What can ranked abundance distributions tell us about anthropogenic change in stream ecosystems?

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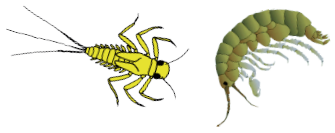

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Summary and future directions

Ranked abundance distributions were fitted to stream invertebrate community data using the **niche pre-emption** model.

Polluted locations showed a **steeper decay rate** driven by **increased dominance of tolerant taxa** and **fewer rare taxa**.

Taxa distributions conformed to the **'core-satellite' hypothesis** where locally abundant taxa were regionally common, but regionally rare taxa did not change in mean abundances or total occupany at polluted locations.

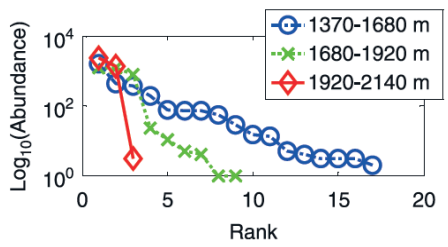
However, polluted sites showed greater variation in assembly patterns, potentially reflecting 'winners and losers'. This suggests that local anthropogenic disturbances may **destabilise** community assembly processes at the regional scale.

Future analyses will further consider **trait modalities** to better understand variation in community responses.

Introduction

One fundamental macroecological pattern is the hollow curve of species ranked by abundance, also known as ranked abundance distributions (RADs).[1] These describe that frequently, communities consist of a few abundant and many rare species. Despite their ubiquity, the underlying processes controlling the shape of RADs are still the focus of ongoing discussion.[2]

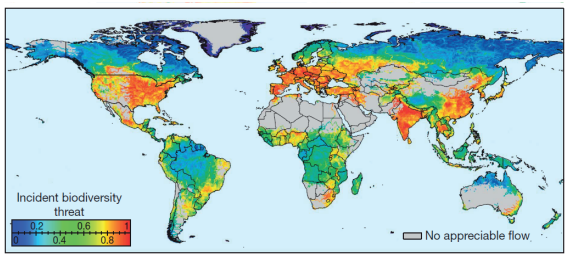
Moreover, despite many studies having found strong negative effects of anthropogenic disturbances on biodiversity, only a few researchers have considered these impacts with regards to RADs. This is surprising, considering their potential for explaining changes in biodiversity patterns at a meso-level. The aim of this research was to assess how well RADs explain pollution-induced changes in stream invertebrate biodiversity, and to extend the paradigm to consider dynamics of regional distributions.



The elevational gradient in vegetation diversity from Whittaker's surveys of the Siskiyou Mountains is a classic example of RADs.[3]

Anthropogenic pressures

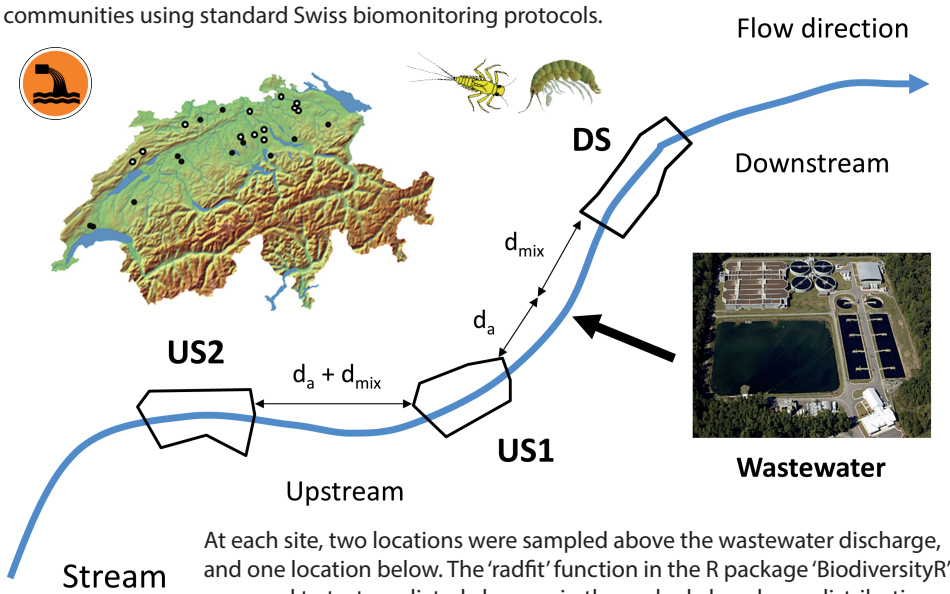
Freshwater biodiversity is under pressure globally from a myriad of stressors associated with human activities.[4]



Treated wastewater is a common point-source of pollution that affects communities in receiving environments through eutrophication and toxic influences of micropollutants.[5]

Study design

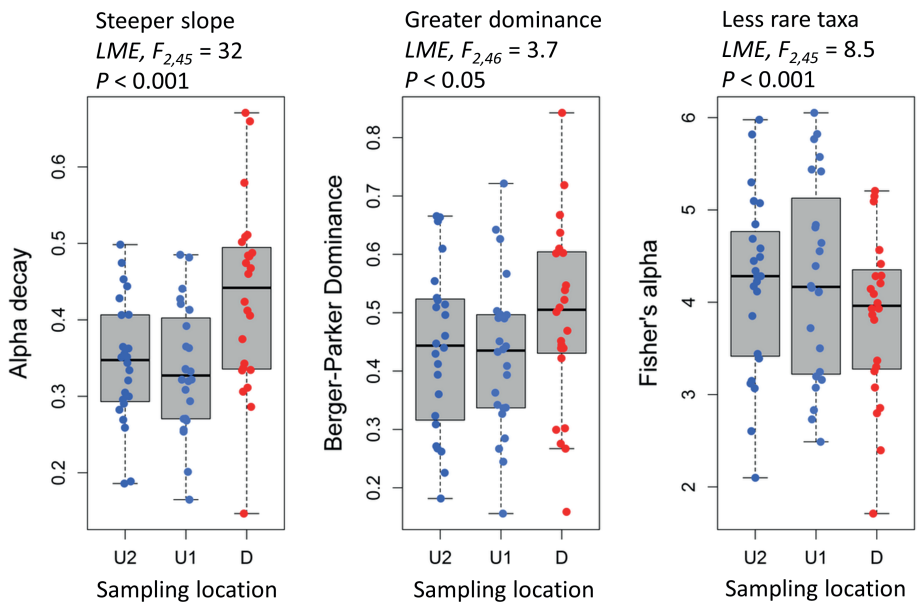
The EcoImpact project is a large-scale study of micropollutants in the environment. 24 Swiss streams with wastewater inputs have been surveyed for a wide variety of environmental parameters and biological responses. These include the one-off sampling of stream invertebrate communities using standard Swiss biomonitoring protocols.



At each site, two locations were sampled above the wastewater discharge, and one location below. The 'radfit' function in the R package 'BiodiversityR' was used to test predicted changes in the ranked abundance distributions of stream invertebrate communities as a response to wastewater pollution.

Ranked abundance distributions

The alpha decay parameter from the niche pre-emption model became steeper with wastewater pollution due to increasing dominance by tolerant taxa and the loss of rare taxa. Mixed-models account for the non-independence of sampling locations, and taxa richness is used as a covariate for modeling the reponse of alpha decay and Fisher's alpha.



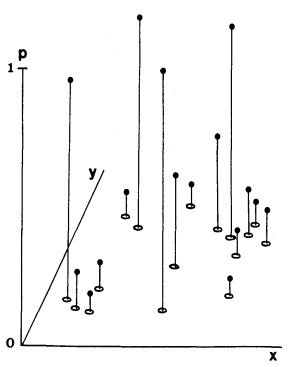
The 'core-satellite' hypothesis

The local abundance of taxa increases as they become regionally more common, thus conforming to the predictions of the 'core-satellite' hypothesis.[6]

However, there are significant disruptions in this relationship at locations affected by wastewater pollution.

Contrary to predictions, regionally rare taxa (≤33% of sites occupied) do not change in average abundances or total occupancy at impacted locations.

Dynamics of regional distribution

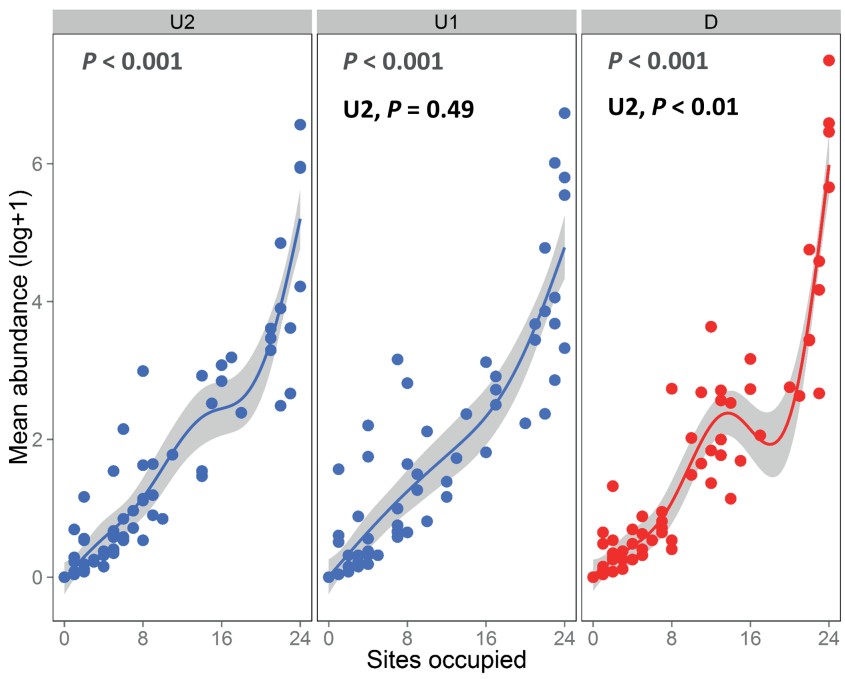


The core-satellite hypothesis predicts that as taxa become regionally more common:

1) their average abundance locally should increase, and

2) their probability of extinction should decrease.

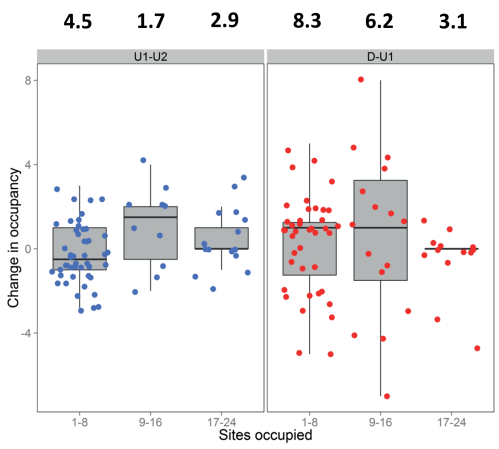
Ilkka Hanski rationalised that the 'core' taxa should be well spaced-out in niche space, whereas the opposite should be true for the 'satellite' taxa.



Part of this contradiction may be explained by the turnover of taxa, with new taxa replacing lost rare equivalents.

Instead, the coefficient of variation for the change in occupany patterns of rare and moderately common taxa is greater at locations impacted by wastewater.

This suggests that wastewater pollution may destabilise community assembly processes at the regional scale.



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