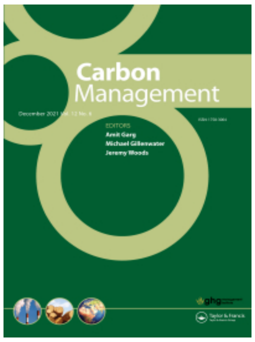

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A calculator for local peatland volume and carbon stock to support area planners and decision makers

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ABSTRACT

Conserving soil carbon is one of many actions to take in limiting global warming. However, carbon dense peatlands are still being drained or excavated. Infrastructure development is one of the major current threats to boral peatlands in Fennoscandia, but few tools are available for calculations of carbon stocks in peatland areas, necessary for decision makers planning development projects. Thus, we compiled a reference database of key peat characteristics from main boreal peatland types sampled in Norway and tested "best practice" peat depth sampling methods and peat volume interpolations. We implemented our findings in CarbonViewer, a tool and easy-to-use app that reliably calculates carbon stocks of delimited peatlands. Tool and method presented, estimates carbon stocks to assess potential soil carbon loss in planned infrastructure development on peatlands and will give decision makers the necessary knowledge base to limit emissions from soil carbon.

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Area planning; bog; fen; land-use change; mire; peat; soil carbon

Introduction

Soil carbon is invaluable in the combat against climate change as the global soil organic carbon (SOC) stock is currently approximately three times larger than the atmospheric C pool [1]. Part of the SOC is considered irrecoverable and losses non-compensable within the time target of net-zero emissions [2–4], set to avoid catastrophic effects of climate change, even with mitigation and restoration efforts [4]. Avoiding further losses of SOC is therefore critical for curtailing the ongoing climate change [5,6], and offers a relatively low cost natural climate solution which includes provision of co-benefits such as halting biodiversity loss [6].

Peatlands are C-dense ecosystems harbouring more than 20% of the global SOC on 3% of total land cover [7]. High and stable water level is essential for peat accumulation as peat forms under water-saturated, anoxic conditions where C sequestration rates of plants exceed SOC decomposition rates [8]. Peatlands, however, lend themselves poorly to biomass production or construction purposes and alterations to hydrology such as drainage, excavation or compression are typically required prior to use. Globally, drained peatlands constitute 4% of all anthropogenic greenhouse gas (GHG) emissions [9]. Consequently, anthropogenic activities on peatlands have large effects on global GHG emissions and with "business as usual" their climate impact will continue to increase [10,11].

Owing to their large land cover of C rich peatlands, the Nordic countries are globally important in preserving SOC, unique biodiversity, and water [12]. In Finland, Sweden, and Norway, peatlands cover 27%, 20%, and 9%, respectively, of terrestrial land [13,14]. These Nordic peatlands have been and still are under great pressure from land use change from peatland conversion to forestry, fodder and fuel production, with consequent increases in GHG emissions. Only recently, infrastructure development (IPCC category settlement including building of roads, housing and various other type of infrastructure) has gained attention as an underestimated contribution to the degradation of peatlands and subsequent loss of ecosystem services provided by them. Therefore, the area

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of peatlands and volume of peat affected by construction are poorly documented and the legislative framework regulating construction work on peatlands in the Nordic countries is insufficient. Furthermore, guidelines and instructions to adequately and efficiently quantify peat volume and SOC stocks potentially subjected to infrastructure development are mainly lacking. Therefore, a practical and user-friendly tool for rapid assessment of total peat volume and C content of peatland sites considered for infrastructure development is urgently needed.

Here we define "best-practice" for reliable measurements of SOC stock in peatlands within the boreal zone, specifically the required measurement intensity of peat depth, and build a peatland database of peat properties. We also developed a calculator [hereinafter referred to as CarbonViewer; 15] for quick quantification of SOC stocks at a given peatland site, targeted to serve decision makers and those planning and undertaking construction work on peatlands. The peatland database is integrated in CarbonViewer. We tested the CarbonViewer on different case studies with diverse sampling approaches for mapping peat area, peat depth and peat properties.

Materials and methods

Peat characteristics and carbon density

To convert estimated peat volumes into carbon stocks, reliable estimates of peat characteristics representative of various peatland types and environmental context, are needed. We therefore compiled a reference database of key peat characteristics to be used for this. Peat samples were collected from southern Norway (Trøndelag, Innlandet, Viken and Vestland counties) in 2017, 2019, and 2020. The sampling covered peatland types along the poor to rich fen gradient and bogs, which is representative for dominant peatland types in the Nordic countries, according to the nature type classification Nature in Norway version 2 [16]. Using an Eijkelkamp peat corer, peat cores were mainly sampled from three depths: 0–50 cm (beneath the active vegetation layer), 100–150, and 200–250 cm. In peatlands shallower than 150 and 250 cm, the second and third depth were collected from 50–100 or 150–200 cm, respectively. In total, 30 peatland sites were sampled, and 87 samples were collected and analysed.

Gravimetric water content and bulk density (BD) were measured from a sub-sample (~50 g) cut from the peat core, set into ceramic crucibles (Almath Ltd), and oven dried to constant mass at 70 °C for 24 h, before being weighed again. From heterogenous peat cores, the subsample included several smaller samples presenting the variation based on colour and texture. Stones (>2 mm) were removed from all samples prior to the start of analysis. A lower than standard drying temperature (typically 105 °C for soils), was chosen in order to avoid organic matter (OM) charring that can occur at or above 80 °C in peat, and 70 °C was determined to maximise moisture loss from pore cavities, which can retain water at 60 °C [17,18]. Soil organic matter (SOM) was estimated through Loss of Ignition (LOI-450), using gravimetric weight change from high temperature oxidation of the organic matter within the peat. One profile from each peatland site was tested for carbonate content (inorganic C) following the addition of 10% HCl [19], but none were reactive. This is supported by geological maps, which suggest all assessed peat areas lay above non-carbonate bedrocks (typically granites). The previously oven-dried peat samples were combusted in a programmable muffle furnace at 450 °C for four hours, and the ash weight measured after cooling. Between each drying or LOI step, samples were covered before removal from the ovens and immediately weighed, or stored in a desiccator, to prevent any re-saturation from atmospheric moisture.

Total carbon (TC) and total nitrogen (TN) contents were analysed with a dry combustion CN elemental analyser (Vario Cube EL), using 3–4 mg taken from a representative sub-sample of pulverised oven-dried peat. Sample soil organic carbon (SOC) was calculated through SOM:SOC conversion factor of 0.5 (SOM × 0.5 = SOC), as recommended by Pribyl [20], and considering the lack of carbonates [21].

Peat depth and volume

Peat depths were measured in five study sites with contrasting size, geometry, peatland types and peat depth sampling methods (Table 1). Differing sampling methods allowed us to apply CarbonViewer for both systematically collected data and data collected as part of applied projects, covering the likely range of end user data. At sites 1, 2, and 3 the full peat depth was sampled intensively and systematically in a 20 × 20 m grid. At

Table 1. **Background information, mapping and sampling strategies of five test sites from Norway used to find best practice peat depth measurements and test carbon stock calculations in peatlands.**

ID	Site	Background	Peatland type	Peatland area	Peatland depth	Peat properties
1	Tydal	A fictional power plant was drawn by Statnett to reflect former construction work on peatland. It was situated close by an existing power plant and considered suitable for access points and connection to the power net. There are no existing plans to build down the peatland area.	Mapped using Nature in Norway classification [16]	Borders defined in field	Peat depths measured using a peat probe at intervals of 20 m in a grid. All points georeferences using a high precision GPS device (Trimble R2 integrated GNSS system).	Peat cores sampled randomly within each peatland type, as defined by NiN. At each location samples were taken at the depths 0–50 cm, 100–150 cm, and 200–250 cm (with a few exceptions).
2	Kinn	Two peatland sites surveyed as part of a municipality-wide survey of carbon rich areas [34].	Mapped using Nature in Norway classification [16]	Borders defined in field	Measured using a peat probe at intervals of approx. 20 m. All points georeferenced with a handheld Garmin GPS device.	Peat samples collected from each peatland at 0–50 cm, 50–100 cm, 100–150, and 150–200 cm (latter two from only one site).
3	Voss	Area regulated for housing. Mapping of biodiversity and carbon content in areas with peatland was commissioned as part of planning and decision making [35].	Mapped using nature in Norway classification [16]	Borders defined in field	Measured using a peat probe at intervals of 10 m. All points georeferenced with a handheld Garmin GPS device.	Not provided
4	Geilo	Several smaller peatlands were surveyed as part of updated local regulation plan of land use change for recreational purposes (cabin, access roads, resorts). In the regulation plan, 40% of peatland area may be converted to other land use, and all peatland massifs may be affected [36].	Not provided	Borders defined in field	Measured at irregular intervals, but mostly at about 10 m, measurement pole 2,8 m long. All measurements deeper than the pole given as 300 cm.	Not provided
5	Modalen	Area regulated for upgrading of existing power plant. New power plant will be constructed partly on peatland.	Not provided	Estimated from area where peat was found combined with aerial photos and topographic map	Geotechnical analysis conducted with measurements of various soil layers. Measurements were taken at irregular intervals of about 30–50 m.	Not provided

site 1, 17 points were sampled with a 10 m spacing, before it was deemed too time consuming for the total area, thus 20 m spacing was used in the continued sampling. At these three sites, all measurements were taken using a peat probe. Site 4 was intensively sampled, but without a systematic approach, with depths measured at 0.26 m to 28.9 m intervals, using a 2.8 m probe. Peat depths of more than 2.8 m were standardised to 3 m. Peat depths at site 5 were collected at irregular intervals every 30–50 m as part of soil boring for geotechnical analysis.

Interpolating the volume of peat

We used inverse distance weighting [IDW; 22] to interpolate the total volume of peat in our five study sites based on the peat depth measurements. The output was a 1 × 1 m raster grid cropped to the extent of the mapped peatland site. IDW was chosen because of its simplicity which was important for incorporating the interpolation procedure into the online application CarbonViewer (see below). As the goal was to allow end users to easily estimate peat volume and carbon content from their own data, we set out to generalize a model parameter setting which would be easy to use. The maximum number of neighbors was set to 30. We then created a function to identify the optimum level for the power parameter based on a criterion of lowest mean absolute error (MAE). End users might still want a more local model which preserves the real values (i.e. depths), because identifying deeper and shallower sections of the peatland may be important for development decisions. Such cases may be identified by the appearance of excessive *spots* or *islands* in the map of predicted peat depths, indicating that too much smoothing has occurred (see Figure S7.4 in Appendix A in Supplemental Online Material). We therefore added the possibility to manually change the power. We tested this approach on five contrasting test sites (see Appendix A). This model parameter setting generally worked quite well, and we validated this by looking at how different settings influence model residuals (Figure S3.9 in Appendix A) and the total peat volume (Figure S3.10 in Appendix A).

Peat depths and minimum required sampling intensity

The minimum field sampling intensity required for reliable estimation of peat volume was tested using site 1 and 4 (Chapter 4 in Appendix A). These two sites (one mire polygon at site 4) were chosen because they had a high density of sampling points. Using the best model (see above), the peat volume for each site was estimated several times, starting with the full number of data points, and then sequentially removing one of the two points that were closest to each other. We visually checked that the original systematic sampling design was maintained (Figure S4.3 and S4.4 in Appendix A). For each iteration we estimated the total peat volume (Figure S4.9 in Appendix A) and calculated the coefficient of variation (Figure S4.10 in Appendix A) and MAE (Figure S4.11 in Appendix A) to evaluate how few data points you could base the interpolation on before the uncertainty in the results would become unacceptable.

CarbonViewer

The carbon calculator was developed as an interactive web shiny app [23] using R [24] version 4.1.2. The user needs to provide a zip file containing a shapefile of the sampled location and a table containing the associated depths measurements. Based on further user inputs (i.e. peatland types), CarbonViewer then calculates peat volume and total carbon content for the given site. We tested the calculator with five datasets using different peat depth data collection strategies (Table 1).

Calculating total carbon content

To calculate total carbon content (tons) in CarbonViewer, the equation from Cannell et al. [25] is used:

$$SOC = v \times BD \times LOI \times 0.5$$

where SOC = total carbon (t C m^{-3}), v = peat volume (in m^3), BD = dry BD (in t m^{-3} or g cm^{-3}), LOI = loss of ignition (fraction of compostable organic matter in peat), 0.5 = SOM:SOC (set to 0.5, as recommended by Pribyl [20]). To quantify the uncertainty in the carbon stock estimates we did bootstrapping with 1000 iterations, resampling, with replacement, the peat characteristics in the reference dataset.

Results and discussion

Peat depths, volume estimation and sampling density

We tested the peat volume interpolation with datasets using different measurement approaches for peat depth. Four datasets were collected mainly systematically, while one was sampled more randomly and sparsely (Table 1). The total peat volume was relatively insensitive to model parameter settings, but the visual appearance of the prediction maps was clearly affected. The "best model" result of total volume was close to the total volume calculated by multiplying the mean of peat depth from the depth measurements with the area of the peatland (Table 2). This is likely due to the predominance of systematic sampling in our data, and bigger differences could be expected with more opportunistic or random sampling.

Analyses of best practice peat depth sampling show that peat volume can be reliably calculated with reduced sampling effort, provided that a systematic sampling strategy is followed. At Site 1, $>$30 m median distance between datapoints resulted in an abrupt decline in total peat volume (Figure 1). The cv (Figure S4.10 in Appendix A) and MAE (Figure S4.11 in Appendix A) increased already with a median distance between points of about 25 meters. At this site, larger median distances rendered the proportion of sampling points at edges with shallow peat relatively more important than that of sampling points at the peatland centre with deeper peat. At site 4, the estimated peat volume increased from the original point density and to a distance of 10–12 meters between points, after which it levelled off. We think this is due to the overrepresentation of data points from mire edges in the original data. The interpolation could not control for this (although a more local interpolation, i.e. a higher power, does help), and this example highlight the need for a balanced sampling design. Subsequently, the estimated peat volume, and the variations in the estimated peat volume, increased as the median distance from nearest neighbour got above 20 meters (Figure 1). The cv and MAE increased in parallel. After removing $>$90% of the datapoints from site 4, the median distance between datapoints was 28.9 m, and the volume estimate differed only by 6% as compared to the full dataset (108 497 m^3, $n = 100$ vs. 102,029 m^3, $n = 1137$). Similarly, the volume estimates for site 1 changed considerably only after removing 75% of the datapoints which translates to median distance of 29.6 m between datapoints ($n = 24$).

Irrespective of relatively stable volume estimates, lower sampling intensity compromises information on local variability of peat depth (Figure 2), which is often needed for detailed decision making. As the interpolation tests show, the estimations of peat volume are stable at high frequency peat depth sampling and drops after a certain density (Figure 1). In spatial planning, we therefore recommend maintaining a maximum distance of 20 m between peat depth measurements, but this distance can be increased in larger,

Table 2. Overview of peatland type, area, peatland polygons, mean peat depths, calculated peat volume, number of peat depths measurements, density of measurements, interpolated peat volume, optimum and chosen power, MAE and carbon stock of five peatland sites from Norway.

ID	1	2		3	4	5
Site	Tydal	Kinn 1	Kinn 2	Voss	Geilo	Modalen
Coordinates EPSG:25832	636444, 6991973	292403, 6822904	292773, 6825542	366286, 6721847	455902, 6709703	337872, 6753851
Peatland type	Bog; poor and intermediate fen	Rich fen	Blanket bog	Treed poor fens	Unknown	Unknown
NiN-classification	V1-C-1, V1-C-2, V1-C-3, V3-C-1	V1-C-4	V3-C-1	V1-C-5	Unknown	Unknown
Area (m^2)	37,923	13,542	33,242	8700	91,152	16,753
No. of peatland polygons	1	1	1	2	13	5
Mean peat depth (m)	2.03	2.44	0.90	1.06	1.08	1.02
Calculated peat volume (m^3)	76,994	33,041.3	33,915.9	9208	986,990	17,031
No. of peat depth measurements	104	35	78	54	1136	12
Peat depth measurement density (points 100 m^{-2})	0.27	0.26	0.23	0.62	1.25	0.07
Interpolated peat volume m^3 (best model)	77,337	33,530	33,037	9270	102,444	16,793
Optimum power	4	5	4	2	2	2
Chosen power	4	5	4	3	3	3
MAE (m)	0.39	0.80	0.40	0.39	0.59	0.82
Carbon stock (tons) [95% CI]	3501 [2977–4014]	1531 [1312–1741]	1500 [1290–1712]	420 [356–485]	4661 [3962–5332]	765 [656–881

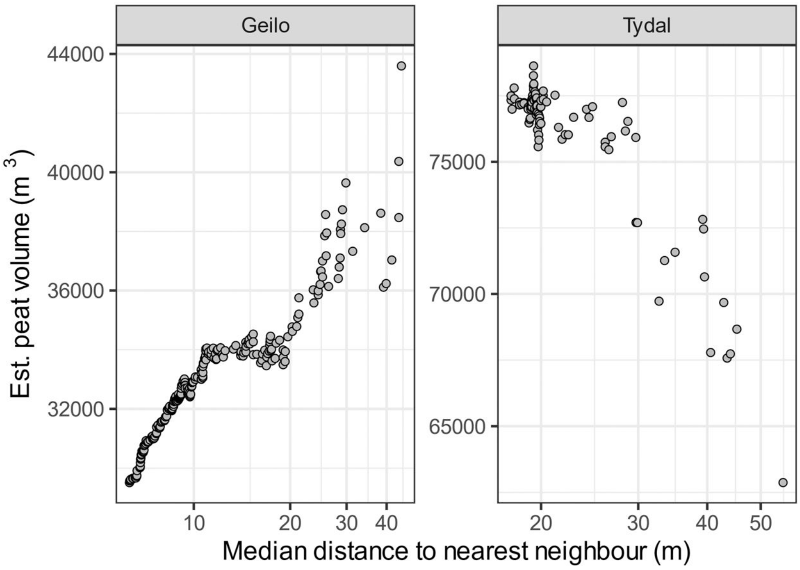

Figure 1. **Estimated peat volume as a response of the median distance between sampling points for two test sites: site 1 (Tydal) and site 4 (Geilo).**

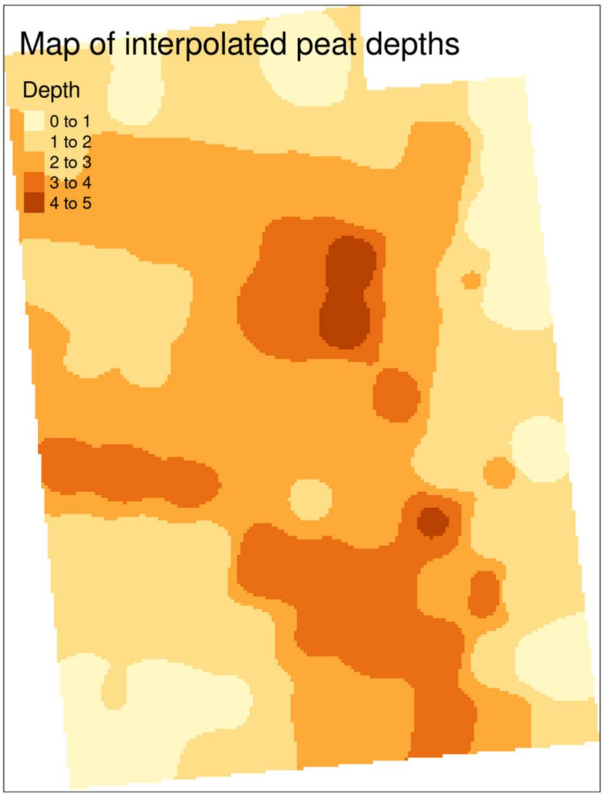

Figure 2. **Map of interpolated peat depths of a hypothetical power plant at site 1 Tydal. The map is produced by CarbonViewer.**

homogenous peatlands. For small peatland areas, we recommend a denser sampling strategy whilst keeping the total number of sampling points balanced between peatland edges and centre. Also, more frequent peat depth measurements could give more accurate peat volume estimates in areas of abrupt surface changes due to for example erosion.

Peat properties and peatland database

We analysed 87 peat samples. After discarding samples with organic matter content or BD greatly outside the ranges documented in Chambers et al. [26] or from degraded peatlands (21), altogether 66 samples were included in the statistical analysis. A reference dataset with peat properties of the 66 samples was integrated in CarbonViewer. The dataset represents four main peatland types (rich, intermediate, and poor fen and bog, Table 3).

The conversion from SOM to SOC has been debated widely over the years, and studies show that the SOC content of peat varies slightly, but not overly, between 48% and 56% [26,27]. A conversion factor of 0.5 is recommended by most [20,26,27]. We calculated SOC from the conversion of SOM from LOI measurements while validating against total C content from the dry combustion analysis. In general, the results from the two different methods were similar (±5%).

The mean SOC of 49% from LOI and dry combustion analysis, respectively are within typical range of peatlands [28] and reflect that most of our samples are from *Sphagnum*-dominated peatlands (bog, poor and intermediate fen, Table 3). The mineral content of the peat samples (residue ash content after LOI) was generally very low (mean 2.8% ± standard deviation 3.6%, $n = 66$) with 7 out of 66 samples having a mineral content greater than 5%. As reflected in our peat samples, most ombrotrophic peatlands have negligible mineral content. Minerotrophic peatlands, on the other hand, can be subjected to a multitude of

Table 3. **Bulk density (BD), soil organic carbon (SOC), carbon (C) density and carbon/nitrogen (C/N) ratio of peat samples taken at different depths of four main peatland types.**

Peatland type	Depth (cm)	BD (t/m^3)	SOC (%)	C density (kgC/m^3)	C/N
Bog	0–50	0.11 ± 0.07 (16)	48.92 ± 1.99 (14)	43.23 ± 40.15 (14)	30.92 ± 9.85 (12)
	50–100	0.12 ± 0.04 (6)	48.25 ± 1.78 (4)	23.54 ± 25.29 (4)	34.50 ± 7.78 (2)
	100–150	0.08 ± 0.04 (12)	49.45 ± 0.62 (10)	28.91 ± 22.20 (10)	41.70 ± 9.30 (10)
	150–200	0.13 ± 0.01 (4)	49.78 (2)	31.61 (2)	48.50 (2)
	200–250	0.08 ± 0.08 (4)	48.20 ± 1.44 (4)	35.75 ± 34.52 (4)	44.50 ± 11.90 (4)
	Profile mean	0.09 ± 0.04 (13)			
Poor fen	0–50	0.10 ± 0.07 (5)	48.24 ± 2.06 (5)	39.01 ± 34.59 (5)	29.00 ± 4.40 (4)
	50–100	0.10 ± 0.05 (2)	47.64 ± 1.41 (2)	32.80 ± 34.12 (2)	25.00 (1)
	100–150	0.08 ± 0.05 (3)	49.51 ± 0.08 (3)	41.27 ± 24.34 (3)	28.00 ± 7.00 (3)
	150–200	0.12 (1)	49.57 (1)	59.48 (1)	19.00 (1)
	Profile mean	0.09 ± 0.05 (5)			
Intermediate fen	0–50	0.11 ± 0.05 (5)	47.97 ± 3.51 (5)	42.43 ± 26.98 (4)	22.25 ± 7.93
	50–100	0.14 (1)	44.44 (1)	31.11 (2)	ND
	100–150	0.06 (2)	48.21 (2)	30.48 (1)	23.00 ± 5.66
	200–250	0.08 (1)	49.20 (1)	40.34 (1)	17.00
	Profile mean	0.10 ± 0.04 (4)			
Rich fen	0–50	0.05 (3)	49.32 ± 0.44 (3)	19.97 ± 13.37 (3)	20.33 ± 2.31 (3)
	50–100	0.11 ± 0.04 (2)	48.02 ± 2.17 (2)	34.90 ± 32.79 (2)	22.00 (1)
	100–150	0.08 ± 0.04 (3)	47.67 ± 2.55 (3)	27.93 ± 22.15 (3)	19.00 ± 1.41 (2)
	150–200	0.13 (1)	46.03 (1)	29.92 ± 42.31 (2)	ND
	200–250	0.06 ± 0.03 (3)	48.78 ± 0.83 (3)	21.72 ± 17.60 (3)	26.00 ± 5.66 (2)
	Profile mean	0.07 ± 0.04 (4)			

The presented values are average (± standard deviation) of the number of samples analyzed (in parenthesis).

mineral inputs. In addition, deeper layers of ombrotrophic peatlands may carry minerotrophic legacies from flooding of adjacent lakes or streams. Also in our dataset, samples from peatlands with larger oceanic influence tended to exhibit higher mineral content.

The BD is shown to markedly influence C stock estimates in peatlands, and C stock scales linearly with BD. Our results were generally within the range of 0.01–0.25 g cm^{-3} which is common in peatlands [26,29]. One site, a rich fen along a riverbed in a valley with extremely high BD (0.62 and 0.74 g cm^{-3}) and low SOC (33% and 26%), was excluded from the final dataset as it was judged to be atypical. Typically, BD increases with disturbance, being the lowest with little compaction and humification and the highest in humified and compacted peat. Source material of the peat further defines BD [26,29] and therefore *Sphagnum*-dominated bogs have lower BD than graminoid-dominated fens [30–32]. The BD also varies throughout the peat column depending on state and origin of the peat layer reflecting development and events through time [27,31]. In our dataset, this vertical variation was idiosyncratic (Table 3; Figure 3). We found no clear differences in either SOC or BD between peatland types (Table 3). This may be due to small sample size, as Watmough et al. [33] found clear differences between peatland types in their larger dataset. Thus, we have kept the categorization of peatland types in CarbonViewer.

The database integrated in CarbonViewer is set up to be dynamic and can be updated with additional contributions from founders, collaborators and app users. We expect that an increased amount of data on each peatland type, will eventually result in differences between types. The database is currently rather small and from Norwegian sites, and when using the database on sites outside of Norway, results should be interpreted with caution. To improve carbon calculations, end users can provide their own data on peat characteristics from their site of interest. Several samples should then be taken to include the variation found throughout the peat layers. Peat properties are associated with the dominating vegetation that created the peat deposits, and the vegetation composition has most likely changed as peat develop over a millennial scale. Ideally, the full peat profile at the site should be examined and calculations based on the volume of the different peat layers at the site. However, this is presently not included as an option in CarbonViewer, as the complexity of data input and requirement of expertise in peat sampling would make the app less user friendly. Hence, samples from degraded

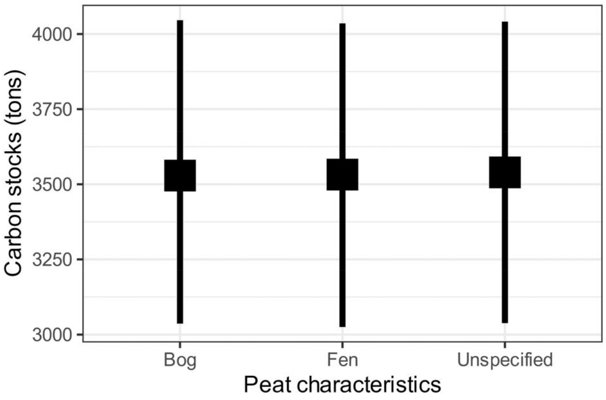

Figure 3. **Mean (± 95 CI) carbon stock for site 1 Tydal calculated specifying different peatland types.**

peatlands were excluded from the database for now, as the sites they were taken from were degraded only in the top layer (down to approximately 1 m).

Using CarbonViewer

The user of CarbonViewer must upload a zip-file including a csv-file of peat depth data with coordinates and a shapefile containing the polygon of the site (see example data files in Supporting Information or the test dataset provided in the GitHub repository of the application). We recommend analysing one peatland polygon at a time in CarbonViewer. Then, CarbonViewer interpolates the peat volume using the optimal power setting. After viewing the interpolated map, the user may choose to manually change the power setting and re-run the interpolation until the maps are satisfactory. The user will obtain an output including the total peat volume and the total carbon stocks. In addition, a map of the interpolated peat depths is displayed and downloadable (Figure 2). We anticipate several uses of the map for developers including serving as a decision-making tool to estimate the total peat volume of a specific peatland and for identifying local variability in peat depth to potentially minimize the extent of planned intervention.

The reference dataset is used as default in CarbonViewer to estimate carbon stocks. If the peatland type is known, the user can choose the type in the app providing peat characteristics for that type to be used in the calculation of C stocks. When the user has no knowledge of the peatland type at the site, this is set to unknown, and the mean of all included peat samples is used in the calculation. Due to the large variation in peat characteristics in the reference dataset, the choice has currently no real impact on the estimated C stocks (Figure 3). Alternatively, users can also add their own values for peat properties such as BD. A larger reference dataset may however provide more representative estimates than a limited set of local samples, due to high small-scale variability and the possibility for sampling errors.

Conclusion and perspectives

We developed CarbonViewer to provide an easy-to-use tool for decision makers across different sectors. CarbonViewer requires simple data collection with inexpensive equipment (peat depth and area delineation). CarbonViewer uses peat depth measurements to interpolate the total peat volume on a relatively small “peatland” scale. Therefore, spatial covariates, that are only relevant on larger spatial scales, such as topography and climate, have been neglected. The underlying database of CarbonViewer covers all relevant peatland types in subarctic, boreal, hemiboreal, and northern temperate climate zones and can therefore be used in peatlands of those climate zones for comparatively accurate assessments of SOC stock with small amount of input data. Caution is warranted if used without or with insufficient input data for other peat types than *Sphagnum* peat, e.g. *Carex* and ligneous peats that are common in southern temperate and tropical climate zones. CarbonViewer provides estimates for current SOC stock in peat and accounts for neither the loss of current C in vegetation nor for the future C sequestration capacity of vegetation. Furthermore, current SOC stock is not an estimate on SOC loss caused by partial disturbances, which depends on a multitude of factors, such as time, loss rate, and extent of disturbance. Thus, CarbonViewer is not suited to evaluate the changes in GHG emissions from peatlands caused by these land use changes.

Determining impacts of infrastructure development on peatlands must be assessed with a holistic approach considering the impacts on various ecosystem services provided by peatlands. More specifically, assessing the impacts of construction work on both climate and biodiversity and providing tools to evaluate synergies and tradeoffs between them are of utmost importance. To date, there are no reliable estimates on the impacts of different end uses of peat deposits (e.g. rewetting, restoration, or abandonment) resulting from construction work on GHG emissions or on biodiversity value. Until such data are available, attempts for comprehensive evaluation of climate and environmental impacts of construction work on peatlands are redundant. With CarbonViewer, we provide a tool and methodology for decision makers to estimate C stocks of given peatland sites when planning infrastructure development and include this in their knowledge base, minimizing the loss of carbon rich areas.

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CRediT authorship contribution statement

Magni Olsen Kyrkjeeide: Conceptualization, Methodology, Investigation, Writing – Original draft, Writing – Review and Editing, Visualization, Project administration. **Marte Fandrem:** Conceptualization, Methodology, Investigation, Software, Validation, Formal analysis, Data Curation, Writing – Original draft, Writing – Review and Editing, Visualization. **Anders L. Kolstad:** Methodology, Software, Validation, Formal analysis, Data Curation, Writing – Review and Editing, Visualization. **Jesamine Bartlett:** Investigation, Writing – Review and Editing. **Benjamin Cretois:** Software, Writing – Review and Editing. **Hanna Marika Silvennoinen:** Methodology, Writing – Original draft.

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Data availability statement

Data are available from the app CarbonViewer at https://carbonviewer.nina.no.

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