PROCEEDINGS FROM THE 7TH SWS 2012 EUROPEAN CHAPTER MEETING

Wetland restoration – challenges and opportunities

Programme and abstracts

17-21 June 2012

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DCE – CENTRE FOR ENVIRONMENT AND ENERGY

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Brian Kronvang
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Data sheet

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VENUE: JEPPE VONTILLIUS AUDITORIUM, LAKESIDE LECTURE THEATRES

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VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

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12.00 – 13.00 **Lunch**

VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

09.00 – 09.40 **Key note lecture**
Constructing wetlands in the desert: solutions for management of oilfield produced water and other wastewaters in the Middle East [O70]
Thomas Headley, BAUER Nimr LCC , Oman

VENUE: JEPPE VONTILLIUS AUDITORIUM, LAKESIDE LECTURE THEATRES

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VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

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Sara Gargallo, Miguel Martín, Carmen Hernández-Crespo, Nuria Oliver, Laura Blasco & Vicente Botella

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VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

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Chairman: Brian Kronvang

For each poster presentation will be allocated 3 minutes.

VENUE: WILLIAM SCHARFF AUDITORIUM, LAKESIDE LECTURE THEATRES

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Chairman: *William J. Mitsch*

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VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

15.30 – 17.00 **Poster presentation**
Chairman: Brian Kronvang

For each poster presentation will be allocated 3 minutes.

VENUE: WILLIAM SCHARFF AUDITORIUM, LAKESIDE LECTURE THEATRES

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Wednesday 20th June 2012

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Towards a theory of constructed wetland functioning and with the help of mathematical models [O65]
Joan Garcia, Universitat Politècnica de Catalunya-Barcelona, Spain

VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

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10.50 – 11.30 **Session 5 continued**
Chairman: *Carl Christian Hoffmann*

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Loc Xuan Nguyen, Thomas R. Headley, Narumol Piwpuan, Xu Zhai & Hans Brix

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VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

09.00 – 09.40 **Key note lecture**
Towards a theory of constructed wetland functioning and with the help of mathematical models [O65]
Joan Garcia, Universitat Politècnica de Catalunya-Barcelona, Spain

VENUE: JEPPE VONTILLIUS AUDITORIUM, LAKESIDE LECTURE THEATRES

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Kim Andersson

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Jenny Davis & Ian Kidd

11.10 – 11.30 **Recognising ecosystem services from Wetlands of International Importance: an example from Sussex, UK [O64]**
Robert McInnes

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Anette Jægerfeldt Baisner, Kristine Thrane, Annette Baattrup-Pedersen & Tenna Riis

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Agnieszka Jaszczak & Katarzyna Glińska-Lewczuk

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12.10 – 13.20 **Lunch**

VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

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Brian Kronvang

13.30 – 13.50 **Hydro-biogeochemical phosphorus mobilization – evaluating a wetland restoration "P risk" assessment tool [066]**
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Ditte M. Forsmann & Charlotte Kjærgaard

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Joachim Audet, Carl Christian Hoffmann, Lars Elsgaard & Charlotte Kjaergaard

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Chairman: *Dominik Zak*

15.20 – 15.40 **Quantifying sediment retention by restored wetlands using fallout radionuclide tracer technology (^{137}Cs and ^{7}Be): The River Odense, Denmark [O63]**
Brian Kronvang, William H. Blake & Alex Taylor

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Carl Christian Hoffmann

16.00 – 16.20 **The role of nitrogen in controlling the distribution of groundwater dependent vegetation in Danish riparian areas [O67)**
Annette Baattrup-Pedersen, Carl Christian Hoffmann & Peter Mejlhede Andersen

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VENUE: JEPPE VONTILLIUS AUDITORIUM, LAKESIDE LECTURE THEATRES

13.20 – 14.50 **Session 8: Workshop:** Linking wetland, floodplain and river restoration **(RESTORE)**

AIM: The Restore EU-Funded Life project aims to identify some of the main limitations and drivers for river and floodplain restoration across Europe. As part of the project, RESTORE, collects and collates information through a range of mechanisms including the delivery of workshops. The outputs of these workshops are then used to help develop the RESTORE tools and guidance to ensure that they provide valuable information for a range of end users including river basin managers, policy makers and targets interested groups for deliver and future research. This workshop focuses on how to make better links between restoring rivers and wetlands. Currently, the two restoration activities are often delivered independently, which can result in conflict of interests.

DELIVERY: This workshop will enable participants to suggest how we can work together more effectively and through RESTORE ensure that the key elements of improving the synergy between river, wetland and floodplain restoration can be made.
The workshop will comprise a mixture of longer guided discussion periods which will be interspersed with presentation on the following:

- Introduction to RESTORE as a tool to communicate, educate and disseminate knowledge about river and floodplain restoration through its case study handbook, and wiki database.
- Outline of the workshop: Exploring the concepts of river restoration in the context of wetland and floodplain restoration.
- A case study about linking rivers and floodplains: multiply benefits for wildlife, flood risk and recreation. Outputs and lessons learned.

13.20 – 14.50 **RESTORE: WORKSHOP Part I**

14.50 – 15.20 **Coffee break**

15.20 – 16.20 **Session 8 continued**
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VENUE: PER KIRKEBY AUDITORIUM, LAKESIDE LECTURE THEATRES

16.20 – 17.20 **Closing**
Brian Kronvang & Jos Verhoeven

18.30 - **Conference dinner**

Opening of SWS2012

Photo: Jan Kofoed Winter.

SWS-Europe: towards better linking wetland science and practice [O75]

Jos T.A. Verhoeven

Ecology and Biodiversity, Dept. of Biology, Utrecht University, Padualaan 8, 3584 CH Utrecht, The Netherlands.
Email: j.t.a.verhoeven@uu.nl

Europe is a continent with a long history of land use and water management by humans. Agricultural activities with structured land use date back more than three millennia. Rather large-scale hydrological manipulations happened as early as in Roman times, when even major river courses were modified through channeling. With its steady growth of the human population towards the current, generally high densities, the continent is strongly dominated by rural areas with moderate to intense agricultural use, urbanized regions, forest plantations and channelized rivers and streams.

Although a vast percentage of the continent's original wetlands has been lost, there are still large and valuable wetland resources. In the northern areas, there are still very extensive peatlands which are more or less pristine. Blanket bogs, raised bogs and fens also remain in the British Isles and in the Baltic countries, with many of them severely altered. Depressional wetlands and shallow lakes remain in the agricultural landscapes as (semi-)natural elements contributing to regional biodiversity. River channels, large floodplains and river deltas have been very strongly modified and now function in a totally different way. In the Mediterranean, most coastal lagoons and groundwater-fed wetlands have been subject to salinization and desiccation.

Overall, the ecosystem services and biodiversity of European wetlands have been minimized in the course of history and continue to be threatened today. Although it is widely recognized that there is a need for protection and restoration of these values, we have a long way to go before we achieve effective protection and wise use of existing wetlands and large-scale restoration of deteriorated or lost ones. The Society of Wetland Scientists can facilitate these objectives by organizing effective and frequent interaction between wetland scientists and practitioners. This general goal of SWS is especially challenging in Europe, with its many cultures, languages and legal systems. However, there are a number of EU-driven policies which are being implemented in Europe, such as Natura 2000 and the Water Framework Directive. We have the HQs of Wetlands International, the IWRB, IUCN and the Ramsar Bureau. We also have world-class leading wetland research groups in universities and research institutes. It just takes active people to make the connections and exchange knowledge and experience. YOU can make it work!

Key Note

River and wetland restoration: Applying ecological engineering principles

Photo: Carl Christian Hoffmann.

River and wetland restoration: Applying ecological engineering principles [O72]

William J. Mitsch

River/wetland complexes are highly complex systems that must be carefully investigated before applying wetland creation/restoration approaches and stream modifications. We have investigated the primary succession of created wetlands for 17 years in mid-Ohio and found that several basic principles such as self-design and even maximum power appear to apply. Larger scale wetland restorations in the Florida Everglades, the Mississippi-Ohio-Missouri River Basin, and the Louisiana Delta in the USA, the Skjern River in Denmark, and the Mesopotamian Marshlands in Iraq all share similar patterns that suggest that restoration needs to occur with ecological engineering approaches that recognize Mother Nature and Father Time.

Key Note

Emission of methane and nitrous oxide from constructed wetlands

Photo: Joachim Audet.

Emission of methane and nitrous oxide from constructed wetlands [O69]

Ülo Mander

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The emission of greenhouse gases (GHGs) methane (CH_4), nitrous oxide (N_2O) is a "byproduct" of constructed wetlands (CWs) which have been increasing in importance recently. Among several environmental factors controlling the GHG emission, the availability of C and nutrients (especially N) that directly depend on wastewater loading, temperature, hydrological regime (pulsing vs steady-state flow, groundwater depth, moisture of filter material (water filled soil pores), and the presence of aerenchymal plants play a significant role.

A literature-based relationship between the input C and N loading and respective CH_4 and N_2O emission in main types of CWs shows that there is a significant positive correlation ($p < 0.05$) between the input loading and CH_4 and N_2O emission in both free water surface (FWS) and vertical subsurface flow (VSSF) CWs, whereas no correlation was found in horizontal subsurface flow (HSSF) CWs. It appears that the high variability of conditions and combination of several factors in HSSF CWs may be the reason for this. In addition, the limited quantity of data did not allow ust o derive reliable relationship for HSSF CWs.

The proportion (%) of CH_4 and N_2O fluxes in the input loading of total organic carbon (TOC) and total nitrogen (TN), respectively, in the main types of CWs are presented in Table 1.

Table 1. Emission factors: The proportion (%) of CH_4-C in the initial loading of TOC and N_2O-N in the initial loading of TN. Average and standard error (in brackets) are presented.

Type of CW	CH_4	N_2O
FSW	40 (5.9)	0.24 (0.10)
VSSF	1.44 (0.24)	0.021 (0.005)
HSSF	5.1 (2.4)	1.0 (0.5)

The high emission factor for CH_4 in FWS CWs is caused by the additional CH_4 from sediments accumulated at the bottom of surface flow wetlands (Table 1). Due to the lack of data, no clear relationship has been found between the emission of CH_4 and N_2O and other environmental factors.

Session 1:

Biodiversity of wetlands

Photo: Carl Christian Hoffmann.

Restoring key-biogeochemical features of groundwater-fed rich fens [O76]

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Rich fens belong to the most species-rich communities and are categorized as EU priority habitats. They can persist for centuries under optimal conditions but have disappeared almost completely from NW-Europe because of drainage and peat digging. Consequently, fen restoration has a high priority in the Netherlands and Belgium and many brook valleys are being rewetted. Unfortunately the outcomes are often not as planned and the reasons for failures or successes are poorly understood. We carried out a pilot study to determine optima and tolerances in key biogeochemical constraints for fen peat formation. We recorded soil and water chemistry at 22 restoration sites in the Netherlands and Belgium and in reference areas in Poland, together with vegetation composition and soil profile. Our sites comprise a wide range in humification, chemical composition of the soil water and in vegetation composition. Nutrient availability appeared to be much higher in most restoration areas than in the reference sites and consequently these were covered with species-poor high-productive vegetation. Sites rewetted with Fe-rich water, on the contrary, were low-productive but species-poor, probably because of Fe-toxicity. Not only high Fe- and NH_4-values in the interstitial water but also lack of source populations in the close vicinity may hamper the re-establishment of characteristic species in restored sites. Recent peat formation was only found at acidifying sites, not suitable for rich fen development. We conclude that restoration of optimal conditions for rich fen remain extremely difficult. The study also showed there is great demand for further research on the interaction of biogeochemical conditions, recruitment of peat forming brown mosses and vegetation management. Especially the development of micro-structures seems important.

Nutrient and water level effects on *Phalaris arundinacea* and *Carex acuta*: A mesocosm experiment [O02]

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Phalaris arundinacea L. can be a dominant species in nutrient-rich wet grasslands, resulting in low diversity conditions. A field study in the Třeboň Basin Biosphere Reserve (TBBR) showed that a nutrient-poorer section of a wet grassland had changed over time from an almost monoculture of *P. arundinacea* to a slightly more diverse grassland with two co-dominant species (*P. arundinacea* and *C. acuta*) possibly as a result of the cessation of fertilization and mowing. Nutrient-richer areas remained as *P. arundinacea* monocultures. Based on the field results, a mesocosm experiment was established in 2009 to determine the effect of nutrient level and flooding regime on the growth and spread of these two common wet grassland species. Nutrient treatments consisted of Low (= 65 kg NPK*ha-1*yr-1) and High (= 300 kg NPK*ha-1*yr-1) additions, while there were three flooding regimes (saturated = water level -5 cm below soil surface; flooded = +10 cm above soil surface; spring flood = flooding for four weeks in spring with saturated conditions for the remainder of the growing season). Half of the pots were harvested in August 2010 and the remaining half the following August. Measurements included final plant height, above and belowground dry weight, number of daughter plants and plant nutrient (C, N) levels. Nutrient additions significantly increased stem height and aboveground biomass in *P. arundinacea* vs *C. acuta*. However, *P. arundinacea* was negatively affected by constant flooding, having significantly lower belowground and total biomass than *C. acuta*. Also, *C. acuta* was better at capturing nutrients (C, N) under long-term flooding. The results are in agreement with studies from North America showing that *P. arundinacea* is at a competitive disadvantage in nutrient-poorer conditions as well as when subjected to long-term flooding.

The effect of germination on riparian plant species distribution along hydrologically restored lowland streams [O05]

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Throughout Europe, many hydrological stream restoration projects have been carried out, but many of them (so far) failed to ecologically improve the deteriorated channelized streams. A better balance between hydrology and morphology may improve stream functioning, i.e. more natural flow velocities, flooding regimes and hydrological gradients in the riparian zone. Individual restoration projects, however, largely differ in morphological designs, because of various reasons, e.g. differences in hydrology and spatial limitations, culminating to different stream profiles and riparian gradients. The latter is especially important for a bio diverse vegetation, as demonstrated by several studies on distributional differences of adult plants. Mechanistic studies on these patterns, however, are scarce, but would be highly valuable facing the current hydrologic experimentation in stream restoration. In this research, germination, as one of the initial processes in vegetation development, was studied in a field experiment by introducing seeds of nine wetland species along hydrological gradients at two restored lowland streams in the Netherlands. Surface water level, soil moisture content, and groundwater level were measured hourly at each sowing location. Germination percentages were determined two and three months after sowing for each species, and related to the average soil moisture content and groundwater depth in these periods. With curve-estimation, a normal distribution was fitted on these data, providing an optimal soil moisture content or groundwater depth for germination per species; the value with highest germination. These optimal values showed a positive relation with species' Ellenberg values for moisture (a 12-point scale indicating a species habitat preference as adult plant), demonstrating the determining influence of germination on the distribution of species along a moisture gradient. In the light of stream restoration, these results urge that subsequent surface area of a range of moisture conditions are needed to provide the optimal conditions for different plant species. When these conditions are met, an important step is made to a higher biodiversity.

Seed dispersal in streams [O08]

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Flooding has long been recognized as an important factor structuring vegetation in riparian areas i.e. by supplying seeds and vegetative fragments that may establish in the areas. The 'River Collector Hypothesis' suggests that the river accumulates and transports propagules by water and that the number of water-dispersed plant species increases with increasing stream size. Here we analyse 1) species recruitment from deposited sediments in streams and riparian areas, 2) the influence of catchment land use on species recruitment from sediment seed pool, and 3) how this recruitment in riparian areas vary with distance to the stream channel. For the two first mentioned purposes, we collected sediments from two river sites i.e. River Skjern and River Vorgod with contrasting landuse in the catchment and investigated species recruitment in stream and riparian habitats as well as in the greenhouse. River Skjern and River Vorgod have contrasting catchment land use especially in the riparian zones, with River Skjern representing one of the less anthropogenic disturbed areas in Denmark. For the third purpose we established a transect perpendicular to the stream channel in River Odense extending 101 m into the stream valley. Sediment samples were collected in a total of twenty five 20 x 20 cm artificial grass mats positioned 2, 16, 23, 41, 70 and 101 meters from the stream. We then followed species recruitment in the greenhouse. Overall the results showed that deposited sediments have large contents of viable seeds of species associated both with stream and riparian habitats and also the potential to introduce variability in compositional patterns in riparian areas. Thus we observed both large variation in species recruited among the three rivers and also variation relating to distance to the river channel. We did not, however, observe that differences in land use characteristics in the riparian zones both locally at the sampling site and in upstream reaches in River Vorgod and River Skjern, influenced the total number of species recruited or the number of species recruited associated with undisturbed riparian vegetation. Thus most recruited species were common and widely distributed species in the Danish landscape. Therefore limitations can exist as to which species can be recruited from sediments from rivers, but further studies are needed to elucidate this issue further.

Ecological consequences of wet grassland abandonment [O15]

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The distinctive and ecologically valuable communities and services of wet grasslands are maintained by periodic inundation or a high water table, and regular appropriate vegetation management, usually cutting for hay or grazing. Abandonment of wet grassland management is consequently a serious threat because it leads to potentially damaging ecological changes, such as shifts in plant and animal community composition, loss of rare species, reduced diversity, and possibly degraded ecosystem functioning and services. Neglect and abandonment are widespread issues that affect wet grasslands in many regions, including: Western Europe, where isolated grassland remnants present logistical challenges for management; Eastern Europe, where land ownership changes have prevented grassland management; and North America, where marginal wet grasslands have been withdrawn from agricultural management. This paper aims to review the ecological consequences of wet grassland abandonment on an international scale in order to assess its extent, dynamics and importance. It seeks to establish the scale and speed of vegetation succession during abandonment, evaluate impacts upon biodiversity, and identify common indicators and traits. It will also consider the reversibility of abandonment in order to assess wet grassland restoration potential. The paper will incorporate historical and contemporary literature, as well as case studies.

Aquatic and Wetland Plants and Vegetation in Semihaline Fishponds of South Moravia, Czech Republic. Is their Occurrence Sustainable? [O40]

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The "Lednice Fishponds" National Nature Reserve represents semihaline wetlands characteristic of the Pannonicum biogeographical region. The geological substrate (Tertiary sea sediments) and soils are mildly alkaline and relatively rich in salts, especially sulphates. In summer, these soils usually dry out even along the fishpond shores. Rising capillary water thus enriches the surface soil layers with salts. This habitat hosts halophilous plants, and so does the slightly saline water. As the Lednice Fishponds are primarily managed for fish rearing, the Czech Nature Conservancy still aims at defining an acceptable compromise management of this protected territory. Some halophytes have become extinct (*Salicornia prostrata*, *Suaeda prostrata*), but most of them have survived there to-date. This applies to 4 large fish-rearing ponds (total area 582 ha) and 15 smaller ones, frequently serving as nursery and/or hibernation ponds. The facultatively halophilous aquatic algae include, e.g., *Dunaliella salina* and some *Cladophora* spp.. The aquatic macrophytes with similar habitat requirements include, e.g., *Batrachium baudotii*, *B. rionii*, *Ceratophyllum submersum*, *Nitella mucronata* and *Utricularia vulgaris.* The most valuable plant species colonizing emerged fishpond shores and bottom sediments are *Crypsis aculeata*, *Cyperus michelianus*, *Heleochloa alopecuroides*, *H. schoenoides*, *Pseudognaphalium luteoalbum* and *Samolus valerandi.* The fishpond littoral zones host well developed communities of helophytes such as *Phragmites australis* or *Typha angustifolia*, which provide valuable breeding habitats and shelter to an animal community consisting of numerous species of wetland mammals, birds, reptiles, molluscs, amphibians, insects, spiders, crustaceans, etc.. The Lednice Fishponds, especially Nesyt, the largest (322 ha) and oldest one (first mentioned in 13th century), have been studied by ecologists of different professions and ornithologists since the 1920s, most intensely within the International Biological Programme (1965-74). Some of these data (Květ 1973, Husák and Hejný 1973, Úlehlová, Husák and Dvořák 1973, Dykyjová and Květ 1978, Husák 1987) are compared with more recent ones.

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Wetlands Biodiversity, Livelihoods and Climate Change Implications in the Ruaha River Basin, Tanzania [O47]

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Wetlands are the Tanzania's most biologically productive ecosystems and are store houses of valuable biodiversity. Agricultural production and fisheries which have significant contribution to economic wellbeing of many societies are among the major wetland utilization livelihood activities. Wetlands and their resources on the other hand are vulnerable to both human induced and climate change impacts. We studied a wide variety of valley bottom wetlands in the Ruaha River basin in southern Tanzania to quantify the plant species composition, diversity, associated livelihoods and climate change impacts. It was observed that the plant richness and diversity in wetlands was much higher than that in other adjacent habitats within the basin and wetlands are refuge for some endangered plant species making them important habitats for biodiversity conservation. Overall, wetland cultivation and fisheries contributed over 40% of the total household income and food. Furthermore over 90% of the dry season agricultural production is associated with wetland cultivation making wetlands the major livelihood source for majority of the population in the basin. Among the most visible climate change impacts on wetlands was reduced water levels and drying of wetlands in the basin. Under the scenarios of climate change water flows in the Ruaha will decrease by 10%. This will cause substantial reduction in the area of wetlands in the basin with negative impacts on all wetland dependent livelihoods and resident biodiversity. With increasing climate change impacts the livelihood aspect of Ruaha basin wetlands may override the biodiversity values. If this becomes the case it will lead into degradation of ecological functions of most wetland habitats in the basin. The dual value of the wetlands (biodiversity and livelihoods) makes them unique habitats requiring integrated management approach to ensure achievement of both without impairing the ecological integrity of the wetlands.

Restoration under Climate Change: anticipating shifting goal-posts [O20]

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Climate change is transforming the landscape and with it the priorities for restoration sites and goals. South-western Australia is a global biodiversity hotspot and is recognised as one of the most vulnerable regions to the effects of climate change (Davies, 2010). Previously, restoration has focussed on systems suffering from anthropogenic impacts such as eutrophication, salinisation and/or degraded riparian vegetation. In the now drying climate (a 15% decline in rainfall and 55% decline in runoff since 1975), the focus must be on which sites can retain water into the future and issues such as temperature and connectivity become paramount. Climate change has forced us to consider restoration at the landscape scale rather than as individual sites. While the focus may have shifted, the necessity to mitigate multiple anthropogenic stressors that reduce the resilience of wetlands to adapt to climate change, is still a major driver. In some instances, eg salinisation, climate change has alleviated the rate of environmental decline but in most cases it has exacerbated stressors. Our capacity to recognise opportunities to allow newly emerging ecosystems to manifest is also considered. A key element of restoration must now be getting the best predictions for climate change effects to ensure investment in restoration will provide long term benefit. This paper outlines a spatial risk assessment tool to predict climate change impacts to allow rational prioritisation of restoration sites and projects to maximise biodiversity and resilience.

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The Gelså river restoration revisited: what has been achieved after more than 20 years? [077]

Friberg, N.[1], Baattrup-Pedersen, A.[1], Kristensen, E.[1], Kronvang, B.[1], Pedersen, M.L.[2], Thodsen, H.[1] and Wiberg-Larsen, P.[1]

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River Gelså is a lowland river located in the southern part of Jutland, Denmark. In 1952, parts of the river were straightened and channelised in order to increase drainage efficiency and discharge capacity, thereby reducing the risk of flooding of agricultural land. In 1989, a restoration project was carried to rehabilitate a 1.3 km straightened and channelised course of the River Gelså at the town of Bevtoft to a 1.8 km meandering course. Before the restoration, the in-stream environment was unstable with sand transport along the river bed due to erosion of stream bed and banks. Creation of 16 new meanders changed the stream channel morphology, decreasing the channel width by 3–4 m and the discharge capacity by almost 50% (from 6.6 to 3.5 m^3 s^{-1}). Prior to restoration of the Bevtoft reach a 0.5 km upstream reach with very similar physical, chemical and biological characteristics was selected for comparison with the restored reach. The restored and the upstream reach have been monitored during the last 20 years.

Among the most striking result has been the continuous development in both physical and biological conditions over the entire period. Habitat quality was still improving in the restore reach in the period from 8 to 19 years after restoration. Similarly, macroinvertebrate community composition has shown a high degree of community turn-over and low persistence. In contrast, very limited changes in local diversity have been recorded over the years. Another key result is the role of macrophytes in creating habitat structure and hence their positive impact on other components of the biota. Available trout (*Salmo trutta*) habitat was found to be intimately linked to total macrophyte coverage more than the restoration *per se*. Overall, the restoration of Gelså have had limited impact on the biota with minor improvements in macrophyte and macroinvertebrate communities, while trout densities are still at the pre-restoration level.

Session 2:

Carbon sequestration and GHG emissions

Photo: Joachim Audet.

Factors controlling the mobilization of dissolved organic matter in rewetted degraded fens [O28]

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The concentrations of dissolved organic carbon (DOC) have been nearly doubled in some inland waters of Central Europe and Northern America during the last three decades. This phenomenon has been proposed to be caused by a decrease of atmospheric sulfate deposition and the large-scale drainage and agricultural use of riparian peatlands. Own field investigations raise some evidence that also the rewetting of degraded fens might be responsible for a higher DOC export into adjacent water courses. Thus, DOC concentrations of pore water nearby the soil surface were up to 10-fold higher in calcareous rewetted fens (> 200 mg/L) compared to natural fens (Zak et al. 2010). Over the last ten years, we performed a number of field and lab investigations in numerous degraded fens to derive some general conclusions on the temporal and spatial heterogeneity of DOC concentrations in pore waters of different degraded fens as well as on the factors controlling the mobilization of dissolved organic matter. Accordingly, high DOC concentrations in soil water of rewetted fens correspond with an enhanced DOC mobilization potential in the upper degraded peat layer. Moreover, it was shown that chemical composition of rewetting water influence the level of DOC mobilization. Detailed investigations on matter retention at the peat surface as a redox-barrier (Zak et al. 2004) and measured in-situ DOC surface water concentrations of inundated fens reveal that only a minor part of released organic carbon will be exported to adjacent water courses. The comparison of experimentally gained data on net release rates of DOC, carbon dioxide and methane led to the conclusion that DOC export could be important for the computation of the total carbon budget of rewetted fens. However, it is still questionable which amount of DOC will be exported via ground and surface water to downstream ecosystems.

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Rewetted fens as novel ecosystems: carbon, nitrogen and phosphorus accumulation [O10]

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Fen restoration projects are based on raising water levels up to the soil surface in order to restore peat forming conditions. However, restoration of such conditions is often impossible under the present circumstances. Rewetting often results on the creation of shallow eutrophic lakes rather than restoring pristine conditions. As a result, novel ecosystems are created where C, N and P accumulate takes place in a new-formed sediment layer instead of within the peat. In this presentation, a first estimation of C, N and P accumulation in the new sediment layer of rewetted fens and the potential importance of those novel ecosystems as C, N and P sinks are evaluated. Moreover, the influence of top-soil removal and the age, i.e. time after rewetting, on C, N, and P accumulation rates is investigated. To accomplish this goal, sediment cores were collected and C, N and P accretion rates were estimated in 12 rewetted fens located at NE Germany. Our results indicate that previous top-soil removal decreases sediment accretion at rewetted fens, indicating a lower net ecosystem production, what could be expected due to a lower nutrient availability at those sites. On the other hand, OM mineralization seems to be higher at places where top-soil removal was performed. Time after rewetting modifies at some extent the effect of top-soil removal, although future research is required to test its effect. C, N and P accumulation seems to depend more strongly on sediment accumulation rates rather than on sediment composition. C, N and P accumulation via sediment formation at rewetted fens are similar to those reported for natural fens at the temperate area, although comparison must be made with care due to their different functioning. Moreover, rewetted fens have a greater potential as C, N and P sinks than other freshwater ecosystems at the temperate area.

Carbon Sequestration in a Sedge-Grass Marsh Monitored for Five Years [O04]

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Seasonal courses of gross ecosystem production (GEP), net ecosystem production (NEP) and ecosystem respiration (Re), measured by the eddy covariance technique (open path infrared gas analyzer Licor 7500 LI-COR, USA), were studied in a sedge-grass marsh for five consecutive years (2006-2010). The sedge-grass marsh is a part of the large "Wet Meadows" complex (about 420 hectares) situated in the Třeboň Basin Biosphere Reserve at the edge of the town of Třeboň, South Bohemia, Czech Republic. The "Wet Meadows" are a flat area at an altitude of about 426 m, covered by an up to several meters thick acidic fen peat layer superimposed on quaternary alluvial sands and clays. The annual mean air temperature and average annual precipitation are 7.5 °C and 615 mm, respectively (1977-2010). The vegetation of the study site is dominated by the tall sedge *Carex acuta*. Distinct stand structure of hummocks and hollows has developed here as a result of tussock formation by this sedge. The courses of the GEP, NEP and Re recorded during the above five years were highly variable, mainly owing to variable precipitation and inflow of surface water, causing distinct water level fluctuations. The water level is controlled by a system of drainage ditches; most frequently it is about -0.1 m. Its random fluctuations between -0.3 m and 2 m are due to meteorological events such as drought periods on the one hand and floods on the other. The resulting seasonal fluctuations of carbon exchange were most marked in 2006, when high floods occurred. GEP was the highest in the driest year of 2007 (1375 g C m^{-2}.$year^{-1}$) and lowest in 2009 and 2010 (1075 and 1032 g C m^{-2}.$year^{-1}$, respectively). The NEP was highest in 2010 (232 g C m^{-2} y^{-1}) when a high Re was also recorded. The lowest NEP's were recorded in 2006 and 2008. In 2006, two high floods occurred and the low NEP was due to almost no plant growth during the floods. In 2008, the low NEP was caused by high Re due to low water level predominating during that year. On the whole, carbon sequestration was positive in the sedge-grass marsh ecosystem which acted as a sink of atmospheric carbon in all five years of its monitoring.

Biomass production and soil organic carbon balance in a surface flow constructed wetland with fluctuating hydroperiod in North Eastern Italy [O14]

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The surface flow constructed wetland (SFW) tested in this work covers an almost square area of 3200 m^2 and receives the drainage waters from an a surface of 5.5 hectares of agricultural land. It was created in summer 1996 and initially vegetated with cattail (*Typha latifolia* L.) and common reed (*Phragmites australis* (Cav.) Trin.ex Steud.). Since January 2007 the wetland vegetation is composed almost exclusively of common reed.

Eleven sampling points with the same size (0.5x0.5x0.5m depth) were considered in the wetland. *P.australis* was collected every year from 2007 to 2012 at each sampling point for the biomass production, measuring aerial part, straw, belowground parts at 0-20 and 20-50 cm depth. The soil content of organic carbon was determined in 2007, 2009, and 2012.

During 2006-2011 about 6000 mm of water entered yearly the basin against 840 mm of rainfall. Annual average flooding was 24 days with discontinuity over time, from a minimum of 3 days in 2011 to a maximum of 54 days in 2009.

During the study period the belowground biomass was higher than aerial part (annual average of 20 t/ha and 10t/ha of dry matter, respectively), with an increment of the production in roots and rhizomes compared to the aerial part from 2006 to 2011. For the first three years of the study the belowground biomass was higher in the upper soil layer (0-20 cm depth), whereas from 2009 it was localized mainly between 20-50 cm depth.

Soil organic carbon content in the surface layer was 12.3 g/kg in 2007and 13 g/kg in 2009.

Carbon emissions from ponds [O30]

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Carbon budgets in freshwater systems with surface areas less than 0.02 km^2 ('ponds') constitute a knowledge gap. Ponds are numerous globally, but remain little studied in this context (Downing, 2010). Previous research suggests that in wetlands the proportion of littoral area has a strong positive influence on emissions (Huttunen *et al*., 2003). Ponds inherently have a high proportion of shallow and edge area compared with larger water bodies, suggesting they may comprise rapid processing environments in terms of production and emission of greenhouse gases. We analysed carbon dioxide and methane emissions from three UK ponds under farm, forest and heath land management regimes. Carbon dioxide (CO_2) and methane (CH_4) emissions were sampled from floating chambers five times per day, at monthly intervals from spring 2011 to spring 2012. Sampled gas concentrations were analysed by membrane inlet quadrupole mass spectrometry (ESS, using Quadstar 32 bit software). Flux chamber sampling captured diffusive and ebullitive emissions; to estimate the ebullitive flux contribution bubble gas contents were sampled and analysed separately. The rate of ebullition was calculated by carrying out surveys of 1 m^2 sections of water surface area, counting bubbles spontaneously appearing at the surface, classified by size category. The volume of bubbles and the constituent gas concentrations provide an estimate of the rate of the ebullitive proportion of emissions, whilst flux chamber sample concentrations were plotted against time (applying a correction for gas concentration gradient change within the chamber modelled on that of Bastviken *et al*., 2004). Linear regression analysis provided the rate of emissions, further corrected by comparison with diurnal measurements (Spring 2012). Comparisons between farm, forest and heath ponds highlight the influence of fertiliser application (N,P and K) on freshwater carbon emissions.

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Greenhouse gas emissions in riparian wetlands [O82]

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Riparian wetlands are the place of important bio-geochemical transformation. The high water level and the low oxygen content often found in wetlands slow down the decomposition rate of organic material resulting in accumulation of organic carbon. However, wetlands are also a natural source of greenhouse gases (GHG). According to IPCC (IPCC, 2007), wetlands are the largest natural source of methane (CH_4) in the world. Furthermore, when nitrate is present in wetlands, nitrous oxide (N_2O) might also be produced.

We monitored over a year the fluxes of N_2O, CH_4 and carbon dioxide (CO_2) in a total of four Danish riparian wetlands each comprising three sub-sites presenting contrasting characteristics regarding vegetation, water level, peat quality and water physico-chemistry. A total of 816 flux measurements per gas were recorded during the study.

The emission of GHG from the different sites ranged between -0.2 and 38.3 g C m^{-2} y^{-1}, -0.01 and 0.12 g N m^{-2} y^{-1}, 944 and 2295 g C m^{-2} y^{-1} for CH_4, N_2O and CO_2, respectively. Water level was the main driver for CH_4 emissions and soil temperature was correlated to CO_2 emissions. Despite the fact that the wettest site emitted more CH_4, these sites also had a higher carbon content in the soil.

This study documented the emission of GHG from Danish riparian wetlands. A better understanding of the factors influencing GHG emission can provide valuable information in order to improve the design of restored wetlands when aiming at mitigating GHG emission and increasing C storage.

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Controlling factors for transport of methane through *Juncus effuses* [P60]

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Plants can affect methane emissions from wetlands in several ways. First of all the plants provide the rhizosphere and the methane producing microorganisms with organic compounds through root exudation, and secondly, aerenchymatous plants can transport methane from the rhizosphere to the atmosphere bypassing the oxidizing layers of the soil. This process is very important for the carbon cycle in wetlands, but still our knowledge about the specific physiological and morphological factors that govern the transport of methane is limited. We investigated the transport capacities of small tussocks of *J. effusus* grown hydroponically in the laboratory with the roots submerged in a methane solution. Through a range of manipulations of the roots and shoots, we identified sites providing the greatest resistance to gas transport as well as the sites for uptake and release of methane by the plant. Additionally we identified the sites for oxygen release from the roots by submerging the roots into a reduced methylene blue solution. The results clearly show that the root manipulations had the greatest effect on methane transport. Removing root material reduced methane transport significantly, and especially the lateral roots and the root tips were sites of great importance. The methylene blue experiment also revealed these sites as sites for oxygen release. Cutting of the shoots, with or without subsequent sealing, did not alter methane transport significantly. We conclude that the limiting factor for methane transport in *J. effusus* is the amount of permeable root surface, and that methane enters the plant through the root tips and the lateral roots. The foliar tissues do not provide any significant resistance to the transport, and all the methane leaves the shoots through the lower parts of the shoots. Studies like this are important when we want to understand the small scale variations in methane emissions from wetlands.

Methane emission from pristine, drained and restored peatlands in Central Europe (Bohemian forest) [P37]

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Most of peatlands in Central Europe were drained mostly for forestry purpuses during the last 50 years. Some drained peatland have been restored nowadays. We studied effect of drainage and restoration on methane emission in these mountain bogs.

Three ombrotrophic bogs were located in the Šumava National Park within the Bohemian Forest, in the Czech Republic. An intact site represents a mountain slope bog with a well-developed surface structure consisting of wet hollows, drier hummocks and intermediate lawns. Drained site was restored by blocking ditches with timber dams and by filling ditches with organic material (branches, remains of timber, etc.). This site is covered mostly with *Trichophorum cespitosum* on the wettest areas away from ditches, while hollows are still totally absent. The blocked ditches are surrounded by dwarf shrubs (*Vaccinium myrtillus*, *V. uliginosum*) and small *Picea abies* trees are spread out sparsely on the entire site. Rewetting of the restored bog site was undertaken in August 2008. The drained bog is covered with hummock-type vegetation with *V. uliginosum* and *V. myrtillus* and *Molinia caerulea* predominant in the drier areas along the ditches while *Betula pubescens* covers the whole site. Methane emission were significantly lower on drained and on restored bogs as compared to the pristine one. On the restored site methane emissions did not increase within three years after water regime restoration. Also the number of methanogens did not change between first and third year after peatland restoration. The vegetation did not change significantly within three years after restoration except some dwarf shrubs dieback close to the ditches. We suppose that vegetation is more important factor affecting methane emission from restored ombrotrophic bog than the abiotic factors like water level.

Flooding-induced N_2O emissions following extreme weather flooding of a non-managed wetland soil [P23]

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Flooding of wetland soil promotes subsurface N_2O production in the soil and potential emission to the atmosphere in distinctive emission pulses. Changes in flooding frequency of wetland soil following future climate change will likely affect the timing and magnitude of nitrous oxide (N_2O) emissions from the soil to the atmosphere. In this study we focused on the N_2O emission effects of extreme precipitation events happening in a typical growing season of *Phalaris arundinacea* in a non-managed Danish wetland.

Rapid flooding of the wetland was observed twice during the growing season of 2010 in response to high precipitation events, but a flooding-induced N_2O emission pulse was only observed when the soil conditions had been oxidized to soil depths below approximately 30 cm in more than 2-3 weeks before the flooding. The flooding events observed in this study are likely examples of the pattern of future climatic conditions, where prolonged drainage during dry summers are combined with late season precipitation events with increasing intensity and frequency.

Under current climatic conditions and nitrification rates in the soil, flooding-induced N_2O emission pulses at the studied field site constitute only a small percentage of the net annual N_2O emission budget. Laboratory experiments mimicking the flooding events showed that the surface emission patterns are linked to variations in plant-mediated gas transport via *P. arundinacea* and N_2O producing/consuming processes in the root-zone.

We conclude that unless the future balance between the inherent N_2O consumption capacity in the peat soil and the rates of NO_3^- formation and net availability is markedly altered, a future increase in extreme weather flooding events is not expected to increase net N_2O emissions significantly or play a major role in the annual N_2O emission budget from this type of non-managed natural wetland.

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Key Note

Constructing wetlands in the desert: solutions for management of oilfield produced water and other wastewaters in the Middle East

Photo: Carl Christian Hoffmann.

Constructing wetlands in the desert: solutions for management of oilfield produced water and other wastewaters in the Middle East [O70]

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In the water scarce Middle East region, sustainable management of polluted waters is an increasingly critical environmental challenge. Land-based oil extraction activities generate vast quantities of hydrocarbon contaminated brackish water ("produced water"), which needs to be treated and managed in a sustainable way. Management of sewage and sludge is another growing challenge in the region, both in rapidly expanding peri-urban areas and labourer camps established in remote locations for construction or industrial projects. Many of these produced water and sewage management problems occur in remote, desert locations far from service technicians and equipment vendors, which means that solutions need to be operationally simple and robust with minimal technical components that require regular servicing, maintenance or replacement. For these reasons, constructed wetlands represent one of the most appropriate technologies for solving many of the wastewater management challenges of the Middle East. However, the technology needs to be carefully developed and adapted to suit the local climate, water quality and physical conditions of the region.

One of the largest industrial constructed wetland systems was built in the Nimr oilfield in the desert in southern Oman and has been operating since the end of 2010 for the treatment of 45,000 m^3/day of produced water. The system consists of a mechanical oil-separator process to recover residual crude oil. The water then flows through 240 ha of surface flow wetlands planted with *Phragmites australis* where the remaining hydrocarbons are removed and degraded. A secondary function of the reeds is volume reduction via evapotranspiration. Then the water flows into a 350 ha series of evaporation ponds. The system operates with zero-discharge of water, with industrial grade salt being the final product. The entire 600 ha wetland-pond system operates via gravity and uses less than 2% of the electricity of the conventional alternative disposal method which is pumping the produced water into deep aquifers under high pressure (145 bar). Thus, the overall carbon footprint of the produced water management is minimised. The wetlands produce approximately 3000 tonnes/year of dry reed biomass, opening up potential reuse opportunities and provide habitat for migratory and resident birds. Several challenges had to be overcome in building such a large wetland in the middle of the desert, including the levelling and lining of the large 10 ha wetland cells using locally available soil material, propagation and planting of 1.2 million *Phragmites australis* seedlings, and ensuring healthy reed growth under the high-stress conditions (lack of nutrients in the water and soil, high salinity of the water, high temperatures, and oil in the water).

BAUER has also been active in implementing constructed wetland systems for management of sewage and sludges from residential areas, labourer camps and hotel resorts in Oman, Qatar and Jordan. An overview of these projects will also be presented. In general, it can be stated that constructed wetlands represent a suitable solution for many wastewater management problems in the desert environments of the Middle East where land is available, especially with regards to their low maintenance requirements and operating costs. There is also growing interest in the biodiversity values, especially with regard to providing habitat for water-birds, which is otherwise scarce in the region.

Session 3:

Wetland biogeochemistry

Photo: County of Funen.

Biogeochemical drivers of phosphatase activity in salt marsh sediments [O07]

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Salt marshes are highly productive wetlands, which represent an interface between freshwater/terrestrial ecosystems and marine systems. The availability of nutrients in a salt marsh is directly related to salt marsh biological productivity. Although nitrogen has become a major concern for wetlands scientists dealing with eutrophication problems, phosphorous represent another key element to be examined as well as it biogeochemical cycling. The microbial communities are a central component of trophic dynamics and biogeochemical processes on coastal systems, since most of the processes in sediments are mediated by microorganisms and carried out by enzymes. Salt marshes daily receive large inputs of organic matter during tidal flooding, from which organic phosphorous forms compose a very important part. Sediment extracellular phosphatases are key players in the decomposition process of this phosphorous-rich organic matter, being very active in all kind sediments due to its pH-isoforms. Although acid phosphatase is the most abundant enzymatic form, also alkaline and neutral phosphatase can be found along a pH gradient in salt marsh sediments. In the present work, the authors investigate the biogeochemical sediment drivers that control this enzymatic activities and how the different enzyme forms are controlled and its influence on the enzyme-mediated phosphorous cycling processes in salt marshes.

Problems in determining the amounts of nutrients removed in wetlands created to abate run-off from agricultural fields without using excessively costly measurements [O39]

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Creation of wetlands in the agricultural landscape has in Sweden been identified as a cost-effective way of decreasing nutrient transports to the Baltic Sea. Approximately 3,000 wetlands have been constructed so far in southern Sweden through different subsidy systems. The purpose is that these wetlands should counteract eutrophication by removing nitrogen and phosphorus while simultaneously contributing to increased biodiversity in the landscape.

Continuous automatic (flow or time proportional) water sampling for nitrogen and phosphorus removal measurements were carried out in the inlet and outlet of 7 wetlands during 1.5 to 10 years. Strategic grab sampling, also in the inlet and outlet, was conducted in 14 wetlands during 2 years. Flow was measured only in the outlet in most wetlands. The wetlands were all located in agricultural areas and were chosen to represent wetlands with different nutrient loads from agricultural field run-off.

Large temporal variations in water flows and concentrations complicated the interpretation of data. Analyses of the large dataset, in some cases comprising parallel measurements using different methods, showed that estimations of nutrients removal were, for example, sensitive to if short intensive inflows were adequately captured with the measurements or not. This led in particular to substantial underestimations of phosphorus removal.

This suggests that removal rates or coefficients used in models to estimate the total amounts of nutrients removed from agricultural run-off in large-scale national programs for creating wetlands may be based on field measurements with severe shortcomings. National assessments may therefore have given misleading results and, at least for phosphorus, seriously underestimated the amount of removal that has been obtained. We need to find ways to accurately determine nutrient removal levels of a large amount of wetlands without using too costly measurements so that created wetlands retain their status as a cost-effective way to reduce nutrient transports from agriculture.

The effect of small pH shifts on the phosphorus adsorption and desorption behaviour of floodplain sediments with different hydrological connectivity [O50]

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Large river floodplain systems play a key role in the transport, transformation and storage of nutrients, especially phosphorus. The introduced phosphorus is either subject to short-term storage mediated by plants and algae or to long-term storage mediated by sediment deposition or adsorption. Sorption–desorption processes within the sediment are influenced by the mineral composition of the sediment, which is susceptible to changes in pH and redox conditions. A pH gradient can be found from freshwater to marine systems, but also within one floodplain systems pH differences can temporal or spatial be found. Flood events and primary production can alter the pH of the surface water and influence the phosphorus adsorption mechanisms. The magnitude of the impact depends on the hydrological connectivity of the floodplain area.

The present study was conducted to evaluate the impact of two different pH ranges (6.5 – 7.5 and 7.5 – 8.5), which can occur in the system, on the phosphorus (P) retention on floodplain sediments. The chosen sites represent a connectivity gradient from 140 days to 1 day of connection and differed in fine sediment texture and organic matter content. Core samples were collected from six sampling sites in the floodplain system "Untere Lobau" and batch sorption experiments followed by desorption measurements with H_2O or oxalate were performed. For the phosphorus balance, analyses of different functional phosphorus fractions from the surface water, pore water and sediment were realised.

Effect of temperature on oxygen microprofiles and denitrification rates in freshwater sediments [O53]

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Denitrification, the conversion of nitrate to nitrogen gas, permanently removes bioavailable nitrogen from freshwater ecosystems and can therefore play an important role in counteracting eutrophication (Seitzinger 1988; de Klein 2008), however, the mechanisms and factors affecting denitrification are still unclear. This study aims to investigate the coupled effect of temperature and oxygen availability on denitrification rates in freshwater sediments.

We measured oxygen microprofiles and denitrification rates in microcosms at four different temperatures (10, 15, 20, 25 °C) under dark and light conditions. Sediment oxygen microprofiles were measured with a microsensor, denitrification rates with the isotope pairing technique (IPT, Nielsen 1992) analysed on a membrane inlet mass spectrometer (MIMS).

Denitrification rates (DR) increased with temperature and compare well to values found in literature. Values in the light ranged from 13.8 ± 6.4 μmolN m^{-2} h^{-1} at 10 °C to 62.8 ± 15.6 μmolN m^{-2} h^{-1} at 25 °C. Under dark conditions values ranged from 2.7 ± 2.2 μmolN m^{-2} h^{-1} at 10 °C to 81.0 ± 15.6 μmolN m^{-2} h^{-1} at 25 °C. The rate of oxygen decrease over depth in the top layer of the sediment did not change with temperature under dark conditions, under light conditions rates were higher and increased with temperature. This is probably caused by higher initial oxygen availability at the sediment-water interface under light conditions. The depth at which anoxia occurred did not differ significantly between treatments. The stronger temperature effect on denitrification under dark conditions (θ_{dark} = 1.13, θ_{light} = 1.10) was probably caused by the stronger temperature effect on respiration than photosynthesis, as was also indicated by sediment and water oxygen measurements. Changing temperatures will affect the oxygen profile in the top layer of the sediment, thereby coupling the effect of temperature and oxygen availability on denitrification rates in freshwater sediments.

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Wetland development, nutrient accumulation and runoff in New Zealand dairy pastures with very high annual rainfall [O55]

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Agricultural activity in regions with high annual rainfall raises particular challenges for managing nutrient runoff. Here we report on a four-year study of patterns of nutrient accumulation and loss in dairy pastures from a catchment of the West Coast of the South Island of New Zealand, receiving up to 3500 mm annual rainfall. Due to poor drainage in the gley soils, farming practice involves contouring the pasture in broad corrugations, termed 'humps and hollows', to improve drainage; grazing is restricted to the humps, whilst wetland vegetation (predominantly a marsh of *Juncus* and *Carex* species) naturally colonizes the wetter drainage hollows. We aimed to quantify nutrient accumulation and runoff at this site, paying particular attention to the function of the wetland hollows in nutrient cycling. Subsurface flow was found to be negligible in the poorly draining soil, with water loss and nutrient yields restricted to surface flows. No fertiliser was applied the first year at one site. Specific nitrogen and phosphorus yields ranged from 11-56 kg N ha^{-1} yr^{-1} and 2.0-13.4 kg P ha^{-1} yr^{-1}. The highest P yield (mostly in particulate form) was recorded even when no P fertiliser was applied. Wetland vegetation and soils showed prolonged accumulation of both N and P throughout their development, but failed to intercept peak events that occurred when cattle were allowed to graze the pastures following heavy rainfall events. Potential soil denitrification, measured from denitrification enzyme activity experiments, was very low, with median values < 50 ng N g^{-1} h^{-1} throughout the study, predominantly due to low nitrate concentrations. We conclude that (i) significant nutrient discharge is a feature of this system; (ii) the natural wetland formation in drainage hollows is an important nutrient sink that mitigates discharge; and (iii) much of the remaining discharge could be ameliorated by improved farming practices.

Effect of Hydrological Regime of Lowland River on Water Quality of Oxbow Lakes - a Case Study of the Biebrza River (Poland) [P19]

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Floodplain lakes, unlike lakes of other origin which receive nutrient inputs from various point and diffuse sources, are additionally fed by the river. Interactions between a floodplain lake and the river, which are governed by hydrological regime, hydrological connectivity and lake morphology, play an important role in determining the impact influent nutrients. These interactions also affect the manner in which nutrients are recycled and/or distributed within a river-fed lake and lead to the establishment of longitudinal gradients in concentrations. The lakes exhibit longitudinal and vertical gradients in nutrient concentrations which are influenced by the hydrologic characteristics of the river. Exchanges of water and material affected by flow regime play an important role in the seasonal dynamics of nutrients.

Based on the study carried out in the middle Biebrza river valley within the protected area under Biebrzański National Park (Poland, Central Europe) floodplain lakes function as `biogeochemical sinks' for transported nitrate nitrogen by providing more sites for effective denitrification (anoxic, organic sediments, vegetation beds), and total phosphorus load except for flooding periods when the net export of this nutrient takes place due to internal loading, being the source of TP for downstream river section. In lotic environments, the inflows as well as outflows are important sites for the transformation of fluvial matter and nutrients, as well as for river habitat patchiness. However, the direct input of nutrient-rich water to the floodplain lakes leads to the deterioration of their trophic status. In order to stop the development of water blooms and to restore the lakes to reasonably healthy conditions, both the external and internal loading has to be reduced. The solution should be found in a river, which is a primary, but to date unexploited, instrument in restoration of degraded floodplain reservoirs.

Session 4:

Wetland ecophysiology

Photo: Hans Brix.

Halophyte influence in salt marsh phosphorous retention capacity [O03]

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Salt marshes have great ecological value for the ecosystem, namely in nutrient regeneration, primary production, habitat for wildlife species and as shoreline stabilizers. Their important role has been recently admitted by the inclusion of these ecosystems in the Water Framework Directive (WFD). Multiple services of wetlands and its value are already well known. Vascular plants in salt marshes are crucial to the dynamics of the estuarine ecosystem, strongly influencing the processes of retention of heavy metals, reduction of eutrophication and mitigation of carbon. One of the key aspects to consider while addressing elemental retention in salt marshes is the halophyte specie-dependent biogeochemical speciation in sediments. As well as for heavy metals, this is also true in terms of phosphorous retention. In this work the authors investigate the influence of an annual halophyte, *Scirpus maritimus* and its influence on phosphorous speciation in salt marsh sediments. This halophyte goes through an annual growing with periods of maximum nutrient harvesting ability with highly root activity and complete dormancy periods, with complete loss of aboveground biomass and almost no root activity. This will cause a differential influence on phosphorous speciation due to different periods of root activity, with consequent influence on the phosphorous retention capacity of salt marsh sediments.

Prescribed fire increases coastal marsh plant productivity through canopy removal [O16]

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Prescribed fire is used widely in the Unites States for coastal marsh management and usually results in increased plant productivity. This increase has been thought to be either due to a fertilization effect from nutrients mineralized in the fire and deposited as ash or to the removal of the plant canopy, which may allow for greater light availability and increased soil temperatures. We conducted a manipulative field study to assess the effects of these two mechanisms on plant productivity at marsh sites on the eastern shore of the Chesapeake Bay in Maryland, USA (Mid-Atlantic Coast). At four non-burned sites, fire effects were simulated by clipping the canopy and depositing ash (two-way factorial experiment). At three burned sites, artificial plant canopies were constructed using senesced plants (one-way factorial experiment). At non-burned sites, canopy removal increased biomass production 40% aboveground and 260% belowground. At burned sites, canopy replacement decreased biomass production 41% aboveground and 40% belowground. Canopy removal increased light availability at the soil surface and soil temperatures at a 5-cm depth. In the non-burned sites, the positive effect of canopy removal on plant production was greater at sites dominated by the sedge *Schoenoplectus americanus* than those dominated by the grasses *Spartina patens* and *Distichlis spicata*. As measured using cotton strip assays, canopy removal was associated with 66% lower organic matter decomposition rates at peak growing season (July), which was related with lower amounts of porewater NH_4^+ and PO_4^{3+}. Ash deposition showed no effects on plant productivity or other study variables. The ash provided a mean fertilizer pulse of 0.22 g N/m^2 and 0.16 g P/m^2, which are rates likely too small to increase plant productivity. Prescribed fire programs may benefit by maximizing canopy removal if increased biomass production and lowered organic matter decomposition rates are desirable outcomes.

Elevated CO_2 alters the phenotypic plasticity of *Phragmites australis* with respect to temperature and nutrient availability [O18]

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Phenotypic plasticity - the capacity of a genotype to produce distinct phenotypes when exposed to different environmental conditions - is of interest for predicting species responses to global environmental change and for understanding species interactions. We studied the phenotypic plasticity on genotype level of different traits in two geographically and phylogenetically distinct genotypes of common reed (*Phragmites australis* (Cav.) Trin. Ex Steud.).

Replicates of a genotype from Denmark (DK genotype) and a genotype from Algeria (ALG genotype) belonging to the European and African strain, respectively, were grown at 15°C or 25°C and high or low fertilization level, either at ambient or double atmospheric CO_2 concentration. Phenotypic plasticity of different plant traits was quantified as plasticity indices (PI) in relation to temperature and fertilization. The functional significance of the plasticity was assessed by determining the contribution of the plant traits to fitness.

Under ambient [CO_2], the DK genotype responded more and had the highest PIs with respect to temperature, contrary to the ALG genotype, which responded mainly to fertilization. Overall, PIs for biomass and growth traits were highest. Under double [CO_2], however, those differences disappeared and both genotypes were equally plastic for both temperature and fertilization and across distinct traits.

Some of the plastic traits contributing to fitness were the same for growth at ambient and double [CO_2], but some were also distinct. In both treatments, not all plastic traits correlated with fitness, indicating that phenotypic plasticity *per se* is not a precondition for plant fitness, regardless of growth [CO_2].

We conclude that the responses of the two contrasting *P. australis* genotypes to temperature and fertilization are genetically determined and related to their climatic origin. Increased growth [CO_2] changes these responses and their impact on plant fitness, which may influence how the genotypes will respond to global environmental change.

Phytotreatment of grey and yellow waters obtained from source separation of sewage by oleaginous plants suitable for biodiesel production [O44]

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A lab-scale research study was undertaken at the University of Padua using a system to separate domestic wastewater into three fractions (greywater; yellow water - urine; brownwater - fecal stream). Two plant species, *Glycine max* (soybean) and *Helianthus annuus* (sunflower), grown in pots using sand as substrate, were watered with a mixture of grey and yellow waters. The aim of the study was to evaluate the phytotreatment efficiency of oleaginous plants, whose seeds could be eventually used for biofuel production.

The growth of the plant treated with grey-yellow waters was 80% (sunflower) and 65% (soybean) of control plants watered with complete nutrient solution. During the experimental period high efficiency (>90%) of N, P and COD removal was measured, independently from the plant species

The scarce inhibition registered in the growth of plants was not associated to the toxic effects of the pollutants present in wastewaters, rather evidenced the need to increase the percentage of yellow waters in the mixture, to compensate for the poor presence of nutrients in grey waters. At the end of their life cycle, the plants produced viable seeds, suitable for use in biofuel production, thereby contributing to improve the environmental sustainability of the wastewater management cycle. The results obtained confirm the feasibility of using oleaginous species in the phytoremediation of grey waters and yellow waters, particularly in view of the high removal efficiencies of pollutants obtained.

The *Phragmites* world: phylogeography and ecophysiology within a cosmopolitan polyploid species complex [O81]

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Phragmites australis is a cosmopolitan species and is broadly studied by wetland scientists being a key-species in aquatic ecosystems, largely used in constructed wetlands, and an invasive species. The genus *Phragmites* includes more species than *P. australis*, which are much less known in ecology and distribution. *P. mauritianus* is a tall woody species with runners, and its known distribution range is in tropical Africa. However, hybrids of this species with *P. australis* have been recently found in South America and in the US Gulf Coast (Lambertini et al. 2012). *P. frutescens* is another species, with rare occurrences in the Mediterranean region, but it shares chloroplast sequences with *P. mauritianus* and with a fourth, robust woody species, *P. karka*, distributed in tropical Asia . Mediterranean *P. australis*, taxonomically known as *P. australis* ssp. *altissimus* (which means very tall) shares several nuclear DNA alleles with *P. mauritianus* and *P. karka*. In East Asia, there is another species, *P. japonicus*, which appears restricted in distribution to the Far East. However hybrids of *P. australis* with *P. japonicus* have been found in South Korea (Chu et al., 2011). In the temperate range, *P. australis* populations consist of contingents of similar genotypes, but their closest relatives are often found in populations thousands of kilometers away or in other continents. In general, *P. australis* shows morphologic variation in size and leaf colour, in eco-physiology, cytology and large phenotypic plasticity.

In this work we revisited the ecophysiological traits associated with photosynthesis in populations showing long-distance phylogeographic relationships and cytological variation. We could not find a clear correlation between growth rates, gas exchange and cytology, despite cell size and stomata length often increase with ploidy level. Variation in CO_2 assimilation rates, as well as in pigments and enzymatic activity, however, existed among clones and could not be attributed to their geographic origin *per se*. However, when the origin was in Africa and implied relationships with the tropical species *P. mauritianus*, photosynthetic rates jumped to 35 μmol m^{-2} s^{-1} in the common garden and to 45 μmol m^{-2} s^{-1} in the field (average values) and differences in pigment contents and CO_2 assimilation capacity (Vcmax and J) appeared evident.

Future studies aimed at explaining differences in plant behavior between P. australis populations should be careful in the selection of target genotypes and/or populations, and should avoid generalizing their findings beyond the genotypes and/or populations studied.

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Effects of different NH_4^+ concentrations on growth and some physiological responses of *Cyperus laevigatus* [P34]

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The perennial sedge, *Cyperus laevigatus* L., is predominantly growing in brackish wetlands and has a higher capacity to take up NH_4^+ than NO_3^- at 0.5 mM. Hence, this species may have potential for use in constructed wetland systems receiving nitrogen-rich waters in hot and dry regions, but its tolerance to higher concentrations of particularly NH_4^+ needs to be clarified.

In this study, growth and physiological responses of *C. laevigatus* to high concentration of NH_4^+ were assessed on plants growing in hydroponic solutions with 0.1, 3, 6, 9 and 12 mM NH_4^+-N. Plant relative growth rate, shoot production rate and root elongation rate decreased with increased NH_4^+ concentration from 3 to 12 mM. Plants grown at 9 and 12 mM NH_4^+ lost the ability to produce new tissues. Root cell pH, analysed in water extracts, was significantly lower (pH 5.83 ± 0.06) when plants grew on NH_4^+ concentrations >3 mM than at 0.1 mM (pH 6.25 ± 0.06). Also root respiration rate was significantly lower in plants fed with 0.1 mM NH_4^+ than in others (respiration rate = 49 ± 4 and 127 ± 13 μmol O_2 g^{-1} dry weight h^{-1}, respectively). Photosynthetic rate was highest for plants grown at 0.1 mM NH_4^+ and lowest for plants grown at 12 mM NH_4^+ (A_{max} = 15.1 ± 0.9 and 1.8 ± 0.9 μmol CO_2 m^{-2} s^{-1}, respectively). Dark respiration rate of shoots was lowest in plants grown at 12 mM $NH_4^+$and unaffected at lower NH_4^+ levels. From the results, we conclude that even though concentrations of NH_4^+ >3 mM have negative effects on *C. laevigatus*, this species tolerates relatively high NH_4^+ concentrations up to 6 mM. As NH_4^+ concentrations in most types of wastewater generally are well below 6 mM, *C. laevigatus* is a good candidate species for use in different types of treatment wetlands.

Response to Increasing Salt Stress of Genetically Different *Phragmites australis* Clones [P35]

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The salt tolerance of 15 *Phragmites australis* clones with different ploidy levels (4n, 6n, 8n, 10n, 12n) and different geographic origins (Romania, Russia, Japan, Czech Republic) was investigated in order to identify possible key factors in the species' dominance and/or invasion in oligo- to mesohaline tidal wetlands.

During exposure to increasing salinity (8-72ppt), the effects of salt toxicity on growth, photosynthesis, transpiration, stomata conductance, as well as organ-specific mineral ion accumulation were measured.

Salt stress strongly reduced plant height in average by 54.4% with higher values (63%) for the tallest clones and lower (44%) for the shortest. Average chlorophyll and carotenoid/xantophyll contents were first reduced at 72ppt by 10% and 14% respectively. Significant differences between clones were related to the genotype, but no correlation to ploidy level was found.

The physiological parameters' responses differed significantly between genotypes. The sensitive clones lowered their rates of photosynthesis, transpiration and stomata conductance already at concentrations of 16ppt, while tolerant clones showed significant stress signs at salinities starting at 40ppt. The net-photosynthesis of the most sensitive clones was reduced by 64% at 16ppt, compared to only 1% for the most tolerant ones, while at 56ppt the rates were reduced by 89% and 33% respectively.

The mineral ion distribution in different plant organs of the surviving plants at the end of the experiment revealed that salt (Na^+, Cl^-) accumulated particularly in old leaves (1261 µmol g^{-1}dw Na^+ and 913 µmol g^{-1}dw Cl^- more than control). Na^+ levels in roots were low, especially in tolerant clones (9 times more than control in the roots, compared to 29 times more in the old leaves), indicating that roots of tolerant clones possess a mechanism to diminish entry of Na^+ ions into the tissues.

All in all, *Phragmites australis* has a relatively high tolerance towards salt stress, but a significant variability occurs between the clones. These responses can be attributed to genetic differences. Further experiments are planned in order to establish a relation to ploidy levels or plant origin.

Plant allelopathic interactions by root exudates from *Phragmites australis:* toxic effect of gallic acid on seed germination and growth [P25]

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Plant roots produce and secrete a diverse array of metabolites into the rhizosphere. In allopathic plants some of these compounds have harmful effects on the members of the recipient plant community can contribute to explain plant invasions. An European strain of *Phragmites australis* is considered one of the most invasive species in wetland ecosystems in North America. Gallic acid (3, 4, 5-trihydroxybenzoic acid) released by *P. australis* has been shown to impede growth of neighbouring plants and hence to contribute to the invasiveness of this species. In this study, we examined root secretions from three *P. australis* genotypes from North America and Europe and tested the phytotoxicity of the root exudates on seed germination and growth. We compared the effects of root exudates by the effects of gallic acid solution.

Ten days old *Medicago sativa* (alfalfa) seedlings that had been germinated in sterilized water were transferred to petri dishes with 10ml Murashige and Skoog's liquid medium (1% sucrose) containing 0, 50, 100, 150, and 200µM of gallic acid (n=3). Plants were incubated in growth chambers at 25 ± 3 °C and a 14:10 h Light/Dark photoperiod. The final plant biomasses of the seedlings in the treatments after 10 days growth were recorded.

The germination rate of alfalfa seeds in sterilized water was 80% in 4 days. The average initial fresh weight (FW) of the seedlings was 62mg. The final biomasses of the seedlings after 10 days growth were 146, 124, 98, 94 and 75mg FW in the 0, 50, 100, 150 and 200µM gallic acid treatments, respectively. On-going experiments study the effects of two additional species, *Trifolium pratense* (red clover) and *Daucus carota* (carrot). Furthermore, the effects of root exudates from three genotypes of *P. australis* will be tested and compared to the effects of gallic acid.

Potential distribution of the cryptic, invasive Haplotype M of common reed *Phragmites australis* in North America under present and future climate change [P32]

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Since the non-native haplotype M of *P. australis* was introduced into North America from Europe in the late 1700s or early 1800s (Saltonstall, 2002), its rapid spread has dramatically altered the composition and functionality of many estuarine and freshwater wetland communities (McCormick *et al*., 2010). Knowing the potential distribution under the present and future climate is vital for predicting the impact and environmental management needs. Most plant invaders have climatic niche conservatism in space and time (Petitpierre *et al*., 2012), thus ecological niche models could be applied to predict the potential geographical distribution of haplotype M of *P. australis* in the introduced range in North America based on the distribution in Europe.

The main objective of this research is to develop predictive models to identify the present and future potential distribution of haplotype M in North America. We used the species distributional model, maximum entropy model (Maxent, Phillips *et al*., 2006), due to its outstanding performance on a small sample size and its predictive power (Wisz *et al*., 2008). The occurrence databases of haplotype M included our sample data in Europe (Lambertini and Brix, 2012) and North America (Lambertini *et al*., 2012), and some occurrence records from published papers and GenBank accessions. The current climate variables are the averages for the ~1950-2000 period (Hijmans *et al*., 2005) and the future climate scenarios are from IPCC based on a consensus-forecast approach combining the CCCMA and HADCM3 climate models under two emission scenarios (A2a and B2a) by 2050 (IPCC, 2007). By combining niche distribution data of haplotype M with the global distribution of the other *Phragmites* haplotypes, we try to predict hot spots of diversity that might affect future evolutionary scenarios in this invasive species.

The results will be helpful to identify areas where hybridization among haplotypes might take place and enhance invasiveness, and to prioritise implementation of control measures in the most sensitive areas.

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Session 5:

Constructed wetlands

Photo: Carl Christian Hoffmann.

The role of plants and design in subsurface flow treatment wetland performance [O38]

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The first documented use of wetlands for sewage treatment dates back more than 100 years. By 1900, the idea of creating wetlands specifically for wastewater treatment had been developed. In the 1950s and 1960s, two German scientists began to investigate in detail the capabilities of specially engineered wetland systems for wastewater treatment. The momentum of their work spread to the implementation of wetland technology in the United States and in many countries throughout Europe (Austria, Czech Republic, Denmark, France, Germany, Holland, Norway, Spain, and the United Kingdom, among others). As research on this topic has grown, new designs of wetland treatment systems have developed across the globe. Generally speaking, however, specific countries tend to implement specific wetland designs, making a direct comparison of different designs impossible.

In 2010, a treatment wetland research facility in Langenreichenbach, Germany was established with the aim of bringing together both conventional and innovative treatment wetland designs for side-by-side comparison, with and without wetland plants. The site consists of 15 stand-alone treatment systems of various designs. All systems receive real wastewater and are operated year-round. This presentation will highlight the main findings from the first 18 months of operation, comparing various metrics of treatment performance for removal of organic matter, nitrogen and *E. Coli*.

Table 1. Design and operational details for the 15 treatment systems.

System Abbreviation[1]	System Type	Depth of Main Media (cm)	Saturation Status	Main Media Type	Dosing Interval (hour)	Surface Area (m^2)	Hydraulic Loading Rate (L/m^2-d)
H25, H25P	HF	25	Saturated	Medium gravel	0.5	5.64	18
H50, H50P	HF	50	Saturated	Medium gravel	0.5	5.64	36
VS1, VS1P	VF	85	Unsaturated	Coarse sand	1.0	6.20	95
VS2, VS2P	VF	85	Unsaturated	Coarse sand	2.0	6.20	95
VG, VGP	VF	85	Unsaturated	Fine gravel	1.0	6.20	95
VA, VAP	VF + Aeration	85	Saturated	Medium gravel	1.0	6.20	95
HA, HAP	HF + Aeration	100	Saturated	Medium gravel	0.5	5.64	130
R	Reciprocating	85	Alternating	Medium gravel	1.0	12.4	160

[1]Systems planted with *Phragmites australis* are denoted with "P" in the system abbreviation.

Treatment of urban runoff in constructed ponds and wetlands [O11]

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The need of effective technologies to handle urban runoff is getting more important in Denmark because of heavier and more intensive rain events. Additionally, the proportion of paved areas increases and consequently a larger proportion of our water systems get influenced by urban runoff. There is therefore also more and more focus on treatment of urban runoff before outlet to streams, lakes and estuaries.

Different types of rain water ponds have been constructed for decades for rain water storage to avoid flooding, erosion of recipients and other hydraulic disadvantages, but in recent years focus has also been concentrated increasingly on removal of e.g. nutrients in these systems before outlet.

The thousands of existing facilities in Denmark handling urban runoff are often constructed as small wetlands with shallow ponds eventually combined with zones consisting of a kind of filter system or temporally wet areas. Their efficiency regarding nutrient removal is very varying as many of them are not originally designed to remove nutrients. Many Danish freshwater systems are though eutrophied by excess loading of nutrients and therefore these pond systems may be a valuable help to decrease the loading from e.g. urban runoff. Therefore more knowledge is needed regarding their efficiency and the processes going on in these systems.

Here we will present data from an ongoing study of approximately 70 different pond systems constructed to handle urban runoff from different catchments. The aim is to evaluate their efficiency and the reasons for the variability between them dependent on a wide range of parameters like pond type, dimensions, age, catchment type, etc. The overall purpose is to determine the potential for nutrient removal in all the existing ponds and improve our knowledge for dimensioning future constructed ponds and wetland systems.

Modeling of nutrient removal in constructed ponds and wetlands [O12]

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Constructed ponds and wetlands are often built to retain rainwater and ensure a discharge equal to natural runoff, thereby reducing the hydraulic load of recipients during heavy rain events. These facilities have become more important in recent years, because of more intensive rain events resulting in an increased runoff from urban and agricultural areas.

The design and size of these systems depend on the catchment but also on the available area. The latter is often the case in city centers where space is limited. Another parameter causing quite variable systems is the construction of different pond types depending on the consulting company.

Additionally, the potential for nutrient removal in these systems are getting increasingly important. Sedimentation processes in ponds and also in shallow filter areas, if available, can remove up to a substantially amount of the incoming suspended solids, including nutrients on particulate forms. The filter areas may though clog after a certain period of time. Unfortunately, the removal efficiency of dissolved substances like e.g. dissolved phosphorus is often very low in existing ponds including those with filter areas.

It would be valuable to have modeling tools to help predict these processes and the efficiency of the ponds dependent on type, design, size and catchment. We have therefore developed a dynamic model to simulate nutrient removal in ponds with shallow filter areas. The aim of the model is to help designing future systems for nutrient removal and to understand the processes going on in existing systems. The model can also handle new technologies like testing of different filter materials. Filters often consist of sand, but the model can also simulate e.g. filters of crushed concrete, an alkaline material with a very high phosphorous retention compared to sand.

Nutrient removal for tertiary treated urban wastewater by Sub-surface Flow Constructed Wetland [O26]

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Lake L'Albufera is situated into Albufera de Valencia Natural Park, a Wetland of International Importance. However, due to anthropic pressures, its water is hypertrophic. In order to improve its trophic state, a full-scale set of Sub-surface Flow Constructed Wetlands (HF/VF CW) has been built to treat, during an experimental period of three years, wastewater from tertiary WWTP before its discharge into Lake L'Albufera.

These CWs have been designed to remove nutrients, mainly Total Phosphorus. There are nine independent units where different media, hydraulic loadings, flow and vegetation species are tested.

This abstract is focused on a vertical flow unit, whose aim is removing Total Phosphorus by adsorption. Previously to construction, laboratory experiments have being carried out to determine what materials and in what proportions are best suited to achieve that goal. Two different sands (*type 0* and *1*), as filling material, and two kinds of iron oxides (*type a* and *b*), as sorption agent, have been used to make different adsorbent mixtures. The main parameters studied were the isotherm adsorption for phosphate, which is the 76% of the Total Phosphorus in the wastewater, the hydraulic conductivity and the depletion of adsorption capacity in columns.

Laboratory results show that the best mixture is formed by sand *type 0* (Q_{max}=2.94 mg P kg^{-1}) and 10% of iron oxides *type b* (Q_{max}=1666.67 mg P kg^{-1}). Operation mode has been established in two daily cycles, with a hydraulic loading of 0.068 m day^{-1} and a hydraulic retention time of 0.5 hour.

Following this, one 117x20x0.9 m unit with 157 m^3 capacity per cycle was constructed and started up in October 2011. The inflow contained 0.48 mg TP l^{-1}, 2.92 mg NH_4^+-N l^{-1} and 8.80 mg TN l^{-1}. During the first four months of operation Total Phosphorus removal was 76%, ammonium 95% and Total Nitrogen 15%.

Allocation of metal concentrations in sediments and biota from stormwater ponds and rural, shallow lakes [O27]

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The stormwater runoff from cities and roads contains significant loads of environmental pollutants. Main sources for these pollutants are release from buildings, roads, vehicles and atmospheric deposition. Untreated stormwater runoff can therefore be a significant source for environmental pollution of the receiving waters. Wet detention ponds are constructed to treat stormwater runoff from cities and roads and remove environmental pollutants before the water is discharged to natural systems such as streams and lakes. Between rain events these stormwater treatment facilities function as small and shallow ponds where a number of pollutant removal processes take place; e.g. pollutant accumulation in the sediment, biodegradation and uptake of pollutants in the vegetation. The ponds are established as "treatment" facilities, but over time they will turn into urban aquatic ecosystems and serve as wildlife habitats.

Depending on the characteristics of the pollutants conveyed by the stormwater runoff, these can be taken up and bioaccumulate in the biota. This study contribute to the understanding on how metals distribute between sediments, plants and water-dwelling fauna (e.g. benthic invertebrates, molluscs, nymphs and fish) from stormwater detention ponds. Samples of biota and sediments were collected from 9 wet detention ponds in Denmark. To compare the stormwater detention ponds with natural aquatic systems, sediment and biota samples from 11 small and rural lakes, unaffected by stormwater runoff, were included in the survey. The stormwater ponds were grouped into three land use classes; residential, highway and commercial use. The lakes were categorised in three groups depending of geographical surroundings; agriculture, plantation and forest. The study contributes with knowledge on the fate of metals from stormwater runoff in the detention pond, and increases our understanding of the role of technical stormwater detention ponds as an urban aquatic ecosystem and wildlife habitat.

Environmental benefits of a constructed wetland; balancing carbon sequestration and GHG emissions [O42]

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Waterpark "Lankheet" is created in 1999 on historic inundation areas of the Buurser Beek, a small lowland stream. The park consists of a series of constructed wetlands with reed and was designed for multiple purposes: water conservation and treatment, production of biomass, restoration of nature values and recreation. Since 2005 Wageningen University and Research centre (WUR), together with the estate-manager and the water board, have studied the performance of the wetlands intensively, addressing different aspects of the waterpark.

In view of interest in bio-based economy special attention has been paid to the efficiency of biomass production. The reed is harvested each year to be used for energy production. Harvested reed, increase in root biomass and soil organic matter are monitored frequently. In addition, nutrient fluxes of incoming and outgoing surface water, plant uptake and exchange with groundwater have been measured. With data of the period 2007-2009 partial carbon and nitrogen budgets are set up. Unfortunately gaseous components were not measured in that period, so emission of N_2O is estimated based on denitrification rates resulting from the overall nitrogen budgets. CH_4 emission is estimated from literature data.

Results of the calculations show that for biomass production an average 33-36 tons CO_2 $ha^{-1}year^{-1}$ are consumed, whereas on average 22-28 tons ha^{-1} $year^{-1}$ N_2O and CH_4 are emitted (expressed as CO_2 equivalents). This suggests that the wetlands still have an environmental benefit by reducing greenhouse gasses (apart from the benefit of improved water quality and nature values). However, the uncertainties in the measured fluxes and estimates are substantial. Extrapolation of discontinuous measurements, interpretations of literature data and presumptions in the budgets significantly affect the outcome. To partly overcome this uncertainty denitrification and fluxes of N_2O and CH_4 will be measured, starting May 2012.

This presentation will show the budget results with uncertainties and preliminary results of GHG emission measurements.

Hydraulics and phosphorus retention of permeable filters treating artificial agricultural drainage water [O56]

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Wetlands and constructed wetland systems are widely used for water treatment. While extensive knowledge is gathered regarding phosphorus (P) and nitrogen retention from such systems, less is known about the combined influence of hydraulic capacity and efficiency on P retention in the filter media. Agricultural drainage water from the farm land is becoming a main concern for causing the algal bloom, and there is a need of efficient water treatment technologies. The implementation of drainage filters or subsurface constructed wetlands treating tile drainage water can be a solution to reduce nutrient loads to surface waters. However, optimization of the filters regarding P retention and hydraulic capacity/efficiency is still a challenge.

The objective of this study was to investigate variable filter media and size fractions in order to obtain at the same time suitable hydraulic capacity and P retention. Several size-fractions of calcium and iron-based filters were tested in laboratory experimental systems. Measurement of saturated hydraulic conductivity (K_{sat}) demonstrated a positive correlation with mean particle diameter (D_{50}). Further hydro-physical parameters (bulk density, shape, grain size distributions, surface area, and porosity) are included to improve predictions of K_{sat}. The hydraulic efficiency (active flow volume) was investigated by applying tritium tracer at 3 different flow rates allowing different hydraulic retention times. The tritium effluent breakthrough curves as a function of time were fitted using a two-region non-equilibrium transport model using the CXTFIT code. P-retention and P-desorption of the filters were also analyzed at variable flow rates. Selected results regarding these experiments will be presented at the conference.

The overall results from this study will help the application of subsurface horizontal constructed wetlands and drainage-well filters in field conditions, treating agricultural drainage water.

A new Approach to Run Off pollution treatment: Planted wetponds [O57]

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Run off from urban areas transport pollutants that harm receiving waters. Runoff is not usually treated, and if so, the treatment involves the retention of water in basins to remove TSS and the associated pollutant. Colloidal particles and dissolved pollutants are not targeted and therefore are discharged freely. Additionally, stormwater treatment facilities design and operation present several challenges; such as the irregularity of rain events, the spatial and load variation of pollutants and the operational implications on the rain the treatment system. Retention ponds' capacity to remove pollutants is low but effective at eliminating TSS. Additional pollutant removal can be obtained with the use of sorption filters or the addition of salts. Macrophites also play an active role in the removal of pollutants.

A new approach to runoff pollution control intends to improve design and operation and to enhance removal by combining elements by establishing three demonstration systems to test and optimise the removal of colloidal particles, dissolved organics (PAHs) and heavy metals. The three planted systems were constructed in Aarhus, Silkeborg and Odense. Designed and constructed so that new components are integrated to achieve advanced treatment, and included the use of selected plants, special filtering media, as well as the addition of salts to improve performance. Samples of water, sediments and plants were analyzed to determine typical water quality parameters, organic micropollutants and heavy metals.

The performance of three systems was effective regardless of the water quality of the influent. PAHs and heavy metals were detected on waters and sediment in the systems but concentration on discharging waters was below detection limits. The plants also play a significant role in the removal processes occurring in the systems. The three planted systems have demonstrated capacity to remove, reduce and store the targeted pollutants and mitigate harmful effects to the environment.

Drainage filters and constructed wetlands to mitigate site-specific nutrient losses [O78]

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Despite substantial efforts, the leaching of nutrients from agricultural land is still a serious and costly environmental problem in Denmark and elsewhere. The quality goals of the European Water Framework Directive (WFD) for the aquatic environment require a substantial reduction of diffuse nutrient loads from farmland in Denmark. Tile drains and ditches connect fields to receiving waters and act as subsurface highways for both soluble and particulate phosphorus (P), nitrogen (N) as well as other agricultural contaminants. Drainage losses of nutrients contribute to estimated 33% of total P losses and 45-60% of total N losses. Hence, for a large number of recipients, drainage water nutrient loads has a major impact on water quality, however, mitigation options targeting subsurface drainage are lacking. An end-of-pipe drainage filter solution offers the benefits of a targeted measure typically applied to point sources. This calls for a shift of paradigm towards the development of new, cost-efficient technologies to mitigate site-specific nutrient losses in drainage.

A newly launched Danish research project "SUPREME-TECH" (2010-2015) (www.supreme-tech.dk) funded by the Danish Strategic Research Council, aims at providing the scientific basis for developing cost-effective filter technologies targeting P-retention and N-removal in agricultural subsurface drainage. The project studies different approaches of implementing the filter technologies including drainage well filters as well as surface-flow and subsurface flow constructed wetlands. Various natural and industrial P filter substrates are tested towards P sorption properties, as well as hydraulic efficiency and P retention efficiency during variable flow regimes. A major challenge is to reduce comparatively low P concentrations in drainage water to below environmental threshold values (<0.05 mg P l^{-1}) under transient flow conditions and at the same time ensure sufficient hydraulic capacity of filters. The retention of other agricultural pollutants as well as the potential for recycling P saturated filters is also investigated. The project further explores the denitrification capacity and potential green house gas emissions in different types of constructed wetlands and filter solutions. Sensitivity analyses using integrated models will provide filter design parameters for optimized filter performance and allow analysis of cost effectiveness of the drainage filter technologies.

Raw Wastewater Behaviour in Constructed Wetlands and Wooded Buffer Zones [P43]

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Constructed wetlands (CWs) implie the re-integration of water and organic compounds in the cycles of water and organic matter, through the efficient contribution of the vegetation. Monitoring of three CWs planted with helophytes and ligneous species commissioned in 2003 and 2004, treating raw domestic wastewater, and located in three different French regions, is presented. Efficiency of reed beds combined with trees or wooded buffer zones (WBZs) are well documented (Kucerova et al. 2001, Koenig et al. 2010) As primary treatment and cycling of nutrients are regarded as the main benefits of CWs, valorization of wastewater should be considered on different points of view : water table recharge, production of organic amendments and wood, reconstitution of protected areas for fauna and flora. Such ancillary benefits begin to be compiled in this work, as a part of a long term monitoring.

Effluents of the three CWs analyzed by authorized laboratories show satisfactory qualities, regarding French regulation (BOD^5: 35 mg/L or 60% efficiency, COD 60%, SS 50% eff., Arrêté du 22 juin 2007). In the reed beds, the only one species (*Phragmites australis*) initially planted evolves to associations of the *Phragmition communis*. In the WBZs, at least one piezometer per 250 m2 units allows the control of water, facing local constraints and quality levels defined in regulation (Arrêté du 2 août 2010). Cycling of nutrients in WBZs has been evaluated (Koenig et al. 2010), and can be considered of less importance (20 - 25% TKN removal, 5 – 10% TP removal), regarding more interesting benefits in the water balance: infiltration (depending on soil structure and texture): 36 – 81%, evapotranspiration + standing stock in trees: 12 – 19%, discharge overflow: 0 – 47%. The most common plant communities are *Salicion albae* and *Alnion incanae*. Apart from water, other benefits concern mainly the vegetation itself and its products. Concerning the reed beds: yearly mowing of the helophytes aerial parts; every ten years, removal of the 1st stage deposits brought by raw wastewater. Concerning the WBZs, wood material produced locally is got.

In the beginning, maintenance problems can be encountered: Water: saturation of one treatment area; Helophytes: aerial parts of the plants burned on site; 1st stage deposits considered as sludge or wastes, and burned; Wood of branches and boughs burned outside on site. Solutions are a question of time, information and self-education: Water: alternate feeding is the rule, and has to be done regularly; Helophytes: Aerial parts mown composted in heaps or crushed directly on the filters; 1st stage deposits: put into compost-maturation heaps (DM > 53%, C/N ratio ~ 9. Liey et al. 2010), and then feed the hedges planted around the reed beds; Wood of the WBZs is variously used: for heating, as pellets, structuring material for sludge composting, as stakes, or let the trees grow to their mature stage; through maintenance of

the trees of the WBZs, the water element is heightened and as a result the light and air can have more of an influence on the ground (Vahle 2008.)

As a conclusion, wastewater treated in CWs and WBZs, apart immediate results, lead to ancillary benefits related to renewal of wetlands: evidently as wildlife habitats, source of organic material for humus reconstitution, polished landscapes close to living places; for students, by concrete knowledge of species, plant populations and communities; for pupils, by building up herbarium; all resulting in respect due to life in natural and semi-natural environments.

Screening plant species for use in constructed wetland systems in arid regions: water use efficiency [P49]

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In arid regions, constructed wetland systems are increasingly being used for the treatment of various types of wastewaters while at the same time producing an effluent suitable for irrigation. Optimal plant species used in these systems should stimulate the wetland removal processes and at the same time have a high water use efficiency to minimize evaporative loss of water. We studied the ecophysiological characteristics of seven candidate plant species for use in constructed wetland systems in arid regions: *Bolboschoenus maritimus, Carex acutiformis, Cyperus involucratus, Schoenoplectus tabernaemontani, Phragmites australis, Typha latifolia* and *Juncus effusus*. The plants were grown in triplicate in a mesocosm setup in Leipzig, Germany, and fed with artificial wastewater. Photosynthetic rates, stomatal conductance, pigment contents and stomata size and density of leaves from each species were measured. Light-saturated photosynthetic rates were high in *T. latifolia* (19.9 μmol CO_2 m^{-2} s^{-1}) and *P. australis* (18.1 μmol CO_2 m^{-2} s^{-1}) and low in *J. effusus* (8.9 μmol CO_2 m^{-2} s^{-1}). However, the water use efficiency (WUE) was high in *J. effusus* (118 μmol CO_2 mol^{-1} H_2O) and low in *S. tabernaemontani* (54.4 μmol CO_2 mol^{-1} H_2O). A principal component analysis showed that the WUE was related to specific leaf area (SLA), stomatal conductance and the total content of chlorophylls in the leaves. The analysis suggested that *J. effusus* is the most suitable species for use in constructed wetland systems in arid regions when focusing on water relations. However, plant nutrient uptake and growth rates should be considered in concert with water use efficiency when evaluating the suitability of plant species in constructed wetlands in arid regions.

Key Note

Towards a theory of constructed wetland functioning… and with the help of mathematical models [O65]

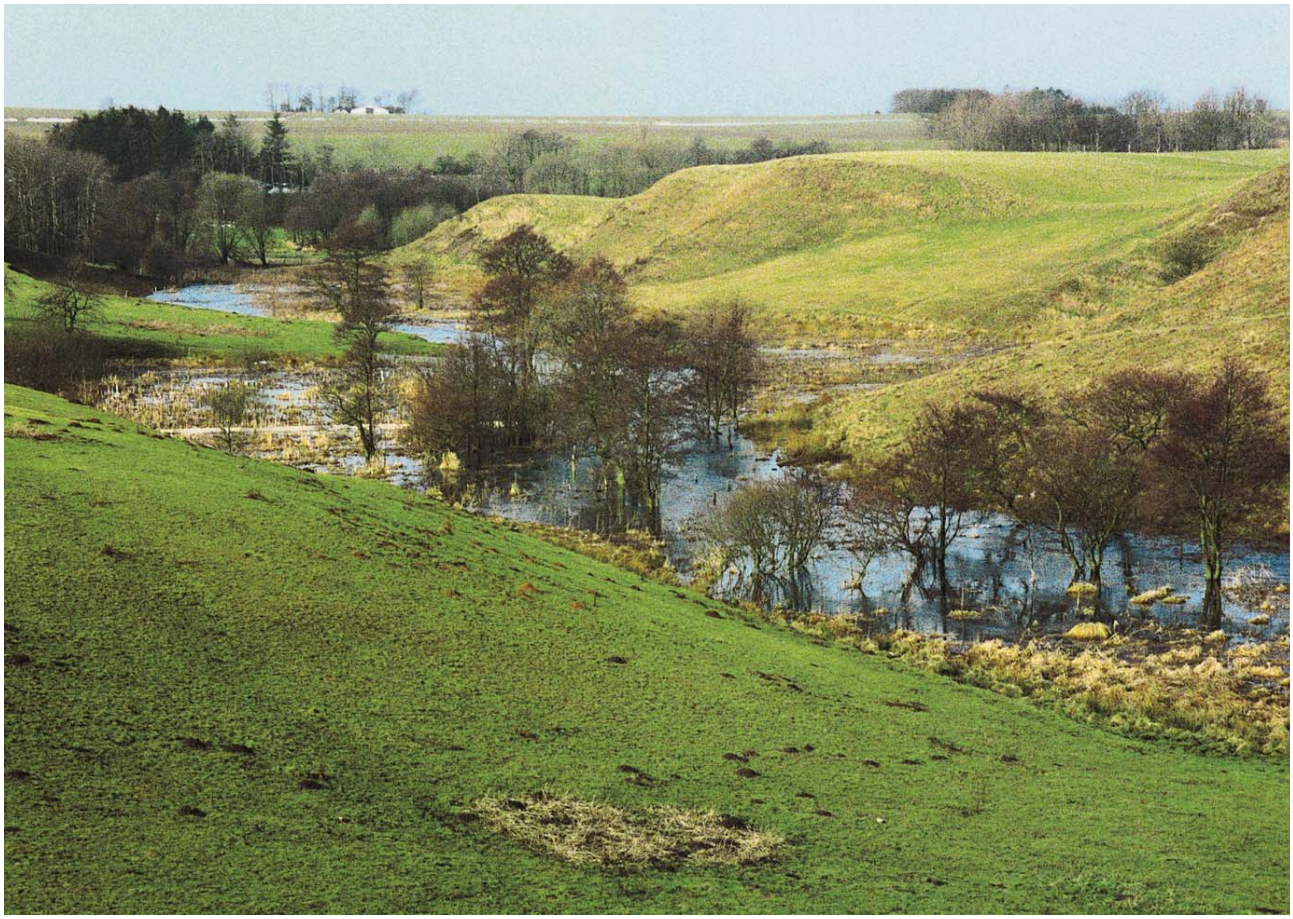

Photo: Carl Christian Hoffmann.

Towards a theory of constructed wetland functioning… and with the help of mathematical models [O65]

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Knowledge of subsurface flow constructed wetlands (CW) is mostly empiric and there is a lack of a general conceptual framework of their functioning. This is mainly due to the fact that important driving processes are not well understood and also to the non-static and simultaneous nature of these processes. One of the most important challenges behind the science of CW is determining the distribution, composition and dynamics of bacterial communities. This is relevant because affects contaminant removal efficiency through modulation on reaction kinetics and changes in hydraulic and hydrodynamic patterns. In this paper we present long term dynamic mathematical simulations of bacterial groups growing in CW which allow to understand (1) how and when a steady state of bacteria communities is reached, (2) in which regions the different groups are located, and (3) if the groups are permanently located in the same regions. Simulations show that a steady state is effectively reached for relative bacterial composition, but the bulk active biomass locates through time in different places in the direction of the prevalent flow. The model therefore indicates that in the long term CW behave like a cartridge in which active bacterial reactions occur in different places with time. This behavior is linked to substrate availability and, more important, to the reduction of pore volume due to the accumulation of inert solids produced internally by microbial activity. The results of this study coupled with field studies give new insights and perspectives on wetland performance. In the end our main goal is to contribute to establish the knowledge basis for a general conceptual framework of the functioning of CW.

Session 6:

River and wetland restoration

Photo: Carl Christian Hoffmann.

Denitrification in restored and unrestored Danish streams [O01]

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Restoring channelized streams is an effective tool to reduce nitrogen loads to downstream waterbodies. However, although overall restoration effects at the catchment level are well established, it is still unclear how in-stream denitrification is affected by restoration. In this study, denitrification rates as well as factors controlling denitrification in unrestored and restored sections of two Danish streams (S1 and S2) were compared. The ^{15}N isotope pairing technique was used to measure denitrification *in situ*. Denitrifier presence was analysed by denaturing gradient gel electrophoresis (DGGE) and quantitative PCR of the nitrite reductase gene (*nirK).*

Denitrification rates were highly variable, with denitrification rates of 3106 µmol N m^{-2} h^{-1} in the unrestored section of S1, but no detectable denitrification in the restored section of S1, whereas in S2 restored and unrestored sections had similar denitrification rates of around 250 µmol N m^{-2} h^{-1}. These large differences in denitrification rates were mainly due to differences in hydrologic conditions and sediment characteristics. High nitrate fluxes from upwelling groundwater created denitrification hotspots in the unrestored section of S1. Moreover, a lack of organic matter in the restored section of S1 may have resulted in a low abundance of denitrifiers and consequently no detectable denitrification. Our results indicate the importance of hydrology for stream nitrogen dynamics, which should be considered in restoration design. Additionally, our results show that removal of organic sediment as a restoration measure may reduce the potential for denitrification.

The effects of experimental flooding of riparian wetlands on nutrient dynamics and plant communities in lowland streams [O61]

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The expected human induced changes to our future climate have resulted in a need to investigate and understand the consequences of these changes for aquatic ecosystems – including streams and their adjacent riparian wetlands. Different modeling scenarios predict that for temperate lowland areas the future will bring changes in precipitation with a general increase in rainfall but also a shift in timing of the rainfall towards a future with more intense rainfall events. This will have consequences for riparian wetlands as they are expected to flood more frequently in the future. To investigate the effect of winter flooding on nutrient dynamic and plant communities in riparian wetlands we conducted an experiment manipulating flooding in two Danish lowland streams. One stream had low nutrient loading and the other had high loadings enabling us to investigate the effect of nutrient level as well as flooding on nutrient dynamics and plant communities in the riparian wetlands. The experimental flooding will be repeated over three successive years helping to disentangle longer-term effects of increased flooding, and in this presentation we will discuss the results from the first year.

Stream restoration in an agricultural landscape: limited possibilities, limited success? [O06]

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In the Netherlands, Regional Water Authorities (*waterschappen*) are responsible for the implementation of the Water Framework Directive (WFD). It is their task to achieve the goals for designated water bodies, which should ultimately reach a Good Ecological Potention – GEP. Stream and river restoration, including remeandering is often the tool of choice for water managers. There are, however, concerns and uncertainties about the actual effect of restoration projects on Ecological Quality Ratios (EQR): the WFD metrics to evaluate the ecological quality. Especially in cases when space for restoration is limited with respect to length and width of stream and riparian zone, EQR values often do not increase as much as expected.

To gain more insight in this relationship, one recent stream restoration project is extensively monitored and evaluated as part of a larger national program. The restoration project was carried out in 2011 in a tributuary of the river Dommel. Over a length of 2.3 km the channel was remeandered and a narrower profile was dug. Two fish migration barriers (weirs) were mitigated by constructing fish passes. In addition, an active riparian zone was established through shallow excavation, thereby increasing the chance of (winter) flooding. Important constraints in the design of the project were strict demands on groundwater levels in the adjacent agricultural and horticultural fields and legal obligations to safeguard areas outside the project area from flooding. We will assess the development of riverbed hydromorphology, riparian vegetation development and changes in aquatic macrofauna communities.

In spring 2012 the first results from the monitoring in the newly restored river stretch will become available. We can already see that due to absence of riparian vegetation directly after the restoration works, morphological dynamics – i.e. active streambed meandering – are still very high.

Figure 1. Aerial photographs of the restoration project in 2010 (before) and 2011 (near the end of the works).

Reference

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Particle sedimentation alters habitat structure driving benthic invertebrate community composition in degraded peatland waters [O13]

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Peatlands of the lower Dutch delta system are highly managed, comprising a network of interlaced channelled waters (ditches) and lakes dispersed by small land plots. Modified over centuries they've been exposed to oxidation, intensive farming practices and increased nutrient inputs. Such activities promote rapid peat degradation, causing the accumulation of fine degraded peat particles in the aquatic environment. These particles not only cause high turbidity but also dramatically alter benthic habitats by smothering surfaces, thereby inducing dramatic declines in submerged vegetation and homogenisation of aquatic habitats. Thirty years of monitoring data from the region indicates that changes in vegetation may have triggered shifts in the aquatic invertebrate community, resulting in the diversity of benthic invertebrates to decline dramatically in peatland ditches. We hypothesize that the drivers for these interlinked long-term processes are related to a reduction in substrate availability and habitat complexity caused by the accumulation of degraded peat particles. By performing an experimental analysis on the habitat preferences of benthic invertebrates we provide a better understanding of the mechanisms responsible for driving the distribution of species. This information is necessary for the development of management strategies that promote diversity and improve the ecological condition of these environments.

Establishing a protocol to create and restore wetlands for water quality and biodiversity improvement in agricultural territories [O17]

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Wetland restoration and creation can be a useful tool for improving water quality and biodiversity of agricultural territories if adequately planned. In order to establish a demonstrative plan (European Life Program CREAMAgua, http::/www.creamagua.com) for improving wastewater from irrigated agricultural lands discharged to river Flumen (Ebro River Valley, NE Spain), a semiarid territory (1430 km^2) with 70% of the area used for irrigated agriculture, and to improve biodiversity, wetland restoration was planned at watershed scale in zones were wetlands existed in the past or were created in disturbed drainage creeks. The protocol consisted on, first, using SWAT (Soil and Water Assessment Tool) to estimate water and nitrate discharges through the tributaries to the main river. Second, selecting potential sites for wetland restoration in the lower parts of tributaries and drainage creeks based on their capacity to remove nitrates (the major pollutant causing water quality deterioration in the zone) according to an areal first order removal model for dimensioning wetlands for wastewater treatment. Third, based on social availability, the potential for land owners to offer their lands to establish wetlands, a further selection of sites for wetland restoration was performed. Finally, accordance between available sites and funding was used to define 300 ha as zones for the restoration of wetlands distributed in the territory. Additionally, 54 has in the river Flumen shores were selected for restoration of riparian sites and defining the set of actions to be performed in accordance with the European Water Framework Directive using biotic and ecological indexes. A set of restrictive measures were established to finally agree funding, social availability and ecological requirements to improve biodiversity at site and watershed scale. Lessons learned from this case study are discussed and how they can be used for upscaling and integrating the experience in land use and agricultural policies.

Wetland restoration using numerical tools for assessing the hydrological change [O21]

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Freshwater wetlands are important ecosystems for a number of unique species. During the past 10 years there have been significant efforts for protecting and restoring some of the remaining wetlands in Europe and Denmark. Freshwater wetlands are defined as areas that are partially inundated or where partial saturated conditions exist. For this reason there are clear conflicts of interest between maintaining a natural habitat within the wetland and the need for artificial draining of surrounding farm areas. This issue is often the main reason for degradation of wetlands in Europe and Denmark, as the intensive construction of drainage channels and ditches during the 1950 and 1960 has impacted the natural hydrological processes in many freshwater wetlands.

The hydrological processes in freshwater wetlands are complicated as both surface and groundwater processes are vital for a conceptual understanding of the wetland. Hence the use of integrated hydrological models could be an important tool for assessing the impact of different measures with the objective of restoring the natural hydrology within wetlands.

The integrated hydrological model system MIKE SHE – MIKE 11 has been used in a number of wetland restoration projects in Denmark and internationally. The model is a fully integrated hydrological model covering the main hydrological processes, including a description of the exchange between surface and groundwater which is vital in wetlands.

Based on case examples from Denmark and internationally, the use of the model as a valuable tool for understanding the hydrology and assessing the impacts of measures, as well as using the results for coupling the hydrology and the habitat within the wetland, and assessing the hydrological impact outside of the wetland will be described.

Approach to modelling of large scale wetland hydrology [O29]

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Restoration and protection of small to large scale wetland systems calls for characterisation, mapping, field data collection and modelling. A thorough understanding of wetland hydrology and flow dynamics is a key element in evaluation of current conditions and alternative future management scenarios including specific habitat requirements.

Whereas wetland restoration projects in Denmark typically involve detailed field studies looking at localised, smaller scale wetland systems the approach required to address hydrology of large scale systems often is different. Data scarcity, limited site accessibility and project objectives on one hand constraints the hydrological modelling approach while on the other hand use of e.g. remote sensing and integrated models offers opportunities in representing larger scale hydrological processes.

Examples of approaches to large scale wetland hydrological models of the Okavango Delta in Botswana and Everglades in Florida are presented. Both are large scale RAMSAR sites but representing distinctly different hydrological systems. In addition the level of regulation is quite different which sets the stage for potential wetland management scenarios to be evaluated. The close interaction and feedback between surface water-groundwater, vegetation, ET processes and flood extents/duration is stressed as common features to be addressed in wetland hydrology.

Mapping of hydroperiods, flood frequency, soil moisture and depth to groundwater tables are all examples of essential model outputs when different wetland management scenarios are evaluated, potentially considering climate variability and climate change.

Large scale hydrological models of wetlands may serve overall management and conservation purposes but in many cases they form the basis for sub-sequent downscaling and development of local scale model to

Multi-Functional Wetlands Strengthens Stakeholder Engagement? Lessons from Sweden [O33]

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Wetlands is one of the agri-environmental measures included in the EU's palette of instruments to retrieve a more environmental sustainable European agriculture. Some of the Baltic Sea Region countries have been promoting wetlands, mainly as a measure to reduce nutrient leaching. Drawing upon Swedish experiences it can be concluded that despite the great effort invested in the scaling-up of wetland implementation the country will not achieve the national target of constructing 6.000 hectares in the agricultural landscape between 2007-2013 (SJV, 2011).

The main objective of the study, conducted within the EU financed project Baltic COMPASS, was to examine the lessons on wetland implementation in Sweden to identify key enabling and disabling factors, especially in the governance system. Of special interest is to what extent wetlands can generate multiple benefits, such as climate change adaptation and mitigation, environmental protection and conservation, biomass production for potential biogas generation, nutrient recycling, and human recreation. The main focus for the implementation of wetlands as an agri-environmental measure has been on a single target basis, namely the removal of nutrients, i.e. nitrogen and phosphorous. However, putting emphasis of all relevant benefits that can be obtained from wetlands has a potential to enable a stronger commitment among stakeholders and attract and involve new stakeholder groups that can strengthen the process.

The result suggests that project and financial scheme is a key issue for the effect of the wetland implementation, both regarding the expansion of wetland areas and nutrient retention capacity. Furthermore the concept of payment for ecosystem services seems to be a promising way forward to generate the platform for a broader stakeholder approach. A key here is recognising farmers' potential for nature conservation, but at the same time always taking into consideration that farms are private enterprises that need to achieve financial sustainability.

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Tidal wetland creation to improve flushing in a degraded urban estuary [O36]

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Excessive silt deposition in the upper Tamar River estuary in Tasmania, Australia, has resulted in a major loss of ecosystem services including commercial activities, marine transportation and recreational, landscape and biodiversity values. The causes of siltation have long been attributed to poor watershed management and high concentrations of flocculated and suspended sediments transported upstream by asymmetrical tides. However, historical analysis revealed a 30 % reduction in the tidal prism and a 95% reduction in base flow to the upper estuary due to the damming and diversion of a major tributary for hydropower. These were the major stressors resulting in the poor condition of the upper estuary. Reduction of the tidal prism was attributed to the draining of tidal wetlands and re-direction and in-fill of the main channel. Sustainable remediation requires re-instatement of riverine and tidal processes to support a tidal prism that is large enough to flush sediments through the upper estuary. The return of significant freshwater inflows to the upper estuary remains problematic because hydropower is essential for sustainable energy production. However, a potentially significant increase in tidal flushing could be achieved through the reconnection of existing swamps and the creation of one or more tidally connected wetlands. The re-instatement and creation of tidal wetlands would have the added benefits of reducing flood vulnerability and increasing the habitat available for wildlife. The feasibility of restoring existing tidal wetlands and creating new wetlands to reduce siltation and return valued ecosystem services to the upper estuary is currently being assessed.

Recognising ecosystem services from Wetlands of International Importance: an example from Sussex, UK [O64]

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The benefits human societies derive from natural systems and, particularly from wetlands, are well established, although not necessarily enshrined in legislation or incorporated into local management regimes. The wise use of wetlands, as promulgated under the Ramsar Convention on Wetlands, is intended as a mechanism to ensure that the benefits delivered to society through ecosystem services are maintained and, where appropriate, restored. The designation process for Ramsar Sites explicitly records information on ecosystem services as well as the more traditionally recorded information on the biodiversity and management procedures. Analysis of four Ramsar Sites from the county of Sussex in south east England showed that even for internationally important wetlands there is a failure to recognise the full value of the benefits provided through ecosystem services and, importantly, several valuable ecosystem services remain unrecognised. The gap between recognised and unrecognised ecosystem services has implications for the consideration of wetlands in decision-making and the protection and wise use of all wetlands within Sussex and beyond. The example presented provides a "wake-up call" for wetland managers and decision makers and the wider community. In particular, more effective incorporation of ecosystem services into wetland management provides greater opportunities for engaging with local communities and for ensuring the conservation and wise use of wetlands.

Emerging contaminants in a restored wetland system: Occurrence and attenuation [O48]

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Emerging pollutants are ubiquitous compounds present in the aquatic environment and include pharmaceutical, personal care products, detergents, plasticizers and fire retardants. The use of chemical products in daily life and in agricultural activities augments the discharge of emerging pollutants into surface waters as conventional wastewater treatment plants are not designed to remove emerging contaminants. The study aims at identifying and quantifying emerging pollutants discharge to Braband Lake catchment and drainage and assessing the capacity of the ecosystem to attenuate such pollutants.

Braband Lake (153 ha) is a natural lake fed by two principal streams, Aarhus stream and Lyngbygaards stream. Water enters the lake through a 100 ha restored wetland (Årslev Engsø), established in 2003 as a nutrient sink to mitigate the effect of agricultural originated nutrients to the Lake and coastal waters. The lake drains through Aarhus stream and flows through the city of Aarhus to discharge in the bay of Aarhus. Additionally, the stream receives discharges of treated water from two local wastewater treatment plants.

Grab samples were taken from five points along the flow (figure 1) in six sampling campaigns in the fall and winter of 2010. Water samples were analyzed by GC-MS to identify and quantify ca. 30 of the emerging pollutants.

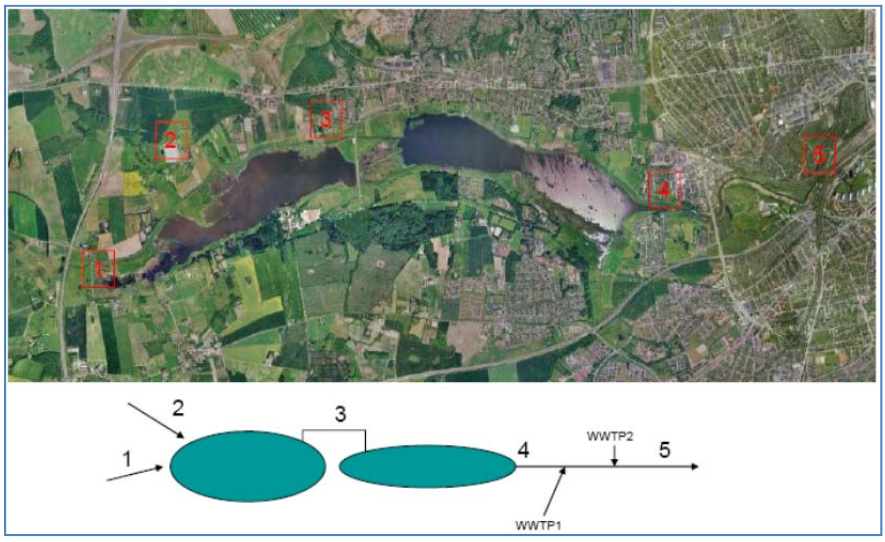

Figure 1. Aerial photograph and schematic diagram showing the sampling places (modified from Google earth).

Most of the 30 compounds were detected in all the sampling sites. Seventeen contaminants were identified and quantified in the surface waters. The compounds with the highest concentrations in surface waters were diclofenac, 2-methyl-4-chlorophenoxyacetic acid (MCPA), caffeine, carbamazepine, and tris(2-chloroethyl) phosphate (TCEP). The restored wetland attenuated some of the pollutants with efficiencies varying from no attenuation to 84% attenuation. Hence, restored wetlands have some capacity to remove emerging contaminants from surface waters.

Stream metabolism – focus on the effect of macrophytes [P31]

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Primary production and respiration is important controlling components of ecosystem biomass and energy flow. Measurements of stream metabolism give data for these two fundamental ecosystem functions consisting of gross primary production (GPP) and community respiration (CR). GPP is an expression of the organic material produced within the ecosystem, and CR is an expression of the total degradation of organic material. Comparison of GPP and CR on spatial and temporal scales is important to obtain a better understanding of how different physical and chemical parameters affect these ecosystem processes and thereby the energy flow in streams. Stream metabolism is estimated by measuring oxygen exchange for 24 hours, for a whole reach as an open system or for habitats in chambers with or without bottom.

We measured habitat metabolism and stream reach metabolism on six reaches, three with and three without macrophytes. The studies showed that GPP was 6-11 and CR_{24} 10-20 times as high in a macrophyte habitat compared to sand, gravel and stone habitats. A comparison of habitat weighted stream reach metabolism showed, that reaches with macrophytes had approximately 4 times as high GPP and CR_{24} compared to reaches without macrophytes. For open water stream reach metabolism GPP and CR_{24} was approximately 1.5 times higher for reaches with macrophytes. Furthermore it was found that macrophytes produced 50% of GPP and 60% of CR_{24} even though they only covered 14% of the reach. By comparison with earlier studies on habitat level, we found that both GPP and CR_{24} were positively correlated with the biomass of the primary producers in the habitat. Overall the study clearly indicates that macrophytes have a great influence on stream metabolism.

Restoration of historical elements of the coastal landscape - a case study of the Ostfriesland region in Germany [P24]

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The change and loss of historical and ecological landscape values are particularly evident in the coastal zone, where the most of world's population dwells. In the past, the landscape management was focused on the benefits for agriculture and water resources, rather than environmental protection, what caused the alteration of natural processes of remained costal zone habitats. The ecology of coastal wetlands (saltwater marshes and sloughs, tide pools) native vegetation and wildlife have been greatly affected and transformed by the development of modern technologies in rural areas against tidal activity of the sea. The changes of the open landscape can be also found in the cultural and historic structures. The idea of the dynamic landscape at the interface with the tidal activity of the sea imposes the identification of cultural forms, in particular polders, dykes, groynes, built-up areas and the designed green areas.

The aim of the paper is to put attention onto the lack of the synthetic context of ecological restoration and historic preservation efforts on the example of the remnants of native coastal landscape in the Ostfriesland region in NW Germany. Towards the aim of the complex and active landscape protection we used a number of different kinds of evidence to examine the human history of the Ostfriesland as well as the costal landscape itself. The analyses showed that green areas were planned according to the land relief, sea activity, relevant techniques along with ecological standards. Nevertheless, according to lessons learnt from the Dutch (Cortner, Roij 2010), the proper functioning of the area should be related to the active protection of historical landscapes. It requires both ecological aspects and establishment of a baseline for the land use as well future plans and perspectives. An attempt has been made towards restoration of the complex landscape structures consisted of environmental, cultural and visual components. It seems very important for the cultural heritage for the future.

References

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PeatCap – Natural capping in the polluted Volgermeer Polder (the Netherlands) provides new chances for peat growth counteracting land subsidence [P51]

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The Volgermeer Polder is a peatland situated near Amsterdam that was formerly used for dumping garbage and chemical waste. It is the largest toxic waste area of the Netherlands and most heavily contaminated area in Western Europe. The total cleanup of the hazardous waste (including dioxins) appeared to be impracticable and risky. Therefore, a novel approach has been chosen which involves covering the waste with special foil and sand, called PeatCap. A research program (comprising three interrelated PhD projects) was established to study the initiation and formation of new peat on top of the foil, acting as a natural cap that will persist after degradation of the foil on the long term.

The rehabilitation of peatlands, i.e. not only the realization of natural vegetation types but also of peat formation, poses several problems and has been shown in the past to be a great challenge. If nutrient availability is very low, plant production will be limited and hence peat production rates will be very low. Although a high availability of nutrients from surface water or eutrophic soils potentially leads to high biomass production, decomposition rates will also be high preventing peat accumulation. For this reason, many eutrophic wetlands show net carbon loss to the atmosphere. In the Volgermeer Polder the interacting roles of different substrate types (sand, peat sludge), water quality (alkalinity and nutrient level), water table and key plant species (ecosystem engineers) will be tested at the field scale in controlled, replicated water basins in order to optimize wetland development and peat formation.

We would like to present this research using two posters; one with general information about the natural capping of the Volgermeer Polder, and one with specific information about the three research projects.

The wireless measurement network for the PeatCap project [P52]

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The PeatCap project studies the interaction between environmental parameters and vegetation development in a wetland situation. The project and its aims are introduced in Overbeek et al. (this conference). This poster shows the setup of the innovative measurement network that is used to characterise the environmental parameters and their change in time. The different start conditions in the various mesocosms are expected to influence long term changes in abiotic conditions, especially in the sediment-water interface.

The experimental site has been equipped with a set of 9 wireless sensors for EGV, watertable, redox potential and temperature. Both the water column and the sediment layer are under study, given the set of vegetation types desired. The redox potential and temperature are measured by a new wireless probe (Paleo Terra, Amsterdam), based on previous experiences with continuous measurements. The probe consists of 15 platinum measurement points for the redox potential, and 5 internal temperatures. Data of redox potential and temperature are, together with watertable and conductivity, transferred to a local computer via a mesh type of network. In this setup, a combination of local transmitters and transponders is used to create a local wireless network, with only battery fed equipment. From the local computer in the server room, data is served to a website, available for all project partners.

The continuous measurement of these parameters throughout the project time will give deep insight into the abiotic development of the sediment-water interface over time. The wireless aspect of the measurement network makes the setup relatively easy and cheap, as no long cabling is required.

Rehabilitation and extension of wetlands within floodplains of embanked rivers [P80]

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Embankment works modify the river and floodplain hydrology by interrupting the transversal connectivity between the two ecosystems. Such anthropogenic changes alter the natural flow regime and have severe impacts in the ecology of riparian wetlands. This paper describes the rehabilitation possibilities of Trifesti-Sculeni embanked area within the Prut River's floodplain in Romania, by restoring connectivity of the river and topographically low zones on the floodplain (oxbows, backwaters, brooks). In order to achieve this, the history of the area has been studied from old maps, as well as the current conditions in terms of hydrological and ecological regimes. We propose to assure refreshment of water in the riparian drainage network by active pumping of river water from upstream the riparian areas during low flow periods in summer and evacuation of the excess during high rain periods, thus controlling the water level in drainage channels, floodplain ponds and the ground water table. For this purpose we suggest to create connections between drainage channels and oxbow lakes, ponds and backwaters for improving the ecological conditions in such restored wet habitats.

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Session 7:

Wetland Monitoring and Planning Technology (MONITECH)

Photo: Carl Christian Hoffmann.

Hydro-biogeochemical phosphorus mobilization – evaluating a wetland restoration "P risk" assessment tool [O66]

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Restoration of wetlands on reclaimed agricultural lowland has been recognized as one of the most important mitigation options in obeying the quality goals of the European Water Framework Directive. While the nitrogen removal efficiency of restored wetlands is well accepted, the impact of wetland restoration on phosphorus (P) is less obvious. An increasing number of studies have called to the attention that wetland restoration on former agricultural soils may result in P release. Despite the high priority of wetland restoration there is a serious lack in understanding the fate of P following wetland restoration, and predictive model tools are highly needed. Prediction of P dynamics in restored wetlands is extremely challenging because of the complex interactions and feedbacks between hydrology, hydrochemistry and sediment geochemistry.

In the Danish Strategic Research project MONITECH, one of the major objectives was to investigate the possibility of developing a P risk assessment tool to predict the potential risk of P release following restoration of wetlands on former agricultural lowlands. Batch incubation experiments investigating changes in soil-water concentrations of PO4-P, total P and total dissolved Fe as a function of time after rewetting in 31 riparian peat and minerogenic lowlands, demonstrated significantly different responses to rewetting in terms of Fe-reduction and P mobilization. Statistical analysis to identify key controlling geochemical parameters included content, form (oxalate, bicarbonate-dithionite, citrate-bicarbonate-dithionite extractable) and ratios of P, Fe, Al, as well as carbon content, C:N-ratio, C:Fe-ratio, Fe crystallinity, pH and bulk density. Soil analysis demonstrated very large variations in all key parameters e.g. carbon contents varied from <1 to >40%, oxalate extractable P (Pox) from 20-5.000 mg/kg, oxalate extractable Fe (Feox) from 80-75.000 mg/kg and variation in bulk density from 150-1400 kg m-3. Statistical analysis revealed that the soil FeBD:PBD-molar ratio (BD – bicarbonate-dithionite extractable), and bulk density (indicator of soil type, carbon content) turned out to be the best parameters in describing P mobilization in rewetted lowland sediments. Based on the experimental results a statistical model was developed describing potential P mobilization as a function of time with soil FeBD:PBD-molar ratio and bulk density as key predictive variables. The model has further been operationalized as a risk assessment tool to predict the potential risk of P losses following wetland restoration.

Based on new experiments simulating the continuous upward percolation of groundwater in selected intact soil cores we investigated the hydro-biogeochemical mobilization of phosphorus during variable flow conditions. Soil redox conditions and hydrology turned out as major factors controlling

phosphorus release. The presentation will focus on an evaluation of the P risk assessment tool based on data form the continuous flow experiment.

Identifying factors influencing denitrification and greenhouse gas production in riparian wetland soils [O09]

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Wetlands constitute the largest source of methane to the atmosphere (IPCC, 2007). However, there is still a need for quantifying and understanding the processes involved in the production of greenhouse gas (GHG) and in the removal of nitrate (NO_3^-), especially under the perspective of wetland restoration.

Therefore, the capacity of removing NO_3 in wetlands through denitrification and the production of methane (CH_4) and nitrous oxide (N_2O) were investigated in a laboratory setup. Intact sediment cores were collected from four different riparian wetlands in Jutland, Denmark, representing contrasting water and soil characteristics. Anoxic ^{15}N-NO_3^- enriched groundwater was pumped through the sediment cores and the concentrations of dissolved species (CH_4, N_2O, NO_3^-, $^{15}N_2$, NH_4^+, SO_4^{2-}) were measured at seven depths and throughout the incubation time (15 d).

The nitrate removal rate ranged between 37.8 ± 4.3 to 71.4 ± 6.8 mmol NO_3^--N m^{-2} d^{-1}. Our results showed that a large proportion of the produced N_2O was subsequently used as an electron acceptor when the groundwater was depleted in NO_3. Methane production increased after groundwater depletion of NO_3^- and SO_4^{2-}.

This study provides valuable results contributing to the development of models predicting denitrification and GHG emission in restored wetlands.

Reference

IPCC, 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA.

Active Pore Volume in Danish Peat Soils [O46]

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Phosphorus release within the soil matrix caused by the changed redox conditions due to re-establishment of a riparian wetland can be critical for the aquatic environment. However, phosphorous released in the soil will not always result in an immediate contribution to this loss to the aquatic environment.

Lowland soils are primarily peat soils, and only a minor part of the total soil volume of peat soils is occupied by macropores (>30 µm). Since water primarily flows in these macropores, the majority of the soil matrix is bypassed (the immobile domain). Phosphorus released in the immobile domain is not actively transported out of the system, but is only transported via diffusion, which is a very slow process. Thus it is interesting to investigate the size of the active pore volume in peat soils.

The hypothesis of this study is that the active pores volume of a peat soil can be expressed using bulk density as a key parameter.

This hypothesis is investigated using intact soil cores (d:6 cm; h: 15 cm) from 20 Danish peat soil locations. The volume of macropores was determined for samples, drained to a matrix potential of pF 2, using a pycnometer. Furthermore, retention curves were conducted using 100 cm^3 intact soil samples. Finally, breakthrough of tritium (^3H_2O) was used to construct breakthrough curves for each peat soil, which indicates the flow pattern in the soil. A mobile-immobile domain model (MIM-model) in CXTFIT was used to derive parameters describing the size of the immobile and mobile domains as well as the exchange between the two domains. Finally, the samples were dried in the own for determination of the bulk density.

The bulk density was correlated to parameters from the MIM-model and to the macropore volume to determine, whether bulk density can be used as a key parameter.

Effect of riparian wetland restoration on greenhouse gas emissions [O59]

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The restoration of riparian wetlands often aims at increasing the removal of nitrogen and phosphorus by re-establishing the hydrological connectivity between the stream and the surrounding floodplain. However, the change is redox conditions also alters the biogeochemical conditions in the newly restored area and this may also favour the emission of greenhouse gases such as nitrous oxide (N_2O) and methane (CH_4).

The effect of the restoration of a Danish riparian wetland on the emission of greenhouse gases was investigated by monitoring the fluxes of N_2O, CH_4 and carbon dioxide (CO_2) 7 months prior and 12 months after restoration of a stream and its adjacent riparian areas. The gas fluxes were measured using static chambers and the gases were quantified by GC analysis.

The results of the first year after restoration revealed a decrease in both CO_2 and N_2O emissions. However, regarding CH_4 emissions, a dramatic increase from -0.05 g C m^{-2} to 30.80 g C m^{-2} (total fluxes from spring to winter, before and after restoration) could be measured at a site that became permanently flooded after restoration. Nevertheless, the CH_4 emission after restoration was comparable to the fluxes measured in natural wetlands. The water level and the soil temperature correlated with the CH_4 fluxes and no CH_4 emission could be detected when the water level was deeper than 20 cm below ground.

This study highlights the importance of taking into consideration the water level when restoring a wetland. We recommend avoiding permanently flooded areas particularly during summer season when the warmer temperature increases the methanogenesis and the subsequent emission of CH_4.

Quantifying sediment retention by restored wetlands using fallout radionuclide tracer technology (^{137}Cs and ^{7}Be): The River Odense, Denmark [O63]

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River restoration projects that allow temporary inundations of the floodplain are important for increasing the water storage potential of the landscape which can decrease flood risk to vulnerable downstream urban areas. During inundation, coarse and fine fluvial sediments are deposited on the floodplain leading to reduced organic matter and nutrient (flux downstream. In this context, information on sediment accretion rates by floodplain units is required to inform restoration decisions. Sediment traps are widely used to determine contemporary accretion rates in floodplain units but there are questions about the representativeness and resolution of data. Here, we have tested the application of radionuclide tracer technology (^{137}Cs and ^{7}Be) for use in Danish river and floodplain monitoring for longer and shorter term quantification of sediment accretion rates.

The testing involved a pilot study to quantify ^{7}Be delivery to the catchment surface and transfer downstream with suspended sediments in 9 different Danish streams selected to represent three types of catchment as regard to risks of surface runoff. The ^{7}Be concentration of suspended sediment was measured for two storm events in each catchment. The data was used to model ^{7}Be floodplain inventory for a series of accretion scenarios to test the sensitivity of the ^{7}Be method and minimum detectable accretion rates. The modelled excess ^{7}Be inventory amount exceeded analytical uncertainties only if sediment accretion rates on floodplains were higher than 500 g DW m^{-2}. We compared this threshold of applying ^{7}Be with *in situ* measured accretion rates on the floodplains of the restored River Odense where data has been collected during several winters since 2003/04. We also tested the use of ^{137}Cs for measuring longer term accretion rates on the River Odense floodplain comparing an inventory done in the spring of 2011 with *in situ* measured accretion data for the previous winter periods since 2003/04.

Evaluation of nutrient retention before and after restoration of the riparian areas and remeandering of Odderbaek stream [O68]

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In the Odderbaek Restoration Project changes in groundwater discharge and transport of nutrients through the riparian areas were followed both before and after restoration of the floodplain and remeandering of the stream. The study was initiated approximately one year before restoration in autumn 2009. Eight transects were laid out across the river valley and equipped with piezometer nests, which were used for measuring groundwater levels and for sampling of water to be analysed for nitrogen and phosphorus species, sulphate, chloride etc. Comparing nitrate concentrations before and after restoration of the riparian areas revealed that there was a 50-90% decrease in nitrate concentrations following rewetting. Groundwater oxygen concentrations also decreased significantly following rewetting of the riparian areas, indicating that denitrification was responsible for the decrease in nitrate concentrations; however, change of land use in the riparian areas may also have influenced nitrate levels. Phosphorus concentrations did not change noticeably and generally remained at the same level before and after the restoration, but a few piezometers showed elevated phosphate concentrations after rewetting.

The role of nitrogen in controlling the distribution of groundwater dependent vegetation in Danish riparian areas [O67]

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Eutrophication is a major threat for species rich riparian communities in Europe. Considering that agricultural catchments are becoming increasingly contaminated with nutrients we may expect that biodiversity is closely regulated by the availability of nutrients entering the riparian zone from upland areas. Several studies have documented that both nitrogen, phosphorus and potassium can play important roles for the distribution of different types of vegetation. In western Europe, however, evidence exist that nitrogen is the growth limiting component and we therefore expect that nitrogen availability is closely linked to the development of the vegetation. In this study we investigate the spatial and temporal variability in inorganic nitrogen availability in 10 riparian areas and examine the role of nitrogen for the distribution of groundwater-dependent vegetation. Specifically we hypothesized 1) There is large spatial and temporal variability in nitrogen availability in riparian discharge areas that is closely linked to agriculture in the catchment and 2) The spatial distribution of vegetation in riparian areas is controlled by nitrogen e.g. reed beds dominate in areas with high inputs of nitrogen whereas species-rich fens occur in areas with low inputs of nitrogen.

Development and test of new cost-effective monitoring technologies and planning design for restoration of wetlands – MONITECH [P62]

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Restoration of wetlands is an important and cost-effective mitigation measure to prevent losses of nutrients to the aquatic environment and to improve conservation status of natural habitats and species of European importance. Throughout Europe the one major consequence of implementing the Water Framework Directive and the Habitat Directive will be a marked increase in the number of wetland restoration projects to fulfil obligations set in these Directives. During the last decade more than 50 wetland restoration projects have been implemented in Denmark. The aim of this presentation is to show the main scientific topics, the methods and design applied, and the preliminary results obtained within the different topics covered by the MONITECH project: i) development and test of novel sensor technologies for use in monitoring programmes and an analysis of their cost-effectiveness against traditional monitoring techniques; ii) biogeochemical process studies in riparian areas where groundwater and surface water interactions take place and the hydrological gradients created serve as a reactor for a range of nutrient and carbon retention mechanisms, potential greenhouse gas emissions and habitats for plants. In the project we are studying this system via controlled laboratory and field experiments for a typology covering riparian soil types, geochemical variants and hydrological variants, coupled to in situ measurements in a restored wetland study site. The MONITECH project consists of seven work packages which works together in an interdisciplinary attempt to achieve a holistic understanding of wetland processes: (i) wetland hydrology with studies of soil hydrology in riparian areas and groundwater-surface water modelling; (ii) Deposition of sediment and nutrients in restored wetlands using in situ sampling with traps and testing Be-7 as a tracer for sedimentation; (iii) Wetland phosphorus content and cycling in riparian areas; (iv) wetland denitrification and GHG-emissions using in situ sampling systems; (v) wetland ecohydrology studying 11 riparian sites covering a gradient in biodiversity; (vi) sensor monitoring technology testing SorbiCell's.

Linking hydraulics and sedimentation patterns on floodplains along a restored river channel: River Odense, Denmark [P58]

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Restoration of river channels involving recreation of meanders commonly gives rise to a significant decrease in discharge capacity, and thereby an increase in the frequency of inundation of riparian areas. Inundations are important for modifications of the floodplains, both in terms of erosion/accretion of sediment, deposition of nutrients and organic matter, and settling of plant seeds from upstream areas. We present a study, which links a numerical 2D model of flow on the floodplain to in situ measurements of flow and net deposition of sediment, organic matter and nutrients. The study is part of a larger Danish research project 'MONITECH', which focusses on developing advanced tools and methods to improve the understanding of wetland processes.

The study is carried out on a floodplain along River Odense, Denmark. Along a 6 km reach, the channel was narrowed and re-meandered in 2003. The restoration created a frequently inundated riparian area of ca. 0.25 km^2. Artificial grass mats have been deployed on the riparian area in transects and at increasing distances from the main channel during the winters from 2003 to 2012.

The numerical model which is set up for the floodplain is the 2D Mike21 model by DHI. The model estimates average velocities and water depths within a combination of triangular and rectangular areas of the floodplain, based on information about the water stage and discharge in the river channel and the floodplain topography. A one-day field campaign was carried out in January 2012 during a flood event, where 51 point measurements of water velocities were conducted with a Nortek Acoustic Doppler Velocity Meter.

The in situ measured velocities will be used to validate the simulations from the 2D numerical model. Moreover, flow velocities and micro-topography on the floodplain will be analysed against the in situ measured spatial patterns of sediment deposition, organic content, grain sizes and nutrient content.

Potential Phosphorus Mobilisation in Peat Soils: Interaction between Geochemistry, Redox Conditions and Hydro-physics [P45]

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Re-establishment of wetlands on peat soils containing phosphorus bound to iron(III)-oxides can lead to an undesirable phosphorus loss to the aquatic environment due to the reductive dissolution of iron(III)-oxides. Thus it is important to be able to assess the potential phosphorus mobilisation from peat soils before a re-establishment takes place. The potential phosphorus mobilisation from a peat soil depends not only on the geochemical characteristics but also on the redox conditions, the hydrological regime in the area as well as the hydro-physical properties of the soil.

The hypothesis for this study is (i) the release of phosphorus in peat is controlled by the geochemistry; (ii) the mobilisation of phosphorus is controlled by both geochemistry and hydro-physics of the soil.

For this study, 10 Danish riparian lowland areas with peat soil were selected based on their geochemical characteristics. Batch experiments were used to determine the potential phosphorus release for each location. The measured phosphorus release was related to the geochemical characteristic for the respective location. Furthermore, the potential phosphorus release was compared with the measured phosphorus mobilisation for each location. This mobilisation was measured using intact soil cores (d: 6 cm; h: 15 cm) from the 10 locations set up in an anaerobic closed-flow system. Finally, the hydro-physical parameters like soil-water retention curves, break-through curves, air-filled porosity and bulk density were measured on intact soil samples from each of the 10 locations.

As a result the geochemical key parameters controlling the potential phosphorus release from peat soils has been pointed out. Furthermore, it has been emphasised how much the hydro-physical properties influence the potential phosphorus mobilisation from a Danish peat soil.

Evaluation of channel morphological changes 10 years after restoring the lower parts of River Skjern, Denmark [P79]

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The River Skjern, located in Jutland, Denmark is one of the largest river and wetland restoration projects in Northern Europe. During the period 1999-2002, 19 kilometres of the lower part of the River Skjern and 22 km^2 of its cultivated river valley were restored into a new meandering river, wetlands, meadows and a shallow lake. A comprehensive monitoring program was initiated to study the consequences of the restoration including a monitoring of the changes in river morphology.

The effect of the restoration of River Skjern on channel morphology was investigated by comparing 65 cross sections measured using a differential GPS in 2001 and 2002, just after the restoration, and about ten years later in 2012. Changes in the cross-sectional profiles divided into the channel bank and river bed environments enabled us to quantify the volume changes that have taken place due to both erosional and sedimentation processes. Sediment cores of channel bed sediments and river banks for bulk density estimates enabled us to calculate the amount of sediments being either eroded or deposited after the restoration.

The preliminary results of these investigations show an evolution of the morphology of the restored river channel. It highlights the importance of internal channel processes following the creation of a new river restored morphology. The changes affected both the river banks and the river bed indicating that the river has started to adjust and recreate a more natural river morphology.

Further analysis will aim at quantifying the magnitude of erosion and sedimentation in such a new meandering channel, to know in what extent the man-made cross sectional channel morphology is stable, the expected dynamics (movements) of such a new formed channel and the impacts it may have for changes in sediment dynamics and transport in the restored system.

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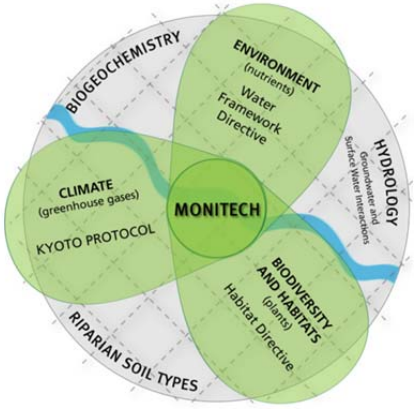

The River Restoration Centre

Life

PROCEEDINGS FROM THE 7TH SWS 2012 EUROPEAN CHAPTER MEETING

Wetland restoration – challenges and opportunities

The history of SWS European chapter is young compared to the chapters in U.S. despite the fact that serious wetland research has been carried out in Europe for at least five decades. The Chapter was formed in 2005 with the first meeting held in Bangor, Wales in January 2006.

SWS Europe is focused on understanding and advancing wetland science, as well as assuring that decision-making processes affecting wetlands are based on an understanding of wetland science. Carrying out this mission requires members who are informed about both the underlying science and the kinds of considerations that affect decision-making, many of which are specific to Europe and in particular the European Union.

This report is the proceedings from the 7th SWS 2012 European Chapter meeting, which will be held 17-21 June in Aarhus, Denmark, and will provide an opportunity to review and collaborate on advances in wetland science with focus on the European perspective. The meeting will be a forum to discuss challenges and opportunities for sustainable restoration and management of wetlands in our changing world.

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