

A thesis by
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Directed by
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**WHEN THE RIVERS RUN DRY:
EFFECTS ON INVERTEBRATE
COMMUNITIES AND THE DYNAMIC
OF PARTICULATE ORGANIC MATTER**

**Defended on
April 19th 2013**



Irstea, UR-MALY, DYNAM Team

Doctoral school E2M2

HYNES (Irstea-EDF)



Agenda of the presentation



— Generalities, conceptual framework and objectives



— Sampling sites and techniques



— Terrestrial invertebrate communities



— Particulate organic matter decomposition



— A rewetting event



— Synthesis, discussion and perspectives



Generalities, conceptual framework & Objectives

The ecotone concept and aquatic-
terrestrial transitions

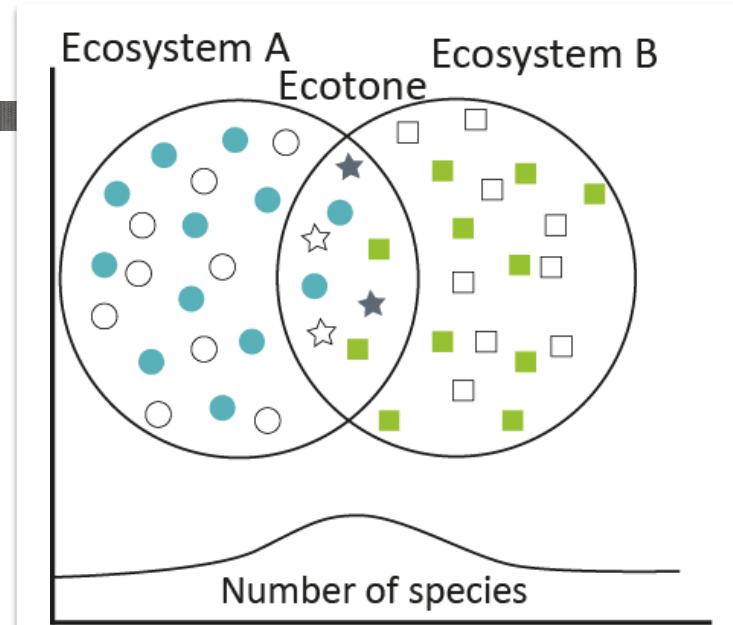
The concept of **ecotone**

A **transition zone** between two ecosystems



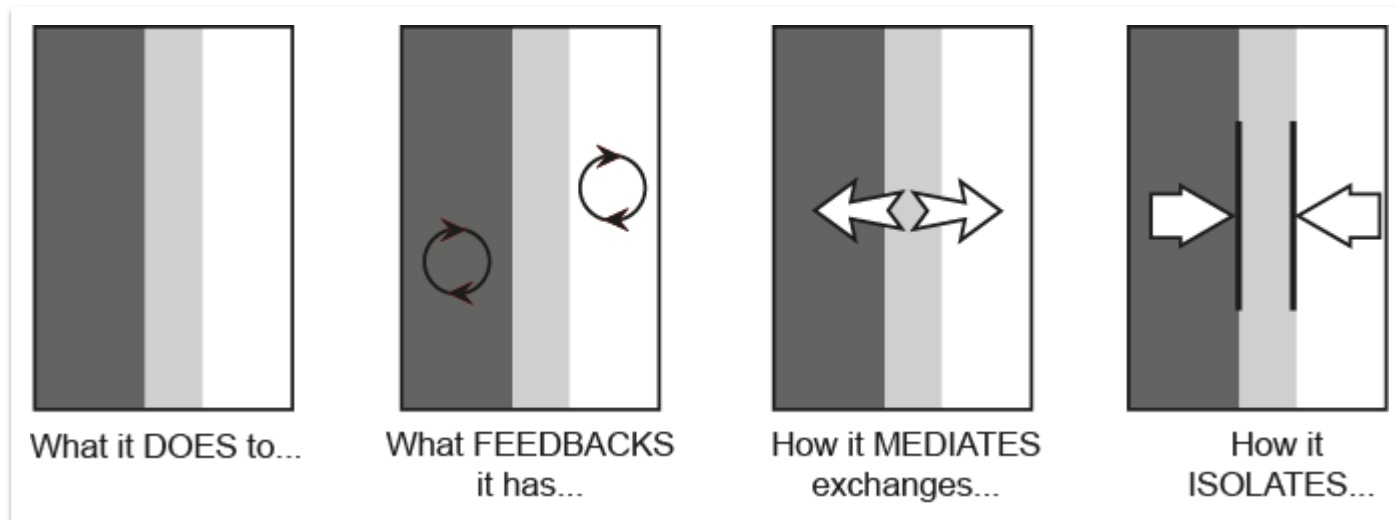
The concept of **ecotone**

Edge effect : an ecotone harbors species from the adjacent ecosystems and species specific to the transition zone



From Barnes, 1974

Four main **functions** of an ecotone

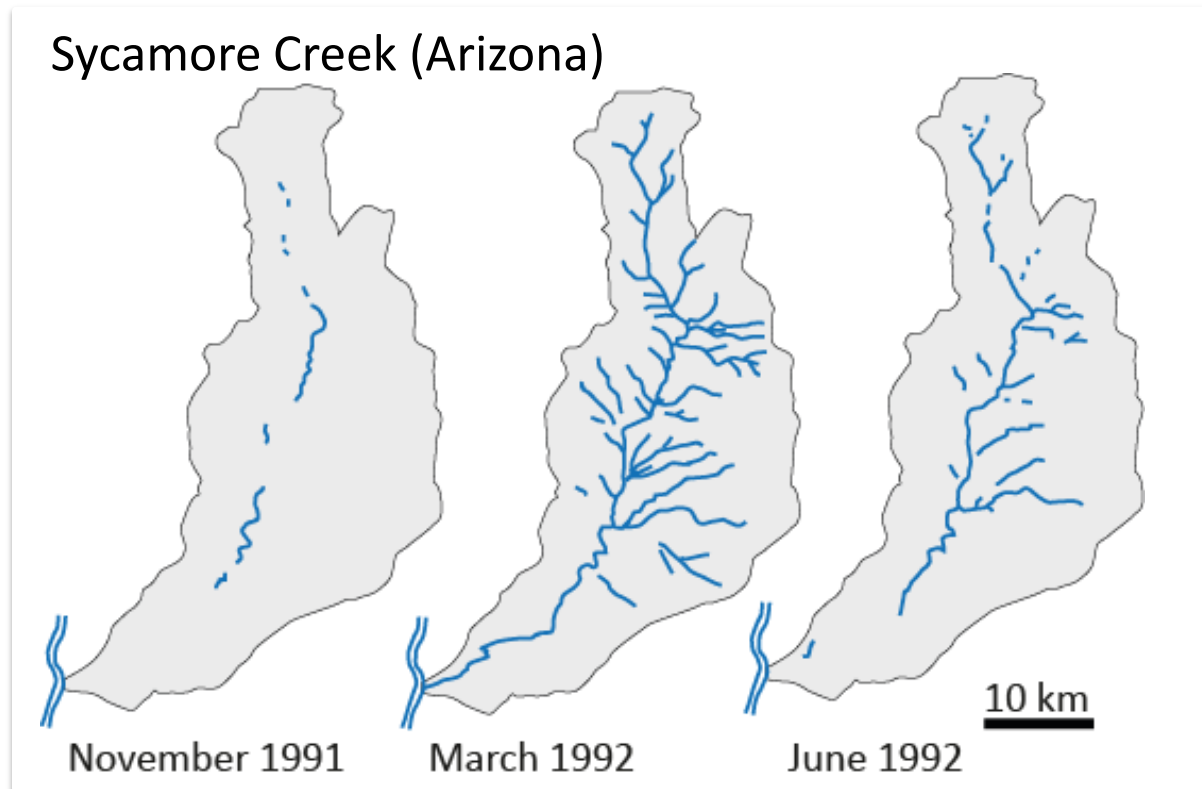


From Kolasa & Zalewski, 1995

Aquatic-terrestrial transitions

Rivers are dynamic ecosystems with **contraction and expansion** cycles

Habitats alternate between terrestrial and aquatic conditions

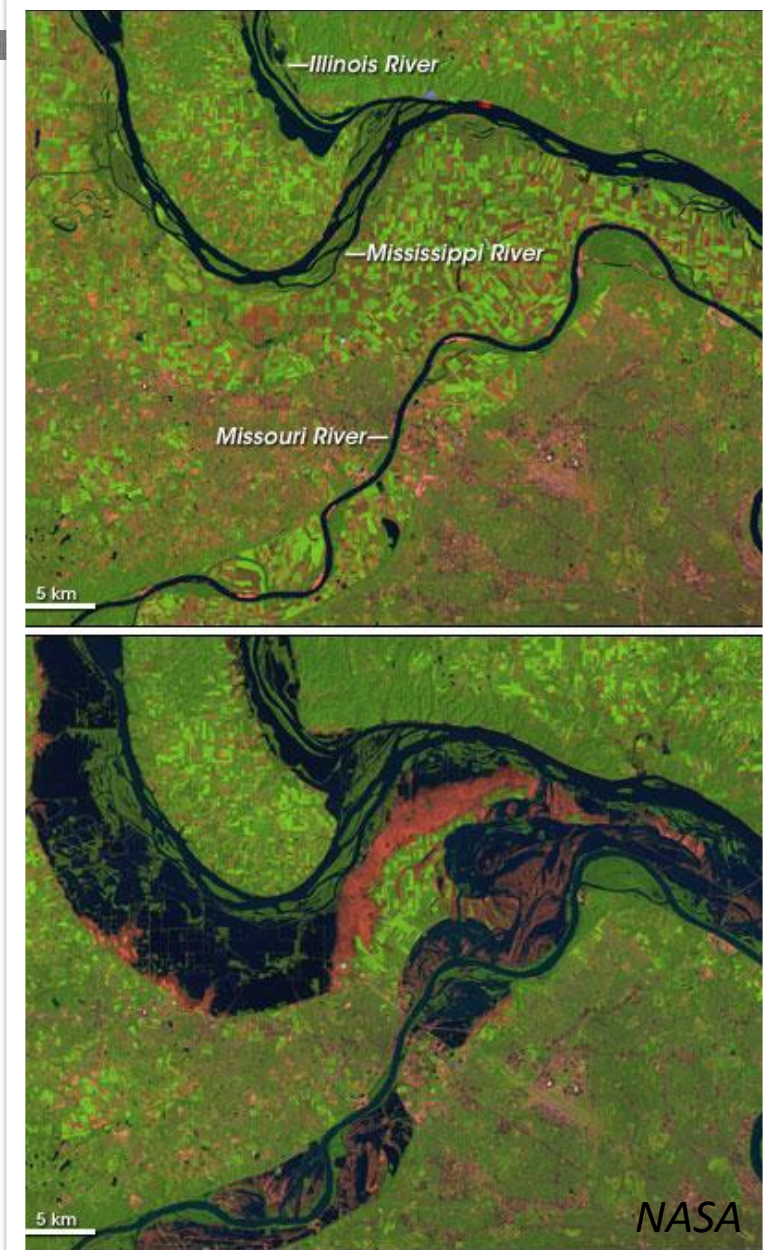


From Stanley et al., 1997

The flood pulse concept (FPC)

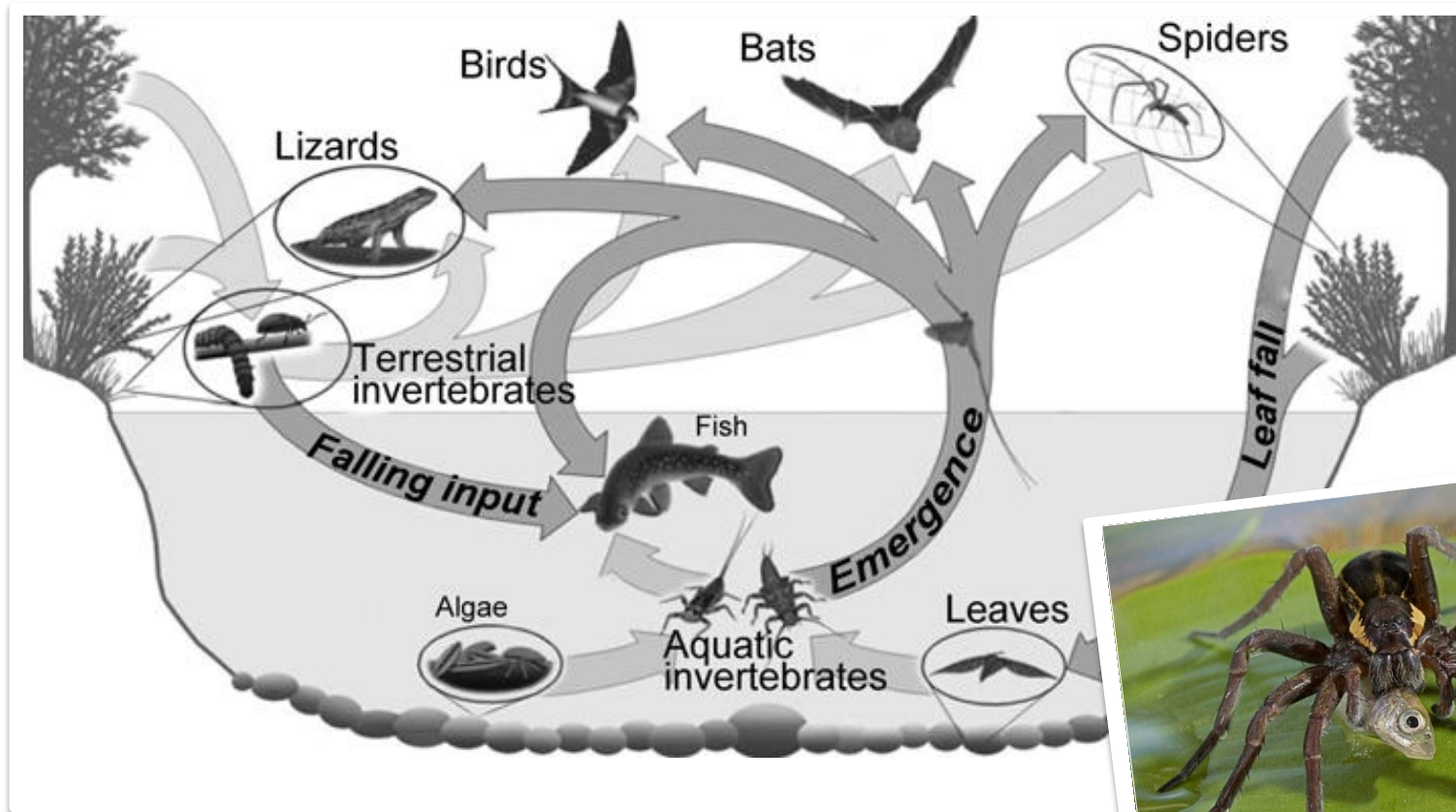
The FPC (Junk et al. 1989) models the **interactions** between aquatic and terrestrial ecosystems in the transition zone

→ Aquatic and terrestrial species use the same habitats at different times



Aquatic-terrestrial interactions

Aquatic and terrestrial **food webs** are interdependent



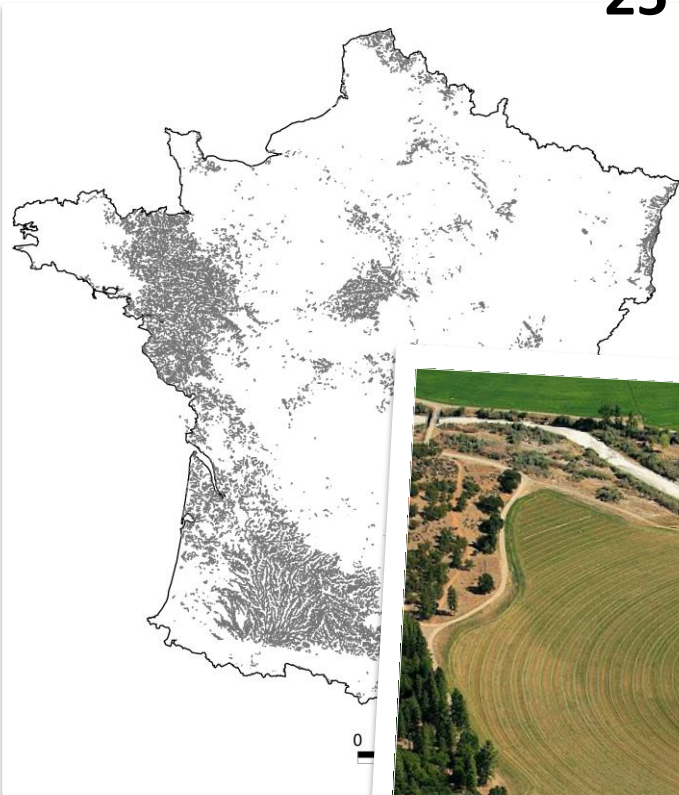
Baxter et al., 2005

Temporary rivers

Widespread and abundant ecosystems

25 to 40% of French rivers are temporary

Increasing tendency



Snelder et al., 2013

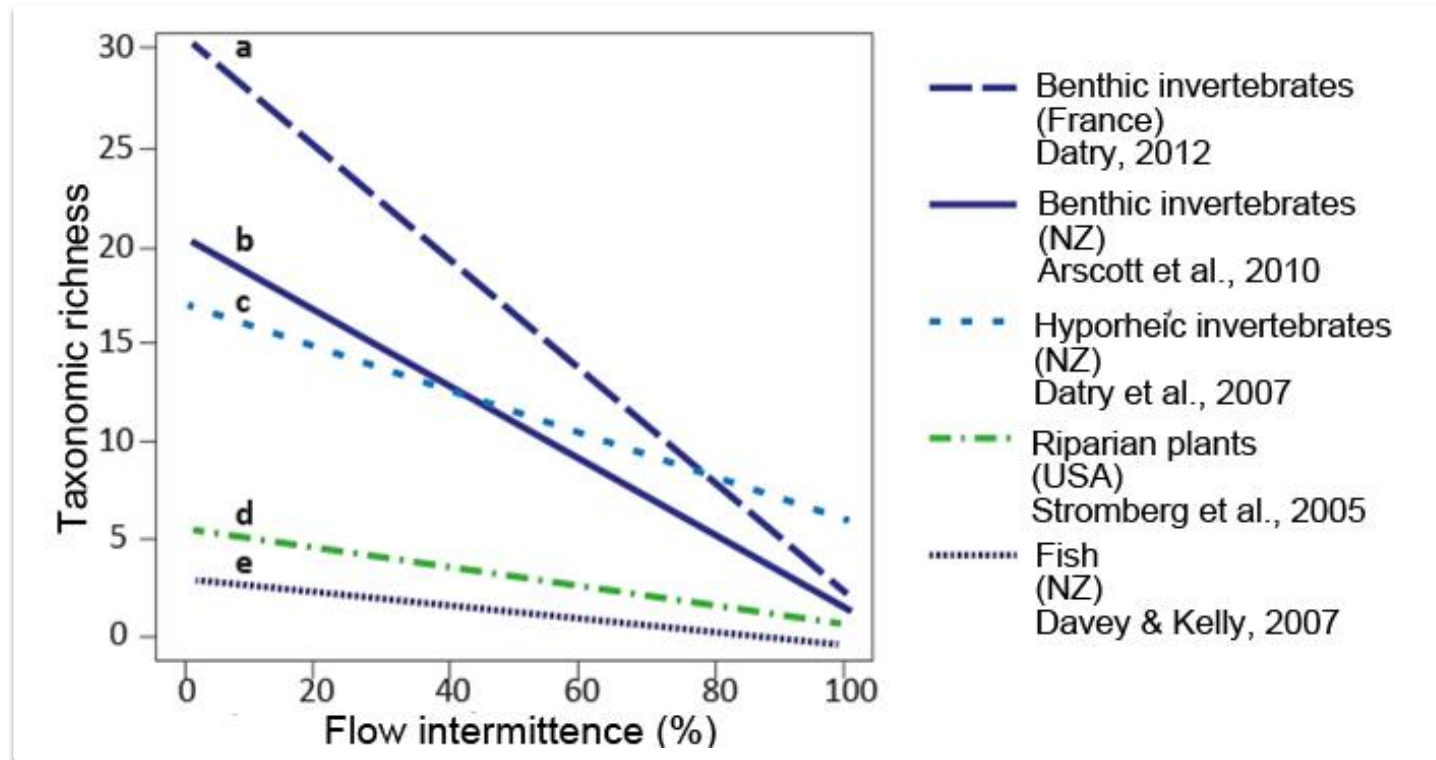


A shifting habitat mosaic



Aquatic biodiversity in temporary rivers

Flow intermittence – biodiversity relationships



Datry et al., submitted

Communities in temporary rivers are **nested subsets** of those in perennial rivers

Terrestrial biodiversity in temporary rivers

Dry riverbeds have been neglected by aquatic and terrestrial ecologists

Lack of standardized and tested sampling methods

Riparian zones are sources of colonists

Dry riverbeds are harsh habitats

➡ **Different ecological successions?**

Riparian invertebrates depend on **water resource and aquatic preys**

➡ What is the effect of river drying on riparian invertebrates ?



Decomposition of particulate organic matter

Transport, storage and decomposition of organic matter are fundamental processes in rivers



Decomposition through the action of shredders and micro-organisms



Current models and concepts do not apply to temporary rivers

→ Discontinuities

Key objectives

Terrestrial

invertebrates

1. Compare 2 common sampling methods for collecting terrestrial invertebrates in dry riverbeds
2. Characterize terrestrial invertebrate communities in dry riverbeds
3. Specify the effect of river drying on riparian invertebrate communities

Organic

matter

4. Address the role of drying events on the decomposition of particulate organic matter

Transition

periods

5. Characterize the fluxes of invertebrates and organic matter in an advancing wetted front

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1

Generalities, conceptual framework and objectives

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Sampling sites and techniques

3

Terrestrial invertebrates communities

4

Particulate organic matter decomposition

5

A rewetting event

6

Synthesis, discussion and perspectives

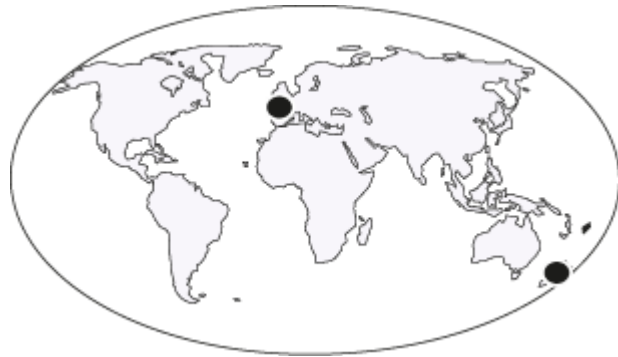


Methods

Sampling sites & techniques

A **multi-site** and **comparative**
approach

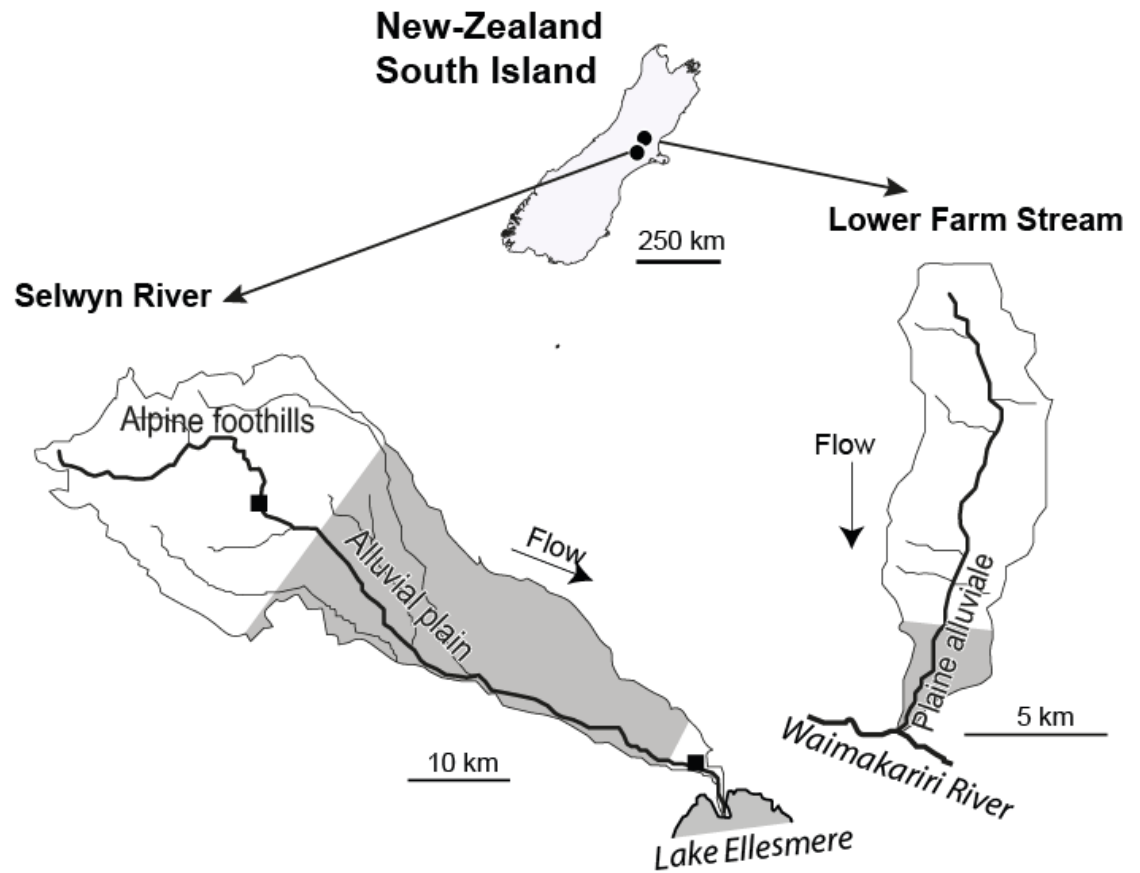
Studied sites



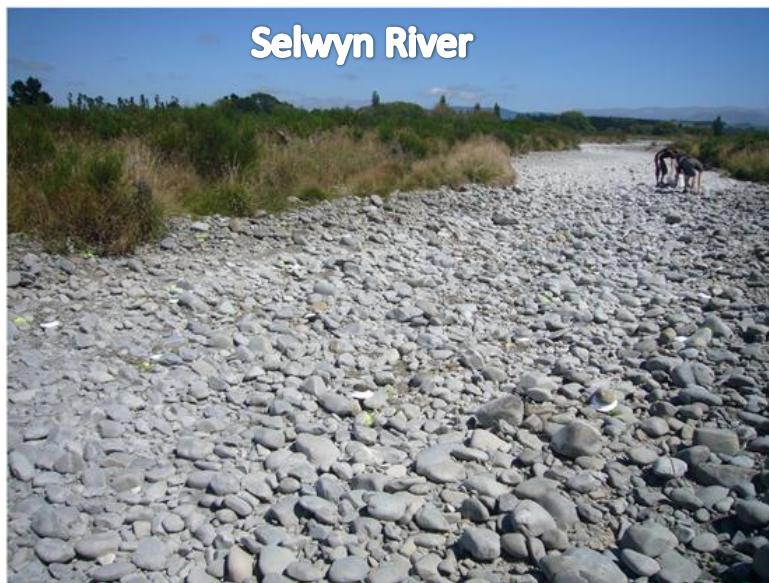
4 gravel-bed temporary rivers in contrasted climates of **France** and **New-Zealand**



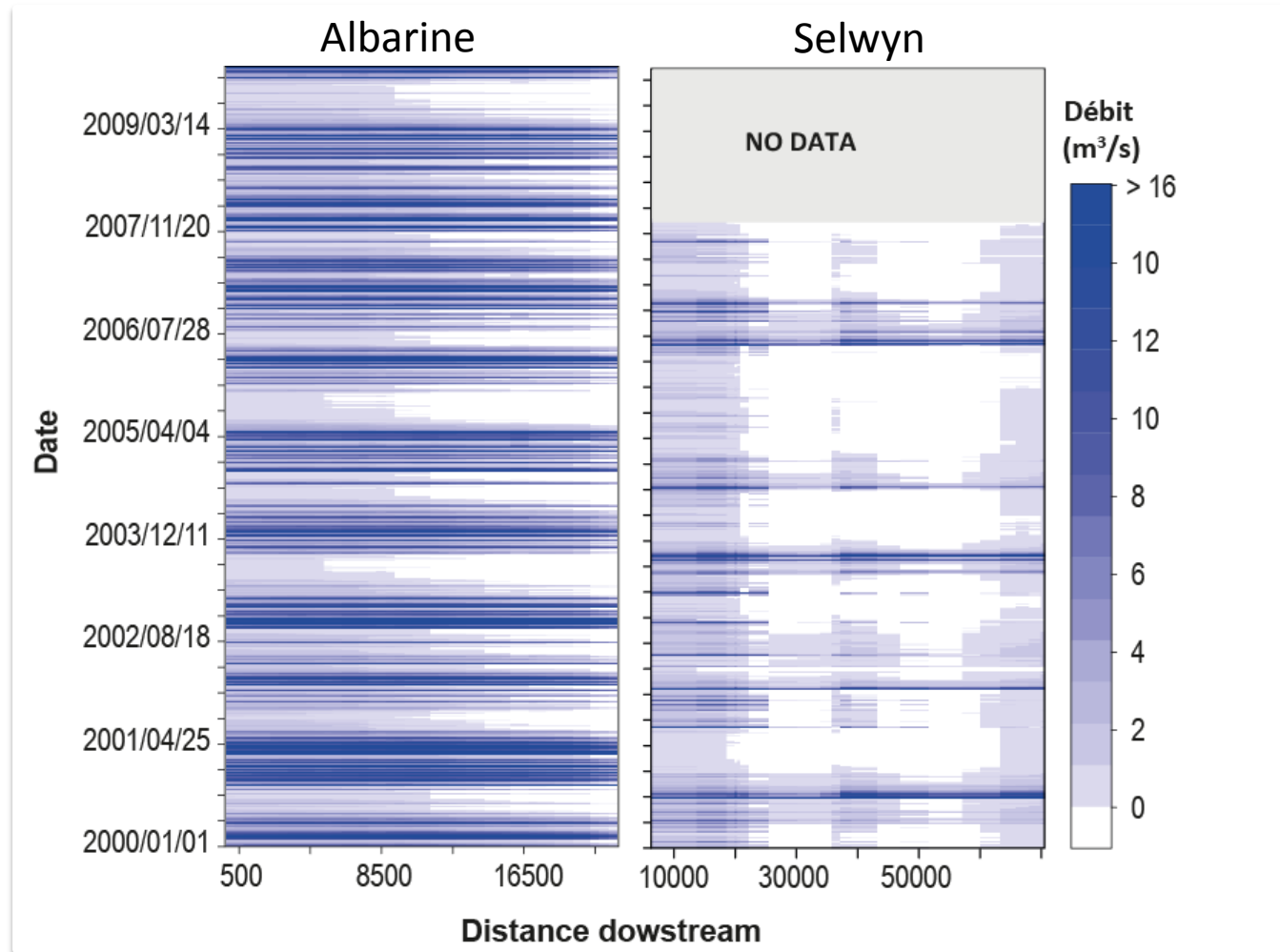
- Perennial section
- Temporary section
- Flow recorder



Studied sites



Hydrological characteristics



Larned et al., 2011

Contrasted patterns and longitudinal **gradients** in flow intermittence

Sampling techniques

2 sampling techniques for **terrestrial invertebrates**



1 sampling technique for the **decomposition of organic matter**



1 sampling technique for invertebrates and organic matter in **transitional habitats**



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— Synthesis, discussion and perspectives



Terrestrial invertebrate communities in temporary rivers



Comparison of pitfall-trap and quadrat methods



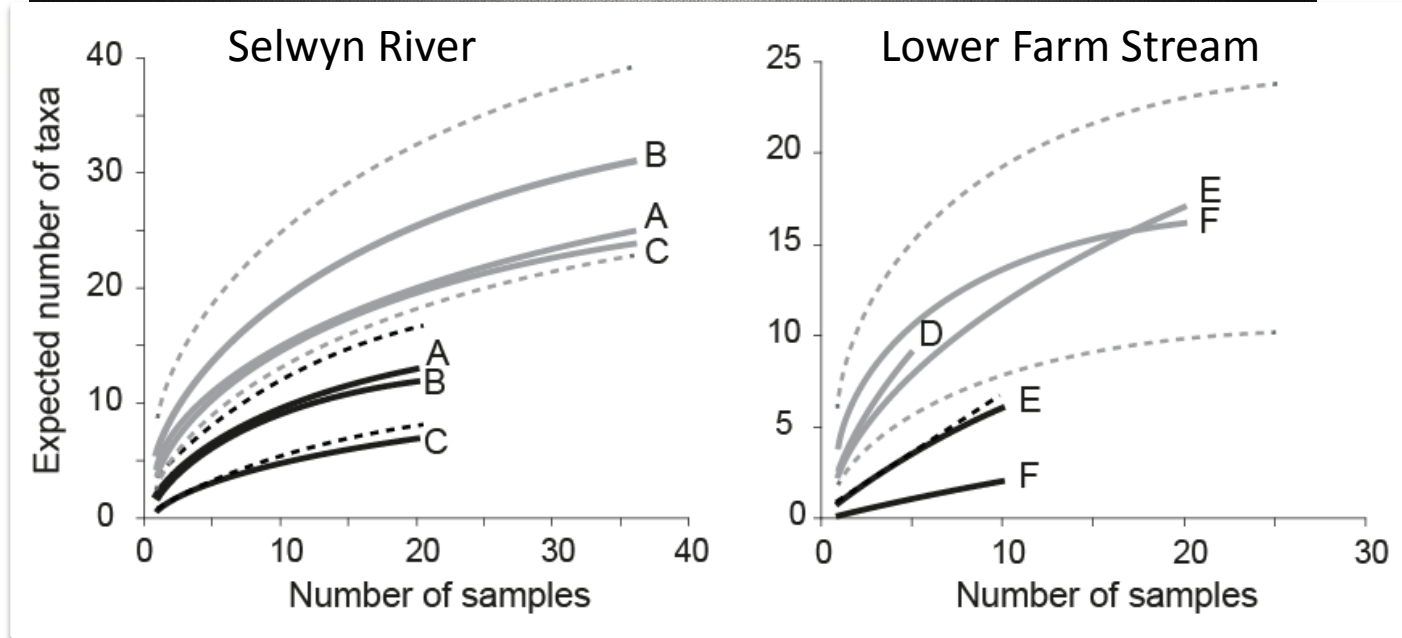
Colonization of dry riverbeds



River drying and riparian invertebrate communities

3.1

Pitfall-trap and quadrat methods



Corti et al., in revision, Hydrobiologia

Pitfall traps accumulated **more taxa** than quadrats and **more rapidly**

Communities in quadrats were **subsets** of those in pitfall traps

Pitfall trapping is the most efficient method

8 to 11 pitfall-traps / 100 m² = 80% of the taxonomic richness



Terrestrial invertebrate communities in temporary rivers



Comparison of pitfall-trap and quadrat methods



Colonization of dry riverbeds

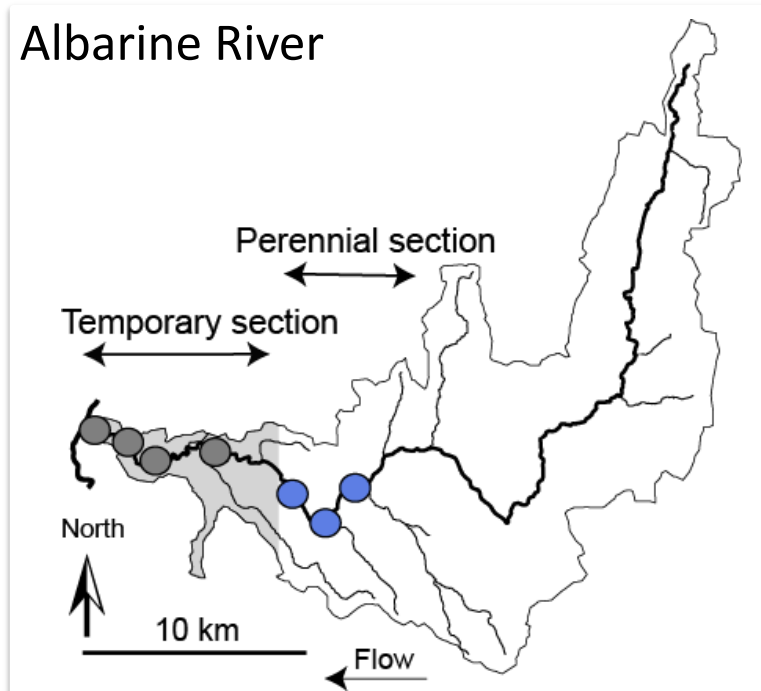


River drying and riparian invertebrate communities

Albarine

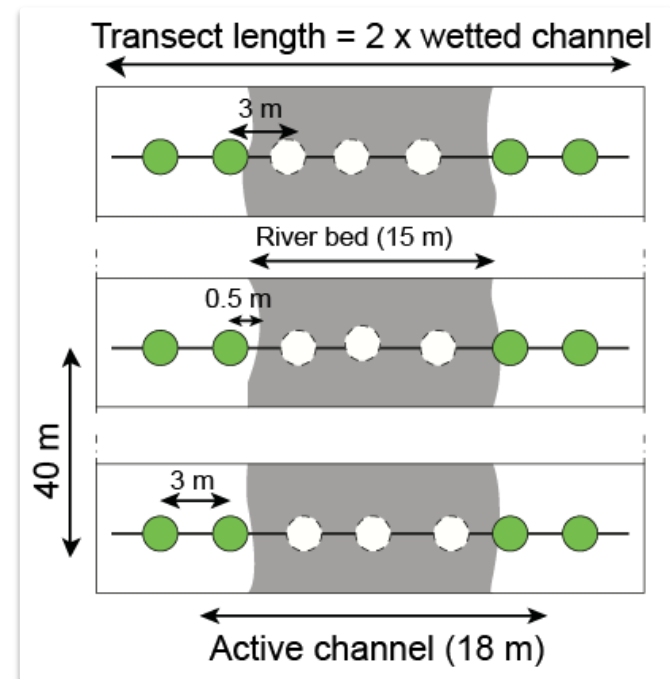
- 4 temporary sites
- 3 perennial sites
- 3 transects / site
- 7 pitfall traps / transect
- 2 sampling dates before the dry period
- 2 sampling dates during the dry period

Albarine River



Asse

- 1 temporary site
- 7 transects / site
- 6 to 7 pitfall traps / transect
- 3 sampling dates before the dry period
- 2 sampling dates during the dry period



Most of Coleoptera, Araneae and Formicidae were identified to species or genus level

Other taxa were identified to family, order or class

All arthropods were assigned to feeding guilds (predators, herbivores, and detritivores)

Araneae, Carabidae and Formicidae species were characterized according to their moisture preferences (Hygrophilous species)

Data from temporary sites of the Albarine and Asse rivers

298 taxa: 241 taxa in the Albarine River and 84 in the Asse River

Most abundant taxa

Albarine

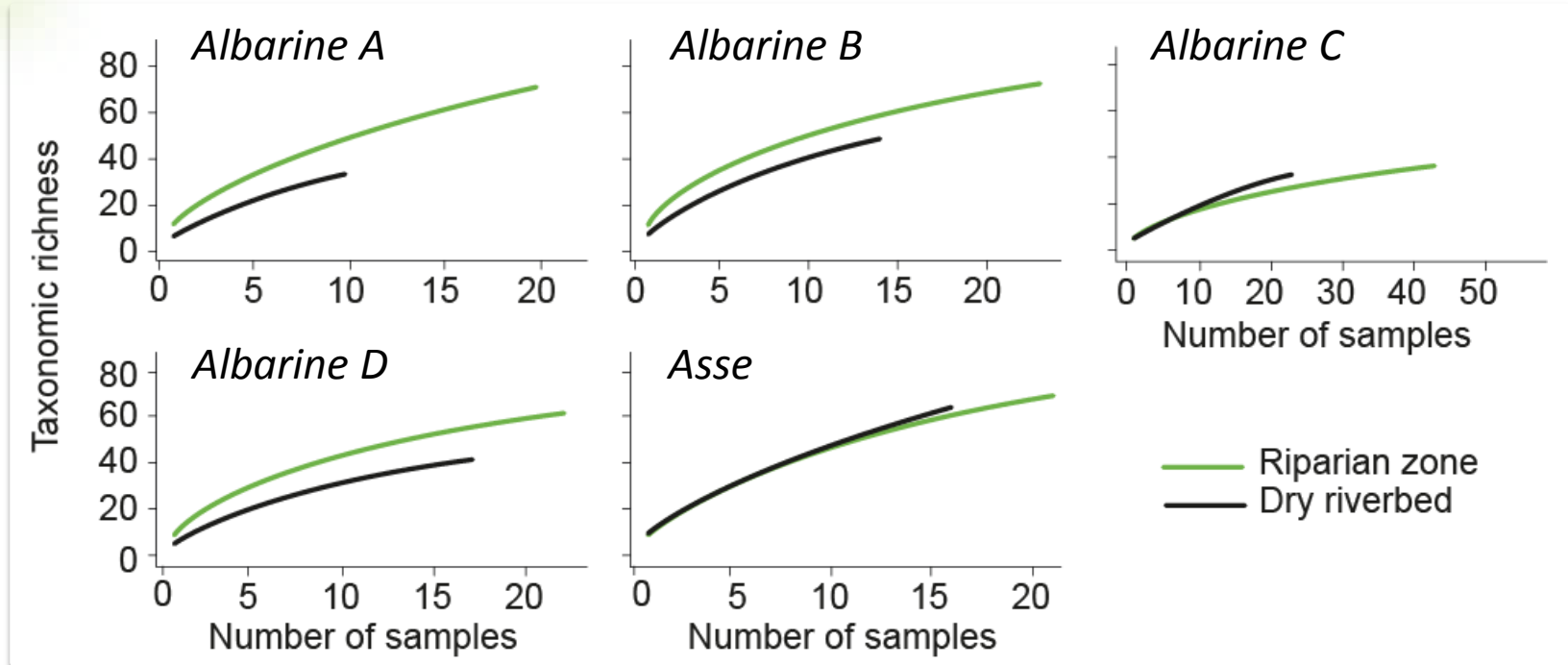
Oniscidae, Aleocharinae
(*Staphylinidae*), *Myrmica rubra*
(*Formicidae*), *Opiliones*

Asse

Labidura riparia (*Dermaptera*),
Pardosa wagleri (*Araneae*),
Formica selisy (*Formicidae*),



Riparian zones vs dry riverbeds



Corti et al., in prep

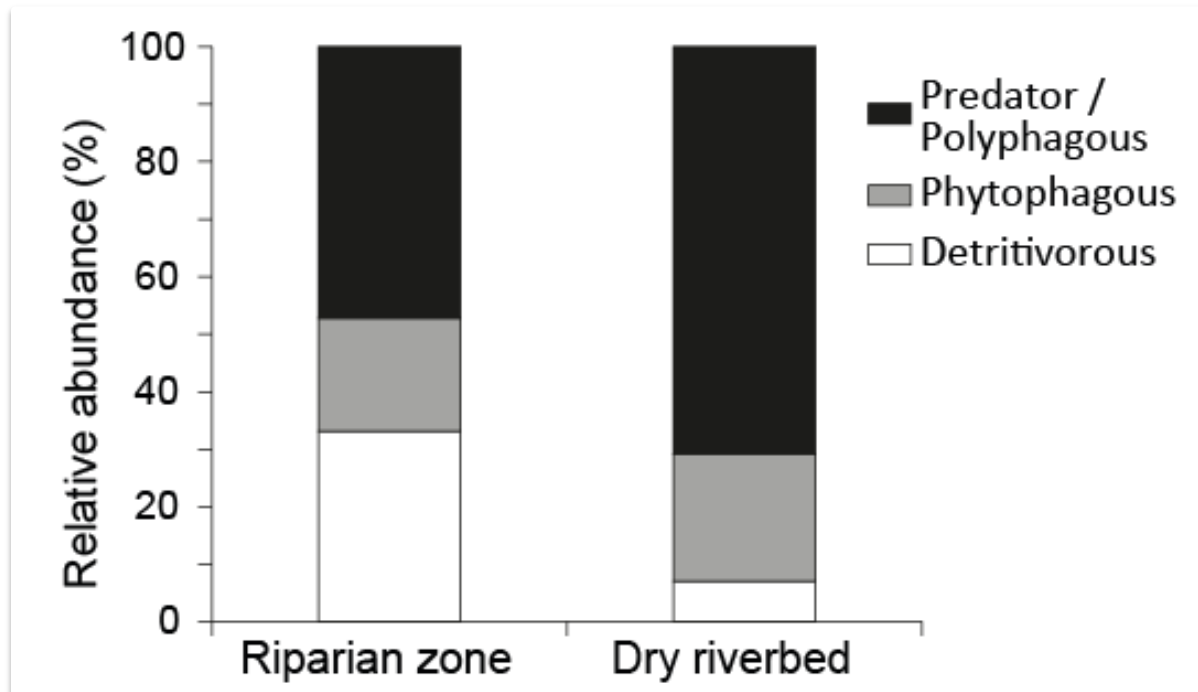
Higher taxonomic richness in riparian zones compared to dry riverbeds in the Albarine River

Consistent patterns in sites and rivers

Riparian zones vs dry riverbeds

Dry riverbed communities were **subsets** of those in riparian zone (Adonis, $R^2 < 0.1$, $p < 0.05$ for all sites)

➔ Dry riverbeds did not harbor particular communities



More predators in dry riverbeds

Colonization of dry riverbeds

The colonization of dry riverbeds likely follows a **source-sink dynamic** with density-dependence mechanisms

Absence of **ecological successions**





Terrestrial invertebrate communities in temporary rivers



Comparison of pitfall-trap and quadrat methods



Colonization of dry riverbeds

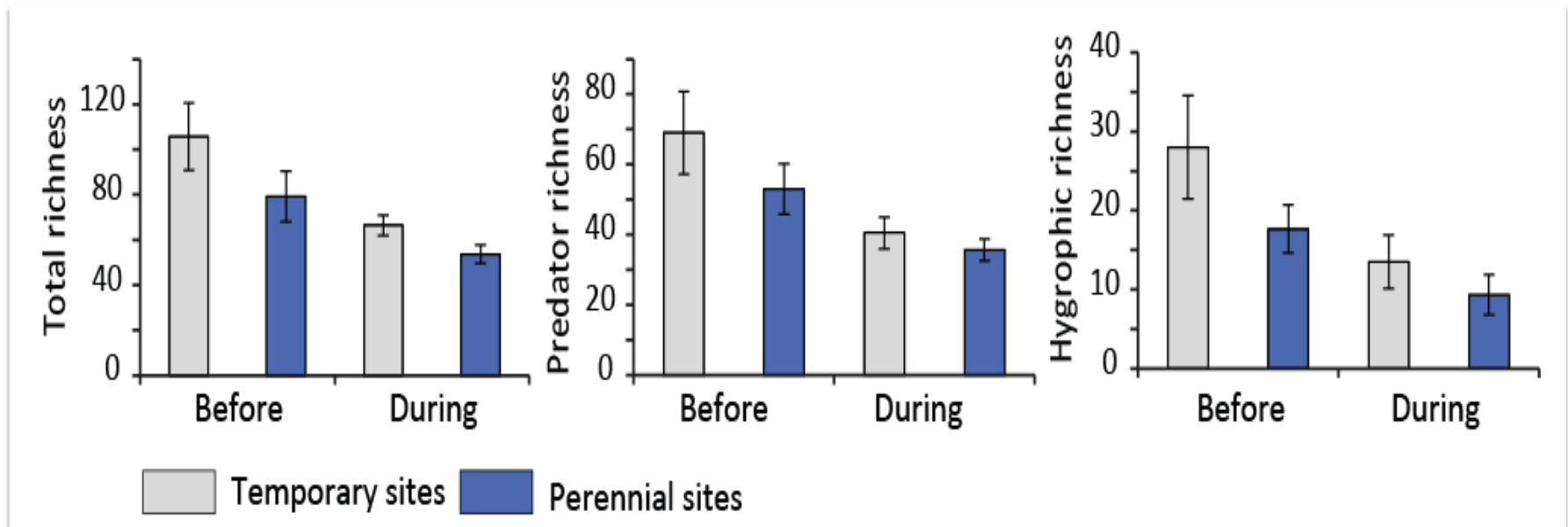


River drying and riparian invertebrate communities



Effect of drying on community structure

Data from temporary and perennial sites of the Albarine River



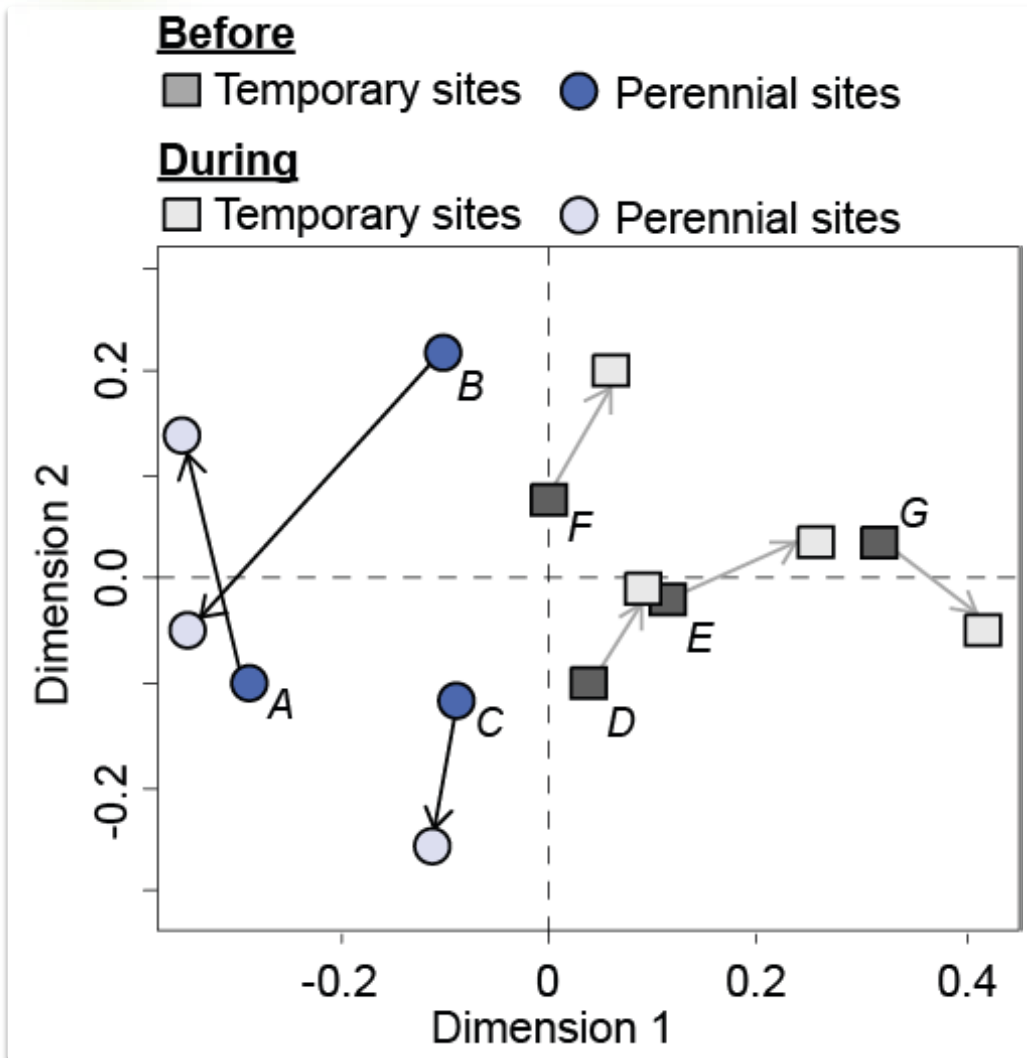
Corti et al., in prep

1.5-fold decrease in taxonomic richness at both temporary and perennial sites

➔ Activity patterns of invertebrates are **synchronized** with the summer drying period

Effect of drying on community composition

Procrustes analysis



Separation of temporary and perennial sites was more pronounced during the dry period compared to before

➔ **Recolonization** of temporary sites during flowing periods

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Synthesis, discussion and perspectives

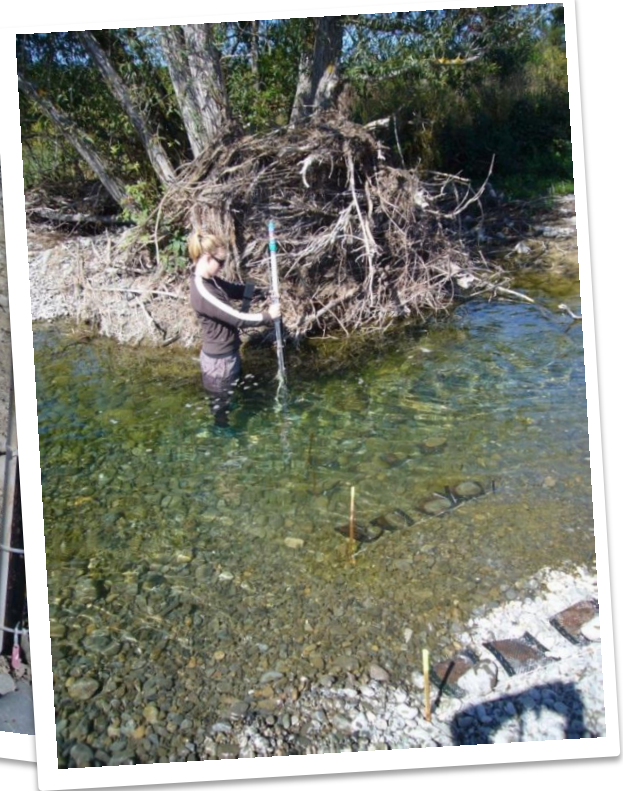
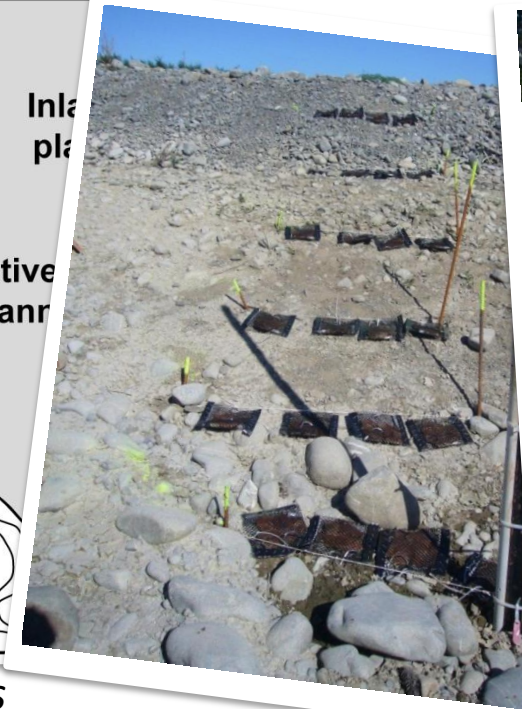
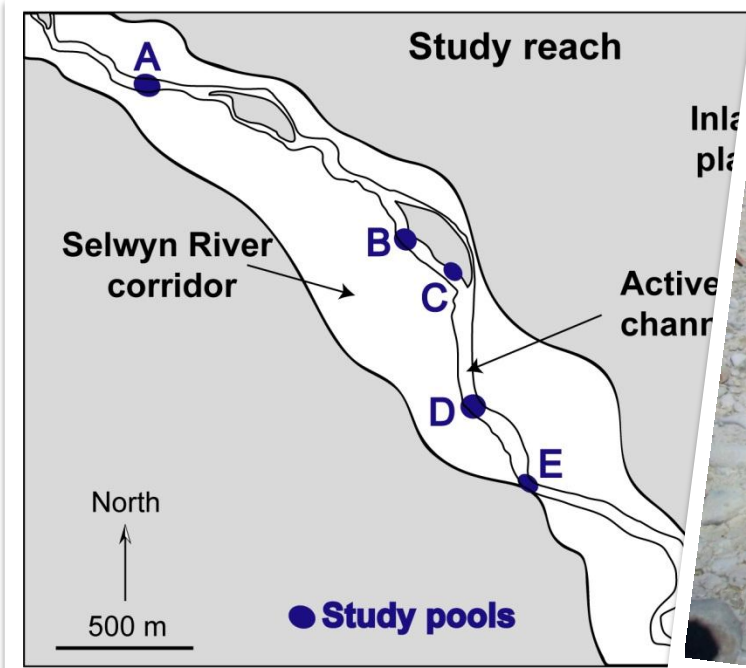


Particulate organic matter (POM) decomposition in temporary rivers

Effects of drying-rewetting cycles

Sampling design

6 pools with contrasted drying-rewetting cycles in the Selwyn River



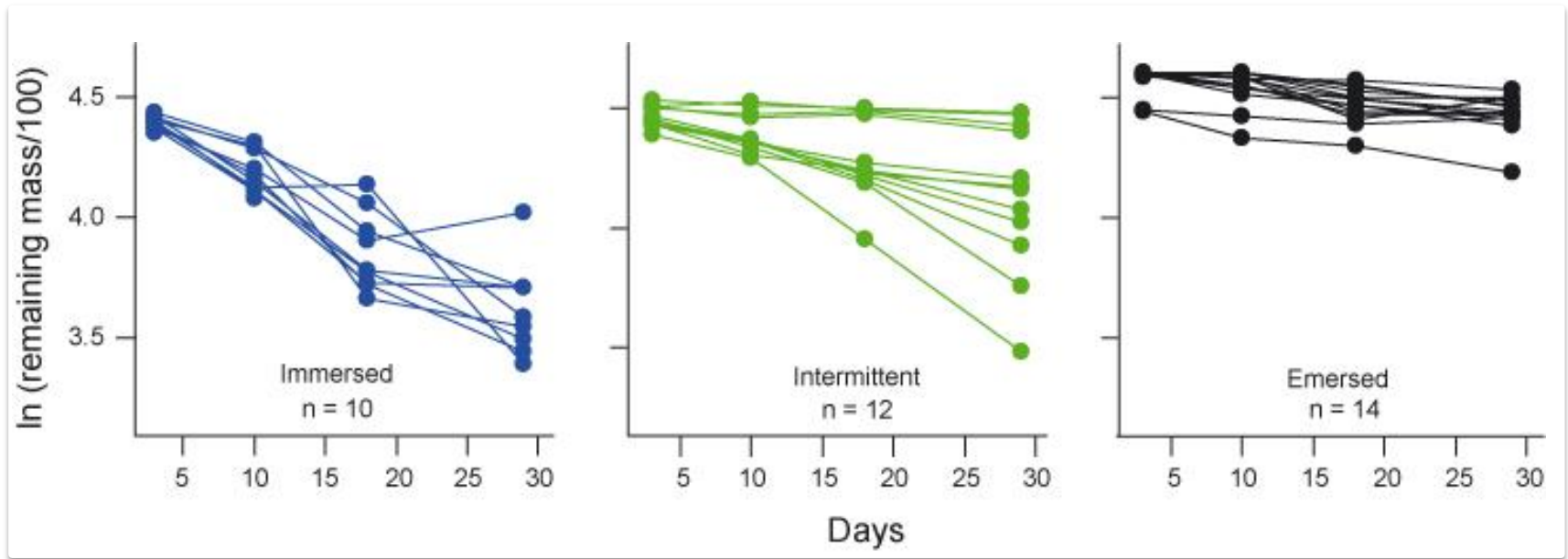
Corti et al. 2011, Aquatic Sciences

30-day experiment

Estimation of microbial activity using FDA

Identification of aquatic and terrestrial invertebrates

POM decomposition in the habitat mosaic



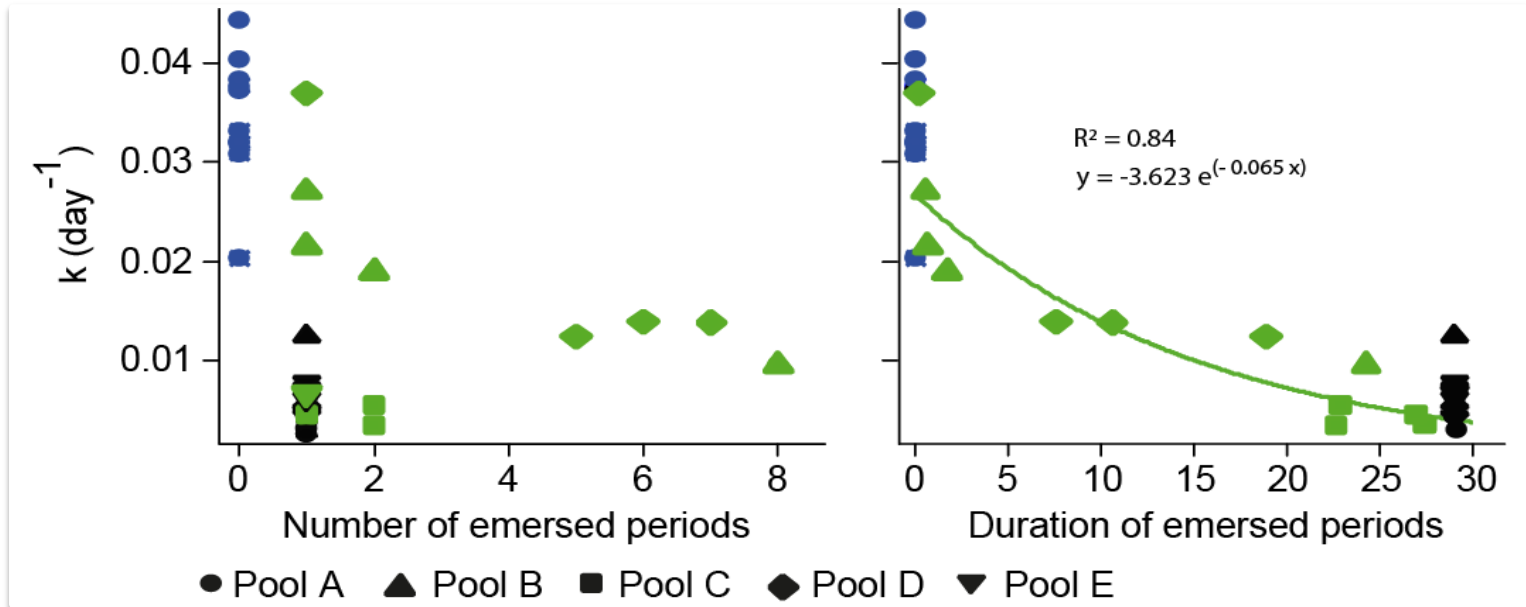
Corti et al. 2011, Aquatic Sciences

Fastest decomposition on immersed conditions

Drying-rewetting cycles have strong effects on POM decomposition

➔ Decomposition is highly **heterogeneous** in the habitat mosaic

Effect of drying-rewetting cycles



Corti et al. 2011, Aquatic Sciences

Decomposition rate (k) varied with cumulative emersion duration

Quantitative relationships are crucial ...

➔ ... to compare and predict the influence of drying-rewetting cycles and to manage river hydrology

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A rewetting event

Invertebrates and particulate
organic matter in a rewetting front

Objectives

Rewetting fronts in the Albarine river

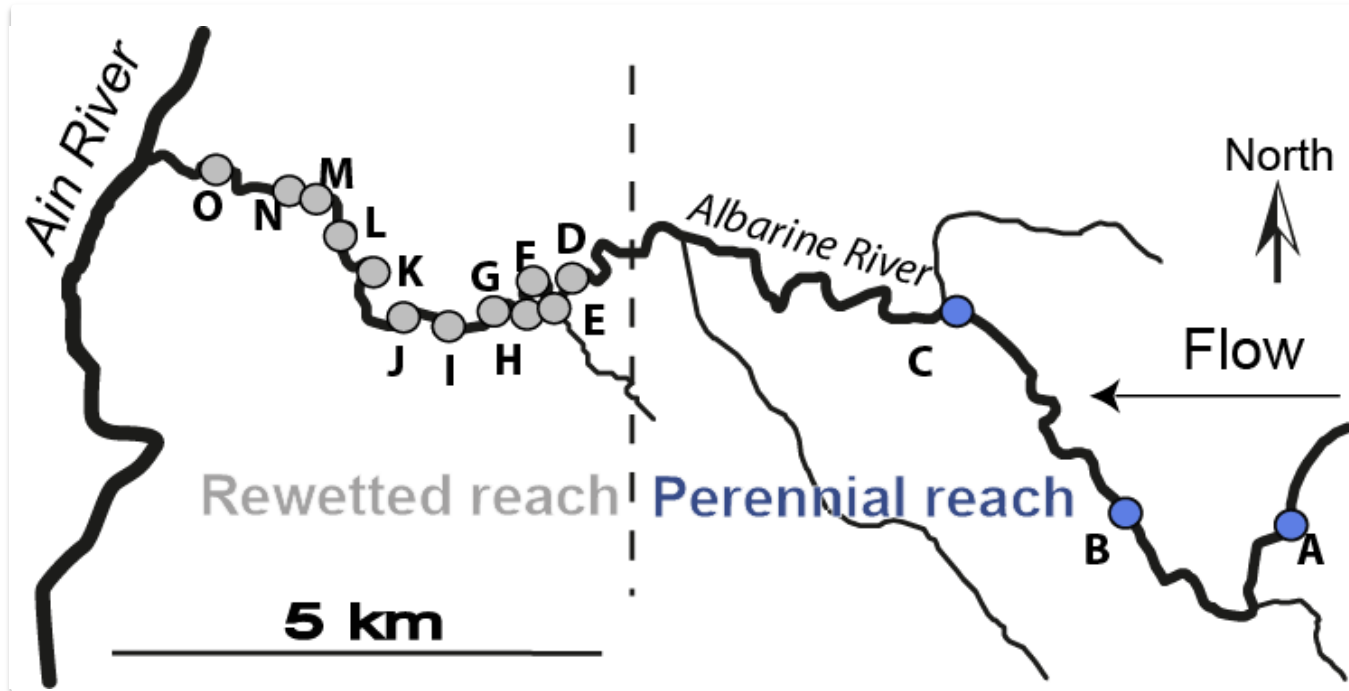


Corti & Datry, 2012, Freshwater Science

Characterize the composition of a rewetting front in invertebrates and particulate organic matter

Examine the longitudinal distribution of communities and particulate organic matter along a rewetting front

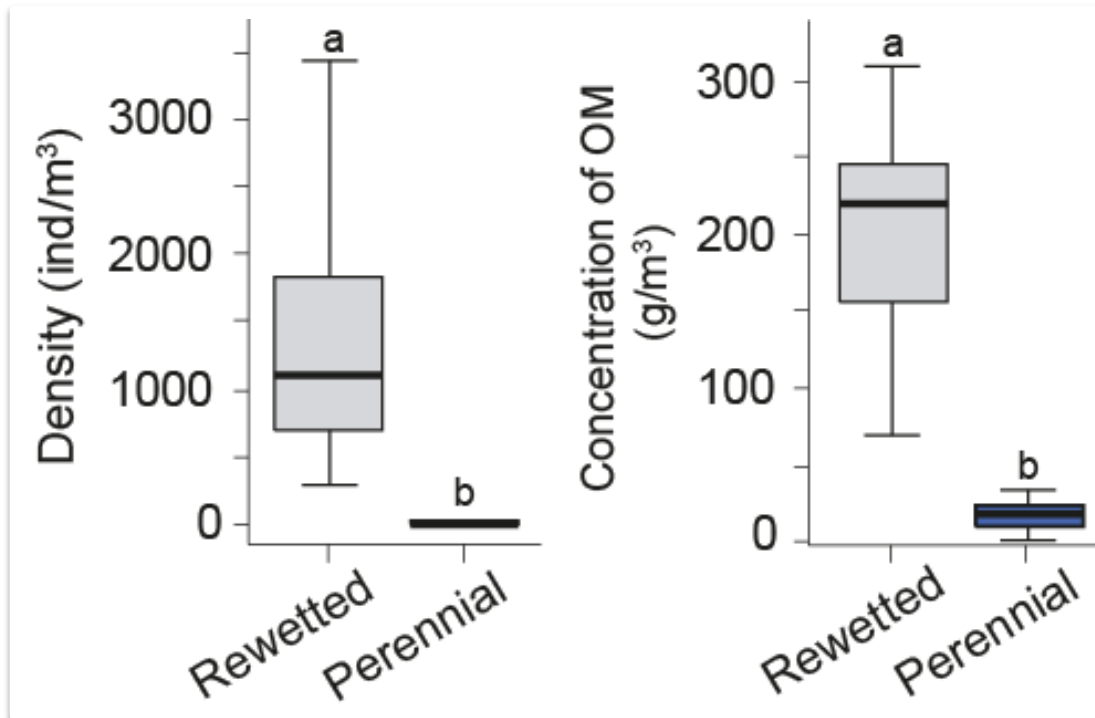
Method



11 rewetted sites and 3 perennial sites in the Albarine River

Alive and dead terrestrial invertebrates were sorted on the field

Results



Rewetting fronts entrained large quantities of terrestrial invertebrates and organic matter

Corti & Datry, 2012, Freshwater Science

A **longitudinal pulse** analogous to lateral flood pulses observed in large perennial rivers

➔ Positive and negative consequences

1. Results

24/70 alive taxa



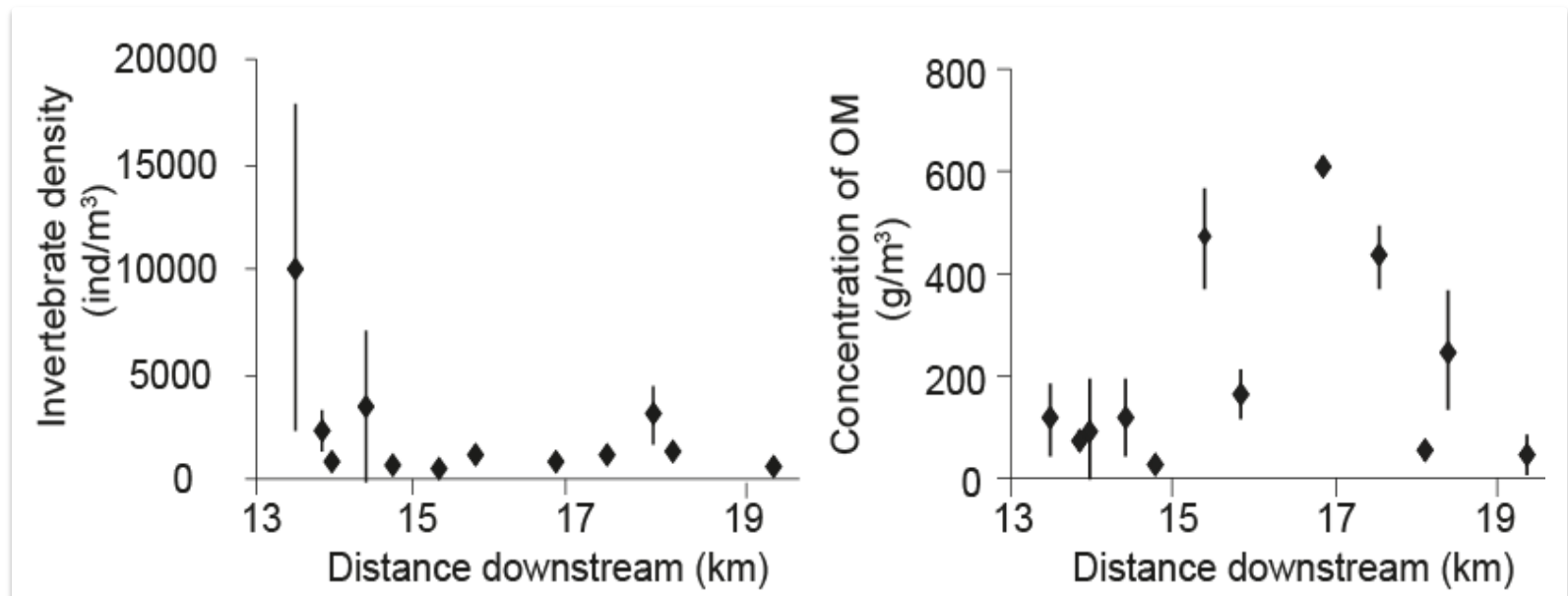
Rewetting fronts are a **dispersal mechanism** for some dry riverbed invertebrates



Riparian zones are refuges



Invertebrate successions in riparian zones?



Corti & Datry, 2012, Freshwater Science

Intermediate zones of deposition and accumulation

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Synthesis and perspectives

Synthesis 

Invertebrates in the habitat mosaic

Terrestrial invertebrates account for a large part of invertebrate biodiversity in temporary rivers

→ 2-4 times more terrestrial taxa

No specific taxa = No edge effect

The dynamic of terrestrial communities differs from the dynamic of aquatic communities

→ Aquatic = longitudinal dispersion

Terrestrial = lateral dispersion

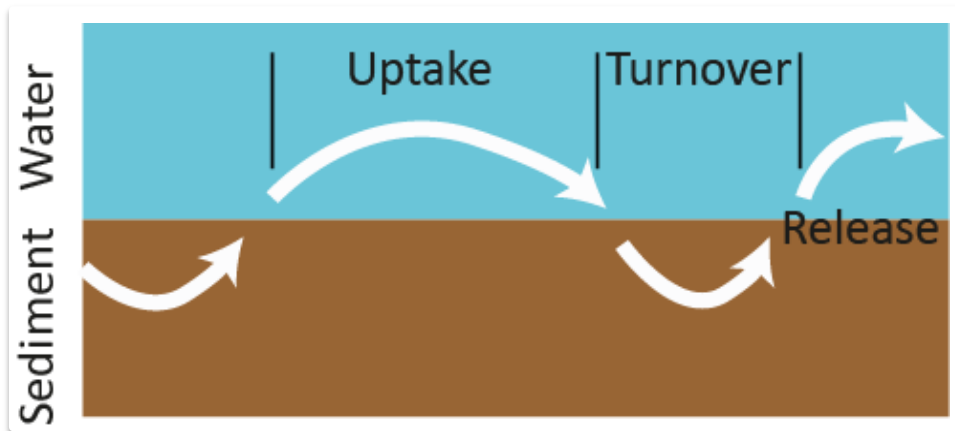
→ Nestedness



Dynamic of organic matter in temporary rivers

Drying events influence the transport, accumulation and decomposition of organic matter

Nutrient spiraling concept



From Newbold et al., 1981

Uptake and turnover depend on the dry period duration

Decomposition, accumulation and transport of particulate organic matter is longitudinal and punctuated in temporary rivers

Managing dry riverbeds

Monitoring sites as for aquatic invertebrates?

→ Is there a link between human impacts and terrestrial communities?

Riparian zones harbor specific communities

20% of gravel-bar carabidae are endangered species

→ Management of riparian zones needs to be expanded to dry riverbeds





Synthesis and perspectives

Perspectives



Terrestrial invertebrate dispersal

Are rewetting events important pathways for the dispersal of riparian invertebrates?

- A metapopulation approach
- Capture-Mark-recapture

Aquatic-terrestrial interactions

How trophic regimes of terrestrial invertebrates change during dry periods in temporary rivers?

- Analysis of stable isotopes

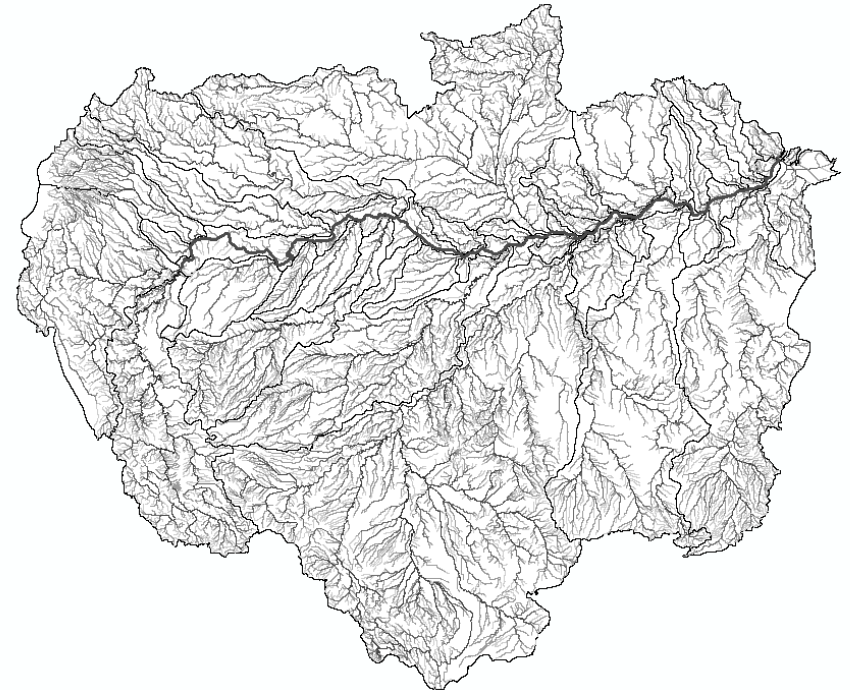
Organic matter in river networks

Rivers are responsible of a large amount of CO₂ outgassing to the atmosphere (Battin et al. 2009)

What is the role of temporary rivers in controlling Carbon (C) fluxes in river networks?



Measuring and modeling import, export and decomposition rates of organic matter



Acknowledgement

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