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Fine-grained sediment deposition alters the response of plant CSR strategies on the gravel bars of a regulated river

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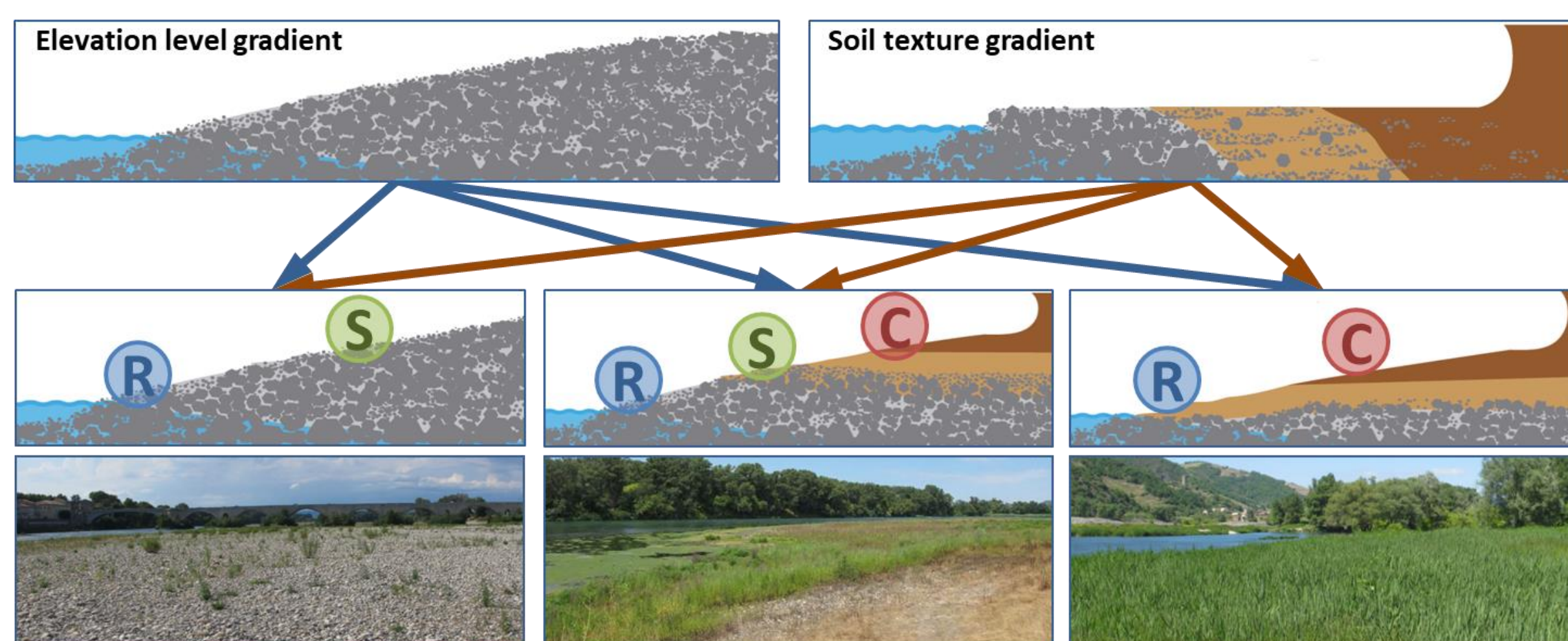
Introduction - Objectives

Understanding the responses of plant communities to human-mediated environmental gradients is essential for ecosystem management. In riverine ecosystems, variations in disturbance and stress intensities along the flood gradient shape the community structure. However, human modifications to the flood regime may change the magnitudes of disturbance and stress, leading to a shift in the distribution of plant species.

Grime's CSR (competitor, stress tolerator, ruderal) theory (Grime, 1977) allows understanding the assembly and successional processes of communities. By describing the functional responses of plants to various disturbance and stress intensities, this theory can predict changes in the community structure along environmental gradients.

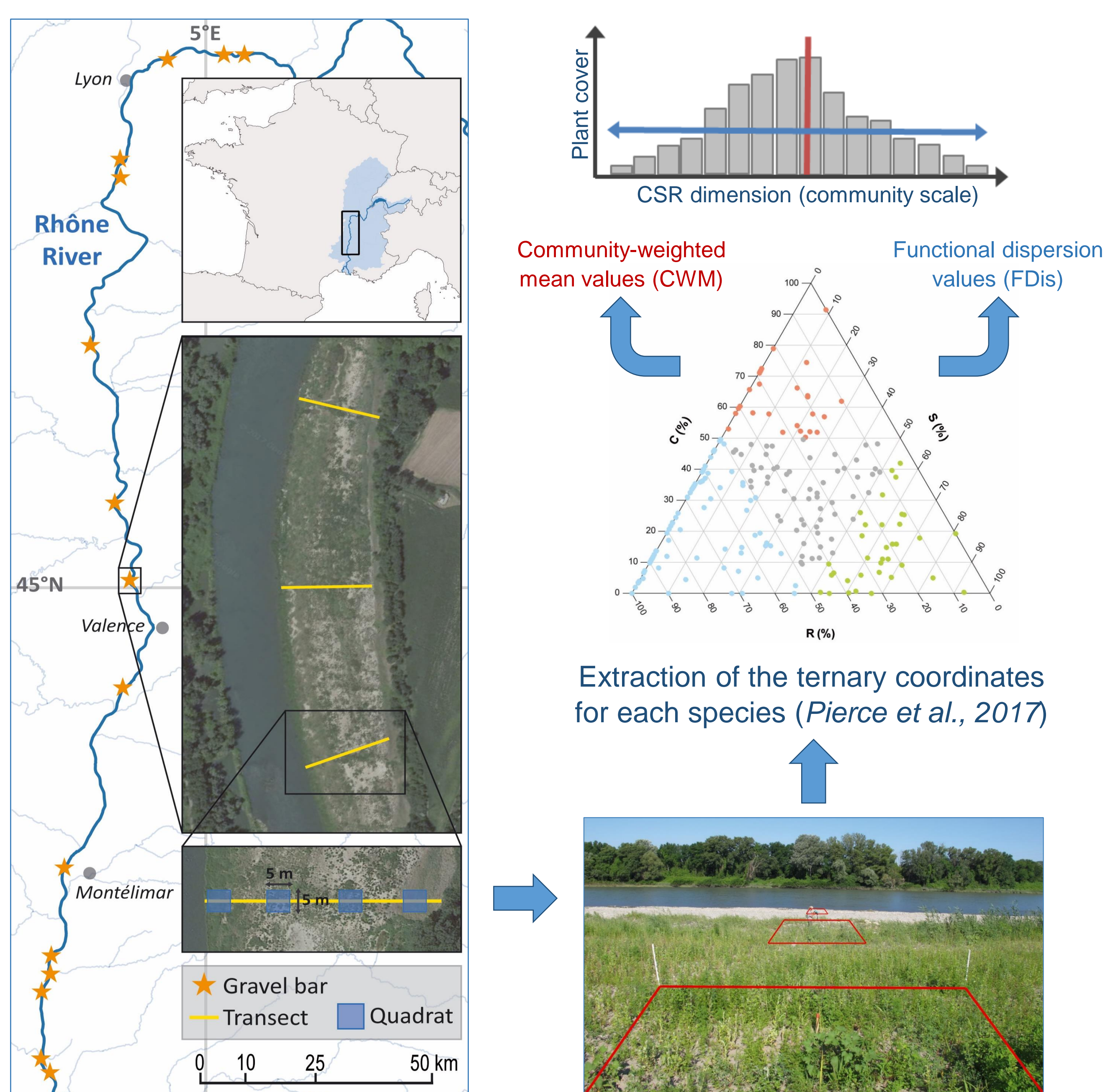
Using a highly regulated river as a case study, we investigated how riparian communities were structured by two local-scale (elevation level and soil texture) and one broad-scale environmental gradients (climate). The following three hypotheses were explored:

- Competitors increase from low to high proportions of subsoil fine sediments at middle/high elevations along the northern gravel bars of the river corridor;
- Stress-tolerators increase from high to low proportions of subsoil fine sediments at middle/high elevations along the southern gravel bars of the river corridor;
- Ruderals increase from high to low elevations, regardless of the proportion of subsoil fine sediments and the mean annual temperature.



Materials and Methods

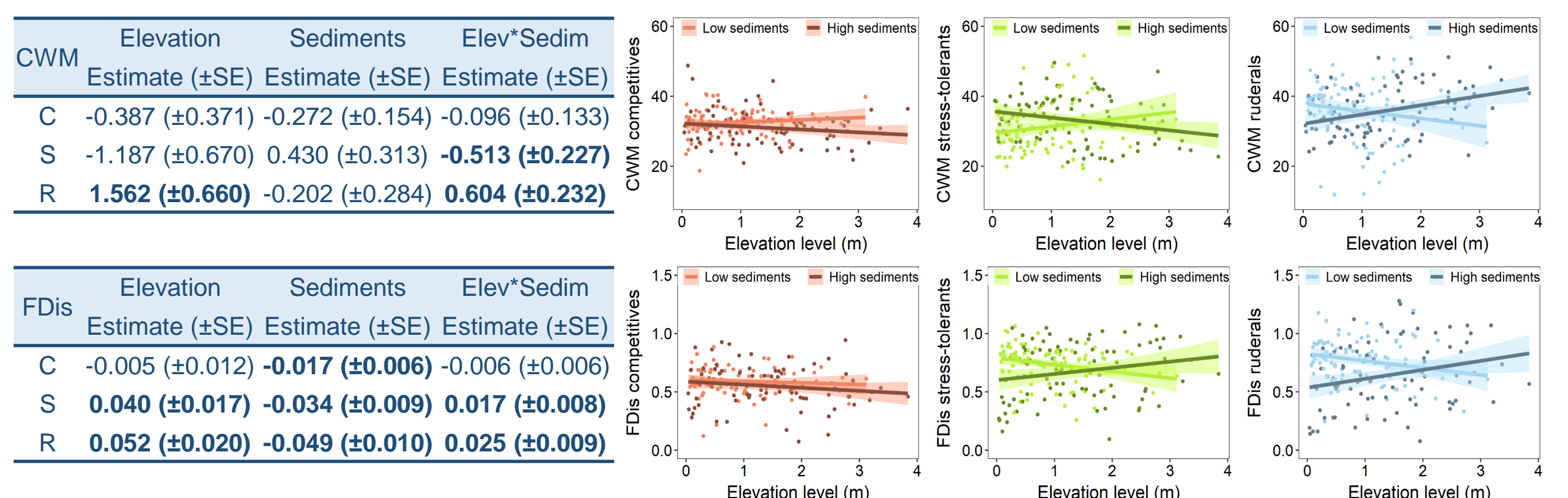
- Study system: the Rhône, a large and highly regulated and channelized river (total length = 810 km, catchment area = 96,500 km², mean annual discharge = 1,700 m³/s);
- Sampling design: 15 gravel bars (n quadrats = 180) along an approximately 250 km north-south reach (mean annual temperatures, north = 11.6°C, south = 13.6°C);
- Analysis strategy: mixed models and multi-model inference.



Results

At the local-scale:

- Plant species with contrasting ecological strategies (i.e. dispersion values) co-occurred less on gravel bars subject to fine sediment alluviation;
- Also, local-scale environmental gradients have non-independent effects and induce a shift in the response of stress-tolerant and ruderal communities to the flood gradient:
 - ✓ Bars subject to fine grained deposition favor the spread of stress-tolerators at low elevation and a low co-occurrence of species with different strategies (S, R);
 - ✓ Gravel bars support ruderal dominated communities at low elevation and a high co-occurrence of species with different strategies (S, R).



At the broad-scale

- Warmer climate benefits ruderals, i.e. fast-growing annual species better adapted to exploit environments that become intermittently favorable;
- Also, the co-occurrence of different ruderal species increases more with elevation level in the south, possibly related to the arrival of new species, increasing the species pool, with downstream position of gravel bars in the river network (Kuglerová et al. 2015);
- Finally, fine-grained sediment deposition mitigates the effect of climate by promoting less stressful environmental conditions, which induce:
 - ✓ A convergence in CWM values between north and south gravel bars ;
 - ✓ A more pronounced decrease in the co-occurrence of different stress tolerant species in the north, increasing the functional similarity of gravel bars communities.

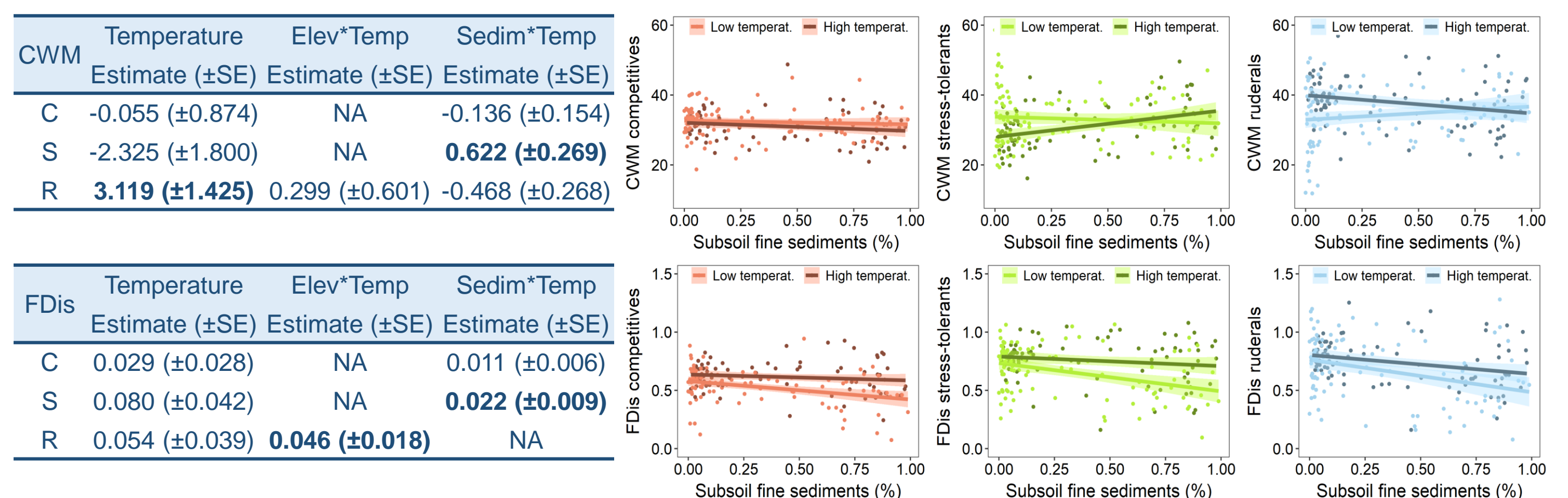
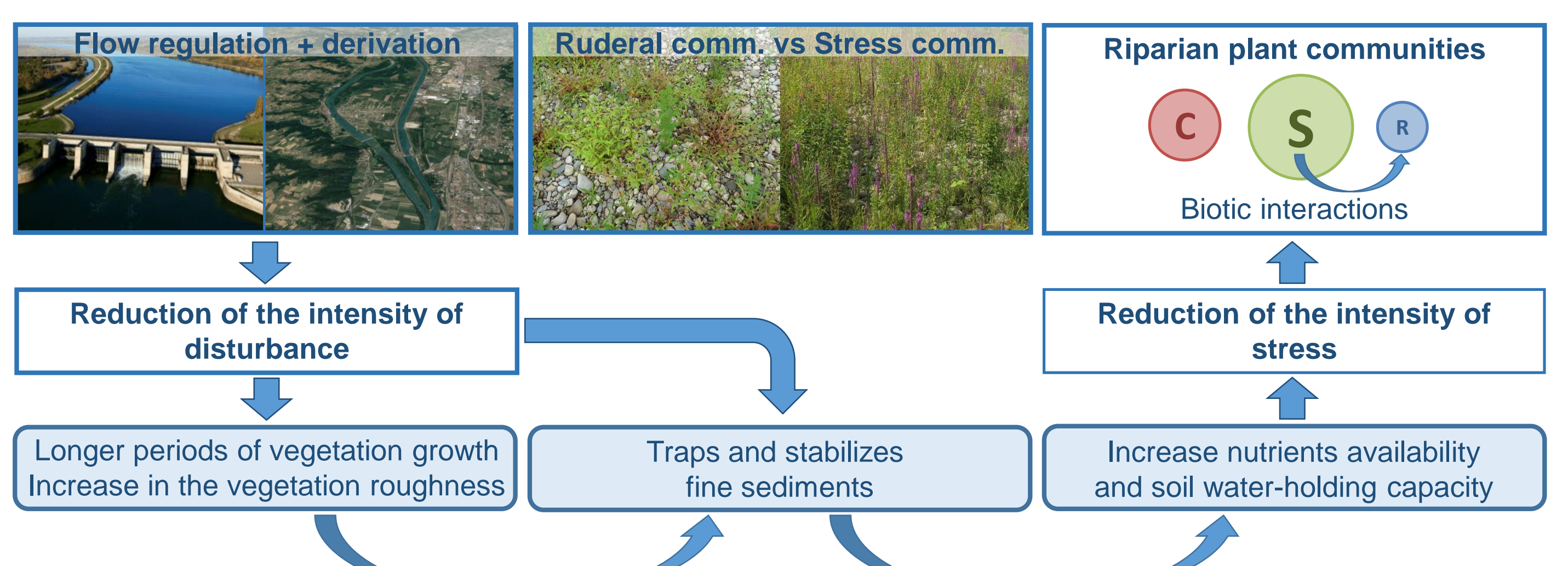


Table: average coefficients (Estimate (±SE)) for fixed effects used to predict changes in CWM and FDis values of CSR plant strategies along local- and broad-scale environmental gradients of the Rhône River. Coefficients in bold excluded 0 from the 95% confidence intervals. NA, not available estimate and associated standard errors in multi-model inference.

Conclusion

- In regulated rivers, fine-grained sediment deposition may strongly alter the strategy-environment relationships of riparian plant communities on gravel bars by:
 - ✓ Alleviating the intensity of stress along the flood and climatic gradients;
 - ✓ Homogenizing the functional composition of riparian plant communities.
- These changes in environmental conditions fosters the spread of competitive and stress-tolerant communities at low elevation to the detriment of ruderal communities;
- Restoring the functionality of riparian zones in highly regulated rivers requires an increase in the intensity of (i) disturbance, through the reactivation of bedload supply and transport, and (ii) stress, through increased flow dynamics.



Financial support



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Acknowledgements

