A low-cost portable method for ground vegetation structural assessment using the iPhone 15 Pro lidar scanner

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Contribution to SmartForest 2025, 13 & 14 March 2025 | TU München, Freising smartforest.ai/

Highlights: Methods for estimating the structure of habitat mosaics are needed to improve biodiversity monitoring and inform restoration efforts. This work examines the potential of iPhone lidar scanning to estimate the 3D structure of ground vegetation surrounding a diversity of trees outside woodland landscapes.

Key words: *iPhone lidar, vegetation structure, ground-layer, foraging ecology, agroforestry.*

Introduction

Increasingly, plant structural diversity is being recognized as a critical metric for predicting biodiversity (Schneider et al., 2017; LaRue et al., 2019; Calders et al., 2023); however, traditional methods for measuring vegetation structure are often time consuming, lack consistency, and limited in their capacity to capture complexity (Anderson et al. 2021; Atkins et al. 2023). It is difficult to encourage increased 'messiness' (i.e., structural complexity) of an environment when methods to assess it are limited. The use of lidar found in the iPhone Pro models numbered 12 or greater for scanning trees has recently emerged in the forestry sector (Bobrowski et al. 2022; Tatsumi et al. 2023, Guenther et al. 2024), and while it has been suggested as a tool to enrich herbarium specimens (Zizka et al. 2022), little has been done to facilitate the use of iPhone Lidar for capturing ground vegetation structural data. Furthermore, the iPhone Pro versus other scanning equipment such as the GeoSLAM Zeb Horizon is more accessible in both weight and cost, i.e. approximately 187g vs. 1450g plus a 1270g data logger and £1,000 vs £40,000, respectively. The low-cost and portability of the iPhone Pro models open methods to researchers with limited funds, limited access to other scanning equipment, and/or limited by how remote a field site may be.

Methods

Over 30 plots in either a 5m by 2m, or 10m by 2m rectangles were scanned using an iPhone 15 Pro Lidar across different trees outside woodland systems in the United Kingdom: a silvoarable (Wakelyns Farm, Suffolk), silvopastoral (Glensaugh Farm, Laurencekirk), woodpasture (Hepple Estate, Northumberland), woodmeadow (Three Hagges Woodmeadow, Yorkshire), and a roadside biodiversity strip (North Tyneside A quadrat was then randomly placed within the grid, scanned, and then intensive vertical structure, cover, and species validation data was collected. Plot scans took approximately 4 -12 minutes, and quadrat scans approximately 1- 3 minutes depending on the height of the vegetation within and were collected by scanning in regular strokes along each side of the quadrat either parallel or at a 45 degree angle to each height layer and then finally by scanning from above. All scans were repeated three times to allow for variance calculations when analyzing. Data is then imported into CloudCompare (v2.13.2) for visualization, and to determine appropriate steps for extracting the plot and quadrat data. Scanning methods and sensitivities were tested and compared to an iPhone 12 Pro Max's lidar and handheld terrestrial laser scanning (TLS, GeoSLAM ZEB Horizon) capabilities with results currently being analyzed and nearing write-up. Trees were also separately sampled at key sites using the iPhone 15 Pro lidar, TLS with validation data collected in parallel.

Preliminary Results

As illustrated in Figure 1 iPhone 15 Pro lidar scanning can be used to capture 3D structure and produce enhanced quadrat data. A small patch of predominantly orange poppy (*Eschsolzie californica*), and garland daisy (*Glebionis coronaria*) can be seen recreated in 3D space. Preliminary comparisons to the validation data has indicated agreement.

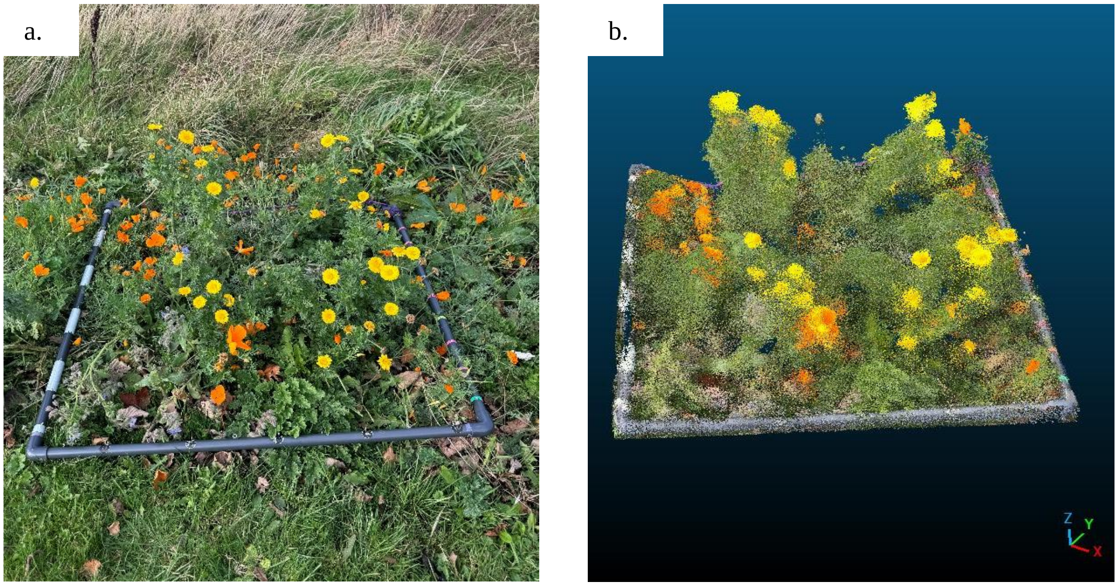

Figure 1: An example of a quadrat placed along a biodiversity strip in North Tyneside (a), which was then scanned using iPhone 15 Pro lidar (b).

A more complex set of scans collected under trees within a silvoarable agroforestry system is shown in Figure 2. The site was predominantly ‘messily’ overgrown by brambles (*Rubus* spp.), cleavers (*gallium aparine*), and hawthorn (*Crataegus* spp.*),* nettles (*Urtica* spp.), thistle (*Cirsium* spp.), amongst a mixture of grass species and other species commonly considered weeds.

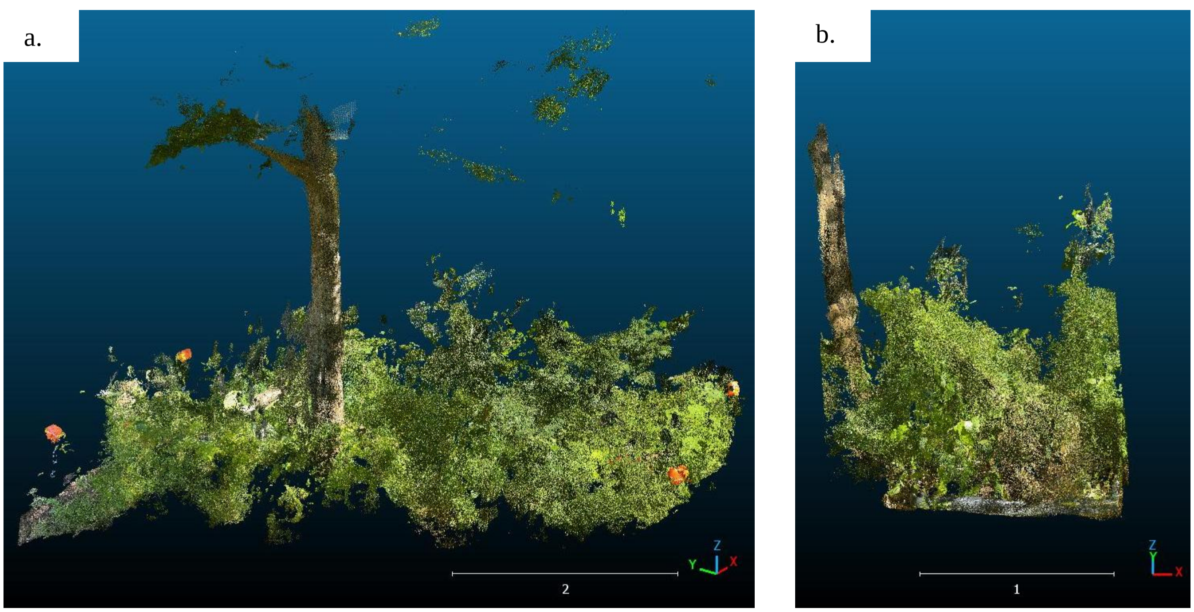

Figure 2: One of the most complex plots scanned for the study. 2a: A 5m by 2m plot scanned in a mature silvoarable system (Wakelyns Farm). 2b: The side view of a quadrat later placed within the plot.

A process for separating the quadrats from within scans and extracting transects with minimal bias for comparison to the validation data has been established and sensitivities will soon be tested. Methods for extracting meaningful metrics from the quadrat data to link to optimal foraging theory and network ecology are being developed.

Discussion

Ecologists interested in capturing vegetation structure in any landscape type could benefit from the use of this method to produce enhanced quadrats, and, given the development of an app or portal, farmers/landowners could submit their own land assessments during routine land inspections. Whilst ways of extracting meaningful metrics from the data are being explored advice on dealing with the unique challenges of these datasets would be highly beneficial. Unmanned aerial vehicle RGB and multispectral data were also collected for integration to represent the different benefits and nested scales of each method, which will be assessed later in the PhD work.

Acknowledgements

We would like to acknowledge the support and use of sites for this project by The Tree Council, the James Hutton Institute, PlantLife, Wakelyns Farm, Hepple Estates, and the North Tyneside Council. The research is funded by Fera Science Ltd, Newcastle University, and the Natural Sciences and Engineering Research Council of Canada.

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