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The importance of sub-peat carbon storage as shown by data from Dartmoor, UK

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Abstract

Peatlands are highly valued for their range of ecosystem services, including distinctive biodiversity, agricultural uses, recreational amenities, water provision, river flow regulation and their capacity to store carbon. There have been a range of estimates of carbon stored in peatlands in the UK, but uncertainties remain, in particular with regard to depth and bulk density of peat. In addition, very few studies consider the full profile with depth in carbon auditing. The importance of sub-peat soils within peatland carbon stores has been recognised, but remains poorly understood and is included rarely within peatland carbon audits. This study examines the importance of the carbon store based on a study of blanket peat on Dartmoor, UK, by estimating peat depths in a 4x1km survey area using ground penetrating radar, extraction of 43 cores across a range of peat depth, and estimation of carbon densities based on measures of loss-on-ignition and bulk density. Comparison of ground penetrating radar estimates of peat depth with core depths shows excellent agreement, to provide the basis for a detailed understanding of the distribution of peat depths within the survey area. Carbon densities of the sub-peat soils are on average 78 kg C m^{-3} and 53 kg C m^{-3} for the overlying blanket peat. There is considerable spatial variability in the estimates of total carbon from each core across the survey area, with values ranging between 56.5 kg C m^{-2} (1.01 m total depth of peat and soil) and 524 kg C m^{-2} (6.63 m total depth). Sub-peat soil carbon represents between 4 and 28 percent (mean 13.5) of the total carbon stored, with greater values for shallower peat. The results indicate a significant and previously unaccounted store of carbon within blanket peat regions which should be included in future calculations of overall carbon storage. It is argued that this store needs to be considered in carbon audits.

Keywords

Peatlands; peat depth; ground penetrating radar; carbon storage; soil carbon; Dartmoor

Introduction

Peatlands are highly valued for their range of ecosystem services, including distinctive biodiversity, agricultural use, recreational amenities, water provision, river flow regulation and their capacity to store carbon (Holden *et al.*, 2007; Joosten and Clarke, 2002; Keddy *et al.*, 2009). Peatlands have accumulated carbon throughout the Holocene (Clymo *et al*., 1998; Yu, 2012), and the role of peatlands in moderating atmospheric CO_2 concentrations has been widely recognised (Holden, 2005; Joosten and Clarke, 2002), resulting in increased interest in carbon stores and an agenda for peatland restoration (e.g. Tuittila *et al*., 1999; Waddington and Warner, 2001). Under the United Nations Framework Convention on Climate Change (1992) the UK is required to estimate levels of carbon stored in terrestrial biomes (e.g. Gorham, 1991; Milne and Brown, 1997) and to achieve this accurate carbon auditing is needed (Beilman *et al*., 2008). There has been a range of estimates of carbon stored in UK peatlands, but uncertainties remain, in particular associated with estimates of peat depth and bulk density (Bradley *et al.*, 2005; Buffam *et al.*, 2010; Chapman *et al.*, 2009; Garnett *et al.*, 2001; Parry *et al*., 2012; Tomlinson, 2005; Yu, 2012; Zhang *et al.*, 2008). Despite recent advances in improving the accuracy of these measures, very few studies consider complete profiles for peat. Eswaren *et al.* (1995) suggest that if the total soil depth is not considered when estimating carbon storage a large under-estimation in global soil carbon estimates will result. Poor estimations of peat depth impair the accuracy of carbon inventories, especially when the focus is limited to the top 100 cm (e.g. Bradley *et al.*, 2005; Milne and Brown, 1997) though there are studies concerned with deeper soils (e.g. Jobbagy and Jackson, 2000;

Zhang *et al.,* 2008). Inferred peat depths based on relationships between topographic parameters and measured peat depths, have been used for developing spatially-explicit peat depth models for undertaking carbon audits (Holden and Connolly, 2011; Parry *et al.,* 2012). These offer the potential for improved estimates of carbon stores in blanket peatlands at landscape scales (>10,000ha) where peat is able to develop on sloping ground.

Despite efforts to improve the accuracy of carbon estimates from within peat (e.g. Bradley *et al.,* 2005; Garnett *et al.,* 2001; Wellock *et al.,* 2011) using high resolution datasets (e.g. Beilman *et al.,* 2008; Frogbrook *et al.,* 2009), an additional carbon store beneath the peat is not well understood in spite of the recognition of its importance (Turunen *et al.,* 1999; Turunen and Moore, 2003; Moore and Turunen, 2004). Carbon in the sub-peat mineral horizons underlying peatlands are shown by Turunen *et al*. (1999) to be equivalent to 0.18 m of peat depth, and store 1.5 times more carbon than equivalent horizons which do not underlie peat. This is related to adsorption of dissolved organic carbon in the subsoil from the overlying peat (Turunen and Moore, 2003). The available data on sub-peat carbon indicate that this is a significant additional store, but there are limited measurements of this store, and there is need for quantification.

This study examines the role of sub-peat carbon for soils beneath a region of extensive blanket peat in southwest England. Ground penetrating radar (GPR) was used to establish peat depths across a 4 x 1 km survey area of blanket bog. Representative cores from across a range of peat depths were used to assess the relative importance of sub-peat and within-peat stores of carbon across the study area. The aim of the study was also to compare results with the landscape-scale (>10,000 ha) peat depth model of Parry *et al.* (2012). The term 'peat' is used to describe material with high loss-on-ignition values (>95%) that are characteristic of the blanket bog in this region. The 'sub-peat soil' is taken as the material that underlies the blanket peat, as we seek to demonstrate differences between carbon storage in blanket peat and the underlying material. This 'sub-peat soil' may be peat *sensu-stricto* by ecological or soil science definitions (e.g. Avery, 1980); here the term is used to differentiate it from the blanket peat.

Study area

Dartmoor National Park is an area of moorland in the south-west of England, where the underlying impermeable granite together with rainfall of ca. 2000 mm a^{-1} (Met Office, 2013) has led to the formation of an extensive area of hyper-oceanic blanket peatland. The survey area is ca. 550 m above sea level, and lies within an area of spatially extensive blanket peat on the northern part of Dartmoor (Figure 1), characterised by the NVC M17 *Scirpus cespitosus – Eriophorum vaginatum* community (Rodwell, 1991). No detailed mapping of vegetation sub-communities, or of blanket bog mesotopes within the broader blanket bog macrotope, has been undertaken either in this survey or previously. The Princetown association characterises the moorland soils away from the deep peat, which are coarse loamy cambic stagnohumic gleys (NSRI, 2013). A thin peaty topsoil overlies a grey, gritty often slowly permeable sandy loam horizon. However, it is unclear whether the soils under the blanket peat are similar other than for the lowest horizons: peat formation on Dartmoor began at least 4000 cal BP (Caseldine 1999; Fyfe and Woodbridge, 2012) and management of the moorland through grazing (Meyles et al., 2006) and burning (Yallop *et al.,* 2006) is likely to have altered significantly the properties of soil away from the blanket peat. The area is currently the focus of peatland restoration being carried out by Dartmoor National Park

Authority (The Dartmoor Mires Project). There are few available and direct measurements of peat depth within the study area and no direct measures of carbon storage. Palaeoecological studies from peat deposits on the northern part of Dartmoor have recovered cores of up to 6 m (e.g. Amesbury *et al*., 2008; Fyfe and Woodbridge, 2012).

Methods and study site

A GPR survey was used across the survey sites as a non-intrusive method for the determination of peat depth and extent. The survey used a PulseEkko Pro system with 200 MHz antennae which previous experience in this region had shown to be effective to over 6 m of peat. Readings were taken every 0.5 m in 'step-mode', i.e. with the antennae moved manually into the correct position for each data collection point, aided by 50 m tapes. Transects between 200 and 1200 m in length were spread across the region of interest (Figure 1). Locations of GPR survey data were established using differential GPS. The location of the transects was designed to optimise sampling rather than impose a rigid grid, informed by the first-order peat depth approximations of Parry *et al* (2012). Areas of known peat cutting or disturbance were avoided. Previous experience of GPR survey by the lead author within the wider region suggested that a radar velocity of 0.04 m ns^{-1} was appropriate for estimation of peat depths based on comparison with depths established through probing at different locations. GPR data were post-processed using EkkoView Deluxe, with topographic correction using a 0.5 m resolution LiDAR dataset. The peat/granite contact was the strongest reflector within the GPR traces below the ground surface: the depth of this contact was picked from the GPR from each trace and imported into ArcGIS 10.

The GPR data were used to select locations for extraction of 43 peat cores for measurement of carbon density from the peat and the sub-peat soil. Cores were taken at regular intervals along transects to sample a range of peat depths across the topographic and slope range of the survey. Cores were extracted using a closed-chamber (Russian-type) corer with a short nose cone (5 cm) which was pushed into the peat until contact with the underlying granite was made. The basal 0.5 m of each core was retained and the total depth noted; the lowest 5 cm of the sequence was not recovered owing to the corer design. Bulk density and loss-on-ignition were measured from contiguous 2 cm slices in each core. Bulk density for each sample was calculated by drying a known sample at 105 ^{0}C overnight prior to measurement of dry weight. Loss-on-ignition was calculated using standard methods (Allan, 1989): the samples were combusted at 550^{0}C for four hours for calculation of the mass loss. The start of peat formation was determined through examination of the bulk density and loss-on-ignition profiles from each core. Cores showed a transition from stable greater bulk density and lesser loss-on-ignition values to stable lower bulk density and greater loss-on-ignition values. The transition from the first state to the second was normally over 2-4 cm depth in the cores. Mean values of bulk density and loss-on-ignition were established for each core from above and below the depth of peat formation; it was assumed that the 5 cm un-sampled sub-peat soil (as a result of the corer nose cone) had the same values as the measured sub-peat soil. Carbon densities for the peat and sub-peat soil for each core were calculated using the equation in Cannell *et al* (1993), expressed as kg C m^{-3} (Equation 1).

$$CD = 10 \times d \times \rho \times f_{om} \times OM_C \qquad \text{Equation 1}$$

where: CD = carbon density (kg C m^{-3}); d = thickness of peat (2 cm); ρ = dry bulk density (g cm^{-3}); f_{om} = organic fraction of dry matter (loss-on-ignition value); OM_C = carbon fraction of f_{om} (assumed to be 0.5).

The application of Equation 1 resulted in two carbon density values at each core location. This allowed point-based estimates of total carbon stored per unit area (expressed as kg C m^{-2}) at each core location, by adding the product of carbon density of peat and the depth of peat to the product of carbon density of sub-peat soil and the total depth of sub-peat soil (Equation 2). The relative importance of the sub-peat soil carbon in the total carbon store was established by expressing it as a percentage of the total carbon at each point.

$$TCS_{point} = (CD_p \times TD_p) + (CD_{sps} \times TD_{sps}) \quad \text{Equation 2}$$

where: TCSpoint = total carbon stored at each location represented by the core (kg C m^{-2}); CDp = carbon density of peat (kg C m^{-3}); TDp = total depth of peat (m); CDsps = carbon density of sub-peat soil (kg C m^{-3}); TDsps = total depth of sub-peat soil (m).

Results

GPR-derived peat depth measurements

The GPR survey resulted in 38637 estimates of peat depths at 0.5 m intervals along each transect. GPR-derived peat depths and measured peat depths through coring are strongly correlated (Figure 2). There is a considerable range of peat depths within the study area

(Figure 3). The mean GPR-derived peat depth is 2.78 m (standard deviation 1.18 m). The data are normally distributed with a positive skew (0.78). The deepest peat measured through coring is 6.39 m; the deepest estimated from the whole GPR dataset is 7.28 m. These values are greater than expected for this area, and over 40% of the peat sampled is deeper than 3 m (Figure 3). There is reasonable agreement with the results of Parry *et al.* (2012) for the distribution of blanket peat, and good agreement between inferred depths and GPR derived peat depths where these are < 3 m.

Comparison between slope and GPR-derived peat depths, and slope and core depths, confirms the established relationship between slope and peat depths (Figure 4a). Peat is generally deeper on flatter slopes and thinner on steeper slopes. Sample cores span an adequate range of this scatter, indicating good representation of both slope and depth in the this study. There is no clear relationship between elevation and peat depth in the survey area (Figure 4b).

Carbon densities of peat and sub-peat soil

The average carbon density from the peat section of cores is 52.5 kg C m^{-3}, with a standard deviation of 10.1 (Table 1). The average carbon density from the sub-peat section of cores is 77.7 kg C m^{-3} (standard deviation 14.3). The average depth of sub-peat soils is 0.20 m (range 0.12-0.48). Multiplication of carbon densities from both stores with their respective depths (total peat depth and total sub-peat soil depth) provides an overall estimate of kg C m^{-2} at each coring location. There is variability at an order of magnitude between estimates of C m^{-2}, largely controlled by peat depth. The shallowest peat of 1.01 m stores 56.5 kg C m^{-2} and the deepest (6.63 m) 524.8 kg C m^{-2}. Mean carbon storage is 158.1 kg C m^{-2} (standard deviation 105.6). The relative importance of sub-peat carbon is very much controlled by peat depth (Figure 5). In shallower blanket peat (<2 m) 16.8 percent of the total carbon store is beneath the peat but with considerable variability between cores.

Discussion

Estimating depth of blanket peat

Empirical peat depth measurements obtained through coring compare well with GPR-based estimates of peat depth (Figure 2). This confirms earlier findings of Holden *et al.* (2002); Rosa *et al.* (2009); van Bellen *et al.* (2011); Plado *et al.* (2011) and Parsekian *et al.* (2012). Uncertainties with the estimation of peat depth are likely to be due to variations in the physical properties of the peat, which affect the speed of the radar pulse through the peat matrix, especially the peat composition or moisture content, and the number of calibration measurements (Rosa *et al.*, 2009). When processing the GPR data it is not possible to vary the radar velocity across a blanket peat area; 0.04 m ns^{-1} is therefore considered a reasonable value for blanket peat in this region as confirmed by comparison of core depth measurements and GPR derived depths, and is similar to other values (Rosa *et al*., 2009; Plado *et al*., 2011).

Model-based approaches to estimating peat depths rely on establishing a relationship between peat depth and topographic parameters such as slope and elevation (Graniero and Price, 1999; Holden and Connolly, 2011; Parry *et al*, 2012). It has been suggested that GPR-derived peat depths are useful for validating inferred peat depths (Holden and Connolly, 2011). The results here show good agreement with the GPR-derived peat depths and the Parry *et al*

(2012) model for peat depths below 3 m and the model successfully predicts peat distribution. The match is less successful for deeper peat in this study area. This is not a failing of the inferred peat-depth approach, which is designed to work at the landscape scale (>10000 ha), rather than at the local scale as in our study. The comparison does, though, confirm the need for field-based measurements for studies that require detailed understanding of peat depths in localised areas.

Comparisons between peat depth and slope (Figure 4a) show a non-linear relationship. There is no relationship between peat depth and elevation in this study (Figure 4b). Peat depth inference models are applicable at the landscape scale (Holden and Connolly, 2011; Parry *et al*., 2012), and at this scale relationships between elevation, slope and peat depth can be shown, if appropriate stratified sampling is applied. Whilst elevation may be important at the landscape scale (e.g. Beilman *et al*., 2008 and Parry *et al*., 2012), our results demonstrate that elevation does not play any role in peat depth across local blanket-bog complexes. In this area the elevation range (500-570 m OD) is too narrow to influence orographic rainfall or decreases in temperature associated with increases in elevation. Graniero and Price (1999) demonstrate that sub-peat topography plays an important role in influencing peat distribution. However, once peat has started to form, prevailing climatic conditions and autogenic processes of peat development also become an important determinant of peat distribution (Damman, 1979). Factors involved in autogenic peat development, in part controlled by slope, are likely to have controlled the observed distribution of peat depths our study area.

Importance of sub-peat soils as carbon stores

Estimates of peat depth and models that predict peat depth are used to determine carbon storage within peatlands at the site- and landscape-scale (Garnett *et al*., 2001; Chapman *et al*., 2009; Billett *et al*., 2010; Holden and Connolly, 2011). Chapman *et al.* (2009), for example, calculate a mean peat depth for Scotland of ca. 2 m, a lower value that in this study. Inaccuracies in representation of peat depth, such as those discussed here, result in poor estimates of carbon storage. It has also been recognised that sub-peat soils are an additional store of carbon: Turunen *et al*. (1999) estimate that the carbon densities of mineral sub-soils under boreal mires in Finland (typically 0.7 m thick) represent some 0.18 m equivalent storage in peat. The processes that control the accumulation of carbon in this mineral subsoil are discussed by Turunen and Moore (2003), and include the adsoption of dissolved organic carbon from pore water in the overlying peat. Few studies explicitly include this component in audits of carbon stores in blanket peat (e.g. Joosten and Clarke, 2002; Chapman *et al*., 2009; although see Turunen, 2008). The results from our study are the first for carbon in sub-peat soils for the UK, and indicate that on the granitic upland of Dartmoor, the soils that underlie the peat represent a significant additional carbon store with a greater density of carbon than the equivalent depth of peat. Carbon densities for sub-peat soils from Dartmoor are on average 77.7 kg C m^{-3}, compared with 52.5 kg C m^{-3} measured from the overlying peat. Variation in the carbon densities of peat determined from the cores may be a consequence of sampling different mesotopes within blanket bog macrotopes, or be a result of spatial differences in mire vegetation and/or management in the past. This cannot be tested given the absence of the necessary data. The value for peat is broadly in line for what has been described as the standard ‘cubic metre’ of Cannell *et al.* (2003) at 47 kg C m^{-3}. The proportion of total carbon stored below peat can be as much as 28 percent of the total carbon stored within the sample locations analysed here (Figure 5). The relative importance of the sub-peat soils in the total carbon audit is strongly controlled by peat depth, and represents a much larger proportion in shallower blanket peat (<2 m) than deeper peat (16.8 compared to 6.7 percent for peat over 4 m deep). It should also be recognised that other factors may also have an impact on carbon density, including the degree of peat decomposition and the composition of the peat (e.g. Mäukiläu, 1997) and sub-surface erosion such as from piping that can result in peat voids (Holden *et al.*, 2002).

The estimates of sub-peat carbon can be used in two ways when developing improved carbon audits of blanket peat regions. First, a uniform depth of sub-peat soil can be assumed across a surveyed area, and added to the inventory based on mean peat depths. The mean sub-peat soil depth in this study was 0.20 m (range of 0.12 to 0.48 m), providing an additional 15.71 kg C m^{-2}. It may be incorrect to assume uniform sub-peat soil depth, as the depth of pre-peat soils are likely to be strongly controlled by slope (Graniero and Price, 1999) with thinner soils on steeper slopes. Examination of the relationships between sub-peat soil depth and surface slope in the Dartmoor dataset showed no clear association which was unexpected. This may in part reflect the poor ability of surface topography to predict sub-peat topography in deep blanket peat, and it is very difficult to derive the slope of sub-peat from GPR data. The second approach to incorporating sub-carbon is to use frequency distributions of peat depth in a region of interest rather than the mean peat depth (e.g. frequency of classes of peat depth: Figure 3). Carbon densities for classes of peat depth can then be increased by the appropriate multiplier, based on the proportion of carbon stored in the sub-peat soil. Thus a carbon density of 53 kg C m^{-3} for peat 1-2 m thick can be scaled as appropriate to include sub-peat carbon, resulting in an estimate of 63.7 kg C m^{-3}. Where peat is 2-3 m deep, total carbon storage estimates indicate that 14.8 percent of carbon is stored under the peat. Incorporating the sub-peat carbon results in an amended carbon density of 62.2 rather than 53 kg C m^{-3}. This second approach does require measures of peat depths, which may not always be possible for large-scale carbon audits; however, detailed compilations of peat depth in the UK are being made and are likely to become available as a consequence of peat restoration initiatives.

The new depth-dependent carbon densities as proposed in this paper fully incorporate sub-peat carbon in the audit. They provide improved estimates as they incorporate the non-linear relationship between peat depth and proportion of carbon stored beneath the peat (Figure 5). For the survey in this study, if sub-peat carbon was not considered, then there would be an underestimation of total carbon by 15 percent based on the distribution of peat depths obtained from the GPR survey. A considerable proportion of the peat in this survey is > 2 m. The values are based on blanket peat developed over soils on a granitic upland. It is not yet clear whether blanket peat in other regions, developed over different geological formations, will have the same sub-peat soil carbon densities, and this remains to be explored. If the pattern is correct, then other regions which are characterised by shallow blanket peat (most < 2 m) may store considerably more total carbon than is presently assumed.

Conclusions

The results from our study support previous calls for scale-appropriate measurement of carbon in peatlands (e.g. Frogbrook *et al.*, 2009) and contribute to the need for more detailed studies of peat depth and carbon storage in peatland (Yu, 2012). We find that GPR is a reliable and effective method for collecting spatially-extensive measures of peat depths. Comparison with empirical measurements of peat depths demonstrate a very good match. GPR survey produces a very large number of peat depth estimates compared to manual depth measurements, and are useful for exploring spatial variation in peat depth, and relationships between depth and topographic parameters when combined with high-resolution topographic datasets such as LiDAR-derived DTMs. At the scale of our study there is no relationship between elevation and peat depth, although a non-linear relationship between slope and depth is apparent. Scale of enquiry is thus an important factor in deciding the most appropriate method for estimating peat depths. Existing landscape scale model-inferred peat depths based on slope and elevation provide good spatial matches in peat extent, and reasonable estimates for peat depths up to 3 m.

Measurement of carbon densities beneath and within blanket peat demonstrates the significant stores of carbon in sub-peat soils, with a mean value of 78 kg C m^{-3} for sub-peat soils, the first published measure of this carbon store in the UK. The mean carbon density of 53 kg C m^{-3} for blanket peat derived in this study is slightly greater than previous estimates, but is broadly comparable. The results from our study strengthen the call for more comprehensive carbon inventories for blanket peat regions. These must fully incorporate sub-peat carbon, in particular for regions with shallow blanket peat where it may represent a significant proportion of the store (up to 28% in the shallower peats in our study).

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Table 1: Details of cores, including location, depths, carbon densities and the proportion of carbon at each location stores in the sub-peat soil.

Core	Core coordinates (British National Grid)	Peat depth (m)	Peat C density (kg C m^{-3})	Sub-peat soil depth (m)	Sub-peat soil C density (kg C m^{-3})	Total C at core location (kg C m^{-2})	Total C in sub-peat soil (%)
DP01	256918, 81363	0.85	54.2	0.16	65.3	56.5	18.5
DP02	257073, 81452	4.60	47.5	0.16	75.1	230.4	5.1
DP03	257204, 81523	3.21	43.4	0.16	71.7	150.8	7.6
DP04	257337, 81592	2.52	47.1	0.14	57.0	126.7	6.3
DP05	257426, 81639	2.55	44.0	0.20	61.0	124.5	9.8
DP06	257560, 81703	1.21	43.7	0.18	55.9	62.9	16.0
DP07	258023, 81461	2.47	48.4	0.30	65.2	139.2	14.0
DP08	258102, 81370	1.69	42.6	0.22	60.2	85.3	15.5
DP09	258187, 81273	2.13	40.6	0.20	81.2	102.6	16.2
DP10	258352, 81083	1.69	45.7	0.14	71.9	87.3	10.0
DP11	258207, 80947	1.64	43.1	0.20	64.6	83.5	15.5
DP12	258099, 80846	3.80	50.2	0.14	71.7	200.9	10.0
DP13	257991, 80740	1.75	49.0	0.16	74.6	97.7	12.2
DP14	259070, 80897	4.09	73.5	0.20	86.5	318.0	17.3
DP15	259117, 80881	3.28	51.5	0.20	68.2	182.6	7.5
DP16	259212, 80847	3.71	52.3	0.22	71.9	209.7	7.6
DP17	259335, 80804	3.11	44.6	0.20	76.7	154.1	10.0
DP18	259467, 80758	4.22	68.1	0.40	79.7	319.2	10.0
DP19	259590, 80716	1.44	49.3	0.20	70.0	84.9	16.5
DP20	259796, 80642	1.67	38.3	0.22	67.0	78.7	18.7
DP21	259784, 80963	6.39	78.9	0.24	85.0	524.8	3.9
DP22	259435, 80955	4.69	69.1	0.22	90.7	344.1	5.8
DP23	259617, 80593	1.60	42.4	0.22	54.9	79.9	15.1
DP24	259617, 80704	1.49	54.1	0.30	94.8	109.0	26.1
DP25	259618, 80800	2.95	60.6	0.50	89.2	223.5	20.0

DP26	259618, 80901	4.22	69.4	0.18	101.0	310.9	5.9
DP28	259819, 80954	4.79	74.6	0.48	95.7	403.2	11.4
DP29	259818, 80880	2.43	44.8	0.26	65.4	125.9	13.5
DP30	259818, 80780	1.91	46.9	0.30	76.3	112.5	20.4
DP31	259818, 80680	1.50	46.7	0.26	74.6	89.4	21.7
DP32	259818, 80605	1.64	47.6	0.14	83.1	89.6	13.0
DP33	259818, 80380	1.40	46.7	0.20	80.0	81.4	19.7
DP34	258335, 80821	2.60	43.2	0.36	95.5	146.6	23.5
DP35	258335, 80921	1.09	43.8	0.30	64.3	67.0	28.8
DP36	258335, 81046	1.45	50.6	0.14	80.5	84.7	13.3
DP38	258335, 81221	1.39	49.9	0.14	76.0	80.0	13.3
DP39	258535, 81121	1.16	51.9	0.14	81.6	71.6	16.0
DP40	258535, 81071	1.71	60.0	0.16	104.6	119.4	14.0
DP41	258535, 81021	1.73	64.0	0.12	118.3	125.0	11.4
DP42	258535, 80921	1.44	59.2	0.20	102.2	105.6	19.4
DP43	258535, 80821	2.97	54.2	0.22	78.6	178.2	9.7

Figures

Figure 1: (A) Position of GPR lines (solid black lines) within the general survey area (white box). White circles indicate sample core locations. Background is a hillshade model of 0.5 m resolution LiDAR dataset. (B) Location of survey region within Dartmoor National Park (stipples) and southern Britain.

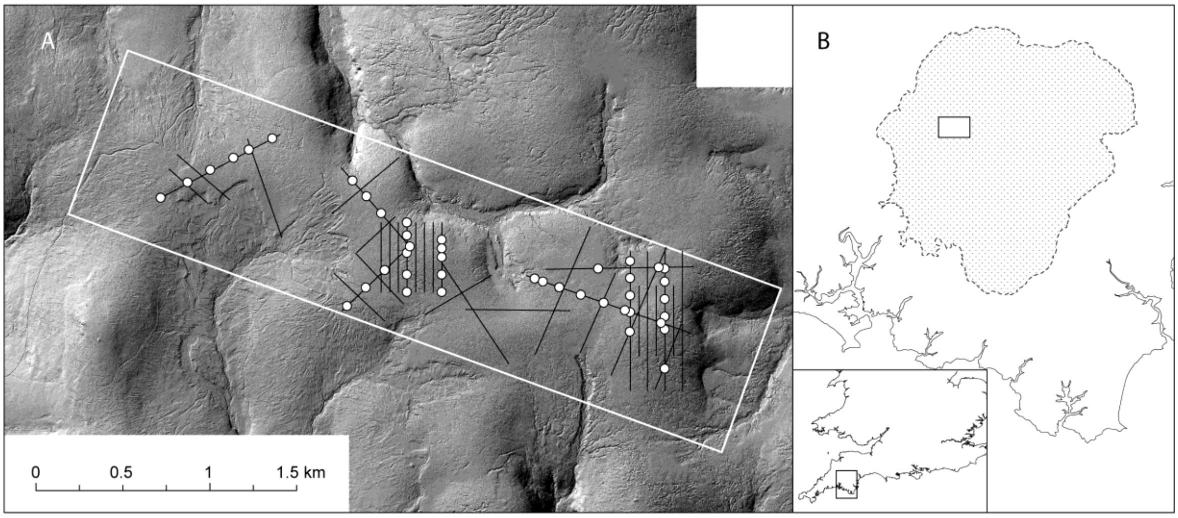

Figure 2: Comparison of GPR-derived peat depths with measured core depths.

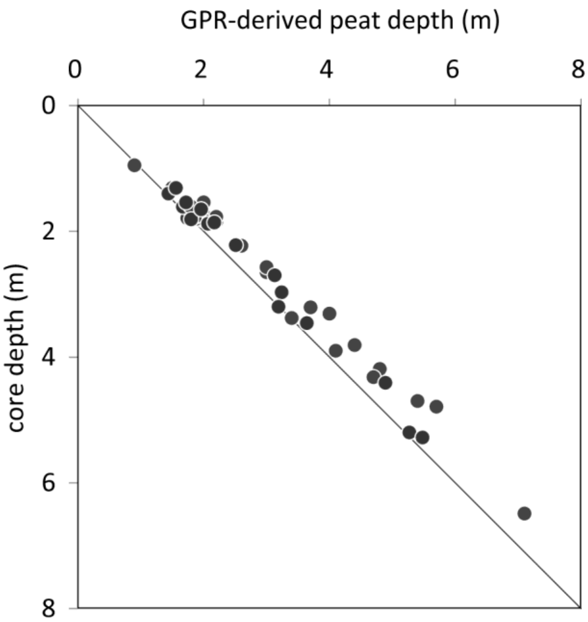

Figure 3: Distribution of GPR-derived peat depths by depth class.

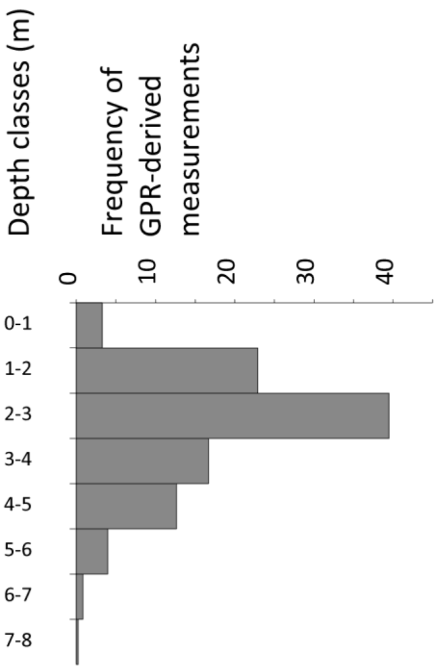

Figure 4: Relationship between GPR-derived peat depths and (a) slope and (b) elevation. Solid black symbols on (a) indicate position of cores samples.

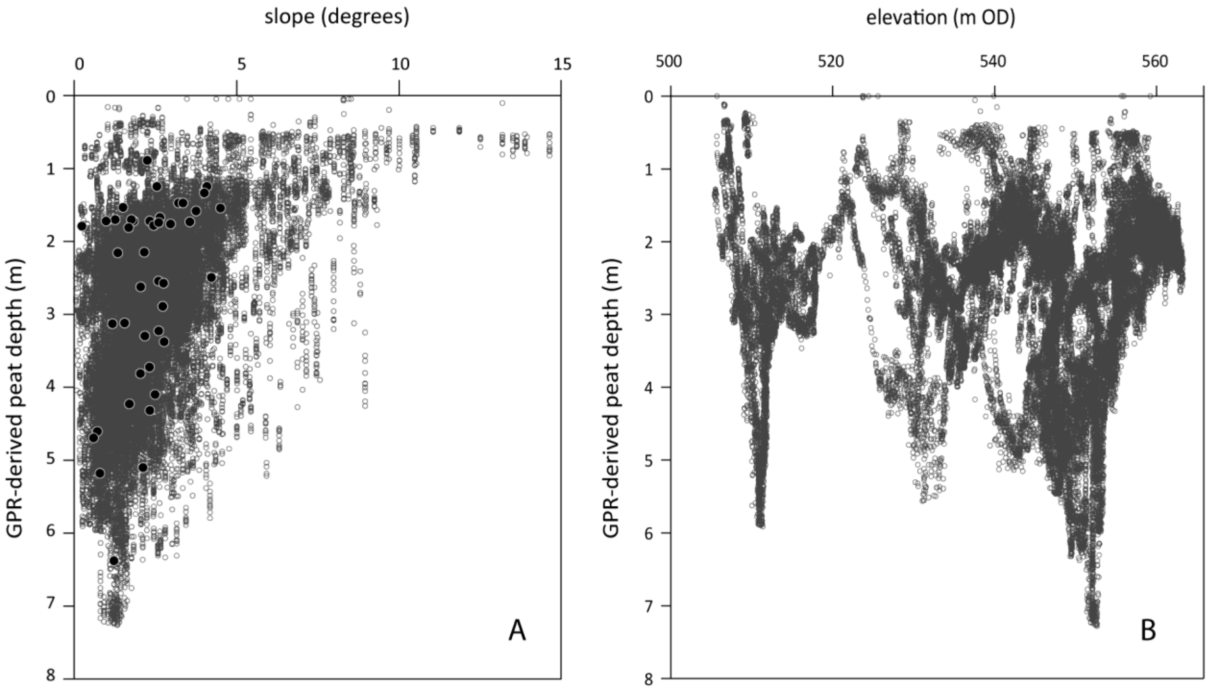

Figure 5: Relative importance of sub-peat carbon in total carbon inventory at each coring location, summarised in peat depth classes.