

COMPARING BIOMASS ESTIMATION METHODOLOGIES FOR THE VALIDATION OF CARBON OFFSETS GENERATED FROM WOODLAND SCHEMES :- TRADITIONAL ASM VS. TLS AUGMENTED ASM



CARBON OFFSETS FROM WOODLAND PROJECTS

- The increase in Net-Zero pledges will result in a greater demand for Carbon Offsets to mitigate GHG emissions.
- Greater demand for offsets will lead to increased creation of projects that generate Carbon Offsets.
- One of the most widely used project types to generate carbon offsets is from woodland creation and management schemes.
- Accurate measurements of the total biomass and biomass growth of a woodland is imperative to ensuring integrity of the carbon offsetting mechanism.
- Significant overestimation of woodland biomass and carbon sequestration has the potential for this offset mechanism to cause a net-increase in emissions.
- Conversely, significant underestimation could result in lower revenue from offset creation and less financial incentive to implement a woodland creation scheme.



VALIDATING CARBON OFFSETS

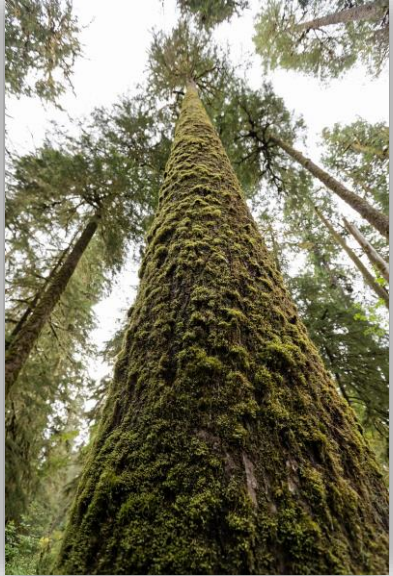
- Validation of carbon offsets generated by a woodland project relies upon a confident estimation of the total biomass in a forest.
- The most accurate method of determining the Biomass of a tree is through comprehensive destructive testing (*Clark, Kellner, 2012*).
Not suitable for validating certain Carbon Offset projects.
- Allometric Scaling Models (ASM) have been derived from destructive tests so that structural characteristics of a tree can be inferred from non-destructive measurements (*Roxburgh et al., 2015*)
- Current methodology¹ to calculate total biomass of a woodland for the purpose of validating carbon offsets in the UK uses an Allometric Scaling Model which relies on two primary inputs. From a sample of trees, measurements are taken of:-
 - 1) Tree heights, and
 - 2) Tree Diameters at Breast Height (DBH, taken 1.3m from ground level)

¹ UK Woodland Carbon Code (WCC)



PROBLEMS WITH ALLOMETRIC SCALING MODELS

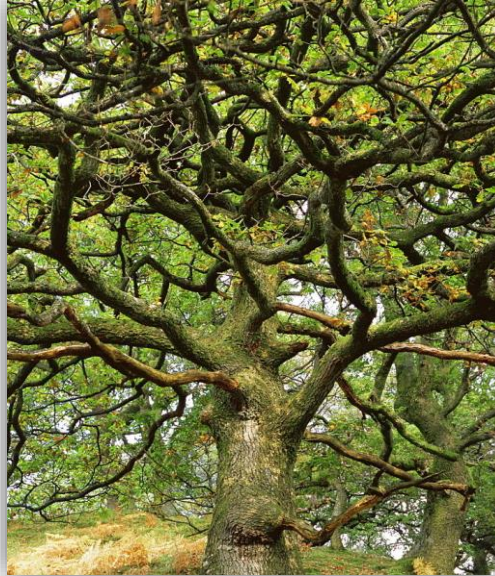
- These models can provide reasonably accurate biomass estimates for tree species that have comparably simpler, uniform structures (*Demol et al., 2021*), for example;
 - Sitka Spruce (*Picea sitchensis*)
 - Douglas Fir (*Pseudotsuga menziesii*)
 - Silver Birch (*Betula pendula*)
- ASM is less reliable at accurately calculating the biomass of more structurally complex species (*Demol et al., 2021*), for example;
 - Sessile Oak (*Quercus petraea*)
 - Common Beech (*Fagus Sylvatica*)



Sitka Spruce



Douglas Fir



Sessile Oak



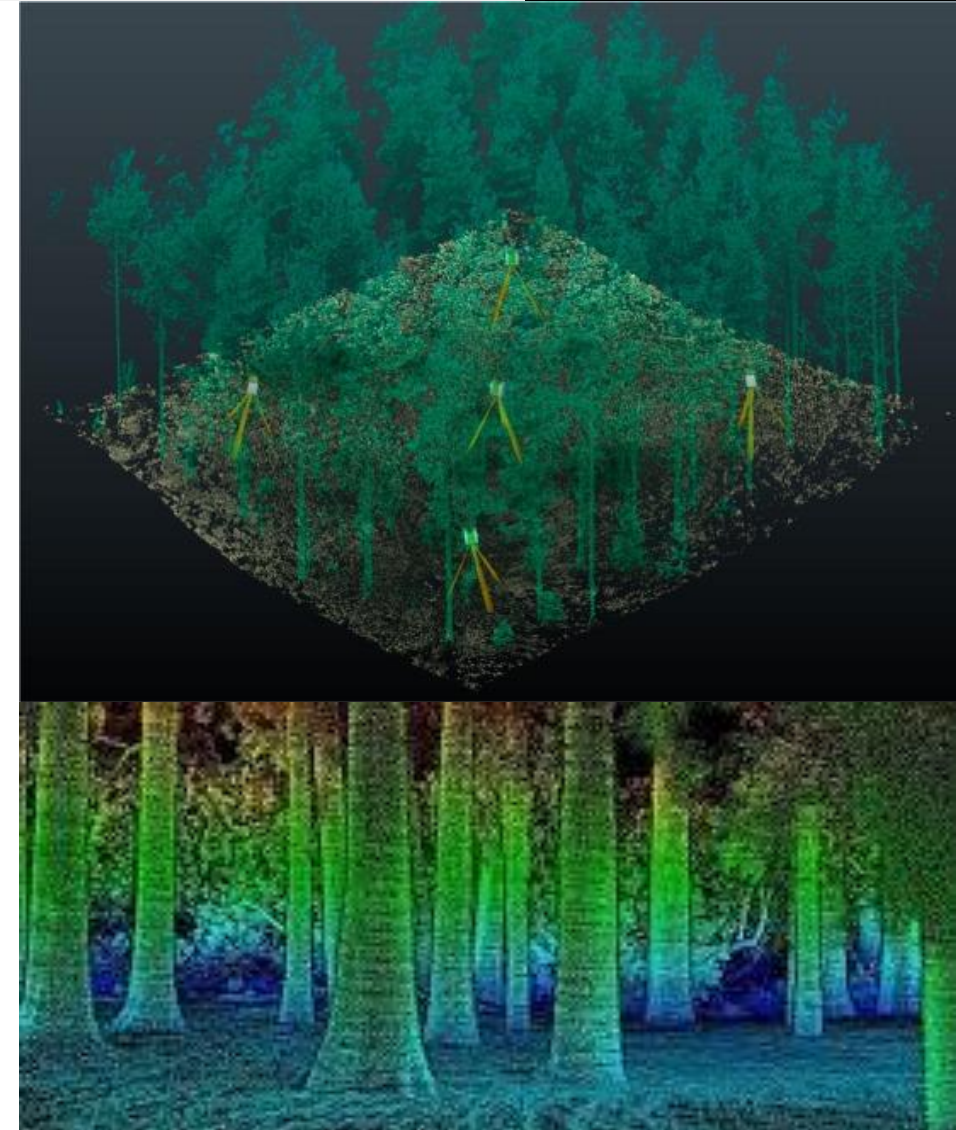
Common Beech



TERRESTRIAL LASER SCANNING IN FORESTS

TLS measurements are a promising method to non-destructively measure tree characteristics.

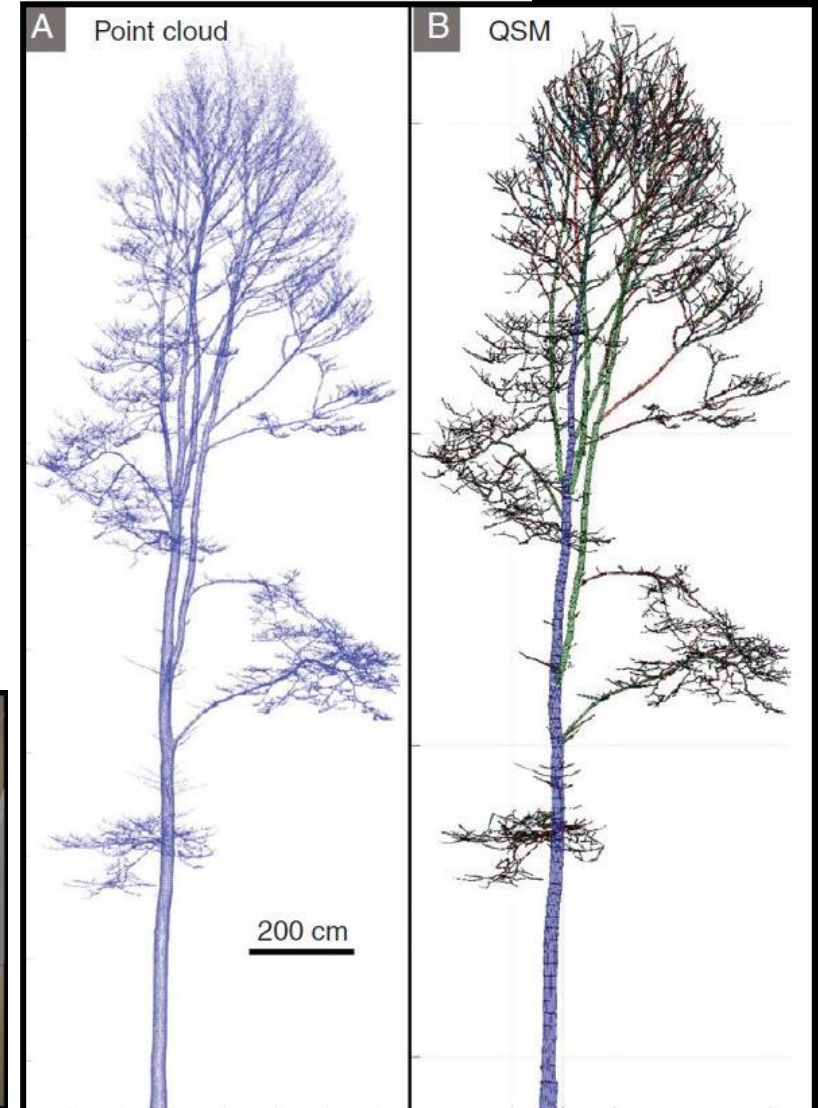
- Terrestrial lasers enable individual and multiple trees and to be fully 3D scanned.
- The scanning equipment produces Point Cloud data which can be processed and analysed with software.
- Accurate 3D models can be reconstructed from the point cloud data and measurements from those models can be obtained.
- Completely non-destructive and non-evasive way to measure tree and forest characteristics.



TLS POINT CLOUD ANALYSIS

Analysis of 3D tree models derived from point cloud data enable measurements of a tree's characteristics.

- Custom software packages have been developed to produce Quantitative Structure Models (QSM) from point cloud data.
- Measurements for tree heights, trunk and branch diameters, and total volume can be calculated within this software.
- Specifically, TreeQSM² which runs in MATLAB uses a technique 'cylinder fitting' to create a QSM from the point cloud data.



RESEARCH STEPS

IDENTIFY SUITABLE SURVEY LOCATION

Identify a predominantly deciduous woodland that is accessible and representative of a carbon offset woodland project, identify the woodlands general characteristics;

- Multiple or single tree species
- Density/spacing of trees
- Uniform or non-uniform tree spacing

DETERMINE SAMPLING REGIME

- Using the WCC methodology, determine the sampling regime required for the location based on the woodlands characteristics.
- Identify the specific trees that will be measured with both the conventional ASM method and the TLS

PERFORM ASM MEASUREMENTS

- From the trees selected for sampling measure;
- The height
 - The trunk diameter (DBH)

PROCESS ASM MEASUREMENTS

Input the data obtained from the ASM measurements into the WCC model to obtain AGB. (A spreadsheet is available from the WCC to perform this task.)

PERFORM TLS MEASUREMENTS

- From the trees selected for sampling measure;
- Perform scans of the tree with the TLS equipment from multiple positions (minimum 2)

PROCESS TLS DATA

- Process the point cloud data obtained from TLS
- Denoise and cleanse extraneous points
 - Using TreeQSM, obtain tree metrics
 - Calculate AGB from cylinder fitting model

ANALYSIS

Calibrate the WCC Allometric Scaling Model with the Above Ground Biomass estimates calculated from the outputs obtained from the TreeQSM cylinder fitting model.

Compare the AGB obtained from the calibrated model with the AGB estimated from the original WCC Allometric Scaling Model.

Determine and quantify any deviations in AGB and the inferred AGC between the two models.

Determine the implications of any deviations between the AGC on the issuance of hypothetical carbon offsets.

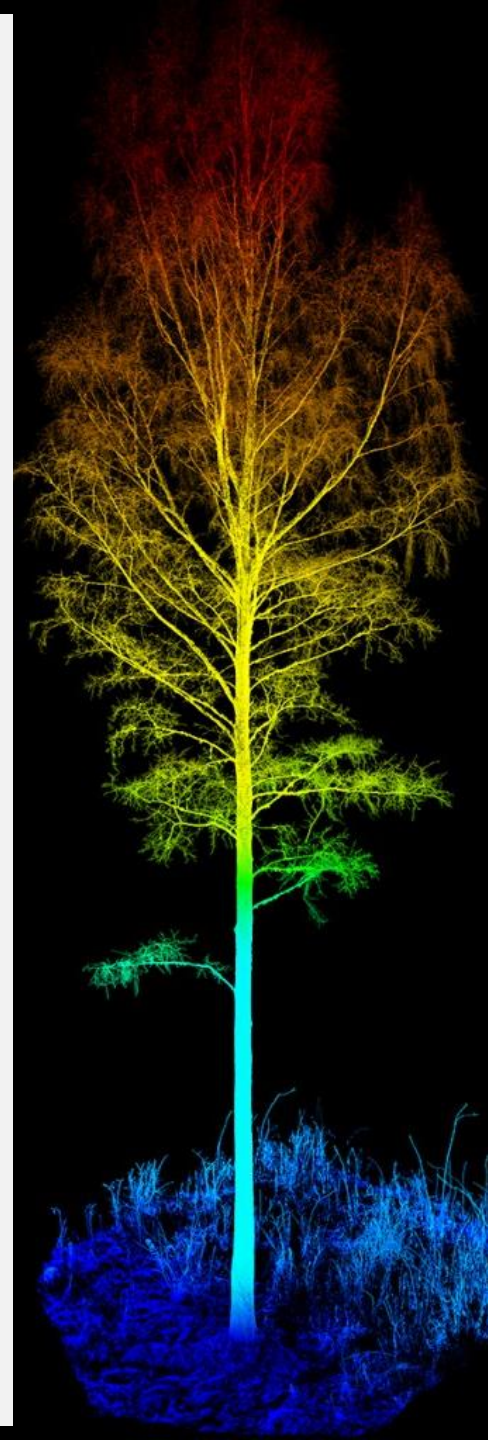


SPECIFIC RESEARCH AIMS

- To directly compare the Above Ground Carbon estimates produced from :-
 - 1) The Woodland Carbon Codes Allometric Scaling Model
 - 2) A TLS calibrated Allometric scaling Model
- In order to determine if there is a significant deviation in the estimates of Above Ground Carbon and what implications that would have on the issuance of Carbon Offsets for a hypothetical woodland offsetting project.
- Evaluate the implications of any discrepancies in the actual amount of AGC sequestered by a woodland with the amount of Carbon Offsets that would have been issued under the current WCC ASM methodology

Potential Issues

- Seasonal suitability for optimal TLS measurement
 - TLS measurements of deciduous trees ideally are performed when trees are 'leafless'
 - Poor weather such as high wind and rainy conditions restrict ability to perform TLS measurements.
- Procurement of suitable TLS equipment.
- Identification of a suitably accessible and appropriate site to conduct survey



THANK YOU – QUESTIONS?

References

Clark, D.B. & Kellner, J.R. 2012, "Tropical forest biomass estimation and the fallacy of misplaced concreteness", *Journal of Vegetation Science*, vol. 23, no. 6, pp. 1191-1196.

Demol, M., Calders, K., Verbeeck, H. & Gielen, B. 2021, "Forest aboveground volume assessments with terrestrial laser scanning: a ground-truth validation experiment in temperate, managed forests", *Annals of Botany*, vol. 128.

Roxburgh, S., Paul, K., Clifford, D., England, J. & Raison, R.J. 2015, "Guidelines for constructing allometric models for the prediction of woody biomass: How many individuals to harvest?", *Ecosphere*, vol. 6, pp. art38.