REWETTING OF THE MESOTROPHIC TERRESTRIALIZATION MIRE "MELLNSEE" (GERMANY) – RAISING WATER LEVEL VERSUS NUTRIENT INPUT

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Abstract: The Mellnsee originally was a mesotrophic lake without outlet. In the final stage of silting-up the lake was surrounded by peat-producing brown-moss vegetation. Drainage started in the Middle Ages. Lakes were connected with ditches, silting-up was intensified and parts of the region were used as grassland. At present time there is no more open water and peat soils in major parts of the mire are in the process of decomposition owing to low water level. Rewetting the original lake area by blocking the main ditch is part of a EU-LIFE Project.

Mapping of vegetation zones and analysis of nutritional and hydrological states in different parts of the mire revealed conflicts between wetting of higher elevated areas and the preservation of existing mesotrophic habitats which are prone to extinction in Germany and support a great diversity of threatened species. Raising water levels too high could increase the influx of nutrient-rich lagg and ditch backwater into mesotrophic zones and lead to eutrophication. Moss-communities sensitive to flooding may be harmed. Therefore damming-up is done stepwise. The first step realized since 2003 is adapted to the existing oscillation capabilities of mesotrophic areas, determined by water level monitoring with gauges. At this stage water level turned out to be still too low to stop succession to Alnion wood in open transition mires. The second wetting step is projected in several years.

The study has confirmed that, before realizing rewetting measures, the individual ecology of a mire should be examined, at least when rare or threatened habitats are concerned.

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INTRODUCTION

A major part of German peatlands are concentrated in the northeastern Federal States of Brandenburg and Mecklenburg-Vorpommern, where they cover about 7% resp. 12% of the area (Grosse-Brauckmann, 1997). Most fen peatlands have been drained, losing their ecological functions. Only 1% of the northeast German mires are preserved in a natural state, most of them eutrophic (Succow, 1988).

During recent decades growing efforts have been made to restore degraded peatlands by means of rewetting, accompanied by scientific research on matter storage, peat accumulation and water retention (Kratz & Pfadenhauer, 2001; Landgraf, 1998; Schopp-Guth, 1999). However, practical and scientific experiences chiefly exist for the rewetting of eutrophic fen peatlands whereas knowledge about the restoration of vulnerable mire ecosystems is scarce.

Water management activities in catchment areas and high water comsumption in summer frequently lead to water deficit for rewetting (Dietrich & Quast, 2001). Even if water supply is sufficient, in most cases the original state of the mire cannot be regenerated within short time periods, because peat soil characteristics have changed during the draining process. This situation can give rise to conflicts between different restoration aims, and rewetting strategies should take into account the special situation of each individual mire (Pfadenhauer & Zeitz, 2001).

The partly drained mire complex Mellnsee is one of ten project areas within the EU-LIFE project "Bittern Recovery Programme at the SPA Schorfheide-Chorin" (09/1999 – 12/2003). A main task of the LIFE project is to establish natural-like hydrological regimes as precondition for the development of target habitats (Michels & Peil, 2003). The rewetting of the Mellnsee mire was accompanied by a monitoring programme in order to answer the questions:

1. Which water level is needed to stop peat decomposition in drained areas and succession to woodland in open-mire habitats?
2. What is the hydrological situation of the mesotrophic parts of the mire and how valuable are these habitats for conservation of biodiversity?
3. Is it possible to preserve the mesotrophic habitats by damming up the eutrophic main ditch?

In this context we analyse the historical and present situation of the mire and discuss conflicts between biotic and abiotic targets of the rewetting process.

SITE DESCRIPTION AND STUDY METHODS

The mire Mellnsee is situated in the UNESCO Schorfheide-Chorin Biosphere Reserve (Federal State of Brandenburg). The major part of the mire is protected as a "core area", the highest level of protection. The landscape of the Biosphere Reserve was shaped during the last glaciation period and is characterised by hilly moraines and hundreds of lakes, wetlands and small mires, surrounded by extensive woodland and agricultural fields. The climate is intermediate between atlantic and continental, long-term annual means of precipitation amount from 550 to 580 mm, the climatic water balance is in the range 0 to –50 mm (HAD, 2000).

DRAINAGE HISTORY AND MIRE DEVELOPMENT

At the beginning of the holocene era the former lake area of Mellnsee totaled about 300 ha (Fig. 1). Like most of the lakes in the Biosphere Reserve the Mellnsee originally did not have any surficial outlet, the water was provided as groundwater discharging from adjacent slopes. Annual water level fluctuations probably did not exceed 50 cm (Michels & Peil, 2003).

In the course of the holocene era, the mesotrophic lake filled up with mineral and organic sediments, partly calcareous. In the end of the process floating mats formed by brown-mosses and sedges grew on the water surface. Human impact is assumed to have started in the Middle Ages (Seuffert & Stolze, 2001). Lakes were connected by ditches, water levels fell and in the course of the enforced silting-up a brown-moss peat layer grew up in the periphery. In the following centuries the emerging wetlands were drained and used as grassland. In the late 19th century open water completely disappeared. Nevertheless, a large part of the central area remained swampy and at one site a small percolation mire has been preserved. During recent decades the agricultural use in large parts of the area ceased and succession subsequently proceeded from open mire to wet woodland.

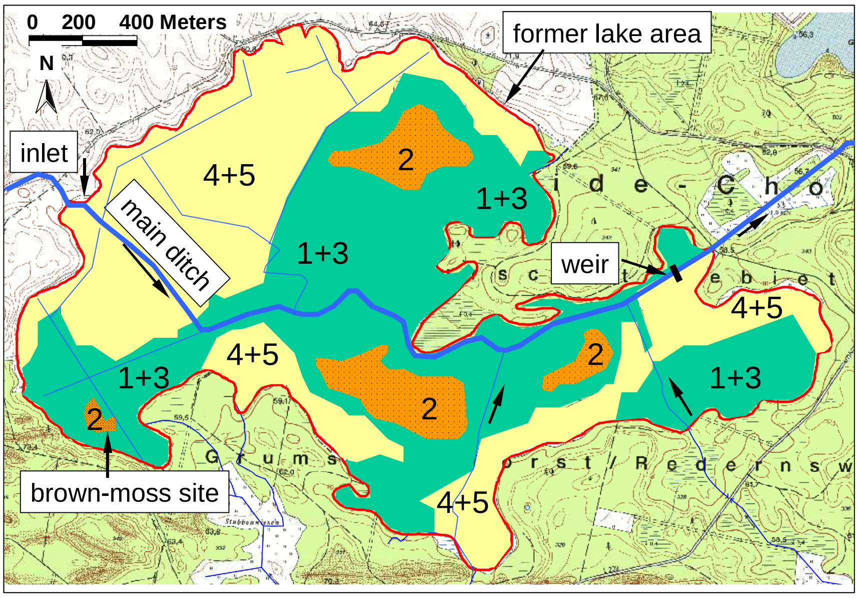

Figure 1. Map of the mire Mellnsee. Numbers 1-5 indicate vegetation zones (see Fig. 2).

PRESENT HYDROLOGICAL SITUATION

Groundwater levels in the Biosphere Reserve dropped down about 7cm per year on average since the beginning of measuring in 1978 (Dreger & Michels, 2002). On the other hand, the Mellnsee area receives a large amount of surplus water supplied by an artificial ditch, comprising a catchment area of about 60km^2 (Rietz & Ruhlig, 1997), including several lakes, drained wetlands, farmland and settlements. The ditch crosses the center of the mire (Fig. 1) and discharges into the river Welse. Due to nutrient non-point and point sources in the upstream, this water is eutrophic. The annual water level fluctuation in the ditch can amount to more than 1 m. Hence the hydrological situation differs much from that in ancient times.

The rewetting of the Mellnsee area was performed by damming up the ditch by means of a weir with varyable effective height at the outlet of the Mellnsee basin.

MONITORING PROGRAMME

The monitoring programme examined the effects of rising water tables on the mire and included vegetation mapping, soil and water analysis, and water table measurements. Special attention was given to the existing mesotrophic habitats.

Water tables in relation to top soil (ground water and surface water) have been determined monthly since July 2001 at 20 sites in different parts of the mire using punctured plastic tubes with holes. Soil samples from 20 sites were analysed in October 2002, including the parameters $CaCO_3$, pH, C/N-ratio, P_t, $P_{(DL)}$, K_t, $K_{(DL)}$, dry gross density and loss on ignition. Water samples were taken every 3 months from September 2001 to July 2003, generally from surface water. Only when hollows dried out we took pore space water from digged holes. Analyses included the following parameters: temperature, electrical conductivity, O_2, pH, NO_2, NO_3, NH_4, TP, ortho-PO_4 and K.

RESULTS

PRESENT VEGETATION

A schematic relief transect of the mire indicates five principal vegetation zones (Fig. 2), reflecting the various hydrological and nutritional conditions in different parts of the mire:

1. Close to the central ditch a mixture of reed and wet alder woods is strongly influenced by the eutrophic surface water coming from the catchment area.
2. Mesotrophic birch woods (NATURA 2000 Code 91D1) and small open transition mires (NATURA 2000 Code 7140) are growing on a thin but solid peat layer (approx. 30cm) which is oscillating above liquid sediments.

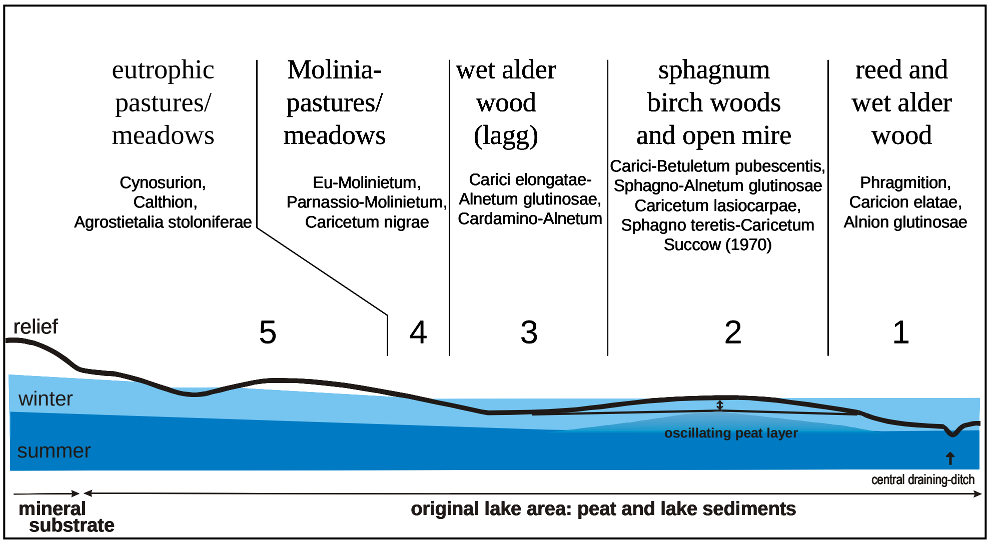

Figure 2. Schematic transect and corresponding vegetation zones 1-5 of the mire Mellnsee.

3. The "lagg" of the mire with great fluctuation of water levels is inhabitated by alder woods.
4. "*Molinia*-grassland" (NATURA 2000 Code 6410) has persisted in small agriculturally used areas where water level in spring is comparatively high.
5. Eutrophic pastures and meadows on degraded peat soils with generally low water levels predominate in the periphery of the Mellnsee.

A further habitat of small scale (approx. 0.5 ha) in the periphery of the Mellnsee adjacent to a sand dune is occupied by brown-moss communities with high diversity of rare species and peat producing mosses like *Drepanocladus cossonii*, *Campylium stellatum* and *Calliergon giganteum* (Fig. 1: brown-moss site). Whereas the mesotrophic habitats in the northern and southern part of the mire (zone 2) are comparatively young (19^{th} century), the history of the brown-moss site reaches back to the Middle Ages.

WATER LEVELS

During the monitoring time the top of the weir was triggered between 57.10 m and 57.54 m above sea level. Since autumn 2003 the height is 44 cm higher than at the beginning of the project. Fig. 3 presents the water level courses at different mire sites. It is not distinguished between ground water and backwater from the weir (surface water) because this situation change at many sites in the course of the year. The results are summarized as:

- Without blocking, the fluctuation of water level at the weir exceeds 1m;

- Raised weir height has stabilised high water tables even in the summer periods (2002, 2004), without blocking the ditch water level declined below the ditch bottom (2003);
- The highest water levels at all sites were observed during a period of extraordinary precipitation in the beginning of 2002, even though the weir height was low at that time;
- Water levels in wet alder woods (zone 1 + 3, Fig. 2) fluctuate with a similar pattern as water levels at the weir. Raised weir height resulted in permanent flooding of these zones;
- Sphagnum birch woods and open mire (zone 2) exhibit a balanced water regime. Even in the dry summer of 2003, when weir height was low, minimum water level did not drop more than 20 cm below soil surface. During a period with extremely high water levels only parts of the area were flooded. The strong oscillation is partly due to swimming-up of solid peat layers on liquid sediments;
- Water levels of grassland habitats (zone 4 + 5) and at the rim of the mire show a strong decline during summer time, mostly independent from backwater levels at the weir (e.g. 2002 and 2004).

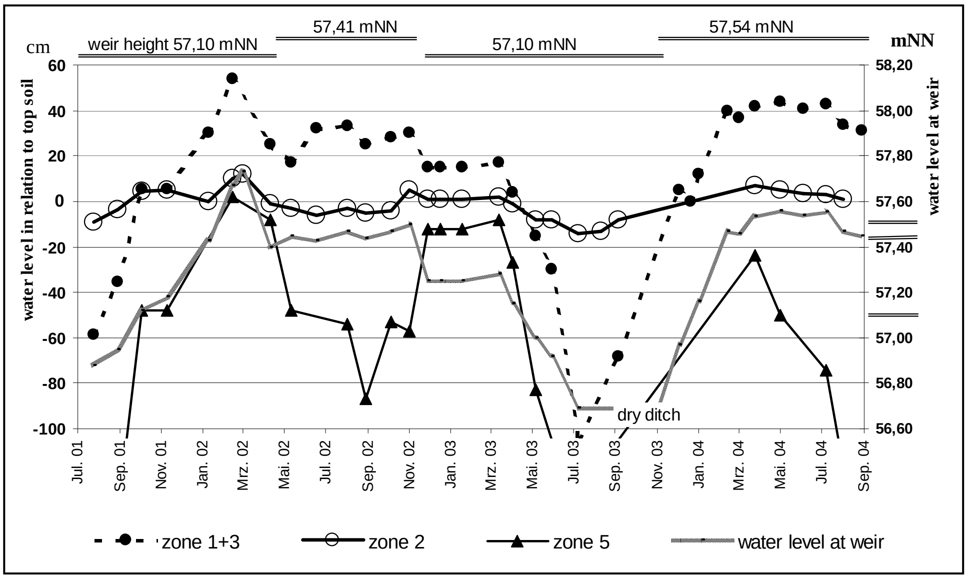

Figure 3. Water level fluctuation in different zones of the mire Mellnsee. Examples of single sites are given for each zone. For description of the zones see Fig. 2.

The water regime at the brown-moss site and its surrounding lagg differs from the remaining area of Mellnsee and is typical for percolation mires. The site is elevated and influenced predominantly by groundwater from the marginal slopes. During the first wetting step the ditch backwater reached the lagg of this site only during high water tables in early spring.

PEAT SOIL AND SURFACE WATER CHEMISTRY

The pH-values of peat soil samples average 5.9 (range 5.8 – 6.0) at the brown-moss site and 5.2 (range 4.3 – 6.1) at the northern and southern sites of zone 2 (upper layer 0-20 cm). For wetland meadows pH-values were estimated between 6.1 and 7.8.

The C/N-ratios (Fig. 4) classify the brown-moss site and parts of zone 2 as mesotrophic (C/N > 20, according to Succow & Stegmann, 2001). With C/N < 15 the peat soil samples from alder woods of zone 1 + 3 and from grassland sites are clearly eutrophic. Plant-available phosphorus in peat soil (Fig. 4) varies between 1.8 and 10.3 mg/100g dry weight in alder woods and grassland sites. Values for zone 2 are lower (0.6 to 3.9 mg/100g). The content of total phosphorus (P_t) averages 0.06% in zone 2 and 0.08% - 0.1% in alder woods of zone 1 + 3 and grassland habitats.

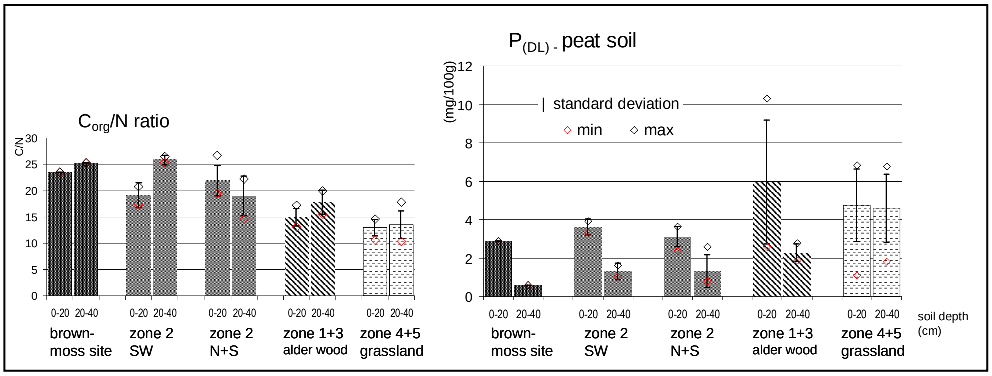

Figure 4. C/N-ratio and available phosphorus of peat soil samples. Description of zones see Fig. 2. SW = southwest, N = north, S = south part of the mire.

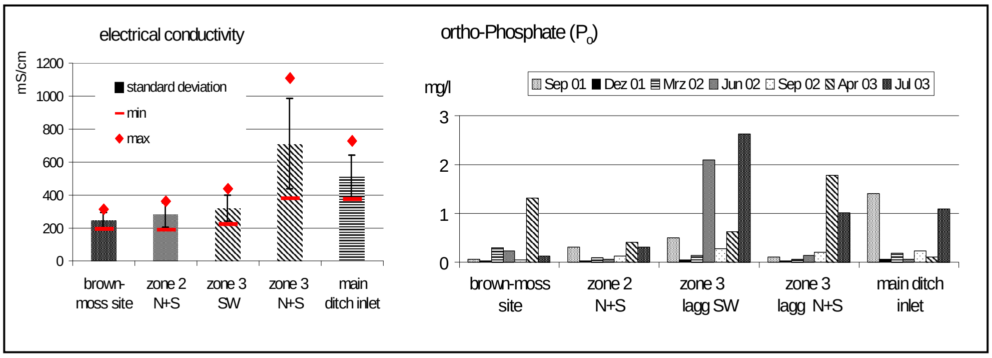

Figure 5. Results of water analysis (ground and surface water) for EC and ortho-Phosphate. Description of zones see Fig. 2 and Fig. 4.

The ditch and lagg water samples (zone 1 + 3) show higher contents of dissolved minerals in comparison with samples from zone 2 or the brown moss site, demonstrated as electrical conductivity in Fig. 5. The content of soluble phosphorus (Fig. 5) varies time-dependent at all sites. The highest concentrations of more than 2.5 mg/l were detected in lagg water (zone 3), whereas concentrations at sites of zone 2 are less than 0.5 mg/l. Total phosphorus (TP) reaches high average values at some time in each zone of the mire (up to 5.3 mg/l in the southwest lagg). The nitrate concentrations are mostly at a low level (<0.1 mg/NO_3/l) except in the main ditch where the maximum of 7 mg NO_3/l was detected at the inlet to the Mellnsee basin. High values of ammonia (3 – 8 mg NH_4/l) at many mire sites during the hot and dry summer period in 2003 are typical for decomposition processes and oxygen-low status (Balla & Quast, 2001).

DISCUSSION AND CONCLUSIONS

EVALUATION OF MIRE HABITATS WITH RESPECT TO BIODIVERSITY

Fig. 6 clearly illustrates the outstanding significance of the mesotrophic mire areas for threatened plant species. Especially important for the Cat. 1 species (status “critical”) are open transition mire and the (open) brown-moss site. The latter represents the only relict of the brown-moss communities which once must have been widespread during the process of silting-up of the lake according to our peat soil analyses.

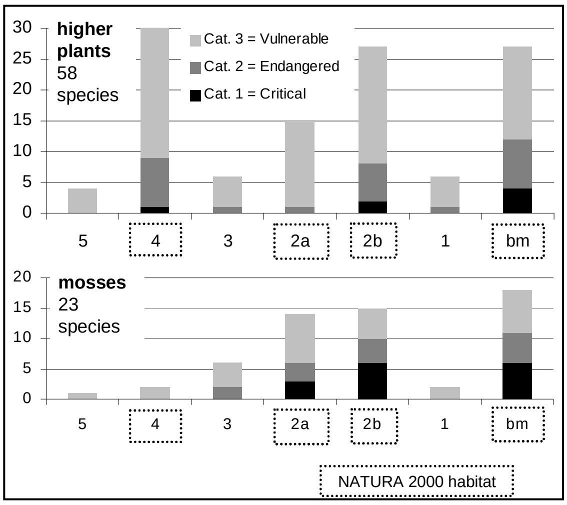

Figure 6. Number of threatened plant species in the vegetation zones of the mire (Classification according to the Red Data Book of Brandenburg, Benkert & Klemm, 1993; Klawitter *et al*., 2002). Vegetation zones see Fig. 2, 2a = mesotrophic birch woods, 2b = open transition mire, bm = brown-moss site.

NATURA 2000 habitat = protected habitat type according to the European Union habitats directive.

The majority of threatened plant species depend on mesotrophic alkaline or subneutral peat soil conditions and open mire. They are very sensitive to nutrient input, drainage or succession to woodland.

This reflects the fact that the mire degradation in northeast Germany has been most dramatic for this type of mire: originally representing 74% of total mire area (405 000 ha), at the end of the last century less then 200 ha (<0.05%) were left (Succow, 1988). Furthermore the regeneration of mesotrophic alkaline mires after drainage or eutrophication seems to be impossible, at least in medium-term time scales (Succow, 2001; Schopp-Guth, 1999). Consequently the preservation of the existing habitats must have top priority in the rewetting process of the Mellnsee from the nature conservation point of view.

CONFLICTS IN THE REWETTING PROCESS AND CONCLUSIONS

The present water level after the first wetting step is not sufficient to stop succession of open mire habitats to wet alder wood and decomposition of peat soils of higher elevated areas. However, further increase of weir height and water levels could finally result in degradation of existing NATURA 2000 habitats:

1. Enhanced water exchange between nutrient-rich ditch water, lagg zones and mesotrophic areas could easily result in eutrophication of the latter;
2. The large water level fluctuations of the main ditch may lead to flooding and degradation of moss communities during periods of high water tables;
3. Enhanced flooding of *Molinia*-meadows will provoke succession to sedge reeds. The existing *Molinia*-habitats concentrate on a small fringe between alder woods and the eutrophic grassland. A shift to higher elevations following the rising water level is unlikely, because at these sites peat soils are degraded and only will allow development of eutrophic wetlands.

BROWN-MOSS SITE

In the case of the brown-moss site the situation is even more complicated. As a typical percolation mire, this special community depends on water influx from the adjacent slopes. At present the water supply from the slopes probably is not sufficient to stop succession to alder wood. However, raising the backwater level from the main ditch to the elevation of this site will destroy the character of the percolation water regime. Considering the quality of surface water supplied by the main ditch it is safe to say that the regeneration of floating vegetation layers of mesotrophic character with brown-moss species is impossible at present time.

CONCLUSIONS FOR MANAGEMENT AND RESEARCH

For the mesotrophic habitats it is essential that ditch water does not penetrate directly on surface into the living moss communities so that nutrients are retained mostly in the peat layer. Preceding a further rise of water levels in the next wetting step the mire should have several years of time to improve oscillation capabilities.

It seems to be rather unlikely that brown-moss dominated open habitats can be preserved or even regenerated by means of raising the water level in the main ditch alone. More important for this community is the increase of groundwater supply from the slopes, e.g. by cutting the forest on the dunes or by at least changing the pine wood to more natural deciduous forest. Nevertheless succession at the brown-moss site probably has to be controlled by cutting young *Alnus* trees from time to time.

The final height of the weir and water levels in the mid-term probably will be a compromise between the biotic and the abiotic aims of the project. A long-term perspective should pay attention to the hydrological situation of the Mellnsee mire on a landscape scale. Improved water retention in the catchment area of the mire would reduce the fluctuation of water levels and the nutrient input from outside. That way, the possibilities for restoring mesotrophic and peat-producing habitats would be extended substantially. On the other hand it is not clear yet, how much surplus water from the catchment is necessary for the stabilisation of mid-term water levels.

The study of the mire Mellnsee has confirmed that, before realizing rewetting measures, the individual ecology of a mire and the available water supply from the catchment with respect to water quantity as well as water quality should be examined, at least if rare or threatened habitats are concerned.

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REFERENCES

Balla D., Quast J., 2001 – *Water quality in fen peatlands.* [in:] Kratz & Pfadenhauer (eds.) - Ökosystemmanagement für Niedermoore. Ulmer, Stuttgart, 111-124 (in German).

Benkert D., Klemm G., (Bearb.) 1993 – *Threatened Ferns and Higher Plants, Alga and Fungi in the Federal State of Brandenburg*. Rote Liste, Ministerium für Umwelt, Naturschutz und Raumordnung des Landes Brandenburg (in German).

Dietrich O., Quast J., 2001 – *Hydrological analyses for the asessment of rewetting possibilities* [in:] Kratz & Pfadenhauer (eds.) - Ökosystemmanagement für Niedermoore. Ulmer, Stuttgart, 35-52 (in German).

Dreger F., Michels R., 2002: *Development of ground water tables in the region Schorfheide 1980-2000* [in:] MLUR (eds) – *Funktionen des Waldes in Verbindung mit dem Landschaftswasserhaushalt.* Eberswalder Forstl. Schr.reihe XV, 11-15 (in German).

Grosse-Brauckmann G., 1997 – *Peatlands and peatland conservation areas in Germany – a review.* Telma 27, 183-215 (in German).

HAD, 2000 – *Hydrological atlas of Germany.* Ministerium für Umwelt, Naturschutz und Reaktorsicherheit (in German).

Klawitter O., Rätzel S., Schaepe A., 2002 – *Species list and Red Data List of mosses in the Federal State of Brandenburg*. Naturschutz u. Landsch.pfl. Brandenburg 11(4), Beilage (in German).

Kratz R., Pfadenhauer J. (eds) 2001 – *Management for fen peatland ecosystems. Strategies and measures for renaturation*. Ulmer, Stuttgart (in German).

Landgraf L., 1998 – *Landscape ecology studies in rewetted peatlands of the Nuthe-Nieplitz-Niederung.* Studien und Tagungsberichte 18, Landesumweltamt Brandenburg, 1-120 (in German).

Michels R., Peil J., 2003 – *Improving landscape water balances and establishing of agricultural buffer zones by the Schorfheide-Chorin LIFE Project*. Proc. Int. Symp. Conservation and Management of Reedbeds and the Bittern at EU-Bird´s Directive Areas, 51-58 (in German with English summary).

Pfadenhauer J., Zeitz J., 2001 – *Models and targets for the restoration of fen peatlands in northern Germany.* [in:] Kratz R., Pfadenhauer J. (eds) – *Ökosystemmanagement für Niedermoore*. Ulmer, Stuttgart, 17-24 (in German).

Rietz C., Ruhlig L., 1997 – *Ecological analysis of the state of the river Welse/Randow – part 2.* LUA-Bericht, Gewässerschutz und Wasserwirtschaft, 51-62 (in German).

Schopp-Guth A., 1999 – *Restoration of mire landscapes.* Schr.reihe f. Landsch. pflege u. Naturschutz, 57, Bundesamt für Naturschutz, Bonn-Bad Godesberg (in German).

Seuffert A., Stolze S., 2001 – *The „Melln(see)" – phytocoenological, ecological, stratigraphical and palynological studies in a terrestrialization mire.* Unpublished Diplom Thesis, University of Greifswald (in German).

Succow M., 1988 – *Landscape Ecology of Mires*. Fischer, Jena, Stuttgart (in German).

Succow M., 2001 – *Revitalisation of mire ecosystems – examples from northern Germany. Basics*. [in:] Succow M., Joosten H. (eds) – *Landschaftsökologische Moorkunde*. 2nd ed., Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 496-497 (in German).

Succow M., Joosten H., 2001 - *Landscape Ecology of Mires*. 2nd edition. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart (in German).

Succow M., Stegmann H., 2001 – *Characterisation of eco-nutritional and chemical states.* [in:] Succow M., Joosten H. (eds) – *Landschaftsökologische Moorkunde*. 2nd ed., Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 75-85 (in German).