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Do biological invasions mask the effects of ecological restoration?

A case study on the Old Rhine River

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R. japonica


N. melanostomus


D. villosus


E. nuttallii

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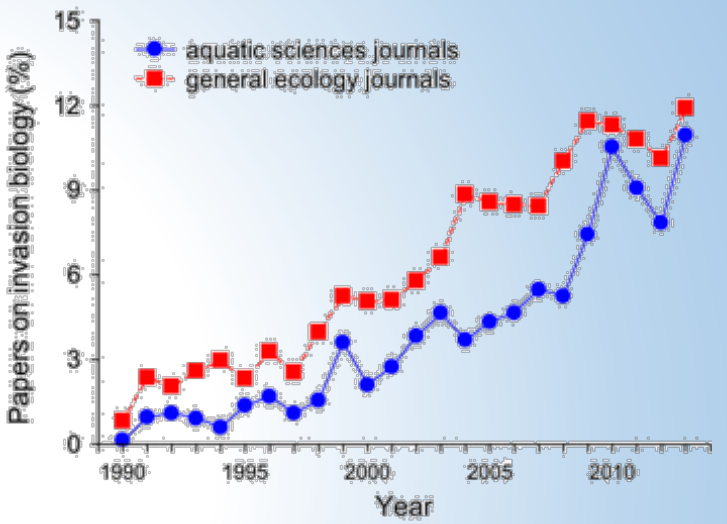
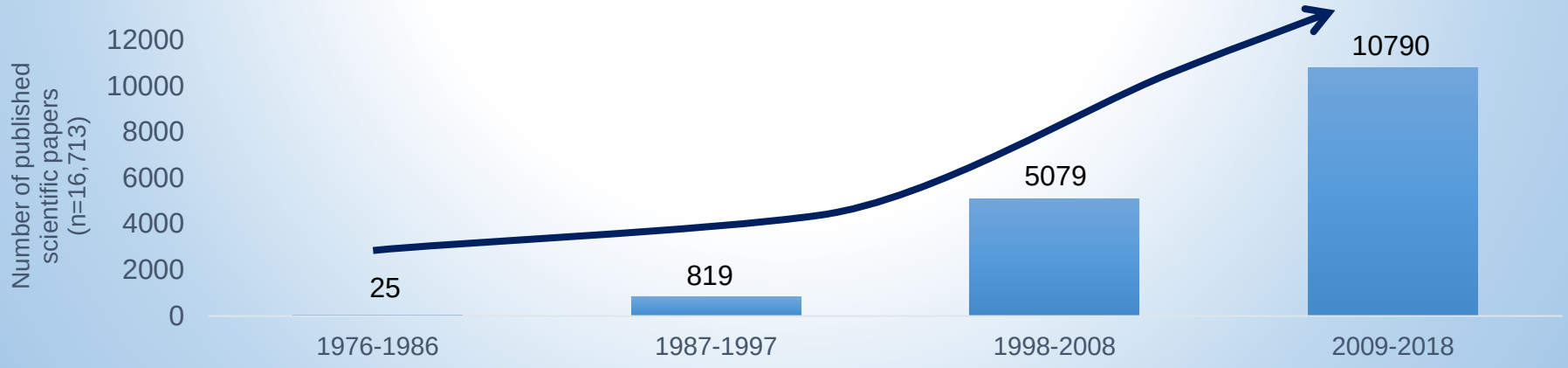
General trends

- From 1990, **high increase** in river restoration actions
- At the **same** time period, **rise in biological invasions**
- Providing **confounding effects…**
- Causing problems **in evaluating the success of restoration actions**

Thomaz et al., 2015 (Hydrobiologia)



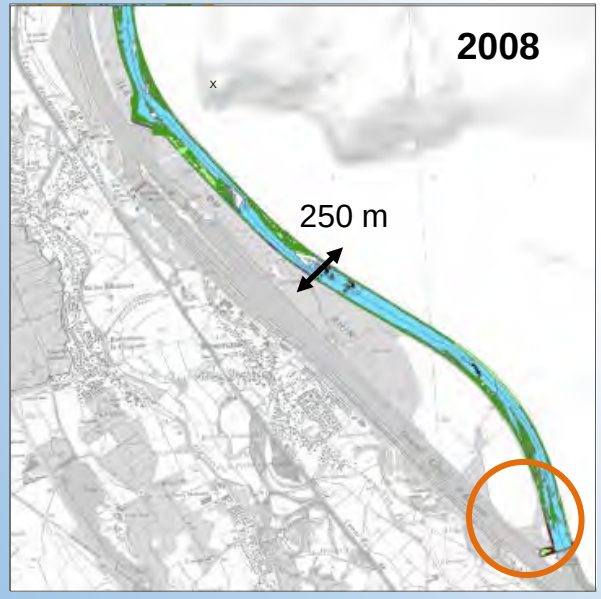
Overview on **40 years** (papers issued from *restor* x terms related to river**)



Staentzel et al., in revision (STOTEN)

Why the Old Rhine River a case study ?

- **Heavily regulated** since the 19th century
- High **loss** of lateral mobility
- **Altered biodiversity and ecological deficits**
- ↗ **Restoration projects in the Old Rhine**

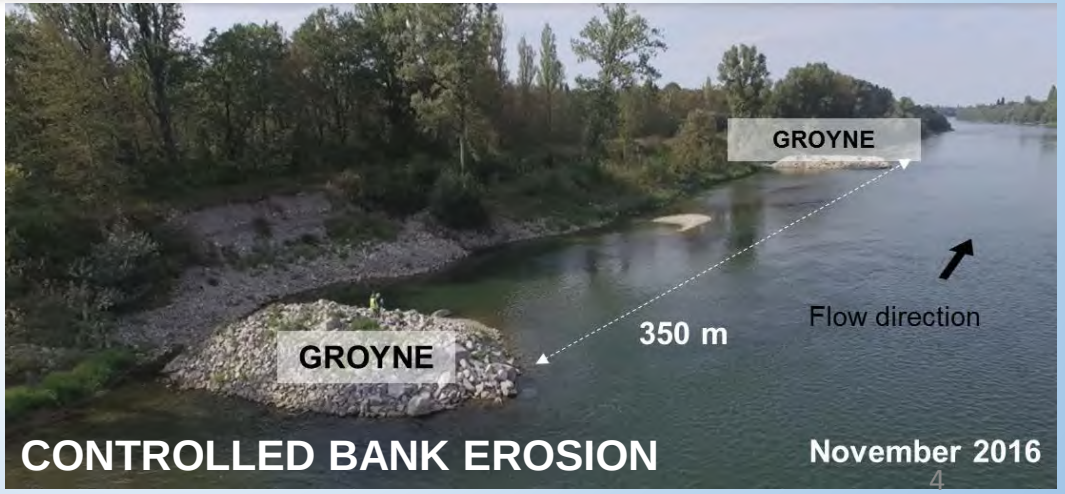


Piégay *et al.*, 2010

Why the Old Rhine River a case study ?

- **First** gravel augmentation in **January-February 2015**
- **A second** one in **March-April 2016**
- **Multi-compartment** monitoring & **BACI** protocol

- Controlled bank erosion with groynes in **April 2013**
- **Unique** restoration action in the world (Staentzel *et al.*, in review)
- **Multi-compartment** monitoring & **BACI** protocol

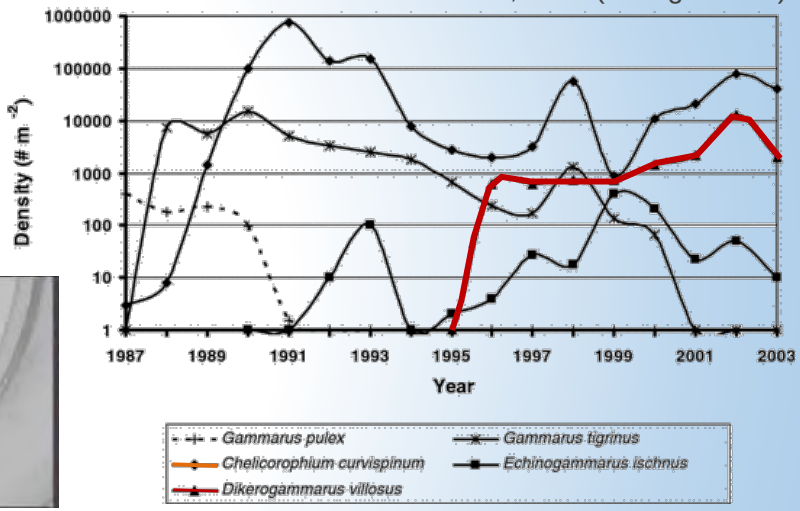


Why the Old Rhine River a case study ?

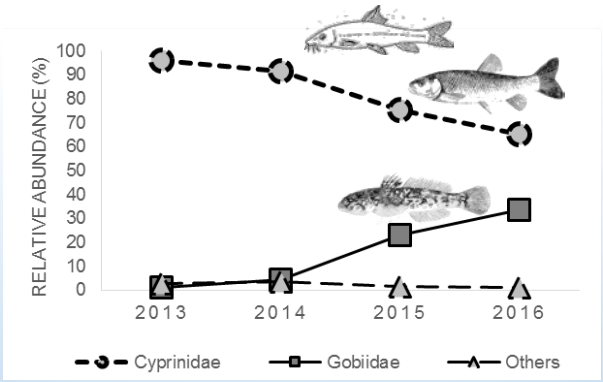
- **Rhine River: a global highway for dispersal of invasive species** (Leuven et al., 2009)

➢ **Long-established** invaders

Leuven et al., 2009 (Biological Inv.)



➢ **Newly installed** invaders



Staentzel et al., 2019 (in prep.)

Research questions

- How to assess **the success of a restoration action** (not directly focused to limit invaders) in an environment **constantly subject to new invaders**?

- What **are ecological impacts of invaders in restored areas** ? Can we **dissociate** effects ?

- Works based on the **ecological scale**

  1. **Landscape level**

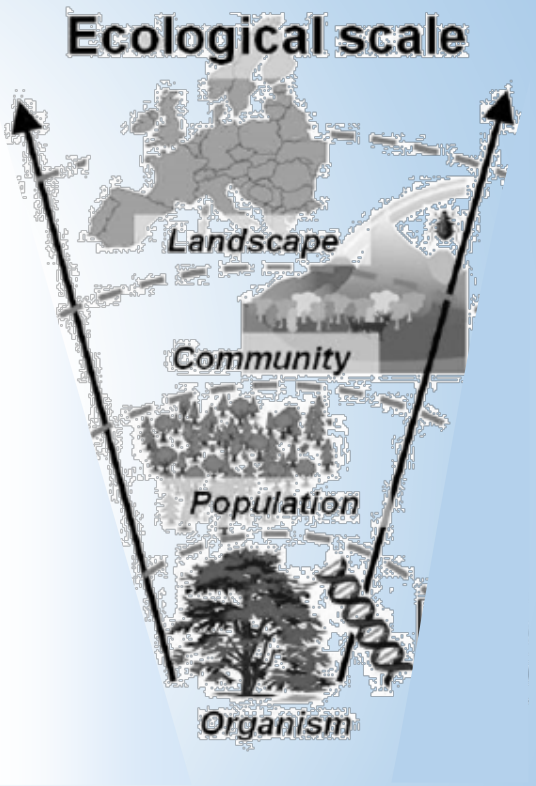
  ✓ Measure proliferation and identify changes in the landscape matrix

  2. Community level

  ✓ Place of the invader *vs* local communities

  3. Organism/species level

  ✓ Interspecific interactions and food-web network

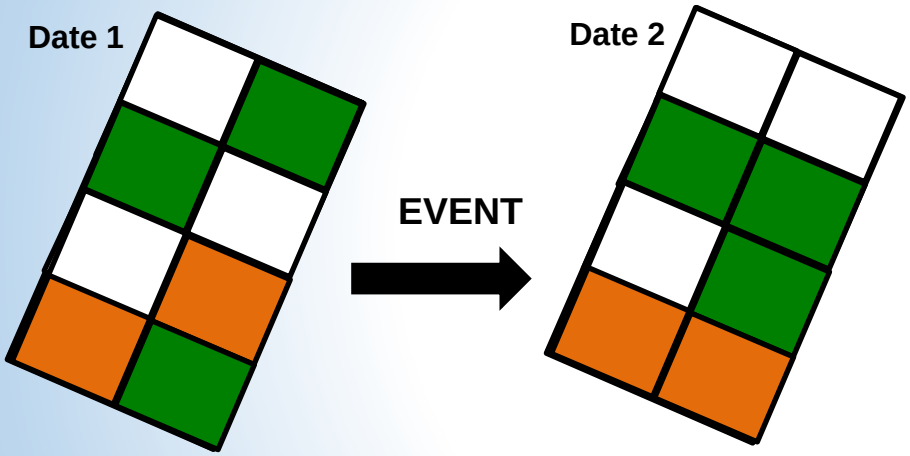


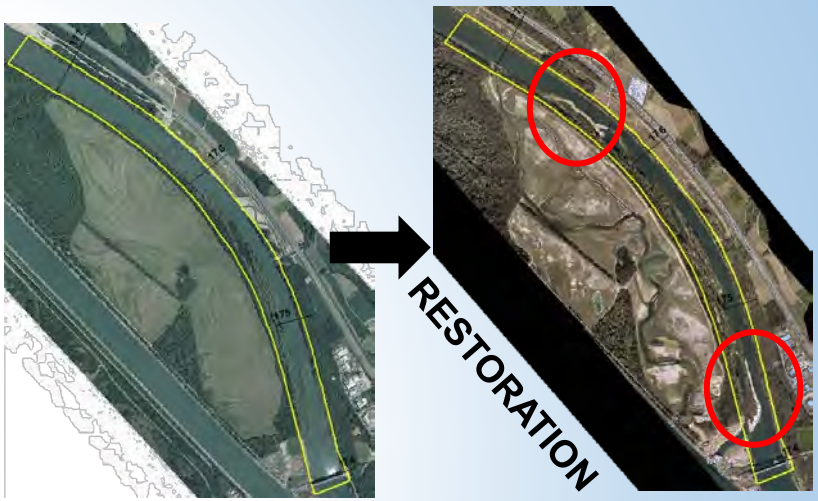
Villani et al., 2014 (Acta horticulturae)

Methods to assess restoration and invasion effects

1. Landscape level

- Using **vegetation mapping**





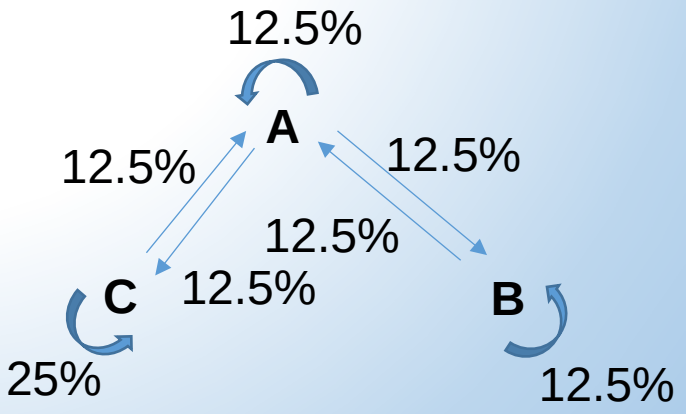
Habitat types

A
B
C

FROM (date 1)

	TO (date 2) A	B	C
A	1/8	1/8	0/8
B	1/8	1/8	1/8
C	0/8	1/8	2/8

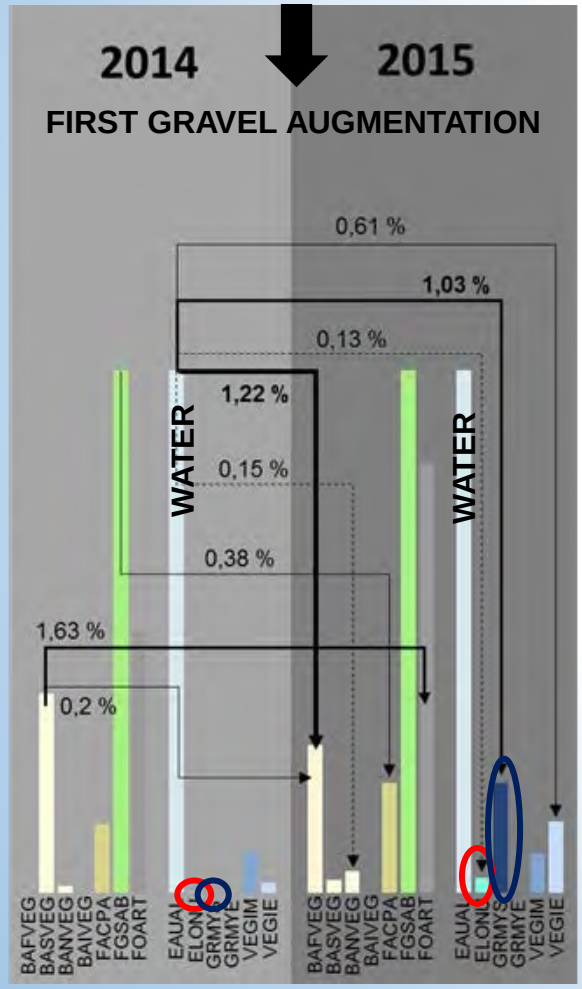
Transition diagram

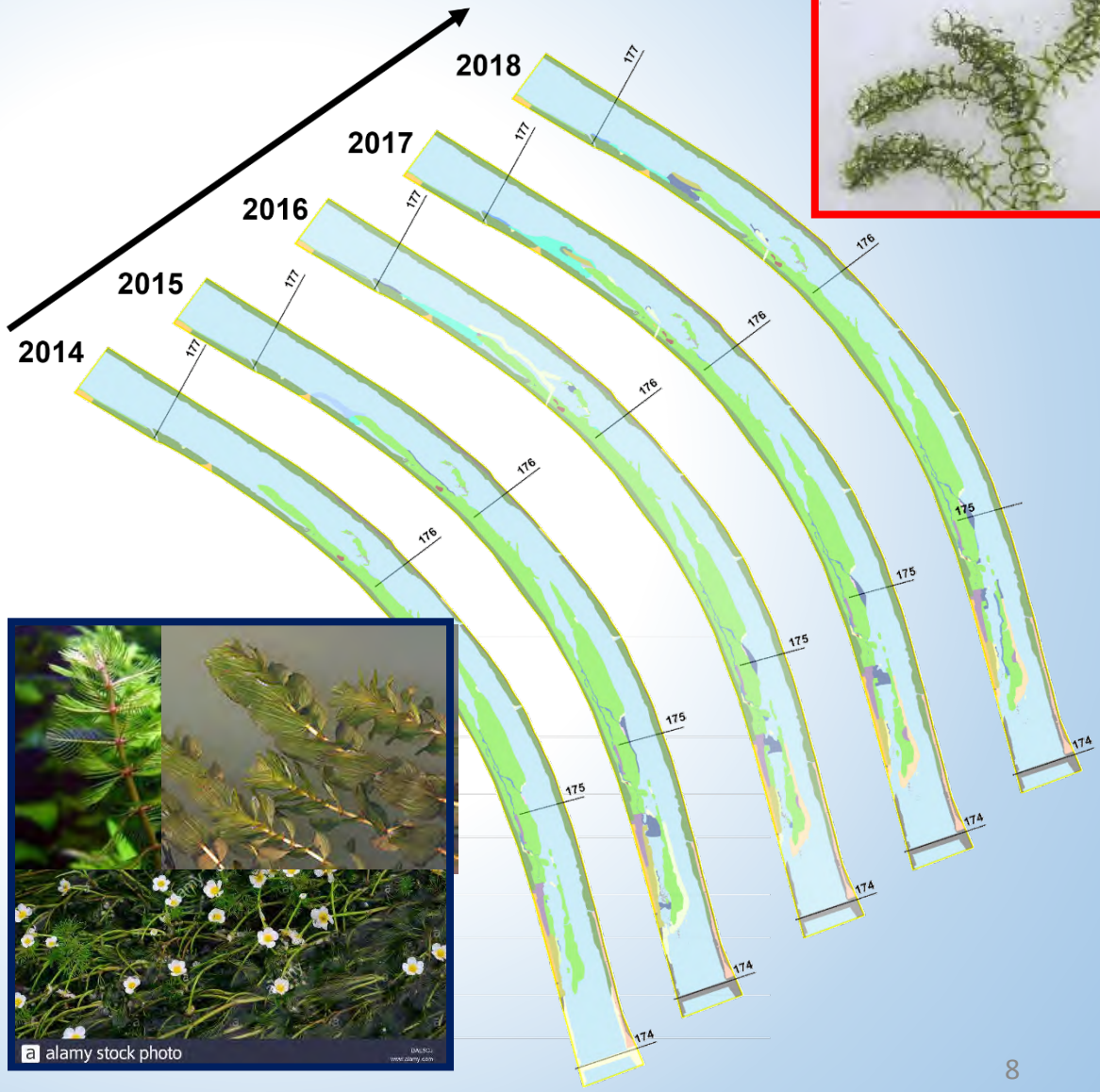


Staentzel et al., (2018) Ecological Indicators

Results

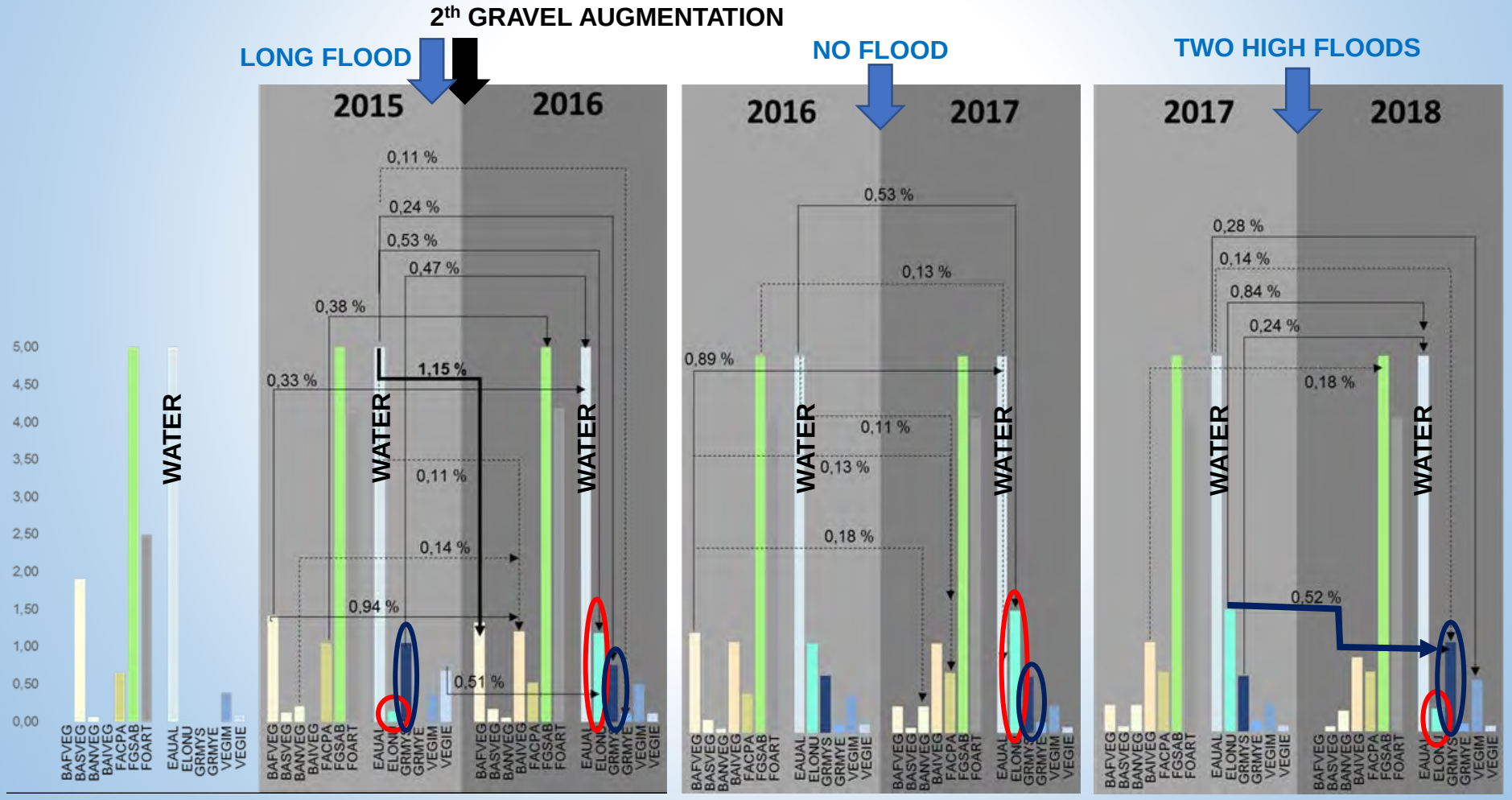
1. Landscape level





Results

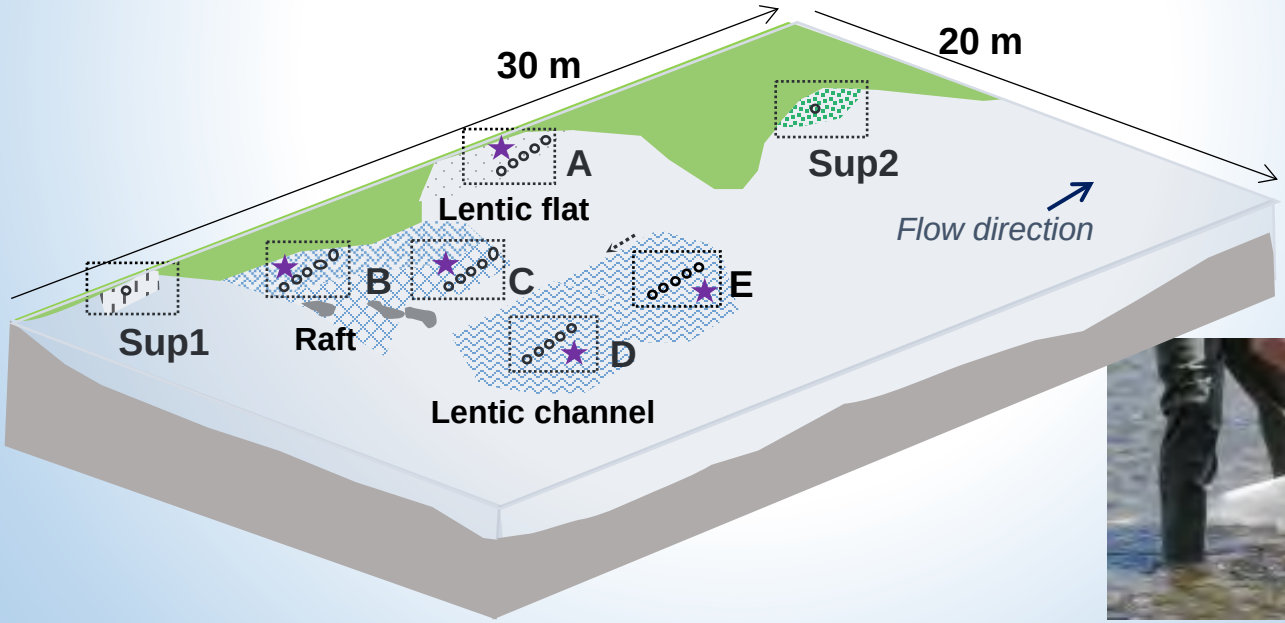
1. Landscape level



Methods to assess restoration and invasion effects

2. Community level

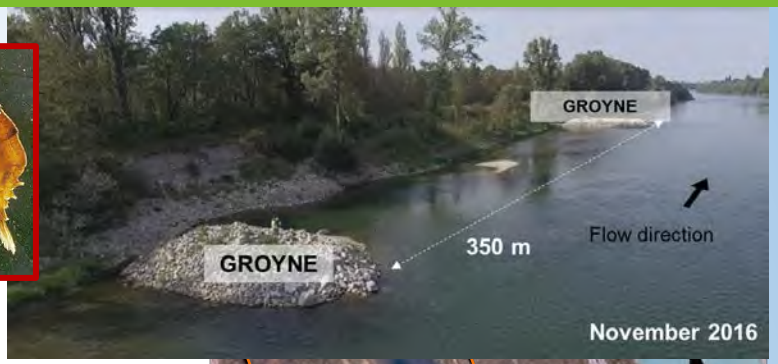
- **Macroinvertebrate sampling:** 4 or 5 samples (A, B, C and D) collected per site depending couples substrates/facies flow
- **Additional measures:** water depth, velocity, water quality and grain size



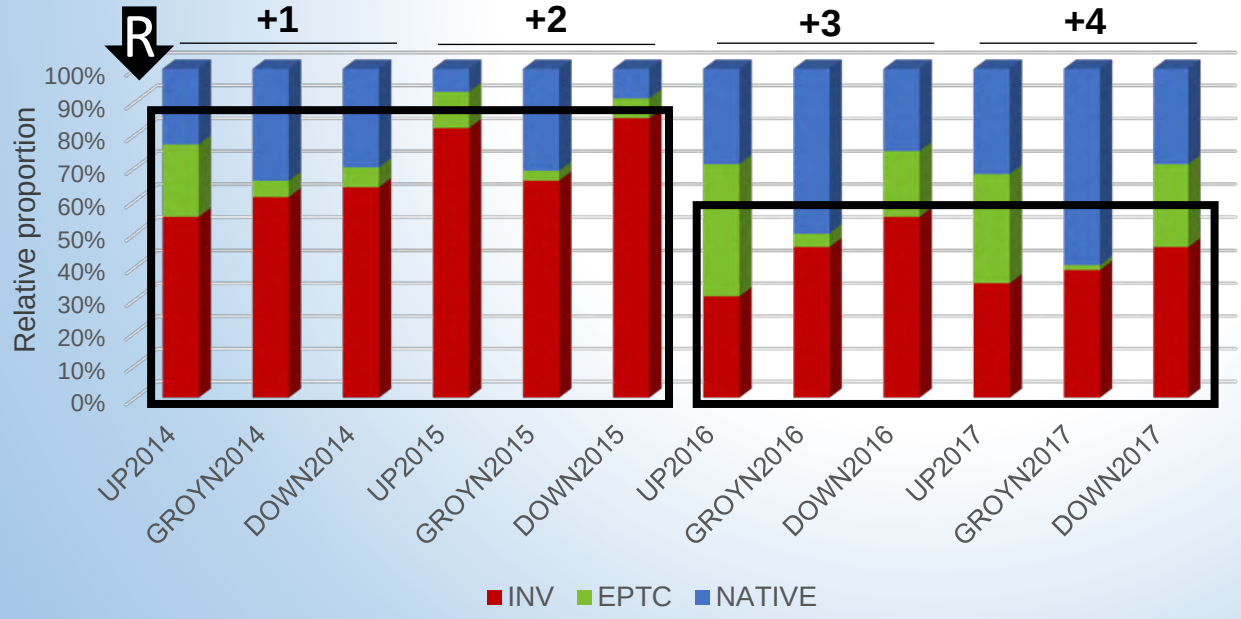
Staentzel *et al.*, 2019, Ecological Engineering

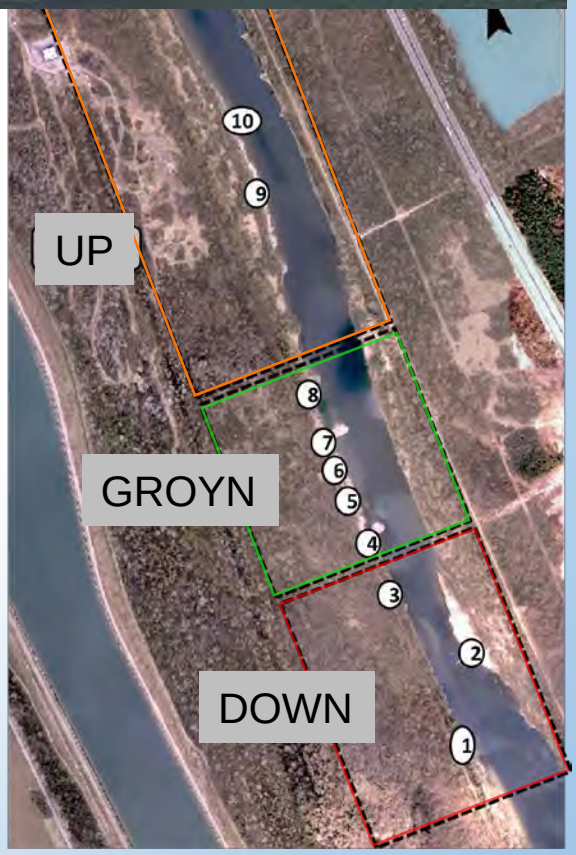
Results

2. Community level



- **High dominance** of invasive species few years after
- **Long-term restoration effect:** rise in **fine-substrate and macrophytes cover (between groynes)**, favoring Odonata.
- Creation of habitats **not suitable for main crustacean invaders**





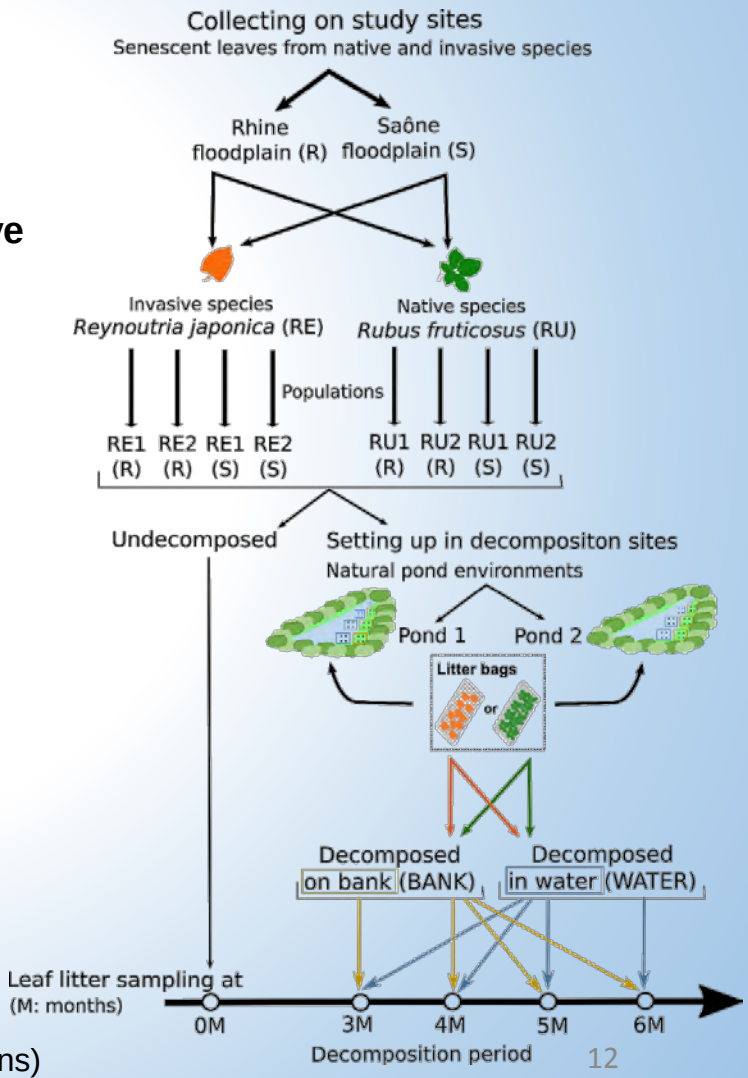
Staentzel *et al.*, 2019, Ecological Engineering

Methods to assess restoration and invasion effects

3. Species level

***Reynoutria japonica* Houtt., 1777**

- Ecological impact of **replacing native leaf litter with invasive leaf litter**
- **Using litter bags – Phytotoxicity tests** (Fuji *et al.*, 2004)
- **Along a decomposition time period**



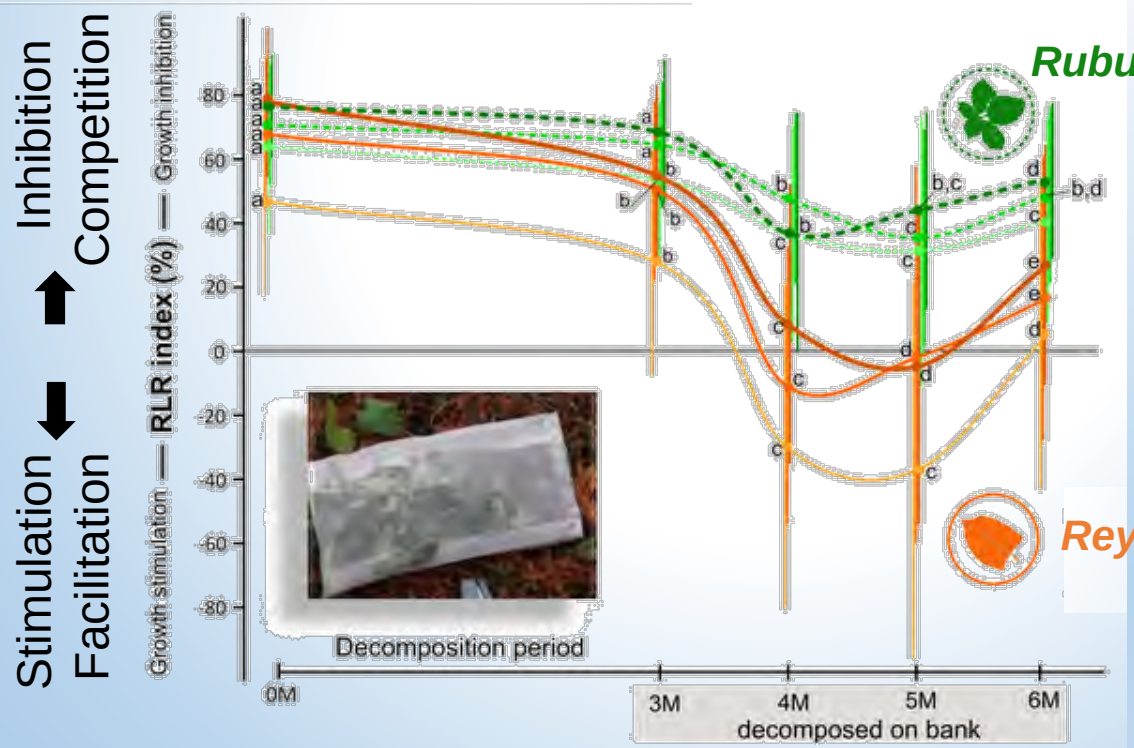
Staentzel *et al.*, 2018, in revision (Biological Invasions)

Results

3. Species level

***Reynoutria japonica* Houtt., 1777**

- Dissimilar effects of **competition-facilitation on riparian and aquatic communities**



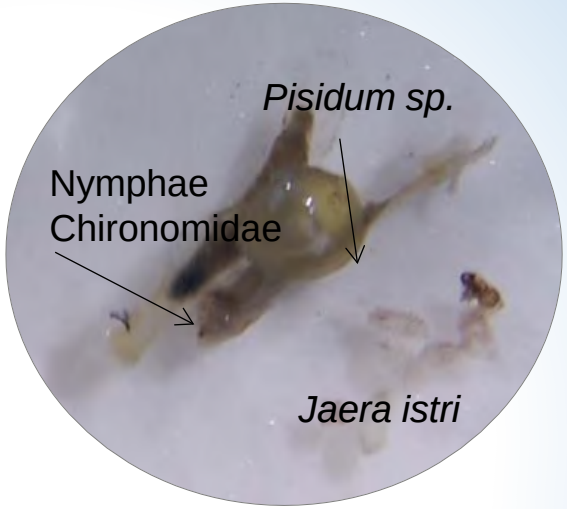
Staentzel *et al.*, 2018, in revision (Biological Invasions)

Methods to assess restoration and invasion effects

3. Species level

Neogobius melanostomus Houtt., 1777

- **Concomitant arrival with restoration actions**
- **Stomacal content** analysis (n=492)
- **+ Metabarcoding**
- **High increase on the whole site**
- **Low** abundance in the restored section – **increase of local fish communities**



	2013	2014	2015	2016	2017
UP	0 (0%)	16 (84.0%)	81 (55.8%)	202 (56.58%)	120 (42.85%)
RESTORED	0 (0%)	29 (4.0%)	240 (18.4%)	191 (20.82%)	234 (26.80%)
DOWN	1 (0.07%)	15 (1.5%)	77 (17.8%)	115 (47.13%)	174 (37.5%)
WHOLE SITE	1	60	398	508	528

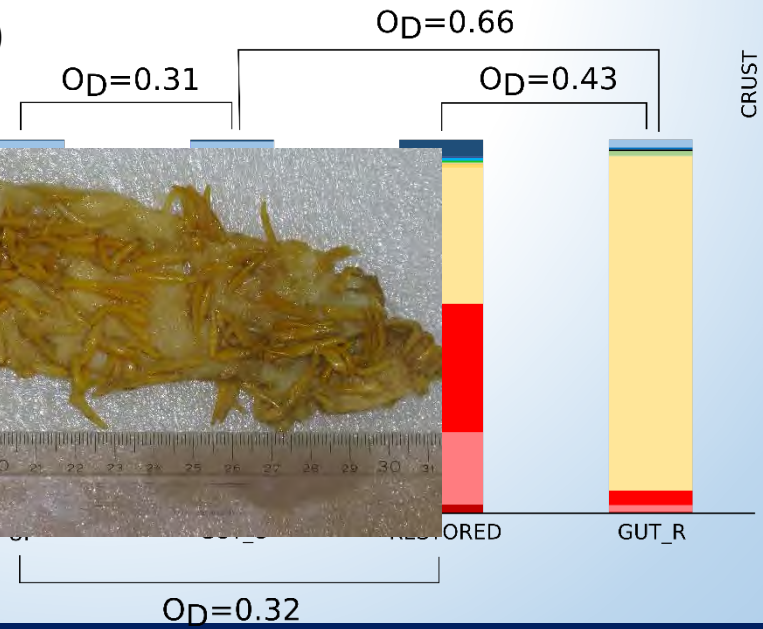
Staentzel *et al.*, 2019, in prep.

Results

3. Species level

***Neogobius melanostomus* Houtt., 1777**

- **High** predation on **low trophic** food-web species and **Ephemeroptera**, favored by restoration
- **Few pollution-sensitive taxa**
- **No Odonata, also favored by restoration**
- **No local fish predatory – Cannibalism (9%)**
- **Coming with an exotic parasite**



TRICHO: *Chematopsyche l.*, *Rhyacophila s.s.*, *Hydroptila o.*, Glossosomatidae, *Psychomyia p.*, *Hydropsyche* sp.
GAST: Hirudinea, Oligochaeta, *Potamopyrgus a.*, *Ancylus f.*
BIV: *Dreissena p.*, *Corbicula* sp.
EPHEM: *Caenis luctuosa*, *Ephemera* sp., *Baetis* sp.
DIPT: *Antocha vitripennis*, Empididae, Tipulidae, *Simulinii* sp., Tabanidae, Chironomidae
CRUST: *Dikerogammarus v.*, *Jaera istri*, *Echinogammarus i.*, *Limnius* sp., *Esolus* sp.

Staentzel *et al.*, 2019, in prep.

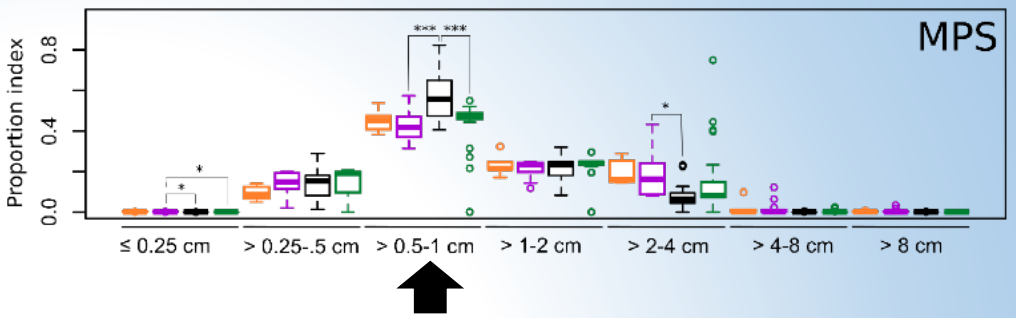
Results

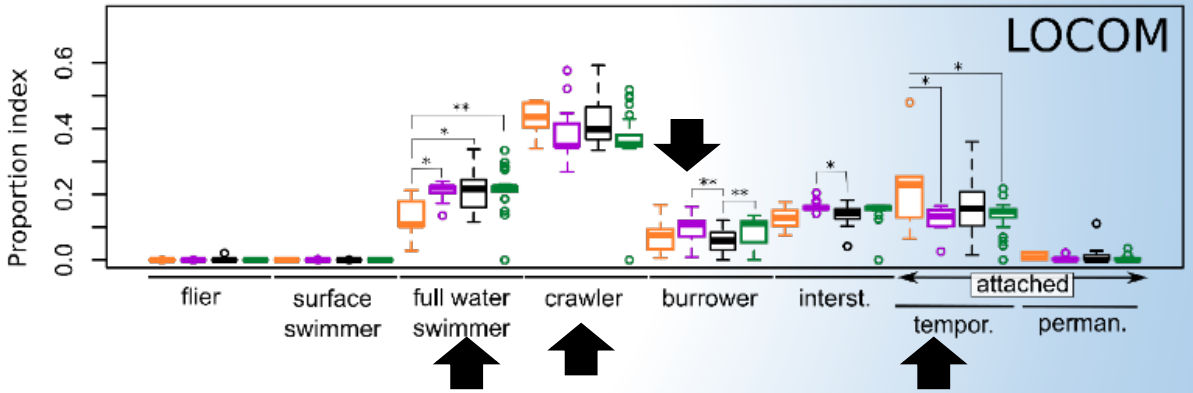
3. Species level

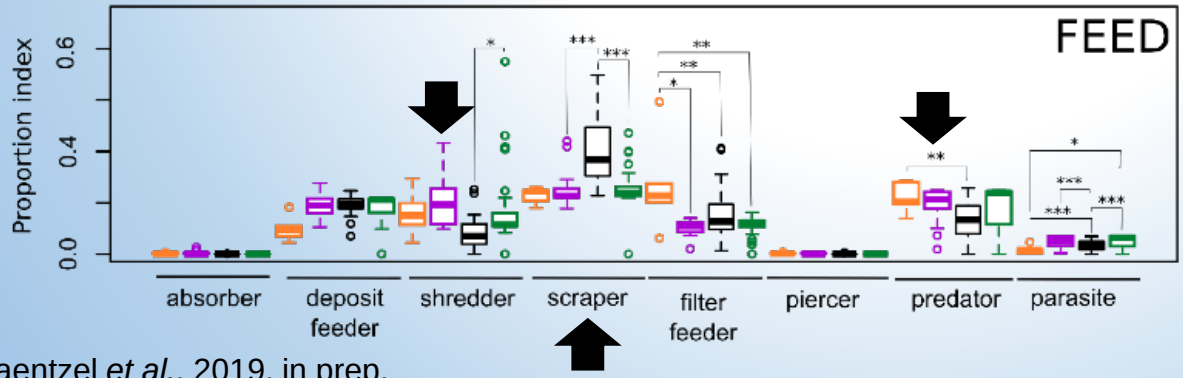
GTN FROM THE RESTORED SECTION

***Neogobius melanostomus* Houtt., 1777**

- **Functional traits of preys**
  - ➢ No-case Trichoptera
  - ➢ Preys attached to coarse particle
- **Opportunistic feeding strategy**







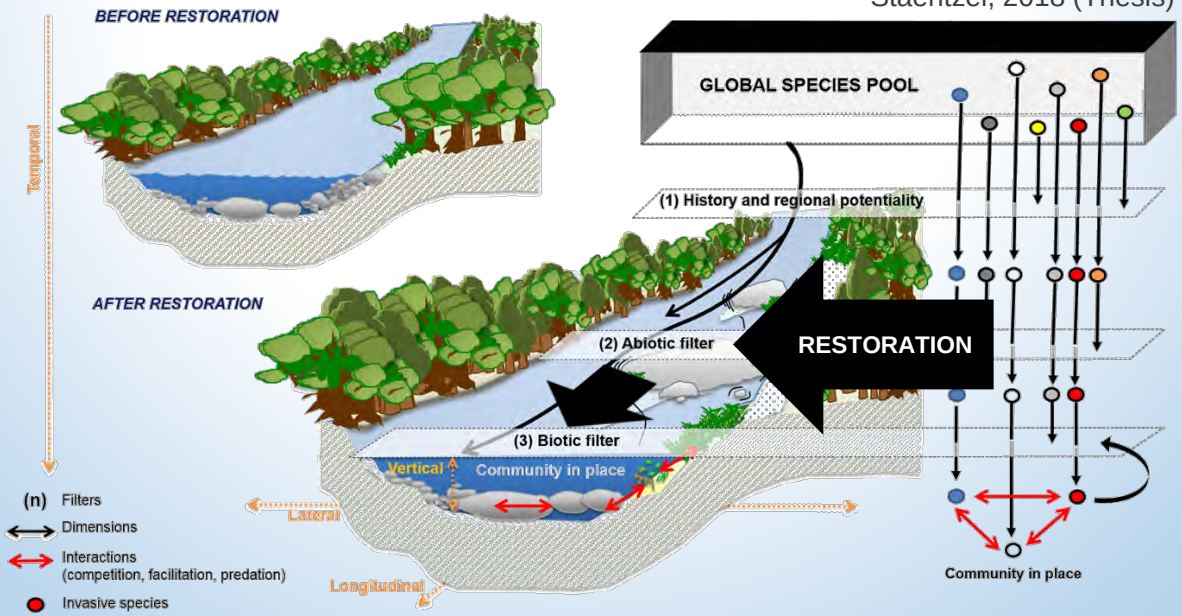
Staentzel *et al.*, 2019, in prep.

What do we learn?

- **Physical restoration actions**: increase **the permeability of the abiotic filter**
- **Short-term: Diversify** habitats > **Opening areas** > **Invader settlement** (high abundance)
- Changes in food web but **also in interspecific interactions** – not only competition but **facilitation**

- **Not as much as expected + Long-term: decrease in abundance of some invaders**
- Biological responses are **context- and environment-dependent (flood)**

Staentzel, 2018 (Thesis)



Working on …

- Studies in progress in river restoration framework

Landscape level

- ✓ Integrate **context- and environment-dependence**
- ✓ Predict **proliferation and hotspots**

Community and species level

- ✓ Physical changes in restoration context: what **functional traits** are favored?
- ✓ **Interspecific** interactions **(competition, facilitation, predation)**
- ✓ ***D.villosus* nursery** – increase in restored areas ?
- ✓ Focusing on **biotic resistance**: Setting up local communities to limit invaders

Transplantations ➡

Working on challenges

- INVASIONS x RESTORATION ACTIONS
- INVASIONS x RESTORATION ACTIONS x CLIMATE CHANGE
- INVASIONS x RESTORATION ACTIONS x CLIMATE CHANGE x POLLUTIONS
- …

MULTIPLE STRESSORS – CHARACTERIZE EFFECTS? PREDICT?

Community level

Landscape level

+ Species level coming (Biological invasions)

Thank you for listening !

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Any comments or questions ?