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

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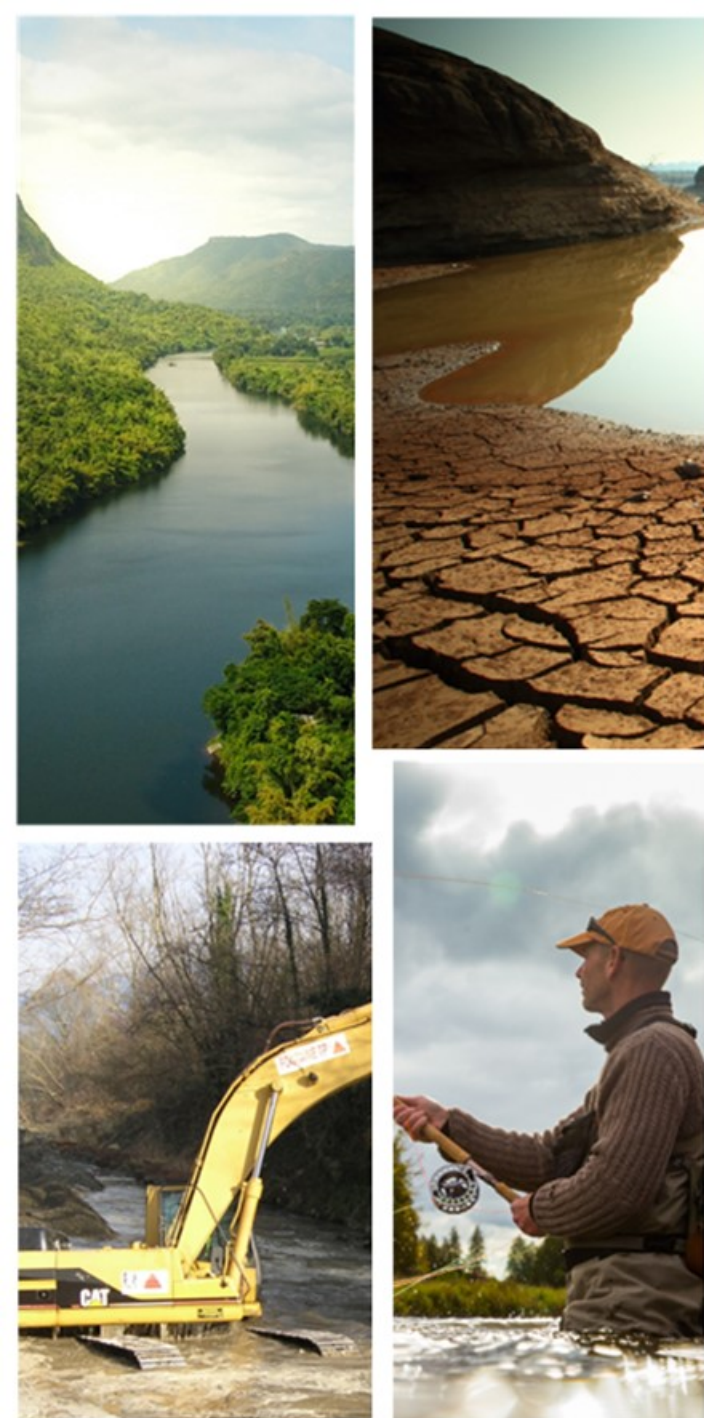
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Hyperspectral and LiDAR remote-sensing for monitoring channel bathymetry and the health of riparian forests : case study on the Ain River

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



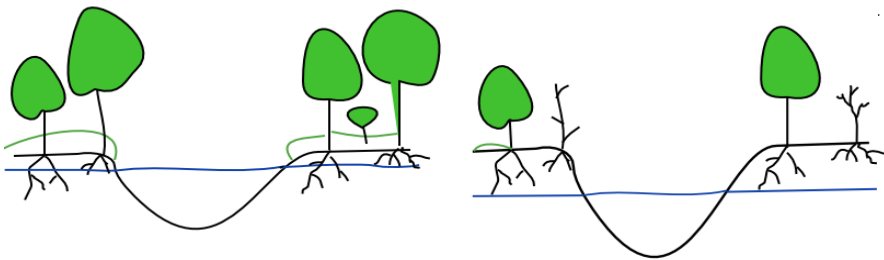
Study site, Context and Aims

- Lower Ain River Basin

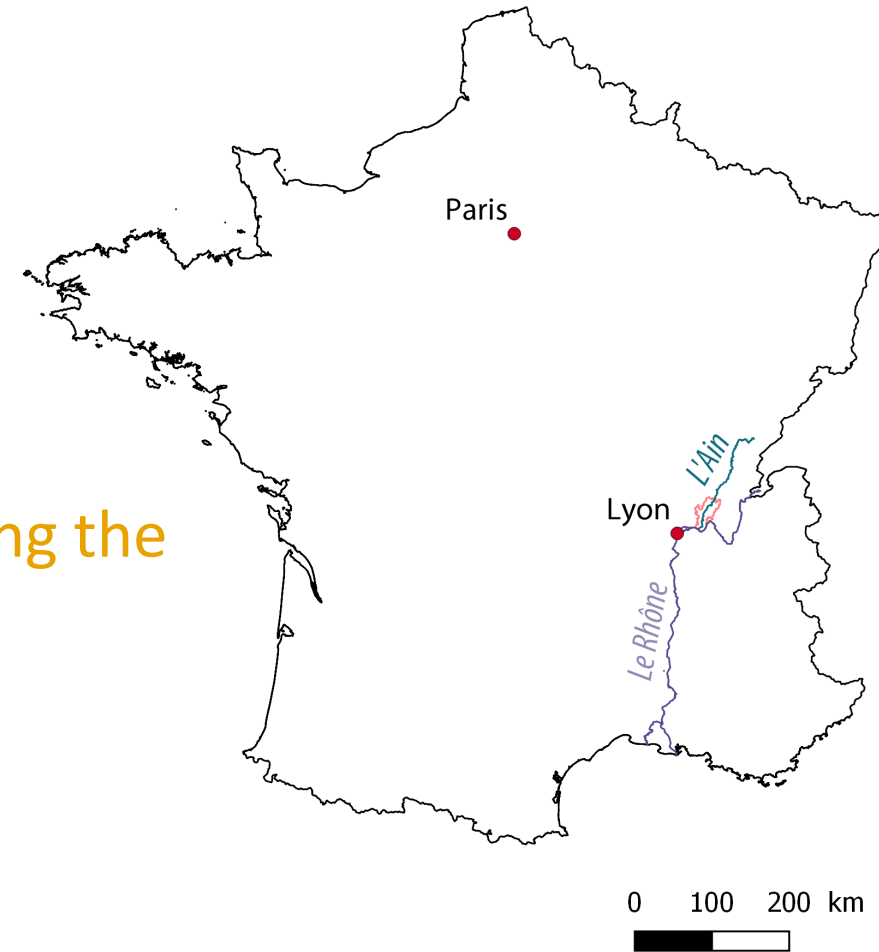
→ Downstream propagation of channel incision following damming

→ 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

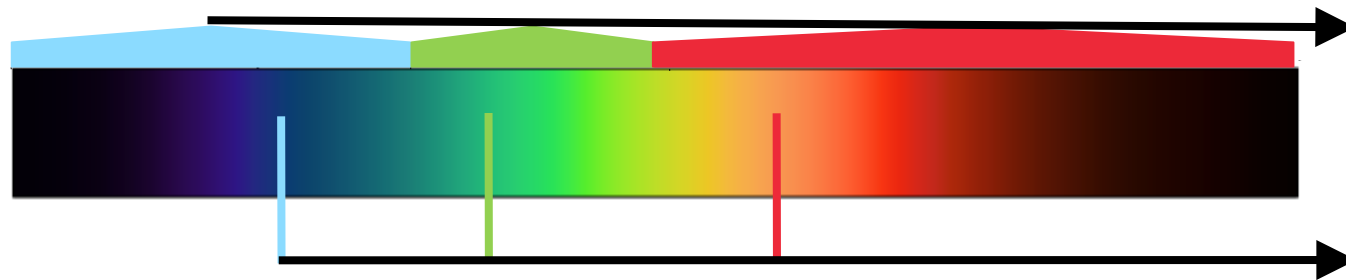


Channel incision limits access to groundwater

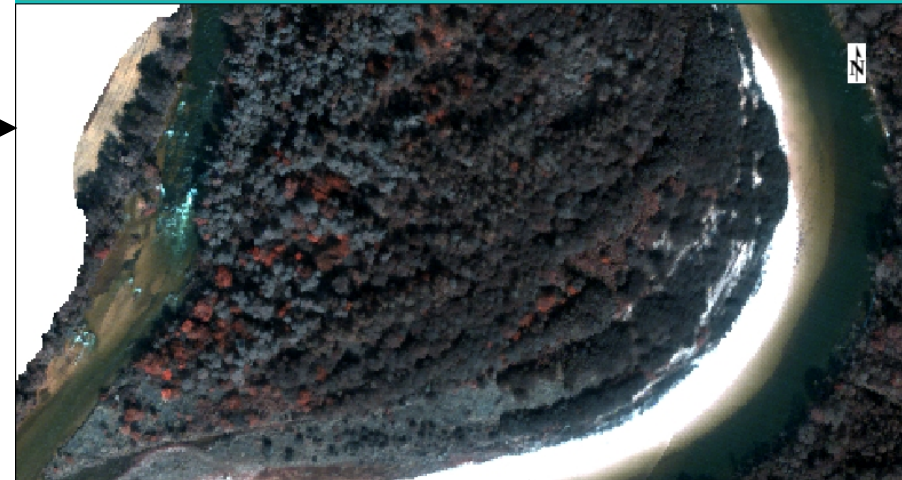


What is hyperspectral data?

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

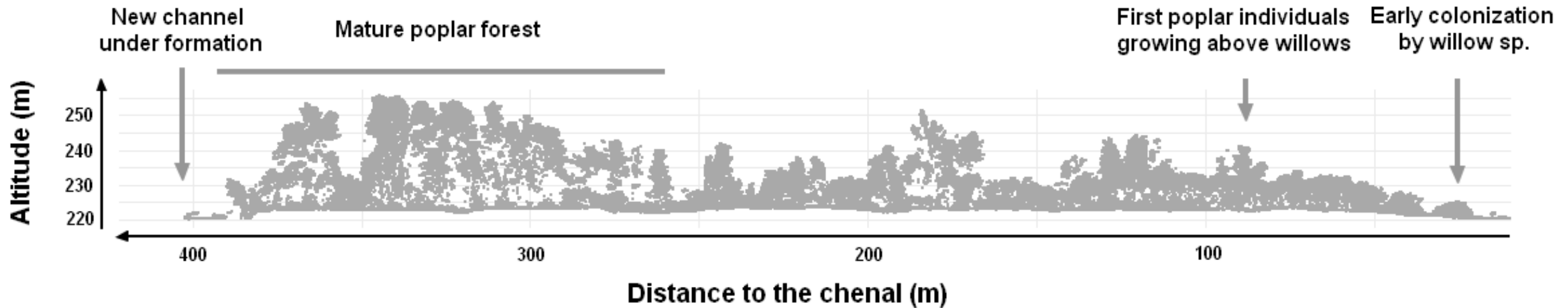


- Hyperspectral imaging :
→ Samples the spectra with a precision similar to lab spectroscopy



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

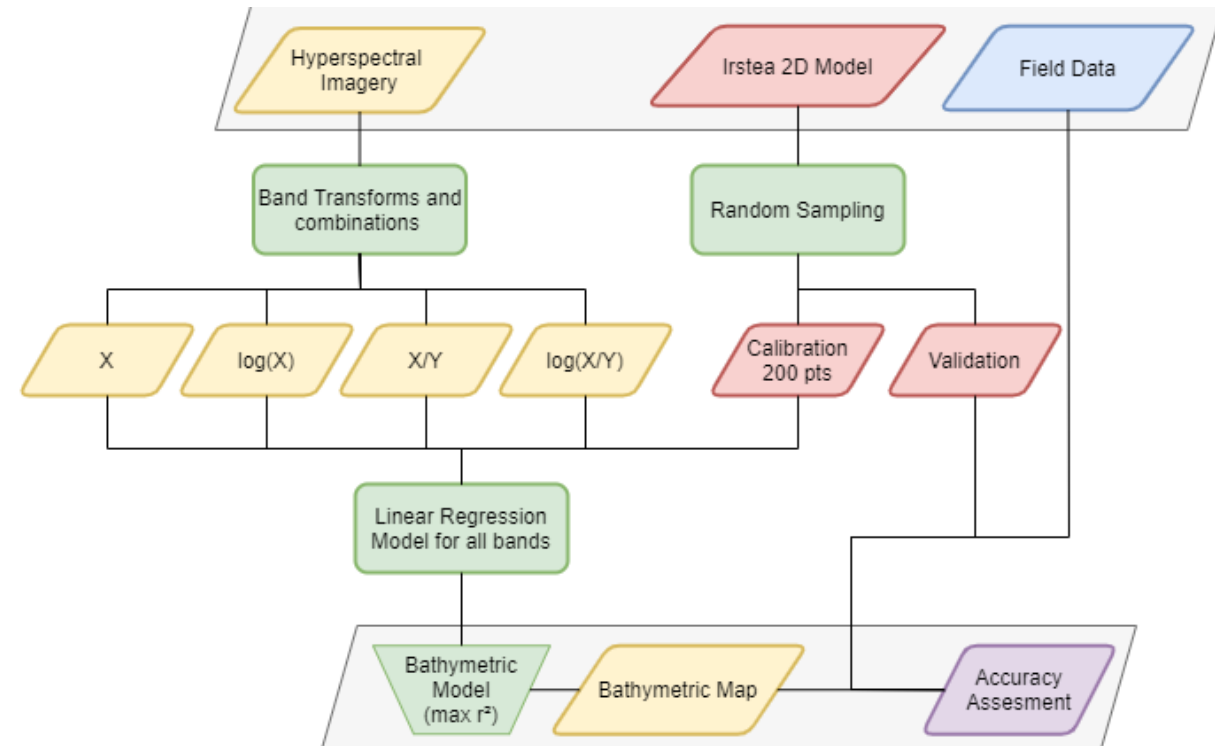
1°) Dimensionality increase

2°) Linear relationship

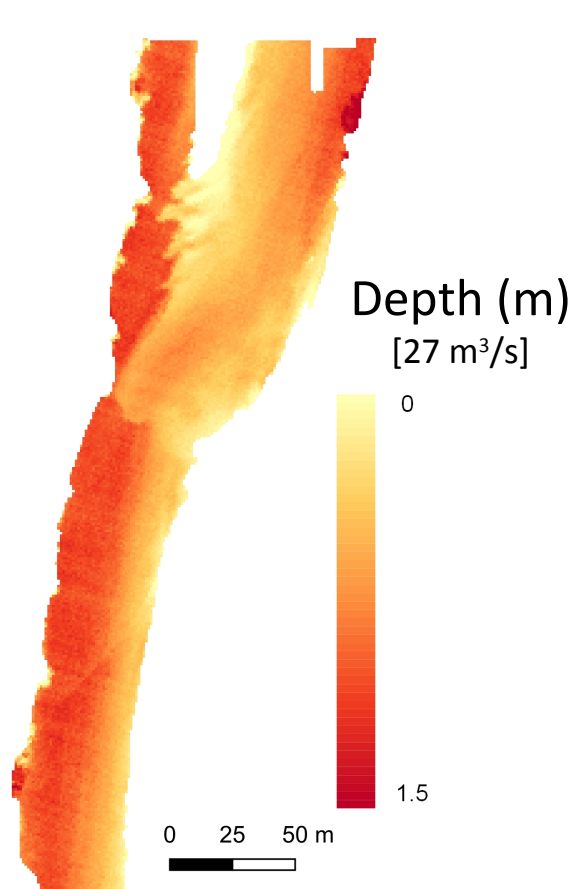
(for $Q=27$ and $Q=127$ m³/s)
depth = f(spectra)

3°) Accuracy assessment

2D model and field data



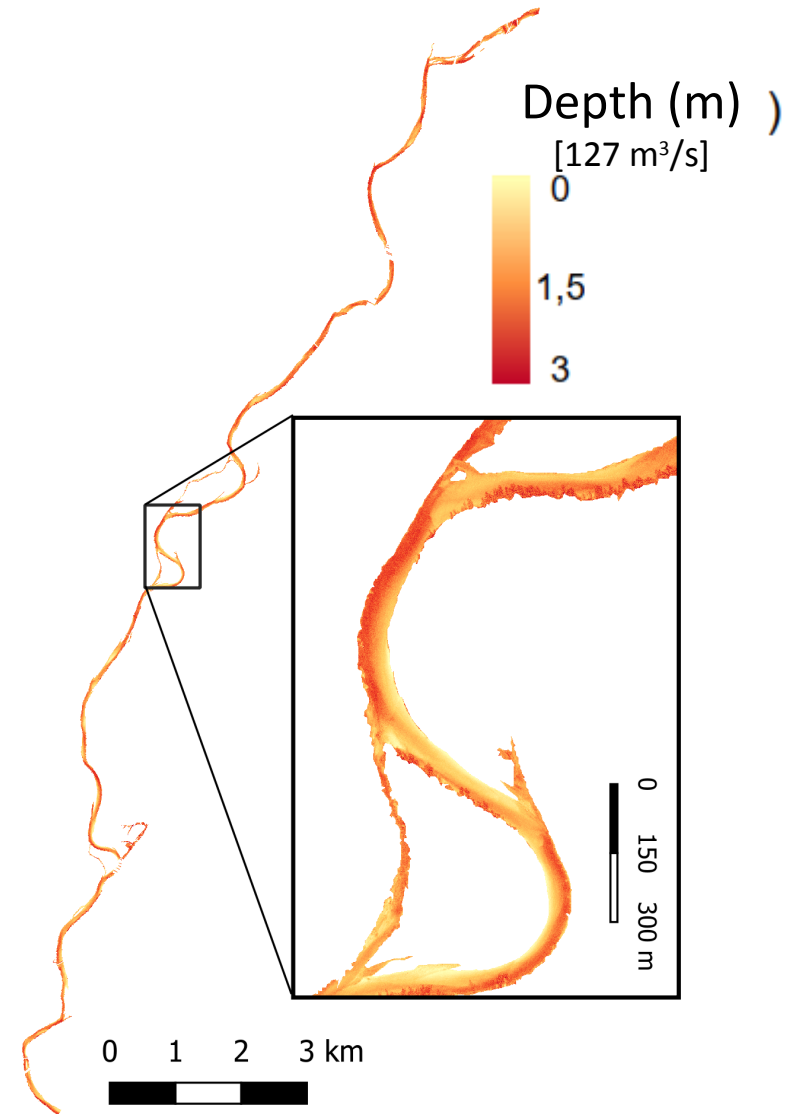
Bathymetric mapping



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:

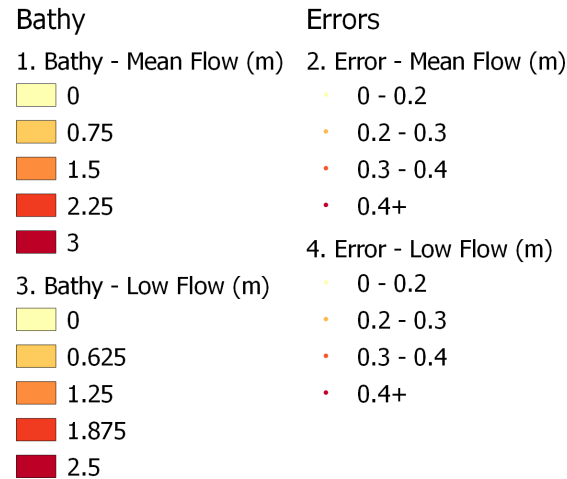
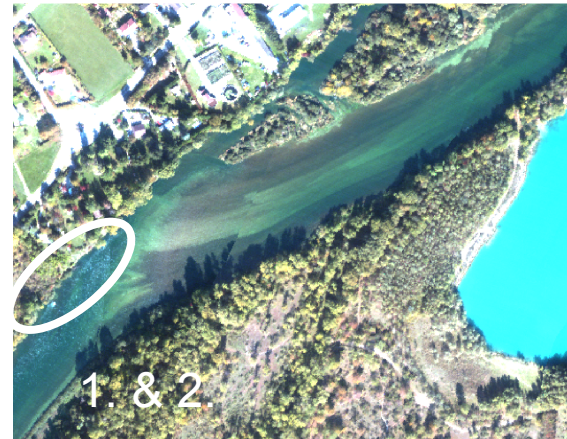
1) Pool areas (< 5% of the river reach)

2) Glint and turbulence

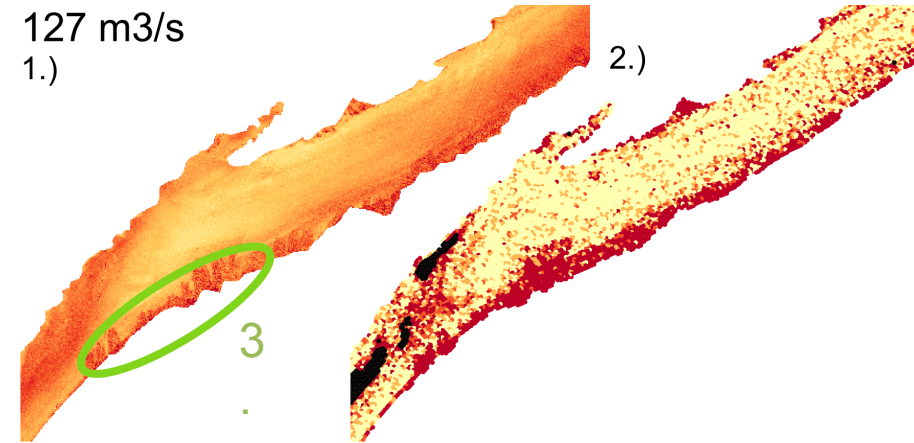
3) Vegetation shadows

4) Changes in riverbed or water column properties

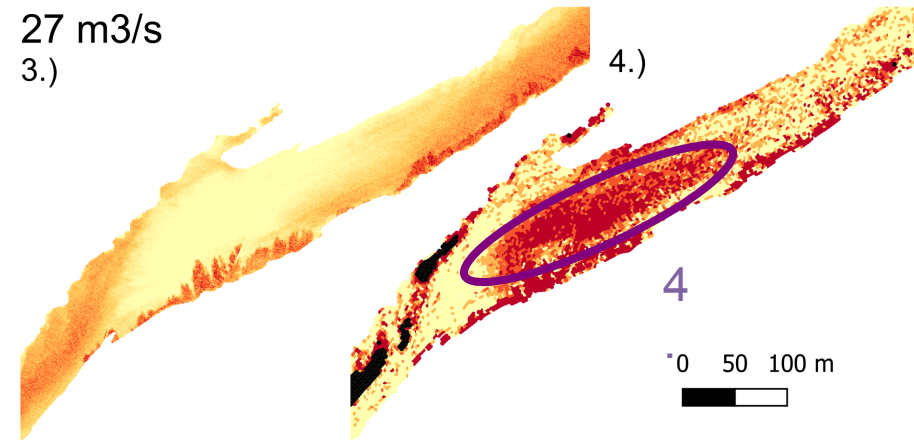
> Sensitivity is dependent on wavelength combination



127 m³/s
1.)



27 m³/s
3.)



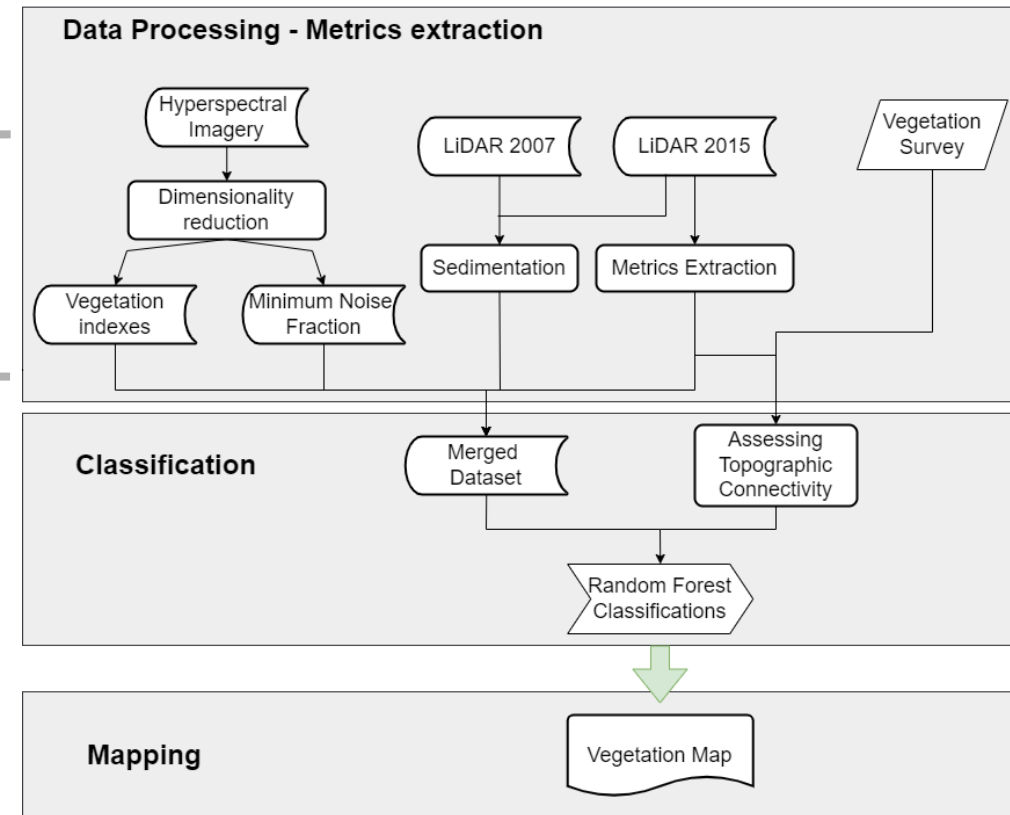
Methodology: riparian forest

Coupling the data with forestry surveys

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

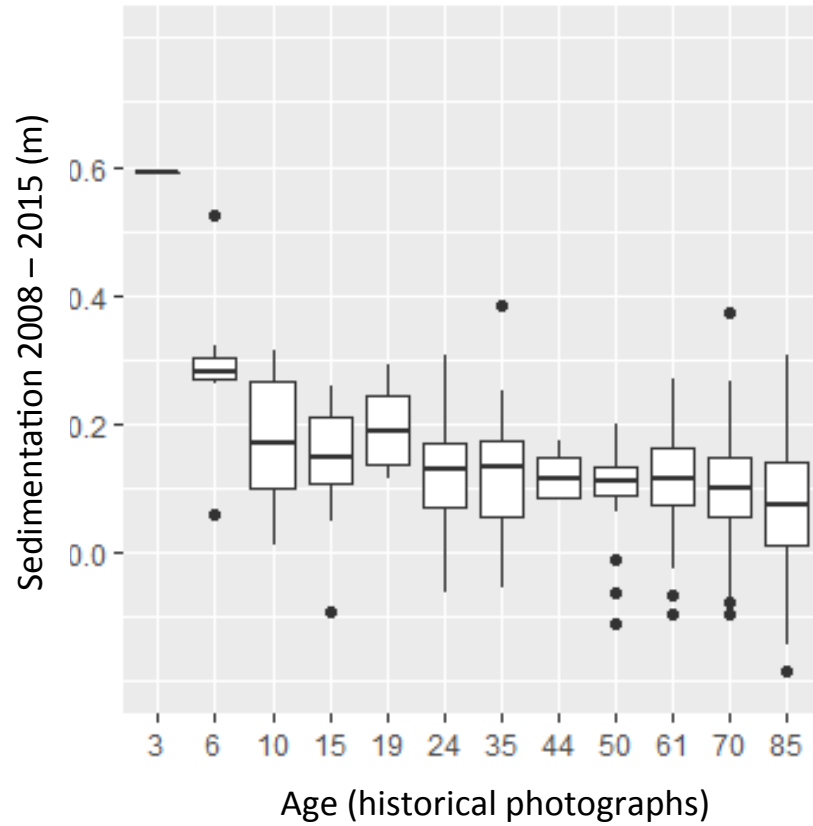
2°) Exploring vertical connectivity and its impact for a given age

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

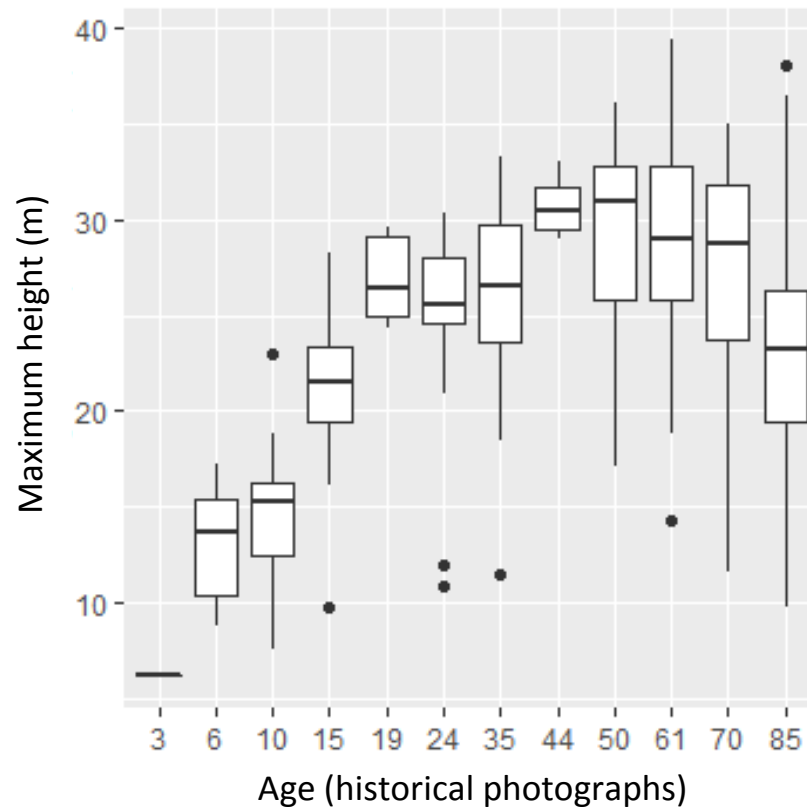


Age gradient

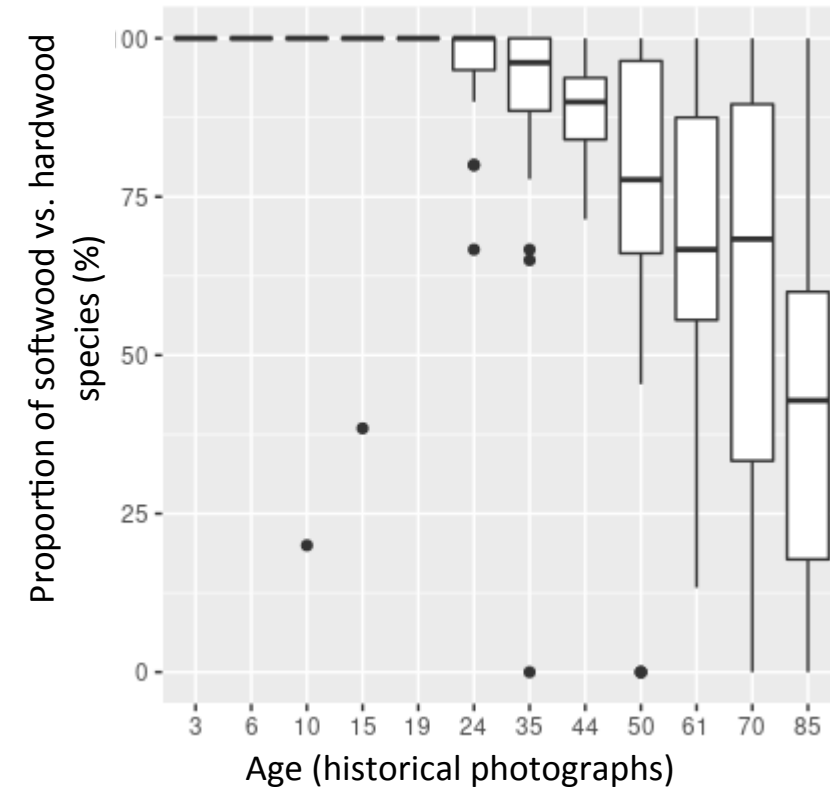
Drop in overbank sedimentation



Early stage growth

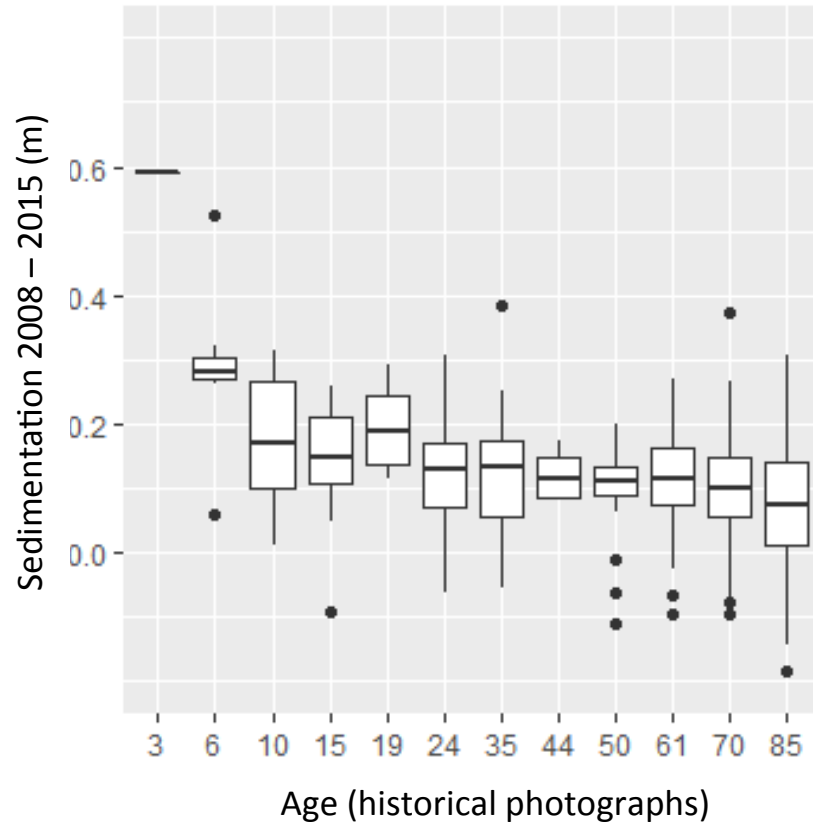


Post-pioneer species substitution

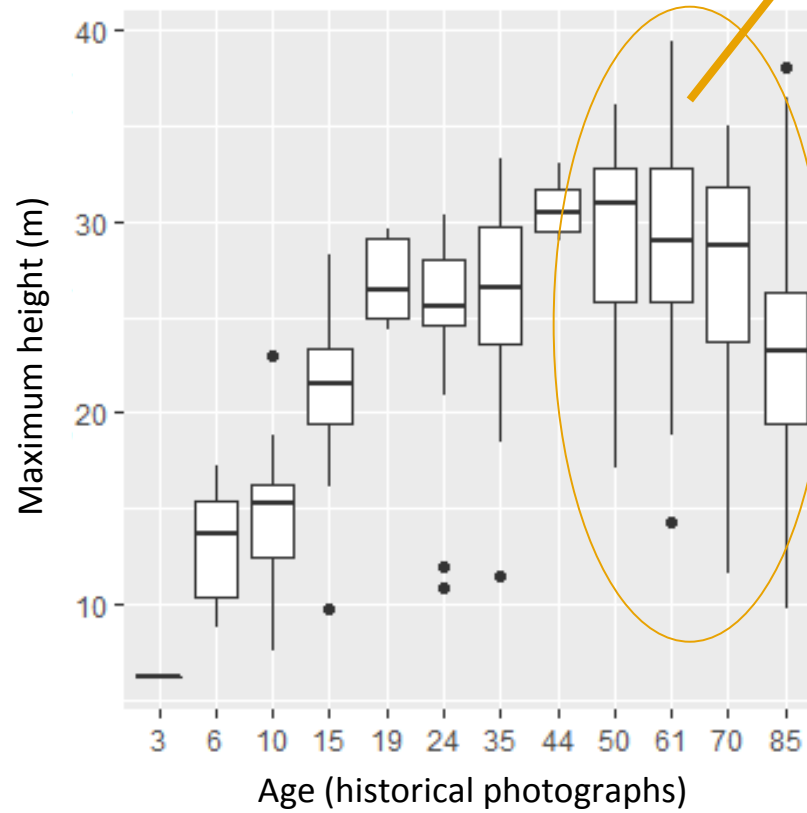


Age gradient

Drop in overbank sedimentation

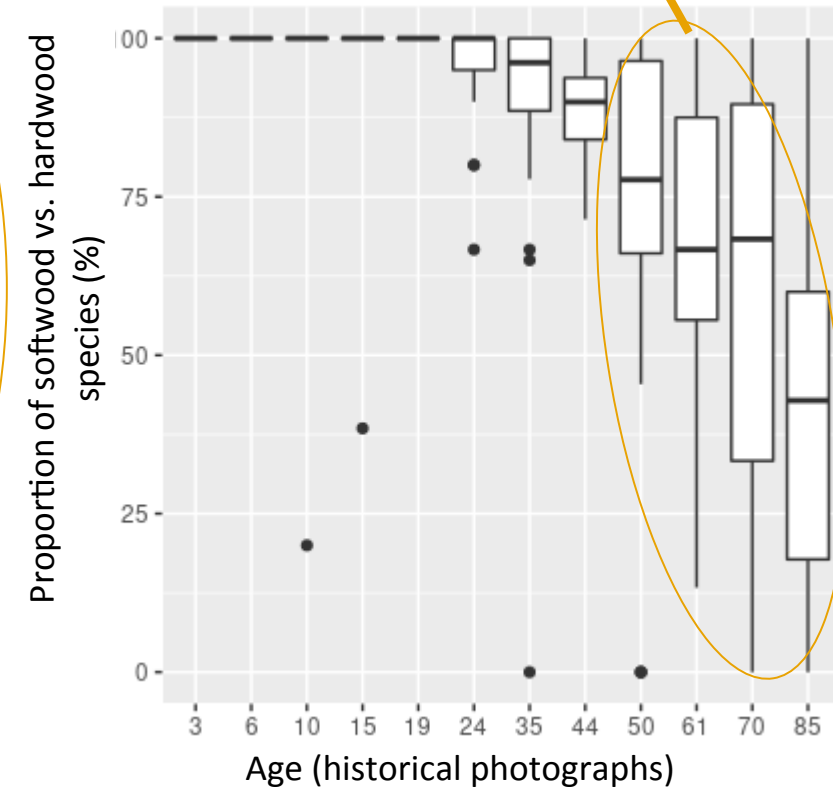


Early stage growth



High variability in old and mature forest plots

Post-pioneer species substitution

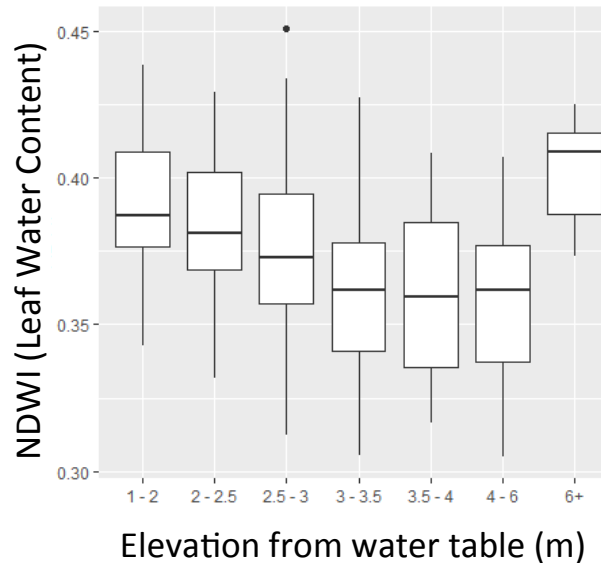


Vertical connectivity gradient

In 50+ y.o. forest plots

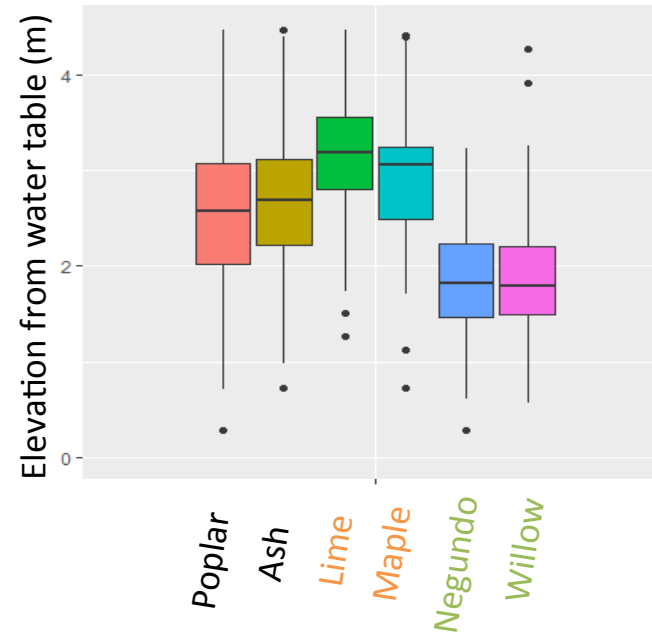
Drop in leaf water content

50+ y.o.

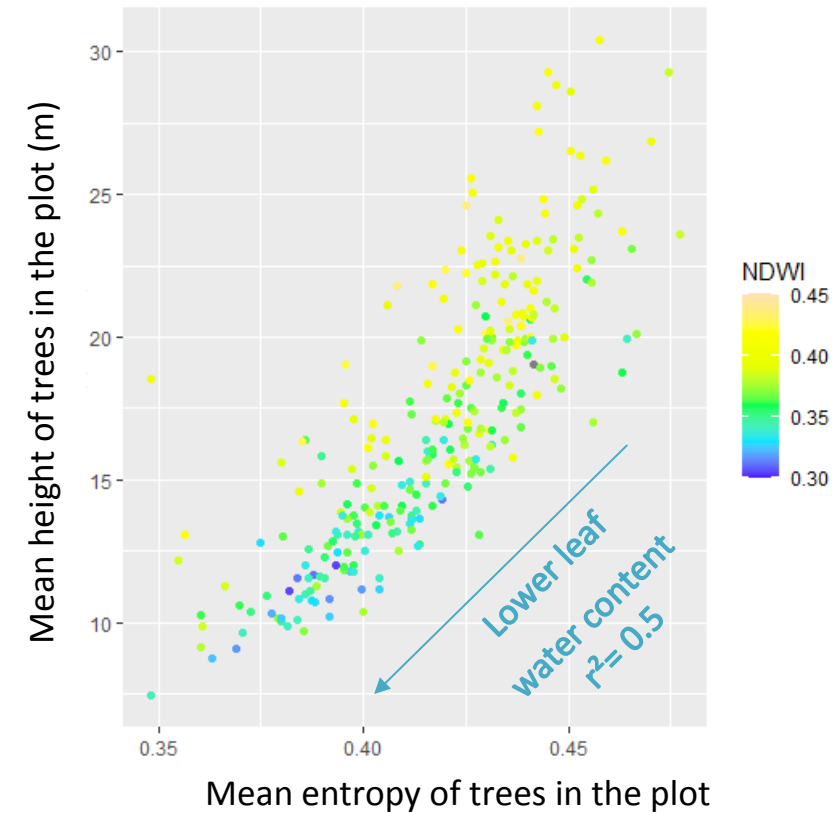


Changes in species composition

50+ y.o.



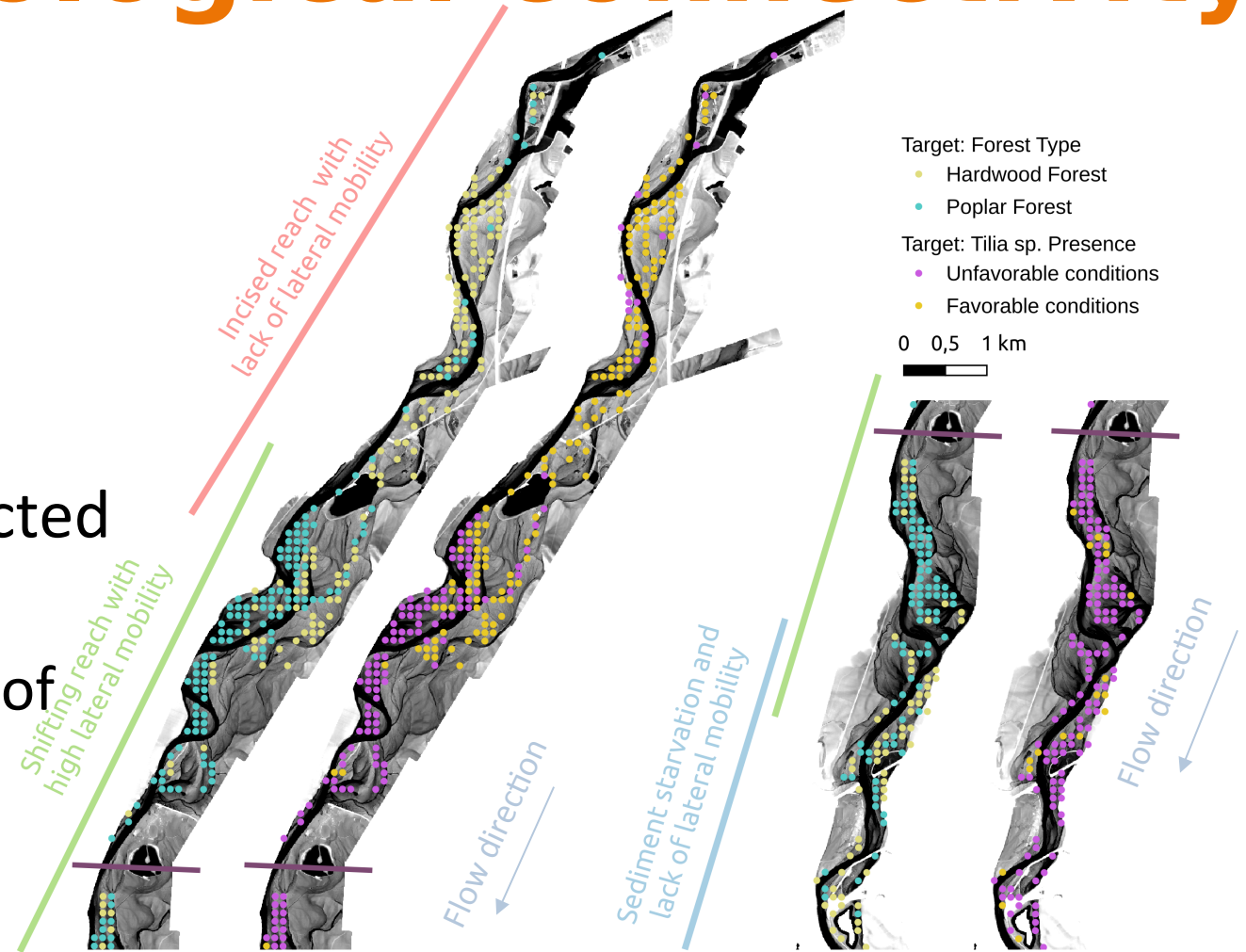
Structural changes



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!

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