Reach scale analysis of riparian vegetation interactions with fluvial morphology using UAV based laser scanning and multispectral imaging

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1. Context

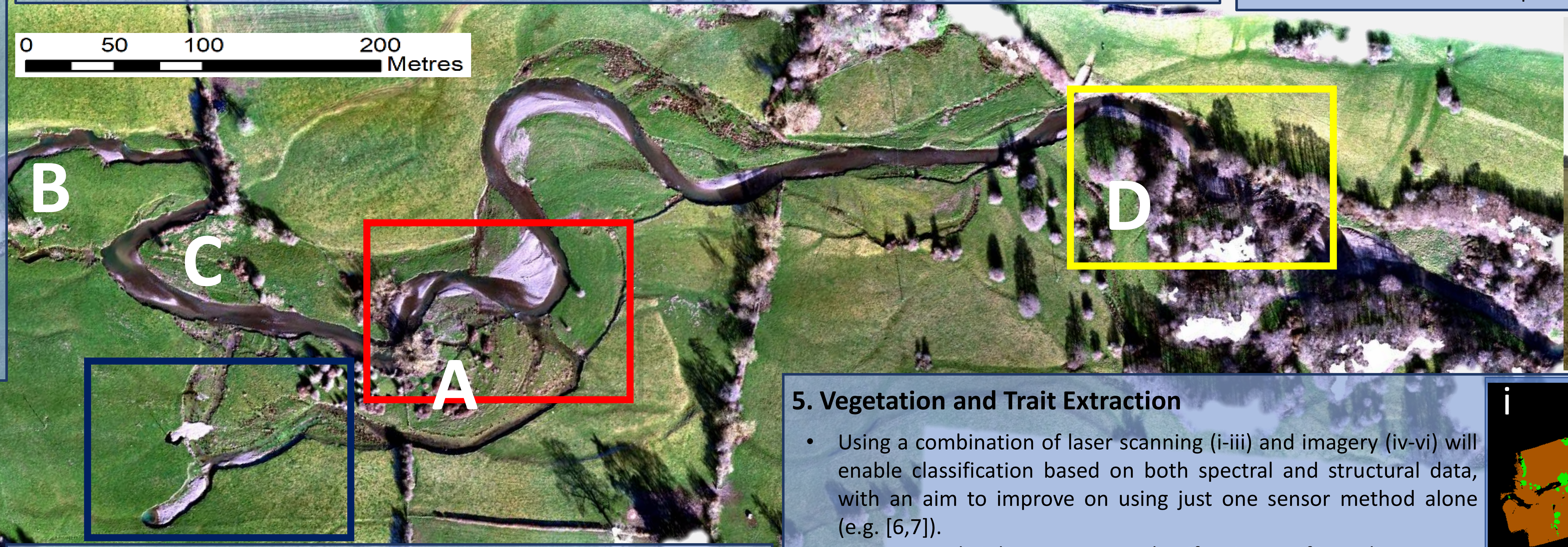
- **Vegetation** is a **critical** component of the river corridor, influencing flow, stabilizing banks, and contributing to roughness, whilst being essential components for river management and restoration schemes [1].
- **Functional traits** measure plant morphology, physiology, and phenology. These provide a scalable method to assess the influence of fluvial vegetation on morphology across riparian ecosystems [2]. Research has investigated the response of traits to environmental conditions within the river corridor, whereas the effects of traits are less well studied. Such effect traits have been highlighted within the literature [3,4], but measuring these across scales is challenging.
- **Remote Sensing** offers the potential to collect environmental data at rapidly increasing spatial resolution and coverage [5]. However, most methods are not adequate for reach scale analysis of riparian vegetation. This research aims to overcome these issues to provide further insight in to eco-geomorphology.

Headlines

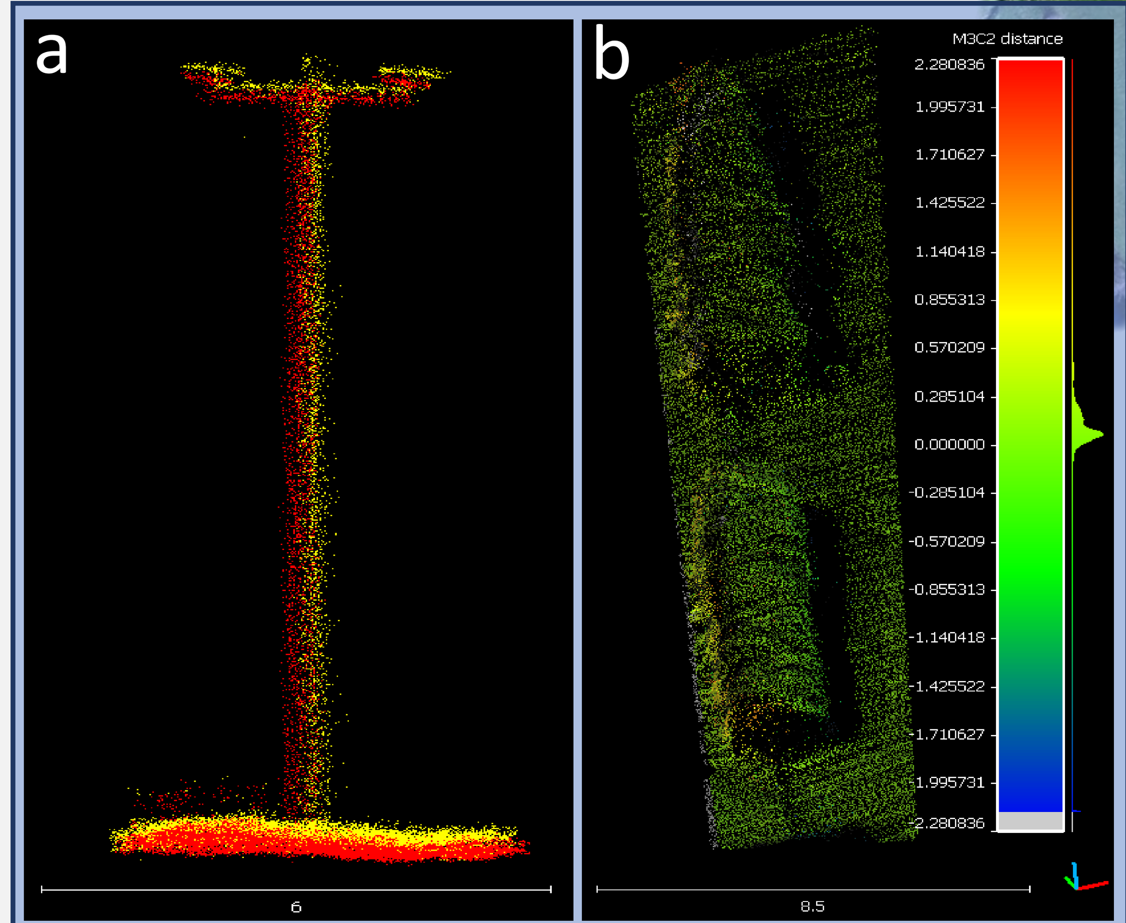
- Collect **hydrologically relevant** plant trait data
- Assess the **complexity-coverage trade off** in collecting trait data
- Examine links between the presence of **traits** and **geomorphic form**

2. Methods

- The study site is a 1 km reach of the upper River Teme, UK. The reach has a flashy response to rainfall, is mobile, with sparse and dense vegetation coverage.
- Use of a DJI Inspire 2 with a modified GNSS unit for PPK direct georeferencing from an RGB camera for structure from motion methods.
- A DJI Matrice 600 with a laser scanner (VLP-16), a multispectral camera (RedEdge-MX), and an on board motion and positioning sensor (APX-15 UAV) is used for point cloud analysis.

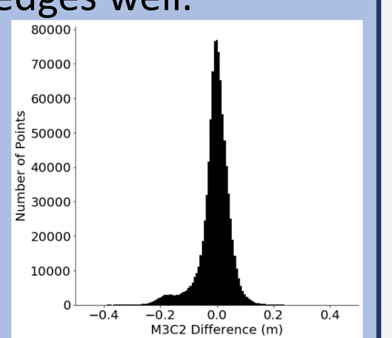


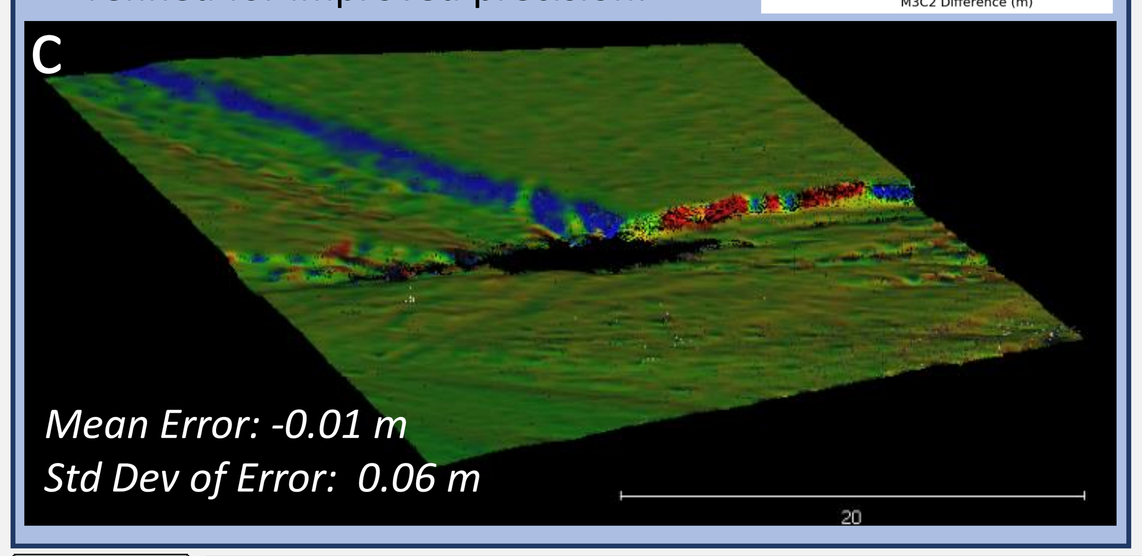
UAV based laser scanning and multispectral set up



3. Laser Scanning Accuracy

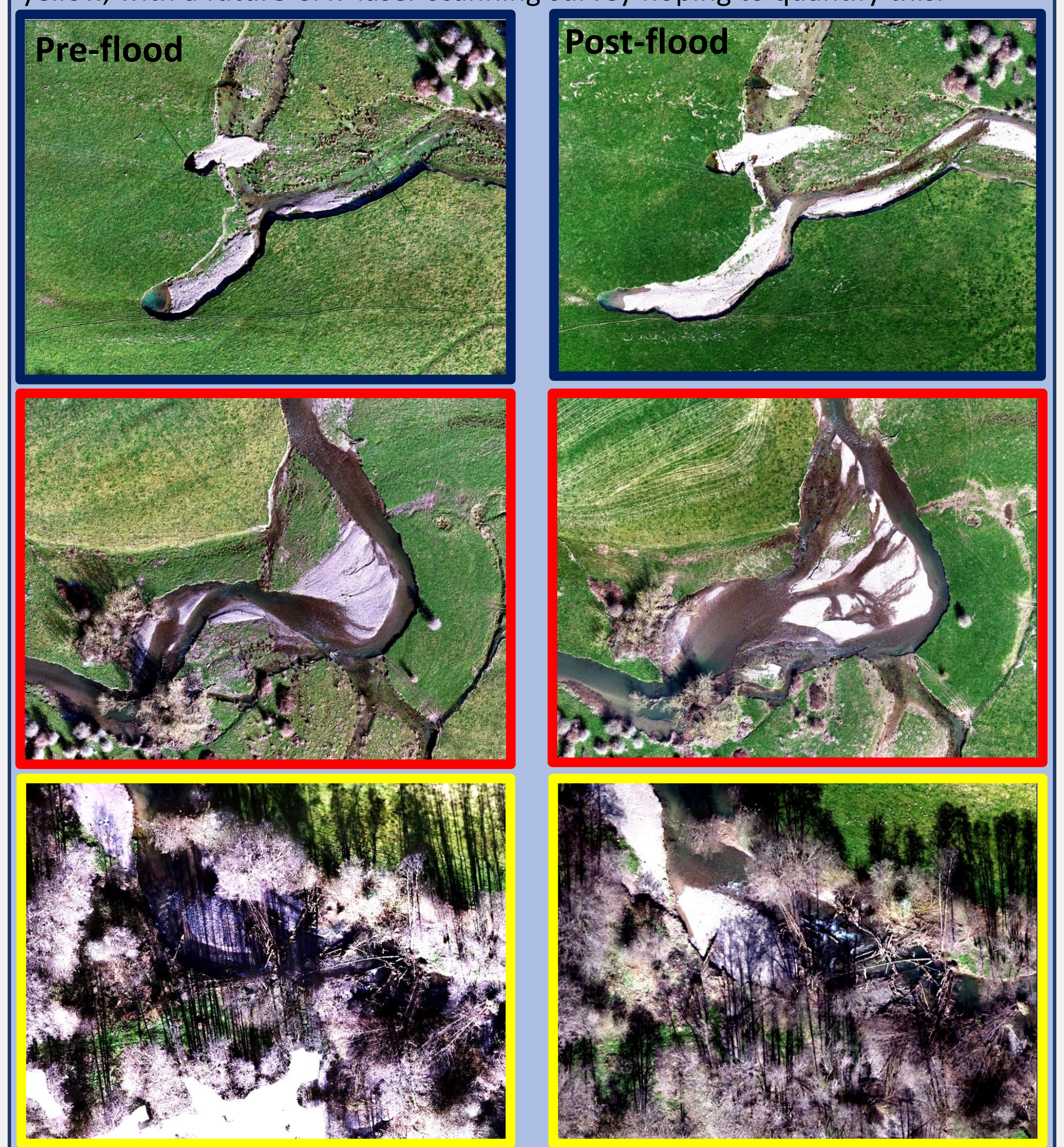
- The laser scan data appears to be consistent between surveys based on analysis of static/consistent objects (pylons in *a*, hedgerow in *b*), although a full accuracy assessment is yet to be undertaken in the field.
- The hedgerow differencing shows the majority of points align within 15 – 20 cm of each other. The error appears to be consistent, and it picks up the edges well.
- Across a larger area of bank and bar (*c*), the two separate surveys align well. The greatest uncertainty is around the banks, which may be reduced when the initial offsets are refined for improved precision.





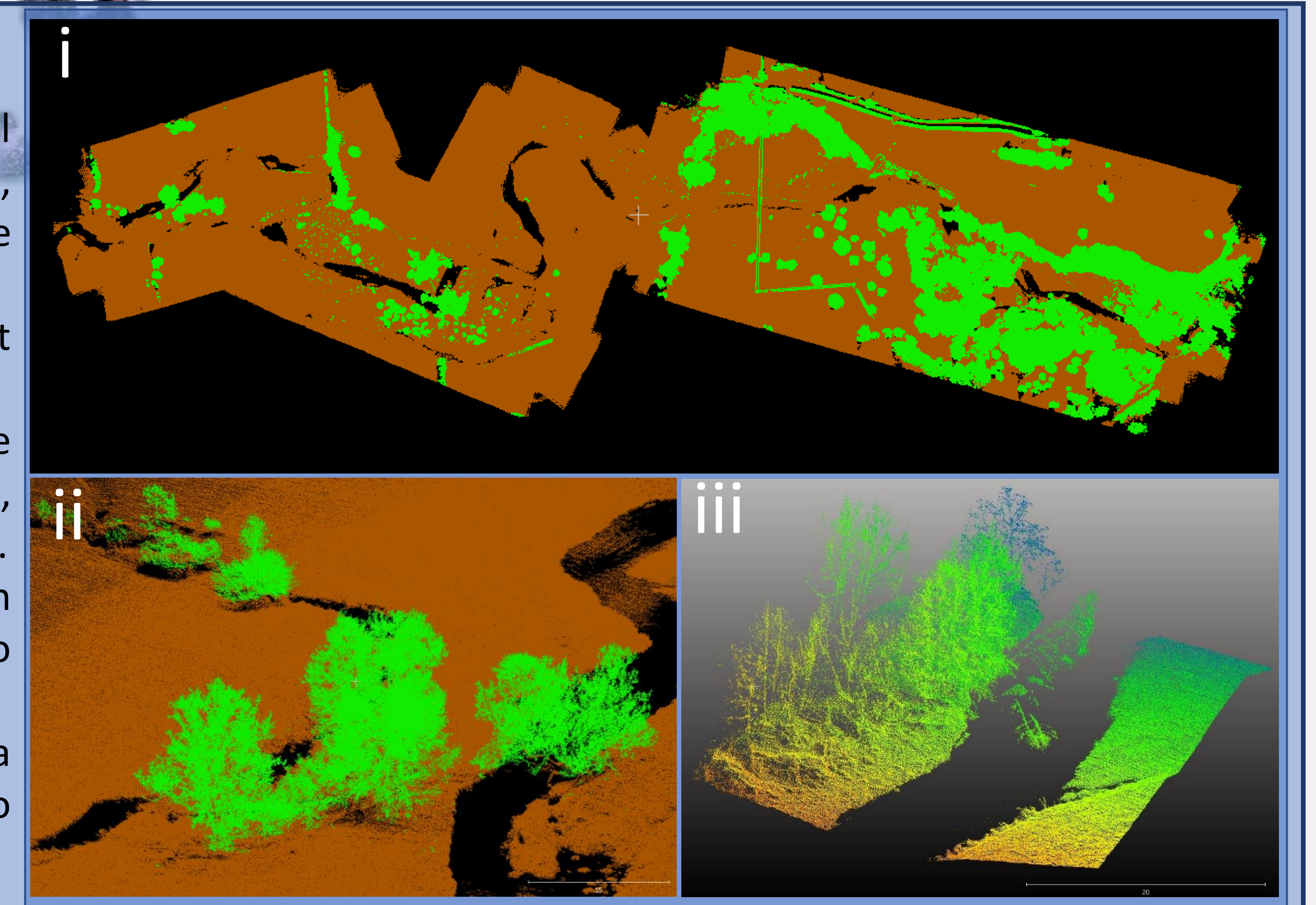
4. Morphological Change –

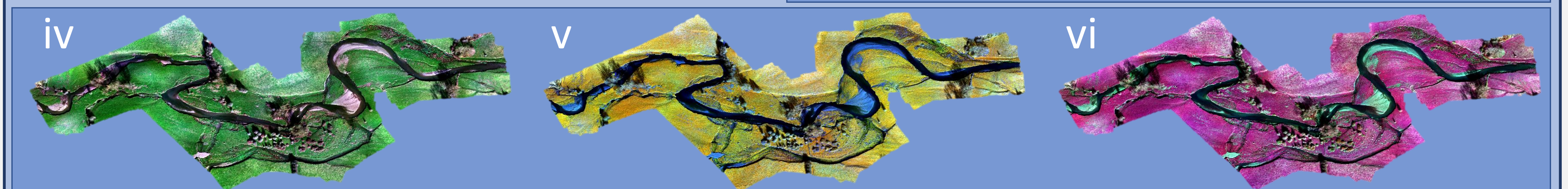
Changes in morphology are evident post a high flood event in February. Evidence of planform change across a bar (*red*) as well as continuing incision of new channels from overbank flow (*blue*). Evidence of pre-existing woody debris trapping more wood can be seen in yellow, with a future UAV laser scanning survey hoping to quantify this.



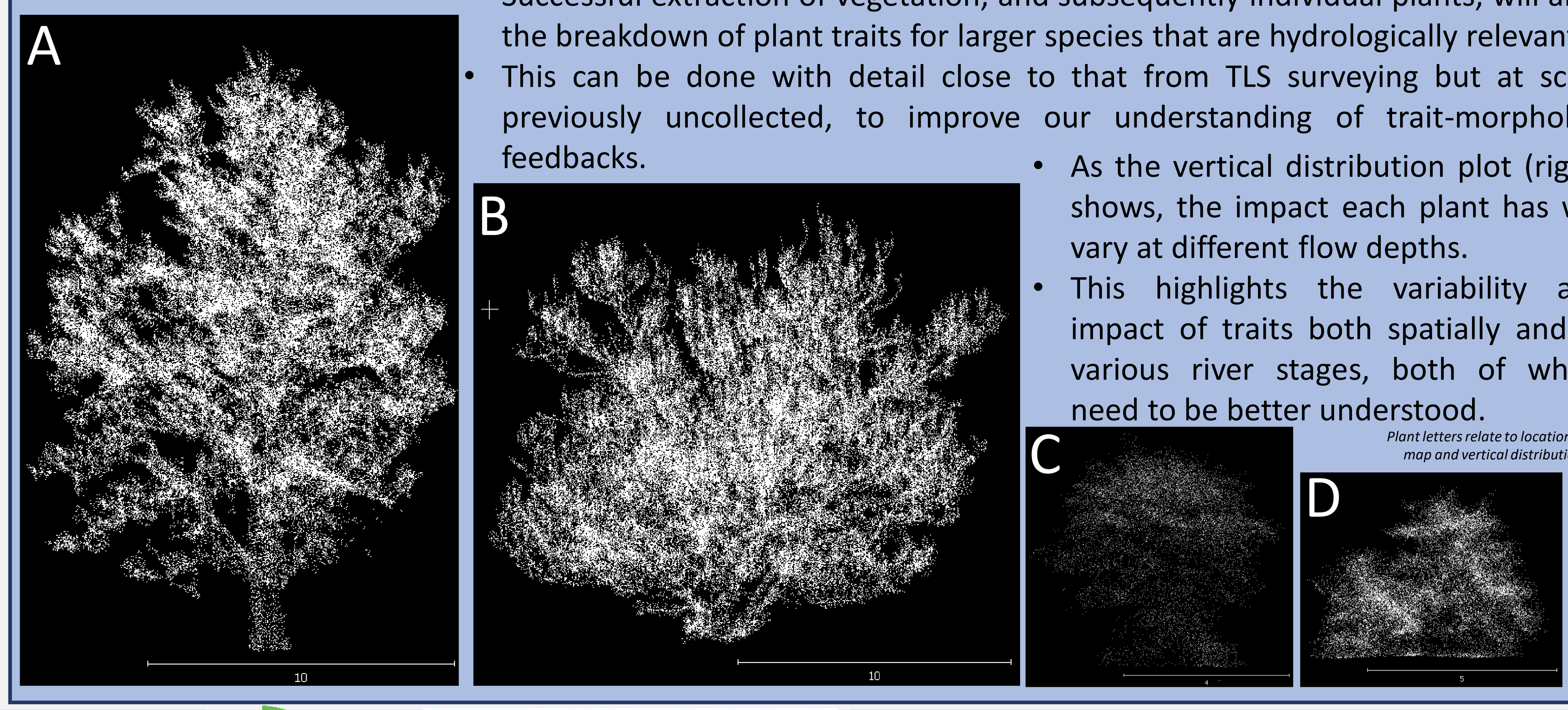
5. Vegetation and Trait Extraction

- Using a combination of laser scanning (i-iii) and imagery (iv-vi) will enable classification based on both spectral and structural data, with an aim to improve on using just one sensor method alone (e.g. [6,7]).
- Images *i* and *ii* demonstrate a classification performed to extract large vegetation to be used for trait extraction.
- Images *iv – vi* demonstrate an RGB orthomosaic, and two false colour composites using the red edge and near infra-red bands, highlighting the differences in land cover and geomorphic features.
- By using a combination of these methods, woody debris dams can both be identified (i.e. in the yellow box) and there is potential to quantify their size and porosity (e.g. Image *iii*).
- Using the multispectral imagery will enhance seasonal data collection, especially through infra-red data which can be used to investigate plant health and phenology [8].

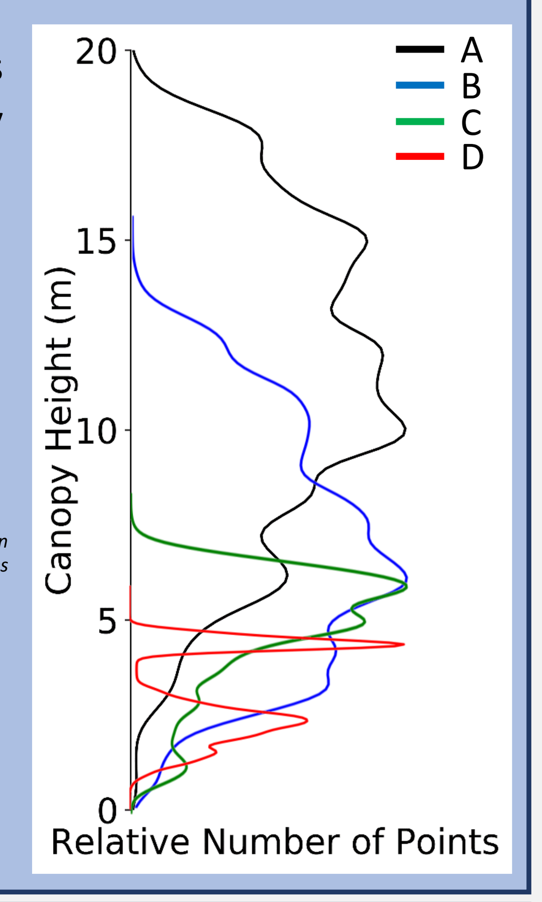




- Successful extraction of vegetation, and subsequently individual plants, will allow the breakdown of plant traits for larger species that are hydrologically relevant.
- This can be done with detail close to that from TLS surveying but at scales previously uncollected, to improve our understanding of trait-morphology feedbacks.
- As the vertical distribution plot (right) shows, the impact each plant has will vary at different flow depths.
- This highlights the variability and impact of traits both spatially and at various river stages, both of which need to be better understood.



Plant letters relate to location on main map and vertical distribution curves



6. References: **[1]** Wilson, C., et al. (2003) 10.1061/(ASCE)0733-9429(2003)129:11(847) **[2]** Naiman, R. *et al.* (2005) https://doi.org/10.1007/0-387-24091-8_14 **[3]** O'Hare, M., et al. (2016) https://doi.org/10.1002/rra.2940 **[4]** Diehl, R. M., et al. (2017) 10.1093/biosci/bix080 **[5]** Tomsett, C. and J. Leyland (2019) 10.1002/rra.3479 **[6]** Arroyo, L. A., et al. (2010) 10.1016/j.foreco.2009.11.018 **[7]** Michez, A., et al. (2017) 10.1016/j.jenvman.2017.02.034 **[8]** Wen, L., et al. (2012) 10.1016/j.ecolmodel.2012.05.018

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EPSRC Engineering and Physical Sciences Research Council
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