STUDY TOUR – GUIDE

PALUDICULTURE

Partner in the

Succow Stiftung

GREIFSWALD MIRE CENTRE

September 19th – 23th 2022

IMPRINT

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Cover photo: Biomass harvest in Sernitz peatland, biosphere reserve Schorfheide-Chorin, Brandenburg, with a Pisten Bully modified by company mera Rabeler (M. Succow).

Unless stated differently, this study tour guide was compiled from following ressources:

Gaudig, G. & Krebs, M 2022: Sphagnum farming – longterm experience in research and application cooperation in Hankhausen, Lower Saxony, Greifswald University, direct contribution.

Haberl, A. et al. 2018: Study tour guide – paludiculture (EUKI project), Michael Succow Foundation, Greifswald/Germany, 46 p.

Hübner, M. 2012: Renaturierung von Niedermoorstandorten, Alnus-Pilotfläche Brudersdorf, Forstamtsarbeit, Landesforst M-V, [Restoration of fen peatlands, Alnus-pilot site Brudersdorf, Forestry authority assessment report, State forestry authority M-V; in German] 33 p.

Kohl, M., Nordt, A., & Limberg, J., 2022: Paludiculture pilots Bargischow Süd and Polder Sundhagen in MV, Landgesellschaft M-V, direct contribution.

Wichmann, S., Neubert, J. & Köhn, N. 2022: Experience in Typha cultivation on rewetted agricultural peatland (PRIMA project) Greifswald University, direct contribution.

Wichtmann, W. et al 2019: Study tour guide – Paludiculture in Northern Germany (Interreg Desire project), Michael Succow Foundation & Greifswald University, 39 p.

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"EUKI - Carbon capturing by Baltic peatland farmers"

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

European Climate Initiative EUKI

tomoorow

UMWELTSTIFTUNG MICHAEL OTTO

Wetlands INTERNATIONAL

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I. SCHEDULE AND ROUTE

Day	Places	Contents
Monday, 19.09	Arrival and start at Berlin airport BER; ATB – Potsdam; Farm Döbritzer Heide Galloways; Brandenburg, Germany	Peatland and climate protection in Brandenburg - Paludiculture product research and upscaling - wet meadow management
Tuesday, 20.09	Greifswald, Bargischow & Sandhagen, Mecklenburg-Vorpommern, Germany	Paludiculture Pilots in Mecklenburg-Western Pomerania - Seminar day in Greifswald and surroundings.
Wednesday, 21.09	Neukalen & Malchin, Brudersdorf, Mecklenburg-Vorpommern, Germany	Typha cultivation & wet meadow management; Heat generation with paludi-biomass; Wet Alder Forestry.
Thursday, 22.09	Bad Oldesloe, Oldenburg, Hankhausen, Lower Saxony, Germany	Reed trading and product development; Peat moss farming for horticultural substrates.
Friday, 23.09	Rahmsloh; Return flight from airport Hamburg HAM, Lower Saxony, Germany	Applied peat moss substrates and processing of peat mosses in peat factory.

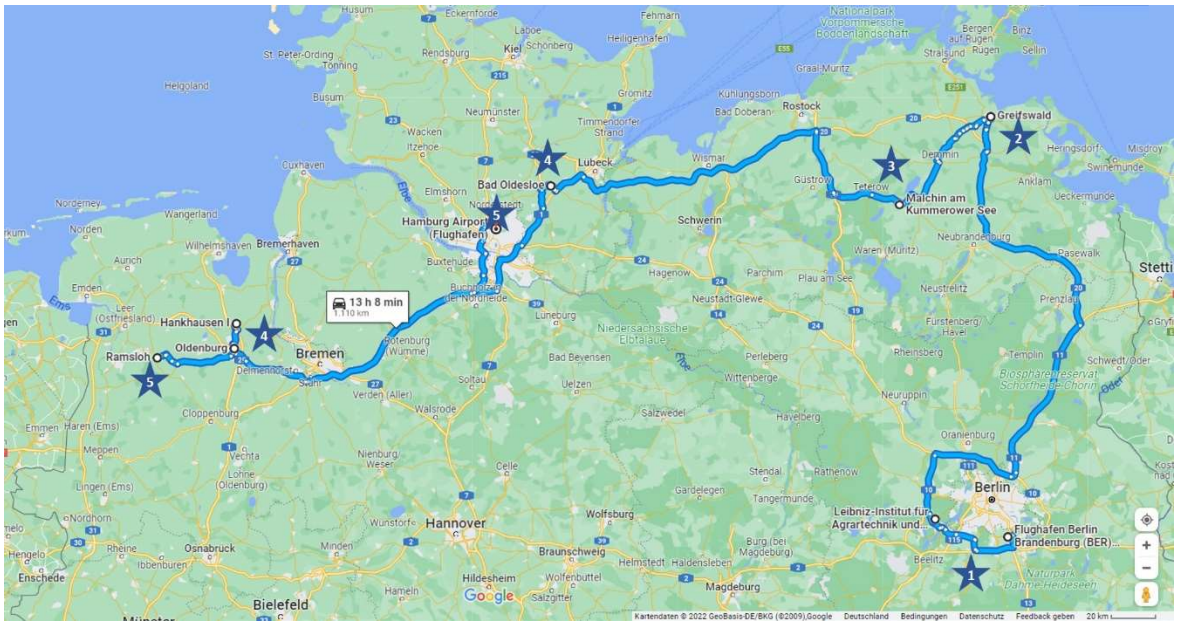

Figure: Tour map Monday 19.09 (1) – Friday 23.09 (5)

EUKI - Paludiculture Baltics

CARBON CAPTURING BY BALTIC PEATLAND FARMERS

Practical exchange for paludiculture & peatland carbon farming
https://www.succow-stiftung.de/en/peatland-climate/euki-carbon-capturing-by-baltic-peatland-farmers

More peatland climate farmers are needed to press ahead climate protection through sustainable use of wet peatlands - also in the Baltic States. Therefore, the Succow Foundation together with partners in the Baltic countries are implementing the project "Carbon capturing by Baltic peatland farmers - Practical exchange for paludiculture & peatland carbon farming". In the Baltic States, drained peat soils are responsible for 53-71% of all greenhouse gas emissions from the Baltic agricultural sector, although they cover only 5-6% of the agricultural soils in the Baltic States. The users of these peat soils, primarily farmers and foresters, cannot change this on their own. In order to switch to wet and climate-smart land use, they need support. To enable them to produce renewable biomass in paludiculture for carbon-neutral or even carbon-negative products in the food, construction or energy sectors, the Succow Foundation and its partners impart knowledge and practical experience on climate-neutral management of peatland sites.

In cooperation with Baltic agri-cultural extension services the Project partners develop training programs and trains farmers in workshops. Paludiculture exhibitions are compiled and then presented at relevant events. Baltic practitioners will travel to German paludiculture pilots along a study tour. The project monitors paludiculture pilots and establishes a Pan-Baltic network for paludiculture and peatland climate economy. It also develops compensation plans for paludiculture and peatland climate management. For policy advice the project will funnel these plans in the political institutions in the Baltic States from local to national level.

Implementing Partners:

Succow Stiftung

E L F

EZERU UN PURVU IZPĒTES CENTRS

PELKIŲ ATKŪRIMO IR APSAUGOS FONDAS

“EUKI - Carbon capturing by Baltic peatland farmers”

Supported by:

Federal Ministry for Economic Affairs and Climate Action

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Box 1 What is paludiculture?

"Paludiculture is the agricultural or silvicultural use of wet and rewetted peatlands. Paludiculture uses spontaneously grown or cultivated biomass from wet peatlands under conditions in which the peat is conserved or even newly formed (Wichtmann & Joosten 2007). Paludiculture differs fundamentally from drainage based conventional peatland use, which leads to huge emissions of greenhouse gases and nutrients and eventually destroys its own production base through peat degradation (Joosten et al. 2012). Paludiculture allows the re-establishment and maintenance of ecosystem services of wet peatlands such as carbon sequestration and storage, water and nutrient retention, as well as local climate cooling and habitat provision for rare species (Chapter 5; Joosten et al. 2012, Wichtmann et al. 2010). Paludiculture implies an agricultural paradigm shift. Instead of draining them, peatlands are used under peat-conserving permanent wet conditions. Deeply drained and highly degraded peatlands have the greatest need for action from an environmental point of view and provide the largest land potential. The implementation of paludiculture is the best choice for degraded peatlands. Paludiculture is a worldwide applicable land management system to continue land use on rewetted degraded peatlands after rewetting. Various plants can be cultivated profitable under wet conditions. Paludiculture is also a land use alternative for natural peatlands particular for regions where the increasing demand for productive land drives the drainage. Because of their vulnerable ecosystem services, pristine peatlands should best be protected entirely. If land use on pristine mires is unavoidable, paludiculture should always be given preference over drainage-based land use (Joosten et al. 2012; Wichtmann et al. 2016).

Paludiculture Crops

Reed canary grass (Phalaris arundinacea) is growing fast, the yields are high, and it burns well. Therefore, it is highly suitable to produce energy. Reed canary grass meadow can also be used as a wetland buffer zone for nutrients; water is directed from the drainage ditches of agricultural lands to re-vegetated peatlands. In this way, reed canary grass can be fertilised, and nutrients removed. It is worth noting that the Estonian variety "Pedja" is cultivated as forage plant, and in Sweden, for example, paper is produced from reed canary grass.

Cattail (Typha spec.) can be used as fodder and energy plant, additionally it is often used as insulation material and for boards in the eco-construction sector. As a pioneering species of wet and muddy lands, it grows well in the restored peatlands and rapidly forms a dense plant cover.

Common reed (Phragmites australis) can be used as a construction material e.g. for roof thatching or construction boards, in handicrafts, and as fuel in heating plants. Because the common reed can withstand brackish water, this plant can be collected also from coastal wetlands. It has good combustion properties e.g. calorific value comparable to wood, mineral contents in comparison to reed from peatlands is lower than e.g. in cereal straw from mineral soils what means less ash during combustion, if harvested in winter low contents in problematic substances, see also Box 9.

Sedges (Carex spec.) are used both as energy and forage plants, but also as a raw material for paper. Compared to the reed canary grass or the common reed, the sedges are more tolerant towards the nutrients found in soil.

Peat mosses (Sphagnum spec.) are adapted to the nutrient poor and acid conditions in rainfed mires (bogs). In natural bogs they formed over millennia slightly decomposed nutrient poor peats the so-called white peat which nowadays is the most important raw material used for professional horticulture substrates on industrial level. Fresh peat moss biomass shows the same properties as white peat and can be cultivated in short rotation fields. That can be harvested every 3-5 years (see Excursion Day 4 Site 2).

MONDAY 19TH SEPTEMBER

Excursion Day 1

II. SCHEDULE AND ROUTE

Time	Places	Contents
10:00	Start from Berlin airport (BER)	Tour bus with 50 places for all participants of the tour.
11:00-13:00	ATB Potsdam - Leibniz Institute of Agricultural Engineering and Bio-economy	Seminar: "Fibres and materials from Paludiculture biomass, market perspectives and upscaling of processing"; Guided tour to experimental production facilities of ATB
13:30-16:00	Döberitzer Heide Galloway - farm	Water buffaloes and wetland management with adapted agricultural grassland equipment.
16:30	Project site of Arge KlimaMoor BB	Paludiculture pilot site assessment and strategy in Brandenburg.
17:00	Transfer to Greifswald	
20:00	Hotel in Greifswald	Dinner buffet at the hotel

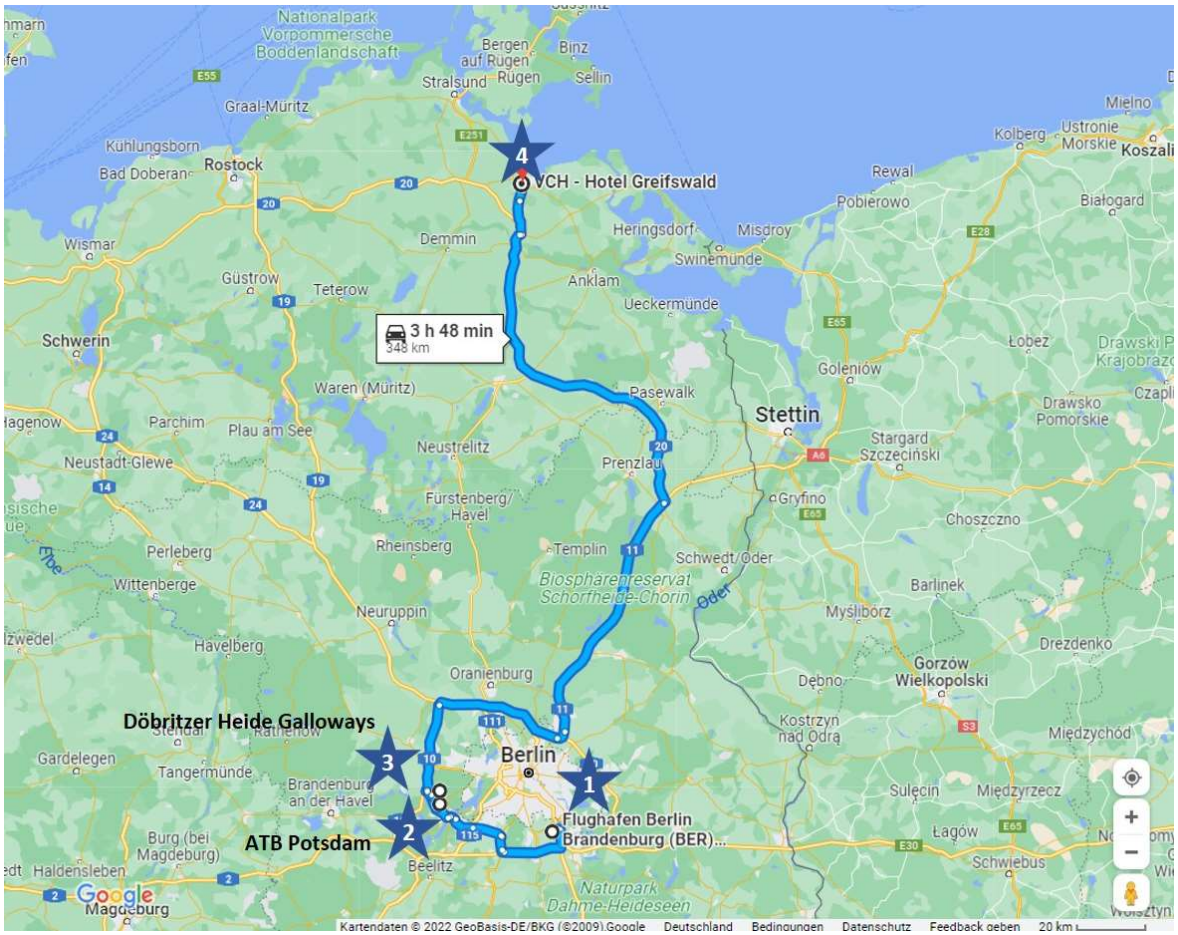
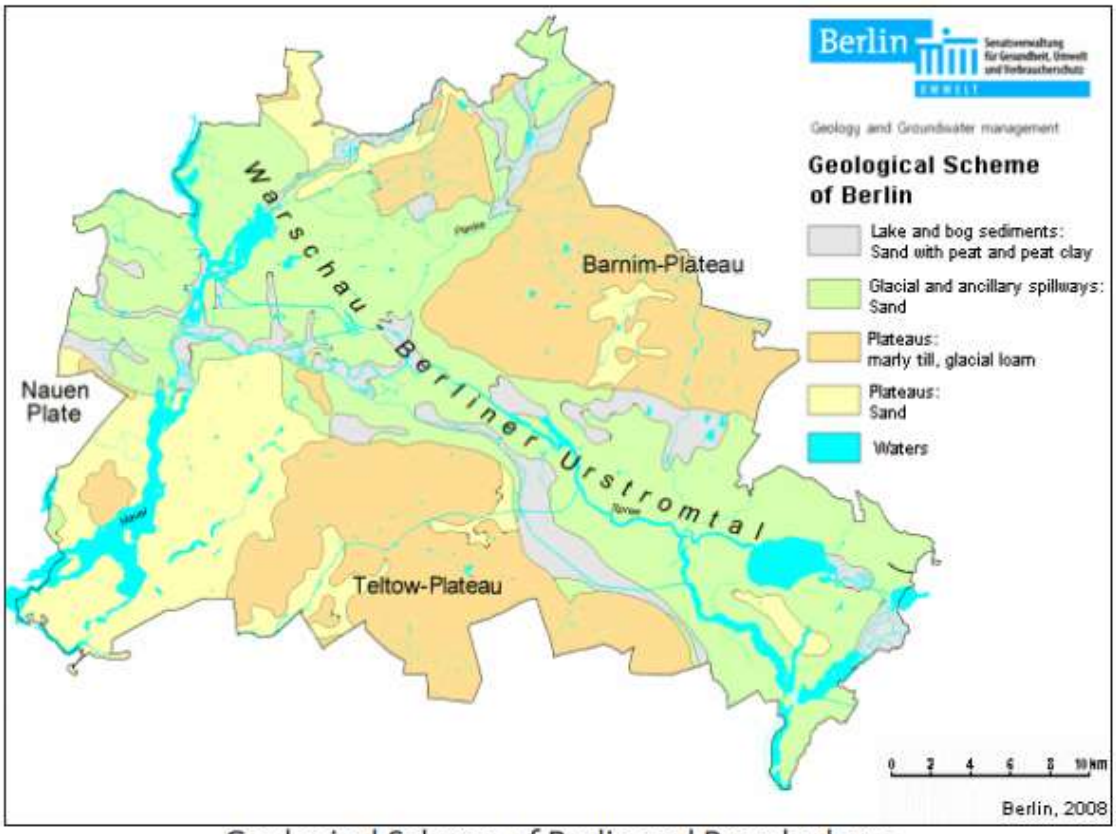


Figure: Tour route Monday 19.09; Sites (1) – (4)

III. INTRODUCTION

Landscape

The federal state of Brandenburg is located in the northeast of Germany covering an area of 29,478 square kilometres. Brandenburg surrounds the national capital and city-state of Berlin, which together form the Berlin/Brandenburg Metropolitan Region, the third-largest metropolitan area in Germany. Brandenburg borders the states of Mecklenburg-Vorpommern, Lower Saxony, Saxony-Anhalt, and Saxony, and has an international border with Poland. Its landscape is very diverse, varying from fragrant pine and beech forests, extensive river valleys with large areas of grassland and wide fen areas.



Geological Scheme of Berlin and Brandenburg

The basic pattern of the surface formation of Berlin and Brandenburg is essentially determined by three major relief units which extend through the area from southeast to northwest. They owe their formation and emergence to the processes which occurred during the Quaternary Ice Age when a large-scale expansion of huge inland ice covered the northern part of central Europe. The Southern Ridge, including the Fläming region and the Lower Lusatian boundary wall. The broad, but very heterogeneous intermediate Plates and Lowlands Area, with many greater and lesser, plateaus. The Northern or Baltic Ridge, which, in Brandenburg, includes the Uckermark district. The „Döberitzer Heide" is a heath area of about 5000 hectares in Brandenburg, close to the city of Podsdam, and not far from the city boundary of Berlin.

Geologically seen, the region has been formed by glaciers and show a lot of landscape forms of moraines and ditches formed by melting waters from the young pleistocene. The main part of the region lies within the district Havelland. Geographically the Havelland refers to the land either side of the Havel river and the area surrounded by the large “U” bend in its course between the city of Berlin and its confluence with the Elbe river, see pictures below.

Land use history

- In the last 100 years the region of Döberitzer Heide has been depopulated and landuse and infrastructure partly abandoned.and is nowadays sparsely under agricultural and forestry use. Reason is the permanent utilisation as military training area, starting in 1713, which made the region for a long time inaccessible for the public. Until 1991 the area was used by the Red Army who characterized the land form intensely. Afterwards the German military took over 550ha of it. Until today some parts of the area are still used for military purposes and not open for public use. Other parts are more and more open for recreational acivities and nature conservation.

Nature conservation

In total eleven nature parks, three biosphere reserves and one national park preserve the valuable natural resources within Brandenburg, covering a third of the federal state territory. This includes two natural reserves, called „Döberitzer Heide” and „Ferbitzer Bruch” that cover an area of around 50 km^2. Flora and fauna are well studied and besides its value in terms of nature conservation, it is since 1999, when some parts opened for the public, also an important recreation area for inhabitants of the metropole Berlin. To support and maintain the open landscapes of the heather Heck and Galloway cattle are used since 1992 by the association “Förderverein Döberitzer Heide”. Thanks to that the biodiversity of the area increased, currently being home for about 5,500 different species.

Box 2 Management of fen meadows with cattle

Since the “Wende” in 1989 the cattle population of northeastern Germany has decreased considerably. Consequently, the demand for grassland declined and large areas were abandoned. Revenues from fen grasslands failed to balance the costs, thus their utilisation relies on subsidies. Consequently, many fen grasslands were abandoned and left to natural succession what made them attractive for re-wetting projects. Several research projects at Greifswald University addressed the sustainable use of rewetted fen peatlands, including cattle grazing. The only animal-based land use concepts for fully rewetted peatlands are keeping geese or water buffaloes. Generally conventional robust cattle are not suitable for fully rewetted opeatlands. But they may be a feasible management option for sites where only moist site conditions can be achieved by rewetting measures due to lack of water or difficult site reliev. For shrub control experience and research showed that extensive grazing with cattle is more effective than static proceeding of mowing. With their feeding behaviour cattle create a diverse pasture landscape which creates refuges for other animals and therefore contribute to local biodiversity.

IV. EXCURSION SITES

1. ATB Potsdam - Leibniz Institute of Agricultural Engineering and Bio-economy, Seminar with ARGE KlimaMoor and ZELFO ® biomass fiber producer

General information

The Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) is a pioneer and a driver of bioeconomy research. The scientific institute focusses on the transformation of agricultural, food, industrial, and energy systems into a comprehensive bio-based circular economy. The aim is to develop and integrate techniques, processes, and management strategies effectively converging technologies to intelligently crosslink highly diverse bioeconomic production systems and to control them in a knowledge-based, adaptive and largely automated manner. ATB conducts research in dialogue with society - knowledge-motivated and application-inspired to provide significant contributions for solving socially relevant issues and to transfer knowledge into economy. The institue advocates interdisciplinary areas of competence like: Microbiome biotechnlology, Postharvest technology, Data science and Engineering for crop production, livestock and horticulture.

Safeguarding quality

The scientific, technical, and administrative staff are committed to the principles and rules of Good Scientific Practice recommendations of the German research Foundation (DFG - Good Research Practice) and the Leibnitz Association (Guidelines for Good Scientific Practice in the Leibniz Association.pdf) to act conscientiously, transparently and comprehensibly towards ourselves and others. They continuously further develop the scientific methods and tools for carrying out research. Through the close linking of research methods with the substantive tasks the quality of the research is ensured. It is a great goal to further strengthen the confidence and recognition from national and international partners by the quality, experience, continuity and commitment of their scientific work.

Research on Paludi-biomass based materials

ATB in 2020 had been commissioned by the Federal Ministry for Agriculture, Environment, and Climate protection of Brandenburg (MLUK) to carry out a throughout feasibility study on the development of technologies and methods for the management of wetland and peatland sites in agriculture in Brandenburg. Paludicultur production chaines had been analysed and tested from harvest up to raw materials and products. ATB is partner of Arge KlimaMoor (see below) to advance value creation chains and marketing of Paludiculture production schemes.

Further Reading:

https://www.atb-potsdam.de/en/

1.a. Arge KlimaMoor

Due to their ability to store climate-relevant greenhouse gases, peatlands are of outstanding importance in terms of climate protection. This concerns Brandenburg nationwide in a special way, as it is very rich in peatlands. Currently, however, more than 200,000 hectares of organic soils (peatlands and peatland succession soils) are being used economically in a way that has a lasting impact on these soils, releasing around 6.2 million metric tons of CO2 equivalents per year as well as previously bound nutrients. Conversion to at least low-impact cultivation by 2030 and to climate-neutral cultivation by 2050 are therefore elementary within the framework of the German Climate Protection Plan 2050. According to the Brandenburg federal-state target agreement on peatland protection, the goal is to reduce emissions from German peatlands by 5 million metric tons of CO_2 equivalents / year by 2030, down from the current 44 million. This is a reduction of around 11.4 percent. For Brandenburg, this requires raising the water table close to the surface level on about 50,000 hectares of peatland. A challenging task.

Therefore, the federal state of Brandenburg launched besides other strategic decisions for peatland and climate protection a project on “Climate protection and climate impact adaptation through peatland-friendly establishment of reservoir areas and water management in relation to peatland areas of the state of Brandenburg and their catchment areas". The aim of the project is to demonstrate through initial positive examples (selection and development of Paludiculture pilot sites) how the future use of our peatlands can generally take place without the negative side effects of drainage, lowering of groundwater, productive land loss by peatland shrinkage, subsidence, and mineralisation of organic soils, nutrient leaching, impoverishment of biodiversity, landscape desiccation and, most importantly, without the release of climate-damaging greenhouse gases. The focus is on best management options under wet and low emission conditions to keep productivity on the sites. The ARGE KlimaMoor coordinates and implements the project on behalf of the Federal ministry for agriculture, environment, and Climate protection of Brandenburg.

Project Sites

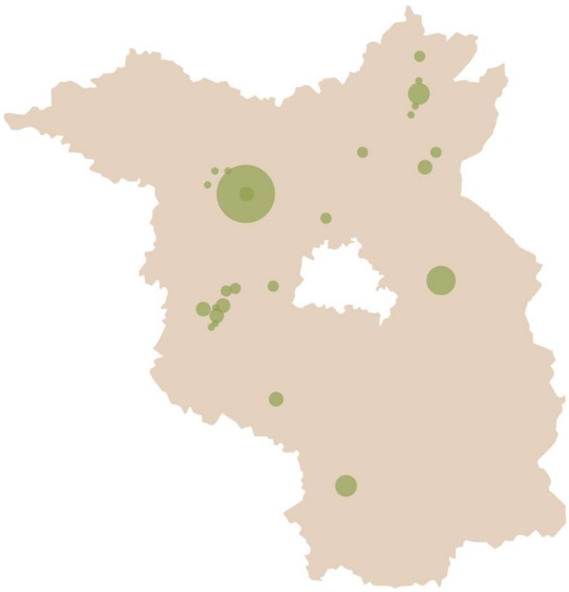


Figure: Location of the Arge KlimaMoor scoping sites for the development of wet agriculture and value creation chains in paludiculture pilots, in Brandenburg

The project will initially start in ten large-scale peatland areas in Brandenburg, where the water level is currently being lowered considerably for current use. In the further course of the project, it is planned that approximately ten additional bog areas will be included in the implementation. By 2026, a management method adapted to natural hydrological conditions is to be established in all project areas. The conversion of management in all larger peatlands in Brandenburg is planned by 2050.

Further reading:

Projekt | Klimamoor Brandenburg Arge Klimamoor (klimamoor-brandenburg.de)

1.b. ZELFO® Technology

Zelfo Technology GmbH develops highly fibrillated macro-, micro- and nano-cellulose fibres, either as separate units or in controlled blends. The company has experience with pre-processed and non-processed agricultural (including reeds and grasses) and industrial lignocellulosic fibres. The company works in product development and improvement for external companies, continuously develops new material types and composites, supports industrial production and also promotes global marketing.

In a practical trial with biomass from the Hammeniederung, Lower Saxony in summer 2019, the biomass was processed in the ZELFO® pilot plant in Schwedt/Oder, Brandenburg, with different defibration intensities and these fibres were then pressed into panels or boards (see Figures above). The input material is chopped, moistened and defibrated, whereby the fibres are cleaned or washed out. The resulting pressed juice can then be fed into a biogas plant. The special feature of this process is that the special fibre preparation splits the individual fibres and thus gives them a high adhesive capacity. If the fibres are then pressed, no additional adhesive is needed; the fibres adhere to themselves.

Figure: ZELFO® fibre boards from different raw biomass from wet and moist peatland management (Photo: S. Abel).

Figure: "Peatland furniture" made from ZELFO® fibre boards (Photo: R. Hurding)

2. The animal farm “Döberitzer Heide Galloways”

Location of animal farm Döberitzer Heide Galloways

In the heath area of Döberitz, the animal farm “Döberitzer Heide Galloways”is grazing with Galloway cattle and for wet sites also with Water buffalo. The owner, Helmut Querhammer, started to graze with Galloway cattle in 1992. His motivation was the production of good quality products for regional markets in combination with gentle nature and landscape conservation. In the beginning he started with an area of 50 hectares on former military training areas and three Galloways. In 2018 around 150 Galloways and 29 goats grazed on an area of 150 hectares.

Picture of the heath in Döberitz

Besides, he has a livestock of water buffaloes standing on the wet meadows of the area which are not suitable for cattle. Within the farm milk, meat and leather in high quality are produced and sold to regional markets and private households. It turned out that farming with water buffaloes is relatively convenient. The animals are very resilient and robust, being able to stand the harsh conditions in German winters, as well as the wet conditions of fen meadows due to their broad claws and preference of watery conditions. Also, regarding fodder, the buffaloes are very undemanding, even feeding on reed and other plants that are refused by other cattle. Required is an open stable, especially in winter times, with dry bedding and shelletered by a mat of straw, eventually with fencing.

Pasture with water buffalo

Shallow, rewetted lowland peatlands and the transition areas from peatlands to mineral soil sites are well suited for water buffalo husbandry. As a rule, the grazing system used is standing pasture or mowing-stand pasture. Water buffaloes can be used for both meat and milk production. Here we look at the keeping of suckler herd and their use as "landscape keepers" to keep moist and wet areas open while at the same time making economical profit.

Water buffaloes in Brandenburg

Water level:	10-20 cm below ground level in summer, 5-15 cm below ground level in winter (water level class 4+); higher water levels possible in some areas or in general (water level class 5+).
Cultivation:	(Heterogeneous) wet meadows and reeds from the succession after rewetting
Yield:	840 g g per day and calf possible
Density:	0,8–1,5 LSU ha^{-1}
Utilisation:	Meat, milk
Project long-term site emissions*:	~8–12 t CO_2-eq. ha^{-1} a^{-1} (Water Level class 4+)

Info-Box: Pasture with water buffaloes, *(assessed with the GEST approach)

Figure: Water buffaloes on rewetted fen in the Uckermark, Brandenburg (Photo: F. Birr)

Why are water buffaloes suitable for grazing on wet peatlands sites?

The water buffalo is adapted to the water depressions and wet areas. Due to its hoof physiology, it copes well with very wet subsoils (water levels 5-20 cm below ground level) and soft soils. It is more frugal than other cattle species to be able to utilise vegetation of lower forage quality (with high crude fibre content). Therefore, wet meadows and meadows resulting from succession after rewetting are also suitable. Preference is given to sweet grasses, including reeds (*Phragmites australis*), cattail (*Typha spec.*) and water mannagrass (*Glyceria fluitans*). Sour grasses, rushes and herbs such as thistles (*Cirsium spec.*), nettles (*Urtica dioica*) and docks (*Rumex spec.*) are grazed on year-round pastures, especially in autumn and winter. Tree foliage, especially alder (*Alnus glutinosa*), grey willow and eared willow (*Salix cinerea, S. aurita*) are also eaten. Smaller trees are "ridden over" and their crowns grazed. This shows the landscape-forming potential of the water buffalo.

Furthermore, herbaceous plants such as yellow iris (*Iris pseudacorus*) and neophytes such as Japanese knotweed (*Fallopia japonica*), Himalayan balsam (*Impatiens glandulifera*) or giant hogweed (*Heracleum mantegazzianum*) are browsed. The browsing of low-energy stands usually takes place after the recovery of higher-value growth.

Despite the unclear effect of poisonous plants on the health of water buffaloes, caution is advised against poisonous plants such as marsh horsetail (*Equisetum palustre*), autumn crocus (*Colchicum autumnale*), celery-leaved buttercup (*Ranunculus sceleratus*), ragwort (*Jacobaea vulgaris*), water ragwort (*J. aquatica*), bittersweet nightshade (*Solanum dulcamare*) and water hemlock (*Cicuta virosa*). In Brandenburg, a pregnant water buffalo cow was fatally poisoned after eating the hay, that contained marsh horsetail (toxins in plant did not degrade).

TUESDAY 20TH SEPTEMBER

Excursion Day 2

I. SCHEDULE AND ROUTE

Time	Places	Contents
7:00-8:00	Breakfast at the hotel	
8:30-13:00	Felix Hausdorff Centre of Greifswald University	Seminar on Paludiculture Pilots and Moorfutures in MW, (see detailed separate schedule for contents).
14:00	Polder Bragischow Süd	Paludiculture Pilot Bargischow Süd, planned site development, monitoring, and GHG measurement (Eddy covariance).
16:00	Polder Sandhagen	Paludiculture Pilot Polder Sandhagen Landgraben, planned site development.
18:30	Greifswald market place	Visiting the Paludi Tiny House – applied paludiculture materials.
18:30	In parallel Seminar Dinner in Greifswald at the market	Informal exchange on GMC activities & reflection on the seminar day.

Figure: Tour route Tuesday 20.09; Sites (1) – (4)

II. INTRODUCTION

The city of Greifswald

In the Northeast of Germany, between the two largest islands of Rügen and Usedom, lies the University and Hanseatic city of Greifswald. The town belongs to Western Pomerania and is situated at a Lagoon of the Baltic sea Southeast. The Harbour of Greifswald is connected to the Lagoon by the River Ryckthat crosses the town and. The coastal part of Greifswald at the mouth of the Ryck, named Greifswald-Wieck, evolved from a fishing village. Today it provides a small beach, a marina, excellent fish restaurants, and fresh fish is bought at best in Wieck.

The Eldena Monastry

Hilda Abbey was founded in 1199 by the Cistercian monks, later called Eldena Abbey, south of the Ryck estuary. It is considered to be the birth-place of Greifswald city. The monastery crumbled into ruins after the Reformation in 1533. The stones were removed for municipal building projects during the Swedish era. Just a few fragments remained from the building complex of the once impressive monastery. These include the west wall and several columns from the centre nave. The huge lancet window juts out between the

History of the city	
1199	Founding of the Monastery of Hilda by Cistercians who had been expelled from Dargun.
1250	Granting of the Lübeck Law and thus of independent self-government after the model of the city of Lübeck by the Pomeranian Duke Wartislaw III (14 May).
1456	Opening of Greifswald University at the initiative of the mayor of Greifswald, Dr Heinrich Rubenow.
1310 - 1363	The heyday of Greifswald as a Hanseatic town.
1535	Reformation in Pomerania, the Monastery of Eldena was transformed into a ducal office.
1648	Peace of Westphalia, Western Pomerania together with Rügen falls to Sweden. The city will suffer for decades more from the effects of the Thirty Years' War.
1774	Caspar David Friedrich, the most important painter of German romanticism, is born in Greifswald.
1815	Transfer of Western Pomerania from Swedish to Prussian possession (Congress of Vienna).
1863	Connection of Greifswald to the Berlin-Szczecin railway line. Sailing experiences, a final heyday right into the 1880s.
1903	Connection of the city to the electricity network.
1945	Peaceful surrender of the city of Greifswald to the Red Army, saving the city from destruction.
1960s – 1980s	The expanding city of Greifswald becomes an economic and scientific centre in the otherwise underdeveloped region due to the arrival of large-scale industry (Lubmin nuclear power plant).
1990	The first free elections of a city parliament since 1933. As a result of structural social and economic changes after 1990, the importance of the university to the city increases.
2005	Opening of the Pomeranian State Museum.

trees like a huge archway. The grounds were designed as a park based on plans by the landscape architect Peter Joseph Lenné (1789 – 1866). The ruin is a setting for theatre performances and concerts in the summer. The Eldena Jazz Evenings have taken place here in July for more than 30 years. The painter Caspar David Friedrich (1774 – 1840), born in Greifswald, made the Eldena Abbey ruins world famous with his paintings and at the same time turned them into a symbol for the entire Romantic period.

Hanseatic times

The Hanseatic League was a commercial and defensive confederation of merchant guilds and market towns in Northwestern and Central Europe. Growing from a few North German towns in the late 1100s, the league came to dominate Baltic maritime trade for three centuries along the coasts of Northern Europe. Due to a steady population increase, Greifswald became at the end of the 13th century one of the earliest members of the Hanseatic League. Through its membership the city experienced an economic boom.

University

From its founding to the present, the university has always provided important impetus for the development of the city throughout its more than 750-years history. In the process, the city and university have always benefited from each other. University studies, teaching and research have greatly contributed to the development of Greifswald as a scientific, medical and cultural centre in the Northeast of Mecklenburg Western Pomerania. For this reason, Greifswald is also one of the first university cities where the partnership between city and university is framed on the basis of a cooperation agreement. This is only logical since the city's mission statement emphasises the strengthening and expansion of the university as key goals of urban municipal policy. The importance of the university to the city is also shown by Greifswald bearing the name The University and Hanseatic City of Greifswald since 2005. The university owes its existence to a former mayor of Greifswald, Heinrich Rubenow, who founded the University of Greifswald in 1456 and was also its first rector. In July 2017, the exhibition on paludiculture plants was opened at the Botanical Garden of Greifswald University. For this the already existing `Paludarium` (exhibition of wetland plants) has been updated and extended by plant containers with additional important paludiculture plants and explanatory plaques.

III. EXCURSION SITES

1. Paludi Pilot Sites M-WP - Polder Bargischow & Polder Sandhagen

General Information and project goals

Rewetting peatland soils has shown to reduce greenhouse gas (GHG) emissions but competes with drainage-based agriculture on peatlands. Paludiculture - the agricultural use of wet and rewetted peat soils - represents a land use concept that combines climate protection and the agricultural use of degraded peat soils. It allows productive use of degraded peat soils, ideally preserving the peat body, minimizes elevation loss as well as soil degradation, and reduces GHG emissions. Furthermore, paludiculture enhances the provision of ecosystem services such as water retention, evaporative cooling, nutrient retention, and the creation of habitats for peatland species. Plant species are used that tolerate high water levels and whose biomass is suitable for energy production or material utilization. Beside grasses such as reeds and cattails sedges and reed canary grass, trees like alders can be grown on fens. In addition, grassland management with e.g. water buffaloes can be carried out.

Despite many years of research, paludiculture is not yet an economical alternative for farmers. More information on long-term stock development and management of paludicultures as well as harvesting biomass from wetlands and the utilization of the biomass produced, are critical issues for economic viability.

The Paludi-Pilot-project in Mecklenburg-Western Pomerania (“Paludi-MV”), carried out by the Landgesellschaft (https://www.uni-greifswald.de/en/) Mecklenburg-Vorpommern (https://www.lgmv.de/) and the University of Greifswald from 2021 to 2031, aims at upscaling paludiculture on large

The following **work priorities** (4 modules) are planned in the project:

Module I: Establishment of project sites
In this just ongoing module the project sites are secured, planned and the implementation of water level elevations and site establishment will be carried out.

Module II: Land management and paludi-„crop“ production
In Module 2 the focus rests on land management and plant cultivation of paludi-"crops" and wet grassland. Establishment and management concepts are regularly reviewed and adapted. Biomass requirements of different utilization methods, individual land conditions, and (interim) results from CO_2 balancing are incorporated.

Module III: Monitoring and evaluation
Module 3 includes accompanying research such as monitoring of key parameters (GHG, water level, biodiversity, time recording of management measures), as well as the establishment of an accompanying research network.

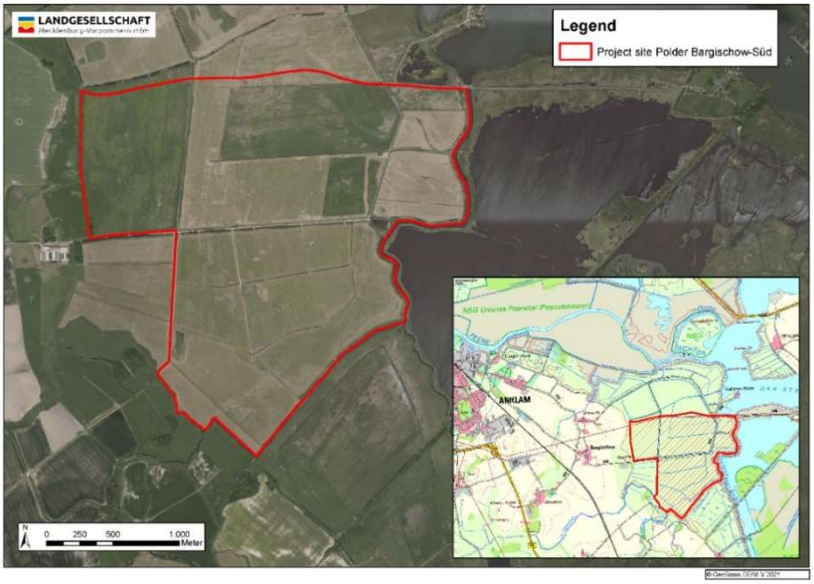
Module IV: Capacity Building
In Module 4, the experience gained in the implementation and management of paludiculture, will be processed for various target groups and transferred into practice in order to promote climate protection through rewetting of previously intensively used peatlands.

scale. The project is intended to help find answers for paludi-„crop“ cultivation and land management by implementing and scientifically monitoring large-scale paludiculture sites and removing obstacles along the production chain.

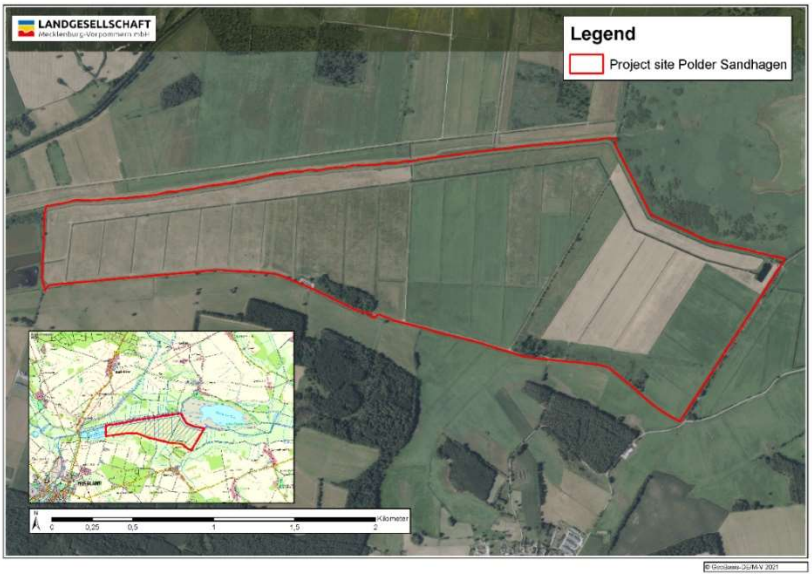
Project sites

Two fen sites in Western Pomerania (Vorpommern), Polder Bargischow-Süd and Polder Sandhagen in the Eastern part of Mecklenburg, will be established to investigate alternative forms of cultivation on fen soils with water levels close to the surface on a large scale (approx. 800 ha including both sides).

1) Polder Bargischow- Süd: Use of wet meadows with focus on reducing greenhouse-gases and species conservation, especially grassland birds.



2) Polder Sandhagen: Testing and optimization of paludi-crops with high market potential and investigation of effects on climate gas emmissions and species diversity.



Box 3 Peatlands in Mecklenburg-Western Pomerania

Peatlands cover currently 12% (about 290,000 ha) of the land area of Mecklenburg-Western Pomerania. Most widespread are river valley peatlands. Pristine river valley peatlands consist of three adjacent and functionally connected ground and surface water fed hydrogenetic mire types from the edge of the river valley to its center: surface flow mires (spring mires), in the valley plain percolation mires, and adjacent to the river flood mires.

Spring mires are fed by ground water and develop where aquifers are truncated and therefore artesian ground water continuously discharges to the surface. Spring mires are sloped sometimes even forming small cupolas and ridges. Where the artesian ground seeps out with high pressure Calcium and other minerals are precipitated; the peat is highly decomposed. In the Peene valley, spring mires can be found e.g. near Loitz.

Percolation mires stretch across the sloped river plain adjacent to the spring mires. They are fed by the spring mire water discharge and continuously ground water inflow therefore the peat is only slightly decomposed and mineral and nutrient contents decrease to the center of the valley until the flood water regime of the river overrules the groundwater flow. The hydraulic conductivity of the peat body is high, and surface water levels are stable due to continuous water supply and the oscillation capacities of the slightly decomposed peat body. Percolation mires are the dominant peatland type of the North-Eastern German Plain, for example in the Peene catchment area.

Flood mires are under the influence of water from neighbouring water bodies. They are inundated periodically or episodically and can also fall dry. This mire type only occurs where inundations regularly take place. Inundation mires can be found in parts of the “Große Rosin” at the “Kummerow” lake and in the Lower Peene valley, downstream of Anklam. The periodically occurring dry periods provoke the development of highly decomposed peat and eutrophic nutrient conditions.

Locally bogs (ombrotrophic mires) can develop in river valley complexes where precipitation water forms rainwater lenses nesting in groundwater fed fen areas. The “Anklamer Stadtbruch” has 500 ha of such bog area nesting in a percolation mire. It is the biggest bog complex in Mecklenburg Western Pomerania but unfortunately widely destroyed by peat extraction.

Technology for wet fen management

Appropriate agricultural technology is of central importance in the implementation of wet fen management. In contrast to conventional peatland use in agriculture with the drainage of the site, the technology must be adapted as much as possible to wet site conditions (see figure below). The highest priority should be given to minimizing soil pressure and reducing the number of crossings which have a high impact (Wichmann et al. 2016).

Figure: Track-based vehicle (refurbished and adapted Kässbohrer PistenBully 200) and round baler with wide tires (Photo: S. Petri).

The technique that should be used in the management of the wet peatlands should be defined based on the following (after Wichmann et al. 2016):

- area characteristics (size, crop, carrying bearing strength for the vegetation),
- water levels and thus soil moisture conditions (e.g. flooding),
- time of harvest,
- biomass form/utilisation (e.g. fresh or dry utilisation; long stalks, chopped material, round bales, bunches),
- biomass transport (e.g. semi-mounted bunker, loading truck with pick-up, separate transport vehicle), and
- location of the harvesting area (e.g. access roads).

Harvesting (mowing, collection and removal of biomass) can be carried out in one or in several separate steps. Only in case of water levels in or above surface level the harvesting must be done in a single shift. An overview of the suitability of existing technology used for the management of wet peatlands is provided below in a table.

Further development of technology for wet fen management

Although many technical solutions for harvesting on the wet and rewetted peatlands are already available, the mechanical adaptations to the wet peatland sites need to be continuously evaluated and further developed. The following aspects should be given special attention while developing the new technology (after Schröder et al. 2015):

- reducing machine weight,
- increasing contact with the surface to reduce contact surface pressure,
- balancing of machine weight, harvesting attachments and payload,
- development of further technical solutions to avoid shearing forces,
- separating harvesting and transport vehicles,
- for tracked vehicles: tracks should have a width-length ratio of 1:4 to 1:5,
- considering the special machine and site requirements for the machine operating staff.

In the optimal case, the areas are cut in such a way that frequent crossings are avoided, and the harvesting machines are primarily used for mowing and not for transportation. Frequent cornering should be avoided as well.

Table: Types of the techniques for the management of wet peatland sites (after Wichmann et al. 2016).

Technique type	Areas of application and advantages	Limits and disadvantages
Small-scale technology: Single-axis or small tractor equipped with cutter bar	- Used for the maintenance of wet meadows (mostly small or hard-to-reach areas). - Usually only mowing; occasionally removal of biomass.	- Low area output with high area-related costs - No large-scale biomass production possible
Adapted grassland technique: Tractor with terra or twin tyres and light baler with tandem axis, bogie belt/delta drives if necessary.	- Use in transitional areas (moderately wet), in dry years or in frosty conditions - High area output - Biomass can be cleared during mowing	- Possibility of use limited by water level or weather conditions. - Biomass removal problematic: individual bales may have to be removed to the edge of the field due to their weight.
Specialised technology, with wheels: mainly Seiga machines (two- or three-axis) with balloon tyres	- Use in reed harvesting - Particularly suitable for overlogging - Low machine weight and balloon tyres ensure low ground pressure - Mowing and stalk pick-up in bunches in one step	- Seiga is no longer produced, only old machines or replicas can be used - High labour input: several people needed for harvesting - Limited engine performance - Possible soil damage due to slippage
Specialised, with tracks: Adapted snow groomers from ski resorts or custom-made machinery	- Landscape conservation and biomass harvesting (e.g. reed harvesting) - also suitable for use under flooded conditions - wide trucks, therefore low ground pressure even with heavy machinery - Many different types and attachment options available on the market	- Cannot be driven on roads, so must be transported on flat-bed trailers; - Shear forces may damage the soil during turns

Further Reading

Birr, F., Abel, S., Kaiser, M., Närmann, F., Oppermann, R., Pfister, S., Tanneberger, F., Zeitz, J. & Luthardt, V. 2021: Sustainable agriculture and forestry on fens - fact sheets for climate-friendly, biodiversity-promoting management practices. [Zukunftsfähige Land- und Forstwirtschaft auf Niedermooren - Steckbriefe für klimaschonende, biodiversitätsfördernde Bewirtschaftungsverfahren; In German],

Hochschule für nachhaltige Entwicklung Eberswalde und Greifswald Moor Centrum (Eds.). Eberswalde, Greifswald, 148 p.

Wichtmann, W. Schröder, C.& Joosten, H. (eds.) 2016: Paludiculture – productive use of wet peatlands, Schweizerbart Science Publishers, Stuttgart, 272 p. ISBN 978-3-510-65283-9

WEDNESDAY 21ST SEPTEMBER

Excursion Day 3

I. SCHEDULE AND ROUTE

Time	Places	Contents
7:00-8:00	Breakfast at the hotel	Check-out from Hotel VCH in Greifswald.
09:30	Neukalen	PRIMATypha cultivation site exchange of experience with establishment and harvest; Wet meadow management with adapted conventional technology
12:00	Lunch	Restaurant at the harbour Neukalen.
14:00	Malchin heating plant	Combustion of wet meadow biomass form lake Kummerow for heatgeneration.
15:30-17:00	Polder Bruderdorf ALNUS site	Research project "ALNUS" evaluate Black alder plantation 20 years after planting.
20:00	Hotel in Bad Oldesloe	Dinner buffet at the hotel

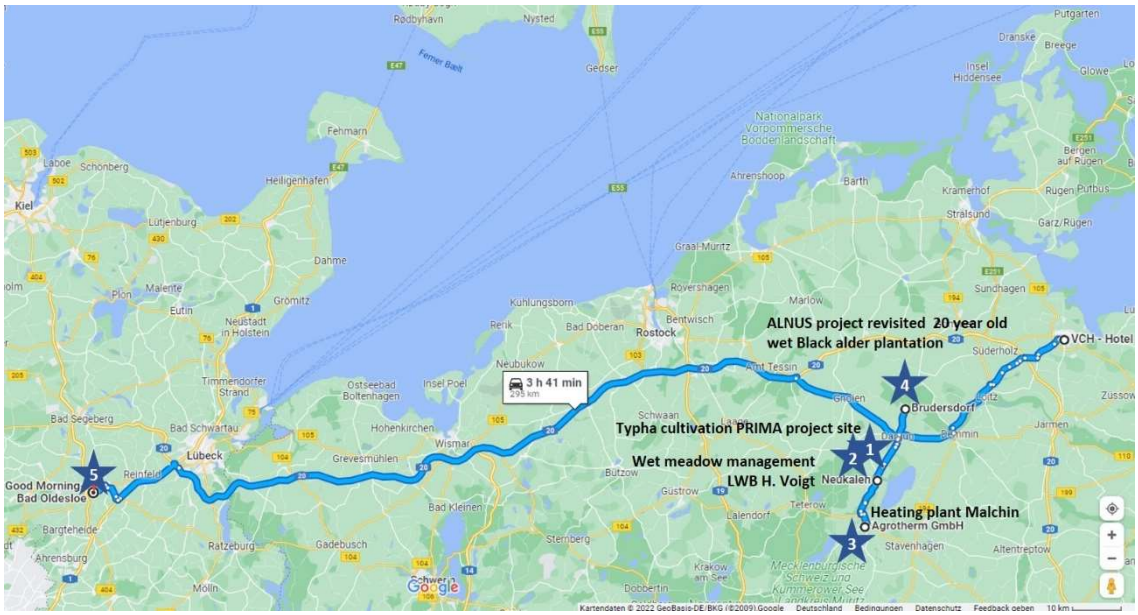


Figure: Tour route Wednesday 21.09; Sites (1) – (5)

Malchin & Neukalen

Landscape

The area is part of the Peene river valley which is one of the largest fen areas in Germany, comprising 45,000 ha land. Due to its wild character it is known as the 'amazon of the north'. This landscape was formed by melting water during the Ice Age and shows landscape units of extended flat ground moraines of Mecklenburg-Western Pomerania. It stretches over 85 km from Lake Kummerow (Kummerower See) in the west to the Oder Lagoon (Oderhaff) in the east. After the Elde River, the Peene River has the second largest catchment area and discharge of all rivers in this federal state. It has an extremely small hydraulic gradient of only 20 cm over 85 km. When water levels in the Baltic Sea are high or at strong Eastern winds blow, an unusual phenomenon can be observed: the Peene River flows upstream. The Peene river valley belongs to the system of the large river valleys of northeastern Germany that were formed during the last ice ages as glacial valleys. By autonomic peat growth extend percolating mires formed, with peat deposits of more than 9 m thick, fed by Calcium rich groundwater from the mineral ridges. Close to the Peene River a narrow area is covered by flood-plain fens, characterised by the special hydrological situation of the river.

Location and Picture of the Peene River Valley

Land use history

Traditionally, the undrained or slightly drained peatlands at Peene river mouth were used for grazing, hay-making and locally also for peat cutting. Most parts of the mire have been under continuous use since medieval times. Its narrowness made it easily accessible and enabled an early use. During 1300-1800, the mire was part of the common land (German: Allmende) and land use was hardly differentiated, a general characteristic of agriculture at that time. The intensity of use varied with the difficulties of society and with population density. Meadows occupied 23 % of the mire. About one-half, located closer to the villages, was mown annually; the rest less frequently. The largest part of the mire was used as pasture, mainly for cattle – 22 % were grazed regularly and 55 % only sporadically. Both meadows and pastures were characterised by superficial drainage.

The medieval tradition of common lands ceased, and the now private land was parceled and more intensively used. Levelling and improved drainage allowed the exclusive use as meadows. Until the mid-19th century the spacius ans still wet common pastures were transformed into small patches of better drained meadows interrupted by peat pits - and the traditional paludiculture use ceased. In the 1920s, the state initiated and funded the formation of cooperatives responsible for largescale drainage of the mire. Until World War II large areas were poldered and used as high-intensity grassland after ploughing. After complex Melioration programs in times of GDR, agricultural use on half of the peatland was introduced with high intensity grassland monocultures after intensified drainage. After 1995 the polder system was abandoned and large parts of the peatlands were given back to nature. This initiated the transition towards a landscape dominated by wetlands and carrs.

Current land use

Today, while part of the peatlands is still used as high intensity grassland, the rewetted parts are either abandoned, used for conservation mowing or for reed cutting. Conservation mowing is implemented on c. 150 ha wet peatland at Peene river mouth by a local nature conservation NGO (Förderverein Naturschutz im Peenetal e.V.) in cooperation with local farmers and supported by the foundation OSTSEESTIFTUNG. Reed cutting for thatch is currently practiced on ca. 80 ha at Peene river mouth. In the region of Vorpommern, in total 10 companies are active in reed cutting on a total area of ca. 550 ha. In 2017 the Federal state strategy for paludiculture was launched in order to find alternative ways to cultivate land under wet conditions.

Peene Valley with its reserves

Nature conservation

The Peene is the best-preserved river valley mire in Germany and a refuge for rare plant and animal species (see introduction above). Therefore, the Peene valley is a Special Protected Area (SPA, since 1990, 20,000 ha). The nature reserve 'Unteres Peenetal (Peenetalmoor)' is an important bird area (IBA, since 1988). Since 1992 the large-scale conservation and restoration project 'Peenetal/PeeneHaff-Moor' has been implemented to create a protection area of 45,000 ha covering the whole valley mire and including a core area of 20,000 ha of strict nature reserves. The nature park Peene valley was founded in 2011 and covers 33,400 ha. In 2017, an alliance of the Greifswald Mire Centre together with regional NGOs has proposed to designate the Peene valley as Ramsar site (decision at the level of the federal state of Mecklenburg-Vorpommern is still pending). From 1992 to 2008 large areas of fens in the Peene valley were rewetted, creating an outstanding nature conservation area.

Research

Several research-projects are taking action in the region. Since 2006, a local nature conservation NGO (Förderverein Naturschutz im Peenetal e.V.). studies the effects of summer conservation mowing at Peene river mouth. With the EU project REPEAT partners from Antwerp, Warsaw and Greifswald universities studied the effect of machine mowing on peat formation in fens in 2017/2018. Vegetation composition, soil and root properties as well as decomposition rates were compared at paired mown and unmown plots in Recknitz and Peene valleys.

Further reading

REPEAT project: www.repeat.paludiculture.com

III. EXCURSION SITES

1. Teichweide (Polder Bauernhand), PRIMA project Cattail cultivation

General Information

The joint project Paludi-PRIMA investigates Reed and Cattail as native plant species that are adapted to water-saturated soils, enable peat conservation and have a high value creation potential based on the material use of the biomass. Reed is traditionally used as thatching material while cattail arouses growing interest in the construction and insulating material industry. The research site is located near the rural town of Neukalen in an otherwise drained fen peatland which is used for cattle farming and fodder growing.

Paludi-PRIMA intends to contribute to putting paludiculture into practice on degraded fen sites. To this end, the project tasks cover a broad spectrum, ranging

from basic scientific research to a field trial on approx. 8 re-wetted hectares and to the elaboration of recommendations for farmers, authorities and politicians. The following questions will be addressed:

- Which species or genotypes of Cattail (*Typha angustifolia, Typha latifolia*) and Reed (*Phragmites australis*) are suitable for different site conditions and utilisation lines?
- What influence does site selection and management (water level, nutrient availability and harvest regime) have on productivity and biomass quality?
- What are the costs of switching to paludiculture (site preparation, planting, management, harvesting, drying and storage)?
- How can the economic viability of paludicultures be assessed in dependence of biomass quality and utilisation options
- How can paludiculture be integrated into agricultural policy, approval (water and nature conservation law) and planning processes?

Project progression

In december of 2021 the first mechanical harvest took place. For this the company „Wellink Equipment“ from Groenlo (Netherlands) was commissioned to use special equipment (Sotrak 120 with a frontal ELHO double chopper and a 11m^3 bunker on top). After harvesting the crop was dispatched to trials for drying and material processing.

First harvest on the PRIMA site

Harvest and logistics were accompanied by detailed recordings of working time and biomass (yield, water content, bulk density etc.).

A specific challenge arose from the fact that cattail grows leaf biomass as well as „seed wool“ which are processed in different ways. However a process for seperate harvesting of those products is yet to be developed. By now the „seed wool“ may compromise the quality of the harvest yield and impair the possibilities of processing, which has to be examined.

Further reading

https://www.moorwissen.de/en/paludikultur/projekte/prima/index.php

https://mowi.botanik.uni-greifswald.de/praxisanbau-von-rohrkolben.html

Neubert, J. 2021. Nasse Moorbewirtschaftung in der Praxis. – B&B Agrar online Dezember/2021

Wichmann, S. 2022. Erste Ernte im Rohrkolben-Praxisanbau bei Neukalen (D); Paludikultur-Newsletter 2022_01. S. 7

Cattails (*Typha spec.*), natural growth or in cultivation

Cattails are suitable as a cultivation crop because they produce very high yields on rewetted sites with a high nutrient supply, even in the case of long-term overflooding, and, as expected, yields are stable over the first ten years. The high productivity of the plant in connection with the growing demand, especially for ecological building materials, offers versatile potential for creating the regional value.

Cattail mowing with caterpillar-based technique (12/2018, photo: lensescape.org)

Water level:	(1) in summer -10 to 0 cm, in winter -5 to 15 cm (water level class 5+) or (2) 0 to 20 (40) cm above ground level in summer, 10 to 20 (40) cm above ground level in winter (water level class 6+).
Cultivation:	Sowing, planting or self-seeding after the water level has been raised
Yield:	4,3-22,1 t DM ha^{-1} a^{-1}
Harvest:	once a year in summer or winter (depending on utilisation); first harvest after 1-2 years
Area size:	Individual areas up to 10 ha
Requirements:	High nutrient and water availability, flat relief
Utilisation:	ecological building materials, bioenergy, fodder, foodstuffs
Projected long-term site emissions*:	7 t CO_2-eq. ha^{-1} a^{-1} (water level class 5+) 6 t CO_2eq. ha^{-1} a^{-1} (water level class 6+)

Info-Box: Cattail (*Typha* spec.), spontaneous or cultivated,
*(assessed with the GEST approach)

Reed (*Phragmites australis*), natural growth or cultivation

Reed produces high and stable yields on wet sites, even with long-term flooding. Reed is a flood- and salt-tolerant sweet grass that grows up to four meters high and whose culms remain upright after the growing season, making it suitable for harvesting in winter. Vegetative propagation results in the formation of large, competitive stands. Dead rhizomes and roots can contribute to renewed peat formation. Reed is traditionally used as a building material (e.g. thatch). Reed is also well suited for energy production.

2. Wet meadow management practice of LWB H. Voigt at Neukalener Seewiesen

Water level:	(1) in summer -10 to 0 cm, in winter -5 to 15 cm (water level class 5+) or (2) in summer 0 to 20 (40) cm above ground level, in winter 10 to 20 (40) cm above ground level (water level class 6+)
Cultivation:	Planting, rhizome cuttings, stolon stlaks or natural establishment after water level rise
Yield:	3,6 - 23,8 t TM ha-1 a-1
Harvest:	once a year, first harvest after 1-2-(3) years
Utilisation:	ecological building materials, bioenergy, raw material for lignin and cellulose production
Projected long-term site emissions*:	7 t CO2-eq. ha-1 a-1 (water level class 5+) 0 t CO2-eq. ha-1 a-1 (water level class 6+)

Info-Box: Reed (*Phragmites australis*.), spontaneous or cultivated,
*(assessed with the GEST approach)

The area of the Neukalener Seewiesen (ca. 400 ha) is characterized by peatland meadows and fens. It has been drained for agricultural use and is nowadays a re-wetted peatland with dominating sedge-meadows. Also some mosaics of Reed Canary Grass meadows occur, as well as Reed Mannagrass (Glyceria maxima) dominated patches. Small areas are covered by Common Sedge or Black Sedge. Red list species like Marsh stitchwort (Stellaria palustris), Ragged-Robin (Lychnis flos-coculi), Brown Sedges (e. g. Carex disticha) as well as Common Meadow-Rue (Thalictrum flavum) are remarkable.

The area of the wet meadow complexes notably increased after the pumping station was closed down. As, since that time, the groundwater tables are corresponding with the water tables of the Lake Kummerow, from time to time the peatland is fully inundated, depending on the wind and water table conditions of the lake. The change in water level affected the species composition of the sites, consequenting in a lowered fodder quality unsuitable for cattle feeding.

The agricultural Enterprise of Hans Voigt was forced to switch to an alternative. Therefore, they pioneered in using sedge and reed biomass for powering a district heating unit. The hay that is meanwhile grown and harvested on the site, is used as a fuel in the biomass heating plant in Malchin (detailed information see below).

Picture of Neukalener Seewiesen

Tall sedge meadows (*Carex* spec.)

Tall sedge meadows are dominated by productive sedge species and complemented by a variety of wetness-tolerant species. A firm sward makes the stands passable even at high water levels. Sedges prove to be tolerant to flooding and altering wetness. They can be used forage meadows with eiter one or two cuts per year. Energetic utilisation of the biomass is also possible.

Onsite Compaction (baling) of Sedge hay with adapted grassland technology for energy utilisation in the Spreewald (09/2019, Photo: F. Birr)

Water level:	(1) 10-20 cm below ground level in summer, 5-15 cm below ground level in winter (water level class 4+) or (2) in summer -10 to 0 cm, in winter -5 to 15 cm (water level class 5+)
Cultivation:	Natural establishment after water level rise or targeted through planting or seeding
Yield:	2-12 t DM ha-1 a-1 (One- to two-rotation)
Utilisation:	Energy biomass (fuel, substrate for biogas plants), fodder, bedding
Projected long-term site emissions	~10 t CO2-eq. ha-1 a-1 (water level class 4+) ~3 t CO2-eq. ha-1 a-1 (water level class 5+)
First harvest:	3 years after establishment

Info-Box: Tall sedge meadows (Carex spec.)
*(assessed with the GEST approach)

3. Biomass heating plant Agrotherm Ltd. Malchin

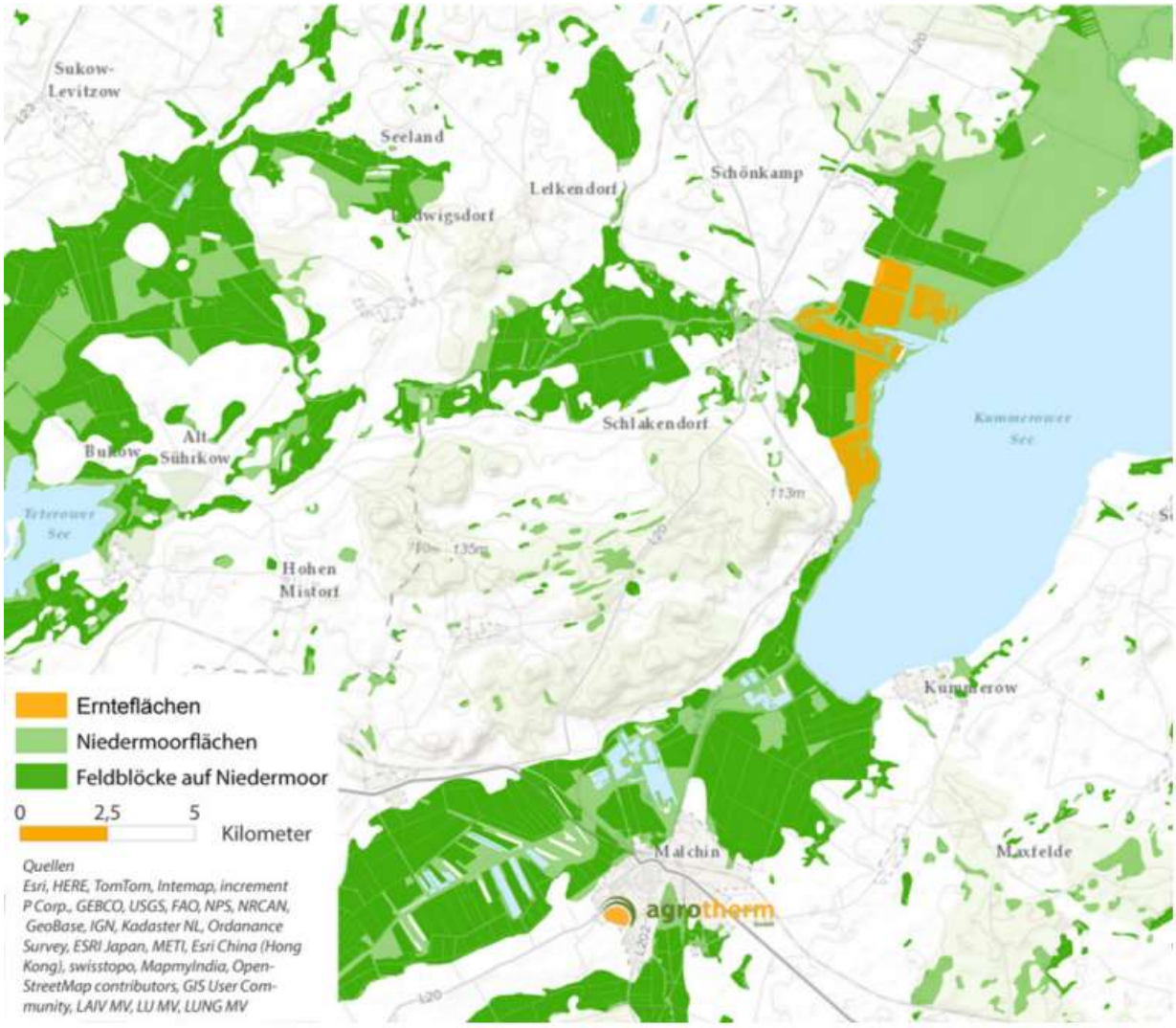
The decision to build up a heating plant to use the hay from wet meadows (Neukalener Seewiesen) as a fuel was motivated by several reasons. As the biomass quality was due to the re-wetting no longer good enough to feed cows, an alternative use for the biomass, now mainly sedges, reed and reed canary grass, was needed. Though, fertilization on rewetted fen peatlands is not allowed, after several years of planning, and working cooperation with on-going research projects at the University of Greifswald, the thermal utilisation of fen biomass was chosen as a promising alternative.

Within this process an optimal scheme for harvesting hay as a fuel on 250-350 ha could be elaborated, which provides the regular demand of a regional heating plant with biomass. The local energy provider could be convinced to cover the basic load for heat provision of about 500 households, a school and a kindergarten in the city of Malchin by using bioenergy. With side adapted machinery the 2-4 t of biomass per hectare can be cut, swathed and baled in summer during dry periods. Approximately 6,000 bales, each with a weight up to 250-300 kilograms, are harvested per year. In the exemptional summer 2018 sites which are normally not accessable could be reached for harvest and totally around 11,000 Bales were processed. The heating plant has been constructed by Ludwig Bork to convert this fen biomass to heat. In addition to the reduction of the emissions from the formerly drained peatland, the 1,000 t of harvested fen biomass provide a total energy supply of 4 GWh and replaces 375,000 l of fossil heating oil. Adding value on rewetted peatland the thermal utilisation of the fen-biomass enables farmer Hans Voigt to continue the use of his land, keep his employees and preserve the nature heritage. The local production of sustainable biofuels increases regional collaboration and added value.

However, to increase acceptance of peatland re-wetting and restoration for climate and regional development, it is vital to create local networks between land users, administration, district heating stations and energy user.

Main Features	
Location:	Heat supply grid Malchin
Performance:	800 KW (thermal)
Biomass need:	800-1.000t/year
Biomass origin:	Rewettet fen peatland sites in the Peene river valley respectively at Lake Kummerow
Harvest area (yield):	400 ha (~ 4 – 5 t/ha)
Substitution effect:	290.000-380.000 l oil

Info-Box: Key figures of the biomass heating plant of the Agrotherm GmbH in Malchin.



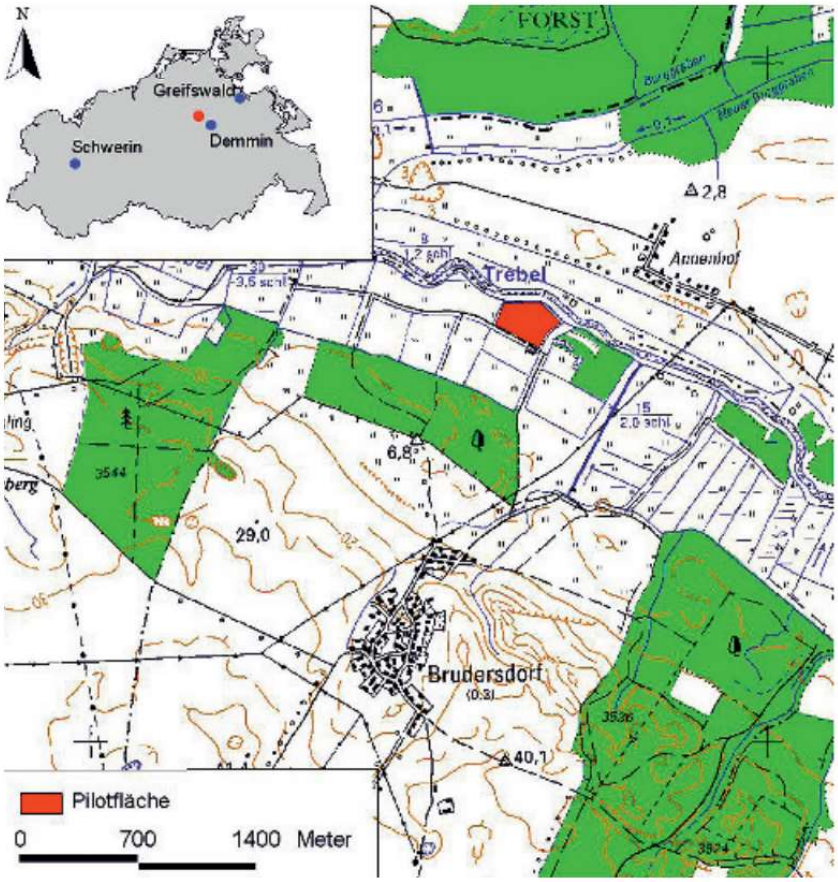
Location of Agrotherm and Meadows Neukalener Wiesen (orange) and peatland area (green)

V. The ALNUS Pilot-Site in Trebeltal

Box 4 Black Alder (*Alnus glutinosa*) in Forestry	
Life time:	~120 years, fast growing (80 years forest rotation)
Adaptations:	High demand of nutrients
(wet conditions):	Lenticells at trunk deliver tree with oxygen to roots
	In symbiosis with bacteria in root area to enable supply with nitrogen
Water level:	0-20 cm below surface (endures spring flooding)
Establishment:	Planting/Growth from the stump (high forest/low forest)
Harvest:	High forest: 4-6 use cycle within 60-80 years, ca. 600-800m³/ha
	Low forest: 1-3 use cycles within 20-40 years, ca. 200-500 m³/ha
Application:	Timber or fuel wood
Emissions:	Reduction of ca. 18 t CO^2 per ha and year (compared to drained fen)

In autumn of 2002 a fen peatland area with a size of circa 10 hectares in the Trebeltal near Brudersdorf (county of Demmin) was afforested with alder. This was overseen by the Landesforst Mecklenburg-Western Pomerania. After three vegetation periods one could observe promising growth rates. The chosen site proved to be optimal to discuss basic questions regarding afteruse of degraded fens. The area is a representative part of a valley fen with typical conditions of pleistocenic lowlands. It is subsidiary for a great expanse of neigbouring rewettable parts of the landscape.

The pilot-site will serve as object for conception and discussion. On the one hand this refers to silvicultural issues: Different variants of foundation have been tested and are represented directly next to each other for easy comparison. Effects on successful accretion and vitality of the trees are monitored constantly. Novel procedures like borehole-planting into tilled or plowed patches will have to prove their practicallity. Qualitative ramifications of relatively spacious planting will have to be examined. Furthermore the pilot site shall contribute to create integratively tuned concepts of land use for fen peatland sites with relatively low potential for conflict regarding practice.

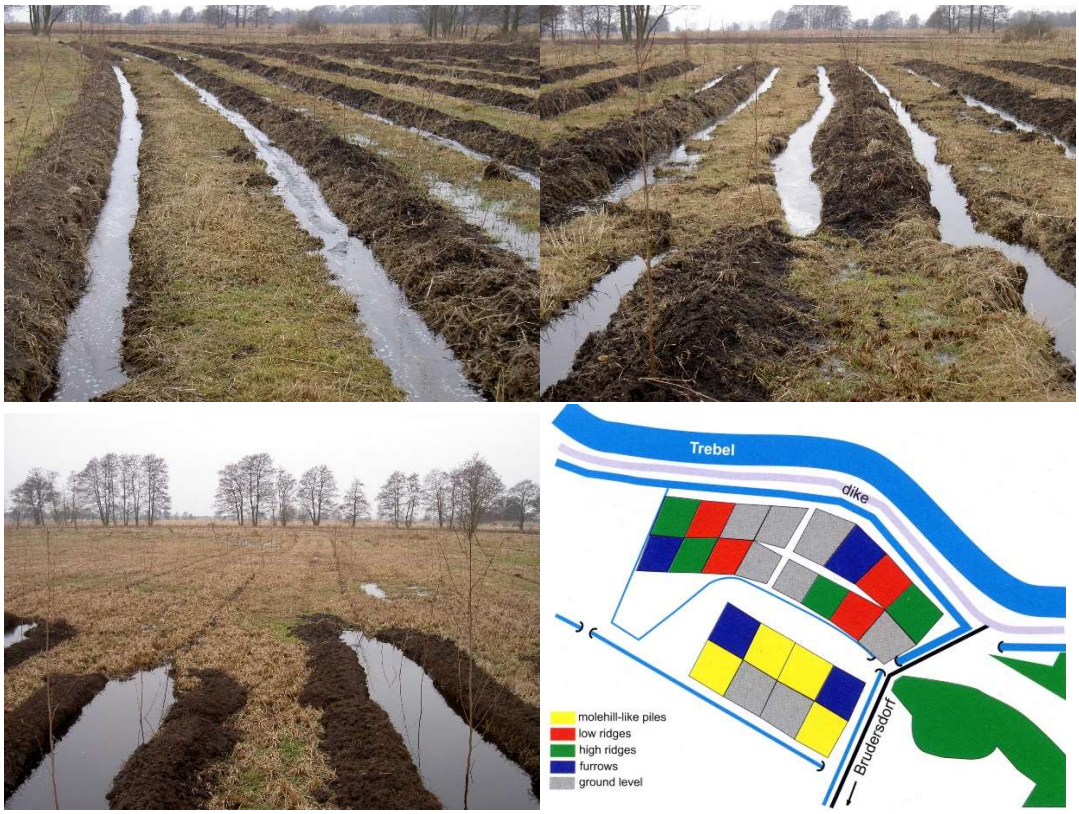


Position of the pilot site.

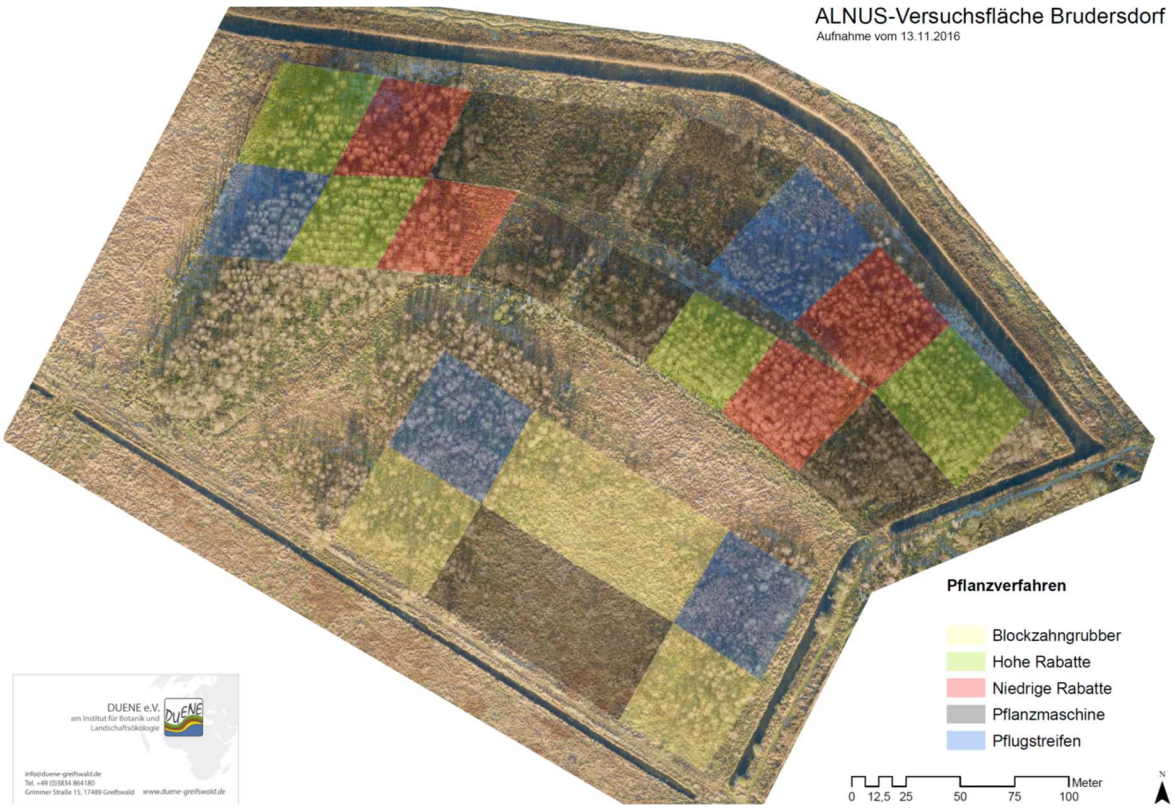
Depiction based on spatial base data provided by the land surveying office Mecklenburg-Western Pomerania permitted by the University of Greifswald

Box 5 ALNUS-Project

The wood of black alder (Alnus glutinosa) is a valuable material for carpentry, interior fittings, and furniture. Besides, tailings can be used as firewood. The ALNUS project carried out from 2002 to 2005 by the University of Greifswald developed a method for producing high grade alder timber on a small patch of 10 ha rewetted fen peat land. The project showed that with the right management, wet alder woods can provide profitable wood yields while simultaneously preventing peat oxidation or even allowing peat accumulation. Criteria and indicators for site selection and management were developed by integrating silvicultural, ecological and economic expertise. Convinced by the project's results the state forestry service of the German federal state Mecklenburg-Vorpommern started an ambitious program to rewet drained peatland forests for alder cultivation.



Different planting method at the ALNUS site in 2002, u.l.: low ridge, u.r.: high ridge, l.l: furrows, l.r.: site map of the different of the ALNUS project (Photos: A. Schäfer).



Georeferenced drone imagery from 2016 shows the impact of extent summer flood in 2010 which led to a major dying of trees several parcells. Spontaneuous rejuvenation after 2010 closed the gaps. Today stand is ripe for development of quality timber. (lensescape.org 11/2016)

Alder as a high forest

Sites with a good nutrient supply and moving soil water are ideally suited for alder-wood management. This also applies to wet and deep peatlands sites. A conversion of the area from grassland or arable land to forest is necessary and must be carefully weighed up. On shallow and wet sites, coppice management can also be partially considered.

Very moist alder high forest in the Barnim, Brandenburg, Germany (Photo: T. Lüdicke)

Water level:	10-20 cm below ground level in summer, 5-15 cm below ground level in winter (water level class 4+), so-called O.2 sites for forestry purposes.
Cultivation:	Plantation
Yield:	4-6 tree thinnings, mature after 60-80 years with a total growth capacity of 600-800 m^3 ha^{-1}
Harvest:	Value timber
Utilisation:	further research necessary
Optimal Harvest:	tree age of 60-80 years

Info-Box: Black alder (*Alnus glutinosa*) as high forest.

Alder as coppice forest

Shallow, degraded, rewetted areas on fens, especially marginal areas of rewetted areas, are suitable for alder coppice forestry. For areas previously used as arable land or grassland, conversion to forest is required. Alder coppice is productively superior to other coppice types (e.g. oak) and can also be a form of use on sites that are water-logged all year round and are not suitable for high forest production.

Alder coppice in the Spreewald, Brandenburg (Photo: P. Schulze)

Water level:	in summer 10-20 cm below ground level, in winter 5-15 cm below ground level (water level class 4+), so-called O.2 forestry sites
Cultivation:	Plantations
Yield:	Rotation period 20-40 years with 1-3 thinnings with a total growth capacity of 200-500 m^3 ha^{-1}
Utilisation:	Energy wood, commercial timber
Site emissions:	Further research needed
Harvest:	every 20 – 40 years

Info-Box: Black alder (*Alnus glutinosa*) as coppice.

Further reading

Schäfer, A. & Joosten, H. (Hrsg.) 2005: Erlenaufforstung auf wiedervernässten Niedermooren: ALNUS-Leitfaden. [Afforestation with Black Alder in rewetted fen peatlands: ALNUS-Guideline. In German], Institut für Dauerhaft Umweltgerechte Entwicklung der Naturräume der Erde (DUENE) e.V. (ed.), Greifswald. 68 p.

Excursion Day 4

I. SCHEDULE AND ROUTE

Time	Places	Contents
7:00-8:00	Breakfast at the hotel	Check-out at Hotel in Bad Oldeslohe
08:30-11:00	Company “Hiss Reet”	Marketing of products from reed, reed trading for roofing and construction materials.
13:00	Seminar with Lunch buffet in Oldenburg	Peat moss farming - site management and peat substitutes in horticultural substrates.
15:30	Peat moss farming site of MoKuRa in Hankhausen	Peat moss farming implementation - experience and optimisation of water manafgement with constructed reed and Cattail beds. Horticultural entrepreneur reports experience with Peatmoss based substrates.
18:00	Hotel in Oldenburg	Dinner buffet at the hotel

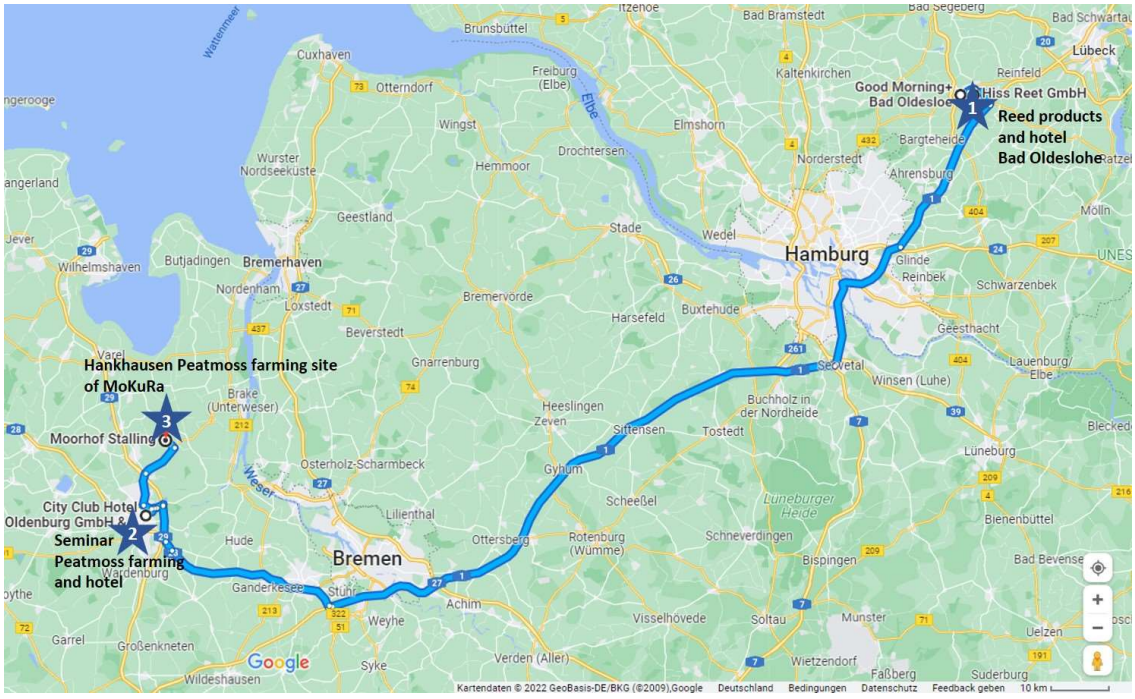


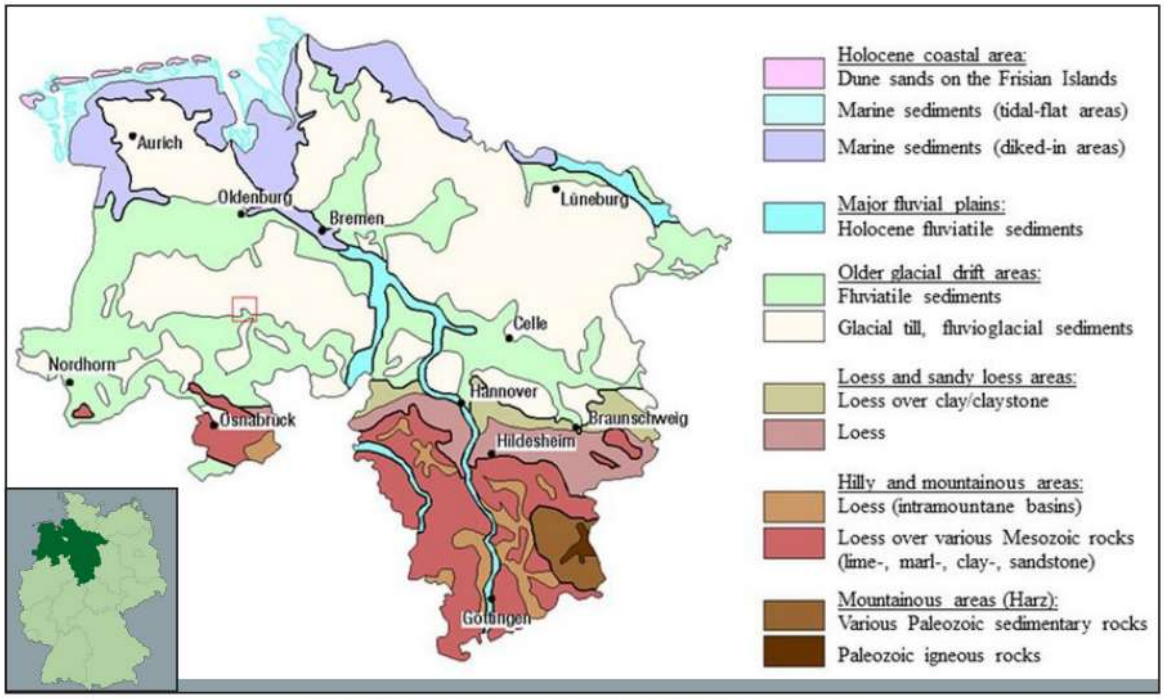
Figure: Tour route Thursday 22.09; Sites (1) – (3)

II. INTRODUCTION

Bad Oldesloe, Hankhausen, Ramsloh – Lower Saxony

Landscape

The excursion will take place in the northwestern part of Germany, Lower Saxony and Schleswig-Holstein. This region was shaped by the last glaciation and thus characterized by deposits of ground moraines, mainly sandy boulder clay or till, which were partly covered by drifting sand and river deposits. After the glaciation large areas paludified and fens and in particular, due to high precipitation rates, bogs developed. The northwest part is the main distribution area of bogs in Germany, and consequently the region with the main peat extraction activities. This region is also characterized by humid and oceanic (atlantic) climate.



Geologal units of Lower Saxony, and below its location in Germany

Land use history

In medieval times the bogs of this region were used for small-scale peat cutting. Slightly decomposed Sphagnum peat (white peat) was used as litter, while black peat was mainly used as fuel. At the end of the 17th century large bog cultivation started and land use on peat soils became more intensive. In the 19th and beginning of 20th century peat cutting increased in large mire complexes. Remarkable was the buck wheat fire cultivation on bogs, which caused substantially air pollution by smoke. In 1868 M.A.F. Prestel published a scientific paper „On the fire cultivation in peatlands in East Frisia“ in which he documented the peatland fires induced by the buck-wheat culture on drained peatlands and the distribution of haze plumes in central Europe. The environmental problems of this drainage based peatland utilisation led to the establishment of the Mire Experimental Station Bremen (in northwest Germany) in 1877, where peatlands and peatlands utilisation was investigated. In particular the ‘German raised bog cultivation’ was developed and studied. Bogs were mainly used as grassland and to a small extent as arable land. Before the Second World War peat cutting changed from manually to industrial extraction techniques.

Under the NS-regime in the first halve of the 20th century prosecuted Jewish and political imprisoners and prisoners of the Second World War were forced to hard peatland reclamation and drainage works in 15 concentration camps of Emsland. Today the memorial site Esterwegen reminds of the fate of the forced labourers and the crimes of the NS-regime. After the Second World war the agricultural use was intensified with more effective drainage systems and heavy agricultural machinery of the Company Ottomeyer in particular during the 1950- 1970s. Geologal units of Lower Saxony, and below its location in Germany 18 19 Tuesday 25th September

Current land use

Peat extraction decreased over the last 30 years and will substantially decrease within the next years as the slightly decomposed peat ('white peat'), the most valuable raw substance for substrates in professional horticulture, is getting exhausted. Moreover, it becomes more difficult to get permits for extraction due to policy changes and refusal by local populations. The current licenses for white peat excavation are fading within the next years and new licenses are not issued. A sensitive issue is the cultivation of Zea mais as energy crop for production of "Biogas" on drained peatland a widespread practice, subsidised by bioenergy programmes in Germany, that causes up to 8-10 times more emissions of GHGs as the direct combustion of coal. Nowadays the total bog area in Lower Saxony is around 208,000 ha and only < 1 % is in a natural state. More than 50 % of the bog area is agriculturally used including 44 % bog grassland and around 8 % for peat extraction. To cover the growing demands from world-wide urbanisation, the cultivation of vegetables, fruits and flowers takes place in pre-prepared growing media, consisting mainly of slightly decomposed Sphagnum peat, which is mined from peatlands. Currently, peat provides 92 % of the German demand. In Germany, approximately 4 million cubic metres of white peat is used annually for professional horticulture and hobby gardening.

Nature conservation

The rapid loss of natural bog areas led to the 'Moorschutzprogramm' (program for peatland conservation; part 1- 1981 and part 2- 1986) of Lower Saxony, where priority areas for peat extraction and for nature conservation as well as the restoration by rewetting of cut-over bogs were specified. Major aims were to protect around 50,000 ha not extracted and 31,000 ha extracted bog areas as well as several small bogs as nature conservation sites.

Research

In the last years the use of Sphagnum biomass as a raw material for growing media in modern professional horticulture has been successfully tested and in some cases it demonstrates even better results than the peat-based substrates developed over many years.

Further reading

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J. Köbbing & S. Wichmann 2015: Common reed for thatching—A first review of the European market, Industrial Crops and Products 77:1063-1073 (DOI: 10.1016/j.indcrop.2015.09.027)

Distribution of the peatland fires between 1848-1863: http://reader.digitale-sammlungen.de/en/fs1/object/display/bsb10298347_00031.html

Monument Esterwegen: https://www.gedenkstaette-esterwegen.de/english/

Short Movie about peat extraction by Company Ottomeyer/Pyrmont 1970: https://www.youtube.com/watch?v=hk-ktzVIK9Y

III. EXCURSION SITES

1. Company Hiss Reet

The family-owned company HISS REET (Schilfrohrhandel GmbH) was founded 1833 in Bad Oldesloe. It has been trading reed since the 1920s and has grown to become the biggest merchant for reed in Germany. Subsidiary companies in Turkey, Rumania and Hungary harvest the reed and are responsible for its processing. The reed products are directly distributed to Germany, Holland, England, Ireland, and Denmark via ship or truck. The company also trades complementary products of other manufacturers, for example dormer windows, wall heatings, fastening material. In addition to the traditional trade with thatch reed a growing focus is put on the trade with other reed products. Due to the constantly growing demand Hiss Reet founded the sector of natural building material in 2004. Clients also revealed a stronger interest for the sector of Hiss Reet Garden Products which hence was extended by new products.

Harvest prozedure of Company Hiss Reed

During the excursion there will be the chance to see construction materials of Hiss Reet applied in a in a small show pavilion.

Box 6 Utilisation of Common Reed (Phragmites australis)

Common reed (Phragmites australis) is a globally distributed emergent wetland plant. For thousands of years it has been traditionally used by people all over the world. Applications such as the manufacture of schnapps, coffee and boats are meanwhile less popular than they have been in the past. Reed as constructing has a long tradition in many cultures whole buildings, garments, mats, boats, were and are made from reed especially in Europe still wide spread are reed-thatched roofs. Many of the traditional fishing villages in the Fischland-Darß-Zingst area (northeastern Germany) are still characterised by the typical architecture with reed-thatched roofs. Nowadays the touristic region is keen to maintain the traditional scenic appearance of the fisher villages. Traditional craftsmanship for the harvest of reed and the construction of thatch roofs is still present in enterprises and workshops in the region and finds also application in contemporary modern architecture. Local demand for thatch reed cannot be satisfied by local reed resources only. Land degradation and nature conservation restrictions limit the availability of suitable reed beds for the harvest of thatch reed and therefore imports from Eastern Europe and China are necessary.

2. Peat Moss (*Sphagnum* sp.) Farming – Hankhausen

General Information

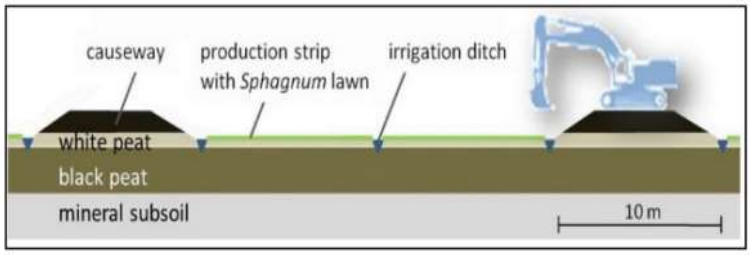
The peatland “Hankhauser Moor” is located near to the city Oldenburg in Lower Saxony. In 2011 there was a Sphagnum farming pilot site installed by the peat company Torfwerk Moorkultur Ramsloh GmbH & Co. KG (MoKuRa) in cooperation with the University of Greifswald.

Aerial View of the peatland Hankausen

This area of former bog grassland was strongly degraded after decades of intensive use as grassland for dairy farming with deep drainage, leading to 1 m subsidence since 1958. Recently the region is situated 0.5 m below the sea level and drainage water has to be pumped out actively to the North Sea.

Project progress

For installation of the trials over 4 ha (10 acres) the upper highly mineralized peat layer (~30 cm) was removed and used for constructing dams resulting in 10 m



Schematic cross section of the Sphagnum farming area consisting of causeway, ditch and production strip with Sphagnum lawn on white peat above black peat and the mineral subsoil

wide production strips bordered by irrigation ditches. After site preparation Sphagnum fragments were spread on the bare peat and subsequently covered with straw. Afterwards the site was rewetted, irrigation water was pumped from the adjacent channelized 'Schanze' rivulet, east of the study site, which drains the entire surrounding territory. 1.5 years after initial establishment Sphagnum palustre, S. papillosum and S. fallax already covered 95% of the area with mean lawn height of 8.3 cm (maximum 22.4 cm, Figure 3). Sphagnum productivity is high with a dry mass of around 8.7 t ha-1 yr-1 after the lawn establishment. Five years after field installation first mechanical harvest of the Sphagnum mosses was conducted in 2016 the peat company Moorkultur Ramsloh GmbH & Co. KG. Harvest of the mosses was done by an excavator reaching into the cultivation site from the installed causeways with a long arm and mowing bucket. Two third of the upper Sphagnum mosses were cut as former experiences showed that residual Sphagnum stems left regenerate fast. The material was directly spread to newly prepared fields to enlarge the cultivation area to 14 ha.

Box 7 Current applications of Sphagnum fresh biomass

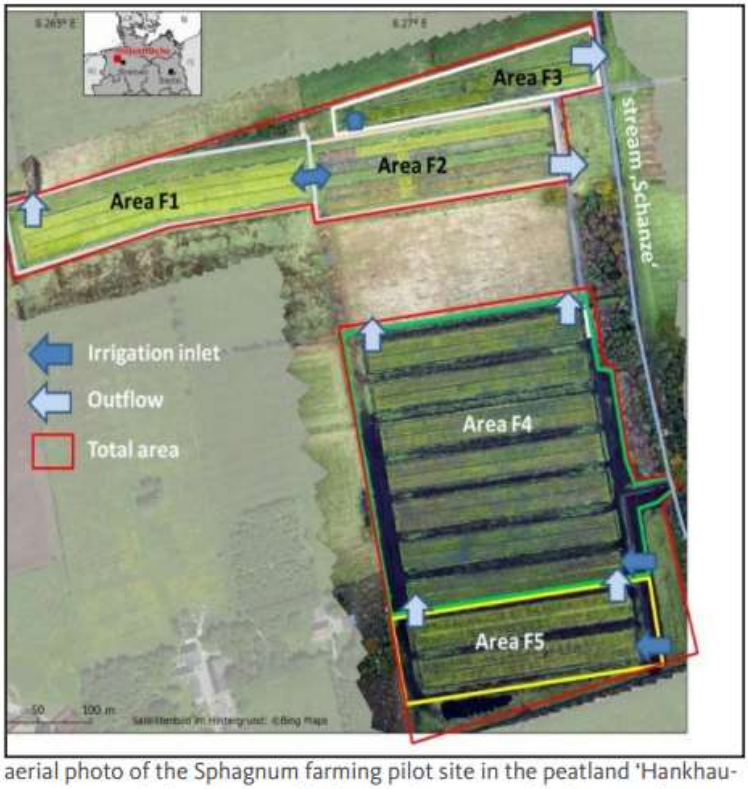
Sphagnum vegetation restoration aims to re-establish Sphagnum dominated vegetation on degraded bogs (including sites where peat extraction has occurred) for nature conservation, erosion control or carbon sequestration with no intention to harvest the re-established mosses.

Sphagnum gathering is the collection of Sphagnum (e.g. for orchid cultivation) from wild populations which are not (or minimally) managed to maintain or increase yields.

Sphagnum farming aims to cultivate Sphagnum biomass for harvest, originally as founder material for restoration, but increasingly nowadays as an agricultural crop, e.g. as a raw material for agricultural growing. This new type of paludiculture includes the selection of highly productive species and active management to maximise yields, see also Box 10 Sphagnum farming.

Project results

Up to now the experiments in the 'Hankhauser Moor' has convincingly proven the feasibility of large-scale Sphagnum farming already during the establishment phase, and also with the subsequent high Sphagnum biomass productivity. The pilot site now allows developing methodologies and testing machines for further upscaling of the cultivation and harvest of Sphagnum biomass. Furthermore many sundew (Drosera rotundifolia) plants are spontaneously growing in the Sphagnum culture. Recently pharmaceuticals from Drosera sp. (dried above-ground plant parts) are used to medicate respiratory diseases. The plants are mainly collected from wild populations in intact peatlands, while all Drosera species are endangered now in Europe (Baranyai & Joosten 2016). Prospects of Drosera cultivation in combination with Sphagnum farming is investigated at the Sphagnum farming site in Hankhausen. Research on germination, survival, biomass growth and content of medicinal ingredients is done at the University of Greifswald.



aerial photo of the Sphagnum farming pilot site in the peatland 'Hankhauser Moor' with the parts installed in 2011 (Area F1+F2) and in 2016 (Area F3-F5) and the irrigation system (stream 'Schanze' as origin of the water + inlets and outflows)

Further reading

Blievernicht, A., Irrgang, S., Zander, M. & Ulrichs, C. 2013. Sphagnum biomass - the next generation of growing media. Peatlands International 1/ 2013: 32-35.

Emmel, M. 2008. Growing ornamental plants in Sphagnum biomass. Acta Horticulturae 779: 173-178.

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Wichmann, S., Prager, A. & Gaudig, G. 2017. Establishing Sphagnum cultures on bog grassland, cut-over bogs, and floating mats: procedures, costs and area potential in Germany. Mires & Peat 20, Art. 3

www.moorkultur-ramsloh.de

Box 8 Sphagnum Farming

Sphagnum farming is the cultivation of peat moss (Sphagnum) aiming for the production and harvest of peat moss biomass. For this purpose the Sphagnum is cultivated in order to gain renewable raw material for the production of horticultural growing media. Blueprints for modern Technology and hydro-engineering date back to the early stage of the soviet union in the beginning 20th century where Lenin installed hords of engineers to develop schemes and technology to realise his vision of a modern and electrified Russian empire also with the exploitation of the huge Russian peatlands for energy and material utilisation. Nowadays almost all vegetable and decorative plants and flowers that are grown in professional horticulture are potted in substrates based on white peat. The Netherlands and Lower Saxony in Germany have largely depleted their white peat resources and continue to exploit the resource in the Baltics. We literally eat our way through the peatlands in a Northeast expansion. Paludiculture with Peat mosses cultivate Sphagnum as a renewable raw material in exploited peat mining areas drained agricultural peatland after rewetting. The Fresh Sphagnum biomass can be harvested in short rotations of ~5 years and can replace white peat in horticultural substrates and thus reduce the need for new peat extraction sites. Cultivation tests have shown its feasibility, but the initial production volumes are small and currently cannot provide enough raw material to substitute all horticultural peat. Further technological and economic research and development needs to be carried out to scale-up existing cultivations to provide future horticulture markets with high quality and affordable Sphagnum biomass that is able to compete with the well-established productions schemes and markets for white peat.

Sphagnum as an alternative to peat in growing media

To cover the growing demands from world-wide urbanisation, the cultivation of vegetables, fruits and flowers takes place in pre-prepared growing media, consisting mainly of weakly decomposed *Sphagnum* peat (‘white peat’, also known as ‘blond peat’ and, confusingly, ‘peat moss’) which is extracted from peatlands. Currently, peat provides 86 % of the raw material required by the European Union for horticultural substrates and 92 % of the German demand. In Germany, approximately 4 million cubic metres of white peat is used annually for professional horticulture and hobby gardening. In contrast, the stocks of white peat in most countries of western and central Europe are largely depleted, and living bogs have become so rare that the few remaining examples are strictly protected. Thus the availability of peat becomes limited, and the growing media industry is forced to source it from ever more remote areas. Consequently there is an urgent need to develop sustainable alternatives for peat not only from ecological but also from economic and social point of view.

The most promising alternative is *Sphagnum* biomass as an environmentally friendly and high quality raw material for horticulture (Gaudig et al. 2014, 2018). Its use as a raw material for growing media in modern professional horticulture has been successfully tested and in some cases demonstrates even better results than the peat-based substrates developed over many years (Emmel 2008, Blievernicht et al. 2013, Gaudig et al. 2018).

Excursion Day 5

I. SCHEDULE AND ROUTE

Time	Places	Contents
7:00-8:00	Breakfast at the hotel	Check-out from Hotel in Oldenburg.
9:00	Saterland-Ramsloh, Baumschule Franz Scheper	Visit of a tree nursery and horticultural enterprise experienced with peat moss fresh biomass-based substrates.
10:30	Horticultural Peat factory “Torfwerk Moorkultur Ramsloh”	Peat factory tour - Procession of peat moss fresh biomass for professional horticultural substrates.
12:00	Lunch in Ramsloh	
13:00	Transfer to Hamburg airport (HAM)t	arrival at Hamburg airport 16:30.

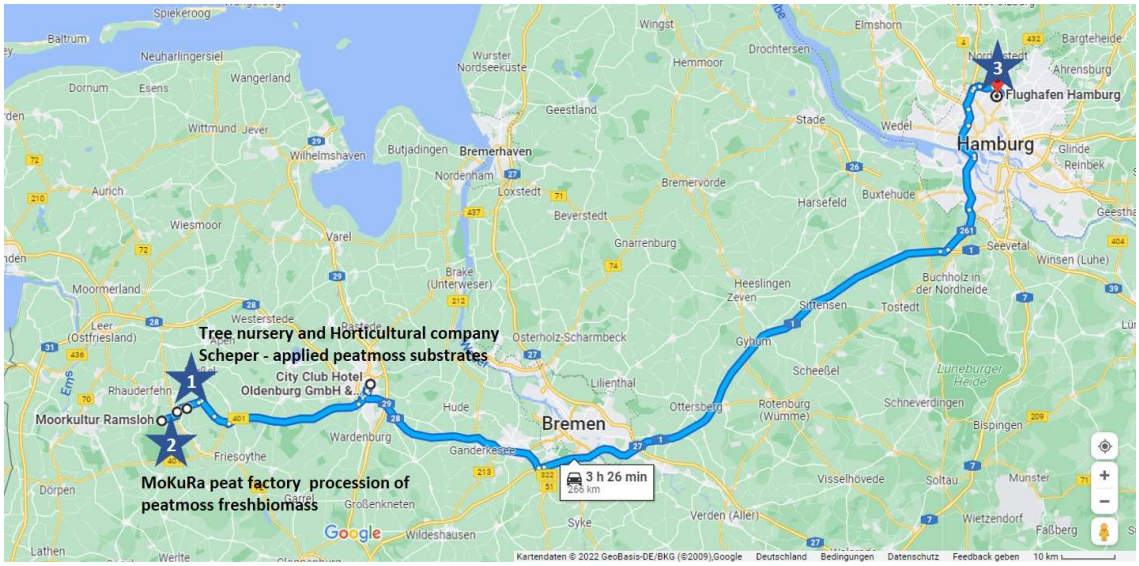

Figure: Tour route Friday 23.09; Sites (1) – (3)

II. INTRODUCTION

(see Excursion Day 4)

III. EXCURSION SITES

1. Treenursery and horticultural enterprise working with Peatmoss fresh biomass-based substrate mixtures

Horticulturists Franz and Antje Scheper tested pure peatmoss based substrates and blends with in mixtures with peat produced by substrate producer MoKuRa. The substrats matched the properties of purely peat besed substrates and the company would use more peatmoss fresh biomass-based substrates if availability would be sufficient and prices could compete with regular peat based professional horticultural substrates.

2. Moorkultur Rahmsloh - Peat substrate factory

General Information

The peat company Torfwerk Moorkultur Ramsloh Werner Koch GmbH & Co. KG (Mokura) has nearly 100 years experience in the production of growing media for horticulture as well as the production of raw materials for growing media. They are well connected in the growing media industry, being also a longtime partner of the Floragard GmbH, Oldenburg as a supplier of growing media.
For more than 18 years now they are partners of the University of Greifswald and others in different *Sphagnum* paludiculture projects, already having converted 17 ha of former drained bog grassland into *Sphagnum* paludiculture fields.

Aerial view of the peat processing plant

- The extraction of the raw material takes place mainly on agricultural pre-used areas.
- The extraction quantity amounts to approx. 37,000 m^3 per year.
- The peat raw material is further processed in the modern production facilities. These include grinding and screening plants and two wood fiber plants.
- From here, the peat raw material, which is prepared for a wide variety of requirements, is either loaded onto trucks for further processing companies or prepared for further refinement into a finished growing medium.
- The raw material is transported by conveyor belt to a warehouse with a capacity of approx. 10,000 cbm and prepared for each customer by adding various additives (wood fiber, fertilizer, lime, and small charges with peatmoss fresh biomass).

https://www.moorkultur-ramsloh.de

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Emmel, M. 2008: Growing ornamental plants in Sphagnum biomass. Acta Horticulturae 779: pp 173-178. DOI: 10.17660/ActaHortic.2008.779.20

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Joosten, H., Couwenberg, J., Schäfer, A., Wichmann, S. & Wichtmann, W. 2012: Perspektiven der Regeneration und Nutzbarmachung von Mooren. Mitteilungen der Gesellschaft für Pflanzenbauwissenschaften 24: pp. 13–16.

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Wichtmann, W. & H. Joosten, H. 2007: Paludiculture: peat formation and renewable resources from rewetted peatlands. IMCG-Newsletter, issue 2007/3, August 2007, pp 24-28. URL: http://www.imcg.net/media/newsletter/nl0703.pdf.

Wichtmann, W., Tanneberger, F., Wichmann, S. & Joosten, H. 2010: Paludiculture is paludifuture: Climate, biodiversity and economic benefits from agriculture and forestry on rewetted peatland. Peatlands International (1): 48–51. URL: https://www.moorwissen.de/files/doc/Projekte%20und%20Praxis/enim/pi_paludifuture_2010.pdf

Further Links:

Legal study paludiculture in Europe: https://www.dropbox.com/s/ei2qipc5pczgvdk/Report_Laura_Koelsch_Iur_Cinderella_09062016.pdf?dl=0

Technical report Cinderella Nijmegen: https://www.dropbox.com/s/774xec067awznt4/Final-Report-Cinderella-Nijmegen.pdf?dl=0

FACCE-JPI: https://www.faccejpi.com/content/location/96954

Cinderella: www.paludiculture.uni-greifswald.de/en/projekte/cinderella /index.php

EUKI Homepage: https://www.euki.de/

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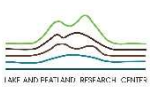
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