Estimates of the carbon stocks in Danish mires

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ABSTRACT

Substantial amounts of organic carbon may be stored in peat lands. The carbon stocks in selected Danish mires were investigated by comparing two national surveys of peat resources from 1930 and 1956 and new data based on field work which involved mapping of six drained bogs and fens. The objective was to evaluate whether the old surveys may be used for estimating the present carbon stocks in Danish mires. A total of 150 peat samples representing different mire types and land use history were analysed for bulk density, carbon, degree of humification, ash content and pH. GIS and kriging interpolation were used to make 3D models of peat volume and to calculate the carbon stocks in the mires. The results showed that the carbon stocks were reduced about 40 % between 1930 and 1956 due to cutting of peat for fuel, suggesting that the 1930 survey is unsuitable for estimating the present carbon stocks. Only small changes were found in the carbon stocks from 1956 to 2000 with no clear dependency on land use, indicating that the 1956 survey is more suitable for present carbon stock calculations. The peat samples showed a carbon density in both bogs and fens between 50 and 70 kg m^{-2} (mean 60 kg m^{-2}) in the uppermost one meter of soil. The Danish mire area is estimated at 90,000 hectares, which gives a carbon stock of 54.6 Mt. Total carbon stocks in Danish soils (uppermost one meter) have recently been estimated as high as 579 Mt. This means that although peat land soils cover only 2.1 % of the Danish land area, they store nearly 10 % of the total soil organic carbon stock, and even more if deeper layers are included.

Key words: Carbon, peat land, GIS, kriging, 3D models, Denmark

YFIRLIT

Mat á kolefnisforða í dönskum mýrum

Mikið magn lífræns kolefnis er geymt í mýrlendi. Kolefnisforðinn í völdum dönskum mýrum var rannsakaður með því að bera tvær kannanir á mýraforða í Danmörku frá 1930 og 1956 saman við nýjar upplýsingar sem byggja á kortlagningu sex þurrkaðara mýra- og flóasvæða. Markmiðið var að meta hvort nota megi eldri mælingar til að meta núverandi kolefnisforða í dönskum mýrum. Samtals 150 mismunandi sýni úr mýrum sem höfðu verið nýttar á mismunandi vegu voru notuð til að mæla rúmþyngd, kolefni, rotnunarstig, öskuinnihald og sýrustig. Landupplýsingakerfi (GIS) og brúun með krigingu ("kriging interpolation") voru notuð til að gera þrívíddarlíkan af rúmmáli mýranna og til að reikna út kolefnisforða þeirra. Niðurstöður sýndu að kolefnisforðinn rýrnaði um 40 % frá 1930 til 1956 vegna brennslu á torfi til orkuvinnslu, sem sýnir að könnunin frá 1930 er ónothæf sem grunnur að mati á núverandi kolefnisforða. Einungis litlar breytingar hafa orðið á kolefnisforða frá 1956 til 2000, án augljósra tengsla við landnotkun, sem bendir til að upplýsingarnar frá 1956 henti betur til mats á núverandi forða. Mælingarnar sýna að kolefnisþéttnin í efsta metra mýrjarðvegsins er á milli 50 og 70 kg m^{-2} (meðaltal 60 kg m^{-2}). Dönsk mýrasvæði eru talin 90.000 hektarar sem gera 54,6 Mt af kolefnisforða. Heildarkolefnisforði í dönskum jarðvegi hefur nýlega verið metinn 579 Mt. Þetta þýðir að enda þótt mýrlendi sé aðeins 2,1 % af yfirborði Danmerkur, þá geyma mýrarnar 10 % af heildar kolefnisforðanum, og jafnvel meira ef tekið er tillit til dýptar.

INTRODUCTION

Estimates of carbon stocks in soil and determination of carbon sinks and sources have received much attention in the last decade. Specifically, the Kyoto Protocol stipulates that its parties shall determine their level of soil organic carbon in 1990, and shall enable an estimate of changes in carbon stocks in subsequent years (United Nations 1998).

Mires play an important role in these estimates because they accumulate organic carbon as peat and also emit large amounts of greenhouse gases (Succow & Joosten 2001). In their natural state mires are characterized by a high groundwater table that promotes anaerobic conditions leading to a slow decomposition of the produced biomass. The mire vegetation buries older material and creates a sequential deposition of peat (Succow & Joosten 2001). The mires in Denmark have formed during the past 10,000 years (Averdieck 1990) and carbon constitutes between 50 and 60 % of the stored peat (Assarsson 1961, Mathur & Farnham 1985), which makes them an important component of the estimates of the national carbon stocks.

In Denmark, as well as in most of northern Europe, mires have been drained and utilized for industrial or agricultural purposes, forestry or grazing during the last 100-150 years. Draining leads to a lowering of the groundwater table and consequently deepening of the aerobic zone, which increases the mineralization of peat. In addition, the loss of capillary forces leads to subsidence of the surface through compaction and shrinkage (Hansen 1989). As drainage conditions persist, mires may turn from being carbon sinks to potential carbon sources. The degradation of the mires is a function of drainage practices and land use. Hence they develop in a number of ways as regards the carbon stock (Eggelsmann 1990). Furthermore, during the two World Wars huge amounts of peat were cut for fuel. An estimate of the Danish industrial and public fuel peat cutting from 1902 to 1962 gives a total peat loss of 69.3 million tons (Hedeselskabets Tidsskrift 1902-1962).

An estimate of the present carbon stocks in Danish mires can be assisted by the two major surveys of peat lands in Denmark. From 1919 to 1940 The Danish Heath Society carried out the only nationwide survey of peat lands (Thøgersen 1942). The objective of this 'Meadow and Mire Survey' (hereafter termed 'the 1930-survey') was to map the peat fuel resource in Denmark, and it included all mires larger than five hectares in size. Information on land use, peat volume, bulk density, degree of humification and ash content is available from this survey. From 1955 to1956 The Danish Heath Society carried out another survey (hereafter termed 'the 1956-survey') that covered only Viborg and Randers Counties (Krøigaard 1960). Again, the objective was to map the peat fuel resource, but this time areas with a potential fuel resource, regardless of size, were also mapped. Information on land use, peat volume, bulk density, degree of humification and ash content is also available from this survey. Furthermore, maps showing mire area and peat sample points were presented in this survey. Peat lands in both of the surveys were defined by Mentz (1910) as areas having a peat layer at least 30 cm deep.

The objective of this study was to evaluate the suitability of the two existing peat land surveys for estimating the carbon stocks in Danish mires and to present a preliminary estimate of the stocks. This was accomplished by comparing the old data with new data obtained from a selected research area where detailed field studies were carried out, combined with GIS-based 3D modelling.

MATERIALS AND METHODS

Selection of research area

The Bjerringbro Municipality in Viborg County was chosen for the research site because the peat land area had been mapped in both of the earlier surveys by the Danish Heath Society and maps and sampling records from the 1956 survey have been digitised and stored in a GIS.

During the summer of 2000 the area and peat depth of six bogs and fens covering an area of 73 hectares were mapped and chemical and physical properties of peat samples were analyzed. Six drained bogs and fens with fairly constant land use in the period 1930 to 2000 were selected as representing different mire types typical for Denmark. Classification of the mires followed the Mentz definition from 1910. Hence the mineral soil/peat boundary was mapped at the 30 cm peat depth. An overview of the research area is shown in Figure 1.

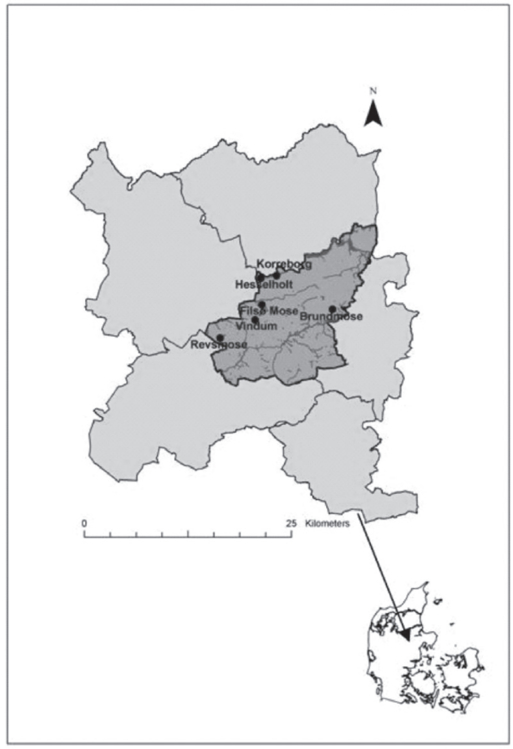

Figure 1. Overview of Bjerringbro Municipality and location of the six drained bogs and fens chosen for the study.

Site descriptions

Filsø Mose is a drained bog with an area of 19 hectares lying in a flat moraine terrain with spruce plantation dating back to 1950. There are 1.5 - 2 meter deep ditches running through the bog and there is evidence of some peat cutting. It was surveyed in both 1930 and 1956.

Brundmose is a 2.8 hectare drained bog lying in a deep north-south orientated meltwater erosion valley. The bog has been highly influenced by tree felling and cutting of peat. In the older part of the bog there are some spruce and birch stands left after felling. The northern end is dominated by growing *Sphagnum* mosses, birch and bog myrtle. It was surveyed in 1956.

Revsmose is a 4 hectare drained bog lying in a deep basin bordered by moraine hills to the south and west and a gentler sloping moraine landscape to the north and east. About 5 hectares of the mire were cut away during the Second World War and there are clear evidences of peat cutting in the remaining part. *Sphagnum* mosses grow in some of the cut-away pits, but ash and birch dominate. It was surveyed in both 1930 and 1956.

Vindum is a 1.4 hectare drained bog lying in a gently sloping flat moraine landscape with some spruce stands planted in 1950 and newer birch stands. Pits resulting from peat cutting dominate the mire surface. It was surveyed in 1956.

Korreborg is a 42 hectare drained fen lying in an east-west orientated river valley bordered by higher lying moraine landscapes to the north and south. The fen is mainly covered with pasture grass, but in the west end there are some *Sphagnum* mosses and *Carex* grasses and smaller birch trees. The mire was surveyed in both 1930 and 1956.

Hesselholt is a 4.5 hectare fen lying in a deep basin surrounded by a higher lying moraine landscape. It is covered with pasture grass. Two shallow ditches run through the middle of the mire. The mire was surveyed in 1956.

Sampling strategy

Systematic grid sampling was used in order to create the best basis for interpolation. A cylinder auger (diameter 20 mm) was used to map the areas with more than a 30 cm peat depth and to determine the actual peat depth. The humification degree of the samples was described in the field using the von Post scale (von Post 1922) and therefore used as a basis for selecting the vertical sampling strategy. The underlying soil was described as either sand or clay. A total of 450 determinations of peat depth were made. Co-ordinates of each sampling point were logged using GPS.

For bulk peat samples a liner sampler consisting of a 520 cm^3 cylinder and specially developed for soft soils was used. As peat enters the tube the air escapes through a small vent hole. When lifting the tube out of the hole, the core settles a bit, which creates a vacuum so the core sample stays in the tube. Prior to peat sampling the overlying peat was removed with an Edelman auger to the desired depth and the hole was cleaned with a Riverside auger. Peat samples as deep as 4.5 meters below groundwater level were successfully collected using this sampler. Furthermore, samples were collected at many depths for describing the variance in bulk density and carbon content throughout the peat column. The peat cores were stored in dark airtight PVC tubes before drying at 105 °C in a laboratory. About 150 peat samples were collected.

Laboratory analysis

Peat samples were dried at 105 °C and bulk density determined after all water had evaporated, normally after 24-36 hours. The peat samples were ground and a fraction was further ground in an agate mortar. Analysis of ash content (inorganic content) was carried out by burning 3-5 g at 800 °C for 4 –5 hours and weighing the remainder. Ash content is expressed as % of whole sample. pH was determined in a 0.01 M $CaCl_2$ suspension using a soil:suspension ratio of 1:10. The normally used 1:2.5 ratio was not obtainable because of the suction effect of the peat. Analysis of the carbon content was carried out using a Dohrmann DC-190, which is an NDIR detector that translates developed CO_2 during burning at 1000°C to % carbon. Samples were diluted with SiO_2 five times because of the high carbon content in the peat.

GIS analysis

The GIS analysis was carried out using ArcView 3.3 and ArcGIS 8.3 (ESRI ® ArcMap™8.3, ESRI Inc). The main tool for estimating the mire area, peat volume and the carbon stocks was 3D-models created by using ordinary kriging interpolation. Firstly, the GPS co-ordinates of points constituting the mire boundary and peat depth sampling points were loaded into Arcview 3.3 and polygon shapes of the boundary area and point shapes of the peat depth sample points were created. The ArcView extension X-tools were used to calculate the mire area in hectares. Mire area changes between 1956 and 2000 could then readily be calculated.

The interpolation was carried out in ArcMAP, which is an integrated program of ArcGIS 8.3. The kriging procedure uses known values and a semivariogram to determine unknown values as well as error estimates. The semivariogram assigns optimal interpolation weights to known values to calculate the unknown values (Goovaerts 1998). Semivariograms were fitted

Table 1. Chemical and physical parameters from the analyzed peat sampled in the six bogs and fens.

Location	Depth, cm	Bulk density, g cm-3	Ash, %	pH, 1:10 $CaCl_2$	von Post, H1-H10	Carbon, %
Filsø Mose	0-70	0.127	4.11	2.9	4	45.6
	70-100	0.133	5.97	3.0	5	47.5
	100-150	0.143	5.22	3.2	6	49.3
	150-200	0.144	6.89	3.2	7	50.6
	200-250	0.142	2.96	3.1	8	51.7
	250-300	0.145	7.38	3.4	9	52.3
Brundmose	0-25	0.045	5.65	3.7	1	41.2
	25-50	0.140	24.71	3.4	6	42.7
	50-100	0.160	30.70	3.5	6	43.0
	100-150	0.136	33.35	3.8	7	38.2
	150-200	0.120	32.2	4.0	8	38.4
Revsmose	50-100	0.1236	1.61	3.0	4	49.1
	140-180	0.1299	3.19	3.3	4	50.5
	240-270	0.1004	2.91	3.2	4	47.4
	340-400	0.085	2.57	3.3	5	47.6
	425-500	0.0734	2.38	3.4	5	48.2
Vindum	70-80	0.0908	1.34	2.6	4	44.5
	135-140	0.1752	4.76	2.8	7	52.0
	200-225	0.1804	7.15	3.0	8	54.4
Hesselholt	70-80	0.164	10.2	4.7	4	46.4
	155-180	0.136	13.5	4.5	5	47.4
	270-300	0.113	14.1	4.6	6	48.4
Korreborg	50-100	0.175	15.7	4.7	6	42.3
	100-150	0.152	18.91	4.6	6	43.4
	150-180	0.104	20.68	4.4	7	38.2
	185-210	0.123	13.52	5.1	8	44.2

using the Geostatistical Wizard that provides an error prediction of the different kriging methods with various lag sizes (distance between sample points) and number of lags. An important feature in this analysis was the incorporation of anisotropy in the kriging interpolation, especially when interpolating the valley fen Korreborg, which is very much longer than it is wide. A further application introduced was the zero-grid, consisting of points with zero peat depth surrounding the mire in order to force the interpolated peat depth at the mineral soil/peat boundary to converge towards 30 cm, thus further optimizing the interpolation.

The semivariogram features sill, range and lag size were used in the 3D analyst extension to perform the kriging interpolation and creation of the 3D models. Before calculating the peat volume from the 3D models, the interpolation grid was clipped with the area shapefiles in ArcView grid analyst, thereby deleting the outside area. This was done to minimize the risk of overestimating the peat volume if the convergence towards 30 cm was not perfect. The peat volume was calculated using the 3D analyst.

RESULTS

The results from the analysis of chemical and physical properties of the peat samples are shown in Table 1.

The bulk density was between 0.04-0.18 g cm^{-3} and was of the same magnitude in both bogs and fens. Filsø Mose and Vindum show a positive correlation between humification degree and bulk density, which is to be expected in slightly cultivated and undisturbed bogs (Assarsson 1961). In Hesselholt, drainage has led to subsidence and consequently the bulk density is highest in the top-layer.

The ash content was generally below 10 % in the bogs and between 10 and 20 % in the fens where inorganic material is transported with the groundwater from the surrounding mineral soil. Forestry practices in Brundmose have led to a mixing of mineral soil with the peat, and the ash content is therefore very high (53 % in one sample).

The pH in the bogs was between 2.6 and 4.0 and was, as expected, lower than in the fens where the pH was > 4.4. Organic acids accumulate in the bogs, which only receive low amounts of base cations through rainfall, whereas in the fens, bases are added from the soil minerals which buffer the acidity.

The carbon content was generally between 45 and 55 %, though slightly lower where the ash content was high.

Comparison of bulk density, von Post scale and ash content from the 1930, 1956 and 2000 surveys showed only small differences, so we conclude that using the carbon content measured in 2000 for calculation of the carbon stock in 1930 and 1956 would not introduce large errors.

3D models of four mires in 1956 and six mires in 2000 were constructed to calculate the peat volume. A 3D model of Filsø Mose 2000 is shown in Figure 2. Because of the high sampling intensity the peat volume is well described and the boundary between mineral and organic soil is well defined. Based on the 1956 survey 3D models of four mires were made using kriging interpolation. This was done in order to compare the peat volume calculated by The Danish Heath Society, whose calculation method is unknown, with our interpolated peat volumes. The results are shown in Table 2.

The relatively small differences between the two calculations indicate that the surveys are comparable as regards estimation of carbon stocks. Area and peat volume in the six mires investigated in 1930, 1956 and 2000 are shown in Table 3.

It is clear that there was a greater loss of peat between 1930 and 1956 than between 1956 and 2000. In Filsø Mose cutting has reduced the peat volume by 17 % and almost five out of nine hectares of mire in Revsmose were cut away during the Second World War. The great reduction in the peat volume in Korreborg of 628,950 m^3 between 1930 and 1956 may partly be a result of subsidence following drainage. In Revsmose, a growth of 76 % was calculated in peat volume from 1956 to 2000, which probably is not correct when considering it is a drained mire. Because of insufficient mapping in 1956, the maximum peat depth found was 310 cm, whereas in 2000 it was 550 cm, indicating that the 1956 estimate was much too low. Brundmose bog showed a 52 % increase in peat volume from 1956 to 2000 because it had grown to the north and the peat depth has now exceeded 30 cm. The loss of 33 % of the peat volume in Vindum is due to peat cutting. No great losses of peat caused by subsidence from 1956 to 2000 were detected. One reason could be that the

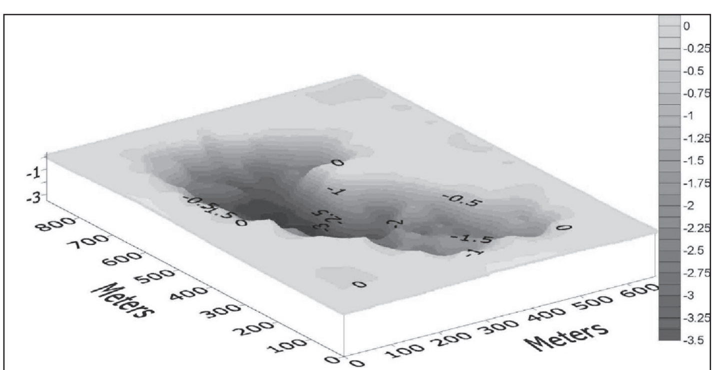

Figure 2. 3D model of Filsø Mose in year 2000 interpolated with ordinary kriging.

Table 2. Comparison of the peat volume in four mires calculated by The Danish Heath Society in 1956 and of the kriging interpolated peat volume.

Location	DK Heath Society 1956 peat volume, m^3	Kriging peat volume, m^3	Difference, m^3	Difference, %
Filsø Mose	366 700	335 761	-30 939	-8.44
Revsmose	70 700	68 049	-2 651	-3.73
Hesselholt	95 200	91 614	-3 586	-3.77
Korreborg	375 300	340 079	-35 221	-9.38

Table 3. Calculated area, peat volume and depth in the six bogs and fens investigated in 1930, 1956 and 2000.

Location	Year	Area, ha	Volume, m^3	Depth ^{max,} cm	Depth cm	1930-1956, m^3	1930-1956, %	1956-2000, m^3	1956-2000, %
Filsø Mose	1930	27.0	405 000		150				
	1956	19.16	335 761	360	175	-69 239	-17.1		
	2000	19.20	341 667	350	178			5 907	1.7
Brundmose	1956	1.7	22 100	200	130				
	2000	2.87	33 539	290	117			11 439	51.8
Revsmose	1930	9.0	180 000	500	200				
	1956	4.12	68 049	310	165	-111 951	-62.2		
	2000	4.12	119 864	550	291			51 815	76.1
Vindum	1956	1.3	23 400	260	180				
	2000	1.42	15 507	250	110			-7 893	-33.7
Hesselholt	1956	4.51	91 614	440	203				
	2000	4.65	87 684	460	189			-3 930	-4.3
Korreborg	1930	60.0	1 200 000		200				
	1956	42.0	571 050	270	140	-628 950	-52.4		
	1956	31.26	340 079	270	109				
	2000	31.41	405 488	305	129			65 409	19.2

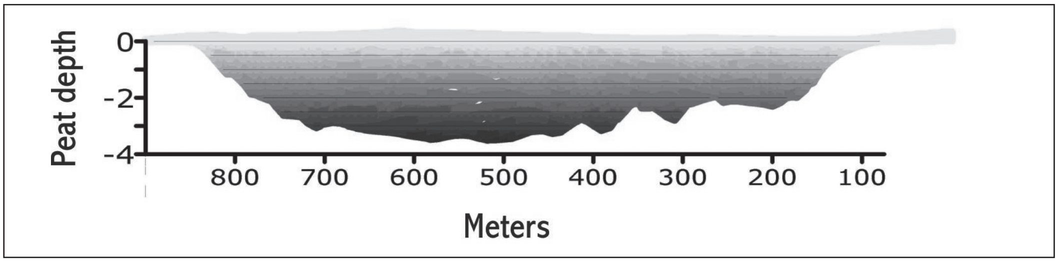

Figure 3. Viewing Filsø Mose in 2000 from the west. The horizontal lines mark the 50 cm intervals used for calculating the carbon stock integrated with depth.

Table 4. The carbon stock in the six bogs and fens investigated in 1930, 1956 and 2000.

Location	Year	Depth, cm	Area, ha	Volume, m^3	Peat, tons	Carbon, tons	Carbon, tons ha^{-1}	Carbon, kg m^{-2}
Filsø Mose	1930	150	27.00	405 000	55 485	26 910	997	100
Filsø Mose	1956	0-360	19.16	335 761	45 999	22 198	1 158	116
		0-100		182 942	25 063	11 657		61
Filsø Mose	2000	0-350	19.20	341 667	46 300	22 354	1 164	116
		0-100		179 793	23 096	10 657		55
Brundmose	1956	0-220	1.70	22 100	3 138	1 349	794	79
Brundmose	2000	0-290	2.87	33 539	4 626	1 922	670	67
		0-100		24 130	3 404	1 454		51
Revsmose	1930	0-500	9.00	180 000	22 500	10 913	1 213	121
Revsmose	1956	0-310	4.12	68 049	5 784	2 731	689	69
		0-100		39 423	3 351	1 575		40
Revsmose	2000	0-550	4.12	119 864	12 131	6 100	1639	164
		0-100		39 979	5 574	2 991		61
Vindum	1956	0-260	1.30	23 400	3 112	1 556	1197	120
	2000	0-240	1.40	15 507	1 764	844	603	60
		0-100		11 511	1 083	488		35
Korreborg	1956	0-270	31.26	340 079	54 073	24 062	740	74
		0-100		257 777	40 987	18 239		56
Korreborg	2000	0-300	31.41	405 488	62 851	27 969	790	79
		0-100		271 959	42 154	18 758		53
Hesselholt	1956	0-440	4.51	91 614	10 627	5 001	1109	111
		0-100		38 453	4 461	2 060		46
	2000	0-460	4.65	87 684	12 716	5 964	1282	128
		0-100		38 992	6 408	2 959		64

mires were drained long before 1956, so that compaction and shrinkage of the peat have ceased and only mineralization of the peat causes the subsidence.

The carbon stock in the mires was calculated by dividing the 3D models into 50 cm depth intervals and calculating the volumes (shown in Figure 3) multiplied by the bulk density and carbon content found in these depth intervals, thus integrating the variation of the chemical and physical properties with depth. The carbon stock expressed in total tonnage and carbon density are shown in Table 4.

The greatest changes in carbon stocks were found in Revsmose, Brundmose and Vindum. In Revsmose, the insufficient mapping in 1956 gave an erroneously low carbon stock, but comparing results from1930 with 2000 a reduction of 40 % is seen. Although the mire area grew in Brundmose from 1956 to 2000 the carbon density was reduced because the carbon content of fresh peat is much lower than well-humified peat. In Vindum cutting of peat has led to a 46 % reduction in carbon stock and the total carbon density was bisected. Filsø Mose showed a 17 % reduction in carbon stock from 1930 to 1956 due to peat cutting but no change from 1956 to 2000. In Hesselholt there has been a 19 % increase in carbon stock from 1956 to 2000, mainly because of the higher bulk density found in the upper peat layers in 2000. Korreborg showed a 16 % increase in the carbon stock from 1956 to 2000 due to the higher mean peat depth found in 2000, but the higher bulk density found in 1956 counteracts this result. A comparison of all mires surveyed in the Bjerringbro Municipality in 1930 and 1956 showed a 40 % reduction in mire area, peat volume and carbon stock from 1930 to 1956 due to peat cutting for fuel and subsidence after drainage.

DISCUSSION

The Danish mire area has been reduced intensively in the past 80 years through peat cutting and drainage. Especially during the Second World War huge amounts of peat were used as fuel which led to a considerable loss of carbon from the mires. Drainage is often a pre-cutting practice but loss through drainage is difficult to separate from cutting in the available data. Based on data from the selected research area it is estimated that carbon stocks were reduced 40 % during the period 1930 to 1956, primarily caused by peat cutting. However, there is no single authoritative inventory showing the same figure. The loss of carbon from 1956 to 2000 was much smaller and although subsidence should occur no unambiguous trend was found in the data.

The results suggest that the 1930 survey is not suitable as a basis for a current estimation of the carbon stock in mires. The 1956 survey seems more representative, however, it provides only local coverage.

The 3D model approach used in this study proved to be a powerful tool for estimating carbon stocks in mires. The kriging procedure in ArcMap reduces uncertainties in the interpolation through the error prediction when specifying the semivariogram. Furthermore, introducing anisotropy and a zero-grid resulted in even better interpolation (Webster and Oliver 2001).

The comparison of the kriging interpolated volumes with the volumes calculated by The Danish Heath Society of four mires surveyed in 1956 gave only small differences and thereby validated our survey as comparable to the earlier surveys. The integration of the variation of chemical and physical properties in the peat with depth was also of great importance in the carbon stock estimation. Through the laboratory analyses it became clear that these properties vary a great deal with depth and can introduce errors if mean values or only samples from one depth are used, a finding consistent with the results by Päivänen (1990).

Carbon stocks are often estimated using carbon density in the uppermost one meter as the scale. In the 2000 investigation the mires in Revsmose and Hesselholt showed a carbon density of between 61 and 64 kg m^{-2}. In Filsø Mose, Brundmose and Korreborg carbon density was between 51 and 55 kg m^{-2} and in Vindum 35 kg m^{-2}. Vindum can hardly be compared with the other mires as the peat volume quickly decreased in the uppermost one meter.

Based on the differences in types and land use of the investigated area Danish mires show a carbon density in the uppermost one meter between 50 and 70 kg m^{-2}, a figure that is somewhat lower than reported by Päivänen and Vasander (1994). According to the Danish Forest and Nature Agency (Skov og Naturstyrelsen 1997), the present total Danish mire area is 91,000 hectares or 2.1 % of the total land area. Given a carbon density in the uppermost one meter of 60 kg m^{-2} a preliminary estimate of the total carbon stock in Danish mires is 54.6 Mt. Krogh et al. (2003) estimated the total carbon stock in Danish soils at 579 Mt. This means that although the mire area only accounts for 2.1 % of the total land area, they store about 10 % of the total soil carbon stock and are therefore an important land cover class in these estimates for Denmark.

It is, however, evident that the support area for scaling up to a nationwide carbon figure is relatively small and that, given the method, there is no way of calculating the uncertainties of the estimate.

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