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A TLS based model for assessing crown-level light microenvironments on forest stand productivity

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Terrestrial laser scanning (TLS) is quickly becoming an indispensable tool for quantifying individual tree and whole forest structure. In recent years, developments have been made in several areas, including tree segmentation from whole forest scans, quantitative structural model (QSM) reconstruction and leaf-wood separation (Åkerblom et al., 2017, Burt et al., 2019, Wang et al., 2020). One research area that could benefit greatly from a widespread use of TLS is that of functional-structural plant models (FSPMs), which simulate both the structure and function of plants. In FSPMs, the structural component of these models is usually derived using theoretical methods that reproduce remarkably realistic tree forms (Perttunen and Sievänen, 2005). However, it is often challenging to compare and validate these structural models with real trees, particularly those occurring in 'natural environments'.

TLS-derived structural models in FSPMs have the potential to uncover new insights into the role of tree architecture on physiological plant processes, particularly in how tree 3D shape influences resource capture. Here, we will assess the impact of light fluctuations in the crown on individual tree productivity, scaling up to the productivity of whole forest stands. We will outline a new generic method that bridges the gap between TLS data and FSPMs as well as introduce ways of utilising other remote sensing techniques to validate FSPM outputs. Firstly, we will produce individual tree QSMs from a whole forest point cloud. Secondly, we will simulate tree-by-tree productivity in the context of the original forest environment. Lastly, we will use drone and satellite imagery to validate the FSPM productivity outputs.

Explicit 3D tree structure is an often-overlooked component of vegetation modelling, despite the feedback process between form and productivity. We aim to highlight the role of light microenvironments within the crown and understand how uneven resource capture might extrapolate to whole forest estimates of productivity. We hope that this new method will encourage overlap of practice between researchers in this growing field and lead to further use of virtual plants in studies of tree evolution and ecology.

Citations:

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