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Assessing surface flow pathway connectivity in semi-natural unimproved grasslands using structure from motion

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In addition to providing a valuable habitat, semi-natural unimproved grasslands may have significant value as part of natural flood management strategies. However, further understanding of the hydrological functioning of these landscapes is required and this study is developing new methods for using proximal remote sensing techniques to assess surface flow pathway connectivity.

Purple moor grass (*Molinia caerulea*) dominated fields are seasonally saturated and have a dense tussock structure, hypothesised to result in long surface flow pathways with low hydrological connectivity and greater surface roughness than neighbouring intensively managed improved grassland. Quantifying these surface flow pathways required fine-scale understanding of topography not available from available datasets such as airborne LiDAR. After prescribed burning (a local management practice) at a study site in South West England, the underlying *M. caerulea* tussock structure and flow pathways were exposed. A DJI Mavic Air quadcopter was flown over the *M. caerulea* field shortly after to capture this structure. A neighbouring improved grassland field of similar size and slope was also surveyed.

Drone surveys were carried out using an automated flight path over an area of 1.7ha of *M. caerulea* and 2.2 ha of improved grassland. Imagery was captured with an overlap/sidelap of 85% and with a ground sampling distance of 25m. Ground control points were geolocated, using a GNSS with an accuracy of ~0.03m to constrain subsequent structure from motion (SFM) photogrammetry processing.

SFM was used to create dense point clouds, from which digital surface models (DSM) of the two sites were derived at a resolution of 0.03m. The standard deviation of points within each DSM grid cell was also calculated to describe the uncertainty resulting from converting point cloud data to raster. An automated classification method was developed, in R using the LidR package, to identify individual *M. caerulea* tussocks. The edges of tussocks were characterised by greater error due to the variability in topography and therefore could be used to identify tussock features.

The resulting DSMs were used to quantify surface flow pathway length in both sites using the Arc

GIS flow routing algorithm. This included flow pathway length and drainage density (length of flow path per unit area). *M. caerulea* had longer, more sinuous surface flow pathways through the dense tussocks, with an average drainage density of 2.54m m^{-2}. This was significantly greater than drainage density in the improved field (1.82m m^{-2}). Flow pathways in the improved grassland were straighter and more in-line with the slope in comparison. Longer, tenuous surface flow pathways in *M. caerulea* sites theoretically result in a slower velocity of surface runoff, reduced soil erosion, greater evapotranspiration and root uptake than improved grassland sites. It is proposed that this understanding will be incorporated into hydrological modelling to improve understanding of the hydrological functioning and possible natural flood management potential of these landscapes.