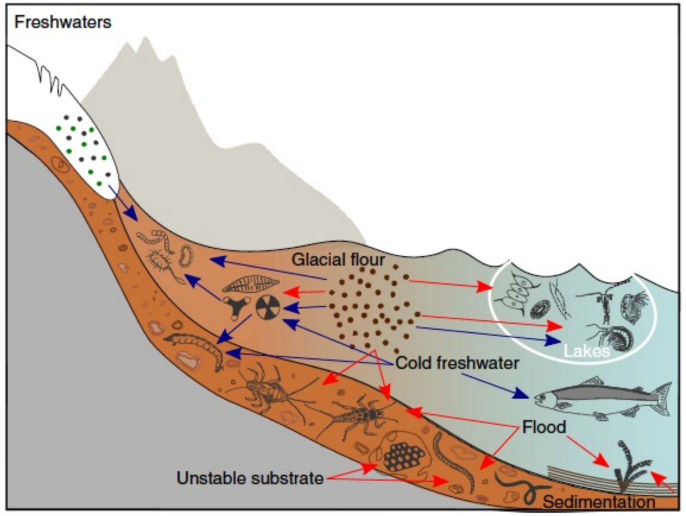


Fig. 1 | Global distribution of the biodiversity surveys analysed in this study. The map indicates the area of glaciers (orange), the rate of glacier retreat (red discs) and the number of effect sizes for abundance and richness (pie charts) for glacier-influenced fjord (blue), freshwater (grey) and forefield systems (green). Fjords are deep estuaries, carved by glaciers, that form important boundary zones between the cryosphere and the ocean. Freshwaters include streams and lakes influenced by periodic glacier melting. Glacier forefields are the leading edge of glaciers and moraines. We used the Randolph Glacier Inventory[262,263], which defines 17 regions with different ice mass budget (kg m^{-2} yr^{-1})[254]. Photographs show (left to right) a fjord, freshwater, and forefield systems: O.D. and S.C.-F.

Glacier shrinkage impacts downstream ecosystems

- Temperature
- Turbidity and light availability
- Channel stability
- Resource availability



Stream and river biodiversity in time

Homogenisation of stream biodiversity

nature climate change
LETTERS
PUBLISHED ONLINE: 11 MARCH 2012 | DOI: 10.1038/NCLIMATE1435

Biodiversity under threat in glacier-fed river systems

Dean Jacobsen[1*†], Alexander M. Milner[2,3], Lee E. Brown[4] and Olivier Dangles[5,6,7*†]

Glacier shrinkage impacts downstream macrozoobenthos biodiversity patterns

- Overall loss and homogenisation owing to increasing similarity across communities (that is, from one to the next glacier)
- Increasing local (alpha) diversity attributed to upstream migration
- Increasing regional (gamma) diversity

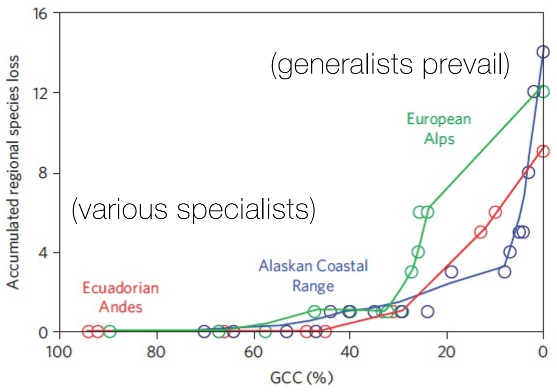


Figure 1 | Accumulated loss of regional species richness (γ diversity) as a function of glacial cover. Obligate glacial river macroinvertebrates begin to disappear from assemblages when glacial cover in the catchment drops below approximately 50%. Each data point represents a river site and lines are Lowess fits.

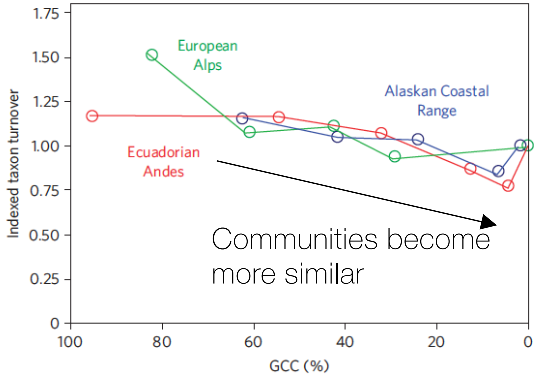


Figure 2 | Taxon turnover (β diversity) as a function of glacial cover. The data shown are for species turnover (Alaska) and family turnover (Ecuador and Alps). Assemblages at river sites close to glaciers are more spatially variable than those at sites with less glacial influence. Data are indexed to 1 at non-glacial sites (0% glacial cover). Each data point represents a river site and lines are Lowess fits.

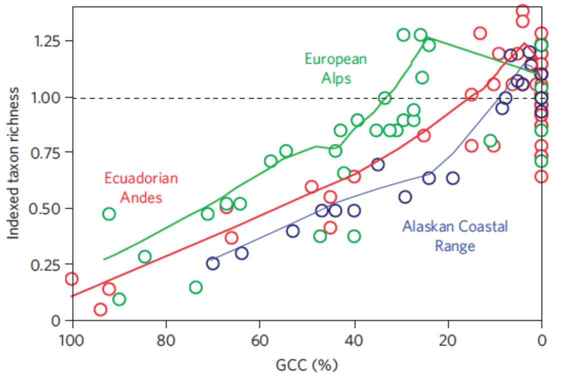


Figure 3 | Local richness (α diversity) as a function of glacial cover. The data shown are for species richness (Alaska) and family richness (Ecuador and Alps). Local taxon richness peaks at 5–30% GCC. Data are indexed to 1, indicated by the horizontal dashed line, at non-glacial sites (0% glacial cover). Each data point represents a river site and lines are Lowess fits.

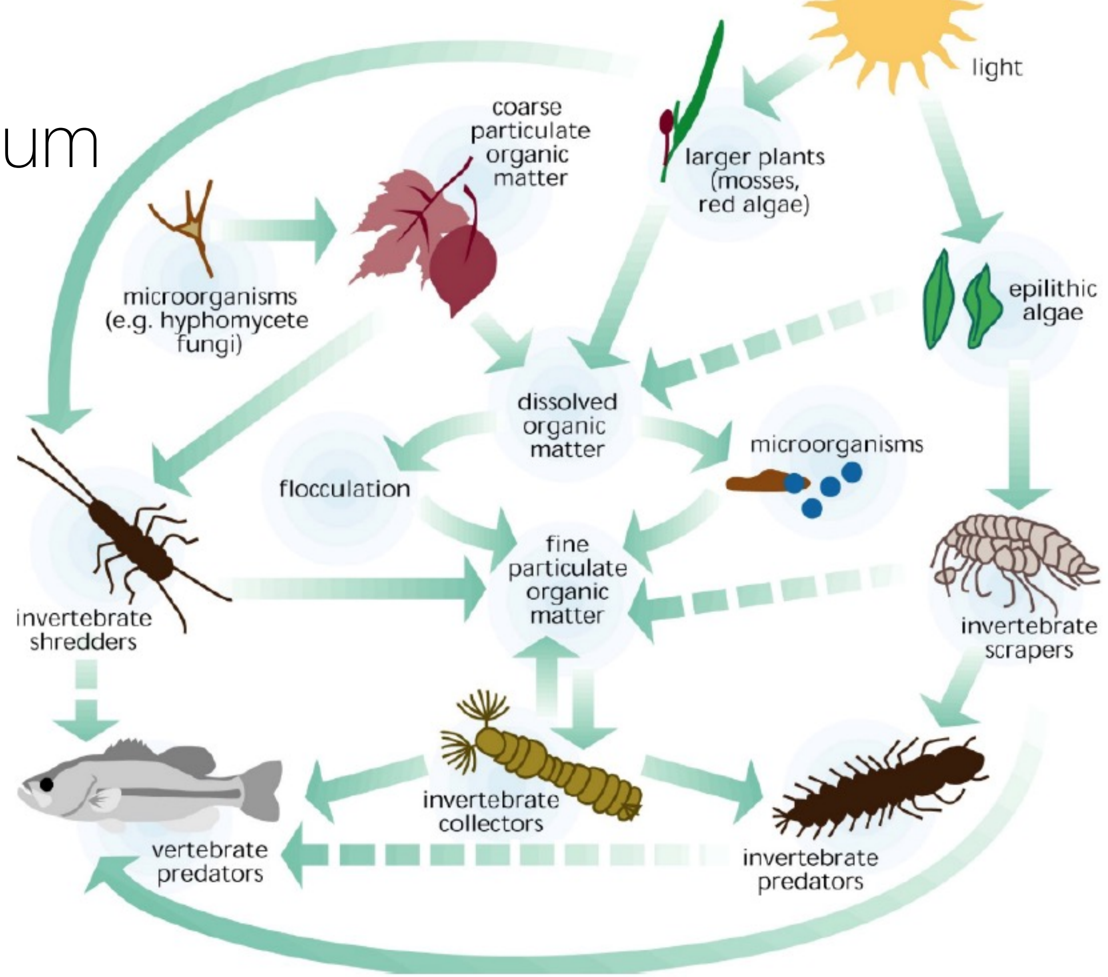
A food web along the longitudinal continuum

- Sustained by allochthonous and autochthnous energy
- Grazers and scrapers (feed on microbial biofilms/GPP)
- Shredders (feed on plant material; POM)
- Collectors (feed on suspended particles; FPOM)
- Invertebrate predators
- Vertebrate predators (e.g., fish)

Why do we need to understand food webs?

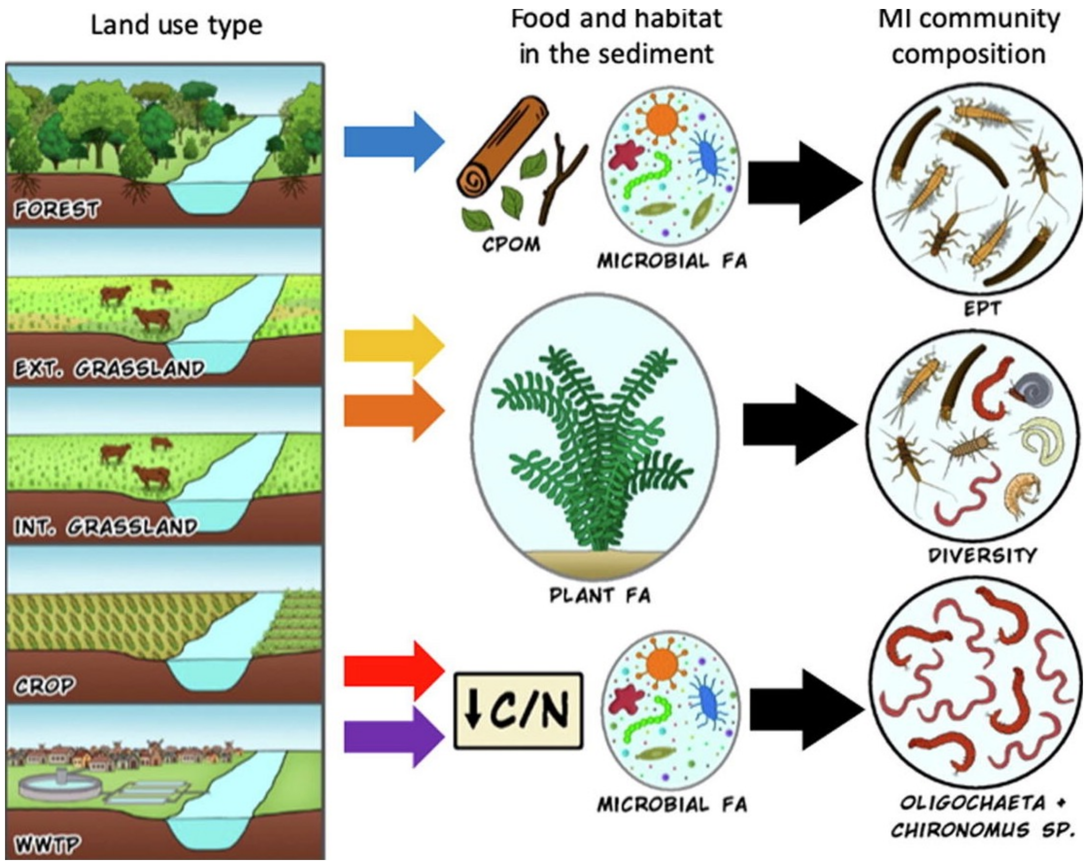
a. <u>Ecosystem degradation and biodiversity loss</u>
b. <u>Bioaccumulation</u>
c. Energetics (see paper by Sabo et al.)

Figure 2. Example of an aquatic food web.
Source: princetonhydro.com.



Ecosystem degradation and biodiversity loss

Macrozoobenthos as 'indicator species'




Science of The Total Environment
Volume 703, 10 February 2020, 135060

Responses of macroinvertebrate communities to land use specific sediment food and habitat characteristics in lowland streams

Paula C. dos Reis Oliveira [a], Michiel H.S. Kraak [a], Michelle Pena-Ortiz [a], Harm G. van der Geest [a], Piet F.M. Verdonschot [a, b]

- Macrozoobenthos communities are used to assess ecosystem health/integrity
- Land use affects sediment environment and resource structure, thereby macrozoobenthos diversity and community composition
- Impacts on ecosystem processes

Ecosystem degradation and biodiversity loss

Bioaccumulation of pharmaceuticals

nature COMMUNICATIONS

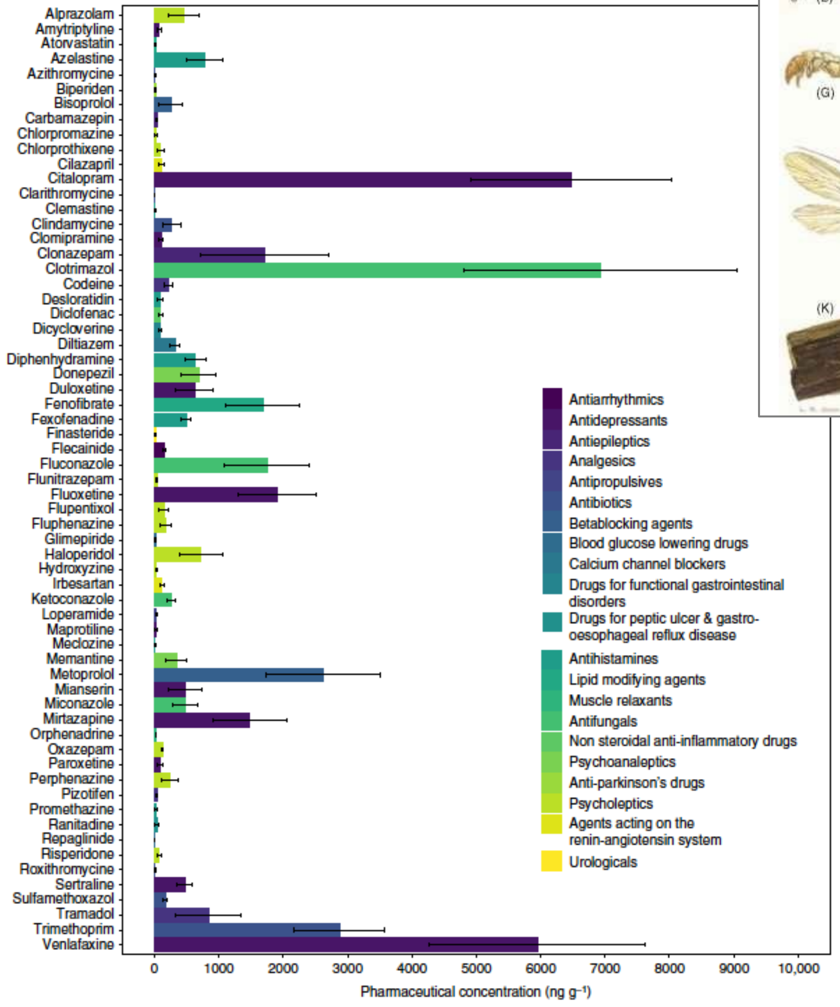
ARTICLE

DOI: 10.1038/s41467-018-06822-w OPEN

A diverse suite of pharmaceuticals contaminates stream and riparian food webs

Erinn K. Richmond[1], Emma J. Rosi[2], David M. Walters[3,8], Jerker Fick[4], Stephen K. Hamilton[2,5], Tomas Brodin[6,7], Anna Sundelin[4] & Michael R. Grace[1]

- Over 60 pharmaceutical compounds detected in aquatic invertebrates and riparian spiders in streams near Melbourne.
- Antidepressants and antibiotics!
- Anthropogenic imprint on aquatic food webs
- Impacts poorly understood – antibiotic resistance!



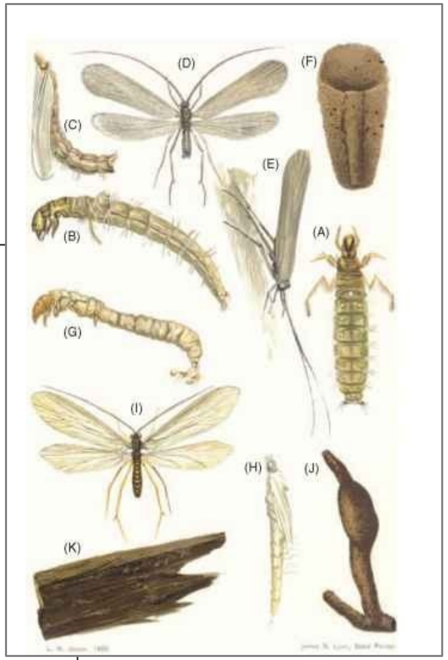


Fig. 1 Pharmaceutical concentrations in caddisfly larvae. Mean pharmaceutical concentrations (ng g^{-1} dry weight ±1 SE) in caddisfly larvae (Hydropsychidae) ($n = 6$) at wastewater-influenced Brushy Creek. Each bar represents the mean concentration of a pharmaceutical compound in the six individuals collected over two sampling dates. Colours represent therapeutic drug classes

Ecosystem degradation and biodiversity loss

Bioaccumulation of pharmaceuticals

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- Over 60 pharmaceutical compounds detected in aquatic invertebrates and riparian spiders in six streams near Melbourne.
- Similar concentrations in aquatic invertebrate larvae and riparian predators suggest direct trophic transfer via emerging adult insects to riparian predators that consume them.
- Transfer from used waters to aquatic biomass to terrestrial predators…
- What is the next step?

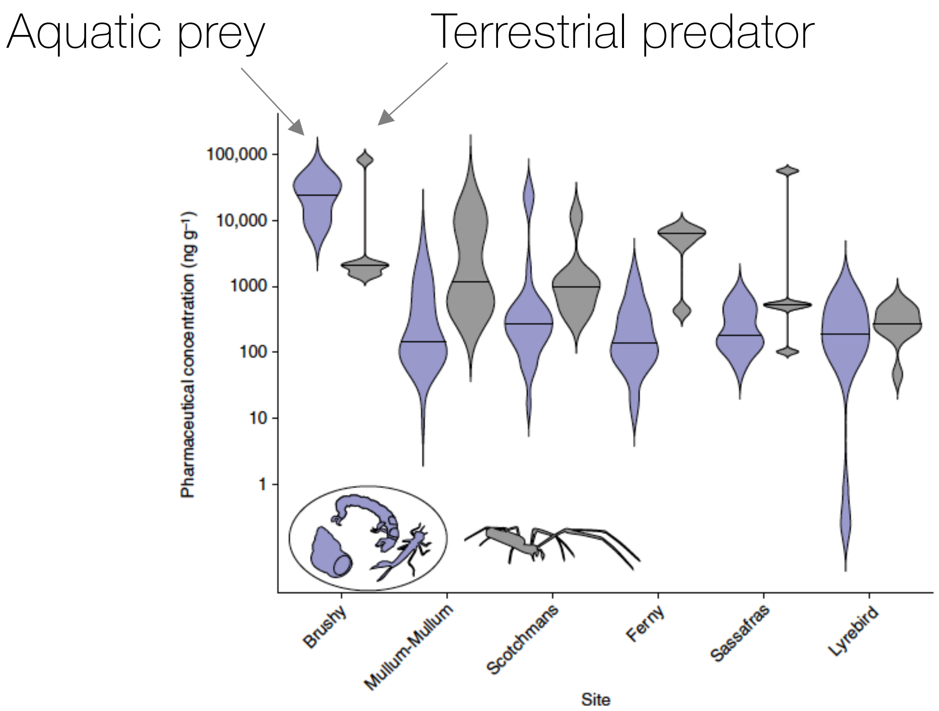

Fig. 2 Pharmaceutical concentrations in benthic aquatic invertebrates and riparian spiders. Total pharmaceutical concentration (ng g^{-1} dry weight) in aquatic invertebrates (purple) and riparian web-building spiders (dark grey) for each study site, arranged in decreasing wastewater influence (indicated by $\delta^{15}N$ in biofilms; Table 1). Violin plots illustrate kernel probability density and horizontal lines within each plot indicate median concentrations (see Methods for additional details on violin plots). The caddisfly image in this figure was adapted from Walters, D.M., M.A. Ford, and R.E. Zuellig. 2017. An open-source digital reference collection for aquatic macroinvertebrates of North America. Freshwater Science 36(4):693–697. DOI: 10.1086/694539. The spider image was adapted from a photo by Ryan R. Otter (Middle Tennessee State University)

nature COMMUNICATIONS

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A diverse suite of pharmaceuticals contaminates stream and riparian food webs

Erinn K. Richmond[1], Emma J. Rosi[2], David M. Walters[3,8], Jerker Fick[4], Stephen K. Hamilton[2,5], Tomas Brodin[6,7], Anna Sundelin[4] & Michael R. Grace[1]

- As representative vertebrate predators feeding on aquatic invertebrates, platypus and brown trout could consume some drug classes such as antidepressants at as much as one-half of a recommended therapeutic dose for humans based on their estimated prey consumption rates
- Yet the consequences for fish and wildlife of this chronic exposure are unknown
- Who eats trout?

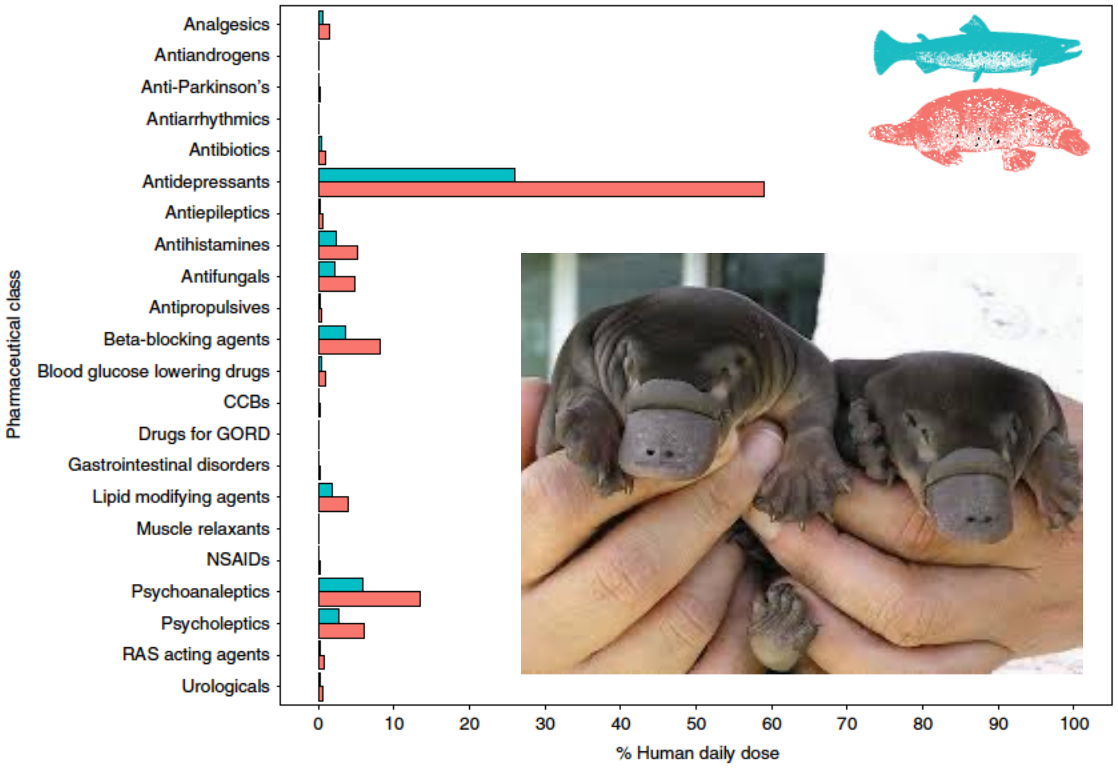
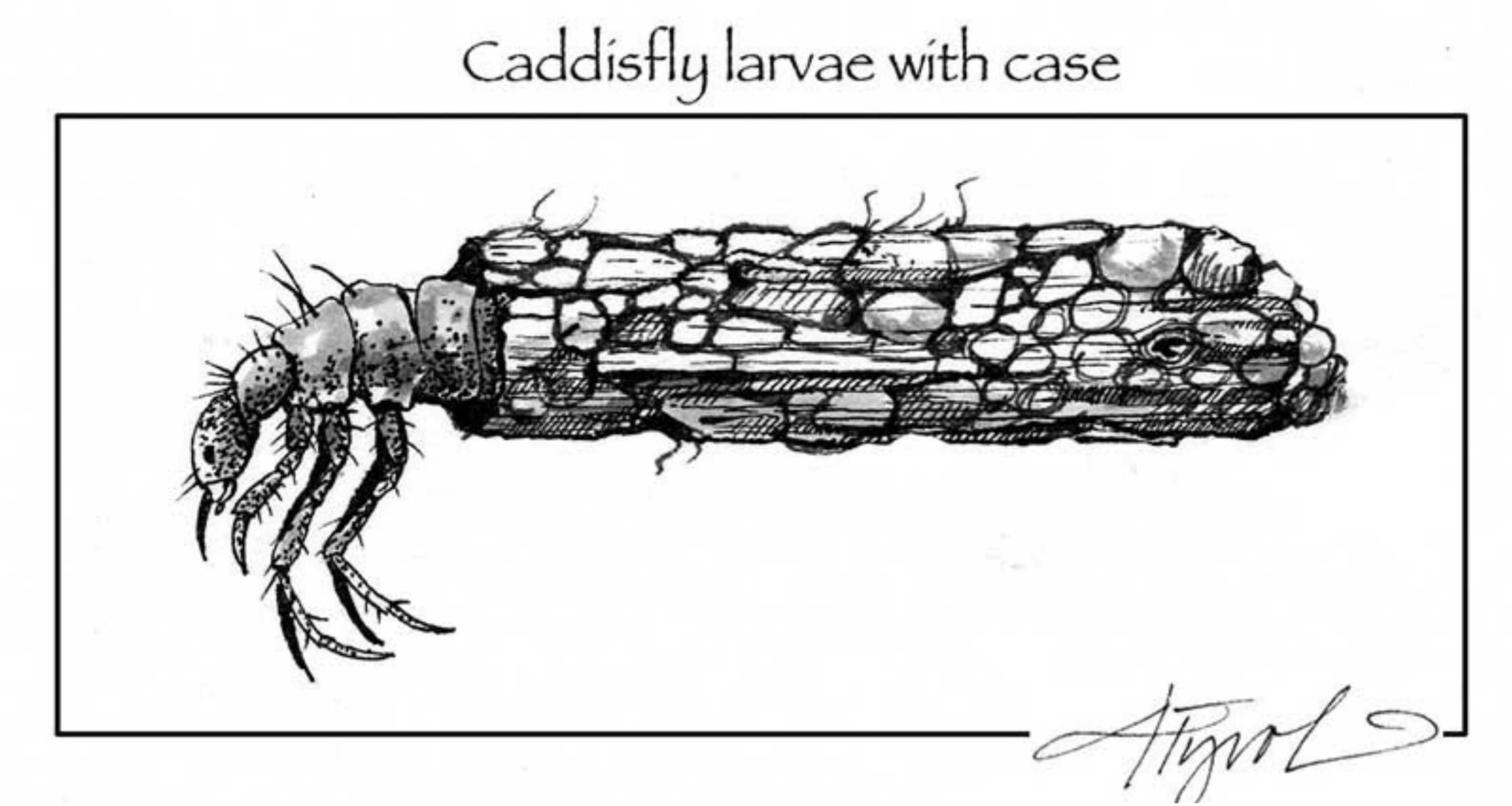


Fig. 4 Estimated dietary intake of pharmaceuticals by two representative invertebrate predators compared to recommended human pharmaceutical doses. Dietary intake rates as a percentage of recommended human pharmaceutical daily doses by therapeutic class for platypus (pink) and brown trout (blue) in Brushy Creek. (CCBs calcium channel blockers, GORD gastroesophageal reflux disease, NSAID non-steroidal anti-inflammatory drugs, RAS renin angiotensin system). Calculations appear in Methods section (equations 2-5). The trout and platypus images in this figure were adapted from Harter, Jim. 'Animals 1419 copyright-free illustrations of mammals, birds, fish, insects, etc. A pictorial archive from Nineteenth century sources' Mineola, New York. Copyright Dover Publication Inc. (1979). All rights reserved

The beauty of the life in streams and rivers



The beauty of the life in streams and rivers

Caddisfliy larvae (Trichoptera)

- Filter and gather particles from the water
- Exposed to the flow
- Trade-off between hydraulic stress and resource supply

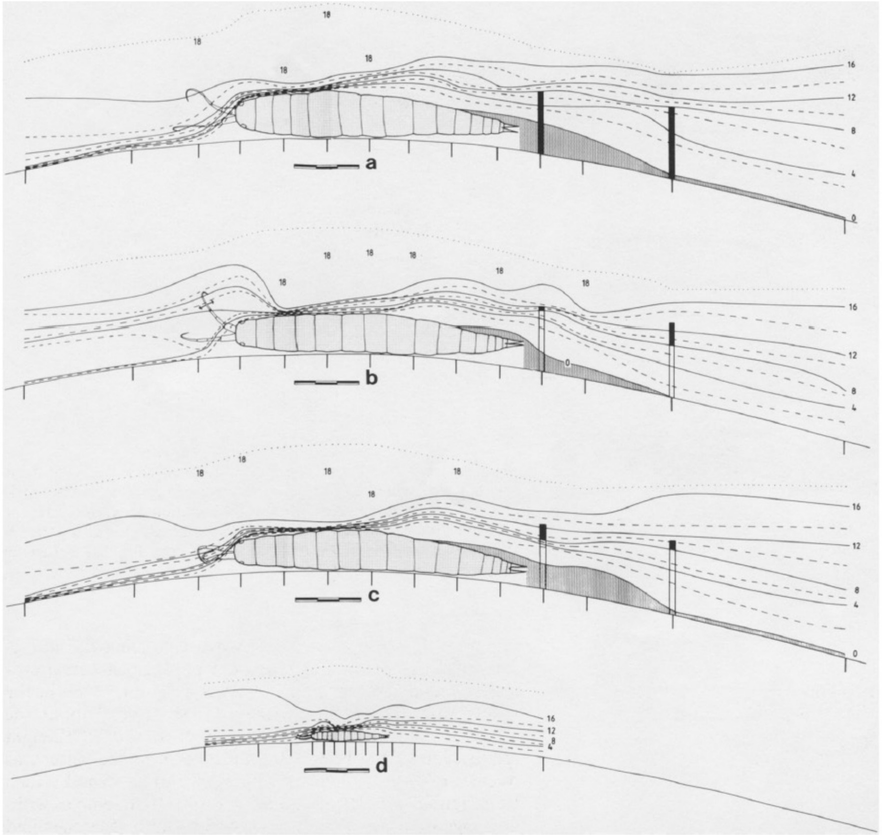
Ecohydraulics and the adaptive traits of benthic organisms in streams

Stream organisms experience complex flow fields around their bodies

Hydraulic constraints on life in streams

Trade-offs between
- Diffusive transport of gases and solutes through boundary layer
- Erosion through lift forces

Biota have developed adaptive traits to respond to hydraulic constraints
- Compressed body shape to remain within the laminar flow
- Various anchoring mechanisms



EPFL

Hydraulic niches contribute to the high biodiversity in stream ecosystems

- Different species occupy and exploit different hydraulic niches in streams
- Promotes taxonomic and functional diversity
- Impacts for ecosystem processes (i.e., OM degradation)

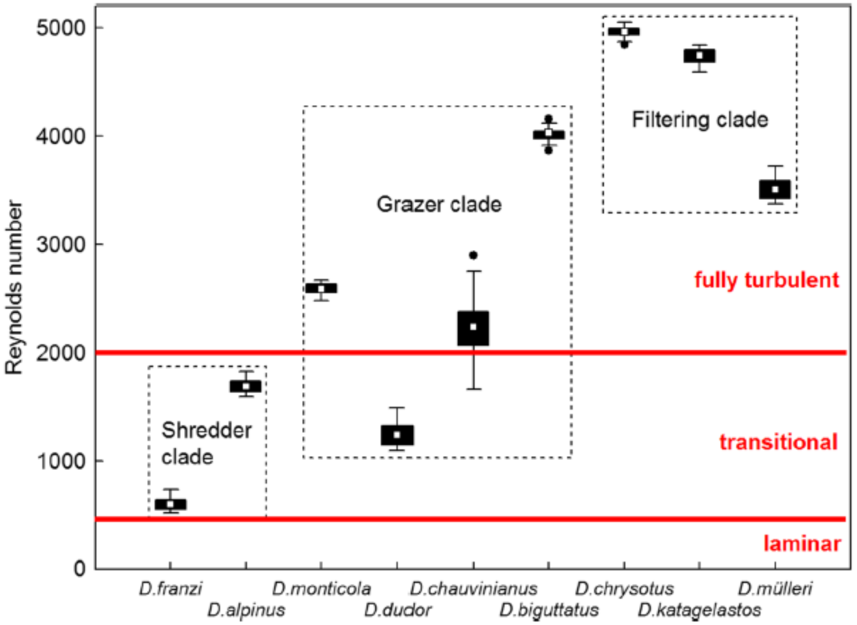


Fig. 4 Box plots of organismic Reynolds numbers acting on fifth instar larvae of nine Drusinae species (= 68 specimens), heads directed upstream. Red bars indicate thresholds between laminar, transitional and fully turbulent regimes. The two species of the shredder clade and *D. dudor* were well in the transitional range (R = 500–2000), the rest of the grazer clade and the filtering clade species were in the fully turbulent range of R, with *D. chauvinianus* taking an intermediate position between transitional and fully turbulent. White rectangles = means, black bars = 25/75% quartiles, whiskers = range without outliers, black dots = outliers. The differences between the three clades were very highly significant ($p = 0.000$; Kruskal-Wallis ANOVA)

Biologia (2021) 76:1465–1473
https://doi.org/10.2478/s11756-020-00648-y

ORIGINAL ARTICLE

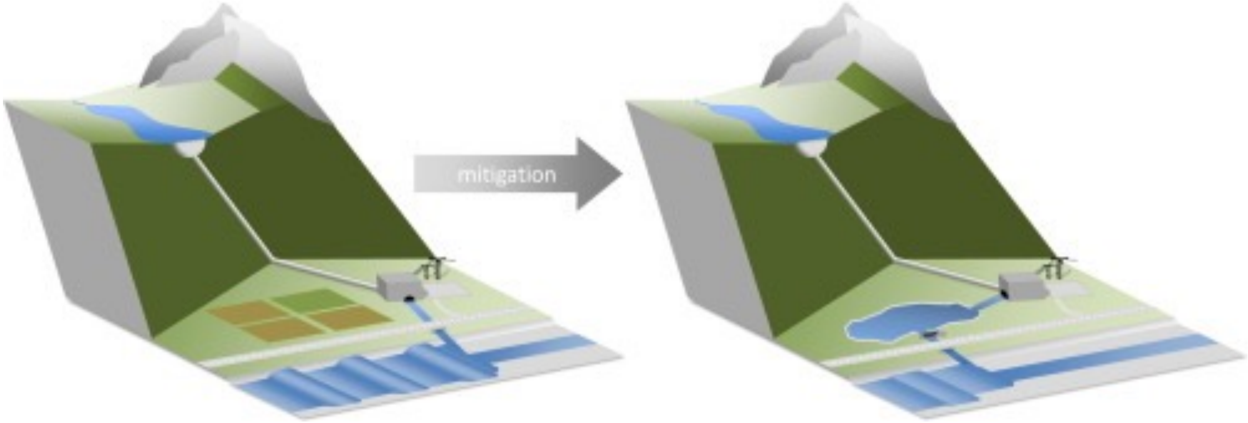
Check for updates

Hydraulic niche utilization by larvae of the three Drusinae clades (Insecta: Trichoptera)

Johann Waringer[1] • Simon Vitecek[2] • Jan Martini[1] • Carina Zittra[1] • Stephan Handschuh[3] • Ariane Vieira[4] • Hendrik C. Kuhlmann[4]

EPFL

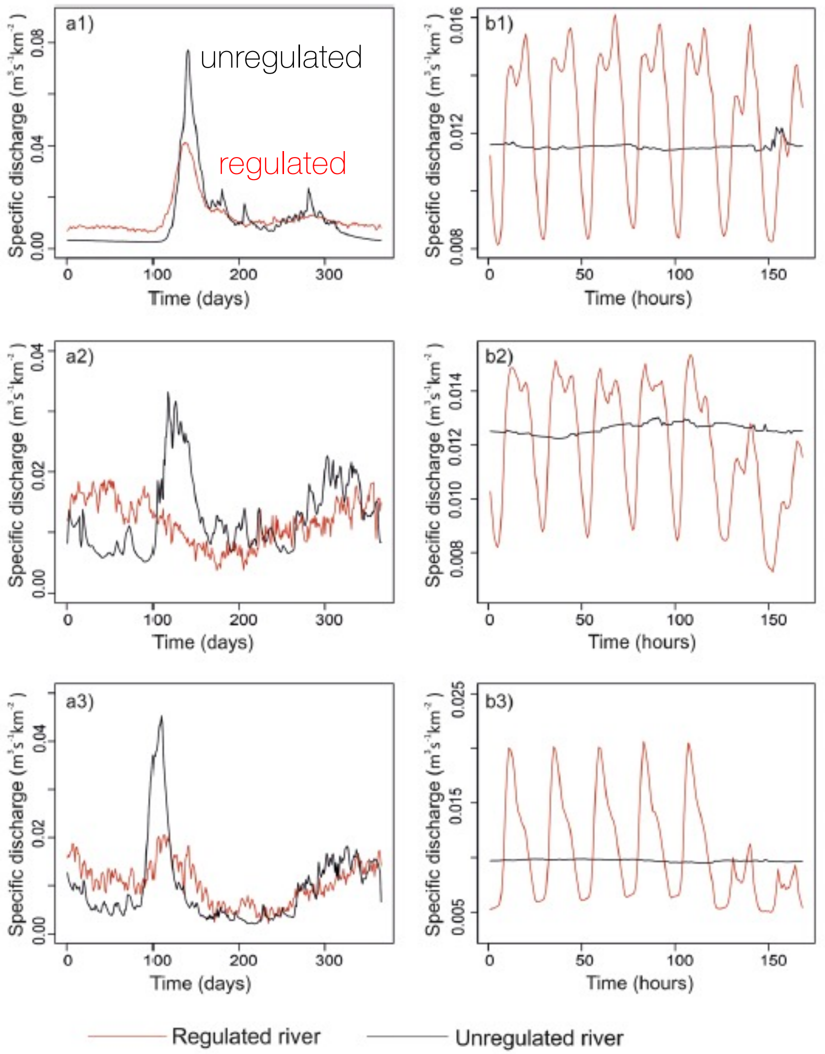
Hydropeaking affects hydraulics and invertebrate communities



Possible mitigation measures:
Buffering volume

Annual flow regime

Daily fluctuations



Changes in short term river flow regulation and hydropeaking in Nordic rivers

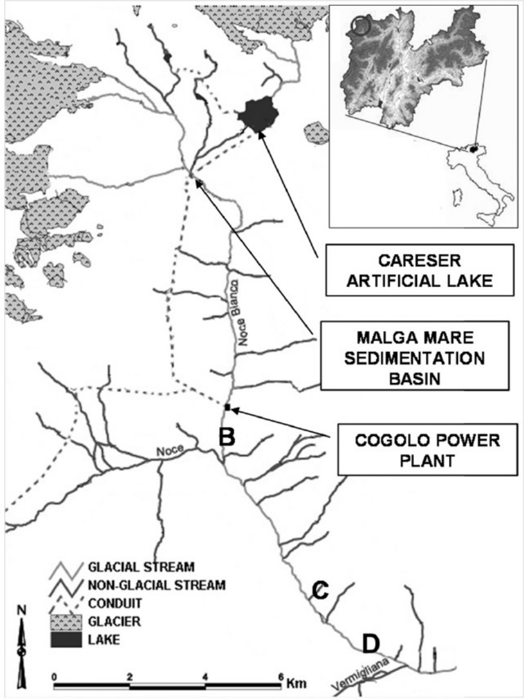
Faisal Bin Ashraf[1], Ali Torabi Haghighi[1], Joakim Riml[2], Knut Alfredsen[3], Jarkko J. Koskela[4], Bjørn Kløve[1] & Hannu Marttila[1]

SCIENTIFIC REPORTS

igure 5. Aggregated mean long term regulation (**a**) and aggregated mean short term regulation (**b**) pattern terms of specific discharge on large (1) medium (2) and small river (3) and that of comparable unregulated ations. Taivalkoski (regulated), Ounasjoki at kongas (unregulated) on daily scale (**a1**) and hourly scale (**b1**). lontta (regulated), Sanginjoki (unregulated) on daily scale (**a2**) and hourly scale (**b2**). Kyröskoski (regulated), akkola (unregulated) on daily scale (**a3**) and hourly scale (**b3**). The x-axis shows (**a1–a3**) show days of the year and (**b1–b3**) hours of the day.

EPFL

Hydropeaking affects hydraulics and invertebrate communities



Limnologica 40 (2010) 281–290

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Limnologica

journal homepage: www.elsevier.de/limno

Short time-scale impacts of hydropeaking on benthic invertebrates in an Alpine stream (Trentino, Italy)

Maria Cristina Bruno*, Bruno Maiolini, Mauro Carolli, Luana Silveri

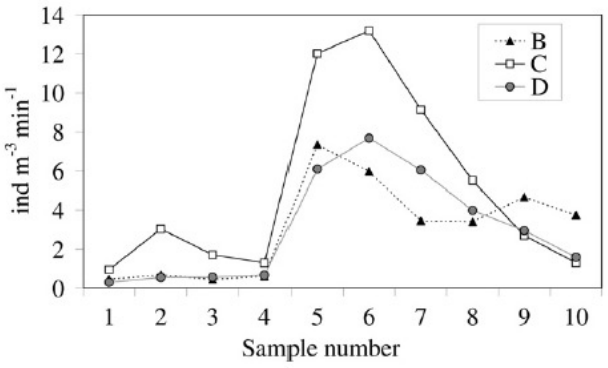

Fig. 6. Loss from bed of drifting aquatic invertebrates (ind m^{-3} min^{-1}) in each station for each drift sample in the Noce Bianco Stream, Trentino, Italy, calculated by averaging three replicates for each sample. For sampling station locations, see Fig. 1.

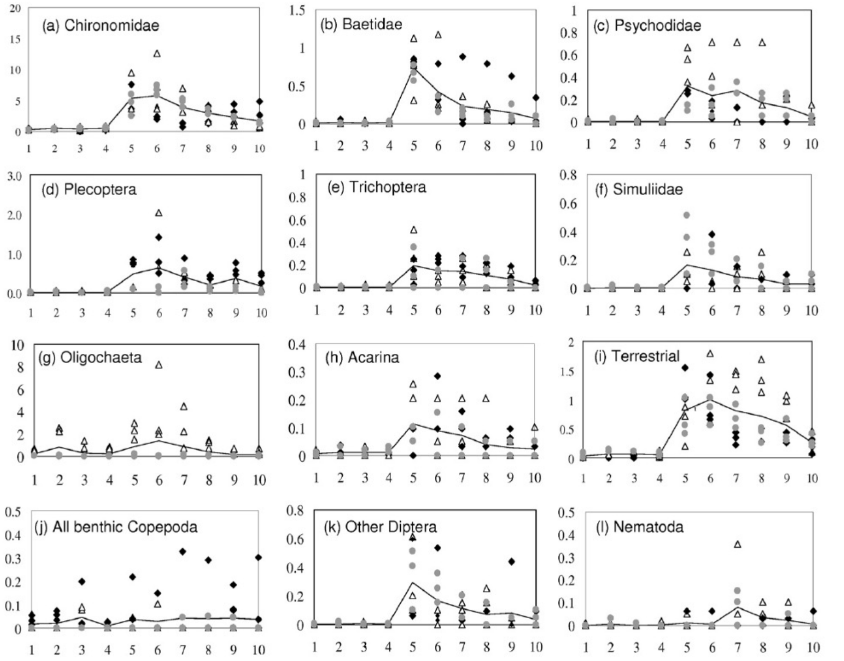

Fig. 5. Mean loss from bed of drifting aquatic invertebrates (ind m^{-3} min^{-1}) in each station for each time sample in the Noce Bianco Stream, Trentino, Italy. Taxa in figure are those that contributed most to the dissimilarities between all three stations (see Table 2). All terrestrial taxa, Nematoda, and all Copepoda are added because they represent the impact on riparian habitat, and on the benthic/hyporheic interface, respectively. Black rhombs: station B; white triangles: station C; grey circles: station D; continuous line: mean of all samples. For sampling station locations, see Fig. 1.

- Export of invertebrate biomass
- Reduces invertebrate biodiversity

It is not all good with our streams and rivers!