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UAV monitoring of urban stream restoration sustainability

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High-resolution imaging using unmanned aerial vehicles (UAV, UAS, drones) opened up in the last decade a new potential for a detailed, reliable, operable, and affordable approach for riverscape monitoring. Based on the experience with the pilot research on UAV detection of fluvial dynamics on natural and modified streams, we have proposed a framework for the assessment of the sustainability of stream restoration projects based on UAV imaging and photogrammetry. The approach focuses on aspects where the high-resolution UAV imagery can bring reliable and quantitative information, applicable for assessing restoration success and incorporation into standard assessment schemes.

We distinguish four critical aspects of stream restorations, where the UAV monitoring can provide reliable quantitative information, applicable for assessment of stream restoration success or failure: (i) Restoration effect, (ii) Dynamics of fluvial processes, (iii) Hydrological connectivity, and (iv) Riparian vegetation. For each aspect, there are derived relevant indicators, allowing quantitative assessment and scoring.

We have tested the framework on the evaluation of restorations on three urban streams in the metropolitan area of Prague, Czech Republic, which were subject of revitalization in the past decade. We have maintained regular recurrent UAV monitoring campaigns of these streams over four years, which enabled tracking the restorations since their completion and identifying the positive aspects and the failures in the sustainability of the realized restoration projects.

UAV monitoring enabled to identify stream restoration features that would be hard or impossible to assess by other mapping techniques. As for the restoration effect, the UAV assessment revealed that although the basic goals of restoration projects were fulfilled, the newly shaped stream patterns significantly differ from the approved restoration plans. The restored channels are typically less complex and featuring simpler geometry than planned. Multitemporal assessment enabled to track stream instability and to measure the extent of bank erosion. UAV monitoring over a low flow period enabled to identify the stream segments where the inappropriate channel transformation led to disruptions in hydrological connectivity, and to detect and measure the extent of eutrophication in the stream and the newly created shallow ponds. UAV monitoring also enabled tracking the progress of vegetation succession after the restoration and quantitatively assessing the extent of riparian shading as a substantial element of sustainability of stream restoration.

Despite the limitations stemming from the nature of optical sensing, UAV monitoring proved to be a highly efficient and reliable technique suitable for evaluating stream restoration projects with versatile applications even in the urban environment's specific conditions.