Survey Protocol for WCC projects at year 5
Version 2.0
08 March 2018

Introduction

The purpose of this methodology is to confirm the stocking density and health of seedlings and saplings in Woodland Carbon Code projects at approximately 5 years after planting. Where there are trees with Diameter at Breast Height (DBH) of 7cm or greater, the Carbon Assessment Protocol should be referred to for a more appropriate methodology.

Tree Size Category	Definition
Seedling	A living stem less than 50 centimetres tall.
Sapling	A living stem greater than 50 centimetres tall and with a dbh less than 7 centimetres.

The survey can be summarised in 5 easy steps, which are explained in further detail below:

1. **Stratify:** If necessary, divide your project area into sub-areas which are of similar makeup.
2. **Plot size:** Decide how big your plots will be, based upon planting density
3. **Plot number & location:** Decide how many plots you need, based upon the area / sub-areas, and where they should be located.

   → Get your survey plan approved by your chosen verification body PRIOR to proceeding with Step 4 - The Survey
4. **Survey:** Go to the site and count/measure trees
5. **Calculate:** Enter data into spreadsheet to work out planting density and overall tree health

The 5-year assessment should be carried out during the growing season where possible, in order to more accurately assess tree health.

The project developer should also complete a project progress report and include details of the surveyor, survey dates, stratification and any quality assurance/checking that has been carried out already.

The following documents should then be submitted to your chosen verification body:

1. Project Progress Report
2. Data Collection and Calculation Sheets

3. Plot-based location-tagged photographs. Filenames should reflect the Project Name, Stratum Number and Plot number and date taken.

1. Stratify

1. The gross project boundary, including both planted and open areas, should be clearly defined using appropriate maps. Open ground should ideally be clearly mapped.

2. Open areas greater than 0.25ha should be mapped and identified as a separate stratum or sub-area. Where this is not possible and/or open ground is randomly placed throughout a native woodland planting scheme, a greater number of sample plots will be required.

3. If you have distinctly different areas of woodland, the remainder of the area (ie the net planted area) should first be sub-divided into relatively uniform strata or sub-areas. This can be based upon planting year, species, growth rates or stocking density. Native species planted in an intimate mixture can be considered as one strata or sub-area.

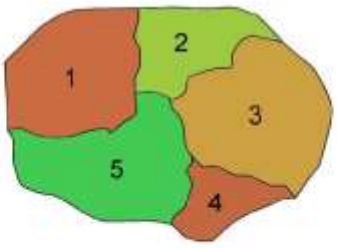
4. Next, decide whether the strata you have selected are 'uniform' or 'variable'. We do this because areas or sub-areas with greater variability, require more plots to obtain a result of similar precision: A stratum would be considered uniform if trees were:

    a. Planted within 3 years and were of similar height (ie no more than 4m height difference) AND
    b. Single species AND
    c. DBH range is 'normal' AND
    d. Planting positions were fairly evenly distributed.

    And a stratum would be considered 'variable' if there are

    1. Several species planted in an intimate mixture OR
    2. More than 3 years / 4 metres height difference across the stratum OR
    3. The DBH range is unusually wide OR
    4. The spacing of the planting positions is not uniform but varies across the stratum.

Native species planted in an intimate mixture would normally considered 'variable'. Please refer to Section 3 – Stratification in the Carbon Assessment Protocol for further clarification.



Compartment	Species	YC	Planting year	Area (ha)	Stratum
1	OK	8	2008	2.4	I
2	BI	8	2007	2.1	II
3	OK	6	2006	2.6	I
4	SP	14	1978	1.5	III
5	AH	8	2006	2.8	II

Fig 1: A simple example of stratification within a small area of woodland. In this example the five compartments are sub-divided into three strata.

2. Plot Size & shape

1. Next decide how big your plots should be for each stratum. The aim is to have a plot size which includes at least 20 live stems, so depends upon the spacing of each stratum or sub-area. Table 1 acts as a guide to the likely plot size for a range of planting densities/spacings.
2. The plot size and shape should not vary across a stratum, so when you get to site, the surveyor should ensure that the plot size chosen for a stratum will pick up 20 stems for the majority of the plots. If in doubt or you think the stocking density could be less in other areas of the stratum, choose a larger plot size which will be suitable across the whole stratum.
3. Ideally circular plots should be used, as these are less likely to introduce bias, but where the plant rows can be clearly seen square plots can be used. Plot shape should remain the same within a stratum/sub-area but you could for example use a circular plot for a native woodland stratum and a square plot for a regularly spaced SS stratum.
4. Plot size should not change within a stratum, but if strata have different planting densities it is OK to vary the plot size of each stratum.
5. If the ground to be surveyed is on a significant slope (eg over 25 degrees), plot size may need to be increased to account for the slope. Please contact the FC WCC team for further advice before completing your survey (climatechange@forestry.gov.uk).

Table1: Alternative plot size and area

Planting density (plants/ha)	>3967	2000-3965	1006-1999	399-1005	200-398
Spacing (m)	<1.59	1.60-2.24	2.25-3.15	3.16-5.01	5.02-7.07
Plot area (ha) which gives at least 20 locations / plot	**.005**	**.01**	**.02**	**.05**	**.10**
Circular Plot Radius (m) which gives at least 20 locations / plot	4.0	5.6	8.0	12.6	17.8
Square Plot Length (m) which gives at least 20 locations / plot	7.1	10.0	11.1	22.4	31.6

3. Plot Number and location

1. Next, decide how many plots should be assessed, based on the area and variability of the stratum (See Table 2). If open ground within the project boundary is not mapped, then a larger number of plots are required to compensate for this.

Table 2: Indicates the minimum number of sample plots for uniform and variable strata, based upon the size of each stratum and whether or not open ground is clearly mapped.

Net area of stratum	Uniform Stratum	Variable Stratum – OG mapped	Variable stratum – OG is less than 20% but not mapped	Variable stratum, OG is over 20% and not mapped
<0.5ha	4	6	7	8
0.5–2.0ha	6	8	9	10
2.0–10.0ha	8	12	14	16
Over 10.0ha	10	16	19	21

2. Now that we know how many plots we are to survey in each area or sub-area, we need to decide where to place them. The plots should be randomly located across the relevant area, not within 5m of the edge of a stand/the woodland. These locations/ grid refs of each plot location should be recorded before going to the site. This can be done, for example, by placing a regular grid across the project area and selecting 'nodes' which occur within the planted area (See Fig 2).
3. **The survey plan should be approved by your chosen verification body PRIOR to undertaking the survey.** If you do not get your survey plan approved, the verification body could ask you to re-survey if they find that your survey plan is not correct.

Figure 2: Example of plot selection for the Topps Wood project, which was made up of two strata – a conifer 'uniform' stratum (2-10ha) with 8 plots and a broadleaved 'variable' stratum (10ha+) with 16 plots. In this case, the open ground within the project was clearly mapped.

4. Survey

A data collection spreadsheet is available (See 'Plot Survey Sheet' in the WCC Year 5 Data Collection and Calculation Sheet). Before you head out to survey, make sure your survey plan has been approved by your chosen verification body.

4.0 You will need:

- Map of the site with plot locations indicated
- Sufficient blank stratum level data collection sheets (available separately), possibly printed on weather-resistant paper or loaded on an electronic device suitable for outdoor use e.g. toughbook.
- A Weather Writer or other waterproof clipboard if using paper sheets
- A pencil or pen with waterproof ink
- a tape or a cane marked at 0.1m intervals to assess tree height.
- a length tape (such as a 20 or 30 m logger's tape) suitable for laying out sample plots and measuring other horizontal distances
- rope to use to indicate plot radius
- spray paint or tape to mark central trees or plots
- Compass and/or GPS device (Garmin, other GPS or smartphone) to help navigate to each plot.
- Camera/smartphone or GPS device which can record the location/(8-figure) Grid Reference of the plot.
    - Smartphone Apps such as 'OS Locate' or 'Grid Reference' (FREE for Android) will give the current location as 6, 8 or 10-figure grid reference
    - Most smartphone cameras and newer cameras have location-tagging capability and can 'tag' a photo with its latitude/longitude
- A camera / smartphone camera ideally with location-tagging capability.
- Painted stakes/pegs to mark the location of plots (Royal blue or white are effective).

4.1 Boundary and planting maps and site photographs

1. Where it is feasible, check that the boundaries on the ground agree with the mapped boundaries shown at validation. Any areas known to be left unplanted should be annotated. Any site maps produced between validation and this survey may help. If any boundaries or species planted differ to those given at the time of validation, a new map should be produced, and project areas/species amended accordingly.
2. Whilst onsite take 2 or 3 photos across the whole site which are representative of the general site condition. Ideally tag the location and note the direction in which the photo was taken.

4.2 Locating & photographing each plot

1. Navigate to each plot location in turn, using GPS device/smartphone app or map & compass.
2. If open ground is mapped, and you find that the target plot location is in or on the edge of a mapped ride or other open area, then move the plot up to 10m so that it sits within a planted area. Note the change of location on the data collection sheet.
3. If open ground is not mapped, DO NOT MOVE PLOTS if they occur within an unplanted or low density planted area as this will bias results. You are expected to complete more plots, with the expectation that some of them will fall in more open areas with few or no trees. A plot sheet should still be completed if this is the case.

4. Mark with a stake/peg the centre of a circular plot or SW corner of a square plot. It is also possible to mark the closest tree to the centre with spray paint/tape. If you do this, you should note on the survey sheet the distance and direction of the plot centre from the marked tree.
5. For each plot, stand at the stake/peg (centre of a circular plot or SW corner of a square plot) and take a photograph.
    a. Where possible location-tagging should be enabled so the lat/long of the photo is embedded within the 'details' of the image. This is possible with most smartphones and newer digital cameras.
    b. Record the direction in which photograph was taken. It may be feasible to take all photographs facing the same direction (eg all to the North).
6. If you have not recorded the location of the plot via photo location-tag, record the 8-fig Grid Reference using a GPS device (Garmin or other) or suitable smartphone app.
7. Use measuring tape/rope and spray paint to locate and mark the boundary of the plot, or use measured rope as a 'spoke' to identify radius as you work your way round the plot.

4.3 Assessing Stocking Density

1. Within each sample plot, count and record the number of both live and dead seedlings/saplings of each species.
2. Note the number of live trees damaged.
3. Specify the main reasons for damaged or dead trees in the plot. Eg due to: Deer Browsing, Deer fraying, Sheep/Goat browsing, Vole, Rabbit, Weevil or other pest damage, Human damage.
4. Where feasible note the reasons for tree mortality.

4.3 Assessing Tree Growth & Health

Tree growth

Assess the overall growth of the seedlings/saplings by assessing within each plot:

Number of seedlings/saplings with:

- Poor leader growth (last year's leader growth is less than the average to date)
- Multiple stems

Estimate the height of each tree to the nearest 0.1m below 1m (e.g. 0.6m, 0.7m, 0.8m, 0.9m and 1.0m) and to the nearest 0.5m above 1.0m (eg 1.5 and 2.0). If tree shelters are used and the height of shelters is known this is a helpful guide. A cane painted in 0.1m intervals and at 1.5m is also a useful tool to help gauge height

Specify detail/observations for any poor growth in the 'General Comments' box.

Tree health

Assess the overall health of the seedlings/saplings by assessing within each plot:

1. Number of seedlings/saplings with:

- Poor foliage colour or needle/leaf size

- Poor needle or leaf retention

2. Number of seedlings/saplings suppressed by weeds

Specify the main weeds which are a problem within the plot E.g.: Heather, Thistle, Bramble, Willow-herb, Nettle, Juncus/Rushes, Bracken, Gorse/Broom, Rhododendron, Grass.

Tree Protection

For each stratum as a whole note the presence or condition of:

1. Tree Shelters/Individual tree protection –
    - Presence (Yes/No)
    - Condition
        - Good – all shelters in good condition
        - Average – some missing or damaged but majority intact
        - Poor – majority missing or damaged
2. Fencing –
    - Presence (Yes/No)
    - Condition
        - Good – Fencing in perfect condition
        - Poor – Requiring attention (Specify detail)

5. Further calculations

The WCC Year 5 Data Collection and Calculation Sheet will automatically carry out further calculations if data from each 'Plot Survey Sheet' is entered correctly into the 'Stratum Survey Sheet'.

The calculations to be carried out are summarised here for information:

5.1 Stocking Density

1. For each stratum, separately by species, estimate the **number of seedlings/saplings of each species per hectare** by adding together the total number of seedlings sampled and dividing by the total area of all the sample plots used.

2. For each stratum, estimate the **total seedling/sapling per hectare count** by summing the seedling/sapling per hectare figure for each species**.**

5.2 Compare predicted and actual stocking density

For each stratum, compare the predicted stocking density (as per the PDD) with the actual stocking density as indicated by the survey results.

Providing there are **<10% evenly distributed losses**, it will not normally be necessary to intervene as this is considered an acceptable minimum for beating up, but remember that the distribution of these losses is just as important. Losses confined to a particular area leaving a 'gap' should be beaten up.

Provided the actual stocking density is at least 90% of the planned stocking density, we will assume that the carbon sequestration of the project at year 5 is as predicted, and there is no under- or over-delivery at this stage.

5.3 Tree Growth

For leader growth and multiple stems

For each stratum, calculate the number of seedlings/saplings per hectare exhibiting poor growth by adding together the total number of seedlings sampled exhibiting poor leader growth or multiple stems and dividing by the total area of all the sample plots used.

Tree Height

For each stratum, separately by species, calculate the average height of the sampled seedlings/saplings.

5.4 Tree Health

For each stratum, calculate the number of seedlings/saplings per hectare exhibiting each health indicator (foliage colour, foliage size, browsing or fraying damage, weed competition) by adding together the total number of seedlings/saplings sampled exhibiting that indicator and dividing by the total area of all the sample plots used.