Extended abstract No. 191

# HYDBOS – A GUIDANCE TOOL FOR UTILIZATION AND PROTECTION OF HYDROMORPHIC SOILS UNDER CHANGING CLIMATE CONDITIONS: PART II – VEGETATION AND PRODUCTION

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## SUMMARY

Hydromorphic or fen soils engage are particularly vulnerable compared to changing climate conditions. The expected rotation of soil humidity accelerates mineralisation processes and cause increasing emission of greenhouse gas followed by a loss of agricultural productivity and biodiversity. Groups of plant species like vegetation forms or biotope types are successfully used as bio-indicators for site conditions and for indicating greenhouse gas fluxes or productivity. The guidance tool HYDBOS will contain information about the profitable utilization combined with the protection of fen soils under changing climate conditions.

KEYWORDS: *Vegetation, grassland, land use, fen soils*

## INTRODUCTION

Fen soils act as a carbon sink and are of high value for local climate regulation. The history of agricultural use of peatlands and humid lowlands (meadows and pastures) created typical grasslands with a large biodiversity of species adapted to wet conditions and with a high conservation value (Succow and Joosten, 2001). On the other hand most of the hydromorphic soils in Central Europe are affected by mineralisation processes that are caused of drainage and very intensive land use during the last decades. Drained peatlands constitute an important source of anthropogenic greenhouse gas emission (Couwenberg *et al*., 2011). Locally relevant climate trends predict displaced amounts of precipitation in combination with drier summers and wetter winters as well as more frequent extreme weather events like heat waves and heavy rainfall. The expected rotation of soil humidity accelerates mineralisation processes of soil organic matter that causes increasing emission of greenhouse gas followed by a loss of agricultural productivity, biodiversity and biotopes (Holsten *et al*., 2009).

In times of the climate change, grassland-based farming systems are under increasing pressure to combine profitable land use and nature-conserving managements. First of all a higher moisture status throughout the year (less drainage) is relevant to conserve the native function of fen soils (Mueller *et al*., 2007). But also a periodical agricultural use is essential. Free succession is followed by a loss of typical biotopes (Succow and Joosten, 2001). For this reason the land use on fen soils must stay profitable for land users. Opportunities and alternatives must be found, adapted to high groundwater levels and plant communities that are often characterized by a low forage quality. The guidance tool HYDBOS will contain information about the profitable utilization combined with the protection of fen soils under changing climate conditions. Information is intended to be formed in modules: *site conditions* (soil and water), *plant* (standing crop, forage quality, biodiversity) and *management* (productivity and opportunities of management). The module *plant* shall be an instrument for an easy and effective evaluation of moist and wet grassland by using plant species as indicator for productivity (standing crop and forage quality) and conservation (biodiversity, quality of soil and groundwater dynamics). This will form a base to show the impact of climate change and to find opportunities of management of humid grassland.

## MATERIALS AND METHODS

In Brandenburg, a federal state in North-East Germany fen soils engage about 44 % of the country's territory. Furthermore the focused study site Brandenburg is characterized by a low average annual precipitation below 600 m. The main problem of the relatively dry Brandenburg will be displaced amounts of precipitation in combination with frequent extreme weather events (Holsten *et al*., 2009). In cooperation with 10 agriculturists, several locations in Brandenburg with differences in soil carbon content, groundwater dynamics and intensities of land use are investigated. In the northern part of Brandenburg for instance two lowland areas called *Randow-Welse Bruch* and *Gartzer Bruch* with a great variance of land use (very extensive to intensive, meadows and pastures) and groundwater regime (very wet to moderately moist) are examined. In the southern part of Brandenburg measurements are made on wetland meadows in the *Spree Forest*.

Botanical investigations were carried out in vegetation seasons of 2010 and 2011 at each site. Altogether 91 surveys of vegetation were made according to the method of Braun-Blanquet (Braun-Blanquet, 1964): five 5m x 5m squares per sample area. Plant populations were assigned to vegetation types or biotope types for a better transferability. Sample mowings were made on 1m x 2m squares at the same point of botanical investigations contemporary to the use by the farmers. The crops were weighed and the fresh matter per hectare and year was calculated. After drying at a drying chamber at 60°C for 48 hours, the grassland yields of dry matter per hectare and year (dt DM/ ha/ a) could be measured. For a first estimation of forage quality, the energy concentration mega joule net energy lactations per kilogram dry matter (MJ NEL/ kg DM) was calculated with the Model for calculating grassland yields and forage quality in North-East Germany by Käding *et al*. (2005). *In-situ*-data like p. e. crude protein and crude fibre are still analyzed at the Common Laboratory of Analytics of the Humboldt-University of Berlin and can be requested at the author.

Groundwater pipes and special data-logger were installed for measuring groundwater level and precipitation. In addition to field measurements of groundwater dynamics, the water supply levels and the Ellenberg's indicator of soil moisture for each vegetation survey were calculated. Correlation between groundwater level, water supply level and the indicator of soil moisture are shown in Table 1 (Ellenberg, 1992; Käding *et al*., 2005; Succow and Joosten, 2001). In this article the water supply level and soil water regime are used for characterization of groundwater dynamics.

Table 1: Possibilities to characterize the groundwater level.

| Groundwater table | Water supply level | Ellenberg's indicator | Soil water regime |
|---|---|---|---|
| > 0 cm (above surface) | 5+ | > 8.4 | Very wet |
| 0 to 20 cm (below surface) | 4+ | 7.2 to 8.4 | Wet |
| 20 to 45 cm (below surface) | 3+ | 6.2 to 7.2 | Moist |
| 45 to 80 cm (below surface) | 2+ to 2- | 4.5 to 6.2 | Moderately moist |
| > 80 cm (below surface) | 2- to 5- | < 4.5 | Dry |

About 10 soil profiles and 200 borings were made to explore to explore the area and to measure the peat thickness. Token samples provided information about p. e. oven-dry density and organic carbon. Data about detailed soil analyses are handled by and can be requested at Evelyn Wallor (HYDBOS – A guidance tool for utilization and protection of hydromorphic soils under changing climate conditions: Part I – Soil and hydrology, Abstract No 201/190). The so called Greenhouse gas Emission Site Types (GEST), which are assessed by vegetation and water supply level, were used for a first estimation of greenhouse gas emission of the examined areas in this study (Couwenberg *et al.*, 2011).

## RESULTS

Because of high heterogeneity of vegetation of humid grassland, the use of single species as an indicator seems to be difficult (Fig. 1). For this reason the following results are divided into four groups due to soil water regime and intensity of land use for a better overview:

I. Wet to very wet, Landscape conservation, 1 use/ year by grazing or mowing
II. Moist to wet, extensive used grassland, 1 cut + 1 grazing/ year
III. Moist, intensive used grassland, 3 cuts/ year
IV. Moderately moist, intensive used grassland, 3 cuts/ year + aftermath grazing.

Vegetation of the measured grasslands is very heterogeneous (Fig. 1). As expected the average cover of forage grass species like *Poa* sp. or *Lolium perenne* increases with decreasing water supply level and increasing intensity of land use. Typical indicator species of moist or wet habitats like *Agrostis stolonifera* or *Phalaris arundinacea* could be found at nearly every study area.

As shown in Table 2, study areas with higher water supply levels and extensive agricultural management offer well soil conditions as well as lower greenhouse gas fluxes. Vegetation of these extensive used grassland is more divers (high number of plant species) but less useful because of energy concentration below 6,0 MJ NEL/ kg DM. Intensive grassland shows good forage qualities but, however, combined with soil-damaging groundwater dynamics (water supply level 2- to 3+) and higher greenhouse gas emission.

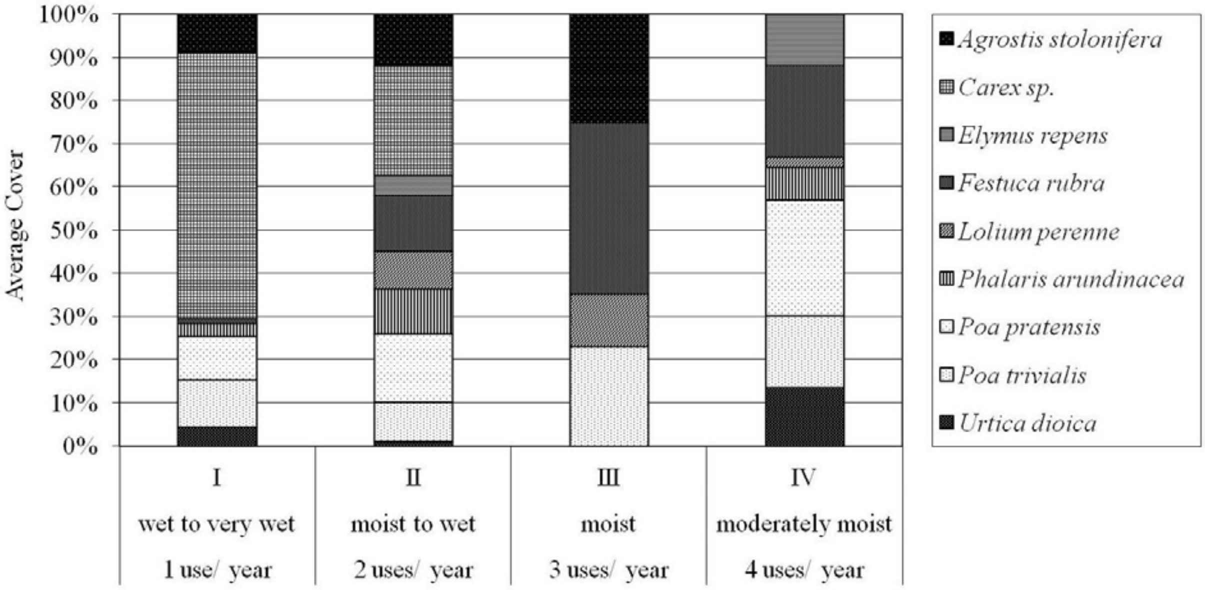


Fig. 1. Vegetation of grasslands on fen soils – dominant species with their average cover (%).

Table 2. Vegetation of four different types of land use on fen soils.

| Group | I | II | III | IV |
|---|---|---|---|---|
| **Biotope type** | Wetland meadows | Moist pastures | Intensive grassland | Intensive grassland |
| **Vegetation type** | large-sedge communities, reed canary grass-reed sweet grass beds | bent-grass communities, reed canary grass grassland | sown grassland | older sown grassland |
| **Plant species number** | 53 | 59 | 10 | 31 |
| **Water supply levels** | 4+/ 5+ | 3+/ 4+ | 3+ | 2-/3+ |
| **Soil water regime** | Wet to very wet | Moist to wet | Moist | Moderately moist |
| **Peat thickness [cm]** | > 300 | 40 to 300 | > 200 | 50 to 120 |
| **Soil characteristics** | Fen soil, variable decomposition | Fen gley soil to fen soil, variable decomposition | Fen soil, variable decomposition | Fen gley soil to fen soil, strongly decomposed |
| **GHG fluxes [t CO2-eq./ ha/ a]*** | 5.7 to 8.5 | 8.5 to 13 | 15 | 24 |
| **Land use** | Landscape conservation (1 use/ year) | Extensive pasture (2 uses/ year) | Meadow grassland (3 cuts/ year) | Meadow grassland (4 uses/ year) |
| **Standing crop [dt DM/ ha/ a]** | 26.12 | 31.67 | 50.95 | 40.66 |
| **Energy [MJ NEL/ kg DM]**** | 4.4 | 5.3 | 5.9 | 6.4 |

* Estimation of greenhouse gas emission with the method of Couwenberg *et al.* (2011)
** Modeled with the Model for calculating grassland yields and forage quality in by Käding *et al.* (2005)

## DISCUSSION AND CONCLUSION

Using single species as an indicator for productivity and conservation for humid grassland seems to be difficult because of high heterogeneity of vegetation of grassland (Fig. 1). Groups of plant species like vegetation forms or biotope types are successfully used as bio-indicators for site conditions and for indicating greenhouse gas fluxes or productivity (Couwenberg *et al*., 2011; Ellenberg, 1992; Käding *et al*., 2005). Biodiversity can be derived from the number of species, different diversity indices and especially the appearance of rare species of the Red List (IUCN, 2001; Washington, 1984).

Groundwater levels near to the surface and periodical agricultural use must be combined with profitable but also nature-conserving managements. Because of difficult traffic ability on wet grassland, several technical solutions for harvesting are measured. Modified caterpillars, reed harvester with low-pressure huge wheels or conventional tractors equipped with tandem axis and very wide tyres work very effective (Wichtmann and Tannenberger, 2009). The results of this research program show that older seeded grassland and seasonally flooded bent-grass communities produced goodquality forage even on fen soils. They are useful for e. g. low-intensive grazing systems. Special seed mixtures for moist or wet soils already exist and offer high standing crops and forage quality in combination with higher moisture status and well condition of soil (Tab. 2, Group III). Several research projects have successfully tested the alternative usage of reed *Phragmithes australis*, sedges *Carex* sp. or reed canary grass *Phalaris arundinacea* energetically and industrially (Wichtmann and Tannenberger, 2009). After completion of field assessments, an economic calculation will provide information of productivity. The impact of climate change, simulated from 2007 to 2060 on local scale, will be illustrated with the Peatland Management Decision Support System (PMDSS) developed by Knieß *et al*. (2010). Researched management options adapted to expected climate change will be integrated in economic simulations. All results will be united in a guidance tool (HYDBOS).

## ACKNOWLEDGEMENTS

The research project is part of the Innovation Network for Climate Change Adaptation Brandenburg Berlin (INKA BB) funded by the Federal Ministry of Education and Research (BMBF). Program duration is from 2009 to 2014. Thanks to all co-operation partners (www.inka-bb.de).

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