Extended abstract No. 190

HYDBOS – A GUIDANCE TOOL FOR UTILIZATION AND PROTECTION OF HYDROMORPHIC SOILS UNDER CHANGING CLIMATE CONDITIONS: PART I – SOIL AND HYDROLOGY

Evelyn Wallor
Humboldt-Universität zu Berlin
Faculty of Agriculture and Horticulture/ Division of Soil Science and Site Science
Albrecht-Thaer-Weg 5, D-14195 Berlin/ Germany
+49(30) 2093 46483
E-mail: evelyn.fiegert.1@agrar.hu-berlin.de
Janine Dzialek, Jutta Zeitz , Humboldt-Universität zu Berlin

SUMMARY

In Brandenburg, North-East Germany, fen soils cover about 44 % of the area. They are principally used as grassland and, hence, affected by drainage and cultivation. Local climate trends intensify the importance of these soils according to their native functionality of carbon and water retention. To describe soil development and actual site status, previous data sets are referenced to actual soil analysis. This is exemplarily shown for intensive and extensive used sites of the Randow lowland. Calculated carbon loss accounts for intensive grassland between 2.5 and 6.5 t per ha and year, regulated by groundwater level and thickness of fen soil. As expected, carbon loss under extensive land-use is less. The applied Peatland Management Decision Support System provides with appropriate data and allows for a differentiation between the impact of drainage and land-use and the impact of local climate change.

KEYWORDS: fen soils, climate change, carbon loss, modelling

INTRODUCTION

Brandenburg is a federal state of Germany located in the North-East of the country and part of the temperate climate zone. Mean annual temperature does not exceed 8.3 °C. Annual precipitation amounts to 551.3 mm on average while for entire Germany mean annual precipitation is 779.3 mm. Fen soils cover about 44 % of the area and are in up to 99 % affected by drainage and cultivation and, hence, by soil degradation (Joosten and Couwenberg, 2001). Related to groundwater level and land-use intensity decrease of carbon storage differs (Höper, 2007; Mueller et al., 2007). Principally, fen soils in Brandenburg are used as grassland, either as extensive pasture or as intensive meadow for milk production. Some humid grassland sites are cut only once a year in the framework of nature conservation. Depending on climate model local climate trends predict an increase of mean annual temperature between 1 and 2.5 °C (Linke et al., 2010). Expected rotation of soil humidity accelerates mineralisation processes of soil organic matter and consequently the increase of greenhouse gas emissions, especially CO_2. This is controversial to current national and international requirements and increases the emission of greenhouse gases and nutrient losses (IPCC, 2007; UNFCCC, 2008). The first aim of the HYDBOS project is to quantify the range of carbon loss according to the intensity of anthropogenic impact factors. The second aim is to prove that degradation of fen soils in Brandenburg is prospectively increased by local climate trends. This impact is illustrated by simulated model achievements.

MATERIALS AND METHODS

Data sets

One very important data set used in HYDBOS is based on an intensive soil mapping of all existing lowlands in Brandenburg, executed in the period of 1963 to 1970 (HU Moorarchiv, 1965). In preparation for conceptual drainage in order to increase grassland yields in the GDR soil mapping has been realised in a grid of 100 to 100 meters. Representative soil profiles has been defined and sampled up against subsurface. Relevant soil analysis, which has been carried out in the HYDBOS project are loss on ignition and oven-dry density. The results of soil mapping are partially digital available in GIS. Georeferencing of the data set is not fully practicable due to falsification emerging from missing GPS single point positioning in that period of time. Nevertheless, the importance of this data set is undisputed because it provides with detailed information about site status of Brandenburgs' lowlands before intensive drainage and cultivation.

Examination sites

All examination sites are part of the Randow lowland, a 6000 ha large mire developed by combined terrestrialisation and percolation processes, located in the North-East of Brandenburg. In the northern territory of the Randow lowland (53°9′ N, 14°7′ E) thickness of fen soil comes up to 6 meters, while the lower fraction of soil profile often consists of muddy horizons, especially calcareous and silt mud. Above storing peat horizons consist mainly of *Phragmites*- and *Carex*-peat showing variable decomposition. Groundwater level is measured there exemplarily on a 14.9 ha large field extensive used in the framework of nature conservation. Southern territory (53°14' N, 14°2' E) is dominated by minor thickness of fen soil, not exceeding 1.20 meters. Peat horizons are usually strongly decomposed. In case of lower peat decomposition *Phragmites*- and *Carex*-peat are classified. Muddy horizons are less thick but show the same substrate dominance as in the northern territory. Groundwater level is measured here in a transect covering two fields, 19.8 and 14.6 ha large, separated by one central drainage channel. Predominate land-use is intensive mowing of grassland. Altogether, peat horizons are more or less calcareous with pH values about 7 in the upper soil layer. Soil profile is drilled and sampled always in the centre of each examination site. Samples are taken to estimate loss on ignition, organic carbon content and oven-dry density in order to balance the change of organic carbon up to 0.5 meters soil depth.

Carbon balance

Calculation of carbon balance is realised by comparison of so-called profile pairs. For the described examination sites a precise locating of representative soil profiles sampled in 1965 has not been possible. Hence, categorisation of fen soil thickness has been improved compared to 1965 (Fig. 1). According to that new categorisation reference profiles have been defined that are located in equal polygons of fen soil thickness as soil profiles sampled in 2010. In addition, original soil descriptions of drilling points located near by the centre profiles of examination sites 2010 have been studied to provide with comparability of the defined profile pairs. At least, four profile pairs have been defined based on the following profile numbers of 1965: 305 and 547 for the northern examination site (extensive land-use), 184 and 396 for the southern examination site (intensive land-use). Conversion from loss on ignition to organic carbon content has been carried out by using the equation developed by Klingenfuss et al. (2012). Subsidence of fen soils has been calculated additionally.

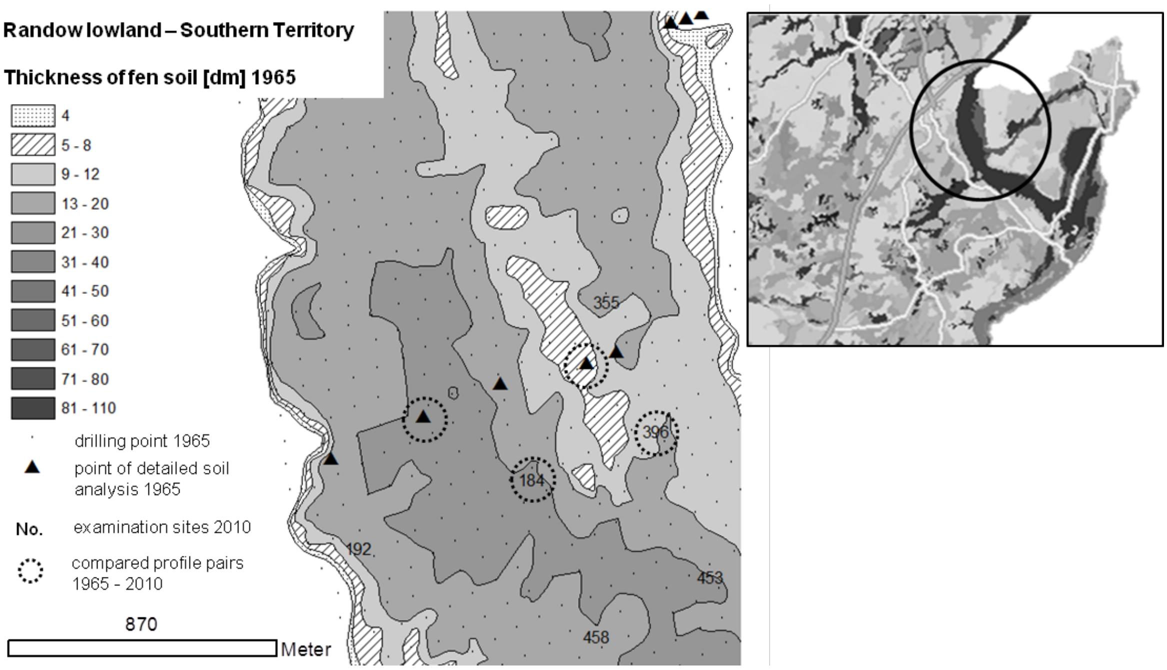

Fig. 1: Thickness of fen soil of the Randow lowland, southern territory with improved categorisation; small picture: location and shape of the Randow lowland (LBGR, 2010).

Impact model

Illustration of climate change impact on local scale is realised by using a semi-quantitative decision support system developed by Knieß et al (2007). The system is called Peatland Management Decision Support System (PMDSS). It is able to predict long-term changes of peatland functions. The model operates with annual time steps for a time span of 100 years. Input parameters are easily collectable, e. g. peat thickness, mean summer water table (MSWT), annual precipitation and actual land-use. The results give a rough estimate for the development trend of a peatland site. In the HYDBOS project model achievement is focussing on the following output parameters: subsidence of peatland and CO_2 emission as well as their change according to increasing mean annual temperature up to 10.3°C in the year 2060.

RESULTS AND DISCUSSION

Carbon balance

Calculated carbon loss accounts for intensive grassland between 2.5 and 6.5 t per ha and year, regulated by groundwater level and thickness of fen soil (Table 1). MSWT at site 184 amounts to 0.57 meters and 1.06 meters at site 396, respectively. Documented thickness of fen soil in 1965 is 2.10 meters for profile 184 and 1 meter for profile 396 (Fig. 2). Hence, range of calculated carbon loss is equal to results of Augustin (2001) and Renger et al. (2002). Profile 305, representing the very extensive grassland site under nature conservation, shows less high loss of carbon (0.55 t per ha and year) resulting from a high MSWT of 0.22 meters below surface. Research of archived profile description provides the information of a water supply level in 1965 of 3+ for profile 305, while actual water supply level reaches 4+. Hence, rising groundwater level in a long duration is supposable. Calculated increase of carbon content at site 547 is also interpretable: due to its location near by a hillside coluvial processes may take place. It is also possible that melioration of soil fertility has been generated by covering the border sites of the lowland with sandy substrates after soil mapping in 1965. Sequence of soil horizons confirms an increased input of mineral material. Nevertheless, subsidence of fen soil is comparatively high with 2 cm per year but corresponding to high thickness of fen soil of 2.70 meters in 1965 (Mundel, 1976; Renger et al., 2002).

Table 1. Summarised results of carbon balance for intensive and extensive used fen soils of the Randow lowland ([1] derived from Blume et al., 1995; [2] calculated from similar horizons)

Profile No.	Examination time 1965					Examination time 2010				Results	
	Soil horizon	Soil depth [cm]	Oven-dry density [$g\ cm^{-3}$]	Loss on ignition [%]	C_{org} [% by mass]	Soil horizon	Soil depth [cm]	Oven-dry density [$g\ cm^{-3}$]	C_{org} [% by mass]	Change of C_{org} [$t\ ha^{-1}$]	Annual change of C_{org} [$t\ ha^{-1}\ a^{-1}$]
184						nHmv	0-12	0,44[1]	23,39		
	nHv	0-40	0,34	63,54	36,76	nHa	12-25	0,47	22,75		
						nHt	25-37	0,49[2]	21,72		
	nHw	40-50	0,27	52,70	30,15	Fw	37-50	0,42	15,07	**(-) 114,16**	**(-) 2,54**
396	nHv	0-30	0,29	73,90	43,07	nHvm	0-10	0,53[1]	43,32		
						nHa	10-20	0,57	26,16		
	nHw	30-50	0,19	81,90	47,95	Fo	20-50	0,51	15,25	**(-) 293,78**	**(-) 6,53**
547	Aa	0-20	0,57	22,20	11,55	Aa	0-10	0,76	9,47		
	nHw	20-30	0,30	40,30	22,59	Aa1	10-30	0,76	10,17		
	nHr	30-50	0,15	71,00	41,31	nHw	35-55	0,20	34,09	**(+) 43,68**	**(+) 0,97**
305	nHv	0-20	0,33	63,20	36,55	nHv	0-15	0,46	15,25		
	nHw	20-30	0,20	82,30	48,19						
	nHr	30-50	0,13	79,25	46,34	nHt	15-50	0,50	18,85	**(-) 24,68**	**(-) 0,55**

Summarised, the degree of subsidence is superior for mighty fen soil than for fen soil of minor thickness (Fig. 2).

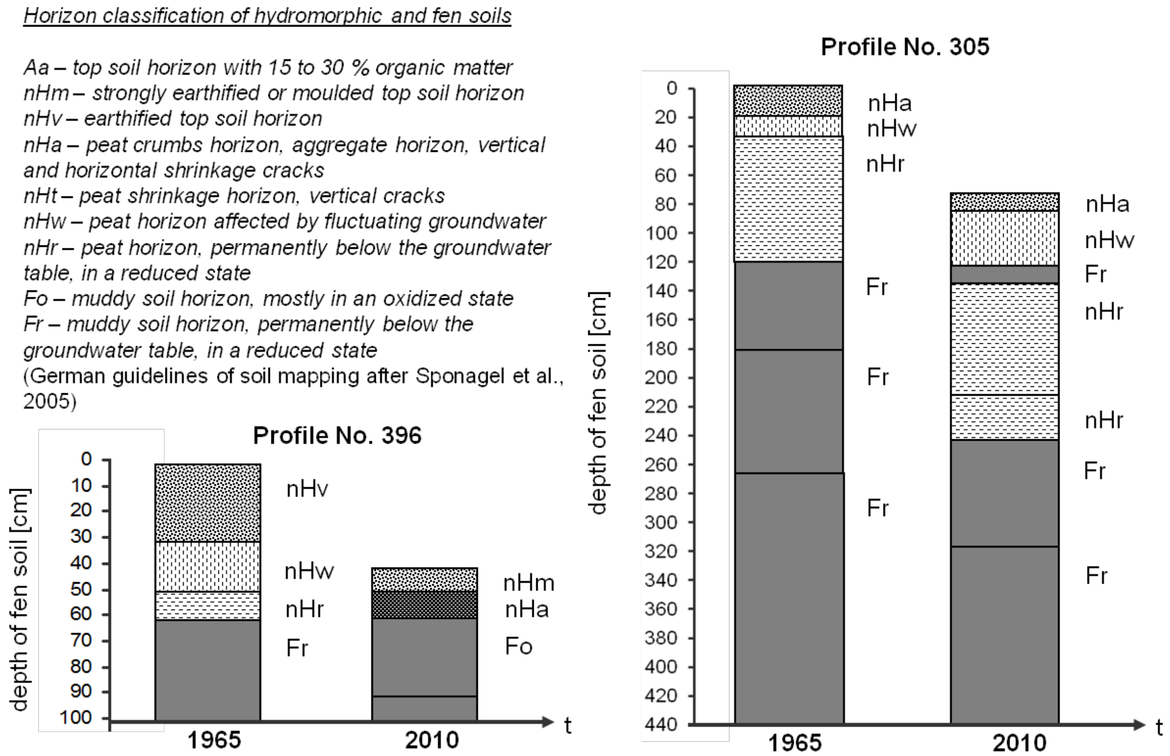

Figure 2: Illustration of soil development and subsidence of fen soil, exemplarily for profile 396 - intensive grassland and 305 - extensive grassland.

Modelling

Model achievements by the PMDSS confirm the trend estimated by comparison of profile pairs concerning differentiation of carbon loss and subsidence level due to intensity of drainage and land-use (Fig. 3). Simulation has been carried out exemplarily for profile 184 and 305. Results for profile 396 are excluded, because actual peat thickness is too low. Hence, simulation does not supply with data for an adequate time span. Simulation for profile 547 has not been carried out, because of high mineral content in the topsoil. Model performance starts for profile 184 with a loss of carbon of 4.6 t per ha and year and 2.3 t per ha and year for profile 305, respectively, under present climate conditions. In case of increasing mean annual temperature up to 10.3°C in 2060, simulated values of carbon loss increase, too. Implementation of climate change into the PMDSS produces carbon losses of 2.8 t per ha and year for site 305 in the year 2060 and only 2.2 t per ha and year without implementation of climate change. For site 184 relation is 3.8 to 3.4 t per ha and year but for the 35th year of model run. Simulation stops here because of not applicable parameter combination. Nevertheless, the PMDSS is an appropriate instrument to describe the development of fen soils as well as the additional impact of local climate trends.

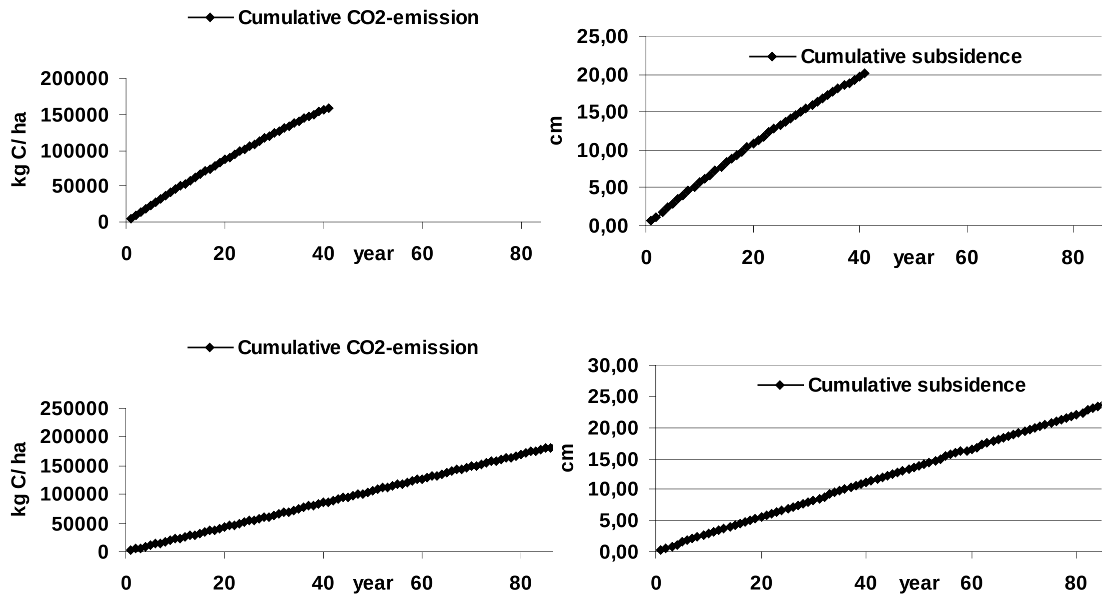

Fig. 3: Output data of the PMDSS (first line shows results for profile 184, second line for profile 305, both without increasing temperature).

CONCLUSION

Relating to the development of the HYDBOS guidance tool, present results are suitable to be integrated into the module *site condition*. Hence, farmers and influencers are informed about the quantified range of subsidence and mineralisation of fen soils in Brandenburg as well as about influencing local climate trends. However, for the rest of examined local backdrops a precise positioning of the reference profiles from 1965 is planned. After comparison with actual data an improved assessment of present results will be possible. Furthermore, model performance will be extended by describing the impact of different land-use scenarios. In order to become an improved impression about the effect of local climate trends concerning specific hydrological parameters, recent climate data and prospective climate projections on local scale will be interpreted next.

ACKNOWLEDGEMENTS

The HYDBOS project is part of the Innovation Network for Climate Change Adaptation Brandenburg Berlin (INKA BB). We thank the Federal Ministry of Education and Research (BMBF) for funding the project from 2009 to 2014.

REFERENCES

For detailed references it is referred to the author.