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Téledétection hyperspectrale et LiDAR pour le suivi de la bathymétrie du chenal et de la santé des forêts alluviales

Julien Godfroy, Jérôme Lejot, Luca Demarchi, Kristell Michel, Simone Bizzi,
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Julien Godfroy, Jérôme Lejot, Luca Demarchi, Kristell Michel, Simone Bizzi, et al.. Téledétection hyperspectrale et LiDAR pour le suivi de la bathymétrie du chenal et de la santé des forêts alluviales. I.S. Rivers 2022, GRAIE, Jul 2022, Lyon, France. hal-04081195

HAL Id: hal-04081195

<https://hal.science/hal-04081195>

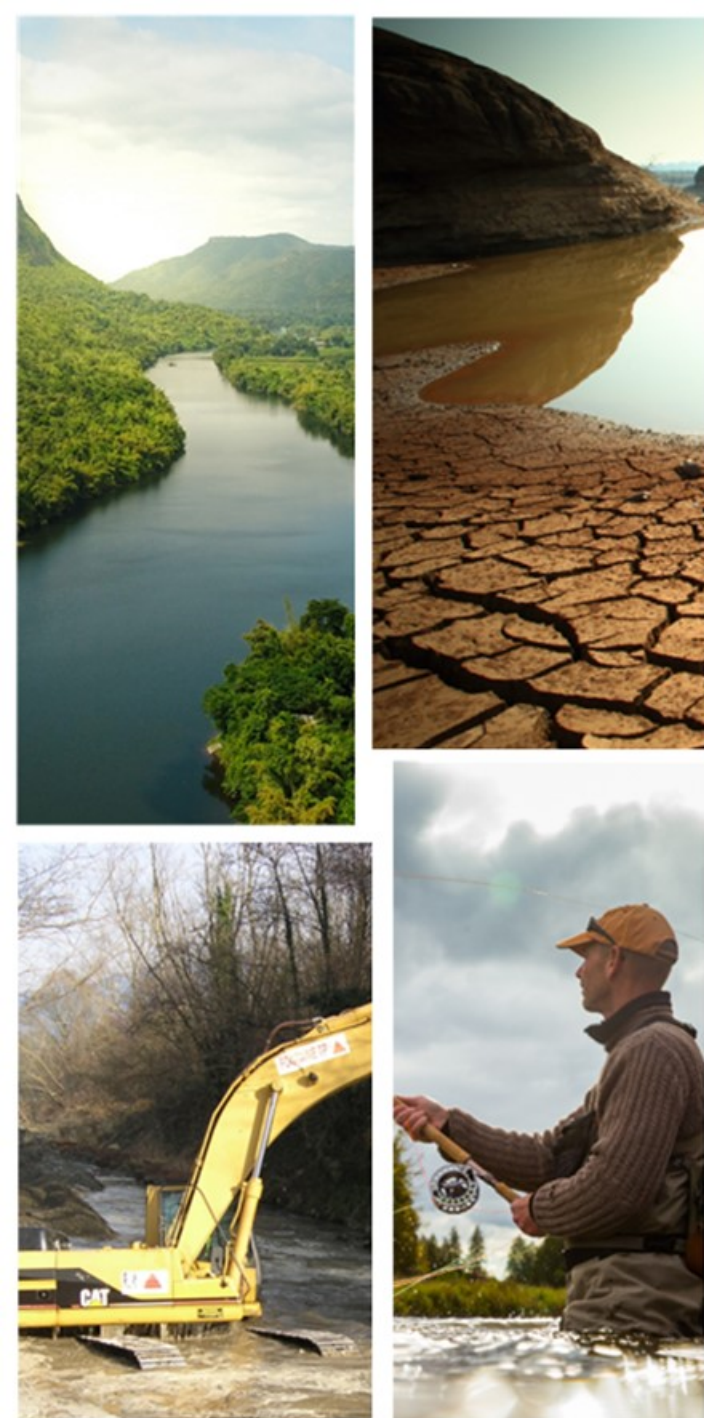
Submitted on 25 Apr 2023

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Hyperspectral and LiDAR remote-sensing for monitoring channel bathymetry and the health of riparian forests : case study on the Ain River

**J. Godfroy, J. Lejot, L. Demarchi, K. Michel,
S. Bizzi, H. Piégay**



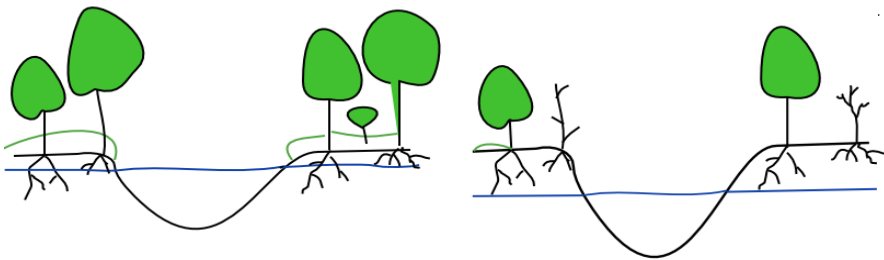
Study site, Context and Aims

- Lower Ain River Basin

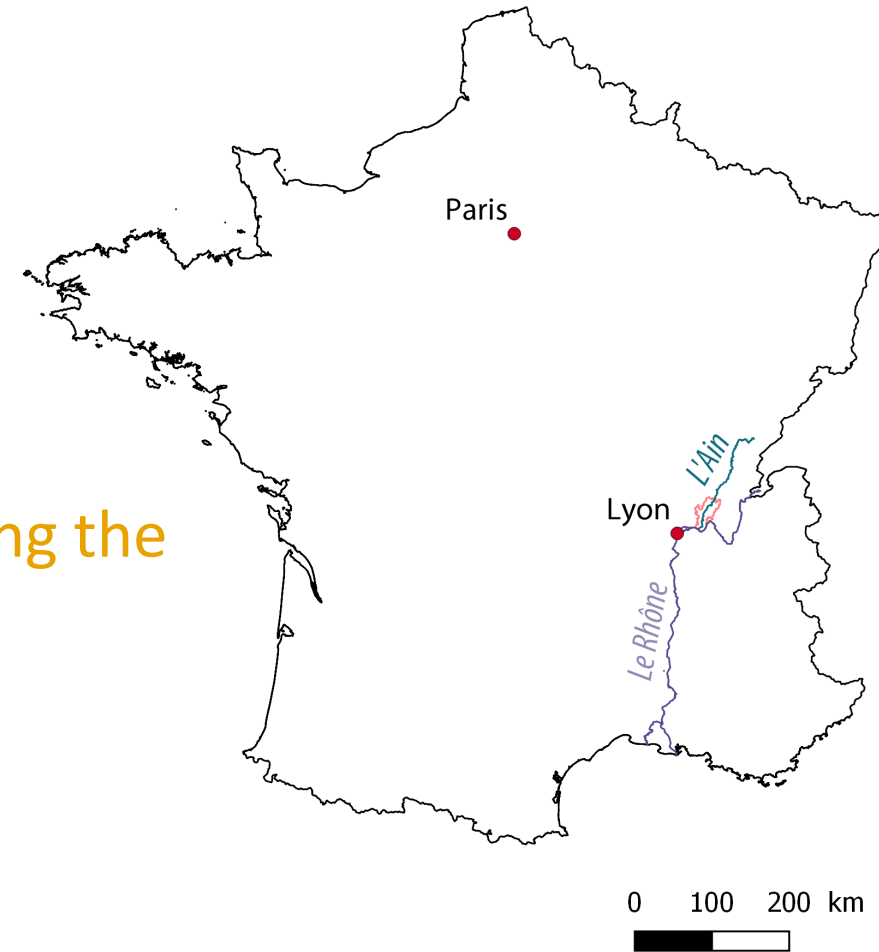
→ Downstream propagation of channel incision following damming

→ Gravel augmentation is done to feed sediment transport and preserve lateral mobility

=> Aim : mapping channel bathymetry and characterizing the physical disconnection of the riparian forest by using hyperspectral and LiDAR data

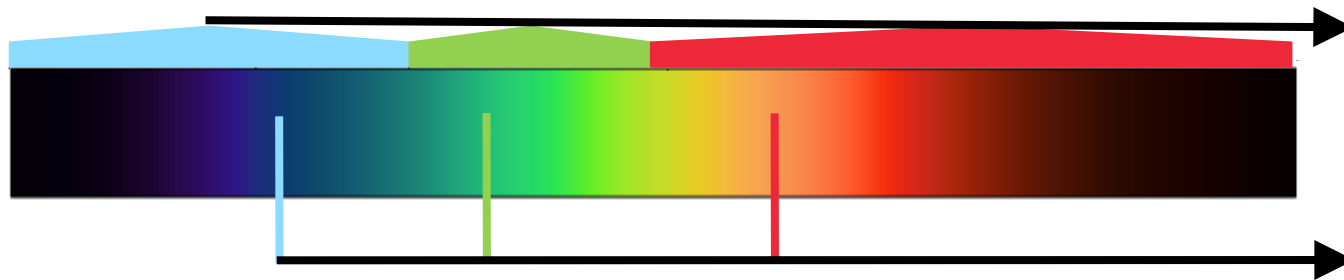


Channel incision limits access to groundwater

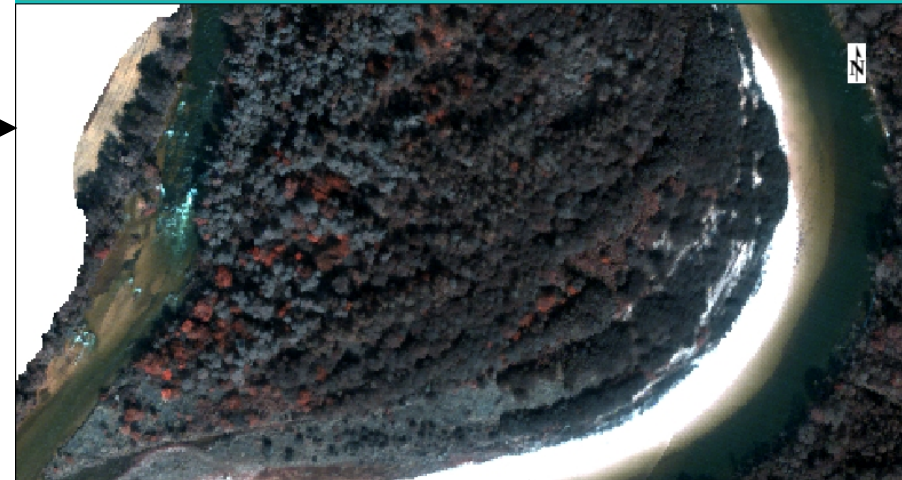


What is hyperspectral data?

- Traditional colour imagery :
→ Summarizes the spectra to recreate what we can see

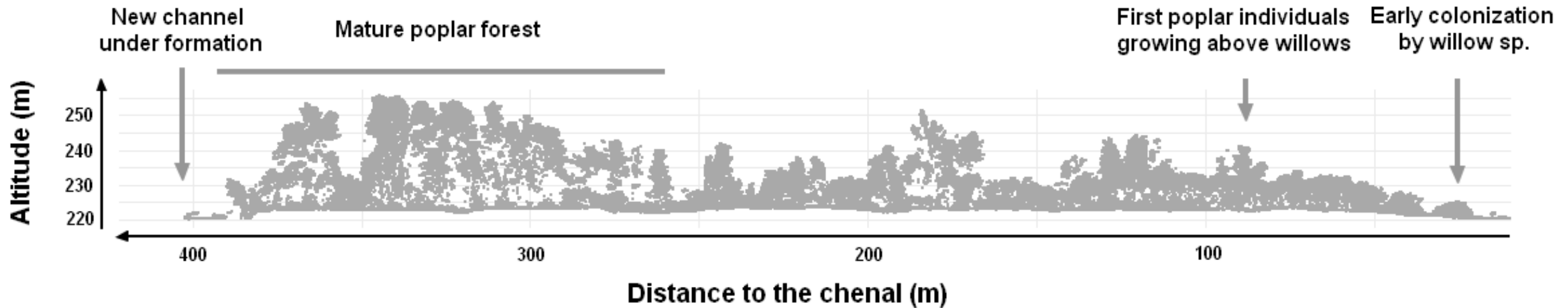


- Hyperspectral imaging :
→ Samples the spectra with a precision similar to lab spectroscopy



What is LiDAR data?

- Three dimensional point cloud
- Generates information about forest structure
- Provides topographic data under canopy cover



Methodology: river bathymetry

Coupling the HS data with depth measurements

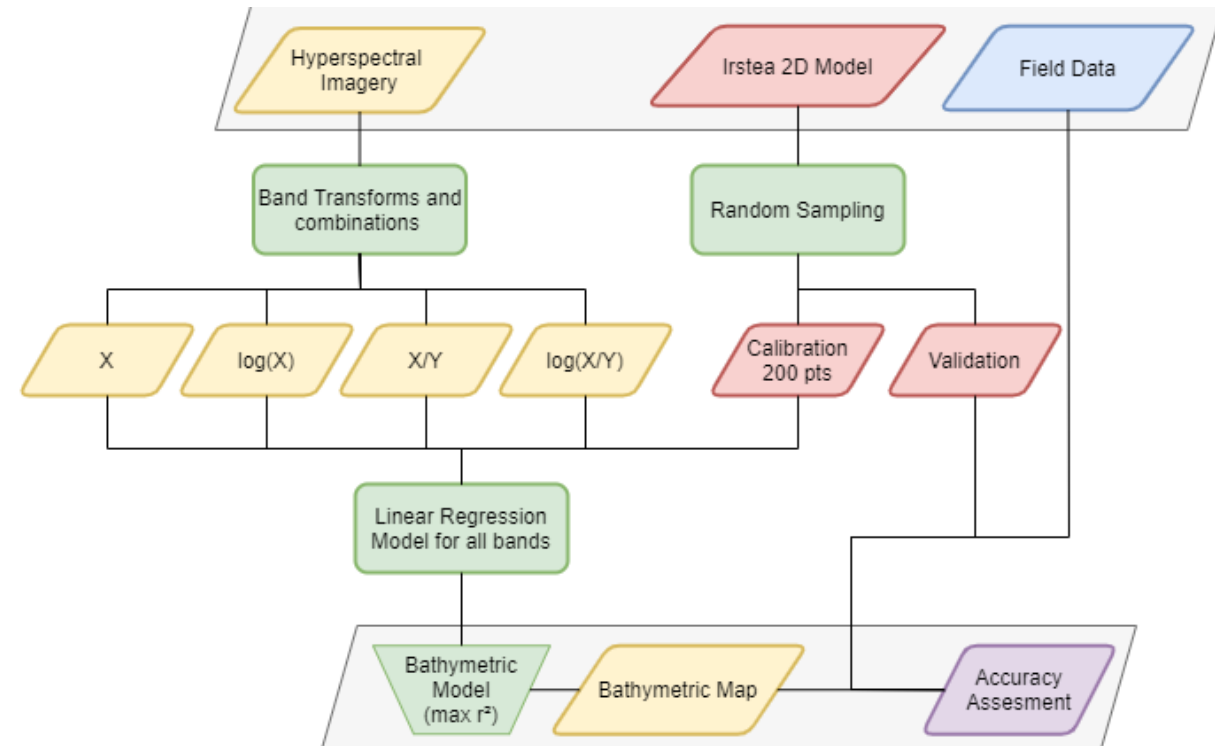
1°) Dimensionality increase

2°) Linear relationship

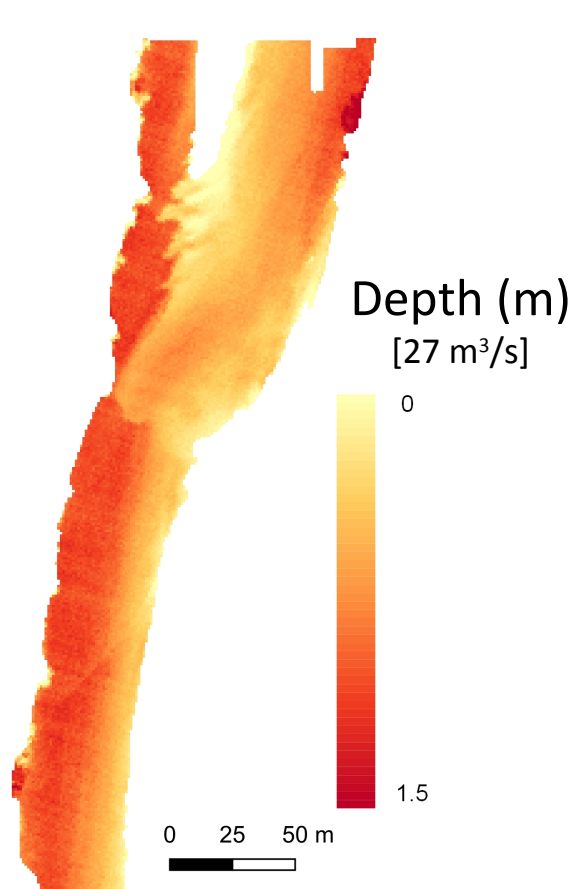
(for $Q=27$ and $Q=127$ m³/s)
depth = f(spectra)

3°) Accuracy assessment

2D model and field data



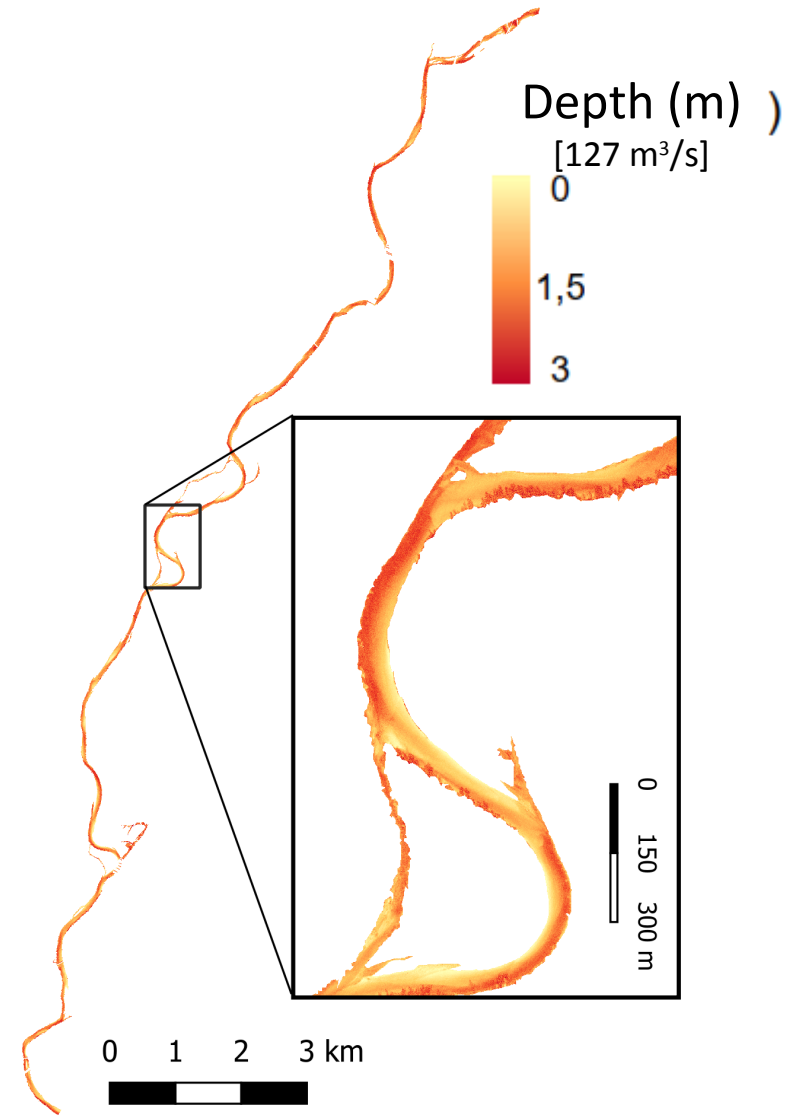
Bathymetric mapping



Accuracy: 10 – 15 cm
Single bands and ratios

Scaling to a
20 km reach

Accuracy: 15 – 20 cm
Only band ratios



Uncertainty of bathymetric maps

- Sources of errors:

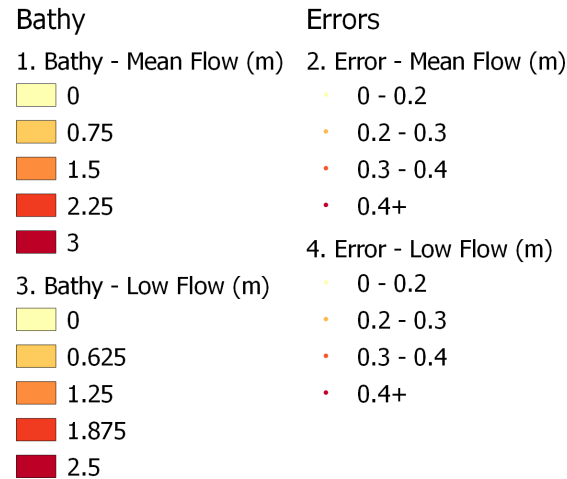
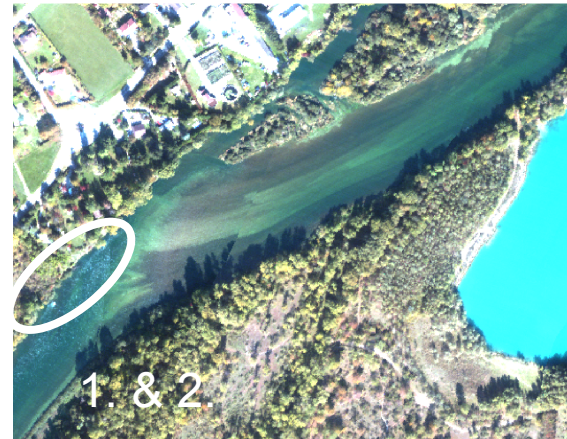
1) Pool areas (< 5% of the river reach)

2) Glint and turbulence

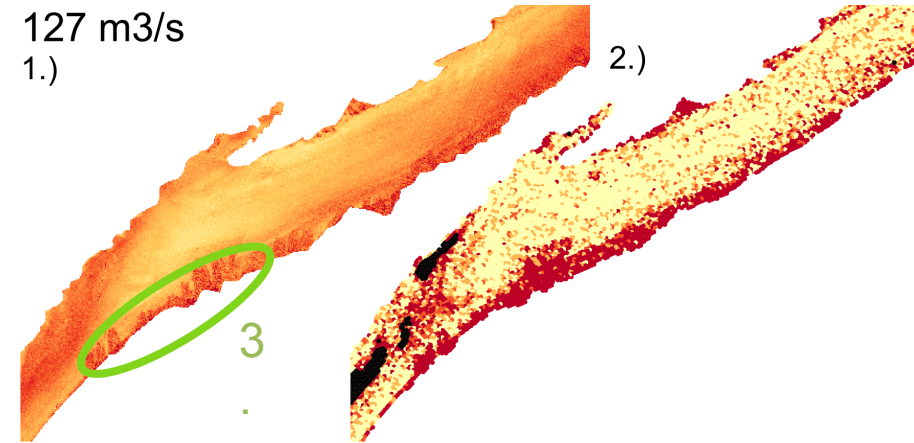
3) Vegetation shadows

4) Changes in riverbed or water column properties

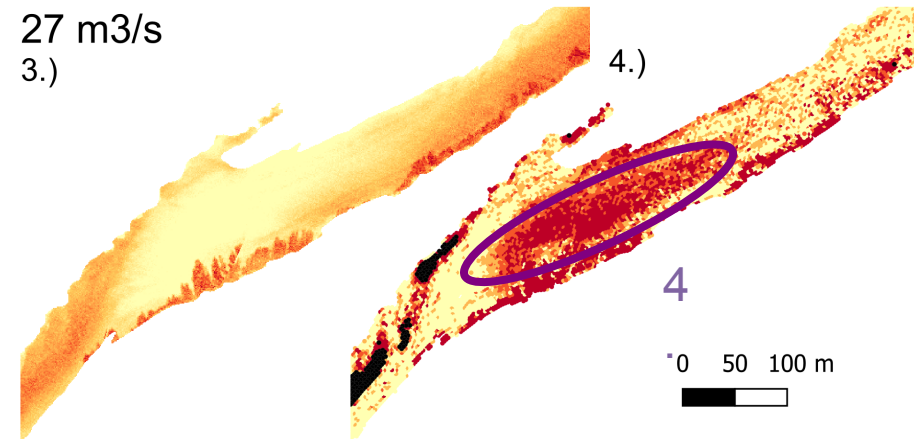
> Sensitivity is dependent on wavelength combination



127 m³/s
1.)



27 m³/s
3.)



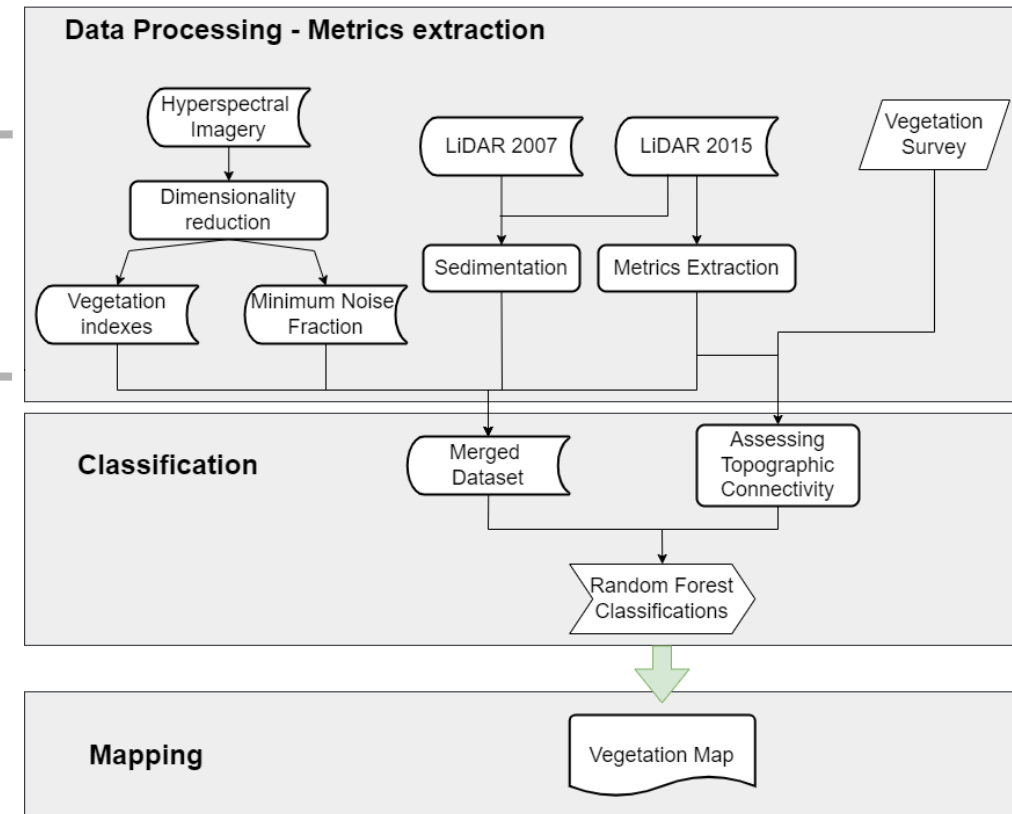
Methodology: riparian forest

Coupling the data with forestry surveys

1°) Exploring the growth of the riparian forest with age

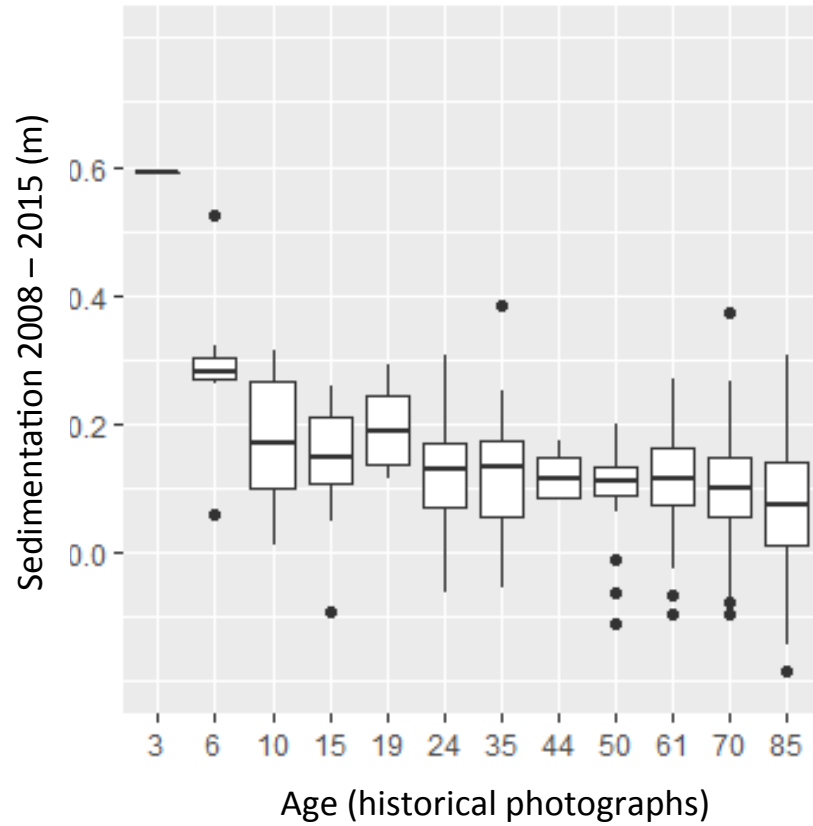
2°) Exploring vertical connectivity and its impact for a given age

3°) Classification and mapping of forest status and sensitivity to change

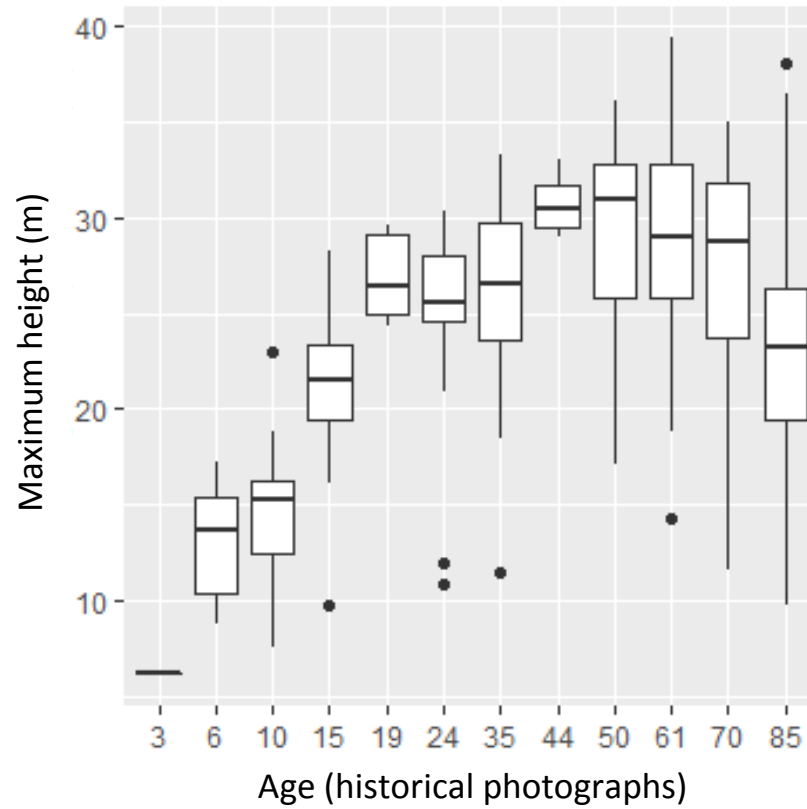


Age gradient

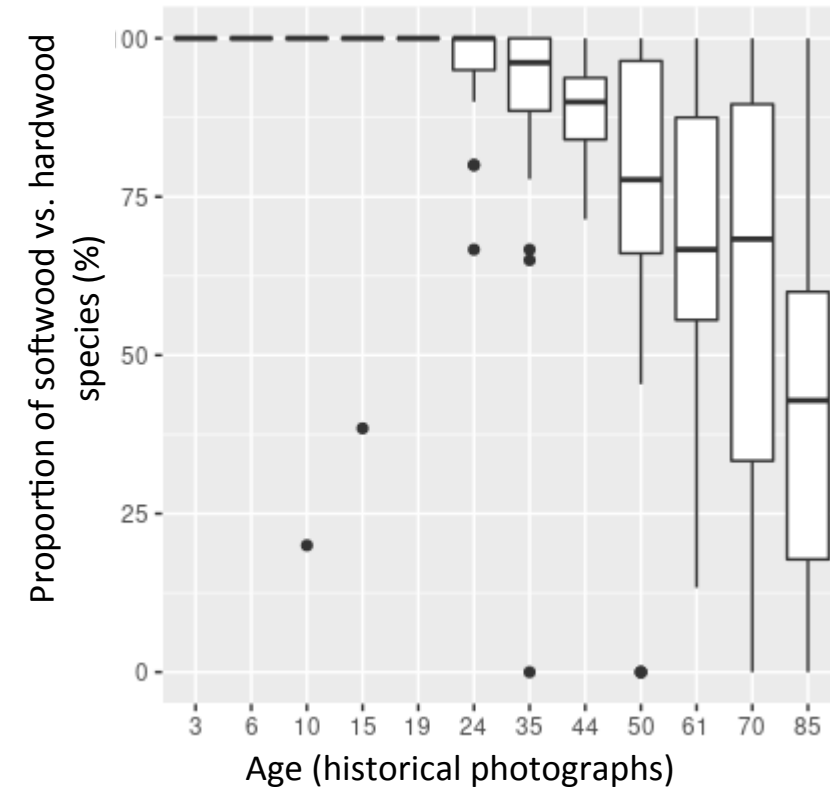
Drop in overbank sedimentation



Early stage growth

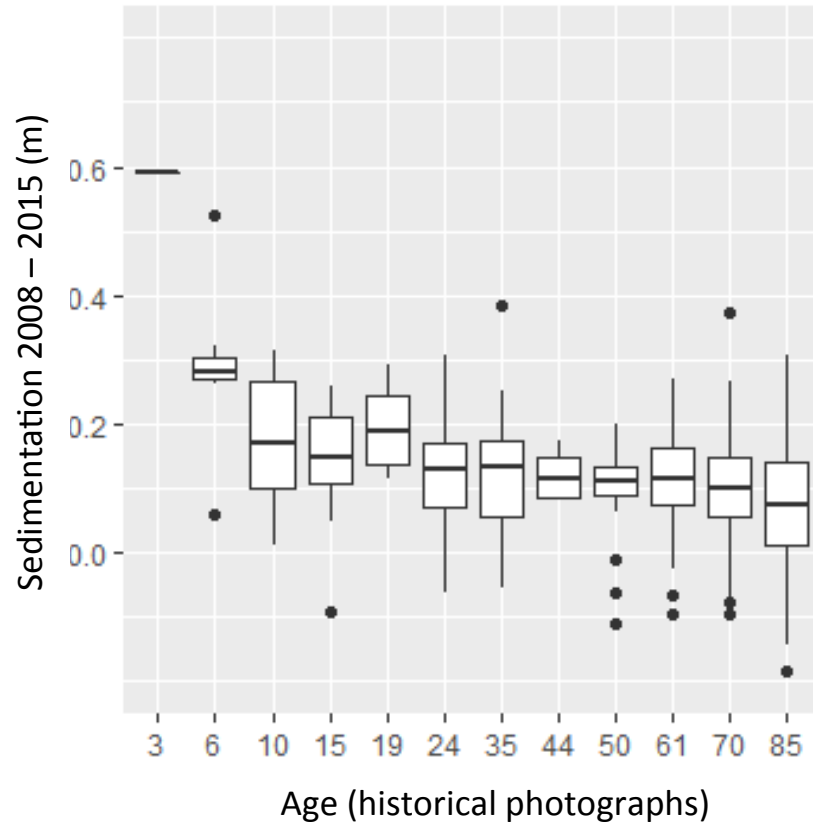


Post-pioneer species substitution

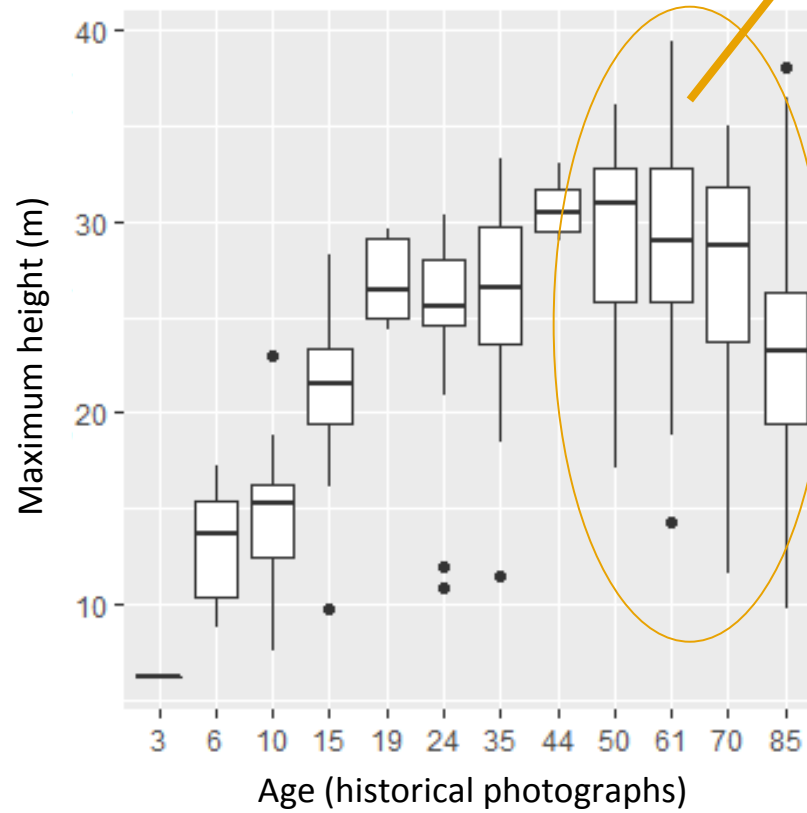


Age gradient

Drop in overbank sedimentation

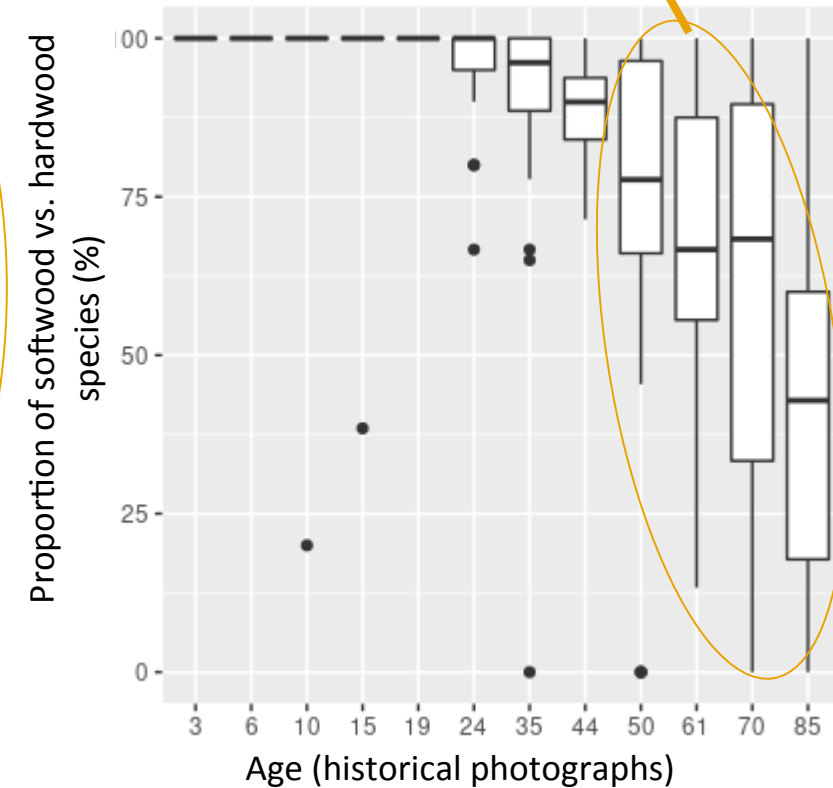


Early stage growth



High variability in old and mature forest plots

Post-pioneer species substitution

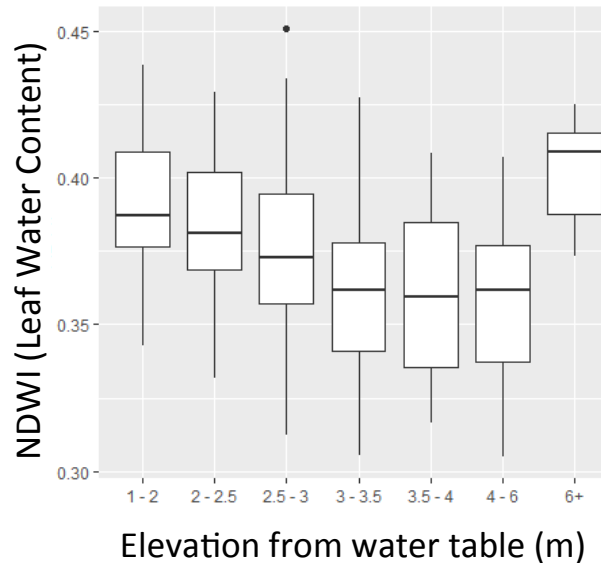


Vertical connectivity gradient

In 50+ y.o. forest plots

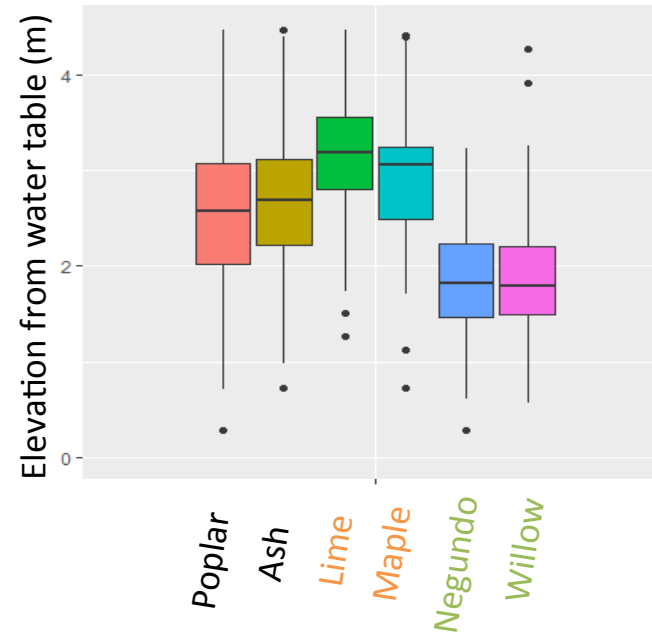
Drop in leaf water content

50+ y.o.

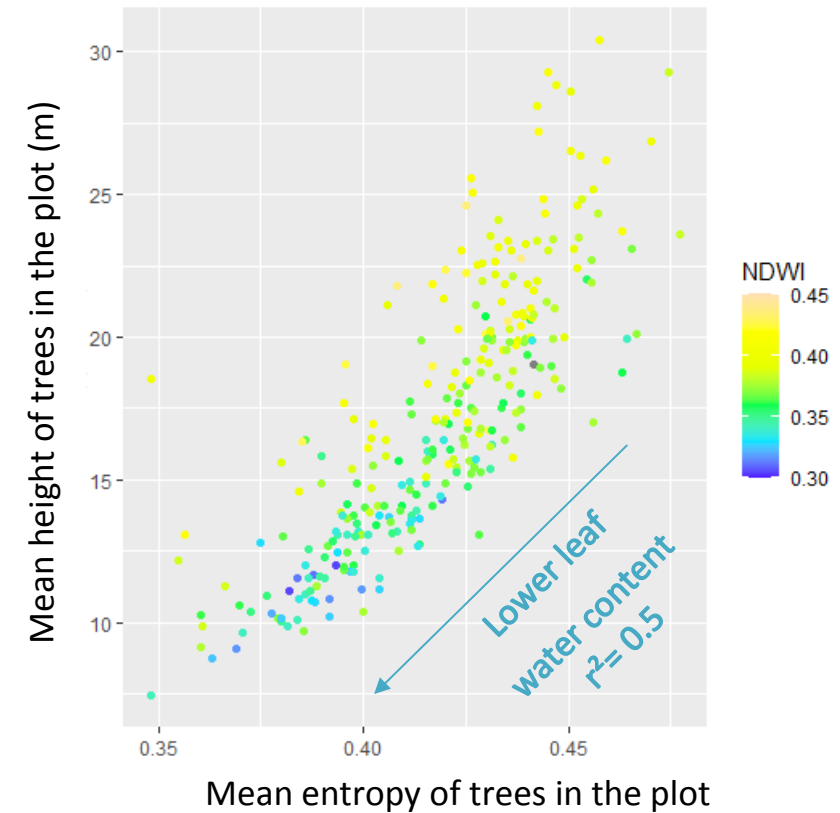


Changes in species composition

50+ y.o.



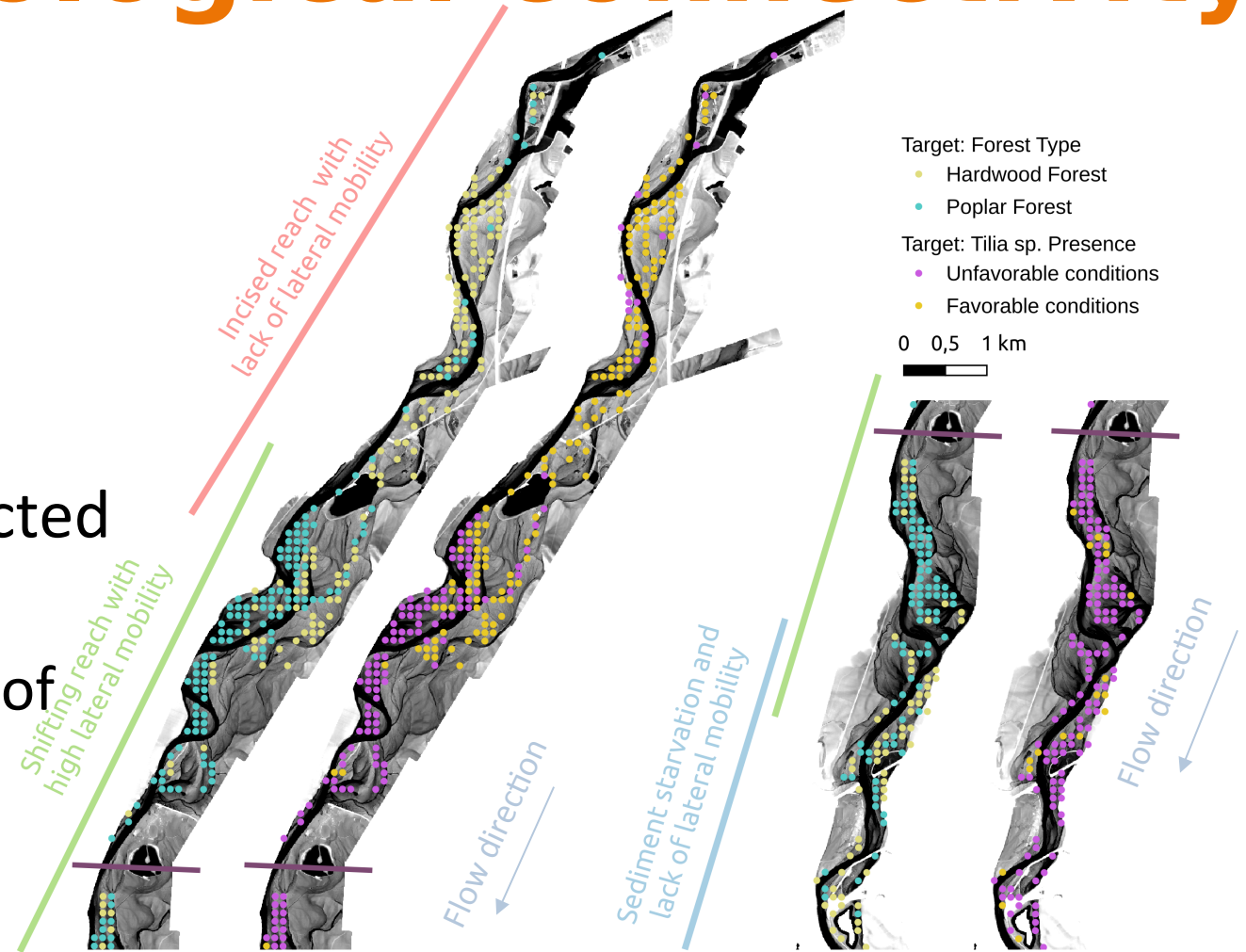
Structural changes



Mapping hydrological connectivity

- Random forest targets:
 - Poplar / Hardwood forest (13%)
 - *Tilia sp.* Presence (19%)

- Identification of forest plots affected by groundwater drop
 - Upstream – downstream gradient of disconnectivity related to channel incision



Conclusion

- Novel fluvial remote-sensing techniques can characterize both bathymetry and forest health at large scales
 - Site-based bathymetric models can be scaled to a 20km reach
 - Combining LiDAR and HS data can help identify potential drought effects on riparian forests
- Future work should focus on better understanding reproducibility and on monitoring
 - Sensitivity of depth retrieval to substrate and turbidity changes, applications to monitor channel changes
 - Downscaling forest health assessments at the individual tree level (e.g. crowns) and linking it with eco-physiological measurements of tree water stress



Thank you for you attention!

**Contact information:
julien.godfroy@ens-lyon.fr**

