



The peat resources in Sweden

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Summary

Assessments of the Swedish peat resources have so far been based on non-uniform observations of peat thickness, originating from various sets of data collected for different purposes. As a result, the estimates of the total peat volume suffer from unreliability and low accuracy. Since 2003, a nationwide and systematic collection of data has been made, including measurements of peat thickness down to a depth of 5 m. The aims of this study were to analyse this new data and assess both total peat resources in Sweden as well as the volume of peat on drained peatlands as a basis for an analysis of the potential for future peat harvesting in the country. The total peat volume on drained and undrained peatlands was calculated to be ca 95 billion m³, and the potential of peat for harvesting, on drained peatlands of sufficient size, was about 8 billion m³. Based on the present harvesting pace this volume would last for approximately 2,500 years.

Key index words: peat cover, peat thickness, peat volume

Introduction

Background

In spite of its small coverage (about 3 %) of the Earth's land area (Bragazza *et al.*, 2006), peat-covered wetlands represent a major pool of relatively labile carbon, in the global carbon cycle. Meaningful modelling of the carbon flows from these important C reservoirs requires reliable data. The importance of good national data to aggregate a global estimate is obvious. This certainly applies to Sweden, with approximately one quarter of the land area, about 10 million hectares, covered with shallow or deep peat. Estimates of this carbon pool have not been very accurate. From the Swedish perspective, the use of peat for energy production may be of critical importance for the national energy budget. From both perspectives, there is a need for reliable assessments of the total peat volume.

Assessments of the Swedish peat resources have so far been based on non-uniform observations of peat thickness, originating from various sets of data collected for different purposes. Fewer observations of peat thickness have been made in northern Sweden, compared to central and southern parts of the country. As a result, the estimates of the total peat volume suffer from unreliability in general, and low accuracy regarding the peat resources in the north in particular. Since 2003, however, a nationwide and systematic collection of data has been made, including measurements of peat thickness down to a depth of 5 m. This allows for an assessment of peat volumes with greater accuracy than was possible earlier.

Peat harvesting, for energy and soil improvement purposes, has a long history (more than a century) in Sweden.

A prerequisite for the establishment of a sustainable harvesting policy is more detailed information on the peat resources available. The Swedish Government has proposed that future peat harvesting in the country should be restricted to peatlands that are already drained (Anon., 2005). About 900.000 ha of the 6.3 million ha wetlands covered with peat (30 cm thick, or more) have been drained for forestry (Hånell, 1990), but far from all drainage projects have proved successful. Approximately 300.000 ha of drained peatlands have remained non-productive from a forest growth and yield perspective. Information on the varying peat thickness in these drained productive, treed forestland (yielding $\geq 1\text{m}^3\text{ha}^{-1}\text{yr}^{-1}$) and non-productive, more or less open mires ($<1\text{m}^3\text{ha}^{-1}\text{yr}^{-1}$), is necessary to allow for a selection of the most suitable sites for harvesting.

Aims of the study

The aims of this study were to analyse and assess (i) total peat resources in Sweden and (ii) the volume of peat on drained peatlands, as a basis for a further analysis of the potential for sustainable future peat harvesting in the country.

Materials and methods

The data used in this study were collected in the Swedish Forest Soil Inventory (SFSI, started in 1983). It performs long-term monitoring on permanent sample plots of the Swedish National Forest Inventory (SNFI, carried out since the 1920s). The SNFI sample plots, circular with a 10 m radius, are laid out objectively and systematically in a grid pattern, covering the whole country every year, with the exception of the Scandinavian mountains in the NW. Thus,



SNFI encompasses a total land area of about 410,000 km² in four regions and 21 counties (Hänell and Magnusson, 2005; Anon., 2001). SNFI measured peat thickness to a maximum of 1 m. With SFSI this measurement (since 2003) is made to a depth of 5 m. This enhanced measurement means significantly improved data for calculating the distribution and location of peat-covered land with varying peat thickness, and for assessing the total peat potential of the country. Consequently, this study is based on all currently available SFSI data, i.e. from the inventories 2003 – 2006 which include about 7900 sample plots. Measurements of peat thickness were made with a modified 'Toompo-meter' at one spot per sample plot about 1 m from plot centre. The peat thickness was measured from soil surface and registered to the nearest full 10 cm (1 dm).

The results from SNFI and SNSI are not true values but estimates subject to random and systematic deviations. The random deviations are commonly expressed as standard error, which decreases with increasing sample size. Acceptable accuracy at the county level requires that results represent the means for periods of at least 5 years. The relative standard error of county and whole country estimates is then around 5 % and 3%, respectively. Four-year period based means (as from SNSI in this study) are however quite sufficient for calculations on large region and country levels.

Results

Geographical distribution of peatlands with various peat thickness

The peatland area assessments based on SFSI 2003-2006 and SNFI 1998-2002 data correspond well on regional and whole country levels (Table 1). The major part of the peatlands, more than 3 million ha of undrained mires, dominate in the two northernmost regions but cover significant areas in the southern regions as well. More than two thirds of the undrained mires have peat layers thicker than 1 m (Fig. 1a). The undrained forested peatlands, on the other hand, occupy a much smaller area and are most widely spread in the two southernmost regions (Fig. 1b). The drained forested peatlands (Fig. 1d) are fairly well spread over the country, with some dominance in the south, and cover about twice as large an area as the drained mires (Table 1, Fig. 1c).

Peat volumes on peatlands with various peat thickness

The total peat resource on all undrained and drained forestland and mires in the country (Table 2, Table 3) thus comes to about 90 billion m³. More than half of the peat on undrained forestland is in the South Central and South regions, but almost two thirds of the peat on all undrained land is located in the two northernmost regions due to the

Table 1.

Area (x 1000 ha) of drained and undrained peatlands, subdivided into productive forestland ($\geq 1 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$) and non-productive mires ($< 1 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$), in peat thickness classes according to the Swedish Forest Soil Inventory (SFSI 2003-2006) and the National Forest Inventory (SNFI 1998-2002). Norra Norrland, Södra Norrland, Svealand, and Götaland are the four main regions in Sweden (North, North Central, South Central, and South Sweden, respectively)

	SFSI 2003-2006							SNFI 1998-2002	
	Peat thickness, m							Total	Total
	0.3-1	1-2	2-3	3-4	4-5	5+	Total	Total	
<i>Drained forestland</i>									
North	57	57	15	4	-	-	134	133	
North Central	31	35	17	2	4	4	94	78	
South Central	37	35	23	18	-	7	120	108	
South	77	81	32	16	5	25	236	239	
Total	202	209	88	40	9	36	584	558	
<i>Drained non-productive mire</i>									
North	70	91	29	14	7	11	222	138	
North Central	16	24	16	7	3	-	65	57	
South Central	5	10	8	1	3	-	28	36	
South	2	7	8	10	2	-	31	43	
Total	93	132	61	32	16	11	345	273	
Total drained	295	341	149	72	25	47	929	831	
<i>Undrained forestland</i>									
North	24	24	13	3	-	6	70	108	
North Central	50	34	11	20	3	2	133	133	
South Central	73	52	10	10	5	6	159	147	
South	39	65	36	16	8	8	187	210	
Total	185	175	71	49	17	22	549	599	
<i>Undrained non-productive mire</i>									
North	408	569	241	136	76	37	1522	1661	
North Central	227	279	138	86	44	26	866	774	
South Central	138	183	93	36	51	48	552	525	
South	29	52	41	31	21	35	221	232	
Total	802	1084	513	289	192	147	3162	3192	
Total undrained	987	1258	584	338	209	169	3711	3791	
<i>All forestland and mire</i>									
North	559	741	298	157	87	54	1948	2040	
North Central	324	372	182	115	54	32	1158	1042	
South Central	253	280	134	65	59	61	859	816	
South	920	205	117	73	36	68	747	713	
Total	2056	1598	731	410	236	215	4712	4611	

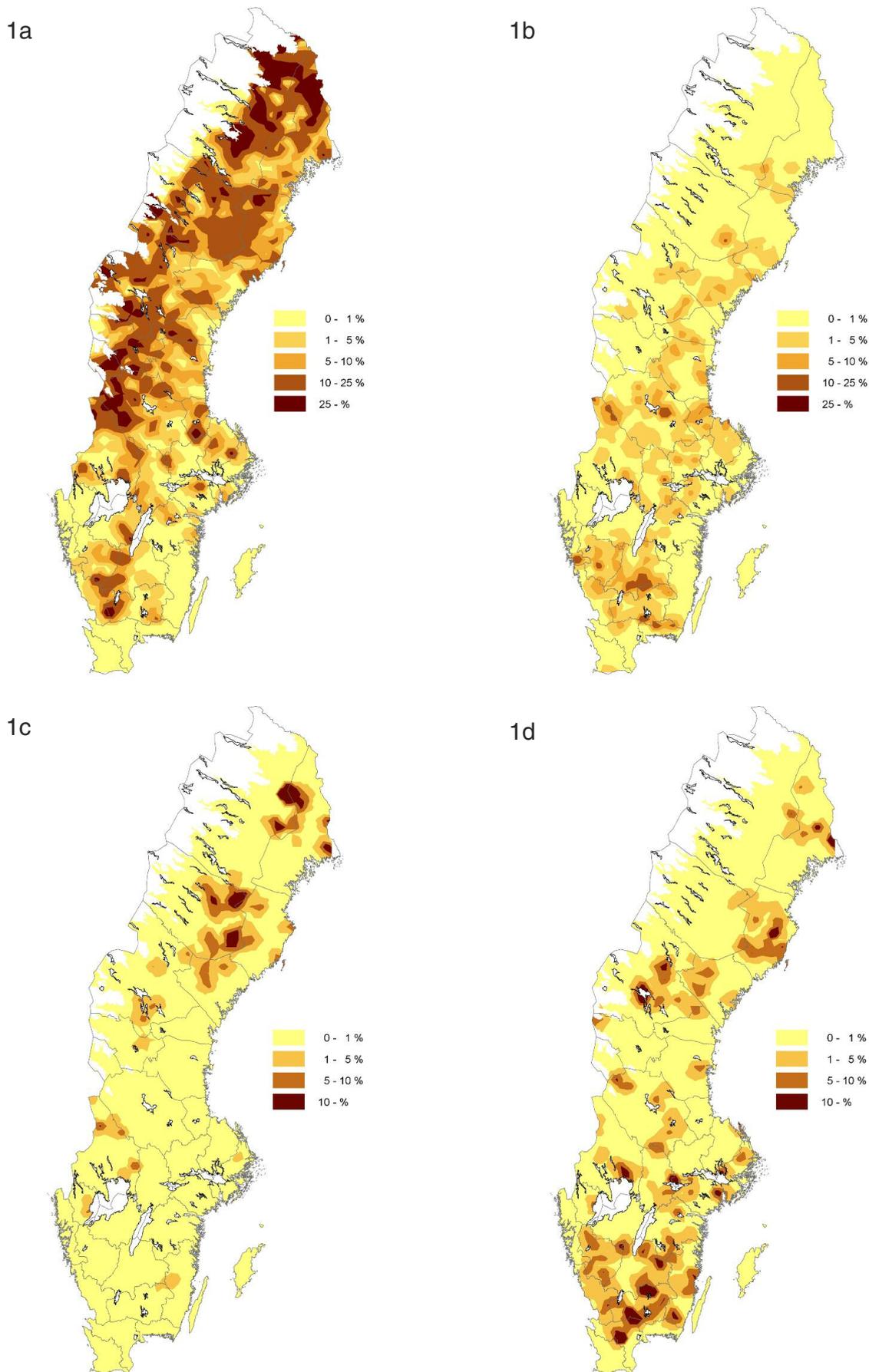


Figure 1. Peatlands with peat thickness > 1 m. Proportion of total land area (%). Key to symbols in figure.

- a) Undrained non-productive mire
- b) Undrained productive forestland
- c) Drained non-productive mire
- d) Drained productive forestland



richness of mires there (Table 2). Thus, there is a clear north-south gradient in the distribution of the total peat resource on undrained land (73 billion m³) - the peat volume is more than 3 times larger in the North region than in the South. The greatest proportion, about one quarter of the peat, is stored in 1-2 m thick peat layers, whereas the rest of the peat is fairly evenly distributed in the other thickness classes used. The peat volume on drained peatlands is about 17 million m³ (Table 3), most of which is stored in productive forestland (ca 10 million m³). Also in the drained sites more peat is stored in 1-2 m thick peat layers than in shallower or thicker layers. The 90

billion m³ total is a conservative estimate based on the assumption that the average thickness of the thickest peat layers (more than 5 m) is 5.5 m. If this average is set to 8 m the estimated grand total peat volume for Sweden amounts to 95 billion m³.

Discussion and Conclusions

According to SNFI 1998-2002 and SFSI 2003-2006, the total peatland area is around 4.6 – 4.7 million ha. This is about 1.6 million ha less than the 6.3 million ha earlier reported (Hänell, 1990), which reflects the fact that protected areas are not included in the recent inventory data.

Table 2. Peat volume (x 10⁶ m³) on undrained productive forestland and non-productive mires in the main regions of Sweden. The average peat thickness on land with peat layers exceeding 5 m was set to 5.5 m

		Peat thickness, m						Total
		0,3-1	1 - 2	2 - 3	3 - 4	4 - 5	5 +	
<i>Undrained forestland</i>	North	191	297	189	97	-	275	1049
	North Central	319	389	275	890	-	110	1983
	South Central	579	643	380	368	229	275	2474
	South	349	945	818	432	496	440	3480
	Total	1439	2275	1661	1787	726	1045	8933
<i>Undrained non-productive mire</i>	North	3690	9225	5883	4587	3687	2805	29877
	North Central	1984	3918	3114	3103	2195	1320	15634
	South Central	1250	2596	2114	1630	2234	2530	12354
	South	230	795	1032	1170	958	2090	6275
	Total	7153	16533	12143	10489	9075	8745	64138
<i>Total</i>	North	3881	9522	6072	4684	3687	3025	30871
	North Central	2303	4307	3389	3993	2195	1430	17617
	South Central	1829	3240	2494	1998	2464	2860	14885
	South	579	1740	1850	1601	1455	2475	9700
	Total	8592	18809	13805	12276	9800	9790	73072

Table 3. Peat volume (x 10⁶ m³) on drained productive forestland and non-productive mires in the main regions of Sweden. The average peat depth thickness on land with peat layers exceeding 5 m was set to 5.5 m

		Peat thickness, m						Total
		0,3-1	1 - 2	2 - 3	3 - 4	4 - 5	5 +	
<i>Drained forestland</i>	North	420	802	297	160	-	-	1679
	North Central	192	500	415	63	402	-	1572
	South Central	226	467	530	569	-	330	2122
	South	628	1198	928	405	222	1320	4701
	Total	1466	2966	2170	1197	625	1705	10129
<i>Drained non-productive mire</i>	North	524	1372	496	438	363	605	3798
	North Central	122	323	622	-	129	-	1196
	South Central	40	267	88	38	152	-	585
	South	43	124	259	234	109	110	879
	Total	729	2086	1465	710	752	715	6457
<i>Total</i>	North	944	2174	793	599	363	605	5478
	North Central	313	822	1037	63	532	-	2767
	South Central	266	734	617	606	152	330	2705
	South	671	1322	1187	639	331	1485	5635
	Total	2195	5052	3635	1907	1377	2420	16585



Table 4. Peat harvesting potential on peatland sites larger than 10 ha and peat layers thicker than 1 m in North, North Central, South Central, and South Sweden. The potential is expressed as billion m³ peat and years of harvesting with the present harvesting rate.

	Peat on forested peatlands, billion m ³	Time for use with current harvesting rate, years	Peat on non-productive peatlands, billion m ³	Time for use with current harvesting rate, years	Total time for use with current harvesting rate, years
North	0.79	238	2.52	757	995
North Central	0.55	166	0.75	226	392
South Central	0.89	268	0.31	92	360
South	1.91	575	0.74	221	796
Total	4.1	1247	4.3	1296	2543

The assigned sites for future peat harvesting are restricted to the drained peatlands, but the potential harvesting area is significantly smaller than the total area of all drained peatlands. According to Staffansson (2002) sites with less free space than 10 ha cannot be used for peat harvesting, and the thickness of the peat should be at least 1 m. It has been assessed (Hänell, 2006) that the total areas of drained forested peatlands and drained non-productive peatlands smaller than 10 ha, and with at least 1 m thick peat, are about 185,000 ha and 60,000 ha, respectively. After a deduction of these areas, the future peat harvesting potential totals 187,000 ha productive forest land and 184,000 ha non-productive mire.

Assuming that peatlands smaller than 10 ha are equally distributed on peat layers of various thickness as larger peatland units, the total peat volume calculated for drained forested peatlands with thicker peat than 1 m, about 8.7 billion m³ (Table 3), should be reduced for sites too small for harvesting to 4.1 billion m³ (Table 4). Likewise, the peat volume calculated for drained non-productive peatlands with as thick a peatlayer (5.7 billion m³) should be reduced to 4.3 billion m³. With the current annual harvesting rate, about 3.3 million m³ (2005), the forested peatlands could be used for harvesting for more than 1200 years. About half of this harvesting could take place in South Sweden (Table 4). The non-productive peatlands allow for harvesting at the same

rate for another 1,300 years. Most of this potential is found in North Sweden.

It can be concluded that the total peat resources on all peat-covered land in Sweden (protected areas not included) is about 95 billion m³. The drained peatlands account for nearly one fifth of this volume. After reduction for peatlands too small for harvesting, the peat harvesting potential (drained forested peatlands + drained non-productive peatlands) can be specified to ca 8.4 billion m³. At the current harvesting rate this resource will last for 2,500 years.

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