

Appendix 5: Worked example for a small-scale broadleaf project

Carbon assessment protocol: Broadleaf project example

Description:

A 1.12 ha broadleaved woodland – “Coed Glas”, containing an intimate mixture of approximately 1400 stems of oak, ash and birch approximately 30 years old. Oak and ash are the major tree species, with birch making up less than 10% of the total number of tree stems. Ash and birch were therefore treated as one species group and oak as another.

Using the decision tree in Figure 4.1 (page 23) Method E was chosen to estimate the above ground “tree” carbon in the project.

Field work

Sampling fraction:

Oak = approximately 700 stems

Looking at Table 3.2.2 the recommended dbh sampling fraction is 1:6 and 1:10 of the dbh sample trees will be assessed as height sample trees. The diameter of every 6th tree was therefore measured and every 60th tree had timber height assessed.

Ash and birch = approximately 700 stems

Looking at Table 3.2.2 the recommended dbh sampling fraction is 1:6 and 1:10 of the dbh sample trees will be assessed as height sample trees. The diameter of every 6th tree was therefore measured and every 60th tree had timber height assessed.

The data collection form (see Appendix 7) was used to collect plot, dbh and height data for the two compartments/strata within the project containing trees. The completed forms are shown in Figures A5.1 to A5.3.

Office work and calculations

The following section follows the procedure set-out in Section 4.2.3, starting on page 40.

Seedlings:

There were no seedlings recorded. No further office work is therefore required for seedlings.

Saplings:

There were no saplings recorded. No further office work is therefore required for saplings.

Trees:*Total stem volume*

See page 41.

- a. Tariff numbers were estimated for each sample tree with a dbh of 10 cm or greater using Equation 2 on page 42 and the species-specific constants listed in Table 4.2.3 on the same page.

For the oak component, the equation used is:

$$T = 5.88300 + (2.01230 \times h) + (-0.0054780 \times \text{dbh}) + (-0.0057397 \times \text{dbh} \times h)$$

Where T is the species-specific single tree Tariff number being calculated.

Taking tree number 1 from Figure A5.1 on page 80 as an example:

dbh = 17 cm

timber height = 10.6 m

$$T = 5.88300 + (2.01230 \times 10.6) + (-0.0054780 \times 17) + (-0.0057397 \times 17 \times 10.6)$$

$$T = 26.09$$

Single tree tariff numbers are always rounded to the nearest whole number. In this instance a Tariff number 26 is recorded.

The above calculation is repeated for each oak sample tree with a dbh of 10 cm or greater.

For the ash component, the corresponding single tree Tariff equation used is:

$$T = 9.16050 + (2.02560 \times h) + (-0.0668420 \times \text{dbh}) + (-0.0044172 \times \text{dbh} \times h)$$

Taking tree number 26 from Figure A5.1 on page 80 as an example:

$$\text{dbh} = 25 \text{ cm}$$

$$\text{timber height} = 8.8 \text{ m}$$

$$T = 9.16050 + (2.02560 \times 8.8) + (-0.0668420 \times 25) + (-0.0044172 \times 25 \times 8.8)$$

$$T = 24.34$$

Single tree tariff numbers are always rounded to the nearest whole number. In this instance a Tariff number 24 is recorded.

The above calculation is repeated for each ash sample tree with a dbh of 10 cm or greater.

- b. The average tariff number is calculated for each species.

For the oak component of the stand, the average tariff number is:

$$235 \div 9 = 26.11$$

The average Tariff number is always rounded down and an average of 26 is therefore recorded for the oak.

For the ash component of the stand, the average tariff number is:

$$221 \div 9 = 24.56$$

The average Tariff number is always rounded down and an average of 24 is therefore recorded for the ash.

- c. Calculation of the (quadratic) mean dbh for each species.

The number of trees in each centimetre dbh class for each species (based on adding together the values in each row) is shown in column (3) of Section 4 of the

data collection form (Figure A5.3). Multiplying the trees in each class (column 3) by the square of the dbh for each class (column 4) and then adding these results together for each class (total, column 5) and dividing by the number of trees measured gives a mean "squared" dbh of 217.5 for oak and 285.4 for ash. The square root of this value gives the mean (quadratic) dbh:

$$\text{For the oak} \quad \sqrt{217.5} = 14.7 \text{ cm}$$

$$\text{For the ash} \quad \sqrt{285.4} = 16.9 \text{ cm}$$

- d. Calculate the mean merchantable volume for each species.

Firstly, the (quadratic) mean dbh is converted into the mean basal area for each species using the equation in Section 4.2.3.

$$\text{Mean basal area (oak)} = \frac{\pi \times 14.7^2}{40000} = 0.017 \text{ m}^2 \text{ (shown to 3 decimal points)}$$

$$\text{Mean basal area (ash)} = \frac{\pi \times 16.9^2}{40000} = 0.022 \text{ m}^2 \text{ (shown to 3 decimal points)}$$

The mean tree basal areas are used in Equation 5 in Section 4.2.3 in conjunction with the average tariff numbers estimated in step b in order to estimate the mean merchantable volume for each species.

$$\text{Mean merchantable tree volume (oak)} = a_1 + (a_2 \times 0.017) = 0.104 \text{ m}^3$$

$$\text{Mean merchantable tree volume (ash)} = a_1 + (a_2 \times 0.022) = 0.141 \text{ m}^3$$

where:

$$a_1 = (0.0360541 \times 24) - (a_2 \times 0.118288)$$

$$a_2 = 0.315049301 \times (24 - 0.138763302)$$

- e. Estimate the mean total stem volume for each species. The mean total stem volume includes volume above 7 cm top diameter and is calculated by multiplying the appropriate factor given in Table 4.2.5 (page 44) by the mean merchantable volume calculated above.

$$\text{Mean total stem volume (oak)} = 0.104 \times 1.05 = 0.1092 \text{ m}^3 \text{ (unrounded).}$$

$$\text{Mean total stem volume (ash)} = 0.141 \times 1.03 = 0.14523 \text{ m}^3 \text{ (unrounded).}$$

- f. Find the total estimated volume for each species by multiplying the unrounded mean total stem by the estimated total number of trees of that species.

$$\text{Total estimated volume (oak)} = 0.1092 \text{ m}^3 \times 678 \text{ trees} = 74.0 \text{ m}^3$$

$$\text{Total estimated volume (ash)} = 0.14523 \text{ m}^3 \times 630 \text{ trees} = 91.5 \text{ m}^3$$

Total biomass of stems:

The total stem biomass is estimated by multiplying the total stem volume of the stratum by the nominal specific gravity of the species (see Section 5.3.1):

For the oak, $74.0 \text{ m}^3 \times 0.56 = 41.44$ oven dry tonnes.

For the ash, $91.5 \text{ m}^3 \times 0.53 = 48.50$ oven dry tonnes.

Crown biomass per tree:

The crown biomass (branches and foliage) is estimated using the appropriate equation for the species from Table 5.3.2 (page 47). The oak the equation, which uses dbh and total height, will be applied to both oak and ash (as there is no specific crown biomass equation for ash):

$$\text{Crown biomass} = \gamma(\text{DBH}^p)(\text{Totht}^q)$$

Where: $\gamma = 0.00054224$
 $p = 2.35009373$
 $q = -1.02161521$

Inserting the appropriate average values for both species gives us:

Oak crown biomass = 0.01957 oven dry tonnes
 (based on an average dbh of 14.7 cm and average total height 14.48 m)

Ash crown biomass = 0.02660 oven dry tonnes
 (based on an average dbh of 16.9 cm and average total height 14.78 m)

Total crown biomass in the stratum:

The total crown biomass in the stratum is estimated by multiplying the crown biomass (per tree) by the estimated number of trees in the stratum:

Total oak crown biomass = $0.01957 \text{ ODT} \times 678 \text{ trees} = 13.27 \text{ oven dry tonnes}$

Total ash crown biomass = $0.02660 \text{ ODT} \times 630 = 16.76 \text{ oven dry tonnes}$

Root biomass per tree:

The root biomass is estimated using the appropriate equation from Table 5.3.3 (page 48). Although there is currently only one equation applicable for use with broadleaved tree species, the calculation will need to be done separately for each species as the quadratic mean diameter differs (14.7 cm for the oak component, 16.9 cm for the ash component).

Root biomass per tree (oak) = $0.000149 \times 14.7^{2.12} = 0.0445 \text{ oven dry tonnes}$

Root biomass per tree (ash) = $0.000149 \times 16.9^{2.12} = 0.0597 \text{ oven dry tonnes}$

Total root biomass in the stratum:

The total root biomass in the stratum is estimated by multiplying the root biomass per tree by the estimated number of trees of the requisite species present in the stratum:

Total root biomass (oak) = $0.0445 \times 678 = 30.17 \text{ oven dry tonnes.}$

Total root biomass (ash) = $0.0597 \times 630 = 37.61 \text{ oven dry tonnes.}$

Total tree carbon in the stratum:

The total tree carbon in the stratum is calculated by adding together the total biomass from the stem and crown components in the stratum and multiplying by 0.5:

Carbon in oak = $(41.44 + 13.27 + 30.17) \times 0.5 = 42.44 \text{ tonnes C (carbon).}$

Carbon in ash = $(48.50 + 16.76 + 37.61) \times 0.5 = 51.44 \text{ tonnes C (carbon).}$

For the project:

Total above ground tree carbon for the project:

This is the sum of the carbon estimates for all of the species in the project:

Total carbon = 42.44 + 51.44 = **93.88 tonnes C** (carbon).



CARBON ASSESSMENT DATA COLLECTION FORM

METHOD E

Section 1 – Basic Assessment Information

Woodland: COED GLAS Compartment(s): —
 Species: OAK (OK), ASH (AH), BIRCH (BI) Gross area (ha): 1.2
 Diameter sampling fraction: 1: 6 Net area (ha): 1.2
 Height sampling fraction: 1: 10
 Date measured: 15 SEPTEMBER 2010 Measured by: HOW NELSON

Section 2 – Details of height and diameter sample trees

N.B. For conifer species record total height; for broadleaved species record timber height and total height. Tariff number should be rounded to the nearest whole number, except where stated otherwise.

No.	Spp code	Dbh (cm)	H _{timb} (m)	H _{total} (m)	Tariff no.	No.	Spp code	Dbh (cm)	H _{timb} (m)	H _{total} (m)	Tariff no.
1	OK	17	10.6	16.4	26	26	AH	25	8.8	13.2	24
2	OK	8	1.4	12.4	—	27	AH	23	11.5	17.4	30
3	OK	25	14.6	17.8	33	28	AH	9	6.0	15.0	—
4	OK	19	12.5	16.5	30	29	AH	17	10.0	13.9	28
5	OK	11	7.6	13.1	21	30	BI	19	9.4	13.1	22
6	OK	15	9.7	14.2	24	31	AH	25	8.8	17.6	24
7	OK	18	13.1	17.1	31	32	BI	10	5.2	15.9	16
8	OK	12	10.0	15.2	25	33	AH	18	8.2	13.0	24
9	OK	8	2.4	11.7	—	34	AH	19	11.1	14.8	29
10	OK	15	6.7	10.2	19	35	AH	13	8.2	13.9	24
11	OK	17	10.6	14.7	26	36					
12						37					
13						38					
14						39					
15						40					
16						41					
17						42					
18						43					
19						44					
20						45					
21						46					
22						47					
23						48					
24						49					
25						50					
Total (by species group):					235	Total (by species group):					221
Mean tariff number:					26	Mean tariff number:					24
(Rounded down)						(Rounded down)					

Figure A5.1: Page 1 of completed data collection form for Method E.



CARBON ASSESSMENT DATA COLLECTION FORM

METHOD E

Section 4 – Diameter distribution & calculation of mean basal area.

(1) Dbh	Species: OAK (OK)				Species: ASH (AH)(+ BE)			
	(2) tally	(3) n	(4) dbh ²	(5) n x dbh ²	(2) tally	(3) N	(4) dbh ²	(5) n x dbh ²
7		7	49	343		2	49	98
8		15	64	960		4	64	256
9		6	81	486		4	81	324
10		4	100	400		6	100	600
1		6	121	726		2	121	242
2		10	144	1440		5	144	720
3		6	169	1014		6	169	1014
4		3	196	588		6	196	1176
5		11	225	2475		7	225	1575
6		5	256	1280		8	256	2048
7		18	289	5202		12	289	3468
8		4	324	1296		9	324	2916
9		6	361	2166		13	361	4693
0		4	400	1600		1	400	400
1		1	441	441		6	441	2646
2		3	484	1452		2	484	968
3						4	529	2116
4								
5		1	625	625		6	625	3750
6		2	676	1352		1	676	676
7		1	729	729				
8								
9								
0								
Col. totals (Σ)		113		24575		104		29686
Mean dbh ² = Σ(5) ÷ Σ(3)				217.5				285.4
Mean ba = n × mean dbh ² ÷ 40000				0.01708	m ²			0.02242
Mean dbh = sqrt(mean dbh ²)				14.7	cm			16.9

Sheet 3 of 3

Figure A5.3: Page 3 of completed data collection form for Method E.