Nitrogen transformation in lake sediments: Environmental parameters and microbial community structure

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eawag aquatic research
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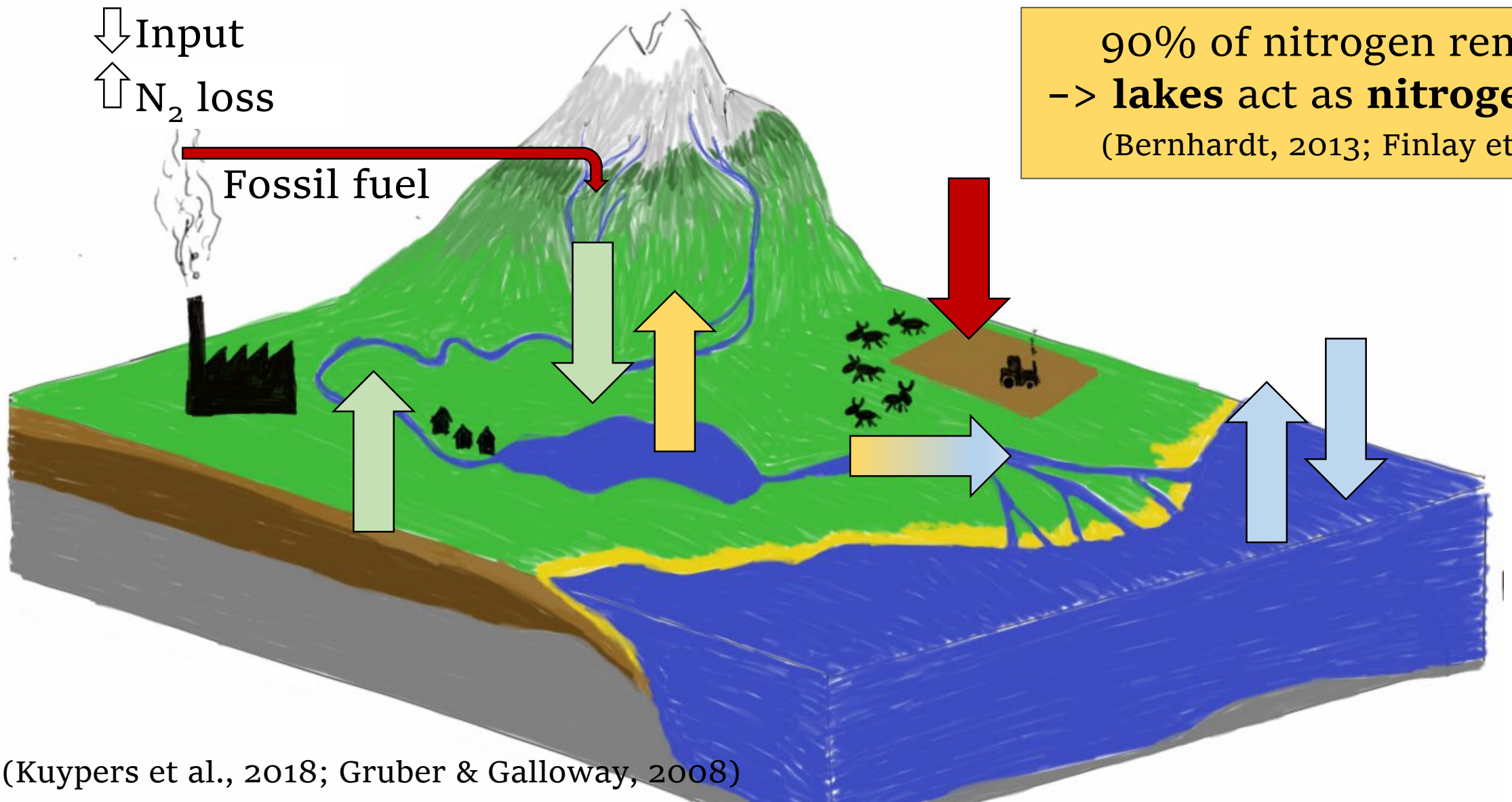
FNSNF Swiss National Science Foundation

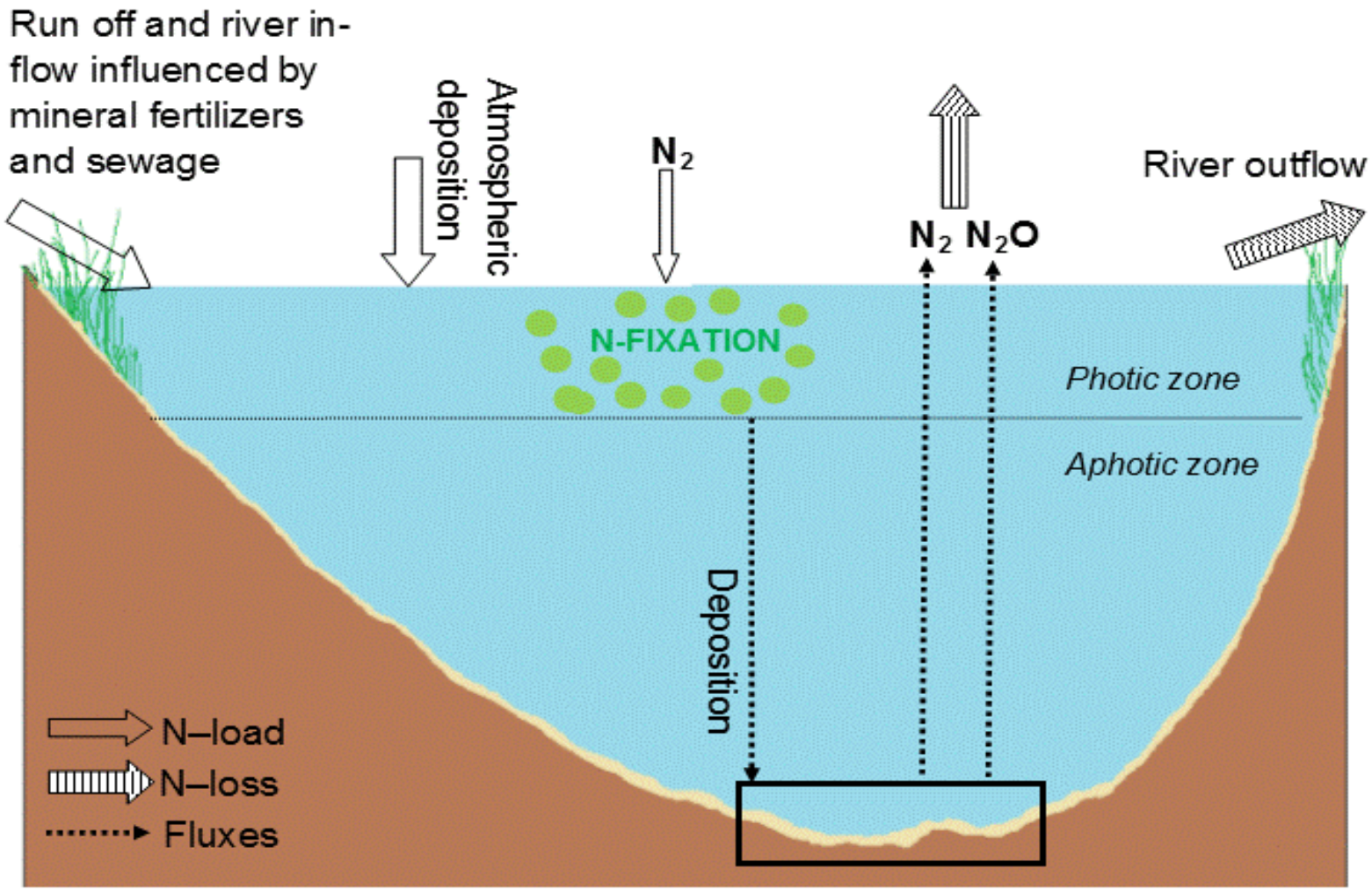
Nitrogen cycle



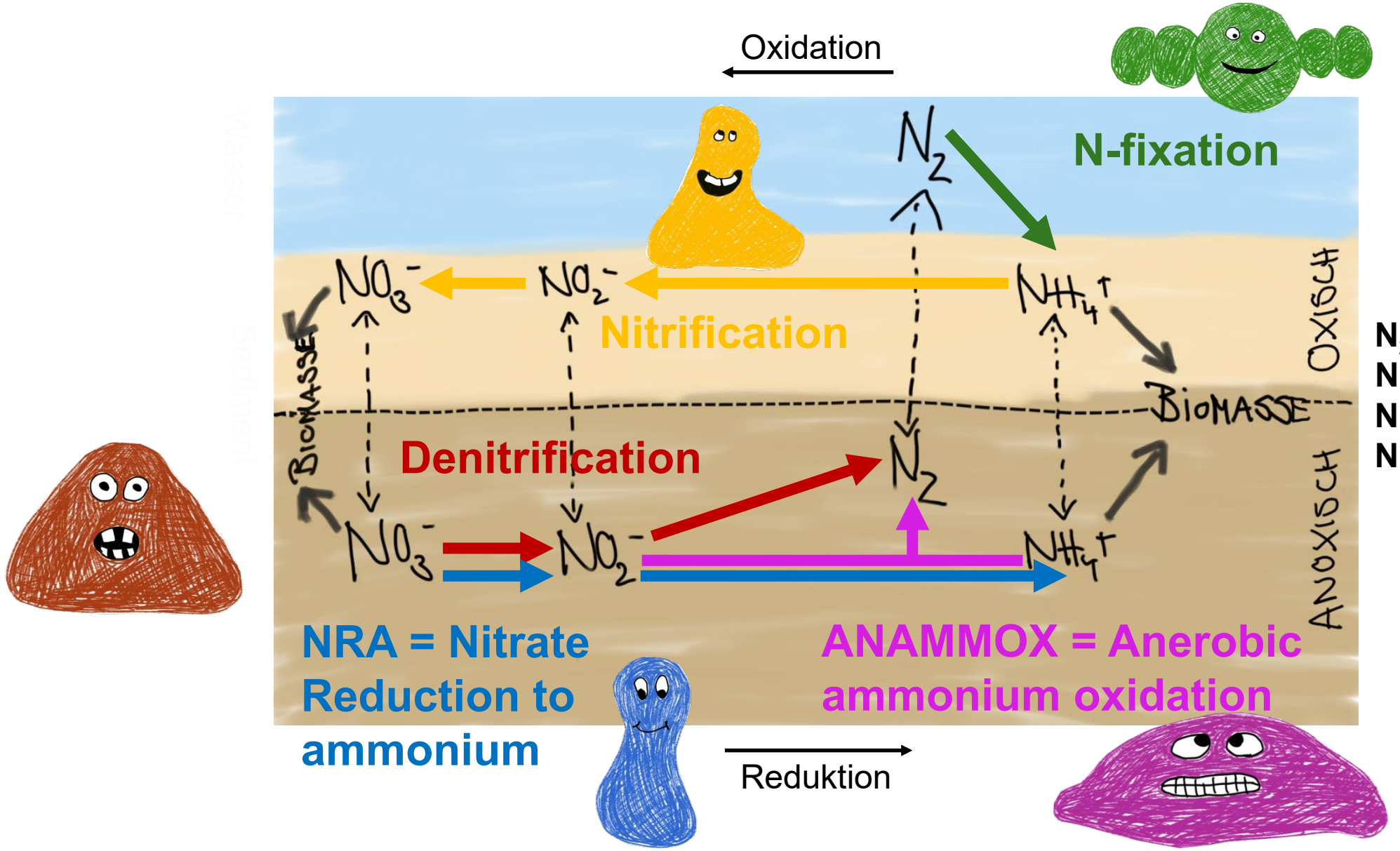
90% of nitrogen removed
-> **lakes** act as **nitrogen sinks**
(Bernhardt, 2013; Finlay et al., 2013)

(Kuypers et al., 2018; Gruber & Galloway, 2008)

Nitrogen fluxes in lakes



Nitrogen transformation processes

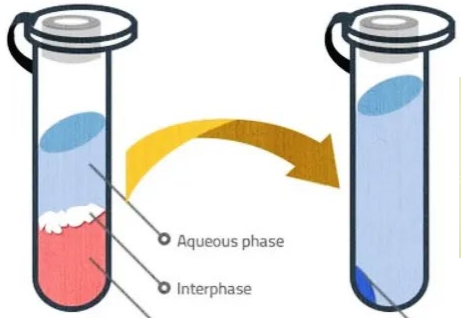


N_2 = atmospheric N
NH_4^+ = Ammonium
NO_2^- = Nitrite
NO_3^- = Nitrate

How to catch benthic microbes?

Metagenomic approach

Sediment samples

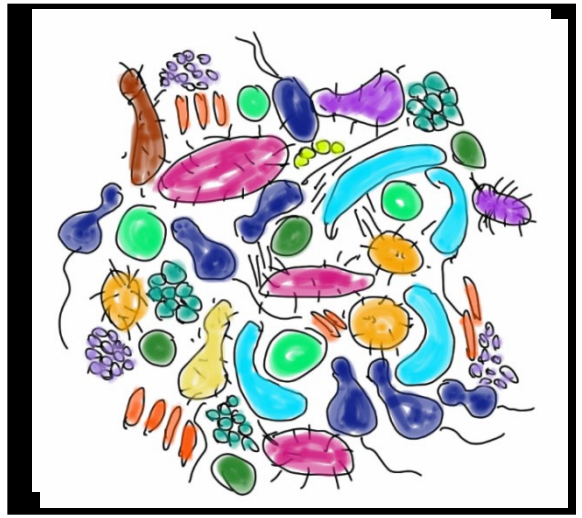


DNA Extraction

ATTGGCCAACG
GCGCGTAATTT

Taxonomy

- Bacteroidetes
- Alphaproteobacteria
- Deltaproteobacteria
- Gammaproteobacteria
- Actinobacteria
- Acidobacteria
- Cyanobacteria
- Verrucomicrobiae
- Thaumarchaea
- Nitrospira
- Oxyphotobacteria
- Ignavibacteria
- Clostridia



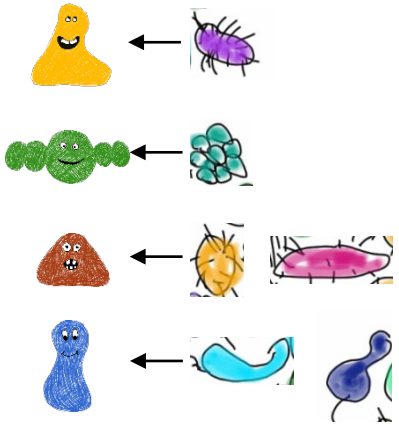
Funktional groups

Nitrification

N-Fixation

Denitrification

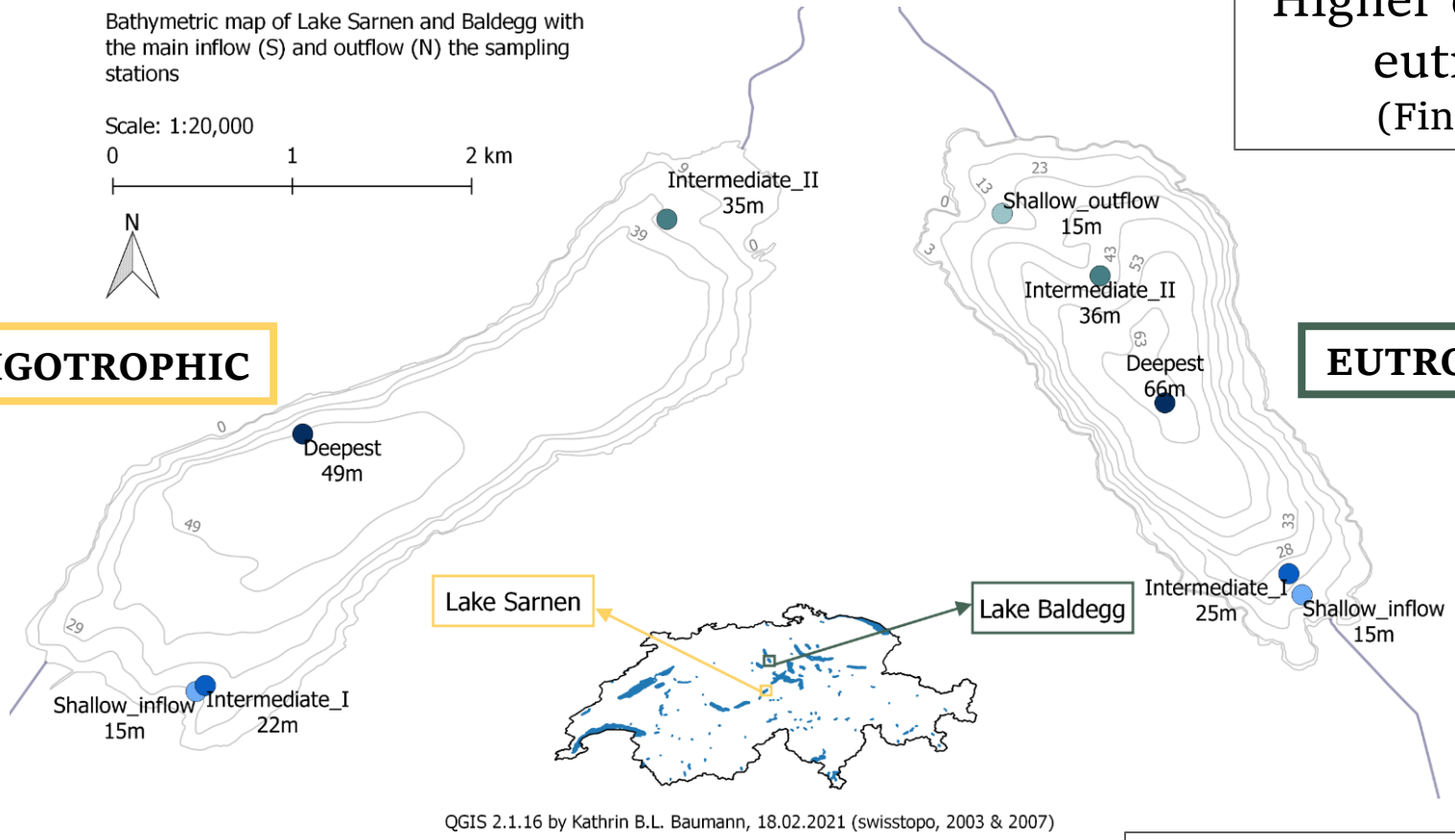
DNRA



Quince, Walker et al. (2017); https://www.sciencemag.org/features/2014/06/explosion-bioinformatics-careers; https://www.illumina.com/; http://howbiotech.com/

oligotrophic vs eutrophic lake

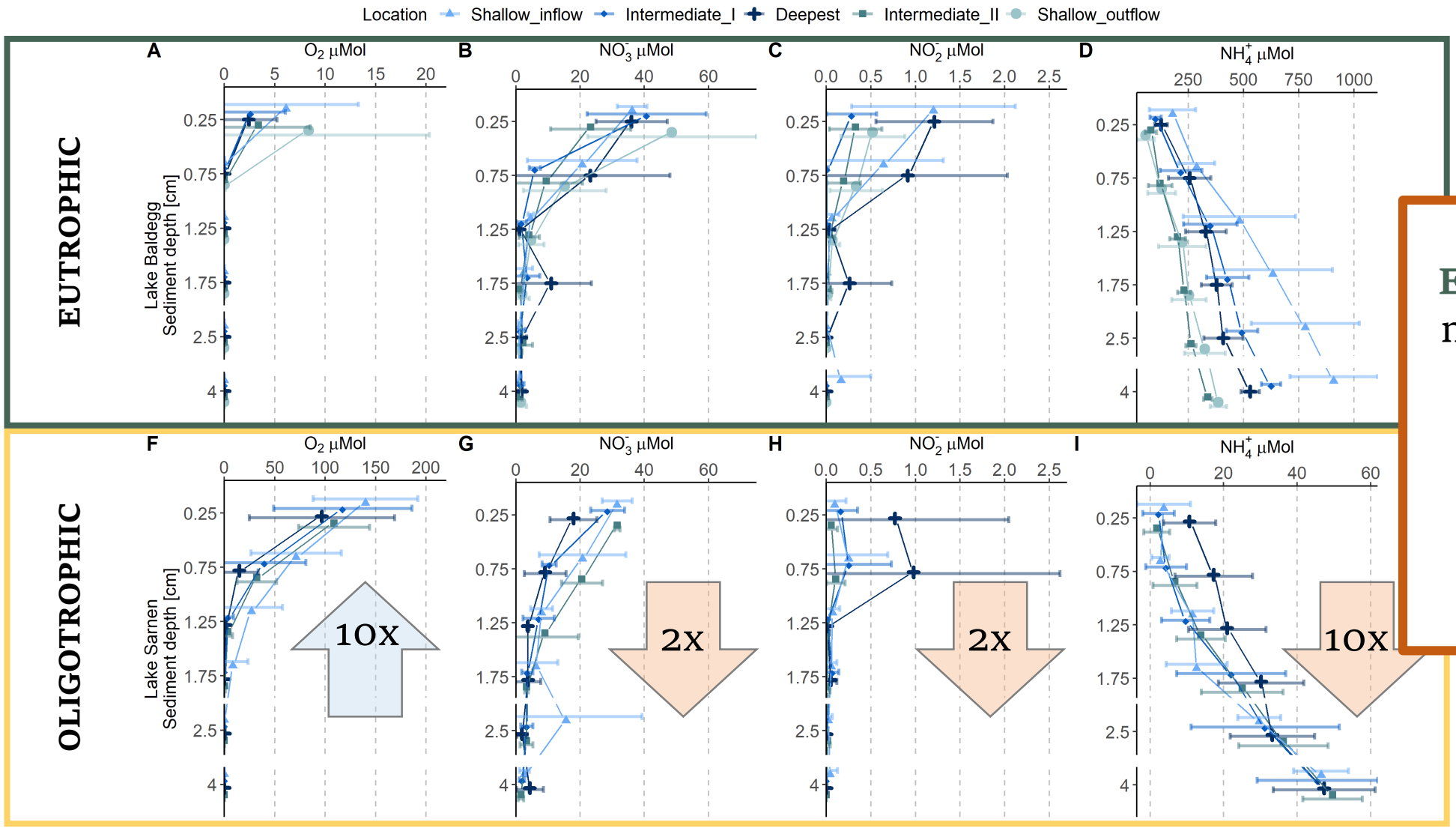
Higher denitrifcation in eutrophic lakes
(Finlay et al. 2013)



2018:
March
May
August
September

Porewater chemistry
16S rRNA amplicon sequencing
Metagenomes

Porewater concentrations

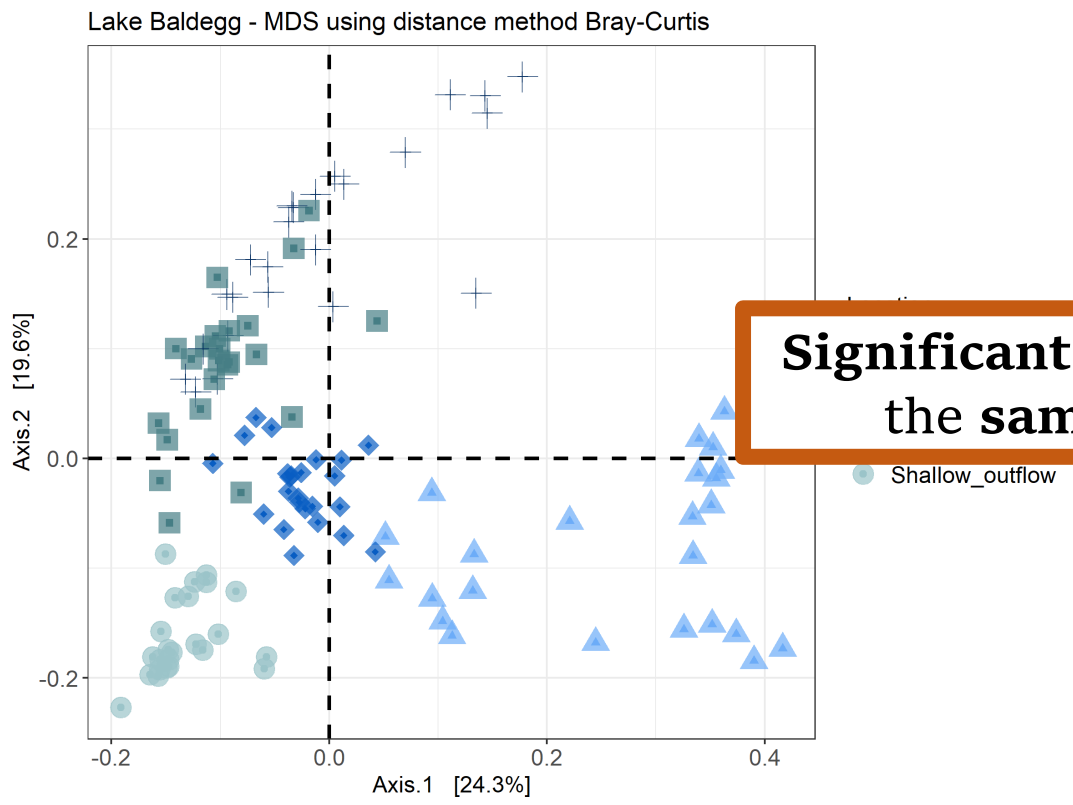


Eutrophic lake higher nutrient concentration

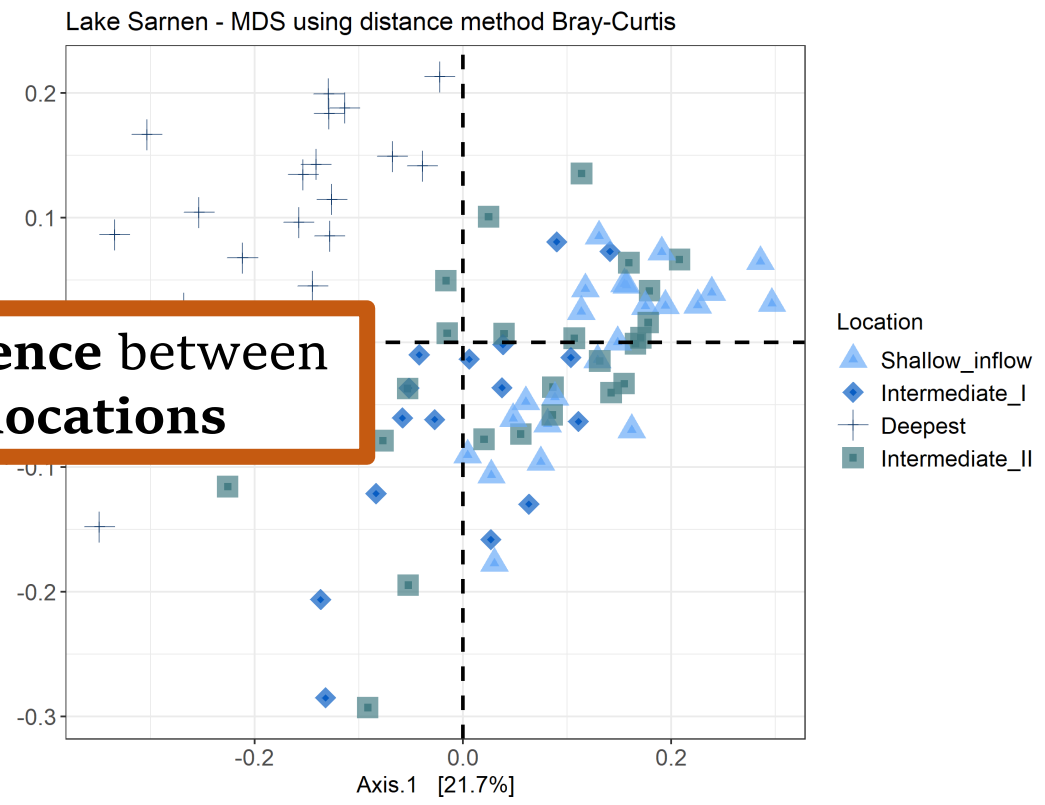
Nutrient fluxes - **temporal changes**
Müller et al. (2021)

Microbial community composition

EUTROPHIC

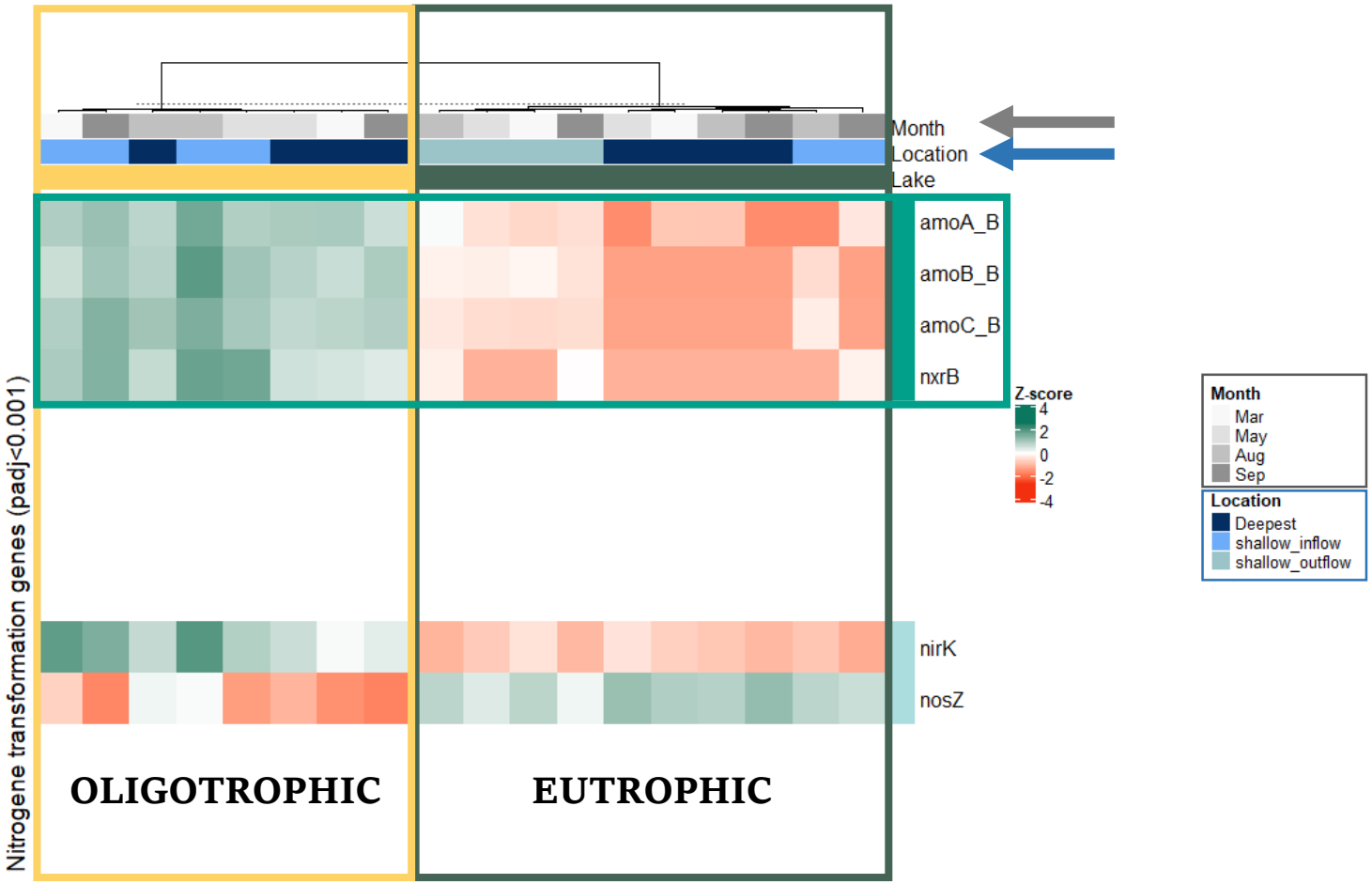


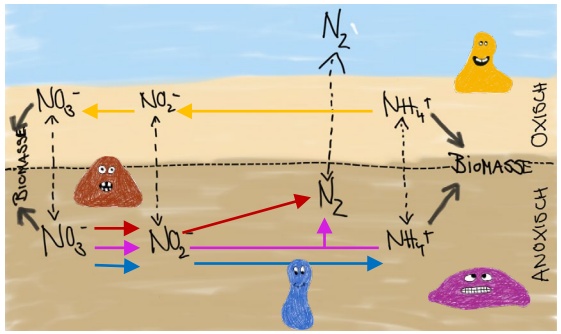
OLIGOTROPHIC



Significant difference between the **sampling locations**

Nitrification





$NH_4^+ \xrightarrow{amoABC} NO_2^- \xrightarrow{nxrB} NO_3^-$

Oligotrophic lake higher potential for nitrification

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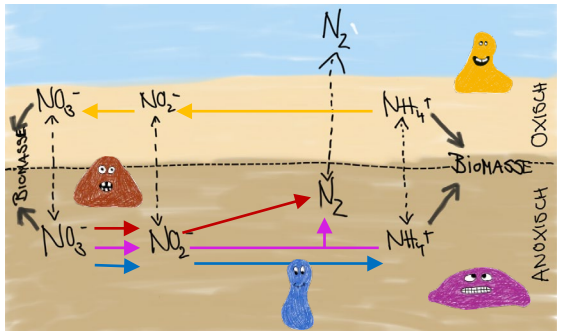
50 % Nitrospirae – Nitrite oxidizing bacteria in low NH_4^+

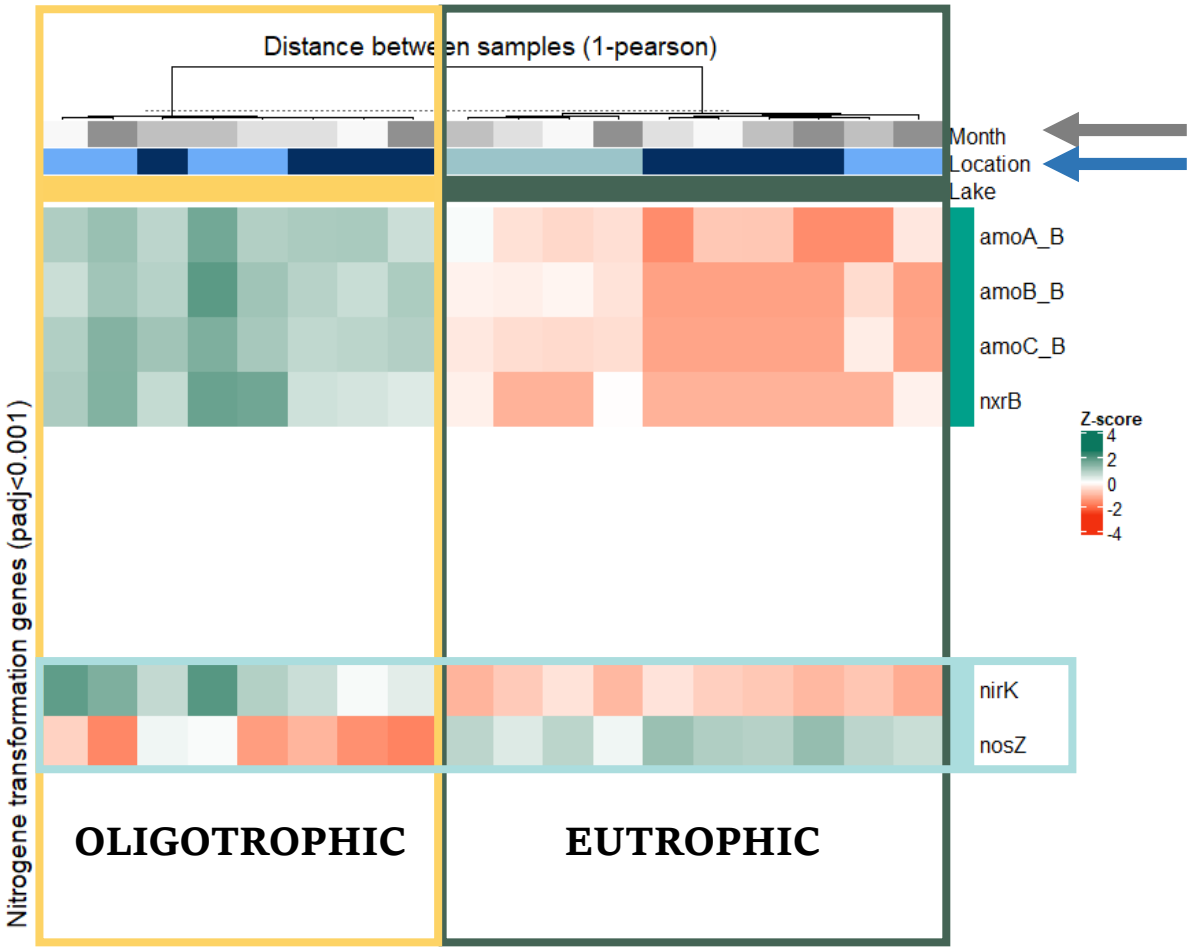
Pester et al. (2014)

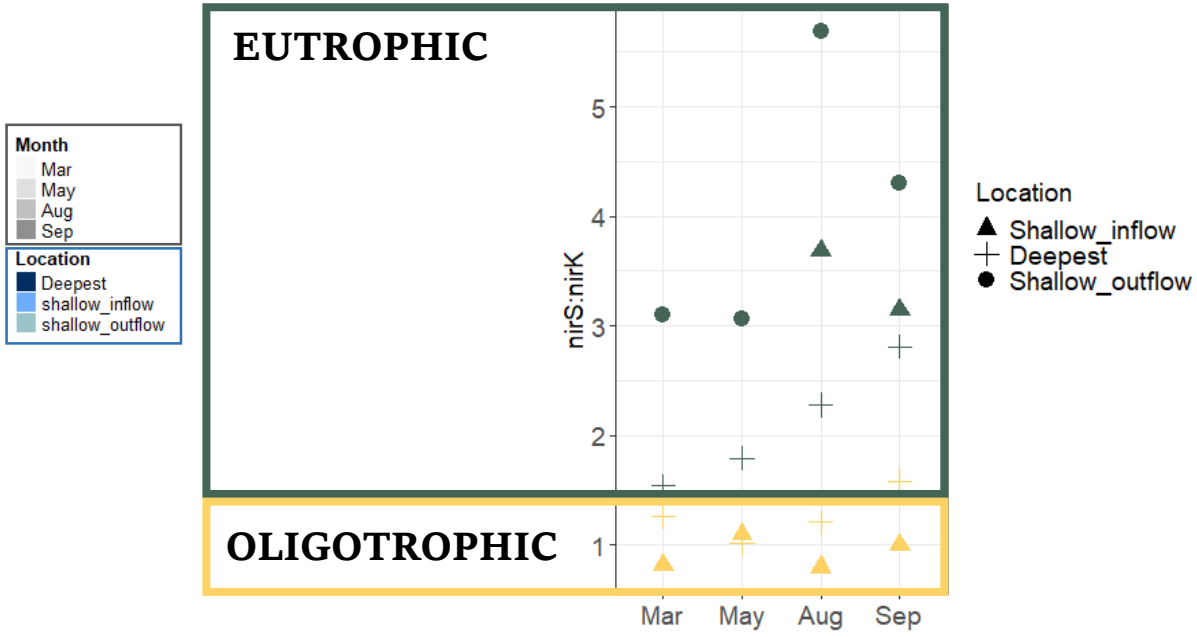
Denitrifcation potential



NO_2^- → NO → N_2O → N_2

nirK *nirS* — *norB* *norC* — *nosZ*





nirS denitrifiers co-occurance with *norBC* and *nosZ* – complete denitrification

Graf et al. (2014)

Eutrohpic lake higher potential for denitrification

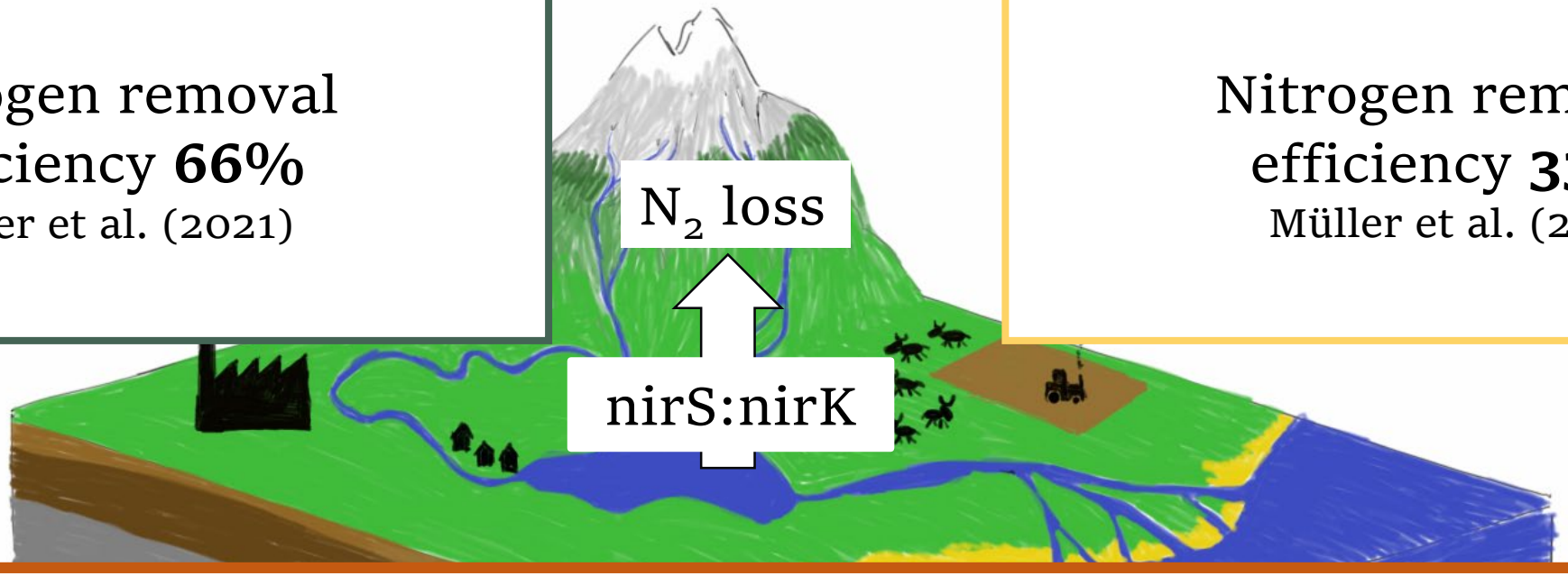
Summary

EUTROPHIC

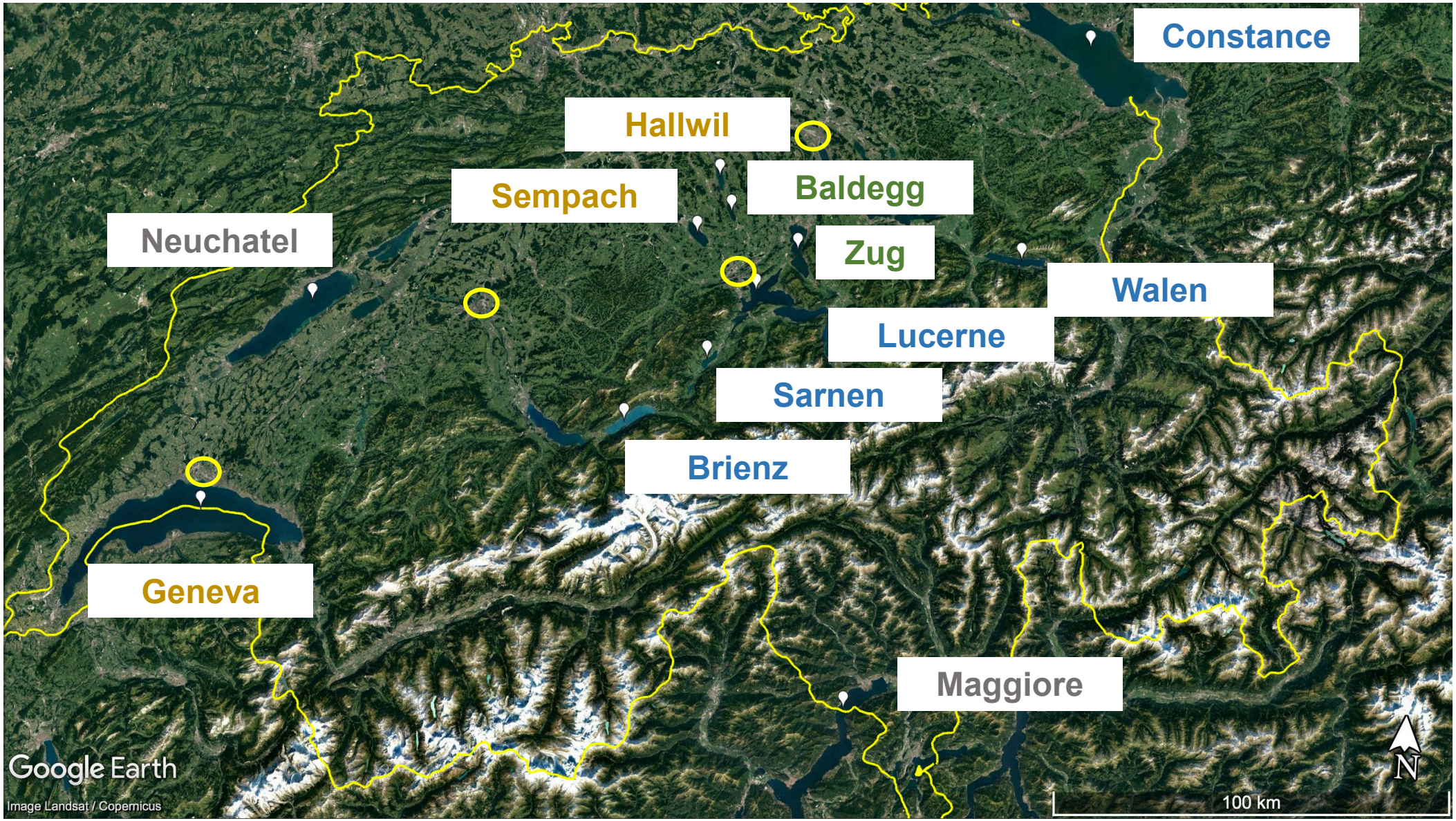
Nitrogen removal efficiency **66%**
Müller et al. (2021)

OLIGOTROPHIC

Nitrogen removal efficiency **33%**
Müller et al. (2021)



Seasonal changes in **porewater** chemistry
-
Spatial changes in **taxonomical** and **functional footprint**
⬇
Metatranscriptomics, Proteomics



Oligotrophic
0-10 ugP/l

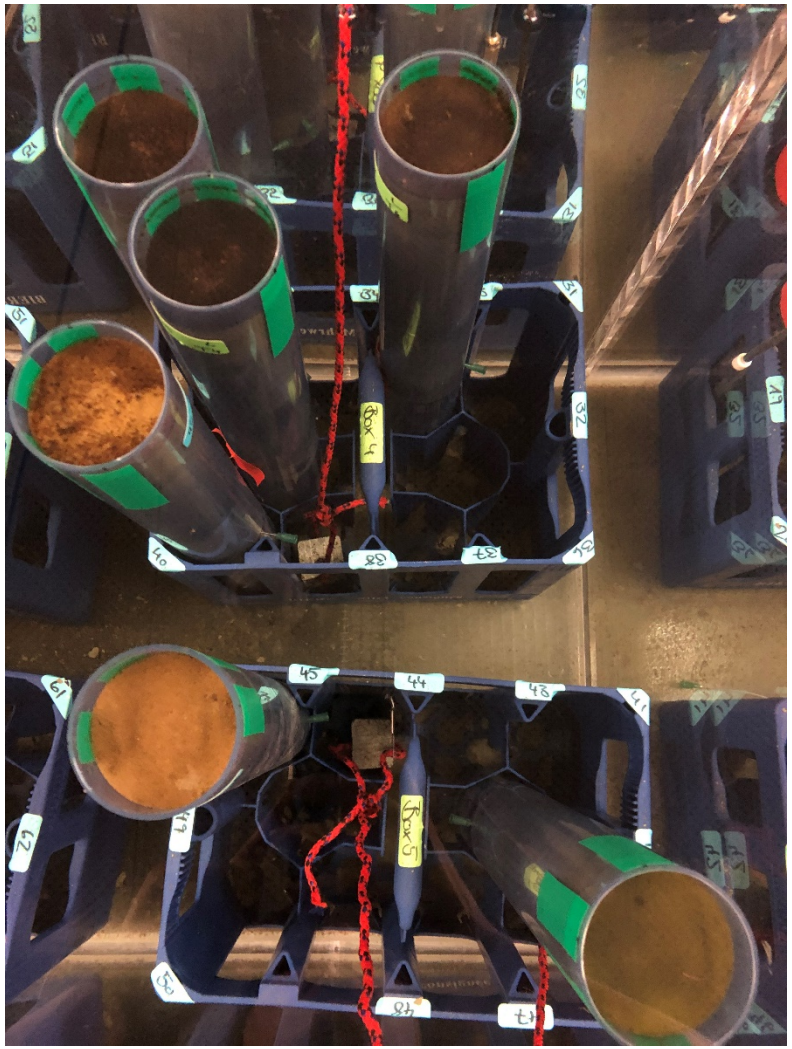
Oligo-mesotrophic
~10 ugP/l

Mesotrophic
10-25 ugP/l

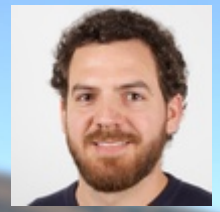
Eutrophic
>25 ugP/l

Wasserqualität der Seen (admin.ch)

Organic matter experiment



Thank you and…



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