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Interactive comment on "Large-scale predictions of saltmarsh carbon stock based on simple observations of plant community and soil type" *by* Hilary Ford et al.

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Anonymous Referee #2

Major comments This is an important topic and it would be useful to have good predictors for a region, however, the information provided does not yet support the validity of a national inventory.

Thank you for your comments. We argue that the manuscript provides the basis for a national (Wales) inventory of blue carbon. We want to take the opportunity to highlight that the scale of our inventory is nearly unprecedented, and that the aim of our

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study is to make available a very simple method to the community of managers and non-academic sectors, which might not be acquainted with (nor have the means to do) elemental analyses, core extraction, etc. but that do commonly have access to vegetation and soil maps. Our manuscript provides support to these simple to use methods that give an estimate of soil carbon stock where estimates were previously largely non-existent, particularly at an individual saltmarsh level.

Methods There is no mention of how the locations of transects and quadrats were chosen. Methods suggest that vegetation types were specifically chosen, but later (ln 118) it is mentioned that an analysis was conducted to determine how they fit in NVC classes. This sounds a bit circular. Were vegetation types specifically targeted?

The 4 vegetation types focused on in this study were located using governmental maps based on vegetation surveys from 1996-2003 (detailed in section 2.6). Vegetation type was therefore validated on the ground as species extent could have altered between the survey date and the present day.

It is not clear why the statistical analyses had to be restricted to a linear model (ln 150) – it should not be restricted to because citizen scientists might use it- application of models is not commonly tasks that citizen scientists perform. If so, authors could provide a spreadsheet to perform the calculation.

Mixed effects models were chosen as they allow the estimation of fixed and random effects on the response variable (in this case SOC). The use of linear models is widespread. They usually assume a linear relationship between x and y variables (although you can always use transformations to model non-linear relationships using the same techniques, where needed [not in this case]). In addition, the analysis of variance that typically follows model building allow presenting the results in a format that is readily interpretable by members of both academia and governmental organisations. We will improve the text to make clear that the only thing that we ask citizen scientists to do as part of the Saltmarsh App is to check soil texture and vegetation

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type. Members of the public are not required to carry out their own analysis at all.

Location was divided into two classes, north and south Wales, and entered as a categorical variable. Is there a major biogeographical change between north and south? If latitude was considered important why not simply use latitude, rather than using a categorical value, to increase the ability to distinguish a gradient?

Location was included as part of the model structure with site nested within location (north or south). If location is removed P value category (i.e. $P < 0.001$, $P < 0.01$ etc.) and r2 values (to 2 significant figures) remain the same, we will therefore follow the reviewers suggestion and remove location from the model for the sake of simplicity.

Vegetation covered To determine how geographically broad the results of this study could be one, needs to know more about the vegetation sampled, and that not sampled. Only 5 salt marsh vegetation classes are listed in this study – all simply identified by a dominant(?) species – two are identified by the same species, Juncus maritimus. How many quadrats were sampled in each vegetation class and were these equally distributed among the marshes?

Part of this information is detailed in the supplementary material (Table S2). For the four vegetation types sampled, between 32 and 66 quadrats were surveyed, across a minimum of 9 and a maximum of 17 marshes, to reflect the dominant vegetation communities of the low, mid and high marsh saltmarsh communities along the coastline of Wales.

What proportion of cover is attributed to the dominant species? What types of species occur with the dominant? It would be useful to provide a table showing typical species composition and cover.

This information is detailed in Rodwell (2000), a table can be provided in supplementary material to determine each British National Vegetation Classification (NVC) with each subcategory. We can also use the maps in the supplementary material to provide an

estimate of the area coverage provided by the focus on 4 main vegetation types.

It is likely that perennials will contribute more to soil carbon than annuals and graminoids over forbs (although Triglochin and Plantago can have substantial below-ground biomass). Species richness was not found to be a significant explanatory variable, but what about the proportion of perennial vs annual plants? How many NVCs are there in UK salt marshes?

While from a purely academic point of view this is a relevant point, we should bear in mind the aim of making our methods applicable for managers and non-academics. Hence, given that the proportion of perennial to annual plants are mapped, the usefulness of this parameter usefulness in an applied tool such as the SCSP is limited. In contrast, NVCs are already mapped, what make them easy to use. There are 7 common NVCs found in the UK, 5 of which are considered in this manuscript. The two pioneer communities which were not assessed directly are included using mapped soil characteristics.

Breadth of Geographical Application Authors suggest that their model can be used to estimate carbon stocks in the UK and perhaps northwestern Europe, as well. Yet, not all plant communities present in Welsh salt marshes were sampled (ln 289). What communities does this study miss from Wales and across the UK? How much salt marsh area is not accounted for? Authors further that their model could be applied from the Baltic to Portugal – is the vegetation really that consistent?

Two pioneer saltmarsh communities common across Wales and the UK (Spartina and Salicornia), accounting for ∼30% area of Welsh saltmarsh, were not directly assessed in this study, however their soil carbon stock is predicted on the basis of mapped simplified-soil characteristics. The 5 common saltmarsh vegetation communities focused on in this study are also widespread across north-western Europe.

Unexplained variability Authors seem to have preliminarily truncated statistical analyses for this study. They note in the Discussion that _50% of the variation in the marshes

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they studied has yet to be statistically explained, further noting that the rest of the variation might be attributed to differences in grazing, salinity, pH, geomorpho-logical context, level of urbanisation, past disturbance, whether in a dynamic or stable area. Authors have reported data on grazing, salinity and pH that could easily be assessed in an expanded model. Geomorphological context can easily be determined from the maps in the supplementary material. As they mention "level of urbanisation" in the context of the study by Deegan et al. (2012). I assume they refer to nutrient loading of the estuary. Nutrient loading is not limited to urban development, but also to agricultural uses. If watershed nutrient loading models have been developed for UK estuaries the nutrient loading could be assessed as a predictor as well. Level of disturbance/ exposure seems to be similar to "whether the marsh sits in a dynamic or stable area", something that could be determined fairly easily.

Wording in this section of the discussion does need to be improved as grazing, salinity and pH were indeed considered in early model selection but were not significant explanatory variables of soil carbon stock. Modelling geomorphological context, level of urbanisation and nutrient loading were considered beyond the scope of this manuscript which focuses on the prediction of soil carbon stock from simple measurements vegetation type and simplified soil type.

Soil Carbon IPCC guidelines for calculation of greenhouse gas emission from land use change in coastal wetlands (Kennedy et al. 2013) suggest stocks be considered over 1 m depth. Granted such depths are difficult to sample and accurately measure bulk density, but not all soil samples in this study reached even 10 cm depth, yet this study is supposedly focussed on the upper 10 cm of soil. And, different soil parameters were measured over different depths.

We will add a section in the Introduction and Discussion to make clear that despite the fact that we are examining surface SOC stock, SOC stock in the top layer of soil is largely indicative of SOC stock in deeper soil layers. We will show that top SOC stock is indicative of deeper SOC stocks using data from Kingham, R.: The broad-

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scale impacts of livestock grazing on saltmarsh carbon stocks. PhD thesis, Bangor University, UK, 2013. This thesis includes 224 samples from a range of UK saltmarshes differing in soil type, plant community type and grazing intensity. By reanalysing this data set, we show that sampling to a depth of 10 cm consistently captures 72 $\pm$ 1 % of total soil organic carbon (Figure S1). We thus argue that surface SOC stock can provide a reliable predictor of deeper carbon stores and is therefore a useful indicator of total SOC stock for UK saltmarshes.

It is not clear how soil was sampled to determine bulk density over 10 cm depth – and this is a very critical element, central to the entire study. Text states that soil was collected from 2 cm to 9.5 cm. I suspect that the sampling ring mentioned was not 3.1 cm high but 7.5 cm high (diameter and height reversed in text?). Soil organic carbon was determined from this sample, as well. This is not quite 10 cm and why was the surface 2 cm not collected?

If text is changed from 'vertically' to 'horizontally' this should improve the clarity of explanation. In addition we can add a diagram to the supplementary material. The bulk density core used was 3.1cm high and 7.5 cm in diameter, it was rotated into a horizontal position to quantify the top 2 – 9.5 cm of soil in line with the methods used in Ford et al. (2016) Soil stabilization linked to plant diversity and environmental context in coastal wetlands. Excluding the top 2cm ensured that above ground vegetation was not accidentally included within the bulk density core. The bulk density and soil carbon measurements do not correspond to the soil texture which was determined only on the surface 5 cm (ln 133). Do authors have any idea what the soil is like below 10 cm depth? Are any of the sampled marshes filled or previously drained ad now restored?

All of the saltmarshes in this study are semi-natural, i.e. they have not been filled or previously drained but are often managed in some way (grazing livestock for food production or conservation, right of way for coastal paths etc.). Soil texture was assessed by hand at $\sim$5cm depth to reflect the mid-point of the bulk density and soil carbon measurements (from a depth of 2cm to 9.5 cm depth to quantify the top 10cm of soil). This

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method was used in Ford et al. (2016) Soil stabilization linked to plant diversity and environmental context in coastal wetlands.

Did Emmett et al. (2010) establish a relationship between OC and LOI to derive the conversion of 55% (Ln 131)?

LOI values were compared to total soil C content measured by elemental analyser in Emmett et al. (2010).

First National Inventory of blue carbon storage? It is a bit preliminary for authors to claim to have the first national inventory of blue carbon storage. We can change this to 'an inventory of blue carbon storage in surface soil layers'. We would like to emphasise that when we talk about National Inventory we do not mean UK-wide. We are talking of a National Inventory, for Wales (a nation within the UK). Technical Editing

Figure 1 fig b needs a scale bar.

A scale bar will be added to Figure 1b.

Figure 2 compares carbon stocks at a single marsh applying results of different models. However, because the areas covered are different it is not a fair comparison of the difference in carbon stocks predicted by the model.

Figure 2 illustrates soil carbon stock in two ways, firstly soil carbon stock is shown visually (in t C ha-1) using a grey scale with each section of marsh assigned a shade of grey based on predicted category of soil carbon stock, this scale is used regardless of saltmarsh area and matches the four models selected in this paper for use in the SCSP tool and the Saltmarsh App. Secondly each figure presents the area of the marsh in hectares alongside the total carbon stock (in the top 10 cm of soil) for that area in t C. Panel D illustrates 'best practice', where the NVC_soil_model is used where NVC communities are mapped, with Soil_model used for the remaining saltmarsh area when NVC information is not available (not mapped), thereby giving the best estimate of soil carbon stock for the whole marsh area.

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Ln 41 Soil organic carbon IS belowground

This sentence will be altered to avoid confusion.

Ln 45 I am surprised that salt marshes are considered terrestrial habitats

In the Scholefield (2013) document they were classified as Coastal Margins alongside terrestrial habitats such as woodlands and grasslands.

Ln 87 What current inventory?

The wording in this sentence is a little misleading, it will be altered for clarity. We refer to the current inventory as information compiled by the IPCC (2014) on blue carbon storage.

Ln121 samples are dried to there is no longer a loss of moisture rather than for a prescribed time –Did authors assess whether 72 hrs adequate?

Drying at 60 or 70 °C for 72 hours is a commonly used methodology for drying plant vegetation. We always test the amount of time needed to get constant weight. In our experience, with the amount of plant material we use it rarely exceeds 72 hours. This was tested with a subset of samples at the beginning of this study and in this case, 72 hours was enough for the small amount of above-ground biomass analysed (<5 g fresh weight).

Ln 367 what is meant by a “pioneer community” here?

Pioneer communities are defined in the previous sentence as Spartina and Salicornia communities.

Ln 390 Since level of disturbance/exposure seems to be similar to “whether the marsh sits in a dynamic or stable area” seem to be the same there is no reason to cite an unpublished manuscript.

We will remove this reference from the manuscript.

Ln 269 shouldn't 0.45 be 45%?

Footnotes to tables will be edited to ensure use of either proportion (0.45) or percentage (45%) is clear.

References cited Kennedy HA, Alongi DM, Karim A, Chen G, Chmura GL, Crooks S, Kairo JG, Liao B, Lin G. 2013. Chapter 4 Coastal Wetlands In: Supplement to the 2006 IPCC Guidelines on National Greenhouse Gas Inventories: Wetlands. We will double check citation guidelines for this publication. At present we have cited it as IPCC (2014).

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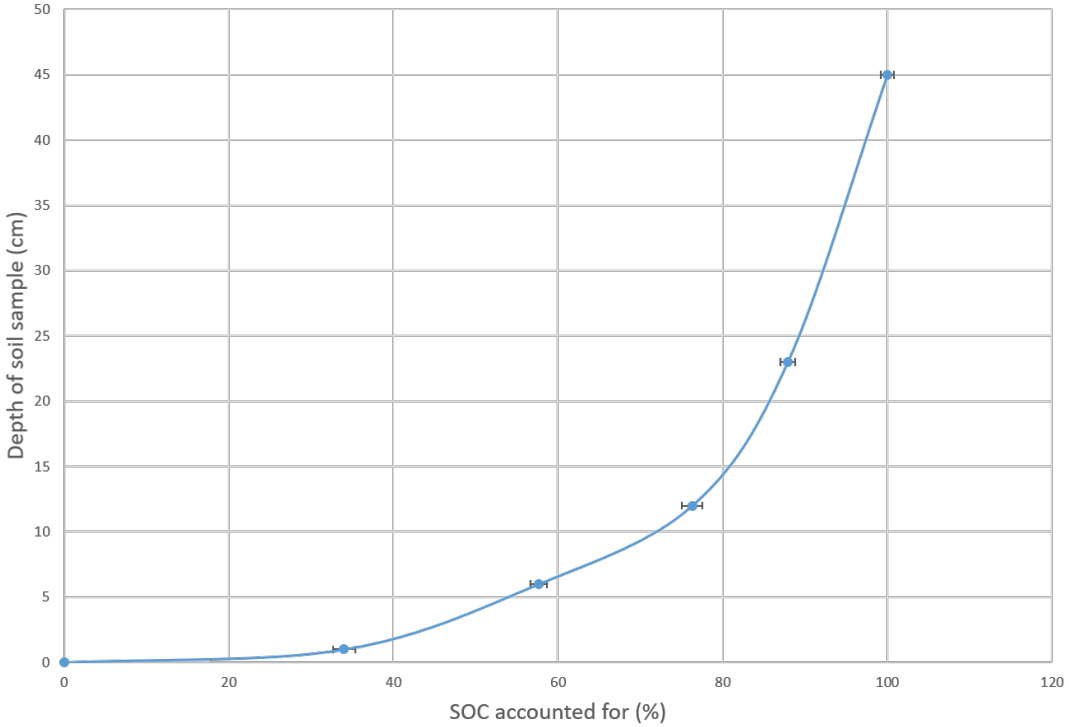

Fig. 1. Figure S1. Soil carbon (%) accounted for by soil depth based on 224 saltmarsh cores from 22 saltmarshes in the study region, differing in soil type, plant community type and grazing intensity.

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