Draft guidance for pilot of drone surveys at year 5

Version 0.8

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The Woodland Carbon Code is the voluntary standard for UK woodland carbon projects.
The Code is managed by Scottish Forestry on behalf of the Forestry Commission, Welsh Government and the Northern Ireland Forest Service
www.woodlandcarboncode.org.uk

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1. Introduction

The UK Woodland Carbon Code team is assessing remote sensing options such as drone and satellite derived data to aid land managers and project developers with the Woodland Carbon Code 5 and 15-year verification surveys.

This is a first version v0.8 of the draft guidance focused on the 5-year verification survey. It aims to support the use of drones to capture data to further help us assess and understand the way in which we can leverage drone-derived data in the monitoring and verification process. During the pilot in 2025, this methodology will be used by selected individuals or companies experienced in flying drones and analysing aerial imagery. Some of it will be prescriptive, while other parts will be descriptive.

All projects monitored using the “Aerial Photography Plot-based Survey” method at year 5 must additionally conduct a minimum of two field plot surveys for every stratum. If there are more than 20 aerial plot surveys per stratum, then one field plot survey must be conducted for every 10 aerial plot surveys) using the field plot-based survey from the Survey Protocol for Woodland Carbon Code Projects. A whole-site aerial survey should also be provided.

Project developers selected to trial a drone-based approach should follow this drone survey guidance, understanding that due to this being a pilot study, Pending Issuance Units (PIUs) will not be converted to Woodland Carbon Units (WCUs) unless a full, plot-based field survey from the Survey Protocol for Woodland Carbon Code Projects has been conducted.

We recommend flying when leaf is on for best results.

The Woodland Carbon Code team requires you to provide a summary of your methodology and to provide us ‘lessons learned’ feedback. We also encourage you to share raw data for processing by third parties. This will help us rapidly develop our methods for monitoring and verifying Woodland Carbon Code projects in new ways.

ICVCM places a high importance on measurement and error/uncertainty. This states:

“5) assess the overall uncertainty of emission reductions or removals associated with an activity type and/or require that the mitigation activity proponent assess the overall uncertainty in accordance with an approved methodology. In estimating overall uncertainty all causes of uncertainty shall be considered, including assumptions (e.g., baseline

scenario), estimation equations or models, parameters (e.g., representativeness of default values), and measurements (e.g., the accuracy of measurement methods). The overall uncertainty shall be assessed as the combined uncertainty from individual causes."

Understanding and accounting for uncertainty and error is now a fundamental part of what can and can't be included in future monitoring options. We would like to understand both

1) How closely remote sensing methods match the current plot-based field survey and

2) How accurate and precise remote sensing methods are in their own right.

This first iteration of a new methodology for year 5 aims to answer question 1 above.

2. Aerial photography plot-based survey (aerial plots)

Feedback to date has indicated that plot-based field surveys can be time consuming, hazardous, and expensive. Slope, vegetation density, and structure of ground all play a role in the scale of difficulty in undertaking these field surveys. For some elements of the WCC survey protocol, there are already potential solutions from remotely sensed data products, however, there are also still elements that present a more complex or difficult challenge to overcome.

Currently, data collected by the plot-based field surveys includes; species, stem count, sapling height, tree health and competition with other vegetation. By using drones as an inspection tool, data captured in plot-based field surveys could be captured using aerial imagery instead. Being able to identify species and assess tree health are challenges still not wholly solved by remote sensing. However, there are a range of methods able to differentiate broadleaf versus coniferous and determine stem counts within the research literature, although typically for trees of a more mature age than what is required for the WCC at year 5. Replacing WCC plot-based field surveys with remote sensing methods could significantly reduce surveying time, increase efficiency and coverage, minimise fieldwork health and safety risks, and reduce costs,

The WCC team would like to investigate the most effective method to identify species, tree health and stem count data using high-resolution aerial imagery and consider whether this approach could replace traditional plot-based field surveys.   The aerial plot approach could also act as an intermediate step for smaller projects whereby the cost of advanced, drone-assisted whole-site assessments may not be financially viable.

Equipment and software

Required

- Drone - choice is at the discretion of the operator.
- RGB sensor - type is at the discretion of the operator.

Optional (to provide accurate locational data):

- High precision/accuracy Global Navigation Satellite System (cm level), whether via a Real-Time Kinematic or Post-Processed Kinematic enabled drone, or through using a GNSS station and ground control points (GCPs).

Methodology

As experienced drone operators and surveyors, there will be no instruction as to which type of drone or type of Red-Green-Blue sensor (traditional camera) you choose to deploy.

For this WCC test phase, the plots derived and surveyed for your site that are derived from the Survey Protocol for Woodland Carbon Code Projects must be copied/replicated using an aerial survey with a drone fitted with an RGB sensor. The footprint of the camera image needs to be calculated to allow a plot survey area as required under the plot-based survey guidelines for any given stratum. For example, a 5.6m radial plot survey will require a minimum of 12m along one of the images axes, if the image is a standard 4:3 format, then the image footprint would need to be calculated as 16m x 12m.

Using the Pix4D GSD calculator found here: https://support.pix4d.com/hc/en-us/articles/202560249 a single image footprint can be calculated, and the required flying height should be applied as *above canopy* (not above ground for safety) for your given set up obtained from the calculator.

Individual nadir images can then be captured at the required survey plot locations with the correct footprint area. The number of images captured for each stratum must, at a minimum, be equal to the number of survey plots required from the traditional survey.

Once captured, you should georectify individual images. This allows GIS or other software to correctly apply a 5.6m plot radius (or other radius as required) around a centroid for tree counting. Georectification can be applied using the methodology described in this paper (although georectification in your chosen GIS will also be viable):

https://www.sciencedirect.com/science/article/pii/S0272771424002415?via%3Dihub

A full text of which can be found here:

https://www.researchgate.net/publication/381675390_Georectifying_drone_image_data_over_water_surfaces_without_fixed_ground_control_methodology_uncertainty_assessment_and_application_over_an_estuarine_environment

Data outputs

Stem counts with species and/or broadleaf/conifer label.

For each plot image, the individual stems within a given image must be labelled with GIS ready point data. This should, as a minimum, include conifer/broadleaf split in the associated attribute table. If the surveyor/analyst is confident with species level ID, this can also be included. This information should also be entered into the WCC Year 5 Aerial Monitoring Report.

It will be important for the results to pass an eye-test. This is when an auditor looks at a stem count data output and sees that the numbers and labelling/marking looks to be appropriate.

Tree mortality counts

Any dead trees must be labelled in the GIS ready point data attribute table of the aerial survey. A simple 'alive/dead' can be added and assigned to an individual tree. This should also be entered into the WCC Year 5 Aerial Monitoring Report.

Accuracy assessment

For each stratum, results from the field survey plots sampled must be entered into the 'standard' WCC Year 5 Monitoring Report.

For the plots which are sampled by both methods, ground-based and aerial-based results must be entered and compared in the 'Drone Trial AP_FP_comparison' sheet.

3. Whole site survey

You are also asked to complete whole-site data collection usingthe camera fitted to the drone to produce an orthomosaic(s).

Equipment and software

Required

- Drone - choice is at the discretion of the operator.

- RGB sensor – choice is at the discretion of the operator.
- Processing software - choice is at the discretion of the operator, however, the librar-ies/programme/software you use must be able to output a self-generated report that has calculated Ground Sampling Distance (GSD)

Optional (to provide accurate locational data):

- High precision/accuracy Global Navigation Satellite System (cm level), whether via a Real-Time Kinematic or Post-Processed Kinematic enabled drone, or through using a GNSS station and ground control points (GCPs).

As experienced drone operators and surveyors, there will be no instruction as to how you collect standard aerial survey data or which type of sensors you choose to deploy.

It is recommended that the minimum whole site survey data required, will be an RGB derived orthomosaic with the accompanying photogrammetry report produced by the orthomosaic software.

Minimal accuracy requirements for the photogrammetry data collected are listed below:

- RGB derived photogrammetry products must be =<5cm GSD

Data outputs

Please provide orthomosaic images and the report produced by the photogrammetry soft-ware. Ensure that the GSD of the data outputs are listed within these reports.

Checking the net area of new woodland

You should check the overall extent of the new woodland creation from the whole site orthomosaic and the Woodland Carbon Code vector data maps. You should note if there is any approximate variation in boundary captured from the aerial data versus the original project map. If there is significant variation in the boundaries, i.e planting area or open ground, then the project net area may need updating, a new map may be required or there may be a requirement to update the WCC carbon calculator at this or a subsequent verification.

4. Submitting data

Method description

For both the aerial plot and whole site survey, please provide a description explaining your chosen equipment, including the model of drone and sensor used, the approach you used for identifying and capturing plots (pre-planned waypoints etc), the photogrammetry software used. Any methods derived from others work need citation, referencing the relevant scientific publication/guidance.

Lessons learned

For both the aerial plot and whole site survey, please provide a 'lessons learned' summary. This should cover both your experience of surveying and verifying using these pilot methods. This will help us improve the methodology prior to the 2026 survey season.

Summary of documents required:

- Aerial Plot Monitoring Report for each stratum
- Year 5 Field-based Monitoring Report for a subsample of plots in each stratum
- Comparison of aerial and field plots for a subsample of plots in each stratum
- Othomosaic(s) of whole site
- Photogrammetry report of whole site
- Method description (equipment, and approach) with references
- Lessons learned document
- Other documents normally required for verification.

Summary of GIS data required:

- Vector layer showing WCC map, including planted and naturally regenerating areas, any areas of open ground or existing woodland within the boundary, following WCC mapping rules.
- Georectified and labelled aerial plot survey images.
- Geotiff orthomosaic for each of the plots or the whole site.

Raw data for whole site surveys is not required but derived data outputs are. All data that can be opened in GIS (ArcGIS, QGIS etc) should be stored in a single geopkg or geodb format. Any other accompanying file types/formats (i.e the photogrammetry self-generated reports, spreadsheets etc) should be stored in a folder/directory along with the geopkg/geodb, and that can be compressed into an archive format (zip etc).

5. Further information/ advice

If you would like further advice or guidance, contact leon.debell@forestry.gov.scot.