Functional composition of gravel bar plant communities
along the Rhône River:
implications for management and restoration operations

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Riparian biodiversity


Riparian communities from the upper to the lower part of the banks
Environmental gradients

Merritt et al. 2010, Dawson et al. 2017, Bejarano et al. 2017

Xiong et al. 2001, Kyle and Leishman 2009
Environmental changes and human activity

• Civil engineering widely used
  – Control flood risk
  – Prevent channel migration

  Added-value of restoration operations ?

• Maintenance/clearing operations
  – Prevent vegetation encroachment
  – Maintain wide channels

  Related effect on pioneer communities ?

Research questions

Study the effect of topographical and pedological gradients on the functional composition of gravel bar plant communities

• How environmental gradients shape riparian plant functional composition along a highly degraded large River?

• How human activity, through maintenance and restoration operations, mediate the response of plant functional composition to environmental gradients?
Case study: the Rhône River

• A large River
  – total length = 810 km
  – watershed area = 96,500 km²
  – mean flow = 1,700 m³/s

• A highly degraded system
  – rectification phase in the 19th century
  – derivation phase in the 20th century

• Riparian zones intensively managed

• Ambitious ecological restoration program
Study area and sampling design

- **Fixed** = 9, Qdts = 108, Sp = 203
- **Rejuvenated** = 4, Qdts = 48, Sp = 198
- **Dynamic** = 4, Qdts = 48, Sp = 175

Minimal distance = 100 m

Mineralogical composition

- Fixed gravel bars
- Rejuvenated bars
- Dynamic gravel bars
Trait-based approach

• Three groups of plant traits:
  - Ecological traits
  - Functional traits
  - Species groups

• Modeling framework: LMMs / GLMMs + multimodel inference
Analytical strategy

• How do environmental gradients shape plant communities along the Rhône River?

• How do maintenance operations mediate their response to environmental gradients?

• How is the response consistent among fixed, rejuvenated and dynamic bars?
Effect of environmental gradients

- Elevation gradient
- Soil texture gradient
Effect of environmental gradients

- Elevation gradient
- Soil texture gradient

Species

- Functional

Ecological

- Elevation gradient
- Soil texture gradient
Effect of environmental gradients

- **Fixed gravel bar of the Rhône River**
- **Elevation gradient**
  - Shift in ecological and functional traits
  - Environmental selection
    (hydrological niche segregation)
- **Soil texture gradient**
  - Patterns of trait convergence
    (rejuvenation = habitat heterogeneity)

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Effect of environmental gradients

Elevation gradient

Soil texture gradient

Brush clearing

Ploughing

Brush clearing

Ploughing
Effect of maintenance operations

- Elevation gradient
- Soil texture gradient

Species

Ecological

Functional

Effect of maintenance operations:
- Brush clearing
- Ploughing

- Richness of alien
- < 1 year
Effect of maintenance operations

- Fixed gravel bar of the Rhône River

Elevation gradient:
- Shift in ecological and functional traits
- Environmental selection (hydrological niche segregation)

Soil texture gradient:
- Patterns of trait convergence
- Biotic homogeneization (rejuvenation = habitat heterogeneity)

Brush clearing:
- Biotic homogeneization
- Species diversity

Ploughing:
- Biotic homogeneization

- Effect of maintenance operations
Effect of restoration operations
Effect of restoration operations

Elevation gradient

Soil texture gradient

Fixed

Rejuvenated
Effect of restoration operations

Elevation gradient

Soil texture gradient

Dynamic

Fixed

Rejuvenated
Effect of restoration operations

Species

Functional

Ecological

Elevation gradient

Soil texture gradient

Dynamic vs Fixed

Fixed vs Rejuvenated

Fixed

Rejuv.

Fixed

Rejuv.

Fixed

Dyna.

Fixed

Dyna.

Fixed

Dyna.

Fixed

Dyna.

Fixed

Dyna.

Fixed

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Effect of restoration operations

- **Fixed gravel bar of the Rhône River**
  - Elevation gradient
    - Shift in ecological and functional traits
      - Environmental selection (hydrological niche segregation)
  - Soil texture gradient
    - Patterns of trait convergence
      - Biotic homogeneization (rejuvenation = habitat heterogeneity)

- **Species diversity**
  - Brush clearing
  - Biotic homogeneization
  - Ploughing
  - Soil texture gradient
    - Patterns of trait convergence
      - Biotic homogeneization (rejuvenation = habitat heterogeneity)

- **Dynamic vs Fixed**
  - Distinct functional assemblages
    - Natural reference bars = more stressful environmental conditions
  - Rejuvenated vs Fixed
    - Same ecological trajectories
      - Alteration of disturbance regimes (mainly bedload and scouring)
Take-home message…

• Both gradients have strong effect on plant functional composition;
• Co-occurrence of species is higher on highly disturbed sites;
• Rejuvenation processes avoid biotic homogenization and promote habitat heterogeneity;

• Human activities mediate environmental gradients:
  – ploughing promote pioneer communities but also alien species;
  – dynamic gravel bars are more stressful environments;
  – rejuvenated surfaces follow the ecological trajectories of fixed ones.

• Effective ecological restoration strategies should imply:
  – reactivation of bedload transport and supply + greater variability of the minimum flow;
  – engineering operations that better mimic landform and soil properties of dynamic gravel bars.
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