

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

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12 **Running title:** Sub-peat carbon storage

13 Received May 2013; accepted after revision October 2013

14

15 **Published as:**

16 Fyfe RM, Coombe R, Davies H and Parry L (2014) The importance of sub-peat carbon
17 storage as shown by data from Dartmoor, UK *Soil Use and Management* 30, 23-31. DOI:
18 10.1111/sum.12091

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20

21 **Abstract**

22 Peatlands are highly valued for their range of ecosystem services, including distinctive
23 biodiversity, agricultural uses, recreational amenities, water provision, river flow regulation
24 and their capacity to store carbon. There have been a range of estimates of carbon stored in
25 peatlands in the UK, but uncertainties remain, in particular with regard to depth and bulk
26 density of peat. In addition, very few studies consider the full profile with depth in carbon
27 auditing. The importance of sub-peat soils within peatland carbon stores has been
28 recognised, but remains poorly understood and is included rarely within peatland carbon
29 audits. This study examines the importance of the carbon store based on a study of blanket
30 peat on Dartmoor, UK, by estimating peat depths in a 4x1km survey area using ground
31 penetrating radar, extraction of 43 cores across a range of peat depth, and estimation of
32 carbon densities based on measures of loss-on-ignition and bulk density. Comparison of
33 ground penetrating radar estimates of peat depth with core depths shows excellent agreement,
34 to provide the basis for a detailed understanding of the distribution of peat depths within the
35 survey area. Carbon densities of the sub-peat soils are on average 78 kg C m^{-3} and 53 kg C
36 m^{-3} for the overlying blanket peat. There is considerable spatial variability in the estimates of
37 total carbon from each core across the survey area, with values ranging between 56.5 kg C m^{-2}
38 2 (1.01 m total depth of peat and soil) and 524 kg C m^{-2} (6.63 m total depth). Sub-peat soil
39 carbon represents between 4 and 28 percent (mean 13.5) of the total carbon stored, with
40 greater values for shallower peat. The results indicate a significant and previously
41 unaccounted store of carbon within blanket peat regions which should be included in future
42 calculations of overall carbon storage. It is argued that this store needs to be considered in
43 carbon audits.

44

45 **Keywords**

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

47

48 **Introduction**

49 Peatlands are highly valued for their range of ecosystem services, including distinctive
50 biodiversity, agricultural use, recreational amenities, water provision, river flow regulation
51 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;
52 Yu, 2012), and the role of peatlands in moderating atmospheric CO₂ concentrations has been
53 widely recognised (Holden, 2005; Joosten and Clarke, 2002), resulting in increased interest in
54 carbon stores and an agenda for peatland restoration (e.g. Tuittila *et al.*, 1999; Waddington
55 and Warner, 2001). Under the United Nations Framework Convention on Climate Change
56 (1992) the UK is required to estimate levels of carbon stored in terrestrial biomes (e.g.
57 Gorham, 1991; Milne and Brown, 1997) and to achieve this accurate carbon auditing is
58 needed (Beilman *et al.*, 2008). There has been a range of estimates of carbon stored in UK
59 peatlands, but uncertainties remain, in particular associated with estimates of peat depth and
60 bulk density (Bradley *et al.*, 2005; Buffam *et al.*, 2010; Chapman *et al.*, 2009; Garnett *et al.*,
61 2001; Parry *et al.*, 2012; Tomlinson, 2005; Yu, 2012; Zhang *et al.*, 2008). Despite recent
62 advances in improving the accuracy of these measures, very few studies consider complete
63 profiles for peat. Eswaren *et al.* (1995) suggest that if the total soil depth is not considered
64 when estimating carbon storage a large under-estimation in global soil carbon estimates will
65 result. Poor estimations of peat depth impair the accuracy of carbon inventories, especially
66 when the focus is limited to the top 100 cm (e.g. Bradley *et al.*, 2005; Milne and Brown,
67 1997) though there are studies concerned with deeper soils (e.g. Jobbagy and Jackson, 2000;
68

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

74

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

86

87 This study examines the role of sub-peat carbon for soils beneath a region of extensive
88 blanket peat in southwest England. Ground penetrating radar (GPR) was used to establish
89 peat depths across a 4 x 1 km survey area of blanket bog. Representative cores from across a
90 range of peat depths were used to assess the relative importance of sub-peat and within-peat
91 stores of carbon across the study area. The aim of the study was also to compare results with
92 the landscape-scale (>10,000 ha) peat depth model of Parry *et al.* (2012). The term 'peat' is

93 used to describe material with high loss-on-ignition values (>95%) that are characteristic of
94 the blanket bog in this region. The 'sub-peat soil' is taken as the material that underlies the
95 blanket peat, as we seek to demonstrate differences between carbon storage in blanket peat
96 and the underlying material. This 'sub-peat soil' may be peat *sensu-stricto* by ecological or
97 soil science definitions (e.g. Avery, 1980); here the term is used to differentiate it from the
98 blanket peat.

99

100 **Study area**

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

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

121

122 **Methods and study site**

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

139

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

160

161 $CD = 10 \times d \times \rho \times f_{om} \times OM_C$

Equation 1

162

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

166

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

173

$$174 \quad TCS_{\text{point}} = (CD_p \times TD_p) + (CD_{\text{sps}} \times TD_{\text{sps}}) \quad \text{Equation 2}$$

175

176 where: TCS_{point} = total carbon stored at each location represented by the core (kg C m⁻²);
177 CD_p = carbon density of peat (kg C m⁻³); TD_p = total depth of peat (m); CD_{sps} = carbon
178 density of sub-peat soil (kg C m⁻³); TD_{sps} = total depth of sub-peat soil (m).

179

180 **Results**

181 *GPR-derived peat depth measurements*

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

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

192

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

199

200 *Carbon densities of peat and sub-peat soil*

201 The average carbon density from the peat section of cores is 52.5 kg C m⁻³, with a standard
202 deviation of 10.1 (Table 1). The average carbon density from the sub-peat section of cores is
203 77.7 kg C m⁻³ (standard deviation 14.3). The average depth of sub-peat soils is 0.20 m (range
204 0.12-0.48). Multiplication of carbon densities from both stores with their respective depths
205 (total peat depth and total sub-peat soil depth) provides an overall estimate of kg C m⁻² at
206 each coring location. There is variability at an order of magnitude between estimates of C m⁻²
207 ², largely controlled by peat depth. The shallowest peat of 1.01 m stores 56.5 kg C m⁻² and

208 the deepest (6.63 m) 524.8 kg C m⁻². Mean carbon storage is 158.1 kg C m⁻² (standard
209 deviation 105.6). The relative importance of sub-peat carbon is very much controlled by peat
210 depth (Figure 5). In shallower blanket peat (<2 m) 16.8 percent of the total carbon store is
211 beneath the peat but with considerable variability between cores.

212

213 **Discussion**

214 *Estimating depth of blanket peat*

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

225

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

231 (2012) model for peat depths below 3 m and the model successfully predicts peat distribution.
232 The match is less successful for deeper peat in this study area. This is not a failing of the
233 inferred peat-depth approach, which is designed to work at the landscape scale (>10000 ha),
234 rather than at the local scale as in our study. The comparison does, though, confirm the need
235 for field-based measurements for studies that require detailed understanding of peat depths in
236 localised areas.

237

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

252

253 *Importance of sub-peat soils as carbon stores*

254 Estimates of peat depth and models that predict peat depth are used to determine carbon
255 storage within peatlands at the site- and landscape-scale (Garnett *et al.*, 2001; Chapman *et al.*,
256 2009; Billett *et al.*, 2010; Holden and Connolly, 2011). Chapman *et al.* (2009), for example,
257 calculate a mean peat depth for Scotland of ca. 2 m, a lower value than in this study.
258 Inaccuracies in representation of peat depth, such as those discussed here, result in poor
259 estimates of carbon storage. It has also been recognised that sub-peat soils are an additional
260 store of carbon: Turunen *et al.* (1999) estimate that the carbon densities of mineral sub-soils
261 under boreal mires in Finland (typically 0.7 m thick) represent some 0.18 m equivalent
262 storage in peat. The processes that control the accumulation of carbon in this mineral subsoil
263 are discussed by Turunen and Moore (2003), and include the adsorption of dissolved organic
264 carbon from pore water in the overlying peat. Few studies explicitly include this component
265 in audits of carbon stores in blanket peat (e.g. Joosten and Clarke, 2002; Chapman *et al.*,
266 2009; although see Turunen, 2008). The results from our study are the first for carbon in sub-
267 peat soils for the UK, and indicate that on the granitic upland of Dartmoor, the soils that
268 underlie the peat represent a significant additional carbon store with a greater density of
269 carbon than the equivalent depth of peat. Carbon densities for sub-peat soils from Dartmoor
270 are on average 77.7 kg C m⁻³, compared with 52.5 kg C m⁻³ measured from the overlying
271 peat. Variation in the carbon densities of peat determined from the cores may be a
272 consequence of sampling different mesotopes within blanket bog macrotopes, or be a result
273 of spatial differences in mire vegetation and/or management in the past. This cannot be tested
274 given the absence of the necessary data. The value for peat is broadly in line for what has
275 been described as the standard ‘cubic metre’ of Cannell *et al.* (2003) at 47 kg C m⁻³. The
276 proportion of total carbon stored below peat can be as much as 28 percent of the total carbon
277 stored within the sample locations analysed here (Figure 5). The relative importance of the
278 sub-peat soils in the total carbon audit is strongly controlled by peat depth, and represents a

279 much larger proportion in shallower blanket peat (<2 m) than deeper peat (16.8 compared to
280 6.7 percent for peat over 4 m deep). It should also be recognised that other factors may also
281 have an impact on carbon density, including the degree of peat decomposition and the
282 composition of the peat (e.g. Mäukilä, 1997) and sub-surface erosion such as from piping
283 that can result in peat voids (Holden *et al.*, 2002).

284

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

304 be possible for large-scale carbon audits; however, detailed compilations of peat depth in the
305 UK are being made and are likely to become available as a consequence of peat restoration
306 initiatives.

307

308 The new depth-dependent carbon densities as proposed in this paper fully incorporate sub-
309 peat carbon in the audit. They provide improved estimates as they incorporate the non-linear
310 relationship between peat depth and proportion of carbon stored beneath the peat (Figure 5).
311 For the survey in this study, if sub-peat carbon was not considered, then there would be an
312 underestimation of total carbon by 15 percent based on the distribution of peat depths
313 obtained from the GPR survey. A considerable proportion of the peat in this survey is > 2 m.
314 The values are based on blanket peat developed over soils on a granitic upland. It is not yet
315 clear whether blanket peat in other regions, developed over different geological formations,
316 will have the same sub-peat soil carbon densities, and this remains to be explored. If the
317 pattern is correct, then other regions which are characterised by shallow blanket peat (most $<$
318 2 m) may store considerably more total carbon than is presently assumed.

319

320 **Conclusions**

321 The results from our study support previous calls for scale-appropriate measurement of
322 carbon in peatlands (e.g. Frogbrook *et al.*, 2009) and contribute to the need for more detailed
323 studies of peat depth and carbon storage in peatland (Yu, 2012). We find that GPR is a
324 reliable and effective method for collecting spatially-extensive measures of peat depths.
325 Comparison with empirical measurements of peat depths demonstrate a very good match.
326 GPR survey produces a very large number of peat depth estimates compared to manual depth

327 measurements, and are useful for exploring spatial variation in peat depth, and relationships
328 between depth and topographic parameters when combined with high-resolution topographic
329 datasets such as LiDAR-derived DTMs. At the scale of our study there is no relationship
330 between elevation and peat depth, although a non-linear relationship between slope and depth
331 is apparent. Scale of enquiry is thus an important factor in deciding the most appropriate
332 method for estimating peat depths. Existing landscape scale model-inferred peat depths
333 based on slope and elevation provide good spatial matches in peat extent, and reasonable
334 estimates for peat depths up to 3 m.

335

336 Measurement of carbon densities beneath and within blanket peat demonstrates the
337 significant stores of carbon in sub-peat soils, with a mean value of 78 kg C m^{-3} for sub-peat
338 soils, the first published measure of this carbon store in the UK. The mean carbon density of
339 53 kg C m^{-3} for blanket peat derived in this study is slightly greater than previous estimates,
340 but is broadly comparable. The results from our study strengthen the call for more
341 comprehensive carbon inventories for blanket peat regions. These must fully incorporate
342 sub-peat carbon, in particular for regions with shallow blanket peat where it may represent a
343 significant proportion of the store (up to 28% in the shallower peats in our study).

344

345

346 **Acknowledgements**

347 This work was funded as part of the ESA scheme of Natural England, by the Trustees of the
348 Forest of Dartmoor ESA. The Trustees are thanked for their encouragement and interest in
349 the project. Helen Perry, Chris Carey and Chris Wildblood assisted with parts of the

350 fieldwork. We are grateful to Frances Cooper and Jane Marchand (Dartmoor National Park
351 Authority) for their encouragement and support of the project, which contributes to the wider
352 understanding of Dartmoor's peatlands and the Dartmoor Mires Restoration Project. The two
353 anonymous reviewers are thanked for their constructive comments that improved the earlier
354 version of the manuscript.

355

356

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473

474 Table 1: Details of cores, including location, depths, carbon densities and the proportion of carbon at
 475 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

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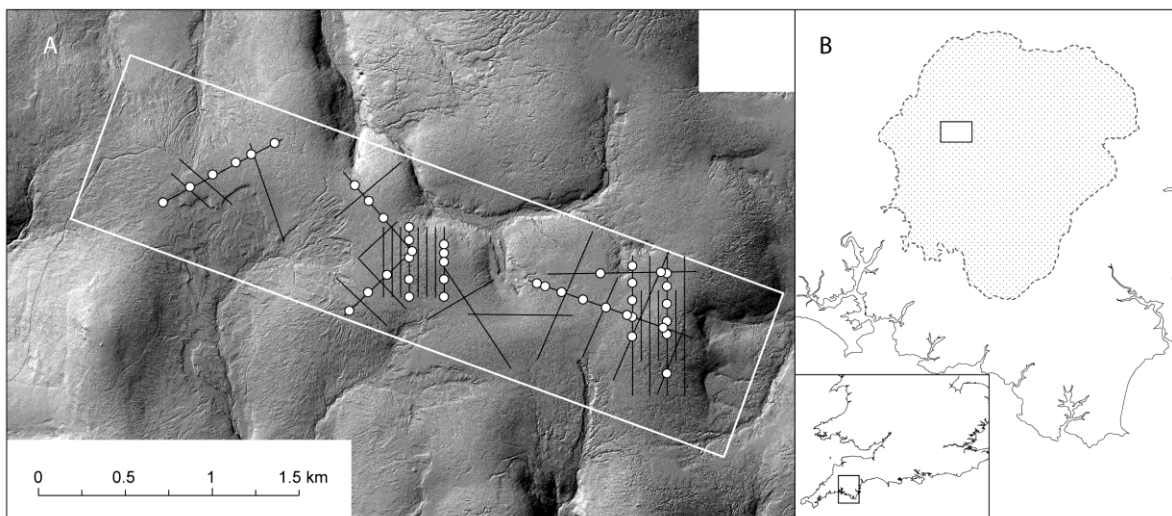
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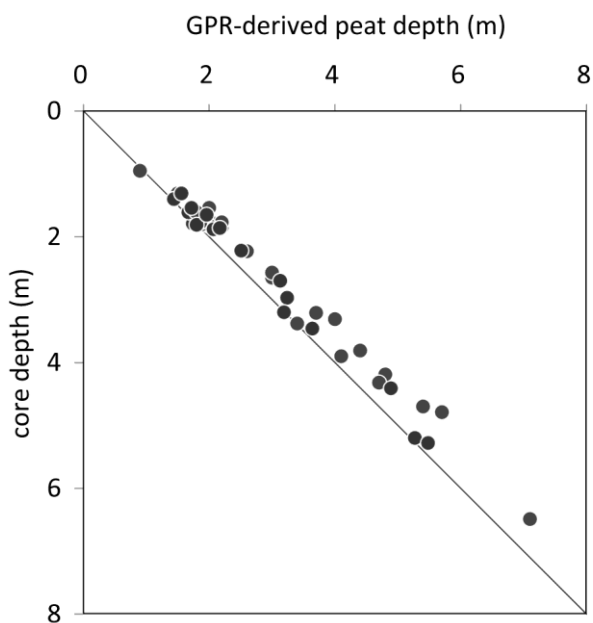
480 **Figures**

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



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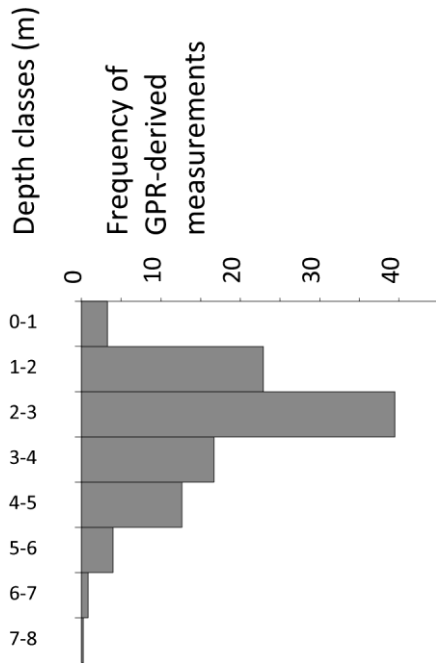
486 Figure 2: Comparison of GPR-derived peat depths with measured core depths.



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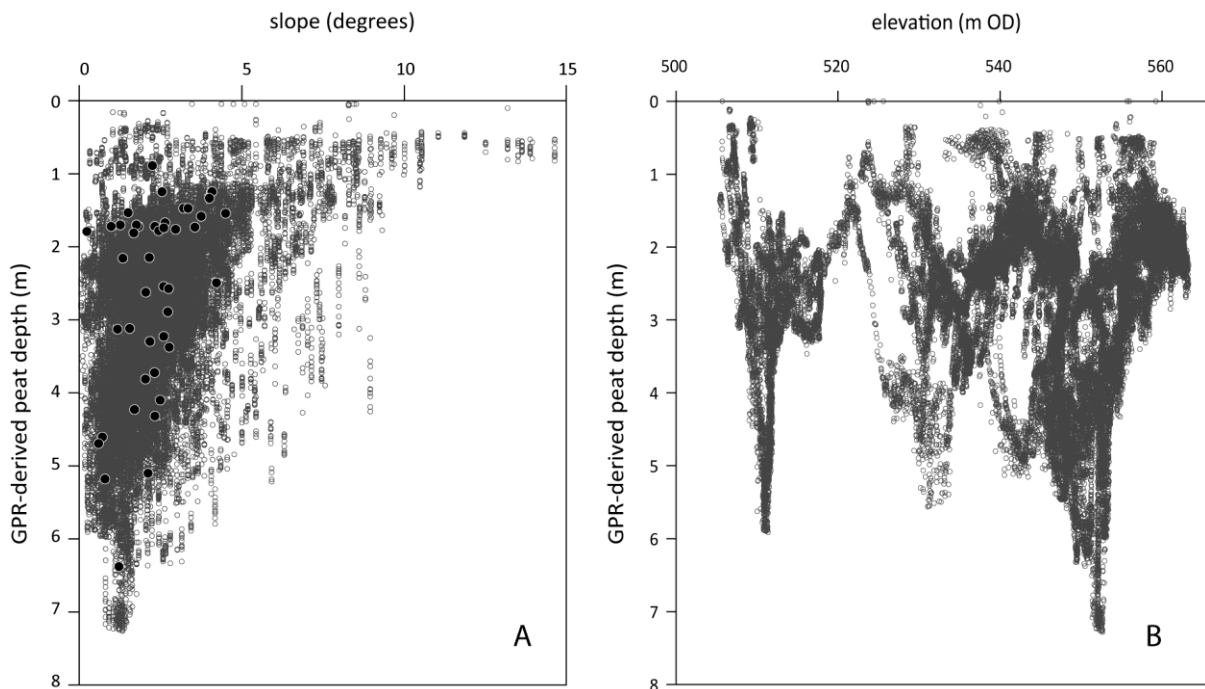
489 Figure 3: Distribution of GPR-derived peat depths by depth class.



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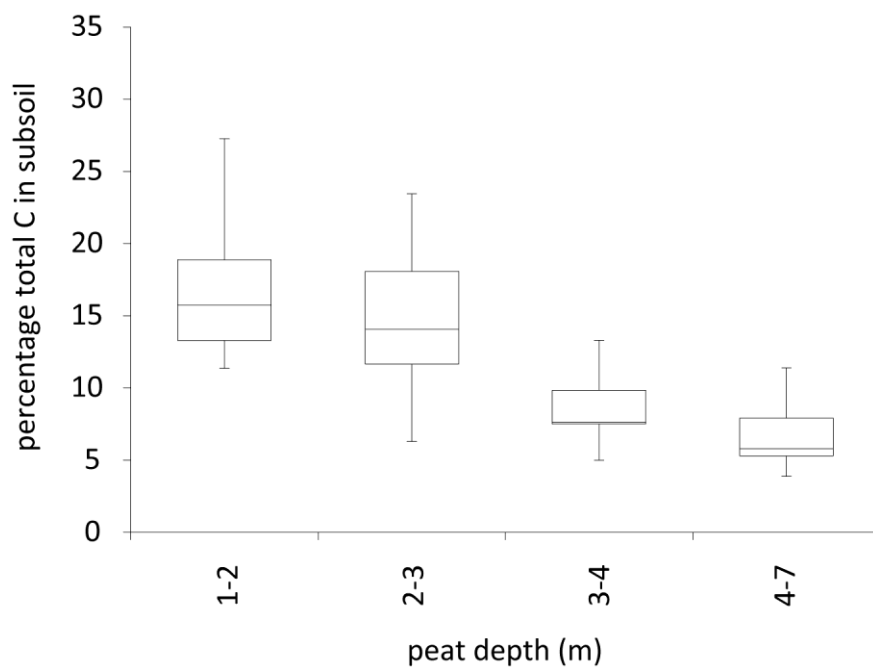
491 Figure 4: Relationship between GPR-derived peat depths and (a) slope and (b) elevation.

492 Solid black symbols on (a) indicate position of cores samples.



493

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



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