What can ranked abundance distributions (RADs) tell us about anthropogenic change in streams?

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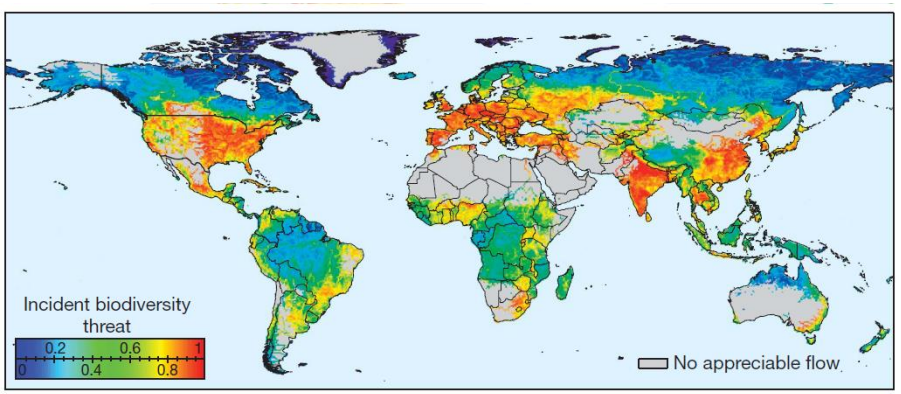
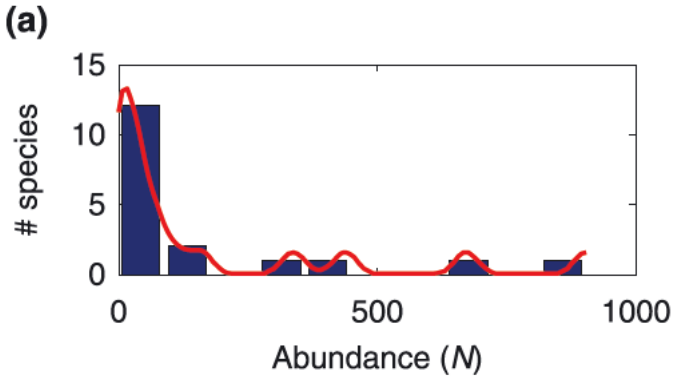
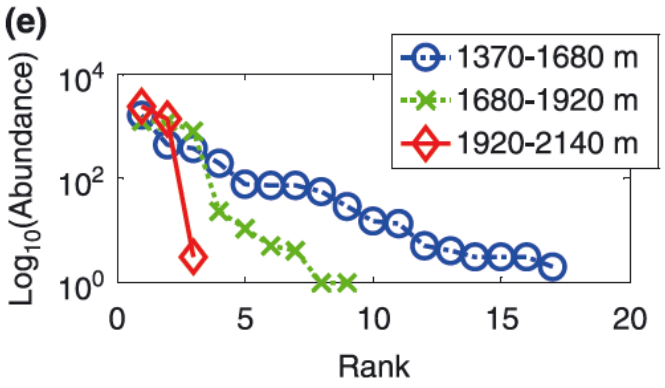
Freshwater ecosystems face multiple threats



Vörösmarty et al. 2010 *Nature*

Ranked abundance distributions (RADs)





Whittaker 1960 in

McGill et al. 2007 *Ecology Letters*

- Universal pattern explaining communities
- Rarely used in stream ecology
- Recent studies have shown useful applications

Journal of Animal Ecology

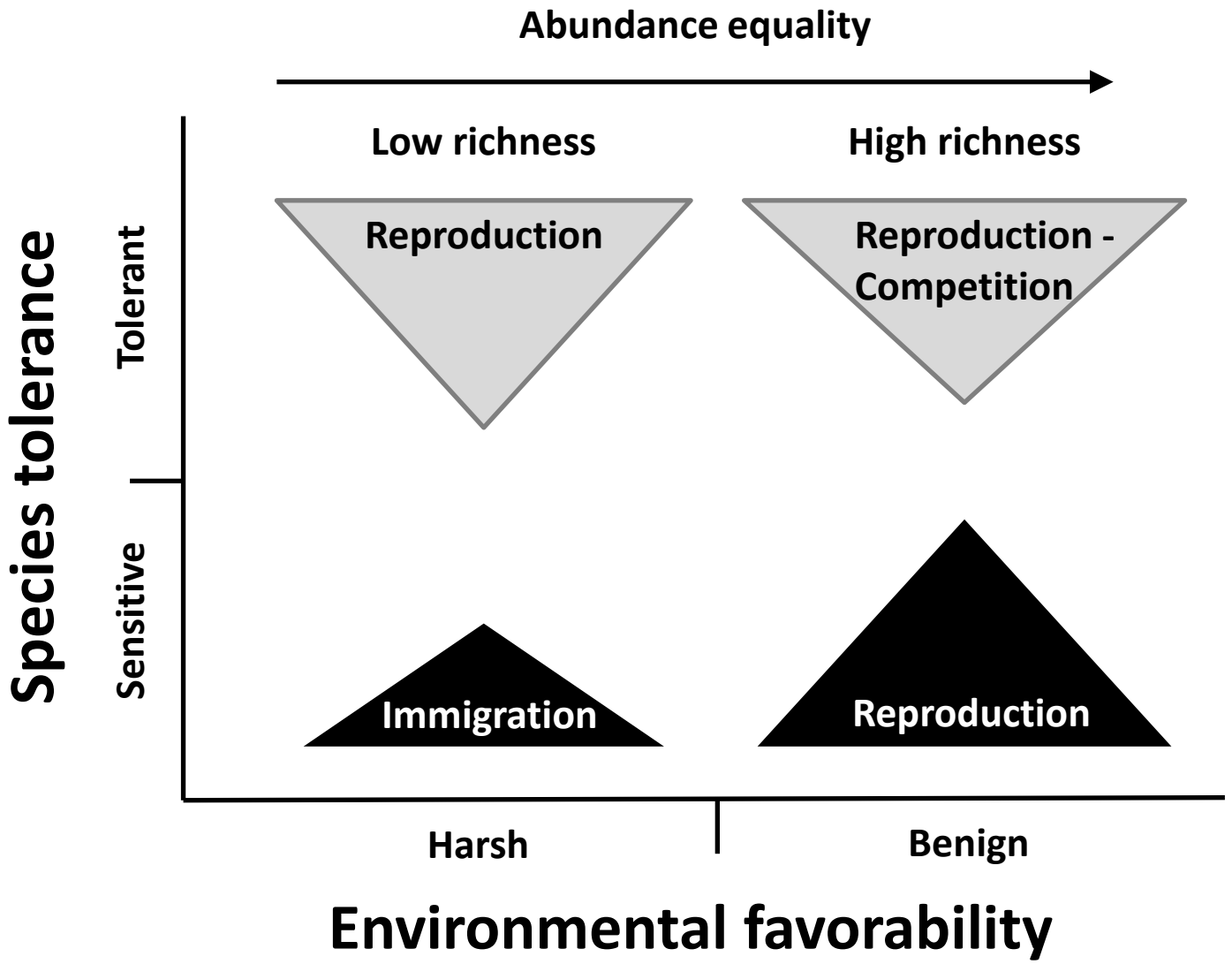
British Ecological Society

Journal of Animal Ecology 2014 doi: 10.1111/1365-2656.12278

Effects of land-use intensity on arthropod species abundance distributions in grasslands

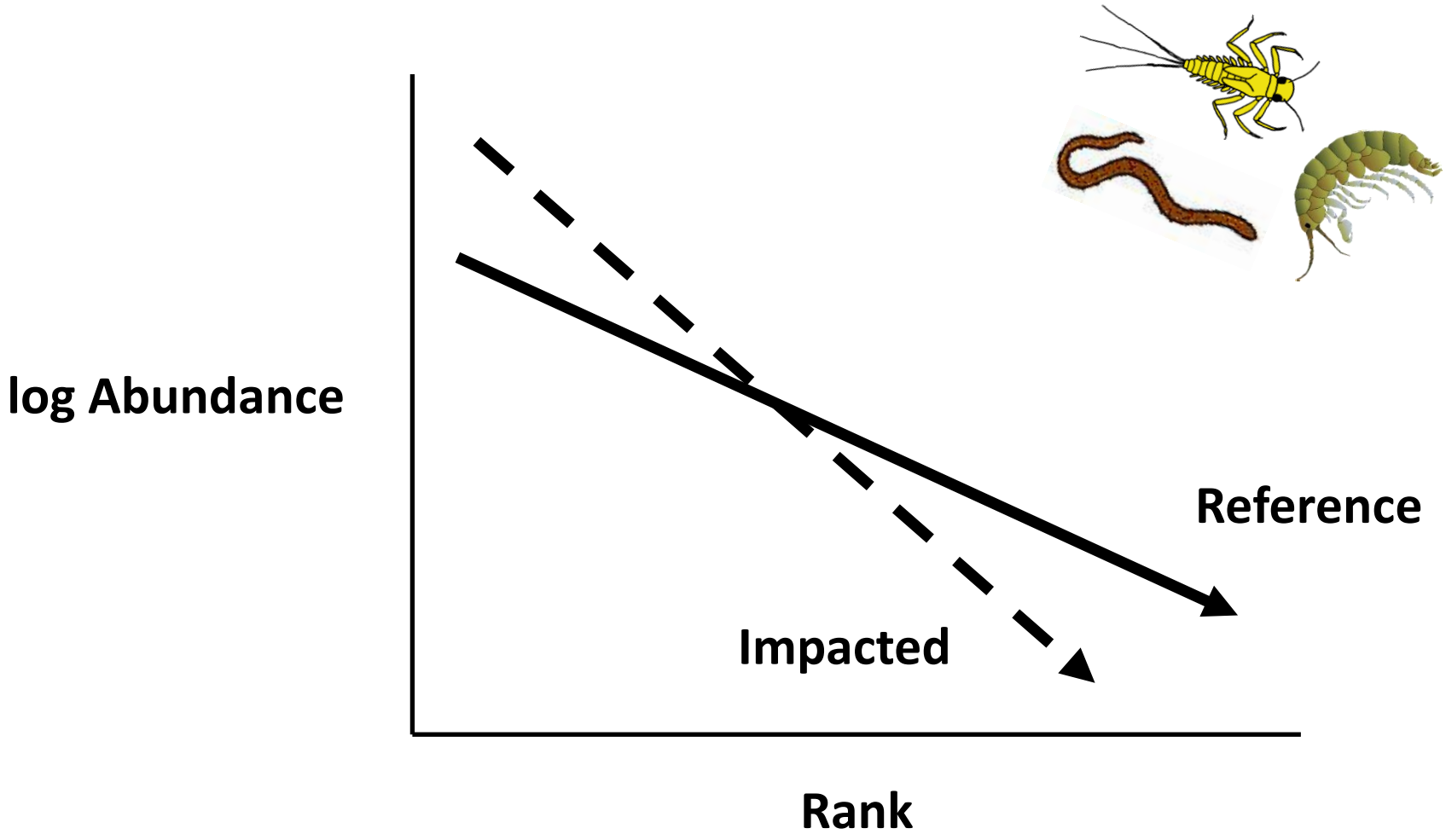
Nadja K. Simons[1]*, Martin M. Gossner[1], Thomas M. Lewinsohn[2], Markus Lange[3], Manfred Türke[1] and Wolfgang W. Weisser[1]

Abundance inequality has ecological origins



Passy 2016 *The American Naturalist*

Abundance inequality in response to disturbance/stress



What influences the size of the change?

Extent of change | Environmental context | Disturbance

$$\Delta Y_i = \frac{\partial Y_i}{\partial X} \times \Delta X$$

Ecology and Evolution

Open Access

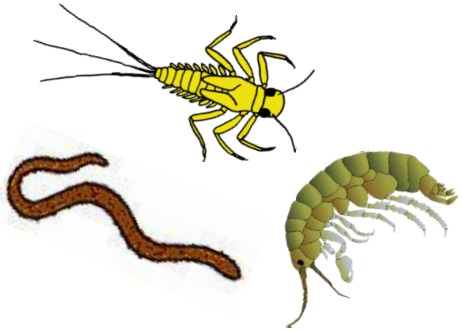
Environmental context and magnitude of disturbance influence trait-mediated community responses to wastewater in streams

Francis J. Burdon[1], Marta Reyes[1], Alfredo C. Alder[1], Adriano Joss[1], Christoph Ort[1], Katja Räsänen[1,2], Jukka Jokela[1,2], Rik I.L. Eggen[1,2] & Christian Stamm[1]

[1]Eawag, Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland
[2]ETH-Zurich, Swiss Federal Institute of Technology, Zurich, Switzerland

Multi-pressure catchments

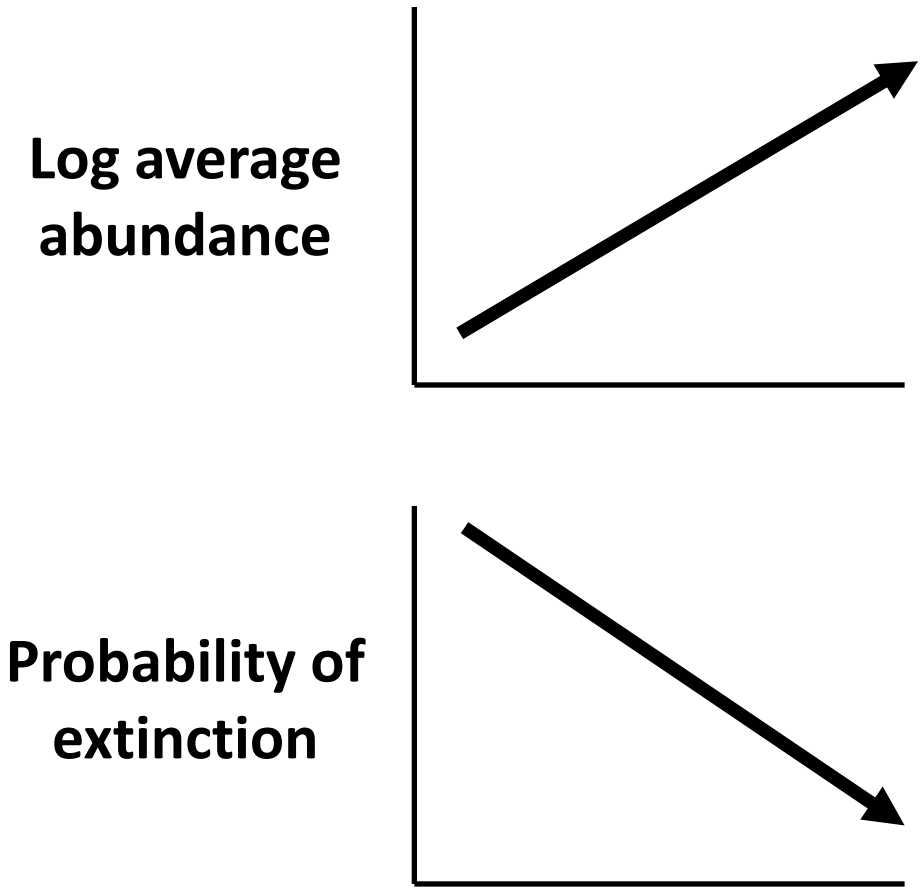
Extent of community change (downstream) = **Catchment landuse** × **Wastewater input**

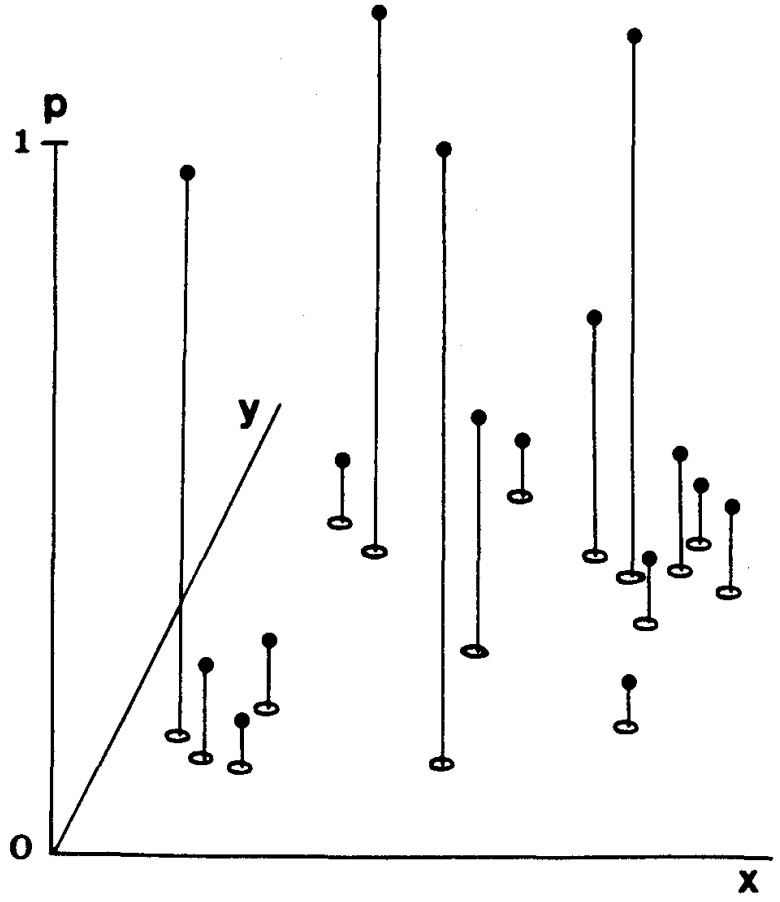


$$\Delta Y_i = \frac{\partial Y_i}{\partial X} \times \Delta X$$

Burdon et al. 2016 *Ecology and Evolution*

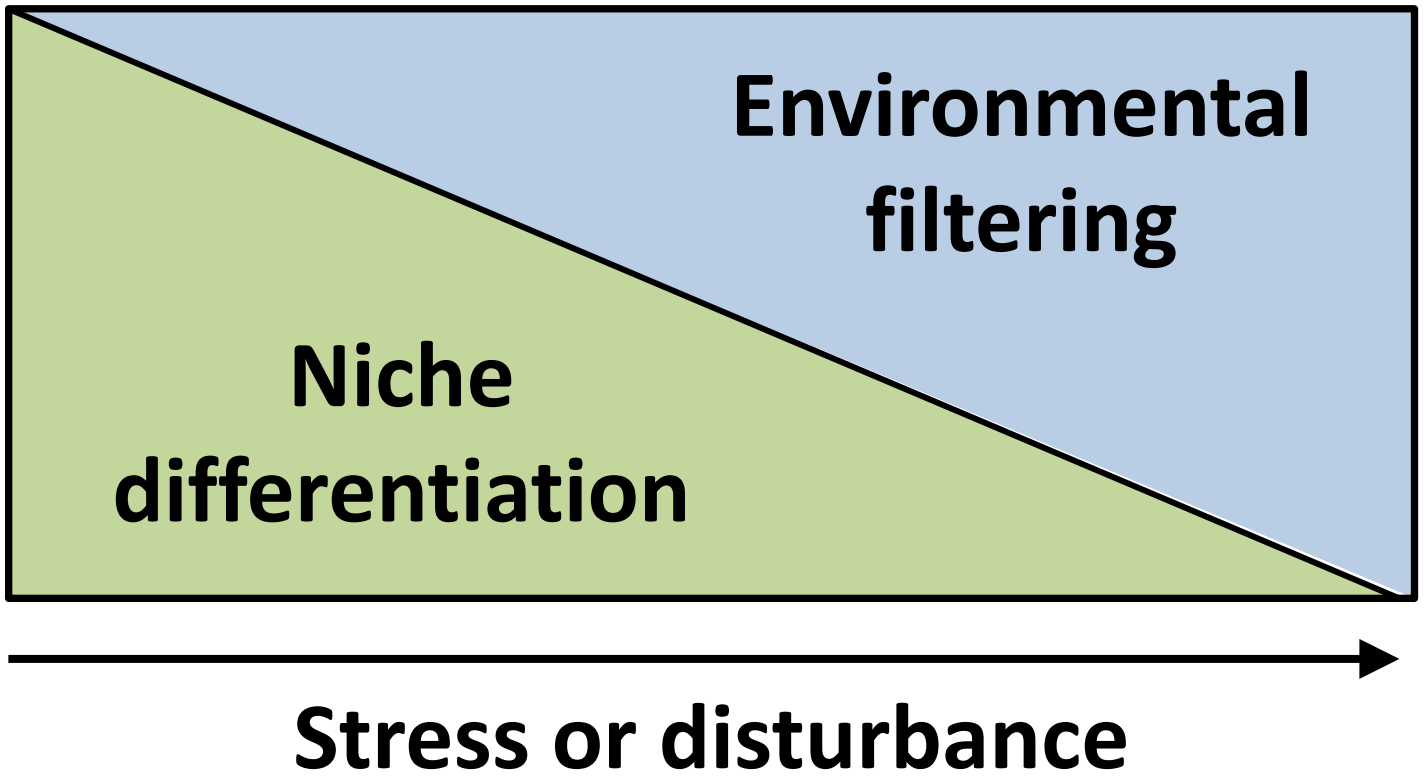
Regional distributions and the ‘core-satellite’ hypothesis





Hanski 1982 *Oikos*

Factors driving community assembly



Exceptions: Mass effects (source-sink dynamics)

Heino 2013 *Biological Reviews*

Main hypotheses

H_1: Does RAD slope change and why?
Is ranked abundance steeper at more disturbed sites?

H_{1A}: Dominance
Does dominance increase?

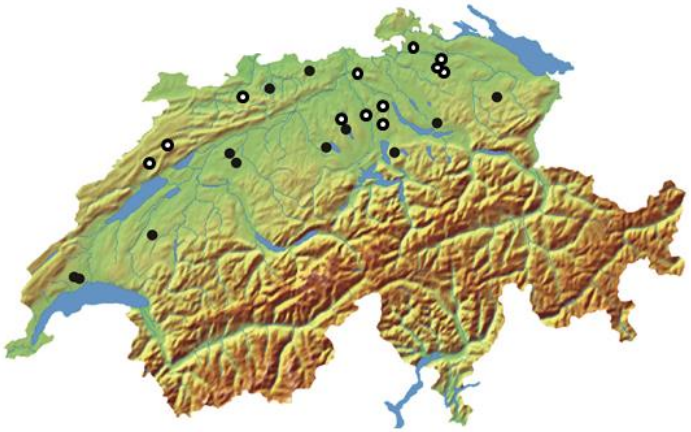
H_{1B}: Rare taxa
Are rare taxa less frequent?

H_2: What drives the magnitude of change?
Is change in slope influenced by the context or disturbance?

H_3: Scaling from local impacts to regional effects
Are regionally rare taxa more likely to be lost?

Study design

24 Swiss streams



Flow direction

DS

Downstream

d_{mix}

d_a

US2

$d_a + d_{mix}$

US1

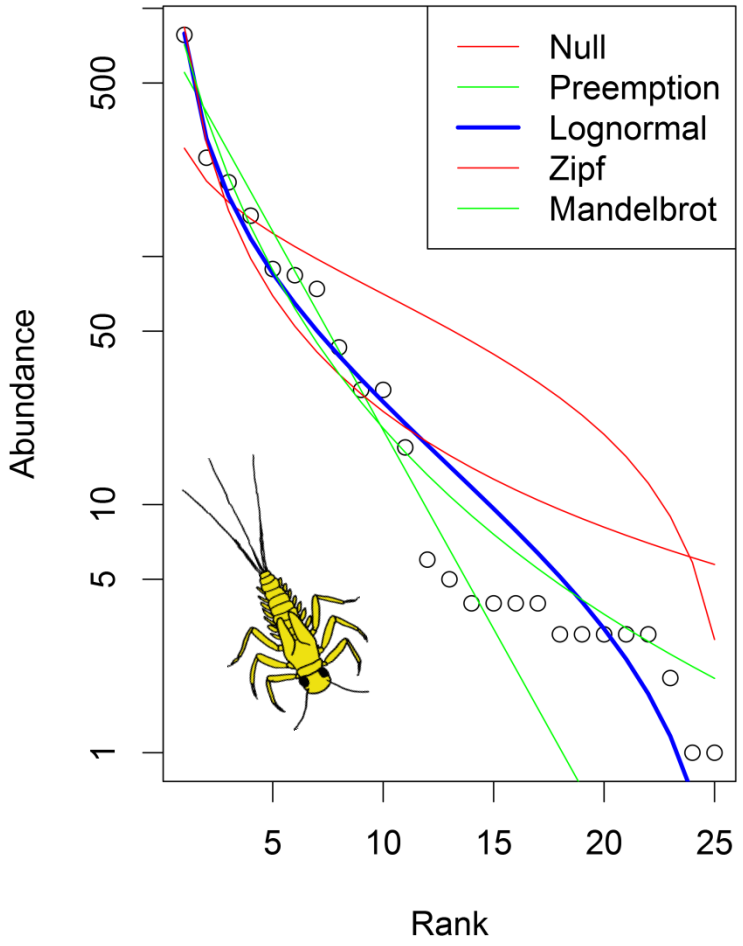
Upstream

Stream

Wastewater

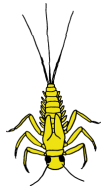
Sampled in Spring 2013/14
using Swiss BDM protocols

Fitting ranked abundance curves



- **Niche pre-emption** model used for analyses
- Species divide single niche dimension in constant fractions
- *radfit* in 'BiodiversityR'
- 'Mandelbrot-Zipf' model fits data better

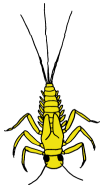
Increased dominance and less rare taxa cause steeper slope at sites impacted by wastewater



Steeper slope

LME, $F_{2,45} = 32$

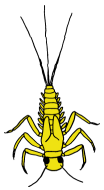
$P < 0.001$



Greater dominance

LME, $F_{2,46} = 3.7$

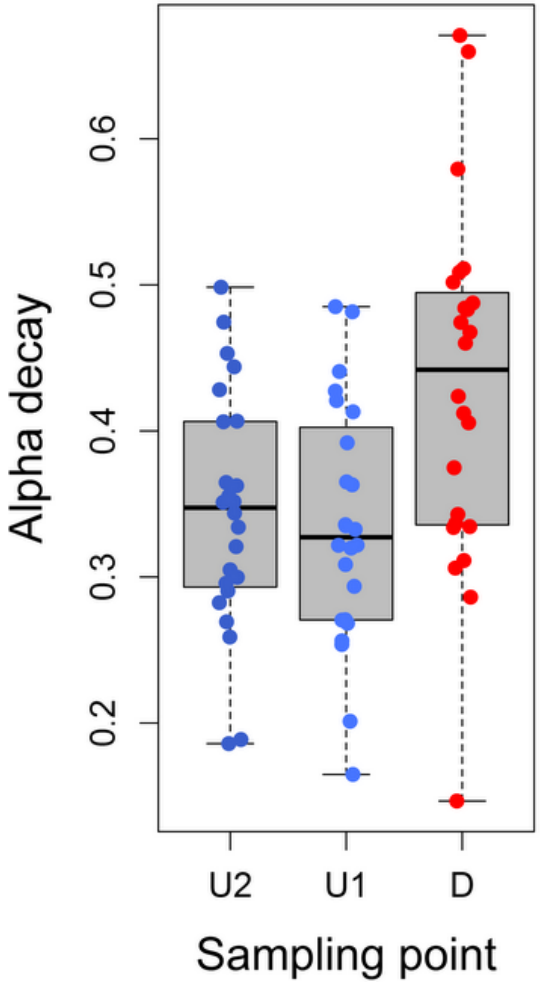
$P < 0.05$

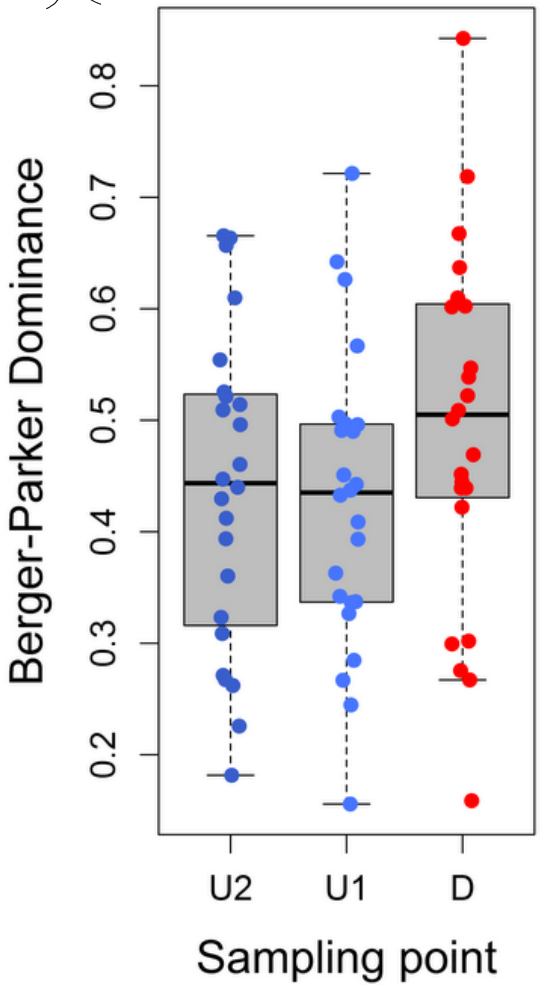


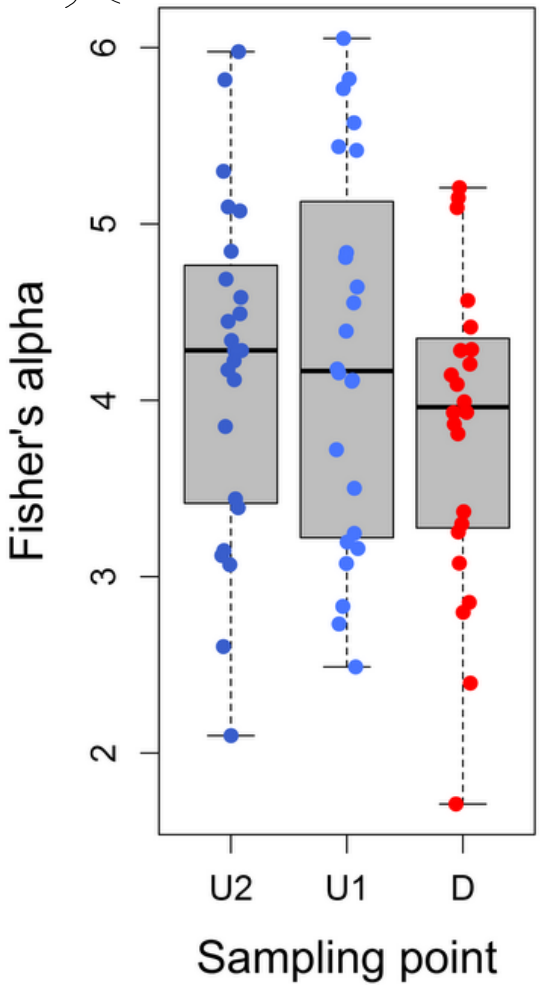
Less rare taxa

LME, $F_{2,45} = 8.5$

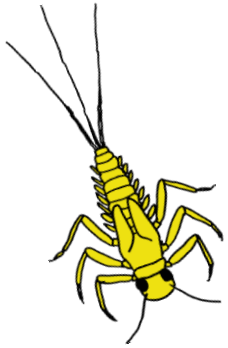
$P < 0.001$

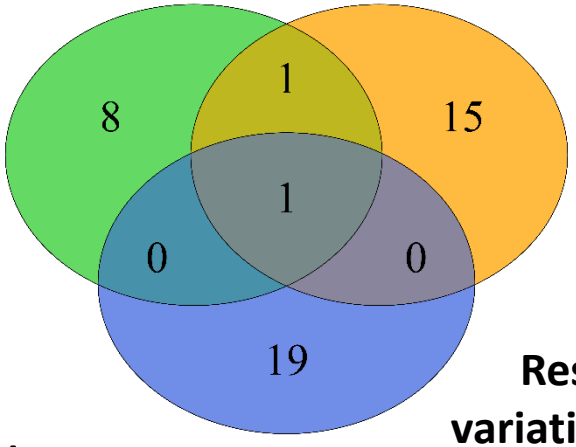




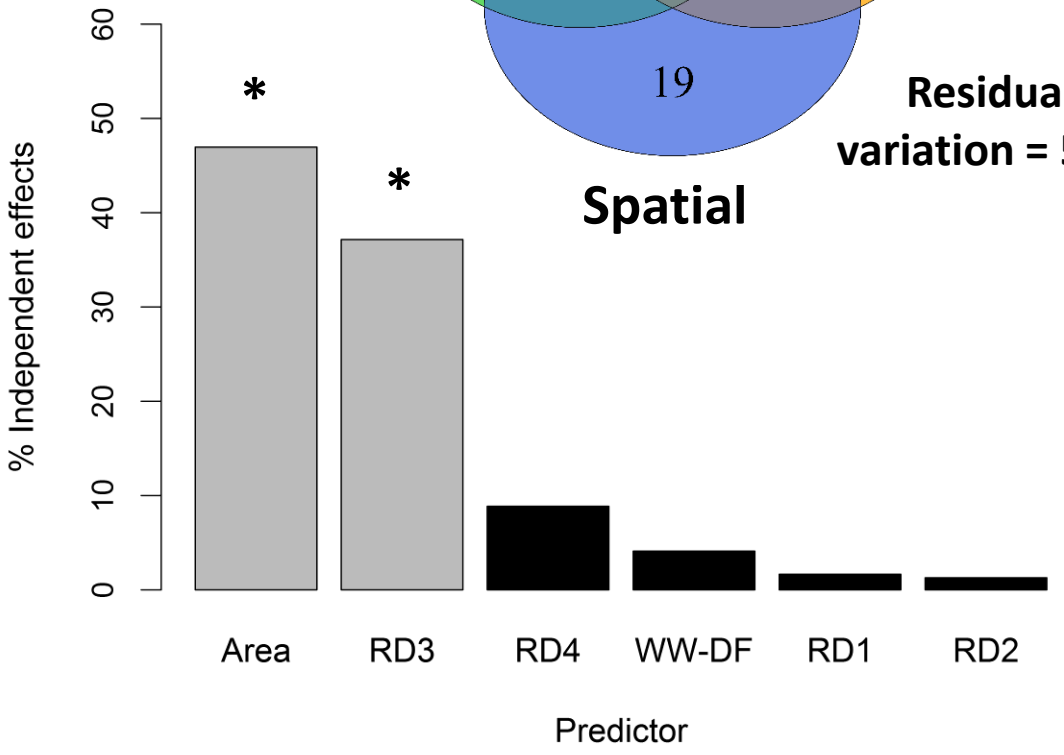


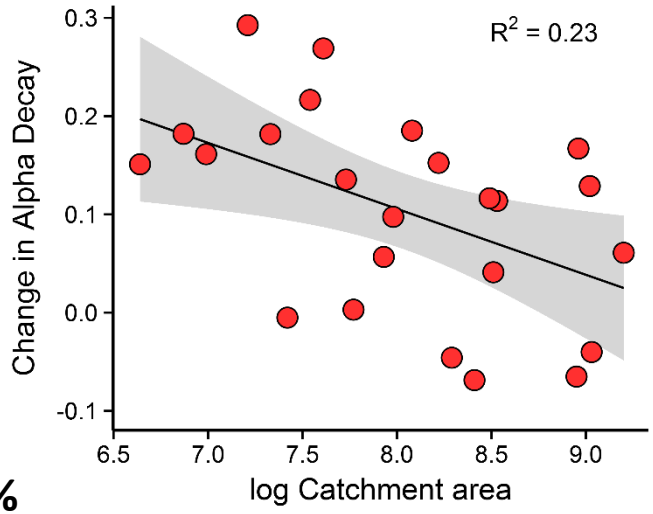
Size of change is context dependent

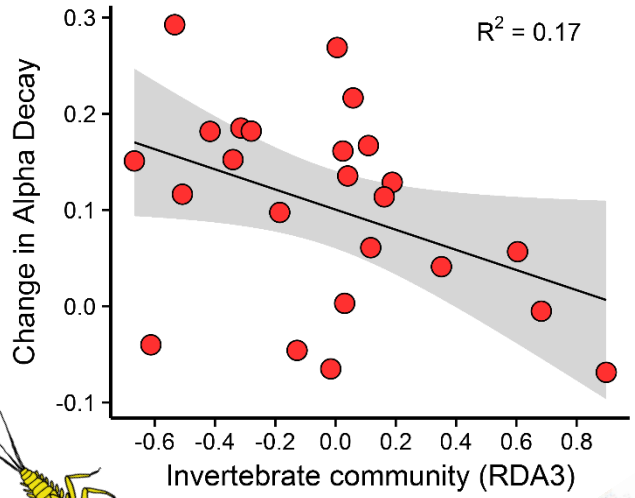


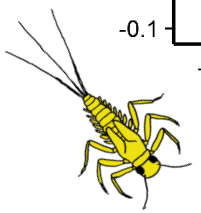


Residual variation = 56%







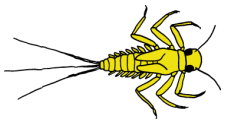


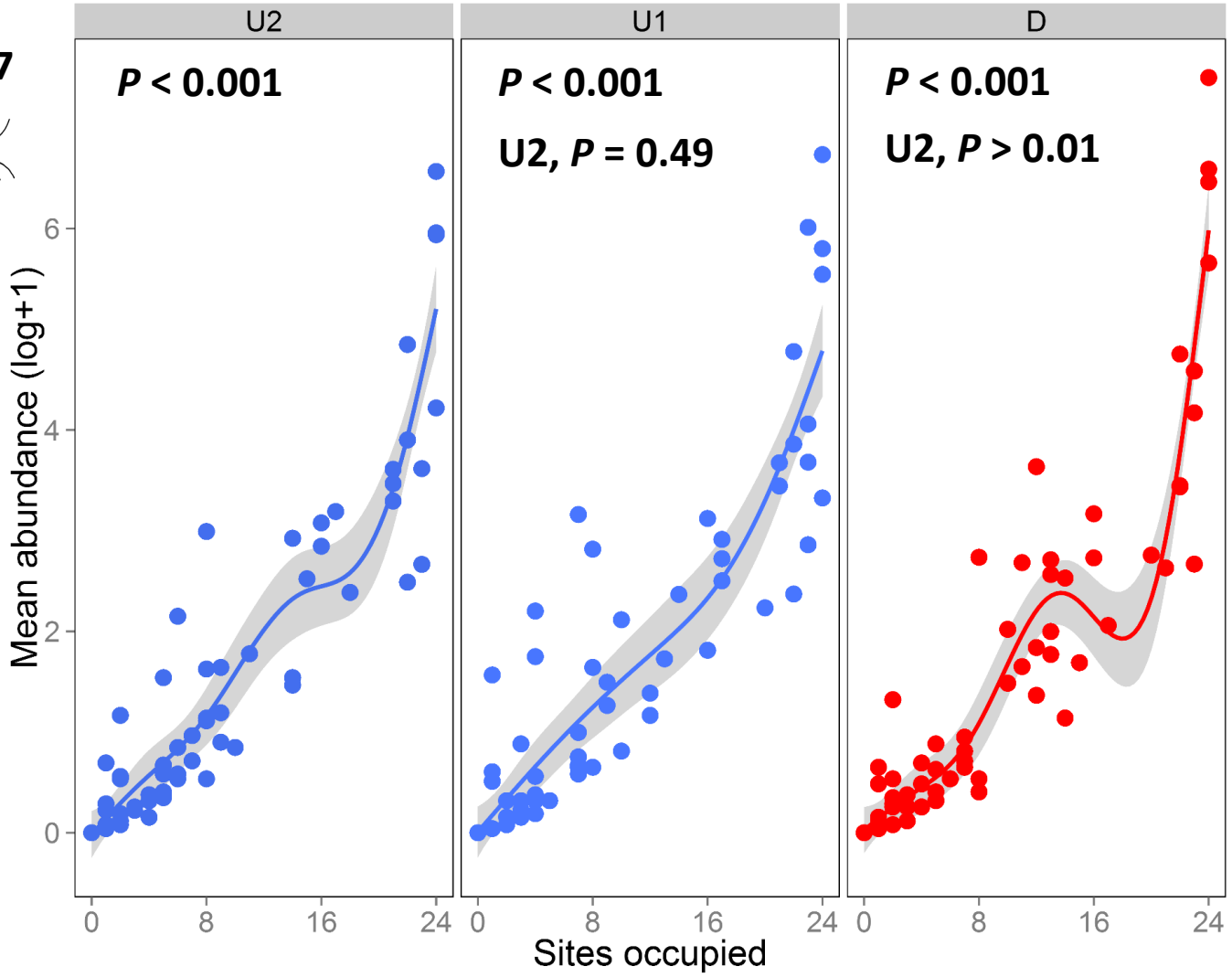
Changes in abundance-distribution relationship

GAM, $y = x \times Site + s(x, by = Site, k = 6)$

$R^2 = 0.872$

$\Delta BIC = -1.77$





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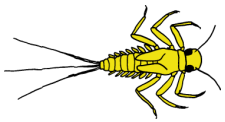
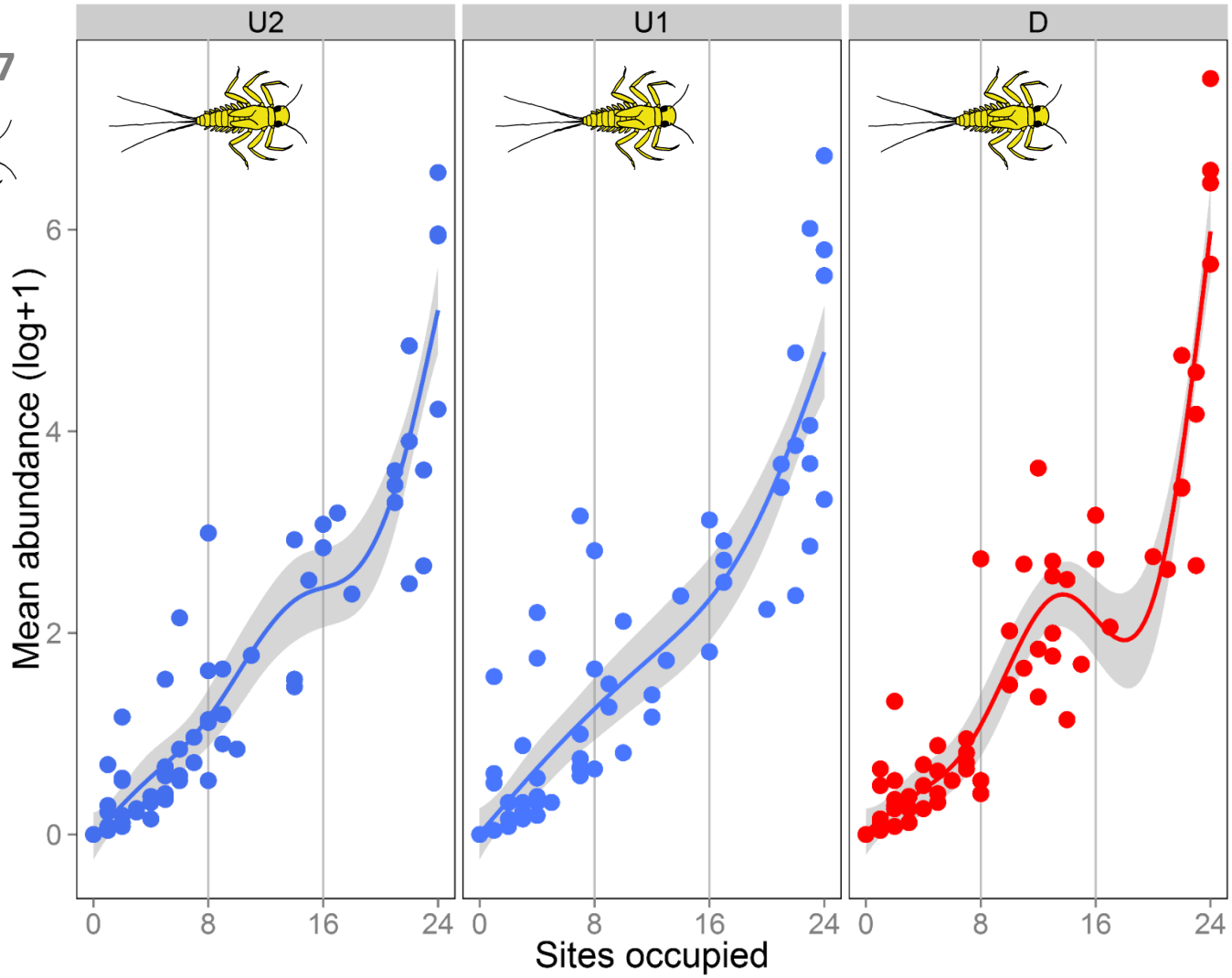
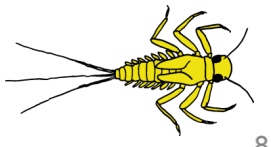
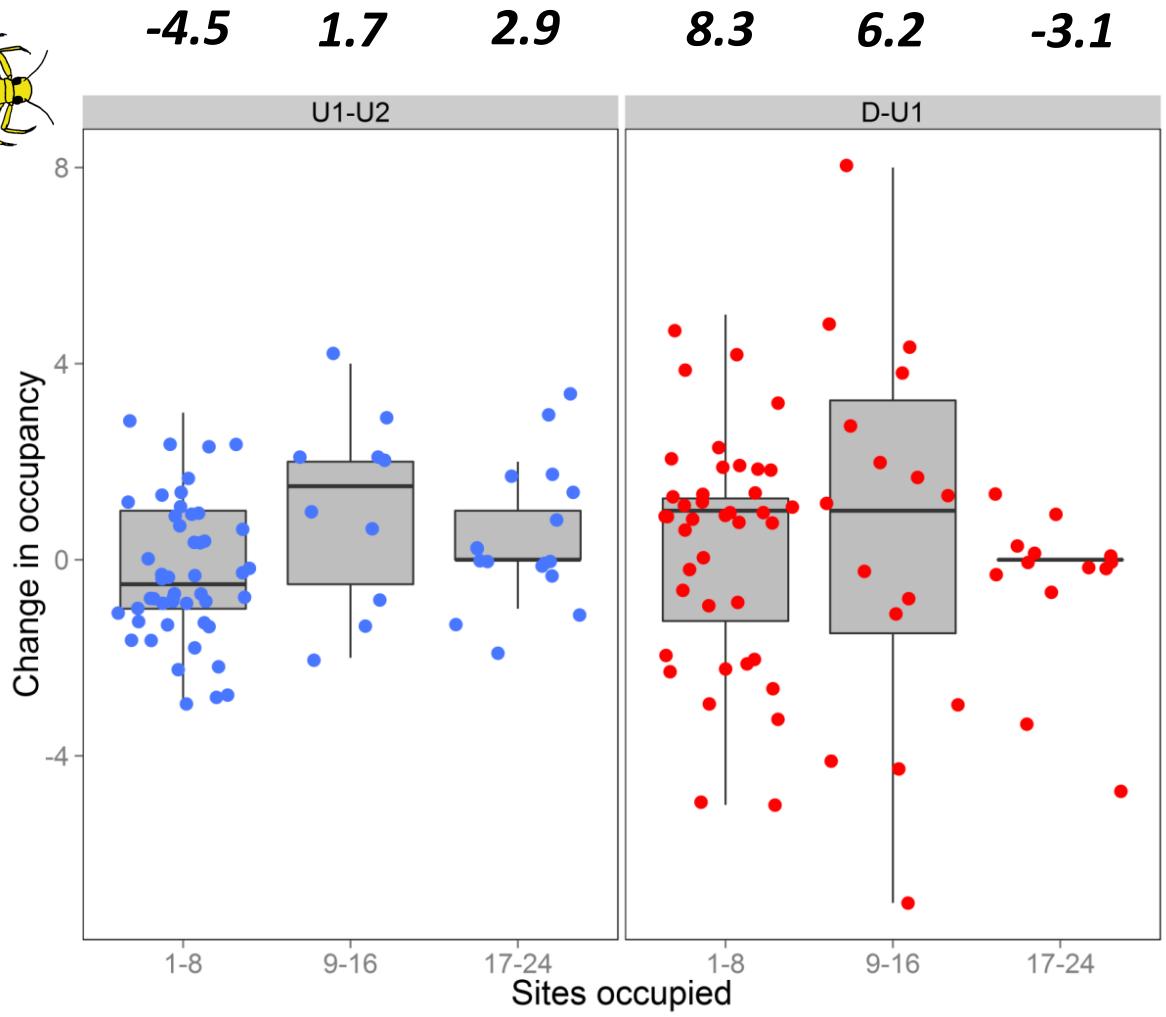




Pollution destabilises regional assembly patterns?





Winners

- r-selected
- Small-bodied
- Generalists

Losers

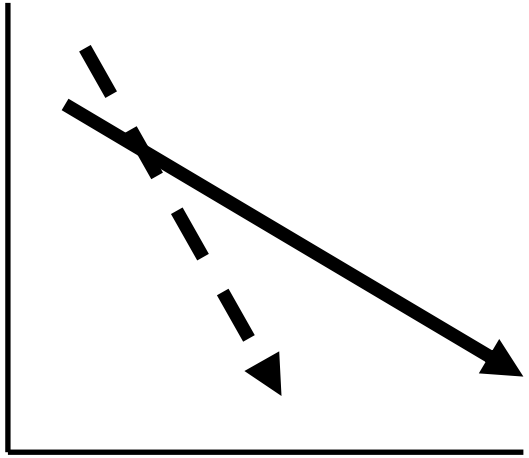
- K-selected
- Large-bodied
- Specialists

Summary

- RADs fitted to stream invertebrate data using **niche pre-emption model**
- Polluted sites showed **steeper decay rate** driven by **increased dominance** and **fewer rare taxa**
- Magnitude of change in RAD **context dependent** reflecting **landuse pressures** and **catchment size**
- Taxa distributions conform to **'core-satellite'** but regionally **rare taxa** numbers unchanged
- Polluted sites showed greater variation in assembly patterns reflecting **'winners and losers'**

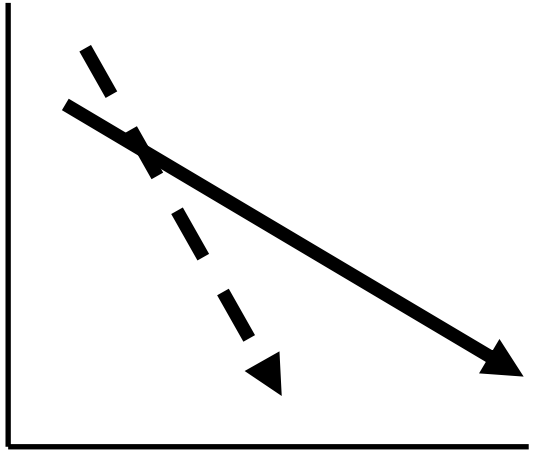
RADs, mass-abundances, and ‘core-satellite’?

log Abundance

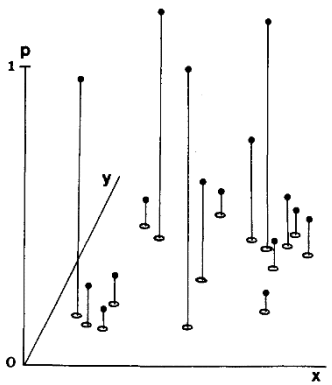


Rank

log Abundance



log Body mass



Hanski 1982 *Oikos*

Connect abundances and body-size to regional distributions?

Acknowledgements

Drs. Katja Räsänen and Christian Stamm

Profs. Jukka Jokela and Rik Eggen

Prof. Florian Altermatt

Marta Reyes & wider EcoImpact group

Aquabug and collaborators

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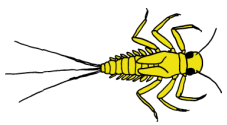
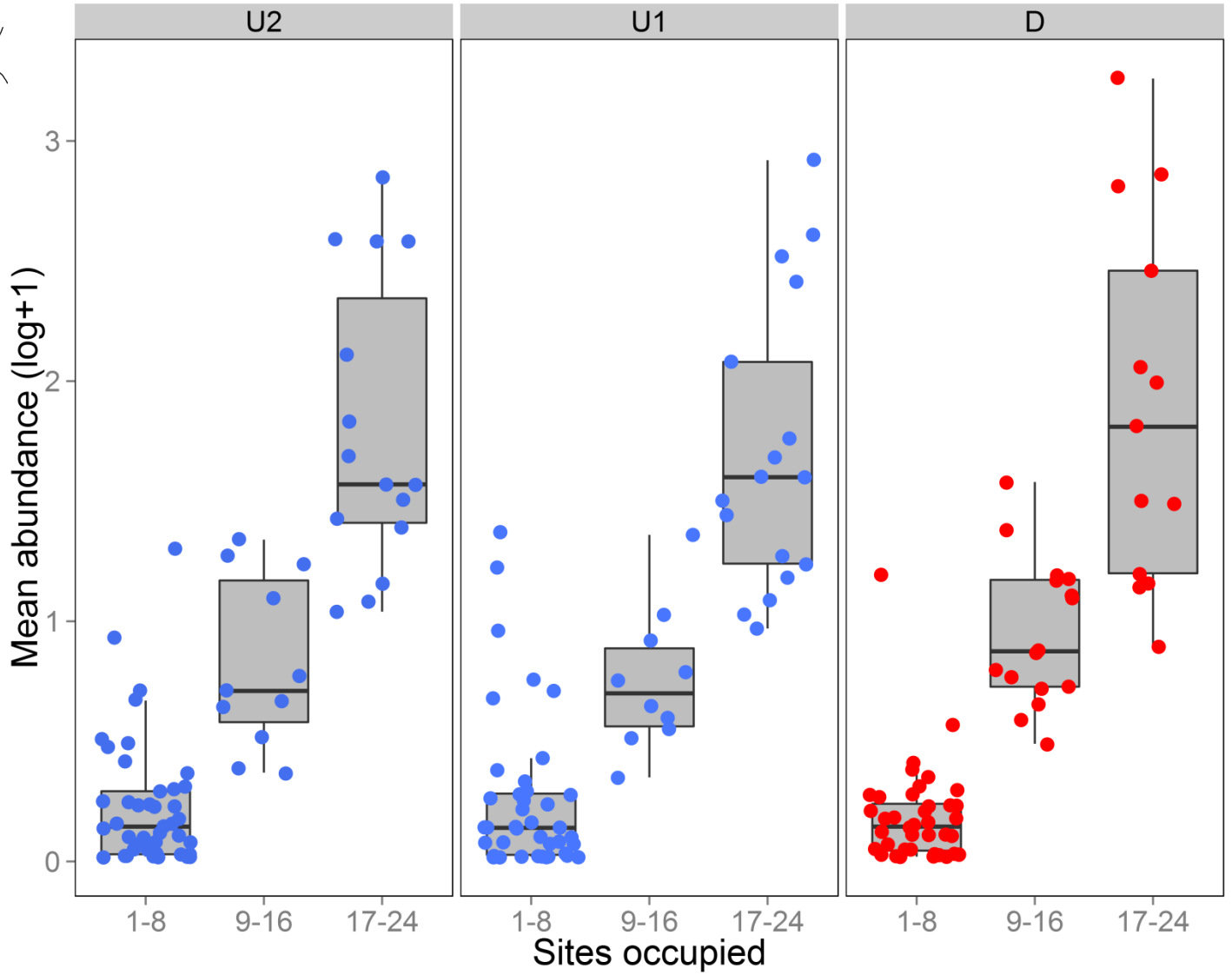
Questions?

Increased abundances for common taxa





Increased abundances for taxa still present