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Terrestrial Laser Scanning of Peatland Surface Morphology for Eco-Hydrological Applications

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BACKGROUND: Ombrotrophic (rain-fed) lowland raised bogs are scarce habitats with high conservation importance in Europe. A reproducible measurement technique which is capable of capturing the spatial patterning of vegetation and surface topography is important in peatlands because structure is linked to ecological function, hydrology, biodiversity and carbon sequestration. Little attention has been given in the literature to the potential capabilities of active remote sensing systems such as LiDAR for monitoring peatland status, despite the clear opportunity posed by adopting a structurally-focused approach.

APPROACH: The research described in this paper set out to establish the information content of laser scanning data for peatland condition monitoring. Our approach was to use fine scale laser scan data acquired from a terrestrial laser scanner (TLS) so as to understand the data requirements for these types of application. We adopted a transect approach to sampling at the Wedholme Flow peatland site in Cumbria, UK. This is a lowland ombrotrophic peatland exhibiting a range of eco-hydrological condition types and was thus a suitable test-bed for the methodology. Seven sites located along a hydrological gradient were measured using TLS. A Leica HDS 3000 instrument, mounted on a tracked vehicle was used to survey the peatland surface from three viewpoints at each site, meaning that shadows cast by the plant canopy were in-filled during post-processing of the point cloud. Each site was also instrumented with hydrological dipwell recorders and assessed using detailed ecological surveys. Positional data from a differential GPS survey (collected simultaneously) were used to elucidate interpretation of spatial patterns in the TLS data.

RESULTS: The results demonstrate the capabilities of TLS for describing peatland microtopography and vegetation canopy characteristics at a fine spatial scale (cm resolution over 10 m spatial extent). Geostatistical analyses of the laser point clouds permitted measurement of the typical grain sizes of peatland structures, and allowed us to capture the texture and length-scale of hummock-hollow topography, shrub canopy and peatland morphological features. Results demonstrate, for the first time, the advantages of laser scanning methodologies for rapid measurement of 3-dimensional vegetation canopy structure and surface microtopography, at fine spatial scales, in short vegetation. We demonstrate how adoption of such approaches can provide quantitative, spatial data for description of peatland structure, which is inherently linked to eco-hydrological function.

SUMMARY OF KEY FINDINGS:
Specifically, our results show:

(a) The spatial scale (grain size) of vegetation patterning and microtopography in peatland systems. We demonstrate that intact plots on the peat dome with hummock-hollow topography have a distinctive fine-scale isotropic pattern with a range of <1 m. drained plots, where hummock-hollow microtopes are reduced show lower semivariance at this lag.

(b) The optimal spatial resolution for surveying changes in vegetation pattern and structure on peatlands. The study suggests that scaling up the method proposed here to airborne LiDAR is plausible. Other work following this project has already investigated this potential and brief results will be shown.