Excursion 5

Cultivation Methods and Diverse Research on *Sphagnum* Paludiculture on Rewetted Bogs in Lower Saxony/ NW Germany

Guides:

Matthias Krebs (+ other local guides)

Excursion Programme

Time	Programme
06:00	Departure from Greifswald
06:15-12:00	Bus transfer
12:00-14:30	First stop: *Sphagnum* paludiculture site in the peatland 'Hankhauser Moor', Mokura
12:30-13:00	Field lunch
14:30-16:00	Bus transfer to Gnarrenburg
16:00-17:30	Second stop: *Sphagnum* paludiculture site in the peatland 'Gnarrenburger Moor', ZukunftMoor
17:30-23:00	Return to Greifswald

Food packages and drinks are provided during the long travel times. Toilets are available at both stops. There will be appropriate stops at rest stops during the long travel times.

Sphagnum paludiculture site in the peatland 'Hankhauser Moor', 3 years after its installation

General Introduction

The pilot study sites of *Sphagnum* paludiculture on former bog grassland are situated in the peatlands 'Hankhauser Moor' and 'Gnarrenburger Moor' in northwest Germany (Lower Saxony).

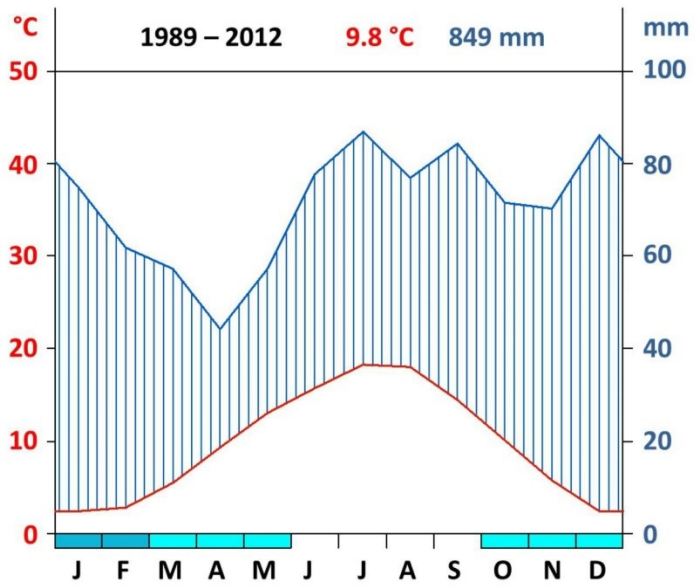

Figure 1. Climate graph of the pilot study site of *Sphagnum* paludiculture on former bog grassland, in the peatland 'Hankhauser Moor'. The left-hand axis is the mean day temperature (°C) and the right-hand axis is precipitation (mm). The x-axis shows the calendar months with dark blue stripes presenting the months where frost events certainly occur, light blue those where frost may occur.

The northwestern part of Germany was shaped by the Saale glaciation and thus is characterised by deposits of ground moraines, mainly sandy boulder clay or till, which were partly covered by drifting sand and river deposits. The Saale glaciation ended 130,000 years b.c. After the glaciation large areas paludified and fens and in particular bogs developed. The Northwest is the main distribution area of bogs in Germany. This region is characterized by humid oceanic (atlantic) climate (Figure 1).

Bog utilisation in northwest Germany (main information from Trepel et al. 2017)

In medieval times, bogs were used for small-scale peat cutting. *Sphagnum* 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 substantial air pollution through smoke. This led to the establishment of the Mire Experimental Station Bremen (in northwest Germany) in 1877, where peatlands and peatland utilisation was investigated. In particular the 'German raised bog cultivation' (Deutsche Hochmoorkultur) 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 manual to industrial extraction techniques. The agricultural use was further intensified with more effective drainage systems, in particular during the 1950- 1970s. The rapid loss of natural bog areas led to the 'Moorschutzprogramm' (programme 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.

Peat extraction decreased over the last 30 years and ran out within the next years as the weakly decomposed peat ('white peat') and for horticultural purposes most valuable constituent is getting exhausted and the use of peat in horticulture must be greatly reduced in accordance with federal government guidelines.

At present, the majority of extensive bog complexes are being affected by drainage for their agricultural use. Nowadays the total bog area in Lower Saxony is reduced to around 201,100 ha and only < 1 % is in a natural state, but ca. 44% are used as bog grassland (Höper 2024).

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, in Germany 8-9 million m³ of peat are used annually with a share of 65% in professional horticultural substrates. The availability of peat is becoming increasingly constrained, compelling the growing media industry to seek alternative sources from increasingly remote locations. Consequently, there is an urgent need to develop sustainable alternatives for peat, not only from an ecological perspective, but also from economic and social viewpoints.

Sphagnum biomass is a promising alternative in terms of its potential to serve as an environmentally friendly and high-quality raw material for horticultural applications (Gaudig et al. 2014, 2018). Its use as a raw material for growing media in modern professional horticulture has been successfully tested (Emmel 2008, Blievernicht et al. 2013, Gaudig et al. 2018).

Stop 1: Pilot Study Site on Former Bog Grassland in the Peatland 'Hankhauser Moor'

The *Sphagnum* paludiculture pilot study site was installed by the peat company Torfwerk Moorkultur Ramsloh GmbH & Co. KG at the peatland 'Hankhauser Moor' near to Oldenburg, Germany (N 53°15.80' E 08°16.05') in May 2011. This area was strongly degraded after decades of intensive use as grassland for dairy farming with deep drainage, leading to 1 m subsidence since 1958. Currently the region is situated 0.5 m below the sea level and drainage water has to be pumped out actively to the North Sea. For installation of the trials over 4 ha (10 acres) the upper highly mineralised peat layer (~30 cm) was removed and used for constructing bunds used as causeways. The production fields with *Sphagnum* mosses are 10 m wide and bordered by irrigation ditches (Figure 3). After the removal of the degraded top layer, the surficial peat layer of the study site consists of weakly decomposed *Sphagnum* peat (section SPHAGNUM), mainly with degrees of humification from H2-4 (after von Post 1924, Figure 3). It is characterised by a high saturated hydraulic conductivity (Roßkopf et al. 2016). After site preparation, *Sphagnum* fragments were spread as founder material on the bare peat and subsequently covered with straw (straw cover only in 2011, Figure 4). After installation the site was rewetted. Irrigation water is pumped from the adjacent 'Schanze' stream, east of the study site, which drains the entire surrounding territory. Experience has shown that a straw cover is not necessary to improve the establishment of peat moss.

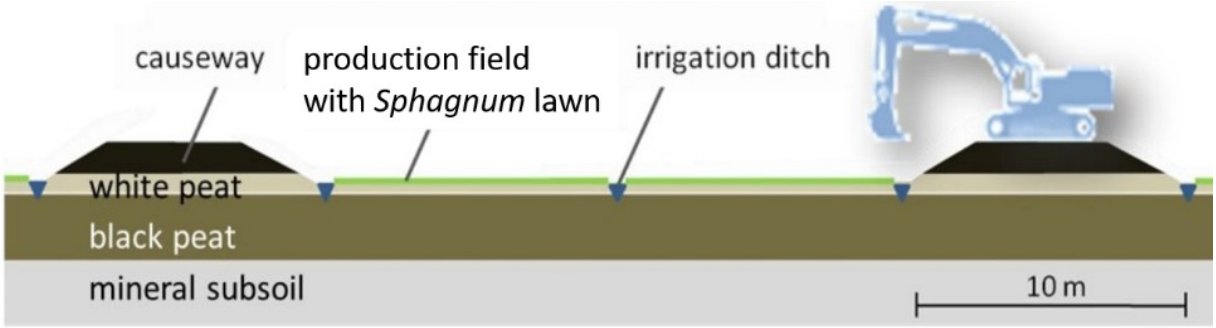

Figure 2. a schematic cross section of the *Sphagnum* paludiculture area consisting of causeway, ditch and production fields with *Sphagnum* lawn on white peat above black peat and the mineral subsoil. Photo: Google Earth March 2022.

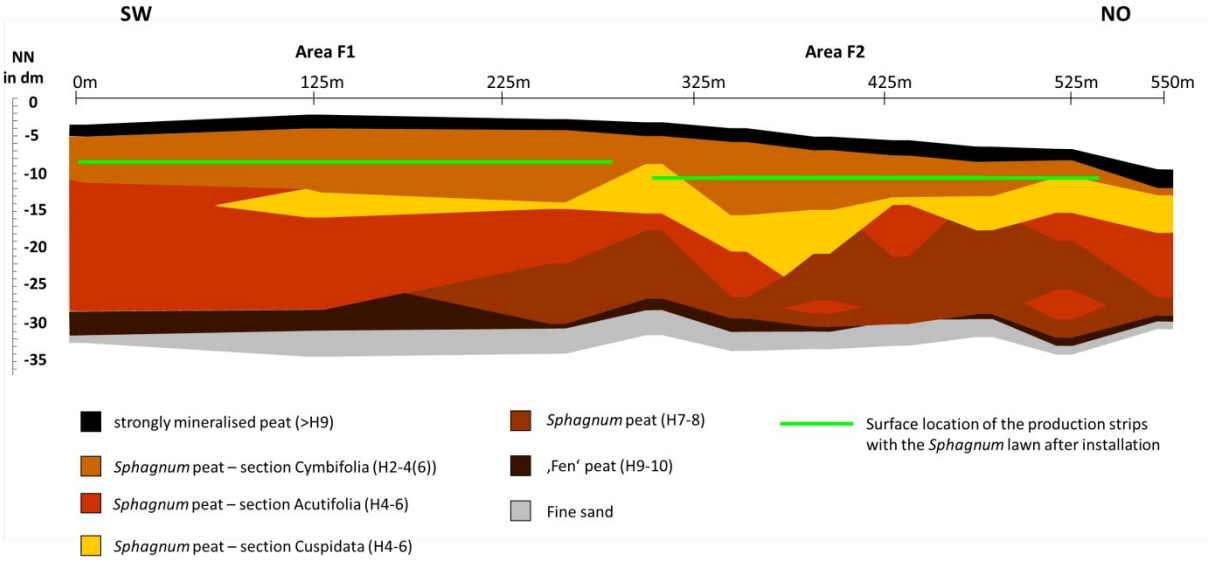

Figure 3. Cross section of the peat stratigraphy of the *Sphagnum* paludiculture site in the peatland 'Hankhauser Moor' (installed in 2011) directly before the site's installation with peat types, degree of humification (after von Post 1924), and the location of two production areas F1 and F2.

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 4). As soon as a closed *Sphagnum* lawn established, *Sphagnum* productivity was high with a dry mass of in 4.9 t ha^{-1} yr^{-1} (Wichmann et al. 2020).

Figure 4. Installation of a large-scale *Sphagnum* farming field in NW Germany by the peat company Moorkultur Ramsloh GmbH & Co. KG (Hankhausen, spring 2011, left photo) and *Sphagnum* paludiculture field in Hankhausen 1.25 years after installation (right photo). Photos: S. Wichmann

Five years after field installation the first mechanical harvest of the *Sphagnum* mosses was conducted in 2016 by the peat company Moorkultur Ramsloh GmbH & Co. KG. An excavator stood on the causeway and cut the mosses with a long arm and mowing bucket. Recently the harvest practise is to cut the upper 5 cm of living *Sphagnum* lawn and separate it from the biomass below. After harvesting the entire grown up *Sphagnum* biomass the upper 5 cm are spread as founder material again on the bare peat to initiate the *Sphagnum* lawn regrowth. The other biomass material is transported to the substrate facilities. Several other experiments were conducted with regard to optimising the production process, enlarging the production field share in the production system, and reducing greenhouse gas emissions etc. The recent total area of the site is 20 ha.

Up to now, the site in the peatland 'Hankhauser Moor' has convincingly proven the feasibility of large-scale *Sphagnum* paludiculture by fast establishment of *Sphagnum* lawn and high *Sphagnum* biomass productivity. The pilot site now allows developing methodologies and testing machines for further upscaling cultivation and harvest of *Sphagnum* biomass.

During the excursion you can see experiments on best practice, top soil removal depth, water management (different ditch distances, subsurface irrigation), regeneration after harvest, a small-scale field trial on the selection of productive provenances of 12 potential *Sphagnum* paludiculture species and field tests of axenic in vitro-cultivated *Sphagnum* clones; sundew cultivation. Long term investigations on GHG, water quality and demand, biodiversity, nutrient purification etc. were conducted since 2011 and its results will be reported during the excursion.

Figure 5. *Sphagnum* paludiculture site in the peatland 'Hankhauser Moor' with areas installed in 2011 (right side at the picture) and in 2016 (upper left side at the picture). photo: T. Dahms and S. Busse, April 2017.

Stop 2: *Sphagnum* Paludiculture Site on Former Bog Grassland of the Company ZukunftMoor in the Gnarrenburger Moor

Site Description

The ZukunftMoor company is the first start-up company globally which only cultivate *Sphagnum* in paludiculture. It has been operating its 13.4-hectare *Sphagnum* paludiculture site in the peatland 'Gnarrenburger Moor' (Lower Saxony, 53° 22.156'N, 9° 1.344'E, Figure 6) using the results and experiences gained from implementation and research by the University of Greifswald. The area was previously intensively farmed with grassland and its installation started in October 2024.

Today, the area comprises 12 individually controllable polders for agricultural production and a water management system incorporating ditches, pipes, pumps and two reservoirs. The team is working with technology and cooperating with scientific institutes to analyse how *Sphagnum* paludiculture reduces greenhouse gas emissions, promotes biodiversity and retains water. The team is planning to enlarge the *Sphagnum* biomass production with new cultivation areas in the region to prove the economic viability of paludiculture.

Figure 6. *Sphagnum* paludiculture site in the peatland 'Gnarrenburger Moor' picture: ZukunftMOOR GmbH.

Excursion Topics of *Sphagnum* Paludiculture

Research conducted at the University of Greifswald on *Sphagnum* paludiculture is subject to continuous assessment for already 20 years. The primary research topics will be presented during the field trip, along with the main results:

- establishment and development of different *Sphagnum* species on former bog grassland (Gaudig et al. 2024),
- regrowth after harvest of different *Sphagnum* species, cut depths and repeated harvest (Krebs et al. 2018)
- effects on biodiversity: plant species (Gaudig & Krebs 2016), spider fauna (Muster et al. 2015, 2020), fungi (Borg Dahl et al. 2020), dragonflies, birds
- risk potential of growth inhibitory factors (Borg Dahl et al. 2020),
- hydrological requirements of *Sphagnum* paludicultures (water budget, water table) (Brust et al. 2018, Quadra et al. 2025),
- nutrient supply and stoichiometry of *Sphagnum* paludicultures due to nutrient rich irrigation water (Temmink et al. 2017, Koks et al. 2019, Gaudig et al. 2020, Vroom et al. 2020, Käärmelahti et al. 2023, Temmink et al. 2024),
- topsoil removal due to minimise its removal for decreasing greenhouse gas emissions (Käärmelahti et al. 2024),

- balancing the fluxes of greenhouse gas emissions of the production areas, the irrigation system and causeways of a *Sphagnum* paludiculture site (Günther et al. 2017, Daun et al. 2023),
- technical feasibility (procedures of establishing *Sphagnum* paludicultures – Wichmann et al. 2017, 2020),
- effects of harvesting, processing and storage of *Sphagnum* biomass for substrate (Kumar 2018),
- economy of *Sphagnum* paludiculture (establishment costs of a *Sphagnum* culture – Wichmann et al. 2017, entire production cycle with costs and revenues - Wichmann et al. 2020).

Contacts

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