ERNST MORITZ ARNDT
UNIVERSITÄT GREIFSWALD

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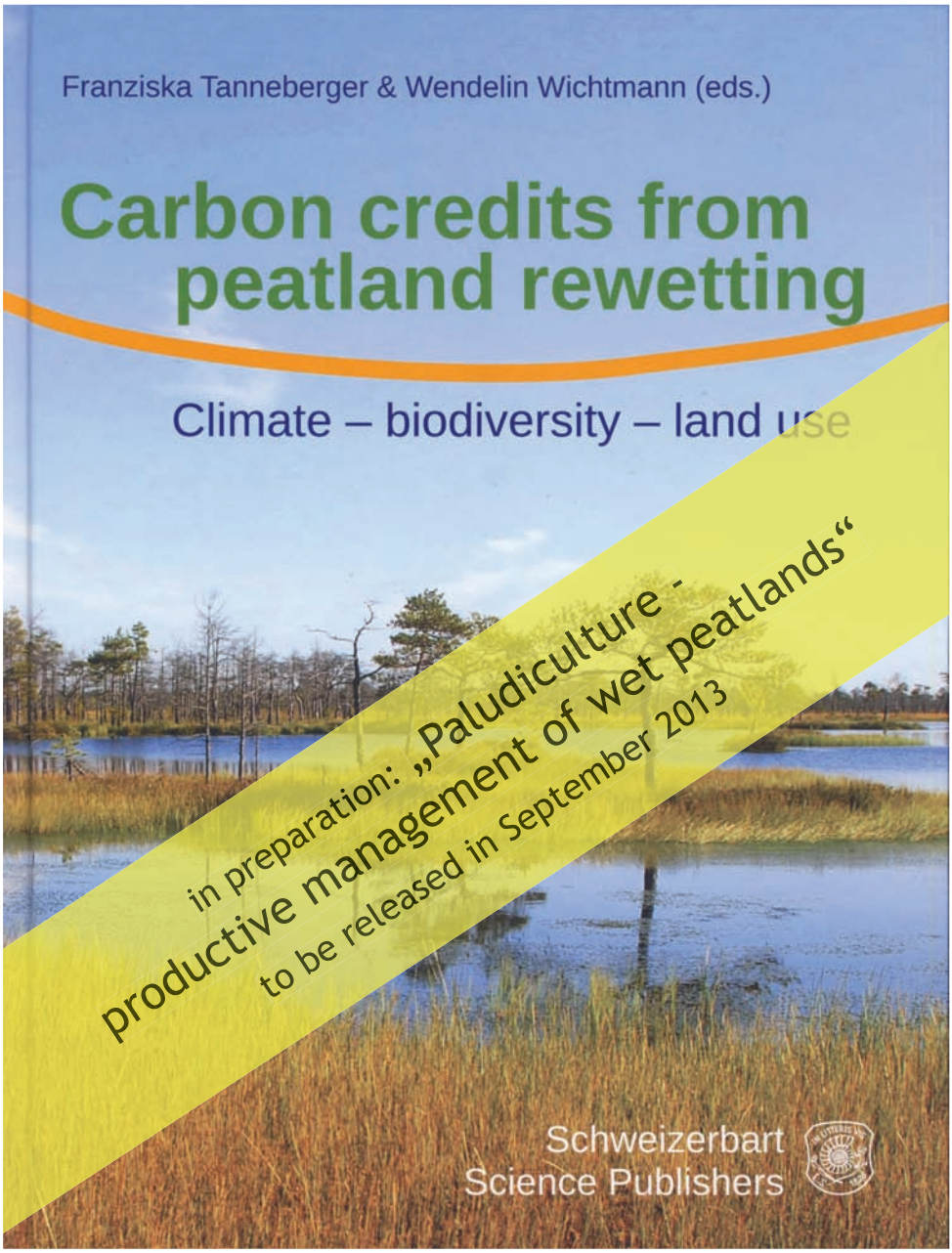
International Conference on
the Utilization of Emergent Wetland Plants

REED AS A RENEWABLE RESOURCE

February 14th - 16th 2013
Alfried Krupp Wissenschaftskolleg,
Greifswald, Germany

Book of Abstracts


Franziska Tanneberger & Wendelin Wichtmann (eds.)
Carbon credits from peatland rewetting
Climate – biodiversity – land use
in preparation: „Paludiculture - productive management of wet peatlands“
to be released in September 2013
Schweizerbart Science Publishers

Reed as a Renewable Resource

SCOPE

The use of wetland biomass offers many opportunities to address the increasing and diverse demand for biomass. Wetland biomass can substitute fossil resources as a raw material for industry and energy production, using both traditional and new processing lines and techniques. The cultivation and exploitation of reeds like common reed, sedges, reed canary grass, cattail, etc. can provide sustainable land use options for wet areas and can reduce competition between biofuels and food production, while maintaining and restoring many ecosystem services.

AIM OF THE CONFERENCE

The use of wetland biomass is reflected by research activities going on all over the world. With this conference we want to encourage *various actors* from research, governance and agriculture and nature protection that work on or have an interest in the utilisation of reed to communicate and build *networks*, identify *research needs* and in particular *exchange experiences and information*. We also want to make progress in reed energy production and its large scale implementation. Therefore this conference is not only addressed to scientists but also engineers and companies.

SCIENTIFIC COMMITTEE

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Prof. Dr. Dr. h.c. Hans Joosten University of Greifswald, Germany

Members

Dr. Wendelin Wichtmann, Michael Succow Foundation & DUENE e.V.

Drs. John Couwenberg, University of Greifswald, Germany

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IMPRINT

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Contents

Host Institutions

Ernst Moritz Arndt University Greifswald

Founded in 1456 as the Pomeranian State University (German: *Pommersche Landesuniverstität* it is the second oldest university of Northern Europe. At present, more than 11,500 students from 74 countries are registered at the university, taught by some 200 professors. The number of students has more than tripled since 1990, accompanied by an ongoing reorganisation of the university structure. The university offers a traditional, wide range of subjects and is structured in five faculties: Theology, Law and Political Sciences, Philosophy, Mathematics and Natural Sciences, and Medicine, being subdivided into several institutes and clinics. Research and teaching increasingly span the "borders" of all faculties and institutes.

Thanks to the excellent scientific work of the university, the city of Greifswald has increasingly gained in charisma and importance on a national as well as on an international level. The numerous university buildings witness the architectural and intellectual wealth of centuries. The assembly hall in the university's main building that was once a baroque library is one of the most beautiful of its kind in Germany. With the Max-Planck-Institute for Plasma Physics, the Leibniz Institute for Low Temperature Plasma Physics and the Biotechnikum (Biotechnological centre) Greifswald also distinguishes itself as a place for technology and research.

Institute of sustainable development of landscapes of the earth (DUENE) e.V.

The scientific non-profit association Institute of sustainable development of landscapes of the earth (German: *Institut für Dauerhaft Umweltgerechte Entwicklung von Naturräumen der Erde e.V. - DUENE*), was founded on May 13th, 1999 by mostly past and present staff members of the Botanical Institute. The managing committee consists of Dr. Manthey (Chair, Landscape Ecology) Professor Dr. Joosten (Peatland Studies and Palaeoecology), Dr. Rühs (Landscape Economy) and Mr. Schäfer (Landscape Economy). The Managing Director is Dr. Wichtmann (Landscape Economy, Peatland Studies). The main objective of DUENE is to support the sustainable development of landscapes by means of

- landscape ecological research,
- scientific research on revitalization and sustainable use of landscapes,
- dissemination of scientific information,
- coordination of active participation in scientific research,
- planning and execution of measures for improving habitats for threatened species,
- improvement of quality of ground and surface water and restoration of degraded habitats.

Current research focuses on questions regarding economy of paludicultures, and productivity and usability of wetland plants. Other activities are concerned with the im-

provement and restoration of stressed and degraded sites under nature conservation aspects, as well as planning and execution of measures for improving habitats for threatened species. DUENE shares expertise and knowledge through professional training courses. Topics range from peatland restoration and peat soil characterisation to the application of the "vegetation form" concept (German: Vegetationsformenkonzept), a tool to understand the relationship between site ecological parameters and vegetation[1]. DUENE members are involved in the delivery of the lecture programme at the Institute for Botany and Landscape Ecology.

Michael Succow Foundation for the Protection of Nature

The Michael Succow Foundation ("Michael Succow Stiftung zum Schutz der Natur") was established in 1999 as the first charitable nature conservation foundation under the Civil Code in the new federal states of Germany after reunification. The foundation's motto is to "Preserve and Sustain" It was founded using the money from the Right Livelihood Award, bestowed upon Prof. Dr. Michael Succow in 1997.

The Michael Succow Foundation is an operational foundation at national and international levels. It is engaged in the development and protection of national parks and biosphere reserves in some of the transition countries of the former Eastern bloc (e.g. Azerbaijan, Turkmenistan, Uzbekistan and Russia).

The foundation's main emphasis has been the recognition and conservation of Germany's natural heritage for the last decade. Accordingly, the foundation is currently overseeing the care of three nature conservation areas in north-eastern Germany, with other soon to follow. The goal is the development of wilderness oases, accompanied by offering opportunities to visit and experience nature firsthand, which are meant to foster a deeper understanding for the process of re-transformation of the Central European cultural landscapes into wilderness.

Professor Michael Succow and his deeply committed team are supported by Board of Trustees and countless volunteers. The foundation works in close co-operation with the Institute of Botany and Landscape Ecology of the Ernst-Moritz-Arndt University in Greifswald, as well as with many other national and international research institutions such as The International Institute for Deserts, Flora and Fauna in Ashgabat, Turkmenistan. The foundation is one of the active parts of the Greifswald competence centre for peatlands.

[1] The "vegetation form" concept integrates floristic and environmental parameters to derive comprehensive vegetation based proxies such as greenhouse gas fluxes. Couwenberg (2011) Vegetation as a proxy for greenhouse gas fluxes - the GEST approach, in Tanneberger and Wichtmann (eds): Carbon Credits from Peatland Rewetting, Schweizerbart Science Publishers, Stuttgart, 2011.

Conference Venue

Alfried Krupp Wissenschaftskolleg

The Alfried Krupp Institute for Advanced Studies (German: *Alfried Krupp Wissenschaftskolleg*) is an academically independent institution sponsored by the Alfried Krupp Lectures Foundation (German: *Stiftung Alfried Krupp Kolleg Greifswald*). The Institute is intended to assist outstanding research and projects through interdisciplinary and international co-operation.

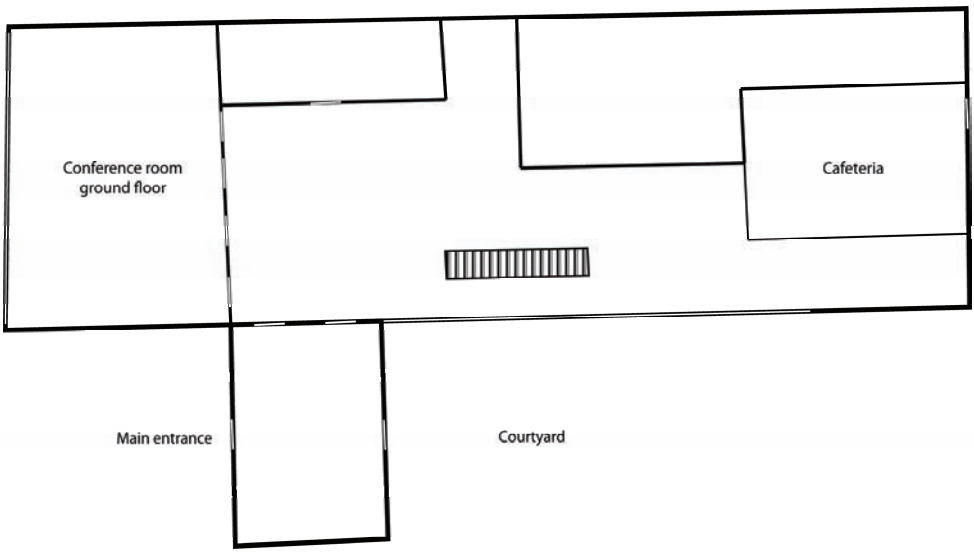

Fig. 1: Conference venue ground floor

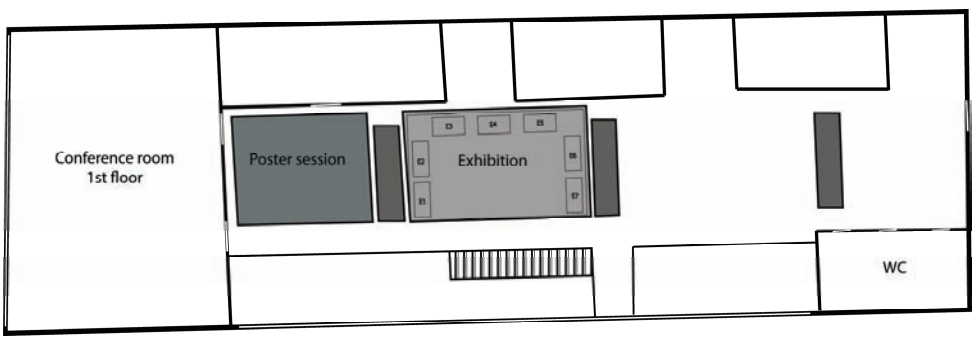

Fig. 2: Conference venue 1st floor

Location

The city of Greifswald, situated in north eastern Germany at the Baltic Sea coast, is a founding member of the Hanseatic League of Towns (1299). It is situated amidst extensive forests, peatlands, lakes, seascapes, and ecological agriculture, including seven national parks and biosphere reserves and many large restoration projects.

The old part of town that avoided destruction during World War II and was lovingly restored is one of the greatest cultural assets of Greifswald. 200 years ago, the old city's skyline had already fascinated its most popular resident, Caspar David Friedrich. Its medieval layout, arranged like a chessboard, as well as the picturesque narrow streets are completely preserved. The Cathedral and the imposing churches of St. Nikolai, St. Marien and St. Jacobi tower above them. "Long Nicholas," "Fat Mary" and "Little James," as the churches are lovingly called by the Greifswald residents, are a reminder of the prosperity of the city in medieval times and together with the gable houses out of brick at the east side of the market they are Greifswald's contribution to the fascinating world of the Brick Gothic, the European route of which spans from the Danish city of Århus up to the Estonian city of Tartu.

The Market Square with its view of the churches offers the visitor one of the most beautiful Northern German market place ensembles. The Pomeranian Regional Museum in Greifswald allows a good exploration of the geological past and 14,000 year history, culture and arts in the region. The museum hosts a high-calibre exhibition, among the exhibits its art treasures from the university like the Croy Carpet dating back to the year 1557.

In spite of its more than 750 years old history, Greifswald is a young, lively city: "a university with a city, rather than a city with a university," the residents say. Thanks to the excellent scientific work of the university, founded in 1456, that celebrated its 555th anniversary in 2012, the town of Greifswald has more and more gained in charisma and importance, on a national as well as on an international level.

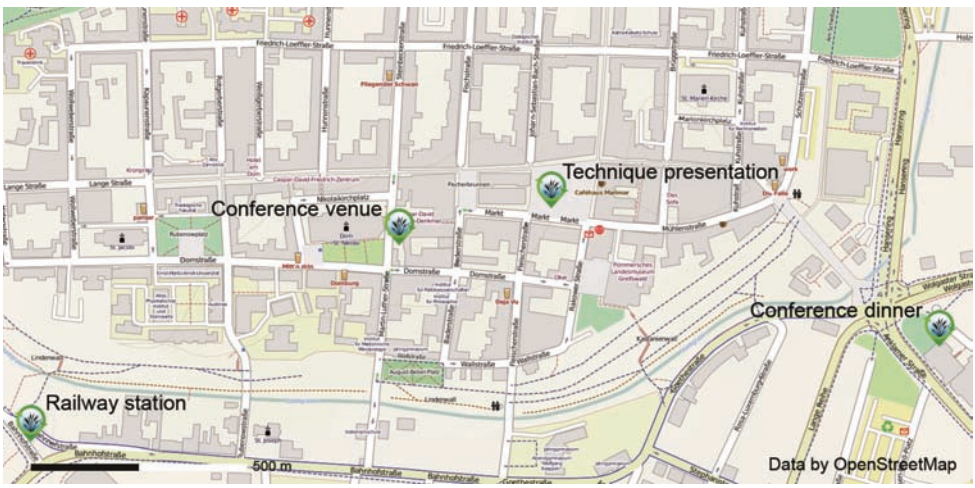

Fig. 3: City map of Greifswald (T.Dahms)

Welcome to Greifswald!

Wendelin Wichtmann [1)], Jan Felix Köbbing [2)] & Hans Joosten [1,2,3)]
[1)] Michael Succow Foundation & DUENE e.V.
[2)] University of Greifswald
[3)] International Mire Conservation Group

Greifswald is surrounded by reeds. Along the Baltic coast, the inland lake shores and the streams in ice marginal valleys, waving vegetation and thick peat deposits illustrate the lasting relation of reeds with the land of Mecklenburg-Western-Pomerania.

This is the land where the Institute of Botany and Landscape Ecology of the University of Greifswald works. Since Michael Succow became Professor of Geobotany and Landscape Ecology in 1992 the Institute has intensified its attention to peatlands, their ecology, functionality, degradation, restoration and management with an increasing focus on sustainable peatland utilization.

We try to combine environmental protection and nature conservation with land use, by utilizing biomass (alder, reeds, peatmoss…) from rewetted degraded peatlands. And we are convinced that such innovative paludicultures may solve major problems associated with land use of peatlands worldwide.

We are glad that you have come to Greifswald, to share your experiences and dreams, to critically reflect ours and to develop joint approaches.

In the recent past we have organised several workshops and conferences on the use of reed and other wetland plants, such as ‘Harvesting techniques for wetlands’ (2007), ‘Paludiculture and nature protection’ (2007 and 2011), a small regional conference ‘Heating with reed’ and a national conference ‘Peatlands utilization in the context of climate change’ (2008), all for the German audience.

Globally many activities on wetland management and sustainable use are taking place. Therefore we aimed to organize an international meeting on reed as a renewable resource to facilitate exchange of ideas and to build up networks. What was originally intended to be a small workshop has now developed into an international conference and we are very glad to host such an event!

We wish you a pleasant and inspiring stay in Greifswald!

Instructions for Participants of the Conference

Instructions for session organizers and chairpersons

Please arrive at the conference rooms at least 10 minutes before the session starts and make contact with your speakers. There will be an assistant who will help with technical questions and a laser pointer for the speakers to use during their presentations. With so many speakers and another session running concurrently we need to run the talks strictly according to the time schedule and we rely very much on you as chairperson. Please notify the speakers that they have 15 minutes speaking time and 5 minutes for discussion. You are requested to show a yellow paper to the speaker after 13 minutes and a red paper after 15 minutes to allow some discussion.

Instructions for delivery of oral presentations

The timing of your presentation is of utmost importance. With so many speakers and another session running concurrently, we need to adhere strictly to the time schedule. Please, practice your talk and make sure that it will not overrun your time slot. The length of your talk is limited to 15 minutes with an additional 5 minutes reserved for discussion, which is considered as important as your presentation.

All speakers are requested to be in the room of their session at least 10 minutes before the session starts and to contact the session chairperson. Please be responsive to the indications by the chair on the timing near the end of your talk. Your chairperson will show you a yellow paper if you have only five minutes left of your total time. You are requested to quickly wrap up your talk then, to allow some time for discussion. If the chairperson shows you a red paper, you have used all of your time and need to end your talk immediately.

Please note that it will not be possible to connect your own laptop to the projector. We want your presentation in a recordable CD or a memory stick readable by a Windows PC (pdf, ppt or pptx), preferable at the time of your registration at the desk (Alfried-Krupp-Kolleg). We will put all presentations for a certain session on a memory stick and bring that to the lecture hall. In order to have smooth transitions between talks, it is very important that we have your presentation on a labelled CD or on a memory stick. *Please write the names of the presentation(s) on the CD, with your name of your session.* It is recommended that you use the break between the sessions to setup and test your presentation e.g. for adjusting to the 1280 x 768 resolution.

Instructions for poster presentations

Posters can be mounted on boards of 1.50 m height and 1.20 m width for display in the 1st floor of Alfried-Krupp-Kolleg. Poster slots will be labelled with your name. Drawing pins and adhesive tape will be provided. Please mount your poster as soon as possible after your registration at the desk. There will be a poster session on Thursday (11.45 – 12.30 h) and Friday before the lunch break (11.45 – 12.30 h). Please stand next to your poster at least on Thursday to answer questions.

Conference Program

AGENDA

Thursday, 14th February 2013

Time	Conference room ground floor	Conference room first floor
08:00-09:00	Registration	
	Opening Session: Key Speakers Moderator: **Wendelin Wichtmann**	
09:00-09:05	Welcome on behalf of Krupp Kolleg **Christian Suhm** Organisational issues **Jan Köbbing**	
09:05-09:35	The role of reeds in the world of peatlands **Hans Joosten, Germany** (p 23)	
09:35-10:05	Growth and ecosystem services of *Phragmites australis*: a cosmopolitan invasive species **Hans Brix, Denmark** (p 24)	
10:05-10:25	Coffee Break	
	Harvesting Techniques, Logistics and Economic Feasibility I Moderator: **Sally Mills** (p 25)	**Case Studies/Country Reports I** Moderator: **Nathalie Soethe** (p 33)
10:25-10:45	The utilization of common reed (*Phragmites australis*) – a review **Jan Felix Köbbing, Germany**	Reed resources in Poltava Oblast, Ukraine: biodiversity conservation and bioenergy production **Theo van der Sluis, The Netherlands**
10:45-11:05	Fen mires management in eastern Poland: methods, financing and impact on habitat **Jarosław Krogulec, Poland**	Large-scale management of common reed, *Phragmites australis*, for paper production: a case study from the Liaohe River Delta, China **Siyuan Ye, China**
11:05-11:25	Saving reedbeds through giving economic value to reed **Frank Croon, The Netherlands**	Industrial design research on reed processing and use in Canada **François Nsenga, Canada**
11:25-11:45	Exploring the potential of reed as a bioenergy crop in the Netherlands **Vasco Diogo, The Netherlands**	Case study Lake Pape, Latvia - reed biomass potential analysis **Aija Zučika, Latvia**
11:45-12:05	Challenges for the commercial use of reed: experience from the exploitation of reed, used for thatching and insulation **Tom Hiss, Germany**	Reed as a building material in Finland, Cofreen-project **Rauli Lautkankare, Finland**
12:05-12:45	**Poster Session and Exhibition**	**Poster Session and Exhibition**
12:45-13:45	Lunch	Lunch

Time	Conference room ground floor	Conference room first floor
	Harvesting Techniques, Logistics and Economic Feasibility II Moderator: **Christian Schröder** (p 29)	**Case Studies/Country Reports II** Moderator: **Jarosław Krogulec** (p 39)
13:45-14:05	Sustainable management of reedbeds for conservation **Sally Mills, United Kingdom**	Pelleting and co-combustion of reed, sedge and *Cladium* biomass in Poland **Dariusz Gatkowski, Poland**
14:05-14:25	Harvesting wetland biomass: specifying costs and benefits on company level **Sabine Wichmann, Germany**	Can commercial reed cutting coexist with biodiversity protection? A case study from Rozwarowo Marshes, Poland **Franziska Tanneberger, Germany**
14:25-14:45	Harvesting technologies for reeds in Austria **Georg Beckmann, Austria**	Wetland restoration and sustainable harvesting of biomass from reedbeds in the Lower Danube Region **Paul Goriup, United Kingdom**
14:45-15:05	New generation of vehicles for harvesting of biomass and modern method of forming biomass bales train **Adam Dubowski, Poland**	Determinants of sustainable biomass production in permanent wet grasslands dominated by *Phalaris arundinacea* **Jan Kvet, Czech Republic**
15:05-15:25	Coffee Break	Coffee Break
	Processing Biomass I (Energy) Moderator: **Ülo Kask** (p 43)	**Ecosystem Services I (Water & Nutrient Removal)** Moderator: **Hans Joosten** (p 51)
15:25-15:45	Energetic utilization options of wetland biomass considering substrate specific traits- the example of *Equisetum palustre* L **Christian Jantzen, Germany**	A regional bioeconomy: Harvesting *Typha* for multiple co-benefits of nutrient capture, bioenergy, phosphorus recovery, and carbon offsets **Richard Grosshans, Canada**
15:45-16:05	Reed as gasification fuel compared to woody fuels **Siim Link, Estonia**	Alum sludge: From "waste" to valuable raw material **Lordwin Girish Kumar**
16:05-16:25	Sustainable energy conversion from reed biomass - overview of lab scale and field test results **Jürgen Krail, Austria**	Back to basics. Self-maintained simple concept of multifunctional water management in reed beds **Anne Hemmi, Finland**
16:25-16:45	Coffee Break	Coffee Break
	Processing Biomass II (Energy) Moderator: **Paul Goriup** (p 47)	**Life Cycle Assessment** Moderator: **Tobias Dahms** (p 55)
16:45-17:05	Floodplain meadows as alternative source of biomass for bioenergy production **Indrek Melts, Estonia**	Life cycle assessment of energy conversion from reed **Doris Rixrath, Austria**
17:05-17:25	Biomass characteristics of wet fens in Belarus and the potential to substitute peat briquettes as a fuel **Wendelin Wichtmann, Germany**	Sustainability assessment of common reed-based production **Tanja Myllyviita, Finland**
17:25-17:45	Essential properties of reed and their influence on combustion equipment **Ülo Kask, Estonia**	LCIA: feasibility of impact categories & indicators for paludicultures assessment **Valentina Korda, Belarus**
19:30	Conference Dinner	

Friday, 15th February 2013

Time	Conference room ground floor	Conference room first floor
08:30-08:45	General Technical Information	General Technical Information
	Ecosystem Services II (GHG) Moderator: **Hans Joosten** (p 59)	**Processing Biomass III (Material)** Moderator: **Frank Reiche** (p 63)
08:45-09:05	GHG emissions from peatlands: Effects of rewetting and land use **Gerald Jurasinski, Germany**	The use of cattail material in building construction – innovative technological development, environmental relevance and examples of application **Werner Theuerkorn, Germany**
09:05-09:25	Methane emissions from *Phragmites australis* in two Belarusian rewetted fens – the importance of chamber design and site conditions **Merten Minke, Belarus**	Thermal conductivity of timber framed walls insulated with reed **Jaan Miljan, Estonia**
09:25-09:45	Influence of biomass harvesting on the GWP of a sedge fen – two years in situ experiment **Andrei Burlo, Belarus**	Cattail-reinforced clay plasters in sustainable building and spatial planning **Georgi Georgiev, Germany**
09:45-10:05	Reed canary grass on peat soils in northern Sweden – carbon dioxide emission measurements on restored agricultural land **Cecilia Palmborg, Sweden**	Thatched roofs deterioration and impact of overgrowing with moss **Kristina Akermann, Estonia**
10:05-10:25	Effect of ground water level on greenhouse gas emissions from rewetted peatland cultivated with reed canary grass **Sandhya Karki, Denmark**	The role of lignin decomposing *basidiomycetes* in the decay of water reed **Frieder Schauer, Germany**
10:25-10:55	Coffee Break	Coffee Break
	Legal and Economic Framework Moderator: **Sabine Wichmann** (p 67)	**Genetics** Moderator: **Hans Brix** (p 69)
10:45-11:05	Economic and legal conditions for reed use in Germany **Simone Witzel, Germany**	The genetic variability of Common reed – Ecophysiological aspects in a present and future perspective **Franziska Eller, Germany**
11:05-11:25	Winter reed cutting in the backlight of the German legislation: demands of nature conservancy and commercial use **David Ritterbusch, Germany**	Phylogeography within the cosmopolitan genus *Phragmites*: A global approach to understand genetic diversity in *P. australis* populations **Carla Lampertini, Denmark**
11:25-12:10	**Poster Session and Exhibition**	**Poster Session and Exhibition**
12:10-13:20	Lunch	Lunch

Time	Conference room ground floor	Conference room first floor
13:20-14:10	**Harvesting Technique Presentation at the Market Square**	**Harvesting Technique Presentation at the Market Square**
	Ecosystem Services III (Biodiversity) Moderator: **Franziska Tanneberger** (p 71)	**Productivity & Site Characteristics** Moderator: **Richard Grosshans** (p 75**)**
14:10-14:30	Regulation of reed encroachment for nature conservation purposes by grazing water buffaloes **Weert Sweers, Germany**	Multipurpose planning of the Finnish coastline **Iiro Ikonen, Finland**
14:30-14:50	Assessing human impact on animal assemblages typical for fens **Sebastian Görn, Germany**	Remote monitoring of reed expansion on the coasts of the Baltic Sea and on the shores of large shallow lakes **Urmas Peterson, Estonia**
14:50-15:10	Effect of different cutting regimes on species diversity of rewetted fens **Stefanie Raabe, Germany**	Common reed as a promising natural energy crop in Estonia **Livia Kask, Estonia**
15:10-15:30	Common reed (Phragmites australis) fuel pellets and habitat management **Erik Kiviat, USA**	Potential of paludiculture in North East Germany **Christian Schröder, Germany**
15:30-16:00	Coffee Break	Coffee Break
16:00-16:45	**Final Discussion and Perspectives** Moderator: **Hans Joosten**	
16:45-17:00	Closing Ceremony	
17:00-18:00	**Networking/ Workshops** Harvesting techniques and performance Moderator: **Christian Schröder, Wendelin Wichtmann**	**Networking/ Workshops** Project cooperations Moderator: **Hans Joosten, Nathalie Soethe**
20:00-21:30	**Keynote (open for public)** History of fen peatland use in Central Europe - from degradation to sustainable use **Michael Succow**	

POST CONFERENCE EXCURSIONS

Saturday, 16th February 2013

Time	Excursion I Rewetted peatlands: peatland restoration, biomass, productivity & greenhouse gas emissions	Time	Excursion II Utilization of reeds: hydrothermal carbonisation, biogas, reed mats & peatland rewetting
	Guide: **Wendelin Wichtmann** (p 17)		Guide: **Christian Schröder** (p 20)
08:00	Departure at the Greifswald Central Train Station, distribution on busses		Departure at the Greifswald Central Train Station, distribution on busses
09:00-11:30	Productivity and greenhouse gas emissions after rewetting of a fen peatland	09:00-10:30	Biocoal production from wetland biomass, HTC plant Relzow
	Vegetation development after restoration of the bog “Rauhes Moor” and rewetting of Trebel valley fen peatlands	11.00-12:00	Prospective biogas production from wetland biomass, Pinnow
12:00-13:00	Lunch buffet at the „Nudeloper“ in Gnoien	12:30-13:30	Lunch at restaurant "Peeneidyll" on Usedom
13:30-15:00	Production of timber in a rewetted polder in the “Peene river valley”	13:30-14:00	Manufacturing of traditional reed mats, Zecherin
16:00-17:00	Restored polder “Randow-Rustow: vegetation development after 15 years of succession	14:30-15:30	Peatland restoration in the Peene valley, polder Menzlin
		15:30-16:30	Vikings in Pomerania - Historical trading connections to the north
		16:45	Klein Bünzow station train dep. 16:57, arr. Berlin 19:28
18:00	Back at Greifswald station train dep. 18:43, arr. Berlin 21:29	17:30	Back at Greifswald station train dep. 18:43, arr. Berlin 21:29

Some activities will be strongly dependent on weather conditions. If these are inconvenient, alternatives will be offered.

Fig. 4: Outline map of Greifswald and the excursion routes (S. Sommer)

Excursion I: Rewetted peatlands: biomass, productivity & greenhouse gas emissions

Guide: Wendelin Wichtmann, Michael Succow Foundation/DUENE e.V., Greifswald

The Trebel valley

Vytas Huth, Claudia Oehmke, Anke Günther, Gerald Jurasinski

Investigating greenhouse gas dynamics and productivity of reeds from long-term re-wetted fens are two of the key topics of the project "Vorpommern Initiative Paludiculture" (VIP). The excursion will visit the Trebel valley mire (54°06'N, 12°44'E), which is a complex of minerotrophic fens and one raised bog. The regional climate is humid with a continental influence, a mean annual air temperature of 9.1 °C, and an annual precipitation of 626 mm. The climatic water balance is positive with +60 to +100 mm. The Trebel valley is a typical percolation mire of the southern Baltic region. The peats are mainly of reed and sedge origin with depths ranging between 4 and 6 m. In addition, a sphagnum and cotton grass peat layer of 1 m depth has developed in the bog part of the mire system during the last 2.000 years. First drainages were built in the Trebel valley in 1744 to fire the nearby located salt refinery with cut peat. In the early 20th century a wide-spread drainage system already allowed the use of lawn and grazing during the summer season. From the 1960s, deep drainage ditches (~ 1.5 m) enabled intensive grassland use all year round. In 1997 more than 3.000 ha of the Trebel valley mire were re-wetted keeping the water table close to the ground surface. Productive reeds of *Phragmites australis* and *Phalaris arundinacea* L. with stands dominated by *Carex sp.* or *Typha sp.* have replaced plants like *Agrostis sp.*, *Alopecurus geniculatus* L. and *Phleum pratense* L. During the excursion we will visit experimental sites of the VIP-Project, where green-house gas emissions, productivity and combustibility of reeds are studied. Furthermore we will go into the centre area of the raised bog and we will look into the restoration processes of the Trebel valley mire during the last decades.

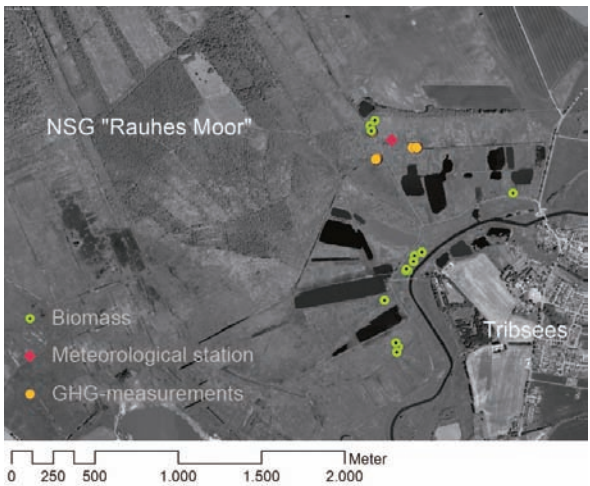

Fig. 5: Fen peatland excursion sites in the Trebel river valley and nature protection area (NSG) "Rauhes Moor"

Alder plantation in Brudersdorf

Achim Schäfer, Alexandra Barthelmes

This polder (300 ha) is situated in the lower part of the river Trebel. It was rewetted in 2006 within the framework of the peat conservation strategy of Mecklenburg-Vorpommern (Moorschutzprogramm) by decomissioning the pumping station, creating a defined overflow in the dike along the Trebel River, and blocking ditches. Since then there are several problems concerning the restoration measures. The dike was sabotaged and several blocked ditches were dug open. This causes strong oscillating water levels in the polder, resulting in successive cycles of drying off and flooding of large parts of the polder. This leads to high nutrient dynamics and a suboptimal vegetation development. Situated in the middle of the polder is an experimental plot of the research project AL-NUS. The project studied environmental and economic aspects of alder plantation on rewetted degraded fen soils. The experimental plot was established in autumn 2002 to test planting techniques.

Polder Randow-Rustow

Kees Vegelin

This 310 ha degraded “fen-polder” has developed into a peat- forming flood-mire since its rewetting in 1990-2000. The water table was risen (dikes and pumping station still existent) in three phases until reaching the level of the river Peene. This project also shows how the planning and construction of the new motorway A-20 was affected by the EU Birds Directive and the Habitats Directive. At present we see a nature reserve rich in different structurally rich habitats such as sedge-swamps, flood-meadows, open water, reeds and willow-shrubs. It is already inhabited by otters, beavers, bitternes, white-tailed eagles, ospreys, marsh harriers, black terns, whiskered terns, lapwings, bluethroats, snipes, penduline tits, moor frogs and tree frogs.

Fig. 6: Route of excursion I (S. Sommer)

Excursion II: Utilization of reeds: hydrothermal carbonisation, biogas, reed mats & peatland rewetting

Guide: Christian Schröder, University of Greifswald

Biocoal production from wetland biomass

Murchin: NN, BV-HTC

The hydrothermal carbonisation is one of the upcoming technologies for the processing of various biomasses. Under high pressure and heat biomass is converted to biocoal, which may be used for power generation or heating. One of the first large scale biocoal plants was erected in Murchin near Anklam in 2012. It is operated by the recently founded German Association of Hydrothermal Carbonisation (BV-THC). The plant is testing different biomasses on industrial scale as a preparation for a continuous production of biocoal. Among the tested biomasses was dry reed (*Phragmites australis*) and further biomass from rewetted peatlands. The BV-THC will guide through the entire process of biocoal production. Subsequently, first results of processed wetland biomass and future perspectives of converting wetland biomass to biocoal may be discussed.

Fig. 7: HTC plant in Relzow (C. Schröder)

For further information please check: www.bv-htc.de

Prospective biogas production from wetland biomass

Pinnow: Hans-Joachim Behrens, Agrar GmbH Murchin-Pinnow, Mathias Schlegel, University of Rostock

Since bioenergy is heavily promoted in Germany due to the Renewable Energy Law, biogas plants belong to the German landscape. Demand for biomass is growing as it is also increasingly used for biogas production. Thus the use of wetland biomass is an opportunity to tap into a new biomass resource. Participants will get to know how the biogas plant works and how challenging it is to use wetland biomass. Laboratory results of ensilage and biogas yield from fermentation of reed (*Phragmites australis*), sedges (*Carex* spec.) and reed canary grass (*Phalaris arundinacea*) will be presented.

Manufacturing of traditional reed mats

Zecherin: Karl-Heinz Spiegl, Reed Harvester

Reed harvesting in Pomerania has a long tradition. Some families have been harvesting their reed beds for 400 years. However, increased obligation for nature conservation as well as missing support in agricultural subsidies cause an abandonment of the traditional use of reed beds. One of the last reed harvesters in the region will demonstrate the traditional manufacturing of reed beds. Positive and negative impacts of using reed beds in respect to nature conservation and biodiversity may be subject to discussion.

Peatland restoration in Peene valley

Menzlin: Ranger, Nature Park Peene Valley

The Nature Park Peene Valley is one of the last not regulated and nearly natural river beds in Germany. It extends over 33.000 ha and hosts various endangered species, for example 156 species of birds and 37 fish species. From 1992 to 2009 one of the largest nature conservation projects of Germany was realised in the Peene valley. 31 Mio. Euro were spend for acquisition of land and for user contracts ensuring nature conservation management for 30 years. Participants will visit rewetted peatlands and discuss the goals, efforts and results of the rewetting project in Peene Valley. *Note: The excursion will be split in two groups.*

Vikings in Pomerania - Historical trading connections to the North

Menzlin, Rainer Vanauer, Peene valley Adventure Excursions

Between the 8th and 10th century Slaves and Vikings settled at the northern shore of the Peene Valley. Good trading connections promoted the founding of a prospering settlement which was equal like the well-known Haithabu in size. An “original Viking” will present the remains of the Vikings, for example graves in boat shape, and will visualise the busy early medieval trading time. *Note: The excursion will be split in two groups.*

Fig. 8: Route of excursion II (S. Sommer)

Abstracts Oral Presentations

OPENING SESSION

The role of reeds in the world of peatlands

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Although the majority of peatlands are still in a natural state, many peatlands have been drained worldwide for agriculture, forestry, grazing and peat mining. The CO_2 emissions of these drained peatlands (including emissions from peat fires) globally amount to two gigatonnes per year, representing almost 25 percent of the CO_2 emissions of the entire land use, land use change and forestry sector.

Drainage-based peatland utilization causes peat oxidation, soil subsidence, nutrient losses to ground- and surface waters, greenhouse gas emissions, and peatland fires and haze (Couwenberg et al., 2010). Several of these processes destroy the subsistence base of productive use in the long run. Crucial is to change the perspective from dryland oriented peatland agriculture to site adapted wetland utilization.

Paludicultures, biomass cultivation on wet and rewetted peatlands, offer an innovative alternative to conventional peatland agriculture. Paludicultures contribute to climate change mitigation in two ways: by rewetting drained peatland soils and by replacing fossil resources with renewable biomass alternatives.

Reed (*Phragmites australis*) will play a central role in the implementation of paludicultures. As a cosmopolitan species, growing in nearly all temperate and subtropical parts of the World, it can be used for many purposes, including fodder, construction, paper production, water purification, bio-energy etc. Even under regular use, it may build peat and sequester long-term carbon.

Keywords: peatlands, argriculture, greenhouse gas emissions, paludiculture, Phragmites

Growth and ecosystem services of *Phragmites australis*: a cosmopolitan invasive species

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The common reed (*Phragmites australis* (Cav.) Trin. ex Steud.) is a wetland grass that dominates littoral zones of lakes, coastal marshes and wet soils in nearly all temperate and subtropical parts of the world. It is a clonal species that forms monospecific and very productive communities in freshwater habitats. The reed biomass is traditionally used for many purposes, including thatching, biomass for bioenergy, paper production, etc. The common reed has many inherent traits of an opportunistic species such as high growth rates in nutrient-rich habitats, high seed production rate, high capacity for nutrient uptake, high leaf nutrient concentrations and flexible biomass partitioning depending on nutrient availability. There is also a high genetic diversity with different euploidy levels within the species. Hence, it is not surprising, that specific aggressive ecotypes of common reed have been found to be invasive in non-native habitats. The best documented example of this is the European ecotypes that have been invading North American marshes and outcompeted native wetland flora in these sites.

The monospecific and high productive stands play important roles for many biological and ecological processes in native as well as in newly invaded areas. The high primary productivity of the reed ultimately leads to the accumulation of carbon in the wetlands. At the same time, because of the anoxic conditions in the wetland soils, the production and emission of important greenhouse gases such as methane may be significant. Ultimately, the balance between carbon sequestration and emission of methane to the atmosphere determines if the wetland can be considered a net sink or a net source for climate forcing, which is currently under debate. Reed ecosystems also contribute with other ecosystem services, such as biodiversity, nutrient processing, hydraulic control, etc. Invading populations of reed can cause shifts in community structure that result in irreversible changes to ecosystem function. Studies have shown that common reed increases marsh surface elevation relative to un-invaded marsh. Also, reed invasion have been found to result in greater aboveground biomass, increased organic matter accumulation and peat development and lower cellulose decomposition rates relative to un-invaded marsh. Reed has an obvious effect as an ecosystem engineer and may allow invaded marshes to better tolerate increasing water levels due to sea-level rise/land subsidence than native short-stature vegetation.

Keywords: Phragmites, reed invasion, climate forcing, ecosystem function shifts

HARVESTING TECHNIQUES, LOGISTICS AND ECONOMIC FEASIBILITY I

The utilization of common reed (*Phragmites australis*) - a review

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Reed (*Phragmites australis* Trin. ex. Steudel) is a wetland plant, which has been utilized since ancient times. Due to its dominant appearance all over the world, it is a cheap and easy available raw material. Reed is a tall, thin, highly productive grass (*Poaceae*) with an aboveground biomass up to 30 t ha^{-1} y^{-1}.

Reed is used as a fodder plant in summer, while the stems harvested in winter have traditionally been used for craft products, house building and construction material including roofing. In the mid of the last century it became popular for pulp and paper production. In recent years reed has been rediscovered for treating sewage water and as renewable energy source, which may avoid competition to food production.

This presentation is an analysis of the global reed area and potential yields. It shows usage over the past centuries, forgotten applications and new potential ones. The product outputs required quality properties and related stand management (like harvesting time) will be reviewed, too.

Keywords: renewable energy, products, application, pulp and paper, biogas, area

Fen mires management in eastern Poland: methods, financing and impact on habitat

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Up to 15,000 ha of current and potential aquatic warbler habitat in Poland should be managed, as traditional extensive land use had ceased there by the end of the 70s of the past century and much of this area is now in succession and overgrown by trees and bushes, which makes the areas unsuitable for the aquatic warbler. The EU funded LIFE Project "Conserving aquatic warbler in Poland and Germany" has shown that large-scale habitat management is possible using special prototype tracked machinery (a so-called "ratrak" harvester).

In Biebrza, the second largest aquatic warbler breeding site in the world, holding up to 20% of the world population of the species, the Polish Society for the Protection of Birds

(OTOP) uses ratraks that are continually being adjusted to habitat needs to reduce the negative impact on it (e.g. ground compression and/or degradation of tussocks). In 2011 OTOP tested mowing of *Cladium mariscus* stands using two ratrak sets on a Natura 2000 site, the Chelm Calcareous Marshes. Within the project 160 ha of calcareous mire were mown. Technical and conservation problems with large scale mowing of biodiversity rich fens will be discussed. OTOP has prepared a field study to assess the impact of mowing with ratraks on aquatic warbler habitats. The results from this studies show how mowing can be changed to create best habitat for the species.

The agri-environmental schemes targeted at the habitat of the aquatic warbler have been implemented since 2009, thus providing the funding needed to maintain suitable habitat management in current aquatic warbler breeding areas. Apart from this OTOP has built a pelleting facility at Biebrza that will hopefully enable economic use of the biomass derived from mowing.

Keywords: large-scale mowing, aquatic warbler, ratrak, Cladium mires

Saving reed beds by giving economic value to reed

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The extensive reedbeds that occur on the four continents of our world have the potential to supply renewable fuel for electricity generation as well as feedstock for the production of ethanol fuel, pulp, building materials (Medium density fibre board (MDF) and Oriented structural strawboard (OSSB)) and possibly in the future textile replacements. The reed resources are so far virtually untapped. Reedbeds are at the same time environmental and ecological treasures that provide a natural protection against erosion and wave-action, purify the water that flows through the reedbeds (helophytes), serve as CO_2 sinks etc...

The absence of a direct economic value assigned to them and the unawareness of their natural functions make the environmentally valuable reedbeds (especially if they are located close to populated areas) vulnerable to reclamation and development for urban, industrial or agricultural uses. Even if they are not reclaimed they risk being polluted from the economic activities in the surrounding areas. Exploiting the reed resources without causing environmental damage, will create direct economic benefits and incentives to save and protect them.

In spite of a multitude of publications, project proposals and pilot programmes there is little evidence that, other than locally and on relative small scale, the potential of reed as a valuable renewable resource is understood and recognized. In parallel the technologies for converting the reed into commercially interesting end-products are in most cases not fully mature for industrial scale applications.

This paper argues that a sustainable economic value of reedbeds can only be achieved if the exploitation is environmentally acceptable and results in a clear business case that shows economic gains for all stakeholders. To put this into perspective the paper summa-

rizes the value of reed lands for nature and the chances and challenges for a commercial exploitation thereof.

A reed processing plant is commercially attractive if the payback time is 5 years or less or if the return on investment is of at least 20%. The profitability is highly sensitive to scale, meaning that a secure supply of fairly large quantities of reed are required to create a feasible industry. As examples can be given that the annual minimum economic requirement of reed is for OSSB production around 60,000 tons and for ethanol fuel production even 250,000 tons. The production and delivery of these volumes to the processing plant should ideally be evenly spaced over the year to avoid large and costly storage. The price of the reed delivered at the processing plant is another crucial parameter. Since the required quantities are large en the density of the reed is low, transport cost can be a major element of the cost of the delivered reed.

Examples are given of the possibilities of, and criteria for, establishing a, for all stakeholders commercially interesting, exploitation using reed for energy generation and the production of biofuel and building materials.

Keywords: utilisation conflicts, economic value, commercial reed exploitation

Exploring the potential of reed as a bioenergy crop in the Netherlands

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Second-generation biofuels that produce biomass for combustion or ethanol production do not yet appear to be a viable alternative to agriculture as they are low-value products. This may change, however, when energy prices increase and their production is combined with the provision of other services. The current analysis explores the potential for the production of reed, an often overlooked biomass feedstock that can be combined with water and nature management objectives. This crop has the additional advantage that it can be grown under conditions that are unfavourable to most other crops.

Land Use Scanner, a widely applied economics-based land-use modelling tool is used to simulate the local competition between reed and grassland used for dairy farming under four different future scenarios in the Netherlands. Based on a location-specific assessment of potential costs and benefits of these crops under scenario-based conditions, this analysis shows that the cultivation of reed for bioenergy, in combination with providing additional land-use functions is not viable option under current economic and political conditions. However, it may become competitive within the next twenty years if any of the following developments occur: energy prices increase substantially; water tables rise in the low-lying western parts of the country due to climate change; a policy is imple-

mented that increases bioenergy prices; or a policy is implemented that stimulates water buffering and the preservation of peat soils.

Keywords: reed; land use simulation; cost benefit analysis; landscape services; water management; the Netherlands.

Challenges for the commercial use of reed: experience from the exploitation of reed, used for thatching and insulation

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The commercial reed sector is made up of series of failures, the most prominent of them having been Nicolae Ceausescu's order to harvest up to 300,000 tons of reed in the Romanian Danube Delta in 1960. Business plans again and again neglect three major challenges:

(1) Harvesting - technical and meteorological obstacles: Usually reed fields are remote from the dry land. So the logistics within the reed field and the distance to the storing place are decisive factors for its economic usability. Even if you can transport the reed on dams or channels, you have to factor in that the water level, ice and snow can temporarily hinder production. These factors can easily increase costs above the amount to be paid for just harvesting.

(2) Quality Control - transforming a varying quality into a reliable product: Depending on the soil, the availability of water and the climate, the quality of reed differs a lot. Criteria for the quality of thatching reed are length, diameter and density of the stems. In this respect the reed differs a lot depending on the origin of the material. A commercial user has to select and classify the reed. This creates a high percentage of rejected material.

(3) Bringing production and sales in line: The harvested quantity of a reed field varies in connection with the availability of water in spring and other weather phenomena. To be a reliable supplier, a commercial user of reed has to balance out the fluctuating supply by supplies from different countries and a sufficient storage.

At current price levels the use of reed as an energy plant would not cover the costs. The material use of reed is favoured by the good characteristics of the material, but the best CO_2-equivalent is not sufficient to lead to a growing demand.

Promising might be the combination of material and energetic use of reed.

Keywords: reed trade, economic usability, quality, supply chain

HARVESTING TECHNIQUES, LOGISTICS AND ECONOMIC FEASIBILITY II

Sustainable management of reedbeds for conservation

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Many thousands of hectares are managed in the UK for conservation benefit, generating many tonnes of biomass. The RSPB has been driving to utilise this biomass, to resolve issues of disposal, maximise management and explore opportunities for economic sustainability. Initiated in the Somerset levels, one of the largest inland wetlands in the UK, this work began with the conversion of cut reed into a soil conditioner. This enabled larger areas of reedbed to be managed on a conservation rotation, through the mechanical cutting and removal of material which was then composted through an invessel system. Whilst successful the result was a production of a high volume, low value material with an associated cost. In the desire to drive towards making habitat management more sustainable the RSPB looked at the conversion of cut reed and rush into an energy product – briquettes. After two years of successful trials, this work grabbed the attention of government's Department of Energy and Climate Change, which has lead to the launch of a project to look at the end to end process, from harvesting to energy production. This two year project is looking for innovative and practical solutions to convert material harvested from conservation wetlands to produce bioenergy. It is the first time that this work in the UK has had such backing together with a desire to find a solution that could dramatically influence the way we manage our conservation areas in the future.

Keywords: biomass, habitat management, bioenergy, briquettes

Harvesting wetland biomass: specifying costs and benefits on company level

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Paludiculture, i.e. agriculture and forestry on wet or rewetted peatlands, depends on adapted machinery and reasonable processing avenues for plants thriving under wet conditions. Furthermore, harvesting wetland biomass can also be appropriate to achieve management objectives for constructed or natural wetlands such as nutrient removal,

improving habitat conditions or combating invasive species. Thereby the biomass utilisation is hoped to ameliorate the cost-benefit ratio of the management measurements.

However, little reliable data on harvesting costs and revenues are available so far that would be based on large-scale and long-term experience. This paper aims at diminishing this gap. We compare three different harvesting regimes for vegetation stands dominated by reed (*Phragmites australis*). The machines employed are tracked vehicles with equipment adapted to the respective utilisation of reed. The biomass is processed for energetic use (combustion, biogas) or as construction material (thatch). Data are obtained from field tests with a snow groomer adapted to summer harvest and run by the project "VIP - Vorpommern Initiative Paludiculture" as well as from interviews unveiling long term experience of reed cutters and landscape managers in using wetland adapted machinery. Full cost accountings are conducted to estimate biomass supply costs and compare the specific expenses with potential revenues of the three different utilisation avenues.

Keywords: wetland adapted machinery, harvesting techniques, logistic chain, biomass supply costs, economic feasibility, reed

Harvesting technologies for reeds in Austria

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Within the frame of the R&D-Project ENEREED (Sustainable Energy Conversion from Reed Biomass), which aims at the assessment of the energetic utilization of the reed belt around the Lake Neusiedl, the harvesting technology, the logistics and the processing have been investigated.

Reed cutting at the Lake Neusiedl has been carried out for a very long time, but used to be focused on the exploitation of young reeds, needed for the fabrication of construction materials. Existing harvesting machines are tailor-made and their operation is rather manpower consuming.

For the envisaged energetic use, however, fully grown (more than three years old) reeds should be used as feedstock and extensive and economically convincing harvesting technologies are required. Following this aim, an already available and applied harvesting machine (a private development of a local reed-cutter) has been investigated with respect to its suitability, performance, strengths and weaknesses, development and optimisation potential. Harvesting field trips under the circumstances of real conditions concerning the harvesting period during the winter time, the climate and ground conditions and the botanic demands has been carried out and has been monitored with the aid of GPS and accompanying observers. The given technology is, in principle, feasible but still provides a solid base for further improvements. Because the applied technology is based on the production of cylindrical bales, bale chopping has also be considered as a necessary processing step for the industrial application in cement works and as a pre-processing for producing pellets for the domestic

heat application; conventional chopping machines used also for producing wood chips are sufficiently suitable for this application. The economic aspects are still not self-explaining but have to be considered before the background of its collateral biological benefits. The presentation should provide an impact for further measurements to get applicable, replicable and affordable technologies for the described and similar application.

This Project has been kindly funded by the Austrian Klima- und Energiefonds.

Keywords: reeds, energetic use of reeds, harvesting and processing

New generation of vehicles for harvesting of biomass and modern method of forming biomass bales train and coupling with wetland tractor

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Two R&D projects (WND-POIG.01.03.01-00-164/09 & N R 03 0077 06/2009) on technologies implementation for works related to stopping unwanted greenery (grass, reeds, bushes) succession on wetlands and restoring the breeding areas of endangered species of birds are being carried out by the Power and Dynamics of Agricultural Machines Research Group of the Industrial Institute of Agricultural Engineering (PIMR).

The first project is focused on Agricultural Hovercraft Tools Carrier (AHTC) technology mainly for moving/cutting grass, reeds and underwater plants. Technical problems with two aircraft engines (60 kW) forced us to redesign the AHTC. The new AHTC will be subjected to preliminary laboratory and field tests within the next months.

The second project is focused on amphibian, crawler-type vehicle units (towing vehicle with trailer) that are coupled together and are equipped with light track modules a small but comfortable cabin, biomass conveyors' system, hitching system for cutting-shredding devices and unloading system from the trailer to a temporary storage yard.

These two technologies should be less harmful to wetlands than snow grooming ratracs, usually poorly modernized by farmers and causing damages such as surface devastation and dangerous spillages of mineral oils from engines and hydraulic systems –. Since the Ageng 2012 conference in Spain new patent disclosures were made by PIMR for adapter and way of rolling biomass bales. This method of forming biomass bales train will be tested in 2013 with our new Kubota tractor that was transformed by us from a wheeled version into a wetland tractor with Soucy Track modules.

All harvesting vehicles will be transported on a new generation of truck-goosecek trailer units that were built thanks to R&D funds for project N R 100 0006 04/2008.

Keywords: biomass bales, agricultural, hovercraft, amphibian, crawler, vehicles unit, tools carrier, rubber track modules, terrains, devastation, pollution, spillage, mineral, wetlands

CASE STUDIES/COUNTRY REPORTS I

Reed resources in Poltava Oblast, Ukraine: biodiversity conservation and bioenergy production

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Eastern Europe holds a large potential for production of biomass for bioenergy, due to the vast areas available at low opportunity costs. Bioenergy is still a largely untapped resource here. Key issues in a risk-mitigation strategy in biofuel production are: 1) conservation of areas with significant biodiversity value, 2) mitigation of effects related to indirect land use change, and 3) promotion of agricultural practices with few low emissions and low negative impacts on biodiversity. These aspects form the basis for a large bioenergy project in Poltava Oblast (Ukraine). Biomass from natural reed (*Phragmites australis)* stands does not compete with land for food production, potentially giving this biomass an added value. In the trial project in Poltava 6,000 ha of reed beds will be used. There is a vast potential since the total area of wetlands in the Ukraine is some 10,081 km2 (1.68% of the total territory). The reed habitats are currently used for fishing and hunting but can provide significant additional environmental services. Most reed beds are burnt in autumn and winter. Controlled harvesting can result in conserved old reed stands, which will benefit key marshland birds. Use of biomass can significantly benefit rural communities and the national economy. Depending on yield, one hectare of reed can replace about 2,000 litres of heating oil (which equals ca. 6 tons of CO_2 emissions). So as to guarantee sustainability and future markets for biomass in Ukraine and Eastern Europe, it is important to develop certification systems that can be effectively implemented in the specific local context. In this project, the Dutch NTA 8080 standard served as basis for assessment and implementation of biomass sustainability. Important bottlenecks for its successful implementation were identified and recommendations for improvement were provided, to make this a more effective sustainability tool in Ukraine and possibly elsewhere in Eastern Europe. The challenge we face is to develop this potential without compromising biodiversity and other sustainability conditions.

Keywords: biomass, reed, biodiversity monitoring, chain-development, Renewable energy certification, GHG

Large-scale management of common reed (*Phragmites australis*) for paper production: a case study from the Liaohe River Delta, China

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The Liaohe River Delta in northeast China (121°10' – 122°30'E, 40°30'–41°30' N) has a total area of about 5,000 km^2 of which about 1,000 km^2 is covered by reed, *Phragmites australis*. This is believed to be the largest reed field in the world. The wetlands in the Liaohe River Delta are of great importance for biodiversity because a large number of species, including some rare ones, live and breed in the wetlands or use the wetlands as a resting and feeding place during migrations. The reed fields have expanded in recent decades because of human water diversions and management aimed at maximising production of reed for paper production. In 1998 the average productivity of the reed were reported to be 14 tonnes of dry matter per ha and year. More than 90% of the reed is cut annually in winter and used as raw material in two paper factories located in the delta. The total reed biomass used for paper production amounts to 206,400 dry tonnes per year, and a paper production of 94,000 tonnes per year.

The management of the reed fields is based mainly on (i) diversion of freshwater to the reed fields, (ii) management of the water table, and (ii) harvesting and burning for pest control. Diversion of freshwater into former salt-affected marshes has been carried out to reduce the salt content in the soils in order to improve the growth conditions for the reed. It has, however, been found that the reeds grow best when affected by low levels of salt rather than at completely fresh conditions. The water levels in the reed fields are managed according to the different growth phases of the reeds. In the spring, the reed fields are kept water covered, but with a low water table in order to protect the sprouting shoots from frost damage, while at the same time allowing the soil temperature to rise at a relatively fast rate. During the development phase of the reeds, the water table is increased, and then the water is drained to supply oxygen to the root system. This water supply and draining is alternated three to four times during a growing season. During early winter, the reeds are harvested and stored for later transport to the paper factories. Seawater irrigation is used a means of controlling unwanted weeds in the reed fields, and insect pests are controlled by burning off the remaining stubble and litter after harvest.

Keywords: Phragmites, biodiversity, biomass, salt, water levels, pest

Industrial design research on reed processing and use in Canada

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Research in Industrial Design is currently a burgeoning discipline. The approach is either to start with research related to products for which to find a use or uses afterwards, or else one would start from researching on needs for use, for which to find then the most adequate products and services.

In this country report I'll present activities by TECHNOPHRAG, a private Industrial Design research institution, based in Montreal (Canada). TECHNOPHRAG mission was set to develop, design, and demonstrate technologies applied on *Phragmites*. In addition to traditional uses - not yet in North-America - mostly thatching, fencing and matting, to recently engineered processes such as wastewater filtration, polluted soil remediation, paper making, and to newly developing uses such for heat and power extraction, we believe and have demonstrated that this biomass can afford innumerable other daily use products and services.

The proposed presentation will highlight different prototypes of products devised by TECHNOPHRAG since the last 6 years of existence. Some of these have already been satisfactorily tested in their respective contexts of use, and they will soon be developed further for a larger distribution, mostly in replacement of current unsustainable products at the marketplace.

TECHNOPHRAG is a private initiative, in reaction to the general negative perception in North-America towards *Phragmites*. Especially the recently introduced variety from Europe has been labelled as "invasive" weed, a "pest" to eradicate by all means as it "endangers" local biodiversity. Proceeding through a regular perusal of basic research findings published in world scientific literature dealing with *Phragmites*, we are dedicated to apply physical, chemical, mechanical, and environmental properties of the plant and thus develop as many daily useful products and services as possible.

Keywords: Phragmites; Industrial Design; TECHNOPHRAG; Montreal; Canada;

Case study Lake Pape, Latvia - reed biomass potential analysis

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Lakes cover 1.5% of the territory of Latvia, i.e. 1,000 km^2. The lakes of Latvia are characterized by eutrophication that often has a negative impact on lake biotopes. The reed (*Phragmites australis*) is one of the most widespread aquatic plants; it occupies larger or smaller areas in all water bodies of Latvia.

Lake Pape is situated in the south west part of Latvia. The reed is growing in the lake and in the surrounding wetlands. The territory of the lake covers 2,919 ha and the reed beds cover 2,087 ha. It has been estimated that the potential for reed biomass is around 15,000 t per year.

As the lake territory is a NATURA 2000 site, reed bed management is strictly regulated by nature reservation plan, which means, that active reed cutting can be done in 700 ha large territory during winter season. As there is a lack of regulation for reed cutting entrepreneurs, Lake Pape management authority, is facing conflicts of economical and natural preservation interests.

During the COFREEN project there have been developed several solutions to improve reed beds management in Lake Pape. There has been developed a strategic action plan for the reed beds management process in territory.

As there is a large amount of leftovers from winter reed cutting, there has been large scale research for reed biomass use in biogas, pellets and briquettes production. The results show that 40 % of reed biomass in biogas production process can be used to ensure process. 70% reed and 30% peat biomass mixture can be used to ensure the best physical and chemical quality producing reed pallets and briquettes.

The research in Lake Pape's case shows that it is important to arrive to complex solutions to ensure sustainably. Solutions where reeds are cut locally for thatching while residue is used for fuel materials. Due to the problematic handling of reeds it would not be useful to work only within one or another area of use.

Keywords: reed biomass; biogas; pallets; briquettes; NATURA 2000

Reed as a building material in Finland, Cofreen-project

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Ten years ago we did not have any roofs thatched with Common reed (*Phragmites australis*) in Finland. Neither had we had any up-to-date instructions or regulations concerning thatching.

Today we have about 50 thatched buildings, but still we can fairly ask: How they will last here, what is the durability in this northern climate? The first reaction when Finnish people hear about thatch is: What is it or there are thatched roofs in Estonia or in Denmark but will it last here and how about fire safety, does it burn easily?

Cofreen-project (2010-2013) has searched for best practices for reed harvesting, preprocessing, transporting, storing and processing to energy in pilot areas. Local reed entrepreneurship is encouraged and research for developing reed as building material is made. We have plenty of reed beds in Southern Finland (30,000 ha) and the areas keep expanding every year. How to use it wisely and creatively? Since World War II we have lost practically all our know-how concerning natural building materials. According to statistics

we are far behind Sweden and many other European countries about using reed for example covering roofs.

Ecological values and energy efficiency are upward tendency also in construction sector in Finland. The interest and knowledge towards thatching has been increasing. During the project we have made research about characteristics of reed to spread facts instead of speculations. Technological Research Center of Finland tested reed samples thermal conductivity and got good values (λ= ~0.057 W/mK). So, typical thickness of thatch (30 cm) provides significant insulation.

We created also a building information card of thatched roofs. Building information cards have achieved heavy status among the builders like planners, architects, engineers and municipal officers. Fire safety is one of the most important things which are included to this new card containing 16 pages.

Keywords: thatched roof, building materials, energy efficiency, fire safety

CASE STUDIES/COUNTRY REPORTS II

Pelleting and co-combustion of reed, sedge and *Cladium* biomass in Poland

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The lack of suitable outlets for the biomass arising from large scale mowing of fens is threatening to limit the uptake of the new agri-environment scheme designed to protect the habitat of the aquatic warbler. Land users cannot afford to dispose of the biomass as waste product. Therefore, a feasibility study on the possibilities for the alternative use of biomass derived from aquatic warbler habitat management has been prepared as part of the LIFE Project "Conserving Aquatic Warbler in Poland and Germany." The study shows that it is possible to use this kind of biomass as alternative fuel and recommends its use as solid fuel, either in the form of bales, pellets or briquettes. At this stage the necessary technical knowledge and equipment are available in Poland.

In the vicinity of second largest aquatic warbler sites, Biebrza Valley, the Polish Society for Protection of Birds (OTOP) has set up a pelleting facility that will allow to produce pellets from the biomass derived from mowing all the site. The facility was set up in October 2011 and preliminary information about the facility itself and the production will be shared during the conference.

In the vicinity of another large aquatic warbler site in Poland (the Chełm Calcareous Marshes) there currently are three alternative facilities in operation: two pelleting plants and a cement mill accepting biomass for co-combustion in cement kiln. Within the LIFE+ project in September 2011 the biomass from 160 ha was mown, baled and then processed in two alternative ways at the edge of the marsh. Part of the biomass was transported to the Cemex Chełm Cement Plant. There biomass was then used as alternative fuel for the cement burning kiln. The remaining biomass was transported to the "BIOMASS" pelleting factory located in Sielec near Chełm. There Cladium biomass will be pelletised for the first time ever.

Keywords: pelleting, co-combustion, Cladium biomass

Can commercial reed cutting coexist with biodiversity protection? A case study from Rozwarowo Marshes, Poland

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The Rozwarowo Marshes (1,600 ha) are located 15 km off the Baltic Sea between Kamień Pomorski and Wolin in northwest Poland. The peatland developed by terrestrialization and paludification with the peat predominantly formed by reed (*Phragmites australis*). The dominant plant species in Rozwarowo Marshes is common reed (*P. australis*). There are two main vegetation types: Dense stocks of common reed (up to 2.5 m high) grow under eutrophic site conditions at water levels above the soil surface. Moderately high (< 2 m),sparsely growing common reed grows under mesotrophic site conditions at water levels permanently at or below the soil surface. In the latter case, additional species of either marsh fern (*Thelypteris palustris*) or sedges (*Carex* spec.) are characteristic.

After a long period without land use, commercial reed cutting started at the Rozwarowo Marshes in 1989. Today, three family enterprises harvest annually about three quarters of the peatland. The crop is mainly used for thatching and sold either within Poland or (to a larger extent) abroad. The Rozwarowo Marshes are of particular importance for the conservation of fen mire biodiversity: They hold the largest population of the globally threatened aquatic warbler (*Acrocephaus paludicola*, a little brown songbird) and the largest population of the shrub *Myrica gale* in northwest Poland. Additionally, the Rozwarowo Marshes include the habitat type "*Molinia* meadows with *Carex pulicaris"* of the EU Habitats Directive Annex I (*C. pulicaris*is threatened with extinction in Poland) and rare halophytes of the Triglochino-Glaucetum maritimae. To protect the aquatic warbler and other elements of biodiversity of Rozwarowo Marshes, a management plan has been prepared as part of an EU-funded LIFE project. It includes research on experimental summer and winter mowing. Aquatic warblers and reed cutters have apparently largely common "interests." This presentation summarizes the results of the management plan and gives as well some wider information about reed cutting in northwest Poland.

Keywords: reed, biodiversity, Poland, Aquatic Warbler, habitat management

Wetland restoration and sustainable harvesting of biomass from reedbeds in the Lower Danube Region

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Along the River Danube in southwest Ukraine and northeast Romania, common reeds (*Phragmites australis*) grow prolifically in much of the floodplain because of specific continental climate conditions as well as abundant nutrient input from continuous sediment deposition in the delta zone. Indeed, one of the largest extents of reedbeds in the world occurs in the region, and individual plants can achieve heights exceeding 4 m.

However, overgrown reed beds in the Danube Delta have become widespread as a result of floodplain modification since the 1950s. They are now burned by local people in an attempt to recover some pasture, but these efforts invariably fail to the detriment of wildlife and the environment. Our ecologically sustainable business approach solves this problem by harvesting and pelleting the reeds as a renewable biomass source.

There are many plant species suitable, but uniquely Phragmites is waterproof so it can be safely stored in the open without deterioration from rain. In addition, the continental climate means that it grows strongly during the warm summers, and the cold, low humidity of winter allows the stacks of cut reed to dry outdoors without incurring the energy costs for pre-process drying needed in virtually all other biomass crop processing.

Phragmites grows best on land which is viewed as either unusable or extremely risky (due to regular flood events) for food production in the region. Hence it is a biomass feedstock which avoids the “food or fuel” debate. Whilst most biomass sources being exploited around the world today require an agricultural approach to cultivation, with the significant capital expenditure, pesticide and other chemical, fertilizer and fuel costs, reedbeds grow naturally on land not used for crop production and can be harvested to provide raw biomass without the need for any cultivation or fertilization.

The main obstacle for processing is that the natural waterproof properties are derived from a high proportion of silica deposited in the stems (~ 5% of the dry weight). The raw material is therefore fairly stiff, brittle and abrasive, and making pellets entails higher operating temperatures and more robust machinery than for woodchips. Over several years of trials, our team has developed a system that can chop and pellet reed efficiently, including a dust capture facility, while coping with the challenging operating conditions.

In September 2010 a pilot project on harvesting and using reed biomass to produce fuel pellets was started in Ukraine, at Reni in Odessa oblast. An area of some 300 ha of existing reedbeds was secured and an initial test stock of 200 tons of biomass harvested in February 2012 from about 20 ha. A British-built pellet production line was imported and assembled and put in operation in April 2012.

Keywords: reed, Phragmites, biomass, pellets, economical use

Determinants of sustainable biomass production in permanent wet grasslands dominated by *Phalaris arundinacea*: Case study from the Třeboň Basin Biosphere Reserve, Czech Republic

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The results of a field manipulative experiment focused on the cutting frequency and fertilization options indicate that a one- to three-year cut regime of wet grasslands dominated by *P. arundinacea* can be sustainable provided the nutrients removed from the ecosystem with the yield are replenished by suitable fertilization. However, caution is necessary when making implications on the basis of short-term ecosystem studies for their long-term use or management. While extensive use probably imposes a fairly small risk on the ecosystem stability, a question arises about the effects of long-term intensive use of the wet grasslands. Some insight can be obtained on the basis of impacts of long-term intensive management on the ecosystem of the Wet Meadows near Třeboň. In the Czech Republic, stands of *P. arundinacea* were cut and used as fodder for cattle and horses until collective farming was introduced in the 1950s. The use of *P. arundinacea* stands has been limited since by sufficient supply of other fodder of better quality and by lack of machinery suitable for soft wetland soils. Nowadays, it attracts attention as a potential energy crop. Yet, its use in Central Europe is limited by the area of suitable land/habitats and existence of other more productive plant species. Nevertheless, the association of *P. arundinacea* with wet habitats favours its use in specific conditions of temporarily flooded areas, which cannot support regular production of terrestrial crops. The increasing interest in "soft" flood protection on the one hand and the increasing frequency of extreme meteorological events including floods, make *P. arundinacea* a suitable species in areas managed primarily for soft flood control. Low-impact use with one or two cuts per year is adequate for management of wet grasslands in temporarily flooded areas serving primarily for the soft food control.

Keywords: wet grassland, reed canary-grass, cutting frequency, fertilizer application, energy crop, flood control

PROCESSING BIOMASS I (ENERGY)

Energetic utilization options of wetland biomass considering substrate specific traits – the example of *Equisetum palustre* L.

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An ecological as well as an economical value-adding utilization of rewetted peatlands increases the acceptance and shows socio-economic preferences additionally (Joosten 2003, Čižková ET AL. 2011). Due to the stricter qualitative and quantitative requirements of the application as renewable raw material, the energetic utilization of wetland biomass appears reasonable (Deimling 2007, Mandl 2006). Under the current economic conditions, the process of combustion as well as the transformation into biogas are the most viable conversion technologies (Hofbauer et al. 2010, Meier et al. 2010, Friedl et al. 2010). Both utilization pathways place specific, very different demands on the material properties for the feeding stocks. Several stock forming plants of wet peatlands exhibit specific chemical compositions, their knowledge is of great importance particularly for the utilization path of biogas production.

On a case study of the worldwide spread character species of wet peatlands, horsetail (*Equisetum palustre*), the substrate dependence regarding the procedure preference examined more closely below.

For this purpose, biomass samples with a high percentage of *E. palustre* as well as pure *E. palustre* where collected in two consecutive years. These samples where used as pure substrate and to produce defined composites with graminoeus understorey species. Their suitability for different energetic utilization pathways where investigated: A) wet fermentation, B) solid state fermentation and C) direct thermal utilization. Based on the test results, the different advantages and problems where illustrated and the energetic and economic aspects are being discussed.

It is concluded that, the utilization of biogas production by wet fermentation is the most suitable conversion technology for this specific kind of biomass. This statement applies only with the requirements of cheap substrate costs (transport, storage preparation) as well as a good silage management.

Keywords: peatland, biomass, horsetail, energetic utilization, biogas, direct thermal utilization

Reed as gasification fuel compared to woody fuels

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Reed is a widely spread plant among others in the Estonian and southern Finnish coastal areas both on- and offshore, and the species is well-known all over the world. Reed has been used to provide energy in various parts of Europe, such as Estonia, Finland, The Netherlands, Hungary, and Romania. The annual reed energy production potential is modest (for instance, in Estonia, 292 GWh/year), and therefore, it could be used by blending with other types of biomasses, such as woods. The gasification technology together with combined heat and power production gives an opportunity to use fuels with higher efficiency. The application of the integrated gasification combined cycle (IGCC) is commonly considered to have higher efficiency compared to the Rankine cycle. The char conversion stage, following the pyrolysis step in the gasification process, is generally much slower than the pyrolysis itself and is therefore the rate-determining step. High char reactivity is needed to obtain higher energy outputs from the reactors. The gasification temperature is an important parameter affecting reactivity, ash fusion characteristics, tar cracking etc. On the other hand, the ash fusion temperature determines mainly the temperature level in reactor. The properties of ash material of a fuel mix cannot be predicted from the known characteristics of the ash formed from each fuel. Interaction between ashes from different fuels is poorly understood and a number of surprises have been reported when fuel mixtures have been used. In this study the oxidation reactivity of the chars derived from the pyrolysis of reed, pine pellets, and Douglas fir wood chips and the ash fusion characteristics of reed and coniferous wood residue blends was investigated.

Keywords: reed, gasification, sustainable energy conversion, reed biomass, lab scale and field test

Sustainable energy conversion from reed biomass overview of lab scale and field test results.

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The aim of the R&D Project ENEREED (Sustainable Energy Conversion from Reed Biomass) is to analyse the supply-chain of reed from harvesting to thermal utilization in different conversion paths. The examination was done for the reed-belt at Lake Neusiedl (Austria) which offers the largest connected reed potential in Central Europe (area about 18,000 ha and 84,000 t total biomass potential). The results of the experiments are needed

for an economic and ecologic evaluation which leads to a feasibility study. This study presents different conversion possibilities. Field tests in harvesting, chopping and thermal conversion in large scale plants (district heating and cement production) as well as lab scale experiments in pelletizing, combustion in domestic boilers and fluidised bed gasification were carried out and will be presented.

To evaluate the fuel properties, comprehensive proximate as well as ultimate analyses were done. The analyses indicate differences in nitrogen, sulphur and chlorine content depending on the location.

Pelletizing experiments were carried out in a lab scale pelletizing plant. The results show influences of conditioning and additives to the quality of reed pellets compared to wood and straw pellets.

Within field tests in the cement production process, chopped reed was used as renewable source to replace coal and petcoke (petroleum coke). The maximum mass throughput of 8 t/h in the calciner firing substitutes about 32% of the total fuel heat input of the cement production process.

Combustion experiments examine the utilisation of reed in a district heating plant (capacity 3 MW) and in a domestic wood chip boiler (capacity 80 kW). In both plants, different mixtures of reed with wood pellets/wood chips were tested. The results show, that the emissions in both plants meet the targets of the federal law (Combustion Plant Regulation). The high ash content of about 9.3% may cause problems for the ash discharging system, especially for the domestic wood chip plant.

Keywords: reed, conversion, evaluation, fuel, pelletizing, cement, combustion

PROCESSING BIOMASS II (ENERGY)

Floodplain meadows as alternative source of biomass for bioenergy production

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Floodplain meadows on the river plain are important NATURA habitat and Ramsar wetland type. In order to keep the plant communities of floodplain meadows open and diverse, continuous management is required. One late harvesting in July, no fertilisation, and no seeding are typical nature conservation practises in Estonia. Senescent and fibre rich biomass got as a result of this type of management has low nutritional value for ruminants. Therefore, insufficient demand for this kind of biomass in animal husbandry has created a challenging option to use it for bioenergy production. In the current paper we estimate the biomass yield, ratio of functional groups, chemical composition and energy potential in floodplain meadows in different wetland areas in Estonia. Average annual biomass yield in floodplain meadows was more than 6.0 t DM ha^{-1} with an energy potential of about 120 GJ ha^{-1} for combustion. The feedstock-specific methane yield of this biomass was less than 270 l_N CH_4 kg^{-1} VS and only 54% out of the total energy potential of biomass from floodplain meadows could be achieved through conversion into methane. The largest component (more than 50%) of energy potential originated from graminoids (*Cyperaceae*, *Juncaceae* and *Poaceae*), while almost 45% derived from the non-leguminous broadleaf forbs. The contribution of legumes was diminutive, but the content of different chemical elements (C, Cl and N) in legumes was higher than that from other studied functional groups. The other non-leguminous broadleaf forbs contained more ash and had lower calorific value contrary to sedges and rushes with higher calorific value and lower ash content. The energy potential of floodplain meadows can provide an alternative source for bioenergy production, especially in large-scale usage of this biomass.

Keywords: bioenergy, chemical content, energy potential, floodplain meadows, wetland

Biomass characteristics of wet fens in Belarus and the potential to substitute peat briquettes as a fuel

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There is a wide range of use options for biomass from wet peatlands. Here, we present a case study from Belarus, a country (i) rich in wet peatlands and currently rewetting large areas, and (ii) with a substantial need for fuels for heat and power generation produced inside the country (and possibly substituting peat as a fuel). The biomass potentials of selected wet peatlands with stands of common reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), and sedges (*Carex* spec.) have been investigated. Yields of about 9.8 – 11.7 t of dry reed biomass per hectare and year were found. Lower mean yields were obtained for reed canary grass (9.6 t/ha) and sedges (7.0 t/ha). The nitrogen content was very low so that no problems concerning nitrogen oxide emissions from combustion are expected. Compared to pine wood the higher contents of chlorine, sulphur and ash might cause problems regarding emissions and process management if the biomass is used in conventional combustion technologies. The ash content varies between 3 – 5.7 % which is in the same range as the values for grain straw or *Miscanthus*, but not as low as values for wood. Overall, our data proves that the utilisation of biomass from wetlands as a substitute for peat briquettes is promising. An ongoing project currently tests the cooperation with a peat briquette factory to produce mixed briquettes of peat and peatland biomass and further investigates biomass characteristics.

Keywords: paludiculture, rewetting, land use, nature protection, biomass processing, biofuel, briquettes

Essential properties of reed and their influence on combustion equipment

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The properties of reed as a potential bio fuel have to be studied, because the way of handling reed for burning, lifetime of combustion equipment (fouling, erosion and corrosion), combustion regimes and environmental impacts like pollutants, ash handling etc, depends on these properties The reed combustion characteristics vary to some extent depending both on the site of growth (coastal area, lake, river delta or wetland treatment systems) and seasonally, harvested either in winter or summer. Factors affecting the usability of the common reed as fuel for combustion in boiler plants are: moisture of reed mass, calorific value, bulk density, ash content and ash properties etc. The moisture content varies according to the season and stays between 10% and 65%. For instance, the moisture of reed suitable for direct combustion or converting into pellets is 15-18%. The

high ash content of the common reed, ca. 4% is a problem for using it in boilers where wood was previously burnt. Remarkable is that the amount of silicon oxide in winter harvested reed is very high, up to 85%.

This paper presents the results of tests carried out at the Thermal Engineering Department of Tallinn University of Technology between 2006 and 2011. During the tests the following reed properties were determined: chemical composition of summer and winter harvested reed and its ash, ash melting point temperatures, physical properties like moisture and ash content, bulk density and calorific value and energy content. The impacts of different chemical and physical properties of reed on the boilers' operation are also discussed.

Keywords: common reed, chemical and physical properties, impact on boilers

ECOSYSTEM SERVICES I (WATER & NUTRIENT REMOVAL)

A regional bioeconomy: Harvesting *Typha* for multiple co-benefits of nutrient capture, bioenergy, phosphorus recovery, and carbon offsets

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As we move further into the 21st century in the face of widespread concerns around food, energy, water, and resource security and scarcity, the increasing use of renewable inputs to industrial economies is inevitable and urgent. In Manitoba, Canada, a key driver for a regional bioeconomy is the fact plant biomass can soak up nutrients that might otherwise flow into aquatic systems causing eutrophication and large-scale algal blooms. By harvesting novel forms of biomass that effectively absorb nutrients we're creating raw material for industry and removing nutrients that can be recycled. The International Institute for Sustainable Development (IISD) and partners from the University of Manitoba and Ducks Unlimited Canada have demonstrated harvesting of *Typha* spp., a large emergent aquatic plant characteristic of wet environments in North America, as a sustainable source of biomass with multiple co-benefits: nutrient capture and reduction of nutrient loading in aquatic systems, bioproducts, heat, energy, carbon offsets, and recovery of phosphorus - a limited strategic natural resource critical for agricultural fertilizer and global food security. *Typha* yields an average 15 to 20 tonnes (dry) per hectare, and contains 20 to 60 kg of phosphorus per hectare. Nutrients locked in harvested plant tissue are prevented from being released into the environment via natural decomposition. Harvested *Typha* is a sustainable feedstock to displace fossil fuels for heating or electricity generating carbon offsets. Calorific heat value averages 17 to 20 MJ/kg with excellent densification and combustion properties and an average potential energy yield of 300 GJ per ha. Average ash content is 5 to 6% and phosphorus can be recovered in ash following combustion in solid fuel burners. IISD's ongoing research work now continues to demonstrate pilot-scale harvesting, exploring higher value biofuels and bioproducts, and development of commercial scale harvesting.

Keywords: Typha, biomass, bioeconomy, North America, combustion

Alum sludge: From “waste” to valuable raw material

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Alum sludge refers to the drinking water treatment residual when aluminium sulphate is adopted as coagulant for purification purposes. According to EU legislation alum sludge is currently classified as “nonhazardous waste” but increased production is triggering off considerable environmental and economic concerns as well as disposal issues. In Ireland, 18,000 t dry solids of alum sludge in an annual basis is generated with landfill disposal costs of about € 3.2 million. The application of alum sludge in phosphorus (P) immobilization in wastewater treatment has been studied by the water research group in University College Dublin (UCD) to convert alum sludge from a “waste” into low-cost bioadsorbents for beneficial reuse. This research work is mainly aimed in exploring the potential of the intended purposes in the newly developed alum sludge-based Engineered Wetlands (EW) and develop a numerical process-based model to understand the insight of physical, chemical and biological processes within the EWs. *Phragmites australis* were planted on top of each stage of the EW system. The study reports mean monthly removal efficiencies ranged from 57-84%, 36-84%, 11-78%, 49-93%, 75-93%, 75-94%, 73-97% and 46-83% for BOD_5,COD, TN, NH_4-N, TP, P and SS respectively. The pilot-scale novel alum sludge based EW showed a distinct P removal and also the system was effective in reducing the organics and ammonical nitrogen. STELLA (Structural Thinking Experiential Learning Laboratory with Animation) modelling tool has been used in this study to capture the dynamics of biological activities within the system and explore the interrelationships. STELLA as the modelling environment uses finite difference numerical schemes for computations and conceived on the principles of system dynamics. This would be the first time that such tool is successfully applied by the water research group in UCD to simulate the P, and various forms of Nitrogen (N) such as ammonia-N, nitrate-N and total-N. The developed model was in good agreement with the experimental results. Trails on EWs with alum sludge as main substrate indicate that the alum sludge can be carrier for biofilm development and a good medium for wetland plant growth. The system holds great promise as a low-cost wastewater treatment system of choice, particularly agricultural and industrial effluents, small villages, hotels, parks etc. At the same time, it offers a novel reuse alternative for the alum sludge as opposed to landfill. Such development would be environmentally and economically beneficial. Apart from using alum sludge as a substrate medium for wastewater treatment, it can also be used as a eutrophic lake recovery (capping of sediments, with immobilization of P), pit filling and reclamation, capping of waste landfills. Therefore alum sludge offers enormous potential to use “waste” as a resourceful material. Further understanding of the bio-chemical processes of alum sludge based EWs

helps the design engineers to build a standard design EWs to attain maximum removal efficiencies. Because the key for sustainable management for "green environment" is based on reliable and process based information with the help of modern technologies.

Keywords: Phragmites, alum sludge, engineered wetlands (EW), modeling tool, wastewater treatment

Back to basics: Self-maintained simple concept of multifunctional water management in reed beds

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Land-borne nutrient run-off troubles surface water quality throughout the world. There is a large amount of knowledge about the processes in general, but we still seem to lack easy enough applications to reach the goal of efficient water management in many locations. Therefore, we suggest a step back in thinking and encourage putting effort to creating simple "water managing packages" or concepts.

Self-processed measures and easy operated hand-on-tools are needed to diminish the problem in a local scale. Non-crop, aquatic plant species offer diverse possibilities to diminish nutrient run-off and consequently, reach several material and immaterial benefits too.

Diffuse pollution is hard to manage thoroughly with concentrated and expensive industrial or domestic waste water treatment facilities. There is a need for easy-to-manage local solutions. Basically, these solutions have to be economically profitable to work well and serve the communities as well.

We present an on-going multi-functional water quality management concept of using Common Reed (*Phragmites australis*) as a local source of bioenergy and construction material. Coastal zone management plan assures the proper management of reed beds taken all things into account, including both the ecosystem service ideas and benefits to the community as well as nature. Diffuse eutrophication prevention efficacy depends on when and where to cut, where the vegetation belt needs to be left intact etc. When the whole cycle and logistics function on its own, the result is that every partner is a winner and many of the resp. elements are sustainably obtained. The concept is not tight to a particulate ecosystem as such, but instead can be applied to any coastal areas, modified according to the local conditions.

Keywords: multifunctional water management concept; reed beds; diffuse eutrophication.

LIFE CYCLE ASSESSMENT

Life cycle assessment of energy conversion from reed

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Within the project ENEREED, reed from the Lake Neusiedl in Austria is examined as energy source for thermal utilization. The aim of the project is to investigate methods for using reed as a renewable fuel for combustion processes in industry (cement production), biomass power plants and biomass boilers. To evaluate thermal utilization methods an economic and environmental assessment was done. This study presents the examination results of the environmental impact assessment. In order to investigate the environmental impact life cycle assessment (LCA) of the total supply chain (harvesting technology, fuel logistics, fuel processing and thermal supply) was done. Calculations use open source software called openLCA with primary data from field tests along the total supply chain and different combustion processes experiments and secondary data for the component materials (database ecoinvent 2.1).

This study analyses and compares two types of harvesting equipment. The first type of harvester looked at was an ordinary harvester with mow and hand-loading. The second technology was a harvester with mow and baler. Several transport and storage possibilities were investigated. Reed can be used for energy generation in different forms. Therefore another objective in this work was to examine reed chopped short and reed as pellets where combustion experiments were done.

In order to quantify the environmental impact the CML2001 method was used. The CML 2001 is a collection of impact assessment methods which restrict quantitative modelling to relatively early stages in the cause-effect chain to limit uncertainties. To give a good estimation of the environmental impacts of the thermal utilization and harvesting alternatives different impact categories were examined (e.g. climate change, depletion of resources).

The LCA results of energy conversion from reed were compared with results of other fuels which are typical used in the observed fields.

Keywords: LCA, harvesting, transport, conditioning, combustion

Sustainability assessment of common reed-based production

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Sustainability of utilization of common reed (*Phragmites australis*) for energy or other purposes should be assessed including all three dimensions (economic, environmental and social) of sustainability along with the whole life-cycle of a product. Multi-criteria decision analysis (MCDA) techniques enable comparison of different ways of utilization of reed with respect to various sustainability criteria, which may be partly subjective in nature. MCDA is also capable to deal with both quantitative and qualitative criteria, which is often the case with respect to social sustainability. Life cycle assessment (LCA) is a tool aiming to assess products or services' impact from the acquisition of raw-material to final disposal. Traditionally LCA has focused on environmental impacts, however, there has been progress on including economic and social impact into assessments as well. It has been demonstrated that combining MCDA and LCA can provide a suitable framework for sustainability assessments. A framework based on MCDA and LCA for assessing sustainability of using common reed for various purposes (e.g. energy) in Eastern Finland was constructed. Based on the framework, it can be stated that utilization of common reed has several beneficial environmental impacts such as improvements in nutrient balance. Also residents considered that removal of common reed enhanced aesthetic values. Finally economic feasibility of utilization of common reed could be improved by subsidies and by considering new, innovative ways to utilize common reed.

Keywords: common reed, life cycle assessment, LCA, Multi-criteria decision analysis, MCDA

Life cycle impact assessment: feasibility of impact categories and indicators for paludicultures assessment

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Life cycle impact assessment (LCIA) is an important part of LCA methodology in accordance with international standards 14040 series. LCA could be used for estimation of environmental impacts of any product system, including bioenergy.

There are no publicly available reports on LCA of biomass production from wetlands, and our investigation indicates that to certain extent this is accounted for existing gaps in methodology, especially concerning LCIA. By present time more than 25 life cycle impact assessment methodologies that cover more than 75 impact categories, i.e. classes representing environmental issues of concern to which life cycle inventory analysis results may be assigned, are developed. Among the most commonly used methodologies are IMPACT 2002+, Eco-indicator 99, EPS 2000, CML 2002 and EDIP. Despite each of these techniques covers a wide range of environmental indicators, none of them could be

used independently to assess all impacts associated with paludicultures – sustainable production of biomass on wet and rewetted, formerly degraded peatlands.

There are several attempts to create an adapted LCIA methodology for bioenergy sector (e.g. software BEAT (UK), the technique developed by Biomass Research Centre (Italy)). However, they are also not perfect and need further improvements. For example, under the impact category "land use and occupation" there is no option "land conversion to paludicultures". So, neither benefits of paludicultures (e.g. CO_2 emissions reduction, biodiversity conservation, further degradation of peat layer prevention), no risks (e.g. increase of CH_4 emissions during the first years after peatland rewetting, monocultures landscapes creation) could be assessed.

So, all known methods are feasible for paludicultures assessment only to a certain extent and did not show the whole picture. That's why further investigations should be carried out to fill the existed methodological gaps.

Keywords: LCA, life cycle assessment, life cycle impact assessment, LCIA, paludiculture

ECOSYSTEM SERVICES II (GHG)

GHG emissions from peatlands: Effects of rewetting and land use.

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The peatlands of the world store enormous amounts of carbon and are therefore important for global climate: While they cover approx. 3% of the terrestrial area they contain approx. 25% of the carbon stored in terrestrial ecosystems. Drained peatlands contribute to global warming because they emit more greenhouse gases (GHG) than they incorporate. There is a growing body of literature regarding GHG emission from peatlands which we review while focussing on temperate ecosystems and adding some results of own measurements. We correlate the findings with typically measured site parameters like temperature, water table and vegetation composition.

Across studies mean annual water table depths (WTDs) prove to be a good proxy for annual GHG exchange. While CO_2 exchange increases linearly with WTD, CH_4 fluxes are close to zero at mean annual WTDs above -20cm and increase with high variability at decreasing WTDS. Quite similar, N_2O emissions are negligible at mean annual WTDs above -20cm and highly variable at lower WTDs. CH_4 exchange is strongly controlled by vegetation type with higher CH_4 emissions when shunt species are present. CO_2 and CH_4 exchange of moderately rewetted sites with mean annual water table around ground surface seems to resemble the exchange from undrained sites. However, extremely high CH_4 emissions have been reported from temperate eutrophic fens where rewetting lead to water tables >20cm above ground. Combining CO_2 and CH_4 exchange rates in terms of global warming potential (GWP) allows us to estimate the effect of rewetting on GWP and to identify ideal water table conditions for paludicultures.

Finally, we discuss the effects of mowing and grazing on the GWP of rewetted and drained sites. According to the state of the art and own measurements mowing seems to lower the GWP whereas grazing tends to increase the GWP of sites because both CH_4 and N_2O fluxes are increased.

Keywords: carbon, GHG, CH_4, water tables, mowing, grazing

Methane emissions from *Phragmites australis* in two Belarusian rewetted fens – the importance of chamber design and site conditions

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Studies on the gas transport mechanisms of wetland plants found that many of them use convective through-flow what is much faster as compared to diffusion. Also in *Phragmites australis* gas is transported by this mechanism indicating that methane emissions are potentially high. Few works report on annual methane emissions of reed at wet peatlands and the results are contradictory. This may be due to differences in site conditions and applied methods. One aspect is that methane emissions from *Phragmites australis* show a pronounced diurnal dynamic because convective flow requires sun light and it is often assumed that only transparent chambers are suitable for the measurements.

To understand the controlling factors we studied within a BMU/KfW project II. C. 53 the methane emissions from *Phragmites australis* at two rewetted peatlands in Belarus; a mesotrophic one with water slightly above the ground and an eutrophic one inundated with one metre water. Measurements were conducted at long-term and, with opaque and transparent chambers, at short-term scale.

Our results show that opaque measurements do not significantly differ from transparent measurements and that site conditions are of main importance for the emissions. Annual methane emissions from the eutrophic reed are twice as large as from the mesotrophic.

More investigations are needed to identify reasons for the limited influence of the chamber's light transmissivity and to understand the means by which site conditions control the methane emissions of reed.

Keywords: Phragmites australis, rewetted fens, methane emission

Influence of biomass harvesting on the GWP of a sedge fen – two years in situ experiment

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During the last years projects on biomass harvesting on peatlands started in Belarus. However, there is little information about the effect of biomass removal on the greenhouse gas fluxes from peatland sites. Therefore, we investigated the influence of late mowing on a sedge fen in the Paliessie region, SW Belarus. The site is characterized by *Carex nigra* and *Carex rostrata* with a mean water level close to the surface. The investigation covers two variants: with and without removal of aboveground biomass. For both variants we randomly selected three soil collars out of six. Since August 2010 the CO_2, CH_4 and N_2O exchange rates have been measured with chambers (Drösler, 2005). Biomass was removed in November 2010 and 2011.

We found that the emissions of the three gas species were influenced differently by the biomass removal.

For CH_4 a noticeable impact of mowing became evident directly after melting of the ice layer: for a short time the emissions at the harvested plots nearly doubled those from the control. This event, however, did not have a strong influence on the annual methane emissions. The net CO_2 emissions at harvested plots were slightly lower compared to control plots with similar mean annual water level. N_2O emissions were very small and no clearly influenced by mowing. The study was conducted in the framework of the BMU/KfW financed project II. C. 53.

Keywords: sedge fens, greenhouse gas emissions, biomass harvest, paludiculture

Reed canary grass on peat soils in northern Sweden – carbon dioxide emission measurements on restored agricultural land

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Reed canary grass is a grass that can be grown on peat soil. It has a well-developed rhizome system that can stabilize soft soils. In Umeå, Sweden, we have developed a cropping system for use of reed canary grass as a fuel. The grass is cut in autumn, preferably after the soil is frozen, left in in windrows over winter, and harvested when it has dried in spring. Reed canary grass on peat soils, however, often does not yield as much biomass as on mineral soils. The main problem is insufficient drainage. The grass can grow in water-

logged soils but the harvest causes damages to the sward that becomes an entrance point for weeds. Other problems can be low pH and nutrient deficiencies.

There are large areas of abandoned agricultural peat soils in northern Sweden. They are emitting large amounts of carbon dioxide since the peat decomposition process is still proceeding. Growing reed canary grass could be one sustainable way to use these soils. A demonstration project restored a 6 ha abandoned agricultural field that was in early stages of succession to forest. The restoration process: bush removal, ditching, soil preparation and crop establishment, was documented. We measured carbon dioxide emissions both on the reed canary grass field and on an adjacent field that was not restored using the EGM 4 portable equipment from PP systems. There was no indication that the reed canary grass field gave higher carbon dioxide emissions from decomposition of the peat substrate than the abandoned field. We also made a partly successful attempt to increase the groundwater level during the growing season on tile drained parts of the field to mitigate carbon dioxide emissions. Neither carbon dioxide emissions nor the growth of the reed canary grass were significantly affected by the tile drainage regulation.

Keywords: carbon dioxide emission, drainage regulation, restored agricultural fields

Effect of ground water level on greenhouse gas emissions from rewetted peatland cultivated with reed canary grass

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Rewetting of drained peatlands has been recommended to mitigate the greenhouse gas emissions and to restore the carbon sink function of peatlands. Cultivation of bioenergy crops in rewetted peatland (paludiculture) is a new and emerging land use practice which can additionally reduce the carbon dioxide (CO_2) emissions by substituting fossil fuel. However, information on the overall greenhouse gas balance from paludiculture is lacking. Rewetting of peatlands can create favourable anoxic conditions for methane (CH_4) emissions and growing of wetland plants can further accelerate the emission by acting as conduit for CH_4 transport. Furthermore, there is limited knowledge on the effect of wetland plants on nitrous oxide (N_2O) emission. The objective of this study is to investigate the greenhouse gas emissions from peatlands grown with reed canary grass (RCG) and rewetted to various extents (i.e., with different water table levels). In May 2012, soil mesocosms (60 cm height and 30 cm in diameter) were collected from a drained fen peatland used for agricultural purposes (Nørreå river valley, Denmark). The mesocosms were sown with RCG and manipulated to five different levels of water table, i.e., 0, 10, 20, 30 and 40 cm below the soil surface. Gas fluxes of CO_2, CH_4 and N_2O were measured at weekly intervals with static chamber techniques. The gas measurement campaign is still on-going but preliminary results indicate that there is no effect of water table on CO_2 flux. The CH_4 emission is negatively correlated with water table showing the highest rate of emission at high water table. Emissions of N_2O are low at all treatments and seem not to be affected by water table. This study is partly sponsored by the European Regional Development Fund via the IV A Öresund Kattegat Skagerrak programme.

Keywords: reed canary grass, GHG, rewetted peatland

PROCESSING BIOMASS III (MATERIAL)

The use of cattail material in building construction – innovative technological development, environmental relevance and examples of application

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The technology of utilizing cattail (Typha) is based on long-standing analytical research, (during the last 10 years in cooperation with the Fraunhofer Institute for Building Physics (IBP) and is able to serve 2 important aspects:

(1) the cleaning of water, development of retention areas and reduction of CO_2

(2) the lasting production of a highly profitable raw material with approx. 15 t DM/ha.

Products developed out of Typha make use of the specific characteristics of the plant's leaf construction in order to combine good heat insulation capacities with compressive, tensile and flexural strength, - getting a highly innovative product! An additional aspect: due to its growing location related vegetal equipment with tannins, the material is rot proof but can easily be composted and thus recirculated into the material cycles.

The cattail leaves can easily be split lengthwise into particles for industrial use under maintenance of the specific characteristics of the leaf body. Various product lines can be generated depending on alignment and compaction degree of the rod-particles and with usage of non aggressive and environmentally unproblematic adhesives. It is thereby not only possible to produce wall-building material with a compressive strength of up to 2N/mm² and a thermal conductivity <0,045 W/mK, but also by use of the sandwich principle beams and ceiling elements with high bending stiffness. Particularly interesting products are isotropic magnesite boards that are produced with Lambda values between 0,05 and 0,065 W/mK for interior insulation. The irregular alignment of the rods parallel to the flush panel brings a high stability and therefore the magnesite boards are suitable for purpose of stiffening. This specific material is currently being applied in a historic building as insulating infilling of a half-timbered house as well as for the interior insulation of a sandstone exterior wall. This project is metrologically being accompanied and evaluated by the IBP.

Keywords: utilization, Typha, heat insulation

Thermal conductivity of timber framed walls insulated with reed

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Due to the continuing demand for better energy efficiency and use of natural materials in the buildings, need for appropriate research has risen. Therefore the topic of reed usage in buildings as insulation material was researched within the project Cofreen which is part of the program INTERREG IV A.

One goal of this research was building a realistic test structure at the grounds of the Estonian University of Life Sciences.

For finding the best structural design and application methods of reed, during the Autumn of 2010, a test building was erected, where every wall of the building had different structural design and reed application method: horizontal reed layers, reed bales, vertical reed layers, and reed blocks.

The reed layer thickness in all the researched walls was 450 mm. The inner and outer layers of these walls were covered with a layer of clay plaster. As came out, the cheapest and fastest solution was the reed bale wall (5.29 h/m2). Studies of the wall temperature, moisture, and thermal conductivity were done over the course of two years and according to the results of this research, we can tell that the wall made of horizontal reed layers has the smallest thermal conductivity. Already by now, after conducted research, we can give recommendations for the builders of reed walls. Research will continue over the course of winter 2012-2013.

Keywords: reed as insulation material, thermal conductivity, reed bales

Cattail-reinforced clay plasters in sustainable building and spatial planning

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The sustainable development on the building, urban and rural spatial planning level is one of the main goals in global scale. To meet the challenges of the climate change, to avoid the inefficient land usage worldwide and to improve the energy efficiency of buildings, urban districts and cities, we need comprehensive concepts, which observe all of the citizens' actions and needs.

To create an innovative, high-efficient sustainable urban development concept, there should be a profit for all of the following three constituent categories: society, environment and economy. This should apply on all scales of them: local, regional, national and international. Meeting all of these requirements, the idea of the innovative usage of cattail

– lat. *Typha*, – for the production of high-performance building materials, offering high physical quality and sustainable building life-cycle, shows very good results.

Typha grows in fen and swamp areas, also in the slow-flowing rivers' periphery, and is active in their phytoremediation. The *cattail*-plant creates nutrition-rich habitats for various species. It has also a high-efficient mechanical stabilization function for its habitats and because of this fact, it could be used to create natural dams.

The addition of innovative, almost invisible and mould-resistant natural plant fibres for the reinforcement of clay plasters is the central topic of our research project at the Fraunhofer IBP.

The usage of *Typha* in the production of high efficient reinforcement fibres for building materials plays a key role in this concept: The seed-parachutes of it could be used for this purpose, improving also the insulation qualities of the building materials. The *Typha*-reinforced clay plasters offer a perfect indoor climate and are 100% recyclable.

Typha is able to change our understanding for a good functioning spatial system: high-quality urban natural building environment, nature-friendly and economical efficiently used rural areas, as well as 100% easy-to-recycle building materials.

Keywords: sustainability, Typha, plant fibres, insulation, building materials

Thatched roofs deterioration and impact of overgrowing with moss

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Using common reed as roofing material is a centuries old tradition in Estonia, especially in western Estonia. Large and steep thatched roofs, sometimes covered with moss are characteristics to Estonian vernacular architecture. Thatched roof is very durable and long-lived. The lifespan of a thatched roof is dependent on the roof pitch, quality of the reed and expertise of the thatcher, as well as the orientation of the roof and thickness of reed layer. Deterioration by weathering of exposed surface of roof was investigated in order to assess the lifespan of thatched roofs. To detect the problem, the age of the roof, orientation and original thickness of a reed layer was investigated and thickness of present reed layer was measured with a special metal rod. Then the average annual deterioration was calculated and the average deterioration per year of the different sides of the roof were compared. The results indicated that the deterioration by weathering occurs fastest on the south- and west- facing sides of the roofs compared to north -and east- facing sides. The roof side facing south has higher exposure to the sun. This means a fluctuating temperature and higher exposure of UV radiation resulting in cracking and peeling of the reed cells. The roof side facing west is affected by prevailing westerly winds, which damages the roof. To determine the impact of overgrowing with moss, thickness and the range of moss layer on the roofs were assessed and the orientation of the roof sides were investigated. Also some samples of moss were taken from roofs to determine different species of

moss growing on the roof. It was common that various species of moss grew mixed on the same roof. The study showed that moss prefers to grow on the damp surfaces facing north. Most of the studied roofs were overgrown with *Dicranum scoparium* and *Hylocomium splendens*.

Keywords: deterioration and lifespan of thatched roofs, impact of overgrowing with moss.

The role of lignin decomposing basidiomycetes in the decay of water reed

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Phragmites australis has been playing an important role both as forage and fuel ever since the dawn of man. Furthermore the true grass is considered to be one of the world's major natural building materials: Especially along the coasts of Northern Germany, the Netherlands, Great Britain and Scandinavia thatched houses dominate the landscape epitomizing the caesura between nomadic and sedentary life in Europe. In addition to the benefits of thatched roofs such as thermal insulation and sound abatement there is another characteristic attracting homeowners: durability thus longevity. Within the last decades, however, several reports were publicized dealing with an enhanced decomposition of thatched roofs. Therefore, we isolated numerous bacteria, yeasts, filamentous fungi and several fruiting bodies from reed samples and studied their degradative properties. A significant loss of dry weight of reed was only apparent in tests using ligninolytic fungi but not in case of cellulolytic bacteria and fungi. Especially we were able to collect plenty of fungal fruiting bodies from thatched roof which were all and sundry classified as species of genus *Mycena.* We gleaned knowledge from experiments characterizing the decay of reed by these white-rot-fungi on both temperature- and pH-dependence, the supplementation of metals, nitrogen and phosphate and in addition the enzymes involved in reed decomposition were screened. Under optimal conditions the loss of dry weight by several *Mycena* species can reach 45 % after 70 days. The attack and decay of *Phragmites australis* by one species of the genus *Mycena* was studied by scanning electron micrograph imaging.

Keywords: Phragmites australis; thatched roofs; decay; white-rots; Mycena

LEGAL AND ECONOMIC FRAMEWORK

Economic and legal conditions for reed use in Germany

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According to various estimations, the total peatland area in Germany is between 1.4 to 1.8 million ha. Most of these peatlands can be found in Northern Germany and in the foothills of the Alps. Only very few peatland areas are still in a natural state. Most of the peatlands (95 %) were drained to expand the agricultural area and are still used for agricultural purposes. Drainage of peatlands leads to GHG-emissions. Thus, rewetting of peatlands and preservation of natural conditions contributes to important climate protection goals which can furthermore be reached cost effectively.

Germany lacks a general peatland protection policy. Some federal states like Mecklenburg-Western Pomerania introduced their own peatland protection policies. But most of these policies promote cessation of agricultural and other usage.

Similar restoration, rewetting and management projects have been carried out in many German federal states as well as in other European countries. In this paper, selected EU-agri-environmental policies are described, compared, and analysed.

Since most of the peatlands in Germany are still used for agricultural purposes, climate-related peatland protection schemes need to include agriculture and its agri-political conditions. Site adjusted and peat protecting concepts like extensive grazing and paludicultures (Latin *palus* = swamp) are examined. Economic and ecological sound incentives shall be identified to promote a conversion to paludiculture. Furthermore, pecuniary claims according to the First and Second Pillar of the CAP have to be maintained to gain the acceptance of farmers and land-owners. Since only agricultural plants can be funded according to the CAP subsidy scheme, the most important prerequisite is the approval of reed as an agricultural plant.

Keywords: peatland use, policy, EU, paludiculture, incentives

Winter reed cutting in the backlight of the German legislation: demands of nature conservancy and commercial use

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The aim of the study is the feasibility of re-establishing the tradition of winter-cutting of reed as a source of income for fishermen. In a first step, I analysed the German legislation.

The Federal Act for the Protection of Nature sets major limits to the harvest. Reed stands are especially protected; first as valuable biotopes and second as habitat of protected species. Cutting is forbidden and requires the permission of the Environmental Authorities. The withdrawal of reed needs to be reasonable, is restricted to the period between October 1st and February 28th and has to be done in sections with a limited extension. Special regulations by fishery laws are not affected. In Germany, each federal state has its own fisheries law, some of them have quite different contents. Reed cutting as a proprietary right of the fisherman is fixed by law in one state only (Brandenburg). In this case, the winter harvesting of reed is basically allowed to the owner of the fishery rights. However, the environmental authorities have to be informed and can prohibit the harvest.

Reed harvesting changes the stands structure. Horizontal stems are removed; vertical structures are postponed to April/May when the shoots emerge from the water. These effects can severely impact animals, mainly some bird species. On the other hand, reed cutting increases the structural diversity of stands, if done in sections. Scientific investigations of the effect of reed cutting are insufficient for most taxa.

At all, the legal background aggravates the commercial harvest of reed in winter. An intensive use of larger areas seems infeasible at the current conditions. On the other hand, a small scale, local harvest of reed in sections may contribute to both the fisherman's finances and the habitat diversity at the shoreline.

Keywords: reed, winter cutting, legislation, habitat diversity

GENETICS

The genetic variability of Common reed – Ecophysiological aspects in a present and future perspective

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Common reed (*Phragmites australis*) is a dominant clonal wetland plant with a world-wide geographical distribution. It has a high genetic variability both within and between populations, and clone-specific differences have presumably developed as adaptations to various climates. With such large variation in plant traits, unequal responses to climate change can be expected.

Comparing a Northern European with an African reed genotype, exposed to different temperatures and nutrient levels in a factorial design, revealed differences in growth, biomass production, photosynthesis and tissue nutrient concentrations. Quantification of their phenotypic plasticity – i.e. the capacity of genotypes to produce distinct phenotypes when exposed to different environmental conditions – showed that the Northern European genotype responded much more to temperature than the African genotype, which responded mainly to fertilization. These contrasting responses were related to the distinct phylogeographic origin of the two genotypes. However, when grown at elevated atmospheric CO_2, the before mentioned differences were considerably less pronounced, and the contrasting genotypes no longer possessed distinct phenotypic plasticity.

Apart from temperature and nutrient availability, salinity is an important abiotic factor that is supposed to be affected by climate change and that affects the distribution of common reed. Two invasive genotypes from the Mississippi River delta were grown at dissimilar salinities and ambient or elevated CO_2 and temperature, respectively. Both genotypes responded to the treatments according to their phylogeographic origin from respectively Africa and Eurasia. The elevated climate factors affected these responses and ameliorated salt-stress. Hence, a future climate scenario may facilitate invasive processes in these genotypes.

It is concluded that the geographic and phylogenetic origin of common reed needs to be considered for interpretation of responses to diverse environmental factors. Moreover, climate change is likely to influence the various genotypes in dissimilar manners. Especially elevated CO_2 may impact the plasticity and invasive potential of common reed.

Keywords: Phragmites australis, phenotypic plasticity, invasion, elevated CO_2

Phylogeography within the cosmopolitan genus *Phragmites:* A global approach to understand genetic diversity in *P. australis* populations

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Phragmites australis is a cosmopolitan species which tends to dominate the vegetation in aquatic ecosystems all over the world. It is absent only in the polar regions of both hemispheres. Given its abundance, this species has been broadly studied in order to identify the reasons for its ecological success and ways to exploit it. Genetic variation within the species, and the genus *Phragmites* in general, is high and phylogeographic relationships have been shown to be important to understand differences in morphology, distribution and productivity. The genus *Phragmites* includes five species of which *P. australis* is the most widespread and best known. The other four species have restricted distribution ranges in tropical Africa (*P. mauritianus*) in the Mediterranean region (*P. frutescens*), in tropical Asia (*P. karka*) and in the temperate region of the Far East (*P. japonicus*). The alleles of these species often pop up within *P. australis* populations, indicating recent relationships among the species. The relationship with the species *P. mauritianus* has been shown to affect photosynthetic rates (Nguyen et al., under review) and size (Lambertini et al., 2012). Although *P. australis* is a clonal species, sexual reproduction is the main form of dispersal. Pollen and seeds are dispersed by wind and can travel long distances before deposition. The utilization of *Phragmites* as a resource has also contributed to the dispersal of the species. As a consequence, *P. australis* populations are very diverse and can consist of genotypes originated in different parts of world and adapted to a variety of environmental conditions.

Four main *Phragmites* groups can be recognized worldwide based on chloroplast DNA. Of these, one group is restricted to North America, whereas the other three groups have intercontinental distribution. European *Phragmites* extends throughout Europe, Africa, Asia and is an invasive species in North America. Extensive gene flow occurs within the temperate region of Europe. In the Mediterranean region, *P. australis* co-exists with *P. frutescens*. Mediterranean *P. australis*, taxonomically described as *P. australis* ssp. *altissimus* Clayton (which means very tall), shares alleles with *P. frutescens*, but also with the tropical species *P. mauritianus* and *P. karka*. Another important relationship within European *Phragmites* is with an octoploid population of *P. australis* in South Africa. While Mediterranean alleles have a latitudinal limit in distribution, South African alleles can reach as north as the Danish populations. The relationship with the South African population affects plant and leaf size, as well as leaf colour (a distinctive blue-green colour). The study of genetic diversity and phylogeographic relationships within *Phragmites* wild populations is focal to identify genotypes suitable to the various applications and to control the dispersal of the species.

Keywords: Phragmites, genetic diversity, phylogeography, populations, dispersal

ECOSYSTEM SERVICES III (BIODIVERSITY)

Regulation of reed encroachment for nature conservation purposes by grazing water buffaloes

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Despite the numerous beneficial effects of reed stands to the abiotic environmental resources their tendency to form unique, monocultural stands with only few accompanying species limits biodiversity at the landscape scale. This is a problem in special habitats like coastal salt grasslands which have the potential to host a lot of rare species.

We investigated allocation of reed stands and adversary of salt grassland vegetation as influenced by management practice on a 28 ha coastal tied isle. We looked into management history and recent vegetation recording to evaluate the vegetation development in the formerly years and established a grazing experiment with water buffaloes in 2010. In 2011 and 2012 we recorded the distribution of reed stands and additionally we surveyed salt grassland vegetation in 2012. The vegetation development will be discussed with special focus on the rare species and the grazing behaviour. We finally evaluate the potential to cultural landscape preservation by water buffaloes in the South Baltic region.

Keywords: Phragmites australis, reed encroachment, phytodiversity, water buffalo, wetland grazing, preservation of landscape

Assessing human impact on animal assemblages typical for fens

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European fens are inhabited by a number of highly endangered species. However, depending on human influence fens show a wide variation of habitat characteristics which in turn affect animal assemblages. Along the Western Pomeranian river Peene we investigated the impact of five land use regimes on four different animal taxa. To examine the conservation implications of the different land use regimes, we used a conservation value based on regional, national and international endangerment of species.

The highest conservation value for birds was found for reed sites mowed in summer, while threatened *Orthoptera* were most abundant in moist grassland. Butterflies have no

clear preference to a land use regime, but seem to favour open habitats with lower vegetation height. For all three taxa species numbers were very low on locations mowed in winter. Carabid beetle assemblages show a clear separation between the dry intensive grasslands and the rewetted habitats. Endangered ground beetles can only be found at moist locations. In contrast to the other taxa winter harvested sites preserve the highest conservation value for carabid beetles.

The results suggest that only a mosaic of different land use regimes can preserve the fens' specialized fauna.

Keywords: conservation value, fens, birds, Orthoptera, butterflies, carabid beetles, rewetting, cutting regime

Effect of different cutting regimes on species diversity of rewetted fens

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Extensive peatland drainage in Central Europe and worldwide has resulted in high rates of peat decomposition, greenhouse gas emissions, surface and groundwater eutrophication, and habitat loss for endangered species. Nowadays farmers often abandon the cultivation of drained peatland because of raising costs and decreasing economic benefits. From an environmental, social, and economic point of view rewetting these areas is important to reverse the above mentioned negative impacts of drainage. Developing and implementing new forms of biomass use on rewetted peatlands as a renewable resource (e.g. biofuels or insulation materials) would provide alternative income sources for farmers. At the same time this so called paludiculture can help to preserve the remaining peat body with its environmental functions and therefore displays an alternative way of site adapted utilization.

In Western Pomerania many formerly drained fens have been rewetted without any management measures, i.e. allowing free succession. These sites are characterized by a mosaic of a few dominant rhizomatous helophytes (e.g. *Phragmites, Typha, Phalaris, Glyceria*). However, a few examples of long-term cutting with different mowing regimes exist (winter & summer mowing). In our study we investigated the effect of different cutting regimes on the vegetation and species diversity in rewetted fens to evaluate how annual cutting relates to nature conservation aims for fens.

Preliminary results show that rewetted fens without cutting show a higher species density and harbour more endangered species compared to managed sites. Our results are in contrast to the common expectation that regular mowing on meadows leads to an increase of plant diversity.

Keywords: vegetation, cut, harvest, fen, species diversity

Common reed (*Phragmites australis*) fuel pellets and habitat management

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In North America, common reed (*Phragmites australis*) is widespread and abundant in wetlands and on altered soils and constitutes nonnative and native subspecies. Nonnative Old World reed (*P. a. australis*) is considered an environmental weed that should be eradicated. Nonetheless, reed provides considerable ecosystem services, including carbon sequestration, water quality maintenance, sequestration of heavy metals, accretion and stabilization of sediments where sea level is rising, self-maintaining vegetation in vacant urban and industrial areas, domestic wastewater and sludge treatment, and habitat for many native animals and plants. Extensive dense reedbeds are less suitable habitat for native biota than sparse, mixed-species, or patchy reedbeds. Habitat functions can be enhanced for certain marsh birds and other biota by selective removal of reed biomass. Harvested reeds from such managed habitats or from reed eradication sites are potentially a high quality bioenergy feedstock that could be used to produce fuel bricks or pellets, methane, or other fuels. Energy reeds could be harvested in winter using idle farm equipment in existing reed-dominated wetlands and uplands, which would require little or no energy and fertilizer inputs. Reed is as good a feedstock for fuel pellets as switchgrass (*Panicum virgatum*) in most respects. We analyzed reed pellets manufactured by TechnoPhrag from pooled sources in the Montréal region. These pellets contained 6.4% moisture, 3.44% ash, 16,893 joules per gram energy, and ca. 1800 ppm chlorine; levels of several toxic elements were low. The chlorine content exceeds the 300 ppm Pellet Fuels Institute guideline, thus energy reeds might need to be harvested from wetlands selected for low chlorinity. In order for reed to be developed as an efficient and safe biofuel, the methodology for goal-directed management of reedbed ecosystem services, the carbon inputs and outputs, and the potential remobilization of contaminants, should be considered.

Keywords: biodiversity; bioenergy; ecosystem services; habitat management; North America; Phragmites

PRODUCTIVITY & SITE CHARACTERISTICS

Multipurpose planning of the Finnish coastline

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The results of Southern Finnish coastline reed mapping have showed the expansion of reed beds now covering even 10% of total area of some coastal municipalities in Southwest Finland. The total area of reed stands of Southern Finnish coastline was estimated via GIS – analysis of selected satellite images to reveal ca. 30 000 hectares of reed beds. The total number of reed beds in Finland is estimated to be ca. 100 000 hectares. The reverse side of encroachment of reed beds is the area of managed coastal meadows in Finland, that has declined from 40 000 hectares (1950s) to present 4000 hectares which has led to unsustainable network of coastal meadow habitats causing decline of typical and rare coastal meadow species and ecosystem services connected to recreation, water protection and landscape values (Ikonen and Hagelberg).

It is important to find out how we can create and regain optimal ecosystem service network for our coastline via sustainable multipurpose planning. The focus is in finding balance between utilisation, management and preservation of reed beds and coastal meadows. Finnish Ministry of Environment, together with Finnish Ministry of Agriculture, has set up an national group (Multipurpose planning of Finnish coastline) in order to create guide for multipurpose planning of whole Finnish coastline by the end of 2013 and preparation for new kind of sustainable financing incentives included in the Rural development Programme 2014-2020.

New developed support suggestions, including support for reed cutting, nutrient recycling of green biomass and investment supports for entrepreneurs are aiming at remarkable restoration of coastal meadows and management and utilisation of reed beds by the end of 2020. In win-win situation nature, local people and entrepreneurs would all benefit.

Keywords: reed beds, remote sensing, ecosystem services, utilization

Remote monitoring of reed expansion on the coasts of the Baltic Sea and on the shores of large shallow lakes

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National environmental monitoring programme in Estonia includes satellite-based remote monitoring of coastal areas on the shores of the Baltic Sea and on the shores of two large shallow lakes: Lake Võrtsjärv (270 km^2) and Lake Peipsi (3,555 km^2).

We developed a methodology for evaluating a time series of coastal reed dynamics for Estonia and for the neighbouring to Estonia coastal areas on the Baltic Sea in Russia and in Latvia.

The time series of monitoring relies on medium resolution Landsat Thematic Mapper and Landsat Enhanced Thematic Mapper Plus images owing to their long image archive. The time period covers dates from 1985 till 2012. An original non-parametric image interpretation and vegetation classification methodology has been applied on late summer images for image classification. A combined spatial and statistical analysis has revealed factors that support or inhibit reed growth and can help to point on locations of major reed production for renewable use. The medium resolution images are supported by high resolution satellite images and ground-based GPS-recordings of reed belt boundary, which were used for the refinement of classification decisions and for the validation of results.

Keywords: coastal reeds, Baltic Sea, Lake Peipsi, satellite imagery

Common reed as a promising natural energy crop in Estonia

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The Common Reed (*Phragmites australis*) is a perennial grass common in coastal areas and wetlands in different places in Estonia. Reed is amongst the most productive plant species in the Baltic Sea Region due to high bio-production per unit of growing area. One of the most important variables describing the energy use possibilities of the biomass is the annual biomass yield, irrespective of whether biomass is used for direct combustion in boilers or in converting to bio fuels and biogas. The measured average summer yield of reed by dry matter in Estonia in period 2006-2011 is 9.14 t/ha and for winter reed is 7.36 t/ha in the same period. On-site mapping of the reed areas revealed at the same time that the total reed bed area along the Estonian coasts can be considerably high, approximately 20 000 hectares to which the reed beds in lakes can add up to 6,000 hectares. From ancient times Common Reed has been used for different purposes mainly in thatching. Rather new uses of reed are combustion in boiler houses and converting into solid, liquid and

gaseous bio fuels. By preliminary estimations, up to 260 GWh of reed energy could be environmentally friendly harvested every year in Estonia.

This paper presents the results of mapping sustainable reed resources in Estonia that can be used for energy production through direct combustion and converting into bio fuels. Additionally the risks of achieving yield potential of winter reed are discussed.

Keywords: common reed, annual yield, resources of reed

Potential of paludiculture in North East Germany

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The region of Western Pomerania in north east Germany is one hot spot of peatland degradation in the world. About 19% of the land is covered with peatlands (>140,000 ha) which were mainly drained during the last centuries. Because of peat degradation and subsidence the current land use on lots of these peatlands comes to a dead end. Already 12% of the peatlands have been restored for nature conservation but more and more re-wetting induce regional conflicts and lead to a loss of agricultural land respectively. Paludiculture, the wet peatland management may offer new perspectives to stop peat degradation and continue the agricultural use on formerly deep drained peatlands. To implement this new integrative type of land use an interdisciplinary approach is needed which also includes the interests and knowledge of various players. Large changes are needed to transform the current land use. New processing lines are needed for potential paludiculture crops like reed (*Phragmites australis*) and cattail (*Typha* spec.) which can grow under water saturated conditions. Therefore the project VIP – Vorpommern Initiative Paludiculture developed new products from this biomass, tested new harvesting techniques but also evaluated the harvesting effects to greenhouse gas emissions and biodiversity of these sites. Various options have been investigated to use the biomass from wet peatlands as biofuel or as a raw material for construction material. But there are still a lot of technical and political problems which must be solved to implement paludiculture in a large scale. In my talk I will present the new perspectives of a wet peatland management but also the problems which hinder the transformation of the current land use on peatlands.

Keywords: peatland management, reed harvesting and processing, options and barriers

Abstracts Poster Presentations

ECOSYSTEM SERVICES

On the influence of a summer freshwater flooding on methane emissions from a 15-year re-wetted fen

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Re-wetting minerotrophic fens has become an important mitigation strategy of climate change in Germany. However, recent studies report elevated methane (CH_4) emissions during the first years after flooding. A minerotrophic fen in North-East Germany that was re-wetted 15 years ago was exposed to exceptionally heavy rainfalls and a freshwater flooding in August 2011. We measured CH_4 emissions biweekly from March 2011 to March 2012 with extra samplings during the flooding using the closed-chamber method on wetland vegetation stands dominated by *Phragmites australis* L., *Typha latifolia* L. and *Carex acutiformis* L.. The annual emissions were 18.5 ± 1.5, 21.1 ± 1.2 and 47.5 ± 5.0 g m^{-2} a^{-1} CH_4, with the August emissions contributing 40 %, 50 %, and 10 % of the annual emissions, respectively. Despite the freshwater flooding in August, CH_4 emissions from the 15-year re-wetted fen are in the same order of magnitude as those reported from pristine fens. These results indicate that elevated CH_4 emissions will not last for decades and even a flooding event does not alter CH_4 emissions considerably. Hence, re-wetting can reach the goal of reducing greenhouse gas emissions from minerotrophic fens.

Keywords: peatland, heavy rainfall, Phragmites, Typha, Carex

Impact of biomass harvesting on greenhouse gas balances of a rewetted fen

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In peatlands, emergent plants often channel a large fraction of the emitted greenhouse gases (GHGs). Therefore, the GHG balance of peatland ecosystems may be altered if vegetation is removed for agricultural purposes. This is critical with respect to the aim of alternative land use options on rewetted fens to decrease GHG emissions.

We currently investigate the impact of biomass harvesting on greenhouse gas emissions (CH_4, N_2O and CO_2) of a rewetted fen in NE Germany. Closed-chamber measurements have been conducted over almost two years in dominant stands of the potential crop plants common reed (*Phragmites australis*), cattail (*Typha latifolia*) and lesser pond-sedge (*Carex acutiformis*). The vegetation of half of our measurement spots was harvested once per year (during winter in the *P. australis* and *T. latifolia* stand; during summer in *C. acutiformis*).

Our study period covered one very wet and one dry year. Preliminary results indicate an uptake of CO_2 over the years irrespective of dominant vegetation. However, the harvested sites of *Phragmites* and *Carex* sequestered more carbon than the controls. The highest CH_4 emissions can be found in the *Carex* stand. Harvesting seems to have no significant effect on methane emissions of all vegetation stands. Emissions of N_2O during the whole year lay below the detection limit. Overall, the harvested sites of *Phragmites* and *Typha* stands have the lowest global warming potentials if only direct emissions are regarded. In general the measured greenhouse gas balances fall within the range of pristine peatlands. We conclude that biomass harvesting seems to have no effect on the GHG balance of rewetted peatlands.

Keywords: Phragmites, Typha, Carex, cutting, methane, carbon dioxide

The effect of mowing on the GHG emissions from a reed sedge fen in Southern Belarus

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Wet and very productive fens also represent a potentially interesting source for the production of energy plants to substitute fossil fuels. A complete evaluation of the climate benefits needs to take into account the influence of activity like mowing on the GHG emissions of these sites too. However, there is not much literature on that issue. The aim of the work within a BMU/KfW financed climate mitigation project was to identify the effect of mowing by ratrack on the GHG balance in Belarusian fens. The study site is a natural fen in the Jasielda valley in southern Belarus (Paliessie region). We studied two vegetation types, one dominated by sedges and one by reed. The plant shoots were cut in November 2011 at one part of the plots while the second was left as control (each with three replications). Measuring of GHG exchange on the mowing plots started from April 2012, while measuring of GHG exchange on the control plots is running since July 2010 using the closed chamber method of Drösler (2005).

At the conference we will report about the effects of mowing on the current net CO_2 exchange, the GHG flux dynamics, the peat carbon budget, and the climate balance.

Keywords: reed fen, greenhouse gas emissions, mowing

Reed canary grass and grass ley as bio-energy crops on peat soils

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The aim of the study was to investigate whether reed canary grass is a better option than grass ley in the production of substrates for biogas reactors. Reed canary grass can withstand a higher groundwater level while maintaining a high production and competes well for the nitrogen in the soil. Greenhouse gas emissions (CO_2 and N_2O) and yield of ley and reed canary grass grown with different drainage intensities were compared on a fen peat soil located on the farm Majnegården outside Falköping, Sweden (58.12371N 13.5378E) The field trial was conducted during 2011 and 2012. 8 plots of reed canary grass and 8 plots of ley were established. GHG emissions were measured with the dark chamber method. Yield was measured by cutting, drying and weighing the crop from 1 square meter and the dry matter was analyzed for nitrogen content. The different drainage intensities did not result in significantly different water content in the upper part of the soil. Reed canary grass had a higher dry matter yield (11.1 and 12.2 ton for 2011 and 2012 respectively) than ley (8.3 and 7.0 ton for 2011 and 2012 respectively) with a corresponding uptake of nitrogen of 201 kg/ha compared to 155 kg/ha for ley. CO_2 emissions varied between 421 and 2600 mg $CO_2/m_2/h$ from the ley (average 1370) and 120 and 2882 mg $CO_2/m_2/h$ for the reed canary grass (average 1470). The N_2O emissions were very erratic. The highest emissions were from ley between the drainage tiles in October 2011 (1983 $\mu g/m_2/h$). Both the yield and the total nitrogen uptake were higher by the reed canary grass, while there was no significant difference in GHG emissions between the crops. Overall, this indicates that reed canary grass is a suitable bio-energy crop on peat soils.

Keywords: peat, reed canary grass, CO_2, N_2O, GHG emission

Biogeochemical tools to understand the environmental impact of the cultivation of reed canary grass as a bioenergy crop on drained organic soils in Finland

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Eddy covariance and chamber measurements of greenhouse exchange were made from 2004-2011 on a drained organic soil cultivated with a perennial bioenergy crop (reed canary grass (RCG), *Phalaris arundinaceae* L.) in eastern Finland. The study years were

climatically different and thus provided us an opportunity to examine the influence of changing climatic conditions on the RCG CO_2 and water vapor exchange. Wet years were characterized by an even distribution of seasonal precipitation, low to moderate air and soil temperatures, lower solar and net radiation intensities, moderate to saturated soil moisture conditions and lower vapour pressure deficit. These climatic conditions resulted in high bulk surface conductance (g_s), high evapotranspiration (ET). These conditions were favourable for a high uptake of atmospheric CO_2. Dry years, on the contrary, were marked by long dry spells during important phases of crop growth, climatic and soil moisture stress leading to high evaporative demand, low g_s values, reduced evapotranspiration. Owing to the ability of this perennial crop to sequester large amounts of atmospheric carbon into its above- and below-ground biomass, the water use efficiency (defined as the slope of the linear regression of monthly values of GEP against ET) of this cultivation system was found to be 9.1 g CO_2 per kg of H_2O lost as ET. The results stemming from this work support our conclusions that this bioenergy system is a suitable land use option on drained and abandoned cutover peatlands with a high potential for offsetting CO_2 load to the atmosphere.

Keywords: Phalaris, changing climate and precipitation, CO_2, water use efficiency

Effects of land use change on fen soils nutrient dynamics in the nature park Ohre-Drömling

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In the Nature Park Drömling a trade-off exists between the ban of deterioration of the FFH habitat type 6510 and rewetting to preserve typical fen soils. The study aimed of the development of optimized management strategies for this habitant type. It has to be ensured that the main receiving water course, the Ohre River (a tributary of the Elbe River) will not be burdened with additional nutrients, because a considerable part of the total runoff is used for groundwater recharge to ensure drinking water supply of Greater Magdeburg. An in situ experiment was established at two test fields' which comprises two differentiated fertilization and management levels. At least two stakeholder conflicts are important:

(1) to safeguard the raw water quality and assuring the quality of raw water that is needed for a sustainable drinking water supply of the Magdeburg region and (2) to rewet fen sites in the Drömling area for ecosystem renewal and nature protection. The project focused on the rewetting of the specific site FFH habitat type (HT) 6510. The hypothesis is that K, which is limiting factor, must be additionally fertilized to exploit available nutrients to produce a higher biomass yield and hence to prevent a nutrient burden of the Ohre

River. The concentrations of macro-nutrients (nitrogen, phosphorus, potassium) in soil, soil water and plant biomass were analysed. First results of two year field experiments were presented.

The results showed that the soil of the sites was good supplied with the nitrogen and phosphorus but potassium (K) was the limited yield factor. Another conclusion was that the different grassland management had no influence of soil, near surface groundwater and plant biomass nutritions. However the application of potash 60 showed impacts of the soil water regimes and also of the quality parameter of soil, plant biomass and the draining ditch.

The results were a practical contribution to the preservation and development of both, the LRT 6510 and the fen.

Keywords: fens, extensive grassland managements, nature park Drömling, rewetting

Harvesting common reed for bioenergy and to improve the condition of Northern Karelian waters

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Vast areas on the shorelines along the lakes Heposelkä, Pyhäselkä and Ätäskö have been taken over by common reed (*Phragmites australis*). Biodiversity and recreational use of the lakes has suffered due to these changes. There aren't enough funds to restore even the protected areas on these lakes and estate owners cannot afford to cut the reed or do dredging at their own expense. Our aim is to create sustainable ways of restoring the shorelines to improve biodiversity and to encourage contractors to invest on suitable technology and thus create jobs for the local people. In order to achieve these goals we need to have use for the biomasses gathered from the shores. In our project we try out different ways of using reed and sediment materials in order to find economically sound ways to restore the shorelines and use Life Cycle Assessment methods to do this. We also evaluate how the present environmental legislation allows these kinds of actions and develop methods to estimate the distribution and amount of reed on our study lakes. Due to our project we hope to have improved biodiversity and environment as well as conditions for recreational use. As a result we may have increased the value of estates on the shorelines, create new jobs in construction and after use of the biomasses as well as maintained present jobs in tourism.

Keywords: common reed, sediments, biodiversity, harvesting, restoration, employment, environmental legislation, recreational use

Dynamics of aboveground biomass of a sedge fen

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This thesis is part of Project of the Grant Agency of the Czech Republic No P504/11/1151, focused on the role of plants in the greenhouse gas budget of a sedge fen. The thesis deals with the growth dynamics of the dominant sedge, *Carex acuta* L., on the study site, Wet Meadows near Třeboň, Czech Republic. The seasonal changes in aboveground biomass were followed using successive harvests during vegetation seasons of 2010 and 2011.

The seasonal maximum of aboveground biomass of *Carex acuta* L. (both live and dead parts) was 321.44 g m^{-2} and 357.97 g m^{-2} in 2010 and 2011, respectively. The seasonal maximum of total aboveground biomass of all species was 558.22 g m^{-2} and 522.38 g m^{-2} in 2010 and 2011, respectively. The seasonal maximum of shoot density was 485 ks m^{-2} and 435 ks/m^2 in 2010 and 2011, respectively.

Keywords: Třeboň region, Carex acuta L., aboveground biomass, wetland, destructive method

POTENTIAL ANALYSIS

The current land use in the fen Thurbruch (Usedom, NE Germany) and their potentials of changing to paludiculture farming system

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The project "Vorpommern Initiative Paludiculture" investigates how farmers can apply large scale "paludiculture", i.e. agriculture on wet (undrained and rewetted) fens. We study land use history and the current situation of grassland farming in one specific region, Thurbruch, a 1,600 ha drained fen on the island of Usedom in NE Germany. We assess the current situation of beef and dairy cattle farming, with high costs for drainage and high emissions through mineralisation, by interviews of stakeholders and analysis of a digital terrain model (DTM). We map out a future scenario of the ground level elevation, suppose ongoing subsidence through drainage and discuss the potentials of land use after rewetting in this area.

Keywords: land use potentials, digital terrain model, paludiculture

Reed for bioenergy and construction in SW Finland

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The abundantly growing common reed has taken over eutrophicated seaside bays in the northern Baltic Sea and lake shores. Harvesting reed is necessary to maintain biodiversity and open water areas. On the other hand, reed is a multifunctional plant material and forms a local bioenergy and roof thatching potential. Turku University of Applied Sciences (TUAS) has carried out a number of projects to examine the utilization and sustainable management of coastal reed beds. The proper management of reed beds leads to sustainable use of biomass, and in addition has positive effects on water quality and recreation.

A previous reed project brought out the concept of integrated coastal planning. It created a framework for the wider utilization of coastal reed beds and gave background for the project COFREEN, which focuses on bioenergy production with reed, and looks for new ways to use reed in the construction. The project delves into the utilization theme and develops cooperation, knowhow and practices, which can be outright implemented. The objective of the project is to execute sustainable management of reed beds in southern Finland, Estonia and Latvia.

Main challenges in Finland relate to lack of multipurpose harvesting machinery in varying conditions, and lack of tradition. The more phases in processing and transporting reed, the higher the costs are. Thus, numerous immaterial benefits of reed cutting should be taken into account and valued. Achievements and major bottlenecks are discussed.

New perspectives in reed utilization are foreseen in bio-composite development. TUAS is looking for new, innovative ways and cooperation of continuing working with reed in the future.

Keywords: common reed, bioenergy, construction, harvesting

Characterization of peatlands soils and substrates for assessing agronomy potential in the Acadian Peninsula (New Brunswick, Canada).

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The perennial herbaceous or shrubby crops offer several ecological and environmental advantages in comparison to annual crops. After their implantation, long periods without plowing reduces the risk of erosion, while increasing carbon sequestration in the soil. In addition, they reduce the dependence on fossil fuels and CO_2 emissions. The fast-growing willow (*Salix viminalis*) and reed canary grass (*Phalaris arundinacea*) are natural renewable resources that can be used for restoration and environmental claims with an added value of the Acadian Peninsula peatlands in New Brunswick (Canada). The objectives of this study were to: (i) determine the physico-chemical and hydrological characteristic of the New-Brunswick peatlands and evaluate their agricultural potential, their fertility status and the nature of the substrate they contain and (ii) offer to the New Brunswick peat industry a great alternative opportunity of value added of residual peatlands by developing energy crops production while maintaining hydrologic and ecological function of residual bogs. The study was conducted in 2012 on three residual peatlands of Sun Gro Ltd in Lamèque (New Brunswick, Canada) with the Coastal Zones Research Institute (Shippagan, New Brunswick, Canada). The fast-growing willow (*Salix viminalis*) and reed canary grass (*Phalaris arundinacea*), with excellent adaptability to the northern climate and a wide range of soil types, including soil moist and cool as it's found in New Brunswick bogs were planted in unfertilized acid substrates collected in residual peatlands. Despite the poverty of the soil in a few minor elements (B, Mg, Zn) and some major elements (N, K), the first growth test for these two plants show that the physico-chemical and hydrological peat soil can allow the development of energy crops on several residual peatland soils. These crops can also be used directly as biofuel with minimal processing prior to fill the needs of the renewable energy peat industry in New Brunswick.

Keywords: peatland soil, Phalaris, Salix, agricultural potential, northern climate

Coastal reed beds in the Baltic Sea and assessment of the potential for use

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Proper inventory of reed bed areas and reed biomass can only be done on the basis of continuous monitoring. Such an observation system is, however, for the time being missing in most countries of the Baltic Sea Region. Therefore, a study was initiated within the project SUBMARINER to carry out a steady state assessment of the common reed resources along the coasts of the Baltic Sea including the coastal lagoons. The total area of reed in the Baltic Sea probably exceeds 300,000 ha. The total annual biomass of the aboveground part of common reed in the Baltic Sea that can potentially be used is up to one million tonnes, though the resource is quite unevenly divided. The potential annually usable resource constitutes no more than one third of the aboveground biomass in the Baltic Sea and can be much lower in protected coastal areas. Based on those assumptions it can be concluded that the annual energy potential of reed along the Baltic coasts is no more than 4 TWh and can be lower considering that part of the reed resource will be used for other purposes e.g. construction material. Based on the most optimistic scenario, harvesting of reed provides up to 1 % of nitrogen reduction, compared to the target level set by the HELCOM Baltic Sea Action Plan. The large variation in reed available biomass yield data as well as the differences in chemical composition and physical properties of reed highlights the need for further studies about reed productivity and environment friendly utilization.

Keywords: Baltic Sea, reed area, biomass, energy potential, nitrogen reduction

Paludiculture potential in Ireland

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Details: This poster will outline the recommendation for paludiculture in Ireland by the Environment Protection Agency. Paludiculture trials conducted by Bord na Mona to date will be described, and the data from these will be outlined. Resulting from these initiatives, information will be detailed regarding the requirement for a reed species which is suitable for the Irish climate. Ongoing and future projects by the State harvester will be outlined. Bord na Mona's commitment to sustainability, such as its Biodiversity Action Plan 2010-2015 and its "New Contract With Nature" will be noted. Potential projects for private peatland owners will included, such as growing reeds to meet the demand for thatch.

Keywords: biofuel, biomass, bogs, Bord na Mona, Ireland, paludiculture, peatland, reeds, sphagnum moss.

A decision support system for the sustainable use of peatlands

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Conventional agricultural and forestry use of wetlands require increasing drainage intensity. Due to drainage, cultivation and fertilization, wetlands emit large amounts of nutrients into adjacent ecosystems, and greenhouse gases into the atmosphere. Associated with these processes are the degradation of the organic soil and the loss of biodiversity.

We have developed a Decision Support System (DSS) that provides basic information to farmers and planners to enable them to use peatlands in a sustainable fashion by conserving peat. The DSS proposes new land use options both for peatlands currently used for agricultural purposes and uncultivated, degraded ones.

The DSS processes all collected data following a decision matrix. It consists of two main stages. In the first stage land-use options (for example reed, *Typha*, water buffalo) are generated that are suitable for the type of land in question. In the second stage, the most suitable measures for land conversion are identified. The user is given a report containing a list of measures that need to be adopted to facilitate the conversion to the new type of land use, and a summary of every parameter relevant to the decision-making process.

The DSS is based on a modular concept. Dichotomous decision trees are used as main model elements with the identified decision relevant parameters. The DSS gives a basic instruction to every branching point, explaining the decision relevant criteria and classification scheme, and providing further information such as references, weblinks or visual materials. Notable features of the DSS are its capacity to yield reliable solutions based on limited data, and its transparent decision-making process.

The DSS is suitable for producing tailor-made proposals for the sustainable use of peatlands that are currently used for agricultural purposes or uncultivated, degraded ones. The DSS will be published as an illustrated and user-friendly web-based application. The first draft of the DSS will be published spring 2013.

Keywords: soil degradation, rewetting, management strategy, wetlands, non-intensive use, paludiculture, organic soils, peat-conserving, peat-protecting, DSS

ENERGETIC & MATERIAL USE

Usage of harvested common reed – pellets for burning and bedding

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Common reed (*Phragmites australis*) is largely available biomass in Finland. EU obligations for maintaining fresh water quality will create a pressure to harvest thousands of tons of reed annually in the future. Reed is not very good fuel to be burned. Finland has already bad experiences in trying to introduce reed canary (*Phalaris arundinacea*) as a fuel. One potential use of reed is animal bedding. Especially pelletized cheap grass-based biomasses are used for animal bedding already in some extent. University of Eastern Finland made together with Finnish Environmental Institute a study, where reed was pelletized and animal bedding properties of pellets were tested with two different kinds of scientific methods. Results show that technical characteristics of pellets were good from bedding use point of view but dust can cause problems in use if effective dust binders are not used.

Keywords: common reed, burning, pellets, animal bedding, technical characteristics

Solid biofuels from rewetted fens: Combustibility of *Phragmites australis* at different sites and harvest times in NE Germany

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A remarkable amount of greenhouse gas emissions are generated by the drainage of peatlands for agriculture in Western Pomerania (NE Germany). Using biomass from rewetted fens as a renewable energy will preserve peat soils as a carbon sink. At the same time the growing biomass can serve as a renewable resource in order to meet regional demands for energy and raw materials.

In Western Pomerania *Phragmites australis* builds large mono-dominant stands in rewetted fens. There have been studies in Northern Europe indicating that *Phragmites* harvested in winter is more suitable for combustion than common energy crops like *Miscanthus*, because of leaching and relocation of nutrients and metals during the winter month. However, little is known about how strong combustion quality of *Phragmites*

differs under different site conditions or harvest dates, especially on fen soils. Important combustion characteristics like ash deformation temperature, ash content, calorific value and gas emissions are defined by the content of C, H, O, N, S, P, Cl, Ca, Mg, K and Na in the aboveground biomass.

In this study we investigated how strong *Phragmites*-biomass quality for combustion differs under different site conditions and two harvest dates, autumn and winter. According to our preliminary results, the readily soluble elements Cl and K comprise less than 0,1% of the dry weight of late-harvest reed biomass. The Cl contents of biomass from brackish and non-brackish sites are equally low after the winter, while they still vary in autumn. This suggests that leaching evens out at least some site-related differences in chemical composition of reed biomass. The contents of less soluble elements like N and P also decreased, but to a lesser degree. We assume that their decrease results less from leaching than from their being relocated to the roots of the plants at the end of the growing season.

Keywords: bioenergy, Phragmites australis, combustibility, rewetted peatlands, late harvest, fuel quality

Sustainable production of common reed as an energy source from wet peatlands

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The global biomass demand for food and fodder as well as for energy production will continuously increase in the near future, leading to increasing pressure on land and probably adverse effects on ecosystems and especially climate. For example, agriculture and forestry on drained peatlands substantially alters physical, biological and chemical soil properties and results in peat degradation, accompanied by huge CO_2 emissions. This paper describes an alternative, wise use of peatlands for energy production, avoiding ecosystem degradation. common reed (*Phragmites australis*), a peat forming plant offers high biomass yields (3.6-43 t dry matter per ha and year) and can be used as biofuel for the generation of heat and power. The heating value of reed (17.7 MJ/kg) is remarkable and comparable with Miscanthus. Modified conventional agricultural technologies are suitable to harvest, compact, transport and store the reed. Furthermore well established conversion technologies as e.g. boiler technologies for straw can be used for the utilization of the reed biomass.

Keywords: Phragmites, biomass, heating value, CO_2, agricultural technologies

Life cycle assessment of energy biomass from rewetted peatlands

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Using a life cycle assessment approach, the energy demand and greenhouse gas emissions of energy crop production on rewetted peatlands were estimated. The results show that the primary energy consumed during the analysed life cycles is small compared to the energy content of the biomass. If hard coal is substituted by biomass from rewetted peatlands, between 82 % and 92 % of the greenhouse gas emissions and between 70 % and 83 % primary energy depletion can be avoided.

The substitution of hard coal by biomass from rewetted peatlands as fuel in power plants offers a promising potential to reduce primary energy depletion and greenhouse gas emissions.

Keywords: life cycle assessment, energy biomass, paludiculture, rewetted peatlands.

The suitability of late harvested *Phalaris arundinacea* as feed for horses

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The health of horses is closely tied to a specific diet. A general problem is that the common used green fodder or hay supplies more energy as needed. Naturally, horses spend at least 12 hours a day with food selection and intake. But today many horses are in the maintenance metabolism and so they only need energy for maintainance metabolism or for light work. That's why "prosperity diseases" like Laminitis, Equine Metabolic Syndrom and Equine Cushing Syndrome occur frequently. Especially ponies suffer from fatty degeneration. The diet of horses today needs low-energy fodder.

In this study I examine whether it is possible to use late harvested *Phalaris arundinacea* from wet fens as feed for horses. Wet peatlands are important carbon storages and their preservation to climate protection. As one of the peatland richest areas in Germany, Mecklenburg-Western Pomerania has a special responsibility. Almost all of the peatlands have been drained and are used for agricultural reason which leads to enormous greenhouse gas emissions.

Paludiculture is an alternative way of using peatlands while they are wet. One of the occurring important species after rewetting is *Phalaris arundinacea*, a grass species, which was used for feeding horses in the past. This study examines whether late harvested *Phalaris arundinacea* from wet fens is suitable as feed for horses, with regards to their energy balance.

Keywords: Phalaris arundinacea, wet peatlands, late harvest, horses, fodder

Furan derivates from the LCF biorefinery capable of polymerisation

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Sustainable land management needs innovative solutions for creating added values with non-food crops from agricultural and wetland use like short rotation coppice with fast growing wood and reed.

In order to produce bio-based products economically it is important, for one thing, to develop new basic technologies for biorefineries as well as, for another thing, to use already nowadays known methods in a newly combined manner. In the first step of a biorefinery, biomasses containing precursors (i.e. carbohydrates, lignin, oils and proteins) are subject to a physical separation process of substances. The main products and by-products are afterwards exposed to microbiological and chemical reactions changing their substances.

It is necessary to develop efficient product lines on the basis of the carbohydrates precursor (mass fraction: 75% in LCF feedstock) in order to provide polymers, pharmaceuticals, tensides, colors, lacquers, etc. The platform chemical 5-Hydroxymethylfurfural (HMF) can be produced through acid catalysed dehydration of hexoses (e.g. cellulose).

Being a bifunctional molecule, hydroxymethylfurfural allows a specific downstream chemistry for polymer applications. Precious polymer components can be accessed through the reduction of the aldehyde function to 2,5-bis(hydroxymethyl)furan. After the oxidation of the aldehyde and the hydroxymethyl groups, furan dicarboxylic acid is obtained, which could replace terephthalic acid in PET (polyethylene terephthalate) in the future. HMF is on a key position at the development of new product stocks of the chemical industry.

In the future, the task will be to transfer the processes from laboratory to industry scale. Doing so, most attention must be paid to processes using water as a reaction medium because this is a cheap and environmentally friendly solvent. Currently, FI Biopos e.V. is cooperating with industrial partners in the research of how to use efficient catalyzer systems for the selective synthesis of HMF reaction products capable of polymerisation, such as 2,5-bishydroxymethylfuran, 2,5-furan dicarboxylic acid and the diesters of the latter: 5-hydroxymethyl-2-furan carboxylic acid, 5-formyl-2-furan carboxylic acid.

Keywords: polymerization, Hydroxymethylfurfural (HMF), new technologies, chemical industry

CASE STUDIES/PROJECT REPORTS

Utilization of wetland and riparian plants in Central Asia

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In the desert areas of Central Asia, i.e. from the Caspian Sea to China and Mongolia, wetlands play an important role for providing ecosystem services, which are provisioning fodder and other biological raw materials, regulating water cycling (e.g. water purification and groundwater recharge), and regulating the local climate. Part of those wetlands has been converted into irrigated fields, on which manly cotton and wheat is grown. Another part has been degraded due to water shortage induced by large scale irrigation projects. Compared to irrigated crops, many wetland species are less sensitive to periods of water shortage and soil salinization. These properties make them an alternative for land use in downstream regions of Central Asian river systems, because there the water supply often is not reliable. Thus, periods during which the rivers do not carry water may occur. During these periods wetland plants live on the groundwater and remain productive. Next to *Phragmites australis*, plants like *Apocynum venetum* and *A. pictum* as well as riparian forests offer opportunities for utilization. *Apocynum venetum* and *A. pictum* both can be used as medicinal plant and textile plant. The leafs are used to produce tea, which acts against high blood pressure. From the stems bast fibres similar to hemp can be extracted.

Keywords: degradation, water shortage, Apocynum, Phragmites, plant use

Popularization & set up biogas plants in Bangladesh

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Bangladesh, being situated in a hot, humid, sunny region and the landmass being criss-crossed by innumerable rivers and streams, is endowed with a plentiful supply of renewable sources of energy. Out of the various renewable (i) solar, (ii) biomass, (iii) wind and (iv) hydro power are being used in Bangladesh. These sources have already been in use in the primitive way. Bangladesh is in a favourable position in respect of the climatic conditions and availability of the raw materials for biogas production. As biomass fuels are consumed beyond their regenerative limits (unsustainable), it has become mandatory to promote efficient burning devices and conversion technologies. As huge quantity of biomass fuel is wasted due to inefficient way of burning, biogas technology can play a vital role in the conservation of biomass resources. Biogas technology, as it uses animals, In-

dustrial, Municipalities solid waste and agricultural wastes and returns the wastes as fertilizer, supplies energy as bonus. Besides fuel and fertilizer, this technology provides better hygienic conditions in the rural and urban areas with reduction of GHG as a further benefit. Because of the booming growth of poultry farms, a boom in biogas plant installation is expected. This project is mainly concerned with the above issues and The overall goal of the project is to develop and established biogas plants in Dhaka, Gazipur and Barisal district through Sewage Sludge , Agricultural and crops wastes , Industrial Wastes , Animal By-products ,fish wastes, Municipal Solid Wastes, Dry Continuous Digestion of Source Separated Waste, Practically any kind of watery organic substance, households wastes, with the ultimate goal to establish a sustainable and commercial biogas plant and technology in Bangladesh to improve socio-economic health and sanitary conditions of the rural and urban people, and to reduce GHG emissions. It is expected that this project would certainly contribute to the improvement of the living standard of the people of Bangladesh and provide income generation and also contribute to poverty reduction and country's GDP.

Key words: waste, biogas, biomass, sustainable, renewable sources

Bioenergy farms in a new landscape - applied reed canary grass research

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Reed canary grass (RCG, *Phalaris arundinacea* L.) is a potential bioenergy crop for northern Europe. It is a tall grass with a dense rhizome system that stores carbohydrates and plant nutrients during winter, so that growth can start early in spring. In Sweden the commercial RCG production is still limited to a few areas as the market is uncertain, and its profitability is low. A delayed harvest method is practised; cutting the biomass in late autumn, leaving it on the field during the winter, and harvesting in spring when it is sufficiently dry.

The aim of the project *Bioenergy farms in a new landscape* was to develop the cooperation between the different operators within the biofuel sector. Work has been done to develop harvest technique and logistics, combustion studies and cultivation experiments including variety testing. The project has been conducted by researchers at SLU, farmers and energy companies in the Västerbotten region in northern Sweden.

Harvest and logistics are considerable costs in the production of RCG. Large scale on-farm production trials have been conducted in order to find cost efficient systems. Different combinations of machines were tested for baled or bulked RCG.

Combustion studies were carried out in large boilers as well as in smaller. For burning in large boilers (district heating plants) a mixture of RCG and peat or forest residues was

used. Partly the fuel mixtures worked well, depending on boiler type. Briquettes of RCG/peat were tested in the smaller boilers, which worked well.

Both variety trials and experiments with intercropping between RCG and perennial legumes have been conducted. However, intercropping with legumes could not be recommended in a spring harvest system since too much biomass is decomposed during winter. It might be more beneficial in a two harvest system where the biomass is intended to biogas production.

Keywords: biofuel, Phalaris arundinacea, delayed harvest, logistic studies combustion studies

Sphagnum farming in Germany – 10 years on the road to sustainable growing media

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The production of biomass in wetlands can focus on minerotrophic wetlands with plants like common reed or sedges, but can also be reasonable on ombrotrophic, nutrient poor peatlands. One promising option is the cultivation of peat mosses (*Sphagnum spec*.) for horticulture.

The most important raw material for horticultural growing media is slightly decomposed, fossil 'white' *Sphagnum* peat. As 'white' peat mainly consists of peat mosses, a sustainable alternative may be found in the fresh biomass of peat mosses.

After an initial literature survey in 2001, the prospects of *Sphagnum* farming have been and are being investigated by the University of Greifswald and various partners in four projects. The overall aim is not only to offer a sustainable alternative for white peat in horticulture but also to replace widely applied unsustainable land use types, such as peat extraction, German bog grassland and maize cultivation, by a wet, site adapted and sustainable alternative – by *Sphagnum* farming.

Beside degraded bogs (i.e. bog grassland 'Deutsche Hochmoorkultur' and cut-over bogs), also open water areas are being surveyed as potential areas for Sphagnum farming using specially constructed floating mats. This option would allow bog waters not only to function as water reservoirs to supply cultivation areas in dry periods, but also as additional Sphagnum farming areas. A mosaic of rewetted peat areas (with on-the-ground cultivation) and deeper waters (with floating mat cultivation) may present the optimal constellation for Sphagnum farming on degraded bogs. Additionally Sphagnum farming on floating mats can be applied in acid water bodies in abandoned opencast mining areas.

Beside the cultivation of Sphagnum biomass also its suitability as raw material in horticultural growing media has been tested successfully in plant cultivation experiments.

10 years after the start we can conclude that Sphagnum farming in Germany is possible and promising. Its large-scale implementation is currently being investigated in two projects (www.sphagnumfarming.net).

Keywords: sphagnum farming, degraded bog, sustainable land use, growing media

Progress in the assessment of primary production by wetland herbaceous plants

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Production ecological investigations of herbaceous wetland plants and vegetation started and soon became widespread during the International Biological Programme (1965-74). Chapter 2 of the book by Westlake et al. (1998) characterizes the methodology of these investigations and summarizes their principal results. The methods used for obtaining the initial data on the basis of which net primary production by the wetland plants or plant stands is calculated are based either on direct harvesting of plant biomass, or on indirect non-destructive growth assessments calibrated by destructive ones, or on repeated measurements of net photosynthetic rate combined with assessments of the input of photosynthetically active radiation (PhAR) – so-called metabolic methods. Both the direct and indirect methodology can be refined by the application of the principles of growth analysis, developed between the 2nd and 8th decennia of the 20th century. Yield formation of wetland crops such as reeds can thus be described and interpreted. Allometric measurements relate the growth of various plant parts with one another, thus providing additional useful information. The aerodynamic method of measuring CO_2 uptake by plant stands has relatively recently developed into the eddy covariance method which enables direct assessment of CO_2 exchange between plant stands and the atmosphere. This method has gained growing attention, mainly in response to the recent interest in carbon sequestration by various ecosystem types (including wetlands) under changing environmental conditions.

Keywords: wetland plants, photosynthetic production, growth analysis, methodology

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