Ecosystem Service - Carbon Storage & Sequestration

Purpose

The carbon stock and sequestration maps estimate relative values for the carbon stocks and sequestration of the landcover of mainland Cornwall at a resolution of 100 x 100m grid cells. The purpose of the map is to provide an indication of relative values across Cornwall, and not for comparison with other geographical areas, with national accounts or regional carbon audits.

Carbon stocks measure the amount of carbon stored within a habitat at a given time. Stocks are expressed as mass per unit land area (e.g. tonnes of C per hectare). Values can be converted to tCO_2 per hectare by multiplying by 3. (the ratio of the molecular masses of CO_2 and Carbon).

Carbon sequestration rates (carbon or CO_2 equivalents per ha per year) measure net uptake (positive) or release of carbon.

For most terrestrial habitats and wetlands, the majority of the carbon is held within the soil. Woodland and scrub are the only main habitats for which the vegetative, above-ground carbon stock is of a similar magnitude to the below-ground stock.

Sequestration rates are also habitat-dependent but more highly dependent on land management and use. For, example, as most of the carbon in terrestrial habitats and wetlands in England are in the soils, land use practices that reduce the soil disturbance, erosion and oxidation are likely to result in increased carbon stores. Net sequestration rates of agricultural land are highly dependent on agricultural inputs and harvesting regimes.

Background - Estimating carbon stocks

Table 1 provides published estimates of carbon stock by broad habitat group. Estimates from Natural England (2012) are used by the ONS National Ecosystem Accounting (ONS 2016), which include above-ground and carbon estimates for the top 15cm of topsoil. The higher estimates for woodland from the Forestry Commission (Morison et al. 2012) report include carbon estimates for the top 100cm of soil.

Below-ground carbon stocks for any given landcover, particularly when layers deeper than the topsoil are accounted for, will depend upon the underlying soil type. Comparisons of woodland established on different soil types have demonstrated considerable variation, with higher levels in soils possessing a higher organic content (see table 2). However, it should be noted that the values for peaty soils reported for forest habitats are not as high as some carbon estimates for peatland areas under alternative habitats. Reported carbon stock values for deep peat areas under lowland fen, bog and reedbeds, for example, have been estimated to be over 1500tC/ha (Natural England 2010) for parts of England.

Table 1: Examples of carbon stock and sequestration values by broad habitat from different published sources: **A:** Alonso et al (2012) p.29; **B:** Morison et al (2012); **C & D:** Natural England (2019) p.16

Habitat	**A Carbon stock** in vegetation and 0-15cm of topsoil (tC/ha).	**B Carbon stock** in vegetation & soil to 100cm depth tC/ha.	**C Carbon stock** by habitat (tC/ha)	**D C sequestration** by habitat (tCO2/eq/ha/yr)
Coniferous woodland	140	308	260	17.51
Broadleaf woodland	133	308	174	10.71
Acid grassland	88		255	1.61
Semi-natural grassland	61		107	1.55
Grazing marsh	60			
Fen, marsh and swamp	76 (soil only)		423	3.91
Bog	76		423	1.7
Dwarf shrub Heath	90		241 - 264	3.45
Inland rock			107	0
Maritime rock			107	0
Maritime sediment	48		107 - 180	1.14 - 2.34
Water				6.86 (Freshwater)
Improved grasslands	60		106	1.55
Arable and horticulture	43		73	5.39
Coastal margins	48 (soil only)			
Sanddunes			107	1.14
Saltmarsh			180	4.2
Mudflats			180	2.34

The relatively higher levels of carbon stock assigned to non-woodland habitats by the Natural England 2019 report is most likely explained by greater accounting of the soil carbon of those habitats, such as acid grassland, heather and moorland, whose soils possess a high organic content. In effect these figures are more likely to relate to *potential* carbon storage of different habitats, with wetland and moorland habitats typically having greater long-term potential for carbon storage than for example many commercial woodland areas.

Carbon stock estimates vary between different habitat age structures, habitat management regimes (grazing, woodland felling practices). For example, estimates of the above-ground carbon stock of woodland stands (excluding soil, litter and deadwood) vary from an average of 60tC/ha across several rotations to up to 200tC/ha for old-growth stands prior to felling, with average below-ground stocks estimated at c. 260tC/ha (Morison et al. 2012p 15).

Table 2: Typical forest soil carbon stocks (from information in Morison et al 2012, p 30).

Soil type	Mean total C stock to 80cm soil depth
Mineral soil (rankers, redzinas, brown earths, podzols, ironpans, surface and ground water gleys)	~155 tC/ha
Organo-mineral (peaty gleys, peaty podzols and peaty rankers)	~320 tC/ha
Organic soil (deep peats)	~448 tC/ha

Mapping methodology

The maps use adapted values cited in Natural England (2019), despite the source report (AMEC 2019) for these estimates remaining unpublished to date. We have chosen to base our values on these figures due to the range of habitats for which the estimates are available and what we believe is their emphasis on the long-term potential of habitat carbon stock and sequestration. A full list of habitat values is shown in table 3.

Estimates from Natural England (2019) will already reflect national habitat associations with particular soil types. Nevertheless, we have chosen to add a multiplier based on a simple classification of the soil type based on organic content (table 4). A multiplier value has also been used for areas that can be identified as recently restored areas of quarries where the underlying soil organic content is likely to be significantly diminished. As a consequence, and also to reflect the relatively lower levels of carbon estimated in southwest peatland soils compared to other areas of peatland (Natural England 2010 p22), we have reduced the carbon stock of key habitats closely related with peaty soils.

Table 3: Soil and Substrate multipliers used in creation of carbon storage and sequestration maps.

Soil type	Multiplier for carbon stock estimates
Organic soil	2
Organo-mineral	1.5
Mineral	1
Restored soil (inland rock & open mosaic habitats)	0.5

Urban green space is often overlooked in terms of carbon storage. However, this land class could potentially be a significant store stock of carbon (Natural England, 2016). Research is very limited and therefore the estimates provided are highly tentative. Urban features such as parks and playing fields will generally be classified as non-built up areas in our landcover mapping, typically improved grassland or scrub/woodland habitats. For built-up habitat areas (which include gardens, yards etc) carbon stock and sequestration are estimated from the relative vegetative cover of these areas, as measured by mean NDVI (limited to between 0 and 1.0) multiplied by the carbon stock for scrub habitat (150 tC/ha).

Table 4: Carbon stock and sequestration values allocated to each habitat type – these will be subject to a multiplier based on soil type. All estimates are per Ha of habitat coverage including linear features such as hedgerows.

Habitat Code	Habitat Type	Carbon density by habitat (tC/ha)	Carbon sequestration (tCO2/eq/ha/yr)	Reason for changes in C stock from Natural England (2019)
110	Coniferous woodland	260	17.51	
120	Broadleaf woodland	200	10.71	Increase as broad shrub class used.
130	Scrub	150	3.0	
140	Felled, &Young Woodland	150	3.0	Assume soil stock retained to a point and woodland replanted
150	Hedgerows	120 + (10 x height)	1.55 + height	Max hedge height (1-7 metres) of an area from ERCCIS data.
210	Dry grassland	107	1.55	
220	Wet grassland	140	2.0	
230	Acid grassland	180	1.61	Reduced due to association with high C soils.
300	Wetland	350	3.91	Reduced due to association with high C soils.
400	Dwarf shrub Heath	250	3.45	
410	Bracken	120	1.61	
500	Inland rock	107	0	
600	Maritime rock	107	0	
	Maritime sediment	107	1.14	
710	Sanddunes	107	1.14	
720	Mudflats	180	2.34	
730	Saltmarsh	180	4.2	
800	Water habitats	150	6.86	Deposition of organic sediments within lakes, ponds and reservoirs can be significant, but lack of data
810	River	0	3	
910	Arable and horticulture	73	5.39	
920	Improved grasslands	100	1.55	
930	Built-up area	NDVI*150	NDVI*2.0	NDVI curtailed between 0 and 1.0

Uses and Applications

- The maps provide an indication about the relative implications for carbon storage and sequestration of land use change that removes habitat cover and top soil layers.
- Carbon storage values, converted to a normalized value between 0 and 100, are used in the calculation of the 'existing nature network' rankings where the relative carbon storage associated with existing landcover if of interest.
- Absolute map values are not readily comparable with other values of carbon storage or sequestration rates. As can be seen from the tables presented previously, the estimated values of different landcover is highly variable and the carbon contained within the soil layers is often the most significant aspect.
- The removal of 'carbon-rich' landcover and soil is not readily compensated by the creation of equivalent habitat elsewhere as it is likely to take many decades, or longer, for carbon stocks to approach those of existing habitats.
- Map values represent a compromise between short and long-term values for carbon storage and sequestration rates of different habitat and soil combinations.
- Carbon sequestration rates (and to a lesser extent storage) are highly dependent upon land management practices, particularly harvesting, soil treatment or burning practices.
- Methods used in habitat creation or restoration have an important effect for changes in carbon storage and sequestration. Practices involving significant soil disturbance or removal are likely to reduce carbon values at least in the short-term.
- The methods and frequency of harvesting of biological matter is an important variable for certain landcover types such as woodland and arable land.

Bibliographic References

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Data sources – use and copyright

Data used in the creation of this and the other ecosystem service maps on Lagas are listed here.